COMMISSION OF THE EUROPEAN COMMUNITIES
DG XII – RESEARCH, SCIENCE, EDUCATION

RAW MATERIALS

RESEARCH AND DEVELOPMENT

DOSSIERS

III. ALUMINIUM

November 1978

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FOREWORD

This "dossier" on aluminium is part of a series of technico-economic studies that have been prepared under the sponsorship of the "Commission of the European Communities" (Directorate-General for Research, Science and Education) on some of the most critical mineral commodities.

The decision to carry out those studies, as well as other work to be published under the general heading "Raw Materials Research and Development", results from current concern about prospects of supplying the European Community with raw materials in sufficient quantities and at acceptable costs in the mid- to long-term. An essential part in defining the purpose and scope of the dossiers was played by a Sub-Committee of CREST (1), established to investigate on-going activities in the member states, both in the areas of primary and secondary raw materials, in order to determine what R & D actions, if any, should be undertaken by the Community to alleviate its supply problems.

The dossier on aluminium comprises:

A. A report on "Aluminium demand and reserves of the member states, analyses of the data, conclusions on research and development measures to improve the domestic supply within the Community", prepared under contract no. 267-76-ECI-D between the European Economic Community and the Federal Institute for Geosciences and Natural Resources ("Bundesanstalt für Geowissenschaften und Rohstoffe"), Hannover.

   The investigation was carried out in cooperation with the German Institute for Economic Research ("Deutsches Institut für Wirtschaftsforschung"), Berlin. The Federal Institute for Geosciences and Natural Resources was responsible for the part on supply, the German Institute for Economic Research for the part on demand.

B. Two specialized studies on alternative aluminium ores:

   I: "Survey of silico-aluminate materials such as clays and shales amenable to treatment by acid processes for the production of alumina", by Aluminium Pechiney, Paris (contract no. 268-76-ECI-F).

   II: "Leucite-bearing rocks and alunites, and their utilization as aluminium raw materials", by Alumetal S.p.A., Milano (contract no. 269-76-ECI-I).

(1) "Comité de la Recherche Scientifique et Technique" - Set up by the Resolution of the Council of Ministers of the European Communities of 14 January 1974, the Scientific and Technical Research Committee (CREST) is responsible for assisting the Community Institutions in the field of scientific research and technological development.

BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE HANNOVER

DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG BERLIN

Aluminium Demand and Reserves of the Member States, Analyses of the Data, Conclusions on Research and Development Measures to improve the Domestic Supply within the Community

Report

commissioned by the
Commission of the European Communities,
Directorate General for Research, Science, and Education, Brussels

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SUMMARY

World supply and demand for aluminium was examined according to region and consumer groups.

The average aluminium concentration in the earth's crust is ca. 8.2 %. Deposits used for the production of this metal contain 3 to 4 times this concentration. By far, the most important aluminium raw material is bauxite. Nepheline and alunite have been used only in the USSR and the PR China.

Blanket deposits have and will have the most importance for the supply of bauxite. The prospects for discovering new, extensive bauxite deposits in the tropics are very favorable. However, deposits will have to be developed that are less accessible than previous ones.

There is little chance that new large bauxite deposits will be found within the EC countries. But these countries have extensive resources of alumino silicate raw materials, although not yet sufficiently surveyed. In view of continuing technological development, these resources could become minable for economic and political reasons.

Measured and indicated world bauxite reserves are about 17.3 billion tons, inferred reserves add about 14.7 billion tons to this figure. Australia (30.3 %), Guinea (20.7 %), and Jamaica (11.6 %), with 60.6 % of the measured and indicated reserves, have the major part of the reserves. The 11 countries of the International Bauxite Association (IBA) have over 77.3 % of the measured and indicated reserves.

A comparison with the past shows that the world-wide situation with respect to bauxite reserves has at least not deteriorated. Known plans for exploration and development lead to the expectation that discoveries will be made in the foreseeable future which will be adequate for the increase in aluminium consumption.

World production of bauxite increased from ca. 41 million tons in 1966 to ca. 80.5 million tons in 1976, an average annual increase of 7.5 %. The principal producer countries are Australia (29.9 %), Guinea (14.1 %), Jamaica (12.8 %), USSR (8.3 %), and Surinam (5.7 %) -- a total of 71 % in 1976 from these 5 countries. About 73 % of the 1976 world bauxite production came from the IBA countries.

Measured and indicated world bauxite reserves have a static life-time of 215 years on the basis of the 1976 production. Assuming an annual increase in production of 4 - 10 %, a dynamic life-time of 57 - 31 years can be expected.

About 95 % of the present bauxite production is used to produce alumina. World alumina production increased from ca. 14.8 million tons in 1966

to ca. 27.5 million tons in 1976. This is an average annual increase of 6.8 %. Australia (22.5 %), USA (21.5 %), USSR (12.3 %), and Jamaica (6.0 %) produced 60 % of the world total in 1976.

The total alumina production in the EC countries corresponded to 11.8 % of world production. The IBA countries had ca. 37 % of the world oxide production. The trend toward the construction of alumina plants in the bauxite producing countries can be seen in the development of oxide production.

Ca. 90 % of the alumina production is used for the production of aluminium metal.

World production of primary aluminium increased from ca. 7.2 million tons in 1966 to ca. 13.1 million tons in 1976, an average annual increase of 6.6 %. The major producing countries are the USA (29.5 %), the USSR (16.8 %), Japan (7.0 %), the Federal Republic of Germany (5.3 %), and Canada (4.8 %) -- a total of 63 % for these 5 countries.

The countries in which bauxite and to an increasing extent alumina is produced is determined by the conditions under which the deposits were formed. The distribution of the supply of the metal by country is determined by the distance to the consumer and the abailability of energy.

A few companies provide the major part of the aluminium, bauxite and alumina in the western world. Thirteen companies produce ca. 74 % of the bauxite, ca. 75 % of the alumina, and ca. 68 % of the primary aluminium in the western world.

The cost of production and transporting the bauxite contributes ca. 30 % of the alumina production cost and ca. 10 % of the cost of producing the metal.

Royalties, taxes, and greatly increased capital expenses will cause bauxite and alumina prices to rise significantly. The most important factors affecting the production of aluminium are the cost of the alumina and the capital and energy costs.

The aluminium price expressed in \$/t increased by 85 % from the beginning of 1970 to the middle of 1977. The increase in DM/t was only 17 % due to change in the exchange rate. Considering the loss in purchasing power of the DM the real change in price was a 27 % decrease.

World consumption of primary aluminium increased from 7.6 million tons in 1966 to 13.9 million tons in 1976, an average annual increase of 6.2 %. The Western World accounted for more than 79 % in 1976 and the East Block for just under 21 %. In 1976, the Americans accounted for 37.4 %. of the primary aluminium consumption, Western Europe 25.3 % (EC countries 18.9 %), Asia 14.1 % (excluding the East Block), and Australia/ Oceania and Africa 1% each. For comparison, in 1966 the Americans still accounted for 47.8 %, Western Europe 23.8 % (EC countries 13.9 %), and Asia just 7.3 %. The major consumer countries in 1976 were the USA (32 % of world consumption), USSR (12.2 %), Japan (10.7 %), and the Federal Republic of Germany (6.9 %); all other countries accounted for less than 4 % each.

When the use of old and waste material in the form of secondary aluminium and new scrap is considered, the total consumption of aluminium increased from 9.6 million tons in 1966 to 17.6 million tons in 1976 -- an average annual increase of 6.3 %. The Western World accounted for just under 79 % of the total aluminium consumption in 1976 and the East Block for 21 %. As for primary aluminium: among the countries of the western economic region, the Americans with 37.4 % had the largest percentage of world consumption, followed by Western Europe with 25.5 % (the EC with 19.8 %), Asia with 13.9 %, and Africa and Australia/Oceania with 1 % each. The largest consumption of aluminium in the Western World in 1976 was in the USA (32.6 % of world consumption), Japan (10.9 %), and the Federal Republic of Germany (7.2 %).

More than two-thirds of the crude aluminium is processed to semimanufactures in the Western World; most of the rest is accounted for by castings. For 21 countries of the Western World, published figures for semimanufactures production from aluminium and aluminium alloys show an increase from 5.1 million tons in 1966 to 9 million tons in 1976. The USA accounted for 44.2 % of this production in 1976, Japan 15.7 %, and the Federal Republic of Germany 9.9 %.
When the production of the other EC countries is included -- especially France, Great Britain, and Italy -- the percentage for the European Community is 27 %. Western Europe as a whole accounted for 35.6 % of the compiled semimanufactures production of the Western World.

The consumption of aluminium semimanufactures in 20 western countries increased from 4.2 million tons in 1965 to 6.6 million tons in 1975. The breakdown of this consumption according to country is very nearly the same as for its production.

Production of aluminium castings increased in 16 western countries from 1.5 million tons in 1966 to 2.2 million tons in 1976. The USA accounted for 37.5 % of the castings production in 1976, Japan 19.5 %, and the Federal Republic of Germany 11.5 %.

Data on the breakdown of aluminium consumption according to consumer in nine western countries is available over a considerable time span. In these countries, the construction industry with 22 % was the largest end consumer of aluminium, followed by transportation (19 %), packaging materials and export of semimanufactures (12 % each), electrical industry (11 %), metal goods/misc. and household goods (7 % each), and machinery (6 %). The use of aluminium has greatly increased especially for packaging materials, construction, and export of semimanufactures.

Various regression models have been used to predict the consumption of aluminium in 1980, 1985, and 1990. The forseeable development of the gross national product and the net production indices of specific branches of industry relevant to aluminium consumption serve as key variable. The calculated figures (in 1000 t) for 1980, 1985, 1990 are presented in the following table.

	1976[1]	1980	1985	1990
EC countries	3,492	4,023	4,805	5,560
Europe[2]	4,488	5,212	6,239	7,243
Asia[2]	2,442	3,103	3,880	4,662
Africa	151	175	225	275
America	6,579	8,310	9,642	10,710
Australia/Oceania	221	290	350	420
Western World	13,881	17,090	20,336	23,310
East Block	3,720	4,400	5,300	6,200
Total	17,601	21,490	25,636	29,510

[1] present value, [2] excluding East Block

According to this prognosis, world aluminium consumption will increase to 21.5 million tons in 1980, 25.6 million tons in 1985, and 29.5 million tons in 1990. For the period from 1976 to 1990, that is an average annual increase of 3.8 %. In terms of the regional distribution, Asia's share will continue to increase at the expense of Western Europe and America, at a lower rate, however, than in the past.

European aluminium producers should play a leading role in carrying out research plans for improving the supply of aluminium within the European Community. These plans should have the following aims:

-- inventory and comparative assessment of the resources within the EC of alternative materials for bauxite such as clays, clay schists, leucite-bearing rock, etc;

-- erection of common demonstration plants at the site of a non-bauxite deposit that is the most favorable from the viewpoint of production costs and benefit to the community;

-- development and further development of processes for the production of aluminium from non-bauxite raw materials with the special aim of a reduction in the necessary energy;

-- increased recovery of aluminium from old scrap.

ALUMINIUM DEMAND AND RESERVES OF THE MEMBER STATES, ANALYSES OF THE DATA, CONCLUSIONS ON RESEARCH AND DEVELOPMENT MEASURES TO IMPROVE THE DOMESTIC SUPPLY WITHIN THE COMMUNITY

I. The Structure of the World Aluminium Supply

1) Aluminium Raw Materials

1.1 Geochemistry of Aluminium

The average concentration of aluminium in the earth as a whole, in the earth's crust, and in the more commonly occuring rocks is as follow:

earth as a whole	1.79 %
earth's crust	8.2 %
magmatites in the crust	8.05 %
ultrabasites	1.39 %
basalts	8.8 %
granites	7.7 %
slates	10.4 %
clays	10.6-15.9 %

Aluminium is a widely occurring element in the earth's crust. It is the third commonest element in the crust after oxygen and silicon. The minable bauxite used today has, in general, an aluminium content of 24 - 34 %. A minable deposit then need have an enrichment of only 3 - 4 times the crust on average.

Aluminium is a typical element of the outer earth's crust. Its concentration decreases with increasing depth. Magmatic differentiation processes are of some significance for the enrichment of aluminium. In these processes, aluminium is concentrated in the lattice of silicates (feldspar, mica, foids). Weathering processes in humid, tropical regions are of major importance. These processes leave residues of aluminium hydroxide (bauxite minerals) and aluminium-rich silicates of the kaolinite group. Corundum and the andalusite group of minerals are usually formed by the metamorphism of aluminium-rich sediments.

1.2 Economically Important Aluminium Minerals

The minerals which are important as raw materials for the production of aluminium are shown in Table 1. Also included are the more important of those minerals being investigated for the production of this metal.

In addition to the simplified chemical formula, the table gives the theoretical Al_2O_3 content of these minerals and the enrichment factor over the average aluminium concentration in the earth's crust (calc. as Al_2O_3). One can see that except for bauxite (boehmite, diaspore, gibbsite) only corundum and the andalusite group of minerals have concentrations within the range of the currently commercially used bauxite.

Short descriptions of the occurrence of the minerals in Table 1 and of the processes for aluminium production are found in Section 1.3. Detailed discussions on raw material alternatives to bauxite are in Chapter VIII.

1.3 The Production of Aluminium and Major Aluminium Raw Materials

1.3.1 Properties of Aluminium

chemical symbol	Al
position in the Periodic Table	Group III
atomic number	13
valence	3 (rarely 1)
atomic mass	26.9815
isotopes	27 (rarely 23, 24, 25, 26, 28, 29, 30)
space lattice	face-centered cubic
density	2.7
melting point	659°C
boiling point	2450°C
specific heat	0.214 cal/g/°C
linear thermal expansion coefficient	24×10^{-6}/°C
electrical conductivity	33 - 35 m/ Ω • mm^2
thermal conductivity	0.55 cal/cm • sec. °C

Aluminium is a silver-white metal of relatively low density, good workability, highly resistant to corrosion, and good electrical and thermal conductivity. These favorable properties explain, among other things, the comparatively large increase in consumption of this metal.

Aluminium is produced from natural raw materials in two steps:

1) production of alumina from minerals,
2) production of aluminium from alumina.

Several processes have been developed for alumina (Al_2O_3) production from different minerals. The Bayer process is currently the most important.

Table 1

Important Minerals containing more than 15.5 % Al_2O_3

Name	Formula	calculated content in Al_2O_3 (%)	Enrichment Factor
Corundum	Al_2O_3	100	6.5
Bauxite minerals:			
Boehmite	$Al_2O_3 . H_2O$	85	5.5
Diaspore	$Al_2O_3 . H_2O$	85	5.5
Gibbsite	$Al_2O_3 . 3H_2O$	65.4	4.2
Andalusite, Kyanite, Sillimanite	$Al_2O_3 . SiO_2$	62.9	4.1
Kaolinite	$Al_2O_3 . 2 SiO_2 . 2 H_2O$	39.5	2.5
Halloysite	$Al_2O_3 . 2 SiO_2 . 3 H_2O$	36.9	2.4
Muscovite	$K_2O . 3 Al_2O_3 . 6 SiO_2 . 2H_2O$	38.5	2.5
Alunite	$K_2O . 3 Al_2O_3 . 4 SO_3 . 6 H_2O$	36.9	2.4
Dawsonite	$Na_2O . Al_2O_3 . 2 CO_2 . 2 H_2O$	35.4	2.3
Feldspathoids:			
Nepheline	$Na_2O . Al_2O_3 . 2 SiO_2$	35.9	2.3
Leucite	$K_2O . Al_2O_3 . 4 SiO_2$	23.4	1.5
Plagioclase-feldspars:			
Anorthite	$CaO . Al_2O_3 . 2 SiO_2$	36.6	2.4
Albite	$Na_2O . Al_2O_3 . 6 SiO_2$	19.4	1.3

The Hall-Héroult process is by far still the most important for producing aluminium from alumina. The Alcoa smelting process (ASP), developed in the last few years, could attain significance as it promises to save considerable amounts of energy in the production of the metal.

1.3.2 Aluminium Raw Materials and their Uses

1.3.2.1 Bauxite

Bauxite is the name given to those naturally occurring mineral mixtures that contain aluminium hydroxide as principal component, clay minerals and silica as the main secondary components, and hematite, goethite, and titanium oxide as accessory components. To be economically usable for the production of aluminium, a bauxite should contain more than 40% Al_2O_3, less than 5% reactive SiO_2 and less than 20% Fe_2O_3. Bauxites are formed in humid, tropical climates as the residue of lateritic weathering of aluminium-bearing rocks.

Bauxite is by far the most important raw material for aluminium production. We estimate that ca. 95% of the current world alumina production uses bauxite ores as starting material.

The first step in producing aluminium is the production of alumina from bauxite ore by the Bayer process; the second step is the electrolytic reduction of the fused alumina to metallic aluminium (Hall-Héroult process). Fig. 1 contains a schematic of the process.

The products of the digestion of the bauxite, the amounts of chemicals required for the reactions, the amount of energy necessary, and the amount of red mud produced is determined primarily by the chemical and mineralogical composition of the bauxite used. The following general rules apply. These rules are also of significance for the assessment of bauxite ores.

Al_2O_3 content should be more than 40%. Currently used bauxites usually have concentration of over 50 %.

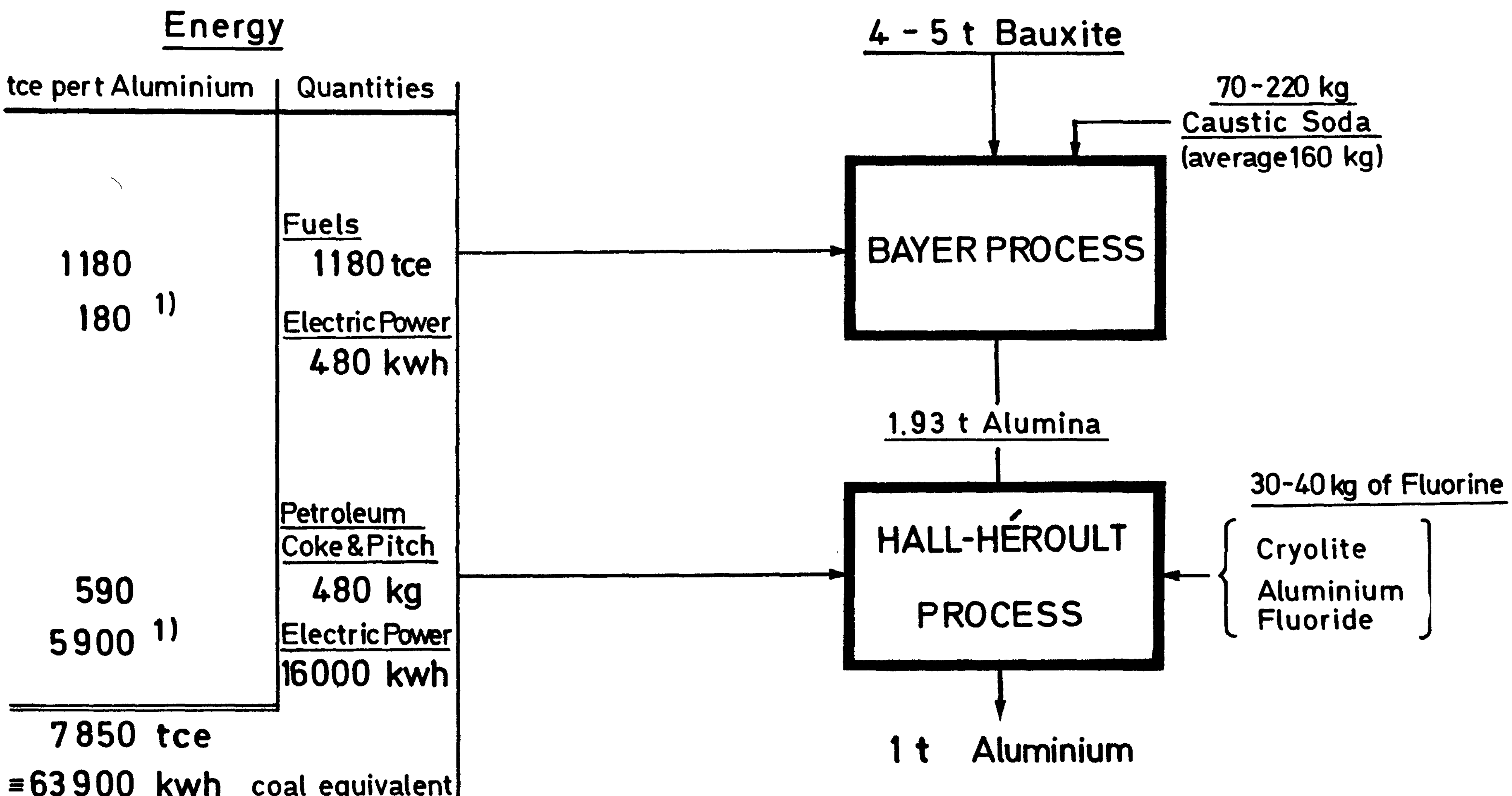
SiO_2 content should not be over 5%. More important is the concentration of reactive silicic acid (generally the SiO_2 present in silicates, not that in quartz) which reacts with the sodium hydroxide in the Bayer process forming hydrated sodium aluminium silicates (hydroxylsodalite). This results in the loss of sodium hydroxide and alumina. The stoichiometry of hydroxylsodalite corresponds to a loss of 0.85% (wt) alumina and 0.69% (wt) Na_2O per 1.0% (wt) reactive silicic acid. Usable Al_2O_3 content is calculated as follows:

usable Al_2O_3 content = total Al_2O_3 content - 0.85 SiO_2 content.

Fig.1

Production of Aluminium from Bauxite

Material & Utility Requirements (average amounts)



1) taking into account specific coal consumption in thermal power plants.

BGR / DIW

Fe_2O_3 and TiO_2 content should be as low as possible as they cause losses of sodium hydroxide during digestion.

Loss on ignition: This value gives an indication of the amount of bound water in the mineral phases of the bauxite and allows conclusions to be drawn about the amount of gibbsite contained. In general, gibbsitic (trihydrate) bauxite requires less energy during digestion than boehmitic and diasporic (monohydrates) bauxite.

Commercially interesting amounts of vanadium and gallium can be obtained as by-product of the digestion of the bauxite (about 1 kg V and 0.1 kg Ga per ton of Al_2O_3). It has been estimated that more than 3/4 of the world resources of gallium occurs in bauxite.

Large quantities of red mud result from the digestion of the bauxite in the Bayer process. Due to its high Fe content it was sometimes added to blast furnace charges. The considerable TiO_2 content of the red mud should also be pointed out. The commercial utilization of the red mud, which today must usually be deposited somewhere, is the object of many investigations.

1.3.2.2 Nepheline

This mineral is the main component of various alkali-rich plutonic rocks, the nepheline syentites. There are large occurrences of this rock in Canada (Ontario), Norway (Stjernoy), and in the USSR (Kola Peninsula and Central Siberia). Nepheline syenite is composed of nepheline, alkali feldspårs, and biotite, hornblende or pyroxene as well; the major accessory mineral is apatite. In the Western World it is used primarily by the glass and ceramic industries. Technical processes have been developed in the USSR for extensive use of non-bauxite raw materials such as nepheline and alunite for the production of alumina. Schematics showing the materials and energy balance in these processes are presented in Figs. 2 & 3.

World-wide nepheline or nepheline syenite resources are considerable. Large rock bodies are to be assumed, especially in old shield areas. There are no sizeable occurrences of this rock within the EC.

1.3.2.3 Alunite

This mineral is formed by the hydrothermal metamorphism of alkali feldspar-rich magmatites.

Fig.: 2

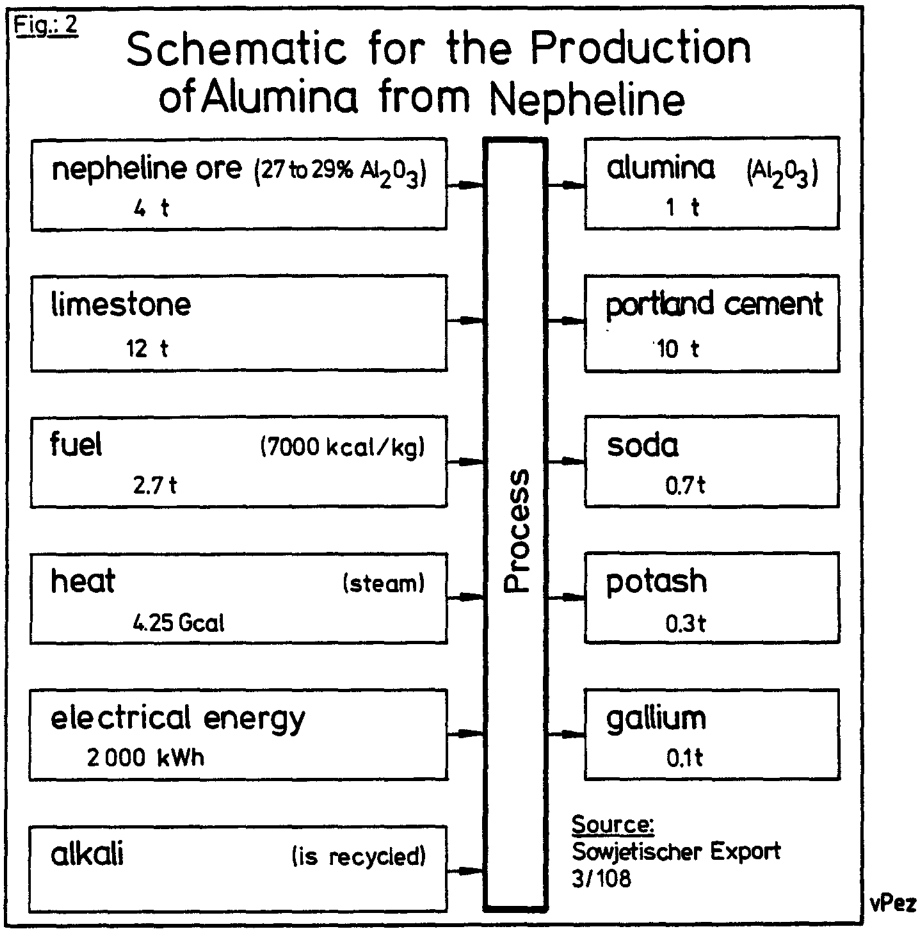
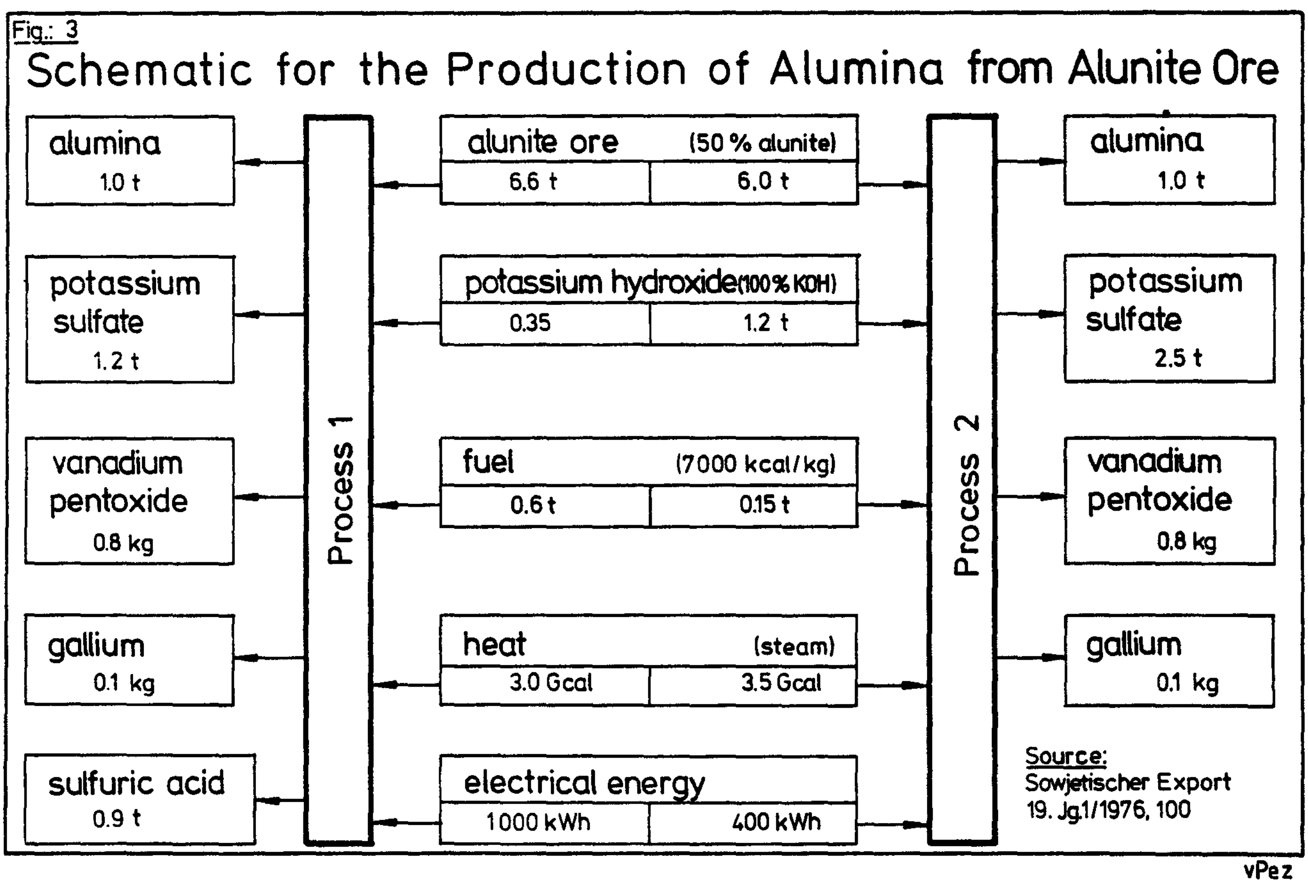

Schematic for the Production of Alumina from Nepheline
nepheline ore (27 to 29% Al_2O_3)
4 t
limestone
12 t
fuel (7000 kcal/kg)
2.7 t
heat (steam)
4.25 Gcal
electrical energy
2 000 kWh
alkali (is recycled)
Process
alumina (Al_2O_3)
1 t
portland cement
10 t
soda
0.7 t
potash
0.3 t
gallium
0.1 t
Source:
Sowjetischer Export
3/108
vPez

Fig.: 3


Schematic for the Production of Alumina from Alunite Ore
alumina
1.0 t
potassium sulfate
1.2 t
vanadium pentoxide
0.8 kg
gallium
0.1 kg
sulfuric acid
0.9 t
Process 1
alunite ore (50 % alunite)
6.6 t
6.0 t
potassium hydroxide (100 % KOH)
0.35
1.2 t
fuel (7000 kcal/kg)
0.6 t
0.15 t
heat (steam)
3.0 Gcal
3.5 Gcal
electrical energy
1000 kWh
400 kWh
Process 2
alumina
1.0 t
potassium sulfate
2.5 t
vanadium pentoxide
0.8 kg
gallium
0.1 kg
Source:
Sowjetischer Export
19. Jg.1/1976, 100
vPez

Large occurrences are known in the USSR, where this mineral is used for the production of alumina, in the USA (Utah), in Mexico (Guanajuato Prov.), and in Iran (Takestan). There are plans in these three countries for the erection of alumina plants using alunite as starting material.

1.3.2.4 Kaolins, Clay Minerals, Argillaceous Slates

The resources of these minerals and rocks are to be described as very large. However, the potential for sizeable Al_2O_3 concentrations ($Al_2O_3 \geq 28\%$) is seen as limited.

A thorough inventory of those occurences not being investigated or utilized (ceramic industry) seems appropriate. There is a detailed presentation in Chapter VII of processes for producing alumina from these rocks.

1.3.2.5 Anorthosites

These plutonic rocks consist primarily of plagioclases; they generally contain 27 - 33 % Al_2O_3.

Large anorthosite occurrences are known in Canada (Quebec, Newfoundland), USA (New York, Wyoming, California), and Norway (Tellnes, Voss, Aurland).

Extensive research has been done in the USA on the utilization of these rocks as aluminium raw materials.

Recently, the two Norwegian firms Elkem Spigerverket A/S and Aardal og Sunndal Verk A/S began research investigating the use of anorthosite from Voss.

1.4 Aluminium Production and Energy Consumption

Aluminium production, compared with the production of other non-ferrous metals, requires a relatively large energy input. The availability of large amounts of energy is therefore a major prerequisite for future aluminium supply. Table 2 gives an overview of the energy sources used in different countries for producing aluminium. Consideration of the specific energy consumption is also decisive for the assessment of processes for producing aluminium from materials other than bauxite.

Much data has been published on the amount of energy used for producing a specific amount of aluminium. These can, however, only be conditionally compared, because

Table 2

Breakdown of the Sources of Energy for Primary Aluminium Production
(in %)

	France[1]	Germany[1]	Great Britain[1]	Canada[1]	USA[1]	Australia[1]	Japan[2]	World[2]	Europe[2]
Hydroelectric power	25	11	11	100	38	41	13	53	48
Coal	11	67	35	-	37	59	7	21	22
Oil	23)	6	-	-	2	-	71	13	11
Natural gas	37)		-	-	20	-	9	11	11
Nuclear power	3	16	54	-	3	-	-	2	8
Other	1	-	-	-	-	-	-	-	-
	100	100	100	100	100	100	100	100	100

Sources: [1] OECD für 1974 (OECD Observer Nr. 81, May/June 1976)
[2] H.P. Drewery (Shipping Consultants) Ltd., 1976 London

- calculations were done for different production stages,
- indirect energy consumption is sometimes also included (e.g. energy needed to produce the energy source used for aluminium production),
- different degreees of efficiency are sometimes assumed (e.g. the production of electricity from coal).

The values given in the literature for the specific energy consumption for the production of 1 ton of aluminium from the bauxites used today lie between

78.9×10^3 kWh/t Al and

14.5×10^3 kWh/t Al (probably only the electricity consumed directly by the electrolysis).

Values between 50×10^3 and 60×10^3 kWh/t Al are often stated. It is very likely that all of the direct and indirect energy inputs are included in the 78.9×10^3 kWh value (Goudarzi et al., 1975).

An energy balance arrived at in Canada for the production of 1 ton of aluminium is given in Table 3. We are of the opinion (see also Fig. 1) that these calculations correspond closest to actual conditions. An average energy content is used for the fuels listed; the efficiency of coal-fired power plants (34.1 %) was included in the calculations. If the efficiency is not considered, a specific electricity consumption of ca. 17×10^3 kWh/t Al results for the electrolysis. This figure is in agreement with the value given by numerous sources.

Page and Creasey (1975) expressed the energy necessary to produce 1 ton of aluminium (expressed in 10^3 kWh coal equivalent) as a function of the Al_2O_3 content of bauxites, clays, and anorthosites. They arrived at curves which may be approximated by the following equations:

bauxite $$y = 39.5 + \frac{509}{x}$$

clay $$y = 42.5 + \frac{877}{x}$$

anorthosite $$y = 42.5 + \frac{1063}{x}$$

where x is the Al_2O_3 content in % by weight
and y is the energy required for 1 t Al in 10^3 kWh coal equivalents.

If bauxite containing 50% Al_2O_3 is used, the equation leads to a value of 49.7×10^3 kWh/t Al. This value corresponds to the energy required by the electrolysis in other publications and therefore is surely too low.

If one modifies the energy equation for aluminium production from bauxite using the data given in Table 3, the following equation results:

$$y = 62.3 + \frac{200}{x}$$

Table 3

Energy Required for Production of 1 t Aluminium from Bauxite
(in 1000 kWh[1] and %)

	1000 kWh[1]	%
For the production of alumina from bauxite	2.845	4.4
Electrolytic reduction of alumina to aluminium (approx. 17,000 kWh/t Al)[2]	50.432	77.4
Carbon electrodes	4.138	6.3
Electricity for general operations[2]	5.172	7.9
Fuels for general operations	2.586	4.0
Total	65.173	100.0

[1] calculated from Btu/lb Al

[2] coal energy equivalent, effectivity of a coal-fired power plant of ca. 34 %

Source: Energy, Mines & Resources Canada, Mineral Policy Series MR 164, 1976.

Since 62.3×10^3 kWh/t Al corresponds roughly to the energy required for producing the metal from alumina, the equations for clay & anorthosite given above for the specific production energy also need to be corrected. A first approximation using values from Cohen & Mercier (1975) would be as follows:

clay $$y = 62.3 + \frac{390}{x}$$

anorthosite $$y = 62.3 + \frac{480}{x}$$

2) Deposit Types & Their Economic Significance

Deposits of aluminium raw materials may be subdivided into bauxite and non-bauxite types.

There are no published figures on reserves of currently minable (or mined) non-bauxite deposits, although resources, especially of nepheline rocks, are quite extensive. Alumino silicate resources are not considered here; occurrences economically useable for aluminium production are not known. By far, the most significant occurrence of aluminium raw materials are, and will be in the foreseeable future, the bauxite deposits.

Several classification proposals have been worked out for bauxite deposits. The following characteristics, with differing importance, are found in these systems:

1. geological age and setting of the deposit,
2. geotectonic position of the deposit,
3. parent rock for bauxite formation,
4. chemical & mineral composition of the bauxite,
5. geometry and extent of the deposit.

to 1: The geological age can be used to distinguish Subrecent and Recent bauxite formations from fossil deposits. The Subrecent and Recent bauxite deposits are found in the present-day regions of humid, tropical climatic conditions in which lateritic weathering and bauxite formation can still occur.

That lateritic weathering occured during all geological periods is shown by the examples of fossil bauxite deposits in the Mediterranean region (France, Yugoslavia, Hungary, Greece, etc.) which are mostly of Cretaceous to Tertiary age, the Ju rassic deposits in Yugoslavia, the PR China, and USA, and the Precambrian deposits in Siberia.

In general it may be stated that

a) fossil bauxite deposits, compared with Subrecent and Recent deposits, are of secondary significance. This is because more recent geological events have caused large portions of the original deposits to be eroded away. Only those deposits remain that have been protected by burial or by the morphology of the rock beneath it. Such deposits are usually minable only by deep mining; the mineralization are often discontinuous.

b) fossil deposits are often monohydrated (boehmite, diaspore); Recent deposits are trihydrated and therefore require less energy during the digestion stage of the Bayer process.

to 2: Bauxite deposits in shield regions can be distinguished from those in orogenic zones, a subdivision that is often used in the Russian literature. Deposits in shield regions are usually more extensive than those in orogenic regions.

to 3: Bauxite can be formed from very nearly any rock. The chemical and mineral composition of the starting material and its permeability are, however, decisive in determining the composition and quality of the bauxite. Weathering can form karst pockets in carbonate sediments in which bauxite can accumulate.

to 4: Chemical classifications consider primarily the mol ratio silica/Al_2O_3. This ratio should be less than 0.5; it is less than 0.2 for high-grade ores.

Mineral classifications consider the relative amounts of monohydrated and trihydrated minerals. Also important are the type of gangue minerals (e.g. kaolinite, quartz).

to 5: Classification according to geometry and extent of the deposit seems to be the most suitable for a division according to economic importance. Blanket deposits, pockets, and detrital deposits are distinguished.

There is also a series of transition types. As example, some bauxite deposits in northern Jamaica have formed an extensive blanket although they overly limestone. A comparison of these types is presented in Table 4 according to geological characteristics and according to their economic significance.

3) Prospective Areas, especially within the EC

3.1 Bauxite

Several climatic and geological conditions are necessary for the formation of economically interesting bauxite deposits:

a. a humid, tropical climate (average annual rainfall over 1500 mm, average annual temperature over 25^{o} C);

b. aluminium-bearing parent rock with good permeability (water drainage for the removal of those rock components dissolved during tropical weathering);

c. a long period of tectonic stability allowing the formation of peneplains and deep-reaching weathering (slight epirogenetic lifting can promote weathering at depth and often leads to especially thick deposits);

d. suitable morphology of the underlying rock and favorable cover for protection from later erosion.

Table 4

Geological, Economic, and Mining Characteristics of Bauxite Deposits

	blanket deposits	pockets	detrital deposits
Proportion of the neasured and indicated reserves	66 - 70 %	18 - 20 %	10 - 14 %
Proportion of the mining production	ca. 52 %	ca. 31 %	ca. 17 %
Production method	mainly surface mining	significant amounts mined in deep mines	mainly deep mines
Order of size of the deposits	$> 2 \times 10^9$ t	up to 200×10^6 t	up to 100×10^6 t
Examples:	Guinea, northern Australia, Brazil	Jamaica, Haiti , France, Yugoslavia	Surinam, USA
Underlying rock	silicates	mostly carbonate sediments	silicates
Geotectonic position	principally in shield areas	usually in orogenic areas	often in shield areas

The following aspects are of special importance for the choice of prospective areas for bauxite and exploration for deposits:

- present-day humid, tropical climate or such conditions in the geological past,
- extensive areas of peneplanation.

It is relatively easy to select the areas which hold promise for the discovery of young (Neogene/Quaternary) bauxite formations according to the present-day climate distribution. Such areas are the wide areas of the Guiana Shield, the Amazon Basin of the northern Brazilian Shield, extensive areas in Central & West Africa (Guinea, Sierra Leone, Liberia, Ghana, Nigeria, Cameroon, Gabun, Zaire). Areas on Madagascar, on the Indian Shield, wide areas in northern Australia, parts of the Southeast Asian island arc- -the prospects for discovery of new, large deposits in these countries are very promising.

In addition to paleoclimatic conditions, criteria corresponding to conditions b to d above are to be considered when selecting prospective areas for fossil bauxite discoveries. The chances of finding older (fossil) formations should be considerably less.There are known deposits in France, Hungary, Yugoslavia, and Greece, and also occurrences in Italy (southern Abruzzi, Sardinia), Great Britain (Northern Ireland, Scotland) and the Federal Republic of Germany (Vogelsberg). These deposits are usually of Lower Cretaceous age (e.g. France), more rarely Tertiary (Great Britain, Federal Republic of Germany, and some occurrences in Italy). The areas in which they are distributed are essentially known: southern France, parts of central and southern Italy, areas of Sardinia, Northern Ireland, Scotland, and Hesse. It is not likely that new discoveries will be made outside of these regions. It is also improbable that new, large deposits will be discovered in the areas named.

Consequently, prospecting for bauxite deposits within the EC is not likely to lead to significant new finds. A reduction in our dependence on imports of aluminium raw materials is therefore not to be expected.

3.2 Alternative Materials to Bauxite

Processes are being developed for the utilization of other aluminium-bearing minerals. In addition, it must be assumed that less favorable (from the standpoint of accessability and chemical composition) bauxite deposits will in the long run have to be opened up oversees. Not the least important, it would seem appropriate from the viewpoint of economic policies to take a look at the potential for alternatives to bauxite within the countries of the EC.

The following subdivision results on consideration of the economic aspects:

- possible aluminium raw materials that are obtained in connection with the utilization of the other raw materials. Possibilities are coal washings, coal ash, and clay-bearing overburden from lignite mining.
- other possible aluminium raw materials include kaolin clays, leucite-bearing rocks, alunite, andalusite-schist, and argillaceous slate.

3.2.1 Automatically Resulting Aluminium Raw Materials

3.2.1.1 Coal Washings

At present, ca. 245×10^6 t coal are produced annually (usable production) in the EC countries- -ca. 51 % in Great Britain, 37 % in the Federal Republic of Germany, 9 % in France, and 3 % in Belgium.

Large amounts of coal washings occur during the washing of coal. These coal washings consist primarily of clay from between the coal seams and usually contain over 20 % (wt) Al_2O_3, often over 25 % (wt). There are few figures on the amount of coal washings that are produced each year, but an estimation can be made.

Chauvin & Delannoy (1977) have stated that ca. 10×10^6 t adjoining rock and washings occur annually during production of coal in the becken in the Nord and Pas de Calais departments or ca. 50 % of gross production. The usable production in this region was 9×10^6 t in 1974 and 7.3×10^6 t in 1976. If one assumes, as the cited publication does, that only 15 % of the tailings are used as back fill, then at least 6.4×10^6 t of washings pile up in the tailings dumps each year in this area.

A comparison of gross production and usable production in the Federal Republic of Germany gives the following figures:

gross production in 1975	159.2×10^6 t
usable production	92.8×10^6 t
difference (tailings)	66.4×10^6 t

If one assumes that not only 10 % but 2/3 of the tailings are required as back fill or are unsuitable for alumina production, then an annual production within the EC of 245×10^6 t of usable coal would yield by conservative estimate clay-bearing tailings on the order of at least 60×10^6 t.
This amount would be distributed amoung Great Britain, the Federal Republic of Germany, France, and Belgium in proportion to the coal production in those countries. In addition to these annual amounts there are also the tailings dumps from previous years. Figures on these amounts are, however, only partially available.

3.2.1.2 Coal Ashes

Coal ashes can contain between 8 and 40% (wt) Al_2O_3. A major source of coal ash is coal-fired power plants. About 130 x 10^6 t coal equivalent are used each year for the production of electricity. If one assumes a yield of 9 % ash (according to Chauvin & Delannoy: ca. 0.902 x 10^6 t ashes from 9.54 x 10^6 t coal equivalent), one obtains an annual yield within the EC of 12 x 10^6 t ashes (45 % in Great Britain, 42 % in the Federal Republic of Germany, 7 % in France, and 2 % in Belgium).

Considerable difficulties stand in the way of utilizing the ashes from power plants for the production of aluminium because their mineral composition is such that enormous amounts of cement are produced by the decomposition of the ash.

3.2.1.3 Overburden in Lignite Mining

Present annual production of lignite in the EC amounts to about 128.6 x 10^6 t at present, ca. 96 % in the Federal Republic of Germany, 2.5 % in France,and 1.6 % in Italy. (According to region: North Rhine-Westphalia (Lower Rhine), 84 %; Bavaria (area near Schwandorf), 6.3 %; Lower Saxony (Helmstedt), 3.8 %; Hesse (Wetterau & the Kassel District), 2.4 %; Tuscany-Umbria-Basilicata, 1.6 %; Aquitania, 1.3 %; Provence, 1.2 %.) Lignite is mined almost exclusively in open-cut mines. Between the lignite seams and in the underlying rock, there are often thick clay layers with an average Al_2O_3 content of 20 - 30 % (wt). This clay must often be excavated with the coal and is used extensively as fill for mined-out areas. Studies are being made in the Federal Republic of Germany on the amounts and useability of such clays. An important aspect for the possible utilization of these clays is that their processing would be to take place synchronized with the mining of the coal deposit.

3.2.2 Other Possible Aluminium Raw Materials

Resources of these materials (clays, argillaceous slates,andalusite schists, mica schists, leucite-bearing rocks, alunite) within the EC can be described as enormous. Large occurrences can be assumed in almost all of the EC countries. The clay-bearing rocks in Great Britain, France, and the Federal Republic of Germany can be viewed as especially extensive. The resources of leucite-bearing rocks should also be extremely large, especially those in the volcanic regions of Italy.

A more exact picture of the actual extent of these resources and their chemical and mineral composition is available for only some of the occurrences. This is especially true for those occurences that are used for other industrial purposes (e.g. kaolin for ceramics, paper, and fillers). The identification of occurrences within the EC other than those already known and used for the production of industrial minerals and their evaluation for use in the production of aluminium is accordingly a significant assignment for the future. For example, leucite-bearing rocks are especially widely distributed in Italy. Resources of these rocks (major occurrences near Naples) were estimated to be ca. 100×10^9 t about 30 years ago. This would be equivalent to about 11×10^9 t of available alumina. Eforts have been repeatedly made in the past to use leucite for the production of alumina and of K_2O for fertilizers.

There are extensive occurrences of alumino-silicates in the Federal Republic of Germany (also in Great Britain, France, and other EC countries). The investigation of these would seem advisable.

4) Reserves of Minable Deposits according to Country

4.1 Preliminary Remarks

Numerous publications in the last few years have dealt with the reliability of reserves data. Several proposals for the classification of mineral resources according to the degree of exploration and the possibilities for economical exploitation have been worked out. Of these, the best known is that by McKELVEY (1973).

When making an inventory of the aluminium raw materials potential in any one country or in the world using news sources and publications of varying quality and terminology, the use of rigid criteria leads to considerable difficulty. For a raw material with immense resources that are not quantified in wide parts of the earth, it is questionable whether a rigid classification system should be used.

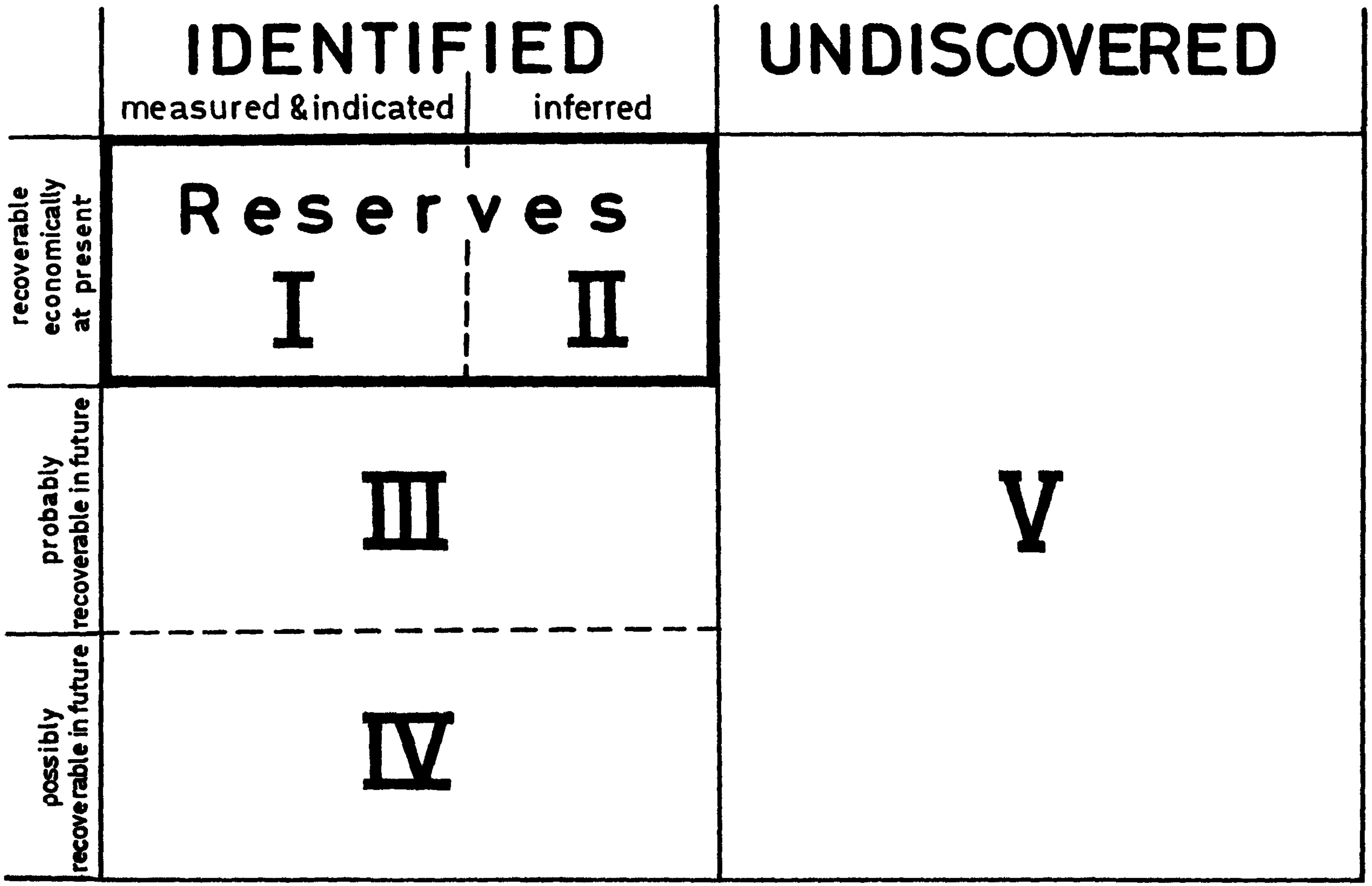
Therefore, resources of aluminium-bearing raw materials will be classified in this study as follows, borrowing from the scheme by McKELVEY (see Fig. 4).

measured & indicated reserves (I)

This consists of those resources that are known as the result of development projects and mining. This classification here comprises almost exclusively bauxite.

Fig. 4

Classification System for Resources of Aluminium-Raw-Materials



BGR/DIW

inferred reserves (II)

This catagory includes estimations from reconnaissance exploration and from geological assumptions on the continuation of known deposits into not yet explored regions. This classification also comprises primarily bauxite ores.

resources of aluminium raw materials probably recoverable in the future (III)

This catagory includes those materials whose economic recovery is being tested at the pilot-plant stage and those that are already of some economic significance for aluminium production in several East Block countries (USSR, PR China). It is not possible at this time to more precisely quantify the surely immense amounts of these materials (nepheline, alunite, kaolinite clays, kaolinite bauxites).

resources of aluminium raw materials possibly recoverable in the future (IV)

This catagory includes those materials that in view of their aluminium content are to be considered for aluminium production in principle but must be thoroughly tested for their economic utility in the production of aluminium. Quantification of these quite extensive materials (anorthosites, clays, argillaceous clays, dawsonite) is not possible, as is the case for (III).

undiscovered resources (V)

All not yet discovered bauxite deposits as well as occurrences of other aluminium raw materials belong to this classification.

It must be pointed out that there are numerous transition types between these classifications. Classification of the various occurrences had to be done according to our own assessment. Only measured and indicated reserves (I) and inferred reserves (II) are considered in the inventory below.

4.2 Measured & Indicated and Inferred Bauxite Reserves according to Country

Measured & indicated world bauxite reserves amounted to about 17.3 billion tons on 1 July 1977 according to estimates and calculations done by the Federal Institute for Geosciences and Natural Resources, Hannover. Inferred reserves add 14.7 billion tons to that figure.

Of the measured & indicated world reserves, 61.9 % are in the developing countries, 35.4 % in the western industrial countries, and 2.7 % in the countries of the East Block.

Australia, Guinea, and Jamaica, with 30.3 %, 20.7 % & 11.6 %, respectively, have the greatest portion of the measured & indicated reserves. These three countries, in the same order, are also the most important bauxite producers. Brazil, Guyana, and Cameroon have 5.8 % each of the world reserves.

France, with 0.3 % of the measured & indicated world reserves, is the only EC country to have significant bauxite reserves.

About 90 % of the measured & indicated bauxite reserves are in the present-day tropical climate regions: 31 % in Africa, 30 % in Australia, and 29 % in Latin America.

When inferred reserves are included, world reserves are increased to a total of 32.0 billion tons: 69.4 % in the developing countries, 24.8 % in the western industrial countries, and 5.8 % in the East Block.

Most of the measured & indicated and inferred world bauxite reserves are in Australia (19.5 %), Guinea (15.8 %), and Jamaica (9.4 %), followed by Surinam, Brazil, and Cameroon (6.3 % each). Thus, these six countries have almost two-thirds of all the bauxite reserves in the world.
Table 5 contains the reserve figures according to country, country grouping, and economic region.

5) Trends in Bauxite Reserves

5.1 Historical Observations

When evaluating the present bauxite reserves situation, it is of interest to know what earlier assessments of world bauxite reserves were and their relationship to the annual production as well as to its development.

Measured & indicated reserves since 1950 are presented in Table 6. World production since 1950 and the cumulative production is compared with the reserves data. World bauxite production from 1950 to 1976 increased at an average annual rate of 8.7 %. The static life-times, based on the data for any one year, average 170 years. If a growth rate of 8.7 % is considered, semi-dynamic life-times of 28 - 35 years are obtained, averaging 32 years.

World reserves, the results of extensive prospecting work, have increased at an average annual rate of 10 % (net growth) or 10.4 % (gross rate). From 1967 - 1977 the measured & indicated world bauxite reserves increased from 6.0 billion tons to 17.3 billion tons. Almost half of this increase was from discoveries in Australia (27.5 %) and Guinea (21 %). A significant portion of the increase came from Jamaica (12.4 %), Brazil, and Cameroon (8.9 % each), and Guyana (7.1 %). It can be seen that the new finds were almost exclusively in the present-day tropics.

In summary, the reserves situation for bauxite, as expressed in life-time of the reserves, has at least not gotten worse since 1950, and has gotten better compared with the time before 1970. The net increase in reserves since 1950 has averaged 10 %; the annual increase in production for the same time period, 8.7 %, has been less.

Table 5

Proven, Probable, and Potential World Bauxite Reserves
(Mio t and %)

Country/Region	proven and probable reserves		potential reserves		total	%
	10^6 t	%	10^6 t	%	10^6 t	
USA	41	0.2	300	2.0	341	1.1
North America	41	0.2	300	2.0	341	1.1
Jamaica	2,000	11.6	1,000	6.8	3,000	9.4
Guyana	1,000	5.8	500	3.4	1,500	4.7
Surinam	800	4.6	1,200	8.2	2,000	6.3
Brazil	1,000	5.8	1,000	6.8	2,000	6.3
French Guiana	42	0.2	30	0.2	72	0.2
Haiti	40	0.2	100	0.7	140	0.4
Colombia			94	0.6	94	0.3
Venezuela			140	1.0	140	0.4
other Latin America	100	0.6	175	1.2	275	0.9
Latin America	4,982	28.8	4,239	28.9	9,221	28.9
Guinea	3,585	20.7	1,450	9.9	5,035	15.8
Cameroon	1,000	5.8	1,000	6.8	2,000	6.3
Madagascar	180	1.0	200	1.4	380	1.2
Mali			1,150	7.8	1,150	3.6
Ivory Coast	10	0.1	30	0.2	40	0.1
Sierra Leone	10	0.1	100	0.7	110	0.3
Ghana	426	2.5	150	1.0	576	1.8
other Africa	62	0.4	110	0.8	172	0.5
Africa	5,273	30.5	4,190	28.6	9,463	29.6
India	350	2.0	1,000	6.8	1,350	4.2
Indonesia	40	0.2	1,000	6.8	1,040	3.3
Malaysia	15	0.1	40	0.3	55	0.2
other Asia	30	0.2	1,000	6.8	1,030	3.2
Asia without East Block	435	2.5	3,040	20.7	3,475	10.9
Australia	5,230	30.3	1,000	6.8	6,230	19.5
France	53	0.3	110	0.8	163	0.5
Greece	600	3.5	200	1.4	800	2.5
Yugoslavia	200	1.2	200	1.4	400	1.3
Europe without East Block	853	4.9	510	3.5	1,363	4.3
Western World total	16,814	97.3	13,279	90.6	30,093	94.2
USSR	150	0.9	150	1.0	300	0.9
Hungary	150	0.9	200	1.4	350	1.1
China PR	150	0.9	1,000	6.8	1,150	3.6
Romania	20	0.1	30	0.2	50	0.2
East Block total	470	2.7	1,380	9.4	1,850	5.8
World total	17,284	100.0	14,659	100,0	31,943	100.0
Group of Countries						
Developed Countries	6,124	35.4	1,810	12.4	7,934	24.8
Developing Countries	10,690	61.9	11,469	78.2	22,159	69.4
East Block	470	2.7	1,380	9.4	1,850	5.8

Table 6

World Bauxite Reserves & Production at Different Times

Year	proven & probable reserves 10^9 t bauxite	world production 10^6 t bauxite	cumulative world production since 1950 10^6 t bauxite	static life time (years)	exponential life index
1950	1.6	8.418	-	190	33
1953	1.6	13.861	46.195	115	28
1963	7.2	30.457	282.531	236	35
1964	5.3	33.143	315.674	160	31
1965	5.8	37.292	352.966	156	31
1966	6.0	41.057	394.023	146	30
1967	6.0	45.369	439.392	132	29
1968	7.4	47.230	486.622	157	31
1969	7.4	55.458	542.080	133	29
1970	8.4	60.612	602.692	139	30
1971	11.8	66.797	669.489	177	32
1972	11.9	70.806	740.295	168	32
1973	15.2	74.866	815.161	203	34
1974	15.8	83.985	899.146	188	33
1975	15.8	77.045	976.191	205	34
1976	17.3	80.492	1,056.683	215	34
1977	17.3				

Sources: Production figures: Metallstatistik
Reserve figures: All years except, 1963, 1972; 1977 US Bureau of Mines; 1963 Gosgeoltechizdat, Moscow 1963
1972 BGR/DIW calculations; 1977 Calculations for this study.

5.2 Future Development

To maintain the present high reserves level in the coming years, reserves of the same order of magnitude as those presently classed as inferred reserves (14.6 billion tons) must be transferred into the measured & indicated reserves catagory. Production growth rates are assumed to remain as in the past.

In the long run, it could be necessary to develop bauxite deposits in areas with no transportation infrastructure. Considering the bauxite resources situation, the utilization of non-bauxite aluminium raw materials does not seem to be absolutely necessary in the foreseeable future. Individual countries may seriously consider their use for political reasons.

6) Trends in Bauxite Production

6.1 Bauxite Production: 1966 - 1976

Of those minerals and rocks that are in principle usable for producing aluminium, almost only bauxite is used. Only in the USSR and PR China are other raw materials (nepheline, alunite) utilized. Their amounts have been estimated and recalculated as "bauxite". World production from 1966 to 1976 is presented by country in Table 7.

World bauxite production increased from 41 million t in 1966 to ca. 80.5 million t in 1976 with a cumulative production of 704 million t. This production trend corresponds to an average annual growth of 7.5 %, a decrease when a longer time period is considered (average annual growth for 1960 - 1976 was 8 %). This decrease in growth is even more evident when the period from 1966 to 1971 (average annual growth rate: 10.4 %) is compared with the last five years (average annual growth rate: 3.8 %). The average annual production growth rate was calculated by fitting the following exponential function to the amounts produced each year.

$$y = a \cdot e^{bx}$$

Fig. 5 contains a graphic presentation of this curve fitting method.

Of the 1976 production, 69.1 million t (85.9 %) came from the countries of the Western World. From the East Block came 11.4 million t. The proportion for the East Block decreased slightly in comparison to 1966.

Production in the individual countries is shown in Table 8 for the years 1974, 1975, & 1976. Those countries with more than 5 % of world production in 1976 are Australia (29.9 %), Guinea (14.1 %), Jamaica (12.8 %), the USSR (8.3 %), & Surinam (5.7 %).

Table 7

Production of Bauxite[1]: 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
France	2,810.6	2,812.6	2,713.0	2,796.9	3,050.7	3,183.6	3,401.9	2,970.2	2,949.9	2,562.9	2,315.3
Italy	255.5	241.4	216.2	216.5	205.6	190.8	84.2	50.0	31.6	32.2	24.2
Germany FR	3.7	2.3	3.3	3.2	3.0	2.9	2.0	1.6	1.4	0.8	0.2
EG total	3,069.8	3,056.3	2,932.5	3,016.6	3,259.3	3,377.3	3,488.1	3,021.8	2,982.9	2,595.9	2,339.7
Austria	-	-	-	-	-	-	-	-	-	-	-
Spain	4.0	4.8	5.8	4.8	5.0	5.4	6.1	8.2	9.2	8.5	13.5
Greece	1,529.0	1,660.9	1,836.1	1,948.3	2,292.2	2,860.7	2,408.5	2,748.4	2,782.7	3,005.6	2,746.9
Yugoslavia	1,887.0	2,131.0	2,072.0	2,128.0	2,099.0	1,959.0	2,197.0	2,167.0	2,370.0	2,306.0	2,033.0
Europe without East Block	6,489.8	6,853.0	6,846.4	7,097.7	7,655.5	8,202.4	8,099.7	7,945.4	8,144.8	7,916.0	7,133.1
USA[2]	1,824.8	1,680.5	1,691.7	1,872.6	2,115.4	2,019.9	1,841.0	1,909.2	1,980.2	1,800.4	1,989.4
North America	1,824,8	1,680.5	1,691.7	1,872.6	2,115.4	2,019.9	1,841.0	1,909.2	1,980.2	1,800.4	1,989.4
Jamaica[2]	9,061.5	9,395.6	8,525.7	10,498.8	12,009.7	12,543.4	12,988.8	13,599.8	15,327.6	11,570.3	10,306.0
Surinam[2]	5,563.0	5,466.0	5,660.0	6,236.0	6,022.0	6,718.0	7,777.0	6,686.0	6,885.1	4,751.0	4,588.0
Guyana[2]	3,357.7	3,381.4	3,723.3	4,306.4	4,417.2	4,233.6	3,668.4	3,621.4	3,606.0	3,828.2	3,107.6
Dominican Republic[2]	833.0	983.0	994.3	1,102.8	1,086.0	1,031.7	1,087.2	1,085.6	1,195.6	785.1	516.0
Haiti[2]	361.4	375.8	477.4	776.0	656.8	764.5	782.8	743.1	659.5	522.1	660.4
Brazil	249.9	302.9	284.7	350.9	509.8	566.4	764.5	849.2	858.5	969.0	1,000.0
Latin America	19,426.5	19,904.7	19,665.4	23,270.9	24,701.5	25,857.6	27,068.7	26,585.1	28,532.3	22,425.7	20,178.0
Guinea	1,608.7	1,639.2	2,117.6	2,458.9	2,490.0	2,630.0	2,600.0 x)	3,800.0	7,600.0	8,406.3	11,316.4
Ghana	322.9	351.0	284.7	269.0	342.0	328.6	340.3	354.4	363.1	325.2	267.3
Sierra Leone	275.2	334.5	470.3	453.8	449.0	590.5	693.9	693.0	672.0	716.0	660.0
Mozambique	5.9	5.0	3.3	4.4	7.1	7.7	5.4	5.6	5.4	5.2	5.0
Rhodesia	2.0	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)	2.0 x)
Africa	2,214.7	2,332.6	2,877.9	3,188.1	3,290.1	3,558.8	3,641.6	4,855.0	8,642.5	9,454.7	12,250.7
India	749.9	804.1	961.0	1,085.4	1,374.0	1,517.1	1,692.1	1,251.0	1,071.1	1,094.2	1,435.9
Indonesia	701.5	920.2	879.3	926.7	1,229.2	1,237.6	1,276.0	1,229.4	1,290.0	992.6	940.3
Malaysia	955.5	899.6	798.7	1,073.0	1,139.3	977.9	1,076.0	1,142.9	947.5	703.6	660.2
Pakistan	-	-	0.9	2.5	0.9	0.3	0.8	0.1	0.3	0.4	0.4
Turkey	32.3	21.5	-	1.9	52.1	153.3	471.4	352.2	664.9	631.2	461.0
Asia without East Block	2,439.2	2,645.4	2,639.9	3,089.5	3,795.5	3,886.2	4,516.3	3,975.6	3,973.8	3,422.0	3,497.8
Australia	1,827.1	4,243.6	4,955.1	7,921.1	9,256.3	12,732.7	14,437.0	17,595.9	19,994.3	20,957.9	24,085.1
Western World total	34,222.1	37,659.8	38,676.4	46,439.9	50,814.3	56,257.6	59,604.4	62,866.2	71,267.9	65,976.7	69,134.1
USSR x) 3)	4,800.0	5,200.0	5,600.0	6,000.0	6,500.0	7,000.0	7,400.0	7,900.0	8,400.0	6,600.0	6,700.0
Romania	206.0	460.0	595.0	632.0	776.0	899.0	893.5	900.0	816.5	779.0	890.0
Hungary	1,429.3	1,649.4	1,959.0	1,936.0	2,022.0	2,090.0	2,358.0	2,600.0	2,750.7	2,889.5	2,917.8
China PR x)	400.0	400.0	400.0	450.0	500.0	550.0	550.0	600.0	700.0	800.0	850.0
East Block total	6,835.3	7,709.4	8,554.0	9,018.0	9,798.0	10,539.0	11,201.5	12,000.0	12,667.2	11,068.5	11,357.8
World total	41,057.4	45,369.2	47,230.4	55,457.9	60,612.3	66,796.6	70,805.9	74,866.2	83,935.1	77,045.2	80,491.9

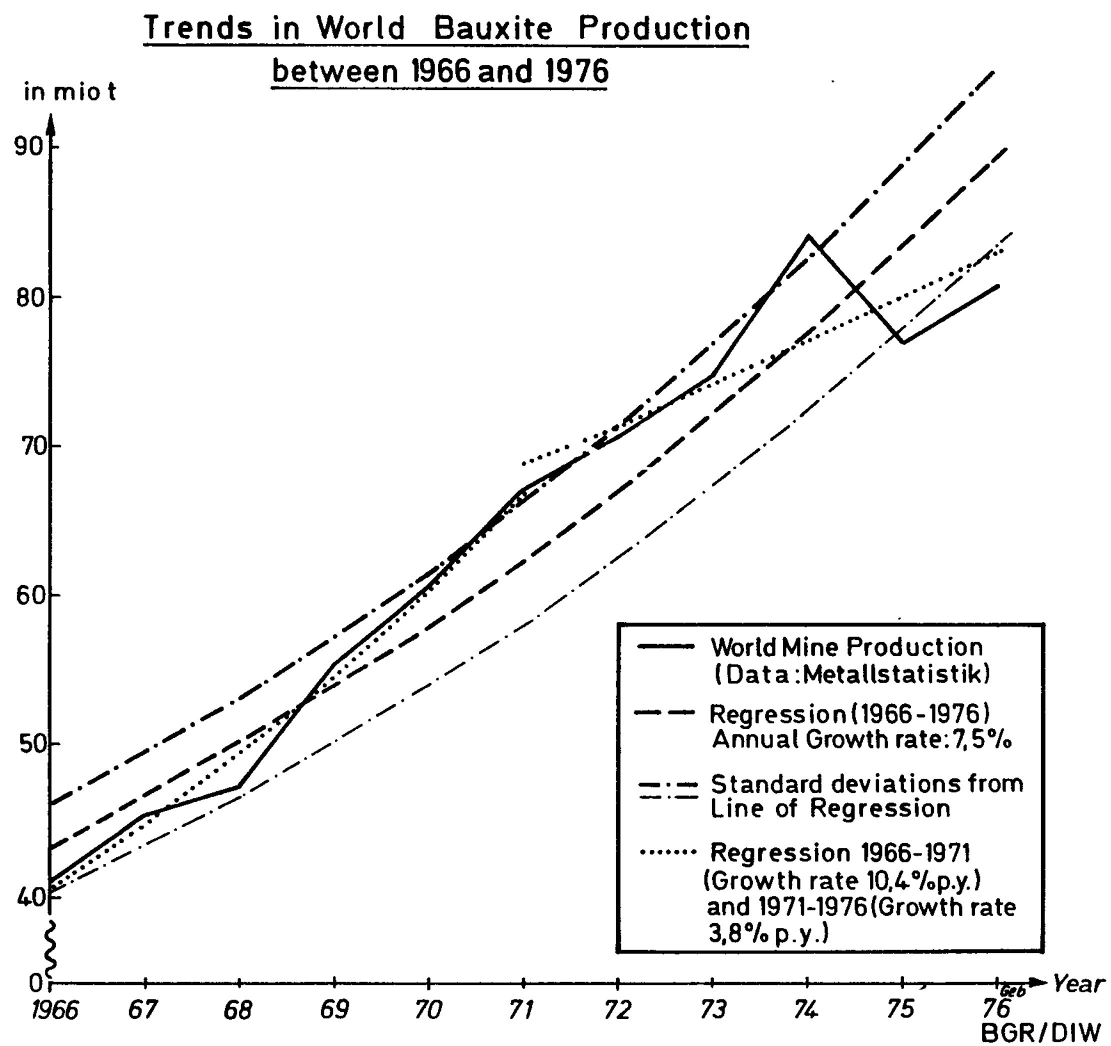
x) estimate

1) Weight of Bauxite as published by official sources, not taking into account variations in composition and moisture content.

2) Dried equivalent. 3) Including other raw materials containing aluminium (Alunite, Nepheline).

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

Fig. 5



Trends in World Bauxite Production
between 1966 and 1976
in mio t
90
80
70
60
50
40
0
1966
67
68
69
70
71
72
73
74
75
76
Year
World Mine Production (Data: Metallstatistik)
Regression (1966-1976) Annual Growth rate: 7,5%
Standard deviations from Line of Regression
Regression 1966-1971 (Growth rate 10,4% p.y.) and 1971-1976 (Growth rate 3,8% p.y.)
BGR/DIW

Table 8

Bauxite[1]: World Production by Country in 1974 - 1976

1000 t and %

Country	1974			1975			1976		
	1000 t	% west. World	% World total	1000 t	% west. World	% World total	1000 t	% west. World	% World total
France	2 949.9	4.1	3.5	2 562.9	3.9	3.4	2 315.3	3.4	2.9
Italy	31.6	<0.1	<0.1	32.2	<0.1	<0.1	24.2	<0.1	<0.1
Germany FR	1.4	<0.1	<0.1	0.8	<0.1	<0.1	0.2	<0.1	<0.1
EC Countries	2 982.9	4.2	3.5	2 595.9	3.9	3.4	2 339.7	3.4	2.9
Austria	-	-	-	-	-	-	-	-	-
Spain	9.2	<0.1	<0.1	8.5	<0.1	<0.1	13.5	<0.1	<0.1
Greece	2 782.7	3.9	3.3	3 005.6	4.6	3.9	2 746.9	4.0	3.4
Jugoslavia	2 370.0	3.3	2.8	2 306.0	3.5	3.0	2 033.0	2.9	2.5
Europe without East Block	8 144.8	11.4	9.7	7 916.0	12.0	10.3	7 133.1	10.3	8.8
USA[2]	1 980.2	2.8	2.4	1 800.4	2.7	2.3	1 989.4	2.9	2.5
North America	1 980.2	2.8	2.4	1 800.4	2.7	2.3	1 989.4	2.9	2.5
Jamaica[2]	15 327.6	21.5	18.3	11 570.3	17.5	15.0	10 306.0	14.9	12.8
Surinam	6 885.1	9.7	8.2	4 751,0	7.2	6.1	4 588.0	6.6	5.7
Guyana[2]	3 606.0	5.0	4.3	3 828.2	5.8	5.0	3 107.6	4.5	3.9
Dominican Rep.[2]	1 195.6	1.7	1.4	785.1	1.2	1.0	516.0	0.8	0.7
Haiti	659.5	0.9	0.8	522.1	0.8	0.7	660.4	1.0	0.8
Brazil	858.5	1.2	1.0	969.0	1.5	1.3	1 000.0	1.4	1.3
Latin America	28 532.3	40.0	34.0	22 425.7	34.0	29.1	20 178.0	29.2	25.2
Guinea	7 600.0	10.7	9.1	8 406.3	12.7	10.9	11 316.4	16.4	14.1
Ghana	363.1	0.5	0.4	325.2	0.5	0.4	267.3	0.4	0.3
Sierra Leone	672.0	0.9	0.8	716.0	1.1	1.0	660.0	0.9	0.8
Mosambique	5.4	<0.1	<0.1	5.2	<0.1	<0.1	5.0	<0.1	<0.1
Rhodesia[+]	2.0	<0.1	<0.1	2.0	<0.1	<0.1	2.0	<0.1	<0,1
Africa	8 642.5	12.1	10.3	9 454.7	14.3	12.3	12 250.7	17.7	15.2
India	1 071.1	1.5	1.3	1 094.2	1.6	1.4	1 435.9	2.1	1.8
Indonesia	1 290.0	1.8	1.5	992.6	1.5	1.3	940.3	1.3	1.2
Malaysia	947.5	1.3	1.1	703.6	1.1	0.9	660.2	1.0	0.8
Pakistan	0.3	<0.1	<0.1	0.4	<0.1	<0.1	0.4	<0.1	<0.1
Turkey	664.9	1.0	0.8	631.2	1.0	0.8	461.0	0.7	0.5
Asia without East Block	3 973.8	5.6	4.7	3 422.0	5.2	4.4	3 497.8	5.1	4.3
Australia	19 994.3	28.1	23.8	20 957.9	31.8	27.2	24 085.1	34.8	29.9
West. World total	71 267.9	100.0	84.9	65 976.7	100.0	85.6	69 134.1	100.0	85.9
		% East Block			% East Block			% East Block	
USSR[+] [3]	8 400.0	66.3	10.0	6 600.0	59.6	8.6	6 700.0	59.0	8.3
Rumania	816.5	6.5	1.0	779.0	7.0	1.0	890.0	7.8	1.1
Hungary	2 750.7	21.7	3.3	2 889.5	26.1	3.8	2 917.8	25.7	3.6
China, PR[+]	700.0	5.5	0.8	800.0	7.3	1.0	850.0	7.5	1.1
East Block	12 667.2	100.0	15.1	11 068.5	100.0	14.4	11 357.8	100.0	14.1
World total	83 935.1	-	100.0	77 045.2	-	100.0	80 491.9	-	100.0

[+] estimate

[1] Weight of Bauxite as published by official sources, not taking into account variations in composition and moisture content.

[2] Dried equivalent, [3] Including other raw materials containing aluminium (Alunite, Nepheline).

Production is presented in Tables 9 & 10 according to country grouping and economic region for the years 1966, 1971, 1974, & 1976. These figures show that in 1976 more than 41 % (1966: almost 25 %) of bauxite production was in the western industrial countries and just under 45 % (1966: ca. 59 %) in the developing countries. The percentage for the EC countries was just under 3 % (1966: almost 8 %).

For the period from 1966 to 1976, about 50 % of the cumulative production came from the developing countries, ca. 34 % from the western industrial countries, and around 16 % from the countries of the East Block. The proportion from the developing countries, according the known development and expansion plans, especially in Guinea, should increase to over 52 % by 1980. Cumulative bauxite production in the EC amounted to ca. 33 million t from 1966 to 1976, corresponding to 4.7 % of the world production for that period.

Seen as a whole, bauxite production within the EC in the last ten years has shown a downward trend (average annual decrease of 1.7 %). However, there was a slight increase until 1972. Some 95 % (in the last few years 99 %) of EC production originates in France, insignificant amounts from Italy & Germany FR. Reserves potential and composition of the bauxite, especially in Italy and the Federal Republic of Germany, do not allow the expectation of a significant increase in bauxite production within the present-day EC countries.

Latin America provided only a quarter of the world bauxite production in 1976, as opposed to more than 47 % in 1966. During this same period production in Australia increased from 5 % of world production to 30 %, in Africa from 5 % to 15 %, whereas the percentage for Western Europe fell from 16 % to 9 %. Production in North America and Asia with 5 % each remained relatively insignificant.

Bauxite production is shown in Figs. 6 & 7 according to country grouping and major producing countries, respectively. The present geographic distribution of the major deposits, reserves, and production of bauxite is shown in Appendices 1 & 2.

6.2 Description of the Major Producing Countries

6.2.1 Australia

bauxite reserves (measured & indicated)	5.23 billion t
percentage of the measured & indicated world reserves	30.3 %
bauxite reserves (inferred)	1.0 billion t
percentage of inferred world reserves	6.8 %

Table 9

Bauxite: Production by Groups of Countries in 1966, 1971, 1974, and 1976

(1000 t and %)

Group of Countries	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
EC Countries	3,069.8	7.5	3,377.3	5.1	2,982.9	3.6	2,339.7	2.9
Developed Countries	10,143.7	24.7	22,957.0	34.4	30,121.3	35.9	33,209.6	41.3
Developing Countries	24,078.4	58.6	33,300.6	49.9	41,146.6	49.0	35,924.5	44.6
Western World total	34,222.1	83.3	56,257.6	84.2	71,267.9	84.9	69,134.1	85.9
East Block total	6,835.3	16.7	10,539.0	15.8	12,667.2	15.1	11,357.8	14.1
World total	41,057.4	100.0	66,796.6	100.0	83,935.1	100.0	80,491.9	100.0

Table 10

Bauxite: Production according to Region in 1966, 1971, 1974, and 1976
(1000 t and %)

Region	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
North America	1,824.8	4.5	2,019.9	3.0	1,980.2	2.4	1,989.4	2.5
Latin America	19,426.5	47.3	25,857.6	38.7	28,532.3	34.0	20,178.0	25.1
Africa	2,214.7	5.4	3,558.8	5.3	8,642.5	10.3	12,250.7	15.2
Europe without East Block	6,489.8	15.8	8,202.4	12.3	8,144.8	9.7	7,133.1	8.9
Asia without East Block	2,439.2	5.9	3,886.2	5.8	3,973.8	4.7	3,497.8	4.3
Australia & Oceania	1,827.1	4.5	12,732.7	19.1	19,994.3	23.8	24,085.1	29.9
Western World total	34,222.1	83.4	56,257.6	84.2	71,267.9	84.9	69,134.1	85.9
East Block total	6,835.3	16.6	10,539.0	15.8	12,667.2	15.1	11,357.8	14.1
World total	41,057.4	100.0	66,796.6	100.0	83,935.1	100.0	80.491.9	100.0

Fig.6

Bauxite : World Production by Groups of Countries between 1966 and 1976

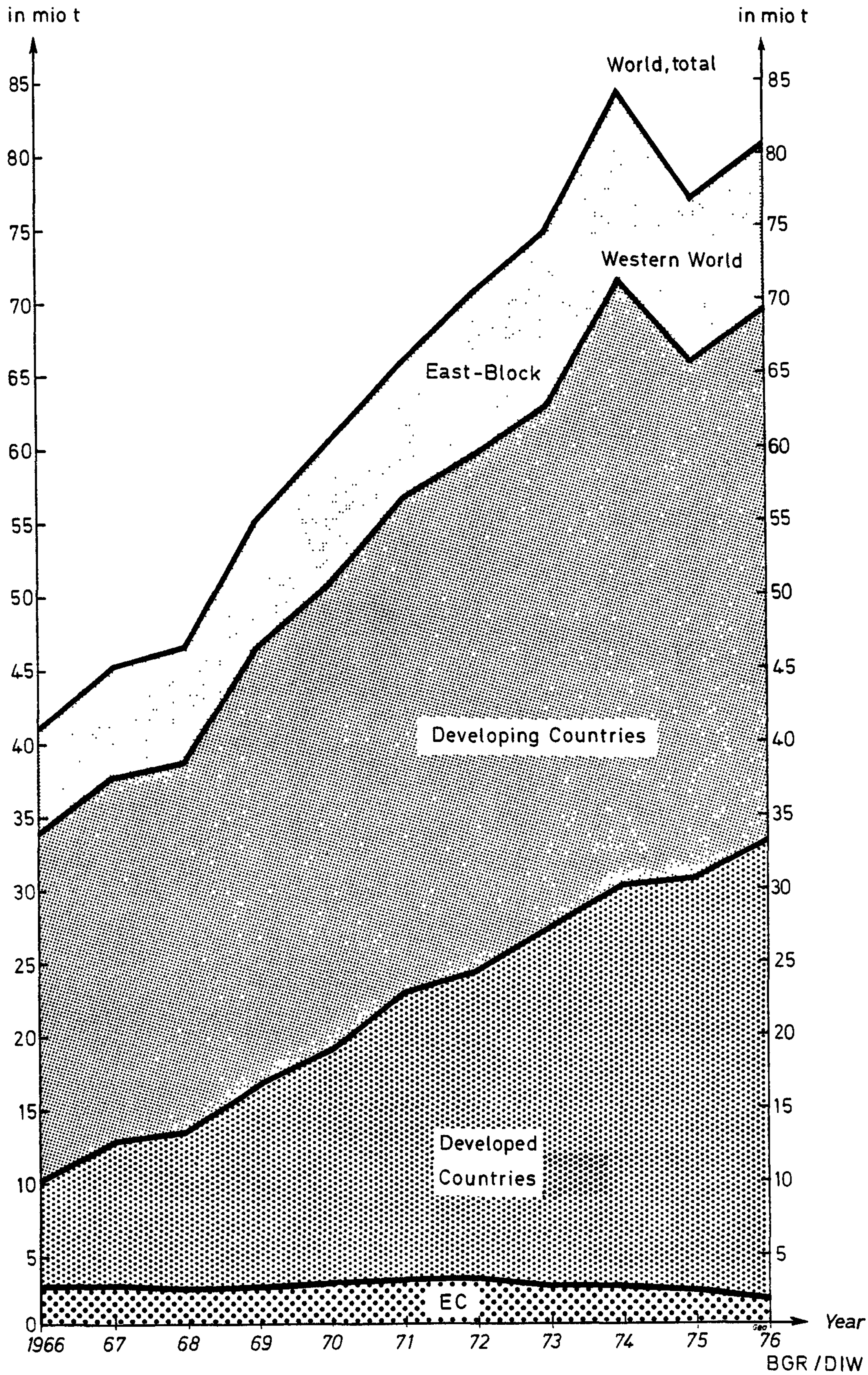


Fig.7

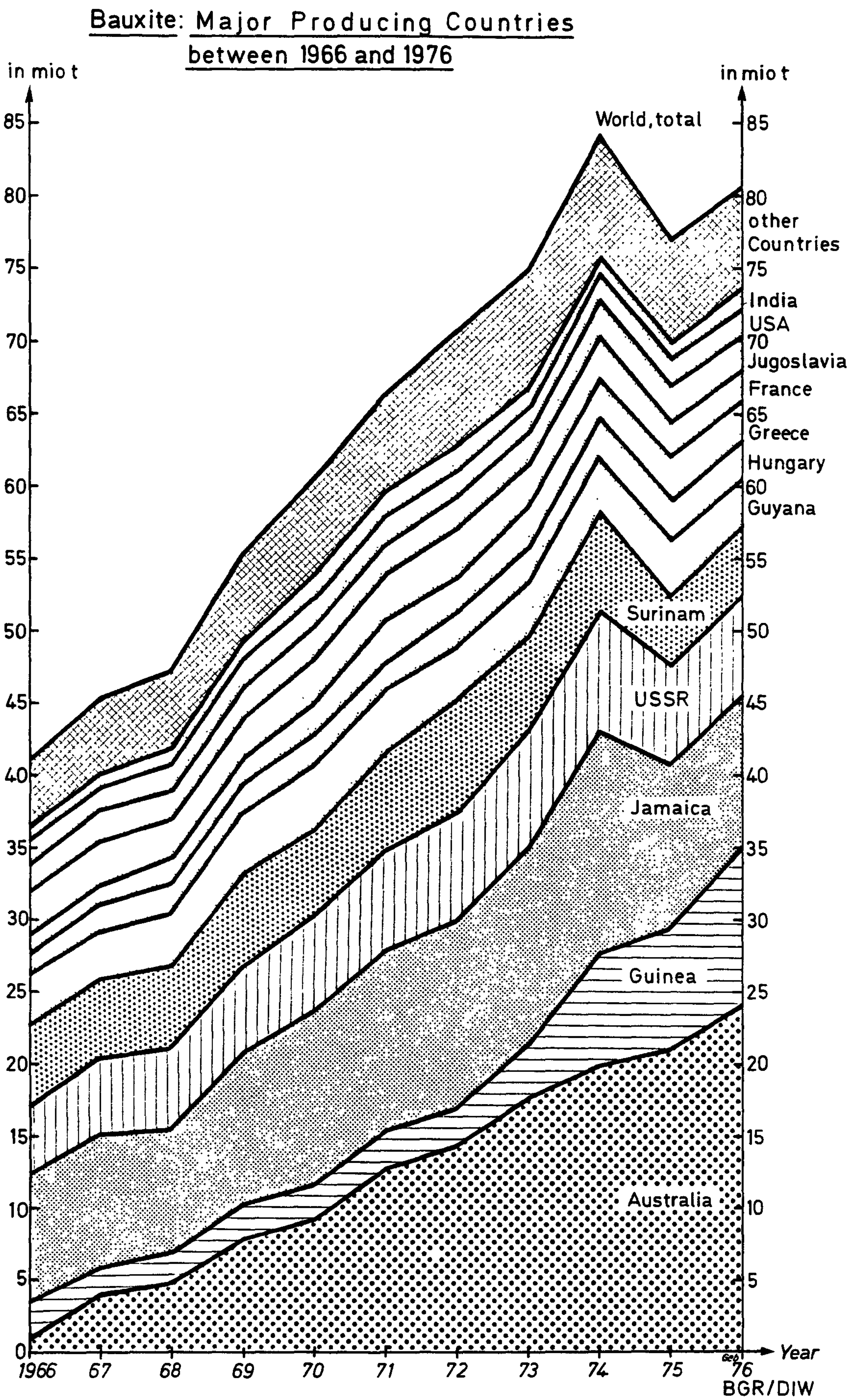

Bauxite: Major Producing Countries between 1966 and 1976
in mio t
in mio t
World, total
other Countries
India
USA
Jugoslavia
France
Greece
Hungary
Guyana
Surinam
USSR
Jamaica
Guinea
Australia
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1966
67
68
69
70
71
72
73
74
75
76
Year
BGR/DIW

Table 11

Bauxite: World Production by Major Producing Countries in 1966, 1971, 1974, and 1976

(1000 t and %)

1966				1971				1974				1976			
Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative
Jamaica	9 061.5	22.1	22.1	Australia	12 732.7	19.1	19.1	Australia	19 994.3	23.8	23.8	Australia	24 085.1	29.9	29.9
Surinam	5 563.0	13.5	35.6	Jamaica	12 543.4	18.8	37.8	Jamaica	15 327.6	18.3	42.1	Guinea	11 316.4	14.1	44.0
USSR	4 800.0	11.7	47.3	USSR	7 000.0	10.5	48.3	USSR	8 400.0	10.0	52.1	Jamaica	10 306.0	12.8	56.8
Guyana	3 357.7	8.2	55.5	Surinam	6.718.0	10.1	58.4	Guinea	7 600.0	9.1	61.2	USSR	6 700.0	8.3	65.1
France	2 810.6	6.8	62.3	Guyana	4 233.6	6.3	64.7	Surinam	6 885.1	8.2	69.4	Surinam	4 588.0	5.7	70.8
Yugoslavia	1 887.0	4.6	66.9	France	3 183.6	4.8	69.5	Guyana	3 606.0	4.3	73.7	Guyana	3 107.6	3.9	74.7
Australia	1 827.1	4.5	71.4	Greece	2 860.7	4.3	73.8	France	2 949.9	3.5	77.2	Hungary	2 917.8	3.6	78.3
USA	1 824.8	4.4	75.8	Guinea	2 630.0	3.9	77.7	Greece	2 782.7	3.3	80.5	Greece	2 746.9	3.4	81.7
Guinea	1 608.7	3.9	79.7	Hungary	2 090.0	3.1	80.8	Hungary	2 750.7	3.3	83.8	France	2 315.3	2.9	84.6
Greece	1 529.0	3.7	83.5	USA	2 019.9	3.0	83.9	Yugoslavia	2 370.0	2.8	86.6	Yugoslavia	2 033.0	2.5	87.1
Hungary	1 429.3	3.5	86.9	Yugoslavia	1 959.0	2.9	86.8	USA	1 980.2	2.4	89.0	USA	1 989.4	2.5	89.6
Malaysia	955.5	2.3	89.3	India	1 517.1	2.3	89.1	Indonesia	1 290.0	1.5	90.5	India	1 435.9	1.8	91.4
Dominican.Rep.	833.0	2.0	91.3	Indonesia	1 237.6	1.9	90.9	Dominican. Rep.	1 195.6	1.4	91.9	Other Countries	6 950.5	8.6	100.0
Other Countries	3 570.2	8.7	100.0	Other Countries	6 071.0	9.1	100.0	Other Countries	6 803.0	8.1	100.0				
World total	41 057.4	100.0		World total	66 796.6	100.0		World total	83 935.1	100.0		World total	80 491.9	100.0	

bauxite production in 1976	24.1	million t
percentage of world production	29.9	%
alumina production in 1976	6.2	million t
calculated quantity of bauxite used for domestic Al_2O_3 production	15.36	million t
corresponds to 64 % of the mine production		
percentage of world alumina production	22.5	%
primary aluminium production in 1976	231,300	t
alumina used for domestic prim. alum. prod.	457,974	t
corresponds to 7 % of the alumina production		
percentage of world prim. alum. prod.	1.8	%
amount of production not further processed within the country:		
bauxite	8.73	million t
alumina	5.75	million t

Trends in bauxite production from 1966 to 1976:

Average annual increase for this period was 26 %. This was the result of the development of the Weipa and Gove mines from 1966 - 1971. The size of the reserves and the high volume of production places Australia in first place among the bauxite producing countries. Known bauxite resources in Australia are estimated by the BMR, Canberra, at 6.678 billion t. This estimate seems extremely conservative when one considers that the sum of the measured & indicated reserves just in the major deposits amounts to 5.23 billion t. It can then be assumed that bauxite resources in Australia are at least 10 billion t. Measured & indicated reserves in the major bauxite deposits in Australia are contained in the following table along with the production figures for 1976.

area	reserves (meas. & ind.) million t	1976 bauxite production million t	Al_2O_3 content %
Queensland			
Weipa	2,270	9.7	59
Wenlock River	.	-	.
Aurukun	600	-	.
Northern Territory			
Gore	250	4.6	50
West Australia			
northern regions			
Cape Bouganville	980		.
Mitchell Plateau	230		.
southern regions			
Chittering	200	-	.
Jarrahdahle) Del Park)	500	9.8	45
Mount Saddleback	200	-	.
total	5,230	24.1	.

1) Calculated from Australian data on the Al_2O_3 content of the bauxite production.

Major producing mines

Weipa

location: 12°40'S, 141°55'E on the Cape York peninsula, Queensland

owner: Commonwealth Aluminium Corporation Ltd. (Comalco)

shareholders:	Conzinc Riotinto of Australia Ltd. (80.7 % RTZ)	45 %
	Kaiser Aluminum & Chemical Corp.	45 %
	Australian & New Zealander shareholders	10 %

capacity: 11 million tpy

The ore is shipped from the Weipa harbor. Part of the production (ca. 50% in 1976) is processed in Queensland by a plant near Gladstone (planned capacity 2 million t Al_2O_3, production in 1976 ca. 2.4 million t Al_2O_3). Some of the production is also used as feedstock for the Eurallumina S.p.A. alumina plant on Sardinia (capacity of 720,000 t Al_2O_3).

geology, reserves: Bauxite, 1 - 10 m thick (average 3 m), covers extensive areas of the Cape York peninsula, especially the western part. It overlies, for the most part, argillaceous clastic sediments of the Upper Cretaceous/Lower Tertiary Bulimba Formation from which it has been formed under humid, tropical climatic conditions since the Tertiary. The bauxite is covered with a layer averaging 0.5 m thick. The bauxite layer is 30 - 50 m above sea level and is cut into several parts by the erosion of several river systems.

Measured & indicated reserves in Comalco's concession area are placed at 2.27 billion t. The bauxite layers continue north & south of Comalco's concession into the Wenlock River & Aurukun deposit areas.

The Weipa ore has in general the following contents:

Al_2O_3	52 - 60 %
SiO_2	2 - 10 %
Fe_2O_3	6 - 12 %
TiO_2	2 - 3 %
loss on ignition	25 - 29 %

The bauxite is composed mainly of gibbsite, boehmite, kaolinite, goethite, hematite, quartz, and anatase. The ore is a pisolitic bauxite in a clayey earthy matrix; it is unconsolidated making it easy to excavate.

plans: An alumina plant is planned with a capacity of 4 million t Al_2O_3 annually. If the Gladstone and Sardinia plants are to be further supplied with Weipa bauxite, the mining capacity will have to be expanded to 17 million tpy.

Gove

location: 11°56'S, 136°51'E on Cape Arnhem

owner: Nabalco, Pty. Ltd.

shares:	Alusuisse	70 %
	Gove Alumina Ltd.	30 %

In addition to Colonial Sugar Refining Co. (CSR: 51.01 %), a number of Australian insurance companies and banks are Gove Alumina Ltd. shareholders.

capacity: 5 million tpy annually (production 1974: 3.6 million t; 1975: 4 million t; 1976: 4.6 million t). The ore is transported from the mine to Gove Harbor by a ca. 20 km conveyor belt. Most of the production is processed in the alumina plant at Gove (cap.: 1 million tpy Al_2O_3; production in 1976: 1,300 mio t Al_2O_3).

geology, reserves: Lower Cretaceous argillaceous clastic sediments (Mullaman Beds) lie discordantly on Precambrian metamorphites and granites. Bauxite overlies these sediments and is formed mainly from the Cretaceous sediments. The bauxite, averaging 3.5 m thick, covers an area of ca. 120 km^2 and lies 30 - 50 m above sea level. Erosion has cut the bauxite layer into four sections.

Measured & indicated bauxite reserves in the Gove area are set at 250 million t; the actual amount should be considerably greater. The ore contains an average of 50 % Al_2O_3 and 4.28 % SiO_2. The main mineral is gibbsite with boehmite as secondary mineral. Gangue consists of kaolinite, goethite, hematite, quartz, anatase, and zircon.

In general, there are three layers along the bauxite profile at Gove, differentiated according to the structure of the ore. A layer of red-brown tubular bauxite is overlain by a layer of pisolitic cemented bauxite, which in turn is overlain by a layer of unconsolidated pisolitic bauxite.

plans: An expansion of alumina capacity at the Gove plant from the present 1 million tpy to 1.5 - 2 million tpy is being considered.

West Australia (Darling Range)

location: inland from Perth, the following mines are

producing: Jarrahdale (32°21'S, 115°50'E),
Del Park (32°35'S, 115°51'E),
Huntley (32°38'S, 115°51'E).

owner: Alcoa of Australia Ltd.

shareholders:		
	Aluminum Co. of America	51 %
	Western Mining Corp. Ltd.	20 %
	North Broken Hill Ltd.	12 %
	Broken Hill South Ltd.	16.6 %
	small shareholders	0.4 %

capacity: ca. 10 million tpy for the three mines together.

Almost all of the production is processed to alumina in Australia. Alcoa has two plants: Pinjarra (cap.: 2 million tpy Al_2O_3) and Kwinana (cap.: 1.4 million tpy Al_2O_3). Export harbors are Bunbury and Kwinana.

geology, reserves: The bauxite in the Darling Range region overlie old granites, migmatites and gneisses as well as the sediment sequences of the Perth becken (Permian to recent). Some of the bauxite is in blanket deposits that lie on a dissected peneplain at a height of 240 - 340 m above sea level, some is detrital bauxite that has collected on the slopes of the Darling Range and formed lens-shaped deposits. The bauxite layers are ca. 4 m thick, the overburden is generally 0.5 m thick.

Measured & indicated reserves in the concession areas held by Alcoa of Australia Ltd. and in the neighboring areas (including the Mt. Saddleback area) amounts to 900 million t, those in the Alcoa area alone are probably 700 million t. The bauxite has a relatively low alumina content (35 - 45 %), above average SiO_2 content (ca. 20 %). However, most of the SiO_2 is in the form of quartz. The bauxite is gibbsitic.

plans: Another alumina plant is planned with a capacity of 0.8 - 1 million tpy Al_2O_3, possibly near Wagerup in West Australia.

Deposits being developed

Mount Saddleback: This deposit is east of the Alcoa concession in the Darling Range 200 km south of Perth, 110 km east of Bunbury harbor. An alumina plant (cap.: 1 million tpy Al_2O_3) is planned near Collie, W. Australia, in connection with the opening up of this deposit (owner Alwest Pty. Ltd.).

Various companies have plans for the development of the following deposits, some in connection with the construction of an alumina plant.

Aurukun: This deposit is the southern continuation of the Weipa deposit. Difficulties stand in the way of its development due to the fact that it is in an area where Australian natives live.

Mitchell Plateau: (Alumax Bauxite Corp.) High-grade bauxite, easily accessable to open-pit mining. The area is in the northwestern part of Australia in an area that has almost no transportation infrastructure. An alumina plant is planned (cap.: 1.5 million tpy Al_2O_3). The construction of a new harbor, possibly at Admirality Bay, would also be necessary.

6.2.2 Guinea

bauxite reserves (measured & indicated)	3.6 billion t
percentage of the measured & indicated world reserves	20.7 %
bauxite reserves (inferred)	1.45 billion t
percentage of inferred world reserves	9.9 %
bauxite production in 1976	11.3 million t
percentage of world production	14.1 %

Trends in bauxite production from 1966 to 1976:

The average annual growth was 21%; there were particularly high growth rates during the last five years due to the opening up of large deposits. Sizable growth rates are also to be expected during the next ten years based on present expansion and development plans.

Guinea's bauxite resources are considerable, they are estimated by the Guinean government at more than 8 billion t. The conservative estimate given here of 5.05 billion t (measured & indicated and inferred reserves) corresponds essentially to the sum of the publicized reserve data for the deposits being mined or opened up.

Most of the bauxite in Guinea overlies Paleozoic sediments that are intruded by Triassic basic rocks. They cover wide areas 4 - 30 m thick, especially in the western and northwestern parts of the country. These immense bauxite layers have been dissected by erosion into numerous plateaus.

The composition of the bauxite is as follows:

Al_2O_3	40 - 65 %
SiO_2	0.5- 5 %
Fe_2O_3	2 - 30 %
TiO_2	3 - 5 %
loss on ignition	22 - 32 %

The main mineral is gibbsite. The Kimbo, Sangaredi, and Kindia deposits are being mined. The Kassa deposit on Conakry Island does not seem to be in production any more.

Major producing mines

Kimbo

location: 10°30'N, 13°50'W

owner: Cie Friguia

shareholders: 49 % Guinean government

51 % Frialco, which belongs to
19.6 % Noranda Mines Ltd.
18.6 % Cie. Pechiney Ugine Kuhlmann
5.1 % British Aluminium Co. Ltd.
5.1 % Alusuisse
2.6 % Vereinigte Aluminium Werke AG

production capacity: 3 million tpy, open-cut production since 1960; an alumina plant near Kimbo (cap. 0.7 million tpy Al_2O_3).

reserves: 250 million t bauxite (measured & indicated), inferred reserves 2 - 4 billion t with 40 % Al_2O_3.

Sangaredi

location: 10°57'N, 14°13'W

owner: Compagnie des Bauxites de Guinée (CBG)

shareholders: 49 % Guinean government
13.77 % Alcan Aluminium Ltd.
13.77 % Aluminum Co. of America
10.2 % Harvey Aluminium Inc.
5.1 % Cie. Pechiney Ugine Kuhlmann
5.1 % Vereinigte Aluminium Werke AG (VAW)
3.06 % Montecatini Edison S.p.A.

production capacity: 7 million tpy with 59 % (wt) Al_2O_3), open-cut mining with removal by rail; production since August 1973.

reserves: The Sangaredi deposit is on one of the numerous plateaus in the Boké region. The surface of the Sangaredi Plateau consists of high-grade bauxite (average thickness 30 m) and has an area of 2.57 km^2. The bauxite reserves on this plateau amount to more than 180 million t with ca. 60 % Al_2O_3.

Kindia (Debelé, Kankan)

location: 10°03'N, 12°49'W

The mine is connected by rail (100 km) with Conakry Harbor.

owner: Office des Bauxites de Kindia (OBK), state owned.

production capacity: 2.5 million tpy with 48 % Al_2O_3 and 3 % SiO_2; production since October 1974.

reserves: The Debelé Plateau is the largest of several in the Kindia area that consist of bauxite. The bauxite layer is 6 - 8 m thick and covers an area of more than 3 km^2. The reserves in the Debelé deposit are quoted at 41 million t with an average of 48 % Al_2O_3 and 3 % SiO_2.

The deposits were developed with Russian aid (rail lines, loading depots and other components of the infrastructure, mining equipment, engineering). Guinea received a loan of 85 million Rubles = $ 113 million; this loan is to be repaid with 90 % of the ore produced at Debelé for a 12 year period (1974 - 1986) or 27 million t bauxite.

Deposits being developed

Aye-Koje (=Ikowi)

location: 10°57'N, 14°13'W in the Boké area

reserves: 500 million t with 50 % Al_2O_3. The deposit was explored by Alusuisse. Production of 9 million tpy is planned (4 million t for domestic alumina production, 5 million t for export).

The mine is to be developed with funds from arab countries (United Arabic Emirates, Iraq, Libya, Kuwait, Saudi Arabia, and Egypt). Alusuisse will prepare a feasibility study.

Togué

location: 11°29'N, 11°48'W 370 km northeast of Conakry

reserves: 3 billion with 40 - 44 % Al_2O_3 and 3 % SiO_2.

The bauxite is 4 - 12 m thick and accessible to open-pit mining. Production is planned to start at 2 million tpy and be increased to 8 billion tpy later. Somiga is the owner (Société miniere et de participation Guinée-Alusuisse).

An alumina plant is planned for processing part of the production from Togué and Dabola (cap.: 1.2 million tpy).

Dabola

location: $10^{o}48'N$, $11^{o}02'W$ 380 km northeast of Conakry

reserves: 450 million t of measured & indicated reserves and 1.5 billion t of inferred reserves.

The deposit has been explored by the Yugoslavian firm Energoinvest. The Guinean-Yugoslavian firm SDB (Sociéte des bauxites de Dabola; 51 % Guinean government) was founded to mine the deposit (planned capacity: 5 million tpy). Part of the bauxite from this deposit, together with ore from the Togué deposit, is to be processed to alumina.

Long-term plans include the construction of an aluminium smelter. According to a 1971 agreement, the Yugoslavian firm Energoprojekt will work out a plan for the Guinean government for a hydroelectric power plant with a capacity of 650 MW for an aluminium smelter with a 300,000 tpy capacity.

Other bauxite occurrences

There are other bauxite occurrences, for which no detailed data is available, north of Gadaoundou, near Pita, near Labé, east of Gaoual, near Télimelé, and east of Koura. Detailed exploration of the occurrences near Télimelé, Pita, Labé, and Gaoual is to take place with Soviet aid.

6.2.3 Jamaica

bauxite reserves (measured & indicated)	2 billion t
percentage of the measured & indicated world reserves	11.6 %
bauxite reserves (inferred)	3 billion t
percentage of inferred world reserves	9.4 %
bauxite production in 1976	10.3 million t
percentage of world production	12.8 %

Trends in bauxite production from 1966 to 1976:

The average annual growth rate was 3.5 %; development was characterized by large fluctuations. In the last few years, 40 - 50 % of the bauxite production was used for domestic alumina production; in 1966 it was 22 %.

Jamaica was the most important bauxite producer until 1970; since then it has been overtaken by Australia and Guinea. The Jamaican bauxite deposits are mostly associated with Eocene to Miocene carbonitic sediments that cover two-thirds of the area of the island. Especially the karstified "White Limestones" are covered with quite thick layers of bauxite of a favorable composition.

The areas viewed today as minable are in the central and western parts of the island. Bauxite is found in a belt across St. Ann and Trelawny provinces in the north and in areas of St. Elizabeth Province (west and east of the Black River) and Manchester Province (Mandeville) in the south and southwest parts of the island.

It is assumed that the bauxite deposits were formed by weathering of the carbonitic Tertiary sediments.

Pocket deposits as well as blanket deposits (particularly in the northern part of the island) are known. The average size of the bauxite ore bodies is as follows:

reserves:	0.25 - 0.4 million t, some of them over 3 million t,
thicknesses:	7 - 13 m,
areal extent:	20,000 - 50,000 m^2, some of them up to 300,000 m^2.

The composition of the bauxite varies greatly; a "typical" bauxite from Jamaica has about the following contents:

50 %	Al_2O_3
19 %	Fe_2O_3
3 %	SiO_2
2 %	TiO_2
26 %	loss on ignition.

An average 2.53 t Jamaican bauxite is used to obtain 1 ton of alumina.

Ore minerals:

Gibbsite is the main component, boehmite is present as a minor component. SiO_2 is present primarily in kaolinite and halloysite, iron in hematite and goethite, TiO_2 in anatase. The P_2O_5 content is about 0.5 % in crandallite.

Present total production capacity in Jamaica is ca. 16.5 million tpy. The following producing mines are designated by the local names.

Discovery Bay (Port Rhodes, Tobolsky)

location: 18°18'N, 77°25'W inland from Port Rhodes on Discovery Bay. Port Rhodes is an export harbor for bauxite.

owner: 51 % Jamaican government

49 % Kaiser Aluminum & Chemical Corp.

capacity: ca. 5 million tpy.

Lydford

location: 18°19'N, 77°08'W inland from the bauxite export harbor Ocho Rios, St. Ann Province.

owner: Reynolds Jamaica Mines Ltd.

capacity: ca. 3 million tpy

The mine is connected with the harbor by a conveyer belt system.

Nain (Port Kaiser)

location: 18°N, 77°40'W St. Elisabeth Province, inland from the Port Kaiser alumina export harbor.

owner: Alpart (Alumina Partners of Jamaica)

shareholders: 36.5 % Kaiser Bauxite Co.

36.6 % Reynolds Jamacia Mines Ltd.

26.9 % Anaconda Jamaica Inc.

capacity: ca. 3 million tpy

Most of the bauxite is processed in the alumina plant at Nain (cap.: 1.18 million tpy Al_2O_3).

May Pen (Woodside, Clarendon)

location: 18°02'N, 77°21'W west of May Pen in the Clarendon district, rail connection via May Pen and Old Harbour to Spanish Town.

owner: Alcoa Minerals of Jamaica Inc.

capacity: ca. 1.88 million tpy

Most of the production is processed in the Woodside alumina plant (cap.: 0.5 million tpy Al_2O_3), which belongs to Jamalco (Alcoa and the Jamaican government).

Schwallenberg (Ewarton)

location: 18°13'N, 77°05'W in the St. Ann and St. Catherine Provinces.

owner: Alcan Jamaica Ltd.

capacity: ca. 1.5 million tpy

Most of the bauxite is processed in the Ewarton alumina plant (cap.: 0.56 million tpy Al_2O_3). Recent reports indicate that the Schwallenberg deposit is almost mined out.

Kirkvine (Mandeville)

location: 18°05'N, 77°29'W in the Manchester Province northeast of Mandeville.

owner: the Jamaican government

capacity: ca. 1.5 million tpy

Most of the bauxite is processed in the Kirkvine alumina plant (cap.: 0.57 million tpy Al_2O_3).

Maggotty (St. Elisabeth)

location: 18°09'N, 17°46'W in the St. Elisabeth Province, rail line via May Pen to the Port Esquivel alumina export harbor.

owner: Revere Jamaica Alumina Ltd. (51 % Jamaican government, 49 % Revere Copper & Brass Inc.)

capacity: ca. 0.7 million tpy

Part of the production is processed in the Maggoty alumina plant (cap.: 0.2 million tpy Al_2O_3). Capacity is to be increased to 0.65 million tpy and later to 1.2 million tpy Al_2O_3.

Other bauxite occurrences in the Trelawny Province (west of Stewart Town and in the Cockpit area), in the St. Ann Province (east of Browns Town), and in St. Catherine Province (west of Spanish Town) are identified as mining concessions of Alcoa Minerals of Jamaica Inc.

No figures are avialable on the breakdown by deposit of the total reserves in Jamaica. The International Bauxite Association has estimated the bauxite reserves on Jamaica at 1.5 billion t. The Jamaican Bauxite Institute in 1976 claimed reserves of 2 billion t.

It is the aim of the Jamaican government to obtain a majority holding (51 %) of all US and Canadian companies and achieve more income by increasing the taxes on bauxite production. At the beginning of 1977, new agreements were made between the Jamaican government and Alcoa, Reynolds, and Kaiser. These contracts with a life-time of 40 years provide for the assumption of 51 % of the mining assets by the government. The bauxite production tax is set for the period up to 1983 at 7.5 % of the metal price. For the long-term, Jamaica would like to construct an aluminium smelter within the country. These plans have had to be postponed due to a lack of energy.

6.2.4 USSR

bauxite reserves (measured & indicated)	150 million t
percentage of the measured & indicated world reserves	0.9 %
bauxite reserves (inferred)	150 million t
percentage of inferred world reserves	1.0 %
Bauxite production[1] in 1976	6.7 million t
percentage of world production	8.3 %
nepheline concentrate production in 1976 containing 25 - 30 % Al_2O_3, 4 tons nepheline concentrate is used to produce 1 t Al_2O_3	3.5 million t
nepheline-syenite reserves	several billion t
alunite ore production in 1976 containing 16 - 18 % Al_2O_3	0.6 million t
alunite ore reserves	ca. 80 - 100 million t
alumina production in 1976	3.35 million t
alumina produced from domestic raw materials	2.5 million t
percentage of world alumina production	12.2 %
primary aluminium production in 1976	2.2 million t
prim. alum. produced from domestic raw materials	1.6 million t
percentage of world prim. alum. prod.	16.8 %

[1] including nepheline and alunite ores

The USSR is, after the USA, the second largest producer and consumer of primary aluminium in the world. The country has however, only limited reserves of high-grade bauxite. Large amounts of alumina are produced in the USSR from non-bauxite raw materials (nepheline-syenite and alunite).

Production of Primary Aluminium in the USSR

from domestic and imported raw materials			domestic raw materials only	
	1000 t	%	1000 t	%
from domestic raw materials	1,600	72.7	1,600	100.0
including bauxite	1,173	53.3	1,173	73.3
nepheline concentrate	382	17.4	382	23.9
alunite	45	2.0	45	2.8
from imported bauxite and alumina	600	27.3		
total production of primary aluminium	2,200	100.0		

Major areas of aluminium raw materials production

bauxite deposits or districts

Krasnaya Shapochka (northern Urals)

location: 60°10'N, 59°36'E in the Severouralsk District on the east slopes of the Urals.

capacity: ca. 3 - 4 million tpy bauxite.

The Severouralsk region provides about three-fourths of the Al_2O_3 content of the USSR bauxite production.
Bauxite is produced mainly from underground mines. Large water influx into the mines have caused great difficulties. The first large open-pit mine was opened up in 1971. The ore is processed in alumina plants in Krasnoturinsk and Kamensk. Part of the alumina is also smelted to aluminium here; part is used as feedstock for the aluminium smelters at Krasnoyarsk and Bratsk in Sibiria.

geology,reserves: The bauxite-bearing series of beds have a N-S strike and dips 20° - 30° to the east. This series has been demonstrated to a depth of 2000 m.

The layer-like or elongated ore bodies, up to several meters thick, are in a karstified area of Middle to Upper Devonian carbonate rock.

The aluminium mineral is diaspore. The best quality bauxite ore has the following composition:

53 - 55 % Al_2O_3
2 - 6 % SiO_2
23 - 25 % Fe_2O_3

Measured & indicated reserves in the Urals should amount to 90 - 100 million t.

plans: Two new deep mines should start producing in 1980. Al_2O_3 capacity at Krasnoturinsk is to be expanded to 600,000 tpy.

Arkalyk (northwestern Kazakhstan)

location: 50°17'N, 66°51'E in the Turgai District in northwestern Kazakhstan.

capacity: ca. 3 million tpy; open-pit mining. The bauxite is transported by rail to Pavlodar (1120 km), where it is processed to Al_2O_3 (cap.: 500,000 tpy Al_2O_3).
The alumina produced at Pavlodar is used by Siberian aluminium smelters (Novokuznetsk, Shelekov).

geology, reserves: The Arkalyk and several other large deposits (the Amangelda group) are found on the eastern margin of the Turgai depression. The Arkalyk bauxite overlies Upper Devonian carbonate sediments and has an overburden of sandy argillaceous rock up to 100 m thick. The ore consists mainly of gibbsite, hematite, and kaolinite.

Its chemical composition is as follows:

46 - 57 % Al_2O_3
10 - 14 % SiO_2
11 - 15 % Fe_2O_3

The Arkalyk bauxite is supposed to have been formed during the Late Cretaceous to Tertiary. Reserves of high-grade bauxite are estimated at 50 - 60 million t.

Further reserves have been demonstrated at the Ashut deposit, these are a lower-grade ore, however. The ore of this deposit is mixed with the richer Arkalyk ore. Thus, 4 t of bauxite are needed for the production of 1 t Al_2O_3 at the Pavlodar alumina plant.

The ore in the Ayat deposits, ca. 450 km NW of Arkalyk, is of the same quality as that at Ashut. These deposits have been in production since 1971.

Boksitogorsk (near Tichvin)

location: 59°39'N, 33°31'E in the Leningrad region

geology, reserves: The bauxite occurrence here is interposed in a Lower Carboniferous, clastic sediment sequence that overlies Upper Devonian sand and clay. Ore minerals are gibbsite and boehmite in varying proportions. The bauxite crops out at the surface and reaches depths of 40 m, sometimes up to 100 and 150 m. It has the following composition:

36 - 49 % Al_2O_3
11 - 18 % SiO_2
10 - 20 % Fe_2O_3

The high-grade Boksitogorsk bauxite is said to be almost mined out. At present, aluminium oxide is produced only for use as abrasives and for polishing.

There are also bauxite occurrences near Pletzk in the Onega River region in the Arkhangelsk district. Of these, the Iksa deposit is the most important. This gibbsitic boehmitic bauxite is also associated with a Lower Carboniferous series of beds at depths of 40 - 110 m. The composition is as follows:

49 - 53 % Al_2O_3
17 - 19 % SiO_2
7 - 15 % Fe_2O_3

It is planned to develop these occurrences by open-pit mining.

Nepheline-syenite occurrences

Nepheline concentrate is used extensively in the USSR for alumina production. Alkaline basic magmatic rock, especially nepheline syenite is used for producing the concentrate. Urtite has the highest nepheline content (75 - 85 %) and can be used without any processing. Nepheline syenite, with more than 5 - 7 % Fe_2O_3, must be concentrated. About 4 t nepheline concentrate are necessary to produce 1 t Al_2O_3. The following by-products are obtained per ton of Al_2O_3: 10 t portland cement, 0.7 t sodium carbonate, 0.3 t potassium carbonate, 0.1 kg gallium.

Kirovsk, Apatity (Kola Peninsula)

location: 67°37'N, 33°39'E in the Kirovsk District on the Kola Peninsula.

capacity: ca. 1.5 million tpy nepheline concentrate.

The concentrate, with up to 30 % Al_2O_3, is obtained from the tailings from apatite mining. Ca. 0.7 t nepheline concentrate are obtained per ton of apatite concentrate. At present, less than a fifth of the nepheline concentrate is being utilized. The concentrate is procesed to Al_2O_3 at Pikalevsk (cap.: 300,000 tpy Al_2O_3) and Volkhov (cap.: 50,000 tpy Al_2O_3).

geology, reserves: Apatite-nepheline rock occurs in parts of the Khibiny alkaline rock complex on the Kola Peninsula. It is a nepheline-syenite that intruded into old gneiss, Proterozoic greenstone and tuffogenic sediments during the late Paleozoic.

Apatite-nepheline rock in the Kirovsk and Apatity region is mined in surface and deep mines and is processed to apatite concentrate for fertilizer production. Nepheline concentrate is a by-product of this processing.
The minable ore bodies have a layer-like or lense shape, are 10-260 m thick, and have a 30 - 40° dip.
Minable reserves may be estimated at several hundred million tons.

Kiya-Shaltyr (Sibiria)

location: 55°02'N, 88°28'E near Belogorsk, Achinsk District in the northern part of the Kuznets Alatau.

capacity: 2.5 - 3 million tpy nepheline concentrate

The ore (urtite) is processed in the alumina plant at Achinsk (cap.: 800,000 tpy Al_2O_3). The plant was producing at two-thirds capacity in 1975 and 1976. The alumina is used by the Siberian aluminium smelters.

geology, reserves: The deposit is in the southern part of an alkaline rock complex that intruded into a vulcanogenic sedimentary and carbonate rock series of Proterozoic to Devonian age. The ore body (urtite) consists of up to 85 % nepheline and has the following composition:

24 - 29 %	Al_2O_3
39 - 42 %	SiO_2
5 %	Fe_2O_3
13 %	$Na_2O + K_2O$

The ore can be used for alumina production without preliminary concentration. To produce 1 t Al_2O_3, 4 - 4.5 tons of ore are needed.

Exact data on ore reserves are not available; they may be estimated at several million tons.

Other nepheline-syenite occurrences whole development has been considered are

Goryachegorsk, 60 km northeast of Keya-Shaltyr and

Tezhsar near Razdan in Armenia.

Alunite Occurrences

The Zaglik deposit in Azerbaidzhan is the only alunite occurrence that has been used for ore production in the USSR. There are other occurrences in Uzbekistan, in the Ukraine, and in the Soviet Far East.

Zaglik

location: 40°32'N, 46°02'E near Kirovabad, in the Dashkesan-Azerbaidzhan region.

capacity: Production is presently ca. 0.6 million t of ore with 16 - 18 % Al_2O_3. The ore is processed in the alumina plants at Sumgait (near Baku) and Kirovabad. To produce 1 t Al_2O_3, 6.- 6.5 tons of alunite ore are needed.

geology, reserves: The central area of the deposit is a shallow syncline. The alunite was formed under the influence of hydrothermal solutions on Jurassic tuffogenenic rock, the alunitized rock series lies concordantly on Jurassic carbonate rocks. The degree of the alunitization varies with depth and along the strike of the layer-like main ore body. The reserve calculations are based on the following conditions: at least 25 % alunite and an average of 48 %, a minimum thickness of 2 m and a maximum stripping ratio of 5 : 1. The ore is mainly alunite and quartz with small quantities of clay minerals. Measured & indicated reserves are estimated at 80 - 100 million t.

The processing of 6 - 6.5 t of alunite ore with 50 % alunite produces 1 t Al_2O_3 and 2.5 t potassium sulfate, 0.8 kg vanadium pentoxide and 0.1 kg gallium as by-products.

7) The Life-time of the Reserves

A comparison of the values for measured & indicated reserves with the amounts that are annually mined can be used for a more detailed assessment of the reserves situation. This assessment should be made from two points of view:

-- the static life-time, for which production is assumed to remain constant in the coming years;

-- the semi-dynamic life-time, for which it is assumed that production will increase in the future (annual growth rates of 4, 6, 8, & 10 %).

The fact that reserves will be added to as the result of exploration work is not considered in the following observations. Static and semi-dynamic life-times are presented in Table 12 for the world, the bauxite producing countries, and for various economic regions and country groupings.

7.1 Static Life-times

Based on world production of bauxite in 1976, measured & indicated bauxite reserves have a static life-time of 215 years. The static life-time of the reserves in the western industrial countries is 190 years, in the developing countries 298 years, and in the East Block 41 years. The static life-times of the reserves in Ghana, Brazil, Guyana, Guinea, India, Greece, and Australia are greater than the world average of 215 years. The static life-times of the measured & indicated reserves in Sierra Leone, the USA, Rumania, the USSR, Malaysia, and France are less than 25 years.

7.2 Semi-dynamic Life-times

Assuming an annual production growth rate of between 4 % and 10 %, the life-time of world bauxite reserves decreases to 57 - 31 years, in the western industrial countries to 54 - 30 years, in the developing countries to 64 - 34 years, and in the East Block countries to 24 - 16 years. If a growth rate of 8 % is assumed, which is in the range for previous years, the six most important producing countries (Australia, Guinea, Jamaica, the USSR, Surinam, and Guyana) have a semi-dynamic life-time of between 35 and 41 years (with the exception of the USSR with only 13 years).

7.3 Results of these Considerations

Seen as a whole, the situation with respect to bauxite reserves, as expressed by the values given for their life-time, can be assessed as favorable. Measured & indicated world reserves are so large that even with an average annual increase of 10 % they should last for more than 30 years. Significant for the future supply of bauxite at present are Australia, Greece, and several countries in South America (Brazil, Guyana) and Africa (Guinea, Ghana). In addition to these countries, several countries (e.g. Cameroon) which have unused reserves will become important.

Table 12

Proven and Probable Bauxite Reserves and their Lifetimes by Country and Group of Countries

country	reserves 10^6 t	1976 production 10^3 t	static lifetime (years)	dynamic lifetimes by production growth rates of 4 % (years)	6 % (years)	8 % (years)	10 % (years)
USA	41	1,989.4	21	15	13	12	11
North America	41	1,989.4	21	15	13	12	11
Jamaica	2,000	10,306.9	194	54	42	35	30
Guyana	1,000	3,107.6	322	66	50	41	35
Surinam	800	4,588.0	174	52	41	34	29
Haiti	40	660.4	61	31	26	22	20
Brazil	1,000	1,000.0	1000	93	69	55	46
other Latin America	142	516.0	.	.	.	.	.
Latin America	4,982	20,178.0	247	60	46	38	32
Guinea	3,585	11,316.4	317	65	50	41	35
Ghana	426	267.3	1594	104	76	61	51
Sierra Leone	10	660.0	15	12	11	10	9
other Africa	1,252	7.0	.	.	.	.	.
Africa	5,273	12,250.7	430	73	55	45	38
India	350	1,435.9	244	59	46	38	32
Indonesia	40	940.3	43	25	21	19	17
Malaysia	15	660.2	23	16	14	13	12
other Asia	30	461.4	.	.	.	.	.
Asia without East Block	435	3,497.8	124	45	36	30	26
Australia	5,230	24,085.1	217	57	44	36	31
France	53	2,315.3	23	16	14	13	12
Greece	600	2,746.9	218	57	44	36	31
Yugoslavia	200	2,033.0	98	40	32	27	24
other Europe	.	37.9	.	.	.	.	.
Europe without East Block	853	7,133.1	120	44	35	29	26
West. World	16,814	69,134.1	243	59	46	38	32
USSR	150	6,700.0	22	16	14	13	12
Hungary	150	2,917.8	51	28	23	20	18
China, People's Rep.	150	850.0	176	52	41	34	29
Rumania	20	890.0	22	16	14	13	12
East Block	470	11,357.8	41	24	21	18	16
World total	17,284	80,491.9	215	57	44	36	31
Group of Countries							
Developed Countries	6,124	32,207.6	190	54	42	35	30
Developing Countries	10,690	35,926.5	298	64	49	40	34
Western World	16,814	69,134.1	243	59	46	38	32
East Block	470	11,357.8	41	24	21	18	16
World total	17,284	80,491.9	215	57	44	36	31

8) World Alumina Production

It is estimated that ca. 95 % of the world bauxite production is processed to alumina. Ca. 5 % of the world alumina production uses non-bauxite raw materials (nepheline and alunite). World alumina production amounted to ca. 245.6 t Al_2O_3 from 1966 to 1976. Production increased from ca. 14.8 million t in 1966 to ca. 27.5 million t in 1976, with a peak of 28.7 million t in 1974. The average annual increase in aluminium oxide production in the world from 1966 to 1976 was 6.8 %.

Similar to bauxite production, alumina production increased rapidly from 1966 to 1971 (9.1 %/yr) and then slowed down from 1971 to 1976 (4 % average annual increase).

Compared with the average annual increase in world alumina production (6.8 %), the group of developing countries were above average with 8.2 % and the East Block was below average with 4.9 %. The increase in production in the western industrial countries (7.0 %) corresponded roughly to that for the world as a whole. The present EC countries had an average annual growth of 6.2 %.

Alumina production from 1966 to 1976 is presented in Table 13 according to country. Ca. 22.5 million t (81.9 %) were produced in the Western World in 1976, in the East Block 5 million t (18.1 %). Compared with 1966 (77.9 %), the percentage for the Western World increased slightly.

Table 14 contains the breakdown of world alumina production by country for the years 1974, 1975, and 1976. Australia and the USA each had more than 20 % of the world production (22.5 % and 21.5 % respectively). The USSR produced 12.2 %, Jamaica 6 %, Japan 5.1 %, and the Fed. Rep. of Germany 4.8 %.

Tables 15 and 16 contain the breakdown of world alumina production by country grouping and economic region, respectively. In 1976, the western industrial countries produced 66 % (1966: 62.2 %) of the aluminium oxide in the world, the developing countries 15.8 % (1966: 15.6 %), the EC countries 11.8 % (1966: 12.4 %). About one-fourth (23.3 %) of world production came from North America, considerably less than in 1966 (42 %). The percentages for Europe (15.1 %), Latin America (11.8 %), and Asia (7.2 %) changed little in comparison with 1966. A third (32%)of European alumina production came from the Federal Republic of Germany, a fourth (24.3 %) from France, and a fifth (19.2 %) from Italy. Almost three-fourths of the alumina production in Asia came from Japan.
The proportion of world production for Africa (2 %) remained of subordinate significance. In contrast, the proportion for Australia rose from 2.1 % in 1966 to 22.5 % in 1976.

Aluminium oxide production is shown in Figs. 8 & 9 according to country grouping and major producing countries, respectively.

Table 13

World Production of Alumina: 1966 - 1976

in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Germany FR	602.9	633.4	651.5	679.6	757.1	836.9	916.4	921.8	1 302.0	1 239.8	1 331.2
France	844.9	919.8	951.9	991.2	1 004.2	1 046.1	1 111.9	1 112.1	1 107.5	1 088.6	1 013.0
Italy	269.5	285.5	293.8	292.0	313.3	262.6	206.3	486.3	688.8	697.1	797.8
Great Britain	119.0	135.3	117.4	105.7	107.1	99.1	116.1	96.9	94.7	82.5	96.0
EG total	1 836.3	1 974.0	2 014.6	2 068.5	2 181.7	2 244.7	2 350.7	2 617.1	3 193.0	3 108.0	3 238.0
Norway	14.8	15.5	15.4	12.3	-	-	-	-	-	-	-
Greece	72.9	180.9	223.2	287.5	312.5	463.8	466.4	470.4	498.0	475.3	461.6
Jugoslavia	95.3	101.4	118.1	121.6	125.1	123.4	126.0	274.7	272.7	283.1	461.9
Europe without East Block	2 019.3	2 271.8	2 371.3	2 489.9	2 619.3	2 831.9	2 943.1	3 362.2	3 963.7	3 866.4	4 161.5
USA	5 310.0	5 582.0	5 489.0	6 277.7	6 051.0	5 937.5	5 656.3	6 199.7	6 403.8	4 738.2	5 915.0
Canada	900.0	1 000.0	1 000.0	1 005.0	1 005.0	1 105.0	1 140.0	1 148.7	1 264.7	1 133.7	490.0
North America	6 210.0	6 582.0	6 489.0	7 282.7	7 156.0	7 077.5	6 805.0	7 333.2	7 668.5	5 871.9	6 405.0
Brazil	68.3	86.9	81.0	87.0	118.6	167.0	192.0	201.0	240.0	267.5	303.0
Guyana	301.7 1)	273.2 1)	269.5	270.0	317.0	305.2	265.3	269.3	316.0	294.0	247.0
Jamaica	803.8 1)	837.8 1)	924.6	1 201.9	1 797.4	1 876.3	2.087.3	2 505.9	2 737.4	2 242.4	1 648.2
Surinam	407.0	741.0	892.0	960.0	1 036.0	1 277.0	1 378.1	1 380.0	1 185.0	1 148.0	1 040.0
Latin America	1 580.8	1 938.9	2 167.1	2 518.9	3 269.0	3 625.5	3 922.7	4 356.2	4 478.4	3 951.9	3 238.2
Africa (Guinea)	525.3	530.0	542.0	577.0	610.0	661.0	663.3	615.0	636.0	639.1	562.0
India	170.0 +)	200.0 +)	240.0 +)	270.0 +)	327.0	362.0	363.0	350.0 +)	299.2	337.0	442.0
Japan	662.3	709.8	826.5	1 064.2	1 284.9	1 603.2	1 644.4	1 987.1	1 800.9	1 565.0	1 411.4
Taiwan	35.0 +)	31.1	37.4	40.9	42.0	43.0	53.0	55.0 +)	45.0	46.4	47.7
Turkey	-	-	-	-	-	-	84.0	109.4	123.7	81.7	70.0
Asia	867.3	940.9	1 103.9	1 375.1	1 653.9	2 008.2	2 144.4	2 501.5	2 268.8	2 030.1	1 971.1
Australia	307.0	854.4	1 309.5	1 931.0	2 152.2	2 712.6	3 068.1	4 088.9	4 899.5	5 128.9	6 205.8
Western World total	11 509.7	13 118.0	13 982.8	16 174.6	17 460.4	18 916.7	19 546.6	22 257.0	23 914.9	21 488.3	22 543.6
USSR +)	2 600.0	2 600.0	2 600.0	2 600.0	2 700.0	2 750.0	2 850.0	3 100.0	3 300.0	3 300.0	3 350.0
Germany DR +)	51.3	51.4	53.6	53.7	54.8	47.4	45.1	47.3	48.2	48.3	48.0 +
Romania +)	95.0	105.0	155.0	180.0	200.0	220.0	245.0	350.0	360.0	400.0	400.0
Czechoslovakia +)	60.0	60.0	60.0	70.0	70.0	75.0	85.0	95.0	100.0	100.0	90.0
Hungary	288.4	327.9	381.5	407.8	441.2	466.6	519.8	655.1	690.9	756.2	754.8
China, Peoples Rep. +)	180.0	180.0	240.0	260.0	270.0	300.0	320.0	320.0	320.0	350.0	350.0
East Block	3 274.7	3 324.3	3 490.1	3 571.5	3 736.0	3 859.0	4 064.9	4 567.4	4 819.1	4 954.5	4 992.8
World total	14 784.4	16 442.3	17 472.9	19 746.1	21 196.4	22 775.7	23 611.5	26 824.4	28 734.0	26 442.8	27 536.4

1) Exports
+) estimate

Source: Metallstatistik 1966 - 1976 64. Jahrgang, Frankfurt am Main 1977

Table 14

Alumina: World Production by Country in 1974-1976

1000 t and %

Country	1974			1975			1976		
	1000 t	% west. World	% World total	1000 t	% west.World	% World total	1000 t	% west.World	% World total
Germany FR	1 302.0	5.5	4.5	1 239.8	5.8	4.7	1 331.2	5.9	4.8
France	1 107.5	4.6	3.9	1 088.6	5.1	4.1	1 013.0	4.5	3.7
Italy	688.8	2.9	2.4	697.1	3.2	2.7	797.8	3.6	2.9
Great Britain	94.7	0.4	0.3	82.5	0.4	0.3	96.0	0.4	0.4
EC Countries	3 193.0	13.4	11.1	3 108.0	14.5	11.8	3 238.0	14.4	11.8
Norway	-	-	-	-	-	-	-	-	-
Greece	498.0	2.1	1.7	475.3	2.2	1.8	461.6	2.0	1.6
Jugoslavia	272.7	1.1	1.0	283.1	1.3	1.0	461.9	2.0	1.7
Europe without East Block	3 963.7	16.6	13.8	3 866.4	18.0	14.6	4 161.5	18.4	15.1
USA	6 403.8	26.8	22.3	4 738.2	22.0	17.9	5 915.0	26.2	21.5
Canada	1 264.7	5.3	4.4	1 133.7	5.3	4.3	490.0	2.2	1.8
North America	7 668.5	32.1	26.7	5 871.9	27.3	22.2	6 405.0	28.4	23.3
Brazil	240.0	1.0	0.9	267.5	1.3	1.0	303.0	1.4	1.1
Guyana	316.0	1.3	1.1	294.0	1.4	1.1	247.0	1.1	0.9
Jamaica	2 737.4	11.4	9.5	2 242.4	10.4	8.5	1 648.2	7.3	6.0
Surinam	1 185.0	5.0	4.1	1 148.0	5.3	4.3	1 040.0	4.6	3.8
Latin America	4 478.4	18.7	15.6	3 951.9	18.4	14.9	3 238.2	14.4	11.8
Africa (Guinea)	636.0	2.6	2.2	639.1	3.0	2.5	562.0	2.5	2.0
India	299.2	1.3	1.0	337.0	1.5	1.3	442.0	2.0	1.6
Japan	1 800.9	7.5	6.3	1 565.0	7.3	5.9	1 411.4	6.3	5.1
Taiwan	45.0	0.2	0.2	46.4	0.2	0.2	47.7	0.2	0.2
Turkey	123.7	0.5	0.4	81.7	0.4	0.3	70.0	0.3	0.3
Asia without East Block	2 268.8	9.5	7.9	2 030.1	9.4	7.7	1 971.1	8.8	7.2
Australia	4 899.5	20.5	17.0	5 128.9	23.9	19.4	6 205.8	27.5	22.5
West.World total	23 914.9	100.0	83.2	21 488.3	100.0	81.3	22 543.6	100.0	81.9
		% East Block			% East Block			% East Block	
USSR	3 300.0	68.5	11.5	3 300.0	66.6	12.5	3 350.0	67.1	12.2
Germany DR	48.2	1.0	0.2	48.3	1.0	0.2	48.0 +)	1.0	0.2
Rumania	360.0	7.5	1.3	400.0	8.1	1.5	400.0	8.0	1.4
Czechoslovakia	100.0	2.1	0.3	100.0	2.0	0.4	90.0	1.8	0.3
Hungary	690.9	14.3	2.4	756.2	15.2	2.8	754.8	15.1	2.7
China PR	320.0	6.6	1.1	350.0	7.1	1.3	350.0	7.0	1.3
East Block	4 819.1	100.0	16.8	4 954.5	100.0	18.7	4 992.8	100.0	18.1
World total	28 734.0	-	100.0	26 442.8	-	100.0	27 536.4	-	100.0

+) estimate

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt/M. 1977

Table 15

Alumina: Production by Groups of Countries in 1966, 1971, 1974, and 1976
(1000 t and %)

Country Grouping	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
EC Countries	1,836.3	12	2,244.7	10	3,193.0	11	3,238.0	12
Developed countries	9,198.6	62	14,225.2	62	18,322.6	64	18,183.7	66
Developing Countries	2,311.1	16	4,691.5	21	5,582.3	19	4,359.9	16
Western World	11,509.7	78	18,916.7	83	23,914.9	83	22,543.6	82
East Block	3,274.7	22	3,859.0	17	4,819.1	17	4,992.8	18
World total	14,784.4	100	22,775.7	100	28,734.0	100	27,536.4	100

Table 16

Alumina: Production by Region in 1966, 1971, 1974, and 1976
(1000 t and %)

Region	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
North America	6,210.0	42.0	7,077.5	31.1	7,668.5	26.7	6,405.0	23.3
Latin America	1,580.8	10.7	3,625.5	15.9	4,478.4	15.6	3,238.2	11.8
Africa	525.3	3.5	661.0	2.9	636.0	2.2	562.0	2.0
Europe without East Block	2,019.3	13.7	2,831.9	12.4	3,963.7	13.8	4,161.5	15.1
Asia without East Block	867.3	5.9	2,008.2	8.8	2,268.8	7.9	1,971.1	7.2
Australia & Oceania	307.0	2.1	2,712.6	11.9	4,899.5	17.0	6,205.8	22.5
Western World total	11,509.7	77.9	18,916.7	83.0	23,914.9	83.2	22,543.6	81.9
East Block total	3,274.7	22.1	3,859.0	17.0	4,819.1	16.8	4,992.8	18.1
World total	14,784.4	100.0	22,775.7	100.0	28,734.0	100.0	27,536.4	100.0

Fig. 8

Alumina : World Production by Groups of Countries between 1966 and 1976

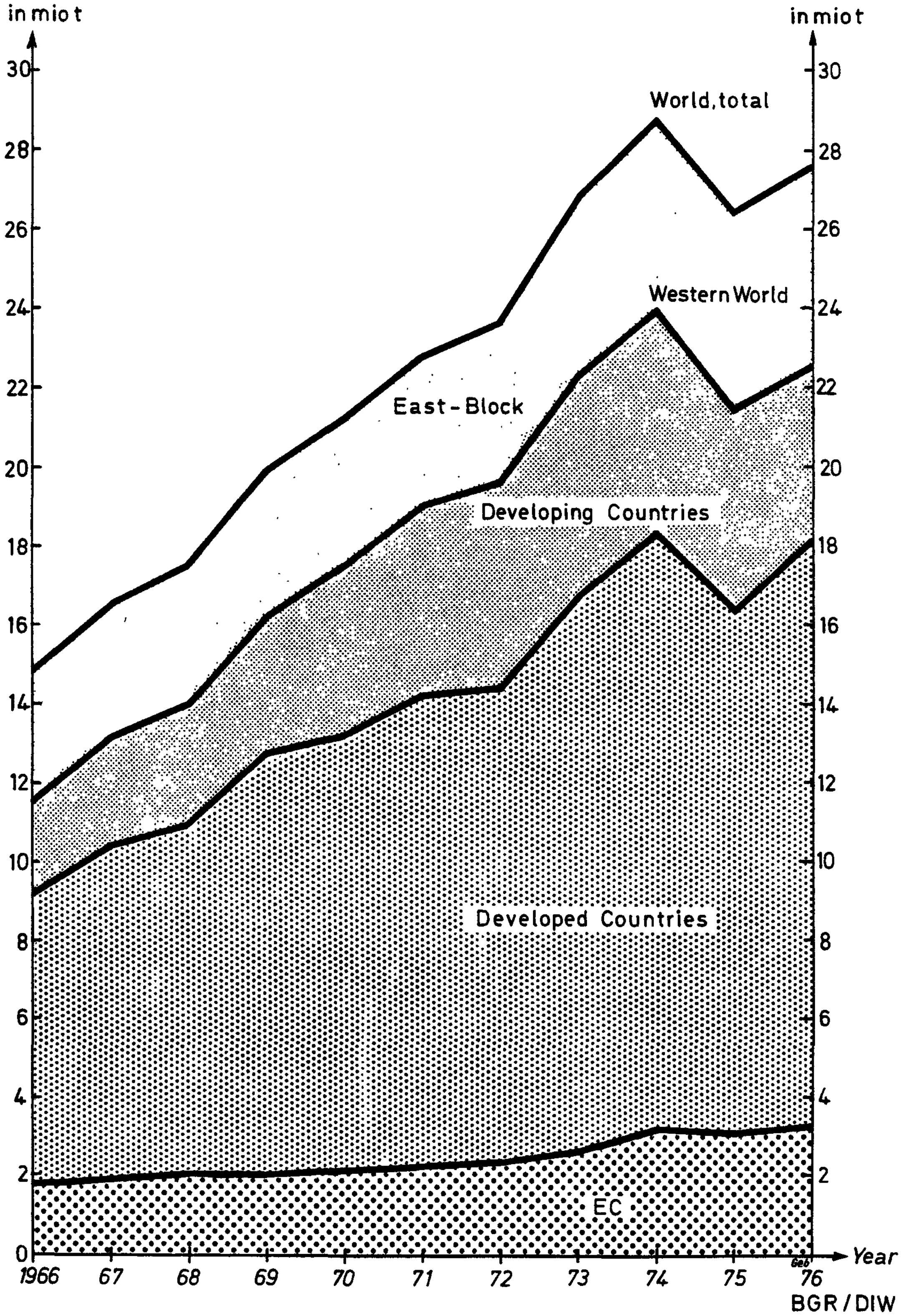
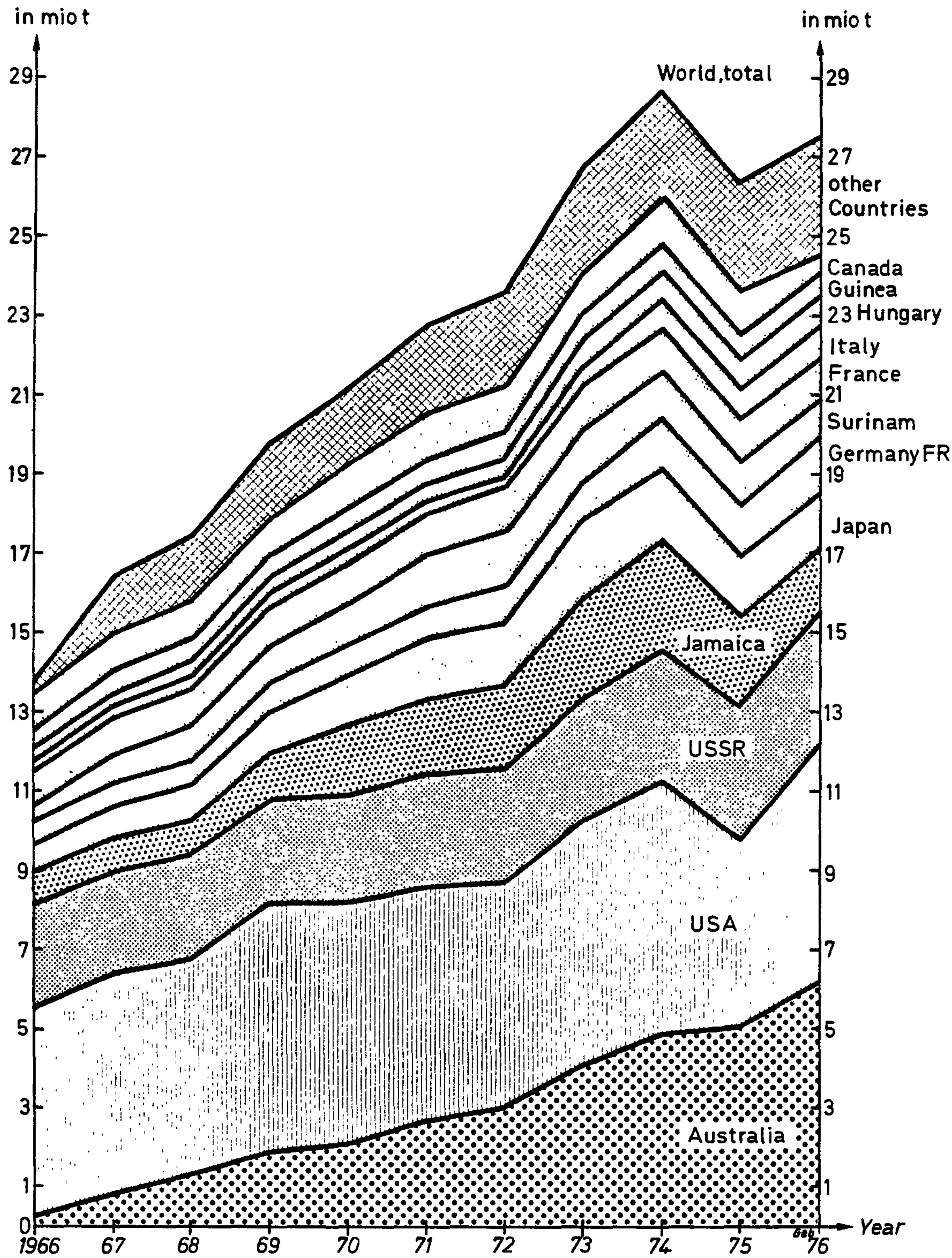


Fig.9

Alumina: Major Producing Countries between 1966 and 1976



The countries with an alumina production of more than a million tons in 1976 are contained in Table 17. In 1966 only two countries (USA and USSR) produced more than one million tons.

As can be seen in Tables 11 & 17, a number of the major bauxite producers also have a high alumina production. The trend since 1966 is for alumina production to be done in the bauxite producing countries. Australia is an especially good example of this, but the same can be said of Jamaica, Surinam, and Hungary. This trend, according to the plans known to us concerning the construction of alumina plants, will continue in the coming years.
Appendix 3 contains the regional distribution of alumina production by country.

9) World Primary and Secondary Aluminium Production

9.1 Production of Primary Aluminium

World primary aluminium production increased from 7.2 million t in 1966 by 5.9 million t or 82 % to 13.1 million t in 1976. That corresponds to an annual growth rate of 6.6 %. Cumulative production during this period was 118.3 million t. Average annual growth from 1966 to 1971 was clearly higher (8.8 %) than from 1971 to 1976 (3.6 %) as was the case for bauxite and alumina.

World primary aluminium production from 1966 to 1976 is shown in Table 18 by country. In 1976, the countries of the Western World produced ca. 10.2 million t (78.2 % of world production), the East Block ca. 2.9 million t (21.8 %). The proportion is little different from that for 1966.

Production in the individual countries and their percentage of world production is presented in Table 19 for 1974, 1975, and 1976. The following countries had greater than 5 % of world production: the USA (29.5 %), the USSR (16.8 %), Japan (7.0 %), and the Federal Republic of Germany (5.3 %). Canada and Norway had just under 5 % with 4.8 % each.

Tables 20 & 21 contain the breakdown of world primary aluminium production by country grouping and economic region, respectively. The western industrial countries produced ca. 70 % of the world primary aluminium production (1966: 74.5 %), the developing countries just under 8 % (1966: 3.1 %), the EC countries ca. 14 % (1966: 11 %). North America had about a third of the world primary aluminium production (34.3 %), a considerably smaller proportion than in 1966 (48.6 %). In contrast, the proportion produced in Europe (25.6 %) and Asia (10.5 %) increased significantly. The Federal Republic of Germany and Norway each accounted for a fifth of the European production. The amounts produced in Latin America, Africa, and Australia, with 2.5 % each, were of minor importance. Two-thirds of the Asian production came from Japan alone.

Table 17

Alumina: Production by Major Producing Countries in 1966, 1971, 1974, and 1976
(1000 t and %)

1966				1971				1974				1976			
Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative	Countries	1000 t	%	% cumulative
USA	5,310.0	35.9	35.9	USA	5,937.5	26.1	26.1	USA	6,403.8	22.3	22.3	Australia	6,205.8	22.5	22.5
USSR	2,600.0	17.6	53.5	USSR	2,750.0	12.1	38.2	Australia	4,899.5	17.0	39.3	USA	5,915.0	21.5	44.0
Canada	900.0	6.1	59.6	Australia	2,712.6	11.9	50.1	USSR	3,300.0	11.5	50.8	USSR	3,350.0	12.2	56.2
France	844.9	5.7	65.3	Jamaica	1,876.3	8.2	58.3	Jamaica	2,737.4	9.5	60.3	Jamaica	1,648.2	6.0	62.2
Jamaica	803.8	5.4	70.7	Japan	1,603.2	7.0	65.3	Japan	1,800.9	6.3	66.6	Japan	1,411.4	5.1	67.3
Japan	662.3	4.5	75.2	Surinam	1,277.0	5.6	70.9	Germany FR	1,302.0	4.5	71.1	Germany FR	1,331.2	4.8	72.1
Germany FR	602.9	4.1	79.3	Canada	1,140.0	5.0	75.9	Canada	1,264.7	4.4	75.5	Surinam	1,040.0	3.8	75.9
Guinea	525.3	3.6	82.9	France	1,046.1	4.6	80.5	Surinam	1,185.0	4.1	79.6	France	1,013.0	3.7	79.6
Surinam	407.0	2.7	85.6	Germany FR	836.9	3.7	84.2	France	1,107.5	3.9	83.5	Italy	797.8	2.9	82.5
Guyana	301.7	2.0	87.6	Guinea	661.0	2.9	87.1	Hungary	690.9	2.4	85.9	Hungary	754.8	2.7	85.2
Hungary	288.4	2.0	89.6	Hungary	466.6	2.1	89.2	Italy	688.8	2.4	88.3	Guinea	562.0	2.0	87.2
				Greece	463.8	2.0	91.2	Guinea	636.0	2.2	90.5	Canada	490.0	1.8	89.0
												Yugoslavia	461.9	1.7	90.7
Other Countries	1,538.1	10.4	100.0	Other Countries	2,004.7	8.8	100.0	Other Countries	2,717.5	9.5	100.0	Other Countries	2,555.3	9.3	100.0
World total	14,784.4	100,0		World total	22,775.7	100.0		World total	28,734.0	100.0		World total	27,536.4	100.0	

Table 18

World Production of Primary Aluminium
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Germany FR	243.9	252.9	257.4	262.7	309.3	427.5	444.4	532.7	688.9	677.6	697.1
France	363.5	361.2	365.7	371.1	381.1	383.6	393.7	358.9	393.3	382.6	385.1
Italy	127.8	127.8	142.3	144.6	146.7	136.4	149.5	184.2	212.3	190.1	206.5
Netherlands	19.5	32.1	47.2	69.3	75.0	116.4	162.6	181.4	247.4	257.6	248.9
United Kingdom	37.1	39.0	38.2	33.8	39.6	119.0	171.4	251.6	293.1	308.3	334.5
EG	791.8	813.0	850.8	881.5	951.7	1,182.9	1,321.6	1,508.8	1,835.0	1,816.2	1,872.1
Norway	330.3	361.0	468.3	502.5	522.3	530.2	557.4	618.1	648.2	594.9	620.9
Greece	36.2	71.5	76.5	83.2	87.5	116.0	131.3	143.3	146.5	135.2	134.0
Iceland	-	-	-	9.4	38.7	41.9	45.7	72.0	69.6	61.8	65.3
Yugoslavia	42.0	44.6	48.1	48.4	47.7	46.6	72.7	90.8	147.1	168.3	197.7
Austria	78.9	78.7	85.9	89.7	90.0	90.7	84.0	89.1	91.6	89.1	88.7
Sweden	28.7	33.4	56.8	66.8	66.2	75.5	77.6	82.8	82.2	78.0	81.4
Switzerland	68.7	72.3	75.9	77.1	91.1	94.0	82.9	85.4	87.2	79.0	78.2
Spain	63.7	78.2	89.3	106.4	119.9	125.8	144.9	160.4	189.6	210.4	209.0
Europe without East Block	1,440.3	1,552.7	1,751.6	1,865.0	2,015.1	2,303.6	2,518.1	2,850.7	3,297.0	3,232.9	3,347.3
USA	2,692.9	2,965.8	2,952.9	3,441.0	3,607.1	3,560.9	3,739.8	4,108.7	4,448.4	3,519.0	3,856.8
Canada	807.3	873.9	888.3	978.6	962.5	1,002.1	907.1	930.0	1,023.9	867.0	633.4
North America	3,500.2	3,839.7	3,841.2	4,419.6	4,569.6	4,563.0	4,646.9	5,038.7	5,472.3	4,386.0	4,490.2
Mexico	21.2	21.5	22.5	32.4	34.0	39.9	39.5	39.2	41.1	39.9	42.4
Brazil	26.9	29.7	41.5	42.9	56.1	80.6	97.4	111.7	113.6	121.4	139.2
Surinam	27.4	31.1 [1)]	43.6 [1)]	53.1 [1)]	54.9	54.2	49.5	51.5	57.0	42.0	44.8
Venezuela	-	2.4	10.3	13.2	22.4	22.4	23.0	25.1	41.5	49.7	46.5
Argentina	-	-	-	-	-	-	-	-	0.7	22.0	43.1
Latin America	75.5	84.7	117.9	141.6	167.4	197.1	209.4	227.5	253.9	275.0	316.0
Ghana	-	50.5	110.5	113.1	113.0	111.1	132.8	152.2	157.2	143.2	151.1
Cameroon	48.2	48.3	45.4	46.7	52.4	50.7	46.2	44.1	46.8	51.9	48.7
Rep. of South Africa	-	-	-	-	-	29.4	52.9	52.8	75.0	75.9	78.4
Egypt	-	-	-	-	-	-	-	-	-	2.0	59.0
Africa	48.2	98.8	155.9	159.8	165.4	191.2	231.9	249.1	279.0	273.0	337.2
Bahrain	-	-	-	-	-	10.2	62.7	102.6	118.0	116.3	122.1
India	83.6	96.4	120.1	132.5	161.1	178.3	179.1	154.3	129.1	167.1	211.8
Iran	-	-	-	-	-	-	6.5	33.7	49.0	45.8	30.6
Japan	335.1	379.3	478.4	565.0	727.9	887.1	1,009.1	1,096.8	1,118.4	1,013.3	919.4
Korea Soutn	-	-	-	6.6	16.8	17.6	15.2	16.6	17.7	17.6	17.6
Taiwan	17.3	15.4	20.0	22.1	27.0	26.5	32.1	35.1	31.3	28.1	25.7
Turkey	-	-	-	-	-	-	-	-	1.9	16.5	37.4
Asia without East Block	436.0	491.1	618.5	726.2	932.8	1,119.7	1,304.7	1,439.1	1,465.4	1,404.7	1,364.6
Australia	92.0	92.8	97.4	126.4	205.6	223.6	205.8	207.2	219.1	214.2	231.3
New Zealand	-	-	-	-	-	22.4	87.7	116.7	110.3	108.6	139.8
Australia and Oceania	92.0	92.8	97.4	126.4	205.6	246.0	293.5	323.9	329.4	322.8	371.1
Western World total	5,592.2	6,159.8	6,582.5	7,438.6	8,055.9	8,620.6	9,204.5	10,129.0	11,097.0	9,894.4	10,226.4
USSR[x)]	1,300.0	1,400.0	1,500.0	1,550.0	1,700.0	1,800.0	1,900.0	2,000.0	2,100.0	2,150.0	2,200.0
Germany DR[x)]	40.0	50.0	48.0	55.0	60.0	55.0	55.0	60.0	60.0	60.0	60.0
Poland	55.2	92.3	93.5	96.8	98.8	100.5	102.0	101.6	102.0	102.9	103.0
Romania	46.9	52.8	76.3	89.7	101.3	111.0	121.6	141.2	187.0	204.2	207.0
Czechoslovakia	23.9	26.4	31.6	34.7	40.0	36.9	42.7	47.6	49.8	43.3	36.0
Hungary	60.5	61.8	63.1	64.5	66.0	67.0	68.2	67.9	69.0	70.2	70.5
China PR[x)]	90.0	90.0	120.0	130.0	135.0	145.0	155.0	160.0	160.0	180.0	180.0
East Block total	1,616.5	1,773.3	1,932.5	2,020.7	2,201.1	2,315.4	2,444.5	2,578.3	2,727.8	2,810.6	2,856.5
World total	7,208.7	7,933.1	8,515.0	9,459.3	10,257.0	10,936.0	11,649.0	12,707.3	13,824.8	12,705.0	13,082.9

x) estimate   1) Exports

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

Table 19

Primary Aluminium: World Production by Country in 1974-1976

in 1000 t and %

Country	1974			1975			1976		
	1000 t	% west. World	% World total	1000 t	% west. World	% World total	1000 t	% west. World	% World total
Germany FR	688.9	6.2	5.0	677.6	6.9	5.3	697.1	6.8	5.3
France	393.3	3.6	2.8	382.6	3.9	3.0	385.1	3.8	2.9
Italy	212.3	1.9	1.5	190.1	1.9	1.5	206.5	2.0	1.6
Netherlands	247.4	2.2	1.8	257.6	2.6	2.0	248.9	2.4	1.9
Great Britain	293.1	2.6	2.1	308.3	3.1	2.5	334.5	3.3	2.6
EC Countries	1 835.0	16.5	13.2	1 816.2	18.4	14.3	1 872.1	18.3	14.3
Norway	648.2	5.8	4.7	594.9	6.0	4.7	620.9	6.1	4.8
Greece	146.5	1.3	1.1	135.2	1.4	1.1	134.0	1.3	1.0
Island	69.6	0.6	0.5	61.8	0.6	0.5	65.3	0.6	0.5
Jugoslavia	147.1	1.3	1.1	168.3	1.7	1.3	197.7	1.9	1.5
Austria	91.6	0.8	0.7	89.1	0.9	0.7	88.7	0.9	0.7
Sweden	82.2	0.7	0.6	78.0	0.8	0.6	81.4	0.8	0.6
Switzerland	87.2	0.8	0.6	79.0	0.8	0.6	78.2	0.8	0.6
Spain	189.6	1.7	1.4	210.4	2.1	1.6	209.0	2.0	1.6
Europe without East Block	3 297.0	29.7	23.9	3 232.9	32.7	25.4	3 347.3	32.7	25.6
USA	4 448.4	40.1	32.2	3 519.0	35.6	27.7	3 856.8	37.7	29.5
Canada	1 023.9	9.2	7.4	867.0	8.8	6.8	633.4	6.2	4.8
North America	5 472.3	49.3	39.6	4 386.0	44.4	34.5	4 490.2	43.9	34.3
Mexico	41.1	0.4	0.3	39.9	0.4	0.3	42.4	0.4	0.3
Brazil	113.6	1.0	0.8	121.4	1.2	1.0	139.2	1.4	1.1
Surinam	57.0	0.5	0.4	42.0	0.4	0.3	44.8	0.4	0.3
Venezuela	41.5	0.4	0.3	49.7	0.5	0.4	46.5	0.5	0.4
Argentina	0.7	<0.1	<0.1	22.0	0.2	0.2	43.1	0.4	0.3
Latin America	253.9	2.3	1.8	275.0	2.7	2.2	316.0	3.1	2.4
Ghana	157.2	1.4	1.1	143.2	1.4	1.2	151.1	1.5	1.2
Cameroon	46.8	0.4	0.3	51.9	0.5	0.4	48.7	0.5	0.4
South Africa	75.0	0.7	0.6	75.9	0.8	0.6	78.4	0.7	0.6
Egypt	-	-	-	2.0	<0.1	<0.1	59.0	0.6	0.4
Africa	279.0	2.5	2.0	273.0	2.7	2.2	337.2	3.3	2.6
Bahrain	118.0	1.1	0.9	116.3	1.1	0.9	122.1	1.2	0.9
India	129.1	1.2	0.9	167.1	1.7	1.3	211.8	2.1	1.6
Iran	49.0	0.4	0.4	45.8	0.5	0.4	30.6	0.3	0.3
Japan	1 118.4	10.1	8.1	1 013.3	10.2	8.0	919.4	9.0	7.0
South Korea	17.7	0.1	0.1	17.6	0.2	0.1	17.6	0.2	0.1
Taiwan	31.3	0.3	0.2	28.1	0.3	0.2	25.7	0.2	0.2
Turkey	1.9	<0.1	<0.1	16.5	0.2	0.1	37.4	0.4	0.3
Asia without East Block	1 465.4	13.2	10.6	1 404.7	14.2	11.0	1 364.6	13.4	10.4
Australien	219.1	2.0	1.6	214.2	2.2	1.7	231.3	2.2	1.8
New Zealand	110.3	1.0	0.8	108.6	1.1	0.9	139.8	1.4	1.1
Australia & Oceania	329.4	3.0	2.4	322.8	3.3	2.6	371.1	3.6	2.9
West. World total	11 097.0	100.0	80.3	9 894.4	100.0	77.9	10 226.4	100.0	78.2
		% East Block			% East Block			% East Block	
USSR +)	2 100.0	77.0	15.2	2 150.0	76.5	16.9	2 200.0	77.0	16.8
Germany DR +)	60.0	2.2	0.4	60.0	2.1	0.5	60.0	2.1	0.4
Poland	102.0	3.7	0.7	102.9	3.7	0.8	103.0	3.6	0.8
Rumania	187.0	6.9	1.4	204.2	7.3	1.6	207.0	7.2	1.6
Czechoslovakia	49.8	1.8	0.3	43.3	1.5	0.3	36.0	1.3	0.3
Hungary	69.0	2.5	0.5	70.2	2.5	0.6	70.5	2.5	0.5
China, PR +)	160.0	5.9	1.2	180.0	6.4	1.4	180.0	6.3	1.4
East Block total	2 727.8	100.0	19.7	2 810.6	100.0	22.1	2 856.5	100.0	21.8
World total	13 824.8	-	100.0	12 705.0	-	100.0	13 082.9	-	100.0

+) estimate

Source: Metallstatistik, 1965 - 1975, 64. Jahrgang, Frankfurt/M. 1977

Table 20

Primary Aluminium: Production by Groups of Countries in 1966, 1971, 1974, and 1976
(1000 t and %)

Group of Countries	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
EC Countries	791.8	11.0	1,182.9	10.8	1,835.0	13.3	1,872.1	14.3
Developed Countries	5,367.6	74.5	8,029.1	73.4	10,292.1	74.5	9,206.4	70.4
Developing Countries	224.6	3.1	591.5	5.4	804.9	5.8	1,020.0	7.8
Western World	5,592.2	77.6	8,620.6	78.8	11,097.0	80.3	10,226.4	78.2
East Block	1,616.5	22.4	2,315.4	21.2	2,727.8	19.7	2,856.5	21.8
World total	7,208.7	100.0	10,936.0	100.0	13,824.8	100.0	13,082.9	100.0

Table 21

Primary Aluminium: Production by Region in 1966, 1971, 1974, and 1976
(1000 t and %)

Region	1966		1971		1974		1976	
	1000 t	%	1000 t	%	1000 t	%	1000 t	%
North America	3,500.2	48.6	4,563.0	41.7	5,472.3	39.6	4,490.2	34.3
Latin America	75.5	1.0	197.1	1.8	253.9	1.8	316.0	2.4
Africa	48.2	0.7	191.2	1.8	279.0	2.0	337.2	2.6
Europe without East Block	1,440.3	20.0	2,303.6	21.1	3,297.0	23.9	3,347.3	25.6
Asia without East Block	436.0	6.0	1,119.7	10.2	1,465.4	10.6	1,364.6	10.4
Australia & Oceania	92.0	1.3	246.0	2.2	329.4	2.4	371.1	2.9
Western World	5,592.2	77.6	8,620.6	78.8	11,097.0	80.3	10,226.4	78.2
East Block	1,616.5	22.4	2,315.4	21.2	2,727.8	19.7	2,856.5	21.8
World total	7,208.7	100.0	10,936.0	100.0	13,824.8	100.0	13,082.9	100.0

Primary aluminium production is shown in Figs. 10 & 11 according to country grouping and major producing country, respectively.

Those countries with a primary aluminium production of more than 600,000 t in 1976 are listed in Table 22. In 1966, only three countries produced above this level. The major bauxite producing countries in Latin America, Asia, and Africa as well as Australia have only a limited primary aluminium producing capacity. Guinea, the second largest bauxite producer, Jamaica, and Guyana produce no primary aluminium yet. In contrast, the western industrial countries, which, except for the USA & France, have little or no bauxite, produced most of the primary aluminium in the world (ca. two-thirds). These countries are completely, or almost completely, dependent on the import of aluminium-bearing raw materials for their smelters.

A summary of the bauxite, alumina, and primary aluminium production is presented in Table 23 for 1966, 1971, 1974, and 1976.

Appendix 4 shows the geographical distribution of the aluminium oxide and primary aluminium plants and contains data on the capacity of the plants and their owners. Appendix 4a contains data on bauxite production capacities and alumina and primary aluminium production capacities in 1976 by country.

Appendix 5 shows the geographical distribution of primary and secondary production in 1976 by country.

9.2. Production of Secondary Aluminium

Production of secondary aluminium is increasing in numerous countries in addition to primary aluminium production. This secondary aluminium production is based on the utilization of aluminium scrap. Secondary aluminium plants are usually separate from primary aluminium plants. These plants process new scrap, such as occurs by the production and processing of ingots, semi-manufactures, and castings, as well as old scrap salvaged from aluminium-containing junk.

Statistics on secondary aluminium production in 26 western countries and groups of smaller consumer countries are continually kept up to date and published in Metallstatistik by the Metallgesellschaft AG. The statistics for 1966 - 1976 are contained in Table 24. Only the total consumption of secondary aluminium is quoted for the East Block countries as well as the direct use of new scrap. These figures can be used, with no significant error, as the equivalent of secondary aluminium production. With this restriction, world secondary aluminium production increased from 2.04 million t in 1966 to 3.9 million t in 1976, an average annual increase of 6.7 %.

Fig.10

Primary Aluminium: World Production by Groups of Countries between 1966 and 1976

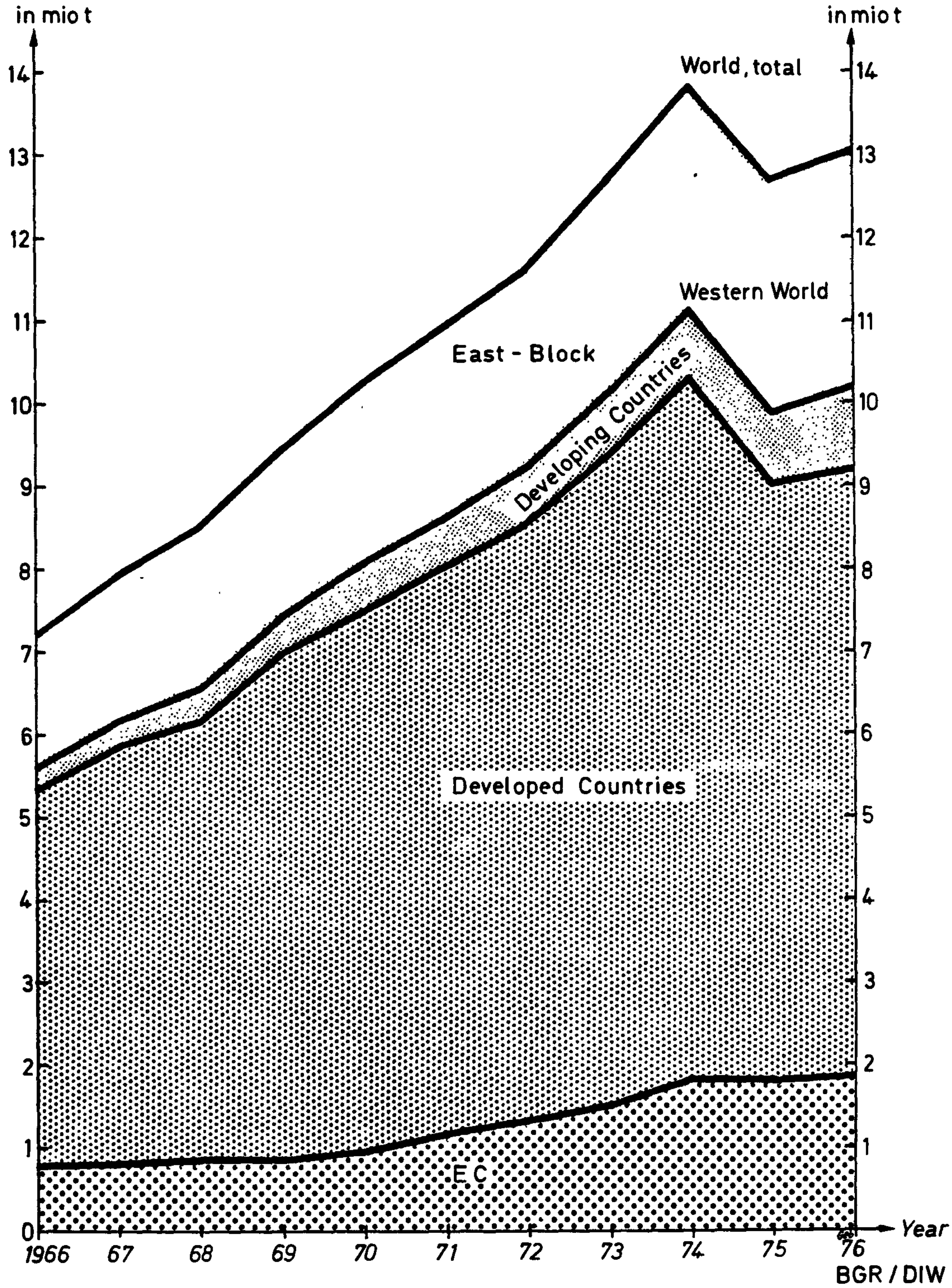


Fig.11

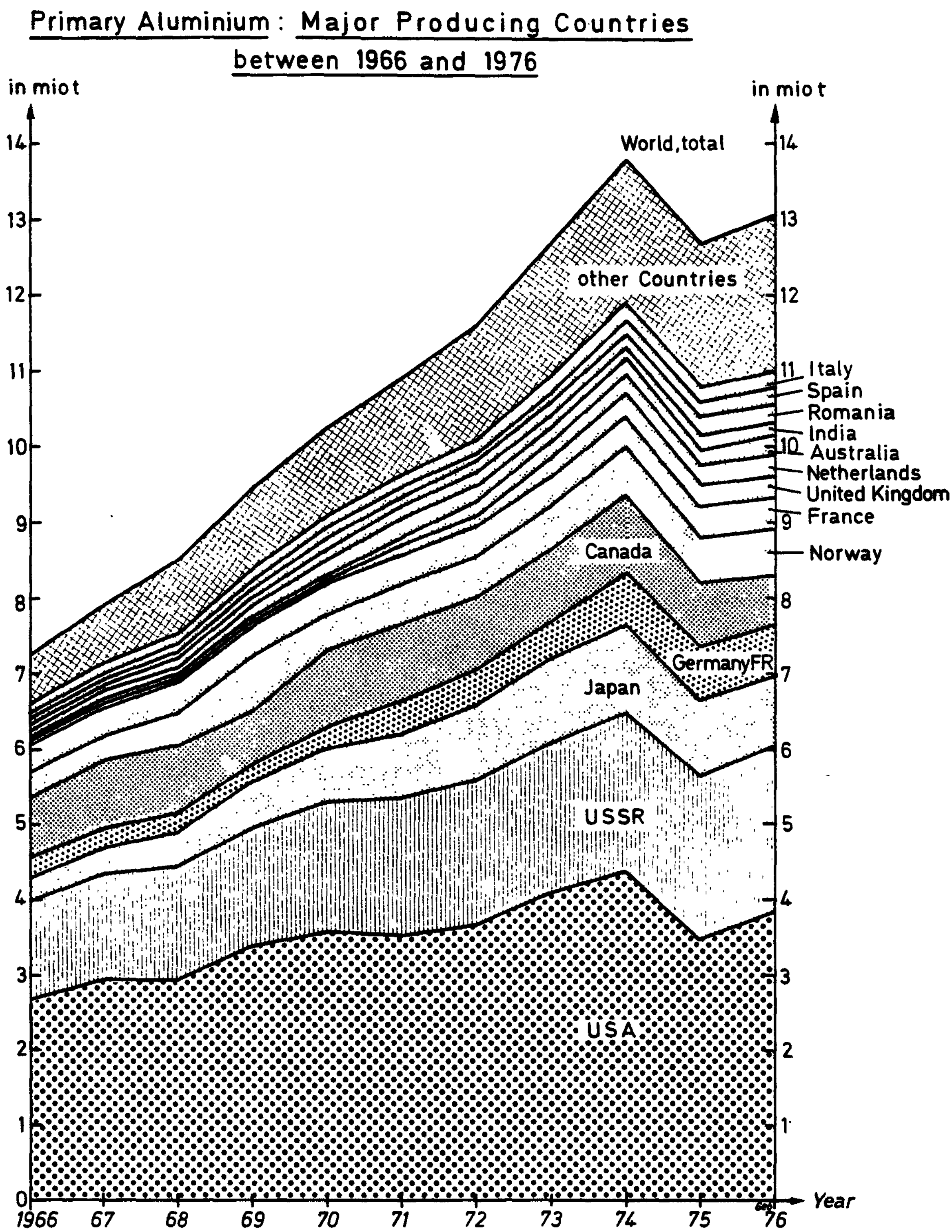

Primary Aluminium : Major Producing Countries between 1966 and 1976
in mio t
in mio t
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
World, total
other Countries
Italy
Spain
Romania
India
Australia
Netherlands
United Kingdom
France
Norway
Canada
Germany FR
Japan
USSR
USA
1966
67
68
69
70
71
72
73
74
75
76
Year

Table 22

Primary Aluminium: Production by Major Producing Countries in 1966, 1971, 1974, and 1976
(1000 t and %)

1966

Countries	1000 t	%	% cumulative
USA	2,692.9	37.4	37.4
USSR	1,300.0	18.0	55.4
Canada	807.3	11.2	66.6
France	363.5	5.0	71.6
Japan	335.1	4.6	76.2
Norway	330.3	4.6	80.8
Germany FR	243.9	3.4	84.2
Italy	127.8	1.8	86.0
Australia	92.0	1.3	87.3
China PR	90.0	1.2	88.5
Other Countries	825.9	11.5	100.0
World total	7,208.7	100.0	

1971

Countries	1000 t	%	% cumulative
USA	3,560.9	32.6	32.6
USSR	1,800.0	16.5	49.1
Canada	1,002.1	9.2	58.3
Japan	887.1	8.1	66.4
Norwegen	530.2	4.8	71.2
Germany FR	427.5	3.9	75.1
France	383.6	3.5	78.6
Australia	223.6	2.0	80.6
India	178.3	1.6	82.2
China PR	145.0	1.3	83.5
Other Countries	1,797.7	16.5	100.0
World total	10,936.0	100.0	

1974

Countries	1000 t	%	% cumulative
USA	4,448.4	32.2	32.2
USSR	2,100.0	15.2	47.4
Japan	1,118.4	8.1	55.5
Canada	1,023.9	7.4	62.9
Germany FR	688.9	5.0	67.9
Norway	648.2	4.7	72.6
France	393.3	2.8	75.4
United Kingdom	293.1	2.1	77.5
Netherlands	247.4	1.8	79.3
Australia	219.1	1.6	80.9
Other Countries	2,644.1	19.1	100.0
World total	13,824.8	100.0	

1976

Countries	1000 t	%	% cumulative
USA	3,856.8	29.5	29.5
USSR	2,200.0	16.8	46.3
Japan	919.4	7.0	53.3
Germany FR	697.1	5.3	58.6
Canada	633.4	4.8	63.4
Norway	620.9	4.8	68.2
France	382.6	2.9	71.1
United Kingdom	334.5	2.6	73.7
Netherlands	248.9	1.9	75.6
Australia	231.3	1.8	77.4
Other Countries	2,958.0	22.6	100.0
World total	13,082.9	100.0	

Table 23

Bauxite, Alumina, Primary Aluminium:
Production by Region in 1966, 1971, 1974,and 1976
in %

Region		1966	1971	1974	1976
North America	Bauxite	4.5	3.0	2.4	2.5
	Alumina	42.0	31.1	26.7	23.3
	Prim. Alum.	48.6	41.7	39.6	34.3
Latin America	Bauxite	47.3	38.7	34.0	25.1
	Alumina	10.7	15.9	15.6	11.8
	Prim. Alum.	1.0	1.8	1.8	2.4
Africa	Bauxite	5.4	5.3	10.3	15.2
	Alumina	3.5	2.9	2.2	2.0
	Prim. Alum.	0.7	1.7	2.0	2.6
Europe without East Block	Bauxite	15.8	12.3	9.7	8.9
	Alumina	13.7	12.4	13.8	15.1
	Prim. Alum.	20.0	21.1	23.9	25.6
Asia without East Block	Bauxite	5.9	5.8	4.7	4.3
	Alumina	5.9	8.8	7.9	7.2
	Prim. Alum.	6.0	10.2	10.6	10.5
Australia/Oceania	Bauxite	4.5	19.1	23.8	29.9
	Alumina	2.1	11.9	17.0	22.5
	Prim. Alum.	1.3	2.3	2.4	2.8
Western World total	Bauxite	83.4	84.2	84.9	85.9
	Alumina	77.9	83.0	83.2	81.9
	Prim. Alum.	77.6	78.8	80.3	78.2
East Block total	Bauxite	16.6	15.8	15.1	14.1
	Alumina	22.1	17.0	16.8	18.1
	Prim. Alum.	22.4	21.2	19.7	21.8
World total	Bauxite	100.0	100.0	100.0	100.0
	Alumina	100.0	100.0	100.0	100.0
	Prim. Alum.	100.0	100.0	100.0	100.0

Table 24

World Production of Secondary Aluminium; 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium/Luxembourg	2.5	1.5[x]	2.2	2.7	2.0	2.2	2.9	7.1	5.9	2.7	2.6
Germany FR[1]	196.7	185.5	231.9	271.3	258.5	275.7	294.0	328.4	324.1	285.5	344.6
Denmark	7.8	7.1	7.5[x]	7.5[x]	7.3	7.5	9.3	9.1	9.6	8.5	9.0[x]
France	59.6	62.7	73.6	88.3	87.4	97.8	111.9	123.5	127.5	107.1	137.0
United Kingdom	183.6	178.6	188.0	209.5	201.4	181.6	184.8	189.3	188.9	176.2	205.8
Italy	85.0	102.0	102.0	128.0	154.0	150.0	164.0	192.0	209.0	151.0	198.0
Netherlands	1.5	2.0	2.2	5.5	7.0	8.3	3.4	23.6	31.3	34.3	38.5
EC Countries	536.7	539.4	607.4	712.8	717.6	723.1	770.3	873.0	896.3	765.3	935.5
Norway	3.1	3.4	3.4	4.1	4.2	4.0	6.1	7.4	7.8	6.9	6.0
Finland	2.8	3.3	3.4	3.5	3.5	4.3	5.0	4.9	5.3	4.5	6.1
Yugoslavia								0.2	1.5	2.0	15.3
Austria	4.8	5.4	5.6	6.6	7.2	7.1	6.3	8.6	7.2	6.2	8.5
Sweden	11.0	13.0	16.8	19.0	20.0	20.0	22.0	24.0	24.7	23.0	24.0
Switzerland	13.5	13.0	14.5	16.8	15.0	13.5	13.9	16.6	17.2	15.6	18.6
Spain	14.0	14.3	19.0	25.0	27.0	29.0	32.0	37.0	46.0	34.5	40.0
Europe without East Block	585.9	591.8	670.1	787.8	794.5	801.0	855.6	971.7	1,006.0	858.0	1,054.0
Iran	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.4	15.4	16.0[x]
Japan	140.5	181.2	226.6	281.1	322.1	349.2	411.9	536.9	517.3	424.0	525.9
Taiwan	1.7	3.9	2.6	1.3	3.1	3.2	4.0	13.2	8.2	5.9	10.0[x]
other Asia[x]	15.0	16.0	18.0	18.0	18.0	20.0	20.0	20.0	22.0	20.0	23.0
Asia without East Block	158.2	202.1	248.2	301.4	344.2	373.4	436.9	571.1	553.9	465.3	574.9
South Africa	4.0[x]	4.0[x]	4.0[x]	4.0[x]	4.0[x]	5.0[x]	5.0[x]	5.0	5.5	5.5	6.0[x]
other Africa[x]	2.5	2.5	3.0	3.0	3.0	3.0	3.5	3.5	4.0	4.5	5.0
Africa	6.5	6.5	7.0[x]	7.0[x]	7.0	8.0	8.5	8.5	9.5	10.0	11.0
United States[2]	832.8	821.5	935.3	1,066.8	937.1	1,003.8	1,021.5	1,120.4	1,163.0	1,124.0	1,311.8
Argentina	8.4	7.1	9.4	12.1	11.6	13.6	18.2	16.9	19.4	16.4	9.5
Brazil	4.1	3.7	4.4	6.5	6.0	7.5	13.0	18.5	22.4	20.6	28.0
Canada	27.7	31.2	32.0	32.3	31.8	33.7	31.8	36.3	29.9	26.3	33.6
Mexico	4.1	6.0	5.4	6.5	7.0	5.8	7.8	9.3	10.1	9.3	10.0[x]
Venezuela	-	-	-	-	-	-	-	-	1.3	0.6	1.8
other America[x]	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5
America	878.1	870.5	987.5	1,125.2	995.5	1,066.4	1,094.3	1,203.4	1,248.6	1,199.7	1,397.2
Australia	12.7	13.6	16.4	18.1	18.6	20.4	19.8	28.7	36.3	24.6	28.0[x]
New Zealand	0.1	0.8	1.0	1.2	1.3	1.5	1.7	1.9	2.1	1.2	2.0[x]
Australia and Oceania	12.8	14.4	17.4	19.3	19.9	21.9	21.5	30.6	38.4	25.8	30.0[x]
Western World total	1,641.5	1,685.3	1,930.2	2,240.7	2,161.1	2,270.7	2,416.8	2,785.3	2,856.4	2,558.8	3,067.1
East Block total	401.1	478.4	517.4	440.2	453.8	591.7	598.5	602.7	968.2	814.0	834.0
World total	2,042.6	2,163.7	2,447.6	2,680.9	2,614.9	2,862.4	3,015.3	3,388.0	3,824.6	3,372.8	3,901.1

x) estimate

1) including production in West Berlin;

2) from domestic and foreign scrap, including the direct use of scrap from metal foundries.

Source: Metallstatistik, 64. Jahrgang, Frankfurt am Main 1977

Secondary aluminium production in the Western World increased from 1.64 million t to 3.07 million t. The annual increase (6.5 %) was less than in the East Block (7.6 %). As can be seen in Table 25, the regional structure of secondary aluminium production changed from 1966 to 1976. The percentage for the Western World dropped from 80.4 % to 78.6 %, due to the comparatively low production growth rate in the USA, the largest producer. Within the Western World, the Americas remained the largest producer even with a drop in its percentage of world production from 43 % to 36 %. The percentage for Western Europe also dropped slightly from almost 29 % to 27 %, the EC countries from 26.3 % to 24 %. In contrast, the percentage for Asia (without the East Block) rose from just under 8 % in 1966 to almost 15 % in 1976, due to the increases in production in Japan, the largest producer.

In 1976, the USA and Japan, with 33.6 % and 13.5 %, respectively, were the largest secondary aluminium producers in the Western World, followed by the Federal Republic of Germany (8.8 %), Great Britain (5.3 %), and Italy (5.1 %).

It may be assumed that the percentage for the USSR is about 15 %.

The ratio of secondary aluminium production to total aluminium production (primary + secondary aluminium) varied from country to country. This was due to different amounts of scrap available and the size of the demand from domestic foundaries. Table 26 contains the ratios of secondary aluminium production to total aluminium production in selected countries and regions for 1966 - 1976. As can be seen in the table, 20 - 40 % of the total aluminium production is secondary aluminium in the large western industrial countries that also produce primary aluminium. In the Western European producer countries, the proportion of secondary aluminium has decreased due to expanded primary aluminium production. In the EC countries, one-third of the total aluminium production is secondary aluminium; before 1970 the ratio was over 40 %.

As already mentioned, new scrap occurs by the production and processing of ingots, semimanufactures, and castings, while old scrap is recovered from metal that has been used by consumers. Within the EC countries, more than 50 % of new scrap consists of pieces and more than 20 % each of turnings and dross. This division varies from country to country and from year to year.

The relationship of the production of primary aluminium, semi-manufactures, and castings to the recovery of new scrap and of aluminium consumption to the recovery of old scrap is shown in Table 27 for the Federal Republic of Germany, France, Great Britain, Italy and the USA. It is remarkable that the proportion of new scrap to aluminium production and processing in these countries remained almost unchanged during this period (1966 - 1976). Differences between the countries also remained the same. The high proportion for the recovery of new scrap in the production and processing of aluminium in Great Britain relative to the other countries is striking.

Table 25

Average Annual Growth in the Production of Secondary Aluminium from 1966 to 1976 and Share of World Production of Selected Countries and Regions in 1966 and 1976
(in %)

	average growth rate p.a. 1966/76	% 1966	% 1976
Germany FR	5.8	9.6	8.8
France	8.7	2.9	3.5
United Kingdom	1.1	9.0	5.3
Italy	8.8	4.2	5.1
Other EC Countries	15.6	0.6	1.3
EC Countries	5.7	26.3	24.0
Other Western Europe	9.2	2.4	3.0
Europe without East Block	6.0	28.7	27.0
Japan	14.1	6.9	13.5
Other Asia	10.7	0.9	1.2
Asia without East Block	13.8	7.8	14.7
Africa	5.4	0.3	0.3
Brazil	21.2	0.2	0.7
Canada	1.9	1.4	0.9
USA	4.6	40.8	33.6
Other America	5.8	0.6	0.6
America	4.8	43.0	35.8
Australia/Oceania	8.9	0.6	0.8
Western World	6.5	80.4	78.6
East Block	7.6	19.6	21.4
World total	6.7	100.0	100.0

Table 26

Percent Secondary Aluminium in the Total Aluminium Production

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium/Luxembourg	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Germany FR	44.6	42.3	47.4	50.8	45.5	39.2	39.8	38.1	32.0	29.6	33.1
Denmark	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
France	14.1	14.8	16.8	19.2	18.7	20.6	22.1	25.6	24.5	21.9	26.2
United Kingdom	83.2	82.1	83.1	86.1	83.6	60.4	51.9	42.9	39.2	36.4	38.1
Italy	39.9	44.4	41.8	47.1	51.2	52.3	52.3	51.0	49.6	44.3	48.9
Netherlands	7.2	5.9	4.5	7.4	8.5	6.7	2.0	11.5	11.2	11.8	13.4
EC Countries	40.4	39.9	41.7	44.7	43.0	37.9	36.8	36.7	32.8	29.6	33.3
Finland	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Norway	0.9	0.9	0.7	0.8	0.8	0.7	1.1	1.2	1.2	1.1	1.0
Austria	5.7	6.4	6.1	6.9	7.4	7.3	7.0	8.8	7.3	6.5	8.7
Sweden	37.0	28.0	22.8	22.1	23.2	21.4	22.1	22.5	23.1	22.8	22.8
Switzerland	16.4	15.2	16.0	17.9	14.1	12.6	14.4	16.3	16.5	16.5	19.2
Spain	17.8	15.4	17.6	18.9	18.5	18.5	18.1	18.7	19.5	14.1	16.1
other Europe	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	99.6	99.5	96.9
Europe without East Block	28.9	27.6	27.7	29.7	28.3	25.8	25.4	25.4	23.4	21.0	23.9
Japan	29.4	32.2	32.0	33.1	30.5	28.1	29.0	32.9	31.6	25.9	36.4
other Asia	14.9	15.7	13.3	11.2	9.7	9.4	7.8	9.1	9.5	9.5	9.9
Asia without East Block	26.6	29.2	28.6	29.3	27.0	25.0	25.1	28.4	27.4	24.9	29.6
Africa	11.9	6.2	4.3	4.2	4.1	4.0	3.5	3.3	3.3	3.5	3.2
Brasil	13.2	11.1	9.6	13.2	9.7	8.5	11.8	14.2	16.5	14.5	16.7
Canada	3.3	3.4	3.5	3.2	3.2	3.2	3.4	3.8	2.8	2.9	5.0
United States	23.6	21.7	24.1	22.3	20.6	22.0	21.4	21.4	20.7	24.2	25.4
other America	21.7	20.4	17.1	16.6	15.6	15.5	20.0	19.6	19.2	15.8	11.9
America	19.7	18.2	20.0	19.8	17.4	18.3	18.4	18.6	17.9	20.5	22.5
Australia/Oceania	12.2	13.4	15.2	13.2	8.8	8.2	6.8	8.6	10.4	7.4	7.5
Western World	22.7	21.5	22.7	23.1	21.2	20.8	20.8	21.6	20.5	20.5	23.1
East Block	19.9	21.2	21.1	17.9	17.1	20.4	19.7	18.9	26.2	22.5	22.6
World total	22.1	21.4	22.3	22.1	20.3	20.7	20.6	21.0	21.7	21.0	23.0

Table 27

Relationships between the Recovery of New & Old Aluminium Scrap and Primary Aluminium Production or Consumption in the Major Consumer Countries

in 1000 t

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Germany FR	primary production	234.4	243.9	252.9	257.4	262.7	309.3	427.5	444.4	532.7	688.9	677.6	697.1
	prod. of semifabricates and castings	504.9	540.6	530.8	663.9	793.3	795.9	834.2	872.8	1,024.7	1,046.0	876.4	1,152.5
	sum	739.3	784.5	783.7	921.3	1,056.0	1,105.2	1,261.7	1,317.2	1,557.4	1,734.9	1,554.0	1,849.6
	recovery of new scrap	120.5	137.6	127.6	140.3	180.5	194.0	200.4	239.7	286.4	281.5	260.0	311.8
	ratio of new scrap to production [1)]	16.3	17.5	16.3	15.2	17.1	17.6	15.9	18.2	18.4	16.2	16.7	16.9
	consumption of aluminium	528.7	561.7	543.6	691.2	824.8	829.9	859.5	923.0	1,062.9	1,081.8	910.3	1,172.6
	recovery of old scrap	51.1	56.1	58.0	62.7	77.1	77.7	82.6	88.5	98.4	100.6	82.7	113.4
	ratio of old scrap to consumption [1)]	9.7	10.0	10.7	9.1	9.3	9.4	9.6	9.6	9.3	9.3	9.1	9.7
France	primary production	340.5	363.5	361.2	365.7	371.7	381.1	375.1	393.7	358.9	393.3	382.6	385.1
	prod. of semifabricates and castings	269.3	322.2	330.9	340.2	409.4	434.0	457.4	509.8	553.9	555.0	498.8	595.6
	sum	609.8	685.7	692.1	705.9	781.1	815.1	832.5	903.5	912.8	948.3	881.4	980.7
	recovery of new scrap	62.1	68.3	67.1	76.9	88.0	93.2	98.2	126.0	125.2	130.4	123.1	152.7
	ratio of new scrap to production [1)]	10.2	10.0	9.7	10.9	11.3	11.4	11.8	13.9	13.7	13.8	14.0	15.6
	consumption of aluminium	307.2	362.9	372.9	379.8	458.4	481.6	504.4	557.4	610.2	629.9	544.5	665.2
	recovery of old scrap	28.3	33.4	37.3	43.5	42.0	34.6	41.8	39.6	43.5	45.9	34.7	54.1
	ratio of old scrap to consumption [1)]	9.2	9.2	10.0	11.5	9.2	7.2	8.3	7.1	7.1	7.3	6.4	8.1
United Kingdom	primary production	36.2	37.1	39.0	38.2	33.8	39.6	119.6	171.4	251.6	293.1	308.3	334.5
	prod. of semifabricates and castings	428.8	436.5	435.8	467.6	487.9	466.8	423.6	463.6	539.8	557.5	476.8	529.9
	sum	465.0	473.6	474.8	505.8	521.7	506.4	543.2	635.0	791.4	850.6	785.1	864.4
	recovery of new scrap	133.8	138.3	131.7	142.6	163.7	164.8	168.1	173.4	167.6	170.3	159.9	177.9
	ratio of new scrap to production [1)]	28.8	29.2	27.7	28.2	31.4	32.5	30.9	27.3	21.2	20.0	20.4	20.6
	consumption of aluminium	450.2	453.6	444.2	483.3	504.9	491.6	449.1	488.4	575.1	614.0	498.4	607.4
	recovery of old scrap	73.2	73.9	76.5	88.6	85.0	65.9	68.1	69.8	67.0	67.5	60.4	61.4
	ratio of old scrap to consumption [1)]	16.3	16.3	17.2	18.3	16.8	13.4	15.2	14.3	11.7	11.0	12.1	10.1
Italy	primary production	124.1	127.8	127.7	142.2	143.6	146.8	136.7	149.5	184.2	212.3	190.1	206.5
	prod. of semifabricates and castings	187.0	242.0	268.0	313.0	372.5	407.5	389.5	442.0	512.5	556.5	425.0	568.0
	sum	311.1	369.8	395.7	455.2	516.1	554.3	526.2	591.5	696.7	769.8	615.1	774.5
	recovery of new scrap	43.0	55.5	61.8	71.1	84.0	92.4	85.7	97.2	105.5	120.6	93.1	113.6
	ratio of old scrap to production [1)]	13.8	15.0	15.6	15.2	16.3	16.7	16.3	16.4	15.1	15.7	15.1	14.7
	consumption of aluminium	195.0	252.0	281.0	323.0	382.0	420.0	402.0	458.0	511.0	556.0	441.6	587.7
	recovery of old scrap	16.4	22.3	26.0	30.0	37.5	43.7	39.3	52.2	58.5	64.9	43.3	58.8
	ratio of old scrap to consumption [1)]	8.4	8.8	9.3	9.3	9.8	10.4	9.8	11.4	11.4	11.7	9.8	10.0
USA	primary production	2,498.8	2,692.9	2,965.8	2,952.9	3,441.0	3,607.1	3,560.9	3,739.8	4,108.7	4,448.4	3,519.0	3,856.8
	prod. of semifabricates and castings	3,215.2	3,673.0	3,576.7	3,972.7	4,247.6	4,033.7	4,282.4	5,035.7	5,863.2	5,545.4	3,992.9	5,243.4
	sum	5,714.0	6,365.9	6,542.5	6,925.6	7,688.6	7,640.8	7,843.3	8,775.5	9,971.9	9,993.8	7,511.9	9,100.2
	recovery of new scrap	529.1	630.7	632.5	689.2	811.3	666.0	640.0	789.3	829.5	767.1	726.8	892.4
	ratio of old scrap to production [1)]	9.3	9.9	9.7	10.0	10.6	8.7	8.2	9.0	8.3	7.7	9.7	9.8
	consumption of aluminium	3,696.8	4,096.9	4,057.9	4,526.9	4,907.0	4,585.8	4,719.1	5,434.1	6,602.1	6,661.5	6,178.5	•
	recovery of old scrap	199.2	185.3	169.2	189.1	199.0	186.1	199.5	237.8	290.2	295.0	316.9	419.9
	ratio of old scrap to consumption [1)]	5.4	4.5	4.2	4.2	4.1	4.1	4.2	4.4	4.4	4.4	5.2	•

1) in %

Sources: Metallgesellschaft and Organisation Europäischer Aluminium-Schmelzhütten

The recovery of old scrap depends on the amount of aluminium consumption and its structure, since different aluminium containing products have different life-times and possibilities for recovery of the metal. Thus, the amount of aluminium recovered is a function of aluminium consumption in previous years. However, a relationship between the recovery of old scrap and aluminium consumption in any one year can be seen. This relationship naturally exhibits deviations due to the influence of foreign trade in aluminium, variations in consumption in the previous years, changes in the price of the metal, etc.

The Federal Republic of Germany, with very nearly 345,000 t, was the largest producer of secondary aluminium in Western Europe in 1976, followed by Great Britain (almost 206,000 t), Italy (198,000 t) and France (157,000 t). Including the other EC countries, production within the Community was 936,000 t, or 89 % of the production in Western Europe. Between 1966 and 1976, the average annual increase in secondary aluminium production in Italy and France was 8.7 - 8.8 %, in the Federal Republic of Germany 5.7 %, and in Great Britain only 1.1 %; for the entire European Community the average annual increase was 5.8 %. Outside the EC, only Spain in Western Europe reached an annual production of 40,000 t.

In contrast to primary aluminium smelters, secondary smelters are not usually connected with the international aluminium companies and only have low production capacities.
Appendix 6 contains the location, capacity and owner(s) of the most important secondary aluminium smelters by country.

Secondary aluminium smelters in Western Europe are as follows:

country	number of smelters	1976 capacity (tpy)
Belgium	4	1,500
Germany FR	27	350,000
Denmark	2	10,000
France	15	140,000
United Kingdom	36	328,000
Ireland	1	5,000
Italy	21	210,000
Luxembourg	1	1,500
Netherlands	3	40,000
Finland	1	7,000
Yugoslavia	.	16,000
Norway	6	10,000
Austria	2	10,000
Sweden	5	25,000
Switzerland	2	25,000
Spain	4	47,000

Japan accounts for most of the secondary aluminium production in Asia (91.5 %). Production increased from 140,500 t in 1966 to 525,900 t in 1976, an average annual increase of 14.1 %. The rest of the production in Asia is distributed among Iran, Taiwan, India, Israel, Turkey, and South Korea. However, the data for these countries is very fragmentary.

country	number of smelters	1976 capacity (tpy)
India	8	10,000
Iran	•	16,000
Israel	1	600
Japan	28	530,000
Korea South	2	5,000
Taiwan	•	10,000
Turkey	1	5,000

At present, Africa has a secondary aluminium production of only 11,000 tpy, mostly from the Republic of South Africa and minor amounts from Egypt, Rhodesia, and Zambia. Production capacities given for South-Africa (Appendix 6) probably include semimanufactures production.

country	number of smelters	1976 capacity (tpy)
Egypt	2	•
Rep. of South Africa	13	6,500
Southern Rhodesia	3	•
Zambia	1	500

The USA alone accounts for 94 % of the secondary aluminium production in the Americas, the remainder distributed among Canada, Brazil, and Mexico. Secondary aluminium production in the Americas increased from 878,100 t in 1966 to 1.4 million t in 1976, an average annual increase of almost 4.8 %. The increase for the USA was just under the average for the Americas: from 832,000 t in 1966 to 1.31 million t in 1976 (4.6 %/yr). Ca. 30,000 tpy of secondary aluminium were produced in Canada and Brazil, in Argentina between 10,000 and 20,000 t, and in Mexico ca. 10,000 tpy. Secondary aluminium was also produced in Columbia, Peru, Puerto Rico, and Venezuela.

country	number of smelters	1976 capacity (tpy)
Argentina	3	20,000
Brazil	6	35,000
Canada	10	35,000
Colombia	1	1,000
Peru	1	1,000
Puerto Rico	1	•
USA	128	1,350,000
Venezuela	3	2,000

Production of secondary aluminium in Australia and Oceania increased from 12,800 t in 1966 to 30,000 t in 1976, an average annual increase of 8.9 %. Australia accounts for more than 93 % of the total production. Production increased from 12,700 t in 1966 to ca. 28,000 t in 1976. The remaining production was in New Zealand.

country	number of smelters	1976 capacity (tpy)
Australia	10	40,000
New Zealand	6	2,500

Figures for secondary aluminium production in the East Block can only be obtained from the difference between total consumption of aluminium and consumption of primary aluminium, from which the direct use of scrap must be subtracted. Accordingly, production must have increased from ca. 400,000 t in 1966 to more than 7 %. Available data on production capacities in the individual East Block countries are especially fragmentary. Thus, the following data must be viewed as incomplete.

country	number of smelters	1976 capacity (tpy)
Germany East	4	55,000
Poland	1	•
Romania	2	50,000
Czechoslovakia	5	•
USSR	5	100,000
Hungary	1	80,000

9.3 Future Trends in Bauxite Production and Alumina and Primary Aluminium Production in the Western World

According to the available data, production capacity of existing bauxite mines is to be expanded and new mines are to be opened up in a number of western countries until 1985. Expansion and new construction is also planned for alumina plants and primary aluminium smelters. No significant closures are expected.

A rough calculation shows that if all of the planned projects in the Western World are realized, a production plateau could be reached in the individual sectors as shown in the following table. Production capacities for 1976 are also shown for comparison. Additionally, the average annual growth rates for 1966 - 1976 are compared with the projected ones for 1976 - 1985.

sector	1976 capacity in million t	capacity plateau in 1985 in million t	average annual growth rate (in %) 1966-1976	1976-1985
bauxite	89.0	140.0 - 150.1	7.3	5.2 - 6.0
alumina	29.4	52.3 - 55.6	7.0	6.6 - 7.3
primary aluminium	12.9	22.2 - 23.4	6.2	6.2 - 6.8

It is evident from this table that the production trend from 1976 to 1985 could continue as it did from 1966 to 1976. The planned expansion of production capacity could accordingly be viewed as sufficient to cover the demand until 1985, assuming the growth rate remains the same as in the past decade.

Ca. 55 % of the planned expansion and new capacity in bauxite production is in Africa (especially Guinea). Ca. 25 % of the planned expansion and new capacity for alumina production is in Australia. Ca. one-third of the planned expansion and new capacity for primary aluminium is in Asia and just under one-quarter in Latin America.

An increase in alumina and primary aluminium capacity within the EC is expected to be only 3 % each. An increase in bauxite production is not planned.

The percentages for individual economic regions in the Western World for bauxite, alumina, and primary aluminium production in 1976 and 1985 (projected) are presented in the following table:

Share of the Production Capacities for Bauxite, Alumina, and Primary Aluminium in %

	bauxite		alumina		prim. aluminium	
	1976	1985[2]	1976	1985[2]	1976	1985[2]
EC Countries	(3.9)	(2)	(14.0)	(9)	(16.3)	(11)
Europe[1]	13.0	10	18.8	17	28.7	22
North America	2.2	2	28.2	17	45.0	32
Latin America	34.8	29	16.8	16	3.0	12
Africa	15.4	31	2.4	10	3.4	7
Asia[1]	5.4	6	12.0	15	16.8	24
Australia/Oceania	29.2	22	21.8	24	3.1	3
Western World total	100	100	100	100	100	100

[1] excluding East Block; [2] averages are rounded off

10) Scrap Aluminium Supply

The supply of aluminium scrap consists of "new scrap", i.e. aluminium waste material from production and processing of aluminium, and "old scrap", i.e. aluminium recovered from aluminium-containing used articles of the previous years. Investigations in the Federal Republic of Germany, Great Britain, and the USA have shown that recovered scrap aluminium consists of 20 - 30 % old scrap and 70 - 80 % new scrap. New scrap occurs especially in the production of semi-manufactures and their further fabrication. Thus, aluminium scrap is generated in those countries with significant production and processing of semi-manufactures, especially in the Federal Republic of Germany, France, Great Britain, Italy, Japan, Canada, and the USA.

In general, the international aluminium scrap supply is determined by the amount generated in the individual countries. Statistics are compiled by the Organization of European Aluminium Smelters (OEA) for aluminium scrap (including alloys) generated in the Federal Republic of Germany, France, Great Britain, Italy, and the USA. The volume of scrap generated in the other countries of the Western World can therefore be only approximately estimated using the figures for scrap consumption (direct use and secondary aluminium production). The compiled figures for new and old aluminium scrap along with those calculated by us are shown in Table 28 for 17 countries of the Western World from 1966 to 1976. It must be pointed out that aluminium scrap is probably recovered in other countries also. Inventory changes and smelting losses are not considered in the calculated values.

The recovery of scrap aluminium in the EC countries for which data was compiled increased from ca. 604,000 t in 1966 to ca. 1.12 million t in 1976, an average annual increase of 6.4 %. The increase for the same period was from 1.66 million t to 3.14 million t for the 17 countries as a whole. These figures are in good agreement with the data and estimations for the recovery of aluminium from old and new scrap in 29 countries and country groupings published in Metallstatistik, Frankfurt. Ca. 36 % of the recovered aluminium

Table 28

Recovery of Old & Scrap Aluminium in Selected Countries: 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium/Luxembourg	9.1	9.8	11.6	11.5	9.3	8.6	7.4	8.5	8.0	6.0	15.6
Germany FR	193.7	185.6	203.0	257.6	274.0	313.0	328.2	384.8	382.1	342.7	425.2
France	101.7	104.4	120.4	130.0	128.0	140.0	165.6	168.7	176.3	157.8	206.8
United Kingdom	212.2	208.2	231.2	245.3	227.1	232.5	243.2	234.6	237.8	220.3	239.3
Italy	77.8	87.8	101.1	121.5	136.1	125.0	149.4	164.0	185.5	136.4	172.4
Netherlands	9.3	7.6	5.2	12.7	10.5	18.5	17.1	33.4	52.5	42.4	58.7
EC Countries[1)]	603.8	603.4	672.5	778.6	785.0	837.6	910.9	994.0	1,042.2	905.6	1,118.0
Norway	4.4	6.9	8.4	10.7	9.5	8.8	12.7	15.1	20.4	15.4	16.1
Austria	8.3	8.4	12.4	10.7	7.8	8.1	0.9	13.7	9.0	12.2	14.8
Sweden	11.5	13.4	15.7	17.4	19.9	20.7	21.6	22.0	24.6	23.2	24.6
Switzerland	13.5	13.0	14.5	16.8	15.0	13.5	13.9	16.6	17.2	15.6	18.6
Spain	13.9	14.3	19.2	25.0	27.1	28.0	28.4	33.6	41.9	32.9	37.3
Europe without East Block	655.4	659.4	742.7	859.2	864.3	916.7	988.4	1,095.0	1,155.3	1,004.9	1,229.4
Asia (Japan) without East Block	121.4	160.4	202.7	262.1	311.5	337.0	374.8	488.7	493.7	395.2	457.4
Brazil	4.1	3.7	4.4	6.5	6.0	7.5	13.0	18.5	22.4	20.6	28.0
Canada	48.0	70.8	64.4	65.3	68.6	71.6	78.4	77.6	77.1	61.0	75.6
USA	816.0	801.7	878.3	1,010.3	852.1	839.5	1,027.1	1,119.7	1,062.1	1,043.7	1,312.3
America	868.1	876.2	947.1	1,082.1	926.7	918.6	1,118.5	1,215.8	1,161.6	1,125.3	1,415.9
Australia	13.3	14.0	18.6	22.2	20.9	24.2	23.4	28.4	37.0	27.3	35.0[x)]
Western World[1)]	1,658.2	1,710.0	1,911.1	2,225.6	2,123.4	2,196.5	2,505.1	2,827.9	2,847.6	2,552.7	3,137.7

[x)] estimated

[1)] as far as available

Source: Organisation Europäischer Aluminium-Schmelzhütten, Düsseldorf in the Western World is accounted for by the EC countries, 42 % by the USA, 15 % by Japan, and ca. 3 % by other Western European countries. Within the EC, the Federal Republic of Germany, the largest aluminium consumer, also generated the largest amount of aluminium scrap, more than 350,000 tpy; Great Britain accounts for 220,000 - 240,000 tpy, Italy and France for 160,000 - 200,000 tpy each.

Aluminium scrap is used primarily for secondary aluminium and alloys, most of which is taken up by the foundries. Thus the secondary smelters and the foundries heavily influence the amount of scrap available for export. Net foreign trade in aluminium scrap (including alloys) of selected western industrial countries for 1966, 1971, and 1976 is shown in Table 29.

Table 29

Foreign Trade of Selected Western Industrial Countries:
Scrap Aluminium - 1966, 1971, and 1976
(in 1000 t)

	1966		1971		1976	
	net import	net export	net import	net export	net import	net export
Belgium/Luxembourg	-	6,6	-	6,4	-	13,0
Germany FR	43,9	-	47,6	-	53,1	-
France	-	8,1	-	10,3	1,1	-
United Kingdom	8,6	-	9,8	-	10,3	-
Italy	53,0	-	53,4	-	71,2	-
Netherlands	-	7,8	-	10,2	-	20,2
Norway	-	1,3	-	4,8	-	10,1
Austria	-	3,5	-	1,0	-	6,3
Sweden	-	0,5	-	0,7	-	0,6
Spain	0,1	-	1,0	-	2,7	-
Japan	19,1	-	12,2	-	68,5	-
USA	-	13,7	29,3	-	-	21,0
Canada	-	20,3	-	37,9	-	42,0
Australia	-	0,5	-	2,3	-	5,0

It can be seen that the Federal Republic of Germany, Italy, Japan, and to a lesser degree also Great Britain were the largest net importers of scrap aluminium for the years listed. Belgium/Luxembourg, the Netherlands, Canada, and usually the USA were the major net exporters. For the EC countries, the net import was permanent and considerable. This will be handled in greater detail in the chapter on foreign trade. Foreign trade in aluminium scrap for the major western industrial countries in 1966 - 1976 is presented in Appendix 7.

11) The Concentration of the Supply of Aluminium and Aluminium Raw Materials according to Country and Company

11.1 Breakdown according to Country

11.1.1 Concentration of Bauxite Production by Country

The ten largest bauxite producing countries accounted for 83.5 % and 87.1 % of the world bauxite production in 1966 and 1976, respectively. Nine countries were among the top ten producers in both of the two years being compared, the USA being replaced by Hungary. The order of the countries changed considerably. This was mainly due to the large increase in the proportion for Australia and Guinea between 1966 and 1976. Seen as a whole, the concentration of bauxite production must be described as high, especially considering the first three (or five) countries. In addition, the concentration increased noticeably during this time period. Details are contained in Table 30.

Table 30

Percentage of the Amount of Bauxite Mined in the Top 10 Countries: 1966 and 1976

Country	1966		Country	1976	
	%	cumulative %		%	cumulative %
1) Jamaica	22.1	22.1	1) Australia	29.9	29.9
2) Surinam	13.5	35.6	2) Guinea	14.1	44.0
3) USSR	11.7	47.3	3) Jamaica	12.8	56.8
4) Guyana	8.2	55.5	4) USSR	8.3	65.1
5) France	6.8	62.5	5) Surinam	5.7	70.8
6) Yugoslavia	4.6	66.9	6) Guyana	3.9	74.7
7) Australia	4.5	71.4	7) Hungary	3.6	78.3
8) USA	4.4	75.8	8) Greece	3.4	81.7
9) Guinea	3.9	79.7	9) France	2.9	84.6
10) Greece	3.7	83.5	10) Yugoslavia	2.5	87.1

11.1.2 Concentration of Alumina Production by Country

The ten largest alumina producing countries accounted for 87.6 % and 85.2 % of the world aluminium oxide production in 1966 and 1976, respectively. Only six countries were among the top ten producers in both of the two years being compared. The order of the countries also changed significantly.

Especially noticeable is the large increase in production in Australia (1966: 2.1 % of world production; 1976: 22.5 %) and the decrease in the proportion for the USA (1966: 35.9 %; 1976: 21.5 %). There is a rather high concentration of alumina production, especially when the first three (or five) countries are considered. The degree of concentration decreased slightly between 1966 and 1976. Details can be seen in Table 31.

Table 31

Percentage of the Amount of Alumina Production in the Top 10 Countries: 1966 and 1976

Country	1966 %	1966 cumulative %	Country	1976 %	1976 cumulative %
1) USA	35.9	35.9	1) Australia	22.5	22.5
2) USSR	17.6	53.5	2) USA	21.5	44.0
3) Canada	6.1	59.6	3) USSR	12.2	56.2
4) France	5.7	65.3	4) Jamaica	6.0	62.2
5) Jamaica	5.4	70.7	5) Japan	5.1	67.3
6) Japan	4.5	75.2	6) Germany FR	4.8	72.1
7) Germany FR	4.1	79.3	7) Surinam	3.8	75.9
8) Guinea	3.6	82.9	8) France	3.7	79.6
9) Surinam	2.8	85.6	9) Italy	2.9	82.5
10) Guyana	2.0	87.6	10) Hungary	2.7	85.2

11.1.3 Concentration of Primary Aluminium Production by Country

The ten largest primary aluminium producing countries accounted for 88.5 % and 77.4 % of the world primary aluminium production in 1966 and 1976, respectively. Eight countries were among the top ten producers in both of the two years being compared. The USA and the USSR continued to take first and second place, respectively. Changes occurred in the order of the other countries. There was a definite decrease in the concentration of primary aluminium production from 1966 to 1976. This is primarily due to decrease in the percentage for the USA (1966: 37.4 %; 1976: 29.5 %). However, the degree of concentration of primary aluminium production must be described as high; this is true whether the three largest or the five or ten largest producing countries are considered. Details are contained in Table 32.

Table 32

Percentage of the Amount of the Primary Aluminium Production in the Top 10 Countries: 1966 and 1976

Country	1966 %	1966 cumulative %	Country	1976 %	1976 cumulative %
1) USA	37.4	37.4	1) USA	29.5	29.5
2) USSR	18.0	55.4	2) USSR	16.8	46.3
3) Canada	11.2	66.6	3) Japan	7.0	53.3
4) France	5.0	71.6	4) Germany FR	5.3	58.6
5) Japan	4.6	76.2	5) Canada	4.8	63.4
6) Norway	4.6	80.8	6) Norway	4.8	68.2
7) Germany FR	3.4	84.2	7) France	2.9	71.1
8) Italy	1.8	86.0	8) United Kingdom	2.6	73.7
9) Australia	1.3	87.3	9) Netherlands	1.9	75.6
10) China, PR	1.2	88.5	10) Australia	1.8	77.4

11.1.4 The Major Producing and Consumer Countries for Bauxite, Alumina, and Primary Aluminium

The results of the previous sections are compared in Table 33. It can be seen that although the most important bauxite producers have a high percentage of the bauxite production, they have a lower proportion of the alumina production and a still lower proportion of the primary aluminium production. In contrast, the principal consumer countries have a low percentage of the bauxite production (the main exception is the USSR). However, these countries have a large proportion of the alumina production and an even greater proportion of the primary aluminium production. These relationships existed for the most part in 1966 already. The production of aluminium oxide has shifted since then in favor of the bauxite producing countries (mainly Australia, Jamaica, Surinam). The proportion of alumina produced by the ten largest bauxite producers more than doubled from 1966 to 1976 (19 - 42.8 %).

The differences in production structures in the countries named are due to differences in the economic factors for mining, energy, marketing, and transportation. This is true particularly for primary aluminium production because the location of the smelter is of importance in terms of energy supply as well as marketing considerations. The heavy concentration of primary aluminium production in the principal consuming countries is primarily determined by the size of the market. This is not only especially true for the USA and Japan, but also for the Federal Republic of Germany and the EC as a whole.

Table 33

Breakdown of the Major Producing and Consumer Countries of Bauxite for the Production of Aluminium Oxide and Primary Aluminium: 1966 and 1976

in %

1966	Bauxite Production	Alumina Production	Primary Aluminium Production	1976	Bauxite Production	Alumina Production	Primary Aluminium Production
Principal Producer Countries				Principal Producer Countries			
1) Jamaica	22.1	5.4	0	1) Australia	29.9	22.5	1.8
2) Surinam	13.5	2.8	0.4	2) Guinea	14.1	2.0	0
3) Guyana	8.2	2.0	0	3) Jamaica	12.8	6.0	0
4) Yugoslavia	4.6	0.6	0.6	4) Surinam	5.7	3.8	0.3
5) Australia	4.5	2.1	1.3	5) Guyana	3.9	0.9	0
6) Guinea	3.9	3.6	0	6) Hungary	3.6	2.7	0.5
7) Greece	3.7	0.5	0.5	7) Greece	3.4	1.6	1.0
8) Hungary	3.5	1.0	0.8	8) Yugoslavia	2.5	1.7	0.5
9) Malaysia	2.3	0	0	9) India	1.8	1.6	1.6
10) Dominican Republic	2.0	0	0	10) Indonesia	1.2	0	0
	68.3	19.0	3.6		78.9	42.8	5.7
Principal Consumer Countries				Principal Consumer Countries			
1) USA	4.4	35.9	37.4	1) USA	2.5	21.5	29.5
2) USSR	11.7	17.6	18.0	2) USSR	8.3	12.2	16.8
3) Germany FR	0	4.1	3.4	3) Japan	0	5.1	7.0
4) Japan	0	4.5	4.6	4) Germany FR	0	4.8	5.3
5) United Kingdom	0	0.8	0.5	5) France	2.9	3.7	2.9
6) France	6.8	5.7	5.0	6) United Kingdom	0	0.4	2.6
7) Canada	0	6.1	11.2	7) Italy	0.1	2.9	1.6
8) Italy	0.6	1.8	1.8	8) Canada[1)]	0	1.8	4.8
9) Belgium/Luxembourg	0	0	0	9) China PR	1.1	1.3	1.4
10) Germany DR	0	0.3	0.6	10) Belgium/Luxembourg	0	0	0
	23.5	76.8	82.5		14.8	53.7	71.9

[1)] A six-month strike at Alcan in Canada; in the previous years, Canada produced 4 - 5 % and 7 - 10 % of the world production of aluminium oxide and primary aluminium, respectively.

11.1.5 Bauxite Reserves, Bauxite Production, and Alumina and Primary Aluminium Production in the IBA Countries

The IBA (The International Bauxite Association) consists of eleven bauxite producer countries. Of these, six countries (Australia, Guinea, Jamaica, Surinam, Guyana, and Yugoslavia) were among the ten largest bauxite producers in 1976 (cf. Table 30). In addition, the Dominican Republic, Haiti, Ghana, Sierra Leone, and Indonesia are IBA members.

More than three-fourths (77.3 %) of the measured & indicated bauxite reserves and almost half of the inferred reserves (45.7 %) are found within the IBA countries. Almost three-fourths (72.7 %) of the world bauxite production comes from these countries. The IBA countries account for about one-third (36.9 %) of the world production of aluminium oxide and just under 5 % of the primary aluminium production. Only three IBA countries produce alumina and primary aluminium as well as bauxite. In contrast, neither alumina nor primary aluminium is produced at present in the Dominican Republic, Haiti, Sierra Leone, or Indonesia. Guyana, Jamaica, and Guinea produce alumina, but no primary aluminium. In Ghana, primary aluminium is produced, but no alumina. Details are contained in Table 34.

IBA countries in 1976 accounted for only 2 - 3 % of the world primary aluminium consumption. Percentages for Australia and Yugoslavia were 1.2 % and 1 %, respectively; that for the other nine IBA countries as a whole was less than 0.5 %. The already very high percentage of world bauxite production in the IBA countries could still be increased by the entry of other bauxite producers. An increase in IBA membership, however, would probably result in greater difficulties in reaching an agreement on interests within the IBA.

11.1.6 Concentration of Bauxite Reserves according to Country

The top ten countries in terms of bauxite reserves accounted for 90.7 % and 92.5 % of the measured & indicated reserves in 1967 and 1977, respectively. The cumulative percentages from first to tenth places in the listing also differ little between the two years; a significant change in the concentration of the bauxite reserves did not occur. The degree of concentration must be described as high, especially when the first three (or five) countries are considered.
It can be seen that only six countries were among the top ten with bauxite reserves in both of the two years being compared. Australia, Guinea, and Jamaica occupied first, second, and third places, respectively in both years.
Details are contained in Table 35.

Table 34

Proportion of the Bauxite Reserves and Production in the IBA Countries as well as the Production of Alumina & Primary Aluminium in 1976

IBA Countries	1977 Reserves				1976 Bauxite Production		1976 Production			
	measured & indicated		potential				of Al_2O_3		of primary aluminium	
	10^6 t	% of World	10^6 t	% of World	1000 t	% of World	1000 t	% of World	1000 t	% of World
1) Dominican Rep.	15	0.1	.	.	516.0	0.7	-	-	-	-
2) Guyana	1,000	5.8	500	3.4	3,107.6	3.9	247.0	0.9	-	-
3) Haiti	40	0.2	100	0.7	660.4	0.8	-	-	-	-
4) Jamaica	2,000	11.6	1,000	6.8	10,306.0	12.8	1,648.2	6.0	-	-
5) Surinam	800	4.6	1,200	8.2	4,588.0	5.7	1,040.0	3.8	44.8	0.3
1 - 5 together	3,855	22.3	2,800	19.1	19,178.0	23.9	2,935.2	10.7	44.8	0.3
6) Ghana	426	2.5	150	1.0	267.3	0.3	-	-	151.1	1.2
7) Guinea	3,585	20.7	1,450	9.9	11,316.4	14.1	562.0	2.0	-	-
8) Sierra Leone	10	0.1	100	0.7	660.0	0.8	-	-	-	-
6 - 8 together	4,021	23.3	1,700	11.6	12,243.7	15.2	562.0	2.0	151.1	1.2
9) Indonesia	40	0.2	1,000	6.8	940.3	1.2	-	-	-	-
10) Yugoslavia	200	1.2	200	1.4	2,033.0	2.5	461.9	1.7	197.7	1.5
11) Australia	5,230	30.3	1,000	6.8	24,085.1	29.9	6,205.8	22.5	231.3	1.8
IBA total	13,346	77.3	6,700	45.7	58,480.1	72.7	10,164.9	36.9	624.9	4.8
World total	17,284	100.0	14,659	100.0	80,491.9	100.0	27,536.4	100.0	13,082.9	100.0

IBA = The International Bauxite Association

Table 35

Percentage of the Amount of the Bauxite Reserves in the Top 10 Countries: 1967 and 1977

country	1967 %	1967 cumulative %	country	1977 %	1977 cumulative %
1) Australia	35.8	35.8	1) Australia	30.3	30.3
2) Guinea	20.4	56.2	2) Guinea	20.7	51.0
3) Jamaica	10.2	66.4	3) Jamaica	11.6	62.6
4) Ghana	5.0	71.4	4) Brazil	5.8	68.4
5) USSR	4.9	76.3	5) Guyana	5.8	74.2
6) Surinam	4.3	80.6	6) Cameroon	5.8	80.0
7) Yugoslavia	3.4	84.0	7) Surinam	4.6	84.6
8) Guyana	2.5	86.5	8) Greece	3.5	88.1
9) Hungary	2.5	89.0	9) Ghana	2.5	90.6
10) China, PR	1.7	90.7	10) India	2.0	92.6

The degree of concentration of the reserves is somewhat greater than of production. It can be observed that the ten principal producing countries also have by far the main share of the measured & indicated reserves (92.6 %). In contrast, these countries have only ca. 58 % of the inferred reserves. Considerable differences can be observed between reserves and production in some countries. About a fifth (21.4 %) of the inferred world reserves are found in three other countries: Mali (7.8 %), Indonesia (6.8 %), and the People's Republic of China (6.8 %); there has been no bauxite production in Mali yet.

11.2 Concentration of the Aluminium Industry in the Western World according to Company

There are numerous private firms active in the aluminium industry of the Western World; in some countries (e.g. Yugoslavia and to some extent in Guinea and Guyana) the companies are run by the government. Details concerning the companies in the individual countries, locations of their alumina and primary aluminium plants, and their capacities can be found in Appendix 4.

11.2.1 Concentration of Bauxite Production in the Western World by Company

Bauxite production capacity in the Western World was 89 million t in 1976. The firms listed in Table 36 accounted for ca. 69.1 % of this capacity. The four largest North American companies accounted for 39.1 %.

Table 36

Concentration of Bauxite Production Capacity in the Western World according to Company: 1976
(1000 t and %)

company	1000 t	%	cumulative %
1) Aluminum Company of America (Alcoa)	15,200	17.0	17.0
2) Kaiser Aluminum & Chemical Corp.	8,600	9.7	26.7
3) State-owned company in Guinea	7,400	8.3	35.0
4) Reynolds Metals Co.	6,100	6.8	41.8
5) Conzinc Riotinto of Australia Ltd. (CRA)	5,700	6.4	48.2
6) Aluminium Company of Canada	5,000	5.6	53.8
7) Schweizerische Aluminium AG (Alusuisse)	4,850	5.5	59.3
8) State-owned company in Yugoslavia	4,500	5.1	64.4
9) Bauxite Industry Development Co.	4,200	4.7	69.1
Total	61,550	69.1	
Total for the Western World	89,030	100.0	

11.2.2 Concentration of Alumina Production in the Western World by Company

Production capacities in the Western World in 1976 totaled 29.43 million t Al_2O_3. The nine most important firms are listed in Table 37. They accounted for almost three-fourths (72.4 %) of the total capacity. The four largest North American firms alone accounted for ca. 50 %.

Table 37

Concentration of Alumina Production Capacity in the Western World according to Company: 1976
(1000 t and %)

company	1000 t	%	cumulative %
1) Aluminum Company of America (Alcoa)	5,979	20.3	20.3
2) Aluminium Company of Canada (Alcan)	3,511	11.9	32.2
3) Kaiser Aluminum & Chemical Corp.	2,850	9.7	41.9
4) Reynolds Metals Co.	2,511	8.5	50.4
5) Pechiney Ugine Kuhlmann S.A.	2,100	7.1	57.5
6) Schweizerische Aluminium AG (Alusuisse)	1,334	4.5	62.0
7) Vereinigte Aluminium Werke AG (VAW)	1,257	4.3	66.3
8) State-owned company in Yugoslavia	930	3.2	69.5
9) Sumitomo Chemical Co.	850	2.9	72.4
Total	21,322	72.4	
Total for the Western World	29,430	100.0	

11.2.3 Concentration of Primary Aluminium Production in the Western World by Company

Primary aluminium capacity in the Western World in 1976 was ca. 12.9 million t. Capacities and percentages for the nine largest companies are listed in Table 38. These firms accounted for two-thirds (66 %) of the total primary aluminium capacity in the Western World. The four largest North American firms accounted for ca. 44 %.

Table 38

Concentration of Primary Aluminium Production Capacity in the Western World according to Company: 1976
(1000 t and %)

company	1000 t	%	cumulative %
1) Aluminum Company of America (Alcoa)	1,767	13.7	13.7
2) Aluminium Company of Canada (Alcan)	1,622	12.6	26.3
3) Reynolds Metals Co.	1,193	9.2	35.5
4) Kaiser Aluminum & Chemical Corp.	1,076	8.3	43.8
5) Pechiney Ugine Kuhlmann S.A.	941	7.3	51.1
6) Schweizerische Aluminium AG (Alusuisse)	722	5.6	56.7
7) Sumitomo Chemical Co.	463	3.6	60.3
8) Vereinigte Aluminium Werke AG (VAW)	377	2.9	63.2
9) Mitsubishi	358	2.8	66.0
Total	8,519	66.0	
Total for the Western World	12,904	100.0	

11.2.4 Concentration by Company of Bauxite, Alumina, and Primary Aluminium Production in the Western World

The results of the previous sections are compared in Table 39. A total of 13 companies account for ca. 74 % of the bauxite production in the Western World, ca. 75 % of the alumina production and ca. 68 % of the primary aluminium production.

Table 39

Concentration of Bauxite, Alumina, and Primary Aluminium Production Capacity in the Western World according to Company: 1976
(in %)

company	Production of					
	bauxite		alumina		primary aluminium	
	%	cumulative %	%	cumulative %	%	cumulative %
1) Aluminum Company of America (Alcoa)	17.0	17.0	20.3	20.3	13.7	13.7
2) Kaiser Aluminum & Chemical Corp.	9.7	26.7	9.7	30.0	8.3	22.0
3) State-owned company in Guinea	8.3	35.0	1.2	31.2	0	22.0
4) Reynolds Metals Company	6.8	41.8	8.5	39.7	9.2	31.2
5) Conzinc Riotinto of Australia Ltd. (CRA)	6.4	48.2	0.6	40.3	0.7	31.9
6) Aluminium Company of Canada (Alcan)	5.6	53.8	11.9	52.2	12.6	44.5
7) Schweizerische Aluminium AG (Alusuisse)	5.5	59.3	4.5	56.7	5.6	50.1
8) State-owned company in Yugoslavia	5.1	64.4	3.2	59.9	1.6	51.7
9) Bauxite Industry Development Co. (ehem. Guybau, Guyana)	4.7	69.1	1.2	61.1	0	51.7
10) Pechiney Ugine Kuhlmann S.A.	4.0	73.1	7.1	68.2	7.3	59.0
11) Vereinigte Aluminiumwerke AG (VAW)	0.7	73.8	4.3	72.5	2.9	61.9
12) Sumitomo Chemical	0	73.8	2.9	75.4	3.6	65.5
13) Mitsubishi	0	73.8	0	75.4	2.8	68.3

II. Aluminium Production Costs and Prices

1) The Production Costs

Bauxite is still the most important raw material used in aluminium production. As a rule the mined bauxite has a content of 50 % Al_2O_3, respectively 25 % Al. In some cases ores are also mined which contain little more than 30 % Al_2O_3, respectively 15 % Al (cut-off grade). In the case of bauxite, treatment of the ore is only of secondary importance. It is normally carried out in the vicinity of the mining operation.

Bauxite is not directly smelted, as is mainly the case with other ores or concentrates, instead, further processing to alumina is interposed between mining/treatment operations and the smelter. Whereas aluminium smelters are mainly located in industrial countries or in industrial centres, there is an increasing tendency to site alumina plants in the bauxite-producing countries and in the vicinity of the deposits, which as a rule are located far from the consumers. Long transport routes therefore result, in part between the bauxite exploitation operation and the alumina plant for the bauxite and again, between the alumina plant and the aluminium smelter for the alumina.

When considering the production costs of aluminium, the following main factors should be therefore considered separately

- Mining operation costs including treatment costs
- Alumina production costs
- Aluminium smelting costs
- Freight costs

1.1 Mining Operation Costs

About 85 % of the bauxite production worldwide is mined by the opencast method. The methods of exploitation in the opencast mines are simple because of the mainly close-to-surface and mantle-like bedding of the bauxite. The mining equipment consists of the normal earth moving machines, namely front-end-loaders, scraper loaders and dragline excavators used in combination with heavy duty trucks. Power shovels or bucket wheel excavators are only used occasionally. Extensive and rapid exploitation is common to all bauxite opencast mines, creating transport and possibly recultivation problems.

The principal difference in the production costs is determined by the varied infrastructure around the deposits, as with their development, there is often a simultaneous and related building of completely new communities, their maintenance, extensive road or rail systems and new harbour facilities. In less developed areas, freight distances to the next sea port of more than 150 km are at the moment still uncommon for economic reasons.

To attempt to confine the infrastructural costs per ton to tolerable limits efforts are made to increase the production capacity.

Further differences in the cost structure of the opencast operations emerge primarily from the characteristics of the deposits:

- The overburden is predominantly thin (as e.g. in Jamaica, Australia and Guinea) and seldom amounts to more than 0.5 to 1 m. In relation to the ore thickness it is therefore insignificant. In individual cases, such as is partly the case in Guyana, the overburden can amount to 75 m and the stripping ratio rises to a maximum of 6 : 1.
- The ore is often so soft that it can be loaded directly (Jamaica). Sometimes it has to be ripped. Drilling and blasting work is however often necessary (Western Australia, Guinea).
- To increase the Al_2O_3 content, or alternatively to reduce that of SiO_2, or to improve the freighting characteristics of the bauxite, the ore is in some cases treated. In most cases simple washing and sieving processes suffice, which not only require investment but which through reduction of the basis for calculation of the costs also increase the total specific costs. With, for e.g. an elimination of 20 % of the mine production due to ore processing, whereby the tailings normally include high contents of Al_2O_3, the production costs per ton of saleable bauxite increase by 25 %.

In other respects the treatment of bauxite consists of crushing the ore into transportable sizes, of blending the ore to obtain a uniform ore quality, and sometimes a drying process with the main aim of reducing transportation weight. To keep dust nuisance within reasonable limits, moisture content is not as a rule reduced below 5 % during drying.

The capacity of bauxite mining operations are generally at least of the order of some 100,000 tons per year. This applies also for underground operations. The largest opencast operations are those of Sangaredi in Guinea with a production from a single mine of more than 7 million t per year and of Weipa in Australia, with a production from 2 separate mines of roughly 10 million t per year.

Currently the running costs for opencast bauxite mining are estimated at 2 to 5 US $/t bauxite. The following breakdown of costs can be taken as typical for a mining operation which has to maintain its own living accommodation for the staff and workers (given in %):

Stripping	9
Drilling and blasting	6
Excavation	10
Trucking	27.5
Crushing, stockpiling, loading	7.5
Administration, maintenance of township	40
Grand total	100

Ore transport costs ex mine have been calculated separately in the example given here.

The operating costs have to be added to the capital costs, which can vary considerably in amount as well due to the varied infrastructural burdens imposed. Investments for the direct mining operation, namely the machinery facilities above all the mobile equipment park, amount to only about 5 US $/t per year of bauxite production. The depreciation period of up to 5 years for these equipments is normally short. With the inclusion of treatment and the infrastructure an estimated investment of 20 to 30 US $/t of the annual production must be taken into consideration. From investments in past years however, much higher rates can in some cases be determined which amount to as much as 90 US $/t per year. In such cases, parts of the overall project are sometimes not borne alone by the mining operator when they serve to improve the general infrastructure of the country.

For new facilities therefore, capital costs amounting to 2 to 6 US $/t bauxite can be assumed.

The total costs arising out of mine operating costs and capital costs for opencast mining therefore amount to about 4 to 11 US $/t of bauxite.

The world bauxite production from underground mining amounts to about 15 %. Room-and-pillar methods predominate here. Drilling and blasting work are in the main necessary. In spite of the higher costs entailed in comparison with more cheaply exploitable opencast bauxite, underground bauxite can still be competitive in Western countries when the opencast product has to be transported over great distances.

In Western countries the overall costs for mining bauxite underground amount to about 8 to 17 US $/t. In Hungary in 1975, costs amounting to up to 30 US $/t of bauxite were known.

Mining Duties

The mining costs arising out of technical and economic circumstances are normally considerably increased by duties (amongst others, royalties) or by producer country taxes which are not related to profits. This applies in particular to the International Bauxite Association (IBA) member countries.

Jamaica, the Dominican Republic, Haiti and Surinam relate their taxes to the aluminium price. Jamaica insists that the individual mining companies maintain set exploitation rates and further, payment of a current bauxite levy of 7.5 % of the average realised price for aluminium ingots in US apart from a constant duty of 0.55 US $/t of bauxite. With a consumption of 4.6 t of bauxite (dry) per ton of aluminium and a price of 53 cts/lb Al (assumption: producer price = realised price) this means a burden of roughly 19 US $/t of bauxite. The rulings in the other countries named are similar.

In Australia, mining duties are raised of up to 1 A $/t[1)] for bauxite that is exported and 0.3 A $/t for bauxite that is processed further in the country itself. The state of West Australia has for the present dispensed with mining duties.

1.2 Alumina Production Costs

In alumina plants the impurities contained in bauxite are separated and alumina (oxide of aluminium) is produced which contains over 99.5 % of Al_2O_3. Traditionally alumina plants are sited in the vicinity of the aluminium smelters and the aluminium consumer. In view of the political pressures of producer countries who wish to take a larger share of the value created by aluminium production from the bauxite mined in their country, then above all, for reasons of environmental protection and consideration of freight charge savings, plants are today built with increasing frequency in the producer countries, fairly close to the deposits.

The capacities of the erected and planned plants during the recent years were mainly above 300,000 tons per year Al_2O_3 and achieved totals in excess of 1 million tons per year. Today, capacities of over 600,000 tons per year are as a rule regarded as an economically minimum size for future plant planning. For these, investment is calculated at 600 to 1,000 US $/t per year of Al_2O_3. In areas with unfavourable infrastructural conditions this amount could be considerably higher.

The operating costs for alumina production arise from the amounts and the prices of the input products etc consumed, the most important of which are listed here:

- The amount of bauxite put in is governed by its Al_2O_3 content and the yield. One differentiates between the total content and the available Al_2O_3 content on the basis of the chemism and the mineralogical composition of the bauxite. In the Bayer process, the bauxite is digested with sodium hydroxide solution which produces insoluble sodium aluminium silicates which are filtered off in red mud. For each percent by weight of SiO_2 bound in silicates (reactive silica) approximately 0.85 percent by weight of Al_2O_3 is lost. If in the case of predominantly trihydratic bauxite, the

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1) 1 A $ = approx. 1.10 US $ (August 1977)

so-called American process is selected, a digestion process with lower temperature and solution concentration, then monohydrates which may be present remain undigested. This leads to further loss of Al_2O_3. The difference between total content and available content is occasionally up to 10 %, the theoretically possible yield is therewith sometimes only 80 %. The technical yield is related to the available content and varies between 90 and 98 %. The total yield is therefore mostly below 90 %. In the case of bauxite from Jamaica and from Gove in Australia one can assume a consumption of about 2.3 t of bauxite (dry) per ton of Al_2O_3. For Boké (Guinea) ores some 2 t and for French bauxites about 2.6 t per t Al_2O_3 are required.

- As a result of sodium silicate formation during the Bayer process the consumption of soda is dependant upon the content of reactive silica in the bauxite. About 0.7 parts by weight of Na_2O can be assumed as loss per parts by weight of SiO_2 in processed bauxite. From this therefore, 1 % of SiO_2 with an assumed consumption of 2.3 t of bauxite, leads to a caustic soda loss of almost 16 kg per t of Al_2O_3. The TiO_2 contents in bauxite too lead to an increased loss.

  In tropical bauxites, the Na_2O consumption is normally about 35 to 80 kg per t Al_2O_3, whereas with European bauxites it is at times over 100 kg.

- The forms of energy used in the Bayer process are coal, oil or gas for producing temperature and pressure, oil or gas for calcination of the Al_2O_3 and electric power for motor propulsion. The consumption of electric power is relatively low and amounts to about 200 to 300 kWh/t Al_2O_3. Otherwise rates of consumption vary in particular, dependant upon the state of technological processing, in a broad range between 2,400 and 6,000 M cal/t Al_2O_3 (calculated as calorific content of the primary sources of energy: oil, coal, gas).

- A modern alumina plant in Europe with an annual production of 650,000 t Al_2O_3 today has about 650 employees. The labour productivity resulting therefrom is 1 employee/1000 tons per year Al_2O_3.

The following table gives an indication of the costs involved for the individually named input products (operating costs) in relation to the assumed total costs of 220 US $/t Al_2O_3:

Input products	Assumed amounts consumed in newer European plants	Price per unit of quantity (estimated)	Operating costs in US $\$$/t	Portion of the total costs (220 US $\$$/t) in %
Bauxite (Australian)	2.3 t	25 US $\$$/t	57.5	26.1
Caustic soda (Na_2O)	75 kg	160 US $\$$/ 1000 kg	12	5.5
Thermal energy	3000 Mcal	10 US $\$$/ 1000 Mcal	30	13.6
Electric power	250 kWh	2.0 cts/kWh (Power plant situated away from the Al-electrolysis plant)	5	2.3
Maintenance (Less manpower)			8	3.6
Labour	1 employee per 1000 tons per year Al_2O_3	17,500 US $\$$/ for 1 employee each year	17.5	8.0
		Grand Total	130	59.1

1 US $\$$ = 2.20 DM

Assuming a service of capital (depreciation and interest) of 12 %, then for an older plant that, for example, formerly cost 250 US $\$$/t per year of Al_2O_3, capital costs of roughly 30 US $\$$/t emerge. For a new plant (investment 600 to 1000 US $\$$/t per year) today costs would arise of 72 to 120 US $\$$/t Al_2O_3.

The capital costs for investments of 750 US $\$$/t per year amount to 90 US $\$$/t Al_2O_3 (40.9 % of the total production costs).

In view of alumina prices today of not more than 160 US $\$$/t, it is clear that new plants to be constructed can then only operate profitably when the alumina price rises significantly.

1.3 Aluminium Smelting Costs

The location of aluminium smelters is mainly decided by the supply of cheap energy as they have an unusually high demand for it. Further factors of prime importance are the infrastructure, with particular reference to bringing in the raw materials and taking out the finished products, the proximity of the market and protection of the environment.

In 1974, more than 50 % of all aluminium smelters obtained their electric power from hydroelectric power stations and therefore relatively cheaply, 20 % from coal power stations and only 13 % (in particular Japan) from oil power stations.

The smelters constructed or expanded during the last years mostly have capacities of between 70,000 and 220,000 tons per year of aluminium. Capacities of 100,000 tons per year of aluminium are currently considered to be the economically lower limit for an aluminium smelter. The necessary capital requirements for new smelters (including the accompanying foundry, nevertheless without special infrastructure costs and without power station) are in the broad range of 2,500 to 3,000 US $/t per year of aluminium. Expansion of capacities produce in part considerably lower investment costs.

The input products for determining the operating costs for aluminium production are in particular, the following:

- Alumina. 1.91 to 1.95 t of Al_2O_3 per t Al are needed, which accords with a yield of 97 to 99.5 %.
- Fluorine in the form of aluminium fluoride and Greenland spar. Disregarding the recovery of fluorine from waste gases and from the lining of the electrolytic cells, the current average consumption is about 30 to 40 kg fluorine/t Al. Assuming a distribution of 3 : 2 it accords roughly with a consumption of 25 to 35 kg of aluminium fluoride and 20 to 30 kg of Greenland spar.
- Anodes. The consumption on average amounts to about 450 kg/t Al using pre-baked anodes and 550 kg for Söderberg anodes.
- Energy costs. Between 15,000 and 17,000 kWh are required today per ton of aluminium for the smelting flux electrolysis and the necessary associated tasks. In the very varied details available, it has not as a rule been indicated as to whether just the electrolysis is covered or whether the additional procedures necessary for the production have been included.

  The determining factor is the price of electric power. In Central Europe the current electric power prices prevailing are around 1 to over 1.6 ¢/kWh. In North America the prices range from 0.3 to about 1.5 ¢/kWh, whereas in Japan prices of up to 4 ¢/kWh are quoted. With a consumption of 15,000 kWh per ton of aluminium, a price or a price fluctuation of 1 ¢/kWh equates to costs or additional costs of 150 US $.

Due to the increase in costs of primary sources of energy and the very great increase in capital costs in recent years as well as the raising of taxes for cheap electric power (hydroelectric power), it is generally assumed that there will be a significant increase in electric power prices in the future.

- Labour. The productive labour needed for the electrolysis process amounts to about 5 man hours/t of aluminium. Including labour for the foundry and the production of anodes, for maintenance operations and administration, it is assumed here that an investment of 11 man hours/t of aluminium is necessary.

A guide to the magnitude of the significant factors affecting the operating costs of a European aluminium smelter per t of aluminium, is given in the following table:

Input products	Assumed amounts consumed	Price per unit of quantity (estimated)	Operating costs in US $/t[1]	Portion of the total costs (1250 US $/t) in %
Alumina	1.93 t	220 US $/t	425	34
Fluorine	30 kg Aluminium fluoride	600 US $/t		
	20 kg Greenland spar	540 US $/t	29	2.3
Anodes	450 kg	245 US $/t	110	8.8
Energy	16,000 kWh	1.4 ¢ kWh	224	17.9
Maintenance (less manpower)			30	2.4
Labour	11 hours	8.75 U$/h	96	7.6
		Grand total	914	73

1) 1 US $ = 2.20 DM

With investment for a new smelter amounting to 2,800 US $/t per year and a capital service rate of 12 %, capital costs arise of 336 US $/t (27 % of the production costs) at full operational capacity. For newly constructed smelters the aluminium price must rise considerably over 1000 US $/t in order to be able to carry the necessary capital service.

From the assumptions described the share of the bauxite input costs (consumption 2.3 x 1.93 t of bauxite per t of aluminium, price delivered 25 US $/t) amounts to only 9 % of the production costs given or roughly 10 % of the current aluminium price.

1.4 Transport Costs

An important, in some cases even a dominant aspect of production costs of bauxite and alumina are the transport costs. A significant cost factor emerges early in the use of heavy-duty trucks in the mining operations, necessitated by the broadly spread location of bauxite occurrences. It follows that a large amount of inland transport is mostly necessary between the mining operation and the port of shipment or the alumina plant. For this, the railroad is used above all, often exclusively or predominantly for freighting bauxite, occasionally also conveyor belts (Gove/Northern Australia, Western Australia) and barges (Guyana, Sierra Leone) are used. Transport distances in these cases have hitherto seldom exceeded 150 km.

Sea freight costs make the most impact. The distance from Jamaican ports to the US Gulf ports is about 2,000 km, between Australian ports on the Gulf of Carpentaria (Gove, Weipa) and the European North Sea ports a round 24,000 km (Cape route). In 1965, 19.6 million t of bauxite and 1.9 million t of alumina were shipped, in 1974 these figures rose to 32.5 million t of bauxite and 10 million t of alumina.

Bauxite and alumina are mainly transported as bulk freight. The volume of transport in 1974 was distributed amongst the following ship tonnages:

28 %	on ships	18,000 DWT
15 %	on ships	18,000 to 25,000 DWT
33 %	on ships	25,000 to 40,000 DWT
24 %	on ships	40,000 DWT

The largest ship employed exclusively for bauxite transport has a round 76,000 DWT.

The demand for larger ships increases with the freight distances and the volume of the freight itself. Harbour facilities are however the principal factor governing the possible sizes of ships and in the case of aluminium raw materials, it is those of the producer countries which in the main limit the maximum size. With favourable tides, the Australian ports of Weipa and Gove can accept maximums of 70,000 and 80,000 DWT. The harbours of Port Kamsar and Conakry in Guinea permit the loading of ships with 30,000 respectively 50,000 DWT, the harbours of Ocho Rios and Port Rhodes/ Jamaica accept ships with 40,000 DWT. All other harbours which are important for bauxite shipment are limited to ships with up to 35,000 DWT. The alumina export harbours can, on average, turn round ships with 40,000 DWT, exceptions being the harbours of Port Vesme (Sardinia) and Gladstone/Australia which accept ships of 60,000 respectively 65,000 DWT.

Alumina freight costs are as a rule higher than those of bauxite. Here it is mainly the longer loading and discharging times, coupled with the necessary cleaning of the ships and the lower specific apparent density of alumina in a ratio of 0.75 to 1 which has to be considered, compared with that of bauxite, which for example with Australian ores amounts to roughly 1.3. In this way, a part of the cost advantage from the production of alumina in the vicinity of the bauxite deposit which arises from the reduction of the transport volume for a ton of aluminium, is compensated for. For freighting alumina from Australia to Europe the following freighting advantage emerges compared to transporting bauxite:

5 t of bauxite with 12 to 13 % moisture content per t of aluminium (about 10 US $/t of bauxite)	50 US $
1,93 t of alumina per t of aluminium (about 15 US $/t alumina)	29 US $
savings due to transporting alumina per ton	21 US $

The following table shows some examples of sea freight rates for tramp shipments:

Bauxite

Year	Port of departure	Destination	Ship size in DWT	Freight rate (fio) in US $
1975	Weipa/Australia	Porto Vesme/ Sardinia	55,000	6.50
		Stade/Federal Republic of Germany	50,000	5.30
	Gove/Australia	Fos/France	75,000	5.00
	Port Kamsar/ Guinea	US Gulf ports	40,000	4.00
	Port Rhodes/ Jamaica	Baton Rouge	33,000	2.25
1976	Weipa	Porto Vesme	50,000	9.10
	Gove	Stade/Federal Republic of Germany	68,000	8.50
	Port Kamsar	US Gulf ports	35,000	4.00
	Dominican Republic	Point Comfort	24,000	2.60

Bauxite, continuation

Year	Port of departure	Destination	Ship size in DWT	Freight rate (fio) in US $
1977	Weipa	Porto Vesme	50,000	9.00
		Fos	55,000	8.50
	Conakry	Russian Black Sea coast	27,000	8.15
	Jamaica	Baton Rouge	38,000	1.85

Alumina

Year	Port of departure	Destination	Ship size in DWT	Freight rate (fio) in US $
1975	Gove	Rotterdam	50,000	9.75
		US Gulf ports	25,000	8.30
	Gladstone/ Australia	Karmoy/Norway	35,000	14.50
		Ferndale/ US West coast	35,000	6.00
	Kwinana/ Western Australia	Ferndale	40,000	5.65
		Bahrein	26,000	8.25
	Paranam/ Surinam	Burnside/USA	9,800	7.65
1976	Gove	Stramsvik/ Iceland	37,000	16.50
	Gladstone	Tacoma/US West coast	50,000	6.66
	Kwinana	Vancouver/ Canada	30,000	6.90
	Port Kaiser/ Jamaica	Gdingen/Poland	25,000	10.75
1977	Gove	Stramsvik	35,000	12.90
	Gladstone	Tacoma	50,000	6.20

2) Prices

2.1 General Comments

The trading forms of aluminium and its raw materials are principally bauxite, alumina (oxide of aluminium) and aluminium metals (primary aluminium, secondary aluminium), also semi-fabricated aluminium products and aluminium scrap.

For bauxite and alumina the prices quoted are related to tons, primary aluminium prices in North America to pounds (lbs.), in Europe to tons, 100 kg or kg.

Trade

Bauxite and alumina trading is largely carried out on a basis of longterm agreements. In view of the high degree of integration within the aluminium industry itself, it is largely conducted between companies owned by the concern. Together with the very varied qualities of bauxite on the market, it is one of the main reasons why there are no regular publications of price quotations affecting bauxite and alumina for metallurgic use in international periodicals.

The assessment of bauxite is based in the first instance on

- the Al_2O_3 content
- the content of reactive silica
- the mineralogical constitution of the aluminium oxide minerals.

The contents of traded bauxite today are normally between 45 % and 55 % of Al_2O_3 and not more than 5 % of SiO_2. The silicic acid content affects the yield and the soda consumption during dissolving to alumina (see III 1.2); it reduces the value.

Compared with trihydric bauxite, monohydric bauxite requires a higher temperature for dissolution and therewith a greater amount of energy.

French bauxites which normally have contents of 55 % Al_2O_3 and 5 % of SiO_2 were for example in 1975, assessed in accordance with the following schema:

$$\begin{array}{ll} & Al_2O_3 \text{ - content (in \%) x 1.8 Francs} \\ \text{minus} & SiO_2 \text{ - content (in \%) x 5.4 Francs.} \end{array}$$

The current factors are probably around 2.7 Francs per % Al_2O_3 and 7.2 Francs per % SiO_2.

Bauxite for the refractory and abrasive industries are normally sold in calcinated form. Refractory bauxite normally contains more than 86 % Al_2O_3, a maximum of 7.5 % SiO_2 and 2.5 % of Fe_2O_3, abrasive bauxite between 80 and 88 % Al_2O_3, 4 to 8 % of SiO_2 and 2 to 5 % of Fe_2O_3.

The primary aluminium-metal market is predominantly a producers' market. The North American producers have always been the price leader, whereby the ALCOA price list has decisively influenced prices in the US domestic market. The so-called "World price" is the Canadian export price which influences the market price in the rest of the Western World.

Free trade (known as "certain other transactions" in the "Metal Bulletin") in primary aluminium is of only little significance compared with the producers' market.

It is estimated that only 10 % of the aluminium ingots sold in the USA emanate from the free trade. The freely traded quantities in the Western World are constituted by those offered from the Eastern Block countries and the smaller producers.

With an increase in the number of sellers, coupled with the increase in smelting capacities surplus to internal requirements, there should nevertheless be an increase in free trade.

Exchange trading in primary aluminium metal has hitherto not taken place. However, in October 1977, the LME officially committed itself to the introduction of an aluminium contract in the future. This should bring about the realization of that which has been striven for from many sides but which up till now has failed, due to the small quantities of primary aluminium which are freely traded and the opposition from the aluminium industry.

Price Publications

Prices for bauxite are only regularly published for calcined, non-metallurgical qualities and then in the periodical "Engineering and Mining Journal", New York, for refractory qualities and in the periodical "Industrial Minerals", London, for both refractory and abrasive qualities.

Their share of about 5 % of the total amount of bauxite sold, is however small.

Price guidelines for metallurgic bauxite of French origin were published regularly up till 1973 in the periodical "Journal de Four Electrique et des Industries Electrochimiques", and also in "Mines et Métallurgie". Since then, information has only been given by sporadic notes, in particular in "Metals Weeks" and "Japan Metal Bulletin".

Prices regularly appear for calcined alumina, in "Industrial Minerals." For alumina required for aluminium production the notes given for metallurgic bauxite apply.

Of the many published price quotations for aluminium metal (predominantly primary metal in ingots) the following are particularly important:

- The so-called "World price", which is the Canadian export price for virgin ingots, quoted in US cts/lb, c.i.f. all main ports excluding the USA, Canada, Latin America, and U.K., is published in particular in "Metal Bulletin", London and in "Metals Week", New York;
- the European free market price cited with "certain other transactions" in the "Metal Bulletin", "in-warehouse Europe, duty unpaid", given in £/t, respectively since July 1976 in US $/t.

Besides US producer prices and US market prices are given in cts/lb. ("Metals Week"), further producer prices for Latin America, Australia, France, Italy, Japan, U.K. and the Federal Republic of Germany are quoted in their respective currencies, whereby the amounts for sale and also the qualities are not always uniform. These quotations have all been taken over by the "Metal Bulletin" from the appropriate national periodicals.

A metal content of 99.5 % of Al is normally accepted as the price basis for primary aluminium. Higher purity grades and smaller deliveries (a few tons) lead to surcharges.

Tariffs

The bauxite trade is fundamentally free of customs duties. Imports of alumina are free in the USA and in trade within the EC countries as well as between these countries and the developing countries. Imports into the EC from the remaining countries are as a rule subject to 5.5 % duty.

Raw aluminium is traded in free of duty within the EC countries and this applies to their imports from associated countries. Tariff rates equivalent to up to 7 % of the import value apply for imports from other countries. The USA levy tariffs at 4 cts/lb (imports from communist countries) and 1 ct/lb (imports from other countries), Japan as a rule applies 9 % of the import value.

2.2 Price Developments from 1966 to 1977

Compared with that of other metals the development of the aluminium price in the past has proved to be relatively stable. This applies particularly to the "World price" already mentioned, which on average only rose by about 1 % per annum during the period 1960 to 1973. The steep increase established in prices after 1973/74 for almost all other metals was less pronounced in relation to aluminium.

The development in monthly prices for primary aluminium based on the "World price" and the European free market price can be seen in Fig. 12. The prices are uniformly presented in US $/t (compare with annex 8 also).

World prices and free market prices generally run on a parallel but the free trading price is constantly lower, with the exception of the boom years of 1969/70 and 1973/74. The very much more even "World price" does not however reflect the prices actually paid as consideration is not given to the in part considerable rebates. Dependant on the market situation, these often amount to 10 % and more.

Fig. 12 also shows the trend of the "World price" in the Federal Republic of Germany, expressed in DM/t, and also deflated to conform to the general index of wholesale prices of the Statistisches Bundesamt in Wiesbaden. Whereas the "World price" in $/t increased by 85 % in the period from the beginning of 1970 to middle 1977, the increase in DM/t which was determined by the up-valuing of the DM was only 17 %. In real terms the aluminium price in fact fell by roughly 27 % which resulted in problems for the German aluminium industry which were not insignificant.

Fig. 13 shows a comparison amongst the half-yearly average prices (producer prices converted to US $/t) , in the USA, the Federal Republic of Germany, in France, U.K., and Italy. The trend here was more or less uniform up till the beginning of 1972. In the following period temporary variations of price emerged in the countries observed rising to a maximum of over 60 %.

In Fig. 14 the prices of aluminium are compared with those of its most important metal competitor, which is copper.

The price ratio of copper to aluminium became steadily smaller (in December 1966: 2.39, 1970: 2.27, 1975: 1.68 and mid-1977 was only 1.26). Related to the volume of the metals, copper cost 8 times as much as aluminium in 1966, in mid-1977 only 4 times as much.

Fig. 15 shows the trend of bauxite and alumina prices for German imports from 1966 to 1976. Thereafter, the average prices were, 1976 23.60 US $/t (59.55 DM/t) for bauxite and 136.00 US $/t (342.26 DM/t) for alumina cif German border. For spot sales in mid-1977, prices of 9.50 $ to 12 $/t of bauxite and 120.00 US $/t of alumina fob Australian ports were known.

Fig. 12

AVERAGE MONTHLY ALUMINIUM (VIRGIN INGOTS) PRICES

1966-1977 (Converted to US-$ per metric ton)

(according to "METAL BULLETIN", London)

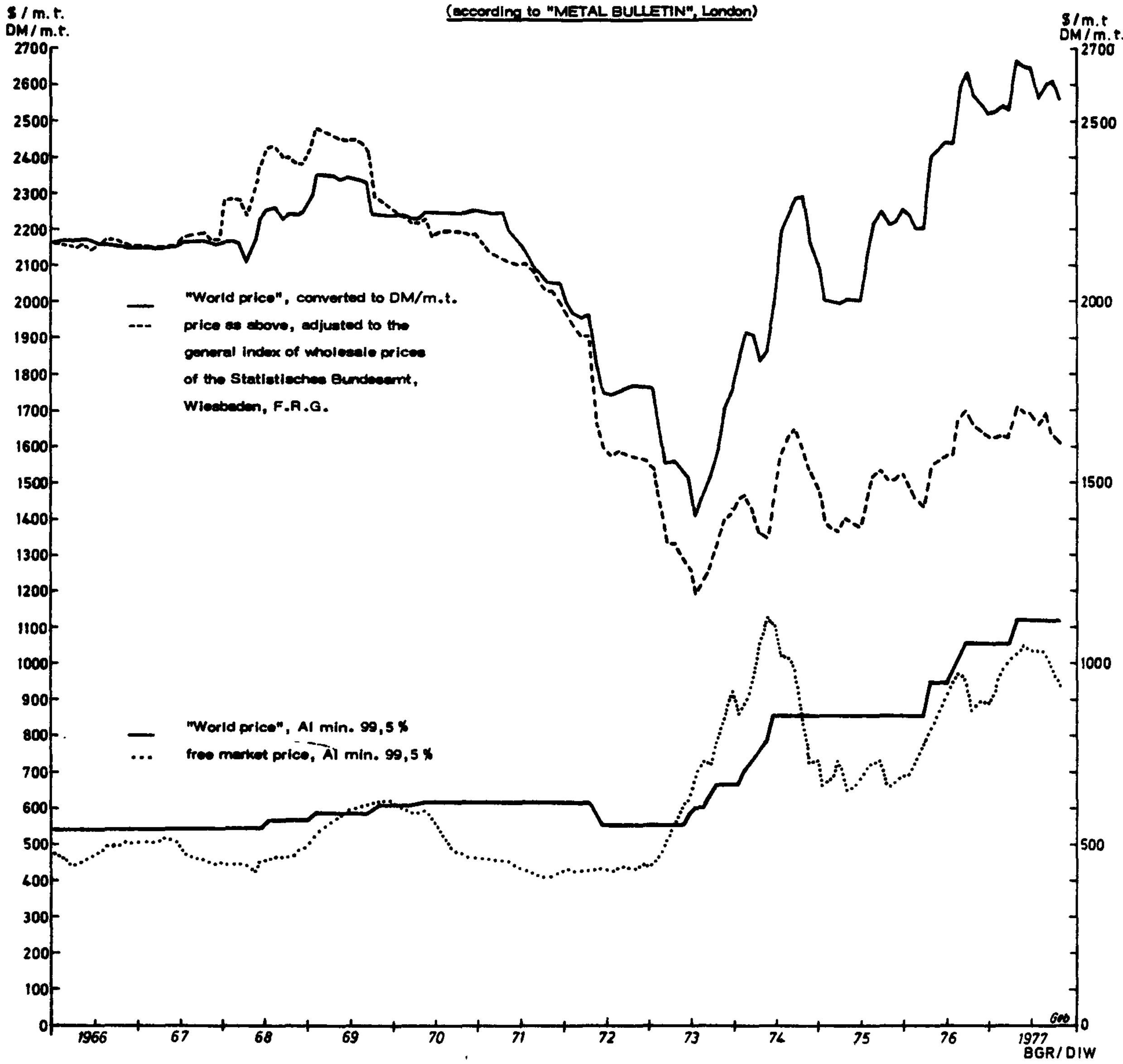


Fig. 13

HALF YEARLY ALUMINIUM PRICES
(VIRGIN INGOTS) IN SELECTED COUNTRIES
for 1966-1977 (at the end of June and December)
(according to "METAL BULLETIN", London)

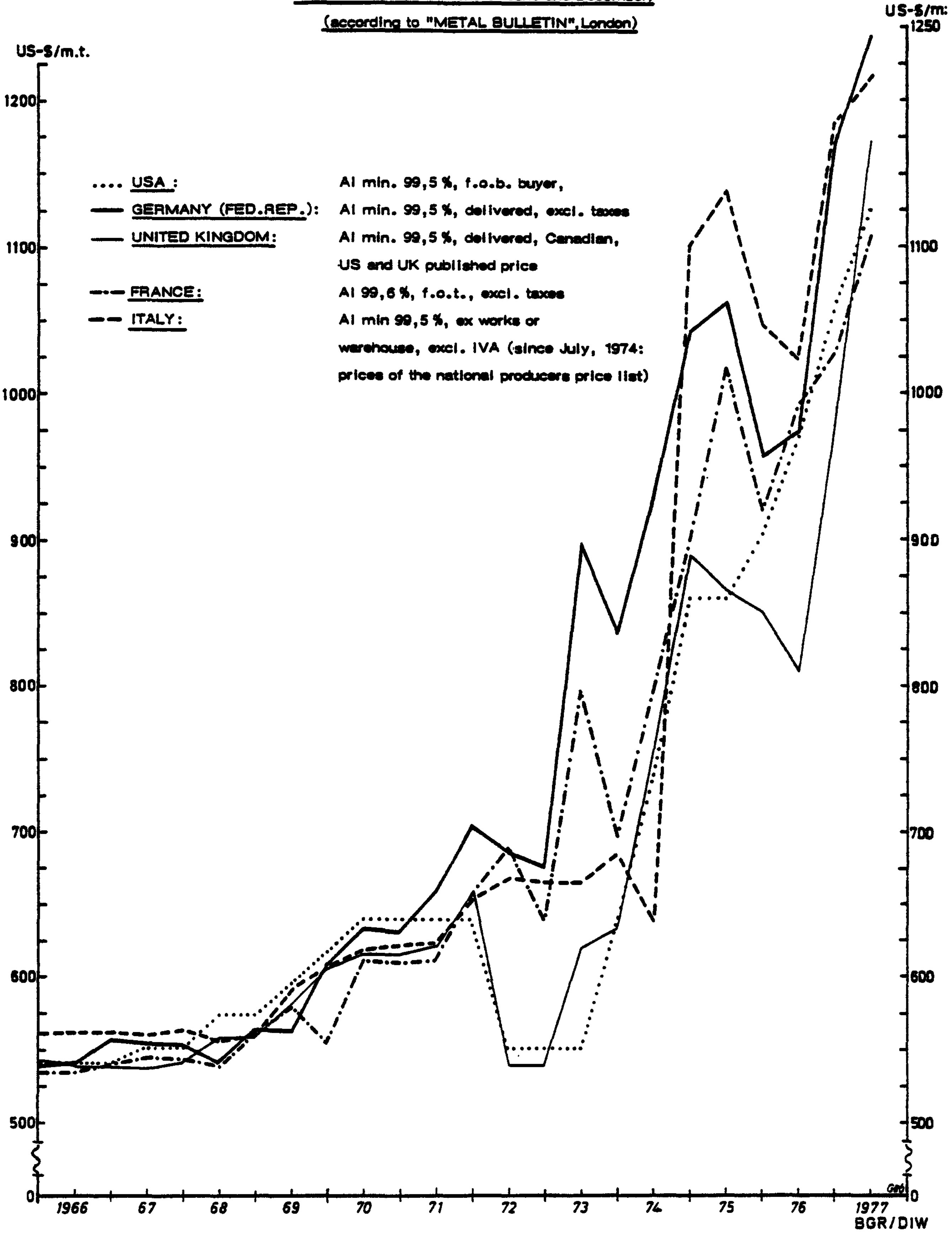


Fig. 14

COMPARISON OF HALF-YEARLY ALUMINIUM PRICES AND COPPER-PRICES

for 1966-1977 (at the end of June and December)

(according to "METAL BULLETIN", London)

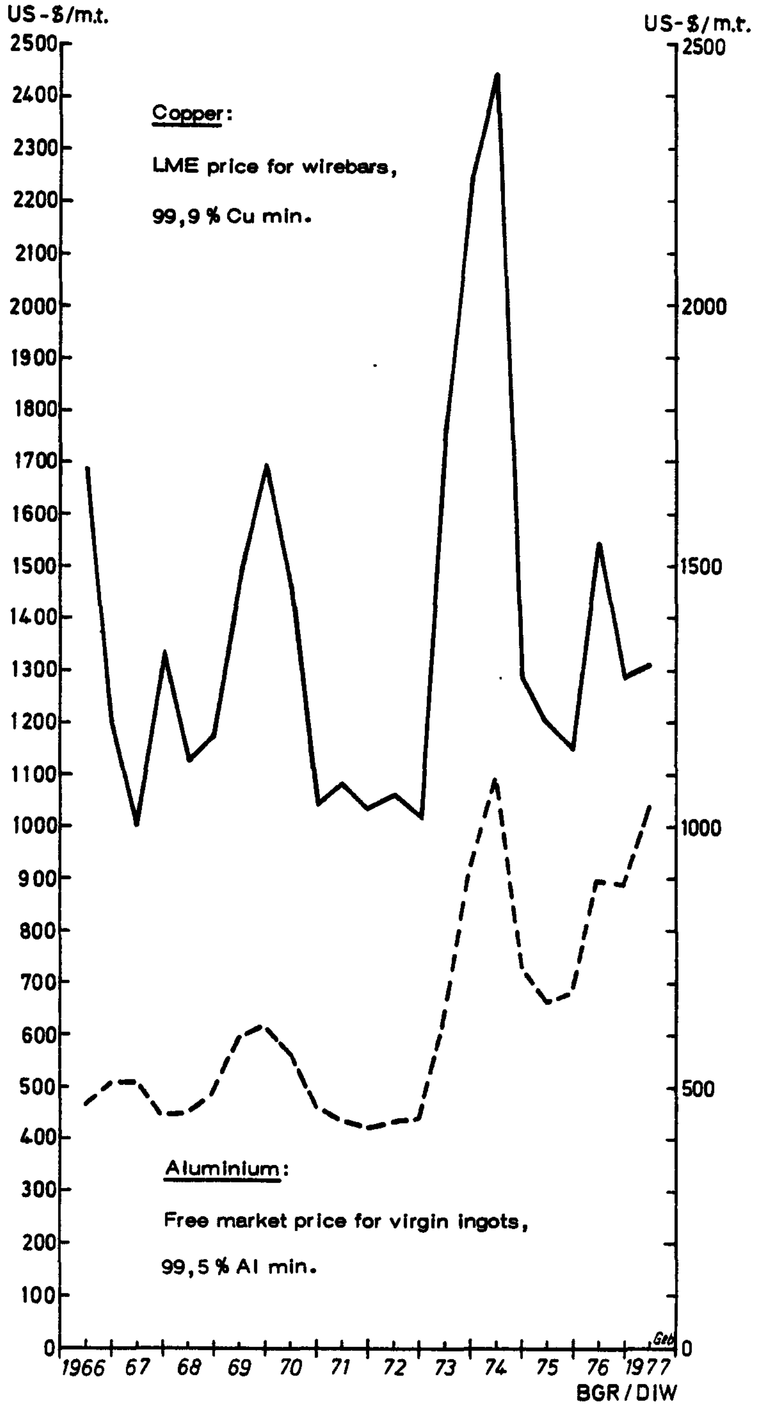
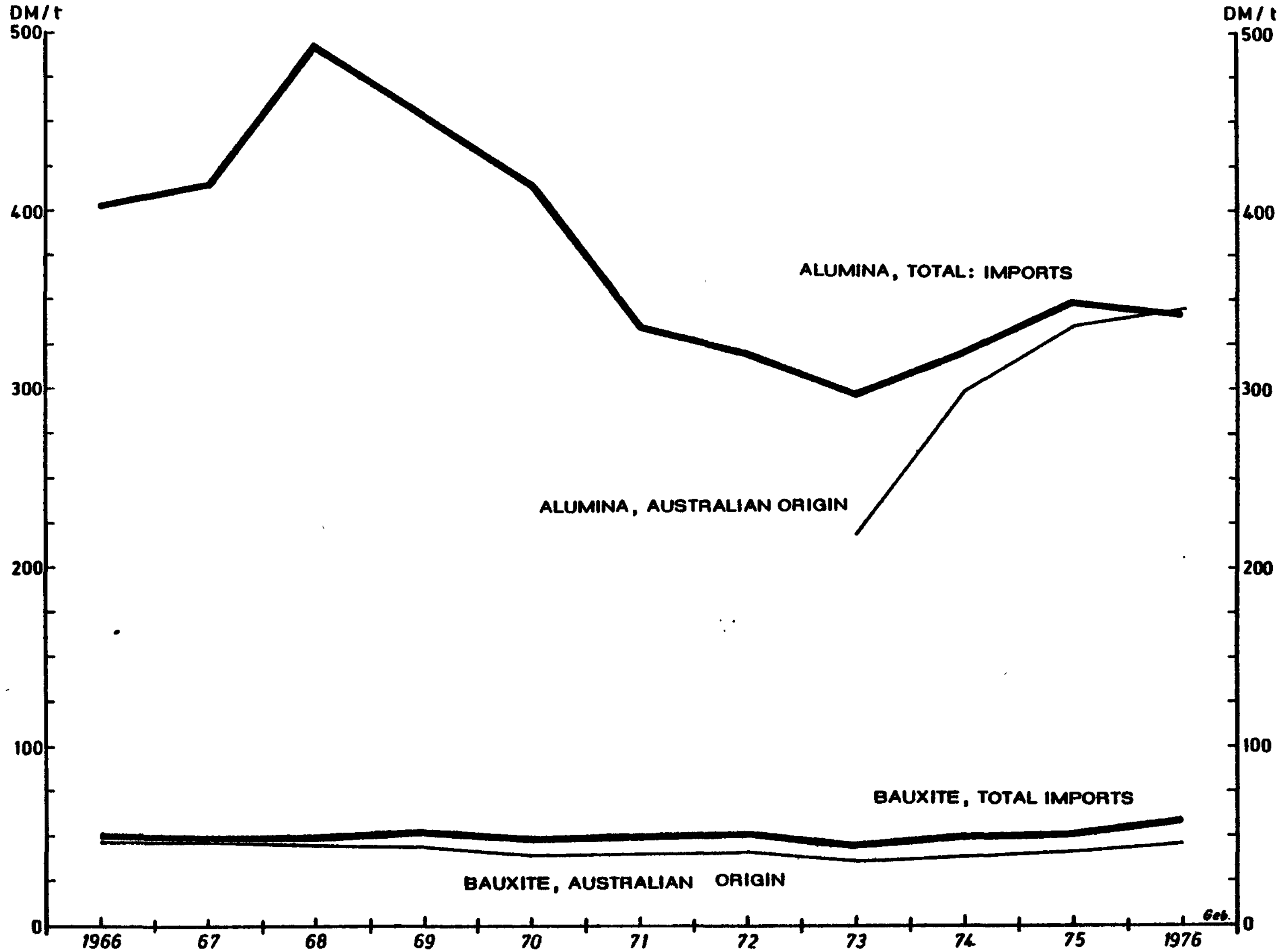


Fig. 15

AVERAGE ANNUAL IMPORT VALUES OF BAUXITE AND ALUMINA, DELIVERY FREE TO GERMAN BORDER

(TURNOVER TAX EXCLUDED) 1966 - 1976 (according to Statistisches Bundesamt, Wiesbaden)



BGR/DIW

III. The World Demand for Aluminium

1) Consumption of Primary Aluminium

The consumption of primary aluminium is calculated yearly by the Metallgesellschaft, Frankfurt, for 51 of the world's countries and is published in the periodical "Metallstatistik". From 7.62 million t in 1966 consumption rose thereafter in the world to 13.86 million t in 1976, an annual average increase of 6.2 %. Up till 1974 a continuous rise in world consumption could be observed that was interrupted by the economic recession in 1975. There was an increase in consumption again in 1976 compared to 1975, but consumption in this year remained below that in 1974.

Almost 79.2 % of primary aluminium consumed in the world was used in the Western World and the balance in the East Block countries. The stagnation of aluminium consumption in the Western World in 1975 and 1976 led to a reduction of the share, compared with earlier years, of over 2 %.

In 1976, 37.4 % of primary aluminium was used in the American countries, 25.3 % in Western Europe (18.9 % in EC countries), 14.1 % in Asia (less East Block countries) and about 1 % each in Australia/Oceania and Africa. In comparison with this, the Americas' share of world consumption in 1966 was 47.8 %, that of Western Europe was 23.8 % (EC countries 13.9 %) and that of Asia 7.3 %.

Table 40 shows the consumption of primary aluminium in the world by country, for the period 1966 to 1976. The trend in consumption according to region is contained in Table 41.

Accordingly, the growth of consumption as viewed over the whole of the period observed was higher in the East Block than in the Western World.

In the Western World the consumption of aluminium rose most sharply in Asia and in Africa. In the EC countries the increase of consumption of aluminium was proportionally higher than the trend for the Western World, but it was clearly less than the growth rate in the other countries of Western Europe.

From the comparison of the average annual growth of consumption in 1971 to 1976 and 1966 to 1976, it can be seen that the consumption of aluminium in Western Europe and in the EC countries, compared with all other regions in the world, increased more sharply between 1971 and 1976 despite the recession in 1975 and 1976, than in the entire period from 1966 to 1976.

Table 40

World Primary Aluminium Consumption ; 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Germany FR	419.5	416.8	539.3	642.3	669.8	684.4	724.4	855.7	872.5	703.7	954.4
Belgium/Luxembourg	149.4	133.2	152.3	166.0	174.9	190.9	200.9	218.6	232.8	178.2	244.0
Denmark	5.9	5.2	7.4	6.9	9.2	9.1	0.7	3.3	3.0	5.0	6.2
France	298.3	294.0	293.5	367.1	413.3	377.4	398.3	450.1	480.0	399.2	492.6
United Kingdom	362.9	356.6	388.4	387.7	404.2	325.6	408.2	487.8	493.6	392.7	444.5
Ireland	10.4	8.4	8.4	8.3	5.1	3.2	3.9	3.1	3.7	2.9	5.8
Italy	171.0	184.0	217.0	258.0	279.0	254.0	304.0	336.0	375.0	270.0	365.0
Netherlands	23.1	26.0	31.4	53.4	52.6	59.2	79.4	94.3	103.7	87.1	105.8
EC Countries	1,440.5	1,424.2	1,637.7	1,889.7	2,008.1	1,903.8	2,119.8	2,448.9	2,564.3	2,038.8	2,618.3
Iceland	-	-	-	-	-	0.9	-	-	0.3	0.1	0.1
Norway	26.1	39.3	54.0	68.1	73.4	83.0	97.0	108.0	93.5	87.8	113.6
Finland	11.2	13.6	11.0	14.6	18.7	14.7	15.3	18.5	24.7	25.0	28.5
Greece	10.8	11.1	14.4	15.1	29.3	27.0	28.7	37.3	41.2	39.2	51.0
Yugoslavia	69.0	63.5	61.2	63.3	100.0	71.8	88.7	107.8	125.7	127.6	140.0x)
Austria	46.0	50.0	60.0	70.0	75.0	72.7	76.4	86.6	80.8	83.7	106.6
Portugal	0.8	0.6	0.7	0.7	1.7	1.6	2.4	3.9	6.3	4.4	8.3
Sweden	59.6	53.4	62.1	76.4	78.7	79.0	88.5	99.6	114.0	110.0	114.9
Switzerland	65.1	62.7	70.5	81.2	92.3	87.9	102.9	111.5	113.2	84.4	104.6
Spain	84.7	78.2	98.2	128.1	129.1	150.4	172.1	186.1	225.7	216.8	222.5
Europe without East Block	1,813.8	1,796.6	2,069.8	2,407.2	2,606.3	2,492.8	2,791.8	3,208.2	3,389.7	2,817.8	3,508.4
Hong Kong	7.2	9.9	13.5	11.6	15.2	12.5	15.6	18.4	24.0	22.5	21.8
India	93.0	118.5	128.0	114.7	162.0	193.0	172.9	148.5	124.6	145.0	170.0
Iran	6.1	3.9	5.0	7.6	5.8	5.8	7.0	17.7	26.3	35.9	36.2
Israel	7.0	5.3	10.5	10.9	12.3	14.4	12.0	12.9	25.0	10.4	14.9
Japan	393.4	496.6	621.1	807.1	911.4	972.9	1,216.3	1,611.8	1,303.0	1,170.8	1,488.4
Korea (South)	4.7	7.4	8.5	12.6	15.3	17.0	18.5	36.4	25.8	34.1	41.9
Lebanon	2.6	3.7	4.3	7.4	7.7	7.3	9.8	10.0x)	14.3	18.6	2.7
Malaysia	1.6	1.5	1.6	1.5	0.2	1.9	5.2	5.4	10.4	5.8	7.6
Philippines	7.2	7.5	9.3	10.3	10.5	10.0	11.1	15.3	18.4	8.4	14.3
Taiwan	15.1	17.3	20.3	25.5	34.2	30.8	36.9	45.0	36.8	45.7	48.6
Thailand	3.9	4.6	5.2	6.0	8.4	9.4	7.5	14.6	23.1	21.0	13.6
Turkey	8.2	9.3	13.1	13.3	13.7	27.7	28.7	36.7	47.5	63.4	68.6
other Asia	6.5	15.0	11.2	5.9	14.3	4.5	5.3	9.0	17.0	17.5	25.2
Asia without East Block	556.5	700.5	851.6	1,034.4	1,211.0	1,307.2	1,546.8	1,981.7	1,696.2	1,599.1	1,953.8
Egypt	8.3	8.5	8.1	4.6	4.7	11.3	12.0x)	13.0x)	15.0x)	15.0x)	20.0x)
Cameroon	-	6.6	8.4	10.0	11.2	17.5	16.4	14.2	21.4	26.9	31.6
South Africa	27.3	17.6	24.2	41.2	49.1	51.9	53.8	65.0	70.0	68.0	68.0
other Africa	7.8	3.1	4.5	5.2	5.5	10.6	9.2	15.7	10.8	18.2	20.5
Africa	43.4	35.8	45.2	61.0	70.5	91.3	91.4	107.9	117.2	128.1	140.1

x) estimate

Table 40 continued

World Primary Aluminium Consumption : 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
United States	3,281.3	3,119.3	3,587.0	3,705.8	3,488.3	3,927.0	4,298.8	5,076.2	5,127.5	3,265.0	4,434.9
Argentina	36.9	31.0	40.2	52.6	50.7	59.3	79.4	73.5	82.8	72.9	56.7
Brazil	72.1	78.0	80.5	84.0	84.4	106.6	137.8	157.6	185.2	209.2	217.9
Colombia	8.6	6.7	7.0	8.0	8.9	10.3	9.2	11.9	12.8	.8.9	10.0 x)
Canada	208.0	190.0	203.0	212.0	220.0	258.5	279.0	301.0	358.0	286.0	355.6
Mexico	20.7	23.4	26.8	29.4	31.8	35.1	46.4	54.8	67.2	51.6	45.0
Venezuela	1.7	3.5	0.5	7.5	9.9	11.9	14.2	20.6	24.9	39.2	44.5
other America	10.0	10.7	12.3	13.0	15.6	17.2	19.0	20.2	22.4	18.5	18.3 x)
America	3,639.3	3,462.6	3,957.3	4,112.3	3,909.6	4,425.9	4,883.8	5,715.8	5,880.8	3,951.3	5,182.9
Australia	75.8	82.5	103.9	107.0	124.3	138.9	112.1	151.3	175.8	137.9	168.4
New Zealand	8.0	10.1	6.9	9.8	13.3	14.7	15.2	33.1	35.8	20.9	22.4
other Oceania	-	-	-	-	-	-	-	-	0.3	-	-
Australia and Oceania	83.8	92.6	110.8	116.8	137.6	153.6	127.3	184.4	211.9	158.8	190.8
Western World total	6,136.8	6,088.1	7,034.7	7,731.7	7,935.0	8,470.8	9,441.1	11,198.0	11,295.8	8,655.1	10,976.0
USSR	1,044.3	1,146.9	1,212.4	1,230.0	1,330.0	1,395.0	1,445.0	1,480.0	1,550.0	1,580.0	1,690.0
Bulgaria	10.0	16.5	17.5	14.0	16.5	25.2	30.5	35.0	36.0	38.0	40.0 x)
Germany DR x)	140.0	150.0	150.0	150.0	155.0	160.0	170.0	180.0	200.0	200.0	210.0
Poland	60.0	90.0	105.0	120.0	120.0	117.0	125.0	134.0	134.0	138.0	145.0
Rumania x)	27.0	24.0	27.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	95.0
Czechoslovakia	55.0	68.0	86.0	110.0	107.0	117.0	130.0	140.0	160.0	153.0	158.0
Hungary	45.4	62.1	71.6	79.8	91.8	128.2	123.0	137.3	155.8	166.0	175.0 x)
China VR x)	95.0	130.0	160.0	180.0	180.0	190.0	200.0	230.0	250.0	300.0	350.0
other East Asia x)	2.0	3.0	3.0	5.0	5.0	5.0	7.0	10.0	15.0	20.0	22.0
Cuba	0.2	1.1	0.1	1.0	0.9	0.9	1.0	1.0	1.0	1.0	1.0
East Block total	1,478.9	1,691.6	1,832.6	1,919.8	2,046.2	2,188.3	2,291.5	2,417.3	2,581.8	2,686.0	2,886.0
World total	7,615.7	7,779.7	8,867.3	9,651.5	9,981.2	10,659.1	11,732.6	13,615.3	13,877.6	11,341.1	13,862.0

x) estimate

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

Table 41

Consumption of Primary Aluminium according to Region

region	1966	1971	1976	average annual growth 1971 - 76	1966 - 76
	in 1000 t	in 1000 t	in 1000 t	in %	in %
Europe[1)]	1,813.8	2,492.8	3,508.4	7.1	6.8
EC Countries	1,440.5	1,903.8	2,618.3	6.6	6.2
Asia[1)]	556.5	1,307.2	1,953.8	8.4	13.4
Africa	43.4	91.3	140.1	8.9	12.4
America	3,639.3	4,425.9	5,182.9	3.2	3.6
Australia/Oceania	83.8	153.6	190.8	4.4	8.6
Western World	6,136.8	8,470.8	10,976.0	5.3	6.0
East Block	1,478.9	2,188.3	2,886.0	5.7	6.9
World total	7,615.7	10,659.1	13,862.0	5.4	6.2

1) excluding East Block

In Table 42 the pattern of aluminium consumption is shown for the major consumer countries.

Table 42

Consumption of Primary Aluminium in the Major Consumer Countries: 1966 - 1976

country	consumption of primary aluminium 1966	1976	percentage of world consumption 1966	1976	average annual growth 1971 - 76	1966 - 76
	1000 t	1000 t	%	%	%	%
Belgium/Luxembourg	149.4	244.0	2.0	1.8	5.0	5.0
Germany FR	419.5	954.4	5.5	6.7	6.9	8.6
France	298.3	492.6	3.9	3.6	5.5	5.1
United Kingdom	362.9	444.5	4.8	3.2	6.4	2.0
Italy	171.0	365.0	2.2	2.6	7.5	7.9
Spain	84.7	222.5	1.1	1.6	8.1	10.1
Japan	393.4	1,488.4	5.2	10.7	8.9	14.2
Brazil	72.1	217.9	0.9	1.6	15.4	11.7
Canada	208.0	355.6	2.7	2.6	6.6	5.5
USA	3,281.3	4,434.9	43.1	32.0	2.5	3.1
Australia	75.8	168.4	1.0	1.2	3.9	8.3
GDR	140.0	210.0	1.8	1.5	5.6	4.1
USSR	1,044.3	1,690.0	13.7	12.2	3.9	4.9
PR China	95.0	350.0	1.2	2.5	13.0	13.9

Of the 1976 world consumption, 32 % was taken up by the USA, 12.2 % by the USSR and 10.7 % by Japan, all in all almost 55 % used by the three largest consumer countries. Including the Federal Republic of Germany, France, and Great Britain brings this figure to 68.4 % of world consumption concentrated in just six countries. All other countries are only represented with consumer shares of less than 3 % in each case.

Compared with world consumption (1966 - 1976: 6.2 % average annual growth), there has been a proportionally greater increase in the consumption of primary aluminium in this period in the Federal Republic of Germany, in Italy, Spain, Japan, Brazil, Australia,and in the People's Republic of China. On the other hand an increase proportionally less occured in Belgium/ Luxembourg, France, Great Britain, Canada, in the USA, in the German Democratic Republic, and in the USSR.

In Western Europe, the Federal Republic of Germany was already by far the largest consumer of primary aluminium in 1966, followed by Great Britain and France. Up to 1976 the share of the Federal Republic of Germany had increased to 27.2 %, due to a sharp increase in consumer growth in comparison to the other large consumer countries, whereby a hitherto maximum consumption of more than 954,000 t (1976) was achieved.

France is currently the second largest consumer of primary aluminium in Western Europe. In 1976 almost 493,000 t of primary aluminium was consumed in France (14 % of consumption in Western Europe).

In Great Britain the consumption of primary aluminium between 1966 and 1976 has on average risen annually by only 2 %. The consumption therefore of just 445,000 t in 1976 amounted to a share of only 12.7 % of the consumption in the Western European countries (20 % in 1966).

Within Western Europe, Italy too had a sharp rise in consumption. By 1976 the consumption in Italy rose to 365,000 t (A share of 10.4 % in the consumption in Denmark and Ireland, the aluminium consumption of the EC countries rose in 1976 to 2.62 million t. Therewith it attained a share of 74.6 % of the consumption in Western European countries.

Outside the EC, but within Western Europe, Yugoslavia, Norway, Austria, Sweden, Switzerland and Spain have an annual consumption of more than 100,000 t of primary aluminium.

Of the primary aluminium consumed in Asia (less East Block) in 1976, more than 76 % was consumed in Japan. Between 1966 and 1976 the consumption rose in Japan from 393,400 t to 1.49 million t, an annual average increase of 14.2 %. Since 1971, however, the growth rate in consumption has reduced to an annual average of 8.9 %. As the second largest consumer of aluminium in Asia, India consumed 170,000 t in 1976 and in this year added a further 8.7 % of the Asian aluminium consumption.

In the African countries recorded, a total of only 140,000 t of primary aluminium were consumed in 1976 (equivalent to 1 % of the world consumption).

In the Americas more than 90 % was used by the USA in 1966, only 86 % in 1976. Compared with a consumption in the USA of 4.43 million t in 1976, both Canada (356,000 t or 6.9 %) and Brazil (218,000 t or 4.2 %) were only of minor significance despite sharply increased growth in consumption rates. With the inclusion of the smaller consumer countries, more than 37 % of the world consumption of primary aluminium in 1976, was consumed in the Americas.

In Australia and New Zealand in 1976, just 191,000 t of primary aluminium were consumed (1.4 % of world consumption).

In the East Block, the USSR is by far the largest consumer of primary aluminium, but nevertheless the share of the USSR in terms of East Block consumption fell from 70.6 % in 1966 to just 59 % in 1976. In 1976, more than 100,000 t were consumed by the People's Republic of China (12 % of total consumption in the East Block) the German Democratic Republic (7 %), Hungary (6 %), Czechoslovakia and Poland (each about 5 %).

2) The Total Consumption of Aluminium

The total consumption according to country is more or less above that of primary aluminium because significant quantities of secondary aluminium and aluminium scrap were also used by most industrial countries. The Metallgesellschaft has calculated and estimated the total consumption of aluminium from 23 individual countries of the Western World and groups of countries. An adequately accurate estimate of the proportion of secondary to the total consumption of the country concerned can be obtained from the difference between consumption of primary aluminium and the total consumption. In Table 43 the share of secondary aluminium and direct scrap input of the total consumption by selected countries is given for 1966 and 1976.

It can be seen from the table that the share of secondary material in the total consumption between 1966 and 1976 throughout the world has only slightly increased. It is notable that the East Block share of secondary material is higher than that of the Western World. This can presumably be traced to state organized scrap metal collection and to a consumption pattern differing from that in the western countries (e.g. less packaging material made from aluminium).

In the Western World, Great Britain, the Federal Republic of Germany, Japan, and the USA consume the largest proportion of secondary material to the total aluminium production. This is due in no minor way to the substantial foundry industry and the associated secondary smelters in these countries. This is why the total consumption of aluminium in these countries is considerably greater than the consumption of primary aluminium.

Table 43

Proportion of the Use of Secondary Aluminium and the Direct Use of Scrap to the Total Aluminium Consumption in Selected Countries: 1966 and 1976

(in %)

	1966	1976
Belgium/Luxembourg	1.6	1.1
Germany FR	29.6	24.5
France	16.6	11.6
United Kingdom	32.6	28.1
Italy	32.1	38.1
EC-Countries[1)]	25.5	25.0
Yugoslavia	0.0	6.1
Norway	10.4	4.2
Austria	9.4	7.0
Sweden	15.6	17.3
Switzerland	17.2	8.2
Spain	14.2	16.6
Western Europe[2)]	23.4	21.2
Japan	21.9	22.6
Asia[3)]	18.6	20.0
Africa	15.4	7.2
Brazil	5.4	11.4
Canada	11.8	8.4
USA	20.2	22.8
America[4)]	19.4	21.2
Australia/Oceania	13.3	13.6
Western World	20.5	20.9
East Block	21.3	22.4
World total	20.6	21.2

1) including the other EC Countries

2) including the other Western European countries

3) including the other Asian countries, excluding the East Block

4) including the other American countries

In Table 44, the total consumption of aluminium is shown according to country and region for the period 1966 to 1976, based on data from the Metallgesellschaft. Fig. 16 shows the pattern of the total consumption of aluminium in the world from 1966 to 1976. As shown, the total consumption in the world rose from 9.6 million t in 1966 to 17.6 million t in 1976. This means an annual increase of 6.3 % and slightly more sharply than the consumption of primary aluminium (6.2 %). Of the 1976 consumption almost 79 % was used by the Western World and 21 % by the East Block. Compared with 1966 there was a slight drop in the share of the Western World. On the other hand, significant changes have emerged amongst the shares of the individual continents within the Western World. Americas' share of world consumption in this period fell from 47 to 37 %, whereas, the Asian share (less East Block) rose from 7 to 14 %. Western Europe's share remained almost constant. This can be traced to consumption trends in countries outside the EC. In Table 45, the shares of the individual regions together with selected consumer countries, in terms of aluminium consumption, are shown for 1966 and 1976.

In Appendix 9, the regional distribution of aluminium consumption by countries is shown for 1976.

3) Comments on the Structure of Aluminium Consumption in Manufacturing

3.1 Aluminium Consumption in the first Processing Stage

In the first processing stage, aluminium is processed to semi-fabricated and forged products, cast products, powder, paste and granules. The breakdown for selected countries in 1975, according to the statistics of the OECD, Paris, is as shown in Table 46.

In the EC countries, more than 66 % of the aluminium consumption in the first processing stage was taken up by the various semi-fabrications (sheets, strips, etc. 30 %, rods and profiles 19 %, wire and calbe 9 %, pipe 3 %, discs and circles 3 %, slugs with pressed and forged products about 2 %, cast products 26 %, foil 6 %, and powder, flakes and paste 2 %).

The share of the semi-fabricated sector in 1975 in Japan and the USA was more than 71 % and almost 78 %, respectively, higher than the corresponding value for the EC countries. Castings, with 25 % and 15 %, respectively, were of comparatively lesser significance in these two countries.

In Appendices 10a - 10h, the development of aluminium consumption in the 1st processing stage for the Federal Republic of Germany, for France, Great Britain, Italy, Austria, Switzerland, Japan, and the USA are shown according to statistics from the OECD and the Metallgesellschaft for the years 1965 to 1975. Due to complete rearrangement of the statistics by the OECD, Paris, in 1973, a longer-term observation of developments in the individual sectors based on these statistics is no longer possible.

Table 44

Total World Aluminium[1] Consumption ; 1966 - 1976

in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Germany FR	595.5	587.2	748.6	878.1	881.0	918.3	969.6	1,140.8	1,145.5	957.4	1,263.7
Belgium/Luxembourg	151.9	134.7	154.5	168.7	176.9	193.1	203.8	225.7	238.7	180.9	246.6
Denmark	13.7	12.3	14.9	14.4	16.5	16.6	10.0	12.4	12.6	13.5	15.2
France	357.6	374.8	386.5	456.3	491.6	475.2	510.2	584.6	596.7	513.0	628.0
United Kingdom	538.5	530.8	578.7	596.2	602.9	513.3	608.0	687.6	681.2	565.2	617.9
Italy	252.0	281.0	323.0	382.0	420.0	402.0	458.0	532.0	579.0	445.0	590.0
Netherlands	24.6	28.0	37.2	53.5	69.8	72.8	89.0	114.6	120.1	103.9	130.2
EC Countries	1,933.8	1,948.8	2,243.4	2,549.2	2,658.7	2,591.3	2,848.6	3,297.7	3,373.8	2,778.9	3,491.6
Norway	29.2	42.7	57.4	72.2	77.6	87.0	103.1	115.4	109.3	94.8	118.6
Finland	14.0	16.9	14.4	18.1	22.2	19.0	19.3	23.4	30.0	22.9	29.3
Greece	10.8	11.1	14.4	15.1	29.3	27.0	28.7	37.3	41.2	39.2	51.0
Yugoslavia	69.0	63.5	61.2	75.0	100.0	73.0	90.0	108.0	126.0	130.0	149.1
Austria	50.8	55.4	65.6	76.6	82.2	79.8	82.7	95.2	87.5	89.5	114.6
Sweden	70.6	66.4	78.9	95.4	108.0	105.5	110.5	123.6	149.9	136.8	139.0
Switzerland	78.6	75.7	85.0	98.0	106.8	99.4	112.9	123.1	126.5	92.1	113.9
Spain	98.7	92.7	117.2	153.1	156.1	179.4	204.1	223.1	262.7	252.4	266.7
other Europe	11.2	9.0	9.2	9.1	6.9	5.7	6.3	7.0	10.3	7.4	14.2
Europe without East Block	2,366.7	2,382.2	2,746.7	3,161.8	3,347.8	3,267.1	3,606.2	4,153.8	4,317.2	3,644.0	4,488.0
Japan	503.4	629.9	813.4	1,034.6	1,177.6	1,254.5	1,514.8	1,975.1	1,638.3	1,480.4	1,921.9
other Asia	180.0	225.0	250.0	250.0	320.0	360.0	355.0	405.0	430.0	470.0	520.0
Asia without East Block	683.4	854.9	1,063.4	1,284.6	1,497.6	1,614.5	1,869.8	2,380.1	2,068.3	1,950.4	2,441.9
South Africa	31.3	21.6	28.2	45.2	53.1	56.9	58.8	70.0	75.5	73.5	74.0
other Africa	20.0	20.0	24.0	23.0	24.0	42.0	41.0	46.0	51.0	65.0	77.0
Africa	51.3	41.6	52.2	68.2	77.1	98.9	99.8	116.0	126.5	138.5	151.0
United States	4,114.1	3,940.8	4,522.3	4,772.6	4,425.4	4,930.8	5,320.3	6,196.6	6,290.5	4,389.0	5,746.7
Argentina	45.3	38.1	49.6	64.7	62.3	72.9	97.6	90.4	102.2	89.3	66.2
Brazil	76.2	81.7	84.9	90.5	90.4	114.1	150.8	176.1	207.6	229.8	245.9
Canada	235.7	221.2	235.0	244.3	251.8	292.2	310.8	337.3	387.9	312.3	389.2
Mexico	24.8	29.4	32.2	35.9	38.8	40.9	54.2	64.1	77.3	60.9	55.0
Venezuela	1.7	3.5	0.5	7.5	9.9	11.9	14.2	20.6	26.2	39.8	46.3
other America	20.0	20.0	20.0	20.0	25.0	30.0	30.0	35.0	40.0	30.0	30.0
America	4,517.8	4,334.7	4,944.5	5,235.5	4,903.6	5,492.8	5,977.9	6,920.1	7,131.7	5,151.1	6,579.3
Australia and Oceania	96.6	107.0	128.2	136.1	157.5	175.5	148.8	215.0	250.3	184.6	220.8
Western World total	7,715.8	7,720.4	8,935.0	9,886.2	9,983.6	10,648.8	11,702.5	13,785.0	13,894.0	11,068.6	13,881.0
East Block total	1,880.0	2,170.0	2,350.0	2,360.0	2,500.0	2,780.0	2,890.0	3,020.0	3,550.0	3,500.0	3,720.0
World total	9,595.8	9,890.4	11,285.0	12,246.2	12,483.6	13,428.8	14,592.5	16,805.0	17,444.0	14,568.6	17,601.0

x) estimate

1) figures for primary and secondary aluminium and direct use of scrap, as far as available.

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

Fig.16

The Development of World Consumption of Aluminium 1966 - 1976

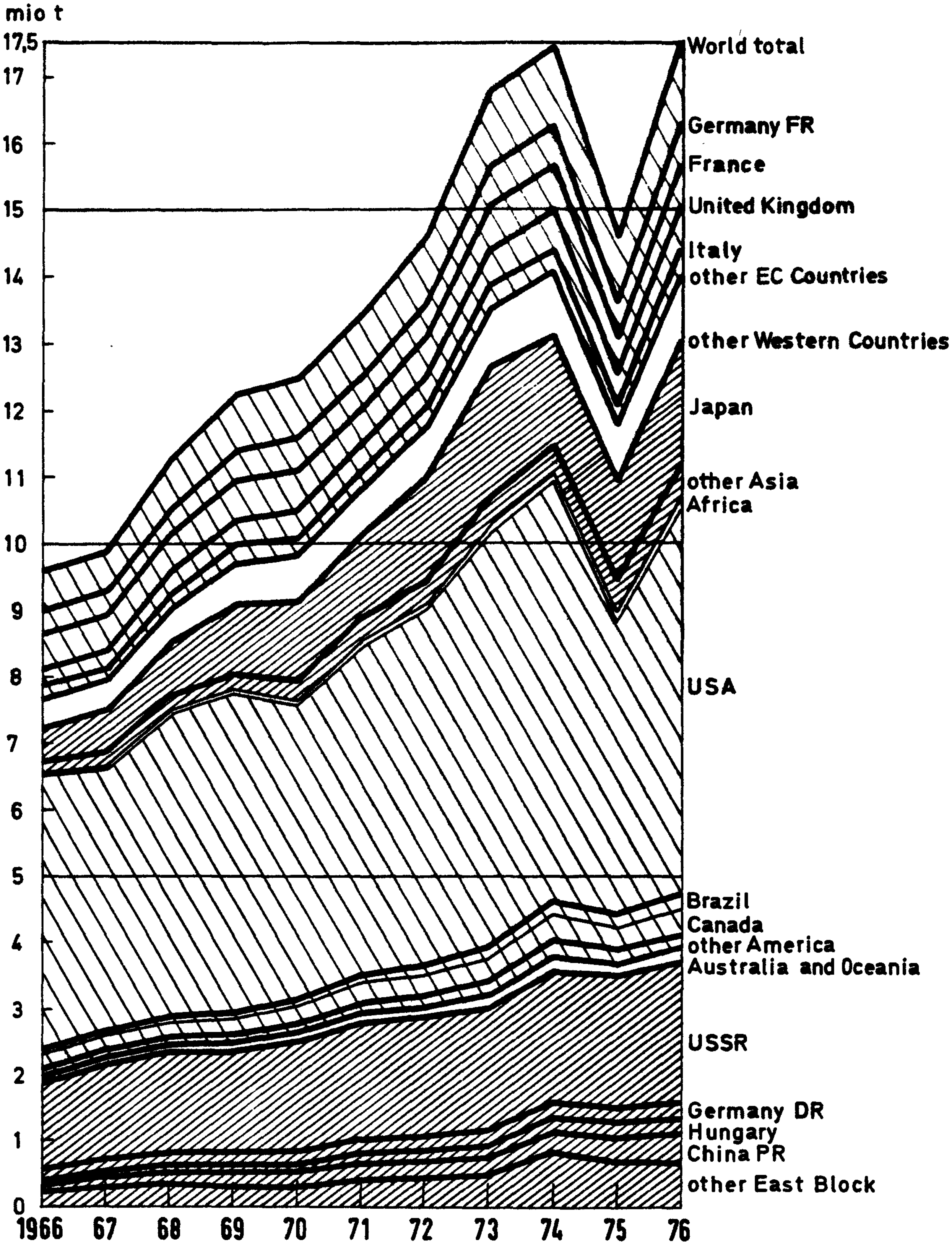


Table 45

Proportion of the World Consumption of Aluminium according to Region & Selected Countries: 1966 and 1976

(in %)

	1966	1976
Belgium/Luxembourg	1.6	1.4
Germany FR	6.2	7.2
France	3.7	3.6
United Kingdom	5.6	3.5
Italy	2.6	3.4
Other EC Countries	0.5	0.7
EC Countries	20.2	19.8
Spain	1.0	1.5
Other Western Europe	3.5	4.2
Western Europe	24.7	25.5
Japan	5.2	10.9
Other Asia	1.9	3.0
Asia	7.1	13.9
Africa	0.5	0.8
Brazil	0.8	1.4
Canada	2.5	2.2
USA	42.9	32.6
Other America	0.9	1.2
America	47.1	37.4
Australia/Oceania	1.0	1.3
Western World	80.4	78.9
East Block	19.6	21.1
World total	100.0	100.0

Table 46

Breakdown of the Consumption of Aluminium at the First Processing Stage in Selected Countries in 1975
(in 1000 t)

	Belgium/ Luxembourg	Germany FR	France	United Kingdom	Italy	Netherlands	EC-Countries[1]	Finland	Austria	Switzerland	Japan	USA
Sheet and strip metal, plate, foil stock	97.7	268.8	153.3	160.3	103.0	.	783.1	-	36.0	56.5	311.1)	
Circles and sections	1.7	13.2)	22.9	17.2	20.0	.	75.0[2]	-	2.8		23.2)	2,082.1
Slugs	4.3	18.2)		3.6	7.0	.	33.1[3]	-	2.1		9.0)	
Rods and sections	47.0	189.0	68.8	96.7	81.0	.	491.5	3.0	11.3		575.3	710.1
Pipe	4.7	25.2	15.5	19.4	12.0	.	76.8	-	2.2	24.5	20.1	117.5
Wire and cable	38.9	59.2	79.9	50.6	18.0	.	246.6	11.8	13.5	1.6	106.8	317.5
Press and forged products	.	9.7	2.4	4.1	0.8	.	17.0	-	-	0.8	1.5	43.4
Total semimanufactures	194.3	592.3	342.8	351.9	241.8	78.1	1,801.2	14.8	67.9	83.3	1,047.0	3,271.2
Cast products	.	213.6	153.5	120.6	184.0	7.7	679.4	0.6	8.1	2.8	361.2	614.0
Foil	9.6	72.8	17.9	36.2	21.2	.	157.7	-	11.6	5.8	52.6	273.1
Powder, flakes, granules	.	8.0)	8.5	5.8	13.0	-	35.3[4]	-	4.1	)	10.2)	44.2
Paste	.	0.8)		2.0	6.2	.	9.0[3]	-	0.4	)	)	
Total consumption	203.9	887.5	522.7	516.5	466.2	85.8	2,682.6	15.4	92.1	91.9	1,471.0	4,202.5

1) as far as available, 2) includes slugs in France, 3) excluding France, 4) includes paste in France

Source: OECD, L'Industrie des Métaux Non Ferreux 1975, Paris 1977

3.2 The Production of Semi-manufactures from Aluminium and Aluminium Alloys

Statistics concerning the production of semi-manufactures from aluminium and aluminium alloys are published continually for 21 countries in the Western World. The total production in these countries rose from 5.06 million t in 1966 to 9.03 million t in 1976, an average annual increase of just 6 %. Table 47 shows the semi-manufacture production according to selected countries for the period 1966 to 1976. During this period there was a particularly sharp increase in production in Western Europe, albeit less than in the EC countries and in Japan, whereas development was quieter in the USA the largest producer country, and in Kanada and Austrlia.

In Table 48 the annual average growth in production for the period 1966 to 1976 is given for individual countries together with the share of these countries in production during the same period.

Accordingly, almost 25 % of the recorded production of semi-manufactures in the Western World in 1966 was produced by the EC countries and about 30 % by the whole of Western Europe, almost 50 % by the USA, 7 % by Japan, 4 % by Canada and just 2 % by Australia. Between 1966 and 1976 the production of semi-manufactures rose in the Western World on average by just 6 % annually, in the EC countries by 6.8 %, in Western Europe by 7.5 % and in Japan by as much as 15.2 %. By contrast, the growth of consumption in the largest consumer country, the USA, was well below average with an annual average increase of 3.3 %. As a result of these differing developments the EC countries' share rose in 1976 to 27 %, that of Western Europe to 36 % and of Japan to just 16 %, whereas a share of only 44 % fell to the USA. Following the USA and Japan, in this year the Federal Republic of Germany with a share of almost 10 % was the third largest producer of semi-manufactures from aluminium and aluminium alloys in the Western World, followed by France and Great Britain (each just 5 %) and Italy (just 4 %). In Appendices 11a to 11g, a breakdown of semi-manufacture production is given for selected countries.

3.3 The Consumption of Semi-manufactures from Aluminium and Aluminium Alloys

Statistics for 20 of the Western World countries are continually published, concerning the consumption of semi-manufactures from aluminium and aluminium alloys. Although they certainly also have a large consumption of semi-manufactures, only very incomplete details are available for the countries of Eastern Europe, the USSR, and the People's Republic of China, so that for this analysis they cannot be taken into consideration.

Table 47

The Production of Semimanufactures from Aluminium and Aluminium Alloys in the Western Industrial Countries: 1966 - 1976

in t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[1)]
Belgium/Luxembourg	162,088	132,594	144,720	167,015	164,798	186,381	205,454	224,849	236,214	194,306	244,890
Germany FR	365,580	380,890	474,948	563,815	554,318	606,833	645,940	770,699	812,079	665,117	897,511
Denmark	8,300	11,400	11,441	15,933	14,779	14,877	16,903	17,833	9,123	6,351	6,600
France	225,838	243,057	252,402	302,602	318,956	325,793	359,952	388,545	406,597	357,006	426,381
United Kingdom	331,204	329,338	350,574	355,370	340,036	301,469	335,970	398,452	424,906	352,442	407,404
Ireland	.	.	.	.	.	.	3,080	4,727	5,533	4,190	5,000[x)]
Italy	144,400	153,000	183,700	229,300	246,500	224,300	268,000	296,300	322,100	237,300	341,000[x)]
Netherlands	24,000	26,000	32,000	48,500	57,000	58,000	70,000	95,587	99,112	78,231	108,600
EC Countries	1,261,410	1,276,279	1,449,785	1,682,535	1,696,387	1,717,653	1,905,299	2,196,992	2,315,664	1,894,943	2,437,386
Finland	11,129	13,495	11,031	14,187	18,319	14,881	16,110	21,462	22,127	20,905	26,200
Greece	10,440	15,100	16,130	16,500	18,600	17,500	21,758	28,194	28,895	25,005	33,000
Yugoslavia	57,281	55,679	53,860	63,926	68,526	70,993	77,291	85,500	95,897	119,846	131,400
Norway	22,730	29,629	38,857	55,376	68,853	72,153	86,091	96,699	91,596	76,138	99,779
Austria	33,899	36,828	44,449	55,944	57,828	51,726	61,131	66,280	69,814	67,932	86,802
Sweden	50,264	52,900	61,892	80,343	78,601	74,693	86,158	98,477	108,716	80,273	95,067
Switzerland	59,850	65,227	71,741	81,726	88,336	89,565	99,124	105,970	109,201	83,336	106,699
Spain	50,441	57,867	69,489	81,355	85,504	107,583	129,807	136,792	187,443	173,202	196,300
Europe without East Block	1,557,444	1,603,004	1,817,234	2,131,892	2,180,954	2,216,747	2,482,769	2,836,366	3,029,353	2,541,580	3,212,633
Japan	345,835	416,833	529,336	701,123	778,326	851,647	1,058,719	1,402,383	1,158,344	1,057,674	1,419,100
Canada	193,000	165,100	182,400	204,300	214,600	249,300	257,600	268,000	300,900	241,300	245,000
United States	2,878,953	2,780,960	3,148,273	3,355,660	3,262,541	3,489,493	4,075,853	4,822,240	4,655,000	3,046,400	3,990,626
Australia	85,627	87,222	103,380	109,563	111,458	128,533	127,171	156,046	168,986	139,543	160,599
total	5,060,859	5,053,119	5,780,623	6,502,538	6,547,879	6,935,720	8,002,112	9,485,035	9,312,583	7,026,497	9,027,958

[1)] provisional data

Table 48

Average Annual Growth in the Production of Semimanufactures in the Western Industrial Countries from 1966 to 1976 and the Share of these Countries in the Production of the Western World: 1966 - 1976
(in %)

	Average growth rate p.a.	Share of Production of Western World	
	1966/76	1966	1976
Belgium/Luxembourg	4.2	3.2	2.7
Germany FR	9.4	7.2	9.9
Denmark	- 2.3	0.2	0.1
France	6.6	4.5	4.7
United Kingdom	2.1	6.5	4.5
Ireland	.	.	0.1
Italy	9.0	2.8	3.8
Netherlands	16.3	0.5	1.2
EC Countries	6.8	24.9	27.0
Finland	8.9	0.2	0.3
Greece	12.2	0.2	0.4
Yugoslavia	8.7	1.1	1.4
Norway	15.9	0.5	1.1
Austria	9.9	0.7	1.0
Sweden	6.6	1.0	1.0
Switzerland	6.0	1.2	1.2
Spain	14.6	1.0	2.2
Western Europe	7.5	30.8	35.6
Japan	15.2	6.8	15.7
Canada	2.4	3.8	2.7
USA	3.3	56.9	44.2
Australia	6.5	1.7	1.8
Western World	6.0	100.0	100.0

Semi-manufactures consumption recorded in the 20 industrial countries of the Western World rose from 4.24 million t in 1965 to 6.63 million t in 1975, which is an average annual increase of 4.6 %. It should be noted here that in 1973 consumption had reached a total of 9.18 million t. Further details of the consumption trends in the individual countries are given by years in Table 49. Of the semi-manufactures consumption in 1965, 60 % was taken up by the USA, 23.4 % by the present-day EC countries and almost 29 % by the whole of Western Europe, 5.3 % by Japan, 4.3 % by Canada and 1.4 % by Australia. Attention is drawn here to Table 50. In the years following up till 1975, the consumption of semi-manufactures in the listed countries rose by widely differing amounts. Whereas unusually high average annual rates of increase were achieved in Japan (16.2 %) and Yugoslavia (12.5 %), the increase over the whole period in the largest consumer country, the USA, was only 1.4 %. From these very different consumption trends, a considerable change occurred in regional consumption structure up till 1975. Due in no small way to the varied severity of the recession in 1975 in the individual countries, the largest share of the recorded semi-manufactures in the Western World was taken up by the largest consumer country, the USA, with 44 %, whereas that of Europe rose to more than 34 %, that of the EC countries to just 26 % and that of Japan to more than 15 %. The share of consumption of Canada and Australia either remained constant or only increased slightly.

As was the case with semi-manufactures production, the Federal Republic of Germany with more than 9 % was the third largest consumer in the Western World in 1975, followed by Great Britain (5.5 %), France (4.7 %), Canada (4.3 %) and Italy (3.2 %). Compared with 1965 the shares of the Federal Republic of Germany, France and Italy rose, whereas that of Great Britain decreased.

3.4 The Production of Cast Products from Aluminium and Aluminium Alloys

Following semi-manufactures, the production of cast products varies in importance for aluminium consumption in individual countries. Up till now the production of castings from aluminium and aluminium alloys has been continually published for 16 Western World countries. There is also unquestionably a castings production in other Western countries as well as in the East Block countries. In the 16 Western World countries recorded, the production of castings rose from 1.51 million t in 1966 to 2.23 million t in 1976, which is an average annual increase of 4 %. Of the castings produced in 1966, 49.4 % took place in the USA, 38.7 % in Western Europe (34.4 % by the current EC countries), 9.6 % by Japan and 2.3 % by Canada. During the following 10 years, castings production rose in Japan and also in Western Europe more sharply than in the sum total of the recorded countries, proportionally less in the USA and Canada. Therefore, in 1976 the USA only produced 37.5 % of the total production, whereas Western Europe

Table 49

Consumption of Semimanufactures from Aluminium and Aluminium Alloys in the Western Industrial Countries: 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Belgium/Luxembourg	50,142[1]	63,850[1]	50,108[1]	50,424[1]	55,967	57,386	67,886	79,786	96,193	102,239	73,565
Germany FR	315,892[1]	348,437[1]	345,757[1]	453,319[1]	540,162	539,753	593,831	657,546	729,950	705,661	619,526
Denmark	16,986[1]	19,117[1]	23,605[1]	25,181[1]	29,930	31,977	30,336	43,237	53,751	43,396	31,646
France	165,030[1]	195,085[1]	203,853[1]	234,194[1]	261,207	263,396	282,178	321,790	355,235	349,262	309,332
United Kingdom	304,446	321,154[1]	328,340[1]	353,388[1]	360,635	362,635	333,903	379,618	430,979	457,094	365,442
Ireland	.	.	.	.	.	.	.	3,380	9,292	11,851	5,703
Italy	102,820	135,470[1]	145,646[1]	160,519[1]	196,708	225,204	202,135	240,201	279,600	319,854	216,222
Netherlands	35,509	42,080[1]	47,066[1]	51,508[1]	65,402	69,272	76,467	81,923	105,261	104,112	84,551
EC Countries	990,825	1,125,193	1,144,375	1,328,533	1,510,166	1,549,623	1,586,736	1,807,481	2,060,261	2,093,469	1,705,987
Finland	16,175[1]	23,542[1]	25,238[1]	23,984[1]	30,136	35,704	31,677	33,685	44,714	49,798	39,138
Greece[1]	10,929	9,739	12,878	14,435	12,357	9,347	13,450	15,291	18,849	18,688	18,953
Yugoslavia[1]	27,930	38,246	37,988	34,131	44,561	58,723	51,117	48,039	56,880	65,511	91,024
Norway	20,988[1]	24,890[1]	28,059[1]	25,361[1]	37,508	39,231	42,491	46,915	53,100	60,450	47,983
Austria	16,702[1]	18,651[1]	21,887[1]	26,669[1]	37,565	39,788	41,312	51,336	61,162	60,168	57,620
Sweden	51,086[1]	54,660[1]	59,243[1]	77,307[1]	86,717	89,004	79,836	91,166	106,386	113,212	99,640
Switzerland	51,098[1]	53,240[1]	56,077[1]	64,273[1]	70,095	77,011	77,043	82,782	91,664	94,339	65,161
Spain[1]	41,820	52,531	45,959	53,771	57,319	61,623	80,904	110,574	122,011	179,111	154,784
Europe without East Block	1,227,553	1,400,692	1,431,704	1,648,464	1,886,424	1,960,054	2,004,566	2,287,269	2,615,027	2,734,746	2,280,290
Japan[1]	224,721	309,269	400,887	497,589	661,215	731,976	805,047	1,030,824	1,399,503	1,168,305	1,010,453
Canada	182,981	215,159[1]	221,048[1]	241,425[1]	271,995	281,679	307,699	317,617	352,045	372,761	286,120
United States[1]	2,543,190	2,901,269	2,732,224	3,085,569	3,274,208	3,190,506	3,409,561	4,003,835	4,676,184	4,480,210	2,916,385
Australia[1,2]	61,708	72,820	77,399	84,386	102,661	107,157	111,748	115,769	134,830	159,498	136,264
total	4,240,153	4,899,209	4,863,262	5,557,433	6,196,503	6,271,372	6,638,621	7,755,314	9,177,589	8,915,520	6,629,512

1) calc. from production and foreign trade figures (gross weight)

2) fiscal year

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Table 50

Development of the Consumption of Semimanufactures Made of Aluminium and Aluminium Alloys according to Country: 1965 - 1975
(in %)

	Average growth rate p.a.	Share of Consumption of Western World	
	1965/75	1965	1975
Belgium/Luxembourg	3.9	1.2	1.1
Germany FR	7.0	7.5	9.3
Denmark	6.4	0.4	0.5
France	6.5	3.9	4.7
United Kingdom	1.8	7.2	5.5
Ireland	.	.	0.1
Italy	7.7	2.4	3.2
Netherlands	9.2	0.8	1.3
EC Countries	5.6	23.4	25.7
Finland	9.2	0.4	0.6
Greece	5.7	0.2	0.3
Yugoslavia	12.5	0.7	1.4
Norway	8.6	0.5	0.7
Austria	13.2	0.4	0.9
Sweden	6.9	1.2	1.5
Switzerland	2.5	1.2	1.0
Spain	14.0	1.0	2.3
Europe	6.4	29.0	34.4
Japan	16.2	5.3	15.2
Canada	4.6	4.3	4.3
USA	1.4	60.0	44.0
Australia	8.2	1.4	2.1
Sum of the above countries	4.6	100.0	100.0

produced 41.2 % and Japan 19.5 %. The share of the EC countries only rose slightly to 35.5 %. In Table 51, production of aluminium castings according to countries is tabulated for the period 1966 to 1976. Table 52 shows the average annual growth of castings production in the period 1966 to 1976 in the individual countries and the share of the countries in the total recorded production for the two years. In 1976, the USA was by far the largest producer of cast aluminium (37.5 %), followed by Japan (19.5 %), the Federal Republic of Germany (11.5 %). The share of Great Britain only amounted to 5.4 % compared to 7.8 % in 1966.

4) Breakdown of Aluminium Consumption according to Ultimate Consumer Groups

4.1 Consumer Groups in Countries of the Western World

A breakdown of aluminium consumption is published annually by the OECD according to end consumer group for 13 countries of the Western World and following international agreement it also contains exports of semi-manufactures. The current statistical subdivisions have been used since 1973 when changes were made in the exact definition of the consumer groups. Moreover, consumer statistics for three Western European countries were then available for the first time and no corresponding statistics have been published for the Netherlands since 1971. A study of long-term consumer trends in individual end consumer groups must therefore be limited to nine countries, six of which are EC countries.

Tables 53 to 55 contain the breakdown of the end consumption of aluminium in Belgium/Luxembourg, the Federal Republic of Germany, France, Great Britain, Italy, Switzerland, and Japan from 1966 to 1976 and in the USA from 1966 to 1975. End consumption of aluminium rose from 6.48 million t in 1966 to 11.43 million t in 1976, an average annual increase of 5.8 %. These nine countries accounted for 63 % of aluminium consumption in the world in 1976. In 1966 the transportation sector accounted for more than 23 % of the total end consumption in these countries, followed by the construction industry (17 %), the electrical industry (13 %), export of semi-manufactures (10 %), metal goods and misc. (9 %), household goods and packaging materials (ca. 8 % each), and machine construction (7 %). End consumption of aluminium rose at an average annual rate of 5.8 % for the statistical subdivisions listed. The end consumer groups packaging materials, construction, chemicals and foodstuffs, and semi-manufactures export had growth rates above this average with 11 %, 8.3 %, 7.3 %, & 7.3 %, respectively. In constrast, transportation, household goods, powder-consuming industries, and metal goods and misc. had growth rates below this average with less than 4 % each.

Table 51

Production of Cast Aluminium and Cast Aluminium Alloys in Selected Countries of the Western World: 1966 - 1976

in t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium/Luxembourg	10,000	11,200	12,100	11,700	17,000	16,100	13,900	19,600	20,000	20,000	21,200
Germany FR	175,000	149,900	189,000	229,500	241,600	227,400	226,900	254,000	233,900	211,300	255,000
Denmark x)	.	.	.	.	1,000	1,300	1,500	4,500	4,500	3,600	3,700
France	109,000	105,400	107,300	128,600	142,000	151,100	166,900	181,600	179,000	168,000	187,700
United Kingdom	117,500	115,300	127,200	139,100	135,200	132,900	133,700	146,600	134,200	120,600	121,100
Italy	98,000	117,000	130,000	144,000	162,000	166,000	175,000	217,000	235,000	184,000	195,000
Netherlands	9,000	8,000	8,000	9,300	8,200	6,200	6,600	8,000	8,700	6,400	7,800
EC Countries	518,500	506,800	573,600	662,200	707,000	701,000	724,500	831,300	815,300	713,900	791,500
Finland	2,600	2,800	2,900	3,000	3,100	3,100	3,300	3,900	4,200	3,900	4,500
Austria	5,800	5,500	6,300	8,500	11,600	9,400	8,800	9,800	9,800	8,100	9,500
Portugal	400	500	300	400	600	600	700	1,400	1,500	1,400	1,000
Sweden	16,500	17,500	18,500	20,500	21,000	19,500	22,600	24,400	28,500	28,000	27,000
Switzerland	14,000	13,500	14,500	17,000	19,400	14,900	13,500	15,000	17,600	13,500	13,500
Spain	25,000	25,000	30,000	41,000	42,000	42,000	55,000	60,000	70,000	67,000	70,000
Europe	582,800	571,600	646,100	752,600	804,700	790,500	828,400	945,800	946,900	835,800	917,000
Japan	143,800	180,900	233,400	282,900	335,500	335,000	366,700	416,100	395,500	361,200	433,400
Canada	34,600	27,100	30,600	33,200	29,700	29,700	39,100	40,200	36,600	30,000 x)	40,000 x)
United States	743,900	696,100	720,400	770,200	683,300	715,400	841,700	919,100	798,100	623,900	836,200
total	1,505,100	1,475,700	1,630,500	1,838,900	1,853,200	1,870,600	2,075,900	2,321,200	2,177,100	1,850,900	2,226,600

x) estimate

Table 52

Development of Cast Aluminium Output according to Country:
1966 - 1976
(in %)

	Average growth rate p.a. 1966/76	Share of Production of Selected Countries	
		1966	1976
Belgium/Luxembourg	7.8	0.7	0.9
Germany FR	3.8	11.6	11.5
Denmark	.	.	0.2
France	5.6	7.2	8.4
United Kingdom	0.3	7.8	5.4
Italy	7.1	6.5	8.7
Netherlands	- 1.4	0.6	0.4
EC Countries	4.3	34.4	35.5
Finland	5.6	0.2	0.2
Austria	5.1	0.4	0.4
Portugal	9.6	0.0	0.1
Sweden	5.0	1.1	1.2
Switzerland	- 0.4	0.9	0.6
Spain	10.8	1.7	3.2
Western Europe	4.6	38.7	41.2
Japan	11.7	9.6	19.5
Canada	1.5	2.3	1.8
USA	1.2	49.4	37.5
Sum of the above countries	4.0	100.0	100.0

Table 53

Breakdown of Aluminium Consumption in the Major Western Industrial Countries :1966 and 1976

in 1000 t

	Belgium/ Luxembourg		Germany FR		France		United Kingdom		Italy		EC Countries 1)	
	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Transport	2.2	2.6	135.6	220.2	114.7	172.8	123.2	123.7	102.0	150.2	477.7	669.5
Machinery	1.1	1.9	55.4	71.4	25.4	32.0	27.3	34.9	17.0	37.9	126,2	178.1
Electrical	2.5	6.6	77.5	67.8	35.9	85.0	59.7	63.1	16.0	27.7	191.6	250.2
Building and construction	12.4	15.8	55.4	183.2	25.4	56.4	35.1	59.8	24.0	110.0	152.3	425,2
Chemical, food and agricultural appliances	1.3	1.0	15.0	14.8	5.9	13.4	8.0	3.7	3.5	10.9	33.7	43.8
Packaging	4.3	9.1	47.2	93.4	26.5	47.8	31.1	45.3	22,5	52.4	131,6	248.0
Domestic and offices appliances	1.8	1.1	16.1	81.6	27.4	34.3	39.3	50.6	14.0	72.4	98.6	240.0
Powder consuming industries	0.2	0.3	5.9	3.4	7.9	2.1	7.9	9.2	1.2	3.0	23.1	18.0
Destructive uses	0.0	0.1	21.7	50.6	11.0	25.0	15.6	23.1	6.2	16.0	54.5	114.8
Metal industries n.e.s / Miscellaneous	20.3	16.8	54.5	111.6	25.6	51.3	55.7	71.4	18.2	22.1	174.3	273.2
Direct exports of semi-manufactures	125.3	189.6	77.4	274.6	57.1	145.1	50.7	65.2	27.4	85.1	337.9	759.6
Total consumption	171.4	244.9	561.7	1172.6	362.8	665.2	453.6	550.0	252.0	587.7	1801.5	3220.4

	Switzerland		Western Europe 1)		2)	Japan		USA		total	
	1966	1976	1966	1976	1976	1966	1976	1966	1975	1966	1975/76
Transport	3.7	3.2	481.4	672.7	750.2	104.7	370.9	924.0	1169.4	1510.1	2213.0
Machinery	9.4	7.2	135.6	185.3	207.7	32.4	82.5	278.0	411,9	446.0	679.7
Electrical	4.7	4.8	196.3	255.0	337.3	62.1	178.5	563.4	780.2	821.8	1213.7
Building and construction	11.8	11.7	164.1	436.9	532.4	69.7	668.0	877.7	1363.1	1111.5	2468.0
Chemical, food and agricultural appliances	0.4	0.4	34.1	44.2	54.5	13.0	38.2	30.4	73.9	77.5	156.3
Packaging	9.6	13.7	141.2	261.7	284.4	11.5	103.7	335.7	1027.4	488.4	1392.8
Domestic and offices appliances	2.5	2.1	101.1	242.1	279.8	87.9	124.6	340.2	400.5	529.2	767.2
Powder consuming Industries	-	-	23.1	18.0	21.1	1.0	8.9	49.9	76.7	74.0	103.6
Destructive uses	0.3	0.3	54.8	115.1	121.8	20.1	52.6	91.6	128.8	166.5	296.5
Metal industries n.e.s. / Miscellaneous	1.3	7.5	175.6	280.7	313.4	79.6	216.2	340.8	318.4	596.0	815.3
Direct exports of semi-manufactures	13.2	58.8	351.1	818.4	992.8	40.5	76.9	265.2	428.2	656.8	1323.5
Total consumption	56.9	109.7	1858.4	3330.1	3895.4	522.5	1921.0	4096.9	6178.5	6477.8	11429.6

1) as far as available
2) includes Norway, Austria, Sweden,and Spain

Table 54

Breakdown of Aluminium Consumption in the Major Western Industrial Countries ; 1966 and 1976

in %

	Belgium/ Luxemburg		Germany FR		France		United Kingdom		Italy		EC Countries 1)	
	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Transport	1.3	1.1	24.1	18.8	31.6	26.0	27.2	22.5	40,5	25.6	26.5	20.8
Machinery	0.6	0.8	9.9	6.1	7.0	4.8	6.0	6.3	6.7	6.4	7.0	5,5
Electrical	1.5	2.7	13.8	5.8	9.9	12.8	13.1	11,5	6.3	4.7	10.6	7.8
Building and construction	7.2	6.5	9.9	15.6	7.0	8,5	7.7	10.9	9.5	18.7	8.4	13.2
Chemical, food and agricultural appliances	0.8	0.4	2.6	1.2	1.6	2.0	1.8	0.7	1.4	1.9	1.9	1.4
Packaging	2.5	3.7	8.4	8.0	7.3	7.2	6.9	8.2	8.9	8.9	7.3	7.7
Domestic and offices appliances	1.1	0.4	2.9	7.0	7.6	5.1	8.7	9.2	5.6	12.3	5.5	7.4
Powder consuming industries	0.1	0.1	1.0	0.3	2.2	0.3	1.7	1.7	0.5	0.5	1.3	0.5
Destructive uses	0.0	0.0	3.9	4.3	3.0	3.8	3.4	4.2	2.5	2.7	3.0	3.6
Metal industries n.e.s.	11.8	6.9	9.7	9.5	7.1	7.7	12.3	13.0	7.2	3.8	9.7	8.5
Direct exports of semi-manufactures	73.1	77.4	13.8	23.4	15.7	21.8	11.2	11.8	10.9	14.5	18.8	23.6
Total consumption	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	Switzer- land		Western Europe			Japan		USA		total	
	1966	1976	1966	1976	1976 2)	1966	1976	1966	1975	1966	1976
Transport	6.4	2.9	25.9	20.2	19.3	20.0	19.3	22.6	18.9	23.3	19.4
Machinery	16.5	6.6	7.3	5.6	5.3	6.2	4.3	6.8	6.7	6.9	5.9
Electrical	8.3	4.4	10.6	7.7	8,7	11.9	9.3	13.8-	12.6	12.7	10.6
Building and construction	20.7	10.7	8.8	13.1	13.7	13.3	34.8	21.4	22.1	17.2	21.6
Chemical, food and agricultural appliances	0.8	0.3	1.8	1.3	1.4	2.5	2.0	0.7	1.2	1.2	1.4
Packaging	16.8	12.5	7.6	7.9	7.3	2.2	5.4	8.2	16.6	7.5	12.2
Domestic and offices appliances	4.4	1.9	5.4	7.3	7.2	16.8	6.5	8.3	6.5	8.2	6.7
Powder consuming industries	-	-	1.2	0.5	0.5	0.2	0.5	1.2	1.2	1.1	0.9
Destructive uses	0.8	0.3	3.0	3.4	3.1	3.9	2.7	2.2	2.1	2.6	2.6
Metal industries n.e.s.	10.9	6.8	9.5	8.4	8.0	15.2	11.2	8.3	5.2	9.2	7.1
Direct exports of semi-manufactures	14.6	53.6	18.9	24.6	25.5	7.8	4.0	6.5	6.9	10.1	11.6
Total consumption	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1) as far as available

2) includes Norway, Austria,and Spain

Table 55

Average Annual Growth Rate of Aluminium Consumption by the Ultimate Consumer in Selected Western Industrial Countries, 1966 and 1976

in %

	Belgium/ Luxemburg	Germany FR	France	United Kingdom	Italy	EC Countries [1]	Switzer- land	Western Europe	Japan	USA [2]	total [1]
Transport	1.7	5.0	4.2	0.0	3.9	3.4	-1.4	3.4	13.5	2.7	3.9
Machinery	5.6	2.6	2.3	2.5	8.3	3.5	-2.4	3.2	9.8	4.5	4.3
Electrical	10.2	-1.3	9.0	0.6	5.6	2.7	0.2	2.7	11.1	3.7	4.0
Building and construction	2.5	12.7	8.3	5.5	16.4	10,8	-0.1	10.3	25.4	5.0	8.3
Chemical, food and agricultural appliances	-2.6	-0.1	8.5	-7.4	12.0	2.7	0.0	2.6	11.4	10.4	7.3
Packaging	7.8	7.1	6.1	3.8	8.8	6.5	3.6	6.4	24.6	13.2	11.0
Domestic and offices appliances	-4.8	17.6	2.3	2.6	17.9	9,3	-1.7	9.1	3.6	1.8	3.8
Powder consuming industries	4.1	-5.4	-12.4	1.5	9.6	-2.5	0.0	-2.5	24.4	4.9	3.4
Destructive uses	.	8.8	8.6	4.0	9.9	7.7	0.0	7.7	10.1	3.9	5.9
Metal industries n.e.s.	-1.8	7.4	7.2	2.5	2.0	4.6	19.2	4.8	10.5	-0.8	3.2
Direct exports of semi-manufactures	4.2	13.5	9.8	2.5	12.0	8.4	16.1	8.8	6.6	5.5	7.3
Total consumption	3.6	7.6	6.2	1.9	8.8	6.0	6.8	6.0	13.9	4.7	5.8

1) as far as available
2) growth in consumption from 1966 to 1975

These differing growth rates resulted in marked changes in the structure of aluminium consumption in these countries up to 1976 (for the USA the figures for 1975 must be taken as a basis). With a share of almost 22 % in 1976, the construction sector was the most important end consumer group, followed by the transportation sector (19 %), packaging materials and semi-manufactures export (ca. 12 % each), electrical industry (11 %), metal goods and misc. (7 %), household goods (7 %), and machinery (6 %).

The large increase in the use of aluminium in construction has occurred mainly by the substitution of other building materials by aluminium. This is due to the increasing use of prefabrication methods in industrial and housing construction and the development of numerous applications in the construction of tall buildings, underground construction, and road construction (facade panels, interiors, etc.). It is evident that the USA, as the forerunner of these technical developments, already had a high consumption in this sector in 1966 and thus in the following years only comparatively small growth rates were attained. This development began later and quite rapidly in the Federal Republic of Germany, Italy, and Japan.

The transportation sector is, after construction, the second largest end consumer. Vehicle production is determining in all countries, including the USA. Increasing amounts of aluminium, primarily as castings, are used for weight reduction in order to cut fuel consumption. Since ca. 60 % of the total aluminium foundry production in some countries goes to the automobile industry, the foundries are dependent to a large degree on market conditions in that branch of industry. Aluminium castings are used for motor blocks, clutch and transmission housings, cylinder head lids, pistons, oil coolers, etc. Aluminium semi-manufactures, mainly sheet metal and profiles, are used increasingly for superstructures for busses, tank and container lorries, dump trucks, etc., as well as for numerous small parts such as radiators, window frames, lamp fixtures, and molding. In addition to superstructures for motor vehicles and caravans, aluminium is being tested for use in the chassis of busses, lorries, and caravans. The main use of aluminium for railway vehicles is in the production of electric rail busses; welded and light aluminium structures contribute to a considerable reduction in energy required for numerous acceleration and braking actions. In some countries, particularly the USA, airplane construction accounts for a large part of the aluminium consumption in the transportation sector.

Very high growth rates characterize the use of aluminium in the packaging industry in the last ten years. This has made it the third largest aluminium consumer in the nine western industrial countries investigated. In the USA, it accounted for almost 17 % of the total aluminium consumption. One of the reasons for this is that the use of refrigeration units and thus the possibility of packaging easily spoiled foods in foil began much earlier in the USA than in the other western industrial countries. In addition, aluminium cans are used much more extensively for beverages than in the other countries. In Japan, this market for aluminium quadrupled from

1973 to 1976 giving an average annual increase from 1966 to 1976 of almost 25 %. The introduction of new packaging for beverages in the industrial countries of Western Europe (foil, screw caps for glass bottles, cans for beverage and other food packaging, packaging for pharmaceuticals, aerosol cans, etc.), in addition to the traditional uses such as tubes, capsules, and cans, has led to an average annual increase of 4 - 9 % for this time period. The lower growth rates in comparison to the USA and Japan reflect different consumption habits, a different foodstuffs market structure, and a stronger market position for the competing packaging materials glass and tinplate.

The fourth most important end consumer sector for aluminium in 1976 in the countries investigated was the export of semi-manufactures with a share of nearly 12 %. It can be seen that the aluminium industry in Western Europe, including the EC, is significantly more export oriented than that of the USA or Japan. In the Western European countries, exports accounts for 12 - 77 % of the total end consumption, in the USA and Japan the figures are only 7 % and 4 %, respectively. Exports of semi-manufactures in 1976 accounted for 22 % of end consumption in the Federal Republic of Germany and 23 % in France, 54 % in Switzerland and 77 % in Belgium/ Luxembourg. Between 1966 and 1976, exports of semi-manufactures increased an average of 12 - 16 % annually in the Federal Republic of Germany, Switzerland, and Italy, 10 % in France, 7 % in Japan, and 5.5 % in the USA.

The electrical industry with just under 11 % also numbered among the most important end consumers of aluminium in the nine western industrial countries. The growth rate for this branch of industry was less than the other principal end consumers and its share of the total consumption decreased in comparison to 1966. In some of the listed countries this development is due to the economic recession of the last few years and the resulting cut back in investment in electricity supply, communications, and railways.

The by far most important application as conducting material, the substitution of the traditional conductor copper for use in the long-distance transmission lines, can be viewed as completed. Aluminium cable (insulated conductors and cable) is being used increasingly for low and intermediate voltage uses and as telephone cable.

The second most important application is for electrical equipment and instruments, including household appliances. For this use there have been high growth rates for aluminium consumption in some of the listed countries in the last few years, caused by greatly increased production and by the substitution of aluminium for copper.

The other end-consumer groups in the nine western industrial countries listed had a share of less than 7.5 % of the total consumption in 1976.

In most cases this was a decrease from the proportion in 1966. Of these groups, the following should be mentioned: metal goods & misc. and household goods (7 % each) and machinery (6 %). The small increase in the use of aluminium by these end consumer groups was substantially influenced by the low growth up to 1975 in the USA. Use of aluminium for metal goods & misc. in Western Europe and also in the EC countries increased by almost 5 % between 1966 and 1976, for household goods by more than 9 % and machinery by only 3 %. A completely different development occurred in Japan with annual growth rates of 10 % for metal goods & misc. and the machinery-building industry and only 4 % for household goods.

Appendices 12 a - k and 13 a - h contain the breakdown for the consumption of primary and secondary aluminium from 1966 to 1976 in Belgium/ Luxembourg, the Federal Republic of Germany, France, Great Britain, Italy, Austria, Switzerland, Japan, and the USA (data from the OECD).

4.2 Aluminium Consumption in the Federal Republic of Germany

According to data from Metallgesellschaft, total consumption of aluminium in the Federal Republic of Germany between 1966 and 1976 increased from 595,000 tpy to 1.26 million tpy, an average annual increase of 7.8 %. Growth rates during this period varied according to market conditions. A low in 1967 was followed by a high growth rate until 1969, which was then followed by weaker growth rates until 1973. After a very small increase in 1974, consumption dropped by 16 % in 1975, falling below the level of 1972. A large increase in 1976 brought consumption to the highest level ever reached. Aluminium production in the Federal Republic of Germany was greater than the growth in net industrial production.

There was a general increase in the proportion of primary aluminium in the total consumption between 1966 and 1976, from 70 - 73 % up to 1969 and 74 - 76 % from 1969 to 1976 (see Table 56). The proportion of secondary aluminium and direct use of scrap in the total consumption fell correspondingly. The use of primary aluminium rose from 419,500 t in 1966 to 954,400 t in 1976, an average annual increase of 8.6 %. In comparison, domestic production of primary aluminium rose from 243,900 t to 697,100 t during the same period (11.1 %/yr). Domestic primary aluminium accounted for less than 50 % of primary aluminium consumption from 1968 to 1970, a period of large increases in consumption. As new primary aluminium smelters were brought into operation, the share of domestic primary aluminium was increased to 79 % and was 73 % in 1976.
Imports of crude aluminium were under 200,000 t only in 1966 and 1967. In the following two years, imports totaled more than 400,000 t. From 1971 to 1976, imports varied between 258,000 t and 380,000 t. Exports of crude aluminium were under 100,000 tpy until 1973, were ca. 120,000 t

Table 56

Production and Consumption of Primary and Secondary Aluminium in the Federal Republic of Germany
(1000 t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Primary aluminium production	243.9	252.9	257.4	262.7	309.3	427.5	444.4	532.7	688.9	677.6	697.1
Consumption	419.5	416.8	539.3	642.3	669.8	684.4	724.4	855.7	872.5	703.7	954.4
Secondary aluminium production[1)]	196.7	185.5	231.9	271.3	258.5	275.7	294.0	328.4	324.1	285.5	344.6
From primary aluminium	40.0	34.0	40.0	54.3	67.6	67.2	75.4	73.3	72.6	68.4	79.2
Consumption	198.9	178.0	230.4	271.1	254.6	265.0	287.0	316.2	300.9	270.0	333.1
Total adjusted consumption (prim. and sec.)[2)]	578.4	560.8	729.7	859.1	856.8	882.2	936.0	1,098.6	1,100.8	905.3	1,208.3
Direct use of scrap	17.1[x)]	26.4[x)]	18.9[x)]	19.0[x)]	24.2	36.1	33.6	42.2	44.7	52.1	55.4
Total consumption	595.5	587.2	748.6	878.1	881.0	918.3	969.6	1,140.8	1,145.5	957.4	1,263.7

1) including ingot made on toll from the first processing stage and virgin metal in the production of secondary ingot

2) excluding an estimated quantity of virgin aluminium used in the production of secondary ingot and ingot made on toll from scrap from the first processing stage

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

in 1974 and 1975, and 230,000 t in 1976. At present, six firms operate ten primary aluminium plants in the Federal Republic of Germany with a total capacity of 757,000 tpy.

Uncertainty concerning future expansion of power plant capacities is not the least important of the reasons why we are not aware of any plans being made for expansion of aluminium capacity.

In addition to primary aluminium, still larger amounts of secondary aluminium are consumed in the Federal Republic of Germany. This secondary aluminium is produced from old and new scrap using some primary aluminium. Secondary aluminium production from 1966 to 1976 was usually slightly greater than consumption. Production from the currently more than 25 secondary smelters increased during this period from 196,700 t to 344,600 t, an average annual increase of 5.8 %. Consumption of secondary aluminium increased from 198,900 t to 333,100 t and has stagnated since 1973.

Direct use of scrap contributed only less than 4 % to total aluminium consumption in the Federal Republic of Germany. It amounted to more than 52,000 t in both 1975 and 1976.

More than 70 % of the crude aluminium produced in the Federal Republic of Germany is processed to semi-manufactures and forged products, just under 25 % to castings, and the remainder to other products (powder, paste, etc.).

Total production of semi-manufactures from aluminium and aluminium alloys increased from 365,600 t in 1966 to 897,500 t in 1976, an average annual increase of 9.4 %. The increase in the production of rolling mill production (sheet metal, strips, plate, and slugs) was slightly less and that for press products (rods, profiles, wire, pipe, pressed and forged products) was greater (11 %). Conducting materials, with an average annual increase of 4.7 %, had the lowest growth rate. Ca. 59 % of the total semi-manufactures was accounted for by rolling mill products, 34 % by pressed products, and 7 % by conducting materials.

Production of mouldcastings increased from 175,000 t in 1966 to 255,000 t in 1976, an average annual increase of 3.8 %. The share of die castings increased from 32 to 44 %. Detailed data for semi-manufactures and castings can be seen in Table 57.

Aluminium Consumption by Individual Consumer Groups

The statistics published by the OECD on aluminium consumption according to consumer group are broken down into the following groups for comparison among the large consuming countries.

Table 57

Aluminium Semimanufactures and Castings Production in the Federal Republic of Germany
(in 1000 t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Rolling mill products	220.5	225.4	283.3	333.3	317.9	338.7	351.8	427.7	487.1	374.3	531.5
Rods, sections, wire	83.7	92.1	122.1	152.2	157.2	182.3	210.7	247.9	221.6	200.5	266.3
Pipe	14.5	14.3	19.7	23.2	22.8	20.7	21.9	28.0	28.7	25.2	30.1
Pressed and forged products	9.5	7.6	9.2	10.8	10.8	11.2	11.6	12.4	10.9	9.7	10.5
Pressings	107.7	114.0	151.0	186.2	190.8	214.2	244.2	288.3	261.2	235.4	306.9
Semimanufactures excluding elect. wire	328.2	339.4	434.3	519.5	508.7	552.9	596.0	716.0	748.3	609.7	838.4
Electric wire	37.4	41.5	40.6	44.3	45.6	53.9	49.9	54.7	63.8	55.4	59.1
Total semimanufactures production	365.6	380.9	474.9	563.8	554.3	606.8	645.9	770.7	812.1	665.1	897.5
Cast products: moldings	175.0	149.9	189.0	229.5	241.6	227.4	226.9	254.0	233.9	211.3	255.0
diecast	56.3	52.9	70.1	89.9	97.0	94.3	100.3	114.9	106.0	92.9	

Sources: Fachvereinigung Metallhalbzeug e. V., Düsseldorf
Gesamtverband Deutscher Metallgießereien e.V., Düsseldorf

1. vehicle construction (transportation)
2. construction
3. electrical
4. packaging
5. household goods
6. iron & steel industry, aluminothermy
7. metal goods
8. machinery and equipment
9. export of semi-manufactures

The aluminium end-use consumption according to this listing is less than the total consumption of crude aluminium because it is compiled after the first processing stage and the Federal Republic of Germany is a net exporter of semi-manufactures. Aluminium end-use consumption increased from 561,000 t in 1966 to 1.17 million t in 1976, an average annual increase of 7.6 %. The development of aluminium consumption according to sector for 1966 - 1976 can be seen in Appendix 12a. Table 58 shows the percentages for the individual end-use consumer groups in 1966 - 1976 and the average annual growth rates for this period. Greatly different consumption trends within the different groups changed the consumption structure markedly. The percentages for the important transportation, electrical, and machinery sectors have steadily fallen, whereas the increase for construction is above average.

Transportation Sector

The transportation sector is still the largest end-use consumer of aluminium in the Federal Republic of Germany, although its share of the total production dropped from 24 % in 1966 to just under 19 % in 1976. As a whole, use of aluminium in transportation rose from 135,600 t in 1966 to 220,200 t in 1976, an average annual increase of 5 %. The large increase in aluminium consumption for this use ended in 1970 (191,600 t) and in the following years consumption was usually under this level. In 1976 it rose again to the present maximum of 220,200 t.

Of the total aluminium consumption by the transportation sector, road vehicles accounted for just under 90 % (1976: 88 %) during the time period observed. By far the greater part of this amount is accounted for by automobiles, trucks, and busses. Production trends for these vehicles have a decisive influence on the amount of aluminium consumed by the entire transportation sector. Production of automobiles increased at an average annual rate of 2.3 % from 1966 to 1976, that of trucks and busses by 3.8 %. With an average annual growth of 4.8 %, aluminium consumption for road vehicle construction increased more rapidly, from 121,000 t in 1966 to ca. 193,500 t in 1976. When this aluminium consumption is compared with the

Table 58

Aluminium End-Use Consumption in the Federal Republic of Germany

	Percentages of total deliveries						Average growth rate p.a. 1966/76
	1966	1968	1970	1972	1974	1976	
Transport	24.1	21.0	23.1	20.3	16.2	18.8	5.0
Machinery	9.9	8.2	7.6	6.6	7.3	6.1	2.6
Electrical 1)	13.8	13.0	12.4	11.8	6.9	5.8	(-1.3)
Building and construction	9.9	11.7	13.5	16.2	13.4	15.6	12.7
Chemical, food and agricultural appliances	2.6	2.3	2.7	1.9	1.7	1.2	-0.1
Packaging	8.4	7.7	8.3	9.1	8.4	8.0	7.1
Domestic and offices appliances 2)	2.9	2.2	2.1	2.3	6.7	7.0	17.6
Powder consuming industries	1.0	0.9	0.9	0.9	0.4	0.3	-5.4
Destructive	3.9	4.3	4.1	3.7	4.8	4.3	8.8
Metal industries n.e.s and miscellaneous	9.7	11.9	9.7	9.2	9.2	9.5	7.4
Exports of semis, foil, cable, powder	13.8	16.8	15.6	18.0	25.0	23.4	13.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1) until 1972 including office appliances
2) since 1973 including office appliances

Source: OECD

production of automobiles, trucks and busses, a value of ca. 40 kg/vehicle results for the years up to 1967 and 50 kg/vehicle since 1975[1]. This increase in the amount of aluminium used per vehicle reflects the efforts of the industry to reduce fuel consumption through the use of lighter materials. This is true not only for automobiles, but also for trucks and busses for which increasing use of aluminium is being found for superstructures. The large increase in production of motorcycles again in the last few years has also contributed to the increase in aluminium consumed in vehicle construction.

In addition to sheet aluminium and profiles, the motor industry uses primarily castings (motor blocks, cylinder heads, pistons, transmission housings, oil coolers, etc.) and takes ca. 60 % of the aluminium castings production. Castings and semi-manufactures accounted for ca. 80 % and ca. 20 %, respectively, of the aluminium deliveries for road vehicles. Until the beginning of the 1970s, the high percentage of air-cooled motors favored the use of castings. Since then air-cooled motors have taken a secondary roll in the total production. The trend toward water-cooled motors for the "large-series" models has not led to the use of aluminium for motor blocks. Aluminium is usually used for cylinder head, valve chamber lid, and oil pan, but the motor block is made of gray iron.

Structural parts, accessories, and mouldings made of semi-manufactures are being partially replaced by stainless steel and plastics, the latter being helped especially by sporty outfittings. Aluminium is also penetrating into traditional uses for steel and copper, for example, in radiators. In comparison to automobiles, trucks, and busses, use of aluminium for caravans, military vehicles, and motorcycles has been relatively small. Mainly flat products are used in caravan construction, rods and cast products are used for motorcycles.

The use of aluminium in the production of rail and water vehicles is less than for road vehicles. For railway vehicles aluminium is used for light-weight construction methods in the Federal Republic of Germany primarily for intra-city transportation ("U-Bahn", "S-Bahn"). The weight saved is especially important in terms of acceleration and low electricity consumption. Aluminium has also proven itself for new light-weight construction methods as applied to electric motor-coaches in long-distance, high-speed trains, e.g. the TEE trains of the German Federal Railways. The principal interest here is protection of the track by lessening the weight on the axles. Aluminium is also used for the pistons as well as the motor housing of some diesel motors. To limit the weight on the axles, aluminium has been used in the last few years for electric locomotives also. In passenger coaches, the use of aluminium is limited for the time being, due to reasons

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[1] The values are somewhat too high since small amounts of aluminium were also used for other types of vehicles such as caravans, military vehicles, and motorcycles.

of price, to trimming and interior appointments. In freight cars, little aluminium has been used yet; use of aluminium has been made for sliding roofs, doors, containers, tanks and refrigerator cars.

Ship building is only a minor user of aluminium. Non-alloyed metal is not sufficiently corrosion resistant to sea water. Castings of Al-Si-Mg alloys are used for example in ship motors (housings, pistons), for the housings of instruments that are protected from sea water (e.g. navigation instruments), and for windows, trimming, etc.

The aircraft and space industry in the Federal Republic of Germany is also only a comparatively small aluminium consumer. For the most part, sheet metal, profiles, and rods are used. Die press and drop forging parts are also significant for airplane production. Details for this consumer group and their aluminium consumption are contained in Table 59.

Construction Industry

Consumption by the construction industry, the second largest aluminium consumer in the Federal Republic of Germany, increased by an average of 12.7 % annually from 1966 to 1976, considerably more than in the other consumer sectors.

In 1966, only 55,400 t of aluminium was used in construction. In 1976, it was 183,200 t. Ca. 90 % of the aluminium consumed by the construction industry is used by the building trades, especially for roofing and facades, sun shades and interiors. More than 70 % of the semi-manufactures used by the construction industry was accounted for by profiles, ca. 20 % by rolling mill products, and the remainder by pipe, rods, and pressed & forged products.

Aluminium is often used for windows, doors, facades, structural parts, and partitions. After the decline in new construction, the modernization of old houses opened up a new market in which major applications are aluminium windows and doors, radiators, and wall panels. Where wages are high, low installation and upkeep costs are an advantage of assembly-line made, low maintenance aluminium parts.

Another major application of aluminium in the construction industry is its increasing use for roofing and facades, not only for industrial and commercial buildings but also for housing. In addition to numerous types of flat products with different surfaces, aluminium cast plates are also used. In connection with aluminium facades, sun shades should be mentioned, for which increasing amounts of profile products are being used. The newest development is solar collectors.

(12)

Table 59

Motor Vehicle Construction in the Federal Republic of Germany

		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Production of												
cars	unit	2,830,050	2,295,714	2,862,186	3,312,539	3,527,864	3,696,799	3,521,540	3,649,880	2,839,596	2,907,819	3,546,900
trucks	unit	220,658	186,605	244,772	292,028	314,383	285,943	294,442	299,185	260,181	278,389	321,189
Camping mobiles and house trailers	unit	15,763	17,049	19,421	30,479	43,198	55,865	65,799	64,520	47,259	61,825	80,960
Motor cycles	unit	213,844	169,226	178,881	210,440	243,920	274,399	290,966	306,819	308,377	284,945	326,692
Aluminium consumption for motor vehicles[1]	t	121,000	100,300	129,400	157,500	167,900	169,500	170,400	185,500	155,600	153,000	197,600
Production of												
railbuses, etc	unit	262	257	102	n.a.	170	171	194	258	339	385	216
streetcar, subway, rapid transit, aerial railway	unit	262	257	328	291	157	218	299	181	291	308	306
elevators, escalator	t	74,300	76,300	68,200	81,800	87,800	105,900	126,800	133,500	129,400	107,100	111,800
ships	1000 BRT	1,078.7	872.2	1,241.7	1,669.3	1,412.7	1,846.3	1,343.9	1,874.8	2,096.3	2,302.3	2,058.6
Aluminium consumption for other vehicles[1]	t	14,600	13,600	15,800	20,500	23,700	15,300	17,200	22,500	18,800	18,000	22,600
Total aluminium consumption in vehicle construction[1]	t	135,600	113,900	145,200	178,000	191,600	184,800	187,600	208,000	174,400	171,000	220,200

[1] reported by: "Aluminium-Zentrale e.V.", Düsseldorf

Another major application within the building trades is for interiors using about egual amounts of profile and rolling mill products (partitions, ceilings, doors, bannisters, elevators, etc.).

Considerably smaller amounts of aluminium than used by the building trades are used in the construction of light bridges and other weight-bearing structures.

Significant amounts of flat products are used for heating and air-conditioning units of all kinds.

Aluminium profiles and flat products are also used for road signs, bridge railings, guard railings, etc.

Production of aluminium-containing structures for the construction industry is presented in Table 60.

Packaging

The use of aluminium as packaging material is the third largest area of application in the Federal Republic of Germany according to the current end-use groupings. Between 1966 and 1976, the use of aluminium for packaging increased from 47,200 t to 93,400 t, an average annual increase of 7.1 %. The percentage of total consumption for this sector varied little from 8 % during this period.

Aluminium foil, strips and sheets accounted for the largest part of this market. Production of aluminium foil, thin strips, and sheet and strip metal for packaging increased from 60,950 t in 1966 to over 100,000 t in 1976. The share of sheet and strip metal for packaging rose from 16 % to 20 %. Since the consumption of these packaging materials in the same time period only rose from 37,500 t to 60,000 t, considerable amounts could be exported (1976: 48,925 t).

Aluminium foil finds many applications as packaging material in the household and in the foodstuffs, pharmaceutical, and electrical industries, etc. Many different forms are possible, untreated and treated (impressed, printed, painted, laminated, etc.), from which, among other things, special packaging is made (various kinds of containers made of foil, etc.). Sheet and strip metal is used to make various types of caps for bottles and jars, "pop-top" lids for cans of various types of metal, and also for several years now, cans for beverages and canned goods, and other light containers. Especially in the last few years, aluminium has been used increasingly for bottle caps mainly by the foodstuffs industry. New applications are "pop-top" and screw caps, used for numerous kinds of carbonated beverages. This use has profited in the last few years more than usual from the change over by bottling companies to standardized bottles with screw caps. In 1976, 1.65 billion aluminium caps were used just for carbonated beverages and mineral water and a further 1.05 billion

Table 60

Production of Structures and Parts containing Aluminium for the Building Industry in the Federal Republic of Germany
(in t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Buildings of steel and light metals											
Simple halls including installations	.	.	361,697	470,982	456,546	499,833	425,505	414,424	353,429	233,922	240,975
Skeleton and supporting structures and girders	.	.	155,524	195,201	260,712	256,407	246,351	222,143	254,036	399,539	426,610
Roof trusses	.	.	23,281	28,699	33,165	38,030	29,957	28,952	27,024	51,976	58,982
Poles and towers	.	.	90,801	82,965	98,116	109,964	102,307	103,490	110,882	126,016	96,601
Scaffolding and trestles	.	.	42,880	55,570	69,677	63,151	70,698	74,381	80,089	67,112	66,677
Small structures	.	.	104,459	126,132	138,577	139,447	134,092	137,164	131,476	112,331	104,215
Total[1)]	927,336	753,596	826,511	1,007,934	1,099,367	1,156,361	1,045,199	1,020,556	995,209	867,283	866,149
Doors	47,980	51,443	44,633	60,732	67,657	84,950	82,290	87,101	88,601	82,107	94,085
Windows: normal frames	13,759	12,925	11,830	17,661	17,915	18,744	19,831	21,093	17,469	.	24,532
special frames	16,219	14,336	14,534	18,393	24,168	26,496	30,174	34,096	26,988	28,005	24,984
Glass roofs (metal weight)	16,330	12,998	11,341	19,726	24,547	26,010	21,156	20,370	16,809	19,204	21,519
Light construction											
Prefabricated houses	29,986	27,624	23,599	38,533	15,282	17,409	11,944	16,870	12,934	9,392	6,256
Other prefabricated buildings					18,081	19,505	20,843	19,635	14,350	131,302	29,030
Roof trusses			32,346	42,445	47,552	53,320	58,228	57,769	42,385	51,976	58,982
Planking, grating			30,487	49,080	60,161	72,300	67,151	63,003	65,237	63,818	71,195
Framework for concrete			39,682	51,850	61,166	71,682	78,887	61,017	22,721	24,535	37,451
Other			-	-	1,070	1,905	4,232	9,469	18,067	.	.
Construction fittings											
Window and skylight fittings	.	.	45,655	49,144	55,444	51,184	56,222	56,099	47,511	45,070	52,252
Door handels and accessories	.	.	9,655	11,492	10,949	9,370	9,655	10,004	8,835	7,644	9,547
Door and window locks	.	.	1,134	1,440	1,767	2,436	2,510	2,760	2,731	2,585	3,304
Total[2)]	97,209	85,785	91,842	103,429	108,534	106,223	118,191	119,369	101,220	92,732	109,391
Air conditioning	161,656	143,671	140,306	178,482	214,312	252,356	252,483	278,499	280,735	257,516	272,086
Window shades and screens (in 1000 m^3)	.	.	2,357	2,504	3,628	4,418	4,799	5,125	5,708	7,198	7,393
Bridges of steel and light-metals	71,113	65,000	54,445	64,248	74,524	90,219	81,958	70,128	62,018	50,033	38,870
Road equipment											
Traffic signs of non-ferrous metal	.	.	3,196	3,097	8,631	9,983	8,643	8,968	6,260	7,376	6,736
Other signs of non-ferrous metal	.	.	4,096	5,570	5,688	4,720	5,236	6,113	8,099	7,514	7,682
Total aluminium consumption by the building industry	55,400	58,600	80,800	101,600	112,200	137,200	149,300	172,600	144,900	137,400	183,200

1) including other building construction, 2) including hinges, fittings, etc., 3) reported by "Aluminium-Zentrale e.V.", Düsseldorf

Source: Statistisches Bundesamt, Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden

caps for non-carbonated beverages (including printed caps for alcoholic beverages). Production of aluminium screw caps for bottles under pressure was 2.02 billion units in 1976 (1975: 1.73 billion) and for bottles not under pressure 1.39 billion units (1975: 1.22 billion). Production of aluminium bottle caps from 1966 to 1976 increased from 3,445 t to 14,750 t (6.7 billion units), an average annual increase of 15.7 %. The share of aluminium in the production of bottle caps from all materials increased from 40 % to 73 % (in terms of weight).

Another major application of aluminium in the packaging industry is for tubes and self-standing containers, which are produced from aluminium slugs by extrusion methods. In comparison to lead and tin, aluminium has much better market position for this use, as can be seen in the production figures for 1966 - 1976 in Table 61. The share of aluminium in the total production of tubes and self-standing containers has increased only slightly since 1966. Tubes and self-standing containers of the materials listed are used for toothpaste, cosmetics, pharmaceuticals, household products and chemicals, and foodstoffs. The consumption of tubes and self-standing containers from production in the Federal Republic of Germany has been between 0.8 and 0.9 million units/yr since the beginning of the sixties. The share of this market held by different consumers has changed markedly. Since 1976, pharmaceuticals has been the largest market, followed by cosmetics, household products and chemicals, toothpaste and foodstuffs (see Table 62). A new development is conical tubes that are made by the usual methods, then flared and packed in one another, saving space for shipment.

The production of aluminium cans, sleeves, and extrusion parts shows large growth rates. Production has increased ten-fold (in terms of weight) since 1966. Bulk packaging materials such as tubes, sleeves, and small cans are used mainly for packaging pharmaceuticals.

Packaging materials made by extrusion methods also include aerosol spray cans, whose markets continue to grow despite the discussion about possible damage to the environment by the propellent gas (with the exception of hair care products and shoe and leather preservatives). Aerosol spray can production began in the Federal Republic of Germany in 1952. Between 1966 and 1976, production increased from 210 million units to 457 million, an average annual increase of 8.1 %. In 1966 almost 52 % of the aerosol spray cans were used for hair care products. This percentage had fallen to 29 % by 1976. In contrast, the percentage for body sprays increased from 15 % to 38 %. Insecticides and pesticides, household products, and auto maintenance each had a share of 6 % of the market. Table 63 contains the figures for the individual market sectors for 1966 - 1976.

The production of aluminium barrels is also a significant consumer of aluminium in the Federal Republic of Germany. They are used in various forms by the beverage, chemical, and pharmaceutical industries. Especially

Table 61

Aluminium Consumption for Packaging Material in the Federal Republic of Germany

in t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Aluminium consumption for packaging material	47,200	43,000	53,500	65,100	69,200	73,700	83,900	92,000	91,400	79,700	93,400
Production of											
aluminium foil and thin strips	51,289	50,351	59,766	69,704	71,959	76,988	83,765	90,457	94,488	72,777	100,109
aluminium sheets and strips for packaging	9,658	10,035	12,993	16,453	18,860	16,649	18,874	25,005	24,084	17,748	
Consumption of aluminium foil, sheets and strips	37,473	35,414	46,346	55,338	57,015	59,082	61,154	70,635	57,333	49,929	57,930[1)]
Production of tubes from aluminium	7,020	6,350	7,188	7,235	7,659	7,286	5,488	5,538	5,868	5,219	5,919
lead (also tin-plated)	702	571	687	666	1,128	985	537	456	353	242	329
tin	29	23	22	21	34	29	35	37	26	22	28
Production of bottle caps from aluminium	3,445	3,254	3,985	5,175	7,122	8,447	8,978	12,269	13,501	12,827	14,750
lead (also tin-plated)	2,678	2,158	2,430	2,411	2,339	2,299	2,699	2,746	2,714	1,899	1,899
other	2,527	2,817	3,593	4,235	3,551	3,824	3,629	3,581	3,186	1,064	3,582
Production of cans, sleeves, and extrusion molded parts from aluminium (including spray cans)	2,778	3,014	4,417	5,583	7,709	11,971	16,728	22,199	23,911	24,229	28,370

1) excluding sheets and strips for packaging

Sources: OECD: The Non-Ferrous Metals Industry, Paris,
Verband der Aluminium verarbeitenden Industrie e.V.,
Statistisches Bundesamt: Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden

Table 62

Aluminium Consumption for Packaging Material in the Federal Republic of Germany
Breakdown for Tubes made of Aluminium, Lead, and Tin
in 1000 units

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Tooth paste	184,025	184,928	161,818	213,783	203,948	176,882	178,913	188,533	169,852	178,683	181,673
Cosmetics	217,481	209,374	205,282	218,826	201,506	195,191	194,435	193,944	198,638	171,538	195,038
Pharmaceuticals	145,544	149,518	168,149	170,210	192,809	168,998	201,546	230,905	266,424	215,559	248,038
Household products and chemicals	148,836	139,826	157,868	157,866,	145,344	164,095	167,438	179,361	190,785	165,153	194,253
Foodstoffs	245,907	230,227	194,942	150,245	146,068	131,432	144,945	100,441	116,255	95,999	109,175
Total	941,793	913,873	888,059	910,930	889,675	836,598	887,277	893,184	941,954	826,932	928,177

Table 63

Production of Aerosol Spray Cans according to Application in the Federal Republic of Germany
in 10^6 units and %

	1966		1968		1970		1972		1974		1976	
	10^6 units	%	10^6 units	%	10^6 units	%	10^6 units	%	10^6 units	%	10^6 units	%
Hair care	109	51.9	136	46.6	160	40.0	132	34.0	139	33.3	133	29.1
Other cosmetics	31	14.8	71	24.0	129	32.1	133	34.3	159	38.0	174	38.1
Insecticides, pesticides	12	5.7	13	4.5	13	3.2	14	3.6	16	3.8	27	5.9
Air fresheners	8	3.8	11	3.7	12	3.0	11	2.8	13	3.1	14	3.1
Shoe and leather preservative	10	4.8	12	4.2	21	5.2	17	4.4	15	3.6	11	2.4
Other household products	7	3.2	11	3.6	18	4.5	25	6.4	22	5.3	29	6.3
Points and varnishes	10	4.8	12	4.2	14	3.5	17	4.4	19	4.6	23	5.0
Sprays for auto maintenance, and other technical purposes	10	4.8	11	3.6	22	5.5	25	6.4	16	3.8	25	5.5
Pharmaceuticals	8	3.8	11	3.6	10	2.5	12	3.0	16	3.8	18	3.9
Other	5	2.4	4	1.4	2	0.5	3	0.7	3	0.7	3	0.7
Total aerosol spray can production	210	100.0	292	100.0	401	100.0	389	100.0	418	100.0	457	100.0

Sources: Aluminium-Zentrale e.V., Düsseldorf,
Fachverband Tuben, Dosen und Fließpreßteile, Frankfurt

the aluminium beer keg has become widely distributed. In 1969, there were ca. 2.5 million in circulation, accounting for ca. 80 % of the beer kegs used. Since then, the aluminium keg has become subject to competition from products of stainless steel, fiber glass, and even wood.

Household Goods and Office Supplies

This end-use group attained a share of 7 % of the total aluminium consumption in 1976 in the Federal Republic of Germany. Office supplies, included in the statistic since 1973, contributed the major portion. The change in statistical classification does not allow a long-term observation of trends in this sector.

Aluminium consumption by household goods increased from 16,100 t in 1966 to 20,900 t in 1972 (4.4 %/yr). A large part of this amount is due to household and institutional kitchen utensils. A smaller amount of aluminium is used in the production of non-electrical household appliances and non-electrical heating and cooking appliances.

Aluminium rolling mill products and castings are the main forms used in the production of household goods.

Office supplies have been included with household goods since 1973 when the two groups together consumed 75,000 t. This amount was not reached again in either of the following years due to the economic recession and was significantly exceeded only in 1976 with 81,600 t. This increase is, among other things, due to the demand for lamps, furniture, and camping and garden furniture.

Machinery and Equipment Construction

Machinery and equipment construction in the Federal Republic of Germany was characterized by low growth (1966 - 1976: 2.6 % per year) and thus its share of the total consumption fell from 10 % to 6 %. Consumption of 66,000 t in 1969 was significantly exceeded only in 1973 and 1974 (78,800 t) and then declined below the 1969 level due to market conditions.

Consumption in 1976 (71,400 t) was considerably below that in 1973 and 1974, which may have been due to the disinclination of the industry for new investment.

Within this consumption sector as a whole, general machine construction is probably the most important consumer of aluminium, using primarily castings as well as profiles, rolling mill products and pressed & forged products. Aluminium and aluminium alloy castings are used for motor blocks, housings, covers, oil coolers, cylinder heads, pistons, armatures, machine parts, etc. Sizable amounts of aluminium are also used for the production of machinery for the textile and clothing industries, and for paper processing, printing, and office machines. In contrast, only small amounts of aluminium are used for machine tools, balances, and machinery for agriculture, forestry, and the foodstuffs industry.

Considerable amounts of aluminium are used, however, for equipment for the chemical and foodstuffs industries and other equipment. Large amounts of aluminium are also used for insulation sheets and strips. The construction of equipment used mainly rolling mill products, to a small extent also profiles, pressed and forged parts, and pipe. Details can be seen in Table 64.

Electrical Industry

The electrical industry today accounts for only 6 % of the total end consumption of aluminium in the Federal Republic of Germany. This is due to the removal of office supplies from this classification in 1973. A long-term consideration of consumption trends is therefore not possible. From 1966 to 1972, according to the old classification, the consumption of aluminium by the electrical industry increased from 77,500 t to 107,100 t, an average annual increase of 4.7 %. From 1973 to 1976, after the re-classification of office supplies, consumption fell from 74,000 t to 67,800 t. Within the electrical industry the most important use of aluminium is as conducting material for electricity. According to data from Aluminium-Zentrale e.V., Düsseldorf, aluminium consumption for this purpose increased from 35,700 t in 1966 to 45,100 t in 1973, its share of the electrical industry market decreased from 46 % in 1966 to 42 % in 1973. Aluminium is used by the cable industry for conducting material and also for cable mantles. Production of high-voltage cable increased in the Federal Republic of Germany from 210,300 t in 1966 to 300,500 t in 1974 and in both of the following years was below 280,000 t. The fact that a part of the Investment Promotion Program of the Federal government had already taken place can be viewed as the reason for the decline in production in the last two years. In addition, delays in the construction of new power plants, especially the completion of new nuclear power plants, has had a large effect on the conductive materials sector.

Aluminium is being used increasingly in place of copper for high-voltage cable. In terms of the total weight of high-voltage cable produced in 1966, each ton of cable contained ca. 56 kg aluminium and 302 kg copper, in 1976 91 kg aluminium and 238 kg copper. The share of aluminium in this market rose in this time period from 15.6 % to 27.7 % in terms of weight, and in terms of equivalent conductance from 27.0 % to 43.4 %. Further details for the years 1966 - 1967 can be found in Table 65.

Table 64

Selected Products of the Machinery and Apparatus-building Industry in the Federal Republic of Germany and the Consumption of Aluminium by these ultimate Consumer Groups

(1000 t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Metal-working machinery	340.6	307.0	316.8	375.6	427.4	432.6	381.9	361.0	393.0	367.8	349.9
Textile machinery	144.7	140.3	156.7	187.7	190.3	197.2	199.6	214.6	236.8	192.8	189.5
Paper processing machinery	84.7	90.1	106.7	100.7	123.6	119.0	107.4	98.7	111.8	106.1[x]	97.8
Packing machinery	10.8	10.8	11.9	13.9	16.6	18.2	15.8[2]	19.1[1]	19.4[1]	22.4[1]	24.7
Office machines	43.2	43.5	43.1	48.1	59.0	67.5	57.4[1]	56.5[1]	54.1[1]	45.0[1]	47.8[1]
Large and fast balances	19.8	18.8	16.7	19.6	26.3	32.2	25.8	26.6	29.0	32.1	25.9
Dairy machinery	10.1	10.7	11.1	12.2	11.8	11.6	14.2	16.9	14.0	13.5	16.7
Food processing machinery	162.7	156.3	157.0	171.2	173.1	186.8	163.4	171.5	186.4	175.3	190.4
Apparatus for the chem. industry	117.2	116.1	110.4	125.5	147.1	150.8	126.4	111.9	124.0	151.9	144.1
Plastic and rubber processing mach.	71.1	71.0	93.6	117.6	115.4	106.3	100.5	117.9	107.2	93.4	96.8
Aluminium consumption by the machinery and apparatus-building ind.[1]	55.4	45.7	56.9	66.0	62.7	57.3	61.1	74.5	78.8	55.3	71.4
Aluminium consumption by the chem. and food processing industrie and agric.[1]	15.0	12.5	15.6	19.4	22.4	19.7	17.8	18.0	18.9	13.8	14.8

[1] Source: OECD: The Non-Ferrous Metals Industry, Paris, [2] incomplete data

Source: Statistisches Bundesamt, Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden

Table 65

Aluminium Consumption by the Cable Industry in the Federal Republic of Germany

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
	in t										
High-voltage cable	210,269	201,419	202,584[1]	251,565[1]	291,259	290,923	294,331	290,278	300,530	272,398	276,870
Aluminium content	11,758	13,614	15,918	21,428	23,753	22,981	25,653	28,512	27,782	24,780	25,229
Copper content	63,498	58,838	61,393	78,869	83,939	83,774	78,818	78,461	72,905	66,568	65,918
	in %										
Breakdown of high-voltage cable by consumer group:											
Utilities	57.3	58.2	59.6	58.4	59.0	60.3	63.3	65.9	64.0	61.0	60.2
Raw materials industry	14.5	13.7	11.7	13.2	13.3	11.5	9.1	7.1	7.9	9.2	9.0
Other industry	5.6	5.7	5.5	6.9	6.6	5.7	5.0	4.4	4.0	4.3	4.6
Federal and state authorities	2.5	3.7	3.0	2.6	2.3	2.7	2.4	2.4	2.5	2.5	3.0
Wholesale trade	7.9	7.8	9.5	9.5	8.7	9.0	8.8	8.8	9.7	11.0	11.3
Retail trade and handcraft trades	4.7	3.7	4.0	3.9	3.9	4.6	4.6	4.9	5.2	5.4	5.8
Other consumer	7.5	7.2	6.7	5.5	6.2	6.2	6.8	6.5	6.7	6.6	6.1
	in t										
Production of communication cables	127,959	121,858	147,124	167,099	169,327	163,232	153,673	156,174	152,841	123,410	106,752
Production of high-frequency cable	4,953	4,947	8,743	10,947	12,031	17,332	17,285	20,050	20,690	16,394	16,067
Production of other cables	2,097	2,028	3,251	1,990[2]	2,186	2,139	1,184	1,217	1,635	2,315	2,194
	in t										
Aluminium consumption for wiring and accessories[3]	35,700	36,700	37,400	44,600	41,300	42,900	39,700	45,100	4)	4)	4)

[1] excluding ship cable and cable with a mantle for oil or pressure, [2] not including the first quarter, [3] according to: "Aluminium-Zentrale e.V.", Düsseldorf
[4] no comparable data available due to a change in the statistical listing

Source: Statistisches Bundesamt, Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden und Fachverband Kabel und isolierte Drähte

More than 60 % of the high-voltage cable sold since 1971 has gone to the electric utilities and communal operations. The proportion of high-voltage cable sold to the primary industries fell from 14.5 % in 1966 to 9 % in 1976. The proportion going to the wholesale business increased in the same period from 8 % to over 11 %. Small percentages of sales were also accounted for by other industries, state and federal authorities, the trades, retail business, etc. In 1976, 93 % of all aluminium electric cable was delivered to the electric utilities. Almost 53 % of all low-voltage cable was aluminium, over 82 % for 20 kV cable. Table 66 contains the details for the intermediate-voltage range for 1966 - 1969. In 1972, 20 kV aluminium cable had already attained a 77 % share of the deliveries.

Table 66

Deliveries of Wire and Cable for Intermediate Voltages (10 - 33 kV) by the German Wire & Cable Industry according to Conductor Metal (Single Wire & Three Strand Cable)[1)]
(in km)

operational voltage	1966	1967	1968	1969
10 kV				
copper conductor	1,386	1,433	1,541	2,049
aluminium conductor	1,544	1,654	1,700	2,494
20 kV				
copper conductor	1,391	1,311	1,133	1,597
aluminium conductor	895	2,608	3,281	4,531
30 kV				
copper conductor	41	58	54	108
aluminium conductor	43	39	10	110
33 kV				
copper conductor	140	120	95	131
aluminium conductor	115	160	195	287

1) The figures in the table were calculated from H.W. LÜCKING and H. GEIS: Einsatz von PE-isolierten Kabeln im Mittelspannungsbereich. - Zeitschrift Elektrizitätswirtschaft, Jg. 69 (1970), H. 15.

The substitution of copper by aluminium in low-voltage cable up to 1 kV (Cu cross-section 50 - 120 mm^2; Al cross-section 70 - 185 mm^2) is especially noticeable. In 1961, only 26 % of the deliveries by German cable producers was aluminium cable (in terms of length); in 1971 the figure was 59.1 %. The absolute length of the aluminium cable delivered in these two years was 1807 km and 11,500 km, respectively.

While aluminium was able to substitute for copper as conducting material, it is being increasingly replaced by plastics as material for mantles. There are no corresponding statistics for intermediate-voltage cable.

Plastics are also being used increasingly as insulation and mantle material for communications cable due to its better mechanical properties compared to paper-insulated cable. Copper is still the major conducting material. Aluminium is used for the exterior conductor in high-frequency cable. Flexible aluminium cable is also being used lately for high-voltage connecting cable.

Another major application of aluminium is for transmission lines, which were to more than 60 % copper cable before World War II, but have been increasingly replaced by aluminium-steel cable since then.

In comparison to the use of aluminium for the distribution of electricity, the other areas of the electrical industry have only a secondary roll as aluminium consumers. Sizable amounts of aluminium, especially rolling mill products, are used for refrigerators and freezers, for electric household appliances, also to a lesser degree for lighting fixtures and other electrical products. Production of refrigerators and freezers for the household increased from 97,500 t in 1966 to more than 142,000 t in 1976 (excluding adsorption refrigerators in 1976). While production of household refrigerators with a compressor only increased from 66,700 t to 80,250 t, production of up-right freezers increased from just under 6000 t to more than 37,900 t. Details can be seen in Table 67.

Aluminium is used additionally for a large number of kinds of electrical tools, household and kitchen appliances. Sizable amounts of aluminium, mainly flat products, are also used for lighting fixtures. Aluminium consumption for all of these uses increased by an average of 5.8 % annually from 1966 - 1973, i.e. somewhat more than for electric cable.

Metal Goods and Misc.

In the very heterogeneous metal goods branch, ca. 18,600 t of aluminium were used in 1966 and ca. 31,600 t in 1973. For the following years, the statistic includes various other applications for aluminium. Consumption of aluminium for this grouping increased from 54,500 t in 1966 to 111,600 t in 1976. The later figure included almost 88,000 t for miscellaneous applications.

Table 67

Electrical Products in the Federal Republic of Germany and the Amount of Aluminium Used
(in t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Refrigerators	66,704	78,837	74,146	68,627	61,262	58,491	.	.	.	68,433	80,248
Deep-freezers: up-right	5,957	6,739	7,244	9,057	13,216	16,152	26,660	27,635	40,311	40,367	37,937
chest	23,111	36,011	46,421	37,614	36,026	40,978	30,693	33,028	37,852	29,164	23,996
Absorption refrig.	1,701	1,527		1,660[1)]	4,742	5,957	5,450	4,519	3,559	.	.
Elect. portable drills grinders and polishers	4,909	4,408	5,785	7,880	8,125	8,425	8,159	8,497	9,510	8,043	8,982
Elect. irons	3,730	3,651	4,120	4,751	4,452	4,176	4,696	4,517	4,871	4,326	5,192
Vacuum cleaners	8,087	8,110	10,037	11,577	14,009	14,303	17,229	20,018	19,817	18,452	24,033
Elect. floor polishers	1,866	1,713	1,526	1,529	1,253	1,281	1,196	1,130	912	1,187	1,139
Elect. kitchen appliances	8,854	8,008	9,793	10,426	10,694	11,324	13,455	15,409	15,765	15,253	15,531
Elect. fans	5,859	5,705	5,319	4,112	3,487	3,276	3,743	5,009	5,150	5,060	6,042
Lighting: interior	42,435	43,480	47,838	59,427	64,191	67,698	73,887	80,542	73,174	65,449	69,342
exterior	8,739	8,997	9,404	11,615	13,019	12,902	13,215	20,155	17,219	14,927	15,299
special	6,340	6,403	6,416	8,359	9,990	9,213	8,740	9,380	8,289	8,201	10,237
Living space and flood lighting	23,914	22,654	23,536	24,187	26,200	28,651	33,964	38,681	39,822	32,525	35,373
Aluminium consumption for refrigerators, consumer appliances, lighting, etc.[2)]	41,800	39,100	52,300	58,100	61,700	61,200	68,800	62,000	3)	3)	3)
Aluminium consumption of the electrical industry as a whole	77,500	75,800	89,700	102,700	103,000	104,100	108,500	107,100	74,400[4)]	67,200[4)]	67,800[4)]

[1)] only the second half year, [2)] data according to: "Aluminium-Zentrale e.V., Düsseldorf, [3)] no data available due to a change in the statistical listing,
[4)] excluding office equipment

Source: Statistisches Bundesamt, Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden

Primarily semi-manufactures are used for metal goods, particularly rolling mill products and profiles, to lesser extent pipe, rods, and wire. A major application is for signs of all kinds, especially road signs and automobile license plates. According to official production statistics, their production from non-ferrous sheet metal (including safety equipment, barriers, and guard railings) increased from 3196 t in 1968 to 9983 t in 1971, declined, however, to 6736 t in 1976. The production of other signs, which increased from 4100 t in 1968 to 7700 t in 1976, also used sizable amounts of aluminium.

Another large area of consumption for aluminium is locks and fittings for the construction and automobile industries, for furniture, refrigerators, etc. Mainly castings, profiles, and rolling mill products are used for these applications. Table 68 shows the production development for metal fixtures from 1968 - 1976.

Considerable amounts of aluminium are also used in the Federal Republic of Germany for furniture, screws, standard lathe and repetition work, and numerous other metal goods. While the furniture industry uses about equal amounts of pipe and profiles, in addition to castings, the various lathe products are made primarily of rods. Other metal goods are made of approximately equal amounts of aluminium profiles and rolling mill products.

Iron and Steel Industry, Alumino-thermy

Aluminium is used by the iron and steel industry for the production of alloys and deoxidation of steel. Another application is alumino-thermy (production of carbon-free metals, e.g. chromium, manganese, molybdenum, vanadium, and titanium; and the thermite process, which is used for example to weld rails together). The aluminium consumed by these two areas of use is reported together, the greater amount goes to the iron and steel industry. Production within this branch then determines the development of aluminium consumption for this classification.

Production of raw steel and the use of the aluminium by the iron and steel industry and for alumino-thermy are shown below for the years 1966 to 1976 in the Federal Republic of Germany (in 1000 t):

	1966	1968	1970	1972	1974	1976
RS	35,316	41,159	45,041	43,705	53,232	42,415
A	21.7	29.7	34.2	34.9	51.5	50.6

RS = raw steel   A = aluminium consumption

Table 68

Production of Metal Fixtures in the Federal Republic of Germany: 1968 - 1976
in t

	1968	1969	1970	1971	1972	1973	1974	1975	1976
Building fixtures									
Window and skylight	45,655	49,144	55,444	51,184	56,222	56,099	47,511	45,070	52,252
Doorhandes and fittings	9,655	11,492	10,949	9,370	9,655	10,004	8,835	7,644	9,547
Door and window locks	1,134	1,440	1,767	2,436	2,510	2,760	2,731	2,585	3,304
Refrigeration equipment	3,220	3,754	3,665	4,303	4,736	5,088	4,146	4,331	2,552
Ornamental fixtures									
Furniture and apparatus wheels	7,854	8,159	8,092	7,886	8,885	11,238	10,247	9,616	12,296
Bread boxes and other fixtures	1,378	988	943	1,953	1,001	1,167	1,066	744	863
Exterior fittings for furniture	14,194	15,827	18,305	19,245	20,732	25,213	24,953	25,253	31,587

Source: Statistisches Bundesamt, Fachserie D, Reihe 3, Industrielle Produktion, Wiesbaden.

The marked increase in aluminium consumption from 0.6 kg/t to 1.2 kg/t of raw steel may be mainly due to the increasing proportion of continuous cast, killed steel.

Exports of Semi-manufactures

In the last few years, exports of aluminium and aluminium alloy semi-manufactures have attained an increasing proportion of the amount of aluminium consumed by the various end-users. Exports rose from 77,400 t in 1966 to 274,600 t in 1976, their share of the total consumption increased from 13.8 % to 23.4 %. Marked changes occured in the semi-manufactures export structure during this period. The proportion of sheet and strip metal in 1972 was ca. 40 % and increased in the following years to ca. 50 %. On the other hand, the proportion for foil dropped from 28 % to 17 %, remained, however, in second place. The proportion for rods, profiles and wire increased from 12 % to 15 %. There was no significant change for the other listings. Figures for aluminium semi-manufactures exports are presented in Table 69 for 1966 - 1976.

4.3 Aluminium Consumption in Belgium/Luxembourg

Belgium and Luxembourg have used more than 200,000 t of aluminium since 1972, reaching a maximum in 1976 of 246,000 t. This amount was 7 % of the total consumption within the EC and 1.4 % of world consumption. Average annual increase from 1966 - 1976 was just under 5 %, somewhat less than for the present-day EC as a whole (6 %).

OECD statistics[1)] shows that 80 % of this consumption was determined by semi-manufactures export. Domestically, the construction industry, metal goods and misc., the electrical and packaging industries were significant consumers of aluminium. In 1976, exports of semi-manufactures accounted for 77 % of the aluminium consumed, metal goods and misc. 6.8 %, construction 6.5 %, packaging 3.7 %, the electrical industry 2.7 %. Average annual growth rates from 1966 to 1976 are as follows:

electrical industry	10.1 %
packaging	7.7 %
export of semi-manufactures	4.2 %
construction	2.4 %

Aluminium consumption by various end-users and the production of relevant products are shown in Table 70.

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1) see Appendix 12 b

Table 69

Germany FR: Export of Semimanufactures Made of Aluminium and Aluminium Alloys; 1966 - 1976

in t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Rods, sections and wire	10,390	16,383	18,178	22,177	22,782	26,146	31,699	32,812	43,739	36,060	47,053
Sheets, strip etc.	34,297	41,849	56,326	76,277	48,726	61,787	78,281	103,844	150,872	102,812	153,409
Foil[1)]	25,470	26,228	31,157	36,696	39,581	38,677	43,967	48,990	59,054	38,456	53,636
Tubes and accessories	1,560	1,912	2,123	3,021	3,487	3,301	3,682	5,309	7,190	6,747	8,432
Powder and flake	2,414	3,168	3,611	3,391	3,888	4,020	4,555	4,670	5,227	4,016	5,585
Hollow-ware	2,762	2,731	2,903	2,634	2,983	3,927	3,685	4,760	6,390	5,535	6,781
Cables, stranded wire	3,391	6,270	4,548	837	732	6,852	3,811	4,342	4,458	3,496	4,324
Other manufactures of aluminium	9,779	10,395	12,841	29,541	32,571	18,783	19,929	24,400	28,478	27,455	36,635
Total	90,063	108,936	131,687	174,574	154,750	163,493	189,609	229,127	305,408	224,577	315,855
Metal content of the exports	77,400	95,700	115,800	142,300	129,300	139,300	165,700	207,100	270,300	191,900	274,600

[1)] Metal content as reported by "Verband der Aluminium verarbeitenden Industrie", Frankfurt

Source: Metallstatistik 1966 - 1976, 64. Jahrgang, Frankfurt am Main 1977

Table 70

Aluminium Consumption in Belgium/Luxembourg and Important Production Figures: 1966 - 1976

in 1000 t

	Unit	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Construction industry (aluminium consumption)	1000 t	12.4	11.9	11.7	12.1	16.1	11.0	12.0	16.1	17.4	14.3	15.8
prefab. living quarters	1000	34.6	34.1	28.9	35.1	27.4	27.6	36.4	40.8	43.2	52.9	49.6
prefab. non-living quarters	1000	6.8	6.3	5.3	7.7	6.2	5.7	6.1	6.0	5.9	6.7	5.5
Electrical industry (aluminium consumption)	1000 t	2.5	2.0	2.1	2.4	5.0	5.6	4.8	6.5	6.7	6.3	6.6
cable and insulated wire (production)	1000 t	17.6	19.8	22.8	28.6	25.3	39.7	42.1	47.2	44.6	38.9	
commercial refrigerators (production)	1000 t	6.4	6.2	6.3	7.0	9.4	10.9	16.0				
house hold refrigerators (production)	1000	11	24	17	18	22	29	28	40	.	.	.
elec. kitchen appliances (production)	1000 t	7.2	8.9	9.5	8.7	8.9	12.1	9.8	1)	1)	1)	1)
Transportation (aluminium consumption)	1000 t	2.2	1.9	2.9	3.2	2.9	3.1	3.1	3.9	4.3	1.7	2.6
vehicle production	1000	202.4	188.9	176.9	316.5	272.4	295.8	271.5	296.9	183.1	222.2	327.0
vehicle assembly	1000	317.6	295.7	458.6	513.2	569.1	671.6	722.7	755.9	654.3	636.7	742.8 2)
Semi-manufactures exports (aluminium consumption)	1000 t	125.3	102.6	122.0	129.3	133.0	142.4	168.1	171.3	183.4	155.7	189.6
Total consumption of aluminium	1000 t	171.4	133.7	162.8	176.4	181.7	195.5	215.3	224.8	236.2	194.3	244.9
Aluminium semimanufactures production	1000 t	162.1	132.6	144.7	167.0	164.8	186.4	209.0	224.9	235.8	188.1	241.3
Exports (gross weight)	1000 t	130.0	112.6	128.0	145.1	145.0	165.6	185.8	201.5	218.8	184.4	229.3
rods and wire	1000 t	28.3	31.9	36.5	42.0	37.6	49.4	53.1	62.5	67.4	56.1	67.7
plates, strips, and sheets	1000 t	86.0	62.6	68.8	76.0	80.8	85.8	94.9	99.0	106.9	90.9	115.0
foil 3)	1000 t	7.0	6.9	7.4	11.4	12.4	13.7	14.0	16.3	16.5	12.3	15.6
pipe	1000 t	2.1	1.7	1.8	2.0	1.7	2.1	3.3	4.2	5.0	5.5	7.9
cable, uninsolated	1000 t	3.0	4.8	6.3	4.6	1.8	2.5	6.5	2.8	3.7	2.6	3.6
Other	1000 t	3.6	4.7	7.2	9.1	10.7	12.1	14.0	16.7	19.3	17.0	19.5

1) not available because of a change in the statistics

2) excluding commercial vehicles

3) mixed weight

Aluminium consumption by the construction industry rose from 12,400 t in 1966 to 17,400 t in 1974, declined in 1976 to 15,800 t. The trends in aluminium consumption for this market paralleled the number of finished residential buildings with a one year lag, i.e. the maximum in finished residential buildings of 52,900 units in 1975 corresponds to the maximum in aluminium consumption of 17,400 t in 1974.

Electrical industry consumption of aluminium until 1970 was less than 30,000 t annually, in the following years usually more than 40,000 t. As far as can be seen from the available production statistics, production of cable and insulated wire, and household refrigerators and kitchen appliances has increased considerably since 1970.

The motor vehicle industry, with 2,000 - 4,000 t annually, belongs to the smaller aluminium consumers in Belgium and Luxembourg. This is due to the fact that mainly motor vehicles of foreign manufacturers are assembled from imported parts. Independent production of motor vehicles rose from 202,400 in 1966 to 327,000 in 1976, an average annual increase of 4.8 %. Aluminium consumption, however, remained far behind with an average annual increase of only 1.7 %, since Belgian motor vehicle production is also done mainly with imported castings.

Aluminium consumption for semi-manufactures exports increased from 125,300 t in 1966 to 189,600 t in 1976, an average annual increase of 4.2 %. Gross weight calculated for semi-manufactures exports was 130,000 t and 229,300 t in 1966 and 1976, respectively. Sheet metal, plate , and strips accounted for ca. 50 % of the export volume, rods and wire for just less than 30 %, followed by foil (7 %), pipe, and uninsulated cable. The very heterogeneous group of other goods accounted for ca. 9 % of the total exports of semi-manufactures.

4.4 Aluminium Consumption in France

With an aluminium consumption of 628,000 t in 1976, France was in fourth place in the Western World. Consumption increased by 76 % from 1966 to 1976, an average annual increase of 5.8 %. Primary aluminium production did not increase during this period, and ranged from 380,000 to 390,000 tpy.

Only the production of secondary aluminium increased in 1966 - 1976, from 60,000 t to 137,000 t, respectively, corresponding to an increase of 77,000 t or an average annual increase of 8.6 %. While imports of crude aluminium rose by 11.1 %/yr to 251,400 t in 1976, the corresponding exports in the same year decreased by 10 % to 149,200 t. That means that the increase in aluminium consumption was covered almost exclusively by imports.

France was affected by an economic recession in 1975 as were the other industrial countries. This recession led to a drastic drop in demand compared to 1974, resulting in large inventories. Consumption in 1976 exceeded that of the previous record year, 1974. The same was true for the per capita consumption.

	1971	1972	1973	1974	1975	1976
Per capita consumption of aluminium (kg)	9.1	10.2	11.4	11.5	9.7	11.8

A per capita consumption of 11.8 kg put France in sixth place in the Western World; per capita consumption in the Federal Republic of Germany was 19.1 kg. Production of semi-manufactures in France increased from 191,600 t in 1966 to 368,200 t in 1976, an average annual increase of 6.8 %. Aluminium castings production increased by 72 % from 1966 to 1976, an average annual increase of 5.6 %. In 1976, 188,000 t of aluminium castings were produced, 43 % of that was die-castings. This area of production increased from 1966 to 1976 by 158 % corresponding to an average annual increase of 9.9 %. As a whole, the production of aluminium castings and semi-manufactures in 1976 exceeded that in 1974 by 7.3 %.

The largest end consumer of aluminium since 1966 has been the transportation sector, which used 173,000 t of aluminium in 1976. Its percentage of the total consumption fell from 32 % (1966) to 26 % (1976). Within the transportation sector, the motor vehicle industry is the largest end-consumer of aluminium. The amount of aluminium used per vehicle has been above the European average for years. The present consumption is more than 42 kg/vehicle. More than 80 % of the aluminium used by the transportation sector goes to the motor vehicle industry. Details are contained in Table 71.

The French automobile industry was able to operate at full capacity in 1976 for the production of almost all types and models. There was an increased trend to utilize aluminium for busses, tank trucks, dump trucks, and flatbed trucks. The substitution of other materials by aluminium increased. Aluminium motor blocks are used by all French motor vehicle manufactures, especially in automobile production. In 1976, the following automobiles have aluminium motor blocks and cylinder heads:

Table 71

Aluminium Consumption by the Transportation Sector in France

	1966	1967	1968	1969	1970	1971	1972x)	1973	1974	1975	1976
Vehicle production in 1000 units	1,830	1,838	1,982	2,240	2,504	2,747	3,017	3,218	3,075	2,861	3,403
Aluminium consumption in 1000 t	114.7	102.6	99.7	122.0	145.0	145.0	163.3	166.5	154.0	138.2	172.8
In transportation sector in 1000 t	64	68	70	80	101	112	132	136	128	119	143
Automobile industry in the transportation sector in %	56	66	70	72	75	77	80	81	82	86	82
Special use of aluminium kg/vehicle	34.9	37.0	35.3	39.3	40.3	40.8	43.7	42.2	41.6	41.2	42.0

x) Figures for aluminium consumption by transportation are estimated as of 1972.

company	aluminium motor block model	aluminium cylinder head model
Citroen	GS (air-cooled) MS Maserati[1)]	-
Peugeot	104	404[1)]
	204	504
	304	-
	604	-
Renault	R 12 (Gordini)	-
	R 15 TS	R 15, TL
	R 16 TX, TL, TS	-
	R 17 TS	R 17 TL
	R 20 TS	R 20 TL, GTL
	R 30 TS	-

1) production discontinued

Intermittently, aluminium oil pans and coolers were used for some series.

A transition to aluminium radiators is foreseeable within the next few years. Renault has already tested aluminium radiators on the assembly line. Brazed aluminium radiators were introduced in several models in 1976; aluminium heat exchangers were also developed further.

Other applications for aluminium in automobile production are safety bumpers (for several export models for the USA) and wheels.

Aluminium is being used for express train coaches (the Mistral) and the modern gas-turbine trains in wholely aluminium construction or partial use for siding panels. From 1977 to 1982, 2000 more coaches with aluminium bodies are to be made for the Paris Metro.

Aluminium consumption for armaments including aircraft is not known, but is probably equivalent to that for the other European industrial countries.

The second largest consumer of aluminium was the electrical industry with 85,000 t in 1976, corresponding to 13 % of the total consumption. With an average of 9 % annually, the growth rate for aluminium consumption by this classification was above average.

Demand for conducting materials can be completely covered by domestic production. Production and consumption of aluminium conductor materials have nearly trebled since 1966 (see Table 72). Production and consumption of electricity increased during the same time period by 70 %.

With the bringing of several nuclear power plants into operation the demand for conducting material for high and intermediate voltage lines has increased, while the length of low-voltage lines in the electric network decreased. This development is probably the reason for part of the growth in aluminium consumption, especially that for conducting materials. Aluminium has been able to replace copper almost completely, especially for overhead transmission lines. Aluminium has been used for some time for self-supporting insulated cable in the low-voltage range. Telephone cable with aluminium strands of 0.6 - 1.5 mm have been used above and below ground in the cities. Aluminium has also found use in coaxial cables, switching systems, as supporting structures, and as electric rails for switching and distribution systems.

The third largest consumer of aluminium is the construction industry with an 8.5 % share of the total consumption in 1976, corresponding to 56,400 t. Consumption has increased by 122 % since 1966, an average annual growth of 8.3 %.

In spite of the only very small increase in construction, aluminium consumption by the industry increased from 1975 to 1976 by 36 %. This can be understood in connection with favorable market conditions, especially in relation to those trades dealing with interiors, which profited mainly from an accumulation of work from 1975. Bringing inventories back to a normal level also contributed to the large growth.

Renovation of older buildings probably increased considerably in the last year.

Because prefabrication methods hold a comparatively small share of the total construction volume, aluminium has been able to enter only a small market.

The packaging industry accounted for 7.2 % of the aluminium consumption in 1976. Sales of aluminium cans for foodstuffs and beverages has increased in the last few years. However, the increase in aluminium consumption in this branch of industry is still far below that in the other industrial countries. An upswing was felt within the packaging industry in France again in 1976, although not all parts of the industry reached the level of 1974. This development was partially reinforced by the unusual weather conditions of the 1976 summer season, for example in the market for bottle caps and for aerosol spray cans.

Aluminium foil for the household showed an rising trend. Production of foil has increased by 82 % since 1966.

Table 72

Electricity Production and Consumption and Development of the Electrical Power Grid in France: 1966 - 1976

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Gross electricity production (in 10^6 kWh)	110,883	116,900	123,292	137,500	146,837	155,862	171,226	182,528	188,357	185,534	197,400[2)]
Gross electricity consumption (in 10^6 kWh)[1)]	113,900	119,463	124,771	136,868	146,331	154,440	165,299	179,562	188,025	188,513	196,861
Length of power lines (in km)											
380/400	2,805	3,560	3,794	4,070	4,491	4,726	5,101	5,464	5,921	6,222	6,333
225	17,356	18,025	18,946	20,094	20,569	21,262	21,673	22,422	22,433	22,688	23,052
200	158	158	158	158	158	158	158	158	158	158	158
150	8,100	7,308	6,997	6,952	6,865	6,864	6,850	6,750	.	6,526	6,382
110/120	40	40	6	5	5	5	5	3	.	.	.
100	34	34	34	33	33	33	33	33	33	33	34
90	8,800	8,908	9,037	9,449	9,549	9,915	10,492	10,687	10,823	11,013	11,301
63	24,900	25,100	25,900	26,400	27,300	28,000	28,088	28,400	28,800	29,166	29,599
45	2,000	2,100	2,000	1,900	2,000	2,000	1,900	1,900	1,900	1,700	1,633
30	15,800	13,900	13,700	13,500	13,200	13,200	12,200	11,700	10,500	10,500	10,200
20	37,700	48,300	60,400	72,500	81,300	90,200	106,100	125,000	132,000	143,000	156,600
15	221,000	227,000	226,700	226,300	226,900	230,800	234,600	235,000	231,000	232,000	233,300
10	44,900	41,000	40,000	39,400	38,900	35,400	31,800	30,000	34,000	34,000	32,800
5,5	32,500	30,000	27,600	24,400	22,100	21,400	15,400)	)	)	)	
3,2	4,300	3,900	3,700	3,400	2,900	2,800	2,000)	15,000)	13,000)	12,500)	11,100
1	80	90	90	80	100	200	100)	)	)	)	
Total	545,000	545,000	550,000	555,000	565,000	565,000	572,000	585,000	586,000	593,000	601,000

1) including imports and exports, 2) provisional figure

Source: Electricité de France

4.5 Aluminium Consumption in the United Kingdom

Primary aluminium production in the UK was ca. 40,000 tpy until 1970 when two new plants began operations. There after, production increased to 335,000 t in 1976. Production increases of the last few years have led to an oversupply on the domestic market. As a result, imports of crude aluminium could be reduced and exports increased. Production and consumption of secondary aluminium remained for the most part constant during this period, if variations in any one year are disregarded. There was a large decrease in primary aluminium consumption in 1975, due to a large drop in demand by the fabrication industries and export. The developments of 1970 - 1976 are presented in Table 73.

Per capita consumption trends in the UK during the last few years may be viewed as favorable, as can be seen in the following table (in kg):

	1971	1972	1973	1974	1975	1976
total	8.9	9.6	10.9	10.2	8.3	9.8
semi-manufactures	6.0	6.7	7.8	7.2	5.8	7.3
castings	2.4	2.4	2.6	2.4	2.1	2.2

The transportation sector continued to be the largest consumer of aluminium in 1976. Its share of the aluminium market fell from 27 % in 1966 to 20 % in 1976 and amounted to almost 124,000 t. Most of the aluminium used by this sector (ca. 86 % including alloys) went to the production of road vehicles. In addition to castings (mainly gravity and pressure die castings), primarily rolling mill products of aluminium alloys were used. Alloys, however, have only a subordinate roll.

Al-Mg-Mn alloys are used primarily for body parts for cross-country vehicles, Al-Cu-Mn alloys for boot (trunk) lids, bonnets (hoods) and other body parts for exclusive limousines and cross-country vehicles, for example at British Leyland (e.g. Rover). Aluminium motor blocks have been used on the Jaguar (12 cylinder) and Rover assemby lines as well as for the Landrover and Range Rover (3.5 l V8). The Jaguar (6 cyl.), Triumph TR 7, Rover (21), Maxi, and Lotus automobiles have cylinder heads of aluminium or aluminium alloys.

There has also been an increase in the use of aluminium for special vehicle superstructures. Other materials, such as coated sheet steel, have begun to substitute for aluminium in fittings, grills and mouldings. Since aluminium consumption by the transportation sector has fallen in the UK as well as vehicle production, the amount of aluminium used per vehicle has remained practically constant since 1973 at 61 - 64 kg.

Table 73

Production, Consumption, and Deliveries of Aluminium in United Kingdom: 1970, 1973, 1975, and 1976

in t

	1970	1973	1975	1976
Primary Aluminium				
Production	39,600	251,600	308,300	334,500
Import	379,100	287,080	160,279	217,901
Consumption	404,200	487,800	392,700	444,500
Secondary Aluminium				
Production	201,400	189,300	176,200	205,800
Consumption	179,200	176,600	141,200	140,700
Direct use of scraps	19,500	23,200	31,300	32,500
Total Aluminium consumption	602,900	687,600	565,200	617,700
Aluminium semimanufactures deliveries	327,927	389,429	352,096	405,121
Sheet metal	92,895	109,763	77,748	88,368
Strip metal	61,545	88,437	82,597	107,472
Circles	23,894	24,816	20,786	20,271
Forged products	421	1,140	634	693
Rods for making wire	6,172	3,696	2,339	2,780
Other rods	12,337	12,600	12,634	12,247
Sections	69,709	92,275	83,909	105,289
Pipe	17,367	20,402	19,449	20,501
Wire	43,587	36,300	52,000	47,500 x)
Cast aluminium deliveries	135,175	146,615	120,566	121,132
Sand casting	18,355	17,854	16,142	14,921
Cold casting	73,004	70,623	55,997	58,037
Die casting	43,816	58,138	48,427	48,174
Forged products	3,679	3,792	4,104	3,669
Aluminium foil	34,966	42,692	36,223	39,815

x) estimated

In other areas of transportation, for example, ship building, the figures for consumption have fallen. The same is true for aircraft construction and rail vehicles. There was a slight increase in the use of aluminium for armaments.

The second largest consumer was the electrical industry, which has had 10 - 13 % of the total consumption for the last ten years. In 1976, 63,000 t of aluminium were consumed. About three-fourths of the demand within the electrical industry was for cable, followed by electrical machines and equipment.

Aluminium has been able to substitute for copper as conducting material for transmission lines in the electricity grid, whose expansion has stagnated in the last few years.
The same is true for communications systems. This substitution as conducting material has not been able to take place with anywhere near the speed of the sixties due to a weaker demand for conducting material and also to a lower copper price.

As third largest consumer of aluminium, the construction industry accounted for 11 % of the demand, in comparison with the other western industrial countries only a halting development. Aluminium windows and doors have not yet had a sizable market. However, the demand for aluminium profiles has risen since 1971, in spite of the fact that there was little new construction. This would indicate increased substitution of aluminium for other materials, expecially in new and replacement windows. As a whole, consumption by the construction industry nearly doubled from 1966 to 1976.

The fourth largest area of consumption was for household goods and office supplies, which has developed during the last few years at almost the same rate as the total consumption. The proportion of the total consumption has remained at ca. 9 % for some years. More than three-fourths of this amount was for office supplies, principally for office furniture and machines. Since sales of office machines and equipment have scarcely increased, this market for aluminium has also stagnated.

Aluminium is used primarily as foil by the packaging industry. The share of foil in the total consumption by this area of application has constantly increased in the last few years. In 1976, 43,600 t of laminated foil were consumed. There was a decline in aluminium consumption for the other parts of the packaging industry -- aluminium cans, "pop-tops" for cans (est. share of the market for beer cans, ca. 90 %; for non-alcoholic beverages 40 - 50 %), beer kegs, and containers.

Aluminium has been used since 1970 only for replacement needs, especially for aluminium barrels, mainly beer kegs, which dominate the market over stainless steel barrels. Details on production, consumption, and deliveries of aluminium and aluminium products for 1970, 1973, 1975, & 1976 can be seen in Table 73.

4.6 Aluminium Consumption in Italy

With an aluminium consumption of 590,000 t in 1976, Italy was the fourth largest consumer of aluminium in Western Europe. As was also the case in other countries, 1975 was characterized by poor market conditions, causing aluminium consumption to decrease by nearly a quarter compared with the previous year. Consumption in 1976 increased again and exceeded the level of 1974. Total aluminium consumption increased by 134 % from 1966 to 1976, an average annual increase of 8.8 %, considerably greater than the EC average.

This large increase in primary and secondary aluminium consumption could be covered by domestic production only for secondary aluminium. Ca. 50 % of the primary aluminium consumption since 1969 has come from imports. Production of secondary aluminium increased by 132 % from 1966 (85,000 t) to 1976 (198,000 t), an average annual growth of 8.8 %. Consumption increased during the same period from 78,000 t to 217,000 t corresponding to an average annual growth of 10.8 %. At the same time primary aluminium production increased by only 62 % (4.9 % annually) to 207,000 t.

Production trends for semi-manufactures, castings and forged parts of aluminium and aluminium alloys from 1965 to 1975 are presented in Appendix 11b.

A reorganization of the individual companies led to a far-reaching integration of the industry from production of castings, semi-manufactures, and end products to a long-term program for marketing and research and development. As a result of this reorganization, most of the Italian aluminium production is controlled by MCS (Mineraria Carbonifera Sarda), a finance group of the government holding firm EFIM. The degree of participation of MCS in the individual companies is shown in Table 74. In this way MCS controls most of the primary aluminium production with an effective capacity of 285,000 tpy. As a result, MCS has moved up to fourth place in Europe. The MCS has a ca. two-thirds share of the Italian production capacity for aluminium semi-manufactures (140,000 t). Ca. 41 % of the Italian aluminium consumption in 1966 was accounted for by the transportation sector, in 1976 it was 25.6 % (150,200 t).

Most of the aluminium used went to road vehicle construction, smaller amounts to ship building, rail vehicles and the aircraft industry. Trends in aluminium consumption by vehicle construction are thus dependent on production of road vehicles. Production of transport containers was begun in 1970; it is estimated that more than 1500 t of aluminium are used annually for this purpose. Aluminium is also being used increasingly for street cars and subways.

Table 74

MCS Participation in the Production of Primary Aluminium and Aluminium Semi-manufactures in Italy

Primary aluminium and aluminium alloys, capacity in tons/year

ALSAR (100 % MCS)	
Porto Vesme	125,000
ALUMETAL (100 % MCS)	
Bozen	45,000
Mori	20,000
Fusina	35,000
SAVA (50 % MCS; 50 % Alusuisse)	
Porto Marghera	30,000
Fusina	30,000
Total	285,000

Semi-manufactures (rolling mill & pressed products)

ALUMETAL (100 % MCS)	
Feltre	28,500
L.L.L. (50 % MCS; 50 % Alusuisse)	
Porto Marghera and Fusina	74,000
SAVA (50 % MCS; 50 % Alusuisse)	
Rho and Nembro	21,500
Total	124,000

Aluminium consumption by the individual branches of industry are presented in Table 75. The second most important sector in terms of aluminium consumption was the construction industry, accounting for ca. 10 % of the total consumption, although in some years after 1966 this was exceeded by the household goods industry. The construction industry consumed 110,000 t of aluminium in 1976 compared with 24,000 t in 1966. As is true for the other industrial countries, consumption by the construction industry has increased at a greater rate than construction volume. This is because new areas of application have been opened up (doors and gates, windows, facades, roofing, radiators, etc.).

Table 75

Aluminium Consumption by Selected Branches of Industry in Italy and the Production of Products

	Einheit	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transportation (aluminium consumption)	1000 t	102.0	114.0	128.0	120.0	140.0	138.0	130.0	133.6	145.3	112.6	150.2
Vehicle production	1000 t	1,365.9	1,542.7	1,663.6	1,596.0	1,854.3	1,817.0	1,826.8	1,956.8	1,772.5	1,458.6	1,590.7
Ship building (merchant ships under construction)	1000 BRT	767	803	930	1,419	2,081	1,835	948	754	1,028	847	662
Construction industry (aluminium consumption)	1000 t	24.0	26.0	30.0	46.0	53.0	48.0	72.0	93.7	115.5	79.5	110.0
Prefab. living quarters	1000	289.3	270.6	281.8	283.1	350.4	345.3	259.2	196.6	165.5	214.6	164.3
Prefab. non-living quarters	Mio m^3	33.1	33.4	40.9	42.8	47.6	54.7	54.5	47.5	46.8	53.2	68.9
Household appliances (aluminium consumption)	1000 t	14.0	18.0	21.0	48.0	52.0	48.0	56.0	63.7	69.2	57.6	72.4
Household refrigerators	1000 units	2,807	3,205	4,387	5,002	5,247	5,257	5,424	5,307	6,707	6,582	6,926
Vacuum cleaners	1000 units	165	239	263	387	350	332	341	353	381	415	.
Kitchen appliances with elect. motor	1000 units	952	1,133	1,342	1,492	1,612	1,620	1,642	1,822	2,164	2,088	.
Sewing machines	1000 units	647.7	806.3	845.7	864.5	1,004.9	899.9	818	922	884	832	812
Electrical engineering (aluminium consumption)	1000 t	16.0	17.0	20.0	28.0	34.0	31.0	36.0	29.0	33.6	28.0	27.7
Wire and cable	1000 t	10.0	9.0	13.5	16.5	22.0	21.0	20.5	14.5	17.0	18.0	13.0
Comercial refrigerators	1000 units	2.5	2.6	3.0[1]	3.5[1]	4.2[1]	4.4	.	.	.	.	.
Mechanical engineering (aluminium consumption)	1000 t	17.0	20.0	21.0	24.0	25.0	23.0	30.0	40.0	42.7	25.4	37.9
Textile machines	1000 t	60.1	65.9	67.6	73.3	.	.	.	.	.	.	.
Textile finishing machines	1000 t	6.7	7.5	7.5	7.9	.	.	.	.	.	.	.
Packing machines	1000 t	2.4[1]	2.5[1]	2.6[1]	2.6[1]	2.6[1]	2.3[1]	2.4[1]	2.6[1]	.	.	.
Machines for processing rubber and plastic	1000 t	21.4	22.9	26.0	32.0	39.0	34.0	34.6[1]	35.0	32.8	37.1	.
Paper machines	1000 t	23.1	27.2	30.0[1]	32.0[1]	34.0[1]	.	.	.	.	.	.
Printing machines	1000 t	23.1	29.0	33.4	29.0	33.7	18.0	17.7	18.6	.	.	.
Large and fast scales	1000 t	68.9	74.8	75.0[1]	75.0[1]	80.0[1]	.	.	.	.	.	.
Office machines	1000 t	1,356.9	1,525.2	1,274.1	1,131.1	1,439.6	1,385.1	1,187.1	1,153.1	1,327.0	1,155.3	840.4
Chemical and foodstoffs industries, agriculture (aluminium consumption)	1000 t	3.5	4.0	5.0	6.0	7.0	6.0	8.0	9.8	10.4	5.0	10.9
Agricultural machinery including dairy equipment	1000 t	168.0	145.4	162.4	200.4[1]	160.9[1]	136.2	140.0	185.7	209.9	.	.
Machines for processing foodstoffs[x]	1000 t	64.0[1]	75.0[1]	85.4[1]	.	.	.	.	.	.	.	.
Apparatus for the chemical industry	1000 t	101.5	37.2	37.8	39.7	38.0	39.0	40.0[1]	28.0[1]	30.0[1]	.	.
Iron and steel industry (aluminium consumption)	1000 t	6.2	6.9	8.0	7.5	9.5	9.7	12.0	14.0	16.0	15.0	16.0
Crude steel production	Mio t	13.6	15.9	17.0	16.4	17.3	17.2	19.6	20.7	23.5	21.6	23.2
Export of semimanufactures (aluminium consumption)	1000 t	27.4	30.9	46.2	53.3	45.1	45.5	45.2	43.3	45.9	59.0	85.1
Total aluminium consumption	1000 t	252.0	281.0	323.0	382.0	420.0	402.0	458.0	511.0	556,0	441,6	587,7
Exports by product[2]												
Sheet-, strip-metal, and circles	1000 t	17.7	18.9	31.5	34.5	23.3	29.2	34.5	30.4	32.5	29.6	41.3
Rods and sections	1000 t	4.3	3.5	3.5	5.0	5.0	4.1	11.2	12.2	14.5	15.3	25.3
Pipes and tubing	1000 t	1.5	3.3	2.4	2.7	5.0	1.1	1.7	2.3	3.3	3.3	4.6
Wire	1000 t	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Cable, cable-wire, and stranded wire	1000 t	1.3	2.5	4.7	5.0	5.8	1.5	1.8	1.0	0.5	3.4	2.0
Other	1000 t	8.7	9.6	5.6	7.2	15.2	18.6	33.8	43.1	43.1	38.7	55.4
Total	1000 t	33.6	37.9	47.8	54.6	53.6	54.7	83.2	89.2	94.1	90.6	128.9

[x] including coffee, alcohol, and tobacco, [1] estimated, [2] gross weight

Sources: OECD: The Non-Ferrous Metals Industry, Paris,
Statistisches Amt der Europäischen Gemeinschaften: Industriestatistik, Luxemburg.

Aluminium consumption for household goods exceeded 20,000 t in 1968 for the first time, increasing to over 72,000 t in 1976, accounting for more than 12 % of the total aluminium consumption in Italy. Consumption increased from 1966 to 1976 by an average of 12.3 % annually. A significant portion of this consumption may be accounted for by electrical household appliances, whose production, especially during the latter half of the sixties, has increased considerably. Household refrigerators should be singled out here; nearly 7 million are being produced annually compared with 2.8 million in 1966. Italy has been the largest producer of refrigerators for several years, producing more than twice as many as the Federal Republic of Germany. In addition to other electrical appliances, numerous quantities of non-electrical household appliances are produced from aluminium; there are no detailed statistics published for these, however.

The electrical industry accounts for ca. 5 % of the aluminium consumption in Italy. Consumption increased from 16,000 t in 1966 to 27,700 t in 1976, an average annual increase of 11.2 %. Most of the aluminium consumption for this sector is accounted for by cable & wire, whose production has been ca. 20,000 t annually since 1970 and has been declining since 1973. Of importance in this connection is the decision in 1970 by the state electric utilities company, "Ente Nazionale per d'Energia Elettrica", to replace copper with aluminium in intermediate-voltage cable; aluminium had been used for low-voltage cable for some time already. Large amounts of aluminium may also be used for numerous other electric machines and equipment, more detailed data is lacking, however.

The packaging sector accounted for ca. 9 % of the Italian aluminium consumption. It has increased from 22,500 t in 1966 to 52,400 t in 1976, an average annual increase of 8.9 %. In spite of this high growth rate, there has been a slight decline in the share of this sector in total consumption of aluminium compared to 1972 - 1974. Production of aluminium foil increased from ca. 22,000 t in 1970 to 30,000 t in 1976. The largest Italian producer of aluminium packaging, Tubettificio Ligure, with headquarters in Como, operates three plants in Italy that produce over 200 million aluminium containers annually. The company has also produced cold-extruded aluminium cans for the foodstuffs and oil industries since 1966. The producers of aluminium packaging see an expanding market for one-way trays, etc. for use by canteens as well as for aluminium cans.

The amount of aluminium consumed by the machine-building industry (including precision machinery and optics) increased from 17,000 t in 1966 to 37,900 t in 1976 (8.3 % annually) attaining a ca. 6 % share of the total aluminium market. As in the Federal Republic of Germany, considerable amounts of aluminium may be accounted for by general machine and equipment construction, production of machines and equipment for the textile and clothing industries, paper handling, printing, and office machines and large and rapid balances. Trends in the production of these products can be seen in Table 75.

The chemical and foodstuffs industries and agriculture accounted for ca. 3500 t of aluminium in 1966 which increased to 10,900 t in 1976, corresponding to 1.9 % of the total aluminium consumption.

The iron and steel industries, which use aluminium for making alloys and as a deoxidation agent, and alumino-thermy accounted for only ca. 3 % of the Italian aluminium market. Aluminium consumption increased from 1966 - 1976 (an average of 9.9 % annually) more rapidly than production of raw steel (5.5 %). The two uses together consumed 16,000 t of aluminium in 1976.

More than 10 % of Italy's aluminium consumption has been accounted for since 1966 by exports of semi-manufactures. These exports increased from 27,400 t in 1966 to 85,100 t in 1976. In terms of gross weight, sheet and strip metal and circles have accounted for more than 50 % of the exports since 1966 (in 1976 only 32 %), rods and profiles for more than 10 % (1976: 20 %), pipe and tubing for ca. 4 % and less than 2 % by wire, cable, cable-wire, and stranded wire -- i.e. more than two-thirds for semi-manufactures. The proportion for cable, cable-wire, stranded wire was as high as 10 % from 1968 to 1970 (1976: 1.8 %). A quarter to a third of Italian exports of semi-manufactures are accounted for by numerous kinds of aluminium goods.

4.7 Aluminium Consumption in the Netherlands

The Netherlands produces ca. 250,000 t of primary aluminium annually, corresponding to ca. 13 % of EC production. Of this amount only 40 % is consumed by the domestic market. This has allowed the large production increase since 1974 to go toward net exports of 130,000 t to 140,000 t of raw aluminium annually. Consumption of primary aluminium increased from 23,100 t in 1966 to 105,800 t in 1976, an average annual increase of 16.4 %. Considering the direct use of scrap and secondary aluminium from old and new scrap, the total aluminium consumption increased from 24,600 t in 1966 to 130,200 t in 1976, an average annual increase of 18.1 %. Aluminium is also processed mainly to semi-manufactures in the first processing stage in the Netherlands. Total production of semi-manufactures increased from 24,000 t in 1966 to 108,600 t in 1976, an average annual increase of 16.3 %. This is as large a growth as for primary aluminium consumption. The only statistics available are that ca. 47 % of the production volume is accounted for by rolling mill production, the remainder by pressed products. In the last few years production of pressed products has doubled, changing the ratio to rolling mill products correspondingly.

Production of castings of aluminium and aluminium alloys totalled 6000 - 9000 tpy.

OECD statistics were published for aluminium end-use in the Netherlands up to 1971, when they were discontinued. Compared with raw metal consumption, these figures seem to be considerably too high. Because they represent a usable basis for considering the structure of aluminium consumption in the Netherlands, they are presented in Table 76 as percentages for 1966 - 1971.

The construction industry was the largest domestic aluminium market with ca. 20 %, followed by the packaging sector (ca. 15 %) and household goods (12 - 13 %). The proportion for semi-manufactures exports had increased from 26 % to 33 % in 1968 already and probably increased further in the following years.

Corresponding to trends in the construction industry, a further increase in its consumption of aluminium is probable up to and including 1973, followed by a large decline in consumption parallel to the large decline in construction in the following two years. (From 1973 to 1976 the industry exhibited a decrease of 30 % in aluminium consumption.) In 1976, aluminium consumption by the construction industry may have increased again due to more favorable market conditions in 1977 than in either of the two previous years.

Trends in the other areas of use for aluminium, with the exception of the steel industry may be assumed to be the same. Exports of semi-manufactures increased from 20,400 t in 1966 to 93,800 t in 1973 followed by a decline to 72,600 t in 1976. In 1976, 37 % of the export volume was accounted for by sheet and strip metal and plate, 34 % by rods and sections, just under 10 % by other semi-manufactures (mainly foil), and 19 % by various aluminium goods.

4.8 Aluminium Consumption in Switzerland

Switzerland is one of the smaller markets for aluminium in Western Europe, nevertheless, per capita consumption of 12.7 kg (1976) exceeds most of the other Western European industrial countries. Consumption of primary aluminium increased from 65,100 t in 1966 to 104,600 t in 1976; total aluminium consumption from 78,600 t to 113,900 t, and average annual increase of 4.9 % and 3.8 %, respectively. The comparatively low growth rate indicates saturation in the individual areas of application.

The breakdown of aluminium end-use from 1966 to 1976 is given in Appendix 12h. The importance of semi-manufactures exports is evident from the percentages in Table 77 derived from these data.

Domestically, the packaging and construction industries are the most important aluminium consumers. Switzerland is a major producer of aluminium foil with a production of more than 18,000 t in 1976. Ca. 12,000 t of this was exported and ca. 7500 t was sold on the domestic market (including imports). Aluminium was also used increasingly for pallet and container production.

Table 76

Consumption of Primary and Secondary Aluminium according to Use in the Netherlands
(in %)

	1966	1968	1970	1971
Transport	8.3	5.7	6.1	6.0
Machinery	7.5	5.7	5.2	4.9
Electrical	7.5	8.0	5.2	5.3
Building & construction	18.2	21.8	19.9	19.5
Chemical, food & agricultural appliances	1.2	0.7	0.8	0.7
Packaging	16.1	15.1	14.7	14.3
Domestic & office appliances	14.1	14.3	13.0	12.4
Powder consuming industries	1.0	0.8	1.3	1.1
Iron & steel industries	1.8	1.4	1.3	1.1
Metal industries, miscellaneous	0.9	0.5	1.7	1.7
Exports of semis, foil, cable, powder	23.4	26.0	30.8	33.0
Total	100.0	100.0	100.0	100.0

Table 77

Aluminium End-Use in Switzerland: 1966 - 1976
(in %)

	1966	1968	1970	1972	1974	1976
Transport	6.4	5.3	5.7	5.6	5.2	2.9
Machinery	16.5	12.6	13.7	8.5	10.0	6.6
Electrical	8.3	6.3	6.0	5.8	6.2	4.4
Building & construction	20.7	17.5	16.5	17.7	12.7	10.7
Chemical, food & agricultural appliances	0.8	0.8	0.6	0.4	0.5	0.3
Packaging	16.8	13.0	16.7	19.6	13.8	12.5
Domestic & office appliances	4.4	3.6	3.4	2.9	2.4	1.9
Iron & steel industries	0.8	0.7	0.6	0.5	0.4	0.3
Metal industries n.e.s.	2.3	1.7	2.0	1.4)	3.7	6.8
Miscellaneous	8.6	6.5	4.3	2.6)		
Exports of semis, foil, cable, powder	14.6	32.1	30.5	35.0	45.1	53.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

Aluminium consumption by the construction industry has stagnated in the last few years as a result of the unfavorable market conditions and remained in 1976 also considerably below the record year of 1972. It is expected that the use of thermally insulated facades will bring an increase in consumption.

Export of semi-manufactures accounts for the largest percentage of sales by the Swiss aluminium processing industry.

Aluminium consumption for semi-manufactures exports increased from 57,000 t in 1966 to 113,900 t in 1974, which has not been exceeded since then. Exports consisted mainly of sheet and strip metal and plates (1976: 36 % of the export volume), foil (27 %) and subordinate amounts of rods, sections, and wire (17 %) and other products (15 %). Pipe and tubing accounted for only 5 %. Compared with 1966, the proportion for flat products increased considerably, while that for foil dropped.

4.9 Aluminium Consumption in Spain

Spain, among West European countries, has a particularly large growth rate for aluminium consumption. The market for primary aluminium increased from 84,700 t in 1966 to 222,500 t in 1976, an average annual increase of 10.1 %.

In the past, this growth could be covered by domestic primary aluminium production so that no increase in raw metal imports was necessary. Production of secondary aluminium also increased considerably, from 14,000 t to 40,000 t for this time period. Total aluminium consumption, according to data from Metallstatistik, increased from 98,700 t in 1966 to 266,700 t in 1976, an average annual increase of 10.5 %.

Statistics on the structure of aluminium consumption in Spain have been published since 1969 by the European Primary Aluminium Association. They show an increase from 138,200 t in 1969 to 268,400 t in 1976. Consumption trends within the individual areas of use are presented in Appendix 12g. The percentages are presented in Table 78.

These figures show that the transportation sector is still the largest consumer of aluminium in Spain, although its share of the total consumption fell from 26 to 23 %. Consumption increased from 36,100 t in 1969 to 61,600 t in 1976. For comparison, vehicle production, especially automobiles, increased from 454.500 t to 866.200.
The per vehicle consumption of 71 kg calculated from these figures seems much too high, due probably to sizable amount of aluminium consumed in this sector by the construction of rail and water vehicles and aircraft.

Table 78

Aluminium End-Use in Spain; 1969 - 1976
(in %)

	1969	1970	1971	1972	1973	1974	1975	1976
Transport	26.1	26.2	24.7	26.2	28.0	23.9	23.4	22.9
Machinery	4.6	4.8	5.1	5.4	5.5	4.5	4.3	4.2
Electrical	8.8	12.4	11.5	11.6	9.6	16.2	15.9	14.5
Building & construction	13.3	12.6	13.3	13.8	14.3	17.0	16.3	19.6
Chemical, food & agricultural appliances	1.5	1.4	1.7	2.2	2.9	2.7	2.6	3.0
Packaging	7.2	7.6	8.1	8.7	9.4	8.4	8.0	9.3
Domestic & office appliances	12.1	11.0	10.3	10.1	10.5	10.8	10.5	9.9
Powder consuming industries	-	-	-	-	-	0.1	0.1	0.1
Iron & steel industries	-	-	-	-	-	0.7	0.5	0.7
Metal industries n.e.s.	-	-	-	-	-)			
Miscellaneous	5.6	4.2	4.2	8.2	0.3)	8.6	8.1	7.1
Exports of semis, foil, cable, powder	20.8	19.8	21.1	13.8	10.5	7.1	10.3	8.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The second largest consumer of aluminium in Spain is the construction industry, taking nearly 20 %. The large volume of house and hotel construction contributed significantly to this development.
Third ranking consumer of aluminium is the electrical industry with a share in consumption of 15 %. Impulse for this development came essentially from the high construction activity of the last few years, which necessitated a corresponding expansion of the electricity gr id and telephone system. The increase in living standard and increasing importance of tourism has led to an increasing demand for electrical household appliances and business equipment.
Tourism and rising living standards have also led to an increase in aluminium consumption by the next most important sectors, house hold goods and packaging, accounting for ca. 10 % and 9 % of the end-use consumption, respectively.

In contrast, the increase in semi-manufactures exports was below the average for the other sectors, because a large proportion of production is sold domestically. Mainly cable, but also sheet metal and pipe is exported.

4.10 Aluminium Consumption in India

India is, after Japan, the second largest consumer in Asia. Production and consumption of aluminium increased considerably up to 1971. The government promoted the production and use of this metal because of the high-grade bauxite deposits present in India, because of the relative scarcity of other nonferrous metals, especially copper, and also because of constantly low foreign currency reserves. Production of primary aluminium increased frm 83,600 t in 1966 to 178,300 t in 1971, consumption increased from 93,000 t to 193,000 t. Primary aluminium production stagnated in the following years at this level and necessarily also consumption. This was due to bottle-necks in the electricity supply hindering an increase in production.
Only since the middle of 1975 have these difficulties (strikes, wage disputes) been overcome by the state of emergency as well as the heavier monsoon rains (hydroelectric energy). This allowed an increase in primary aluminium production in 1976 to 211,800 t. Consumption only reached 170,000 t in 1976 because of the economic recession and large price increases. This made it possible to export sizable amounts of raw metal.

India has an aluminium semi-manufactures capacity of 267,500 t, including 153,000 t for conducting material (wire stock), 95,000 t for rolling mill products, 13,500 t for extrusion products, and 6,000 t for foil. Especially the growth of the cable and wire industry has been promoted by a "prescribed" (lower) price for conducting material, new projects for energy production, and the electrification of rural areas. This growth has displaced the scarce and expensive copper almost completely. Thus the structure for aluminium consumption in India is primarily determined by the share held by the electrical industry as shown by the following for 1976:

electrical industry (electrification, telecommunications)	52 %
household articles	20 %
transportation (busses, cars, aircraft, ships)	12 %
construction	6 %
packaging (cans, foil for tee bags and packets, cigarette packets, pharmaceuticals, containers, tubing, etc.)	4 %
other (e.g. armaments)	6 %

It is expected that this structure will remain nearly unchanged until the end of the electrification program. After that, aluminium will be increasingly important for the expansion of the transportation sector, particularly for production of railway vehicles and bridges of light construction. Only after a reduction of its high price can aluminium acquire a greater significance for consumer articles and packaging. It is estimated that an expected annual growth of 4 % in the GNP and 8 % in industrial production during the next ten years will create an increase in demand for aluminium rolling mill products by 10 %, for extrusion products by 14 - 15 % and for foil by 10 %. This assumes however, that a constant electricity supply is available.

4.11 Aluminium Consumption in Japan

The Japanese aluminium industry, which has grown more rapidly than is the other western industrial countries in the last ten years, was especially hard hit by the 1974/75 recession. While imports of raw aluminium and aluminium semi-manufactures receded only slowly and only by the application of restrictive market policies, the reduced demand influenced the Japanese aluminium industry, which until 1973 exhibited very high growth rates. For these reasons, the smelters sometimes operated to only 50 % capacity. There was an upswing in 1976 again. Per capita consumption reached the level of the record year of 1973 with 16 kg.

	1971	1972	1973	1974	1975	1976
Per capita consumption of aluminium	10.7	12.9	16.1	14.0	12.4	16.0

From 1966 to 1976, aluminium consumption increased by an average of 14.4 % annually. With a total consumption of ca. 0.5 million tons in 1966, Japan was the fourth ranking consumer of aluminium behind the USA, the Federal Republic of Germany, and the United Kingdom. In 1976, Japan was the second largest consumer of aluminium in the Western World with 1.921 million tons.

In 1966, 62 % of the Japanese primary and secondary aluminium consumption was accounted for by the transportation sector, the electrical, construction, machinery, and nonferrous metals industries. These major consumption groups were able to increase their share of the market to 76 % by 1976. Details may be seen in Tables 79 - 81.
The largest growth in aluminium consumption was exhibited by the packaging industry, an average annual increase of 25 % from 1966 to 1976.
The construction industry has been the most important consumer of aluminium in Japan since 1969. Consumption in 1976 attained a level of 668,000 t, corresponding to a 34.8 % share of the total aluminium market. Consumption has increased ten-fold since 1966. This development has been brought about primarily by the preference given aluminium for windows, doors, and door frames, since other materials such as steel, stainless steel, and wood could be replaced in large quantities. Production and deliveries of aluminium windows have even increased fifteen-fold since 1966. Of the total aluminium consumption by the construction industry, windows accounted for 84 %, doors and door frames for under 10 %.
Aluminium rolling mill products, profiles, and structural sheet metal are used for facades, in addition to various construction elements. This area of use also consumed increasing amounts of aluminium.
In terms of ground area of the completed structures, construction volume in Japan increased by 96 % from 1966 to 1976 (see Table 82). This large growth in construction volume since the end of the fifties was due to a sizable unfilled demand from the previous year(s) in housing construction. Another contributing factor was the demolition of existing buildings, sometimes a whole section of a city, brought about by the scarcity of land causing rapidly rising property prices. Construction of private housing increased further and sales of aluminium products set a new record in this sector in 1976, particularly for window frames of extruded metal. Nevertheless, demand for industrial construction remained at a low level.
Average heighth of buildings in Tokyo in 1970 was 1.7 stories. Since then it has increased considerably. Construction of tall buildings for a well-planned utilization of land has led, besides the increase in construction volume, to considerable infrastructural improvements, that led to a large increase in demand for aluminium especially for public buildings (schools, hospitals, administration buildings).

The transportation sector has been the second largest aluminium consumer in Japan since 1966. Aluminium consumption in this sector increased from just under 105,000 t in 1966 to 371,000 t in 1976, an average annual increase of 13.5 %.

Table 79

Structure of the Demand for Aluminium by the first Processing Stage according to Industry in Japan: 1975
in t

	Primary Aluminium	Rolled Semi-manufactures	Castings	Die Castings	Forged products	Conductors	Aluminium Powder	Imports	Other	Total	Share of the total Demand in %		Growth rate in %	
											1974	1975	1973/74	1974/75
Export	83,506	41,631	-	-	-	26,019	168	-	-	151,324	3.7	9.5	211.6	234.3
Household appliances	-	30,393	6,961	2,366	-	-	-	1,424	-	41,147	3.0	2.6	73.6	79.4
Foodstoffs	-	48,648	-	-	-	-	-	-	-	48,648	3.4	3.0	110.9	81.8
Machinery and metal industries	-	144,808	14,593	23,515	425	-	2,525	21,829	47,241	254,936	18.6	15.9	93.6	77.8
Building construction	-	515,250	-	-	-	1,083	-	-	-	516,333	31.6	32.3	83.5	94.6
Electricity production and distribution	-	-	-	-	-	54,397	-	-	2,368	56,765	4.3	3.6	70.7	76.6
Electrical (including telecommunication)	-	63,858	4,885	16,949	-	2,699	-	-	-	88,391	7.1	5.5	83.1	71.7
Transportation	-	33,617	130,407	144,403	396	473	-	-	-	309,296	18.5	19.3	94.1	96.8
Precision machinery	-	7,720	1,251	4,994	-	-	-	-	-	13,965	1.1	0.9	86.7	76.4
Chemicals	-	8,118	-	-	-	-	5,088	-	-	13,206	0.8	0.8	99.2	91.6
Tobacco	-	151	-	-	-	-	-	-	-	151	0.0	0.0	37.0	196.1
Ship building	-	1,560	1,508	-	19.3	-	-	-	-	3,261	0.3	0.2	92.1	54.0
Airplane construction	-	447	-	-	162	-	-	-	-	609	0.1	0.0	123.5	57.3
Other	-	58,628	3,870	5,653	339	5,934	2,487	2,487	22,869	101,962	7.5	6.4	77.7	82.7
Total	83,506	954,829	163,475	197,880	1,515	90,605	10,268	25,438	72,478	1,599,991	100.0	100.0	88.4	92.9

Table 80

Breakdown for Delivery of Rolled Semi-fabricated Products of Aluminium and Aluminium Alloys according to Industry in Japan: 1975

in t

	Plate and sheet metal	Strip metal	Circles	Pipe and tubes	Rods, rails, and shapes	Shapes (extruded)	Wire	Foil	Total
Food industry	30,927	15,756	27	-	-	43	1,895	14,639	63,287
Tobacco	5	-	-	-	3	143	-	5,413	5,564
Chemistry	6,275	661	26	629	55	308	164	2,892	11,010
Household appliances	8,898	3,999	14,584	152	34	1,669	1,057	10,381	40,774
Foil	-	64,097	-	-	-	-	-	-	64,097
Other products of metal	23,041	15,012	10,048	2,213	574	11,646	7,100	1,204	70,838
Equipment for domestic energy production and distribution	6,308	15,119	1,221	2,025	171	3,269	196	460	28,769
Other electrical equipment	8,947	7,378	1,187	3,271	2,217	11,780	769	9,936	45,485
Transportation (land)	11,402	2,157	218	854	3,081	15,570	335	146	33,763
Ship building	428	5	4	25	256	842	-	-	1,560
Airplane construction	127	-	-	26	75	169	50	6	453
Precision machinery	819	377	83	3,594	1,682	1,164	1	-	7,720
Other machinery	2,311	427	10	2,173	264	5,737	155	86	11,163
Building construction	14,762	7,222	178	1,246	204	491,613	25	1,271	516,521
Export	19,134	15,674	2,908	559	1,273	832	1,251	2,601	44,232
Other	25,291	5,854	185	3,374	6,770	13,940	3,214	1,587	60,215
Total	158,675	153,738	30,679	20,141	16,659	558,725	16,212	52,622	1,007,451

Table 81

Production of Castings, Die Castings, and Forged Products from Aluminium and Aluminium Alloys according to Industry in Japan: 1965 - 1975

in t

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Machine production	castings	7,954	9,509	11,789	13,427	15,010	18,875	18,865	16,798	19,013	17,215	11,879
	die castings	4,940	6,142	8,662	12,366	14,645	17,691	16,884	19,158	26,338	27,544	23,515
	forged products	191	374	431	281	398	625	421	585	639	494	365
	total	13,085	16,025	20,882	26,074	30,053	37,191	36,170	36,541	45,990	45,253	35,759
Building construction	castings	-	-	-	-	-	-	-	-	-	-	-
	die castings	-	-	-	-	-	-	-	-	-	-	-
	forged products	-	-	1	-	5	-	-	-	-	-	-
	total	-	-	1	-	5	-	-	-	-	-	-
Agriculture and fisheries	castings	2,688	3,907	4,632	4,861	5,225	4,901	4,831	4,472	5,228	5,558	3,448
	die castings	-	-	-	-	-	-	-	-	-	-	-
	forged products	41	44	36	42	66	30	35	59	83	111	60
	total	2,729	3,951	4,668	4,903	5,291	4,931	4,866	4,531	5,311	5,569	3,508
Communications	castings	3,166	3,593	5,013	4,920	6,416	8,498	6,496	7,599	10,172	8,325	4,885
	die castings	8,151	11,227	14,524	18,515	21,703	22,468	18,773	20,207	25,520	24,388	16,949
	forged products	120	62	23	20	31	58	19	36	-	-	-
	total	11,437	14,882	19,560	23,455	28,150	31,024	25,288	27,842	35,692	32,713	21,834
Vehicle production	castings	34,676	42,373	58,574	82,467	101,077	123,157	119,242	110,526	123,700	120,280	128,613
	die castings	39,758	46,640	54,407	70,628	88,633	102,974	112,893	144,179	157,169	150,950	143,544
	forged products	148	78	113	122	161	235	311	638	572	411	287
	total	74,582	89,091	113,094	153,217	189,871	226,366	232,446	255,343	281,441	271,641	272,444
Buses and cycles	castings	666	765	697	875	1,573	1,350	1,333	1,567	2,097	2,427	621
	die castings	1,151	514	663	787	783	826	1,438	1,636	1,776	1,232	817
	forged products	4	68	221	46	17	62	215	124	87	43	57
	total	1,821	1,347	1,581	1,708	2,373	2,238	2,986	3,327	3,960	3,702	1,495
Railways	castings	331	405	382	459	740	573	552	834	819	842	439
	die castings	19	11	14	71	47	61	31	86	94	104	42
	forged products	4	-	-	-	-	-	-	-	58	86	52
	total	354	416	396	530	787	634	583	920	971	1,032	533
Shipbuilding and harbors	castings	703	1,051	1,187	1,268	1,501	1,699	2,270	2,483	2,973	2,578	1,508
	die castings	-	-	-	-	-	-	-	-	-	-	-
	forged products	5	8	14	17	33	60	78	69	129	241	193
	total	708	1,059	1,201	1,285	1,534	1,759	2,348	2,552	3,102	2,819	1,701
Precision machinery	castings	895	1,085	1,405	1,580	2,580	4,565	3,128	1,272	1,578	1,234	1,251
	die castings	2,338	2,613	3,604	4,145	4,382	5,174	4,724	6,210	8,705	7,633	4,994
	forged products	-	-	-	-	-	-	-	-	-	-	-
	total	3,233	3,698	5,009	5,725	6,962	9,739	7,852	7,482	10,283	8,867	6,245
Household appliances	castings	6,495	6,456	8,523	8,570	8,821	8,797	9,482	10,613	11,253	8,599	6,961
	die castings	1,056	1,296	1,481	2,128	2,627	2,916	3,317	5,379	4,600	3,353	2,366
	forged products	-	-	-	-	-	-	-	-	-	-	-
	total	7,551	9,752	10,004	10,698	11,448	11,713	12,799	15,922	15,853	11,952	9,327
Other	castings	1,749	2,455	3,071	3,591	3,584	5,416	5,254	7,121	6,735	5,732	3,870
	die castings	1,168	1,772	2,269	2,760	3,524	5,599	5,659	6,571	8,304	7,528	5,653
	forged products	247	463	503	443	384	394	387	316	421	594	501
	total	3,164	4,690	5,843	6,794	7,492	11,399	11,300	14,008	15,460	13,854	10,024
Total	castings	59,323	73,599	95,273	122,018	146,527	177,831	171,253	163,285	183,568	172,790	163,475
	die castings	58,581	70,215	85,624	111,400	136,344	157,699	163,719	203,426	232,506	222,732	197,880
	forged products	780	1,097	1,342	971	1,099	1,464	1,466	1,827	1,989	1,980	1,515
	total	118,664	144,911	182,239	234,389	283,970	336,994	336,438	368,538	418,063	397,502	362,870

Table 82

Building Construction and Production of Windows and Doors from Various Metals in Japan

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Building construction (10^6 m^3)		102.3	109.7	137.4	160.5	182.7	205.0	197.8	242.3	281.7	198.6	196.3	215.5
Production of (in tons):													
Aluminium	windows	21.222	36.557	56.524	88.395	143.157	197.404	234.709	322.346	458.478	417.919	355.559	.
	doors	6.017	6.561	6.547	7.589	9.179	11.622	13.709	18.696	26.440	34.386	31.399	.
	other	-	-	-	-	-	-	6.804	9.972	14.803	10.836	13.482	.
	total	27.239	43.118	63.071	95.984	152.336	209.026	255.222	351.014	499.721	463.141	400.440	.
Steel	windows	94.373	83.904	94.386	96.835	107.529	121.256	88.396	90.989	118.453	99.152	61.739	.
	doors	41.480	37.119	40.712	44.159	51.671	63.124	64.071	66.956	88.276	85.667	66.480	.
	total	135.853	121.023	135.098	140.994	159.200	184.380	152.475	157.945	206.729	184.819	128.219	.
Stainless steel	windows	1.687	1.606	1.582	1.385	1.357	1.100	-	-	-	-	-	
	doors	2.056	2.442	1.992	1.804	1.834	2.064	-	-	-	-	-	
	total	3.743	4.048	3.574	3.189	3.191	3.164	-	-	-	-	-	

Source: Economic Planing Agency's Economic Statistics
Light Metal Statistics in Japan.

A record production of 7.8 million vehicles was attained in 1976 thanks to the exceptional export trends. Ca. 70 % of Japanese-made castings went to the automobile industry. That was ca. 305,000 t of sand and pressure die castings, corresponding to more than 85 % of the aluminium consumed by the automobile industry. This led to a record year for the castings industry in spite of a slack period in the machinery-building industry.
More than 5 million trucks and 40,000 busses were produced in 1976. Automobile production had a lower share of the total motor vehicle production (64 %) than in the other western producer countries. The domestic market for motor vehicles had by 1976 developed to the point that it was the second largest after the USA. The degree of motorization has attained the level of the other western industrial countries. Exports accounted for 47 % of the total production and for 50 % of the automobile production.
Third-ranking consumer of aluminium was the electrical industry with ca. 180,000 t in 1976. Its share of the total aluminium market was 12 % in 1966, 9 % in 1976. The under average growth was felt in all parts of the industry. While the construction of electrical equipment used primary rolling mill products and castings, the power companies used principally conducting materials. The demand for wire was mainly due to its use for overhead transmission lines. High-voltage cable designed for 275 kV is used for long distance transmission lines. The Boso Transmission Line, however, has been designed so it can be switched over to 500 kV. The large cities are connected by a high-voltage grid and ring-type primary feeders. The regional grids are primarily 6 kV. In heavily built-up areas, the electricity grid is laid extensively underground. Considerable investment has been made during the past year by the power companies to ensure the long-term supply of electricity. This development of domestic consumption and an increase in exports of aluminium wire and cable has led to a large upswing in production.
Production of electrical equipment continued to increase in 1976 as it had in the previous year. Exceptions to this were black & white TVs and household refrigerators. Production of selected electrical household appliances is shown in Table 83 for the years 1972 - 1976.

Table 83

Production of Selected Electrical Household Appliances in Japan: 1972-1976
(in 1000 units)

	1972	1973	1974	1975	1976
Radio	26,833	24,485	18,027	14,283	16,771
TV	13,038	12,437	11,073	10,625	15,106
Washing machines	4,201	4,297	4,105	3,173	3,920
Refrigerators	3,455	3,926	4,313	3,474	3,927

The percentage of households in Japan with the following household appliances are as follows:

	1961	1966	1970	1975
TV	33	75	91	94
Refrigerators	9	53	78	96
Dish washers	7	32	55	•
Washing machines	27	64	81	98
Air conditioners	-	-	5	•

The metal goods and machinery-building industries are the next largest markets for aluminium in Japan. Increase in consumption by these groups was below the average for total consumption.
Consumption by the packaging industry increased from 12,000 t in 1966 to 104,000 t in 1976. This high growth rate was due primarily due to the change from bottles to cans by the bottling companies and also to the use of aluminium for packaging the ever increasing supply of frozen foods.
Data on end consumption of aluminium in Japan contained in Appendix 12 i for 1966 - 1976.

4.12 Aluminium Consumption in Canada

Canada's low-priced hydroelectric power supply makes it one of the largest producers of primary aluminium in the world. It has a production capacity of just under 1.1 million tpy, of which only 30 - 50 % is used domestically. Exports amount to 500,000 - 800,000 tpy.
Consumption of primary aluminium increased from 208,000 t in 1966 to more than 350,000 t in both 1974 and 1976, an average annual increase of 5.5 %. In addition, more than 30,000 t of secondary aluminium from old and new scrap are produced and consumed each year. Total consumption of aluminium increased from 235,700 t in 1966 to 389,200 t in 1976, an average annual increase of 5.1 %. A statistical breakdown of aluminium consumption in the first processing stage in Canada is published by the Dominion Bureau of Statistics, Ottawa. The statistics for 1965 - 1974 are contained in Table 84. Compared with total consumption of aluminium, consumption in the first processing stage is some 8 % less, increasing from 220,700 in 1966 to 359,700 t in 1974. Data for the following two years were not yet available at the time of this writing. The proportion of semi-manufactures increased from just under 82 % in 1966 to 87 % in 1974. At the same time castings decreased from 16 % to 10 % on the consumption. The remaining 2 - 3 % were accounted for by the iron and steel industry, non-ferrous metals, alumino-thermy, etc.

Table 84

Breakdown of the Consumption of Aluminium in Canada in the First Processing Stage: 1965 - 1974
(in t)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Semimanufactures										
Extrusion products (incl. pipe)	44,070	48,707	46,911	55,563	63,175	58,180	71,815	79,442	92,516	96,120
Sheet and strip metal (incl. rods, forged pieces and slugs)	118,198	131,711	114,816	123,316	137,418	152,849	173,800	174,171	186,588	215,383
Total	162,268	180,418	161,727	178,879	200,593	211,028	245,616	253,614	279,104	311,504
Cast products										
Sand	1,240	1,510	1,528	1,464	1,431	1,448	1,348	1,331	1,632	1,715
Permanent mould	6,811	9,927	9,692	11,179	11,122	10,498	14,029	12,109	13,542	13,934
Die	11,974	14,192	15,855	17,911	20,562	17,728	21,381	25,505	24,859	20,922
Other	3,968	8,970[1)]	56	83	93	66	106	165	132	3
Total	23,993	34,599	27,132	30,637	33,208	29,740	36,864	39,111	40,164	36,574
Iron and steel industry, nonferrous metal industry, alumino thermy, non aluminium alloys, powder, pastes etc.	7,015	5,657	8,399	10,333	10,206	9,331	9,648	9,806	12,448	11,641
Total consumption	193,276	220,674	197,258	219,848	244,007	250,099	292,127	302,530	311,715	359,719

1) including electric rails in the smelters

Source: Canadian Minerals Yearbook, Ottawa

The Canadian semimanufactures industry has an annual production of 250,000 - 300,000 t consisting primarily of flat products (sheet and strip metal, circles) in addition to rods, profiles, pipe, and wire and cable. For the time period studied. the proportion for flat products increased from 36 % to 45 %, wire and cable decreased from almost 32 % to 23 %, and that for rods, profiles and pipe remained constant at ca. 32 %.
The structure for castings remained nearly unchanged. Pressure castings accounted for almost 60 %, permanent mould castings for almost 40 %, sand castings and others for the remainder. Altogether, Canada produces 30,000 - 40,000 t of castings annually.

The steel and non-ferrous metals industries and alumino-thermy uses 10,000 - 12,500 t of aluminium annually. Ca. 0.8 kg of aluminium were consumed for each ton of raw steel produced. This value must be viewed as too high since other areas of use were also included.
There are no statistics on end-use of aluminium in Canada as compiled for the other OECD countries. Only the aluminium consumption of large companies in selected branches of industry is published. It can be calculated from the statistics for the castings industry that almost 30,000 t of pressure castings from aluminium and aluminium alloys are distributed among end-use groups according to the following Canadian classification:

motor vehicle industry	60 %
plumbing, heating, fittings & equipment	4 %
machinery & tools	5 %
household appliances	11 %
communications, office machines	4 %
other	7 %

As in other industrial countries, more than 60 % of the aluminium and aluminium alloy castings are used by the motor vehicle industry, while the rest is distributed among numerous other applications.
No exact breakdown of the total aluminium consumption in Canada is possible because of the incompleteness of the consumption statistics. It can be estimated, however, that vehicle construction, electrical and contruction industries, and perhaps the packaging industry also each have a 15 - 20 % share of the total consumption. The proportion for the very heterogeneous metal goods industry may be as high as 10 %. Export of semi-manufactures, the iron and steel industries, and machinery may also account for 3 - 5 % each.

4.13 Aluminium Consumption in the USA

The USA is by far the largest consumer of aluminium in the world with 32 % of the primary aluminium and 33 % of the total aluminium consumption in 1976. Considering the changes in the strategic reserves, consumption of primary aluminium increased 3.23 million t in 1966 to 4.43 million t in 1976, an average annual increase of 3.1 %. A peak in consumption was reached in 1974 with 5.13 million t which was not attained in the following two years due to the unfavorable market conditions. In the time period under consideration, only in 1970 could raw metal consumption be covered by domestic production. Thus net imports of raw metal were necessary in most years. These reached a peak of almost 0.5 million t in 1972.
Consumption of secondary aluminium increased from 833,000 t in 1966 to 1.31 million t in 1976; total consumption of aluminium increased from 4.11 million t in 1966 to 5.75 million t in 1975 (data from Metallstatistik). A peak of 6.29 million t was attained in 1974. Because of the already high level of aluminium consumption in the USA, growth rates are less than for the other large consumer countries of the Western World. Average annual increase from 1966 to 1974 was only 5.5 %, up to 1976 only 3.4 %.
Inferences can be drawn from the statistics on deliveries of semi-manufacture and castings concerning the consumption of aluminium by the first processing stage. These deliveries are ca. 9 % under the total consumption. The total volume of deliveries incr eased from 3.67 million t in 1966 to 5.24 million t in 1976, peaking at 5.86 million t in 1973.
Semi-manufactures (including forged products) increased from 80 % to ca. 85 % during this period, with a corresponding decline for castings. Deliveries of semi-manufactures and castings from 1966 to 1976 are contained in Table 85. It is evident from these figures that the increasing share for semi-manufactures production was due to a large increase in sheet and strip metal production and also foil, whose share of the total semi-manufactures production increased from 52 % in 1966 to more than 65 % in 1976. The proportion for extrusion products (rods, profiles, bars, etc.), second most important type of semi-manufactures exhibited only a slight growth or even a stagnation of production with the probable exception of insulated cable and wire.
Deliveries of castings increased from 744,000 t in 1966 to 836,500 t in 1976. The proportion for pressure castings increased from almost 57 % to 65 % while that for sand and gravity castings decreased from 18 % to 12 % and from 25 % t to 20 %, respectively.
Statistics on aluminium consumption according to end-consumer group published by the OECD, Paris, and the Aluminum Association Inc., New York, have the same breakdown as for Japan and the West European countries. The OECD statistics show a higher end-use consumption than the American statistics and also are closer to the raw metal consumption given by Metallstatistik. On the other hand, the Aluminium Association statistics give a deeper insight into the consumption struct ure for raw metal consumption in the individual end-user groups. The two statistics will be considered in more detail in the following.

Table 85

Shipments of Aluminium Wrought and Cast Products
(t)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Sheet and Plate	1,332,100	1,300,900	1,544,300	1,690,500	1,673,100	1,803,700	2,162,700	2,604,200	2,552,000	1,838,000	2,533,100
Foil	196,000	203,900	230,800	254,000	253,400	265,600	305,300	351,300	339,400	277,500	350,100
Rolled rod, bar and structural shapes[1)]	68,900	64,900	59,000	65,400	49,900	46,300	82,300	131,300	121,700	114,400[2)]	69,800
Wire, bare	46,800	44,400	45,500	43,000	42,400	43,900	48,300	56,300	59,400		93,400[2)]
ACSR and aluminium cable, bare	230,300	229,600	223,200	215,500	226,600	218,500	205,800	222,300	247,900	304,500	283,700
Wire and cable, insulated	75,000	79,300	97,000	113,600	118,000	143,900	168,300	201,900	202,500		
Extruded shape	779,800	696,400	758,300	812,800	746,600	834,600	967,900	1,090,200	978,300	687,500	884,100
Drawn tube	45,200	40,400	42,000	40,300	38,200	38,300	42,100	50,000	50,100	29,800	44,500
Welded tube	41,400	39,800	48,500	46,100	42,000	43,700	52,900	55,200	53,000	27,900	42,700
Powder and paste	50,500	106,100	125,400	125,200	92,800	76,000	102,700	116,800	80,400	44,900	60,000
Forging and impact	63,100	74,900	78,300	71,000	54,600	44,500	55,700	64,600	62,700	44,100	45,500
Total wrought products	2,929,100	2,880,600	3,252,300	3,477,400	3,337,600	3,559,000	4,194,000	4,944,100	4,747,400	3,368,600	4,406,900
Castings: Sand	132,400	113,700	96,300	100,200	90,600	87,500	104,200	117,800	121,500	88,800	103,400
Permanent mold	183,600	173,500	174,500	196,900	158,800	158,100	190,400	199,700	171,000	131,300	170,900
Die	420,000	397,800	444,000	466,100	427,200	465,500	540,700	591,700	493,700	392,900	544,000
All other	7,900	11,100	5,600	7,000	6,700	4,300	6,400	9,900	11,800	11,300	18,200
Total castings	743,900	696,100	720,400	770,200	683,300	715,400	841,700	919,100	798,000	624,300	836,500
Grand total	3,673,000	3,576,700	3,972,700	4,247,600	4,020,900	4,274,400	5,035,700	5,863,200	5,545,400	3,992,900	5,243,400

1) Including continuous cast. 2) Including Wire and cable, insulated.

Due to incomplete data for 1976, only the period from 1966 to 1975 will be considered.
According to the OECD statistics, aluminium end-use consumption in the USA increased from 4.1 million t in 1966 to 6.18 million t in 1975, an average annual increase of 4.7 %, peaking at 6.6 million t in the boom year 1973. The OECD statistics on end-use consumption trends are contained in Appendix 12 k.
The construction industry has been the largest consumer of aluminium in the USA since 1968, accounting for more than 21 % of the total end-use consumption. During the boom years of 1972 - 1974, its share was as high as 26 % (1972). The growth of aluminium consumption in the construction industry from 1966 to 1975 was an average of 5 % annually, just slightly more than for the total end-use consumption.
The transportation sector is the second-ranking consumer of aluminium. Growth rate in 1975 was below average causing its share of the total end-use consumption to decrease from 23 % in 1966 to 19 % in 1975.
The packaging industry exhibited the largest growth of all the end-use groups for the time period studied (13.2 %/yr). Just from 1966 to 1970 its share of the total end-use consumption increased from 8 to 14.5 % and in 1975 was 16.6 %.
The electrical industry, as fourth largest end-consumer of aluminium, had a below average growth rate of only 3.7 % per annum so that its share dropped from 14 % to 12 - 13 %.
Machinery, household goods, and semi-manufactures exports each had 7 % of the total end consumption in 1975. The share for the machinery-building industry and exports of semi-manufactures changed very little from 1966 to 1975; that for household goods exhibited a slight falling trend.

The proportions for the smallest consumer groups, the iron and steel industries (2 %), the chemical and foodstuffs industries, and the powder consuming industry (ca. 1 % each), have changed only slightly since 1966.
Table 86 contains the proportions of the total end-use consumption of aluminium for the individual consumer groups for 1966 - 1975 and the average annual growth rates for the entire period.
According to the Aluminum Association statistics, which differ greatly from those of the OECD, especially in 1975, aluminium end-use consumption in the USA increased from 4.1 million t in 1966 to 4.5 million t in 1975, peaking at 6.7 million t in 1973. A large increase of 28.4 % in 1976 brought consumption to 5.8 million t.
Data from this source are shown in Table 87 for the years 1966 - 1976 according to end-use group. Because the user groupings do not correspond exactly to those in the OECD statistics, there are slight differences in the figures given. Nevertheless, the same trends are evident. Table 88 contains the proportions for the individual end-use groups in 1966, 1970, 1974, 1975, and 1976.

Table 86

Structure of Aluminium Consumption in the United States: 1966-1975
(in %)

	1966	1968	1970	1972	1974	1975	average growth rate p.a. 1966/1975
Transport	22.6	20.9	16.0	19.6	20.4	18.9	2.7
Machinery	6.8	6.5	5.5	5.7	6.0	6.7	4.5
Electrical	13.8	12.6	12.5	11.8	11.7	12.6	3.7
Building and construction	21.4	21.9	21.9	26.1	24.4	22.1	5.0
Chemical, food and agricultural appliances	0.7	0.6	0.8	0.7	0.7	1.2	10.4
Packaging	8.2	10.3	14.5	15.2	14.0	16.6	13.2
Domestic and office appliances	8.3	8.0	7.6	7.2	7.0	6.5	1.8
Powder consuming industries	1.2	2.7	2.0	1.9	1.8	1.2	4.9
Destructive uses	2.2	2.0	2.0	2.2	2.1	2.1	3.9
Metal industries and miscellaneous	8.3	8.0	5.7	4.9	5.5	5.2	0.8
Direct exports of semi-manufactures	6.5	6.5	11.5	4.7	6.4	6.9	5.5
Consumption total	100.0	100.0	100.0	100.0	100.0	100.0	4.7

Source: OECD

Table 87

Deliveries of Aluminium Semimanufactures according to User in the United States: 1966 - 1976
in 1000 t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transportation	885	807	897	901	701	815	1,009	1,276	1,107	775	1,113
Machinery & equipment	297	280	307	318	274	292	340	430	474	294	410
Electrical	589	566	596	646	616	645	697	841	836	552	602
Building & construction	900	875	1,021	1,077	1,022	1,264	1,449	1,645	1,427	1,019	1,341
Containers & packaging	336	394	465	541	665	686	821	932	1,027	908	1,166
Consumer durables	413	377	448	482	423	441	511	607	526	342	470
Other	412	461	498	488	359	329	376	395	339	238	277
Statistical adjustment	-	-	-	-	-	-	7	109	64	5	21
Domestic total	3,832	3,760	4,232	4,453	4,060	4,472	5,210	6,235	5,800	4,133	5,400
Export	265	298	293	457	527	258	255	426	428	371	382
Total	4,097	4,058	4,525	4,910	4,587	4,730	5,465	6,661	6,228	4,504	5,782

Source: Aluminum Association Inc., New York

Table 88

Structur of Aluminium Consumption in the USA

(in %)

	1966	1970	1974	1975	1976
Transportation	21.6	15.3	17.8	17.2	19.2
Machinery	7.2	6.0	7.6	6.6	7.1
Electrical	14.4	13.4	13.4	12.2	10.4
Construction	22.0	22.3	22.9	22.6	23.2
Packaging	8.2	14.5	16.5	20.2	20.2
Household appliances	10.1	9.2	8.5	7.6	8.1
Other	10.1	7.8	5.4	5.3	4.8
Statistical adjustment	-	-	1.0	0.1	0.4
Exports	6.4	11.5	6.9	8.2	6.6
Total	100.0	100.0	100.0	100.0	100.0

Source: Aluminum Association, New York

The aluminium consumption will be dealt with in greater detail in the following (corresponding to the sequence in Table 87).

Transportation

The transportation sector is the third largest consumer of aluminium in the USA, accounting for more than 19 % of the total end-use market (according to the Aluminum Association data). The increase in consumption by this sector was below the average for total consumption. Since more than two-thirds of this consumption is for the production of motor vehicles, large variations in the latter are to be found in the whole.

It can be seen in the Aluminum Association statistics that also in the USA the motor vehicle industry has a high consumption of aluminium castings, corresponding to an ingot consumption of 300,000 - 600,000 tpy or 46 % of the total aluminium consumption by this branch of industry.

Of the various semi-manufactures specified in the statistics, sheet metal has the largest share with ca. 25 %, followed by the various press products (ca. 15 %) and plates (up to 9 %). Of all the other types of semi-manufactures used, only forged products had as high a share as 3 % of the total aluminium consumption by the transportation sector. Deliveries of ingots and semi-manufactures to the transportation sector from 1966 to 1975 are shown in Table 89.
The detailed statistics further show that 68 - 77 % of the aluminium consumption by the transportation sector goes to the motor vehicle industry; 60 - 74 % goes to automobile production alone. The remainder is distributed among trucks, busses, and trailers (including semi-trailers).
Three-quarters of the 400,000 - 600,000 t of aluminium used annually for automobile production is in the form of ingots for castings. A further 14 % of the consumption is accounted for by sheet metal, 5 % by profiles. Other types of semi-manufactures (foil, rolling mill products, pipe, and forged products) account for ca. 1 % each.
Consumption of aluminium for trucks and busses is 70,000 - 180,000 tpy. In contrast to automobile production, ingots for castings account for only 45 - 50 %, sheet metal for 22 - 30 %, and profiles for 15 %. It is evident that the larger superstructures of trucks and busses, often built of aluminium, are the reason for the greater importance of sheet metal and profiles with repect to castings (which are used primarily in the drive unit) than is the case for automobiles. The proportion for semi-manufactures in the production of trailers is even geater. Of the up to 200,000 tpy of aluminium used for trailers, 10 % is accounted for by ingots for castings, 30 - 40 % by sheet metal and 40 - 50 % by profiles.
Consumption of aluminium for motor vehicle production in 1970, 1973, and 1975 is presented in Table 90.

Machinery & Equipment

Machinery and equipment makers in the USA consume ca. 300,000 - 400,000 tpy of aluminium,6 - 7 % of the total end-use consumption. This percentage has changed little since 1966. Since machinery making uses considerable amounts of castings, the proportion of ingots for making castings is rather high at ca. 35 %. A quarter of the aluminium consumption is accounted for by sheet metal; when plate and foil is also included, flat products account for a third. Profiles (ca. 10 %), pipe (7 - 8 %), rolled and continuous cast rods and bars (5 %) are used, and in lesser amounts wire and forged products. The structure for semi-manufactures has changed little since 1966. The very heterogeneous group of machinery and equipment makers also includes the construction of containers for storage and transportation of petroleum products and other chemicals, for which aluminium is being increasingly used.
Table 89 contains a breakdown for aluminium consumption by the machinery and equipment makers from 1966 to 1975 according to type of semi-manufactures.

Table 89

Delivery of Aluminium Ingots and Semimanufactures in the United States according to User
in 1000 t

	1966	1970	1973	1975
Transportation				
Ingot	383	326	591	376
Sheet metal	231	167	332	160
Plate	80	55	68	73
Foil	2	5	9	7
Rods, shape	7	2	.	.
Other cast products	118	107	198	107
Extruded pipe	3	4	9	6
Drawn tube	9	5	9	5
Welded pipe	-	-	-	0
Continuous casting products	11	5	18	13
Bare wire	3	2	4	2
Cable & wire	-	-	-	-
Forged products	38	19	33	24
Impacts	.	4	5	2
Powder	-	-	-	-
Total	885	701	1,276	775
Electrical				
Ingot	72	78	130	100
Sheet metal	78	89	127	59
Plate	6	4	6	4
Foil	10	10	12	6
Rods, shape	9	10	.	.
Other cast products	40	39	52	35
Extruded pipe	36	28	31	16
Drawn tube	7	5	6	5
Welded pipe	3	2	3	2
Continuous casting products	17	5	39	25
Bare wire	9	8	9	5
Cable & stranded wire	227	219	221	181
Cable & wire, insulated	74	117	202	111
Forged products	1	1	1	1
Impacts	.	1	2	1
Powder	-	-	-	-
Total	589	616	841	551

	1966	1970	1973	1975
Machinery & equipment				
Ingot	109	100	151	105
Sheet metal	68	74	120	71
Plate	15	13	16	13
Foil	3	4	8	5
Rods, shape	5	4	.	.
Other cast products	29	24	36	33
Extruded pipe	23	15	25	14
Drawn tube	8	8	11	6
Welded pipe	9	13	23	24
Continuous casting products	13	6	19	14
Bare wire	9	7	11	6
Cable & wire	-	-	-	-
Forged products	6	5	8	3
Impacts	.	1	2	1
Powder	-	-	-	-
Total	297	274	430	295
Building & construction				
Ingot	42	38	112	85
Sheet metal	432	517	871	520
Plate	1	0	0	0
Foil	7	8	14	10
Rods, shape	6	3	.	.
Other cast products	369	413	591	368
Extruded pipe	18	20	21	12
Drawn tube	2	2	3	1
Welded pipe	1	1	1	1
Continuous casting products	10	7	15	12
Bare wire	12	13	17	10
Cable & wire	-	-	-	-
Forged products	0	-	0	0
Impacts	-	-	-	-
Powder	-	-	-	-
Total	900	1,022	1,645	1,019

Source: Aluminum Association, New York

Table 90

Aluminium Consumption within the Transportation Industry in the USA according to Type of Semimanufactures
(in 1000 t)

	1970	1973	1975
Total	701	1,276	775
for trucks & busses	75	182	73
for ingots	39	82	39
semimanufactures	36	100	34
sheet metal	21	56	16
plates	2	6	2
pressed products	10	28	11
forged products	2	9	4
impacts	0	1	0
for automobiles	324	599	390
for ingots	258	453	292
semimanufactures	66	146	98
sheet metal	43	92	56
foil	4	8	6
rolled and cast rods & bars	1	7	4
pressed products	9	20	19
extruded pipe	2	5	3
drawn tubes	4	7	3
wire, uninsulated	1	1	0
forged products	0	3	4
impacts	2	3	2
for trailers and semi-trailers	102	206	66
for ingots	7	19	9
semimanufactures	95	187	57
sheet metal	40	80	20
plates	5	8	3
rolled and cast rods & bars	0	2	1
pressed products	48	95	33
wire, uninsulated	1	2	0

Source: Aluminum Association, New York

Electrical Industry

The electrical industry in the USA consumes 600,000 - 850,000 tpy of aluminium. Growth in the use of aluminium by this industry was less than average between 1966 and 1975, so that its share of the total end-use consumption fell to ca. 10 %. At present, the electrical industry is the fourth largest consumer of aluminium in the USA.

Aluminium is used primarily as conducting material, which is evident from the consumption structure for semi-manufactures. Aluminium also finds considerable application for electrical machinery and equipment (motors, generators, transformers, etc.), lighting fixtures, substations for electricity distrubution, communications, transmission lines, and cable. Up to a third of the semi-manufactures used is cable and stranded wire and a further ca. 20 % is insulated cable and wire. Including bare wire, more than 50 % of the semi-manufactures used is thus conducting material. Ingots for castings are also of considerable importance with a share of 12 - 18 %. These castings are used for electrical machines and equipment, among others. The industry also uses a sizable amount of aluminium sheet metal, accounting for 10 - 15 % of the aluminium consumption by this industry, or 12 - 17 % if plate and foil is included. A considerable amount is also accounted for by pressed products, pipe, and extrusion products (ca. 15 %).

The aluminium consumption by the electrical industry from 1966 to 1975 is presented in Table 89 according to type of semi-manufactures.

Construction Industry

The construction industry is the largest end consumer of aluminium in the USA with a 23 % share of the market. Growth in the use of aluminium by this industry has been slightly above average. Consumption increased from 900,000 tpy in 1966 and 1967 to 1.65 million t in 1973, dropped to one million tons in 1975 as a result of the recession and reached only 1.34 million t in 1976. Sheet metal and press products (profiles) are the main form of aluminium used in construction in the USA. The share held by sheet metal was usually 48 - 53 %, by press products it was 36 - 41%, with a slight shift toward sheet metal. Next in importance was ingots, whose share increased from 4 % to 8 %. This would indicate that the use of castings increased from 1966 to 1975.

Other types of semi-manufactures (foil, pipe, extrusion products, and wire) each account for only one per cent of the aluminium used in construction. The aluminium consumption by the construction industry according to type of semi-manufactures is shown in Table 89 for the years 1966 - 1975.

About two-thirds of the total consumption is accounted for by the five listings, windows, doors and walls, awnings and roofing, facades, and mobile homes, plus bridges and streets & highways. The first consume 300,000 - 450,000 tpy of aluminium, corresponding to ca. 30 % of the aluminium consumed by the construction industry. Profiles and other pressed products usually account for more than 85 % of this amount, the remainder essentially by ingots and sneet metal. Between 180,000 and 260,000 t of aluminium are also used annually for facades in the USA,

almost exclusively in the form of sheet metal. Aluminium consumption for mobile homes varied considerably depending on market conditions: 207,000 t in 1973, only 89,000 t in 1975. Ca. three-quarters of this was sheet metal, the rest was profiles and ingots. Between 50,000 and 80,000 t of aluminium were used annually for bridges and streets & highways in the USA. Of this amount, 40 - 50% was sheet metal, the rest was ingots, press and extrusion products in nearly equal amounts. Awnings and roofing account for an aluminium consumption of 40,000 - 100,000 tpy. This use of aluminium is also heavily dependent on market conditions. Ca. 80 % of the aluminium used for this purpose is sheet metal, followed by pressed products (10 - 15 %) and extrusion pipe.
Aluminium consumption for the five classifications discussed above is presented in Table 91 for the years 1970, 1973, and 1975 according to type of semi-manufactures.

Packaging

This sector has exhibited the largest growth rates of all end-user sectors in the USA In spite of the recession of the last few years, the average growth rate for 1966 - 1976 was more than 13 % (data from the Aluminum Association, New York). Consumption increased from only 336,000 t of aluminium in 1966 to 1.03 million t in 1974, dropped to 908,000 t in 1975, and reached 1.17 million t in 1976. Almost only flat products are used for packaging purposes, 70 - 75 % is sheet metal, most of the rest is foil. The use of sheet metal increased considerably faster than that of foil, a trend that continued into 1976. Table 92 shows the aluminium consumption by the packaging industry from 1966 to 1975 according to semi-manufactures.
A detailed breakdown of semi-manufactures is shown in Table 93.

Most of the sheet metal is used for metal containers, ca. 50 % of the foil is for household and business use, and almost 30 % is used for containers for semi-rigid foods (e.g. gelatin products, yogurt). The above-average growth in sheet metal consumption is due, among other things, to the expansion of the market for cans for beverages and other foodstuffs, as well as for bottle caps. The aluminium ingot consumption shown is probably used for the production of slugs for producing aerosol spray cans and tubes.

Table 91

Aluminium Consumption within the Construction Industry in the USA according to Type of Semimanufactures
(in 1000 t)

	1970	1973	1975
Total	1,022	1,645	1,019
for windows, doors, screens	286	454	313
for ingots	11	53	45
semimanufactures	275	401	268
sheet metal	38	63	37
pressed products	225	322	221
rolled and continuous cast rods & bars	4	6	5
wire, uninsulated	8	10	5
for awnings and canopies	53	100	42
for semimanufactures	53	99	41
sheet metal	44	84	33
pressed products	6	11	6
extruded pipe	2	2	1
for residential siding	149	259	178
for semimanufactures	149	259	178
sheet metal	148	258	177
for mobile homes	126	207	89
for ingots	2	8	3
semimanufactures	124	199	86
sheet metal	92	149	67
pressed products	32	50	19
for bridges, streets, & highways	55	79	49
for ingots	7	10	9
semimanufactures	48	69	40
sheet metal	21	43	21
pressed products	14	13	10
extruded pipe	13	13	9

Source: Aluminum Association, New York

Table 92

Delivery of Aluminium Ingots and Semimanufactures in the United States according to User
in 1000 t

	1966	1970	1973	1975
Containers & Packaging				
Ingot	5	10	12	5
Sheet metal	166	436	654	681
Plate	2	1	-	-
Foil	163	217	265	221
Rods & sections	-	-	.	.
Other cast products	0	0	-	-
Extruded pipe	-	-	-	-
Drawn tube	-	-	-	-
Welded pipe	-	-	-	-
Continuous casting products	-	-	-	-
Bare wire	0	1	1	1
Cable and wire	-	-	-	-
Forged products	0	-	-	-
Impacts	-	-	-	-
Powder	-	-	-	-
Total	336	665	932	908
Miscellaneous				
Ingot	153	128	180	122
Sheet metal	68	56	35	28
Plate	14	8	5	4
Foil	7	3	3	2
Rods & sections	10	9	.	.
Other cast products	64	24	22	15
Extruded pipe	3	4	4	2
Drawn tube	6	3	2	1
Welded pipe	-	0	0	0
Continuous casting products	18	11	21	13
Bare wire	4	1	2	1
Cable & wire	-	-	-	-
Forged products	15	6	5	6
Impacts	.	16	4	2
Powder	50	90	112	42
Total	412	359	395	238

	1966	1970	1973	1975
Consumer Durables				
Ingot	125	124	187	116
Sheet metal	193	197	248	130
Plate	1	0	0	0
Foil	6	15	39	18
Rods & sections	4	3	.	.
Other cast products	27	28	51	32
Extruded pipe	4	7	10	6
Drawn tube	14	15	19	12
Welded pipe	28	25	34	18
Continuous casting products	3	2	10	5
Bare wire	7	6	7	4
Cable and wire	-	-	-	-
Forged products	1	0	1	1
Impacts	.	1	1	0
Powder	-	-	-	-
Total	413	423	607	342
Exports				
Ingot	172	372	211	172
Sheet metal	62	100	141	104
Plate	6	5	8	21
Foil	3	6	10	11
Rods & sections	-	-	.	.
Other cast products	3	5	8	6
Extruded pipe	2	2	5	6
Drawn tube	0	0	0	0
Welded pipe	0	0	0	-
Continuous casting products	8	15	27	24
Bare wire	3	8	7	10
Cable & stranded wire	4	9	2	12
Cable & wire, insulated	0	0	-	0
Forged products	1	2	2	2
Impacts	-	-	-	-
Powder	1	3	5	3
Total	265	527	426	371

Source: Aluminum Association, New York

Table 93

Aluminium Consumption within the Packaging Industry in the USA
according to Type of Semimanufactures
(in 1000 t)

	1970	1973	1975
Total	665	932	908
for foil for household and business	84	102	105
for metal containers	398	593	640
for sheet metal	398	593	640
for semi-rigid food containers	65	78	68
for sheet metal	5	6	4
foils	60	72	64

Source: Aluminum Association, New York

Household Goods

Household goods is one of the smaller aluminium consumers in the USA and also has a below-average growth rate. Consumption of aluminium has been between 400,000 and 600,000 tpy for the past few years, in 1975 it was only 342,000 t (Aluminum Association data). Sheet metal accounted for 38 - 46 % of the aluminium used from 1966 to 1975, ingots for ca. 30 %. A sizable amount of die cast products and drawn or welded pipe (9 % each) and foil (5 %) was also used. This sector includes refrigerators, freezers and other kitchen appliances, air conditioners, furniture, boats and leisuretime articles.
Aluminium consumption for household goods is contained in Table 92 according to type of semi-manufactures for 1966 - 1975.

Special statistics are published for the use of aluminium in air conditioners, refrigerators and freezers, portable household appliances, and kitchen appliances. These three classifications together have an almost 50 % share of the aluminium consumed by the household goods sector.
Between 80,000 and 170,000 t of aluminium were used annually for air conditioning, refrigerators and freezers, corresponding to about a quarter of the aluminium consumed by this sector. Of this amount, more than 50 % was sheet metal, 20 % was foil, and the remainder was pressed products, extruded pipe, drawn tubing, and ingots (10 - 14 %).
Between 60,000 and 85,000 t of aluminium are used annually for kitchen appliances, of which ca. 80 % is sheet metal and 14 - 16 % is ingots. The small remainder is accounted for by various pressed products.
Aluminium consumption for portable household appliances had reached 41,000 t in 1973, but declined to 21,000 t in 1975. Ca. 55 % of these amounts was ingots, most of the rest was sheet metal.
Aluminium consumption for these three classifications is presented in Table 94 for the years 1970, 1973, and 1975 according to type of semi-manufactures.

Table 94

Aluminium Consumption within the Household Good Industry in the USA according to Type of Semimanufactures
(in 1000 t)

	1970	1973	1975
Total	423	607	342
for air conditioners, freezers, refrigerators	127	170	83
for ingots	11	17	12
semimanufactures	116	153	71
sheet metal	89	94	43
foil	13	38	17
pressed products	6	8	5
extruded pipes	5	6	4
drawn tubes	2	5	2
for portable appliances	29	41	21
for ingots	17	23	12
semimanufactures	12	18	9
sheet metal	11	16	7
pressed products	1	1	1
for cooking utensils	66	86	61
for ingots	9	14	11
semimanufactures	57	72	50
sheet metal	55	70	49
pressed products	1	2	1

Source: Aluminum Association, New York

Miscellaneous

Various small end-user groups are compiled together under this heading in the Aluminum Association statistics. These include all applications for aluminium powder, the steel industry, and producers of alloys. As a whole, the trend is a decline in aluminium consumption from more than 400,000 tpy up to 1969 and 300,000 - 400,000 tpy thereafter. A consumption of only 277,000 t is given for 1976, which corresponds to 4.8 % of the total end-use consumption of aluminium.

Ingots accounted for ca. 50 % of the aluminium consumed by this sector, aluminium powder for 18 - 28 %, sheet metal for 17 % decreasing to 9 - 12 %. In the last few years, press moulded products and extrusion products accounted for 6 % and 5 % , respectively. Other types of semi-manufactures (plate, foil, pipe,

wire, and forged products) accounted for only small amounts and percentages of the aluminium consumed by this heterogeneous grouping.
Table 92 contains the aluminium consumption by this sector for 1966 - 1975 according to type of semi-manufactures.

Exports

The USA exports 250,000 - 530,000 tpy of semi-manufactures made of aluminium and aluminium alloys, corresponding to 6 - 12 % of the total market. Exports reached their highest volume in 1969 and 1970. Ingots account for more than 45 % of the total export volume, down from the 65 - 71 % of the middle sixties. In contrast, the proportion for sheet metal rose from ca. 20 % to ca. 30 %. Of the other types of semi-manufactures, extrusion products (6 %), foil, bare wire, cable and stranded wire (ca. 3 % each) were of significance in the last few years; plate also had 6 % in 1975.
Table 92 contains the breakdown according to type of semi-manufactures exported from 1966 to 1975.

4.14 Aluminium Consumption in Australia

Australia maintained its position as leading bauxite producer also in 1976; 30 % of world production came from this country alone. Production increased twelvefold from 1966 to 1976. In comparison, aluminium production and consumption are relatively of minor importance. Production of primary aluminium increased from 92,000 t in 1966 to 231,000 t in 1976. That is a growth of 151 %, corresponding to an average annual growth rate of 9.6 %. In comparison, total consumption increased from ca. 88,600 t in 1966 to 193,400 t in 1976, an average annual increase of 8.1 %. Consumption is therefore less than production. Production of secondary aluminium doubled from 1966 to 1976, reaching ca. 25,000 t in 1976. This production was used mainly for castings. Semi-manufactures production reached 146,365 t in 1976, 72 % higher than 1966. Almost all of this production was sold on the domestic market. Especially exports were still of little importance in fiscal 1976. Rolled flat products accounted for 54 % of semi-manufactures production in fiscal 1975/76, followed by rods and profiles with 33 %. Production and foreign trade of semi-manufactures can be seen in Table 95. With a per capita aluminium consumption of 13 kg in 1976, Australia continued to be among the top group of western industrial countries.
The Aluminium Development Council has published the following breakdown for aluminium consumption in 1975 and 1976:

	1975	1976
construction	34 %	37 %
packaging	19 %	23 %
transportation	15 %	11 %
electrical	13 %	15 %
machinery & equipment	8 %	7 %
consumer goods	11 %	7 %

Table 95

Production, Imports, and Exports of Semimanufactures made of Aluminium in Australia

in t

	1968/69	1970/71	1972/73	1973/74	1974/75	1975/76
Production by product						
Sheet and strip metal including foil stock, circles, and slugs	51,382	57,274	71,818	85,293	71,818	78,652
Rods and sections	29,860	32,630	41,570	51,661	39,728	48,905
Irrigation pipe	1,872	1,096	1,901	1,583	1,628	•
Other pipe and tubing	2,022	1,699	2,386	2,454	2,874	2,455
Wire	18,244	21,028	18,695	16,525	18,037	16,353
Total	103,380	113,727	136,370	157,516	134,085	146,365
Imports	2,096	1,933	2,054	5,891	6,719	1,900
Exports	2,815	3,912	3,594	3,909	4,540	822

The construction industry (including architecture) has accounted for the largest percentage of aluminium consumption in Australia for some years (37 %). The use of aluminium for supporting structures and roofs continues to increase at a rate considerably above average. Previously, most roofs were built of wood. The percentage of aluminium consumption accounted for by the construction industry increased from 34 % in 1975 back to 37 % in 1976. In the cities aluminium has not been able to replace wood as construction material. But it has been able to do so extensively in areas with a lack of skilled labor and high transport costs.

The packaging industry increased its market share from 17 % in 1971 to 23 % in 1976, remaining in second place ahead of the electrical industry. Consumption by this sector has an above average growth, especially for large containers and aluminium cans, mainly for the beverage industry.

The electrical industry was in third place in consumption in 1976 with nearly 15 % of the total aluminium consumption and exhibited a relatively high and constant growth.
Aluminium was used in this sector to extend the electric power grid.

The transportation sector was in fourth place with a ca. 11 % share of the market in 1976. The increased use of aluminium for motor vehicle production, container construction, and rail vehicles raised the percentage of aluminium used by this sector until 1971; there was a decrease of 4 per cent from 1975 (15 %) to 1976.
The remainder was accounted for by consumer goods with 7 % (1975: 11 %) and machinery and other, also with 7 % (1975: 8 %).

5) The Use of Bauxite and Alumina for Non-Metallic Purposes

The mining of bauxite and production of alumina is done principally for the production of primary aluminium. It is estimated that nearly 95 % of the bauxite mined is processed to aluminium oxide using the Bayer Process and more than 90 % of the aluminium oxide produced is used for making aluminium. Thus there are several million tons of bauxite and alumina that are used for other purposes. It is extimated that 12 % of all the aluminium consumed in the USA, the only country with continuing statistics for this usage, is used in the form of bauxite or aluminium oxide for non-metallic purposes. Ca. 5 % of the total aluminium used finds application in the form of bauxite in abrasives, refractories, and production of chemical compounds. Aluminium sulfate and other aluminium compounds, made from bauxite, are used for water and sewage purification, in dyes, and in the tanning of leather and sizing of paper. Bauxite is used in special cements (chemically and thermally resistant, quick setting), as adsorption agent and catalyst in the chemical and petrochemical industry, for coating welding rods, and as flux in the production of steel and ferro alloys.

Another 7 % of the aluminium used in the USA is in the form of aluminium oxide for abrasives (fused alumina), refractories, and for glass and ceramic products. Aluminium hydrates are used for the production of chemicals (including aluminium fluoride), as fire retardant in carpets, plastics, and masonry. Tabular alumina is a form of corundum used primarily in ceramics and refractory materials. Due to its high porosity, activated alumina is used to remove water from liquids and gases in the chemical and petrochemical industry.

Continuous statistics on the use of bauxite and alumina for non-metallic purposes are available only for the USA and estimations for the rest of the world. According to statistics from the US Bureau of Mines, Washington, D.C., consumption of bauxite and alumina for non-metallic purposes in the USA increased from 375,000 t (aluminium content) in 1966 to 701,000 t in 1974, an average annual increase of 8.1 %. The proportion of aluminium used for non-metallic uses increased during this period from 9.1 % to 11.1 %. A decrease in consumption to ca. 650,000 t could be expected for 1976. Most of the consumption between 1966 and 1974 was for chemicals, which accounted for 41 % in 1966, peaked at more than 60 %, and attained 49 % in 1974. The share for refractories decreased from 38 % to 33 %, that for abrasives from 21 % to 18 %. The US Bureau of Mines estimates that consumption in the rest of the world amounted to approximately 1.2 million tpy in 1973 (aluminium content).
Within the EC, the only data available is that ca. 18 % of the bauxite and 16 % of the alumina (hydrous and fused) were used in France in 1976 for purposes other thar making aluminium.

Consumption of bauxite and aluminium oxide for non-metallic purposes in the USA from 1966 to 1974 is presented in Table 96.

Considering the consumption trends in the USA, we estimate that aluminium consumption for non-metallic purposes rose from 600,000 t in 1966 to ca. 1.5 million t in 1974.
When the USA is included, 2.2 million t of aluminium were used in 1974 for purposes other than the metal itself, just under 13 % of the total consumption of aluminium in metallic form.

Table 96

Bauxite[1] and Alumina[2] Consumption for Non-Metallic Applications: 1966 - 1974
(in 1000 t Al content)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Bauxite USA											
refractory materials	142	134	110	122	123	128	158	222	231		
chemicals	153	153	193	211	270	325	315	323	342		
abrasives	80	67	62	69	75	66	84	112	128		
total	375	354	365	402	468	519	557	657	701		
Other parts of world	600 x)	650 x)	600 x)	800 x)	1000 x)	1100 x)	1150 x)	1204	1500 x)		
World total	975 x)	1004 x)	965 x)	1202 x)	1468 x)	1619 x)	1707 x)	1861	2201 x)		
Production of alumina for non-metallic purposes in 1000 t Al_2O_3											
Europe								651	734	611	666
East Asia								444	430	355	377
South Asia								-	-	-	1
Africa								-	-	-	-
Northamerica								785	841	670	777
Latin America								38	35	63	66
Oceania								-	-	-	-
Total								1918	2040	1669	1887

x) estimate

1) Source: U.S. Bureau of Mines and our own estimations,
2) after International Primary Aluminium Institute.

IV. Foreign Trade in Aluminium and Aluminium Raw Materials in particular in the Community

1) World Trade in Bauxite, Alumina, Raw Aluminium and Aluminium Semi-Manufactures in 1976

1.1 Exports and Imports of Bauxite

In 1976 80.5 million t of bauxite were mined throughout the world, the major portion of which was processed to alumina in its country of origin. From the exporting countries (including re-exports) and the imports of 15 important consumer countries it can be seen that during this year more than 31 million t of bauxite were traded.Table 97 contains the imports of the industrial countries listed according to countries of origin as well as the exports and in some cases also the imports of 30 exporting countries. This makes a clear differentiation of real exports and re-exports possible, as they are above all available for most West European countries. In 1976, Guinea, Jamaica and Australia were by far the most important of the World's bauxite-exporting countries with a volume of exports of 8.5 million t and 6.8 million t respectively. Following with much lower figures were Surinam (1.8 million t), Guyana (1.3 million t), Indonesia (almost 1.0 million t) andGreece (0.8 million t).

From the grand total of almost 31 million t of bauxite imports recorded, 42 % alone were taken up by the USA, 14 % by Japan, 13 % by the Federal Republic of Germany and 11 % by the USSR, in other words 80 % amongst only 4 countries. France und Italy with respective shares of 7 and 6 % were the next most important importing countries.

In 1976 the USA imported more than 13.1 million t of bauxite of which almost 55 % came from Jamaica, 18 % from Guinea and 12 % from Surinam. Further smaller amounts came from Guyana, Haiti and the Dominican Republic.

Japan's bauxite imports rose in 1976 compared with the previous year and amounted to 4.3 million t. Of this almost 64 % was taken from Australia and a further 23 % from Indonesia.
By contrast,the bauxite imports of the Federal Republic of Germany of 4.09 million t were below the 1975 volume, 55 % of the total imports alone came from Australia and 29 % from Guinea. Only Sierra Leone (9 %) was of major significance amongst the remaining delivering countries.

At the moment, only the imports for 1975 are available for the USSR. Of the total of ca. 3.5 million t of bauxite for that year, 53 % came from Guinea, 27 % from Yugoslavia, and 18 % from Greece.

Table 97

World Trade Figures for Bauxite: 1976
in 1000 t

Destination Countries / Countries of origin	Belgium/ Luxembourg	Germany FR	France	United Kingdom	Italy	Netherlands	Austria	Sweden	Switzerland	Spain	USSR	Japan	USA	Canada	Total	Exports (including other Countries)	Production of Bauxit 1976
Denmark	6,0	1.7	7.0	-	-	-	-	0.1	-	1.9	-	-	-	-	16.7	20.0[x]	-
Germany FR	2.2	-	0.9	-	0.0	-	-	0.2	0.1	0.2	-	-	-	-	3.6	4.6	0.2
France	0.7	2.9	-	-	0.6	-	-	-	23.7	1.3	-	-	-	-	29.2	32.3	2,315.3
United Kingdom	-	-	-	-	-	-	-	-	6.2	-	-	-	-	-	0.2	0.1	-
Italy	-	-	-	-	-	-	-	-	1.5	2.4	-	-	-	-	3.9	1.4	24.2
Netherlands	0.3	2.2	-	2.6	-	-	-	0.9	-	-	-	-	-	-	6.0	5.6	-
EC Countries	9.2	6.8	7.9	2.6	0.6	-	-	1.2	25.5	5.8	-	-	-	-	59.6	64.0	2,339.7
Greece	-	91.6	88.2	53.1	2.3	117.0	30.9	4.9	-	17.1	405.3	3.8	-	-	814.2	1,354.6[x]	2,746.9
Yugoslavia	-	-	-	-	-	-	-	-	-		635.3	-	-	-	635.3	700.0[x]	2,033.0
Europe without East Block	9.2	98.4	96.1	55.7	2.9	117.0	30.9	6.1	25.5	22.9	1,040.6	3.8	-	-	1,509.1	2,118.6	7,133.1[1]
India	-	-	-	-	-	-	-	-	-	-	-	0.2	-	5.0	5.2	5.2[x]	1,435.9
Indonesia	-	-	-	-	-	-	-	-	-	-	-	967.3	-	-	967.3	940.3[x]	940.3
Malaysia	-	-	-	-	-	-	-	-	-	-	-	512.5	-	-	512.5	660.2[x]	660.2
Turkey	-	-	14.2	-	-	-	-	-	-	-	-	-	-	-	14.2	90.0[x]	461.0
Asia without East Block	-	-	14.2	-	-	-	-	-	-	-		1,480.0	-	5.0	1,499.2	1,695.7	3,497.8[2]
Ghana	-	48.5	-	195.8	-	-	-	-	-	16.6	—	-	-	-	260.9	261.0[x]	267.3
Guinea	-	1,173.8	1,716.8	0.5	319.7	-	-	-	-	-	2,484.0	-	2,334.8	522.7	8,552.3	8,600.0[x]	11,316.4
Sierra Leone	-	380.1	-	23.9	-	-	-	-	-	-	-	-	53.9	75.1	533.0	578.0	660.0
Africa	-	1,602.4	1,716.8	220.2	319.7	-	-	-	-	16.6	2,484.0	-	2,388.7	597.8	9,345.9	9,439.0	12,250.7[3]
Antilles	-	-	-	-	-	-	-	-	-	4.7	-	-	-	-	4.7		-
Brazil	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	0.1	-	1,000.0[4]
Dominican Republic	-	-	-	-	-	-	-	-	-	-	-	-	599.6	-	599.6	540.0[x]	516.0[4]
Guyana	9.1	82.3	46.9	-	25.9	13.2	-	12.0	-	-	-	41.5	725.2	299.6	1,255.7	1,260.0[x]	3,107.6
Guiana	0.9	-	-	-	-	-	-	-	-	42.4	-	-	-	-	43.3	50.0[x]	-
Haiti	-	-	-	-	-	-	-	-	-	-	-	-	615.4	-	615.4	620.0[x]	660.4[4]
Jamaica	-	-	-	-	-	-	-	-	-	-	-	-	7,165.9	-	7,165.9	6,283.7	10,306.0[4]
Canada	-	-	-	-	-	-	-	-	-	-	-	-	2.6	-	2.6	15.8	-
Colombia	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	0.7	1.0[x]	-
Surinam	-	39.2	10.0	9.7	11.9	-	-	-	-	3.0	-	8.2	1,601.5	133.7	1,817.2	2,500.0[x]	4,588.0
Trinidad and Tobago	-	-	-	-	-	-	-	-	-	-	-	8.3	-	91.9	100.2	100.0[x]	-
USA	-	2.2	-	0.6	-	-	-	-	-	-	-	6.5	-	48.1	57.4	15.2	1,989.4[4]
America	10.0	123.7	57.6	10.4	37.8	13.2	-	12.0	-	50.1	-	64.5	10,710.2	573.3	11,662.8	11,385.7	22,167.4
Australia	-	2,239.2	382.9	9.7	1,383.7	-	-	16.4	-	-	-	2,717.2	-	29.0	6,778.1	6,752.2	24,085.1
Western World	19.2	4,063.7	2,267.6	296.0	1,744.1	130.2	30.9	34.5	25.5	89.6	3,524.6	4,265.5	13,098.9	1,205.1	30,795.4	31,391.2	69,134.1
USSR	-	-	-	-	-	-	-	-	-	5.3	-	-	-	-	5.3	6.0[x]	6,700.0[5]
China PR	0.5	23.0	1.8	0.5	54.0	0.5	-	4.0	-	-	-	11.1	11.0	25.0	131.4	135.0[x]	850.0
East Block	0.5	23.0	1.8	0.5	54.0	0.5	-	4.0	-	5.3	-	11.1	11.0	25.0	136.7	141.0[x]	11,357.8[6]
Other countries	-	0.3	0.2	-	25.5	0.1	-	-	-	0.1	-	-	0.6	-	26.8	30.0[x]	-
World total	19.7	4,087.0	2,269.6	296.5	1,823.6	130.8	30.9	38.5	25.5	95.0	3,524.6	4,276.6	13,110.5	1,230.1	30,958.9	31,562.2	80,491.9

x) estimated

1) including 13,500 t from Spain

2) including 400 t from Pakistan

3) including other countries

4) Dried equivalent

5) including other raw materials containing aluminium (Alunite, Nepheline),

6) including 890,000 t from Romania and 2,917,800 t from Hungary

Due to a fall in internal production the bauxite imports of France in 1976 were increased to 2.3 million t, of which 76 % came from Guinea and 17 % from Australia.

The bauxite imports of Italy in 1976 amounted to more than 1.8 million t. From this total almost 76 % came from Australia and a further 18 % from Guinea.

The supply of bauxite to the European Community as a whole between 1966 and 1976 is analysed in special Chapter V, 2.1.

1.2 Exports and Imports of Alumina

Compared to the previous year, the production of alumina worldwide in 1976 rose and reached 27.5 million t. From the export statistics of 22 exporting countries it can be seen that in this year world trade in alumina amounted to just 11.8 million t. Of this grand total, 9.7 million t or 82 % were imported by the 13 most important consumer countries. Of the 1976 volume of exports, more than 49 % or 5.8 million t came from Australia, 14 % or 1.65 million t from Jamaica, and 7.6 % or 900,000 t from Surinam, followed by the USA (6.3 %), Italy (3.8 %) and Hungary (3.4 %).

The imports of the 13 most important consumer countries of alumina, according to countries of origin, reveals a total volume of imports of 9.7 million t for 1976, equating to 82 % of the volume of exports from 22 listed exporting countries. The USA had a share of almost 34 % of the recorded volume of imports, followed by Norway (14 %), the USSR (11 %), Canada (9 %) and Japan (7 %). The largest aluminium producing countries of the EC only had a minor share of the volume of imports, as almost all have a major alumina production capacity.

The USA imported almost 3.29 million t of alumina in 1976 of which 76 % alone (therewith much more than in previous years) came from Australia. Further important delivering countries were Jamaica (17 %) and Surinam (6 %).

The Norwegian alumina imports rose in 1976 to over 1.31 million t and came in particular from Australia (32 %), Jamaica (28 %) and Surinam (22 %).

Figures concerning USSR imports are only available for 1975 but should not greatly differ from those of 1976. In 1975 the USSR imported 1.03 million t of alumina with more than 39 % from Hungary, 16 % from Jamaica, 12 % from Guyana, 11 % from the USA and 7 % from Italy.

Canada imported about 908,000 t of alumina in 1976, of which (as in the previous year) 47 % came from Australia and a further 32 % from the USA. The remaining alumina came from the Federal Republic of Germany, from France, Jamaica and the Dutch Antillies.

In spite of a renewed increase, Japan's imports of alumina in 1976 of 627,400 t remained below the previous maximum volume attained in 1974. As in the previous year almost all of the material in 1976 came from Australia (98.6 %) and the bulk of the remainder from Surinam.

The suppl y of EC countries with alumina is covered separately in Chapter V., 2.2.

In Table 98 the imports of alumina, according to countries of origin are tabulated for the 13 most important importing countries for 1976, together with the production and export of 22 exporting countries.

1.3 Exports and Imports of Raw Aluminium

In 1976 about 16.2 million t of raw aluminium (primary and secondary aluminium) were produced worldwide. For this year there are as yet no complete statistics available concerning trade in raw aluminium, which often include aluminium alloys. From the available export statistics and estimates for the remaining exporting countries it can however be concluded that about 3.5 million t of raw aluminium were traded. The 10 most important export countries had a share of 82 % of the total exports in this year, including Norway with 16 %, the USSR with 15 %, Canada with 14 %, the Federal Republic of Germany and the Netherlands each with 8 %, United Kingdom with 5 % and France, Ghana, Bahrain, and the USA each with 4 %.

Just three-quarters of the world exports of raw aluminium, about 2.6 million t, were taken up by only 15 of the larger consumer countries in 1976, with almost 20 % by the USA, 17 % by Japan, 16 % by the Federal Republic of Germany, 10 % each by Belgium/Luxemburg and France and 8 % each by the United Kingdom and Italy.

The USA raw aluminium imports, almost 517,000 t in 1976, came largely from Canada with 67 %, and a further round 15 % from Ghana; quotable amounts of raw aluminium came also from Surinam, Yugoslavia, Norway and Japan.

Japan imported a total of 430,000 t of raw aluminium (including alloys) in 1976, which came from a large number of countries. The most important countries of origin were New Zealand (24 %), the USSR (16 %), Bahrein (15 %) and Australia (10 %), followed by the USA (8 %) and Romania (6 %). All other delivering countries had a share of less than 4 %.

The raw aluminium imports of the Federal Republic of Germany in 1976 rose to more than 405,000 t and were therefore more than 42 % above the corresponding value for the previous year. As in the previous years, the Federal Republic of Germany obtained more than 40 % of its raw aluminium from Norway (1976: 43 %), whereas significant quantities were obtained from a large number of other delivering countries including the Netherlands (15 %), United Kingdom (9 %), France (7 %), and Ireland (6 %). The total import share of all other delivering countries remained under

Table 98

World Trade Figures for Alumina: 1976
in 1000 t gross weight

Countries of origin / Destination countries	Germany FR	United Kingdom	Italy	Netherlands	Norway	Austria	Sweden	Switzerland	Spain	USSR (1975)	Japan	USA	Canada	Total	Exports (including other Countries)	Production of Alumina 1976
Germany FR	-	4.8	8.9	1.6	5.0	.	30.4	3.8	72.5	-	0.5	5.3	83.6	216.4	324.2	1,331.2
France	2.7	1.7	6.0	131.1	0.0	0.2	0.1	1.7	46.8	-	0.7	9.4	41.6	242.0	311.9	1,013.0
United Kingdom	0.3	-	0.3	-	0.3	.	9.1	0.0	3.1	-	0.1	0.5	-	13.7	43.0	96.0
Italy	186.3	50.4	-	-	43.1	0.0	-	5.5	5.4	76.3	-	-	-	367.0	448.0	797.8
Netherlands	-	0.3	2.9	-	0.0	0.0	2.5	.	0.1	-	-	0.0	-	5.8	27.0	-
EC Countries	189.3	57.2	18.1	132.7	48.4	0.2	42.1	11.0	127.9	76.3	1.3	15.2	125.2	844.9	1,154.1	3,238.0
Greece	-	-	8.0	169.1	-	-	-	-	-	-	-	-	-	177.1	195.0	461.6
Austria	-	2.9	-	-	-	-	-	-	-	-	-	-	-	2.9	3.0 x)	-
Switzerland	0.3	-	-	-	-	-	-	-	-	-	-	-	-	0.3	0.2	-
Europe without East Block	189.6	60.1	26.1	301.8	48.4		42.1	11.0	127.9	76.3	1.3	15.2	125.2	1,025.2	1,352.3	4,161.5 1)
India	-	-	-	-	-	-	-	-	0.4	47.3	-	-	-	47.7	(47.7)	442.0
Turkey	-	-	-	-	-	-	-	-	-	38.3	-	-	-	38.3	(38.3)	70.0 x)
Asia without East Block	-	-	-	-	-	-	-	-	0.4	85.6	-	-	-	86.0	(86.0)	1,971.1 2)
Guinea	0.8	-	51.1	-	7.7	-	-	17.3	211.9	-	-	-	-	288.8	562.0 x)	562.0
Rep. of South Africa	-	-	-	-	-	-	0.3	-	-	-	-	-	-	0.3	0.3 x)	-
Africa	0.8	-	51.1	-	7.7	-	0.3	17.3	211.9	-	-	-	-	289.1	562.3	562.0
Antilles	-	-	-	-	-	-	-	-	-	-	-	-	22.1	22.1	(22.1)	-
Ecuador	-	-	-	-	-	-	-	-	-	-	-	2.8	-	2.8	(2.8)	-
Guyana	-	47.1	8.8	-	80.5	-	-	-	-	121.3	-	11.6	-	269.3	(269.3)	247.0
Guiana	-	-	-	-	11.3	-	-	-	-	-	-	-	-	11.3	(11.3)	-
Jamaica	21.6	282.7	-	-	373.4	-	129.3	-	53.5	168.6	-	558.6	39.7	1,627.4	1,648.4	1,648.2
Canada	0.1	0.9	0.2	-	15.3	-	0.0	-	0.2	-	-	13.0	-	29.7	10.0 x)	490.0
Surinam	25.2	95.7	-	186.3	287.3	-	16.9	3.2	-	-	6.0	190.9	-	811.5	900.0	1,040.0
USA	1.2	5.6	0.5	0.3	64.4	-	1.2	0.1	0.1	114.3	1.3	-	293.5	482.5	738.2	5,915.0
America	48.1	432.0	9.5	186.6	832.2	-	147.4	3.3	53.8	404.2	7.3	776.9	355.3	3,256.6	3,602.1	9,643.2 3)
Australia	233.8	33.3	-	23.9	425.3	-	-	125.5	-	-	618.8	2,495.8	427.4	4,383.8	5,793.5	6,205.8
Western World	472.3	525.4	86.7	512.3	1,313.6	0.2	189.8	157.1	394.0	566.1	627.4	3,287.9	907.9	9,040.7	11,396.2	22,543.6
Hungary	0.2	-	0.1	-	-	-	-	-	-	405.1	-	-	-	405.4	(405.4)	754.8
East Block	0.2	-	0.1	-	-	-	-	-	-	405.1	-	-	-	405.4	(405.4)	4,992.8 4)
Other countries	0.7	0.1	0.6	0.1	0.0	188.3	0.0	1.1	0.2	57.6	0.0	0.1	0.1	248.9	.	.
World total	473.2	525.5	87.4	512.4	1,313.6	188.5	189.8	158.2	394.2	1,028.8	627.4	3,288.0	908.0	9,695.0	11,801.6	27,536.4

x) estimate 1) including 461,900 t from Yugoslavia, 2) including 1,411,100 t from Japan and 47,700 t from Taiwan, 3) including 303,000 t from Brazil,
4) including 3,350,000 t from USSR, 48,000 t x) from Germany DR, 400,000 t from Romania, 90,000 t from Czechoslovakia, 350,000 t from China PR

3 % in each case. The import structure, sub-divided according to trade within the European Community and other countries, is given in Chapter V., 2.3.

The imports of France of alloyed and non-alloyed raw aluminium rose in 1976 by more than 15 % compared with 1975, to a total of 251,400 t. Of this more than three-quarters came from Western European countries. The most important suppliers were the Federal Republic of Germany (27 %), the Netherlands (21 %), Greece (12 %), Norway (7 %), the USSR, the United Kingdom and Cameroon (each 5 %).

The raw aluminium imports of the United Kingdom also rose again in 1976 and reached 217,900 t. As in the previous years the larger share of the imports came from Norway (51 %), further important suppliers were Ireland (14 %), Ghana (9 %), Canada (8 %) and France (6 %).

In Italy the import of raw aluminium rose in 1976 to 196.500 t, of which almost 35 % came from the Federal Republic of Germany, 22 % from Greece, 17 % from France and 4 % each from the Netherlands and Romania.

In Table 99 the imports of the 15 western industrial countries of raw aluminium are tabulated according to delivering countries, as well as the production and export from 37 exporting countries, for 1976.

1.4 Exports and Imports of Semi-Manufactures

From the production statistics available and some estimates, about 9.4 million t of aluminium semi-manufactures were produced worldwide in 1975. From the frequently incomplete external trade statistics and additional estimates it can be seen that more than 1.2 million tons or 14 % were traded. In this year the largest exporting countries for aluminium semi-manufactures were the USA with 186,300 t (15 % of world exports), Belgium/Luxemburg with 155,000 t (13 %), the Federal Republic of Germany with 150,200 t (12 %), France with 118,200 t (10 %), the USSR with 101,500 t (8 %) and Japan with 68,300 t (6 %). Further, an export volume of between 30,000 and 55,000 t was achieved by the United Kingdom, Italy, the Netherlands, Yugoslavia, Norway, Switzerland and Spain, possibly also some eastern European countries. In as far as the incomplete export statistics enable an estimate to be made, of the semi-manufactures exported in 1976, almost 49 % were taken up by the EC countries and almost 68 % by the whole of Western Europe, 6 % by Asia (less East Block), 16 % by America and almost 90 % by the Western World.

About 756,000 t or more than 62 % of the world exports of aluminium semi-manufactures were taken up by 22 countries of the western world. Among these countries the Federal Republic of Germany was the largest importer of aluminium semi-manufactures with a share of almost 17 % of this volume of export, followed by France (11 %), United Kingdom (10 %), the Netherlands and Canada (each with about 8 %),

Table 99

World Trade Figures for Aluminium: 1976
in 1000 t

Countries of origin \ Destination countries	Belgium/ Luxembourg	Germany FR	France	United Kingdom	Italy	Nether-lands	Norway	Austria	Sweden	Switzer-land	Spain	Japan	USA	Canada	Total	Exports (including other countries)	Production of Aluminium 1976
Belgium/Luxembourg	-	9.5	1.7	0.1	0.2	0.0	-	-	-	-	-	-	0.9	-	12.4	14.2	2.6
Denmark	1.2	1.4	0.4	-	0.1	-	0.1	0.1	1.6	-	-	-	-	-	4.9	(4.9)	9.0[x]
Germany FR	39.5	-	67.1	5.5	67.9	30.4	1.0	6.1	1.0	0.3	-	1.0	0.4	(0.1)	220.3	281.4	1,041.7
France	33.2	27.2	-	12.6	34.0	4.3	-	0.2	0.7	0.2	-	1.1	6.0	(0.9)	120.4	149.2	522.1
United Kingdom	22.2	36.2	12.8	-	4.2	36.3	1.6	0.4	3.3	0.5	0.6	4.3	8.3	(6.2)	136.9	162.1	540.3
Rep. of Ireland	-	-	-	1.9	0	-	-	-	0	-	-	-	-	-	1.9	(1.9)	-
Italy	0	5.7	8.0	-	-	0	-	0.1	-	0.3	-	-	-	-	14.1	9.4	404.5
Netherlands	106.8	61.9	53.5	0.4	8.7	-	0.3	0.1	0.1	0.2	2.0	0.2	-	-	234.2	290.4	287.4
EC Countries	202.9	141.9	143.5	20.5	115.1	71.0	3.0	7.0	6.7	1.5	2.6	6.6	15.6	(7.2)	745.1	913.5	2.807,6
Greece	3.2	0.1	30.5	-	42.8	-	-	-	-	-	-	7.1	-	-	83.7	(83.7)	134.0
Iceland	3.0	22.4	0.8	31.4	2.4	-	-	0.2	0.1	11.5	-	-	-	-	71.8	(71.8)	65.3
Yugoslavia	-	2.1	1.5	-	3.8	0.3	-	1.6	-	-	-	4.0	14.0	-	27.3	(27.3)	213.0
Norway	42.4	175.4	18.5	110.3	4.3	73.6	-	4.6	27.2	11.0	4.9	1.1	14.1	(0.3)	487.7	561.8	626.9
Austria	0.1	5.4	-	-	1.9	0.1	-	-	0.1	0.3	-	-	-	-	7.9	8.6	97.2
Sweden	0	0.8	-	0	-	-	8.0	0.1	-	-	-	0.4	1.5	-	10.8	13.3	105.4
Switzerland	0	9.6	0.2	2.0	1.5	-	-	0.2	1.9	-	-	0.9	1.1	-	17.4	33.2	96.8
Spain	0	1.3	1.7	-	0.1	1.6	-	-	-	-	-	0.1	3.8	-	8.6	3.7	249.0
Europe without East Block	251.6	359.0	196.7	164.2	171.9	146.6	11.0	13.7	36.0	24.3	7.5	20.2	50.1	(7.5)	1,460.3	1,716.9	4,401.3[1]
Bahrain	-	-	1.7	-	-	-	-	-	-	-	-	63.3	4.8	-	69.8	(69.8)	122.1
India	-	-	3.0	0.3	-	-	-	-	-	-	-	15.3	2.0	-	20.6	(20.6)	211.8
Iran	-	.	.	0.5	.	-	-	-	-	-	-	10.0	-	-	10.5	(10.5)	46.6
Japan	-	3.2	0.2	-	-	-	0.1	-	-	-	-	-	12.2	-	15.7	69.7	1,445.3
Asia without East Block	-	3.2	4.9	0.8	-	-	0.1	-	-	-	-	88.6	19.0	-	116.6	170.6	1,939.5[2]
Egypt	-	3.7	-	2.6	-	0.8	-	-	-	2.8	-	2.7	-	-	12.6	(12.6)	59.0
Ghana	1.2	2.6	0.1	18.9	-	7.8	-	-	6.9	-	-	7.0	76.2	-	120.7	(120.7)	151.1
Cameroon	-	-	12.6	-	-	-	-	-	-	-	-	8.2	-	-	20.8	(20.8)	48.7
Rep. of South Africa	0.2	2.0	-	-	0	-	-	-	-	-	-	2.9	3.0	-	8.1	(8.1)	84.4
Africa	1.4	8.3	12.7	21.5	-	8.6	-	-	6.9	2.8	-	20.8	79.2	-	162.2	(162.2)	348.2[3]
Canada	0.1	-	1.4	17.1	0.1	1.3	-	-	-	-	1.0	13.0	345.6	-	379.6	507.5	667.0
Surinam	0.9	10.7	0.3	5.0	4.9	1.3	-	-	-	-	-	-	20.9	-	44.0	(44.0)	44.8
USA	0.3	2.1	6.7	0.4	0.1	0.1	0.1	-	0	0	-	34.2	-	(18.0)	62.0	138.2	5,168.6[4]
America	1.3	12.8	8.4	22.5	5.1	2.7	0.1	-	-	-	1.0	47.2	366.5	(18.0)	485.6	689.7	6,203.4[5]
Australia	-	-	0.1	-	0.1	-	-	-	-	-	-	44.3	0.2	-	44.7	64.4	259.3
New Zealand	-	.	.	-	.	-	-	-	-	-	-	105.2	-	-	105.2	(105.2)	141.8
Australia/Oceania	-	-	0.1	-	0.1	-	-	-	-	-	-	149.5	0.2	-	149.9	169.6	401.1
Western World	254.3	383.3	222.8	209.0	177.1	157.9	11.2	13.7	42.9	27.1	8.5	326.3	515.0	(25.5)	2,374.6	2,909.0	13,293.5
Bulgaria	-	0.5	0.3	1.0	1.0	-	-	0.3	0.4	-	-	1.8	-	-	5.3	(5.3)	.
Germany DR	0.4	-	-	0.4	0.2	-	-	-	-	-	-	0.2	-	-	1.2	(1.2)	60.0[x]
Poland	0.9	-	0.2	-	3.0	-	0.4	-	0	1.7	-	1.0	-	-	7.2	(7.2)	103.0[x]
Romania	0.7	2.2	11.1	0.5	8.5	0.3	-	0.0	0.8	-	-	25.8	0.7	-	50.6	(50.6)	207.0[x]
Czechoslovakia	-	2.6	0.8	0	1.1	0.1	-	0.2	-	0.3	-	2.2	-	-	7.3	(7.3)	36.0[x]
USSR	1.7	6.3	13.7	6.4	2.5	0.1	12.0	1.1	1.8	-	4.1	68.8	0.2	-	118.7	502.4[6]	2,200.0[x]
Hungary	0.1	5.7	1.7	0.1	2.7	0.2	-	5.7	0.3	2.0	0.8	3.3	-	-	22.6	(22.6)	70.5[x]
East Block	3.8	17.3	27.8	8.4	19.0	0.7	12.4	7.3	3.3	4.0	4.9	103.1	0.9	-	212.9	596.6	2,856.5[7][8]
Other countries	0.1	4.5	0.8	0.5	0.4	-	-	-	0.5	-	0	0.7	0.9	-	8.4	(8.4)	-
World total	258.2	405.1	251.4	217.9	196.5	158.6	23.6	21.0	46.7	31.1	13.4	430.1	516.8	(25.5)	2,595.9	3,514.0	16,150.0

[x] estimated

[1] including 6,100 t from Finland, [2] including 113,700 t from other Asia, [3] including 5,000t from other Africa, [4] Including direct use of scrap by manufactures.

[5] including 323,000 t from other America, [6] in 1975, [7] excluding secondary aluminium, [8] including 180,000 t from China PR

the USA and Sweden (each with about 7 %).

In 1976 the imports of semi-manufactures by the Federal Republic of Germany rose only slightly to 124,400 t, equating to an increase of 0.5 % over the volume of the previous year. In this year the Federal Republic of Germany took more than 83 % of the semi-manufactures from other EC countries, in particular from Belgium/Luxemburg and France (each with 22 %), from the Netherlands (20 %) and Italy (7 %). The most important supplier for aluminium semi-manufactures outside the EC was the USA with a share of 6 % of the total volume of imports.

By contrast the semi-manufacture imports of France in 1975 with 86,300 t, rose by almost 20 % above the volume of imports for the previous year. From the imports in 1975 about 88 % came from other EC countries as in the previous year, in particular from the Federal Republic of Germany (36 %), Belgium/Luxemburg (28 %), the Netherlands (12 %) and Italy (9 %). Of the outside countries, the USA was the most important semi-manufacture supplier for France with a share of 3 %.

The import of semi-manufactures of the United Kingdom, 71,600 t in 1975, remained well under the volume of the previous year (-23.5 %). Of this 38 % came from EC countries, in particular from Belgium/Luxemburg (15 %), the Federal Republic of Germany and France (each almost 8 %). In 1975 the USA remained the most imp(tant supplier of the United Kingdom for aluminium semi-manufactures with a share of almost 26 %. Imports of significant size also came from Norway (13 %), Sweden (6 %) and Switzerland (4 %).

The Netherlands imported almost 60,900 t of aluminium semi-manufactures in 1975, over 20 % less than in 1974. Of the total volume 91 % came from the other EC countries, in particular from the Federal Republic of Germany (41 %), Belgium/Luxemburg (35 %) and France (9 %).

Canada imported only 56,900 t of aluminium semi-manufactures during 1975, 56 % of the 1974 volume. Almost 91 % of the imports came from the USA.

The aluminium semi-manufacture imports of the USA rose on the other hand in 1975 by a third, to 56,300 t. Of this, 49 % came from EC countries, in particular from Belgium/Luxemburg (35 %) and from France (8 %). Following Belgium/Luxemburg, Japan became the second-most important supplier with a share of 25 % of the total imports. Larger semi-manufacture imports came, as in the previous years, from Yugoslavia (9 % of the imports), Canada (6 %) and Norway (4 %).

In Table 100 the semi-manufacture imports of 22 western countries are tabulated for 1975 according to countries of origin, together with semi-manufacture production and export figures for more than 34 exporting countries; the appropriate statistics for 1976 are not available as yet.

Table 100

World Trade Figure for Aluminium Semimanufactures: 1975

in t gross weight

Importing Countries / Exporting Countries	Belgium/ Luxembourg	Germany FR	Denmark	Finland	France	United Kingdom	Italy	Yugoslavia (1974)	Netherlands	Norway	Austria
Belgium/Luxembourg	-	33,699	4,135	1,079	23,946	10,745	3,494	4	21,190	2,766	296
Germany FR	21,893	-	6,201	2,052	31,142	5,422	9,164	2,906	24,814	14,032	6,688
Denmark	3	416	-	56	13	706	4	89	91	208	284
France	7,523	33,487	2,234	675	-	5,385	9,078	1,034	5,745	478	412
United Kingdom	995	2,371	741	496	2,183	-	625	15	1,551	747	73
Rep. of Ireland	4	-	-	-	6	758	1	-	10	-	4
Italy	628	8,367	690	724	7,762	2,104	-	1,790	1,717	57	474
Netherlands	10,094	25,113	668	261	10,728	2,218	1,147	238	-	93	513
EC Countries	41,140	103,453	14,669	5,343	75,780	27,338	23,513	6,076	55,118	18,381	8,744
Finland	1	-	14	-	10	90	-	-	2	82	1
Greece	-	302	-	-	39	37	1,495	9	-	-	-
Iceland	-	-	-	122	-	-	4	-	-	47	106
Yugoslavia	135	2,983	198	620	352	651	279	-	633	213	790
Norway	28	571	6,101	3,784	444	9,200	5	483	82	-	527
Austria	48	3,926	1,198	1,187	1,396	1,130	178	1,161	457	775	-
Portugal	-	3	-	215	-	-	-	-	-	-	-
Sweden	30	354	5,262	4,685	258	4,076	77	38	236	5,174	429
Switzerland	597	2,844	2,065	1,153	1,362	3,019	336	336	641	1,204	3,209
Spain	4	521	60	372	173	195	3	2,691	61	14	4
Europe without East Block	41,983	114,957	29,567	17,481	79,814	45,736	25,890	10,794	57,230	25,890	13,810
Hong Kong	-	-	-	-	-	191	-	-	-	-	-
Israel	2	198	-	-	12	122	39	5	327	-	3
Japan	23	262	-	2	582	172	79	-	12	-	-
Philippines	-	-	-	-	-	-	-	-	-	-	-
Turkey	-	1	-	-	-	-	-	420	-	-	-
Other Asia	-	-	-	-	-	76	16	3	-	-	-
Asia without East Block	25	461	-	2	594	561	134	428	339	-	3
Africa	-	-	-	-	-	5	2	-	-	-	-
Canada	-	8	-	-	1,855	364	47	-	22	2	10
USA	767	7,786	4,036	14	2,883	18,344	3,939	763	3,246	1,352	86
Other America	4	-	-	-	-	68	4	-	-	-	-
America	771	7,794	4,036	14	4,738	18,776	3,990	763	3,268	1,354	96
Australia	-	-	-	1	-	-	-	-	1	-	-
Australia/Oceania	-	-	-	1	-	6	-	-	12	-	-
Western World	42,779	123,212	33,603	17,498	85,146	65,084	30,016	11,985	60,849	27,244	13,909
Bulgaria	-	-	-	-	-	-	-	1	-	-	-
Germany DR	-	-	-	912	-	1	-	67	-	-	-
Poland	-	4	3	-	-	3	12	-	-	-	-
Romania	33	263	-	20	20	-	125	-	18	-	17
Czechoslovakia	3	6	-	-	-	-	-	43	17	-	6
USSR	-	19	-	559	991	-	3	5,174	-	-	-
Hungary	-	929	2,182	1,817	160	443	26	1	11	30	5
East Block	36	1,221	2,185	3,308	1,171	447	166	5,286	46	30	28
Other countries	301	3	-	-	-	6,104	6	-	3	-	-
World total	43,116	124,436	35,788	20,806	86,317	71,635	30,188	17,271	60,898	27,274	13,937

Table 100 (continued)

World Trade Figure for Aluminium Semimanufactures: 1975
in t gross weight

Importing Countries / Exporting Countries	Sweden	Switzerland	Japan	USA	Canada	Other 1)	Total	Exports (including other countries)	Production 1975
Belgium/Luxembourg	2,600	707	219	19,943	2,128	3,619	130,570	155,031	194,306
Germany FR	5,546	4,937	444	886	48	2,844	139,019	150,182	655,117
Denmark	527	24	-	4	-	74	2,499	6,749	6,351
France	3,306	988	962	4,612	724	2,213	78,856	118,154	357,006
United Kingdom	2,088	788	2	265	1,031	5,151	19,122	49,968	352,442
Rep. of Ireland	-	-	-	-	-	-	783	3,221	4,190
Italy	1,011	253	-	1,494	247	2,025	29,343	51,608	237,300
Netherlands	707	510	291	97	52	719	53,449	54,578	78,231
EC Countries	15,785	8,207	1,918	27,301	4,230	16,645	453,641	589,491	1,884,943
Finland	101	78	-	976	-	-	1,355	581	20,905
Greece	-	20	-	80	-	57	2,039	12,911	25,005
Iceland	22	-	-	-	-	10	311	311 x)	.
Yugoslavia	300	2	924	5,145	4	13	13,242	52,996	119,846
Norway	17,700	1,648	-	2,400	36	126	43,135	45,791	76,138
Austria	5,319	3,093	-	1,137	286	1,452	22,743	24,357	67,932
Portugal	-	-	-	-	-	12	230	3,345	7,497
Sweden	-	721	1	134	-	425	21,900	27,601	80,273
Switzerland	2,479	-	2	21	15	432	19,715	30,559	83,336
Spain	386	191	-	994	-	298	5,967	32,848	173,202
Europe without East Block	42,092	13,960	2,845	38,188	4,571	19,470	584,278	820,791	2,539,077
Hong Kong	-	-	178	626	-	112	1,107	1,107	15,000 x)
Israel	7	67	-	4	-	99	885	885	15,000 x)
Japan	-	-	-	13,963	419	278	15,792	68,321	1,057,674
Philippines	-	-	320	-	-	-	320	320	3,000 x)
Turkey	-	10	-	-	-	-	431	431	65,000 x)
Other Asia	-	-	636	276	9	-	1,016	1,016	250,000 x)
Asia without East Block	7	77	1,134	14,869	428	489	19,551	72,080	1,405,674
Africa	-	-	-	-	-	-	7	.	80,000 x)
Canada	2	391	3	3,222	-	523	6,449	7,759	237,000
USA	4,231	177	13,879	-	51,755	4,111	117,369	186,339	3,046,400
Other America	-	-	-	41	-	-	117	117	235,000 x)
America	4,233	568	13,882	3,263	51,755	4,634	123,935	194,215	3,518,400
Australia	-	-	7	4	-	-	13	4,540	134,085
Australia/Oceania	-	-	2,045	4	17	23	2,108	4,540	140,000
Western World	46,332	14,605	19,906	56,324	56,771	24,616	729,879	1,091,626	7,683,151
Bulgaria	-	-	451	-	-	-	452	452	40,000 x)
Germany DR	210	-	-	-	-	48	1,238	1,238	150,000 x)
Poland	-	-	-	-	-	-	22	22	70,000 x)
Romania	30	-	743	-	-	-	1,269	1,269	35,000 x)
Czechoslovakia	-	-	-	-	-	-	75	75	90,000 x)
USSR	206	-	-	-	-	-	6,952	101,500	1,000,000
Hungary	3,581	-	-	-	108	23	9,316	9,316	150,000 x)
East Block	4,027	-	1,194	-	108	71	19,324	113,872	1,685,000 2)
Other countries	-	-	-	-	-	427	6,844	6,844	.
World total	50,359	14,605	21,100	56,324	56,879	25,114	756,047	1,212,342	9,368,151

x) estimate   1) Greece, Rep. of Ireland, Portugal, Spain, and Australia   2) including 150,000 t from China PR

2) The External Trade of European Community Countries in Bauxite, Alumina and Raw Aluminium

2.1 Imports and Exports of Bauxite

2.1.1 Imports of Bauxite from Non-EC-Countries

The bauxite imports of the EC countries from outside countries rose from 2.91 million t in 1966 to 8.6 million t in 1976, which is an annual average increase of 11.5 %. Of this total the imports from western countries always amounted to about 98 %. During this period the import structure has completely changed, due to falling bauxite production in Western Europe and a considerable increase in production, particularly in Africa and Australia. Whereas 52 % of the bauxite was still mined in Western Europe (Greece and Yugoslavia) in 1966, this share fell during the following years, particularly sharply after 1974, and in 1976 was only 4 %. The cause may be sought in the fact that Yugoslavian internal consumption has increased by leaps and bounds.

By contrast the share of Africa in EC countries' imports rose from 22 % to 45 %, particularly due to the great increase in imports from Guinea during recent years.

The share of bauxite imports from Australia has increased even more sharply from 11 % in 1966 to almost 47 % in 1976.
By contrast to this the share of imports from Asia (India, Indonesia, Turkey) has been reduced from 5 % to less than 1 % and from America from 7 % to 3 %.

In 1976 almost 47 % of the total imports of bauxite by all EC countries came from Australia and a further 37 % from Guinea, in all 84 % from 2 countries. On the other hand, the shares of the two next important supplier countries, Sierra Leone (5 %) and Greece (4 %), were comparatively small.

In Appendix 14a the bauxite imports are given for the period 1966 to 1976 for the EC countries according to countries of origin (less EC internal trade).

2.1.2 EC Internal Trade (Imports) in Bauxite

There is also a small amount of trade in bauxite within the European Community, whereby with the exception of France, it is mainly trade in re-exports or processed material. In 1968 the countries of the present-day community still imported 162.400 t of bauxite from France, but this amount decreased in the following years due to the increasing internal consumption in France, and in 1976 amounted only to almost 4,200 t. From the Netherlands, too, and the Federal Republic of Germany the remaining EC countries each annually import some 1,000 t, which consists of re-exports and also calcinated, refractory bauxite. In 1975 and 1976 in particular the calcinated bauxite imports of the EC countries from Denmark rose in each case to more than 14,000 t, which came from the Aalborg Portland Cement Factory. In Appendix 14b the structure of bauxite imports of all EC countries from EC supplier countries is given for the period 1966 to 1976.

2.1.3 Exports of Bauxite to Non-EC-Countries

With the exception of France and Italy, the EC countries do not have any bauxite production, so that they only export and re-export small quantities of bauxite to countries outside the EC. With the exception of 1966, it only concerned a total volume of 4,000 t annually to a maximum of 43,000 t between the years 1966 to 1976. These exports went in the main to other Western European countries, in particular Switzerland, Austria and Sweden. Presumably the greater portion concerned was calcinated bauxite. In Appendix 14 c the exports of the EC countries to those outside the EC are given for the period 1966 to 1976.

2.1.4 EC Internal Trade (Exports) in Bauxite

As in the case of imports, a great reduction in the volume of trade is established for bauxite exports within the European Community. From EC countries, in particular from France, bauxite is mainly exported to the Federal Republic of Germany, to Belgium/Luxemburg and also to Italy, whereby in the case of the Federal Republic of Germany quantities of maximum 94,000 t were reached in 1974. In Appendix 14 d the development during the period 1966 to 1976 is shown in detail.

2.2 Imports and Exports of Alumina (Including in Part Alumina Hydrate)

2.2.1 Imports of Alumina from Countries outside the EC

The countries of the European Community are dependent on increased imports to cover their own requirements of alumina, as the capacity of their own oxide plants is no longer adequate and the mining countries are increasing their own capacities for processing bauxite. Up till 1968 the EC countries annually imported less than an annual total of 200,000 t of alumina from outside countries. This situation changed just a few years later in that since 1973 the annual volume of imports has exceeded 1.2 million t. This considerable increase of the volume of imports within a few years was effected above all by the great expansion of consignments from Greece, Guyana, Jamaica, Surinam and Australia, which with the exception of Australia was accompanied by stagnation or even a reduction of bauxite imports. Of the oxide imports in 1976 (total 1.2 million t), almost 26 % came from Surinam, 25 % from Jamaica, 24 % from Australia and just 15 % from Greece.
On the other hand in 1966, 49 % of the imports came from Guinea, 35 % from Surinam and 8 % from the USA. In Appendix 15 a alumina imports of the EC countries from countries outside the community are given for 1966 to 1976.

2.2.2 EC Internal Trade (Imports) in Alumina

Up till 1970 the trade volume in alumina within the European Community was under 100,000 t annually. Since then it has increased to more than 400,000 t, caused by a significant increase in French exports and the construction of a large oxide plant in Sardinia. Of the total volume of imports by all EC countries from countries within the Community in 1976 (424,800 t) 56 % alone came from Italy and a further 40 % from France. In Appendix 15 b the imports of the European Community of alumina from individual countries of the Community are given for the period 1966 to 1976.

2.2.3 Exports of Alumina to Countries outside the European Community

The countries of the European Community supply many aluminium producers worldwide from the production of their oxide plants. The total volume of exports was increased from 248,500 t in 1966 to 747,800 t in 1976; in 1974 and 1975 however, it was in each case just over 400,000 t. In 1976, 28 % of the exports were destined for other Western European countries, 21 % for various countries in the Americas and almost 22 % for various East Block countries; for 28 % of the exports, the country of destination was not given. The most important importing countries were Spain, the USSR, Canada (each almost 20 %) and Norway (5 %). In 1966, 41 % of the alumina was still exported to the Western European countries, 16 % to America and 4 % to the East Block, with 38 % remaining for countries not mentioned. In 1966, Switzerland (26 %), the USA (16 %), Spain (9 %) and Romania (4 %) were the most important countries of destination. In Appendix 15 c the exports of alumina by the EC countries for the period 1966 to 1976 are listed according to countries of destination.

2.2.4 The European Community Internal Trade (Exports) in Alumina

Within the European Community the volume of trade in alumina has risen from an annual total of less than 50,000 t in the years up to 1970 to 400,000 - 500,000 t in the years from 1974 onwards. This sharp increase in the recent years was due above all to exports from Italy and France to the Netherlands. Exports from EC countries to France and the Federal Republic of Germany show a slight increase. In Appendix 15 d the alumina exports from EC countries to individual Community members are given for the period 1966 to 1976.

2.2.5 Imports and Exports of Alumina Hydrate

In the statistics, given up till now concerning trade in alumina, alumina hydrate figures have in part been included as some countries have not provided separate statistics. In as far as separate details are available concerning alumina hydrate trade they will be shown as such in the following text.

- Imports of Alumina Hydrate from Countries outside the EC

  The import of alumina hydrate from countries outside the EC is so small that a separate analysis is superfluous.

- The EC Internal Trade (Imports) in Alumina Hydrate

Trade within the European Community amounts annually to about 60,000 - 80,000 t of alumina hydrate. In as far as can be seen from the sketchy statistics available, the EC countries are supplied annually with 30,000 to 50,000 t from the Federal Republic of Germany as well as 20,000 to 60,000 t from France. Since 1973 deliveries of both countries to the EC have fallen considerably. In Appendix 15e the imports of alumina hydrate by all countries in the EC from individual EC supplier countries are given for the period 1966 to 1976.

- Exports of Alumina Hydrate to Countries outside the EC

Exports of alumina hydrate by EC countries to countries outside the EC rose from about 40,000 t in 1966 to 146,900 t in 1974 and in 1975 amounted to 130,500 t. About 80 % of the exports go to other Western European countries, the balance to America in particular. In 1975, Sweden (36 %), Norway (23 %) and Spain (8 %) were the most important customers of the EC countries for alumina hydrate. In Appendix 15f the EC exports to countries outside the EC are shown for the period 1966 to 1975.

- The EC Internal Trade (Exports) in Alumina Hydrate

Within the European Community, the trade volume in alumina hydrate in 1974 amounted to more than 77,100 t and in 1975 almost 64,600 t. Of this total volume of exports the largest amounts in each case came from Italy (1974: 25,000 t, 1975: 26,500 t) and the Netherlands (1974: 30,900 t, 1975: 21,800 t). Annually about 10,000 t of alumina hydrate are imported by Belgium/Luxemburg from other EC countries. In Appendix 15g the exports of all EC countries to individual member countries in the Community are given for the period 1966 to 1975.

2.3 Imports and Exports of Raw Aluminium (Alloyed and Unalloyed)

2.3.1 Imports of Raw Aluminium from Countries outside the EC

Imports of raw aluminium into countries of the present-day European Community from countries outside the EC in 1966 amounted to about 653,000 t and rose in the following years up to 1.13 million t in 1970. Thereafter in 1973 and 1974 a volume of imports in each case of only 970,000 t was achieved; in 1976 about 793,000 t of raw aluminium were imported from countries outside the EC. During the entire period the share of imports from western countries rose a little from almost 84 % to 88 %, whereby great changes in the supply structure have been completed within the Western World.

Whereas in 1966 only 38 % of the raw aluminium was drawn from other Western European countries, this share rose up till 1976 to more than 75 %. On the other hand the share of the Americas during this period fell from almost 40 % to 7 %. The development in Western Europe was due in particular to the new construction or expansion of aluminium smelters in Iceland, Greece and Norway and a corresponding increase in the exports of these countries. By contrast, the imports of EC countries from Canada and the USA were reduced sharply. In 1976 the largest imports of raw aluminium came from Norway (54 %), Greece (10 %) and Iceland (8 %), followed by Ghana and the USSR (each with 4 %). Of the imports in 1966 however, 32 % came from Norway and 25 % from Canada, 6 % from the USSR and 3 % each from Greece, Switzerland, from Surinam and Romania. In Appendix 16a the imports of raw aluminium by the present-day EC countries from countries of origin, are given for the period 1966 to 1976.

2.3.2 The EC Internal Trade (Imports) in Raw Aluminium

Within the present day European Community the trade volume in raw aluminium has risen from about 190,000 t in 1966 to about 700,000 t in 1976. During this period the amounts drawn by the other EC countries from France remained almost unchanged annually at more than 100,000 t, whereas the Netherlands and the Federal Republic of Germany have developed into the most important supplier countries within the EC. The drawings of the EC countries from the United Kingdom too have increased considerably. In Appendix 16b the imports of all EC countries from individual Community members are shown for the period 1966 to 1976.

2.3.3 Exports of Raw Aluminium to Countries outside the EC

Compared to the imports of raw aluminium from countries outside the EC, the exports of the EC countries to countries outside the EC were considerably smaller. From 1966 to 1976 the exports to countries outside the EC rose from 70,300 t to 160,400 t, but by 1975 had already reached a total of 230,700 t. Of the raw metal exports in 1976, 19 % went to other Western European countries, almost 17 % to Asian countries, almost 40 % to America and 17 % to the East Block. The share of exports to the East Block in the period 1966 to 1976 varied considerably. From an analysis by continents in this period there have been no considerable changes in the Western World. The most important purchasers of raw aluminium from the EC countries in 1976 were Brazil (almost 21 %), the People's Republic of China (16 %), and the USA (13 %), followed by Japan (5 %), Canada and Austria (each 4 %).

The other exports are distributed amongst a number of countries in all continents. In Appendix 16c the raw aluminium exports of the EC countries according to countries of destination, are given for the period 1966 to 1976.

2.3.4 The EC Internal Trade (Exports) in Raw Aluminium

Only 190,000 t of raw aluminium were traded during 1966 between the countries of the present-day European Community. In 1976 however, raw aluminium exports amounted to more than 700,000 t. From other countries of the Community in 1976, more than 200,000 t of raw aluminium were delivered to Belgium/Luxemburg and more than 100,000 t each to France, Italy, to the Netherlands and the Federal Republic of Germany. In 1966 only Belgium/Luxemburg drew more than 100,000 t of raw aluminium from other Community members. In Appendix 16 d the exports of all EC countries to individual Community members are shown for the period 1966 to 1976.

2.4 Imports and Exports of Scrap and Waste Aluminium

2.4.1 Imports of Scrap and Waste Aluminium from Countries outside the EC

The countries of the present-day European Community show high net-imports of scrap and waste aluminium. The volume of imports both for 1966 and 1967 as well as for 1975 and 1976 were about 90,000 t annually, nevertheless there were years between when almost 130,000 t were achieved. The scrap metal imports mostly came from other Western European countries, from America and the East Block. In 1966, 18 % of the scrap and waste material came from other Western European countries, 46 % from America and 9 % from the East Block, with a remaining share of 22 % for countries of origin not listed individually. Up till 1966 the share of the rest of Western Europe of the total imports rose to 58 %, whereas only 15 % still came from America and only 18 % from the East Block. In 1976 the EC countries imported scrap and waste aluminium from the following countries in particular: Austria (32 %), the USA (14 %), Switzerland (12 %) and Hungary (8 %).

In 1966 however, the USA (30 %) and Canada (16 %) were the most important suppliers ahead of the Western European and East Block countries. In Appendix 17 a the imports of scrap and waste aluminium by EC countries according to countries of origin are given for the period 1966 to 1976.

2.4.2 The EC Internal Trade (Imports) in Scrap and Waste Aluminium

Within the European Community the volume of scrap and waste aluminium traded has risen from about 65,000 t in 1970 to more than 160,000 t in 1976; the detailed figures for 1970 were not available in respect of the trade of the United Kingdom. Of the total imports by all EC countries in 1976 26 % came from the Federal Republic of Germany, 24 % from the Netherlands and 15 % each from France and Belgium/Luxemburg. In the period up till 1971 France delivered the largest amounts of scrap and waste aluminium to the other Community members. In Appendix 17 b the imports by all EC countries of scrap and waste aluminium according to EC supplier countries are given for the period 1966 (in as far as available) to 1976.

2.4.3 Exports of Scrap and Waste Aluminium to Countries outside the European Community

The countries of the present-day European Community export only minor quantities of scrap and waste aluminium to countries outside the EC. The total volume of exports between 1970 and 1976 varied annually between 1,400 t and 2,600 t; detailed figures for the exports of the United Kingdom were not available for 1970. In recent years the scrap and waste aluminium exported by the EC countries went mainly to Canada and the USA, presumably also in notable quantities to other Western European countries and to Eastern Europe as well.
In Appendix 17 c the exports by EC countries according to countries of destination are given for the period 1966 to 1976.

2.4.4 The EC Internal Trade (Exports) in Scrap and Waste Aluminium

Within the European Community in 1976 about 160,000 t of scrap and waste aluminium were traded compared with about 65,000 t in 1970. In as far as the statistics reveal the Federal Republic of Germany was the greatest importer of scrap and waste aluminium from other EC countries with amounts of more than 43,000 t both in 1975 and 1976. In 1974 and 1976 Italy in each case took more than 32,000 t from other community members. The Netherlands too (1976: 19,200 t), Belgium/Luxemburg (15,100 t) and France (13,100 t) took considerable quantities of scrap and waste aluminium from other members of the community. In Appendix 17 d the exports of all EC countries to individual Community members are tabulated for the period 1966 to 1976, whereby the years up to 1969 and also in 1976, the exports of the United Kingdom could not be taken into consideration.

V. Supply of Aluminium and Aluminium Raw Materials to Major Industrial Countries, in Particular in the EC

1) EC Countries

With the exception of France and Italy, the countries of the European Community have no bauxite mining areas of their own and therefore to supply their smelters they have to import increasing quantities of bauxite and alumina. Raw aluminium too is imported because the smelter capacities are not fully adapted to the consumption due to a lack of cheap power supply. If the imports of bauxite and alumina are calculated in terms of aluminium content, then the following structure of imports from countries outside the Community (in %) emerge for the period 1966 to 1976.

	1966	1968	1970	1972	1974	1976
Imports of						
Bauxite	50	47	45	43	55	61
Alumina	5	6	8	18	17	16
Raw metal	40	42	43	34	25	21
Scrap	5	5	4	5	3	2
Totals	100	100	100	100	100	100

Related to the aluminium content of the imports, the bauxite share of the total imports rose considerably only after 1972, after sinking at this time to well below the 1966 level. In the case of alumina the share doubled between 1970 and 1972, which resulted from a considerable expansion of oxide production in the mining countries of Greece, Jamaica, Surinam and Australia. Following the great expansion of smelter capacities in the EC countries however, the share of crude metal imports could be greatly reduced. The import of scrap from countries outside the EC has also lessened in significance to the supply of the EC countries.

The exports of the EC countries to countries outside the Community show a completely divergent pattern, as only a small amount of bauxite can be exported, whereas increased amounts of alumina from imported bauxite could be produced for export. The exports of crude metal too could be increased significantly after 1970. The pattern of the exports between 1966 and 1976 has changed as follows, whereby the export of alumina hydrate has not been taken into consideration (in %):

	1966	1968	1970	1972	1974	1976
Exports of						
Bauxite	11	1	2	1	2	1
Alumina	56	63	78	60	54	70
Raw metal	30	35	19	38	43	29
Scrap	3	1	1	1	1	0
Totals	100	100	100	100	100	100

The supply situation of selected large industrial countries is described separately in the following text.

1.1 Federal Republic of Germany

As the greatest consumer of aluminium in Western Europe, the Federal Republic of Germany possesses no bauxite occurrences from which alumina is processed, so that the considerable production of alumina has to be supported by increasing imports of bauxite. From 1966 to 1976 the imports of bauxite rose from 1.88 million t to 4.09 million t, which means an annual average increase of 8.1 %. The regional structure of bauxite imports is represented in Table 101 for 1966, 1971 and 1976. During this period the Federal Republic of Germany continuously imported more than 95 % of its bauxite from countries of the Western World but significant changes have occurred in the pattern of imports. In 1966 almost 62 % of the bauxite could be obtained from EC (France)and Southern European countries (Yugoslavia, Greece), compared with only 8 % from African countries (above all Sierra Leone) and 17 % from Australia.

In the following 10 years, the share of European supplier countries in bauxite deliveries to the Federal Republic of Germany was greatly reduced and in 1976 only amounted to 2 %. This development is explained on the one hand by an increase in the internal requirements of those European producer countries which only have a limited mining capacity and on the other, by the fact that bauxite from overseas can be more economically processed.

By contrast the share of Africa rose to 39 %, due in particular to considerable expansion of production in Guinea. The significance of Australia for supply also increased greatly; in 1976 almost 55 % of the total bauxite imports came from this country.

The bauxite exports of the Federal Republic of Germany can be ignored as they amount to less than 1,000 t per year.

Table 101

The Supply of the Federal Republic of Germany with Bauxite, Alumina, and Primary Aluminium: 1966, 1971, and 1976
in t gross weight

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Belgium/Luxembourg	-	-	517	-	-	978	-	-	9,546
Denmark	-	-	186	2,463	-	286	1,730	-	1,441
France	130,924	370	17,398	43,387	24,996	33,053	2,917	2,657	27,229
United Kingdom	-	212	931	-	41	11,722	-	255	36,152
Italy	-	-	4,146	-	-	3,999	-	186,270	5,660
Netherlands	-	2	9,461	1,332	-	27,191	2,189	-	61,922
EC countries	130,924	584	32,639	47,182	25,037	77,229	6,836	189,182	141,950
Greece	348,498	-	401	68,877	-	3,121	91,613	-	83
Iceland	-	-	-	-	-	4,448	-	-	22,414
Yugoslavia	679,013	-	-	607,446	-	2,043	-	-	2,140
Norway	-	-	64,756	-	-	128,498	-	-	175,433
Austria	-	-	-	-	-	20,472	-	-	5,411
Europe without East Block 1)	1,158,435	693	102,355	723,505	25,037	242,942	98,449	189,510	359,146
India	53,948	-	-	1,816	-	-	-	-	-
Indonesia	27,520	-	-	-	-	-	-	-	-
Japan	-	-	-	-	-	203	-	-	3,162
Asia without East Block	81,468	-	-	1,816	-	203	-	-	3,162
Ghana	-	-	-	32,725	-	2,793	48,464	-	2,618
Guinea	188	45,499	-	-	129,387	-	1,173,848	847	-
Sierra Leone	156,376	-	-	414,002	-	-	380,103	-	-
Africa	156,564	45,499	-	446,727	129,387	2,793	1,602,415	847	8,326 2)
Guyana	51,842	227	-	45,498	-	-	82,284	-	-
Jamaica	-	-	-	-	-	-	-	21,600	-
Canada	-	-	14,768	-	-	-	-	105	-
Surinam	44,051	4,423	13,246	47,734	179,825	12,213	39,229	25,182	10,709
USA	-	672	18,859	13,400	14,676	15,379	2,192	1,246	2,104
America	95,893	5,322	46,873	106,632	194,501	27,592	123,705	48,133	12,813
Australia	328,472	-	264	1,458,755	-	1,299	2,239,240	233,820	-
Western World	1,820,832	51,514	149,492	2,737,435	348,925	274,829	4,063,809	472,310	383,447
Romania	-	-	1,361	-	-	5,842	-	-	2,182
Czechoslovakia	-	-	246	-	-	3,306	-	-	2,550
USSR	-	-	-	-	-	602	-	-	6,270
Hungary	59,687	-	-	76,523	-	729	-	-	5,727
China PR	1,461	-	-	16,322	-	-	22,966	-	-
East Block 3)	61,148	-	2,301	92,845	-	10,794	22,966	-	17,238
Other	472	43	25,001	731	277	29,873	222	837	4,464
World total	1,882,452	51,557	176,794	2,831,011	349,202	315,496	4,086,997	473,147	405,149

1) including Finland, Sweden, Switzerland and Spain; 2) including Egypt and Rep. of South Africa; 3) including Bulgaria and Poland

The imported bauxite is mostly processed to calcinated alumina which in turn is largely consumed by the aluminium smelters. The alumina production in 1966 rose from 603,000 t to 1.3 million t in 1976, which is an annual average increase of 8.2 %. In spite of this high production the Federal Republic of Germany is a net importer of alumina. Imports rose from 51,600 t in 1966 to 473,000 t in 1976. In Table 101 the structure of alumina imports for 1966, 1971 and 1976 is given . Almost 100 % of the alumina imported by the Federal Republic of Germany came from western countries. In 1966, 88 % of the imports still came from Africa (Guinea) and 10 % from the Americas (in particular from Surinam), whereas in 1976 as much as 40 % came from EC countries (Italy), 49 % from Australia and a further 10 % from American countries (Surinam and Jamaica). The great expansion in imports from Italy resulted from the construction of a large alumina plant in Sardinia (in operation since 1973), which processes Australian bauxite and delivers the alumina, amongst others to the Federal Republic of Germany.

Alumina exports from the Federal Republic of Germany rose from 92,100 t in 1966 to 324,000 t in 1976. In 1976, Canada with 31 % and Spain with 28 % were the largest purchasers of this alumina, followed by the EC countries (8 %) and other western European countries.

The greatest part of the alumina production is used to produce primary aluminium which from 243,900 t in 1966 rose to 697,100 t in 1976, which is an annual average increase of 11.1 %. This primary metal production always had to be supplemented by net imports in the past. The imports of raw aluminium rose from 176,800 t (1966) to 405,100 t (1976). In Table 101 the regional structure of raw aluminium imports too is shown for 1966, 1971 and 1976. During this period the share of imports from countries of the Western World rose from 85 % to 95 %. Already in 1966 the Federal Republic of Germany purchased 58 % of its raw aluminium imports in Western European countries (19 % from countries of the present-day Community), whereby up till 1976 a further concentration within this area occurred (89 % or 35 % respectively). In contrast to this, the imports from American countries, those of Africa and the East Block were of minor significance.

The export of raw aluminium rose from 21,500 t in 1966 to 281,400 t in 1976. Above all the Federal Republic of Germany exported raw aluminium to EC countries (1976: 78 %), in particular Italy, France and the Netherlands. Further important countries of destination in 1976 were Brazil and the Chinese People's Republic (each with about 5 %).

1.2 France

France is the only EC country with a major bauxite mining capacity but this stagnated between 1966 and 1974 varying annually between 2.8 and 3.4 million t and since then has fallen to 2.3 million t (1976). This reduction of the internal mining output led to a considerable increase of bauxite imports to cover the requirements of the alumina plants and the aluminium smelters. From 1966 to 1973 the bauxite imports only rose slowly from 154,000 t to 588,000 t but then climbed rapidly to over 1.0 million t and in 1976, were at 2.3 million t. In Table 102 the bauxite imports by countries are given for 1966, 1971 and 1976. France was supplied with a roughly constant amount of bauxite from Greece and Guyana, who in 1966 provided 86 % of the total imported, but who in 1976 only delivered 6 %. Since 1973 France has obtained increasing amounts of bauxite from Guinea, which in 1976 amounted to almost 76 % of the total imports. Australia has also become an important supplier for France with a share of 17 % (1976).

In 1966 the bauxite exports of France reached 280,200 t but fell in the follow - ing year to annually less than 150,000 t and in 1976 were only 32,300 t. The most important customers for French bauxite during recent years were the Federal Republic of Germany and Switzerland.

The production of calcinated alumina in France between 1966 and 1976 was only increased by an annual average of 1.8 % from 845,000 t to 1.01 million t. It is nevertheless sufficient to cover internal needs and beyond this to export considerable amounts. Imports of alumina lie annually between just 10,000 t and seldom more than 30,000 t. The largest amounts imported come from the Federal Republic of Germany, from the Netherlands, the USA and Canada. In Table 102, the alumina imports by countries are listed 1966, 1971 and 1976. Compared to these figures the important alumina export trade was increased from 158,100 t in 1966 to 312,000 t in 1976 although in 1973 it exceeded 408,000 t. France exports alumina in particular to the Netherlands, to Spain, Norway and Italy.

France annually produces between 360,000 and 390,000 t of primary aluminium, whereby between 1966 and 1976 there was only a very small rise in production. To be able to cover greatly increasing demand the country is committed to increasing imports of raw aluminium. From 1966 to 1976 imports increased from 87,300 t to 251,400 t, which is an annual average increase of 11.2 %. In Table 102 the French raw aluminium imports by countries of origin are listed for 1966, 1971 and 1976. During the whole period, more than 84 % of the raw aluminium was obtained from Western countries. Whereas in 1966 just 30 % only came from Western Europe (11 % from EC countries), this share increased up till 1976, to 78 %, respectively 57 %. In 1976 the Federal Republic of Germany (27 %), the Netherlands (21 %) and Greece (12 %) were the most important suppliers, followed by Norway (7 %), the USSR, the United Kingdom and Cameroon (each with 5 %) and Romania (4 %).

Compared to imports, French exports of raw aluminium amounting to 112,500 t in 1966, fell to 72,300 t in 1976. France exported raw aluminium in particular to EC countries (1976: 72 %) as well as to a large number of countries in all continents.

Table 102

The Supply of France with Bauxite, Alumina, and Primary Aluminium: 1966, 1971, and 1976
in t gross weight

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Belgium/Luxembourg	-	-	679	-	30	299	-	93	1,699
Germany FR	-	814	3,657	160	4,536	20,705	914	10,878	67,086
Denmark	-	-	-	1,715	-	-	6,970	-	430
United Kingdom	-	14	32	-	413	1,109	-	256	12,754
Italy	-	-	4,704	-	1	3,362	-	-	7,961
Netherlands	241	2	238	-	1,768	10,351	-	4,067	53,484
EC Countries	241	830	9,310	1,875	6,748	35,826	7,884	15,294	143,414
Greece	87,854	-	11,675	93,766	-	43,436	88,154	-	30,515
Norway	-	-	4,719	-	-	13,744	-	-	18,548
Spain	-	-	-	-	-	1,129	-	-	1,661
Europe without East Block[1)]	88,095	831	25,844	95,641	6,751	95,288	96,038	15,294	196,570
Turkey	-	-	-	-	-	-	14,179	-	-
Asia without East Block[2)]	-	-	-	-	-	255	14,179	-	4,307
Guinea	-	10,300	-	-	-	-	1,716,778	-	-
Cameroon	-	-	25,439	-	-	27,848	-	-	12,631
Africa[3)]	-	10,300	25,439	-	-	29,558	1,716,778	-	12,746
Guyana	44,237	-	-	46,394	-	-	46,907	-	-
Canada	-	-	2,044	-	1,621	8,993	-	626	1,435
Surinam	17,531	-	439	32,056	-	283	9,989	-	283
USA	-	9,258	19,936	-	1,590	8,273	-	2,567	6,714
America	61,768	9,258	22,419	78,450	3,211	17,549	56,896	3,193	8,432
Australia	3,493	-	-	325,018	-	-	382,930	-	99
Western World	153,356	20,389	73,702	499,109	9,962	142,395	2,266,821	18,487	222,154
Romania	-	-	2,119	-	-	3,311	-	-	11,101
USSR	-	-	6,135	-	-	9,817	-	-	13,658
Hungary	-	-	1,531	-	-	2,032	-	-	1,731
East Block[4)]	-	-	12,543	2,910	-	22,784	1,783	-	27,799
Other	200	5	1,025	2,609	5	373	997	993	1,454
World total	153,556	20,394	87,270	504,628	9,967	165,552	2,269,601	19,480	251,407

[1)] including Iceland, Yugoslavia, Austria, and Switzerland, [2)] including Bahrain, India, and Japan,
[3)] including Ghana, [4)] including Bulgaria, Germany DR, Poland, Czechoslovakia, and China PR

1.3 United Kingdom

The United Kingdom has no bauxite deposits so bauxite requirements for alumina production have to be met fully by imports. Bauxite imports in the years up till 1971 varied annually between 420,000 t and 490,000 t and during the period 1975 to 1976 fell to less than 300,000 t. In Table 103 bauxite imports according to countries of origin are shown for 1966, 1971 and 1976. During these years the United Kingdom was constantly supplied with up to 99 % of its bauxite by western countries, in particular Africa. From this continent alone, 66 % of the bauxite imports came in 1966 and in 1976 almost 75 %. The most important supplier country remained Ghana, to which Sierra Leone was added for the first time in 1976.

The United Kingdom's next largest bauxite imports came from Western Europe but this share of 26 % in 1966 fell to 19 % in 1976, due largely to reductions of imports from Greece. From the present-day EC countries, the United Kingdom was still supplied with 12 % (France) of its bauxite in 1966, in 1976 only with 1 % (the Netherlands). Small amounts of bauxite were also obtained from America (in particular Surinam) and from Australia.
Bauxite re-exports of the United Kingdom amount annually to only a few 100 t.

In the period 1966 to 1972 the alumina production from imported bauxite reached an annual maximum of just 120,000 t and in the years following till 1976, were annually below 100,000 t. To cover the needs of the aluminium smelters after 1969, this production had to be supplemented by increasing net imports of alumina. Up till 1969 the imports of alumina amounted annually to less than 10,000 t, rose sharply in the following years due to a stagnation of alumina production and increased demand and since 1973, have annually reached between 520,000 t and more than 600,000 t. In Table 103 the alumina imports for 1966, 1971 and 1976 are listed. Of the 1976 volume of imports (525,753 t) 82 % alone came from American countries, in particular from Jamaica (54 %), Surinam (18 %) and Guyana (9 %). A further 11 % of imports in this year came from Western Europe, in particular from the EC countries, mainly from Italy (almost 10 %). This large amount taken from Italy in 1976 came from the alumina plant in Sardinia. Since 1973 Australia has also become an important supplier for the United Kingdom with a share of more than 6 % of the total imports for 1976.

The United Kingdom exported increasing amounts of alumina, since 1971 more than 18,000 t annually and in 1974 even 110,600t (in each case including alu mina hydrate). In 1976 exports fell to 43,000 t. The most important countries of destination were not given in the statistics but there was probably a notable amount exported to Western European countries.

Up till 1970, the United Kingdom produced less than 40,000 t of primary aluminium annually, but after bringing three new smelters into operation, which each had a capacitiy of more than 100,000 tons per year, the production was raised to 334,500 t in 1976. In view of this expansion in production, the net imports of

Table 103

The Supply of United Kingdom with Bauxite, Alumina, and Primary Aluminium: 1966, 1971, and 1976
in t gross weight

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Germany FR	-	976	1,196	-	1,584	557	-	4,843	5,525
France	59,700	-	5,634	50,042	1,664	576	-	1,691	12,569
Rep. of Ireland	-	-	357	-	-	1,923	-	-	1,857
Italy	-	-	2,153	-	-	379	-	50,363	-
Netherlands	-	-	2,384	-	-	211	2,600	290	352
EC Countries	59,700	976	11,724	50,042	3,248	3,646	2,600	57,187	20,303
Greece	68,534	-	-	61,856	-	-	53,127	-	-
Iceland	-	-	-	-	-	13,103	-	-	31,359
Norway	-	-	115,146	-	-	106,913	-	-	110,348
Austria	-	965	-	-	1,909	2,270	-	2,938	-
Switzerland	-	-	9,533	-	-	2,760	-	-	1,965
Europe without East Block[1)]	128,234	1,941	136,403	111,898	5,157	130,589	55,727	60,125	162,029
Asia without East Block[2)]	6,007	108	-	-	-	1,752	-	-	-
Ghana	322,594	-	-	299,555	-	18,846	195,814	-	18,891
Sierra Leone	-	-	-	-	-	-	23,889	-	-
Africa[3)]	322,594	-	-	299,555	-	18,846	220,181	-	21,461
Guyana	14,843	-	-	2,654	13,293	-	-	47,128	-
Jamaica	-	-	-	-	250,272	-	-	282,722	-
Canada	-	3,228	134,881	-	-	96,620	-	874	17,138
Surinam	15,365	-	-	14,136	-	-	9,723	95,656	4,958
USA	-	1,154	28,093	-	1,483	1,017	592	5,581	424
America	30,208	4,382	162,974	16,790	265,048	97,637	10,315	431,961	22,520
Australia	-	-	1,922	15,644	-	-	9,714	33,337	-
Western World	487,043	6,431	301,299	443,887	270,205	248,824	295,937	525,423	206,010
Germany DR	-	-	8,183	-	-	-	-	-	358
Poland	-	-	716	-	-	9,892	-	-	-
Romania	-	-	11,876	-	-	4,960	-	-	500
USSR	-	-	20,384	-	-	3,722	-	-	6,403
East Block[4)]	-	-	43,852	3,299	-	19,577	500	-	8,362
Other	4,551	538	1,116	-	1,921	1,280	100	330	3,529
World total	491,594	6,969	346,267	447,186	272,126	269,681	296,537	525,753	217,901

[1)] including Yugoslavia and Sweden, [2)] Bahrain, India, Japan, [3)] including Egypt and Guinea, [4)] including Bulgaria, Czechoslovakia, Hungary, and China PR raw aluminium could be reduced from more than 300,000 t to less than 100,000 t in 1976. In Table 103 the raw aluminium imports of this country are shown by countries of origin, for the years 1966, 1971 and 1976. During this period the United Kingdom imported an increasing amount of raw aluminium from countries of the Western World, in 1966 a total of 87 % and in 1976 almost 95 %. In this period the share of imports from western Europe rose from 39 % to 74 %, whereby the share of Norway as the most important supplier rose from 33 % to almost 51 %. Imports from Iceland too have earned increasing importance in recent years (1976: 14 %) and also those of France (6 %). Of supplier countries outside Europe Ghana reached a share of 9 %. The large imports in earlier years from Canada (1966: 39 %) and the USA (1966: 8 %) fell considerably by 1976 (8%, and 0.2 % respectively).

The British exports of raw aluminium have been increased from 26,400 t in 1966 to 162,100 t in 1976. Of the exports in 1976 more than 74 % went to other EC countries, in particular to the Netherlands (42 %), to Belgium/Luxemburg (13 %) and to the Federal Republic of Germany (12 %). The USA (5 %) and Japan (4 %) were also important customers.

1.4 Italy

The Italian bauxite production which fell from 255,500 t in 1966 to 24,200 t in 1976, can only meet a small portion of the greatly increased demands of the alumina plants, so that considerably increasing imports of bauxite have become necessary. From 1966 to 1976 the bauxite imports rose from 534,800 t to 1.82 million t, which is an annual increase of 13.1 %. In Table 104 the origin of bauxite imports is shown for 1966, 1971 and 1976. More than 95 % of the bauxite was always imported from western countries whereby the supply structure has changed completely. In 1966 almost 56 % of the bauxite came from Western European countries, in particular from Yugoslavia (49 %) and Greece (6 %). By 1976 deliveries from both of these countries dwindled to almost nothing as a result of their own sharply increased internal requirements. The African countries too, from which more than 31 % of the bauxite was imported in 1966 became relatively less important by 1976, although in terms of absolute quantity the amounts from Guinea increased three-fold. Since 1974 deliveries from Australia have been of decisive importance to bauxite supply and in 1976 had attained almost 76 % of Italy's total bauxite imports.
Compared to the imports, the small export of bauxite can be ignored; it amounted annually to only a few 1,000 t.

Up till 1972 Italy produced an annual maximum of 313,000 t of alumina. After the Eurallumina oxide plant at Porto Vesme in Sardinia came into operation the production rose to just 798,000 t in 1976. This production was supplemented yearly by imports of 30,000 t (1966) to 132,000 t (1972), the regional structure of these for 1966, 1971 and 1976 is given in Table 104. The imported alumina in these years always came from countries of the Western World, in 1966 up to 84 % from Africa (Guinea), up to 10 % from Western Europe (Federal Republic of Germany,

Table 104

The Supply of Italy with Bauxite, Alumina, and Primary Aluminium: 1966, 1971, and 1976

in t gross weight

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Germany FR	20	1,639	1,918	103	2,505	12,059	10	8,877	67,892
France	4,926	472	10,479	14,009	34,178	26,221	600	6,022	33,971
United Kingdom	581	39	611	305	65	49	-	258	4,180
Netherlands	99	63	300	50	2,505	11,129	-	2,921	8,692
EC countries[1)]	5,626	2,213	13,354	14,467	39,253	49,499	610	18,078	114,981
Greece	33,082	-	489	-	13,650	15,144	2,250	8,000	42,766
Yugoslavia	260,049	895	1,827	236,095	-	17,283	-	-	3,770
Norway	-	-	15,459	1,819	-	7,061	-	-	4,331
Austria	-	-	3,553	-	-	4,111	-	-	1,915
Switzerland	-	8	2,140	1,178	1	980	-	8	1,543
Europe without East Block[2)]	298,948	3,116	36,822	273,302	52,904	94,078	2,860	26,086	171,713
India	16,815	-	-	12,563	-	-	-	-	-
Indonesia	29,065	-	-	10,516	-	-	-	-	-
Asia without East Block[3)]	45,880	-	-	24,279	-	174	-	-	-
Guinea	93,249	25,250	-	126,837	-	-	319,681	51,100	-
Sierra Leone	74,879	-	-	78,153	-	-	-	-	-
Africa	168,128	25,250	-	204,990	-	-	319,681	51,100	-
Guyana	16,314	-	-	20,286	-	-	25,949	8,828	-
Canada	-	10	6,276	-	2,298	8,408	-	173	86
Surinam	4,050	-	5,926	18,049	-	11,855	11,890	-	4,891
USA	-	1,647	3,432	-	2,603	3,765	-	497	69
America	20,364	1,657	15,634	38,335	4,901	24,028	37,839	9,498	5,046
Australia	638	-	-	2,317	-	-	1,383,677	-	147
Western World	533,958	30,023	52,456	543,223	57,805	118,106	1,744,057	86,684	176,906
Romania	-	-	2,045	-	-	9,432	-	-	8,491
USSR	-	-	5,908	-	-	-	-	-	2,514
Hungary	-	-	482	-	-	3,452	-	-	2,662
China PR	501	-	-	3,855	-	-	54,030	-	-
East Block[4)]	501	-	9,617	3,855	-	13,871	54,030	-	18,751
Other	340	-	162	1,049	24	1,212	25,543	760	876
World total	534,799	30,023	62,235	548,127	57,829	133,189	1,823,630	87,444	196,533

[1)] including Belgium/Luxembourg, [2)] including Iceland and Spain,

[3)] including Japan, [4)] including Bulgaria, Poland, and Czechoslovakia

Yugoslavia, France) and up to 6 % from America (USA). By 1976 the share of Guinea fell to 58 %, whereas 30 % alone came from Europe in this year, in particular from the Federal Republic of Germany (10 %), from Greece (9 %) and from France (7 %). A further 10 % of the imports in this year came from Guyana. Since 1973, Italy has exported increasing amounts of alumina, in 1976 just 448,000 t. Of this 42 % alone to the Netherlands, 33 % to the USSR and 3 % to Romania.

The Italian production of primary aluminium rose from 127,300 t (1966) to 206,500 t (1976), which is an annual average increase of 4.9 %. This production was supplemented by imports of raw aluminium which in this period rose from 63,200 t to 196,500 t. In Table 104 the origin of these imports is shown for 1966, 1971 and 1976. More than 84 % of the raw metal always came from western countries, in 1966 alone 59 % from Western Europe (25 % from Norway and 17 % from France) and 25 % from America (Canada, Surinam and the USA). In 1976, 90 % of the raw metal came from western countries alone and more than 87 % from Western Europe (35 % from the Federal Republic of Germany, 22 % from Greece and 17 % from France). The EC countries had a share of 59 % of the deliveries.

Exports of raw aluminium in the period 1966 to 1976 were annually between 4,800 t (1970) and 33,300 t (1975). In 1976 the exports fell to 9,400 t, of which as in previous years more than two-thirds were exported to EC countries.

2) Other Countries

2.1 Japan

As the third largest producer and consumer of primary aluminium Japan is fully dependent on imports of aluminium raw materials. The imports of bauxite for the production of alumina rose from 1.82 million t in 1966 to 4.28 million t in 1976, which is a annual average increase of 8.9 %. In Table 105 the origin of bauxite imports for 1966, 1971 and 1976 are shown. Japan's bauxite requirements in 1966 as in 1976 also,were covered to over 97 % by only 3 countries, i.e. Indonesia, Malaysia and Australia. Thereby the Australian share has risen from 29 % to 64 %, whereas the Indonesian share fell from 33 % to 23 % and that of Malaysia from 35 % to 12 %.
The small re-exports of bauxite were in the main only a few 100 t per year, in 1976 about 1,100 t.

The imported bauxite is processed to alumina, the production of which was increased from 662,300 t in 1966 to 1.41 million t in 1976, which is an annual average increase of 7.9 %. To cover the requirements of aluminium smelters, increasing imports which rose from 98,300 t in 1966 to 627,400 t in 1976, were received.

In Table 105 the origin of imports for 1966, 1971 and 1976 are given. In this period more than 98 % came from Australia.
Japan annually exports less than 150,000 t of alumina (including alumina hydrate), in 1976 a total of 123,500 t, larger amounts to the USSR, to Taiwan,

Table 105

The Supply of Japan with Bauxite, Alumina, and Primary Aluminium[1] 1966, 1971, and 1976

in t gross weight

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Germany FR	-	356	-	-	964	-	-	452	-
France	-	149	1	-	698	-	-	724	1,096
United Kingdom	-	-	4,934	-	-	480	-	85	4,311
Netherlands	-	1	873	-	4,861	-	-	-	-
EC countries	-	506	5,808	-	6,523	480	-	1,261	5,407
Greece	-	-	-	2,898	-	-	3,800	-	7,067
Yugoslavia	-	-	-	-	-	-	-	-	3,968
Norway	-	-	10	-	-	599	-	-	1,078
Switzerland	-	-	-	-	-	224	-	-	918
Europe without East Block	-	506	5,818	2,898	6,523	1,303	3,800	1,261	18,438
Bahrain	-	-	-	-	-	149	-	-	63,290
India	8,601	-	-	30,293	-	-	150	-	15,265
Indonesia	603,760	-	-	1,102,701	-	-	967,255	-	-
Iran	-	-	-	-	-	-	-	-	9,989
Korea South	-	-	-	-	-	2,139	-	-	-
Malaysia	629,326	-	-	834,578	-	-	512,474	-	-
Taiwan	-	-	1,000	-	-	-	-	-	-
Asia without East Block	1,241,687	-	1,000	1,967,572	-	2,288	1,479,879	-	88,544
Ghana	-	-	-	-	-	26,077	-	-	6,959
Cameroon	-	-	-	-	-	-	-	-	8,201
Rep. of South Africa	-	-	78	-	-	-	-	-	2,884
Africa	-	-	78	-	-	26,077	-	-	20,726[2]
Guyana	29,360	-	-	17,517	-	-	41,474	-	-
Canada	-	-	31,317	-	-	85,640	-	-	12,963
Surinam	17,559	-	-	11,763	-	7,264	8,205	6,007	-
Trinidad and Tobago	-	-	-	-	-	-	8,275	-	-
USA	-	537	14,700	22,310	1,483	22,404	6,538	1,325	34,228
America	46,919	537	46,017	51,590	1,483	115,308	64,492	7,332	47,191
Australia	533,269	97,205	3,277	2,632,275	498,194	47,302	2,717,291	618,815	44,319
New Zealand	-	-	8	13,225	-	1,272	-	-	105,171
Australia/Oceania	533,269	97,205	3,285	2,645,500	498,194	48,574	2,717,291	618,815	149,490
Western World	1,821,875	98,248	56,238	4,667,560	506,200	193,550	4,265,462	627,408	324,389
Romania	-	-	-	-	-	8,006	-	-	25,834
USSR	-	-	19,671	-	-	22,004	-	-	68,760
Hungary	-	-	-	-	-	-	-	-	3,304
China PR	-	-	-	600	-	-	11,121	-	-
East Block	-	-	19,671	600	-	30,010	11,121	-	103,079[3]
Other	-	6	1,092	-	19	2,048	-	10	2,657
World total	1,821,875	98,254	77,001	4,668,160	506,219	225,608	4,276,583	627,418	430,125

[1] including alloys, [2] including Egypt, [3] including Bulgaria, Germany DR, Poland, and Czechoslovakia

South Korea and to other Asian countries.

As the third largest producer of primary aluminium in the World, Japan increased production from 335,100 t in 1966 to 919,400 t in 1976, which is an annual average increase of 10.6 %. To cover consumption there were additional imports of raw aluminium which increased from 77,000 t (1966) to 430,100 t (1976). In Table 105 the origin of these crude metal imports are shown for 1966, 1971 and 1976.

During this period Japan obtained up to three quarters of this raw aluminium from countries of the western world, in 1966 about 60 % from America (Canada 41 % and USA 19 %), just 8 % from Western Europe (United Kingdom 6 %) and 4 % from Australia. A good quarter of the total imports came from the USSR also. Up till 1976 the American share was reduced to 11 % (USA and Canada), whereas the Australian share rose to 10 % and that of New Zealand to just 25 %. Further significant suppliers were Bahrein (15 %), India (4 %), the USSR (16 %) and Romania (6 %). Only 4 % of the imports in 1976 came from all the WesternEuropean countries. Japanese raw aluminium exports (including alloys) rose from 19,273 t in 1966 to 69,706 t in 1976. Of the exports in 1976, 34 % went to South Korea, 14 % to the China Peoples Republic, 12 % to Venezuela and 9 % to Brazil.

2.2 United States of America

The United States of America rank eleventh among producers of bauxite in the world but production has stagnated for over 10 years at almost 2 million t annually. To supply the alumina plants between 1966 and 1976, 13 million t of bauxite were imported annually. In Table 106 the bauxite imports for 1966, 1971 and 1976 are given according to countries of origin. In 1966 almost 100 % of the bauxite imported by the USA came from American countries, in particular from Jamaica (59 %) and Surinam (27 %), lesser quantities also from the Dominican Republic (6 %), from Guyana, Haiti and Trinidad. By 1976 the share of the American countries fell to 82 %, whereby Jamaica (55 %) and Surinam (12 %) remained important suppliers ahead of Guyana, Haiti and the Dominican Republic. Since 1974 Guinea has become a further large supplier of bauxite with a share of 18 % in 1976.
Since 1973 the exports of bauxite have averaged less than 20,000 t annually.

The production of alumina in the USA between 1966 and 1976 has only increased slowly from 5.3 million t to 5.9 million t. This production was supplemented by imports which stood at only 486,000 t in 1966 but which rose sharply in the following years and since 1973 have exceeded 3 million t annually. In Table 106 the imports for 1966, 1971 and 1976 are given according to countries of origin.

In 1966, 69 % of the imports still came from American countries, in particular from Surinam (40 %), Jamaica (18 %) and Guyana (9 %). A further 14 % came

Table 106

The Supply of the United States of North America with Bauxite, Alumina, and Primary Aluminium: 1966, 1971, and 1976

	1966			1971			1976		
	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium	Bauxite	Alumina	Primary Aluminium
Germany FR	-	166	284	-	2,259	2	-	5,329	374
France	-	12,641	9,239	-	75,838	1,962	-	9,414	6,006
United Kingdom	9,175	1	1,774	-	4	6,103	-	459	8,279
EC countries[1]	9,175	12,830	11,317	-	78,106	8,835	-	15,242	15,524
Greece	30,996	-	6,150	35,225	56,849	-	-	-	-
Yugoslavia	-	39	-	-	36	200	-	-	13,955
Norway	-	-	71,414	-	-	48,899	-	-	14,064
Spain	-	-	-	-	-	1,661	-	-	3,836
Europe without East Block[2]	40,171	14,366	90,710	35,225	135,249	59,650	-	15,242	50,571
Bahrain	-	-	-	-	-	-	-	-	4,824
India	-	-	-	-	-	-	-	-	2,008
Japan	-	52,131	13,388	-	61,996	464	-	22	12,215
Asia without East Block[3]	-	52,131	13,588	-	61,996	464	-	22	19,047
Ghana	-	-	-	-	-	31,871	-	-	76,179
Guinea	-	67,007	-	15,705	454	-	2,334,828	-	-
Cameroon	-	-	16,699	-	-	-	-	-	-
Sierra Leone	-	-	-	-	-	-	53,896	-	-
Africa[4]	-	67,007	16,699	15,705	454	31,871	2,388,724	-	79,221
Dominican Republic	806,576	-	-	1,112,317	-	-	599,648	-	-
Guyana	478,094	45,942	-	526,653	12,164	-	725,203	11,550	-
Haiti	332,782	-	-	586,061	-	-	615,406	-	-
Jamaica	7,837,410	86,032	-	9,106,511	415,848	-	7,165,913	558,569	-
Canada	102	8,807	350,496	42	15,448	400,344	2,588	12,996	345,633
Surinam	3,596,457	194,887	-	2,946,131	420,201	8,343	1,601,454	190,921	20,940
Trinidad	83,779	-	-	14,995	-	-	-	-	-
America[5]	13,135,200	335,668	350,496	14,292,710	863,661	408,694	10,710,212	776,787	366,856
Australia	-	16,874	1,079	141,237	1,125,125	136	-	2,495,832	168
Western World	13,175,371	486,046	472,572	14,484,877	2,186,485	500,815	13,098,936	3,287,883	515,863
East Block[6]	-	-	-	-	-	1,299	11,000	-	900
Other	46	20	15	62	4	1,085	609	88	63
World total	13,175,417	486,066	472,587	14,484,939	2,186,489	503,199	13,110,545	3,287,971	516,826

[1] including Belgium/Luxembourg and Netherlands, [2] including Finland, Austria, Sweden, and Switzerland, [3] including Taiwan,
[4] including Republic of South Africa, [5] including Ecuador and Mexico, [6] Poland, Romania, USSR, China PR

from Guinea and 11 % from Japan. The Australian share at this time was almost 4 %. This increased greatly in the following years and in 1976 was almost 76 %. On the other hand the share of the American countries fell by 1976 to 24 % (Jamaica 17 %, Surinam 6 %).

Compared with imports, the exports were of minor significance but from 293,200 t (1966) they rose to 738,200 t (1976).

In 1976 Canada (37 %), Ghana (30 %) and Mexico (13 %) were the most important customers, followed by Norway, Venezuela, Sweden and Poland.

The production of primary aluminium in the USA was increased from 2.69 million t in 1966 to 3.86 million t in 1976, according with an average annual increase of 3.7 %. Smelter production in this period was supplemented by imports of raw metal, which rose from 472,600 t (1966) to 516,800 t (1976). In Table 106 the origin of imports is shown for 1966, 1971 and 1976. Raw aluminium (74 %) was imported from Canada in 1966 and 19 % also from western Europe (Norway 15 %, France 2 %). By 1976 the share of the Americas fell slightly to 71 % (Canada 67 %), whereas a further 15 % of the imports came from Ghana and 10 % from Western Europe (Norway and Yugoslavia each with 3 %).

USA exports of raw aluminium attained a yearly maximum of 370,000 t, in 1976 only 138,200 t. Of this 27 % went to the People's Republic of China, 15 % to Japan, 13 % to Canada, 12 % to Mexico and 9 % to Taiwan.

VI. Future World Consumption of Aluminium

1) Total Aluminium Consumption

Table 107 contains a projection of aluminium consumption by country and country grouping.

The projections for the Federal Republic of Germany, Belgium/Luxemburg, France, United Kingdom, Italy, Spain, Switzerland, Japan, and the USA (these countries had ca. 80 % of the aluminium consumption in the Western World in 1976) were made on the basis of the breakdown of end-use consumption according to sector. A projection by sector has the advantage of allowing one to follow and project development trends in detail. Special regression models were developed for each of these countries and the individual sectors within them. Special economic variables were selected for this (e.g. trends in GNP, production indices for specific industries). The projection for total consumption is composed of the projections for the individual sectors.

A projection on the basis of the available statistics for the other countries could be made only for total consumption. Regression models were used for this also. Additionally, control calculations were made considering per capita consumption and population growth trends.

Projected increase in world aluminium consumption from 1976 to 1990 is just under 4 % (3.8 %). The proportion consumed by the countries of the Western World should remain at about 80 %.

The percentage of Western World consumption by Europe (excluding the East Block countries) should also remain the same (somewhat more than 30 %).

2) End-Use Consumption of Aluminium

End-use consumption of aluminium was projected for nine major consumer countries according to user (end-use sector).

2.1 Federal Republic of Germany

Table 108 contains a projection for aluminium consumption in the Federal Republic of Germany according to end-user group. The main consumer groups were semi-manufactures export (23 %), transportation (19 %), construction (16 %), packaging (8 %), household goods (7 %), and machinery (6 %). No significant changes are expected up to 1990. The average annual growth rate may be expected to be about 3.8 %.

2.2 Belgium/Luxemburg

Table 109 contains a projection for aluminium consumption in Belgium and Luxemburg according to end-user group. The main consumer groups in 1976 were semi-manufactures exports (77 %), metal goods & misc. (7 %), and construction (6%).

Table 107

A Projection of Aluminium Consumption for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Germany FR	1,263.7	1,430.0	1,780.0	2,130.0
Belgium/Luxembourg	246.6	275.0	322.0	370.0
France	628.0	750.0	900.0	1,020.0
Italy	590.0	670.0	800.0	930.0
Netherlands	130.2	165.0	225.0	290.0
Denmark	15.2	16.0	18.0	20.0
United Kingdom	617.9	717.0	760.0	800.0
EC countries	3,491.6	4,023.0	4,805.0	5,560.0
Norway	118.6	135.0	160.0	185.0
Yugoslavia	149.1	180.0	220.0	260.0
Austria	114.6	125.0	152.0	180.0
Sweden	139.0	170.0	200.0	230.0
Switzerland	113.9	132.0	155.0	173.0
Spain	266.7	330.0	405.0	482.0
Other Europe	94.5	117.0	142.0	173.0
Europe without East Block	4,488.0	5,212.0	6,239.0	7,243.0
Japan	1,921.9	2,473.0	3,100.0	3,722.0
Other Asia[x)]	520.0	630.0	780.0	940.0
Asia without East Block	2,441.9	3,103.0	3,880.0	4,662.0
Rep. of South Africa	74.0	85.0	110.0	135.0
Other Africa[x)]	77.0	90.0	115.0	140.0
Africa	151.0	175.0	225.0	275.0
USA	5,746.7	7,250.0	8,300.0	9,100.0
Brazil	245.9	310.0	400.0	500.0
Canada	389.2	450.0	580.0	680.0
Other America[x)]	197.5	300.0	362.0	430.0
America	6,579.3	8,310.0	9,642.0	10,710.0
Australia and Oceania	220.8	290.0	350.0	420.0
Western World	13,881.0	17,090.0	20,336.0	23,310.0
East Block	3,720.0	4,400.0	5,300.0	6,200.0
World total	17,601.0	21,490.0	25,636.0	29,510.0

[x)] estimated, [1)] actual figures

Table 108

A Projection of Aluminium Consumption in Germany FR for 1980, 1985, and 1990

in 1000 t

	1976 1)	1980	1985	1990
Transportation	220.2	240.0	285.0	330.0
Machinery	71.4	80.0	90.0	105.0
Electrical	67.8	80.0	100.0	115.0
Building & construction	183.2	215.0	280.0	350.0
Chemical, food & agricultural appliances	14.8	20.0	22.0	24.0
Packaging	93.4	115.0	140.0	170.0
Domestic & office appliances	81.6	95.0	125.0	150.0
Powder consuming industries	3.4	6.0	7.0	8.0
Iron & steel industries	50.6	55.0	61.0	67.0
Metal industries not elsewhere specified	-			
Miscellaneous	111.6	120.0	147.0	170.0
Exports of semis, foil, cable, powder	274.6	310.0	405.0	500.0
Total	1,172.6	1,336.0	1,662.0	1,989.0

1) actual figures

Table 109

A Projection of Aluminium Consumption in Belgium/Luxembourg for 1980, 1985, and 1990
in 1000 t

	1976[1]	1980	1985	1990
Transportation	2.6	3.7	4.1	4.6
Machinery	1.9	3.5	4.5	5.5
Electrical	6.6	8.5	10.8	13.0
Building and construction	15.8	18.5	21.2	24.1
Chemical, food & agricultural appliances	1.0	1.4	1.5	1.5
Packaging	9.1	10.0	12.0	14.0
Domestic & office appliances	1.1	1.6	1.6	1.6
Powder consuming industries	0.3	0.3	0.4	0.5
Iron & steel industries	0.1	0.2	0.3	0.3
Metal industries not elsewhere specified) Miscellaneous)	16.8	17.0	17.0	17.0
Exports of semi-manufactures	189.6	216.0	254.0	292.0
Total	244.9	280.5	327.4	374.1

[1] actual figures

Consumption may be expected to increase from the 244,890 t in 1976 to ca. 374,000 t by 1990, an average annual growth of 3.1 %. The proportion for exports may be expected to remain about the same.

2.3 France

Table 110 contains a projection for aluminium consumption in France according to end-user group. The main consumer groups in 1976 were transportation (26 %), semi-manufactures export (22 %), electrical (13 %), and construction (8 %). Consumption may be expected to increase from the 665,200 t in 1976 to ca. 1.044 million t by 1990, an average annual increase of 3.3 %. No significant changes are expected in the percentages for the individual consumer groups.

2.4 United Kingdom

Table 111 contains a projection for aluminium consumption in the United Kingdom according to end-user group. The main consumer groups in 1976 were transportation (23 %), the metal industry & misc. (13 %), electrical (12 %), semi-manufactures exports (12 %), construction (11 %), and household goods and office supplies (9 %). Consumption could increase to 769,000 t by 1990 (550,000 t in 1976), an average annual growth of 2.4 %. The market shares held by the individual groups are expected to remain relatively constant.

2.5 Italy

Table 112 contains a projection for aluminium consumption in Italy according to end-user group. The main consumer groups in 1976 were transportation (26 %), construction (19 %), semi-manufactures export (15 %), household goods & office supplies (12 %), and the packaging industry (9 %). Consumption could increase to 932,000 t by 1990, an average annual growth rate of 3.3 %. The main consumer groups in 1990 may be expected to be the transportation and construction industries (20 % each), household goods & office supplies and exports (14 % each), and the packaging industry (10 %).

2.6 Spain

Table 113 contains a projection for aluminium consumption in Spain according to end-user group. Consumption could increase from the 268,400 t in 1976 to 479,400 t by 1990, an average annual growth of 4.2 %. The main consumer groups in 1976 were transportation (23 %), construction (20 %), electrical (15 %), household goods & office supplies (10 %), the packaging industry and exports (ca. 9 % each). The percentage for construction may increase to 22 % by 1990, that for transportation may decrease to 19 %, while the other sectors may be expected to remain relatively constant.

Table 110

A Projection of Aluminium Consumption in France
for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Transportation	172.8	193.0	226.0	257.0
Machinery	32.0	39.0	44.0	49.0
Electrical	85.0	100.0	120.0	141.0
Building & construction	56.4	65.0	78.0	92.0
Chemical, food & agricultural appliances	13.4	15.0	18.0	21.0
Packaging	47.8	60.0	71.0	83.0
Domestic & office appliances	34.3	37.0	40.0	43.0
Powder consuming industries	2.1	3.0	3.5	4.0
Iron & steel industries	25.0	33.0	42.0	47.0
Metal industries not elsewhere specified) Miscellaneous)	51.3	58.0	65.0	72.0
Exports of semis, foil, cable, powder	145.1	161.0	200.0	235.0
Total	665.2	764.0	907.5	1,044.0

1) actual figures

Table 111

A Projection of Aluminium Consumption in United Kingdom
for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Transportation	123.7	148.0	156.0	164.0
Machinery	34.9	40.0	45.0	50.0
Electrical	63.1	76.0	83.0	90.0
Building & construction	59.8	69.0	83.0	96.0
Chemical, food & agricultural appliances	3.7	10.0	11.0	12.0
Packaging	45.3	54.0	62.0	70.0
Domestic & office appliances	50.6	54.0	58.0	63.0
Powder consuming industries	9.2	11.0	12.0	13.0
Iron & steel industries	23.1	28.0	30.0	33.0
Metal industries not elsewhere specified) Miscellaneous)	71.4	75.0	81.0	87.0
Exports of semis, foil, cable, powder	65.2	75.0	83.0	91.0
Total	550.0	640.0	704.0	769.0

1) actual figures

Table 112

A Projection of Aluminium Consumption in Italy
for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Transportation	150.2	160.0	175.0	190.0
Machinery	37.9	46.0	56.0	66.0
Electrical	27.7	35.0	40.0	45.0
Building & construction	110.0	125.0	156.0	190.0
Chemical, food & agricultural appliances	10.9	13.0	16.0	19.0
Packaging	52.4	65.0	80.0	94.0
Domestic & office appliances	72.4	86.0	108.0	130.0
Powder consuming industries	3.0	4.0	5.0	6.0
Iron & steel industries	16.0	22.0	29.0	34.0
Metal industries & miscellaneous	22.1	24.0	26.0	28.0
Exports of semis, foil, cable, powder	85.1	90.0	110.0	130.0
Total	587.7	670.0	801.0	932.0

1) actual figures

Table 113

A Projection of Aluminium Consumption in Spain
for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Transportation	61.6	70.0	80.0	90.0
Machinery	11.3	13.5	16.0	18.5
Electrical	39.0	50.0	65.0	80.0
Building & construction	52.5	65.0	85.0	105.0
Chemical, food & agricultural appliances	8.1	11.0	15.0	19.0
Packaging	24.9	30.0	38.0	47.0
Domestic & office appliances	26.5	32.0	40.0	47.0
Powder consuming industries	0.2			
Iron & steel industries	1.8	2.2	2.6	2.9
Metal industries not elsewhere specified) Miscellaneous)	19.1	25.0	29.0	35.0
Exports of semis, foil, cable, powder	23.4	27.0	32.0	35.0
Total	268.4	325.7	402.6	479.4

1) actual figures

2.7 Switzerland

Table 114 contains a projection for aluminium consumption in Switzerland according to end-user group. Consumption could increase from 109,700 t in 1976 to 168,450 t by 1990, an average annual growth rate of 3.1 %. The main consumer groups in 1976 were semi-manufactures exports (54 %), the packaging industry (13 %), and construction (11 %). The percentage for exports could increase to 79 % by 1990, that for the packaging industry could decrease to 10 % and the construction industry to 9 %.

2.8 Japan

Table 115 contains a projection for aluminium consumption in Japan according to end-user group. Consumption could increase to 3.72 million t by 1990 (1.92 million t in 1976), an average annual growth rate of 4.8 %. The main consumer groups were construction (35 %), transportation (19 %), metal goods & misc. (11 %), and the electrical industry (9 %). The percentage for construction may increase to 39 % by 1990, that for transportation to 20 %. The other groups named should remain constant.

2.9 USA

Table 116 contains a projection for aluminium consumption in the USA according to end-user group. The corresponding data for the USA in 1976 were not available at the time of this writing. Trends in total consumption of aluminium in the USA in 1976 indicate a sizable increase. It can probably be assumed that end-use consumption also increased considerably. Consumption could increase to 10.48 million t by 1990 (6.18 million t in 1975), an average annual growth rate of 3.6 %. The main consumer groups in the USA in 1975 were construction (22 %), transportation (19 %), packaging (17 %), electrical (13 %), and machinery & equipment (7 %). No significant changes are expected up to 1990.

3) Future Consumption of Aluminium Raw Materials in Non-Metallic Form

Table 117 contains a projection for the use of bauxite and alumina for non-metallic purposes. Because of the unavailability of statistics for the years after 1974, it was necessary to use 1974 as base year. Average annual growth rate form 1974 to 1990 may be expected to be ca. 4 %, about the same as in the USA. Consumption in the sector may amount to 14 % of the aluminium consumption by 1990.

Table 114

A Projection of Aluminium Consumption in Switzerland for 1980, 1985, and 1990 in 1000 t

	1976[1)]	1980	1985	1990
Transportation	3.2	4.5	5.2	5.8
Machinery	7.2	8.5	9.5	10.5
Electrical	4.8	5.5	6.0	6.5
Building & construction	11.7	14.0	14.5	15.0
Chemical, food & agricultural appliances	0.4	0.5	0.6	0.7
Packaging	13.7	15.0	16.0	17.0
Domestic & office appliances	2.1	2.4	2.7	3.0
Powder consuming industries	-	-	-	-
Iron & steel industries	0.3	0.4	0.5	0.5
Metal industries not elsewhere specified Miscellaneous	7.5	8.5	9.0	9.5
Exports of semis, foil, cable, powder	58.8	70.0	85.0	100.0
Total	109.7	129.3	149.0	168.5

1) actual figures

Table 115

A Projection of Aluminium Consumption in Japan
for 1980, 1985, and 1990
in 1000 t

	1976[1)]	1980	1985	1990
Transportation	370.9	491.5	618.3	745.0
Machinery	82.5	109.0	133.2	157.1
Electrical	178.5	240.5	294.0	347.0
Building and construction	668.0	874.6	1,157.0	1,437.0
Chemical, food, and agricultural appliances	38.2	65.0	70.0	80.0
Packaging	103.7	120.0	150.0	170.0
Domestic & office appliances	124.6	135.0	149.0	164.0
Powder consuming industries	8.9	12.0	15.0	18.0
Iron & steel industries	52.6	65.0	78.0	89.0
Metal industries not elsewhere specified) Miscellaneous)	216.2	275.0	340.0	410.0
Exports of semi-manufactures	76.9	85.0	95.0	105.0
Total	1,921.0	2,472.6	3,099.5	3,722.1

1) .actual figu es

Table 116

A Projection of Aluminium Consumption in USA
for 1980, 1985, and 1990
in 1000 t

	1975[1]	1980	1985	1990
Transportation	1,169.4	1,468.0	1,720.0	1,948.0
Machinery	411.9	476.0	565.0	649.0
Electrical	780.2	970.0	1,162.0	1,347.0
Building and construction	1,363.1	1,765.0	2,092.0	2,400.0
Chemical, food, and agricultural appliances	73.9	80.0	95.0	110.0
Packaging	1,027.4	1,260.0	1,580.0	1,860.0
Domestic and office appliances	400.5	510.0	580.0	650.0
Powder consuming industries	76.7	135.0	155.0	175.0
Iron and steel industries	128.8	162.0	180.0	195.0
Metal industries not elsewhere specified)	318.4	151.0	184.0	215.0
Miscellaneous)		250.0	270.0	290.0
Exports of semi-manufactures	428.2	500.0	570.0	640.0
Total	6,178.5	7,727.0	9,153.0	10,479.0

1) actual figures

Table 117

Projection of Bauxite and Alumina Consumption for Non-Metallic Applications in 1980, 1985 & 1990
(in 1000 t Al content)

	1974[1)]	1980	1985	1990
USA	701	910	1,140	1,360
Remaining world	1,500	1,850	2,400	2,850
World total	2,201	2,760	3,540	4,210

1) actual figures

VII. Proposals for Aluminium Research and Development Projects

1) Summarization of the Basis for Research Projects within the EC

- On a world-wide basis, the supply situation for bauxite is quite favorable. Reserves and resources are sufficient for long-term coverage of demand.
- The situation is quite different in terms of the availability of bauxite within the EC. The EC countries, with the exception of France, have virtually no bauxite reserves, and are thus dependent on imports for the production of alumina as well as aluminium.
- Bauxite deposits are concentrated within a few countries. The IBA countries alone control over 77 % of world reserves and turn out 73 % of current world production. It cannot be excluded that price increases will occur on a political basis.
- Several processes are known for using non-bauxite raw materials for the production of alumina. The economic application of some of these processes is being tested in pilot plants. The results of these tests indicate that the production of aluminium from domestic alumo silicates could compete on a long-term basis if large price increases were to occur.

These statements justify increased research on the production of aluminium in the interest of long-term, secure, and economic raw materials supply.

2) Problems Occuring in the Production of Aluminium Especially from Non-Bauxite Raw Materials

- Resources of alumo silicate rock usable for producing aluminium are considerable. Within the EC, almost all currently considered minerals and rocks except plagioclase (anorthosite) and nepheline (nepheline syenite) can be considered. There are no investigations however, on the extent, specific properties and the usability of the numerous occurrences from a technical and economic point of view, nor from considerations of regional planning.
- The production of aluminium consumes a large amount of energy. Aluminium is produced today in a two-step process (ore to alumina, alumina to aluminium). Most of the energy is required by the second step. Presently known processes for utilizing non-bauxite raw materials are designed for the production of alumina. The energy intensive second step would remain the same. New processes, especially the Alcoa process are alleged to save considerable amounts of energy in comparison with the usual Hall-Héroult process.

- The construction of plants for producing aluminium from non-bauxite raw materials is exceedingly expensive. With the present aluminium market, these costs can scarcely be born by the individual aluminium producers alone.
- Only about 5 % of the energy required for producing aluminium from primary raw materials is necessary for its recovery from scrap metal.

3) Starting Points for Research Projects

The following tasks for research projects on aluminium in the EC countries result from the factors and problems given above:

- comprehensive compilation of the occurrences of aluminium raw materials within the EC and an assessment of their extent and availability considering possible production methods and regional planning.
- development and further development of methods for the production of aluminium from non-bauxite raw materials including the pilot-plant stage, considering especially a reduction in energy consumption.
- construction of common demonstration plants for utilizing non-bauxite aluminium raw materials, based on the outcome of prefeasibility studies, and where possible, near an aluminium smelter.
- support of research plans for increased recovery of aluminium from old scraps.

The European aluminium producers are to participate in carrying out these tasks. Specifically, the following should be pointed out:

The aim of the inventory of deposits of non-bauxite aluminium raw materials within the EC is to create the basis for the erection of common demonstration plants. Therefore, after the first compilation, selected occurrences should be assessed in more detail according to a uniform scheme. The assessment should indicate (similar to a prefeasibility study) what it would cost to produce alumina or aluminium from a deposit.

The known and considerably developed processes should be investigated to see if they can be used to obtain aluminium from selected occurrences of alumo-silicates within the EC countries and to see whether these processes can be modified.
So that the best possible process can be used for occurrences of differing composition in the individual countries, new and previously little investigated methods for producing aluminium should also be developed.
In any case however, the development of these processes must be done considering the inventory and valuation of the alumino-silicate occurrences.

Common demonstration plants should be planned on the basis of this assessment. The site of the plants should be chosen according to which of the raw materials was found to be most suitable.

Possibilities for using less energy in the production of aluminium from non-bauxite raw materials emerge for example if the metal is produced from anhydrous aluminium chloride ($AlCl_3$) instead of alumina (Al_2O_3). Therefore, research work on the production of anhydrous $AlCl_3$ from alumino silicates should be continued and supported. It would also be appropriate to continue research and development work on the improvement of alumina production from non-bauxite raw materials.

The production of Al/Si alloys from alumino-silicates in one-step thermal or electrothermal processes could yield further possibilities for a low-cost and low-energy utilization of European non-bauxite occurrences.

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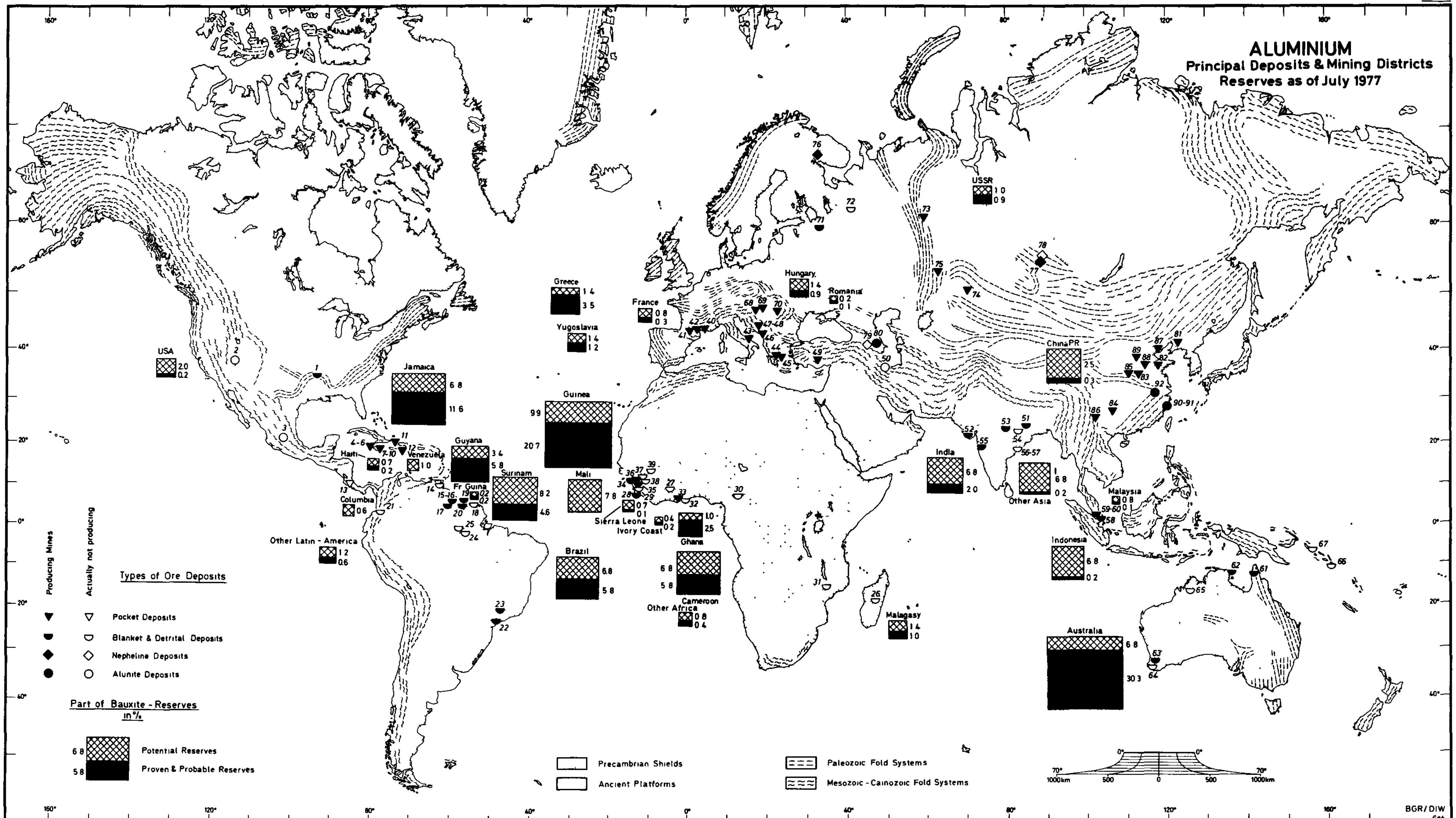
ANNEXES


ALUMINIUM
Principal Deposits & Mining Districts
Reserves as of July 1977
Producing Mines
Actually not producing
Types of Ore Deposits
Pocket Deposits
Blanket & Detrital Deposits
Nepheline Deposits
Alunite Deposits
Part of Bauxite - Reserves in %
Potential Reserves
Proven & Probable Reserves
Precambrian Shields
Ancient Platforms
Paleozoic Fold Systems
Mesozoic - Cainozoic Fold Systems
USA 2.0 0.2
Jamaica 6 8 11 6
Haiti 0 7 0 2
Venezuela 1 0
Guyana 3 4 5 8
Surinam 8 2 4.6
Fr Guina 0 2 0 2
Columbia 0 6
Other Latin - America 1 2 0.6
Brazil 6.8 5 8
Guinea 9 9 20 7
Mali 7 8
Sierra Leone 0 7 0 1
Ivory Coast 0 4 0 2
Ghana 1.0 2.5
Cameroon 6 8 5 8
Other Africa 0 8 0 4
Greece 1 4 3 5
France 0 8 0 3
Yugoslavia 1 4 1 2
Hungary 1 4 0.9
Romania 0 2 0 1
USSR 1 0 0 9
China PR 2 5 0 3
India 6 8 2 0
Other Asia 6 8 0 2
Malaysia 0 8 0
Indonesia 6 8 0 2
Malagasy 1 4 1 0
Australia 6 8 30 3
BGR / DIW

Annex 1

Economically Important Aluminium Deposits and Ore Districts

	Country, deposit or ore district
	USA
1	Pulaski and Saline Country, Ark.
2	Cedar City, Utah (Alunite Deposits)
	Mexico
3	Salamanca, Prov. Guanajuato (Alunite Deposits)
	Jamaica
4	Maggotty, Dist. St. Elizabeth
5	Nain, Dist. St. Elizabeth
6	Kirkvine, Dist. Manchester = Mandeville
7	Port Rodes, Dist. St. Ann = Discovery Bay
8	May Pen, Dist. Clarendon = Wordside
9	Lydford, Dist. St. Ann = Port Kaiser
10	Schwallenberg, Dist. St Ann = Ewarton
	Haiti
11	Miragoane
	Dominican Rep.
12	Pedernales
	Costa Rica
13	Boruca Region
	Venezuela
14	Delta Amacuro

Annex 1 (continued)

Economically Important Aluminium Deposits and Ore Districts

	Country, deposit or ore district
	Guyana
15	Mackenzie (Linden), Dist.
16	Ituni Dist.
17	Kwakwani Dist.
	Guiana
18	Kaw Mountains
	Surinam
19	Moengo, Bakhuis Mountains
20	Onverdacht, Kankantrie, Dist Paranam and Para
	Colombia
21	Popayan, Dept. Cauca
	Brazil
22	Sorocaba, São Paulo
23	Poços de Caldas, Minas Gerais
24	Paragominas by Santarem, Pará
25	Rio Trombetas, Pará
	Malagasy
26	Marangaka
	Ivory Coast
27	Bondoukou
	Sierra Leone
28	Mokanji
29	Port Loho
	Cameroon
30	Minim Martap

Annex 1 (continued)

Economically Important Aluminium Deposits and Ore Districts

	Country, deposit or ore district
	Malawi
31	Mulanje Mountains
	Ghana
32	Kibi, Atewa, Range
33	Awaso, Asato, Kanaierabe
	Guinea
34	Boké (Sangaredi, Aye-Koje)
35	Kindia (Debele, Kankan)
36	Kimbo
37	Tougué
38	Dabola
	Mali
39	Kita
	France
40	Dept. Var
41	Dept. Ariege
42	Dept. Hérault
	Italy
43	Prov. Apulien
	Greece
44	Parnassos
45	Distomon, Eleusis
	Yugoslavia
46	Niksic, Cetinje
47	Sarajewo
48	Vlasenica, Jajce

Annex 1 (continued)

Economically Important Aluminium Deposits and Ore Districts

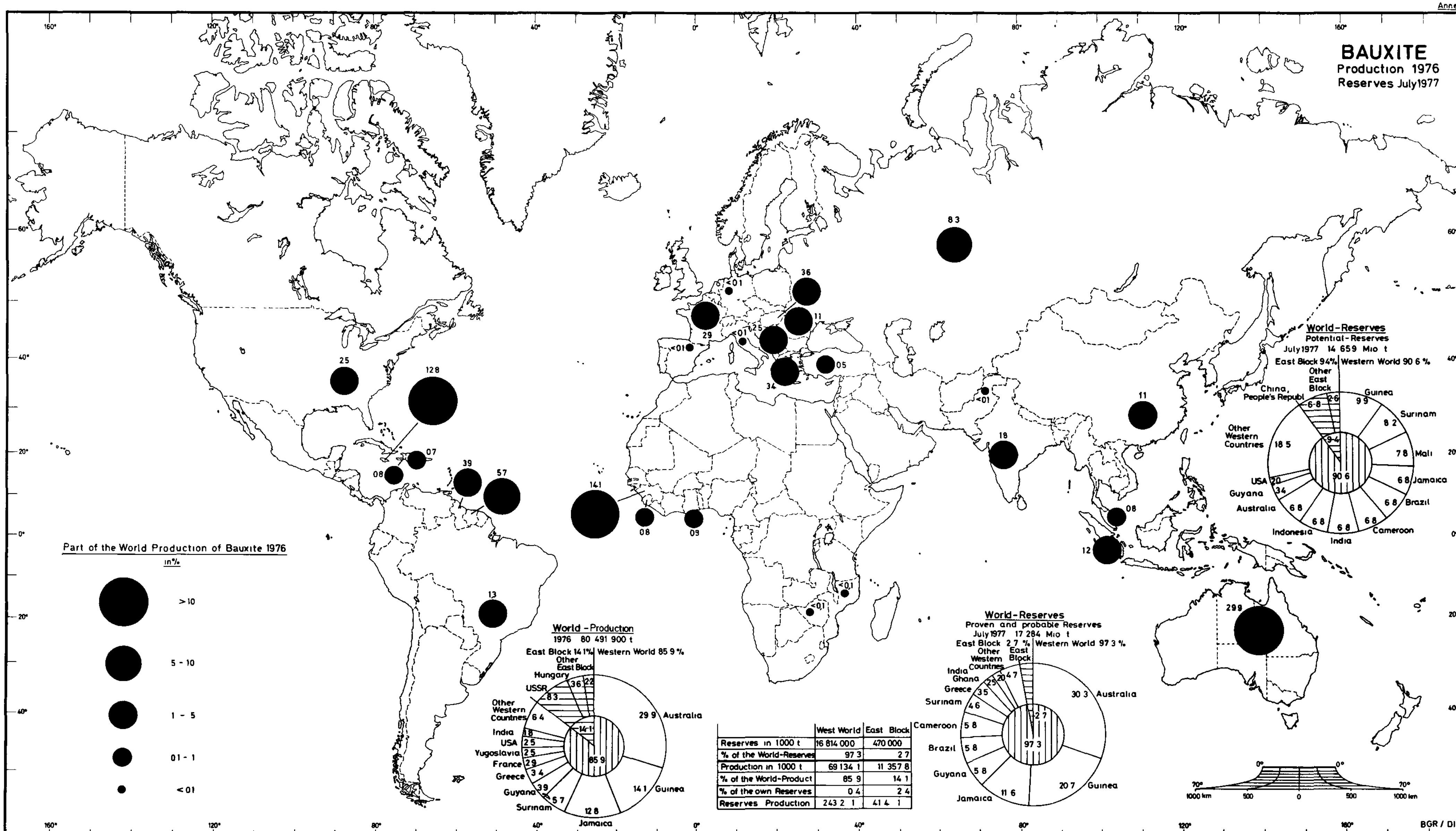
	Country, deposit or ore district
	Turkey
49	Seydishir, Anatolien
	Iran
50	Takistan (Alunite Deposits)
	India
51	Randi and Palamau Dist., Orissa
52	Kutch and Jammagar Dist. Gujorat
53	Jabalpur Dist., Madhya Pradesh
54	Surguja Dist., Madhya Pradesh
55	Koloba and Ratnagiri Dist., Maharashtra
56	Pottangi, Koraput Dist., Orissa
57	Chintapalli, Golinkonda, Visakhapatna Dist., Andhra Pradesh
	Indonesia
58	Kijang (Bitan Island)
	Malaysia
59	Bukit Pasit, Johore
60	Bukit Bopend, Johore
	Australia
61	Weipa, Queensland
62	Gove, Northern Territory
63	Jarradahle and Del Park, Western Australia
64	Mt. Saddleback, Western Australia
65	Mitchell Plateau, Western Australia
	Solomon Island
66	Island Renell
67	Island Wagina

Annex 1 (continued)

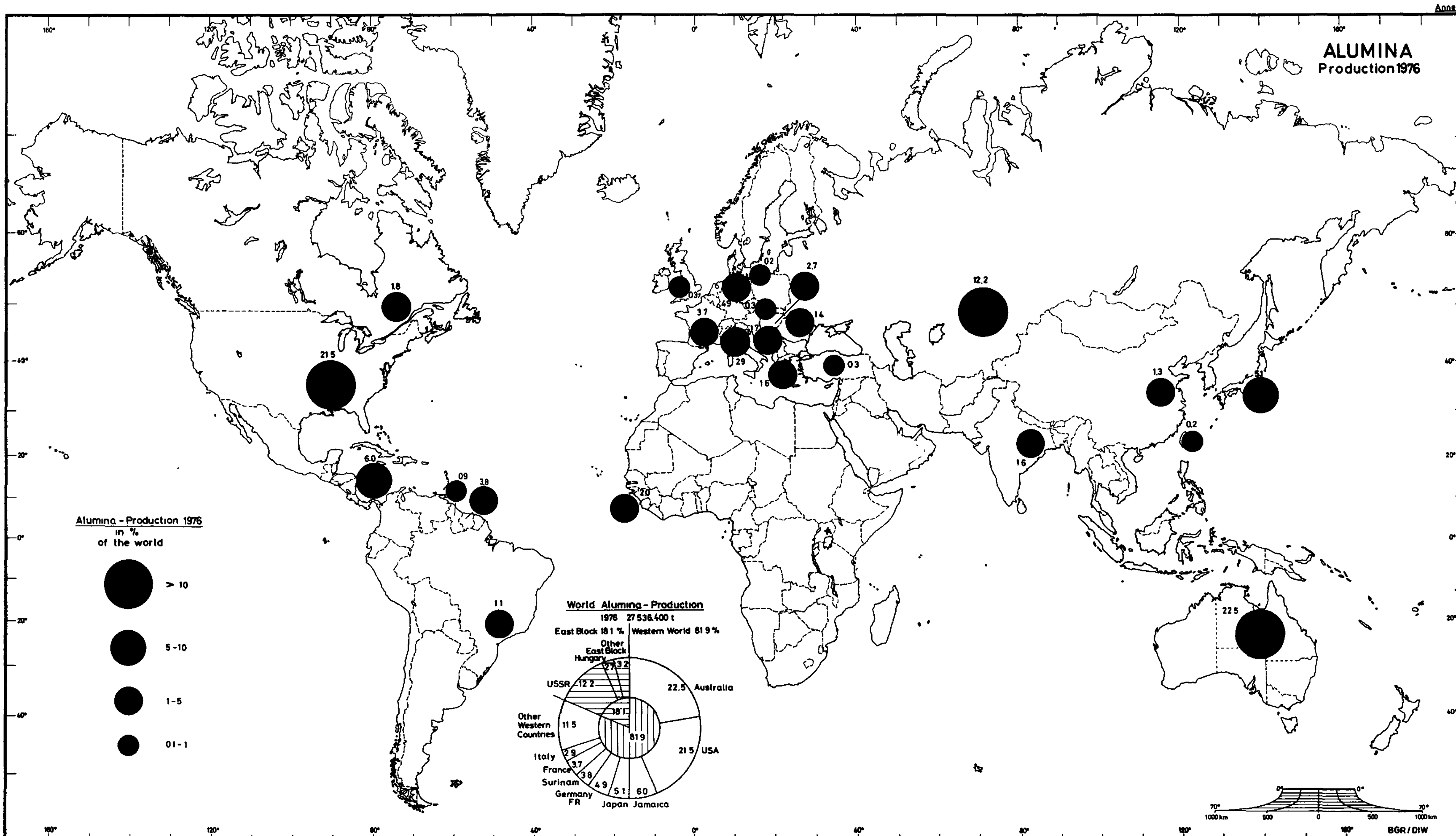
Economically Important Aluminium Deposits and Ore Districts

	Country, deposit or ore district
	Hungary
68	Bakony Region, Tapolca
69	Fejer Region, Kincsesbánya
	Romania
70	Padurea, Crainlui
	USSR
71	Boksitogorsk by Tichwin, Leningrad Dist.
72	Iksa by Plesetsk
73	Krasnaya Shapochka, Severouralsk, Nothern Urals
74	Arkalyk, Turgay Dist.
75	Ayat = Krasnooktyabrsk, NW-Kasachstan
76	Kirovsk Dist., Kola (Nepheline Deposits)
77	Kiya-Shaltyr by Belogorsk, Achinsk Dist., Siberia (Nepheline Deposits)
78	Goryachegorsk, Achinsk Dist., Siberia (Nepheline Deposits)
79	Tezhsar, Razdan Dist. Armenia
80	Zaglik by Kirovabad, Aserbeidshan (Alunite Deposits)
	China PR
81	Fushun Dist., Penchi Dist., Prov. Liaoning
82	Poshan Dist., Tzupo Dist., Prov. Shantung
83	Kunghsien Dist., Prov. Honan
84	Kweiyang Dist., Prov. Kweichow
85	Prov. Shensi
86	Kunming Dist., Prov. Yunnan
87	Kaiping-Kueh-Dist., Prov. Hopeh
88	Chinghsing Dist., Tzuhsien Dist., Prov. Hopeh
89	Prov. Shansi
90	Pinguang Dist., Prov. Chekianing (Alunite Deposits)
91	Juian Dist., Prov. Chekiang (Alunite Deposits)
92	Luchiang Dist., Prov. Ankwei (Alunite Deposits)

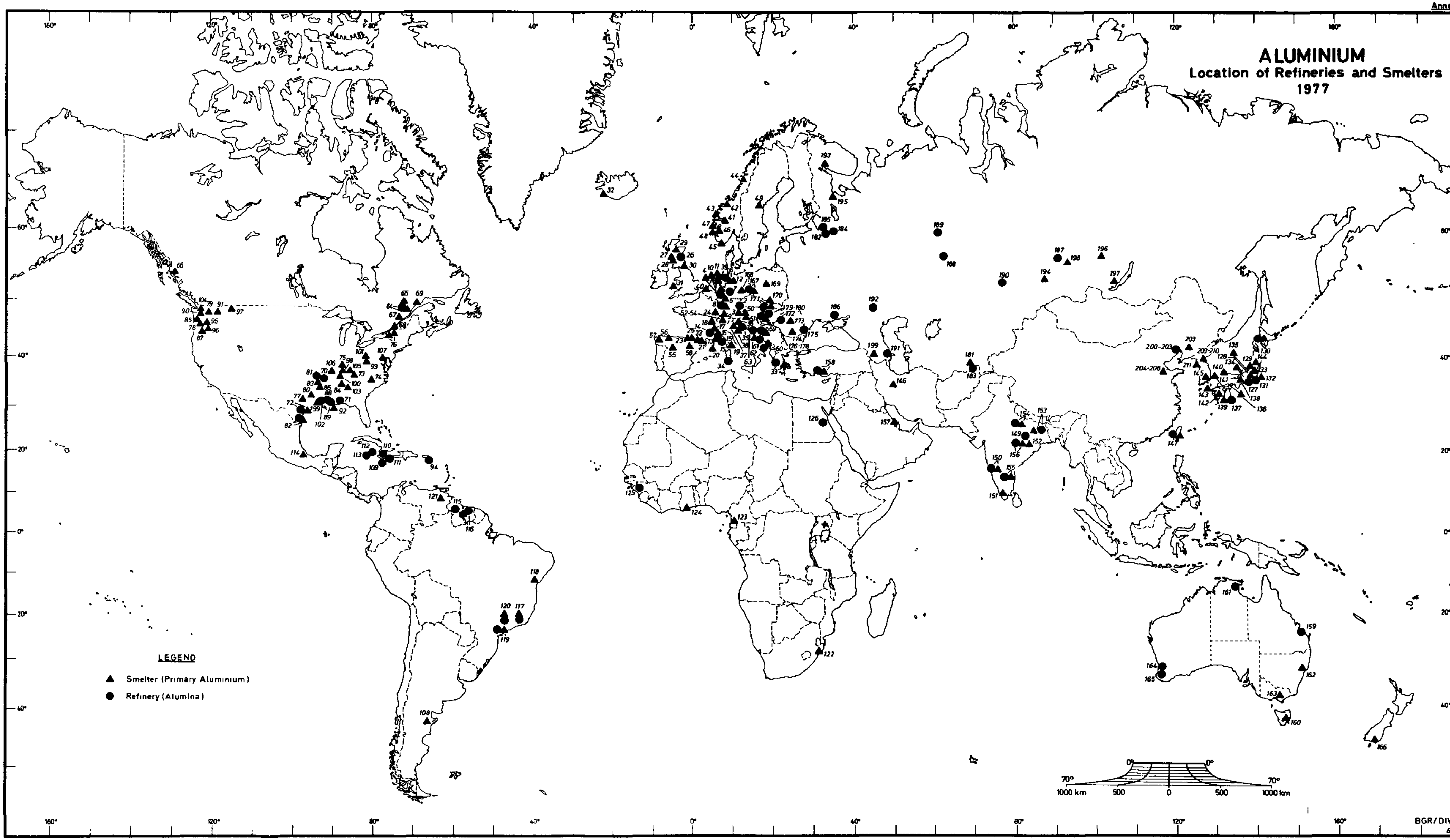
Annex 2



	West World	East Block
Reserves in 1000 t	16 814 000	470 000
% of the World-Reserves	97 3	2 7
Production in 1000 t	69 134 1	11 357 8
% of the World-Product	85 9	14 1
% of the own Reserves	0 4	2 4
Reserves Production	243 2 1	41 4 1


Annex 3
ALUMINA
Production 1976
Alumina - Production 1976
in %
of the world
> 10
5 - 10
1 - 5
01 - 1
World Alumina - Production
1976 27 536 400 t
East Block 18 1 % | Western World 81 9 %
Other East Block
Hungary
USSR
Other Western Countries
Italy
France
Surinam
Germany FR
Japan
Jamaica
USA
Australia
22.5
21 5
6 0
5 1
4 9
3 8
3.7
2 9
11 5
12 2
2 7
3 2
18 1
81 9
BGR / DIW

Annex 4


ALUMINIUM
Location of Refineries and Smelters
1977
LEGEND
Smelter (Primary Aluminium)
Refinery (Alumina)
70° 0° 0° 70°
1000 km 500 0 500 1000 km
BGR/DIW

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company		Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
		1. Europe		
Germany FR				
Vereinigte Aluminiumwerke AG (VAW)	1	Lünen, NRW	430	47
	2	Schwandorf, Bayern	210	-
	3	Töging, Bayern	-	55
	4	Grevenbroich, NRW	-	32
	5	Neuß, NRW	-	145
	6	Stade, Niedersachsen	600	65
Schweizerische Aluminium AG (Alusuisse)	7	Bergheim, NRW	380	-
Gebr. Giulini GmbH	8	Ludwigshafen, Rheinland-Pfalz	130	44
Aluminiumhütte Rheinfelden GmbH I [1)]	9	Rheinfelden, Baden-Württemberg	-	64
Kaiser/Preußag[2)]	10	Voerde, NRW	-	72
Leichtmetallgesellschaft mbH[3)]	11	Essen-Borbeck, NRW	-	133
Hamburger Aluminiumwerk GmbH[4)]	12	Hamburg	-	100
Germany FR total			(1.750)	(757)
France				
Pechiney Ugine Kuhlmann SA	13	Gardanne, Bouches-du-Rhone	720	-
	14	Salindres, Gard	250	-
	15	La Barasse, Bouches-du-Rhone	350	-
	16	La Praz, Savoie	-	4
	17	La Saussaz, Savoie	-	12
	18	St. Jean de Maurienne, Savoie	-	75
	19	L'Argentiére, Hautes Alpes	-	39
	20	Rioupéroux, Isère	-	25
	21	Auzat, Ariège	-	35
	22	Sabart, Ariège	-	25
	23	Noguères, Basses Pyrenées	-	115
	24	Venthon, Savoie	-	28
	25	Lannemezan, Hautes Pyrenées	-	57
France total			(1.320)	(415)
Great Britain				
British Aluminium Co. Ltd. (BACO)[5)]	26	Burntisland	115	-
	27	Lochaber, Scotland	-	29
	28	Kinlochleven, Scotland	-	11
	29	Invergordon, Scotland	-	100
Alcan Aluminium (UK) Ltd.[6)]	30	Lynemouth, Northumberland	-	120
Anglesey Aluminium Ltd.[7)]	31	Holyhead, Wales	-	105
Great Britain total			(115)	(365)

I The footnote numbers indicate the participating companies and their share (see list at the end of Annex 4).

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company	Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
Iceland			
Icelandic Aluminium Co. Ltd.[8]	32 Straumsvik, Hafnarfjordur	-	77
Greece			
Aluminium de Grèce S.A.[9] (ADG)	33 Distomon, St. Nicolas	500	145
Italy			
Eurallumina S.p.A.[10]	34 Porto Vesme, Sardinia	720	-
Mountecatini Edison S.p.A,[11]	35 Porto Marghera, Venetia	210	-
	36 Bolzano, Bolzano	-	60
	37 Mori, Trento	-	20
	38 Fusina, Venetia	-	35
Soc. Allumino Veneto p.A. (SAVA)[12]	35 Porto Marghera, Venetia	-	30
	38 Fusina, Venetia	-	30
		-	125
Italy total		(930)	(300)
Netherlands			
Aluminium Delfzijl N.V.[13]	39 Delfzijl	-	95
Pechiney Nederland N.V.[14]	40 Vlissingen	-	170
Netherlands total		-	(265)
Norway			
A/S Aardal og Sunndal Verk[15]	41 Aardal	-	155
	42 Sunndalsöra	-	120
	43 Höyanger	-	30
Elektroemisk A/S[16]	44 Mosjöen	-	85
	45 Lista	-	80
DNN Aluminium A/S[17]	46 Tyssedal	-	25
Soer-Norge Aluminium A/S[18]	47 Husnes	-	70
Alnor Aluminium A/S[19]	48 Karmoy	-	120
Norway total		-	(685)
Sweden			
Gränges Aluminium A/B[20]	49 Kubikenborg, Sundsvall	-	85
Austria			
Vereinigte Metallwerke Ranshofen-Berndorf AG	50 Ranshofen, Braunau a.Inn	-	81
Salzburger Aluminium GmbH[21]	51 Lend, Salzburg	-	12
Austria total		-	(93)
Switzerland			
Schweizerische Aluminium AG[21]	52 Chippis	-	35
	53 Steg	-	48
Usine d'Aluminium Martigny S.A.	54 Martigny	-	10
Switzerland total		-	(93)

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company	Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
Spain			
Empresa Nacional de Aluminio S.A.[22) (Endasa)	55 Valladolid	-	24
	56 Avilés	-	101
Aluminio de Galicia S.A.[23) (Alugasa)	57 La Coruña	-	78
	58 Sabinanigo	-	15
Spain total		-	(218)
Yugoslavia			
Tovarna glinice in aluminija "Boris Kidric"[24)	59 Kidricevo, Slovenia	150	50
Aluminijski Kombinat-Titograd[24)	60 Titograd, Montenegro	200	50
Energoinvest[24)	61 Mostar, Bosnia -Hercegowina	280	-
Trornica lakih metala, TLM "Boris Kidric"[24)	62 Sibenik	-	110
Energoinvest[24)	63 Obrovac	300	-
Yugoslavia total		(930)	(210)
	2. North America		
Canada			
Alcan Aluminium Ltd.	64 Arvida, Que.	1,260	416
	65 Isle Maligne, Que.	-	118
	66 Kitimat, B.C.	-	272
	67 Shawinigan, Que.	-	86
	68 Beauharnois, Que.	-	46
Canadian Reynolds Metals Co. Ltd.[25)	69 Baie Comeau, Que.	-	159
Canada total		1,260	1,097
USA			
Aluminum Co. of America	70 Bauxite, Ark.	340	-
	71 Mobile, Ala.	930	-
	72 Point Comfort, Tex.	1,225	168
	73 Alcoa, Tenn.	-	245
	74 Badin, N.C.	-	163
	75 Evansville, Ind.	-	254
	76 Massena, N.Y.	-	145
	77 Rockdale, Tex.	-	259
	78 Vancouver, Wash.	-	104
	79 Wenatchee, Wash.	-	168
	80 Palestine (Anderson), Tex.	-	14
Alcoa total		(2,495)	(1,520)
Reynolds Metals Co.	81 Hurricane Creek, Ark.	760	-
	82 Corpus Christie, Tex.	1,255	103
	83 Jones Mills, Ark.	-	113
	84 Listerhill, Ala.	-	183
	85 Longview, Wash.	-	191
	86 Arkadelphia, Ark.	-	62
	76 Massena, N.Y.	-	115
	87 Troutdale, Ore.	-	118
Reynolds total		(2,015)	(885)

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company		Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
Kaiser Aluminium & Chemical Corp.	88	Baton Rouge, La.	930	-
	89	Gramercy, La.	725	-
	90	Tacoma, Wash.	-	73
	91	Mead, Wash.	-	200
	92	Chalmette, La.	-	236
	93	Ravenswood, W. Va.	-	148
Kaiser Aluminium total			(1,655)	(657)
Martin Marietta Aluminium Inc. (ehem. Harvey-Aluminium Co.)	94	St. Croix(Virgin Islands)	335	-
	95	Goldendale, Wash.	-	109
	96	The Dalles, Ore.	-	82
Martin Marietta total			(335)	(191)
Anaconda Aluminum Co.	97	Columbia Falls, Mont.	-	163
	98	Sebree, Ky.	-	109
Anaconda total			-	(272)
Consolidated Aluminium Corp. (Conalco)[26]	99	Lake Charles, La.	-	33
	100	New Johnsonville, Tenn.	-	132
Consolidated Aluminium total			(-)	(165)
Ormet Corporation[27]	101	Hannibal, Ohio	-	227
	102	Burnside, La.	545	-
Revere Copper & Brass Inc.[28]	103	Scottsboro, Ala.	-	104
Intalco Aluminum Corp.[29]	104	Bellingham, Wash.	-	238
National Southwire Aluminum Co.[30]	105	Hawesville, Ky.	-	163
Noranda Mines Ltd.	106	New Madrid, Mo.	-	127
Eastalco Aluminum Co.[31]	107	Frederick, Md.	-	160
USA total			(7,045)	(4,709)
Argentina				
Aluminio Argentino S.A.[32]	108	Puerto Madryn, Prov.Chubut	-	36
Jamaica				
Alcan Jamaica Ltd.[33]	109	Kirkvine, Manchester	560	-
	110	Ewarton, St. Catherine	570	-
Alcoa Minerals Jamaica Ltd.[34]	111	Woodside, Clarendon	500	-
Alumina Partners of Jamaica, Inc.[35] (Alpart)	112	Nain, St. Elisabeth	1,180	-
Revere Jamaica Alumina Ltd.[36]	113	Maggotty, St. Elisabeth	200	-
Jamaica total			3,010	-
Mexico				
Aluminio, S.A. de C.V.[37]	114	Puerto Vera Cruz	-	45
Guyana				
Guyana Bauxite Co.[38]	115	Mackenzie, Linden	354	-
Surinam				
Suriname Aluminium Co.[39] (Suralco)	116	Paranam	1,180	66

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company		Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
Brazil				
Alcan Aluminio do Brasil S.A.[40)]	117	Saramenha, Ouro Prêto, MG	100	32
	118	Aratu, Bahia	-	28
Companhia Brasileira de Aluminio S.A. (BA)[41)]	119	Sorocaba, São Paulo	160	60
Companhia Mineira de Aluminio[42)] (Alcominas)	120	Poços de Caldas	140	60
Brazil total			(400)	(180)
Venezuela				
Aluminio del Caroni S.A.[43)] (Alcasa)	121	Santo Tomé, Puerto Ordaz	-	54
		3. Africa		
Rep. of South Africa				
Alusaf Pty. Ltd.[44)]	122	Richards Bay, Natal	-	82
Cameroon				
Comp. Camerounaise de l'Aluminium (Alucam)[45)]	123	Edéa	-	55
Ghana				
Volta Aluminium Co. Ltd.[46)] (Valco)	124	Tema	-	200
Guinea				
Friguia[47)]	125	Fria-Kimbo	700	-
Egypt[48)]	126	Nag Hamadi	-	100
		4. Asia		
Japan				
Nippon Light Metal Co. Ltd.[49)]	127	Shimizu, Hondo	540	-
	128	Kambara, Hondo	-	112
	129	Niigata, Hondo	-	145
	130	Tomakomai, Hokkaido	360	130
Showa Denko K.K.	131	Yokohama, Hondo	620	-
	132	Chiba (Ichihara), Hondo	-	160
	133	Kitakata, Hondo	-	43
	134	Omachi, Hondo	-	42
Mitsubishi Chemical Industries Co.	135	Naoetsu, Hondo	-	162
	136	Sakaide, Schikoku	-	196
Sumitomo Chemical Co. Ltd.	137	Kikumoto, Schikoku	850	-
	138	Nagoya, Hondo	-	55
	139	Isoura (Niihama), Schikoku	-	80
	140	Toyama, Hondo	-	190
Sumitomo Toyo Aluminium Smelting Co.	141	Toyo, Schikoku	-	100
Mitsui Aluminium Co. Ltd.	142	Miike, Omuta Kiushu	-	80
	143	Wakamatsu	200	-
Sumikei Aluminium Industries	144	Sakata, Hondo	-	45
Japan total			(2,570)	(1,540)

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company	Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
Korea, South			
Aluminium of Korea Ltd.[50)]	145 Ulsan	-	30
Iran			
Iranian Aluminium Co.[51)]	146 Arak	-	50
Taiwan			
Taiwan Aluminium Corp.[52)] (Talco)	147 Kaohsiung I	80	38
	148 Kaohsiung II	-	38
Taiwan total		(80)	(76)
India			
Indian Aluminium Co. Ltd.[53)]	149 Muri, Bihar	80	-
	150 Belgaum, Mysore	140	65
	151 Alupuram, Kerala	-	20
	152 Hirakud, Orissa	-	23
Aluminium Corp. of India Ltd. (Alucoin)	153 Jaykaynagar, West Bengal	25	10
Hindustan Aluminium Corp. Ltd.[54)] (Hindalco)	154 Renukoot, U.P.	181	95
Madras Aluminium Co. Ltd.[55)]	155 Mettur, Madras	60	27
Bharat Aluminium Co. Ltd.[56)] (Balco)	156 Korba, M.P.	200	50
India total		(686)	(291)
Bahrain			
Aluminium Bahrain Ltd.[57)]	157 Bahrain	-	120
Turkey			
Etibank	158 Seydisehir	200	60
	5. Australia		
Australia			
Queensland Alumina Ltd.[58)]	159 Gladstone, Qld.	2,000	-
Comalco Aluminium Ltd.[59)]	160 Bell Bay, Tasm.	-	115
Nabalco Pty. Ltd.[60)]	161 Gove, N.T.	1,000	-
Alcan Australia Ltd.[61)]	162 Kurri-Kurri, NSW	-	45
Alcoa of Australia Ltd.[62)]	163 Point Henry, Vict.	-	95
	164 Kwinana, WA	1,400	-
	165 Pinjarra, WA	2,000	-
Australia total		(6,400)	(255)
New Zealand			
New Zealand Aluminium Smelters Ltd.[63)]	166 Bluff	-	150
Australia and Oceania total		(6,400)	(405)

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters: 1976

Company		Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
		6. East Block		
Germany DR				
VEB Lautawerk[64)]	167	Lauta, Hoyerswerda	65	30
VEB Elektrochemisches Kombinat[64)]	168	Bitterfeld	-	55
Germany DR total			(65)	(85)
Poland				
Huta Aluminium Konin W Budowie[65)]	169	Konin I	-	55
Huta Aluminium Skawina[65)]	170	Skawina	-	55
Poland total			-	(110)
Czechoslovakia				
Za'rod slovenského národniho povstáni[66)]	171	Ziar	100	65
Romania				
State-owned	172	Crisana (Oradea)	250	-
	173	Tirnaveni	-	30
	174	Slatina	-	160
	175	Tulcea	250	-
Romania total			(500)	(190)
Hungary				
State-owned	176	Ajka	385	20
	177	Inota	-	35
	178	Tatabanya	-	15
	179	Almasfüzitö	325	-
	180	Masonmagyarovar	150	-
Hungary total			(860)	(70)
USSR				
State-owned	181	Regar, Tadzhikistan	-	50
	182	Boksitogorsk	150	-
	183	Kirovabad, Caukasus	400	-
	184	Pikalevo, NW-USSR	300	-
	185	Wolkchov	50	.
	186	Zaporozhye, Ukraine	300	.
	187	Achinsk, Siberia	800	-
	188	Kamensk, Ural	500	.
	189	Krasnoturinsk, Ural	400	.
	190	Pavlodar, Kazakhstan	500	-
	191	Sumgait, Azerbaijan	200	.
	192	Wolgograd	100	200
	193	Kandalaksa, Kola Peninsula	-	.
	194	Novo Kuznetsk, Siberia	-	250
	195	Nadvoitsy, Karelia	-	.
	196	Bratsk	-	500
	197	Irkutsk	-	250
	198	Krasnoyarsk, Siberia	-	400
	199	Yerewan, Armenia	-	.
USSR total			(3,700)	(2,400)

Annex 4 (continued)

Capacity of Alumina Plants and Primary Aluminium Smelters; 1976

Company	Plant	Alumina Capacity in 1000 t Al_2O_3	Primary Aluminium Capacity in 1000 t Al
China PR			
State-owned	200 Nanting, Shantung)		
	201 Kweiyang, Kweicho)	400	
	202 Sian, Shansi)		
	203 Fushun, Liaoning)		100
	204 Sanmen, Kansu	)	
	205 Hofei, Anhwei	)	
	206 Wuhan, Hupeh	)	150
	207 Changling, Kirin	)	
	208 Yangchuan, Shansi	)	
	and 4 other small plants	)	
China PR total		(400)	(250)
Korea, North			
State-owned	209 Hungnam	-)	
	210 Tasadoo	-)	50
	211 Chinnampo	-)	
Korea, North total		-	(50)

Explaination for the footnotes in Annex 4

1) Schweizerische Aluminium AG 100 %

2) Kaiser Aluminum & Chemical Corp.

3) Schweizerische Aluminium AG 100 %

4) Vereinigte Aluminium Werke AG 33 1/3 %, Reynolds Metals Co. 33 1/3 %, Vereinigte Metallwerke Ranshofen-Berndorf AG 33 1/3 %

5) Tube Investments Ltd. 49 %, Reynolds Metals Co. 49 %

6) Alcan Aluminium Ltd. 100 %

7) Rio Tinto Zinc Corp. Ltd. 43 %, Kaiser Aluminum & Chemical Corp. 30 %, British Insulated Callender's Cables Ltd. 27 %

8) Schweizerische Aluminium AG 100 %

9) Pechiney Ugine Kuhlmann 50 %

10) EFIM 62.5 %, Comalco Ltd. 20 %, Metallgesellschaft AG 17.5 %

11) EFIM 100 %

12) Schweizerische Aluminium AG 50 %, EFIM 50 %

13) Billiton 50 %, Hoogovens 50 %

14) Pechiney Ugine Kuhlmann 85 %, Hunter Douglas 15 %

15) Government 75 %, Alcan Aluminium Ltd. 25 %

16) Aluminum Co. of America 50 %, Elkelm Spigerverket 50 %

17) Government

18) Schweizerische Aluminium AG 74.8 %

19) Norsk Hydro A/S

20) Granges AB 80 %, Alcan Aluminium Ltd. 20 %

21) Schweizerische Aluminium AG 100 %

22) Government 75 %, Alcan Aluminium Ltd. 25 %

23) Pechiney Ugine Kuhlmann S.A. 68 %

24) Government

25) Reynolds Metals Co. 100 %

26) Schweizerische Aluminium AG 60 %, Phelps Dodge Corp. 40 %

27) Schweizerische Aluminium AG 40 %, Revere Copper & Brass Inc. 34 %, Phelps Dodge Corp. 26 %

28) Alcan Aluminium Ltd. 100 %

29) Amax Inc. 25 %, Pechiney Ugine Kuhlmann S.A. 35 %, Mitsui & Co. Ltd. 25 %, Howmet Corp. 15 %

30) National-Steel Corp. 50 %, Southwire Co. 50 %

31) Pechiney Ugine Kuhlmann S.A. 70 %, Howmet Corp. 15 %

32) FATE 51 %, Alcan Aluminium Ltd. 8 %, Kaiser Aluminum & Chemical Corp. 8 %, Pechiney Ugine Kuhlmann S.A. 8 %

33) Alcan Aluminium Ltd. 100 %

34) Aluminum Co. of America 100 %

35) Reynolds Metals Co. 36.8 %, Anaconda Aluminum Co. 36.8 %, Kaiser Aluminum & Chemical Corp. 26.4 %

36) Revere Copper & Brass Inc. 100 %

37) Aluminum Co. of America 44.3 %

38) Government 100 %

39) Aluminum Co. of America 100 %

40) Alcan Aluminium Ltd. 100 %

41) Industria Votorantim Ltd. 80 %, Government 20 %

42) Aluminum Co. of America 50 %, Hanna Mining Co. 23.5 %

43) Government 50 %, Reynolds Metals Co. 50 %

44) Schweizerische Aluminium AG 22 %

45) Pechiney Ugine Kuhlmann S.A. 60 %

46) Kaiser Aluminum & Chemical Corp. 90 %, Reynolds Metals Co. 10 %

47) Frialco 51 %, Government 49 %

48) Government 100 %

49) Alcan Aluminium Ltd. 50 %

50) Korean Development Bank 50 %, Pechiney Ugine Kuhlmann 50 %

51) Iranian Government 82.5 %, Reynolds Metals Co. 12.5 %, Pakistani Government 5 %

52) Government 100 %

53) Alcan Aluminium Ltd. 65 %

54) Kaiser Aluminum & Chemical Corp. 27 %, Birla and Indian interests 73 %

55) Montecatini-Edison 27 %, Madras State Government 73 %

56) Government 100 %

57) Kaiser Aluminum & Chemical Corp. 17 %, British Metals 17 %, Western Metals 8.5 %, Bretton Investments 5.1 %, Electro-Copper 12 %, Bahrain Government 40.4 %

58) Kaiser Aluminum & Chemical Corp. 32.3 %, Alcan Aluminium Ltd. 21.4 %, Pechiney Ugine Kuhlmann S.A. 20 %, Comalco 13.8 %, Conzinc Riotinto of Australia Ltd. 12.5 % (Comalco: Conzinc Riotinto of Australia Ltd. 45 %, Kaiser Aluminum & Chemical Corp. 45 %, public 10 %)

59) Conzinc Riotinto of Australia Ltd. 45 %, Kaiser Aluminum & Chemical Corp. 45 %, other interests 10 %

60) Schweizerische Aluminium AG 70 %, Gove Alumina Ltd. 30 %

61) Alcan Aluminium Ltd. 70.5 %, other interests 29.5 %

62) Aluminum Co. of America 51 %, other interests 49 %

63) Comalco Ltd. 50 %, Sumitomo Chemical Co. 25 %, Showa Denko K.K. 25 %

64) Government

65) Government

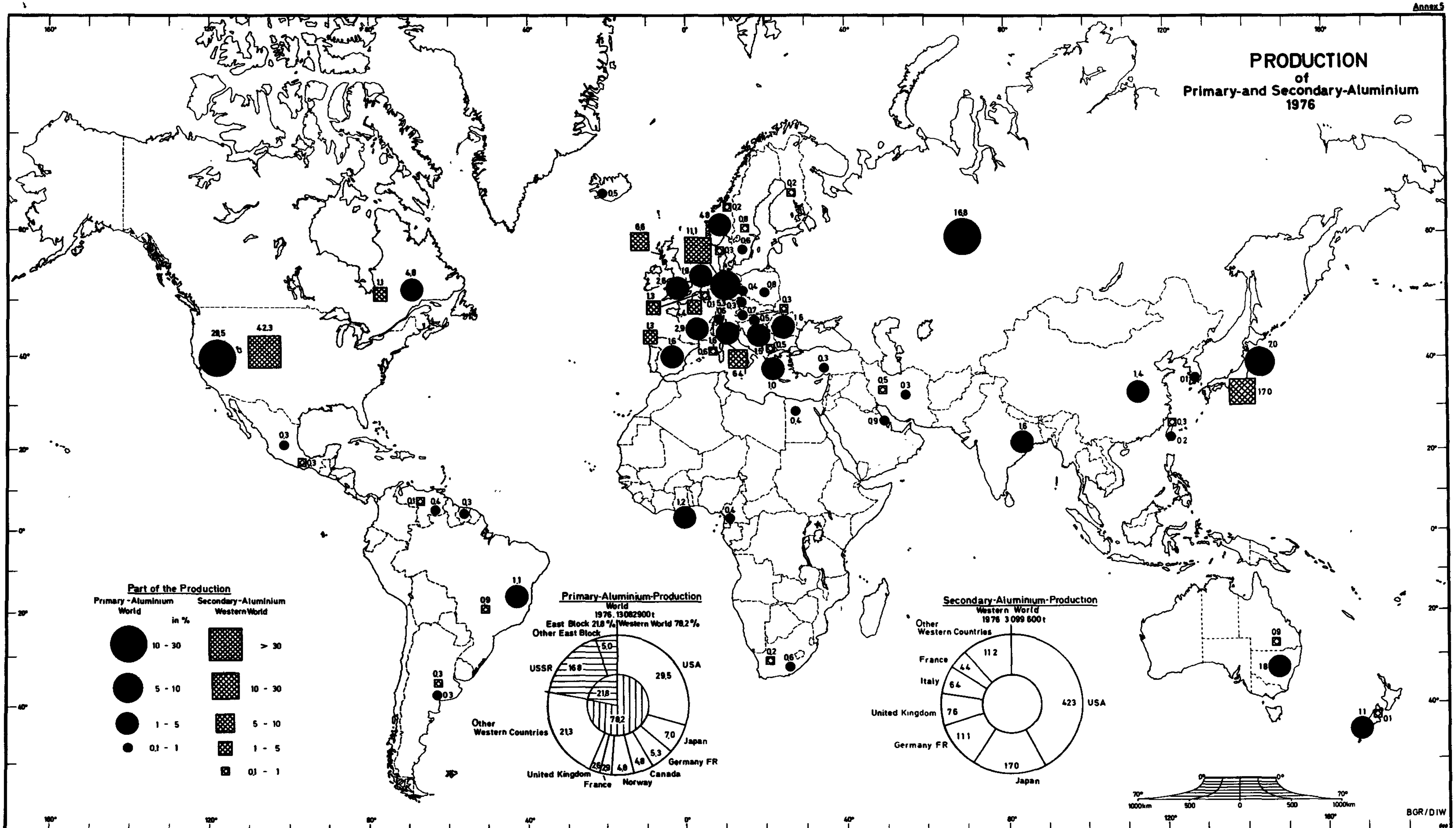
66) Government

Annex 4 a

Bauxite, Alumina, and Primary Aluminium Production Capacity; 1976
in 1000 t/year and %

Country	Bauxite Production Capacity			Alumina Production Capacity			Prim.Aluminium Product.Capacity		
	10^3 tpy	% Western World	% World	10^3 tpy	% Western World	% World	10^3 tpy	% Western World	% World
Germany FR	0	0	0	1,750	5.9	5.0	757	5.9	4.7
France	3,450	3.9	3.4	1,320	4.5	3.8	415	3.2	2.6
United Kingdom	-	-	-	115	0.4	0.3	365	2.8	2.3
Italy	40	< 0.1	< 0.1	930	3.2	2.6	300	2.3	1.8
Netherlands	-	-	-	-	-	-	265	2.1	1.6
EG total	3,490	3.9	3.4	4,115	14.0	11.7	2,102	16.3	13.0
Iceland	-	-	-	-	-	-	77	0.6	0.5
Greece	3.600	4.0	3.5	500	1.7	1.4	145	1.1	0.9
Norway	-	-	-	-	-	-	685	5.3	4.2
Sweden	-	-	-	-	-	-	85	0.7	0.5
Austria	-	-	-	-	-	-	93	0.7	0.6
Switzerland	-	-	-	-	-	-	93	0.7	0.6
Spain	20	< 0.1	< 0.1	-	-	-	218	1.7	1.4
Yugoslavia	4,500	5.1	4.4	930	3.1	2.7	210	1.6	1.3
Europe without East Block	11,610	13.0	11.3	5,545	18.8	15.8	3,708	28.7	23.0
Canada	-	-	-	1,260	4.3	3.6	1,097	8.5	6.8
USA	2,000	2.2	1.9	7,045	23.9	20.1	4,709	36.5	29.2
North America	2,000	2.2	1.9	8,305	28.2	23.7	5,806	45.0	36.0
Argentina	-	-	-	-	-	-	36	0.3	0.2
Dominican Republic	1,300	1.5	1.3	-	-	-	-	-	-
Jamaica	16,500	18.5	16.0	3,010	10.2	8.6	-	-	-
Mexico	-	-	-	-	-	-	45	0.4	0.3
Guyana	4,200	4.7	4.1	354	1.2	1.0	-	-	-
Surinam	7,000	7.9	6.8	1,180	4.0	3.4	66	0.5	0.4
Brazil	1,100	1.2	1.1	400	1.4	1.1	180	1.4	1.2
Haiti	900	1.0	0.9	-	-	-	-	-	-
Venezuela	-	-	-	-	-	-	54	0.4	0.3
Latin America	31,000	34.8	30.2	4,944	16.8	14.1	381	3.0	2.4
Sierra Leone	800	0.9	0.8	-	-	-	-	-	-
Rep. of South Africa	-	-	-	-	-	-	82	0.6	0.5
Cameroon	-	-	-	-	-	-	55	0.4	0.3
Mozambique	0	0	0	-	-	-	-	-	-
Ghana	420	0.5	0.4	-	-	-	200	1.6	1.3
Guinea	12,500	14.0	12.1	700	2.4	2.0	-	-	-
Rhodesia	0	0	0	-	-	-	-	-	-
Egypt	-	-	-	-	-	-	100	0,8	0,6
Africa	13,720	15.4	13.3	700	2.4	2.0	437	3.4	2.7
Japan	-	-	-	2,570	8.7	7.3	1,540	11.9	9.6
Korea, South	-	-	-	-	-	-	30	0.2	0.2
Malaysia	1,300	1.5	1.3	-	-	-	-	-	-
Taiwan	-	-	-	80	0.3	0.2	76	0.6	0.5
Pakistan	0	0	0	-	-	-	-	-	-
India	1,600	1.8	1.5	686	2.3	2.0	291	2.3	1.8
Indonesia	1,300	1.5	1.3	-	-	-	-	-	-
Iran	-	-	-	-	-	-	50	0.4	0.3
Bahrain	-	-	-	-	-	-	120	0.9	0.7
Turkey	500	0.6	0.5	200	0.7	0.6	60	0.5	0.3
Asia without East Block	4,700	5.4	4.6	3,536	12.0	10.1	2,167	16.8	13.4
Australia	26,000	29.2	25.3	6,400	21.8	18.3	255	2.0	1.6
New Zealand	-	-	-	-	-	-	150	1.1	0.9
Australia and Oceania	26,000	29.2	25.3	6,400	21.8	18.3	405	3.1	2.5
Western World total	89,030	100.0	86.6	29,430	100.0	84.0	12,904	100.0	80.0
Germany DR	-	-	-	65 x)	1.1	0.2	85 x)	2.6	0.5
Poland	-	-	-	-	-	-	110	3.4	0.7
Czechoslovakia	-	-	-	100 x)	1.8	0.3	65	2.0	0.4
Romania	1,000	7.2	1.0	500 x)	8.9	1.4	190	5.9	1.2
Hungary	3,500	25.4	3.4	860	15.3	2.4	70	2.2	0.4
USSR x)	8,300	60.2	8.0	3.700	65.8	10.6	2,400	74.5	14.9
China PR x)	1,000	7.2	1.0	400	7.1	1.1	250	7.8	1.6
Korea, North	-	-	-	-	-	-	50	1.6	0.3
East Block total	13,800	100.0	13.4	5,625	100.0	16.0	3,220	100.0	20.0
World total	102,830	-	100.0	35,055	-	100.0	16,124	-	100.0

x) estimated


PRODUCTION
of
Primary-and Secondary-Aluminium
1976
Part of the Production
Primary-Aluminium World
Secondary-Aluminium Western World
in %
10 - 30
> 30
5 - 10
10 - 30
1 - 5
5 - 10
0,1 - 1
1 - 5
0,1 - 1
Primary-Aluminium-Production
World
1976. 13082900 t
East Block 21,8 % Western World 78,2 %
Other East Block
5,0
USSR
16,8
21,8
78,2
USA
29,5
Other Western Countries
21,3
7,0
Japan
5,3
Germany FR
4,8
Canada
4,8
Norway
2,6
2,9
United Kingdom
France
Secondary-Aluminium-Production
Western World
1976 3 099 600 t
Other Western Countries
112
France
44
Italy
64
United Kingdom
76
Germany FR
111
170
Japan
423
USA
BGR/DIW

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Belgium			
Sté. Belge d'Affinage Lips NV (Affilips)	Tienen	60.0	Roba NV
Affinage du Hainaut, Affinal SA	Tournai	6.0	
SA Coralmetal	Herent	7.0	A. Cohen, B.J. Nijkerk
SA Sibor (Sté. Industrielle du Borinage)	Quaregnon (Hautrage-Etat)	..	
production in 1976		2.6 [1)]	
Germany F.R.			
Alunova GmbH	Wallbach/Krs. Säckingen	2.5	
Metallwerke Bender GmbH	Krefeld-Linn	20.0	
Ing. Franz Bierl	Furth im Wald	7.0	
Ernst Biskupek KG, Aluminium Schmelzwerk, Metallhandel	Hannover	25.0	
Metallhüttenwerke Bruch GmbH	Dortmund	30.0	
Gottschol-Metallwerke, KG	Hagen	6.0	
	Stamet, Berlin	0.4	
Metallwerk Jacobs GmbH	Gelsenkirchen-Schalke	15.0	Klöckner & Co.
Gebrüder Jost, KG	Iserlohn	..	
Karl Konzelmann GmbH	Neu-Ulm-Offenhausen/Donau	3.5	
Metallhütte E. Krähe & Cie.	Asperg	..	
Metallhütte Mark KG	Hamburg	6.0	Klöckner & Co.
	Gelsenkirchen	..	
	Stuttgart		
Aluminiumschmelzwerk Karl Oetinger KG	Weissenhorn	20.0	Metallwerk Oetinger Berlin
	Berlin	7.0	Tempelhof GmbH
Metallwerk Olsberg GmbH, Schmelz- und Hüttenbetriebe	Essen-Katernberg	34.0	Metallgesellschaft
Karl Schmidt Metallschmelzwerk KG	Neckarsulm	18.0	
	Hamburg-Altona	..	
	Werdohl-Eveking	..	
	Papenburg	..	
W. Seibel Metallhüttenwerk	Mettmann	30.0	
Metallwarenfabrik Stockach GmbH	Stockach	20.0	
Vereinigte Aluminium-Werke AG (VAW)	Grevenbroich/Ndrh.	50.0	Vereinigte Industrie-Unternehmungen AG (VIAG), VAW Leichtmetall, Aluminium Norf
	Töging/Inn	10.0	
Westmetall Peters & Co.	Wuppertal-Oberbarmen	..	
Wuppermetall GmbH	Wuppertal-Oberbarmen	18.0	
production in 1976		344.6	
Denmark			
Paul Bergsøe & Søn AS	Glostrup	..	Svend Bergsoes Glostrup Fond, Norderk Jern & Metal
Vald Larsens Metalvaerk A/S (Scandinavian Aluminium Smelters Ltd.)	Copenhagen-Valby	10.0	
production in 1976		9.0 [x)]	
France			
Affimet	Compiègne (Oise)	65.0	Pechiney-Ugine-Kuhlman (60%), Peñarroya (40 %)
	Dammarie-les-Lys (Seine et Marne)	..	
Affinerie & Carosserie Industrielle de Bezons	Bezons	2.0	
Bousségui Affinage	Saint-Fons	..	
Affinerie de la Bresle	Saint Quintin	1.5	
	Lamotte	..	
Sté. Francaise de RécuPération Métallurgique	Blanc-Mesnil (Seine et Oise)	..	
A. Jullien	Ollioules	..	
Lemmet	Drancy	..	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/ company	location	capacity 10^3 tpy	major shareholders
France (continued)			
E. Lenne	Villeurbanne	..	
Affinerie du Loiret	Fontenay S/Loing	..	
Léon Mazelier & Cie.	Valenciennes	..	
Métauxblancs SA Usines Métallurgiques	St. Louis	..	Weissmetall AG (Switzerland)
Ets. Sadillek	Ivry	..	
SA Vanhove & Fils	Sequeden	..	
production in 1976		137.0	
United Kingdom			
Alcan Enfield Alloys	London Colney) Bradford)	35.0	Enfield Rolling Mills (Aluminium), Alcan Aluminium (UK)
Aldec	West Bromwich	20.0	Hampson Industries
Aluminium Alloys (Coventry)	Exhall	3.0	
J. Bell (Wirral)	Wirral	..	
B.K.L. Alloys	Telford	45.0	GKN Group
	Kings Norton	33.0	BKL Fittings, Midland Extrusions, Reliable Anodising, Scope Aluminium Products
Blackwell's Metallurgical Works	Liverpool	2.0	BOC
British Oxygen Co.	Sheffield	..	
British Aluminium Co.	Warrington	20.0	Reynolds Metals Co., Tube Investments
A. Cohen & Co. Ltd.	London) Glasgow)	3.0	A. Cohen group companies in S.Africa, Australia, etc.
Coleshill Aluminium	Coleshill	7.0	
Hugh H. Fisher	Stevenage	..	
J. Frankel (Aluminium)	Cannock	30.0	
International Alloys	Aylesbury) Minworth)	50.0	Alcoa Britain
International Refining Co.	London	..	Maryland Alloys
	Wolverhampton	..	Non-Ferrous and Stainless Stockholders
	Bradford		
H. Landseer-Bailey	Mitcham	5.0	
London & Scandinavian Metallurgical Co.	Rotherham	..	Metallurg Inc.
Lowland Aluminium	Hamilton	3.5	Aldec, C.W. Ireland
Maryland Alloys	Stratford) Wolverhampton) Bradford)	1.0	International Refining Co.
Metal Alloys (South Wales)	Pontypridd	..	
Metallic Extractors (Non-Ferrous)	Water Orton	20.0	
Mountstar Metal Corp. Ltd.	Biggleswade	0.75	Amalgamated Metal Corp.
Norton Aluminium Products	Cannock	1.5	Concentric Ltd.
Rees Industries Foundry Co.	Bynea, Llanelli	..	
Sillavan Special Alloys	Macclesfield	..	Leigh & Sillavan
Tame Valley Alloys	Wilnecote	35.0	Tom Martin Group of Companies
B.A. Taylor (Metals)	West Bromwich	5.0	
Trent Alloys (Repton)	Derby	..	
Wolverhampton Metal	Wednesfield	8.0	IMI (Refinery) Holdings
production in 1976		205.8	
Ireland			
P. Carney Ltd.	Crosskiel, Kells	5.0	
production in 1976		.	
Italy			
Alcan Alluminio Italiano SpA	Borgo franco d'Ivrea	20.0	Alcan Aluminium
Raffineria Metalli Capra SpA	Castel Mella (Brescia)	..	
Fratelli Dionigi & C., Metalli SRL	Novate Milanese	..	
FIAT SpA	Turin	50.0	

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Italy (continued)			
Fonderia Industriale Alluminio Sas (FINDAL)	Ambivere	12.0	
Flam SpA	Gallarate	..	
FOMB Fonderie Officine Maifrini Brescia	Brescia	..	
Fratelli Madrigali di Lino & Mario	San Lazzaro di Savena	..	
C.L.Malesci & C. SpA	Caselle Torinese (Fraz. Mappano)	..	
Metalsa, Stà. Metallurgica per Azioni	Cornaredo (Milan)	26.0	Cofermet Metalli SpA Cofermet Accial SpA
Fratelli Pirola SNC	Milan	..	
Guiglelmo Pedrinelli Raffineria Metalli Non-Ferrosi	Biassono (Milano)	..	
Luigi Premoli & Figli SRL	Rovello Porro	..	
Rifometal SpA	Turin	12.0	
Raffineria Metalli Fonderia Riva SRL	Parabiago (Milan)	..	
A. Tonolli & C. SpA	Paderno Dugnano) Pieve Vergonte (Novara)) Turin)	30.0	
Carlo Vedani	Milan	9.0	
G. Veglio & C.	Turin	25.0	
Dott. Giordano Vitali SpA	Pantanedo di Rho (Milan)	20.0	
production in 1976		198.0	
Luxembourg			
Alcnilux SA	Clervaux	1.5	
production in 1976		1)	
Netherlands			
Alcu Metaal BV	De Meern	1.0	
Broder NV	Haarlem	..	
Aluminium Hardenberg BV	Hardenberg	10.0	Klöckner & Co.
production in 1976		38.5	
Finland			
Kuusakoski Oy	Kauklahti	5.0	Oy Moser Ab, Ramutus Oy
production in 1976		6.1	
Yugoslavia			
Mariborska Livarna	Maribor	..	state-owned
production in 1976		15.3	
Norway			
Aluminiumsmelteriet A/S	Lörenskog, near Oslo	4.0	Bergmetall A/S
Høvding Skipsopphugging	Sandenssjoen	..	Høvding Shipping A/S Sandessjøen Slip og Mek. Versted A/S
A/S Rastoff	Lierskogen	..	
A/S Stavanger Tinfabrik	Stavanger	3.0	
Vestlandske Metal-Verk A/S	Bergen	3.0	O.M. Titlestad A/S
K. Vetlesen & Co.	Skien	..	
production in 1976		6.0	
Austria			
Almeta J. Janu & Co. OHG	Sollenau	6.0	
Boschan & Co. Metallhütte Liesing	Vienna	15.0	Gebrüder Boschan
production in 1976		8.5	

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Sweden			
Paul Bergsöe & Son	Landskrona	2.0	Svend Bergøes Landskrona Fond Oy Bera (Finland)
Gränges Aluminium	Avesta	..	Gränges
Oscar Hirschs Metall AB	Stockholm	10.0	
AB Gotthard Nilsson	Almhult	20.0	
Olof Manner A/B	Mölndal	15.0	
production in 1976		24.0	
Switzerland			
Alvico SA	Lausanne	..	Alvico GmbH (Germany F.R.)
Metallwerke Refonda AG	Zürich	25.0	Alusuisse
production in 1976		18.6	
Spain			
Productos Agma SA	Villafranca del Panadés	4.0	
	Monjos	4.0	
Metales Ibérica Aranzadi SA	Lamiaco-Lejona	..	
Remetal SA	Bilbao	15.0	Endasa (33 %), Alugasa (33 %)
production in 1976		40.0	
India			
Bengal Ingot Co.	Calcutta	3.0	A. Cohen & Co.
Bharat Metal Works	Bombay	..	
Bombay Metal & Alloys Mfg. Co.	Magazon	..	
Eyre Smelting Private	Calcutta	2.0	Lead Industries Group Ltd. (UK)
	Madras	..	
Indian Smelting & Refining Co.	Bhandup	..	
Indian Standard Metal Co. Ltd.	Bombay	..	Tata Group
	Madras	..	Unval Industries Ltd.
production in 1976		.	
Israel			
Non-Ferrous Metal Works	Petah Tiqva	0.6	Non-Ferrous Metal Works (Natal) Pty. (South Africa)
production in 1976		.	
Japan			
KK Aluminium Kogyo	Osaka	2.0	
Amino Metal Co. Ltd.	Taito-ku (Tokyo)	15.0	
Asahi Aluminium Industrial Manufactory KK	Yao (Osaka Pref.)	2.5	
Asuka Industries Inc.	Aichi-ken	10.0	
Chiyoda Light Alloys Co. Ltd.	Tokyo	1.5	
KK Dai-ei Aluminium Industrial Plant	Higashi-Osaka-shi (Osaka Pref.)	12.0	
KK Daiki Aluminium Industrial Plant	Yao-shi (Osaka Pref.)	45.0	Showa-Aluminium
	Tochigi	36.0	Daihaku Aluminium
Daishin Light Metal Co. Ltd.	Kita-adachi-gun (Saitama Pref.)	25.0	Kanematsu-Gosho
	Sakai (Osaka Pref.)	..	Furukawa Aluminium
Fukuoka Aluminium Co. Ltd.	Chiyoda-ku (Tokyo)	10.0	
Fuso Light Alloys Co.	Tokyo	15.0	Nippon Light Metal
	Hamamatsu (Shizuoka Pref.)	..	A. Takahashi Co.
	Kita-adachi-gun (Saitama Pref.)	..	
Kansai Aluminium Alloy	Iga-Veno	60.0	NLM, Daishin Light Metal, Marvi Metal

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Japan (continued)			
Kinki Metal Works	Kobe	..	Mitsubishi Metal Corp.
KK Kyoei Aluminium	Nagoya	2.0	
Maeda Metal Industry Ltd.	Tokura-machi (Nagano Pref.)	2.5	Mitsubishi
KK Naniwa Light Metal Industrial Plant	Yao (Osaka Pref.)	1.1	
Sekimei Light Metal Industry	Nagoya	1.0	
Shikishima Aluminium KK	Hirakara Cibey (Osaka)	20.0	Nippon Light Metal Osaka Aluminium
Shimonoseki Saisei Co. Ltd.	Shimonoseki (Yamaguchi Pref.)	5.0	
Shin Toyo Metal Industry	Osaka	10.0	
Showa Metal Industry KK	Ohta-ku (Tokyo)	..	Showa group
Taishin Light Metal Co. Ltd.	Sakai Saitama	.. ..	
Tajima Aluminium Industrial Mftry. KK	Nishi Yodogawa-ku (Osaka)	..	
A. Takahashi & Co. Ltd.	Chuo-ku (Tokyo)	..	
production in 1976		525.9	
Korea (South)			
Hankook Kaiser Aluminium Co. Ltd.	Seoul	..	Kaiser Aluminium (33 1/3 %) Jung Sup Oh (33 1/3 %) Shinjin Motors (33 1/3 %)
Sunhak Aluminium Co. Ltd.	Taegu	2.0	Sanbong Aluminium Co.
production in 1976		.	
Turkei			
Rabak Elektrolitik Bakir ve Mamulleri A/S	Kösekoy Izmit	5.0	Etibank
production in 1976		.	
Egypt			
General Co. for Metals	Abbasio-Cairo	..	
Helwan Co. for Non-Ferrous Metals and Military Products	Ein Helwan-Cairo	..	
production in 1976		.	
South Africa			
H.H. Benesel (Pty.)	Alberton (Transvaal)	..	
Metal & Chemical Industries (Pty)	Heriotdale (Transvaal)	2.0	
Metals & Residues (Pty.)	Benoni (Transvaal)	..	A. Cohen & Co.
Metal Sales Co. (Pty.)	Benoni (Transvaal)) Pinetown (Durban)) Cape Town)	8.0	
Modern Alloys	Alberton (Transvaal)	..	A. Cohen & Co.
M. & R. Metal Refiners (Pty.) Ltd.	Alberton (Transvaal)	3.0	A. Cohen & Co.
National Scrap Metals (Pty.)	Alberton (Transvaal)	..	A. Cohen & Co.
Non-Ferrous Metal Works (Natal) (Pty.)	Jacobs (Durban)	2.0	Non-Ferrous Metal Works (Israel)
South African Smelting Works (Pty.)	Industria (Transvaal)	0.2	
Supreme Aluminium & Brass Co.	Benoni (Transvaal)	..	A. Cohen & Co.
Supreme Metal Works (Pty.) Ltd.	Industria (Transvaal)	2.0	A. Cohen & Co.
production in 1976		6.0[x)]	
Rhodesia			
Metal Sales Co. (Rhodesia)	Salisbury Bulawayo	..	Metal Sales Co. (S. Africa)
Non-Ferrous Metal Works (Rhodesia)	Salisbury	0.8	Non-Ferrous Metal Works (Natal)
production in 1976		.	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Zambia			
Non-Ferrous Metal Works (Zambia)	Ndola	0.5	Non-Ferrous Metal Works Establishment (Liechtenstein)
production in 1976		.	
Argentina			
Cia. Sudamericana de Industria y Comercio SA (Insud)	San Justo	1.5	Mauricio Hochschild Saic (Chile)
Sacima Saic	Partido San Martin	0.25	A. Cohen & Co. Ltd. (UK), Evans Thornton & Cia. (Argentina)
Refineria Metales Uboldi y Cia. SA	Buenos Aires	..	
production in 1976		9.5	
Brazil			
Alcan Aluminio do Brasil SA	Utinga (São Paulo)	22.0	Alcan Aluminium, Aluminio do Brasil Nordeste SA
Bera do Brasil	Santo Amaro	5.0	East Asiatic Co. (Denmark), Paul Bergsøe & Søn (Denmark)
Caribé da Rocha	Poá	4.0	
Enka SA, Metais e Ligas	São Paulo	1.5	
Faé Industria e Comercio de Matais	São Paulo	3.0	
A. Tonolli SA Industria e Comercio de Metais	São Paulo	..	Tonolli group
production in 1976		28.0	
Canada			
H. Bernard (Canada)	West Hill (Ontario)	..	H. Bernard Ltd. (UK)
Federated Genco	Scarborough	..	Federated Metals Canada (Asarco) (60 %), Canadian Electrolytic Zinc (40 %) (Noranda)
	Lachine	..	
	Burlington		
Laprairie Smelters	Laprairie	..	
Liberty Smelting Works (1962)	St. Jerome	3.5	Diversified Industries Inc.
Metals & Alloys Co.	Toronto	30.0	
Tonolli Co. of Canada	Mississauga	..	Tonolli Corp. (USA)
United Smelting & Refining	Hamilton	..	Usarco Ltd.
Z. Wagman & Son	Weston (Ont.)	..	
production in 1976		33.6	
Columbia			
Ciá Metalúrgica Bera de Colombia SA	Cali (Valle)	1.0	East Asiatic Co. (Denmark) Paul Bergsøe & Søn (Denmark)
production in 1976		.	
Peru			
Bera del Perú SA	Lima	1.0	Cerno Corp. Paul Bergsøe & Sø
production in 1976		.	
Puerto Rico			
American Merchant Inc.	Caguas	..	Puerto Rico Smelting Corp.
production in 1976		.	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
United States			
Abasco	Addison (Texas)	..	
Aetna Metals Co.	City of Industry (Calif.)	..	
Alan-Barr Aluminum	Palmyra, (Pa.)	..	
Alcan Aluminum	Joliet (Ill.)	..	Alcan
Alexandria Metallurgical Corp.	Alexandria (La.)	..	
Alpha Metals	Jersey City (NJ)	..	
	Los Angeles (Calif.)	..	
Aluminum Billets Inc.	Niles (Ohio)	45.0	Easco Corp.
	South Amboy (NJ)	30.0	
Aluminum Co. of America	Cressona (Pa.)	..	
	Davenport (Ia.)	..	
	Lafayette (Id.)	..	
	Los Angeles (Calif.)	..	
Aluminum Smelting and Refining Co.	Maple Heights (Ohio)	60.0	
American Alloys Corp.	Kansas City	..	
Anaconda Aluminum Co.	Miami (Fla.)	..	Anaconda Co.
Apex Smelting Co.	Chicago)		Alumax
	Cleveland)		
	Long Beach)	120.0	
	Checotah)		
	Springfield	20.0	
Associated Metals Co. of Oakland	Oakland (Calif.)	5.0	
Atlantic Metals Corp.	Philadelphia (Pa.)	..	
Aurora Refining Co.	Aurora (Ill.)	0.5	
Barmet Industries Inc.	Akron	..	Alumaline Ore, Minerals Processing Inc., Exochem Inc.
	Ulrichsville	..	
Batchelder-Blasius	Spartanburg	11.0	
	Wellford		
Batchelder (Charles) Co.	Botsford	..	
Bay Billets	Sandusky (Ohio)	22.5	Vulcan Materials Co.
Bay State Aluminum Co.	Braintree (Mass.)	..	
Bay State Refining Co.	Chicopec Falls (Mass.)	..	
Joseph Behr & Sons	Rockford (Ill.)	..	Behr Iron & Steel Co.
Belmont Smelting & Refining Works	Brooklyn (NY)	1.5	
Berman Bros. Iron & Metal Co.	Birmingham (Ala.)	..	
Bradley Metal Co.	Cleveland (Ohio)	..	
Briel Industries	Shelbeyville (Ky.)	36.0	
W. J. Bullock	Birmingham (Ala.)	..	
Capitol Products Corp.	Mechanicsburg (Pa.)	..	Ethyl Corp.
Carroll (Donald) Metals	Bensenville (Ill.)	..	
Cleveland Electro Metals Co.	Cleveland (Ohio)	6.0	Keystone Metal Co.
Jon Chersky & Sons	Los Angeles (Calif.)	..	
Commercial Metals Co.	Munford (Ala.)	..	
Culp Smelting & Refining Co. Inc.	Steele (Ala.)	..	Culp Iron & Metal Co. Inc.
Diversfied Industries Inc.	Hazelwood	..	
	Cucamonga	..	
	Tamaqua	..	
J. R. Elkins	Brooklyn (NY)	..	
Excel Smelting Corp.	Memphis (Tenn.)	3.5	
Federated Metals	Perth Amboy (NJ)	..	Asarco
Fitzpatric (R.J.)	Seymour (Ind.)	..	
Garfield Co.	Berea (Ohio)	..	
General Metals Refining Co.	Gardena (Calif.)	..	
General Smelting Co.	Philadelphia (Pa.)	70.0	Wabash Smelting
Gettysburgh Foundry Specialties Co.	Gettysburgh (Pa.)	3.0	
Globe Metals Co.	Oakland (Calif.)	..	
Goldberg Metal Refining Corp.	Gardena (Calif.)	..	
Grand Rapids Smelting	Grand Rapids (Mich.)	..	
Gulf Reduction Corp.	Houston (Texas)	..	
Hall Aluminum Co.	Chicago (Ill.)	10.0	
Harco Aluminum	Chicago (Ill.)	8.0	
Henning Bros. & Smith	Brooklyn (NY)	..	
H. & H. Metals Co.	Louisville (Ky.)	..	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
United States (continued)			
Hi-Duty Alloys Corp.	Seattle (Wash.)	..	
Holtzman Metal Co.	St. Louis (Mo.)	..	
Infeld Metals Co.	Waterbury (Conn.)	..	
Intercontinental Alloys Corp.	Joliet (Ill.)	14.0	Alcan (50 %)
Jersey Billets	S. Amboy (NJ)	27.0	Easco Corp.
Kaiser Aluminum	Ravenswood (W. Va.)	..	
M. Kimerling & Sons	Birmingham (Ala.)	5.0	US Gypsum Corp.
R. Lavin & Sons	Chicago	..	North Chicago Refiners & Smelters
Lee Aluminum Processing Corp.	Sandford (N.C.)	..	
Lissner Corp.	Chicago (Ill.)	..	
Materials Reclamation Co.	Seattle (Wash.)	6.0	
McGowan Co.	Los Angeles (Calif.)	..	
Metallurgical Products Co.	West Chester (Pa.)	..	
Metropolitan Metal Co.	Detroit (Mich.)	2.5	
Michigan Standard Alloys	Benton Harbour (Mich.)	40.0	
Milward Alloys	Lockport (N.Y.)	..	
Monarch Aluminum Manufacturing Co.	Cleveland (Ohio)	..	
Morris P. Kirk & Son	Los Angeles (Calif.)	..	NL Industries
	Fresno (Calif.)	..	
	Emeryville (Calif.)	..	
	Phoenix (Ariz.)	..	
	Portland (Ore.)	..	
	Seattle (Wash.)	..	
	Salt Lake City (Ut.)	..	
North American Smelting & Co.	Wilmington (Del.)	14.0	
Northwestern Metal Co.	Lincoln (Neb.)	4.0	
Oakwood Billets	Niles (Ohio)	27.0	Easco Corp.
Ogden Metal Corp.	Wabash (Ind.)	..	
	Cleveland (Ohio)	..	
	Brook Park (Ohio)	..	
Ohio Valley Aluminum Co.	Shelbyville (Ky.)	..	
Paragon Smelting Corp.	Long Island City (NY)	..	
Precision Extrusions	Bensenville (Ill.)	..	
Progressive Metals Co.	Gardena (Calif.)	..	
Rayclau Corp.	Mount Pleasant (Tenn.)	..	
Reynolds Metals Co.	Listerhill (Ala.)	45.0	
	Bellwood (Va.)	30.0	
Rochester Smelting & Refining Co.	Rochester (NY)	10.0	
Roth Bros. Smelting Corp.	East Syracuse (NY)	20.0	
Russell Anaconda Aluminum Inc.	Miami (Fla.)	..	Anaconda Co.
	Meridian (Miss.)	..	Robert Russell Metals Inc.
George Sall Metals Co.	Philadelphia (Pa.)	25.0	Diversified Industries
I. Schumann Co.	Cleveland (Ohio)	..	
M. Seligman & Co.	Chicago (Ill.)	..	
S-G Metals Industries	Kansas City	47.5	National Compressed Steel Corp.
Shieldalloy Corp.	Newfield (NJ)	..	Metallurg Alloy Corp.
Sitkin Smelting & Refining	Lewistown (Pa.)	..	Sitkin-Midland Inc.
Tomke Aluminum Co.	Baltimore (Md.)	..	United Iron & Metal Co. Inc.
Tower Metals & Ore	Aurora (Ill.))		
	Fort Scott (Kan.))	22.0	Tang Industries
	Osmego (Kan.))		
US Reduction Co.	East Chicago (Ind.))		
	Aurora (Ill.))		
	Toledo (Ohio))		
	Fontana (Ill.))	149.0	Continental Can Co. Inc.
	Alton (Ill.))		
	Russellville (Ala.))		
	Marietta (Pa.))		
Hyman Viener & Sons	Richmond (Va.)	..	
Vista Metals Corp.	Fontana (Calif.)	..	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
United States (continued)			
Vulcan Materials Co., (Aluminum & Magnesium Div.)	Corona (Calif.)) Sandusky (Ohio)) Oak Creek (Wis.)) Hot Springs (Ark.))	30.0	
Wabash Smelting Inc.	Wabash (Ind.)	60.0	Ogden Metals Corp. General Smelting Co.
production in 1976		1.311.8	
Venezuela			
Bera de Venezuela	Guacara	..	East Asiatic Co., Paul Bergsøe & Søn
Fundiciones y Manufacturas de Metal Tecnolet CA	Boston (La California Sur) Miranda	..	
production in 1976		1.8	
Australia			
Alcan Australia	Granville (NSW)	3.0	Alcan Aluminium Alcote Distributors
Consolidated Metal Products Pty.	Sydney Melbourne	.. ..	Sime Consolidated
Nonferral Pty.	Keon Park (Vic.) Lidcombe (NSW) Adelaide (SA)	11.0	A. Cohen & Co. (80 %), Comalco (20 %)
Residues Refineries Pty.	Melbourne	..	Affinity Residues Pty., Alucol Metal Refining
Sims Consolidated	Sydney) Melbourne) Adelaide)	25.0	Simsmetal Pty., Consolidated Metal Products, New Zealand Metal Products, Bryant Bros.
production in 1976		30.0[2)]	
New Zealand			
Bryant Bros.	Petone	0.1	NZ Metal Products Ltd. (Sims Group)
Hayes Metal Refineries Ltd.	Auckland	..	
Ingot Metals Ltd.	Auckland	0.2	
McKechnie Brothers (NZ)	New Plymouth	..	Mc Kechnie Brothers
Metalco (Metallurgical Co. of NZ Ltd.)	Te Papapa (Auckland)	..	
Rolmet Ingot Co.	Christchurch	1.0	
production in 1976		3)	
Germany DR			
Berliner Metall und Halbzeug Werke (BMHW)	East-Berlin	..	state-owned
VEB Elektrochemisches Kombinat	Bitterfeld Aken Stassfurt	54.0	state-owned
production in 1976		.	
Poland			
Zaklady Hutniczo-Przetworcze Metali Niezelaznych "Hutmen"	Wroclaw	..	state-owned
production in 1976		.	
Romania			
Neferal Metallurgical Enterprise	Branesti	18.0	state-owned
production in 1976		.	

Annex 6

World Capacity for the Production of Secondary Aluminium and Production Figures According to Country in 1976

country/company	location	capacity 10^3 tpy	major shareholders
Czechoslovakia			
Bridlicna Remelting Works	Bridlicna (Northern Moravia)	..)	
Kamenice Remelting Works	Kamenice (nr. Jihlava, Central Bohemia)	)	
Prague Remelting Plants	A number of scrap remelting plants near Prague	)	state-owned
Sumperk Remelting Works	Sumperk (Northern Moravia)	..)	
Velvary Remelting Plant	Velvary (Central Bohemia)	..)	
production in 1976		.	
USSR			
Leninogorski Kombinat	Leninogorski (Kazakhstan))	)	
Achisaiski Kombinat	Achisaiski (Kazakhstan))	)	
Moscow Kombinat	Moscow)	100.0)	state-owned
Leningrad Kombinat	Leningrad)	)	
Cheliabinsk Kombinat	Cheliabinsk)	)	
production in 1976			
Hungary			
Székesfehérvár Light Metal Works	Székesfehérvár	80.0	state-owned
production in 1976		.	

1) including Luxembourg,

2) including New Zealand,

3) including in the figure for Australia. x) estimate

Source: World aluminium survey, Metal Bulletin 1977

Annex 7

Foreign Trade of Selected Western Industrial Countries: Old and Scrap Aluminium and Aluminium Alloys - 1966 to 1976
(gross weight in t)

		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium/Luxembourg	import	1,793	1,729	2,940	4,778	6,461	6,920	12,997	18,810	18,138	14,777	19,073
	export	8,417	9,897	12,284	13,610	13,799	13,295	17,507	20,171	20,176	18,096	32,127
	net import	-	-	-	-	-	-	-	-	-	-	-
	net export	6,624	8,168	9,344	8,832	7,338	6,375	4,510	1,361	2,038	3,319	13,054
Germany FR	import	50,848	49,719	67,091	80,716	67,377	58,947	85,956	86,440	77,169	92,626	102,532
	export	6,858	7,554	7,786	6,757	11,881	15,288	17,281	29,519	31,756	31,500	49,388
	net import	43,990	42,165	59,305	73,959	55,496	43,659	68,675	56,921	45,413	61,126	53,144
	net export	-	-	-	-	-	-	-	-	-	-	-
France	import	7,119	5,955	5,523	14,783	13,847	14,991	23,079	30,600	27,201	25,192	31,735
	export	15,243	16,859	16,160	14,819	24,103	25,344	24,664	21,689	20,570	22,297	30,605
	net import	-	-	-	-	-	-	-	8,911	6,631	2,895	1,130
	net export	8,124	10,904	10,637	36	10,256	10,353	1,585	-	-	-	-
United Kingdom	import	16,237	14,132	12,985	13,142	15,471	11,888	13,928	20,697	22,220	13,670	17,250
	export	7,609	2,036	1,617	1,315	1,886	2,084	2,994	3,455	13,033	16,720	7,021
	net import	8,628	12,096	11,368	11,827	13,585	9,804	10,934	17,242	9,187	-	10,229
	net export	-	-	-	-	-	-	-	-	-	3,050	-
Italy	import	53,179	64,867	43,791	54,933	62,192	53,541	59,605	63,256	65,586	53,289	72,470
	export	231	94	263	145	188	69	725	722	733	719	1,334
	net import	52,948	64,773	43,528	54,788	62,004	53,472	58,880	62,534	64,853	52,570	71,136
	net export	-	-	-	-	-	-	-	-	-	-	-
Netherlands	import	3,884	4,588	8,784	9,612	10,898	9,790	18,285	20,856	16,744	24,728	28,341
	export	11,734	10,216	11,832	16,808	14,382	20,033	31,966	30,664	37,925	32,980	48,510
	net import	-	-	-	-	-	-	-	-	-	-	-
	net export	7,850	5,628	3,048	7,196	3,484	10,243	13,681	9,808	21,181	8,252	20,169
Norway	import	580	299	587	53	27	-	-	1,226	168	35	35
	export	1,850	3,788	5,588	6,745	5,313	4,840	6,630	8,923	12,805	8,472	10,148
	net import	-	-	-	-	-	-	-	-	-	-	-
	net export	1,270	3,489	5,001	6,692	5,286	4,840	6,630	7,697	12,637	8,437	10,113
Austria	import	1,976	2,914	2,364	4,050	6,624	10,061	37,381	31,899	17,795	14,120	24,145
	export	5,452	5,899	9,184	8,238	7,154	11,083	31,955	37,018	19,644	20,073	30,419
	net import	-	-	-	-	-	-	5,426	-	-	-	-
	net export	3,476	2,985	6,820	4,188	530	1,022	-	5,119	1,849	5,953	6,274

Annex 7 continued

Foreign Trade of Selected Western Industrial Countries: Old and Scrap Aluminium and Aluminium Alloys - 1966 to 1976
(gross weight in t)

		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Sweden	import	239	1,091	2,133	2,231	2,132	1,380	1,525	4,160	1,947	1,140	1,179
	export	731	1,451	963	552	2,011	2,125	1,144	2,164	1,796	1,250	1,817
	net import	-	-	1,170	1,679	121	-	381	1,996	151	-	-
	net export	492	360	-	-	-	745	-	-	-	110	638
Switzerland	import	.	.	.	.	.	.	.	.	.	.	.
	export	3,451	3,791	4,443	5,969	6,547	8,683	8,749	9,742	11,669	10,263	14,091
	net import	.	.	.	.	.	.	.	.	.	.	.
	net export	.	.	.	.	.	.	.	.	.	.	.
Spain	import	203	99	8	111	4	1,084	3,738	3,453	4,439	4,319	2,861
	export	140	113	193	147	77	74	115	68	264	2,662	215
	net import	63	-	-	-	-	1,010	3,623	3,385	4,175	1,657	2,646
	net export	-	14	185	36	73	-	-	-	-	-	-
Japan	import	19,094	20,845	23,939	18,962	10,832	12,452	37,287	48,296	24,823	29,165	69,304
	export	-	-	-	2	228	270	150	496	1,219	404	752
	net import	19,094	20,845	23,939	18,960	10,604	12,182	37,137	47,800	23,604	28,761	68,552
	net export	-	-	-	-	-	-	-	-	-	-	-
United States	import	30,496	27,659	34,038	26,172	33,366	57,076	47,446	42,464	67,773	49,720	77,758
	export	44,155	49,500	44,905	78,421	51,896	27,828	59,910	104,435	72,719	60,691	98,845
	net import	-	-	-	-	-	29,248	-	-	-	-	-
	net export	13,659	21,841	10,867	52,249	18,530	-	12,464	61,971	4,946	10,971	21,087
Canada	import	21,234	8,659	14,772	14,133	5,201	5,819	7,421	10,286	5,836	7,650	9,136
	export	41,522	48,343	47,232	47,098	42,014	43,740	54,000	51,599	53,040	42,411	51,099
	net import	-	-	-	-	-	-	-	-	-	-	-
	net export	20,288	39,684	32,460	32,965	36,813	37,921	46,579	41,313	47,204	34,761	41,963
Australia	import	952	1,492	870	766	779	662	724	3,191	2,589	1,154	1,100 x)
	export	1,483	1,144	2,069	3,742	1,766	2,953	2,574	1,037	1,171	2,720	6,100 x)
	net import	-	348	-	-	-	-	-	2,154	1,418	-	-
	net export	531	-	1,199	2,976	987	2,291	1,850	-	-	1,566	5,000

Average Monthly Aluminium Prices (Virgin Ingots) for 1966 - 1977

("World prices" i.e. producers list prices, and "certain other transactions" i.e. free market prices according to "Metal Bulletin", London)

	"World price" cts/lb	- ditto - US-$/m.t.	"Certain other transactions" US-$/m.t.
1966/1	24,50	540,13	473,29
2			463,28
3			447,07
4			447,07
5			459,63
6			466,82
7			480,29
8			494,70
9			496,87
10			498,58
11			506,84
12			506,65
1967/1			506,80
2			507,38
3			507,76
4			512,60
5			510,61
6			509,61
7			477,28
8			461,62
9			458,17
10			459,26
11			448,01
12			449,19
1968/1			444,15
2			444,72
3			443,27
4			440,92
5	↓	↓	424,21
6	25,30	557,76	451,18
7	25,50	562,17	459,73
8			461,74
9			461,74
10			463,71
11			479,88
12	↓	↓	489,18

Average Monthly Aluminium Prices (Virgin Ingots) for 1966 - 1977
("World prices" i.e. producers list prices, and "certain other transactions" i.e. free market prices according to "Metal Bulletin", London)

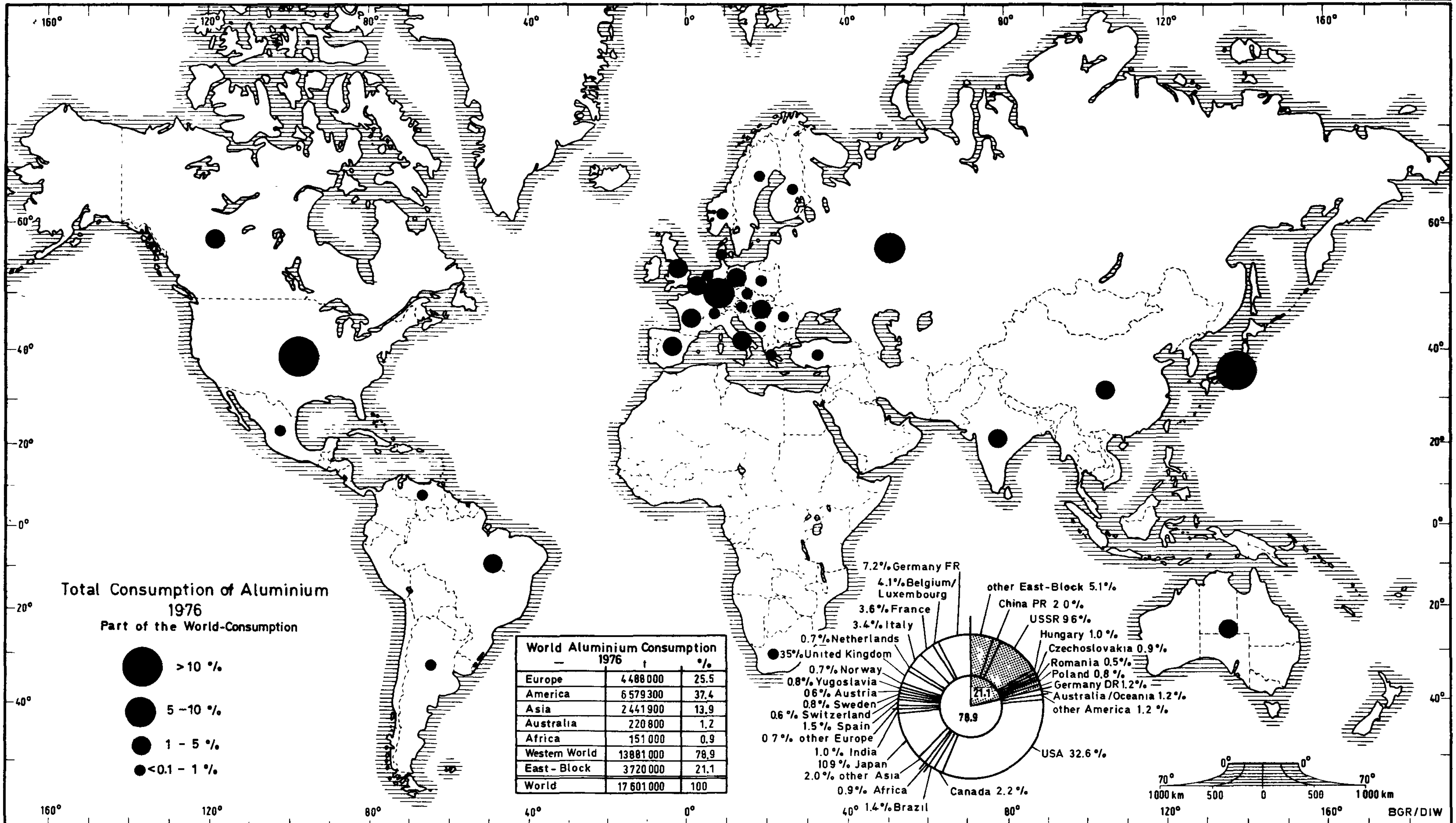
	"World price" cts/lb	- ditto - US-$/m.t.	"Certain other transactions" US-$/m.t.
1969/1	25,85	569,89	503,90
2	26,50	584,22	533,25
3	↓	↓	544,35
4	↓	↓	561,90
5	↓	↓	585,31
6	↓	↓	589,26
7	↓	↓	592,23
8	↓	↓	606,71
9	↓	↓	609,00
10	27,20	599,65	610,27
11	27,50	606,27	615,72
12	↓	↓	615,72
1970/1	↓	↓	604,78
2	↓	↓	601,18
3	↓	↓	588,22
4	27,73	611,33	588,41
5	28,00	617,29	591,36
6	↓	↓	567,56
7	↓	↓	532,84
8	↓	↓	510,56
9	↓	↓	482,96
10	↓	↓	479,48
11	↓	↓	463,88
12	↓	↓	460,25
1971/1	↓	↓	461,47
2	↓	↓	460,61
3	↓	↓	458,11
4	↓	↓	454,00
5	↓	↓	452,63
6	↓	↓	434,12
7	↓	↓	428,26
8	↓	↓	420,35
9	↓	↓	412,79
10	↓	↓	407,34
11	↓	↓	415,59
12	↓	↓	423,62

Average Monthly Aluminium Prices (Virgin Ingots) for 1966 - 1977
("World prices" i.e. producers list prices, and "certain other transactions" i.e. free market prices according to "Metal Bulletin", London)

	"World price" cts/lb	- ditto - US-$/m.t.	"Certain other transactions" US-$/m.t.
1972/1	28,00	617,29	428,77
2	↓	↓	425,45
3	↓	↓	427,84
4	↓	↓	428,04
5	26,06	574,52	429,14
6	25,00	551,15	433,42
7	↓	↓	428,25
8	↓	↓	432,46
9	↓	↓	435,59
10	↓	↓	432,01
11	↓	↓	439,66
12	↓	↓	438,53
1973/1	↓	↓	443,65
2	↓	↓	472,82
3	↓	↓	518,78
4	↓	↓	549,84
5	↓	↓	604,32
6	26,58	585,98	624,57
7	27,50	606,27	698,92
8	27,50	606,27	730,01
9	28,33	624,56	726,04
10	30,00	661,38	782,38
11	↓	↓	855,80
12	↓	↓	922,28
1974/1	↓	↓	861,23
2	32,10	707,68	892,29
3	33,00	727,52	951,35
4	33,00	727,52	1055,99
5	34,04	758,38	1125,81
6	36,00	793,66	1098,94
7	39,00	859,79	1025,43
8	↓	↓	1013,28
9	↓	↓	988,78
10	↓	↓	866,96
11	↓	↓	729,59
12	↓	↓	731,26

Average Monthly Aluminium Prices (Virgin Ingots) for 1966 - 1977
("World prices" i.e. producers list prices, and "certain other transactions" i.e. free market prices according to "Metal Bulletin", London)

	"World price" cts/lb	- ditto - US-$/m.t.	"Certain other transactions" US-$/m.t.
1975/1	39,00	859,79	668,33
2			682,69
3			723,49
4			693,23
5			657,00
6			663,93
7			689,15
8			716,39
9			726,55
10			678,90
11			663,54
12			683,67
1976/1			693,01
2			723,40
3			773,42
4	43,00	947,98	820,50
5			858,25
6			891,48
7			944,44
8	46,64	1028,22	979,38
9	48,00	1058,21	957,81
10			876,94
11			895,28
12			890,00
1977/1			932,50
2			973,13
3			1004,72
4	51,00	1124,35	1021,88
5			1045,56
6			1038,57
7			1038,61
8			1032,19
9			980,56
10			938,44



World Aluminium Consumption 1976	t	%
Europe	4 488 000	25.5
America	6 579 300	37.4
Asia	2 441 900	13.9
Australia	220 800	1.2
Africa	151 000	0.9
Western World	13 881 000	78.9
East - Block	3 720 000	21.1
World	17 601 000	100

Annex 10 a

Breakdown of the Consumption of Aluminium at the First Processing Stage in the Federal Republic of Germany

(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, sheet and strip metal circles, and foil stock	197.3	220.7	229.7[1)]	283.4	333.8	319.0	339.0	352.3	425.6
Press and extrusion products	85.1	96.2	104.9	144.7	182.6	188.6	216.3	237.6	277.3
Wire	28.0	39.3	42.9	41.9	45.4	45.3	54.2	51.3	59.8
Forged products	8.6	9.5	7.6	9.2	10.8	11.2	11.2	11.7	12.4
Cast products	185.9	175.0	152.1[2)]	191.8	232.9	245.0	229.9	229.5	257.3
Al for the iron and steel industry	25.6	23.7	25.6[3)]	32.8	37.3	37.4	33.2	38.4	44.2
Paste	2.5	2.4	1.9	1.4	1.8	2.0	2.1	2.2	2.7
Total deliveries	533.0[4)]	566.8[4)]	570.6[4)]	705.2	844.6	848.5	885.9	923.0	1,079.3
Foil	44.9	51.3	50.3	59.8	69.4	72.0	77.0	83.8	90.5

[1)] including 3,775 t for cable sheathing and 400 t for electrical contact rails

[2)] including 2,215 t for turbine housing

[3)] including 377 t for zinc alloys for galvanizing

[4)] excluding misc.: 1965, 9,201 t; 1966, 13,100 t; 1967, 5,900 t

new breakdown

	1973	1974	1975
Sheet and strip metal, foil stock	296.5	353.3	268.8
Circles and sections	17.3	14.9	13.2
Slugs	21.4	24.0	18.2
Rods, sections	244.9	216.8	198.0
Pipe	28.0	28.7	25.2
Wire and stranded wire	59.8	68.9	59.2
Press and forged products	12.4	10.9	9.7
Total semimanufactures	680.3	717.6	592.3
Cast products	254.0	237.0	213.6
Foil	90,5	94.5	72.8
Powder, flakes, granules	12.6[1)]	12.1[1)]	8.0[1)]
Paste	1.1	0.9	0.8

[1)] partially including paste

Source: OECD: The Non-Ferrous Metals Industry, Paris,

Annex 10 b

Breakdown of the Consumption of Aluminium at the First Processing Stage in France
(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, Sheet and strip metal circles, and foil stock	129.9	152.7	147.8	154.5	186.6	197.8	198.6	215.8	220.4
Press and extrusion products	33.6	37.5	37.9	45.3	57.4	62.4	62.5	76.2	88.5
Wire	22.7	32.4	49.8	50.5	56.0	55.5	62.0	65.0	74.2
Forged products	3.2	3.2	2.9	2.1	2.6	3.2	2.7	3.0	2.5
Cast products	102.7	111.6	112.3	113.3	133.6	147.3	150.6	166.9	182.3
Al for the iron and steel industry	9.9	11.0	17.3	20.3	19.5	17.9	15.3	16.0	20.0
Paste	8.4	9.2	2.2	0.5	0.6	0.7	0.7	0.9	1.0
Total deliveries	310.4	357.6	370.2	386.5	456.3	484.8	492.4	543.8	588.9
Foil	19.5	22.0	23.3	28.0	36.3	40.4	38.1	39.6	44.7

1) Aluminium content of foil stock calculated or estimated according to sales.

new breakdown

	1973	1974	1975
Sheet and strip metal, foil stock	192.4	197.4	153.3
Circles and sections) Slugs)	28.0	28.2	22.9
Rods, sections	75.6	76.6	68.8
Pipe	12.9	15.3	15.5
Wire and stranded wire	74.2	74.4	79.9
Press and forged products	2.5	2.7	2.4
Total semimanufactures	385.6	394.0	342.8
Cast products	182.3	175.6	153.5
Foil	44.7	46.7	17.9
Powder, flakes, granules	8.3	9.8)	8.5
Paste	1.0	1.0)	

Source: OECD: The Non-Ferrous Metals Industry, Paris,

Annex 10 c

Breakdown of the Consumption of Aluminium at the First Processing Stage in the United Kingdom
(1000 t Aluminium)

old breakdown

	1965	1966	1697	1968	1969	1970	1971	1972	1973
Plate, sheet, and strip metal circles, and foil stock [1]	196.2	198.1	168.8	207.0	195.0	178.3	156.4	179.0	223.0
Press and extrusion products	75.5	80.6	103.8	91.2	104.0	101.1	91.6	105.6	127.5
Wire	45.7	48.6	52.7	48.4	40.2	43.7	35.1	36.3	43.5
Forged products	4.3	3.9	4.0	3.9	4.0	3.7	3.8	4.1	3.8
Cast products	120.6	117.5	115.4	127.2	139.1	135.2	132.9	133.7	146.6
Al for the iron and steel industry	11.2	11.5	10.4	13.0	13.1	15.0	12.7	13.4	12.0
Paste	2.5	2.6	2.4	2.4	2.8	2.8	2.1	2.8	2.7
Total deliveries	456.0	462.8	457.5	493.1	498.2	479.8	434.6	474.9	559.0
Foil	31.4	(31.6)	31.8	34.1	35.1	35.0	32.8	35.2	42.7

new breakdown

	1973	1974	1975
Sheet and strip metal, foil stock	198.2	207.7	160.3
Circles and sections	20.2	19.0	17.2
Slugs	4.6	5.1	3.6
Rods, sections	105.1	115.2	96.7
Pipe	20.4	21.3	19.4
Wire and stranded wire	45.5	57.1	50.6
Press and forged products	3.8	3.6	4.1
Total semimanufactures	397.7	429.0	351.9
Cast products	146.6	134.2	120.6
Foil	42.7	44.8	36.2
Powder, flakes, granules	8.8	8.5	5.8
Paste	2.7	3.0	2.0

Source: OECD: The Non-Ferrous Metals Industry, Paris,

Annex 10 d

Breakdown of the Consumption of Aluminium at the First Processing Stage in Italy
(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, sheet and strip metal circles, and foil stock[1)]	75.5	92.0	99.0	118.5	143.0	150.5	134.5	164.0	176.0
Press and extrusion products	28.8	42.0	43.0	51.0	69.0	73.0	68.0	82.5	105.0
Wire	5.7	10.0	9.0	13.5	16.5	22.0	21.0	20.5	14.5
Forged products	0.5	2.0	4.0	0.7	0.8	1.0	0.8	1.0	0.8
Cast products	75.0	98.2	117.0	130.0	144.0	162.0	166.0	175.0	217.0
Al for the iron and steel industry	5.0	6.0	6.9	6.6	6.4	8.1	8.3	11.0	12.6
Paste	2.5	1.8	2.1	2.7	2.3	3.4	3.4	4.0	6.1
Total deliveries	193.0	252.0	281.0	323.0	382.0	420.0	402.0	458.0	532.0
Foil	12.0	(14.0)	(14.0)	15.4	19.5	22.6	21.0	24.3	25.1

1) Aluminium content of foil stock calculated or estimated according to sales.

new breakdown

	1974	1975	1976
Sheet and strip metal, foil stock	143.2	103.0	)
Circles and sections	24.0	20.0	) 189.5
Slugs	12.8	7.0	)
Rods, sections	111.8	81.0	122.3
Pipe	12.7	12.0	15.2
Wire and stranded wire	17.0	18.0	13.0
Preß and forged products	1.0	0.8	.
Total semimanufactures	322.5	241.8	340.0
Cast products	235.0	184.0	.
Foil	28.2	21.2	.
Powder, flakes, granules	14.0	13.0	.
Paste	7.5	6.2	.

Source: OECD: The Non-Ferrous Metals Industry, Paris

Annex 10 e

Breakdown of the Consumption of Aluminium at the First Processing Stage in Austria

(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, sheet and strip metal Circles, and foil stock	26.4	25.4	32.2	32.6	39.2	38.4	35.2	40.3	42.8
Press and extrusion products	0.4	0.5	6.9	6.3	6.8	7.1	6.8	9.6	12.0
Wire	3.4	3.5	2.5	5.6	9.9	12.3	9.8	11.2	11.6
Forged products	-	-	-	-	-	-	-	-	-
Cast products	6.0	6.4	6.1	7.0	9.4	12.7	10.3	9.7	10.8
Al for the iron and steel industry	2.8	2.4	2.2	2.5	2.9	3.2	3.1	3.3	3.9
Paste	2.1	1.3	1.2	0.9	1.5	1.7	0.7	0.3	0.4
Total deliveries	41.1	39.5	51.1	54.9	69.7	75.4	65.9	74.4	81.4
Foil	2.5	4.5	4.5	6.2	7.2	8.1	8.0	10.1	11.8

new breakdown

	1973	1974	1975	1976
Sheet and strip metal, foil stock)	42.8	35.4	36.0	
Circles and sections)		-	2.8	
Slugs			2.1	
Rods, sections	10.7	12.3	11.3	
Pipe	1.3	2.2	2.2	
Wire and stranded wire	11.6	14.9	13.5	
Press and forged products	-	-	-	
Total semimanufactures	66.4	69.9	67.9	86.8
Cast products	10.8	10.5	8.1	9.5
Foil	11.8	13.5	11.6	
Powder, flakes, granules	4.9	4.8	4.1	
Paste	0.4	0.6	0.4	

Source: OECD: The Non-Ferrous Metals Industry, Paris,

Annex 10 f

Breakdown of the Consumption of Aluminium at the First Processing Stage in Switzerland

(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, sheet and strip metal, circles and foil stock	32.6	35.0	41.7	45.4	50.0	54.7	57.1	62.5	65.4
Press and extrusion products	14.3	14.9	21.1	23.5	28.4	30.9	29.7	33.2	38.3
Wire	3.8	2.9	1.8	2.2	2.4	1.6	1.8	2.5	1.5
Forged products	0.2	0.2	0.6	0.7	0.9	1.0	1.0	0.9	0.8
Cast products	3.7	3.7	4.0	3.6	3.7	4.9	5.1	3.6	3.4
Al for the iron and steel industry	0.4	0.3	0.4	0.5	0.4	0.5	0.4	0.4	0.4
Paste	-	-	-	-	-	-	-	-	-
Total deliveries	55.0	57.0	69.6	75.9	85.8	93.6	95.1	103.1	109.8
Foil	3.6	3.9	4.0	4.2	16.6	18.6	19.2	21.4	7.4

new breakdown

	1973	1974	1975
Sheet and strip metal, foil stock	65.4	68.9	56.5
Circles & sections	-	-	-
Slugs	-	-	-
Rods, section	35.4)	) 36.9	) 24.5
Pipe	2.9)	)	)
Wire and stranded wire	1.5	2.4	1.6
Press and forged products	0.8	0.9	0.8
Total semimanufactures	106.0	109.1	83.3
Cast products	3.4	4.3	2.8
Foil	7.4	7.4	5.8
Powder, flakes, granules			
Paste			

Source: OECD: The Non-Ferrous Metals Industry, Paris,

Annex 10 g

Breakdown of the Consumption of Aluminium at the First Processing Stage in Japan

(1000 t Aluminium)

old breakdown

	1965	1966	1967	1968	1969	1970	1971	1972	1973
Plate, sheet and strip metal circles, and foil stock	153.2	195.1	205.3	247.7	300.6	312.6	319.6	384.6	479.1
Press and extrusion products	61.1	99.7	151.6	209.7	316.0	366.5	427.7	551.6	767.8
Wire	7.3	8.6	8.3	9.5	10.2	10.4	11.8		1)
Forged products	0.8	1.1	1.3	1.0	1.1	1.5	1.5	1.8	2.0
Electrical wire	23.5	41.3	50.4	61.4	73.3	87.4	91.2	116.7	151.5
Cast products	117.9	143.8	180.9	233.4	282.9	335.5	335.5	366.5	416.1
Al for the iron and steel industry	12.7	20.1	27.1	35.6	41.9	49.5	57.3	59.2	52.1
Al powder	1.2 x)	2.1 x)	3.0 x)	8.1	8.8	8.7	8.4	6.0	7.4
Total production	377.7	511.8	627.9	806.4	1,034.8	1,172.1	1,253.0	1,486.4	1,876.0

x) estimated

1) listed with electrical wire

new breakdown

	1974	1975
Sheet and strip metal, foil stock	345.4	311.1
Circles and sections	34.8	23.2
Slugs	10.9	9.0
Rods, sections	628.0	575.3
Pipe	25.0	20.1
Wire and stranded wire	102.8	106.8
Press and forged products	2.0	1.5
Total semimanufactures	1,148.9	1,047.0
Cast products	395.5	361.2
Foil	49.9	52.6
Powder, flakes, granules) Paste)	17.5	10.2

Sources: Aluminiumhalbzeug-Verband, Düsseldorf
Metallgesellschaft

Annex 10 h

Breakdown of the Aluminium Consumption in the First Processing Stages in the USA
in 1000 t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
sheet and strip metal, foil	1,362.8	1,528.1	1,504.8	1,775.1	1,944.5	1,926.5	2,069.3	2,468.0	2,955.5	2,891.4	2,115.5	2,877.5
rolled bars, rods, shapes	72.4	68.9	64.9	59.0	65.4	62.7	46.3	82.3	131.3	121.7	84.3)	162.8
wire, uninsulated	37.5	46.8	44.4	45.5	43.0	42.4	43.9	48.3	56.3	59.4	30.1)	
wire and calbe, insulated	58.7	75.0	79.3	97.0	113.6	118.0	143.9	168.3	201.9	202.5	111.6)	283.7
Al & Al-steel cable	194.7	230.3	229.6	223.2	215.5	226.6	218.5	205.8	222.3	247.9	192.8)	
drawn & welded pipe	79.9	86.6	80.2	90.5	86.4	80.2	82.0	95.0	105.2	103.1	57.7	87.2
extrusion products	699.7	779.8	696.4	758.3	812.8	746.6	834.6	967.9	1,090.2	978.3	687.8	884.1
powder & paste	26.7	50.5	106.1	125.4	125.2	92.8	76.0	102.7	116.8	80.4	44.8	60.0
forged products	43.7	63.1	74.9	78.3	71.0	54.6	44.5	55.7	64.6	62.7	44.1	45.5
cast products	639.1	743.9	696.1	720.4	770.2	683.3	715.4	841.7	919.1	798.0	623.9	836.2
total deliveries	3,215.2	3,673.0	3,576.7	3,972.7	4,247.6	4,033.7	4,274.4	5,035.7	5,863.2	5,545.4	3,992.7	5,237.0

Source: Metallstatistik

Annex 11a

Production of Aluminium Semimanufactures in Germany FR; 1965 - 1975

in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Rolling mill products	196,715	220,544	225,372	283,335	333,331	317,902	338,693	351,823	427,737	487,117	374,321
rods, shapes & wire	72,006	83,730	92,072	122,105	152,117	157,188	182,323	210,700	247,868	221,548	200,511
pipes	15,227	14,465	14,336	19,685	23,217	22,806	20,740	21,877	28,019	28,730	25,175
pressed and forged products	8,635	9,460	7,602	9,194	10,839	10,835	11,169	11,646	12,382	10,916	9,669
Extrusion products	96,216	107,655	114,010	150,984	186,173	190,829	214,232	244,223	288,269	261,194	235,355
Al-semimanufactures excluding electrical wire	292,931	328,199	339,382	434,319	519,504	508,731	552,925	596,046	716,006	748,311	609,676
electrical wire	26,023	37,381	41,508	40,629	44,311	45,587	53,908	49,894	54,693	63,768	55,441
Total production	318,954	365,580	380,890	474,948	563,815	554,318	606,833	645,940	770,699	812,079	665,117

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Production of Aluminium Semimanufactures in Belgium/Luxembourg; 1965 - 1975

in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Sheet and strip metal	87,051	106,338	73,699	80,638	93,273	96,084	99,223	110,219	116,226	124,226	97,713
Circles and slugs	5,349	7,028	6,039	5,388	5,554	5,917	6,877	7,936	7,816	7,835	6,004
Rods and shapes	21,997	28,407	30,710	33,107	36,844	35,125	37,710	41,431	49,332	54,828	46,968
Wire	8,868	17,591	19,771	22,827	28,643	25,326	39,703	42,112	47,150	44,596	38,947
Pipes	2,557	2,724	2,375	2,760	2,701	2,346	2,868	3,756	4,325	4,729	4,674
Total production	125,822	162,088	132,594	144,720	167,015	164,798	186,381	205,454	224,849	236,214	194,306

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Annex 11b

Production of Aluminium Semimanufactures in France; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	107,390	124,569	123,355	129,050	155,855	170,024	172,092	189,117	201,363	205,277	165,833
circles and slugs	22,548	28,118	25,985	25,439	30,695	27,806	26,501	26,659	28,403	32,167	24,920
rods and shapes	25,497	28,570	31,185	35,990	46,854	50,409	50,970	63,029	74,970	79,035	73,354
wire	22,747	9,029	8,390	9,321	10,600	12,055	11,495	13,214	15,200	19,658	15,146
pipes	8,053	32,367	51,193	50,502	55,964	55,467	62,014	64,971	66,163	68,372	75,313
pressend and forged products	3,150	3,185	2,949	2,100	2,634	3,195	2,721	2,962	2,446	2,088	2,440
total production	189,385	225,838	243,057	252,402	302,602	318,959	325,793	359,952	388,545	406,597	357,006

Deliveries of Aluminium Semimanufactures in United Kingdom; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	172,841	175,336	168,794	182,920	184,483	167,831	149,812	165,980	198,200	207,669	160,345
circles and slugs	23,327	22,744	22,114	24,107	22,792	23,894	21,166	22,328	24,816	24,079	20,786
rods and shapes	59,594	64,593	67,338	74,768	85,395	83,778	75,787	90,460	106,015	115,967	97,177
pipes	15,924	16,002	14,390	16,477	18,568	17,367	15,778	16,856	20,402	21,266	19,449
wire	45,662	48,652	52,734	48,453	40,170	43,487	35,094	36,285	45,227	52,316	50,581
pressend and forged products	4,255	3,877	3,968	3,849	3,962	3,679	3,832	4,061	3,792	3,609	4,104
total deliveries	321,603	331,204	329,338	350,574	355,370	340,036	301,469	335,970	398,452	424,906	352,442

Production of Aluminium Semimanufactures in Italy; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	77,500	92,000	99,000	98,000	143,000	120,000	106,000	133,500	143,500	143,200	103,000
circles and slugs				20,500		30,500	28,500	30,500	32,500	36,800	27,000
rods and shapes	28,800	42,000	44,400	43,800	69,000	64,200	61,500	75,500	94,000	111,800	77,000
pipes				7,200		8,800	6,500	7,000	11,000	12,700	11,500
wire	5,700	10,000	9,000	13,500	16,500	22,000	21,000	20,500	14,500	17,000	18,000
pressend and forged products	500	400	600	700	800	1,000	800	1,000	800	600	800
total production	112,500	144,400	153,000	183,700	229,300	246,500	224,300	268,000	296,300	322,100	237,300

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Annex 11c

Production of Aluminium Semimanufactures in Netherlands; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
rolling mill products	.	.	.	21,100	31,100	35,000	36,000	43,820	52,700	46,112	37,000
extrusion products	.	.	.	12,300	17,400	22,000	22,000	26,180	42,887	53,000	41,231
total production	22,000	24,000	26,000	33,400	48,500	57,000	58,000	70,000	95,587	99,112	78,231

Production of Aluminium Semimanufactures in Yugoslavia; 1966 - 1975
in t

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet metal	13,633	14,416	17,304	21,286	27,628	.	.	.	36,309	.
strip metal	3,139	4,808	6,613	8,820	8,415	.	.	.	24,811	.
foil (rolled stock)	1,324	1,222	811	722	1,634	.	.	.	2,004	.
circles and slugs	1,474	1,327	1,855	1,613	1,679	.	.	.	3,718	.
other rolling mill	473	173	21	19	-	-	-	-	-	-
rolling mill products	20,043	21,946	26,604	32,460	39,356	.	.	.	66,842	
rods and shapes pipe	14,069	7,313	8,357	8,940	10,060	. .	. .	. .	20,812 3,760	. .
wire	16,895	15,359	8,055	10,078	13,257	.	.	.	19,587	.
other extrusion products	118	7,977	8,968	9,537	6,66	.	.	.	-	.
extrusion products	31,082	30,649	25,380	28,555	29,961		.	.	44,159	.
Al semimanufactures excluding electrical wire	51,125	52,595	51,984	61,015	69,317	.	.	.	111,001	.
electrical wire including Al-steel cable	13,480	14,710	9,177	11,068	14,781	.	.	.	8,775	.
total production	64,605	67,305	61,161	72,083	84,098	70,993	77,291	85,500	119,776	119,846

Source: Fachvereinigung Metallhalbzeug e.V., Düsseldorf

Annex 11d

Production of Aluminium Semimanufactures in Norway; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	11,605	14,400	14,356	18,598	31,579	36,485	35,528	41,848	45,026	41,529	29,921
circles and slugs	2,879	2,800	2,873	3,075	3,630	3,581	3,628	4,448	4,899	4,751	4,327
rods, sections, pipes	1,150	1,910	2,424	3,295	5,685	10,942	11,365	14,986	21,364	21,313	17,562
wire	3,604	3,620	9,976	13,889	14,482	17,845	21,632	24,809	25,410	24,003	24,328
total production	19,238	22,730	29,629	38,857	55,376	68,853	72,153	86,091	96,699	91,596	76,138

Production of Aluminium Semimanufactures in Austria; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	21,359	22,931	24,988	29,930	35,777	35,455	32,339	36,482	37,063	35,387	36,052
circles and slugs	2,185	2,390	2,447	2,678	3,425	2,985	2,838	3,803	5,744	5,132	4,892
rods and sections	2,869	4,657	6,483	5,831	6,259	6,422	6,137	8,769	10,598	12,269	11,331
pipes	423	466	390	388	594	710	662	865	1,242	2,163	2,171
wire	3,445	3,455	2,520	5,622	9,889	12,256	9,750	11,212	11,633	14,863	13,486
pressend and forget products	.	.	.	.	.	.	.	.	.	.	.
total production	30,281	33,899	36,828	44,449	55,944	57,828	51,726	61,131	66,280	69,814	67,932

Production of Aluminium Semimanufactures in Sweden; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	28,961	30,118	31,400	35,733	43,374	37,768	39,475	49,740	56,015	61,283	45,313
circles and slugs				1,979	1,626	1,250	1,298	1,027	957	816	256
rods and sections	7,692	8,579	10,000	10,166	13,350	15,203	14,389	15,608	21,875	23,239	17,403
pipes				1,514	1,993	2,318	2,449	3,665	1,952	2,350	1,870
wire	8,668	11,567	11,500	12,500	20,000	22,062	17,082	16,118	17,678	21,028	15,431
total production	45,321	50,264	52,900	61,892	80,343	78,601	74,693	86,158	98,477	108,716	80,273

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Annex 11e

Production of Aluminium Semimanufactures in Switzerland; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	29,852	31,941	37,186	40,540	44,325	48,652	50,328	56,877	59,731	62,325	51,806
circles and slugs	4,348	4,544	4,522	4,870	5,667	6,068	6,753	5,664	5,690	6,588	4,651
rods and sections	16,661	18,393	19,255	21,709	26,217	28,010	26,231	30,484	35,440	33,645	21,806
pipes	1,723	1,536	1,867	1,762	2,156	2,921	3,500	2,732	2,866	3,318	2,687
wire	3,814	2,972	1,780	2,171	2,465	1,638	1,769	2,495	1,461	2,404	1,596
pressend and forget products	392	464	617	689	896	1,047	984	872	782	921	790
total production	56,790	59,850	65,227	71,741	81,726	88,336	89,565	99,124	105,970	109,201	83,336

Production of Aluminium Semimanufactures in Spain; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	16,500	22,064	22,293	29,229	38,060	36,697	40,507	51,289	57,289	69,075	56,715
circles and slugs		5,117	4,304	5,244	7,424	5,602	6,284	9,192	9,862	11,040	8,901
rods and sections	8,000	6,772	6,965	8,116	11,135	12,288	18,893	25,654	33,892	51,901	49,966
pipes		1,812	1,376	1,500	2,143	2,297	5,150	7,059	8,037	11,476	6,807
wire	18,000	14,676	22,929	25,400	22,593	28,620	36,749	36,838	27,712	43,951	50,813
total production	42,500	50,441	57,867	69,489	81,355	85,504	107,583	129,807	136,792	187,443	173,202

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Annex 11f

Production of Aluminium Semimanufactures in Japan; 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet metal strip metal including	84,404	102,837	109,225	133,556	164,022	170,931	162,893	202,872	243,095	188,127	158,276
foil (rolled stock)	44,451	62,026	65,200	80,225	103,277	109,649	118,843	143,029	188,933	170,390	152,915
circles and slugs	24,318	30,239	30,838	33,921	33,296	32,035	37,856	40,644	44,343	33,192	30,723
total rolling mill products	153,173	195,102	205,263	247,702	300,595	312,615	319,592	386,545	476,371	391,709	341,914
rods	6,163	10,884	11,654	12,365	17,907	15,838	15,929	22,181	28,430	27,072	17,045
sections	47,261	77,185	127,413	180,653	274,640	327,341	384,927	505,156	716,688	603,927	561,248
pipes	7,635	11,605	12,520	16,719	23,407	23,284	26,884	26,034	29,270	26,808	20,827
wire	7,284	8,643	8,264	9,517	10,168	10,427	11,808	17,904	22,264	17,008	16,210
extrusion products	759	1,097	1,342	971	1,107	1,464	1,466	1,827	1,989	1,980	1,515
total extrusion products	69,102	109,414	161,193	220,225	327,229	378,354	441,014	573,102	798,641	676,795	616,845
Al-semimanufactures excluding electrical wire	222,275	304,516	366,456	467,927	627,824	690,969	760,606	959,647	1,275,012	1,068,504	958,759
electrical wire	23,529	41,319	50,377	61,409	73,299	87,357	91,041	99,072	127,371	89,840	98,915
total production	245,804	345,835	416,833	529,336	701,123	778,326	851,647	1,058,719	1,402,383	1,158,344	1,057,674

Source: Fachvereinigung Metallhalbzeug E.V., Düsseldorf

Annex 11g

Production of Aluminium Semimanufactures in Canada, 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet, strip and circles metal	.	.	.	68,000	80,900	78,600	88,000	98,700	118,900	141,700	106,000
rod, shapes, pipes	.	.	.	60,000	63,200	58,100	71,800	79,400	82,400	96,100	77,000
wire and cable	.	.	.	59,000	60,200	77,900	89,500	79,500	66,700	63,100	54,000
total production	166,000	193,000	175,000	187,000	204,300	214,600	249,300	257,600	268,000	300,900	237,000

Deliveries of Aluminium Semimanufactures in United States, 1965 - 1975
in t

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
sheet and strip metal	1,183,300	1,332,100	1,300,900	1,544,300	1,690,500	1,673,100	1,803,700	2,162,700	2,604,200	2,552,000	1,838,000
foil	179,500	196,000	203,900	230,800	254,000	253,400	265,600	305,300	351,300	339,400	276,700
rolled rods and shapes	72,400	68,900	64,900	59,000	65,400	49,900	46,300	82,300	131,300	121,700	84,300
wire, uninsulated	37,500	46,800	44,400	45,500	43,000	42,400	43,900	48,300	56,300	59,400	30,100
Al and Al-steel cable	194,700	230,300	229,600	223,200	215,500	226,600	218,500	205,800	222,300	247,900	192,800
electrical wire, insulated	58,700	75,000	79,300	97,000	113,600	118,000	143,900	168,300	201,900	202,500	111,600
extrusion products	699,700	779,800	696,400	758,300	812,800	746,600	834,600	967,900	1,090,200	978,300	687,800
drawn pipe	37,400	45,200	40,400	42,000	40,300	38,200	38,300	42,100	50,000	50,100	29,800
welled pipe	42,500	41,400	39,800	48,500	46,100	42,000	43,700	52,900	55,200	53,000	27,900
powder and paste	26,700	50,500	106,100	125,400	125,200	92,800	76,000	102,700	116,800	80,400	44,800
forged products	43,700	63,100	74,900	78,300	71,000	54,600	44,500	55,700	64,600	62,700	44,100
total deliveries	2,576,100	2,929,100	2,880,600	3,252,300	3,477,400	3,337,600	3,559,000	4,194,000	4,944,100	4,747,400	3,367,900

Production of Aluminium Semimanufactures in Australia, 1964/65 - 1974/75
in t

	1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75
sheet and strip incl. foil (rolled stock)	29,693	35,968	44,343	44,892	51,382	52,235	57,274	60,218	71,818	85,293	71,818
circles and slugs											
rods and shapes	15,546	17,852	20,378	24,642	29,860	34,129	32,630	36,510	41,570	51,661	39,728
irrigation pipe	1,825	2,130	1,231	2,112	1,872	1,298	1,096	838	1,901	1,583	1,628
other pipe	1,339	1,205	1,759	2,020	2,022	1,752	1,699	1,702	2,386	2,454	2,874
wire	11,960	16,238	17,916	13,556	18,244	17,985	21,028	17,841	18,695	16,525	18,037
total production	60,363	73,393	85,627	87,222	103,380	107,399	113,727	117,109	136,370	157,516	134,085

Sources: Metallgesellschaft AG, Metallstatistik 63. Jahrgang, Frankfurt a. Main, 1976 (USA)
Fachvereinigung Metallhalbzeug EV, Düsseldorf (Canada, Australia)

Annex 12a

Breakdown of Primary and Secondary Aluminium Consumption by Use in Germany FR

in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	135,600	113,900	145,200	178,000	191,600	184,800	187,600	208,000	174,400	171,000	220,200
Mechanical engineering	55,400	45,700	56,900	66,000	62,700	57,300	61,100	74,500	78,800	55,300	71,400
Electrical engineering	77,500	75,800	89,700	102,700	103,000	104,100	108,500	74,000	74,400	67,200	67,800
Building and construction	55,400	58,600	80,800	101,600	112,200	137,200	149,300	172,600	144,900	137,400	183,200
Chemical, food and agricultural appliances	15,000	12,500	15,600	19,400	22,400	19,700	17,800	18,000	18,900	13,800	14,800
Packaging	47,200	43,000	53,500	65,100	69,200	73,700	83,900	92,000	91,400	79,700	93,400
Domestic and offices appliances	16,100	15,400	15,700	17,200	17,300	18,800	20,900	75,000	72,800	67,800	81,600
Powder consuming industries	5,900	5,000	6,200	7,200	7,600	7,600	7,900	5,800	5,000	2,700	3,400
Destructive uses	21,700	23,400	29,700	33,800	34,200	30,200	34,900	44,200	51,500	43,000	50,600
Metal industries n.e.s.	18,600	18,000	29,400	35,100	28,600	32,800	27,700)	91,700	99,400	80,500	111,600
Miscellaneous	35,900	36,600	52,700	56,400	51,800	54,000	57,700)				
Direct exports of semi-manufactures	77,400	95,700	115,800	142,300	129,300	139,300	165,700	207,100	270,300	191,900	274,600
total consumption	561,700	543,600	691,200	824,800	829,900	859,500	923,000	1,062,900	1,081,800	910,300	1,172,600

Source: OECD

Annex 12b

Breakdown of Primary and Secondary Aluminium Consumption by Use in Belgium/Luxembourg

in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	2,224	1,903	2,946	3,166	2,885	3,135	3,063	3,857	4,295	1,688	2,634
Mechanical engineering	1,077	504	1,254	1,328	1,417	1,149	1,642	2,948	4,482	1,639	1,909
Electrical engineering	2,526	2,032	2,085	2,371	5,003	5,636	4,831	6,496	6,662	6,298	6,583
Building and construction	12,432	11,869	11,706	12,117	16,139	11,000	12,024	16,124	17,443	14,260	15,809
Chemical, food and agricultural appliances	1,254	1,334	1,319	1,340	1,142	965	1,620	1,900	1,369	722	981
Packaging	4,321	3,794	5,349	5,426	4,989	3,364	8,120	3,877	6,588	5,752	9,077
Domestic and offices appliances	1,847	1,611	2,008	1,274	1,550	1,533	1,177	1,332	2,026	1,109	1,105
Powder consuming industries	156	190	180	198	271	211	247	269	260	230	293
Destructive uses	37	37	142	236	270	230	210	223	313	54	139
Metal industries n.e.s.	475	405	318	621	615	522	2,011	1,441)	9,371	6,841	16,765
Miscellaneous	19,786	7,417	13,478	19,043	14,450	25,411	12,324	15,078)			
Direct exports of semi-manufactures	25,294	102,571	122,014	129,254	132,957	142,392	168,063	171,304	183,405	155,713	189,595
total consumption	71,429	133,667	162,799	176,374	181,688	195,548	215,332	224,849	236,214	194,306	244,890

Source: OECD

Annex 12 c

Breakdown of Primary and Secondary Aluminium Consumption by Use in France

in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	114,704	102,555	99,729	122,000	144,975	145,000	163,259	166,494	153,990	138,200	172,800
Mechanical engineering	25,396	25,144	23,775	26,400	31,393	27,290	36,128	33,580	36,905	29,600	32,000
Electrical engineering	35,861	44,193	49,268	61,800	56,742	65,329	66,434	77,473	78,672	73,200	85,000
Building and construction	25,436	28,720	29,067	32,800	33,448	33,565	42,253	53,341	53,252	41,600	56,400
Chemical, food and agricultural appliances	5,932	7,622	7,437	7,100	7,352	10,527	9,450	11,395	11,657	9,700	13,400
Packaging	26,496	27,225	30,321	37,800	38,979	42,204	44,893	46,317	50,704	42,000	47,800
Domestic and offices appliances	27,353	20,755	22,810	26,900	21,425	24,638	26,534	30,056	32,231	27,200	34,300
Powder consuming industries	7,930	2,257[1]	2,473[1]	3,000[1]	3,739[1]	2,926[1]	3,091[1]	2,344	2,718	2,800	2,100
Destructive uses	11,033	18,374[1]	20,313[1]	19,500[1]	17,887[1]	15,254[1]	19,816[1]	19,663)	33,338	21,900	25,000
Metal industries n.e.s.	8,283)	30,855	8,461	16,600	8,069	9,643)	38,260	9,146)			
Miscellaneous	17,352)		22,559	19,100	39,247	32,499)		39,537	50,630	45,700	51,300
Direct exports of semi-manufactures	57,077	65,240	63,585	85,400	88,721	95,606	107,325	120,816	125,780	112,600	145,100
total consumption	362,853	372,940	379,798	458,400	481,637	504,456	557,443	610,162	629,877	544,500	665,200

[1] Granulated metal for metallurgical purposes are not included in after 1967 in the figures for "powder consuming industries", but under "Destructive uses".

Source: OECD

Annex 12d

Breakdown of Primary and Secondary Aluminium Consumption by Use in United Kingdom

in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	123,253	124,414	135,340	147,398	134,000	127,809	131,825	158,190	143,682	117,200	123,700
Mechanical engineering	27,281	25,401	27,431	30,731	28,300	23,946	24,994	36,467	41,588	31,300	34,900
Electrical engineering	59,668	62,648	64,220	60,489	64,600	56,006	56,012	65,378	78,158	66,100	63,100
Building and construction	35,061	34,476	36,353	36,680	36,000	34,416	42,238	54,907	61,979	51,500	59,800
Chemical, food and agricultural appliances	8,033	8,703	10,382	12,425	15,300	13,122	10,841	7,218	7,589	5,700	3,700
Packaging	31,145	30,931	36,732	36,237	35,100	33,954	38,290	47,719	53,991	43,100	102,700
Domestic and offic appliances	39,334	39,994	47,675	45,396	43,400	39,947	44,864	55,504	49,020	44,800	50,600
Powder consuming industries	7,860	6,145	7,622	8,005	10,300	7,222	8,374	7,448	11,500	7,600	9,200
Destructive uses	15,630	14,010	15,873	19,684	21,700	21,530	23,283	21,397	21,623	18,400	23,100
Metal industries n.e.s.	7,506	8,110	8,060	7,923	7,500	8,068	9,223	15,784)	71,627	52,900	71,400
Miscellaneous	48,162	46,947	49,802	57,555	58,800	52,555	63,085	54,421)			
Direct exports of semi-manufactures	50,716	42,392	43,816	42,361	36,600	30,615	35,408	50,670	73,200	59,800	65,200
total consumption	453,649	444,171	483,306	504,884	491,600	449,190	488,437	575,103	613,957	498,400	607,400

Source: OECD, after 1975 "EPAA"

Annex 12e

Breakdown of Primary and Secondary Aluminium Consumption by Use in Italy
in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	102,000	114,000	128,000	120,000	140,000	138,000	130,000	133,600	145,300	112,600	150,200
Mechanical engineering	17,000	20,000	21,000	24,000	25,000	23,000	30,000	40,000	42,700	25,400	37,900
Electrical engineering	16,000	17,000	20,000	28,000	34,000	31,000	36,000	29,000	33,600	28,000	27,700
Building and construction	24,000	26,000	30,000	46,000	53,000	48,000	72,000	93,700	115,500	79,500	110,000
Chemical, food and agricultural appliances	3,500	4,000	5,000	6,000	7,000	6,000	8,000	9,800	10,400	5,000	10,900
Packaging	22,500	23,000	25,000	30,000	35,000	35,000	55,000	58,000	54,000	36,300	52,400
Domestic and offices appliances	14,000	18,000	21,000	48,000	52,000	48,000	56,000	63,700	69,200	57,600	72,400
Powder consuming industries	1,200	1,500	2,000	2,500	3,000	2,500	2,700	3,500	3,500	2,500	3,000
Destructive uses	6,200	6,900	8,000	7,500	9,500	9,700	12,000	14,000	16,000	15,000	16,000
Miscellaneous	18,200	19,700	16,800	16,700	16,400	15,300	11,100	22,400	19,900	20,700	22,100
Direct exports of semi-manufactures	27,400	30,900	46,200	53,300	45,100	45,500	45,200	43,300	45,900	59,000	85,100
total consumption	252,000	281,000	323,000	382,000	420,000	402,000	458,000	511,000	556,000	441,600	587,700

Source: OECD, after 1975 "EPAA"

Annex 12f

Breakdown of Primary and Secondary Aluminium Consumption by Use in Austria
in t

	1972	1973	1974	1975	1976
Transport	3,989	4,904	4,773	4,300	5,000
Mechanical engineering	2,808	3,124	2,798	3,300	3,200
Electrical engineering	11,430	10,208	12,567	14,600	15,200
Building and construction	8,190	10,407	9,414	9,300	10,800
Chemical, food and agricultural appliances	1,803	1,510	1,617	600	1,400
Packaging	1,639	2,132	1,052	3,400	5,300
Domestic and offices appliances	3,731	4,354	3,904	2,400	2,500
Powder consuming industries	1,399	1,532	71	2,400	2,900
Destructive uses	3,202	3,872)	4,618	3,500	4,900
Metal industries n.e.s.	2,580	2,600)			
Miscellaneous	4,367	7,094	6,605	7,200	6,500
Direct exports of semi-manufactures	32,544	35,178	43,377	38,400	58,700
total consumption	77,682	86,915	90,796	89,400	116,400

Source: OECD

Annex 12 g

Breakdown of Primary and Secondary Aluminium Consumption by Use in Spain
in t

	1969	1970	1971	1972	1973	1974	1975	1976
Transport	36,100	38,000	38,500	48,800	57,900	62,100	55,800	61,600
Mechanical engineering	6,400	7,000	8,000	10,000	11,400	11,700	10,100	11,300
Electrical engineering	12,200	18,000	18,000	21,500	19,900	42,200	37,800	39,000
Building and construction	18,300	18,300	20,800	25,700	29,500	44,200	38,900	52,500
Chemical, food and agricultural appliances	2,000	2,000	2,700	4,000	6,100	7,000	6,100	8,100
Packaging	10,000	11,000	12,600	16,200	19,500	21,700	19,100	24,900
Domestic and offices appliances	16,700	15,900	16,000	18,800	21,800	28,100	25,100	26,500
Powder consuming industries	-	-	-	-	-	300	100	200
Metal industries n.e.s.	-	-	-	-	-	1,900	1,300	1,800
Miscellaneous	7,800	6,100	6,500	15,200	19,200	22,300	19,300	19,100
Direct exports of semi-manufactures	28,700	28,700	32,900	25,800	21,700	18,300	24,500	23,400
total consumption	138,200	145,000	156,000	186,000	207,000	259,800	238,100	268,400

Source: OECD

Annex 12h

Breakdown of Primary and Secondary Aluminium Consumption by Use in Switzerland
in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	3,684	3,339	3,945	4,735	5,300	5,700	6,000	7,300	5,900	3,100	3,200
Mechanical engineering	9,390	9,357	9,297	10,876	12,800	12,000	8,700	9,400	11,400	7,700	7,100
Electrical engineering	4,722	3,627	4,661	5,697	5,600	5,300	6,000	5,800	7,100	4,100	4,800
Building and construction	11,783	11,544	12,882	15,796	15,500	15,100	18,000	17,400	14,400	9,500	11,700
Chemical, food and agricultural appliances	443	517	567	461	600	500	400	500	600	300	400
Packaging	9,560	8,276	9,615	10,498	25,600[1]	27,400[1]	30,500[1]	31,200[1]	34,100[1]	11,500	13,700
Domestic and offices appliances	2,506	2,505	2,673	2,918	3,200	3,000	3,100	3,300	2,700	1,700	2,100
Destructive uses	330	442	445	495	600	400	500	400	500	200	300
Metal industries n.e.s.	1,326	1,284	1,226	1,444	1,900	1,600	1,500	1,600	1,700)	2,000	7,600
Miscellaneous	4,908	3,754	4,818	5,905	4,000	3,500	2,700	3,500	2,500)		
Direct exports of semi-manufactures	8,315	23,009	23,687	24,875	18,700	20,500	25,700	29,300	33,000	46,200	58,800
Total consumption	56,967	67,654	73,816	83,700	93,800	95,000	103,100	109,700	113,900	86,300	109,700

[1] changed basis for the listings

Source: OECD

Annex 12 i

Breakdown of Primary and Secondary Aluminium Consumption by Use in Japan
in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	104,710	132,565	177,929	219,785	256,661	269,657	309,961	344,085	325,125	312,821	370,937
Mechanical engineering	32,423	41,966	49,951	60,315	71,698	70,214	67,282	86,836	82,389	60,043	82,539
Electrical engineering	62,143	87,088	103,680	143,337	155,816	146,104	166,187	226,205	163,034	123,357	178,492
Building and construction	69,696	103,195	156,884	246,585	297,862	348,905	459,261	654,306	545,954	516,521	667,993
Chemical, food and agricultural appliances	12,990	16,700	18,607	24,727	32,979	38,429	48,768	69,774	39,647	28,411	38,172
Packaging	11,518	12,739	14,531	17,717	20,263	21,022	23,493	28,281	83,033	71,073	103,710
Domestic and offices appliances	87,861	99,790	100,641	104,492	102,716	101,358	124,447	141,578	107,341	82,571	124,612
Powder consuming industries	1,009	1,924	5,099	5,678	5,563	5,391	5,969	7,331	7,761	7,575	8,917
Destructive uses	20,076	27,110	35,556	41,880	49,507	57,332	59,239	52,132	51,798	47,241	52,569
Metalindustries n.e.s.	33,498	33,486	52,382	71,008	80,536	85,313	105,952	135,869	183,353	157,208	216,229
Miscellaneous	46,045	51,061	53,664	63,457	66,841	56,084	82,278	114,944			
Direct exports of semi-manufactures	40,522	22,202	37,430	46,446	52,753	53,129	38,782	29,643	33,716	70,364	76,895
total consumption	522,491	629,826	806,354	1,045,427	1,193,195	1,252,938	1,491,619	1,890,984	1,623,151	1,477,185	1,921,063

Source: OECD

Annex 12 k

Breakdown of Primary and Secondary Aluminium Consumption by Use in United States
in t

End-uses	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Transport	924,000	846,900	947,600	956,200	734,300	867,300	1,066,400	1,354,400	1,356,300	1,169,400	
Mechanical engineering	278,000	252,200	292,600	295,300	250,400	268,500	312,500	399,600	399,600	411,900	
Electrical engineering	563,400	552,500	570,600	623,200	574,200	598,300	640,000	781,100	781,100	780,200	
Building and construction	877,700	846,400	989,700	1,037,800	1,006,400	1,242,400	1,417,900	1,613,900	1,626,200	1,363,100	
Chemical, food and agricultural appliances	30,400	27,700	28,100	35,800	36,700	36,300	35,400	46,700	46,700	73,900	
Packaging	335,700	393,700	465,400	541,100	665,400	686,700	823,700	933,100	932,600	1,027,400	
Domestic and offices appliances	340,200	307,500	361,500	386,900	349,300	343,800	391,500	469,900	470,300	400,500	
Powder consuming industries	49,900	105,700	124,300	125,200	90,300	74,800	103,400	117,000	117,000	76,700	
Destructive uses	91,600	87,500	90,700	98,900	90,700	111,100	119,300	139,300	139,300	128,800	
Metal industries n.e.s.	72,100	73,500	78,500	78,500	76,700	89,400	104,300	119,300	336,500	318,400	
Miscellaneous	268,700	266,500	284,500	271,200	184,600	143,000	164,700	201,900			
Direct exports of semi-manufactures	265,200	297,800	293,300	456,900	526,800	258,500	255,000	425,900	425,900	428,200	
total consumption	4,096,900	4,057,900	4,526,900	4,907,000	4,585,800	4,720,100	5,434,100	6,602,100	6,661,500	6,178,500	

Source: OECD

Annex 13

Legend for the following graphs

A Transport

B General engineering

C Electrical engineering

D Building & construction

E Chemical, food & agricultural appliances

F Packaging

G Domestic & office appliances

H Powder consuming industries

I Iron & steel industries

J Metal industries not elsewhere specified

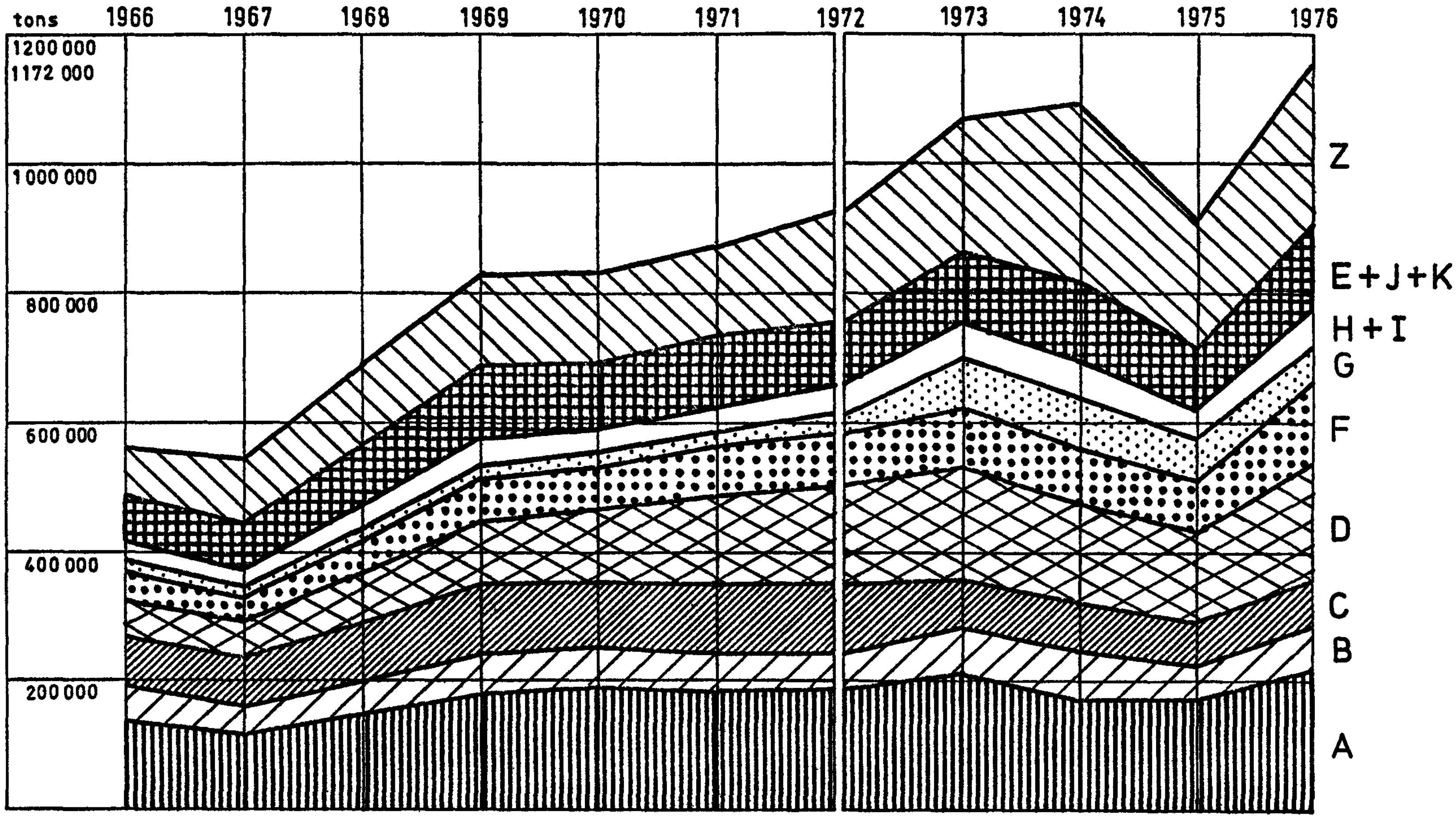
K Miscellaneous

Z Exports of semis, foil, cable, powder

Source: Organisation of Economic Co-operation and Development (O.E.C.D.), Paris.

Annex 13 a

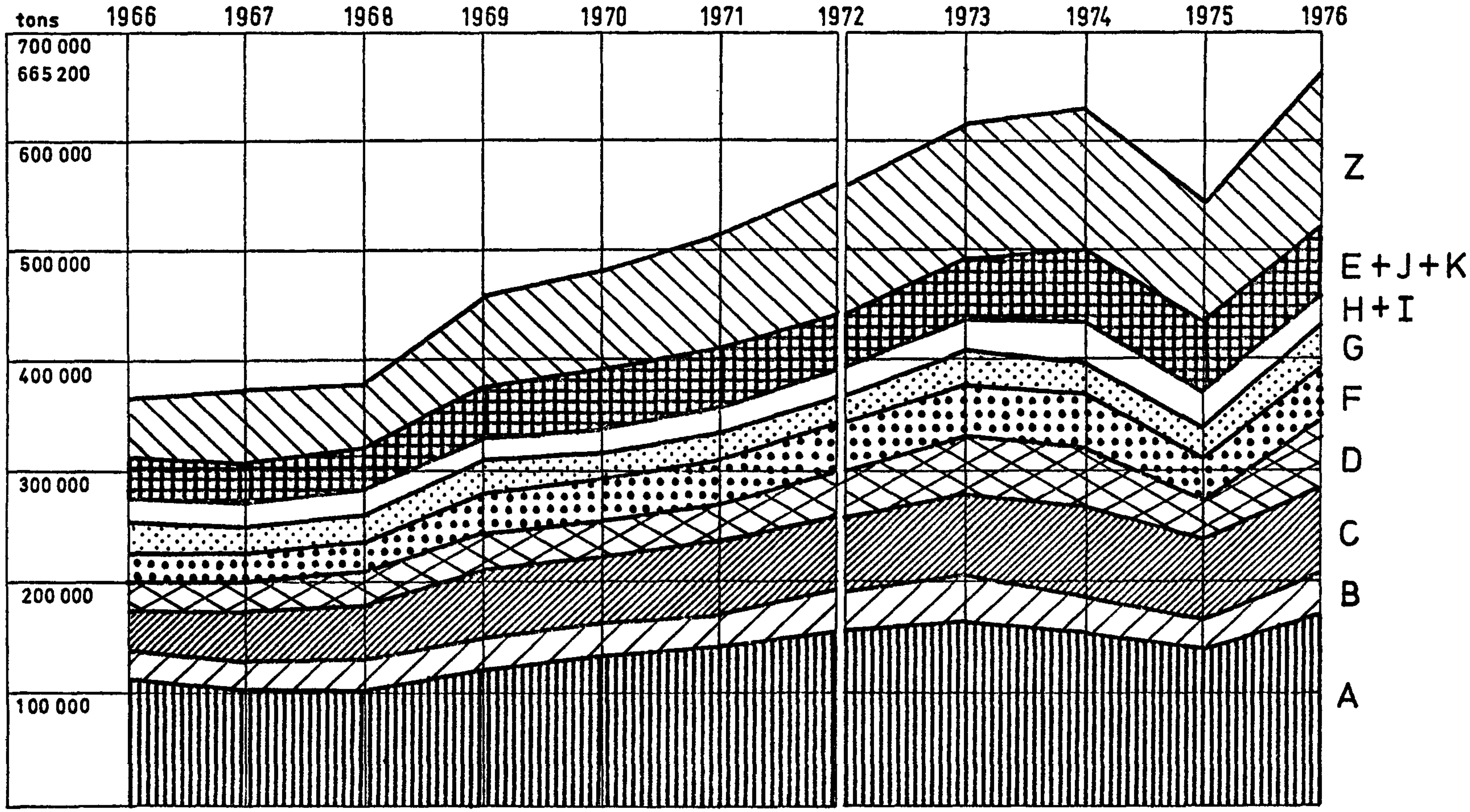
Aluminium end-use consumption in the Federal Republic of Germany



(5)

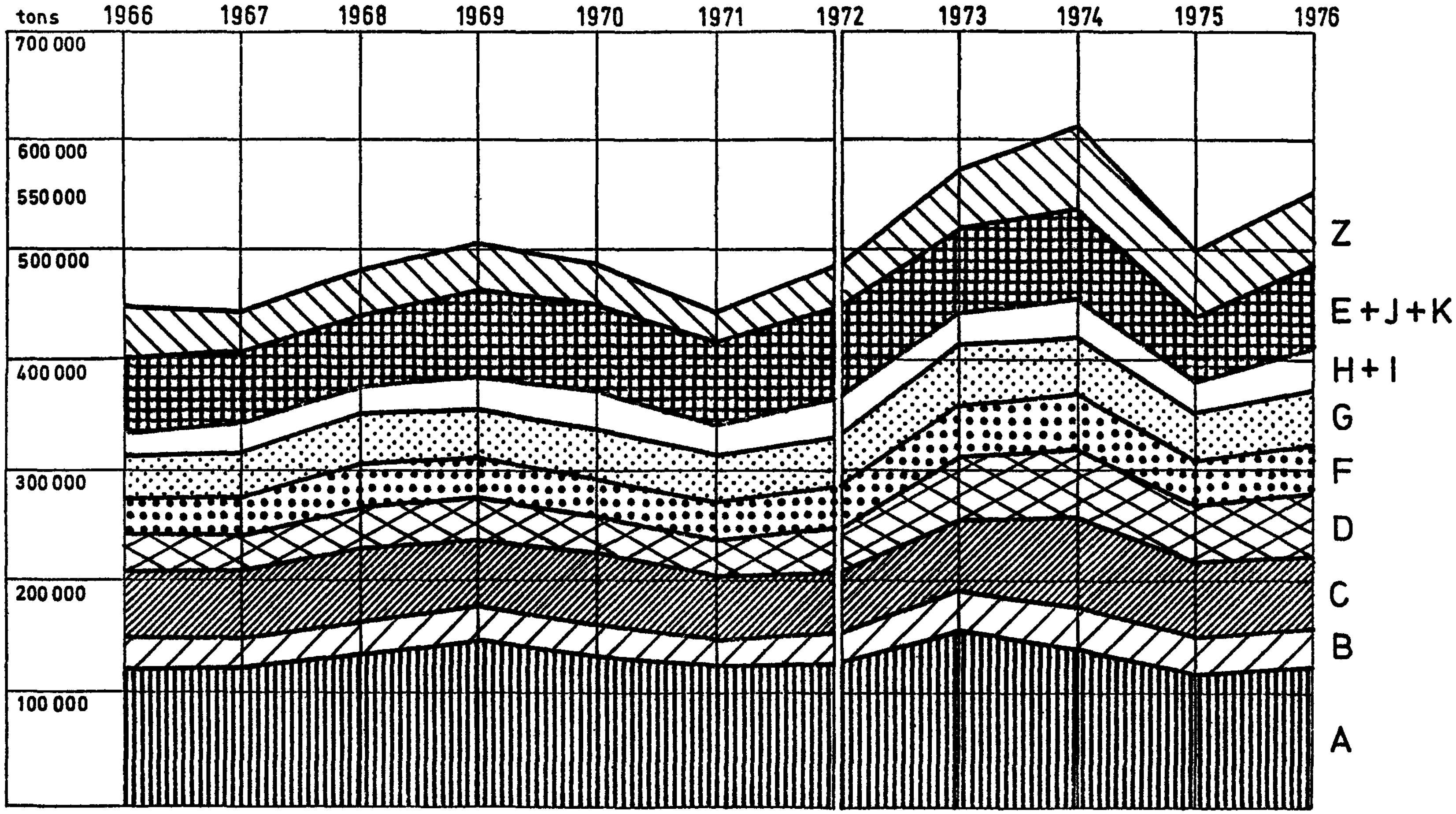
Annex 13 b

Aluminium end-use consumption in France



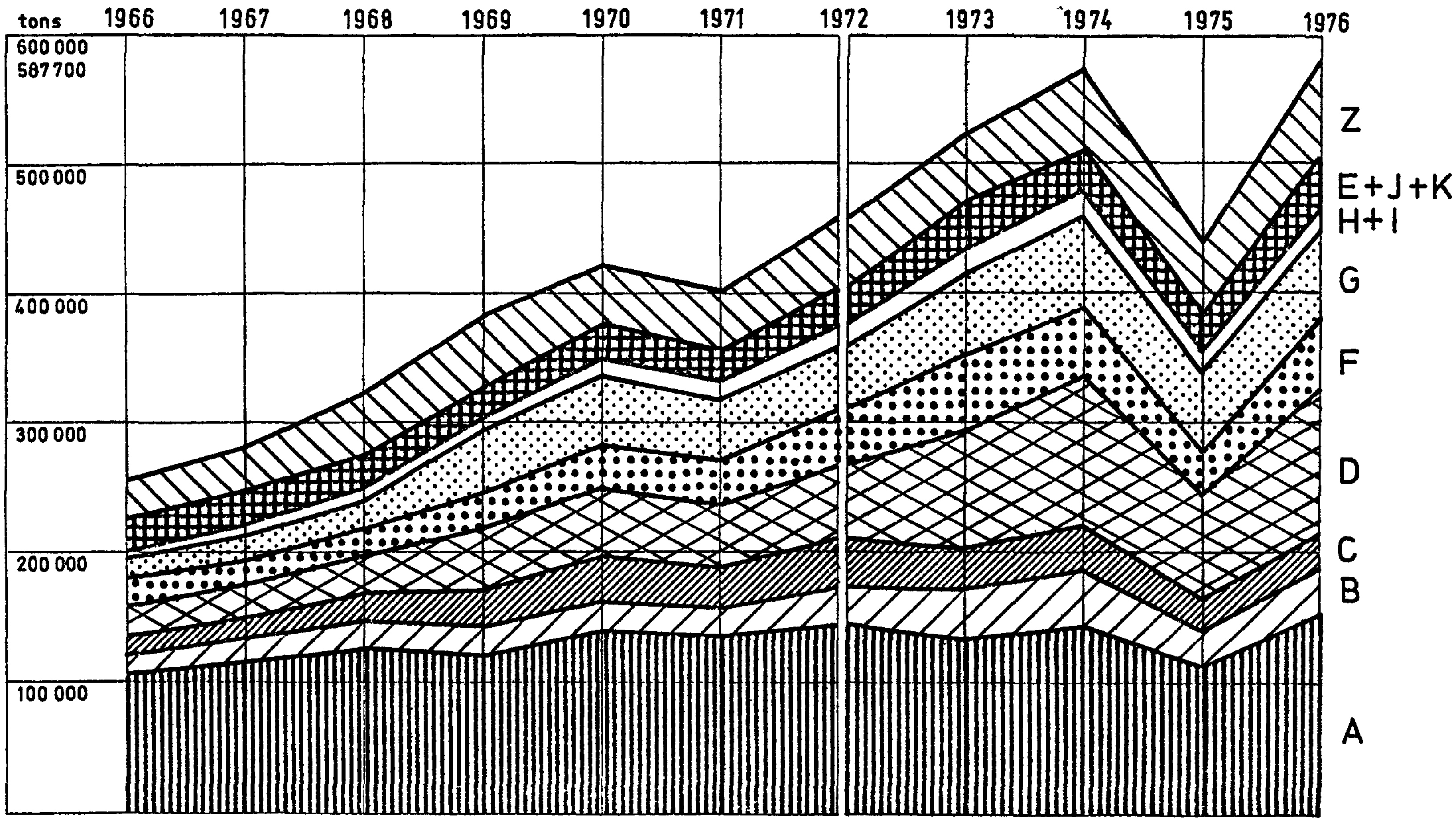
Annex 13c

Aluminium end-use consumption in the United Kingdom



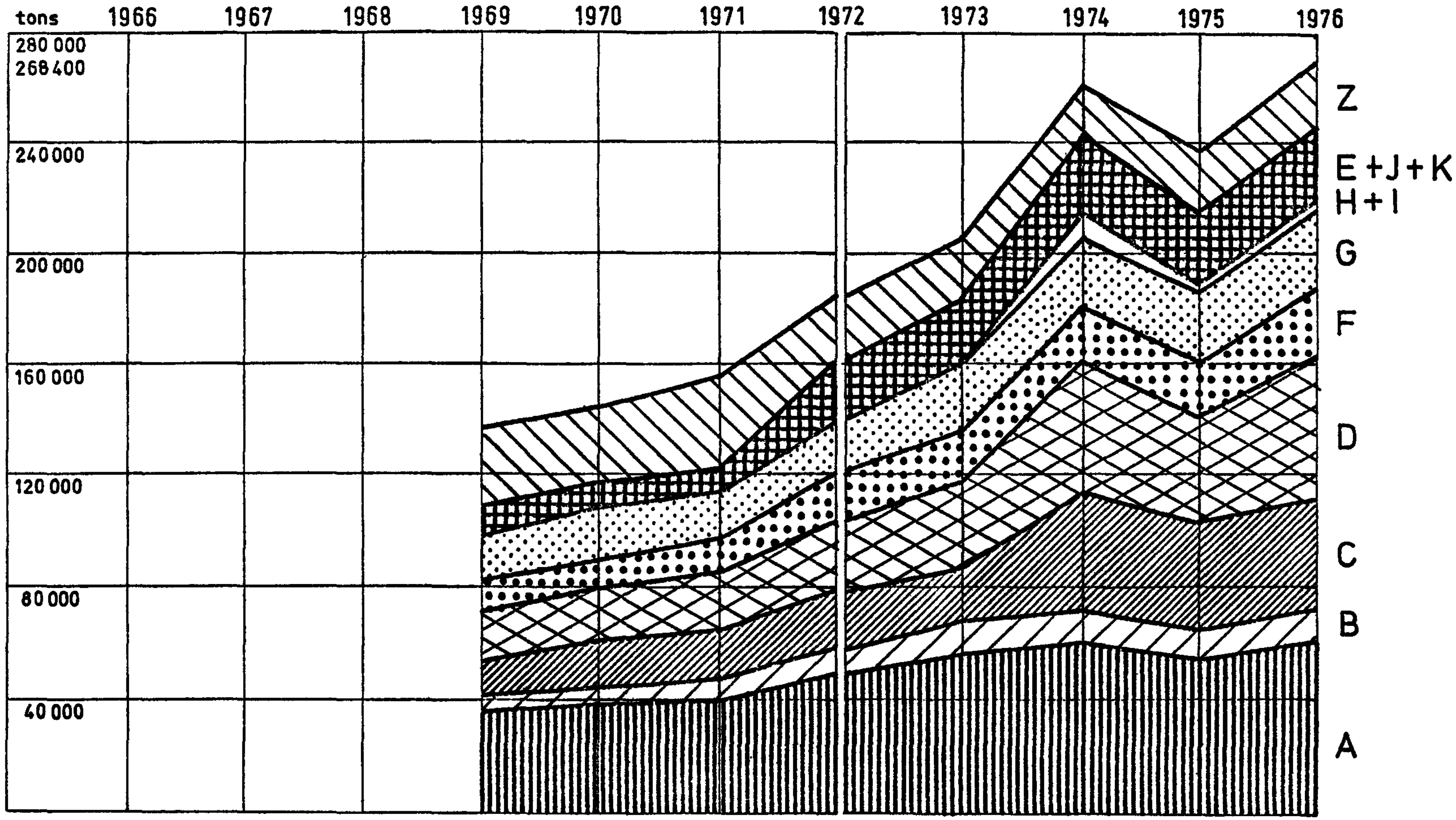
Annex 13 d

Aluminium end-use consumption in Italy



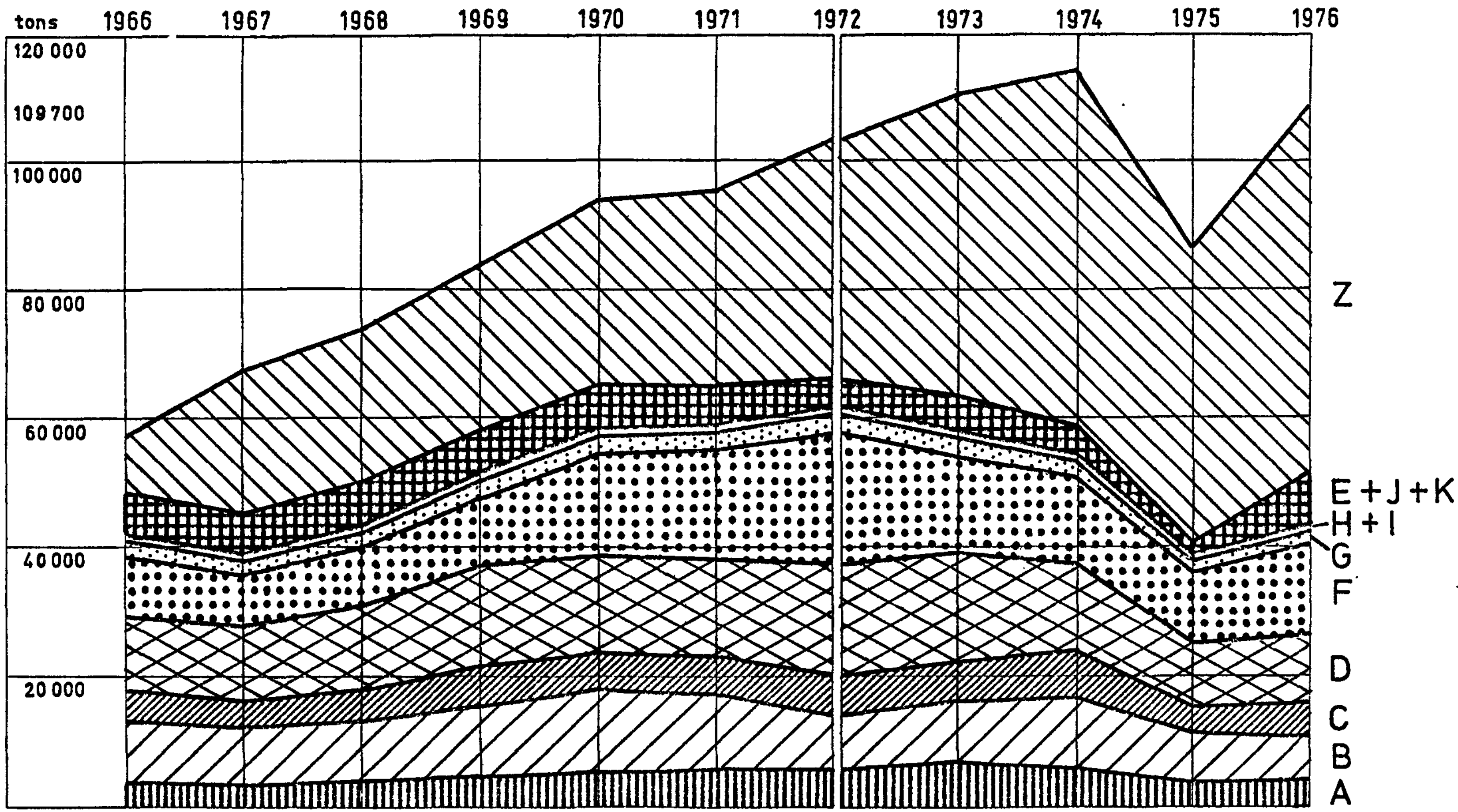
Annex 13 e

Aluminium end-use consumption in Spain



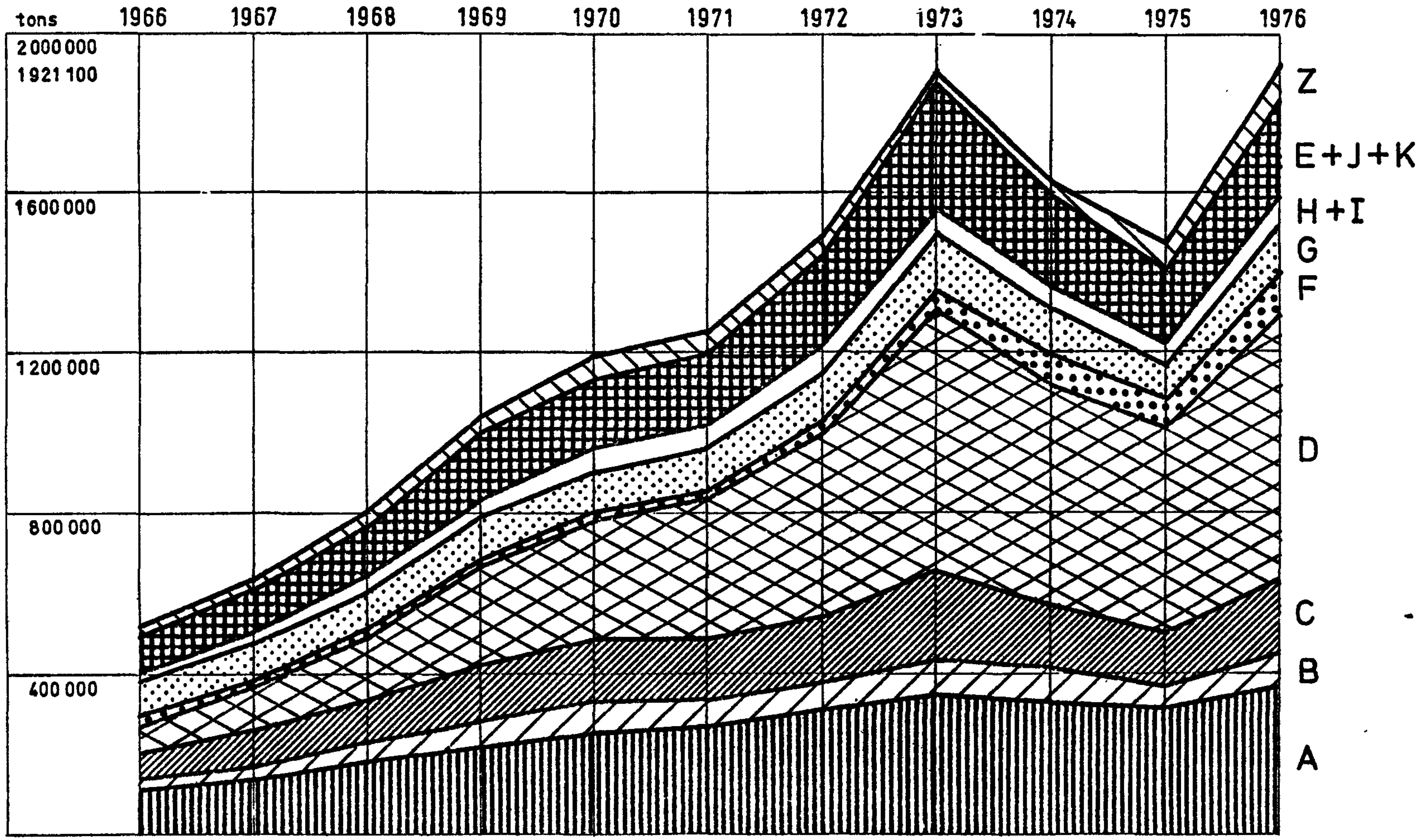
Annex 13 f

Aluminium end-use consumption in Switzerland



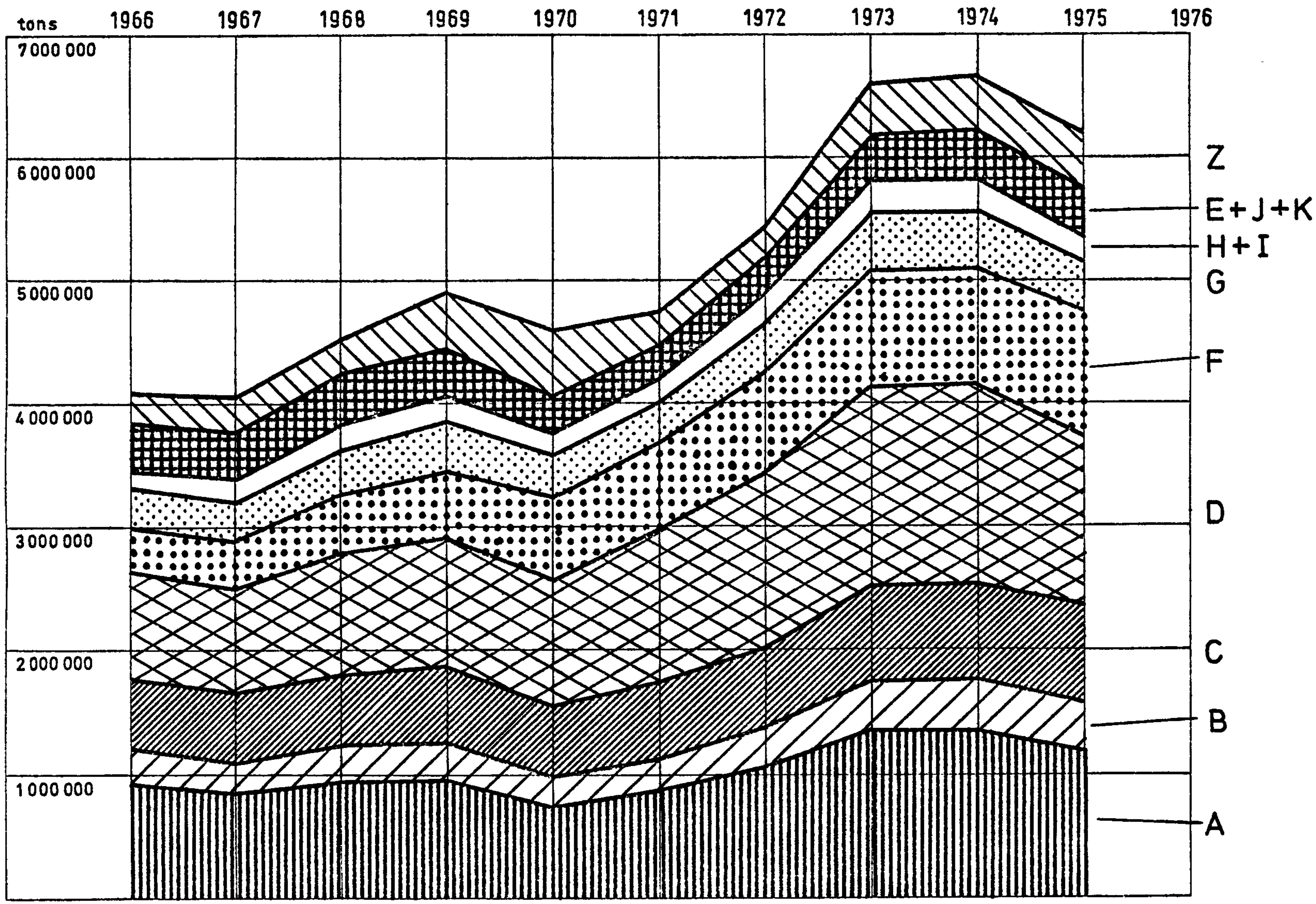
Annex 13 g

Aluminium end-use consumption in Japan



Annex 13h

Aluminium end-use consumption in the United States of America



Annex 14 a

Imports of Bauxite in the European-Community: 1966 - 1976 (excluding trade within the Community)

in t

	1966[1)]	1967[1)]	1968[1)]	1969[1)]	1970[1)]	1971[1)]	1972[1)]	1973[1)]	1974	1975	1976[1)]
Greece	571,005	506,420	528,507	555,776	394,166	287,938	398,244	363,831	426,870	347,689	352,130
Yugoslavia	939,062	846,493	863,357	852,582	951,829	843,541	622,644	567,413	590,051	44,788	.
Norway	.	.	.	.	.	1,819	.	.	.	.	.
Sweden	470	.	.	.	.	.	.	75	.	.	.
Switzerland	.	.	1,749	3,887	3,673	1,178	.	.	16,108	.	.
Spain	191	.	.	.	.	19,743	.	2,698	.	.	.
Europe without East Block	1,510,728	1,352,913	1,393,613	1,412,245	1,349,668	1,154,219	1,020,888	934,017	1,033,029	392,477	352,130
India	76,770	62,045	92,460	92,229	93,516	14,379	21,404	.	.	.	.
Indonesia	56,585	57,768	88,056	69,760	80,101	10,516	16,590	.	.	25,194	.
Japan	.	.	.	.	.	1,200	.	.	.	.	.
Turkey	.	9,700	.	.	.	.	.	.	1,000	16,256	14,179
Asia without East Block	133,355	129,513	180,516	161,989	173,617	26,095	37,994	.	1,000	41,450	14,179
Equatorial Guinea	.	.	.	.	.	.	.	.	.	23,273	.
Ghana	322,594	315,759	253,035	274,714	311,677	332,991	219,983	276,683	322,129	322,087	244,278
Portuguese Guinea	.	.	.	.	.	.	.	.	.	22,461	.
Guinea	93,437	.	.	28,444	99,498	128,424	34,140	248,084	1,128,849	1,642,887	3,210,785
Liberia	.	.	.	.	.	.	.	.	19,049	.	.
Niger	.	.	.	15,935	.	.	.	.	.	.	.
Nigeria	.	.	.	.	.	.	.	249	.	.	.
Sierra-Leone	231,255	351,305	464,459	421,633	423,004	492,155	300,102	342,464	323,101	313,113	403,992
Zaire	.	.	.	.	.	.	809	.	.	.	.
Africa	647,286	667,064	717,494	740,726	834,179	953,570	555,034	867,480	1,793,128	2,323,821	3,859,055
Guyana	135,096	100,558	150,808	168,035	139,155	125,444	169,308	131,372	325,937	183,062	177,374
Fr. Guyana	.	269	1,934	2,139	2,913	4,000	24,255	3,247	8,842	1,317	917
Haiti	.	.	.	.	.	.	.	.	48,034	11,074	.
Jamaica	.	.	.	.	.	.	.	.	129,956	.	.
Peru	.	.	.	.	.	.	.	562	.	.	.
Surinam	80,997	66,447	82,679	104,600	91,711	111,975	68,789	56,269	64,427	225,991	70,831
Trinidad and Tabago	.	350	.	.	.	1,292	.	3,722	8,002	1,735	.
USA	.	11,081	42	.	1,026	14,179	12,213	2,698	18,132	.	2,784
America	216,093	178,705	235,463	274,774	234,805	256,890	274,565	197,870	603,330	423,179	251,906
Australia	332.603	474.024	613,140	857,988	1,477,274	1,801,735	1,894,282	2,382,968	4,181,559	4,770,655	4,015,561
New Guinea	.	.	.	.	.	.	.	.	.	20,334	.
Australia/Oceania	332,603	474,024	613,140	857,988	1,477,274	1,801,735	1,894,282	2,382,968	4,181,559	4,790,989	4,015,561
Western World total	2,840,065	2,802,219	3,140,226	3,447,722	4,069,543	4,192,509	3,782,763	4,382,335	7,612,046	7,971,916	8,492,831
Hungary	59,687	79,976	80,043	80,003	100,263	76,525	59,000	99,398	.	.	20
China, Peoples Republic	2,313	2,536	6,041	5,714	24,803	28,604	72,147	54,386	53,161	67,043	80,304
East-Block	62,000	82,512	86,084	85,717	125,066	105,129	131,147	153,784	53,161	67,043	80,324
Other countries	5,029	5,630	533	914	2,534	1,128	1,560	77	1,391	8,287	27,034
World total	2,907,094	2,890,361	3,226,843	3,534,353	4,197,143	4,298,766	3,915,470	4,536,196	7,666,598	8,047,246	8,600,189

1) excluding Denmark and Ireland

Annex 14 b

Trade within the European Community (Imports) in Bauxite
in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974	1975	1976 1)
France	136,623	140,673	162,397	151,755	141,666	108,198	73,252	32,762	111,729	18,326	4,188
Belgium/Luxembourg	-	-	.	474	.	.	121	.	.	748	-
Netherlands	470	869	3,267	1,728	9,270	3,315	1,939	15,051	2,432	5,528	5,082
Germany FR	2,899	21,664	890	490	1,427	882	5,498	4,870	10,180	6,398	3,092
Italy	-	-	.	-	.	.	.	.	.	.	-
United Kingdom	683	-	.	1,261	.	1,172	148	337	.	.	-
Rep. of Ireland	-	-	.	-	.	.	.	.	.	.	-
Denmark	-	-	.	-	.	4,178	9,396	5,253	3,754	15,943	14,722
Not distributed	55	-	86	-	606	76	1,175	47	490	408	-
Total	140,730	163,206	166,640	155,708	152,969	117,821	91,529	58,320	128,585	47,351	27,084

1) excluding Denmark and Ireland

Annex 14 c

Export of Bauxite from the European Community: 1966 - 1976 (excluding trade within the Community)
in t

	1966 [1]	1967 [1]	1968 [1]	1969 [1]	1970 [1]	1971 [1]	1972 [1]	1973 [1]	1974	1975	1976 [1]
Finland	430	3,346	.	.	.	370	.	181	.	.	.
Yugoslavia	.	.	.	.	.	.	.	.	.	2,561	.
Austria	1,138	682	1,008	1,449	1,198	1,578	221	546	1,976	.	635
Portugal	3,318	1,570	2,165	1,583	2,670	2,020	3,269	2,700	.	3,411	219
Sweden	214	.	162	.	701	.	101	198	.	3,002	.
Switzerland	1,690	.	.	.	2,809	3,095	9,853	9,678	15,527	20,015	24,183
Spain	350	.	.	640	835	.	.	289	.	.	216
Europe without East Block	89,969 [2]	5,598	3,335	3,672	8,213	7,063	13,444	13,592	17,503	28,989	25,253
Asia (Turkey)	.	.	.	100	.	.	.	.	.	.	.
Libya	.	.	.	.	.	1,970	2,400	.	.	.	.
Morocco	.	1,900	2,000	.	2,516	2,720	.	.	.	.	.
Republic of South Africa	.	.	.	114	351	.	.	98	.	4,476	.
Africa	4,000 [3]	1,900	2,000	114	2,867	4,690	2,400	98	.	4,476	.
Western World	93,969	7,498	5,335	3,886	11,080	11,753	15,844	13,690	17,503	33,465	25,253
East Block (Romania)	.	.	.	.	.	.	.	2,023	.	.	.
Other countries	1,020	732	429	271	1,338	448	1,413	579	10,021	9,515	3,752
World total	94,989	8,230	5,764	4,157	12,418	12,201	17,257	16,292	27,524	42,980	29,005

[1] excluding Denmark and Ireland,

[2] including Greece: 82,829 t,

[3] Algeria: 4,000 t

Annex 14 d

Trade within the European Community (Exports) in Bauxite
in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974	1975	1976 1)
France	325	.	.	143	3,425	146	279	711	3,495	6,200	779
Belgium/Luxembourg	3,127	1,925	1,436	1,512	1,639	2,972	6,095	4,890	11,095	6,001	2,204
Netherlands	389	.	148	164	125	249	179	203	.	8,182	.
Germany FR	121,658	86,118	90,062	78,192	92,999	45,819	65,715	48,514	93,839	13,479	2,800
Italy	5,100	5,469	2,600	2,640	17,873	14,905	5,799	1,537	6,379	6,363	2,029
United Kingdom	61,018	59,355	59,801	64,753	44,580	41,842	9,251	-	.	.	.
Rep. of Ireland	-	.	.	-	.	.	.	-	.	.	.
Denmark	-	.	.	-	.	276	.	-	.	.	.
Not distributed	-	75	105	-	1	120	61	121	965	1,189	7,252
Total	191,617	152,942	154,152	147,404	160,642	106,329	87,379	55,976	115,773	41,414	15,064

1) excluding Denmark and Ireland

Annex 15 a

Imports of Alumina in the European Community: 1966 - 1976 (excluding trade within the Community)

in t

	1966 [1]	1967 [1]	1968 [1]	1969 [1]	1970 [1]	1971 [1]	1972 [1]	1973 [1]	1974	1975	1976 [1][3]
Greece	.	.	14,312	28,225	36,825	13,650	37,233	148,654	77,764	119,218	177,090
Yugoslavia	895	.	.	.	.	.	.	10,300	.	.	.
Austria	965	398	985	1,859	.	1,909	2,541	2,204	3,115	1,501	2,938
Sweden	353	.	24	31	.	.	.	.	.	.	.
Switzerland	120	18	23	53	114	13	69	14	837	212	336
Spain	.	.	.	.	.	.	100	.	.	.	.
Europe without East Block	2,333	416	15,344	30,168	36,939	15,572	39,943	161,172	81,716	120,931	180,364
Japan	108	259	181	.	.	.	.	.	.	.	20
Turkey	.	.	.	1,623		.	.	.	.	.	.
Asia without East Block	108	259	181	1,623	.	.	.	.	.	.	20
Africa (Guinea)	81,049	49,141	49,035	67,858	69,708	129,989	88,791	31,809	42,328	17,044	51,947
Guyana	3,008	.	.	.	.	.	20,650	.	63,682	68,886	55,956
Jamaica	4,695	.	15,894	.	11,186	.	298,792	339,126	468,281	449,347	304,322
Canada	3,228	1,947	1,620	5,556	3,693	4,009	3,208	3,512	4,888	3,671	1,152
Surinam	58,396	79,857	103,532	149,153	187,187	368,138	383,912	495,900	369,590	324,733	307,091
USA	13,057	7,069	13,196	7,803	19,476	20,276	16,644	10,916	13,187	8,149	7,581
America	82,384	88,873	134,242	162,512	221,542	392,423	723,206	849,454	919,628	854,786	676,102
Australia	.	.	772	.	.	.	.	1,256	209,484	180,498	291,042
Other Countries	219	155	248	534	44,312	264,121	5,956	181,295	1,429	353	2,098 [2]
Western World total	166,093	138,844	199,822	262,695	372,501	802,105	857,896	1,224,986	1,254,585	1,173,612	1,201,573

1) excluding Denmark and Ireland

2) included 307 t from Hungary

3) included Aluminium-hydroxid from France and United Kingdom

Annex 15 b

Trade within the European Community (Imports) in Alumina
in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974 2)	1975 2)	1976 1)3)
France	1,062	20,944	23,054	32,422	19,605	72,273	106,499	146,498	194,986	166,604	144,424
Belgium/Luxembourg	.	.	39	53	13	152	8	28	392	286	-
Netherlands	421	1,145	1,940	2,965	2,741	4,413	3,677	7,260	9,665	9,606	4,976
Germany FR	4,729	4,386	6,230	8,102	12,924	71,308	112,692	17,468	54,970	47,978	18,315
Italy	.	.	1,009	-	.	41	49	48,466	139,534	234,398	236,633
United Kingdom	290	418	295	824	839	442	273	1,284	906	603	513
Rep. of Ireland	.	.	.	.	.	.	.	.	-	-	244
Denmark	.	.	.	.	.	.	.	.	-	-	13
Not distributed	8	21	.	.	1,249	1,666	80	527	-	-	19,716
Total	6,510	26,914	32,567	44,366	37,371	150,295	223,278	221,531	400,453	459,475	424,834

1) excluding Denmark and Ireland; included Aluminium-hydroxid from United Kingdom,

2) included Alumina from United Kingdom,

3) included Aluminium-hydroxid from France

Annex 15 c

Export of Alumina from the European Community: 1966 - 1976 (excluding trade within the community)

in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[1]	1971[1]	1972[1]	1973[1]	1974	1975	1976[1]
Finland	.	58	72	96	81	168	134	67	1,867	1,238	.
Greece	.	.	.	.	.	.	.	23,560	.	.	.
Yugoslavia	64	3,198	248	2,842	2,448	3,477	11,992	1,356	2,268	2,233	1,968
Norway	6,038	216	39	275	446	630	550	768	11,781	21,621	37,710
Austria	6,396	95,402	80,791	100,724	73,643	71,173	87,924	6,006	1,211	3,804	362
Portugal	305	342	418	517	714	1,059	1,967	811	3,079	1,387	943
Sweden	199	181	483	1,720	1,063	1,190	1,904	2,638	4,342	3,297	12,346
Switzerland	64,570	76,340	106,888	124,227	107,671	88,318	13,096	7,481	834	1,067	10,155
Spain	23,103	49,963	44,203	37,044	53,916	37,907	74,498	130,055	76,366	97,858	146,802
Europe without East Block	100,675	225,700	233,142	267,445	239,982	203,922	192,065	172,742	101,748	132,505	210,276
India	124	229	165	195	184	218	429	390	3,192	289	314
Iran	.	.	67	211	312	2,472	110	132	.	530	635
Israel	241	226	94	232	234	148	352	393	609	377	.
Japan	392	619	1,152	1,333	3,874	6,499	4,531	6,376	6,888	4,718	1,636
Lebanon	1,080	720	1,100	1,600	1,400	200	100	.	1,552	.	300
Saudi-Arabia	.	.	.	.	.	27	.	57	.	614	355
Turkey	.	113	136	278	.	141	194	149	360	.	168
Asia without East Block	1,837	1,807	2,714	3,849	6,004	19,765[7]	5,716	7,497	12,601	6,528	3,408
Libya	.	.	440	.	.	.	199	136	.	306	160
Rep. of South Africa	103	138	248	304	13,655	29,980	43,449	474	4,560	1,022	971
Africa	103	138	688	304	13,655	29,980	43,648	610	4,560	1,328	9,290[11]
Argentina	415	276	433	452	535	873	842	956	1,700	588	397
Brazil	39	.	.	159	356	473	550	455	523	710	543
Canada	102	198	145	151	123	635	376	1,973	81,588	46,102	142,144
Mexico	390	597	961	431	614	400	402	193	806	315	412
USA	39,949	20,110	962	759	14,212	1,725	1,010	1,457	15,945	35,166	13,072
America	40,895	21,181	2,501	1,952	15,840	4,106	3,180	5,034	100,562	82,881	156,568
Australia	120	122	617	295	479	433	891	794	1,790	995	143
New Zealand	.	.	.	.	.	.	.	36,505	.	.	.
Oceania	120	122	617	295	479	433	891	37,299	1,790	995	143
Western World	143,630	248,948	239,662	273,845	275,960	258,206	245,500	223,182	221,261	224,237	379,685
Bulgaria	119	220	163	733	644	678	1,540	1,715	1,885	699	.
Germany DR	.	.	.	.	13	.	.	.	2,479	.	.
Poland	.	23,238	657	262	457	4,933	98	20,436	5,657	567	553
Romania	10,536	6,892	6,947	833	1,786	749	6,915	10,341	10,628	33,785	15,015
Czechoslovakia	.	.	44	.	112	81	20	31	183	.	.
USSR	340	311	18,301	29,210	.	201	11,270	5,176	77,552	50,404	145,939
Hungary	.	.	10,010	28,370	.	.	.	.	.	.	.
East Block	10,995	30,661	36,122	59,408	3,012	6,642	19,843	37,699	98,384	85,455	161,507
Other countries	93,828[2]	23,339[3]	17,992[4]	11,405[5]	3,076[6]	76,262[8]	106,910[9]	103,540[10]	85,791	99,380	206,611
World total	248,453[2]	302,948[3]	293,776[4]	344,658[5]	282,048[6]	341,110[8]	372,253[9]	364,421[10]	405,436	409,072	747,803[12]

[1] excluding Denmark and Ireland, [2] including 13,879 t from United Kingdom (including Al.-hydroxid) (intra + Extra),
[3] including 22,198 t from United Kingdom (including Al.-hydroxid) (intra + Extra), [4] including 17;123 t from United Kingdom (including Al.-hydroxid) (intra + Extra),
[5] including 10,152 t from United Kingdom (including Al.-hydroxid) (intra + Extra), [6] including 1,592 t from United Kingdom (intra + Extra),
[7] including 10,060 t to South Korea, [8] including 13,136 t from United Kingdom (intra + Extra), [9] including 13,596 t from United Kingdom (intra + Extra),
[10] including 17,986 t from United Kingdom (intra + Extra), [11] including 6,756 t to Tunisia, and 1,403 t to Morocco, [12] including Al.-hydroxid from France and United Kingdom

Annex 15 d

Trade within the European Community (Exports) in Alumina
in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[2]	1971[2]	1972[2]	1973[2]	1974	1975	1976[2]
France	732	685	1,744	2,271	3,476	5,416	4,123	4,761	3,593	9,545	13,676
Belgium/Luxembourg	3,187	1,545	1,088	1,692	3,194	4,857	4,245	5,759	5,344	4,024	5,243
Netherlands	739	796	1,077	1,249	1,286	11,397	293	86,429	393,442	435,395	316,897
Germany FR	457	725	1,736	3,114	6,601	26,565	29,032	37,279	89,163	10,843	14,674
Italy	2,338	18,546	23,165	29,732	18,665	44,200	115,062	102,447	22,273	16,308	39,647
United Kingdom	1,349	3,720	2,168	1,982	3,071	3,574	6,345	5,588	8,919	40,067	8,984
Rep. of Ireland	-	-	-	-	-	-	.	.	.	.	.
Denmark	79	-	92	133	159	122	118	194	.	.	.
Not destibuted	-	-	-	-	1,594	13,136	13,598	17,993	439	214	7,899
Total	8,881	26,017	31,070	40,173	38,046[3]	109,267[4]	172,816[5]	260,450[6]	523,173	516,396	407,020[7]

[1] excluding Denmark, Ireland, and United Kingdom

[2] excluding Denmark and Ireland,

[3] including 1,592 t from United Kingdom (Intra + Extra), [4] including 13,136 t from United Kingdom (Intra + Extra),

[5] including 13,596 t from United Kingdom (Intra + Extra), [6] including 17,986 t from United Kingdom (Intra + Extra)

[7] including Aluminium-hydroxid from France and United Kingdom

Annex 15 e

Trade within the European Community (Imports) in Aluminium-hydroxid

in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974	1975
France	8,064	8,124	12,321	14,899	17,562	26,261	52,829	59,810	24,789	22,489
Belgium/Luxembourg	12	65	5	23	10	26	.	.	.	.
Netherlands	205	.	.	.	53	569	1,058	369	.	.
Germany FR	16,656	18,870	25,114	24,328	28,738	29,544	37,528	53,734	45,660	36,031
Italy	46	.	.	.	.	.	.	.	.	.
United Kingdom	138	93	103	167	323	376	1,455	912	4,053	3,700
Rep. of Ireland	.	.	.	.	.	.	29	61	359	304
Denmark	9	8	16	11	.	11	16	68	.	.
Not distributed	.	10	58	46	1,229	1,666	133	525	156	98
Total	25,130	27,170	37,617	39,474	47,915	58,453	93,048	115,479	75,017	62,622

1) excluding Denmark and Ireland; including Al-hydroxid from United Kingdom

Annex 15 f

Export of Aluminium-hydroxid from the European Community (excluding trade within the Community)

in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[1]	1971[1]	1972[1]	1973[1]	1974	1975
Finland	5,299	7,724	3,221	4,953	9,427	7,397	7,611	6,704	8,389	8,873
Greece	2,020	1,750	1,049	1,476	1,594	1,421	935	1,578	1,286	.
Yugoslavia	.	.	1,124	2,459	2,126	.	10,966	.	.	.
Norway	.	3,006	4,702	3,711	22,787	26,780	28,491	25,321	34,635	30,357
Austria	5,001	4,479	6,145	6,299	6,573	6,616	7,232	8,040	9,108	7,497
Portugal	182	238	520	510	605	656	467	587	.	1,169
Sweden	4,234	5,509	5,730	12,381	20,467	24,174	25,516	24,149	38,361	47,511
Switzerland	3,035	3,502	3,437	3,816	4,108	4,034	4,742	4,665	5,854	3,794
Spain	3,642	3,781	6,475	6,676	8,848	13,454	14,040	12,940	16,872	10,932
Europe without East Block	23,413	29,989	32,403	42,281	76,535	84,532	100,000	83,984	114,505	110,133
Indonesia	.	.	20	36	58	34	10	42	611	455
Israel	252	501	490	575	410	657	397	621	700	.
Japan	.	.	.	105	1,516	760	707	463	970	284
Korea South	.	.	.	.	.	10,604	341	.	1,137	.
Thailand	.	.	.	20	65	28	35	66	113	145
Turkey	18	68	35	47	44	53	51	49	132	.
Asia without East Block	270	569	545	783	2,093	12,136	1,541	1,241	3,663	884
Morocco	604	893	543	760	694	813	726	927	1,532	1,310
Rep. of South Africa	315	446	502	87	307	11,559	99	665	3,332	.
Tunesia	138	.	161	.	.	121	222	201	.	1,110
Africa	1,057	1,339	1,206	847	1,001	12,493	1,047	1,793	4,864	2,420
Argentina	4,011	4,487	4,194	6,005	6,073	6,510	6,819	6,508	6,934	4,679
Brazil	549	338	536	424	493	806	704	892	885	433
Mexico	.	1,054	1,135	706	.	.	.	.	.	.
Peru	1,361	1,575	1,107	2,335	2,758	1,556	1,583	1,703	.	1,953
USA	60	64	632	876	1,564	1,287	856	2,851	5,393	3,426
Venezuela	.	.	.	.	.	37	128	372	.	871
America	5,981	7,518	7,604	10,346	10,888	10,196	10,090	12,327	13,212	11,362
Australia	17	22	19	17	14	297	59	188	3,156	.
Western World	30,738	39,437	41,777	54,274	90,531	119,654	112,737	99,533	16,368	124,799
Poland	34	.	.	.	55	446	.	.	.	1,143
China PR	.	.	.	.	.	.	.	.	.	224
East Block	34	.	.	.	55	446	.	.	.	1,367
Other countries	16,144[2]	24,292[3]	18,380[4]	11,630[5]	5,126[6]	9,160[7]	7,411[8]	17,348[9]	7,476	4,332
World total	46,916[2]	63,729[3]	60,157[4]	65,904[5]	95,712[6]	129,260[7]	120,148[8]	116,880[9]	146,876	130,498

[1] excluding Denmark and Ireland, [2] including 13,879 t Al-hydroxid from United Kingdom (Intra + Extra),
[3] including 22,198 t Al-hydroxid from United Kingdom (Intra + Extra), [4] including 17,123 t Al-hydroxid from United Kingdom (Intra + Extra),
[5] including 10,152 t Al-hydrocid from United Kingdom (Intra + Extra), [6] including 1,810 t from United Kingdom (Intra + Extra),
[7] including 5,603 t from United Kingdom (Intra + Extra), [8] including 5,737 t from United Kingdom (Intra + Extra), [9] including 15,342 t from United Kingdom (Intra + Extra)

Annex 15 g

Trade within the European Community (Exports) in Aluminium-hydroxid
in t

	1966[1)]	1967[1)]	1968[1)]	1969[1)]	1970[1)]	1971[1)]	1972[1)]	1973[1)]	1974	1975
France	37	250	272	443	843	1,504	2,254	10,613	3,070	1,756
Belgium/Luxembourg	9,257	11,107	9,866	10,760	9,765	11,199	9,891	10,589	12,629	9,103
Netherlands	9,497	10,837	17,545	18,535	25,902	28,307	28,012	26,995	30,878	21,825
Germany FR	69	120	337	433	202	251	398	766	843	547
Italy	2,818	1,075	5,473	6,372	6,689	10,669	34,263	28,719	25,031	26,550
United Kingdom	94	52	631	1,677	3,778	934	498	552	1,253	1,480
Rep. of Ireland	.	.	.	.	.	.	.	.	3,014	2,717
Denmark	57	.	138	61	71	402	62	169	424	580
Not distributed	13,879	22,198	17,123	10,152	1,810	5,603	5,738[8)]	15,344[9)]	-	-
Total	35,708[2)]	45,639[3)]	51,385[4)]	48,433[5)]	49,060[6)]	58,869[7)]	81,116[8)]	93,747[9)]	77,142	64,558

1) excluding Denmark and Ireland,

2) including 13,879 t from United Kingdom (including Alumina) (Intra + Extra), 3) including 22,198 t from United Kingdom (including Alumina) (Intra + Extra)

4) including 17,123 t from United Kingdom (including Alumina) (Intra + Extra), 5) including 10,152 t from United Kingdom (including Alumina) (Intra + Extra)

6) including 1,810 t from United Kingdom (Intra + Extra), 7) including 5,603 t from United Kingdom (Intra + Extra),

8) including 5,737 t from United Kingdom (Intra + Extra), 9) including 15,342 t from United Kingdom (Intra + Extra)

Annex 16 a

Imports of Primary Aluminium in the European Community: 1966 - 1976 (excluding trade within the Community)

in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974	1975	1976 1)
Finland	267	41	454	151	70	.	51	50	.	.	60
Greece	17,546	48,289	49,849	53,452	54,390	81,985	99,171	107,714	99,304	68,803	76,543
Iceland	-	-	-	8,438	24,090	18,116	33,931	47,017	42,147	21,365	59,972
Yugoslavia	1,827	2,435	14,569	21,262	9,193	21,572	25,107	13,881	9,708	3,948	7,630
Norway	206,173	200,167	273,510	349,790	308,591	316,484	373,813	445,021	439,170	309,077	424,662
Austria	6,528	22,663	26,559	28,856	19,976	28,585	23,296	15,730	14,906	4,990	7,586
Sweden	244	167	6,344	5,464	1,229	2,904	2,462	2,101	1,662	724	805
Switzerland	17,013	13,000	15,381	10,671	9,201	7,187	9,821	11,076	11,150	7,108	13,302
Spain	-	5,361	1,259	3,460	3,484	2,281	2,028	2,984	4,052	437	4,682
Europe without East Block	249,598	292,123	387,925	481,544	430,224	479,114	569,680	645,574	622,099	416,452	595,242
Bahrain	.	.	.	.	.	1,853	3,653	7,894	323	2,111	1,717
Japan	2	.	.	868	2,752	632	.	.	3,553	4,184	3,358
Thailand	.	.	.	.	.	.	.	.	159	195	.
Asia without East Block	2	.	.	868	2,752	2,485	3,653	7,894	4,035	6,490	5,075
Ghana	.	16,531	32,272	66,183	77,959	23,845	22,371	30,832	26,298	14,608	30,628
Cameroon	33,300	49,318	34,420	43,201	38,590	30,727	31,682	21,296	22,172	21,073	12,631
Rep. of South Africa	.	.	25	25	.	103	30	28	2,109	1,927	2,226
Africa	33,300	65,849	66,717	109,409	116,549	54,675	54,083	52,156	50,579	37,608	45,485
Canada	165,347	142,601	138,543	135,650	204,614	126,793	90,652	96,936	115,578	27,676	19,995
Surinam	19,831	24,416	21,340	42,387	47,823	24,424	23,660	31,462	26,309	14,187	23,088
USA	72,911	67,164	63,729	108,681	200,477	48,250	28,379	32,265	22,221	7,447	9,622
Venezuela	.	.	811	328	55	242	60	.	.	.	.
America	258,089	234,181	224,423	287,046	452,969	199,709	142,751	160,663	164,108	49,310	52,705
Australia	4,470	439	.	101	8,589	3,492	1,575	2,617	.	.	246
Western World	545,459	592,592	679,065	878,968	1,011,083	739,475	771,742	868,904	840,821	509,860	698,753
Bulgaria	954	1,859	4,145	840	2,660	890	.	.	809	3,631	2,840
Germany DR	11,422	890	1,289	2,029	1,820	604	200	536	1,266	821	925
Poland	758	3,726	2,877	9,086	6,752	16,869	13,128	12,990	6,041	3,090	4,110
Romania	18,110	8,811	15,749	15,399	17,764	29,698	14,909	11,746	29,276	18,344	23,260
Czechoslovakia	2,129	2,778	5,126	8,536	3,301	6,932	5,042	6,533	4,236	5,071	4,607
USSR	42,021	21,848	24,272	17,511	13,176	14,141	27,221	28,445	35,824	41,475	30,663
Hungary	6,789	3,710	9,225	11,337	10,009	7,317	13,088	13,561	11,231	10,630	10,411
East Block	82,183	43,622	62,683	64,738	55,482	76,451	73,588	73,811	88,683	83,062	76,816
Other countries	25,418	42,887	61,956	52,514	67,167	31,409	20,325	26,816	44,550	20,770	17,445
World total	653,060	679,101	803,704	996,220	1,133,732	847,335	865,655	969,531	974,054	613,692	793,014

1) excluding Denmark and Ireland

Annex 16 b

Trade within the European Community (Imports) in Primary Aluminium
in t

	1966 1)	1967 1)	1968 1)	1969 1)	1970 1)	1971 1)	1972 1)	1973 1)	1974	1975	1976 1)
France	136,958	98,105	128,740	163,457	126,808	105,661	106,968	123,895	130,982	87,141	111,244
Belgium/Luxembourg	1,970	5,399	6,082	3,667	4,292	4,524	8,191	19,425	18,511	10,916	11,601
Netherlands	17,661	22,923	41,934	64,454	63,130	85,732	149,244	170,373	258,467	200,103	231,277
Germany FR	19,527	18,708	20,832	31,014	45,635	56,724	78,943	92,724	129,271	110,521	210,409
Italy	12,846	787	22,039	2,047	2,323	7,992	8,643	11,330	14,962	22,562	13,669
United Kingdom	3,348	5,790	4,159	11,031	15,212	14,549	32,924	39,062	57,547	58,517	111,588
Rep. of Ireland	387	1,672	2,175	2,129	2,015	1,923	3,198	3,996	3,190	2,293	1,906
Denmark	186	635	767	850	845	1,318	2,697	2,331	2,358	2,410	3,132
Total	192,883	154,019	226,728	278,649	260,260	278,423	390,808	463,136	615,288	494,463	694,826

1) excluding Denmark and Ireland

Annex 16 c

Export of Primary Aluminium from the European Community: 1966 - 1976 (excluding trade within the Community)

in t

	1966[1)]	1967[1)]	1968[1)]	1969[1)]	1970[1)]	1971[1)]	1972[1)]	1973[1)]	1974	1975	1976[1)]
Finland	375	1,222	1,214	1,543	3,728	323	285	4,186	808	439	5,439
Greece	1,146	344	409	866	300	911	371	293	370	427	1,556
Yugoslavia	539	1,010	518	1,235	1,416	2,737	453	3,008	4,907	2,284	1,046
Norway	644	2,830	1,035	1,976	2,014	1,729	1,348	2,153	3,096	1,807	1,530
Austria	1,371	1,110	1,419	2,622	2,238	384	535	2,470	3,376	4,694	6,189
Portugal	701	560	493	460	694	737	641	990	1,979	785	4,626
Sweden	3,195	1,565	773	1,029	1,233	1,038	1,850	1,342	3,987	7,128	4,843
Switzerland	348	629	663	700	2,879	1,397	3,999	3,087	1,842	2,925	1,553
Spain	2,384	315	892	545	676	842	813	11,785	3,112	7,650	3,055
Europe without East Block	10,703	9,585	7,416	10,976	15,178	10,098	10,295	29,314	23,477	28,139	29,837
Burma	.	.	.	.	.	.	.	.	.	650	.
India	417	1,635	.	.	.	.	.	.	.	.	.
Indonesia	.	.	105	.	.	.	1	213	332	160	507
Iran	43	25	22	44	12	2,536	859	260	126	177	1,750
Israel	1,603	1,745	2,942	3,522	3,673	2,355	3,241	4,947	5,846	3,368	2,098
Japan	5,028	866	1,293	369	450	548	2,234	2,670	3,543	1,131	8,597
Korea South	.	.	.	.	.	.	.	299	.	497	1,243
Lebanon	3,235	3,322	2,482	89	577	5,438	5,583	2,177	11,124	1,872	1,001
Malaysia	.	.	.	.	.	.	271	464	190	259	252
Philippines	.	.	.	.	.	.	426	1,326	880	519	760
Singapore	.	.	.	30	.	.	185	509	545	358	.
Taiwan	20	15	20	25	.	.	.	50	466	199	3,206
Thailand	.	.	.	.	.	120	856	2,203	1,799	5,573	4,392
Turkey	1,949	2,666	2,532	3,344	4,990	4,402	7,482	10,393	12,745	11,216	2,727
Asia without East Block	12,295	10,274	9,396	7,423	9,702	15,399	21,138	25,511	37,596	25,979	26,533
Egypt	325	.	34	.	.	107	96	176	880	4,137	1,385
Algeria	25	110	91	461	.	170	373	1,490	345	478	817
Ghana	.	.	122	135	143	319	.	151	239	159	.
Malagasy	261	353	690	264	283	399	485	452	141	330	492
Nigeria	19	61	80	95	253	110	61	16	288	1,313	868
Rep. of South Africa	115	79	188	268	285	374	339	4,324	767	393	315
Africa	745	603	1,205	1,223	964	1,479	1,354	6,609	2,660	6,810	3,877
Argentina	16.654	6.580	5,960	3.556	1,042	4.530	4,235	7.245	10,450	4.376	1,040
Brazil	61	251	637	2,617	2,559	5,080	11,370	12,244	27,332	18,010	33,430
Canada	1,983	1,215	1,098	1,600	1,691	5,618	10,236	11,657	8,022	4,191	7,211
Mexico	.	.	.	.	.	.	194	1,198	2,201	209	1,190
USA	22,689	9,019	25,922	2,311	983	10,281	32,289	5,992	9,413	12,465	20,527
America	41,387	17,065	33,617	10,084	6,275	25,509	58,324	38,336	57,418	39,251	63,398
Australia	291	264	558	612	266	221	217	262	286	376	.
Western World	65,421	37,791	52,192	30,318	32,385	52,706	91,328	100,032	121,437	100,555	123,645
Germany DR	3,162	4,493	20	520	92	2,464	.	.	.	120	.
Poland	.	170	.	.	.	21	.	6,070	.	.	1,640
Czechoslovakia	.	.	65	.	.	.	.	296	630	614	552
Hungary	.	.	.	.	.	.	39	42	134	86	.
China PR	.	23,891	31,852	4,999	2,320	3,995	9,652	12,380	11,535	83,899	25,379
East Block	3,162	28,554	31,937	5,519	2,412	6,480	9,691	18,788	12,299	84,719	27,571
Other countries	1,710	2,452	1,363	893	1,067	4,314	26,336	2,145	36,419	45,396	9,195
World total	70,293	68,797	85,492	36,730	35,864	63,500	127,355	120,965	170,155	230,670	160,411

1) excluding Denmark and Republic of Ireland

Annex 16 d

Trade within the European Community (Exports) in Primary Aluminium
in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[1]	1971[1]	1972[1]	1973[1]	1974	1975	1976[1]
France	9,337	5,460	9,942	22,186	24,778	38,035	59,622	95,667	128,819	117,274	144,332
Belgium/Luxembourg	115,319	80,990	73,667	82,619	77,832	94,925	124,075	138,846	177,334	119,954	203,767
Netherlands	8,268	6,479	11,135	10,712	11,180	20,368	34,102	50,045	45,787	42,019	115,251
Germany FR	32,580	29,206	94,576	112,923	86,526	81,400	95,529	114,960	112,473	131,404	137,174
Italy	13,813	25,538	30,492	50,310	60,461	48,498	64,324	73,807	137,589	62,702	119,554
United Kingdom	8,100	4,223	919	2,452	2,359	1,319	1,826	3,954	16,951	16,690	19,063
Rep. of Ireland	263	196	484	242	388	311	1,139	1,768	1,227	3,111	4,923
Denmark	969	786	1,772	1,779	1,538	1,191	1,104	1,459	2,299	1,518	2,221
Total	188,649	152,878	222,987	283,223	265,062	286,039	381,721	480,506	622,479	494,672	746,285

[1] excluding Denmark and Ireland

Annex 17 a

Imports of Old and Scrap Aluminium in the European Community: 1966 - 1976 (excluding trade within the Community)
in t

	1966[1)]	1967[1)]	1968[1)]	1969[1)]	1970[1)]	1971[1)]	1972[1)]	1973[1)]	1974	1975	1976[2)]
Greece	139	137	.	321	94	.	.	166	.	.	.
Yugoslavia	2,471	3,379	5,542	6,820	4,315	6,263	7,799	6,202	5,303	6,374	5,686
Norway	1,564	2,162	4,433	3,645	3,193	2,919	4,428	5,544	7,059	5,124	4,776
Austria	5,289	5,649	7,652	8,905	8,916	9,477	34,532	35,132	18,715	18,163	27,758
Portugal	132	353	504	595	44	.	159	81	681	424	153
Sweden	936	1,339	783	780	1,834	1,837	1,093	1,639	1,057	1,056	1,392
Switzerland	4,317	4,431	5,308	6,741	5,843	8,539	8,050	11,241	12,006	10,332	10,655
Europe without East Block[3)]	14,848	17,450	24,222	27,807	24,239	29,035	56,061	60,005	44,821	41,473	50,635[5)]
Israel	849	899	880	1,365	1,041	985	848	832	972	1,096	2,327
Lebanon	124	47	.	377	187	.	23	58	332	.	.
Cyprus	110	69	111	205	110	75	34	133	.	.	67
Asia without East Block	1,083	1,015	991	1,947	1,338	1,060	905	1,023	1,304	1,096	2,394
Algeria	643	561	763	649	336	527	100	90	337	.	.
Morocco	568	481	393	510	483	473	434	354	548	.	90
Rep. South Africa	794	679	531	908	721	364	378	150	.	.	96
Africa	2,005	1,721	1,687	2,067	1,540	1,364	912	594	885	.	186
Canada	12,896	15,099	11,838	10,156	10,065	6,548	5,299	3,159	2,172	3,658	1,072
USA	24,651	27,673	25,848	46,305	38,853	13,639	13,705	20,223	16,441	23,162	12,069
America	37,547	42,772	37,686	56,461	48,918	20,187	19,004	23,382	18,613	26,820	13,141
Australia	401	380	460	928	781	87	.	97	222	.	65
Western World	55,884	63,338	65,046	89,210	76,816	51,733	76,882	85,101	65,845	69,389	66,421
Germany DR	1,253	423	258	897	1,859	1,269	8,377	5,173	1,191	586	1,560
Poland	.	66	124	29	.	246	.	510	1,766	3,043	3,417
Romania	2,396	2,456	3,042	3,072	2,356	3,097	3,683	3,988	1,507	6,723	2,174
Czechoslovakia	1,270	802	126	397	467	873	1,011	308	614	.	979
Hungary	2,721	4,460	5,317	8,783	10,258	7,693	11,781	15,279	9,290	8,692	7,227
East Block	7,640	8,207	8,867	13,178	14,940	13,178	24,852	25,258	14,368	19,044	15,540[6)]
Other Countries[4)]	18,382	16,429	15,234	18,730	18,701	12,627	15,843	19,468	6,833	4,181	5,429
World total	81,906	87,974	89,147	121,118	110,457	77,538	117,577	129,827	87,046	92,614	87,390

[1)] excluding Denmark and Ireland, [2)] excluding Denmark, United Kingdom, and Ireland, [3)] including Al alloy scrap into United Kingdom from 1966 - 1973,
[4)] including total Al imports into United Kingdom, [5)] including Spain: 215 t, [6)] including USSR: 183 t

Annex 17 b

Trade within the European Community (Imports) in Old and Scrap Aluminium
in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[2]	1971[2]	1972[2]	1973[2]	1974	1975	1976[1]
France	14,192	17,778	16,151	16,263	22,326	25,933	24,765	22,210	21,675	21,048	25,390
Belgium/Luxembourg	8,797	10,239	11,581	13,555	13,232	12,767	15,107	18,491	19,358	16,943	24,780
Netherlands	11,622	10,003	12,500	17,030	14,112	19,978	30,041	30,331	35,847	33,851	40,089
Germany FR	7,534	11,043	8,045	8,123	13,080	17,352	20,660	33,202	33,411	34,198	42,786
Italy	201	27	94	174	412	401	907	864	686	836	960
United Kingdom	7,178	2,860	2,295	1,146	1,005	1,159	1,662	2,714	9,263	13,909	4,941
Rep. of Ireland	844	173	46	82	.	128	.	51	.	350	70
Denmark	773	873	437	468	824	689	1,361	2,069	3,455	2,136	4,340
Not distributed	-	-	-	-	784	1,998	1,490	2,377	360	624	23,404
Total	51,146	52,996	51,149	56,841	65,787	80,405	95,993	112,309	124,055	123,895	166,760

1) excluding Denmark, United Kingdom, and Ireland

2) excluding Denmark and Ireland

Annex 17 c

Export of Old and Scrap Aluminium from the European Community: 1966 - 1976 (excluding trade within the Community)

in t

	1966[1]	1967[1]	1968[1]	1969[1]	1970[1]	1971[1]	1972[1]	1973[1]	1974	1975	1976[2]
Greece	.	.	.	.	.	.	.	150	.	.	.
Yugoslavia	.	.	.	21	.	.	22	.	.	.	.
Austria	43	.	.	.	93	.	62	427	.	.	48
Sweden	.	.	.	24	.	.	.	19	188	.	.
Switzerland	131	178	220	249	.	.	250	.	.	.	.
Spain	.	.	.	.	.	57	228	193	.	.	.
Europe without East Block	174	178	220	294	93	57	1,354[5]	789	188	.	48
Israel	.	.	.	.	22	.	.	.	.	.	.
Japan	.	.	.	.	9	.	.	.	.	.	100
China, Peoples Republic	.	.	123	.	.	.	.	.	.	.	.
Asia without East Block	.	.	123	.	31	.	.	.	.	.	631[8]
Algeria	.	.	25	75	50	50	16	21	.	.	.
Madagascar	.	.	50	.	40	177	248	88	.	.	.
Africa	.	.	75	75	90	227	264	109	.	.	39[9]
Canada	.	.	.	.	.	.	.	.	277	290	162
USA	42	.	30	20	.	.	.	20	836	.	296
America	42	.	30	20	.	.	.	20	1,113	290	458
Western World	216	178	448	389	214	284	1,618	918	1,301	290	1,176
Czechoslovakia	.	.	.	.	127	119	147	82	.	.	.
Hungary	.	.	.	.	.	.	.	101	.	.	.
East-Block	.	.	.	.	127	119	147	183	.	.	.
Other countries	7,770	2,146	1,678	1,333	1,061	1,045	184	297	1,297	1,474	792
World total	7,986[3]	2,324[4]	2,126[5]	1,722[6]	1,402	1,448	1,949[7]	1,398	2,598	1,764	1,968

[1] excluding Denmark and Ireland, [2] excluding Denmark, United Kingdom, and Ireland, [3] including 7,609 t from United Kingdom, [4] including 2,036 t from United Kingdom
[5] including 1,617 t from United Kingdom, [6] including 1,315 t from United Kingdom, [7] including 792 t to Norway, [8] including 531 t to Pakistan,
[9] to the Republic of South Africa

Annex 17 d

Trade within the European Community (Exports) in Old and Scrap Aluminium
in t

	1966[1)]	1967[1)]	1968[1)]	1969[1)]	1970[2)]	1971[2)]	1972[2)]	1973[2)]	1974	1975	1976[1)]
France	4,226	4,967	4,626	8,578	9,419	12,077	19,568	22,171	22,123	19,633	13,116
Belgium/Luxembourg	865	763	839	1,268	3,667	5,961	10,800	15,354	16,206	10,541	15,107
Netherlands	2,102	2,937	6,151	4,836	6,995	7,727	8,840	13,437	13,214	21,770	19,166
Germany FR	16,204	15,599	21,450	23,606	19,697	22,196	27,070	23,605	37,427	44,944	43,202
Italy	18,604	23,159	13,926	13,450	24,087	25,681	24,415	26,144	32,254	23,355	33,448
United Kingdom	106	.	.	.	158	177	.	1,167	1,196	759	2,318
Rep. of Ireland	.	.	.	.	.	.	.	.	552	.	.
Denmark	.	.	.	.	.	57	26	.	171	499	668
Not distributed	.	.	.	.	995	1,233	2,235	3,289	300	379	32,975
Total	42,107	47,425	46,992	51,738	65,018	75,109	92,954	105,167	123,443	121,880	160,000

1) excluding Denmark, United Kingdom, and Ireland,

2) excluding Denmark and Ireland

ALUMINIUM PECHINEY

Division alumine et produits fluorés
Aix-en-Provence

SPECIALIZED REPORT I
ON ALTERNATIVE ALUMINIUM ORES:

SURVEY OF SILICO-ALUMINATE MATERIALS SUCH AS CLAYS AND SHALES AMENABLE TO TREATMENT BY ACID PROCESSES FOR THE PRODUCTION OF ALUMINA

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(English text revised in June 1978
by the Commission)

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SUMMARY[1]

Criteria adopted in the study for the selection of suitable formations are as follows:

i) Geological formations or deposits containing more than 10 million t of alumina

ii) Geological formations or deposits amenable to open-pit mining

iii) Geological formations or deposits of clays and shales, not including schists formed by high-grade metamorphism, with the following characteristics:

- alumina content not less than 20 %
- total content of alkali and alkali-earth metals (CaO, MgO and Na_2O) not more than 5 %
- iron-to-aluminium ratio (as Fe_2O_3/Al_2O_3) less than 0.5.

Belgium

Argillaceous layers appear to be widely developed, but little is known on their potential for production of alumina. It seems that possibilities might exist in several formations:

1- Shales and slates in the Paleozoic of the Ardennes.

2- Carboniferous shales and slates, plus washings and tailing dumps left from coal mining.

3- Tertiary clays.

The only available figures are tonnages of coal-mining dumps (700 Mt in all in 1975) and alumina contents of some Tertiary clays.

Denmark

Potential seems to lie exclusively in some clays of Eocene age, for which a number of chemical analyses and detailed mineralogical studies have been performed.

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[1] written by the Commission Services

France

The survey of french clays and shales is relatively well documented. Of potential interest are:

1- Shales and slates in the upper Precambrian and lower Paleozoic of the "Massif Armoricain" and in the Lower Paleozoic of the Pyrenees. In particular, there certainly exist considerable tonnages of a formation called "schistes à Calymenes", which occurs widely in several areas south of Rennes and is extensively mined for the production of slates near Angers.

2- Tertiary clays of the Aquitaine basin, associated with deposits of lignite. Reserves are given for one basin.

3- Wastes from coal mining and washing. A substantial tonnage is divided between a large number of dumps.

Great Britain

Available information is comprehensive. Six topics appear to have potential interest:

1- Paleozoic slates. They are abundant in the UK, principally in Northern Ireland, the Southern Uplands, the Lake District, North Wales, Cornwall and Devon. Substantial quantities of waste (300 to 500 m t) are also available as a result of very intensive mining in the past. It should be possible to locate formations of suitable chemical composition and sufficiently high alumina content.

2- The Carboniferous "Etruria Marl" of North Staffordshire, Warwickshire and South Derbyshire, used to produce highquality bricks and tiles. Reserves appear to be limited.

3- Carboniferous shales and clays, associated with coal layers. They occur in the North-East, the North-West and the South, especially in the Midlands. Areal distribution is wide and alumina content seems high, but available quantities are not known.

4- The lower cretaceous Weald clay of Kent, Surrey and Sussex, currently worked for brick-making. Nothing is stated on reserves, workable thicknesses or scope for extraction of substantial annual tonnage.

5- China clay wastes. China clay occurs in Cornwall as a result of hydrothermal alteration of granites. Currently, the cost of the pure china clay employed in the ceramics industry far exceeds its potential value as a source of alumina.
Production of china clay involves the removal of various residues, including fine micaceous material of which about 2 m t are stored each year and 20 m t are available in former settling basins. In theory, the quantity of alumina contained in the annual production tonnage of this fine waste material would nearly cover the United Kingdom's annual alumina requirements. However, the mineralogical composition is not stated and the high alumina content of these wastes (32 - 33 %) cannot be ascribed either to clay minerals or to micas.

6- Wastes from coal mining. Coal seams are associated with argillaceous formations and sandstones, which are extracted along with the coal and dumped after separation. Tonnages, grades and composition of dump material are available. Furthermore, it appears possible to locate areas where shales and clays have the highest alumina contents.
The presence of coal in dumps could enhance the value of such silico-aluminate materials in that the coal would supply part of the energy needed for conversion to alumina.

Holland

Only subjects of interest appear to be the "Potkleis" (glacial deposits in Quaternary basins) in the Groningen area, and coal mining dumps in Limburg. Reserves, grade and mineralogy of the Potkleis are known, tonnages of dumps are not.

Ireland

The subjects listed in the inventory often appear to be promising, but confirmation of their potential interest is subject to more geological studies and analytical data.

1. Lower Paleozoic shales and slates. Potential seems concentrated in three areas: the Longford Down massif north of Dublin, the Leinster massif South of Dublin and the Midlands near Limerick.

2. Carboniferous shales. They appear to represent the largest reserves of silico-aluminous rocks. Four areas have been selected for their apparent potential, including a small coal field with considerable amounts of associated shales.

3. Waste and dumps from coalfields. There exist substantial but unspecified tonnages of argillaceous dumps.

Italy

Information on Italy is based only on some general published matter. In the absence of sufficient data on grades and tonnages, it has been impossible to select materials and areas of potential interest for the extraction of alumina by acid processes.
General information is supplied on the following regions: The East Central Alps, Liguria, Tuscany, South Central Italy, Calabria and Sardinia. A notable feature is the existence of lignite deposits in Tuscany and South Central Italy; reserves of lignite are known, but not those of associated clays. Kaolin is found in South Central Italy and Sardinia.

Luxembourg

Further study is warranted only in the Pal eozoic of the Ardennes. There exist a relative abundance of analytical data. The Geological Survey of Luxembourg has systematically sampled three sections of the Devonian, thus providing 51 chemical analyses. Earlier, more dispersed, data are also available; they tend to suggest the potential interest of clays formed by weathering of shales and slates.

Federal Republic of Germany

Available information is restricted to a brief list of potential subjects and to a few chemical analyses.

Potential interest can be expected in:

- the Paleozoic of the "Rheinisches Schiefergebirge"
- the Carboniferous of the Ruhr valley, which could be used as waste material from coal washing plants.
- Argillaceous layers of Mesozoic and Tertiary age.
- The clay/lignite associations in the Tertiary basins (Westphalia, Helmstedt, Hessen and Bavaria). They appear to be subjects of particular interest, in that the lignite could supply part of the energy required for processing purposes.

Conclusion:

Silico-aluminous rocks are abundant in the EC countries, either as in situ open-pit mineable clays, shales and slates from large sedimentary formations, or as waste materials rejected by mines in activity (kaolins, slates, etc.).

It should be recognized that very little is known concerning reserves and qualities of such rocks. In particular, the clays or shales rejected by the lignite or coal mine operations, or more generally associated to fossil fuels, should retain the utmost attention. These materials are believed to be well distributed in the EC and in sufficient quantities to support an aluminium industry; moreover they contain a residual thermic value, presently lost as these materials are disposed as waste,but recoverable if they were processed as an aluminium ore.

SURVEY OF SILICOALUMINOUS SUBSTANCES SUCH AS CLAYS AND SHALES AMENABLE TO TREATMENT BY ACID PROCESSES FOR THE PRODUCTION OF ALUMINA

Following the terms of a study contract signed between the European Economic Community and Aluminium Pechiney, a survey has been carried out by Aluminium Pechiney with a view to making an inventory of silicoaluminous substances such as clays and shales occurring naturally in the EC member countries and amenable to treatment by acid processes for the production of alumina.

Criteria adopted in the study for the purpose of selection of suitable formations are as follows:

- Geological formations or deposits containing more than ten million tons of alumina [1)]
- Geological formations or deposits amenable to open-pit mining
- Geological formations or deposits of clays and shales, not including schists formed by high-grade metamorphism, with the following characteristics:
  - alumina content not less than 20 %
  - total content of alkali and alkaline-earth metals (CaO, MgO and Na_2O) not more than 5 %
  - iron-to-aluminium ratio (as Fe_2O_3/Al_2O_3) less than 0.5/1.

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1) All tonnages are expressed in metric tons

I. BELGIUM

Belgium consists of two principal geological units, viz:

- The Ardennes Paleozoic massif, extending over parts of France, Luxembourg and Germany (Figure 1)
- The Flanders Tertiary plain.

The brief documentation supplied by the Geological Survey of Belgium has been supplemented by consultation of more general references, especially the International Stratigraphic Lexicon.

Argillaceous layers appear to be widely present within these two structural units.

Formations of silicoaluminuous substances amenable to treatment by acid processes (subject to verification of grade) are described in stratigraphic sequence.

1) Paleozoic shales and slates of the Ardennes

1.1 Cambrian slates and phyllites

The Cambrian of Belgium, metamorphic to a various degree, occurs in the Rocroi, Givonne, Serpont and Stavelot massifs.

The two characteristic substages of the Ardennes are:

- The Devillian: Phyllites, partly slaty, of the Fumay belt in the north and of the Deville-Rimogne belt in the south, in the Rocroi massif
- The Revinian: Black phyllites, partly slaty, sometimes graphitic and pyritic, in the Rocroi and Stavelot massifs, e.g. the Mousty black phyllites.

1.2 Ordovician-Silurian shales

The Ordovician system is mainly represented in the Sambre and Meuse belt along the Condroz anticlinal zone.

The main shale formations are:

- The Tetraspis shales of the Fosse layers.
- The La Gazelle black shales, locally pyritic, of the Dave layers.
- Several strata of slaty shales or phyllites of the Gembloux layers, the total thickness of which can be as much as 600 m.
- The Huy "silky" black shales
- The green shales of the Jonquoi layers, the thickness of which can be as much as 300 m.

Figure 1

Sketch map of the Ardennes massif

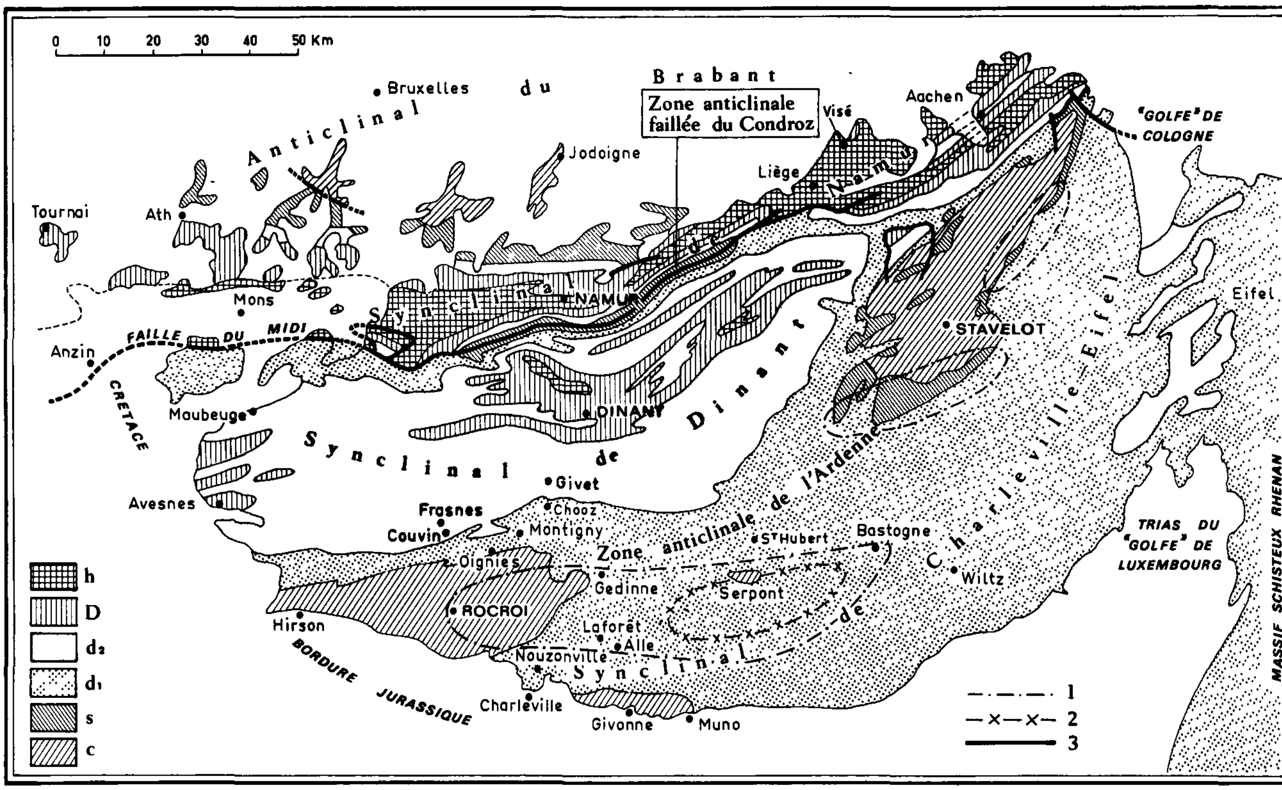
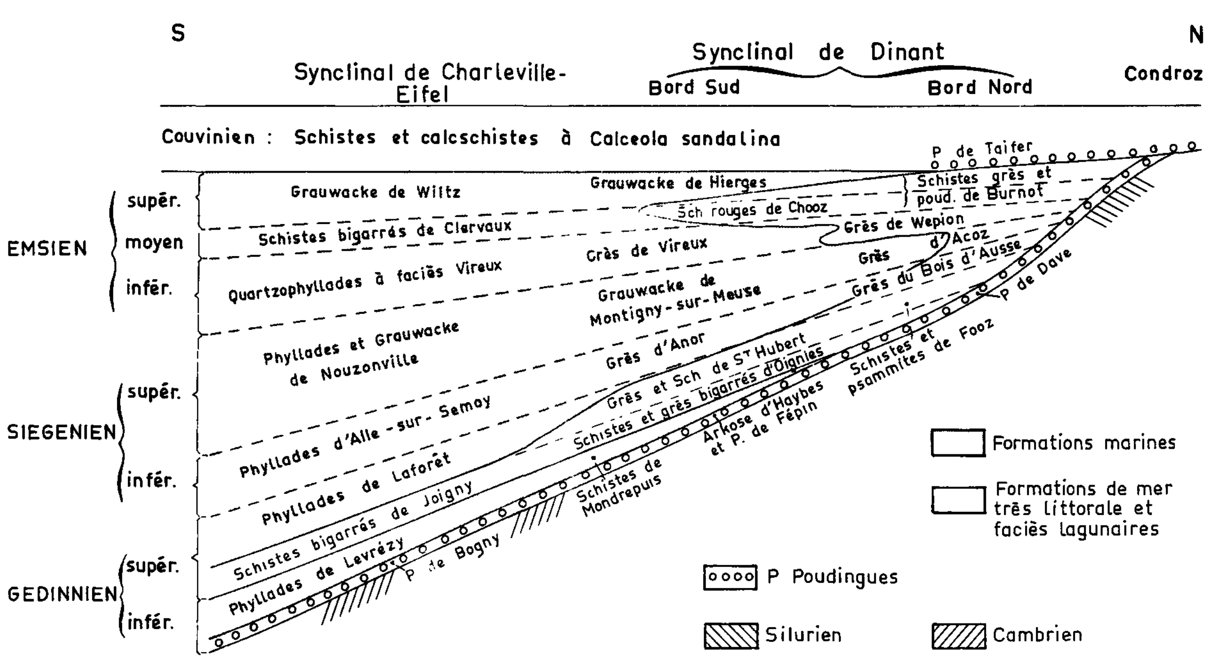


Figure 2

The lower Devonian of the Ardennes



- The Colibeau shales, with a thickness of the order of 650 m.

1.3 Devonian shales

The lower Devonian extends over an important area broadening from west to east from the Mesozoic cover in France to the limestone basins of the Eifel (Figure 2), and comprises from bottom to top: the Mondrepuis shales, the Fooz formation (Oignies shales and Saint Hubert green shales), and the Chooz or Winenne red shales.

In the Bastogne area, the weathered shales are worked for brickmaking.

The middle Devonian is represented in the Dinant and Namur basins and consists mainly of limestones, with the exception of two layers, the basal Emmanuella shales and the Spirifer and Calceola shales.

The upper Devonian (Matagne, Frasnes and La Famenne formations) is essentially shaley. Its thickness decreases from 600 m in the South to 150 m in the North. Shales are especially abundant in the Frasnes formation.

2) Carboniferous shales

2.1 Dinantian to Westphalian series

The Dinantian is essentially calcareous and includes only the Spiriferina shales of the Hastière formation.

The Namurian is marine and almost barren of coal. It forms a clearly individualised unit between the Carboniferous limestone and the productive Coal Measures. The principal formation (Chokier) is entirely marine and free of coal and consists of carbonaceous and phtanitic shales (Baudour shales, Malonne layers, etc.).

The Westphalian, which outcrops in the Haine-Sambre-Meuse belt of the Namur syncline, has been divided into a series of coal districts (Basse Sambre, Charleroi, Centre and Couchant de Mons). This great Hainaut basin is completed to the east by the Andenne-Hay and Liège units. The Campine basin, on the other hand, is covered by barren ground.

2.2 Colliery spoil

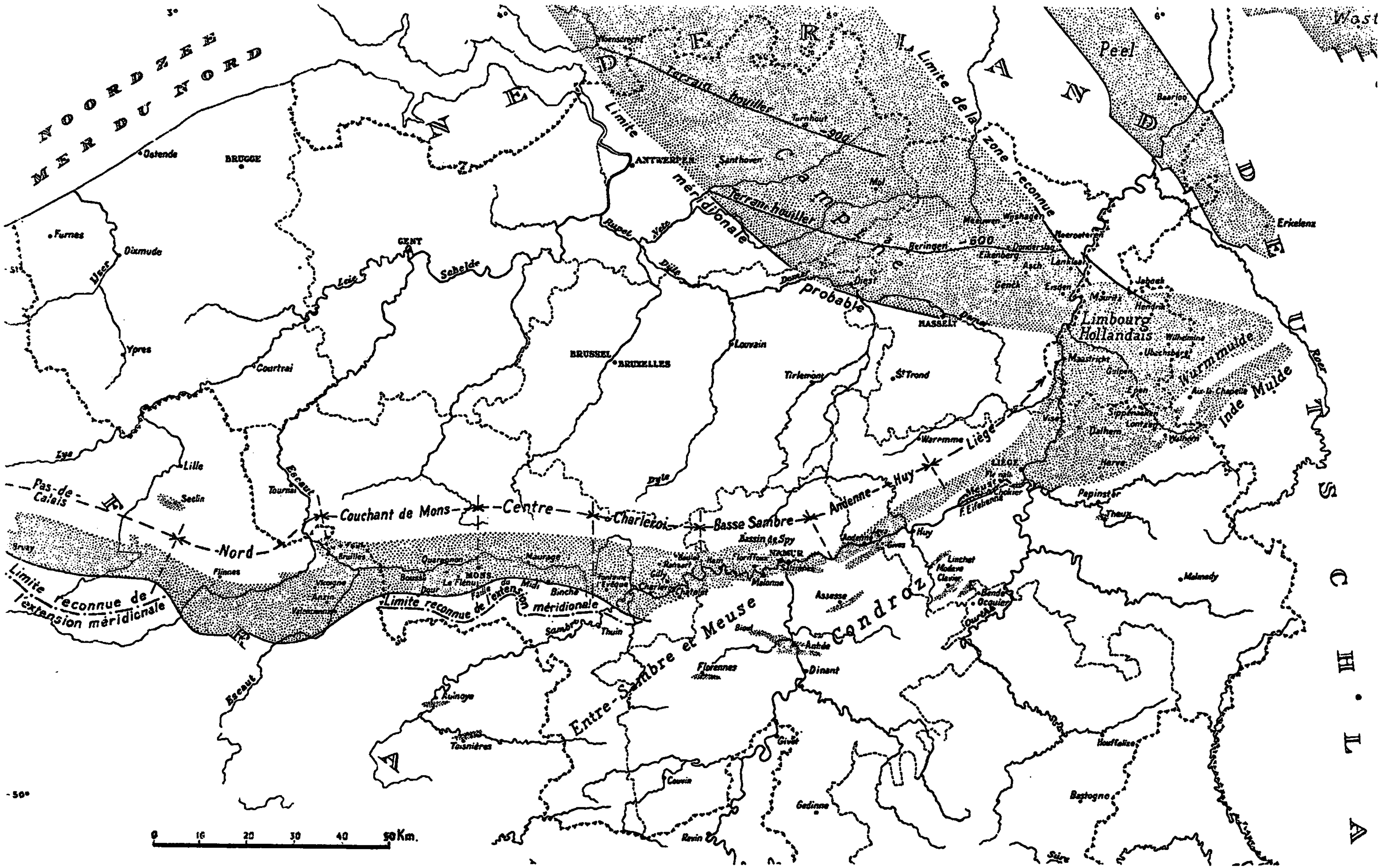
1976 output of coal was 7 million tons from the three coalfields of Hainaut (735,000 t), Liège (255,000 t) and Campine (6,610,000 t); (Figure 3).

The coal seams alternate with layers of sandstone and shale.

In 1974, when net output of coal was 7.48 million t, a quantity of 5.7 million t of spoil was dumped. Recovery was therefore some 56 %.

Figure 3

Sketch map of Belgian and neigh bouring coalfields



The concentration of waste tips is a favourable factor. In 1975, the total quantity of spoil was estimated at 700 mt, divided between 400 or so tips, mainly in the Hainaut district.

3) Tertiary argillaceous formations

The clay formations frequently encountered in the Belgian plain mostly occur in layers of limited thickness and extension.

The formations which appear to be most widespread are:

The Condroz plastic clays, dating from the Oligocene and employed in the manufacture of refractory products and ceramics.

The Boom clay, also Oligocene and directly accessible in the area of Boom, where it can be as much as 30 m thick.

Recent boreholes have shown that in the northern part of the Antwerp province this clay occurs massively over a thickness of 80 m, below a cover of water-bearing sands. It is frequently rich in iron sulphide and, in the region of Rupel, normally contains 15 to 20 % of alumina.

The Flanders clay, Eocene (Ypresian) - very thick and of substantial extension. It becomes very massive and homogeneous towards the north (Tielt borehole).

In the areas currently being worked for the production of brick and tiles, the clay contains 12 to 20 % of alumina.

II. DENMARK

The geological substratum of the country as a whole is covered by glacial and fluvial deposits. It consists, from north to south, in the Upper Cretaceous of the Ålborg region (North Jutland) and of the eastern part of the Danish isles, followed by the Eocene and Oligocene, fringing Jutland and largely outcropping on the Danish isles, and finally by the Miocene in the median and southern parts of Jutland (Figure 4).

The only geological stage featuring any substantial and relatively pure argillaceous sedimentation is the Eocene. These clays are currently being worked in Jutland.

Comprehensive documentation in this connection has been supplied by the Geological Survey of Denmark.

Eocene clays

Geographical location

The areal extent of these marine clays is shown on figure 4. Although generally concealed under extensive glacial till, they can outcrop as a result of erosion (costal cliffs) or glacier pressure accompanied by deformation, particularly in Jutland.

The Eocene extends over a vast area, but the scope for extraction and the reserves which may be available in the various formations are not well known; a thorough study of these matters seems to be warranted.

The thickness of overlying glacial till does not exceed 20 metres in certain regions

The regions concerned are mostly agricultural or touristic.

Stratigraphy

The argillaceous Eocene comprises several layers, from the earliest to the most recent:

Basal Eocene: clay with volcanic ash; maximum thickness 30 m.

Lower Eocene (Røsnaes clay): variegated plastic clay, containing carbonate; maximum thickness 15 m.

Lower/Middle Eocene transition: plastic clay, containing small amounts of carbonate; thickness approx. 20 m.

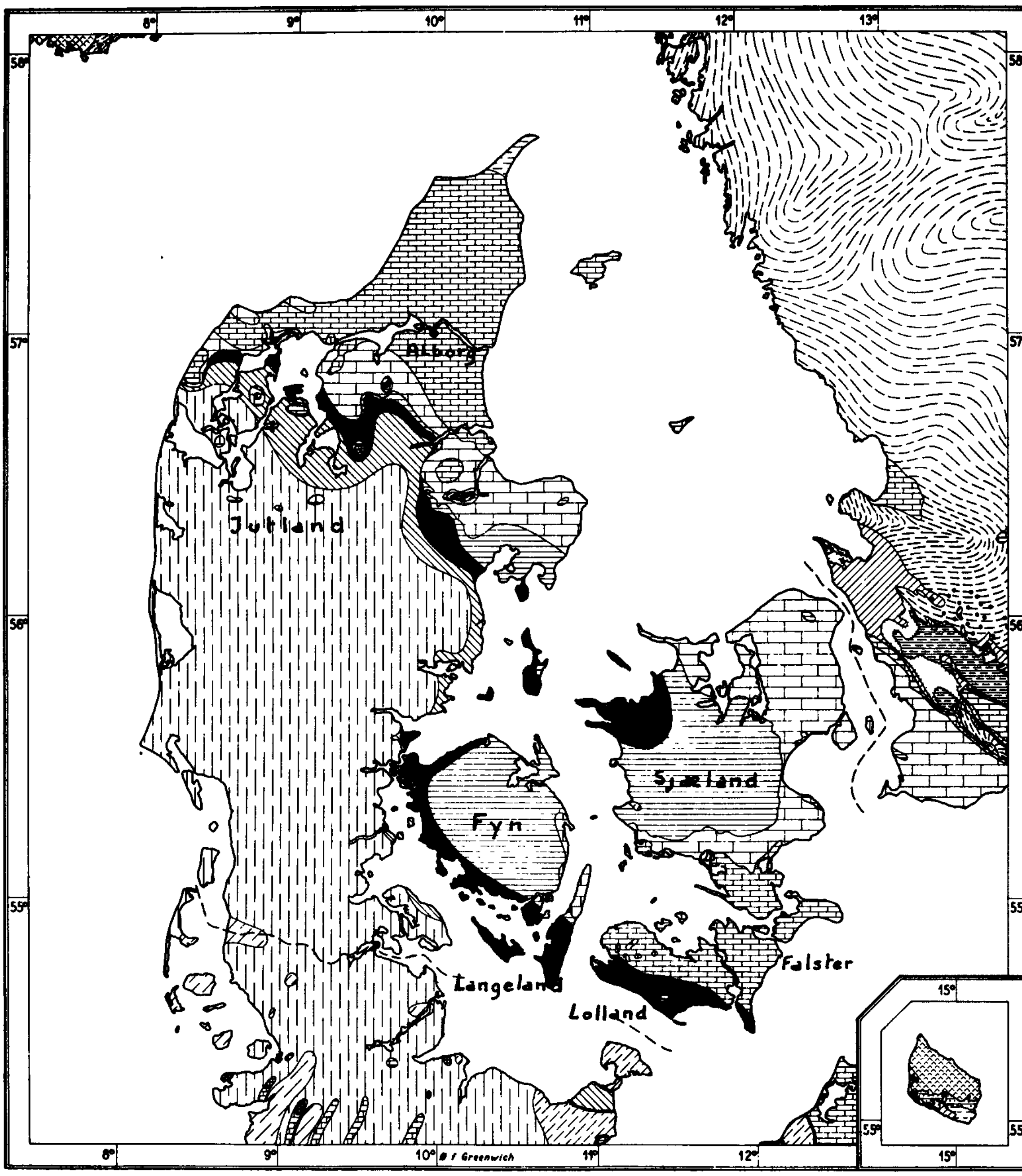
Middle Eocene (Lillebaelt clay): plastic clay, containing small amounts of carbonate; thickness 20 to 30 m.

Middle/Upper Eocene transition: plastic clay containing carbonate, or marl; maximum thickness 30 m.

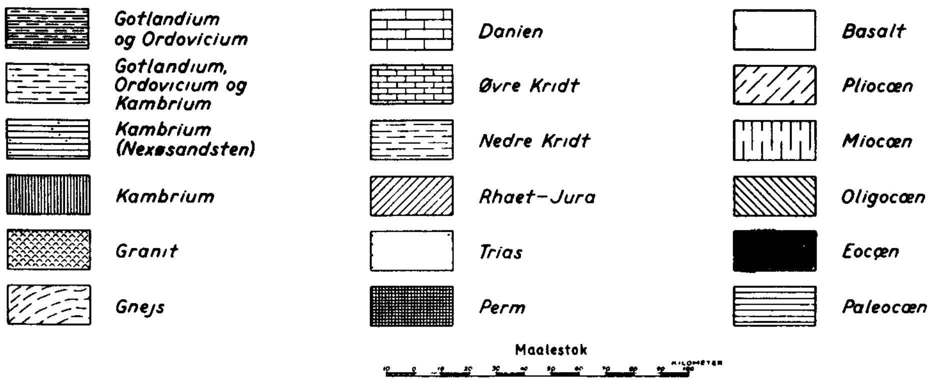
Upper Eocene to Lower Oligocene (Søvind marl): carbonate- and pyrite-rich marl; maximum thickness 20 m.

Figure 4

Geological map of Denmark



GEOLOGISK KORT OVER DANMARK.
FORMATIONERNE VED BASIS AF KVARTÆRET.



Grade

The six analyses below supplied by the Geological Survey of Denmark probably refer to the Middle Eocene (Lillebaelt clay). They are earlier than more recent and detailed stratigraphic studies.

	1	2	3	4	5	6
SiO_2	52.07 %	57.1 %	50.1 %	49.7 %	52.9 %	49.5 %
Al_2O_3	24.82 %	21.7 %	21.3%	24.0 %	22.6 %	26.5 %
Fe_2O_3	11.76 %	7.05 %	4.1%	4.1 %	7.9 %	6.0 %
CaO	0.49 %	0.75 %	0.8%	0.5 %	1.5 %	1.0 %
MgO	0.17 %	0.28 %	2.1%	2.1 %	3.0 %	1.5 %
K_2O	2.10 %	3.22 %	3.9%	5.3 %	1.19%	2.8 %
Na_2O	0.27 %	1.29 %	/	/	0.2 %	0.2 %
CO_2	/	/	/	/	0.3 %	0.3 %

Localities:			
	1	=	Røgle
	2 and 3	=	Refnaes
	4	=	Fredericia
	5	=	Vejle Fjord
	6	=	Trelle Naes

The lower Eocene clays (Røsnaes clay) contain 12.7 to 19.9 % alumina, but more than 10 % CaO + MgO, which is prohibitive.

Mineralogy

An X-ray study of the Lower Tertiary clays (R.W. Tank, Copenhagen, 1963)[1), based on 108 samples, has resulted in a three-fold mineralogical division:

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1) "Clay mineralogy of some lower Tertiary (Paleogene) sediments from Denmark" in: Geol. Survey of Denmark, IV series, vol. 4, n° 2.

Mineral Zones	Subzones	Characteristic Clay Minerals	Stratigraphic Units
	D	Variable amounts of montmorillonite, kaolinite and illite.	Upper Oligocene clay Septarian Clay Upper part of Sövind Marl
	C	Predominantly random mixed-layer montmorillonite-illite with lesser amounts of kaolinite and illite.	Lower part of Sövind Marl
Zone III	B	Predominantly montmorillonite with lesser amounts of kaolinite and illite (illite less abundant than kaolinite).	Lillebaelt Clay
	A	Predominantly montmorillonite with lesser amounts of illite and kaolinite (illite more abundant than kaolinite).	Rösnaes Clay
Zone II		Predominantly amorphous material with minor or trace amounts of montmorillonite, illite, and kaolinite.	Mo Clay Formation (diatomite beds)
Zone I		Predominantly montmorillonite with minor or trace amounts of illite and segregated mixed-layer clay minerals. Absence of kaolinite is particularly diagnostic.	Kerteminde Marl Lellinge Greenssand

The clay minerals of Zone I are detrital and derived from a carbonate mass. The high content of montmorillonite is due to diagenetic modifications in a marine environment.

Zone II is the result of weathering of volcanic ash (apparition of kaolinite).

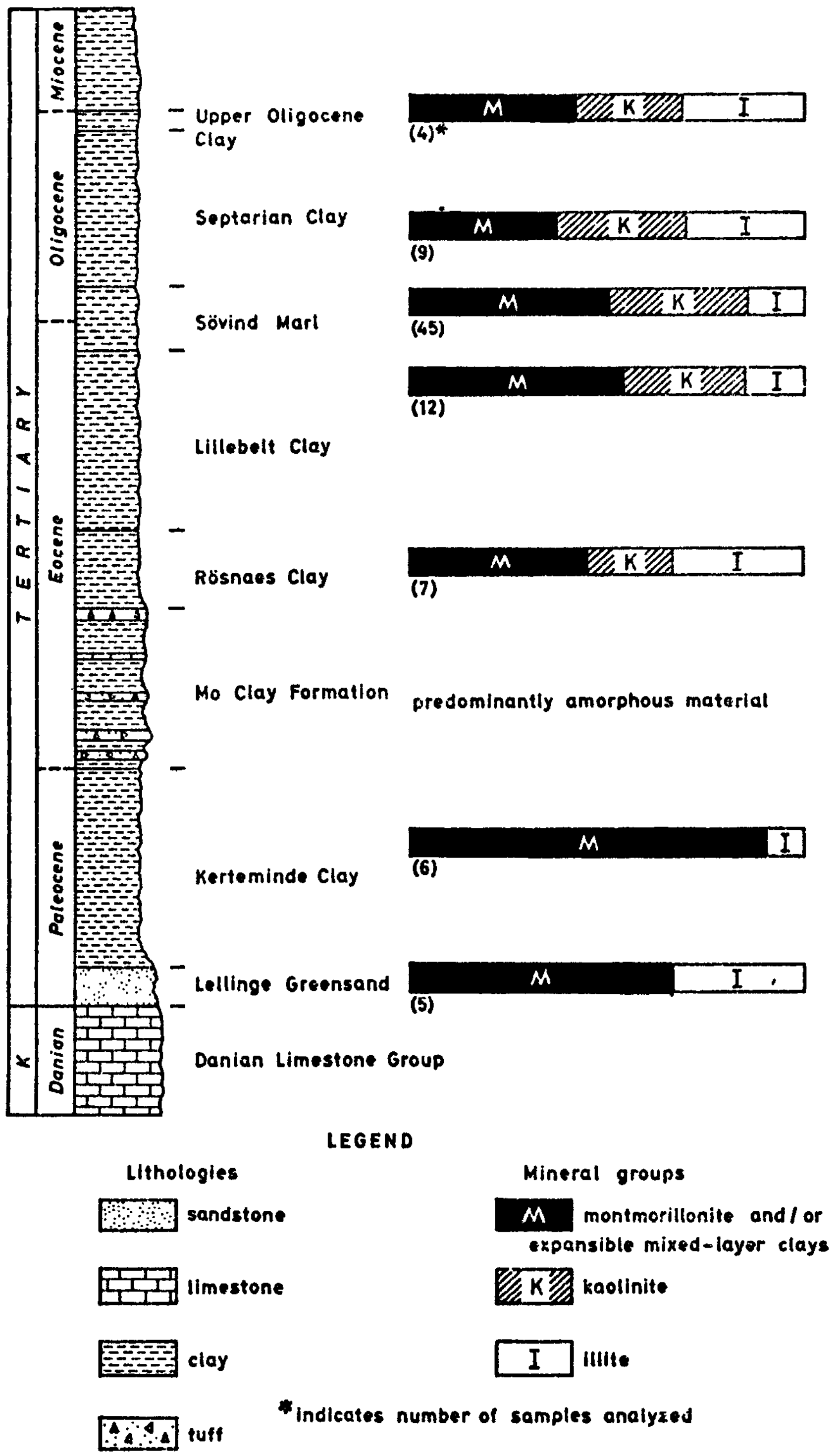
The clay minerals of Zone II represent the final phase of weathering of volcanic material from the Finno-Scandinavian massif.

Only the carbonate-free Middle Eocene (Lillebaelt clay) is of interest in this argillaceous sequence. Montmorillonite predominates as compared to kaolinite and illite. For the fraction under 2 microns, average percentage composition is as follows:

Montmorillonite: 50 to 60%, Kaolinite: 30 to 40 %, Illite: 10 to 20 %. Minor constituents are quartz and chlorite. Figure 5 summarizes the lithology and average composition of the clays in the Tertiary sediments.

Figure 5

Lithology and average mineralogical composition of Paleogene sediments in Denmark



III. FRANCE

From the early Mesozoic onwards, the epi-Hercynian platform has behaved differentially in various areas.

- Certain sectors have been slightly uplifted. These are the older massifs (Ardennes, Armorican Massif, Central Massif, Vosges, Maures and Estérel), which are locally broken up by rifts (Alsace and Limagne).
- Vast areas have settled slowly as a result of subsidence and been filled by Mesozoic to Quaternary deposits: these correspond to major non-folded sedimentary basins (Paris Basin, Central and Northern Aquitaine Basin).
- Others, included in the Alpine orogene, have been strongly folded to form the Alpine ranges (Pyrénees, Provence, Jura, Alps and Corsica.

The formations described in the following pages are considered to be of potential interest for the production of alumina by acid processes.

1) Shales and slates of the Armorican Massif

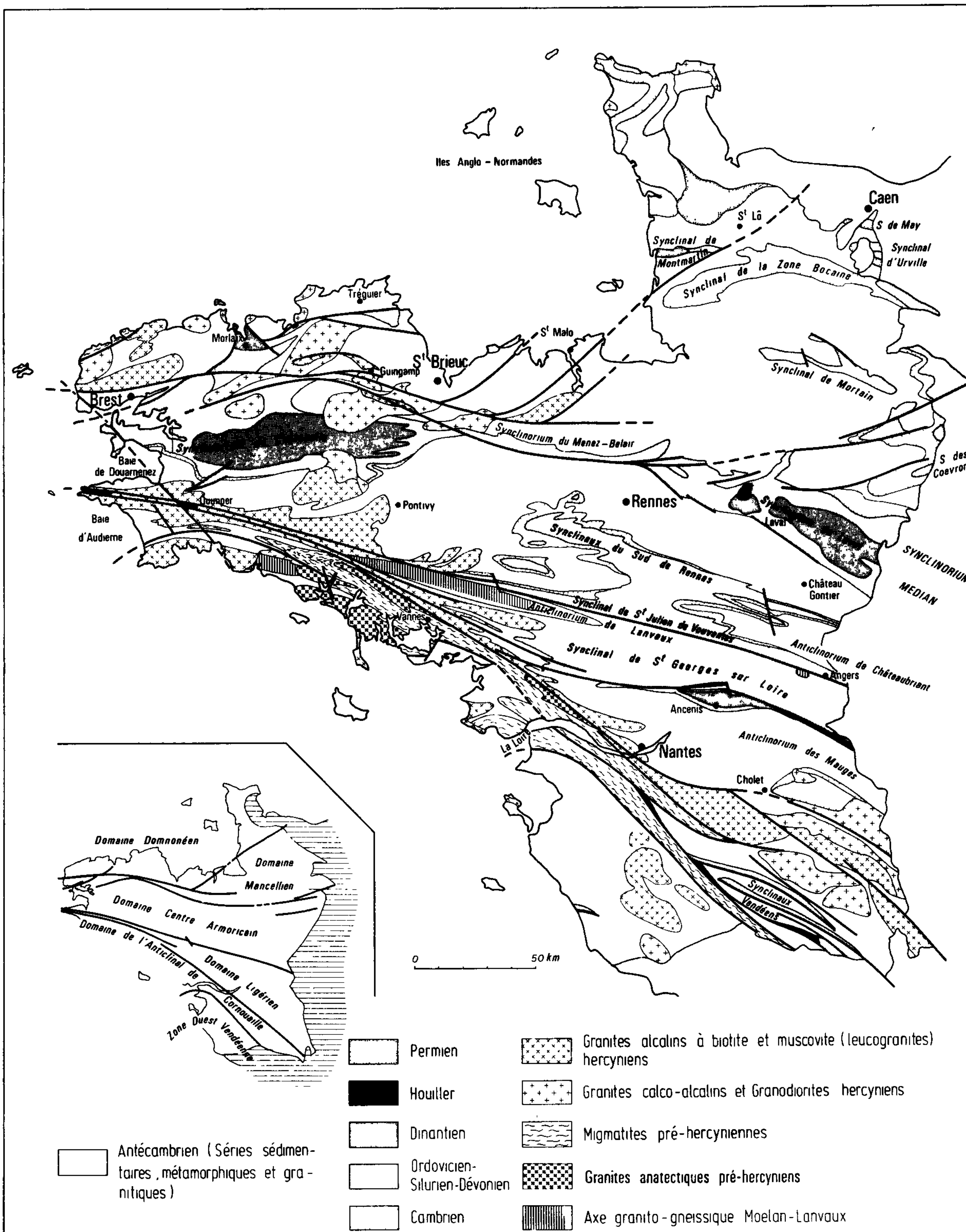
The Armorican Massif consists of a fan of Hercynian folds comprising Paleozoic synclinorialzones separated by anticlinorial zones showing older strata (Precambrian) or granites and deep metamorphites.

This massif covers part of the west of the country, most importantly Brittany and part of Normandy. It is limited to the east by the Mesozoic formations of the Paris basin (Figure 6).

Systematic sampling of the Paleozoic shales has demonstrated the potential of the Ordovician "Calymene shales" as a source of silico-aluminous rock.

Figure 6

The Armorican massif



Le Massif Armoricain : structure et granites hercyniens.

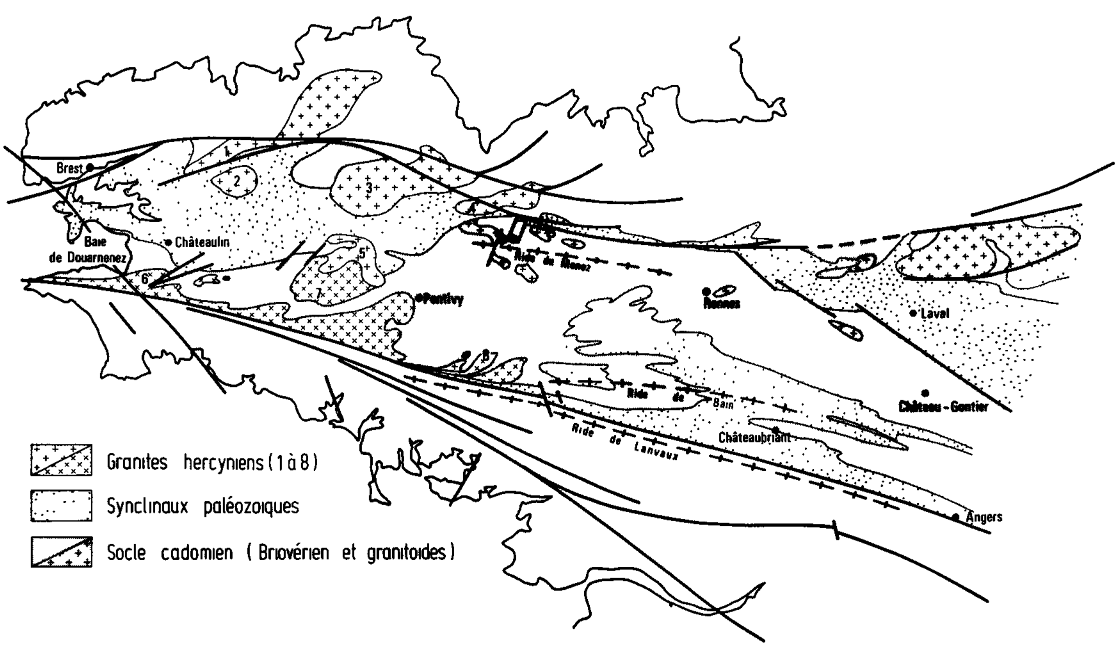
1.1 Ordovician shales

The Middle Ordovician (Llanvirnian and Llandeilian) is represented essentially by the "Calymene shales", a grey or black pelitic formation of fairly regular thickness and of homogeneous and fine-grained lithology. Thickness is some 450 to 500 m.

The facies of these shales, which are largely represented in the Paleozoic synclines south of Rennes (Figure 7), varies from north to south as a result of the combined action of tectonics and of Hercynian low-grade metamorphism. It becomes slaty North of the Loire over vast areas (Angers slates).

Figure 7

Central part of the Armorican massif



Le domaine centre-armoricain : socle briovérien et couverture paléozoïque plissée selon deux grandes trainées synclinoriales : le Synclinorium médian (Chateaulin - Laval) et les synclinaux du S de Rennes. Les granites hercyniens, surtout limitrophes, sont de deux types :

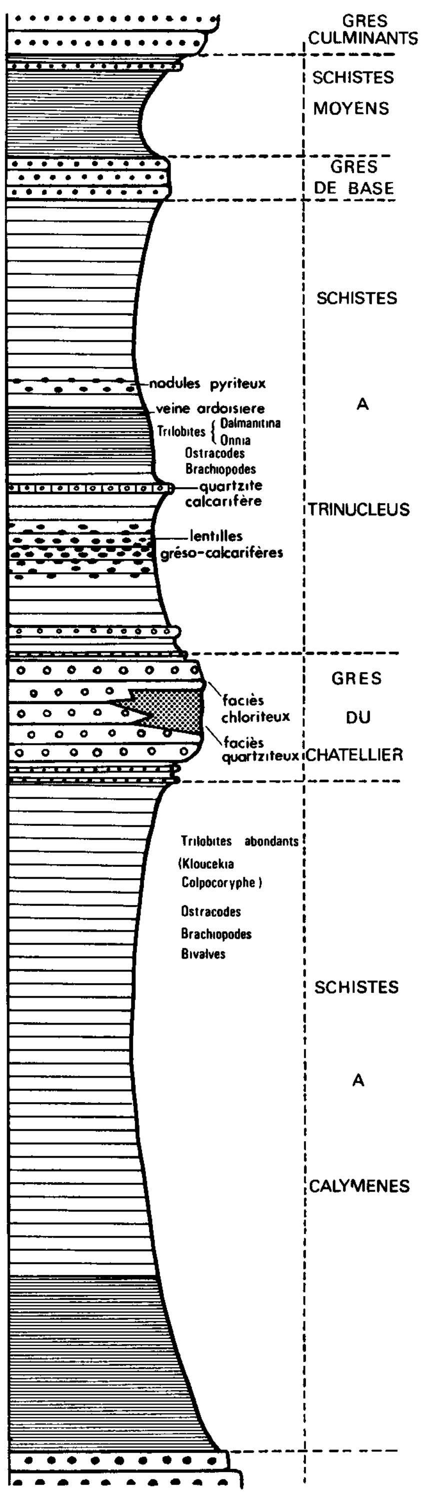
granites calco-alcalins à biotite et granodiorites (1 : Commana. - 2 : Huelgoat. - 3 : Quintin. - 4 : Ploeuc - Moncontour. - 5 : Rostrenen).

leucogranites ou granites alcalins à muscovite et biotite (6 : Locronan. - 7 : Le Faouët - Pontivy. - 8 : Guehenno - Lizio).

By way of example, we may quote the results obtained at two points of the Paleozoic syncline extending from Chateaubriant to Angers.

Chateaubriant region

Geological environment: The Paleozoic forms a synclinorium between Chateaubriant and Angers (Figure 7) on the southern side of an anticlinal zone with a Brioverian core (X schists or phyllites). The Ordovician (S^{2a}) resting on the Arenig Armorican sandstones (S^{1b}) is overlain by the Silurian sandstones and shales (S^{4-3}) (Figure 8).



The Middle Ordovician, formed by the Calymene shales (Llanvirnian and Llandeilian), and the Upper Orodovician (Caradocian) Trinucleus shales, separated by a sandstone episode, constitute the Angers series, containing local occurrences of slate.

A clay formed by weathering has developed locally over varying thicknesses on the Calymene shales.

The synclinal structure, extending over a hundred kilometres or so, points to the existence of considerable tonnages of shales under a thin cover of recent deposits. While the composition could vary laterally, the base of the series would seem to hold out the best hopes.

Figure 8

The middle and upper Ordovician south of Rennes

Grade and mineralogical composition: Forty of so boreholes drilled in this formation have enabled the average chemical compositon to be determined, viz:

	Upper weathering clays	Shales	General average
SiO_2	57 %	54 %	55 %
Al_2O_3	27 %	24 %	26 %
Fe_2O_3	10 %	8 %	8.51 %
CaO	0.4 %	1 %	0.70 %
MgO	0.7 %	2 %	1.95 %
K_2O	3 %	4 %	3.1 %
TiO_2	0.95 %	1 %	1 %
P_2O_5	0.6 %	0.4 %	0.36 %
Na_2O	0.07 %	0.6 %	0.5 %

The mineralogical composition is substantially the same for the clay and the shales: kaolinite, micaceous phyllite, quartz, limonite and carbonaceous matter. The salient feature is the migration and subsequent elimination of iron in the clays.

Angers region

The eastern end of the Chateaubriant synclinorium exhibits a Paleozoic series where the Middle Ordovician becomes slaty. These slates are mined in the Angers region.

Economic activity in this region is based on livestock and agriculture. Habitat tends to consist in scattered large farms which are frequently at some distance from each other.

Geological environment: This region is close to the eastern limit of the Paleozoic and crystalline formations of the Armorican Massif, overlain east of Angers by the Cretaceous of the Paris basin.

Several structural units can be differentiated from north to south:

The Candé anticlinorium (Precambrian orthogneiss)
The Saint Georges sur Loire synclinorial series
The Basse Loire coal basin (a narrow tectonic trough)
The Ancenis syncline.

The Saint Georges sur Loire series comprise a zone of shales, locally slaty, resting on the Bains shales and arkoses (equivalents of the "Armorican sandstones") and overlain by the very thick Upper Ordovician which consists in shales, sandstones and volcano-sedimentary formations.

The Angers shales are the equivalents of the Calymene and Trinucleus shales of Chateaubriant.

Grade: Nine samples taken at the surface show the following mean analysis:

SiO_2	58.1 %
Al_2O_3	21.26 % (extremes 15.56 %-24.16%)
Fe_2O_3	7.83 %
CaO	0.56 %
MgO	1.42 %
K_2O	3.46 %
TiO_2	0.94 %
P_2O_5	0.23 %
Na_2O	0.84 %

The mineralogical composition of these shales is very probably analogous to that of the Chateaubriant shales.

Calymene shales of the Cotentin

In the Cotentin peninsula, the lithology of the Paleozoic is fairly similar to that already described for the synclinal structures south of Rennes. The Middle and Upper Ordovician features an alternance of shales and sandstones:

Calymene shales
Lower May sandstones
Intermediate shales
Upper May sandstones
Caradocian shales

In the northern part of the Armorican Massif, the comparative instability of this epicontinental sedimentation zone is reflected in the frequency of the sandstone facies as high as the Silurian and Devonian.

Here again, the only formation in which argillaceous sedimentation largely predominates is the Calymene shales series. These shales are generally included in structural units of fairly limited extension and their thickness, of around 50 m, is less than that with wich we are familiar in the southern part of the Armorican Massif. An example is the Siouville-Aqueville syncline near the coast, about 20 kilometres south-west of Cherbourg.

Grade: The following is the average analysis for fourteen surface samples:

SiO_2	53.8 %
Al_2O_3	24.64 % (extremes 18.10%-26.58%)
Fe_2O_3	7.18 %
CaO	0.18 %
MgO	1.42 %
K_2O	3.96 %
TiO_2	0.98 %
P_2O_5	0.225 %
Na_2O	0.63 %

The mineralogical composition of these shales is not known.

1.2 Brioverian (Saint Lo phyllites)

The upper part of the Middle Brioverian (Precambrian), is flysch-like and referred to as the "Saint Lo phyllites". In central and northern Brittany, the phyllites have been weathered over a depth of some 10 m.

This weathering clay contains 21 to 25 % alumina. However, the low solubility of the latter, probably to be explained by a phyllosilicate type structure, makes it of lesser interestthan the Calymene shales.

The results of lithologic studies and sampling of the other shale series in the Armorican Massif, with particular reference to the Devonian and Carboniferous, have demonstrated strong heterogeneity and alumina contents generally lower than 20 %. These shales have therefore not been included in the inventory.

2) Silurian of the north Pyrenean margin

The Silurian occurs as carbonaceous grey or black shales, locally pyritic. These are deep-sea deposits with no detrital contribution. Thickness reaches some 200 m. Outcrops occur all along the Pyrenean margin.

Analyses from a Silurian section of the Pyrénées Atlantiques department are as follows:

Al_2O_3	21.7 to 25.0 %
Fe_2O_3	5.6 to 7.5 %
K_2O	2.8 to 3.06 %

The mineralogical composition of these shales is not known.

3) Tertiary clays of the Aquitaine Basin

The bulk of the Aquitaine Basin is covered by a sand formation which conceals the underlying terrains. Numerous boreholes drilled as part of oil or hydrogeological exploration have disclosed a lithostratigraphic sequence extending from the Mio-Pliocene to the recent Quaternary (Figure 9).

Landes sand, eolian or hydroeolian, of varying thickness, containing discontinuous peat layers and ferruginous accumulations (alios).

Early Quaternary terrace, of fluvial origin, consisting of sand, pebbles and silty clays, and including some layers of peat.

Variegated clays, terminal Miocene to Lower Pliocene, of varying thickness, localised in small basins and containing lignite layers which are well developed at the base.

This formation overlies the Chalosse clayey sands.

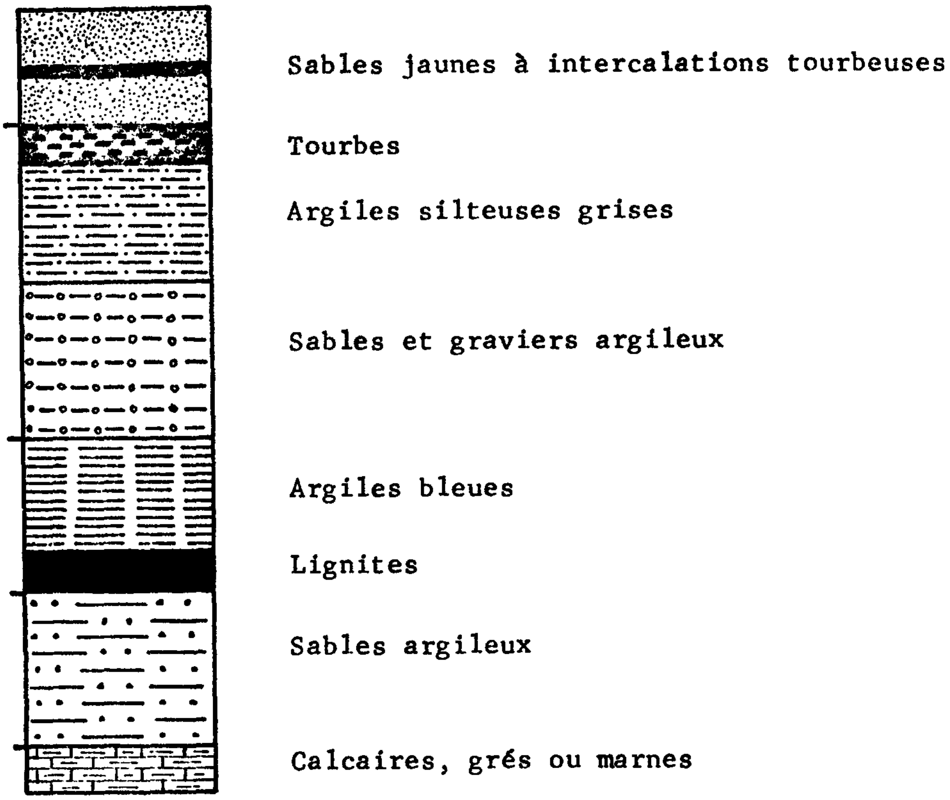
The basement consists of limestones, sandstones or marls.

The region is almost entirely wooded and its economy is based on forestry (resin, timber industry and papermaking).

Geological environment: Small paralic basins, running SSW-NNE and formed in sands containing varying quantities of clay, were filled during two sedimentary phases. The first of these phases has produced lignite deposits in the form of accumulated vegetable debris, frequently coarse, and the second has led to deposits of kaolinic clays associated with sandy seams.

Figure 9

Synthetic section of clays and lignites of the Aquitaine basin



BASSIN AQUITAIN

North of Mont de Marsan, the lignites are extracted and used by a power station of "Electricité de France" (production approx. 3 million t/y).

By means of boreholes drilled over an area of some 5 sq km one of these basins has been shown to contain average thicknesses of 2.80 m of lignite, 11 m of clay and 9 m of sand cover. The tonnage estimate for this zone is some 20 million tons of clay per sq.km.

Grade: Mean of analyses:

SiO_2	57.70 %	
Al_2O_3	21.88 %	(extremes 19.10 % to 24.20 %)
Fe_2O_3	6.4 %	
CaO	0.71 %	
MgO	0.85 %	
K_2O	3.34 %	
TiO_2	1.09 %	
Na_2O	0.56 %	

The mineralogical composition of these clays in not known.

4) Colliery spoil

Coal is mined in three major fields (Nord-Pas de Calais, Lorraine and Centre-Midi), the latter grouping the seven coal basins of south-eastern France (Aquitaine, Auvergne, Blanzy, Cévennes, Dauphiné, Loire and Provence); figure 10.

The appended table shows the total quantities produced in 1975 and 1976 by the French coal authority, the breakdown by coalfield and net-to-gross percentage ratios.

For the three major basins, the quantity of spoil can be estimated at some 13 mt/year, part of which is employed for backfilling of galleries

Nord - Pas de Calais	(50 %)	7.3 mt
Lorraine	(75 %)	3.3 mt
Centre - Midi +	(66 %)	2.4 mt

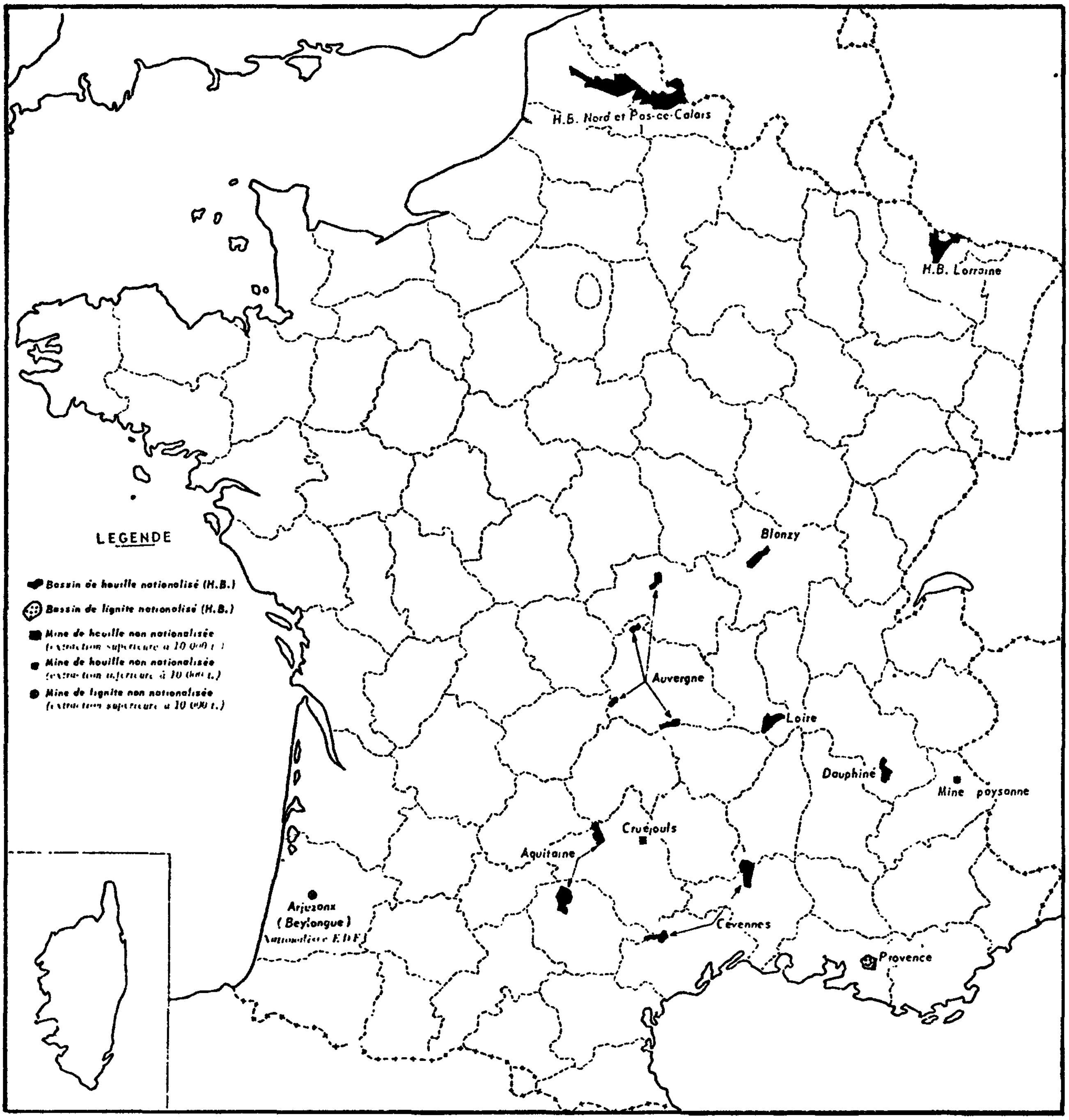
+ with the exception of Provence: Mesozoic coal in a carbonate environment.

The caloric value of wastes from coal washing plants lies between 500 and 1 200 cal/g and alumina content is some 23 to 25 %. A substantial tonnage is divided between a large number of tips.

Figure 10

French mines of coal and lignite

(in production on 31 December 1975)



1976 PICTURE FOR THE 3 COALFIELDS
AND 7 CENTRE-MIDI COLLIERIES

		C.D.F.	H.P.C.	LORRAINE	C.MIDI	AQUITAINE	AUVERGNE	BLANZY	CEVENNES	DAUPHINE	LOIRE	PROVENCE
1975 production ......('000 t)	1	23 959,1	7 715	10 021,5	6 222,6	1 083,8	413,7	1 553,8	822,3	384,1	420,3	1 544,6
1976 PRODUCTION — 1976 programme ...	2	24 635,4	7 253	11 212,-	6 170,4	1 033,4	494,7	1 669	645	400	328,3	1 600
Actual 1976 production	3	23 435,2	7 318	9 970,1	6 147,1	1 066,8	417,4	1 553	606,7	406,8	540,6	1 555,6
% actual 1975 production	4	97,8	94,9	99,5	95,8	98,4	100,9	99,9	73,8	105,9	128,6	100,7
Ratio of actual to planned 1976 production, %	5	95,1	100,9	88,9	99,6	103,2	84,4	93,-	94,1	101,7	164,7	97,2
NET-TO-GROSS PERCENTAGE												
Actual 1975 percentage ...	4	62,53	50,70	73,-	67,24	67,56	54,08	73,81	71,02	60,17	57,91	70,37
Actual 1976 percentage	5	62,54	49,53	74,86	66,47	65,89	50,40	76,89	67,09	60,88	54.01	71.35

IV. GREAT BRITAIN

The Caledonian belt of metamorphic and crystalline rocks covers Scotland and extends into Northern Ireland. Paleozoic, Mesozoic and Tertiary formations extend over the remainder of the country.

- Paleozoic: Occurs in the central and western parts of the country as aureoles surrounding the Barmouth Cambrian core (Cardigan Bay).

  Ordovician and Silurian: Between Liverpool and Pembroke Point, and north of Solway Firth.

  Devonian: In Cornwall and north of Cardiff

  Carboniferous-Permian: Along a very large median zone

- Mesozoic and Tertiary: Extends the paleozoic aureoles to the east and south-east, as far as the Tertiary synclines of London and Southampton which are separated by the Weald anticline.

The silico-aluminous materials amenable to treatment by acid processes for the production of alumina consist of formations of clays and shales in the sedimentary series, or occur as spoil from workings of china clay, slate and coal.

The very comprehensive information supplied by the Institute of Geological Sciences has led to selection of several subjects.

1) Paleozoic slates

Slates occur abundantly in the United Kingdom, in thick formations present throughout the Paleozoic, from the Cambrian to the Carboniferous. Substantial quantities of spoil are available as a result of very intensive working in the past.

Geographical location

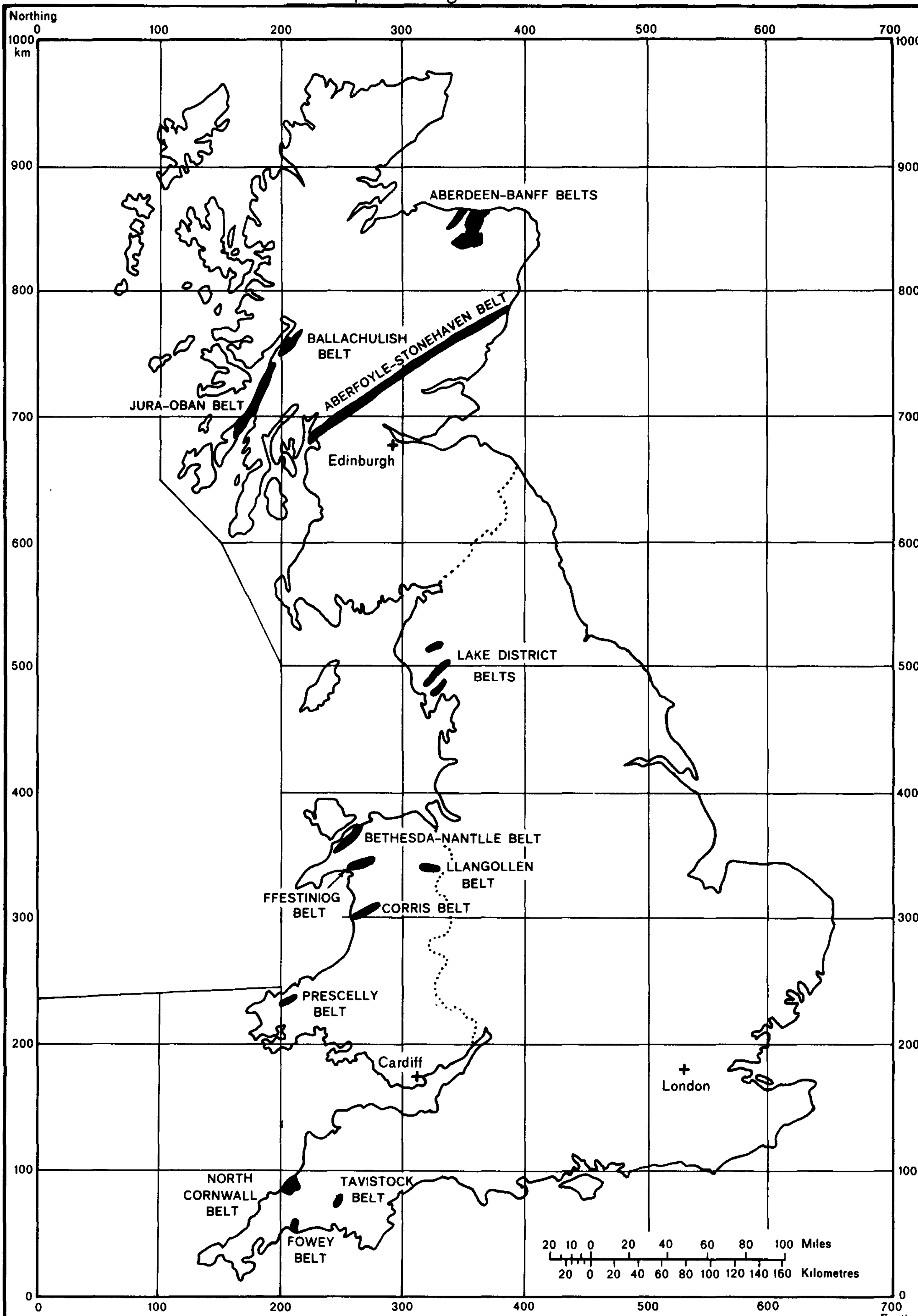
Slate formations are widely distributed and found especially in the following regions:

Northern Ireland, Southern Uplands, Lake District, North Wales, Cornwall and Devon.

The main areas of extraction are shown on figure 11. Wales is by far the most productive area.

Figure 11

State producing belts in Greaf Britain



In certain regions, e.g. Wales and the Lake District, agriculture is not highly developed (mainly livestock farming). Other areas, however, are regions of great natural beauty (Snowdonia and the Lake District National Park).

Formations

The slates were derived from muds or fine silts, interbedded with coarser material. Deposition took place on shallow continental margins.

Their age varies: mainly Cambrian to Ordovician in Wales, Devonian in Cornwall, Silurian-Ordovician in the Lake District, and Cambrian/Pre-cambrian in the Grampians of Scotland.

Welsh formations

Lower and Middle Cambrian: Caernarvonshire and Penrhyn (Bethesda-Nantlle belt). The slate "veins" are separated by clays or sandstone. The thickness of the series can be as much as 1 200 m.

Upper Cambrian (Tremadoc): Arenig and Arthog regions. The slates are generally rich in pyrite.

Ordovician: In the regions of Snowdonia and Ffestiniog: seven workable "veins", the thicknesses of which are frequently in excess of 50 m, with interbedded sandstones.

The Skiddaw Group derives from massive accumulations of lava, pyroclastics and tuffs (Lake District "green slates").

In the South, the thickness of the Bala series can be as high as 500 m (Corris Belt workings).

Silurian: The Llandovery, Wenlock and Ludlow series (between Cornwen and Llangollen) consist of alternating fissile shales and non-fissile silts. The grey-to-black slates worked at Kirby in Furness are of sedimentary origin.

Devonian: Quarrying of the Delabole Slates in the Tintagel/Fowey area.

Carboniferous: Workings near Tavistock.

Slate Waste

The production of slate is a declining industry: from 650,000 tonnes in 1898 to 300,000 tons in 1920/30. 1973 production amounted to only 64,000 tons (20,000 tons in Wales and 44,000 tons in the rest of Great Britain).

Production is mostly by quarrying and the percentage of waste is very high, at some 95 %. 20 tons of spoil are therefore produced for each ton of slate.

The total quantity of waste was estimated in 1971 at between 300 and more than 500 million tons for the United Kingdom as a whole.

Distribution (1971 estimate):

Wales:	Total	300 to 500 million tons
	Annual figure for the Bethesda-Nantlle Belt	1 million tons
Lake District:	Total	15 to 20 million tons
	Annual	123 000 t
Cornwall and Devon:	Total	15 million tons

Grade

Composition tends to vary, as indicated by the following analyses supplied by the Institute of Geological Sciences:

	No 1	No 2	No 3	No 4	No 5	No 6
SiO_2	59.4 %	54.79 %	55.45 %	54.95 %	58.41 %	69.35 %
Al_2O_3	20.0 %	18.10 %	23.29 %	23.33 %	20.25 %	20.38 %
Fe_2O_3	6.7 %	1.7 %	0.70 %	0.60 %	0.63 %	0.31 %
FeO	-	5.4 %	6.26 %	7.04 %	8.05 %	0.12 %
CaO	0.1 %	1.7 %	0.40 %	0.36 %	0.41 %	0.08 %
MgO	3.0 %	3.9 %	2.45 %	1.85 %	2.02 %	0.44 %
K_2O	3.4 %	2.8 %	3.96 %	3.02 %	2.50 %	3.67 %
TiO_2	0.8 %	1.0 %	1.07 %	1.07 %	1.00 %	0.85 %
Na_2O	1.1 %	1.5 %	0.71 %	0.98 %	0.68 %	0.19 %

	No 1	No 2	No 3	No 4	No 5	No 6
P_2O_5	0.1 %	0.15 %	0.20 %	0.11 %	0.23 %	0.05 %
Mn_2O_3	-	0.1 %	-	-	-	-
MnO	-	-	0.20 %	0.42 %	0.07 %	0.01 %
F	-	0.02 %	-	-	-	-
SO_3	-	0.4 %	-	-	-	-
S (other) than pyrite)	-	0.13 %	-	-	-	-
S (organic and pyrite)	-	0.4 %	-	-	-	-

Origin of samples:

1. Precambrian Ballachulish Slate, Main Quarry
2. Cambrian (?) Scotland - Mean of 4 samples
3. Ordovician Skiddaw Slates (Black Fell Mudstones) weathered slates - Barkbeth
4. Ordovician-Non-weathered slates-Barkbeth
5. Ordovician-Non-weathered slates-Mungrisdale
6. Lower Devonian-Cornwall-weathered slate formation of Perran Iron Rode.

Mean composition is as follows, according to the Mineral Resources Consultative Committee:

SiO_2	45/65 %
Al_2O_3	11/25 %
FeO/Fe_2O_3	0.5/7 %
MgO	2/7 %
K_2O	1/6 %
TiO_2	1/2 %
Na_2O	1/4 %

Some slates are rich in calcite (8 % - CaO in the Lake District) or in pyrite (Scotland). Specific gravity averages 2.85.

The main mineralogical constituents cited are:

Sericite	38/40 %
Quartz	31/45 %
Chlorite	6/18 %
Hematite	3/ 6 %
Rutile	1/1.5 %

Accessory minerals are pyrite, pyrrhotite, limonite, magnetite, ilmenite, graphite and calcite.

The presence of chlorite and sericite points to the influence of a slight metamorphism, probably more intense in the older formations (Cambrian or Precambrian).

Chemical and mineralogical compositions vary, depending on the nature of the original sediment, on conditions of deposition and on diagenetic or metamorphic phenomena. It should be possible, in these Paleozoic series, to locate shales or slates of suitable chemical composition, with a sufficiently high alumina content.

2) Carboniferous Etruria Marl

The term "marl" is not strictly correct since the formation is basically clayey sand, and only infrequently includes layers of carbonate.

Geographical location

The Etruria Marl Group occurs principally in North Staffordshire, Warwickshire and South Derbyshire.

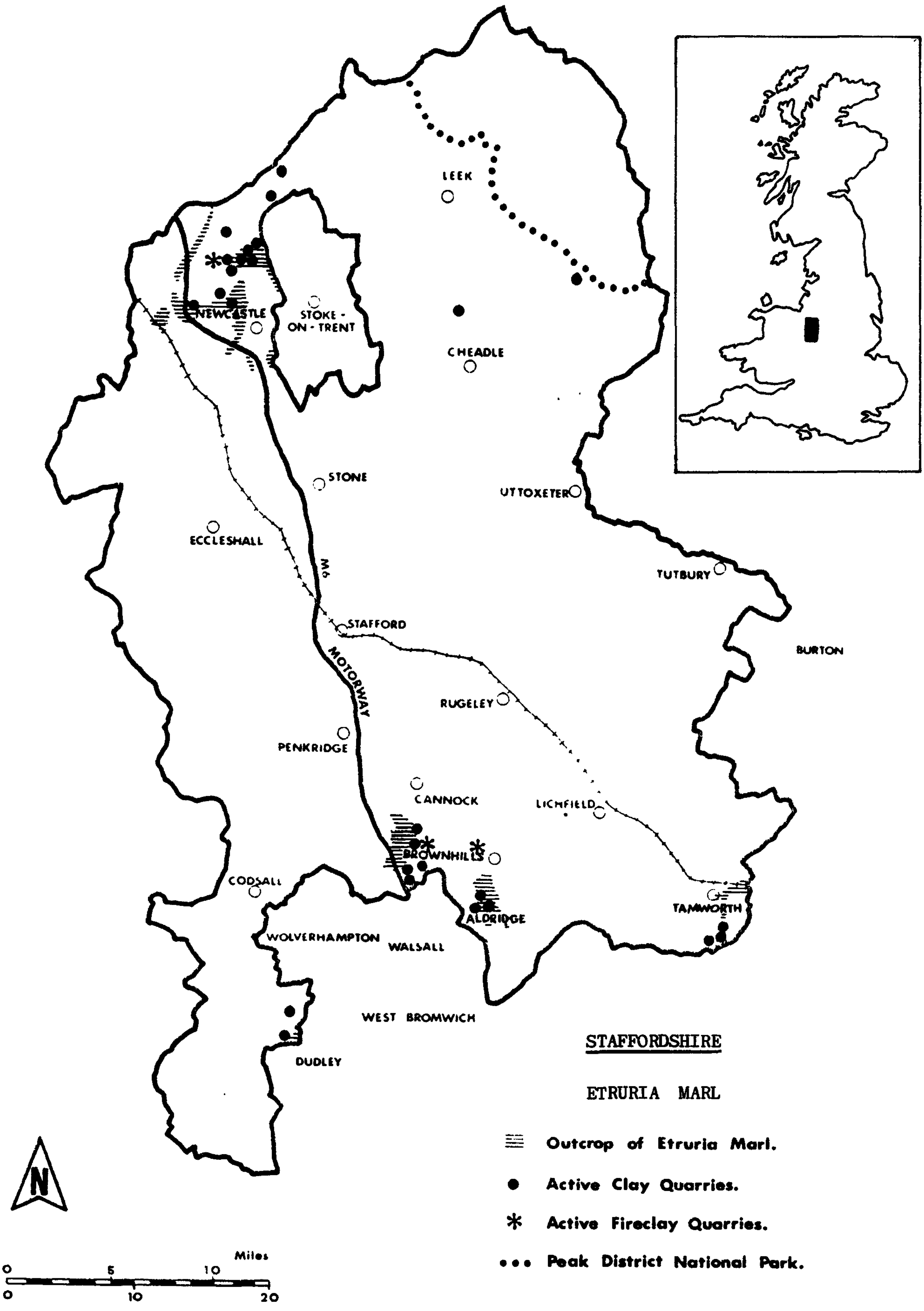
In Staffordshire, the outcrops occur in the Fowlea Valley area (north of Newcastle) and extend from Bradwell Wood to Chesterton, and from south of Cheslyn Hay to south of Essington (Cannock area), between Aldridge and Brownhills and, in a zone east of Dosthill, from Wilnecote to Amington (Figure 12).

This clay is important to the production of high quality bricks and tiles.

It is mined in all the regions referred to, but most intensively in the areas of Bradwell Wood (Fowlea Valley), Cheslyn Hay, Essington and Dosthill.

Figure 12

Outcrops of Etruria Marl in Staffordshire



Fuel requirements are such that the brickmaking industry is strongly concentrated in areas where coal is to be found.

Geological environment

In the regions considered, the productive Carboniferous series gives way to non-productive formations of continental origin. The formation as a whole is characterized by a cyclic pattern of sedimentation, and mainly consists of a non-stratified, variegated,indurated sandy slay (silty mudstone) together with infrequently-occurring lenticular deposits of coarse-grained sandstone not more than 10 feet thick ("espleys").

Although the clay is sometimes calcareous, the bulk of the formation, particularly in North Staffordshire, contains no calcium carbonate.

The formation

The thickness varies because some of the lower layers are missing and because of frequent lateral passage from clay to sandstone and vice versa.

The overall thickness falls off towards the south, from 305 to 213 m in South Staffordshire, 0-100 m in Warwickshire, 45 m in South Derbyshire, 0-61 m at Coalbrookdale and 91 m in the Forest of Wyre.

In North Staffordshire, depths of workings average 18 to 19 metres, some being as much as 31 m.

The glacial overburden is heterogeneous and friable, sometimes very sandy, and of varying thickness.

The reserves represented by outcrops are limited. The reserves evaluated by the brickmaking industry are sufficient to meet demand in the immediate future, but, as far as is currently known, the area of unused potential reserves is small. In some cases, the clay formations are not workable because they lie below thick sandstone lenses.

Grade and mineralogical composition

The following are the results of 51 analyses taken from D.A. Holdridge, 1959, "Compositional Variation in Etruria Marls", Trans. of the British Ceramic Society, 58, n° 5.

	Minimum		Maximum	Average
SiO_2 :	49.66	to	70.32 %	59.94 %
Al_2O_3 :	12.31	to	26.76 %	20.34 %
Fe_2O_3 :	3.04	to	14.10 %	7.96 %
CaO :	0.01	to	2.70 %	0.46 %
MgO :	0.22	to	1.16 %	0.76 %
K_2O :	0.59	to	2.22 %	1.50 %
TiO_2 :	1.06	to	1.46 %	1.25 %
Na_2O :	0.01	to	0.28 %	0.10 %
Loss on ignition :	4.51	to	12.37 %	7.50 %

29 of the 51 samples exhibited alumina contents in excess of 20 % and 37 samples exhibited ferric oxide contents of between 7 and 11 %.

Mineral composition

Major constituents :	quartz	30.5 to 41 %
	kaolinite	33 to 42 %
	micas	14.5 % max.
	limonite	10 % max.

Minor constituents : rutile, manganese oxide, calcite, tourmaline (magnesium); potassium and sodium are associated with the micaceous fraction.

TABLE 1

ULTIMATE CHEMICAL ANALYSIS: ETRURIA MARLS

(means of duplicate analyses)

Sample	$S O_2$	TiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	Li_2O	*Loss-on-ignition*
31	64·00	1·23	18·84	7·22	0·01	0·11	0·71	1·46	0·14	n.d.	6·38
32	67·31	1·33	16·63	6·86	0·01	0·32	0·66	1·23	0·08	n.d.	5·86
32a	66·94	1·21	16·77	6·99	0·01	0·05	0·63	1·10	0·09	n.d.	8·85
33	63·43	1·26	20·31	5·57	0·01	0·38	0·68	1·30	0·06	n.d.	7·15
34	59·08	1·45	20·58	8·43	0·01	0·63	0·88	1·88	0·16	n.d.	7·36
35	55·55	1·35	24·87	6·23	0·01	0·37	0·99	1·85	0·16	n.d.	8·12
36	54·77	1·45	21·80	9·76	0·20	1·57	0·72	1·50	0·15	n.d.	8·18
36a	51·38	1·27	23·09	10·01	0·04	2·00	0·96	1·78	0·10	n.d.	9·09
37	58·46	1·26	21·63	8·00	0·02	0·73	0·84	1·65	0·16	n.d.	7·47
37a	56·50	1·21	22·63	7·70	0·03	0·88	0·76	1·88	0·11	n.d.	8·43
38	61·74	1·30	18·40	9·22	0·07	0·70	0·74	1·52	0·08	n.d.	6·44
39	58·23	1·30	21·62	7·54	0·01	0·67	0·82	1·65	0·11	n.d.	7·65
40	62·95	1·43	17·93	8·59	0·24	0·42	0·75	1·58	0·12	n.d.	6·14
41	53·33	1·29	26·76	6·04	0·01	0·43	1·06	1·39	0·14	n.d.	9·55
58	49·66	1·19	23·22	10·57	0·20	2·70	1·03	1·78	0·12	0·03	9·55
59	61·24	1·18	18·46	9·85	0·03	0·45	0·63	1·39	0·09	0·02	6·85
60	61·33	1·19	18·26	10·00	0·16	0·48	0·72	1·52	0·10	0·04	6·50
61	58·88	1·17	22·00	7·48	0·04	0·52	0·75	1·62	0·12	0·02	7·77
62	64·28	1·35	17·57	8·98	0·03	0·22	0·60	1·29	0·08	n.d.	5·96
63	55·52	1·31	24·74	6·63	0·03	0·34	0·93	1·19	0·12	0·04	9·12
64	57·42	1·29	20·17	10·71	0·15	0·81	0·71	1·17	0·07	n.d.	7·67
65	66·35	1·09	16·63	7·35	0·03	0·22	0·62	1·35	0·10	0·02	6·50
66	58·03	1·08	22·10	8·20	0·02	0·22	0·83	1·57	0·10	0·02	7·94
67	66·04	1·26	18·31	6·36	0·08	0·16	0·67	1·15	0·09	0·02	6·30
68	59·72	1·12	18·79	9·00	0·04	0·52	0·81	1·79	0·12	0·02	7·26
68a	59·12	1·18	20·16	9·26	0·03	0·45	0·86	1·70	0·10	0·02	7·27
69	56·61	1·23	24·69	5·11	0·02	0·35	1·06	2·22	0·12	0·02	8·70
69a	57·78	1·22	24·36	4·67	tr.	0·23	1·06	2·10	0·14	0·01	8·48
70	53·75	1·23	23·74	9·54	0·04	0·27	1·16	2·04	0·16	0·04	8·20
71	58·24	1·18	22·44	7·04	0·03	0·29	0·69	1·54	0·11	0·02	8·69
72	62·29	1·27	18·21	8·74	0·05	0·19	0·84	1·58	0·08	0·02	6·63
73	55·96	1·24	22·71	9·56	tr.	0·42	0·71	0·98	0·07	0·02	8·44
74	63·50	1·42	18·41	8·86	0·02	0·07	0·80	1·69	0·08	n.d.	5·62
A1	56·31	1·32	25·85	4·54	0·02	0·01	0·61	1·67	0·11	0·02	9·43
A2	58·54	1·19	18·94	10·67	0·05	0·01	0·55	1·43	0·11	0·02	8·47
B1	59·93	1·30	23·06	3·83	n.d.	0·01	1·01	1·77	0·11	0·02	8·77
B2	60·92	1·30	23·44	3·04	0·03	0·20	0·90	1·86	0·11	0·02	7·84
B3	49·75	1·12	20·04	14·10	0·20	0·21	0·86	1·44	0·10	0·02	12·37
C	50·80	1·08	26·64	7·75	0·05	0·24	1·04	1·95	0·12	0·02	9·92
D1	66·21	1·28	15·22	9·40	0·26	0·50	0·37	1·11	0·07	n.d.	5·59
D2	69·66	1·06	12·31	0·29	3·27	0·55	0·24	0·59	0·01	n.d.	4·51
D3	65·90	1·31	15·12	9·38	0·23	0·54	0·30	1·20	0·10	n.d.	5·97
E	58·50	1·19	22·03	9·20	0·08	0·38	0·22	1·81	0·16	n.d.	6·91
F	61·55	1·25	20·03	7·26	0·07	0·46	0·43	1·96	0·28	n.d.	6·93
G	65·49	1·31	16·42	9·10	tr.	0·01	0·88	1·17	0·15	n.d.	5·66
H	61·53	1·46	19·82	8·12	tr.	0·06	0·77	1·40	0·09	n.d.	6·89
I	70·32	1·24	14·58	7·12	tr.	0·01	0·74	0·98	0·08	n.d.	5·24
J	63·30	1·21	19·92	6·49	tr.	0·12	0·98	1·20	0·07	n.d.	7·07
K	68·57	1·28	13·66	9·90	tr.	0·01	0·56	0·78	0·07	n.d.	5·08
L	57·18	1·26	21·84	9·54	tr.	0·16	0·88	1·63	0·04	n.d.	7·50
*TR	53·19	1·21	21·81	10·63	0·18	1·84	0·88	1·50	0·10	0·03	8·70

n.d.=not determined tr.=trace

* Calculated from EM 58 and 64 in ratio 6:5.

ETRURIA MARL

MINERALOGICAL ANALYSES SUPPLIED BY THE INSTITUTE OF GEOLOGICAL SCIENCES

1) Brown to grey-green mudstone, Sidway, Maer, Staffordshire, (SJ 760393):- kaolinite, mica-illite and other unidentifiable clay mineral.

2) Grey-red/brown clay, Bradwell Wood, Staffs, (SJ 849500); Lower Marl:- 55 % kaolinite, 14 % mica-illite, 22 % quartz, 7 % goethite, 1.5 % anatase.

3) Dark red brown to grey clay; "Bottom Red" Marl:-[1] 31 % kaolinite, 15 % mica-illite, 42 % quartz, 10 % goethite, 1.5 % anatase, 1.0 % calcite.

4) Red brown to grey clay; "Top Grey" Marl:- 40 % kaolinite, 16 % mica-illite, 33 % quartz, 9 % goethite, 1.5 % anatase, 3 % calcite.

5) Dark-red brown to grey clay; "Middle Red" Marl :- 33 % kaolinite, 14 % mica-illite, 40 % quartz, 10 % goethite, 1.5 % anatase, 1.5 % calcite.

6) Variegated clay; "Drab" Marl: - 40 % kaolinite, 16 % mica-illite, 33 % quartz, 9 % goethite, 1.5 % anatase, 1.5 % calcite.

7) Red-brown silty clay; "Top Red" Marl:- 41 % kaolinite, 15 % mica-illite, 29 % quartz, 11 % goethite, 1.5 % anatase, 1.0 % calcite.

8) Variegated clay, Goldendale, Staffs, (SJ 851519); "Bottom Grey" Marl:- 46 % kaolinite, 14 % mica-illite, 42 % quartz, 8 % goethite, 1 % anatase, 0.5 % calcite.

9) Dark brown-grey siltstone; "Brown" Marl:-[2] 35 % kaolinite, 18 % mica-illite, 40 % quartz, 7 % goethite, 1.5 % anatase, 0.5 % calcite.

10) Grey-purple siltstone; "Top Grey" Marl:- 40 % kaolinite, 12 % mica-illite, 35 % quartz, 10 % goethite, 1.5 % anatase, 1 % calcite.

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1) Nos. 3 to 7: same origin as 2.
2) Nos. 9 and 10: same origin as 8.

3) Carboniferous shales and clays

Geographical location

In parallel with the production of coal, shale and clay formations are worked in most of the north-eastern, western and southern parts of the country. The Institute of Geological Sciences believes the Midlands to be probably the most interesting region.

Geological environment

Coal and limestone veins alternate in a cyclic manner (Coal Measures) with shales and clays (clay/mudstone).

The composition of these shales and clays varies with their position in the sedimentary cycle and also from basin to basin.

Alumina-rich clays are a particular feature of the layers immediately below the coal layers in numerous coalfields and are frequently worked with a view to the manufacture of refractory materials.

These argillaceous substances are of particular interest by virtue of their wide distribution, relatively high alumina contents and the interstratification of thin beds of coal.

The formation

Workable thicknesses, extraction conditions and quantities available are not given.

Grade

The following analyses have been supplied by the Institute of Geological Sciences, Mineral Resources Division.

Data are lacking on mineralogical composition. However, by analogy with other clays or shales associated with layers of coal, the predominant argillaceous ore is probably kaolinite.

	1 Clay	2 Clay	3 Shale	4 Shale	5 Clay	6 Shale	7 Mudstone	8 Shale	9 Shale	10 Shale
SiO_2	63.7 %	67.10 %	49.62 %	59.21 %	64.5 %	53.69 %	60.46 %	55.0 %	63,2 %	62.2 %
Al_2O_3	23.13 %	26.23 %	18/23 %	18.62 %	20.6 %	20.50 %	23.02 %	20.2 %	18.2 %	19.7 %
Fe_2O_3	1.56 %	1.87 %	4.0/7.3 %	2.35 %	2.8 %	6.95 %	1.61 %	7.1 %	4.1 %	3.5 %
FeO	/	/	0.86 %	4.23 %	/	0.86 %	1.22 %	/	/	/
CaO	0.30 %	0.70 %	0.8/1.2 %	0.56 %	0.7 %	0.30 %	0.34 %	0.1 %	0.7 %	0.4 %
MgO	0.46 %	0.65 %	1.0/1.6 %	2.01 %	0.8 %	2.41 %	/	1.4 %	0.8 %	1.2 %
TiO_2	1.25 %	1.73 %	0.9/1.2 %	0.98 %	1.2 %	0.2 %	0.96 %	1.0 %	0.7 %	0.6 %
K_2O	1.74 %	1.52 %	1.9/3.7 %	3.28 %	1.7 %	2.73 %	3.00 %	2.9 %	3.3 %	3.1 %
Na_2O	0.32 %	0.21 %	0.2/1.2 %	1.04 %	0.1 %	0.62 %	0.51 %	0.7 %	1.1 %	0.7 %
P_2O_5	/	/	/	/	/	/	0.14 %	/	/	/
Mn_2O_3	/	/	/	0.12 %	/	/	/	/	/	/
MnO	/	/	/	/	/	/	/	/	/	/
CO_2	/	/	/	0.49 %	1.0 %	/	0.10 %	/	/	/
C	/	/	/	0.53 %	/	/	0.74 %	/	/	/
Loss on ignition	7.40 %	/	7.9/13.4 %	7.46 %	7.3 %	11.14 %	/	10.9 %	6.4 %	8.2 %

Origin of samples

Nos. 1 and 2 (No. 2 on calcined sample): Carboniferous Coal Measure fireclays, Southhook Potteries, Kilmarnock, Ayrshire.
No. 3: Lower Coal Measure shale (origin not determined).
No. 4: Coal Measure shale - mudstone, Accringtone, Lanes and Yorks.
No. 5: Fireclay - Coal Measures (origin not determined)
No. 6: Shale - Coal Measures (origin not determined)
No. 7: Coal Measures, North Wales Colliery, (borehole)
No. 8: Coal Measure Shale, Yorkshire
No. 9: Coal Measure Shale, Lancashire
No. 10: Coal Measure Shale, Northumberland.

4) Lower cretaceous weald clay

Geographical location

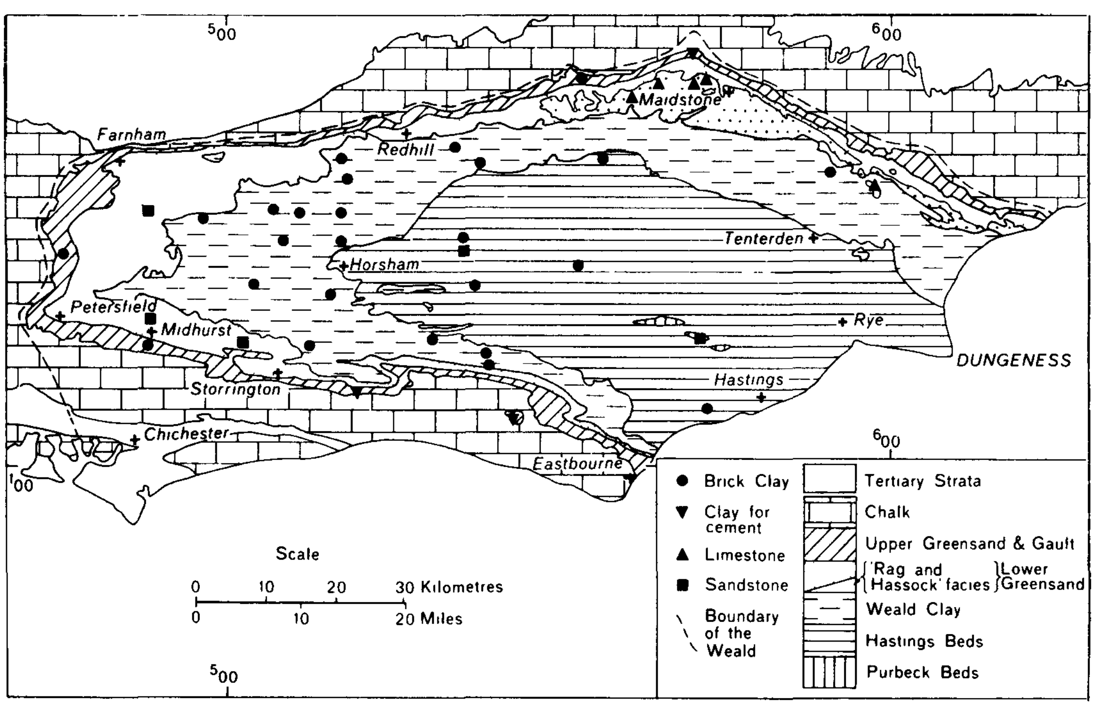
Weald clays, which are currently being worked for brickmaking, occur widely throughout Kent, Surrey and Sussex.

Geological environment

Currently, of the several argillaceous formations occurring between the lower part of the series (Ashdown Sand) and the upper part (Gault), only the Weald clay is being worked, accounting for 80 % of brick production in this region. The bulk of the workings are located in the west, where outcrops are the most substantial and are associated with the great Lower Cretaceous anticline running substantially east-west (Weald anticline, **figure 13**).

Figure 13

Distribution of clay, limestone and sandstone workings in the Weald



The formation

Nothing is stated about reserves, workable thicknesses, or scope for extraction of substantial annual tonnages by open-pit mining.

Grade

The following three analyses have been provided by the Institute of Geological Sciences.

	Weald Clay 1	Weald Clay 2	Weald Clay 3
SiO_2	52.50 %	54.98 %	55.0 %
Al_2O_3	22.37 %	18.43 %	18.4 %
Fe_2O_3	7.85 %	10.37 %	10.4 %
FeO	0.43 %	/	/
CaO	0.62 %	2.66 %	2.7 %
MgO	1.10 %	0.91 %	0.9 %
K_2O	2.72 %	3.25 %	3.2 %
TiO_2	0.90 %	1.01 %	1.0 %
Mn_2O_3	0.10 %	/	/
Na_2O	0.33 %	0.46 %	0.5 %
SO_3	0.19 %	/	/
CO_2	0.25 %	/	/

Origin: 1 : Pluckley

2 and 3 : Not determined

The mineralogical composition of these sedimentary clays comprises argillaceous minerals, quartz and mica. The percentage of argillaceous material varies from 30 to 50 % and is represented by kaolinite or illite, frequently mixed. Secondary minerals are calcite, siderite, iron sulphides and gypsum.

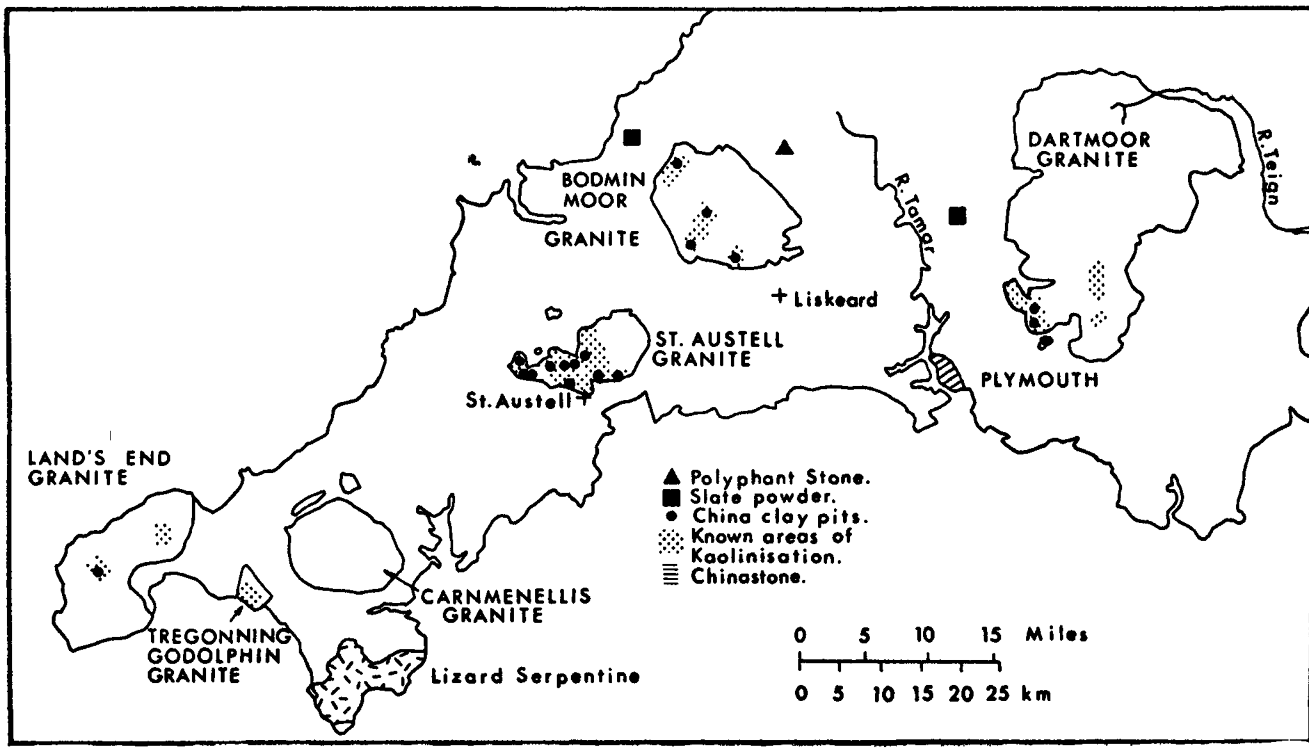
5) China clay wastes

China clay workings are located in the south-western part of the country in the region of Plymouth (St Austell and Dartmoor, figure 14).

Residues are generally contained by means of embankments.

Figure 14

China-clay workings in Cornwall



The occurrence of china clay, which is generally of high mineralogical purity, results from the hydrothermal alteration of Permocarboniferous granites and feldspars.

Production of fine aluminous residues

Currently, the cost of the pure china clay employed in the ceramics industry far exceeds its potential value as a source of alumina. The clay is quarried using jets of pressurised water, followed by multistage settling of the hydraulic mining slurry.

The production of each ton of pure china clay involves the removal, on average, of 3.7 t of coarse-grained sand and 0.9 t of fine micaceous residues, which go to settling basins.

Some 2 million t of fine micaceous residues is stored each year and 20 million t or so is available in former settling basins. There are currently few outlets for these fine materials.

In theory, the quantity of alumina contained in the annual production tonnage of this fine waste material would nearly cover the United Kingdom's annual alumina requirements.

Grade

The following is an analysis of the fine residues, supplied by the Institute of Geological Sciences.

SiO_2	50.3 %
Al_2O_3	32.7 %
Fe_2O_3	2.37 %
CaO	0.07 %
MgO	0.35 %
K_2O	5.3 %
TiO_2	0.11 %
Na_2O	0.24 %
Loss on ignition	8.30 %

The mineralogical composition is not stated. It is important to decide whether the high alumina content of these fine residues is in the form of argillaceous minerals or accounted for by a high proportion of micaceous minerals, in which case they would be of no value because of the low solubility of alumina.

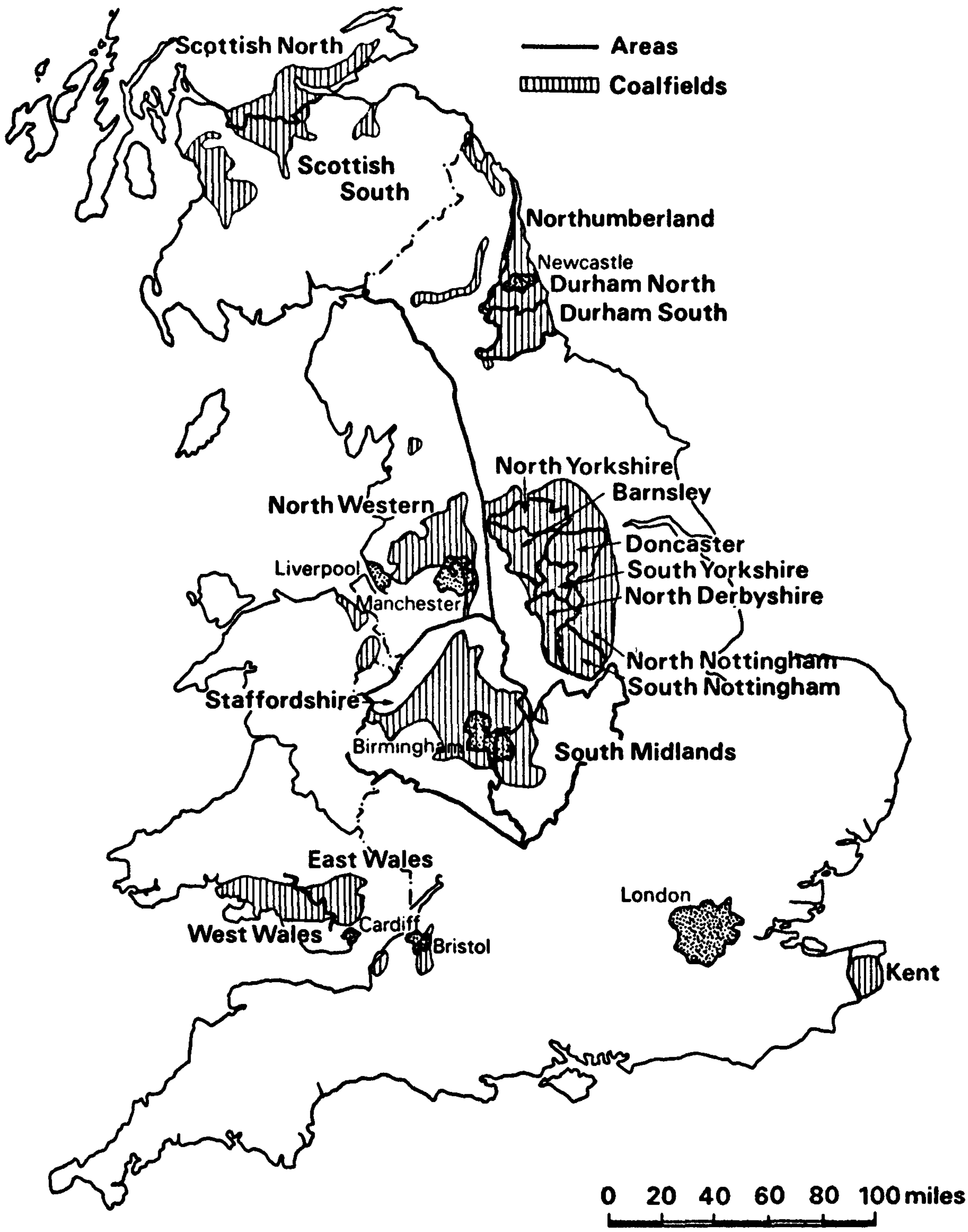
6) Colliery spoil

The main coal mining regions in terms of the number and size of workings are Yorkshire, Nottinghamshire and Derbyshire. In South Wales, on the other hand, there are a large number of smaller mines. Everywhere else, production is concentrated in very large mines (figure 15).

1975 coal production amounted to some 127 million t.

Figure 15

Location of coalfields and National Coal Board areas in Great Britain



The coal seams are associated with argillaceous formations (mudstones, siltstones and shales), sandstones and smaller proportions of limestone.

Present-day methods of mechanical extraction are not selective and, in certain mines, almost half the tonnage extracted consists of surrounding sedimentary rock.

Coal and spoil are separated by physical processes and the waste dumped on the tip.

Until recently, tips were not compacted and were therefore subject to combustion by penetration and contact of air with oxidizable substances.

Modern tips are built up of layers which are compacted and thereby protected against spontaneous combustion.

Based on a 1966 estimate by the National Coal Board, the tonnage breakdown for the three categories of tip was:

Non-burnt tips: 1,185 mt, covering 5,791 hectares

Tips in the process of combustion: 629 mt, covering 2,992 hectares

Burnt tips: 316 mt, covering 1,909 hectares.

The 1972 regional breakdown for quantities transferred to the tips is shown in the accompanying table, produced by the National Coal Board.

Area	Spoil (million t)
Scottish N.	1.298
Scottish S.	2.858
Northumberland	0.760
N. Durham	1.095
S. Durham	0.806
N. Yorkshire	2.649
Doncaster	2.612
Barnsley	3.862
S. Yorkshire	4.353
N. Western	2.095
N. Derbyshire	3.866
N. Nottingham	4.489

Area	Spoil (million t)
S. Nottingham	5.028
S. Midlands	1.557
Staffordshire	1.500
E. Wales	3.197
W.Wales	1.628
Kent	0.657

The total annual quantities transferred to the tips amount to some 44 million t, some 7 million (16 %) of which is employed for banking and filling, or manufacture of bricks, cement and light aggregates.

Grade

Quality is variable because of the diversity of the rock transferred to the tips.

As an illustration, the following analyses of material of unspecified origin have been supplied by the Institute of Geological Sciences.

	1	2
SiO_2	37.9 %	50.2 %
Al_2O_3	15.9 %	20.3 %
Fe_2O_3	2.7 %	0.5 %
FeO	2.7 %	4.3 %
CaO	0.56 %	0.72 %
MgO	1.10 %	1.98 %
MnO	0.08 %	0.11 %
K_2O	1.36 %	1.56 %
TiO_2	0.65 %	0.9 %
Na_2O	0.30 %	0.60 %
P_2O_5	0.16 %	0.21 %
SO_3	2.05 %	0.69 %
Loss on ignition	35.0 %	16.35 %

	3	4
SiO_2	51,9 %	45.4 à 60.2 %
Al_2O_3	19.4 %	21.2 à 31.3 %
Fe_2O_3	6.1 %	3.86 à 13.37 %
CaO	0.66 %	0.16 à 6.3 %
MgO	1.21 %	0.82 à 2.88 %
K_2O	3.0 %	2.50 à 3.45 %
TiO_2	1.03 %	0.17 à 0.24 %
Na_2O	0.44 %	0.29 à 0.65 %
SO_3	0.35 %	0.10 à 4.66 %
S	0.02 %	0.10 à 0.10 %
Loss on ignition	16.13 %	1.9 à 6.3 %

1. Unburnt material
2. Unburnt material
3. Unburnt material, mean of several samples
4. Burnt material, mean of several samples

Mineralogical composition

Quartz, micas, illite, kaolinite and small quantities of pyrite, iron, magnesium and calcium carbonates.

Given the lithological differences exhibited by country rock characteristic of various coalfields or parts of fields, it would appear possible to locate areas consisting predominantly of shales and clays which have the highest alumina contents.

The presence of residual coal in mine or washing plant spoil could enhance the value of these silico-aluminates materials in that the coal would supply part of the energy needed for conversion to alumina.

V. HOLLAND

Throughout the country, the Oligocene to Pliocene substratum is covered by recent fluvioglacial or marine deposits.

In the area of Maestricht, the South-Limburg Paleozoic or Mesozoic outcrops are of limited dimensions.

The argillaceous formations of fluvial or fluvioglacial origin are located in the present-day valleys. From the information supplied by the Geological Survey of Holland, the main subject of interest would appear to be the "Potkleis" (potter's clays) in the Groningen area.

Another subject of potential interest which should also be mentioned is the waste tips at the sites of former coal workings in South-Limburg.

1) Potter's Clay

These clays outcrop in three areas of the Friesland and Groningen provinces, in the north-eastern part of the country. This is a mainly agricultural area and includes a number of regional parks (Figure 16).

The clays consist of glacial deposits in Quaternary basins, and are visible in some low areas.

The formation, which is present either as outcrops or covered by a thin overburden, extends over 10 to 20 sq.km. Thicknesses vary from 10 to 70 m and reserves are estimated at several hundred million t. Alumina contents are around 18 to 20 % (source: Stiboka).

The following is a complete analysis supplied by the Geological Survey:

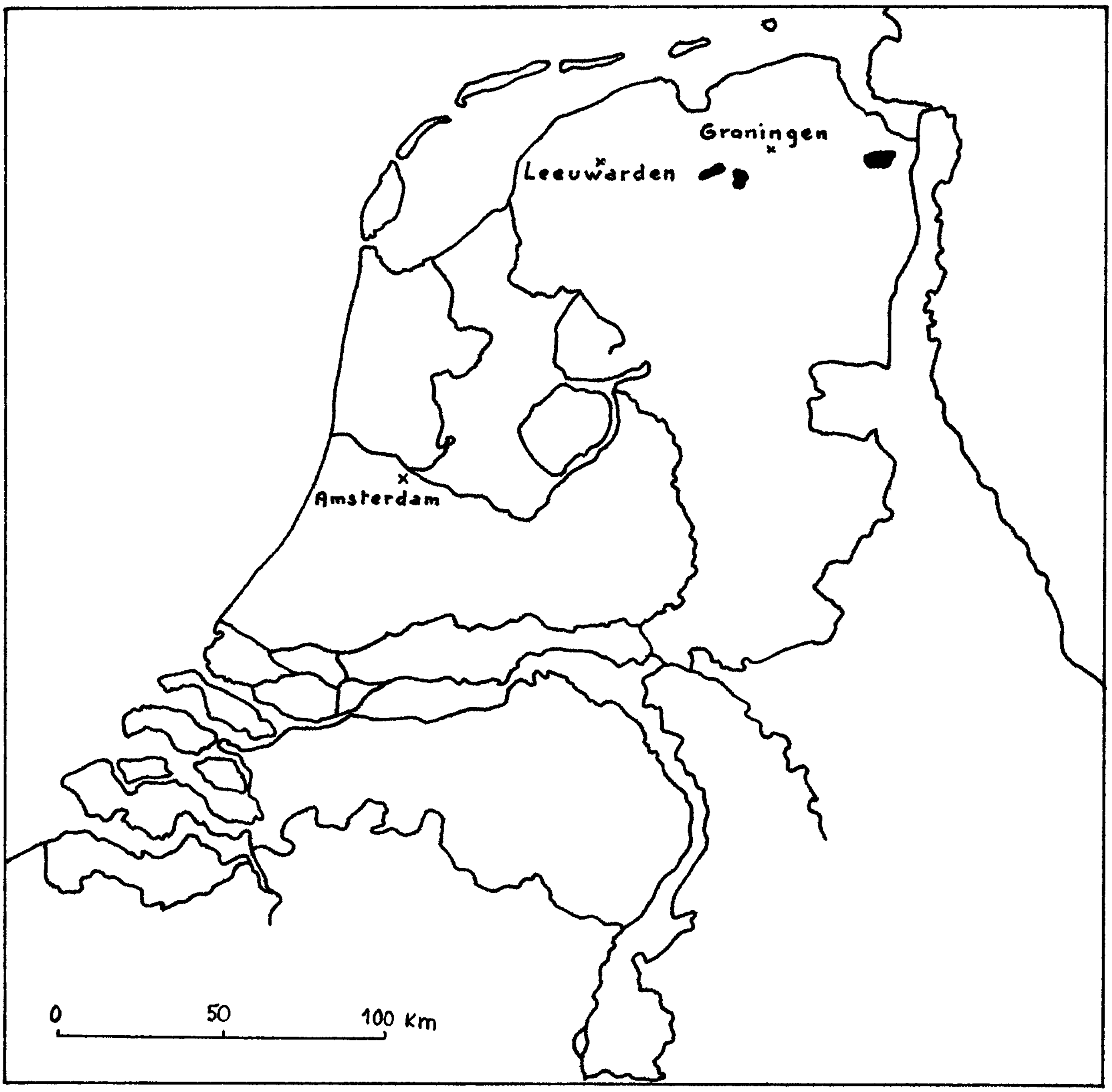
SiO_2	55.0 %
Al_2O_3	21.7 %
Fe_2O_3	6.07 %
CaO	0.99 %
MgO	1.59 %
K_2O	2.36 %
Na_2O	0.26 %
Loss on ignition	9.20 %

Mineralogical composition:

Quartz	25.5 %	
Feldspar	1.5 %	
Mica	11.5 %	
Calcite	1.0 %	
Kaolinite	14.0 %	
Other argillaceous minerals	46.5 %	(swelling clays, intermediate between illite and montmorillonite)

Figure 16

Location of "Potkleis" in Holland



2. Colliery tips from former coal workings

Figure 17 shows former sites of coal mining in South-Limburg.

The following are the analyses of seven samples from the Orange-Nassau I mine (1944):

	1	2	3	4	5	6	7
$SiO_2 + TiO_2$	62.40 %	42,77 %	58.90 %	58,88 %	59.75 %	46.50 %	39.45 %
Al_2O_3	20.95 %	18,83 %	22.00 %	23,08 %	20.94 %	22.36 %	21.43 %
Fe_2O_3	6.45 %	18,57 %	7.85 %	6,42 %	5.71 %	12.14 %	9.64 %
CaO	0.37 %	0,25 %	0.50 %	0,50 %	0.50 %	0.67 %	1.25 %
MgO	1.50 %	1,95 %	1.81 %	1,74 %	2.34 %	2.55 %	1.47 %
Loss on ignition	5.48 %	15,30 %	7.30 %	6,20 %	8.88 %	11.58 %	23.42 %

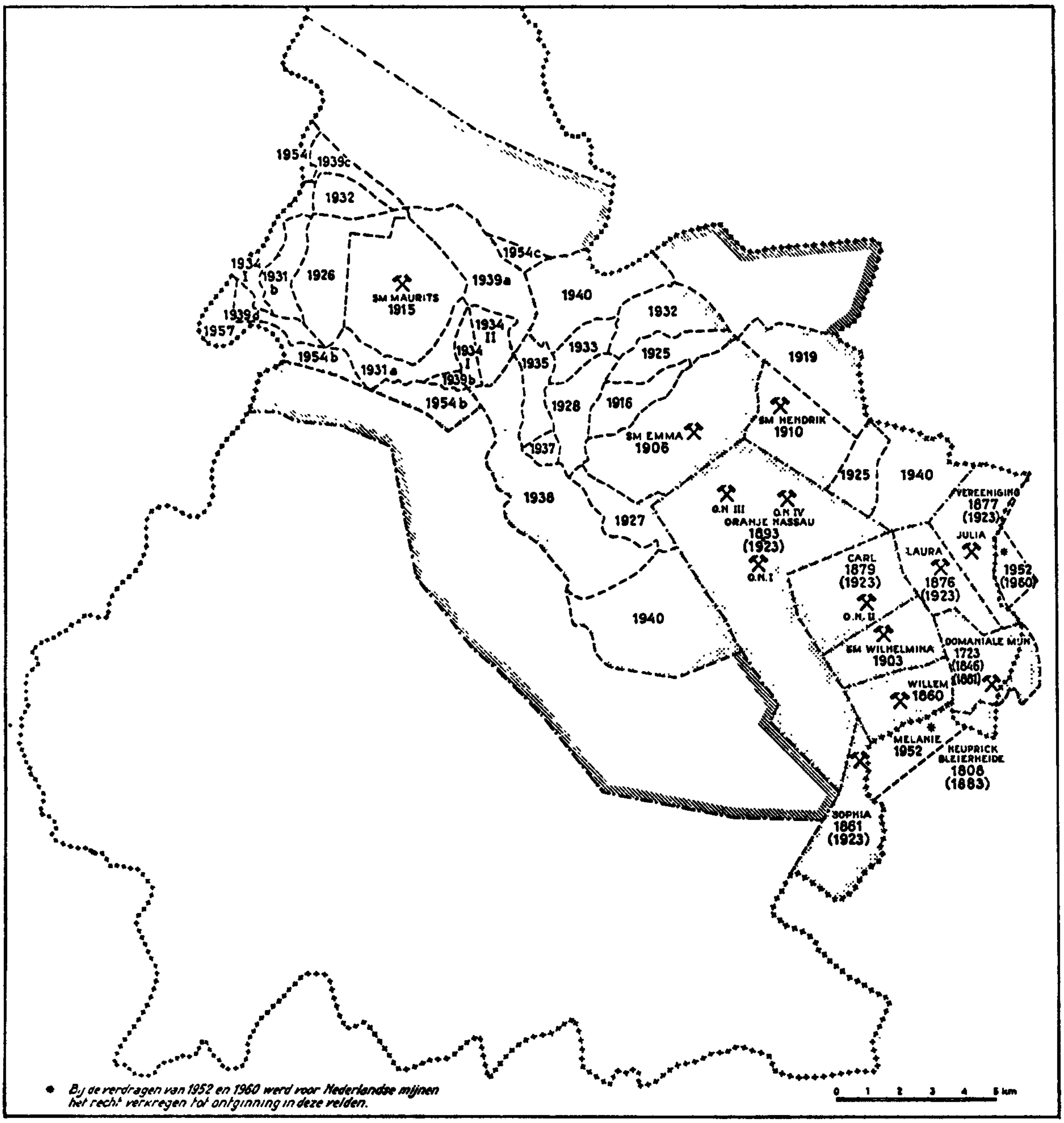
1 to 6: shales

7: rejects from washing plants

Available spoil tonnages are not known. According to published 1976 statistics on world production of coal, production ceased in Holland in 1974, with the exception of 2.68 mt of coking coal.

Figure 17

Concession map of South Limburg coalmines



VI. IRELAND

Ireland consists in the main of Paleozoic formations, where the largely predominant Carboniferous is bordered to the east, in the area of Dublin, by two Siluro-Ordovician areas and to the south, in the Kerry Cork Mountains, by Devonian strata.

The silico-aluminous materials amenable to treatment by acid processes comprise formations of slates and shales, distributed as indicated by figures 18 and 19.

A description of these formations in stratigraphic succession has been provided by the Geological Survey of Ireland.

S everal subjects have been listed in this inventory, subject to confirmation of their potential interest by geological studies and supplementary analytical data.

1) Lower Paleozoic shales and slates

The Lower Paleozoic is mainly represented by sequences of sandstone (greywackes), shales or slates. Outcrops tend to be rare.

The sequences between the Lower Cambrian and Upper Silurian are localised in four areas, viz (Figure 18):

1) The Longford Down Massif, north of Dublin
2) The Leinster Massif, extending to the south of Dublin
3) The Midlands, near Limerick
4) The eastern rim of the Connemara Massif in the north-west.

With the exception of the Leinster Massif and a few other areas for which detailed geological studies have been carried out, little work has been done anywhere else, particularly as concerns the Longford Down Massif.

The three formations described below are considered as the most interesting.

1.1 Longford Down Massif (Upper Ordovician)

This massif is located between the towns of Slane, Navan and Collon, north of Dublin. This was formerly an agricultural area and has only latterly become a mining area with the opening of a lead/zinc mine near Navan.

Figure 18

Areas of lower Paleozoic in Ireland

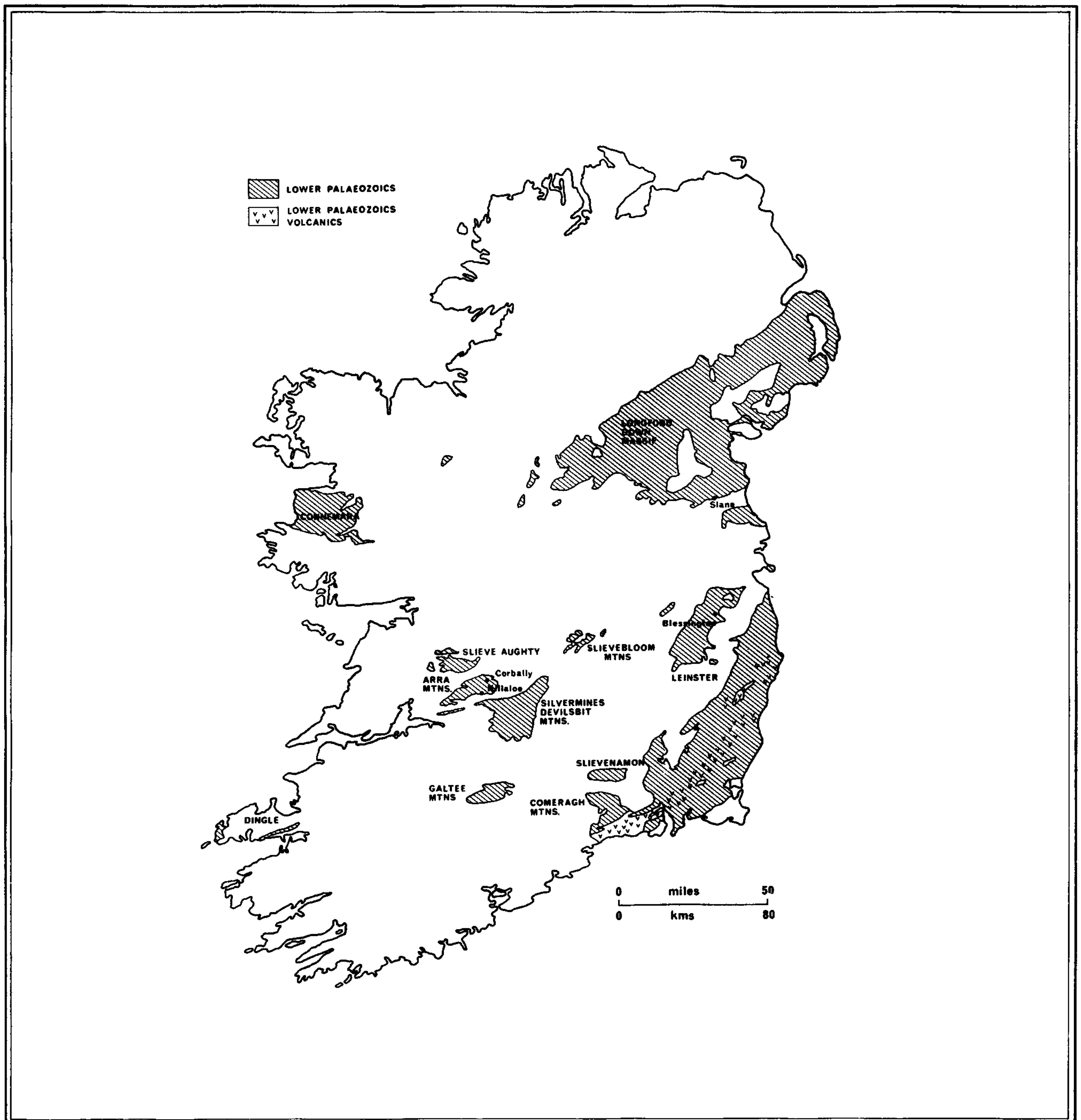
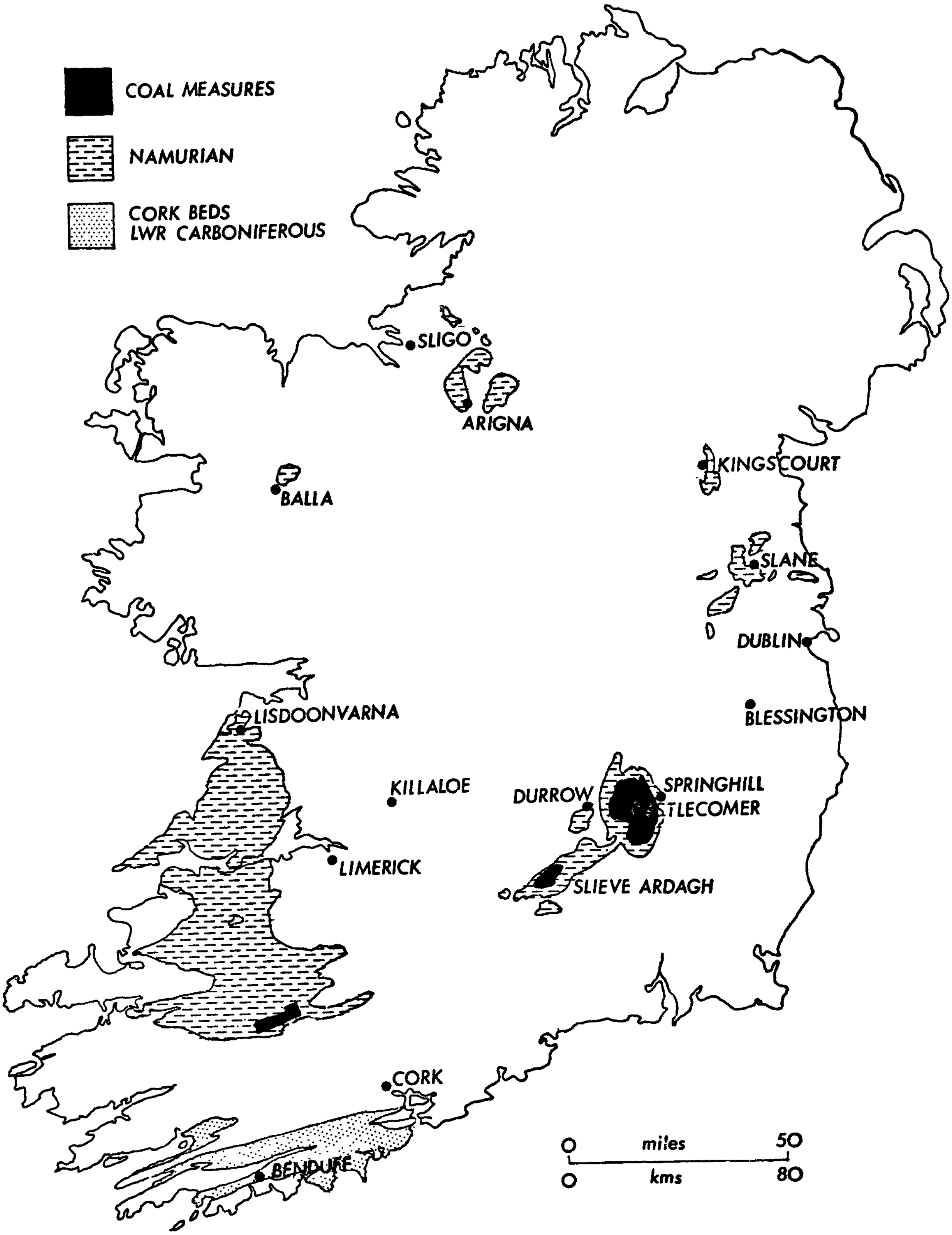


Figure 19

Areas of Carboniferous in Ireland



The formation is the extension towards the south-west of the Ordovician belt of the Scottish Southern Uplands. It is faulted against the Silurian to the north-west and south-east, and overlain to the south by the transgressive Carboniferous limestone.

The lithological sequence begins with volcanic tuffs and is continued by conglomerates, sandstones, and then shales with intercalations of tuffs at the base. The dip is 30 to 45^{o} to the south and the presence of north-south faults results in several repetions of the series.
The stratigraphic section of interest is the shaly upper unit.

In the southern part of the area, in the neighbourhood of a brickmaking quarry, the thickness is 25 m. Towards the north, the formation extends over a notable area but its characteristics are not known.

Grade

Analyses of four samples:

	1	2	3	4
SiO_2	53.6 %	51.85 %	52.1 %	51.22 %
Al_2O_3	27.77 %	21.77 %	24.3 %	24.22 %
Fe_2O_3	8.76 %	9.54 %	9.7 %	10.20 %
CaO	0.76 %	0.67 %	0.5 %	1.90 %
MgO	2.08 %	1.30 %	2.0 %	2.30 %
MnO	/	0.048 %	0.1 %	1.14 %
TiO_2	0.99 %	1.54 %	/	/
K_2O	3.59 %	3.12 %	4.7 %	2.94 %
Na_2O	0.71 %	0.62 %	0.9 %	1.08 %
Loss on ignition	6.12 %	/	5.8 %	6.14 %

Samples 1 and 2 are from boreholes. Samples 3 and 4 are taken from the quarry. The mineralogical composition is not known.

1.2 Slates of the Leinster Massif (Middle Ordovician to Lower Silurian)

The Slate Quarries formation extends over a narrow, 36 km long belt through the agricultural regions of Dublin, Kildare and Wicklow on the western boundary of the Leinster granite.

The formation, dated as Middle Ordovician/Lower Silurian, consists of dark slates with infrequent intercalation of greywackes. Although the Lower Paleozoic is in general strongly folded, this formation dips regularly to the west at an angle of 35 to 75°. The outcrop is faulted at right angles in the direction NW-SE.

The formation is well exposed at Slate Quarries, 5 km north-east of Blessington, thanks to former small workings. In this sector, which appears to be the most favourable, the formation extends uninterruptedly over a distance of 2 km, being 150 m wide and 40 m thick.

The grade of this clay and shale formation, which is the most homogeneous of the Lower Paleozoic units in south-east Ireland, is not known.

1.3 Midlands: Killaloe Slates (Silurian)

The Killaloe Slates facies outcrops north-east of Limerick, in the Arra Mountains, on either side of Lough Derg, on the Shannon.

Very large former slate open-pit quarries are now abandoned.

In this very popular tourist area, the site most propitious to possible industrial development would, if anything, be between Corbally and Protroe, where spoil from former workings is most abundant. There is a well-developed system of communications by road, rail and waterway towards the Shannon estuary.

The Killaloe Slates represent a system of Silurian mudstones within a sequence of conglomerates and sandstones.

Workings are located on the southern flank of a syncline dipping slightly to the west.

The determination of the thickness of the formation, the extension of which is considerable, is complicated by the faulted structure. In the quarries sector, the thickness is approximately 500 m.

Waste solely from those open-pit quarries in the neighbourhood of Corbally amounts to some 9 mt.

Nothing is known of mineralogy and chemical composition.

2) Carboniferous shales

The Carboniferous system is considered to contain the biggest reserves of silico-aluminous rock.

The Lower Carboniferous (Visean) consists mainly of carbonate, with the exception of the clastic formations in the area of Cork (Cork beds) featuring shale and limestone sedimentation (there have been some attempts at working of slates in the Kimsale Formation near Cork).

The Upper Carboniferous (Namurian-Westphalian) contains the great majority of the clay formations.

The Namurian is present in six areas (Figure 19), viz:

- edge of the Castlecomer coalfield in the East Midlands
- Arigna area in County Leitrim
- Balla area in County Mayo
- County Clare and County Limerick
- County Cork
- County Cavan, north of Dublin.

Only the first four areas are of interest.

2.1 Carboniferous shales - East Midland Region

Sandstone and shales outcrop very widely in County Laois, Country Kilkenny and County Carlow on the hills bordering the Castlecomer coalfield (Figure 19). This region is essentially agricultural.

A detailed geological study has been carried out in the two sectors of Tinwear, a locality 2.5 km south-east of Durrow, and Springhill, close to the town of Carlow.

In the Tinwear sector, the formation rests on the Visean limestones and is overlain by the Namurian sandstones. Stratigraphic sections of the syncline show the lower part of the formation to be mainly argillaceous over a thickness of 50 m. The upper part of the formation exhibits intercalations of sandstone layers.

In the Springhill sector, the grey to black shales outcrop on the eastern side of the Castlecomer coalfield. Their stratigraphic position is identical to that for the Tinwear sector.

Grade

Two analyses for brick and tile-making purposes are as follows:

	Tinwear	Springhill
SiO_2	58.9 %	59.83 %
Al_2O_3	25.2 %	22.69 %
Fe_2O_3	11.1 %	5.00 %
CaO	3.0 %	0.63 %
MgO	1.6 %	1.32 %
K_2O	/	1.79 %
TiO_2	/	0.85 %
MnO_2	/	0.21 %
Na_2O	/	0.20 %

The mineralogical composition is not known.

2.2 Carboniferous shales - Arigna region

Arigna is located on the edge of Lake Allen, south-west of Sligo, in County Leitrim.

A small Namurian coalfield (reserves of 15 mt) contains a low-grade coal yielding 45 to 50 % of high alumina ash. The surrounding shales are employed in the production of refractory brick. The reserves present are considerable, but no analysis of the material is available.

Analysis of ash from a power station:

SiO_2	51.46 %
Al_2O_3	35.98 %
Fe_2O_3	8.43 %
CaO	0.90 %
MnO	1.19 %
TiO_2	1.52 %
P_2O_5	0.33 %
Carbon	5 to 15 % (variable according to combustion conditions)

2.3 Carboniferous shales - Balla area

The shales formation is located 8 km east of Castlebar, immediately north of Balla, in County Mayo.

A stratigraphic similarity is observed with the Namurian in the Tinwear and Springhill sectors: the base of the series is mainly argillaceous, after which the sandstone sequences increasingly take over towards the Namurian top.

The formation is a semi-circular basin 8 km in diameter. Sufficient reserves could be found in the base formations of the hills on the east and south-east edges of the basin.

Grade of the material is not known.

2.4 Carboniferous shales - Clare and Limerick areas

The Clare shale formation, composed of marine shales at the base of the Namurian, extends from the Atlantic coast (Lisdoonvarna) to the Killarney-Mallow area, i.e. over some 80 km from north to south (Figure 20).

In the north, around Lisdoonvarna, the region is very popular with tourists. As against this, agriculture and industry are more highly developed towards the south, opposite the Shannon estuary, which is well served with means of communication.

The Clare shale formation, situated in a large sedimentary basin, lies between the Visean limestone and the Namurian sandstones and shales. Angle of dip is generally very small, so that the various layers outcrop over considerable distances. The formation contains thin phosphate layers 1 mm to 30 cm thick.

Recent exploration for phosphates by means of boreholes has demonstrated the irregular nature of the formation.

Thickness increases from north to south, from 25 m at Lisdoonvarna to more than 400 m towards the Shannon, where the most favourable site for possible extraction would apparently be located.

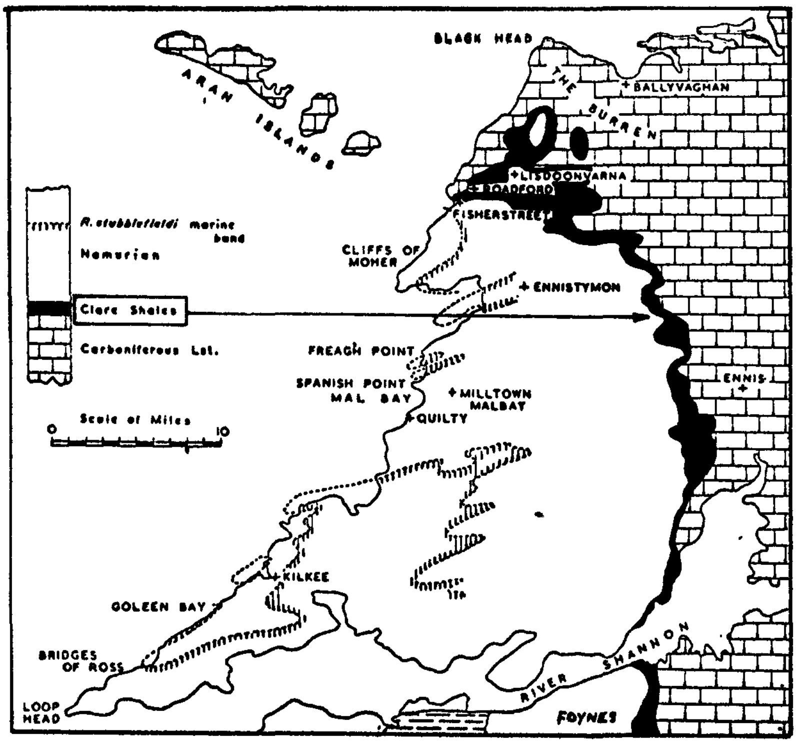
No analytical data on these shales is available.

3) Westphalian coalfields - colliery spoil

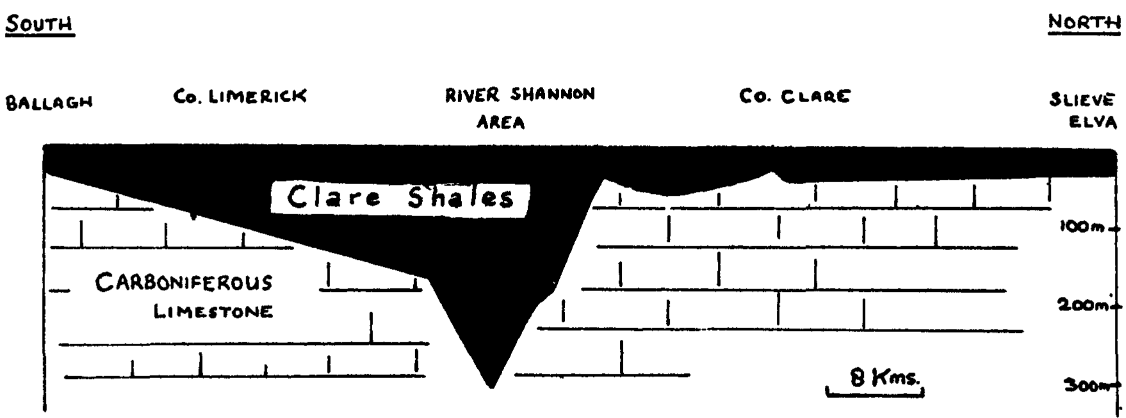
The two coalfields to note are those of Caltlecomer and Slieve Ardagh (Figure 19).

Figure 20

The Carboniferous Clare shale formation



20a - Outcrop map of Clare Shales



20b - North-South vertical section to show variations in thickness of Clare Shales.

3.1 Castlecomer Coalfield

This covers an area of 390 sq. km over parts of County Kilkenny, County Laois and County Carlow.

Only one site is still being worked, at Rossmore near Carlow (Figure 21), where 1975 production was 50 000 t.

The basin, elongated in the north-south direction , is cut by numerous faults exhibiting substantial displacement. Owing to this and to the cyclic nature of sedimentation ("coal measures"), homogeneous thick shale formations are infrequent.

A substantial (but unspecified) tonnage of argillaceous spoil is, however, available in the form of numerous colliery tips.

3.2 Slieve Ardagh Coalfield

This field, located south-west of the Castlecomer field, covers an area of 36 sq. km in County Tipperary.

The structure is complex and the coal measures, comprising layers of clay at the base of the series, are limited to the small Earlshill District.

Coalmining ceased in 1972.

As with the Castlecomer field, there are numerous colliery tips of unspecified size.

Grade of spoil

A examples, four analyses of colliery spoil are tabulated below:

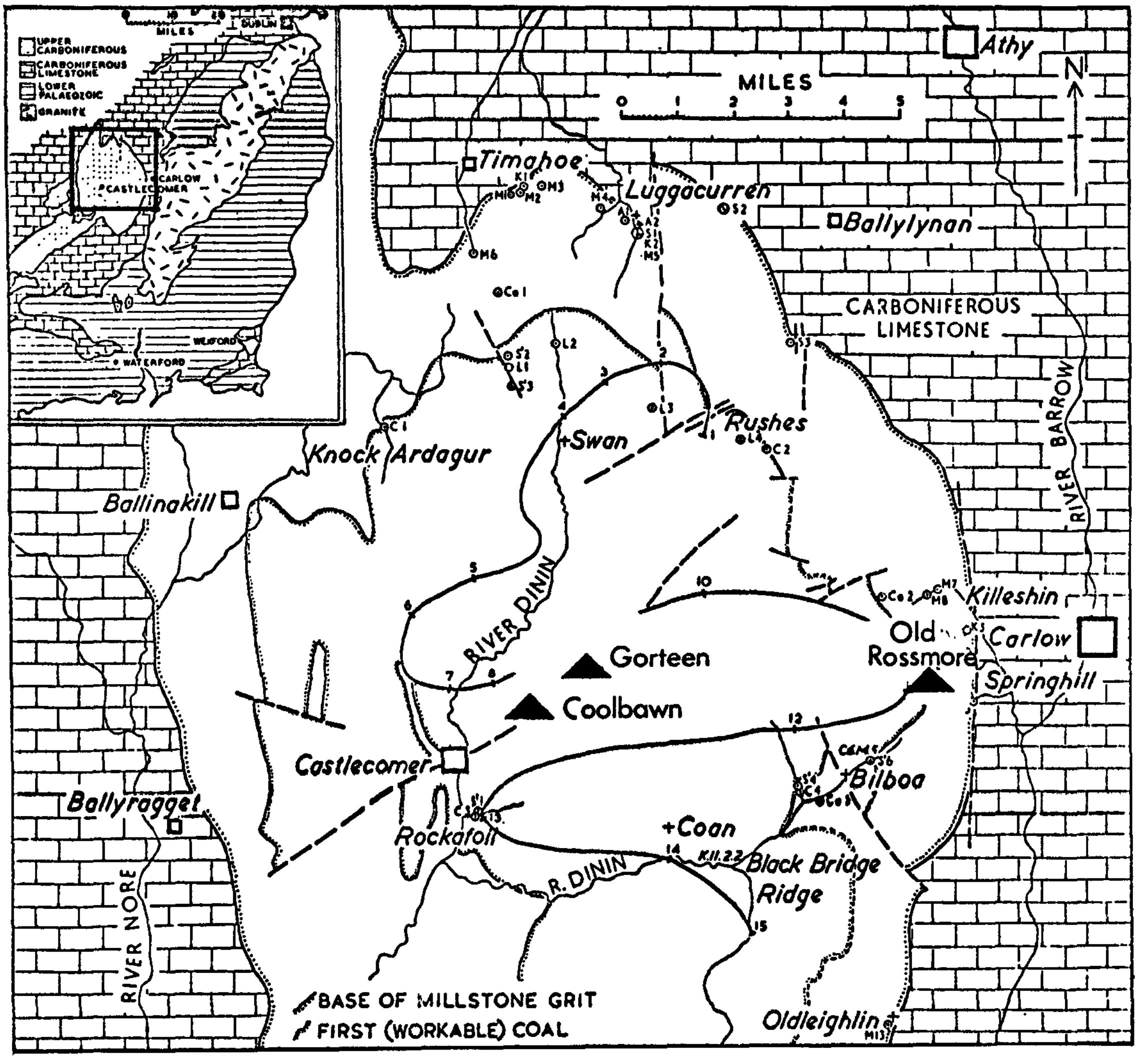
	No 1	No 2	No 3	No 4
SiO_2	60.8 %	52.8 %	73.5 %	67.2 %
Al_2O_3	23.8 %	27.2 %	20.0 %	24.1 %
Fe_2O_3	5.8 %	6.1 %	1.0 %	/
Carbon	4.3 %	6.0 %	3.2 %	4.1 %

Origin of samples:

1 - Castlecomer Coalfield - Old Rossmore tip
2 - Castlecomer Coalfield - Coolbawn tip
3 - Castlecomer Coalfield - Gorteen tip
4 - Slieve Ardagh Coalfield - Aughaterry tip.

Figure 21

The Castle Comer coal field



VII. ITALY

In the absence of specific information, an inventory of shale and clay formations and of clay/lignite associations has been compiled for each province, after a study of the Memorandum accompanying the map of mineral resources of Italy and using the International Stratigraphic Lexicon.

This geographical classification, based on general references, is tentative . Lacking data on grades and available quantities, we are unable to select those silico-aluminous materials which could be of potential interest in terms of the extraction of alumina by acid processes.

1) East central Alps

Triassic:

- Varesotto and La Carnia oil shales
- Scledense kaolinic earths formed by weathering of Triassic vulcanites and consisting mainly of illite, with associated montmorillonite.

Cenomanian: Mollaro shales in the Tesino and Covelo areas

Eocene - Oligocene: Oil shales associated with lignites (M. Palli, Vincentino), approximately 100 m thick in the Friuli Massif.

Quaternary: Leffe lacustrine basin north of Bergamo. 150 m thick series composed of lacustrine clays with three lignite formations; reserves assessed at 19 mt of lignite.

2) Liguria

Mesozoic: Locally, the sedimentary series covering the ophiolitic series consists of shales and clays. These comprise the "palombini" clays and the Val Lavagna shales.

3) Tuscany

Complex tectonics are displayed in ophiolite series, and in sedimentary troughs (Miocene to Upper Pliocene) where marine invasions alternate with lagunar and lacustrine episodes.

Two basins may be noted (Figure 22):

- Mugello: a Pleistocene clay/lignite complex. Reserves of lignite are assessed at several m t.

- Caltelnuovo di Sabbioni: This constitutes the most important lignitiferous area in Italy. A huge open pit is being worked to supply a thermal power station. Clays containing varying proportions of sand comprise three beds of lignite, the thickness of which totals 30 m. Lignite reserves are evaluated at 90 mt.

- Vicchio series: The Miocene upper part of the Macigno series comprises, from bottom to top:
  - marls containing beds of black chert,
  - marls, 200 - 300 m thick,
  - a very thick clay horizon.

4) South central Italy

This region is characterized by a succession of sedimentary shelf complexes, predominantly carbonate. Formations which could be of potential interest were derived from the alteration of sediments of volcanic origin, and are lignite-clay associations in lacustrine basins.

4.1 Altered formations

- Civitavecchia region: alteration of feldspars by H_2S- and CO_2 - rich waters circulating in rhyolitic ignimbrites, has substantially increased the alumina content of these formations and given birth locally to lenticular bodies of kaolin containing 35 - 38 % alumina (La Provvidenza - La Bianca and Fosso Eri-Sasso deposits in the Tolfa and Allumiere area).

- Caserta province, north of Naples: hydrothermal alteration of volcanic tuffs, combined with secondary deposition of silicates formed through the alteration of feldspathic rocks, has led to the formation of pure kaolin which is locally concentrated in substantial quantities, with an alumina content of some 30 %.

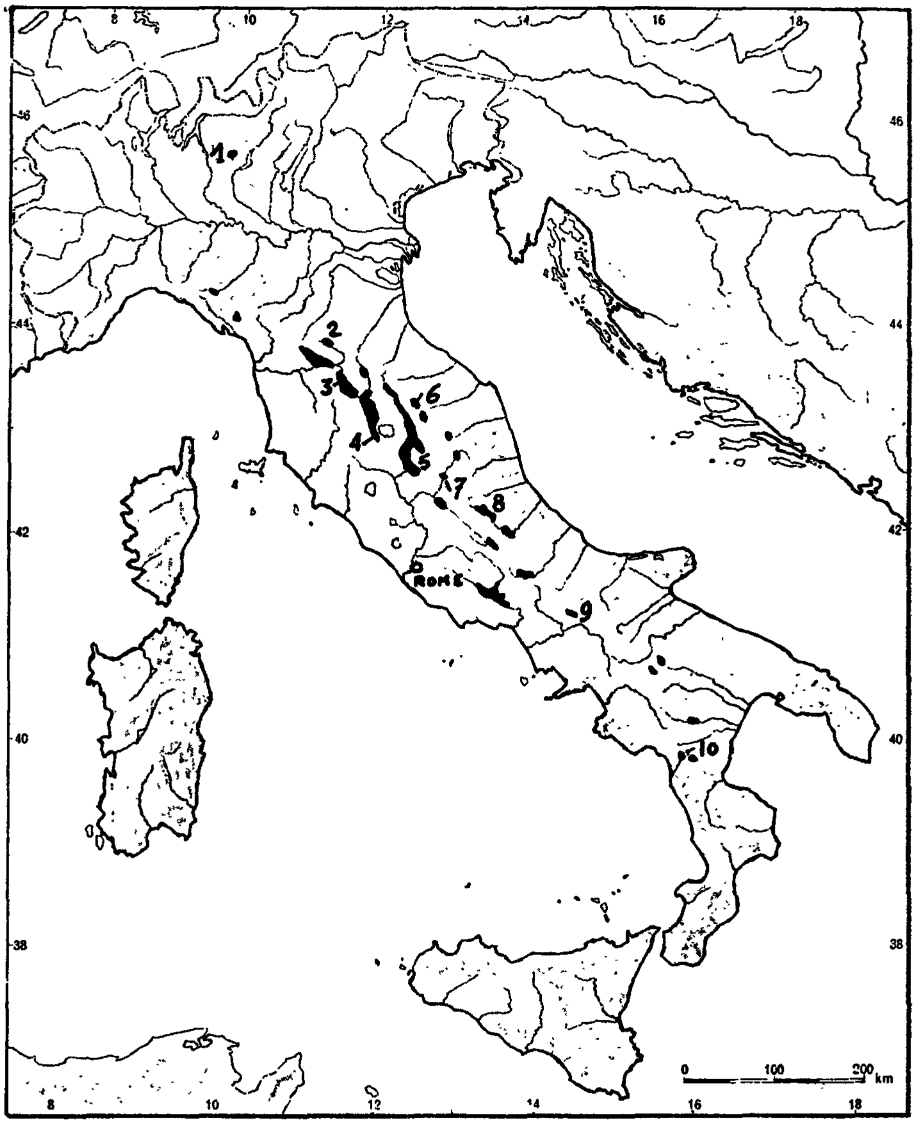
4.2 Lacustrine basins (Figure 22):

Plio-Pleistocene in age, they mark out an area of down-faulting (Bradanic graben) in the Central Appenines. Among the largest basins, only those with predominantly argillaceous sedimentation have been taken into account.

- Umbria: The largest lacustrine basin is that of the Tiberino and its tributaries, south of Perugia. The fluviolacustrine formations resting on a carbonate or sandstone basement (Lias to Miocene) include very numerous deposits of lignite, in particular the following:

Figure 22

Pleistocene lacustrine basins of Italy, containing deposits of lignite and clay



1 – Leffe	6 – Gubbio
2 – Mugello	7 – Leonessa
3 – Castelnuovo di Sabbioni	8 – Aterno
4 – Pietrafitta	9 – Morcone
5 – Bastardo	10 – Mercure

Pietrafitta, in the Nestore valley. The lignite is subhorizontal (average thickness 7 m) and included in Middle Ploistocene lacustrine clays. It is overlain by sandy sediments and by alluvia of the Nestore. Lignite reserves: 29 mt.

Bastardo: consists of six subparallel layers, 2 to 11 m thick, included in the argillaceous complex - the two lower layers being the thickest-and in the stratigraphically higher clay/sand complex. Lignite reserves are evaluated at several tens of mt and there are plans for quarrying.

Gubbio, north-east of Perugia in the Chiasco valley. A 3 m thick lignite bed is included in the clay complex. The estimated quantity present down to a depth of 100 m is 8 mt and the lignite/spoil ratio is assessed at 1/30, which gives approximately 250 mt of clay.

- Lazio: The Leonessa deposit, east of Termi, comprises two beds of lignite intercalated with a Lower Quaternary clay and marl complex. Reserves of lignite are evaluated at 12 mt and the ratio of spoil to lignite at 22.5 m^3/t.

- Abruzzo: the Aterno basin, north-east of Rome, consists of a Pleistocene clay/sand complex. The three subhorizontal layers of lignite (1 to 5 m thick) are estimated to contain a total of 15.5 mt.

- Campania: The Morcone deposit, situated in the Tammaro valley north-east of Rome, comprises three layers of lignite 1 to 6 m thick, included in a Pleistocene argillaceous complex exhibiting sandy seams. The basin consists of two lignite areas, separated by a barren zone. The estimated quantity present down to a depth of 90 m is 8 mt, with a spoil/lignite ratio of 6.7 m^3 per t of lignite.

- Lucania: The Mercure basin is located in the province of Potenza, between the Taranto and Policastro gulfs, north-west of Castrovillari. Three layers of lignite, with thicknesses of 4 to 10 m, 15 m and 1.5 to to 2 m, were formed in a clay and marl series; the quantity present is evaluated at 15 mt.

5) Calabria

This region is characterised by sedimentary formations of extremely varied nature: metamorphic, terrigenous, continental, carbonated, etc.

The fine terrigenous facies are found in the Jurassic or Cretaceous and in the Quaternary series.

- Jurassic: fine pelagic or neritic facies in the Lower and Middle Lias (Cropalati - Colognati series) with local occurrences of subsidence trough deposits (Longobucco unit).

- Cretaceous: Clay/silt flysch north-east of Monte Pollino.

- Quaternary: In the Crotone basin, the Pleistocene is represented by blue clays with diatomite horizons.

6) Sardinia

The fact that Sardinia was a submarine rise explains the predominance of the continental, lagunar and reef facies. Salient features are: continuous sedimentation from the Cambrian to the Holocene, a succession of four main orogenies and the occurrence of three magmatic cycles. The clay/shale facies are present in the Cambrian, Silurian and Tertiary.

- Cambrian: Cabitza clay/shale formation

- Silurian: Black graphitic Graptolite shales, called the Goni shales, largely represented in the Flumendosa basin.

- Tertiary: Numerous argillaceous areas, due to alteration of pyroclastic formations, extend throughout the island. An example is Monte Porceddu, which forms a deposit of more or less pure Kaolin, the diameter of which is several hundred metres, thickness more than 30 m and average alumina content 30 %. Vast, still unexplored areas could well contain substantial tonnages of argillaceous material.

  During the Eocene, formation of lignite took place on a large scale in the Sulcis basin, west of Cagliari. A series of boreholes on the Cortoghiana Nuova concession has demonstrated the existence of 50 mt of lignite extending over an area of 10 sq. km. Potential reserves could be several hundred m t. The lithology of the surrounding rocks varies and includes clay, the extension of which is not stated.

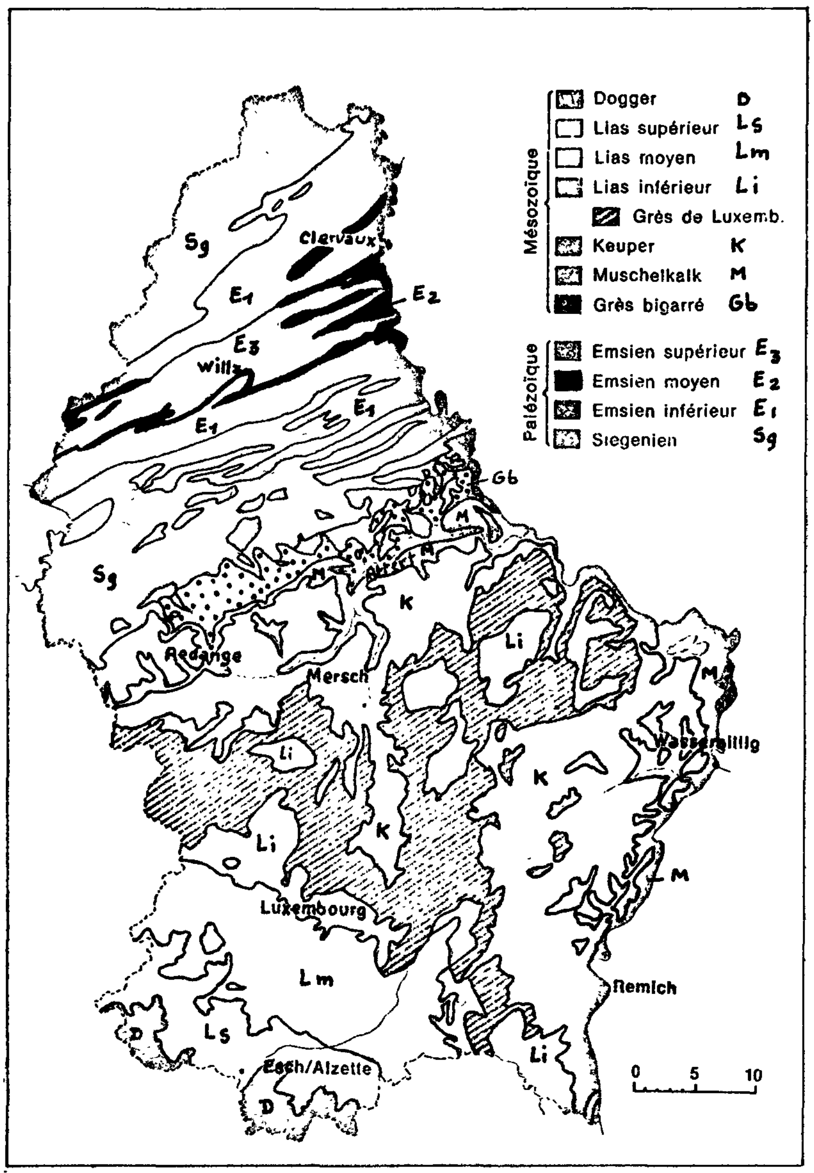
VIII. LUXEMBOURG

Luxembourg consists of two entirely distinct geological units limited by the Attert valley. These are (Figure 23):

- To the north, Devonian formations, Siegenian to Emsian and folded along a WSW-ENE direction. The great Wiltz syncline with an upper Emsian core is flanked by two anticlinorial regions. These Paleozoic formations belong to the Ardennes Massif.
- To the south, Mesozoic strata, transgressive on the Paleozoic and either tabular or slightlydippingtowards the south. These form the north-eastern part of the Paris Basin.

Figure 23

Geological map of Luxembourg



From a lithological classification established by the Geological Survey of Luxembourg it appears that only the Paleozoic formations of the Ardennes deserve further study.

1) Mesozoic

The Triassic, transgressive over the Paleozoic, is characterized by coastal, lagunar or detrital facies exhibiting rapid lithological variations: sandstones, marls, gypsum clays, limestones and dolomites. None of the Triassic argillaceous formations is pure or extensive enough to be considered.

The Liassic forms extensive outcrops between the town of Mersch and the French border. It shows a sequence of limestones, marls and sandstones (Luxembourg sandstones) up to the Middle Lias, and then deep sub-marine terrigenous sediments of Upper Liassic age, known as the Toarcian "paper board shales".

These oil shales have been investigated and two exploratory boreholes were drilled by ARBED ("Aciéries Réunies de Burbach-Esch-Dommeldange") with a view to the possibility of extracting volatile oils by distillation.

The thickness is interesting (some 45 m), but chemical analyses show that they contain little alumina (12 to 18 %) and too much carbonate (7 to 20 % CaO and MgO).

The Dogger is essentially carbonated.

2) Paleozoic

2.1 Stratigraphy

Of Lower Devonian age, the various layers consist of phyllites, which are locally fissile and worked for the production of slates, and of shales containing varying amounts of sandstone. The stratigraphic sequence is summarized below:

Emsian	upper	Wiltz shales	E_3
		Berlè quartzites	E_3q
	middle	Clervaux shales	E_2
	lower	Schuttbourg quartzophyllites	E_1b
		Stolzembourg phyllites	E_1a
Siegenian	upper	Coarse shales	Sg_3
	middle	Sandstones and sandy shales	Sg_2

The Geological Survey of Luxembourg has systematically sampled three sections of the Siegenian and Emsian formations (Figure 24), viz:

Section A (West), passing through the following localities: Petit Nobressart, Holtz, Perlé, Martelange, Wolwelange, Bigonville, Moulin de Boulaide, Boulaide, Surré, Harlange and Tarchamps.

Section B (Center) passing through: Ettelbruck, Niederfeulen, Heiderscheid, Heiderscheidergrund, Büderscheid, Schleif, Niederwampach, Schimpach, Liefrange, carrière Lambert and carrefour Schumann.

Section C (West) passing through: Wiltz, Kautenbach, Erpeldange, Michelau, Lipperscherd, Goebelsmühle, Kleimillen, Maulusmühle, Clerf, Drauffelt, Wilwerwiltz and Lellingen.

2.2 Grade and mineralogical composition

Analyses of the 51 samples taken are appended for information at the end of this chapter on Luxembourg. They have been carried out by the ARBED laboratory by X-ray fluorescence and partially checked by wet chemical analysis.

The table on page 69 gives mean values for the main chemical elements present, after grouping samples by geological formation.

The mineralogical composition of these shales is not known.

- The Lower Siegenian (Sg 1) phyllites and quartzophyllites outcrop at only one point in the country, at the Belgian border.

- The Middle Siegenian (Sg 2) also is hardly represented and a single analysis is not representative of this facies.

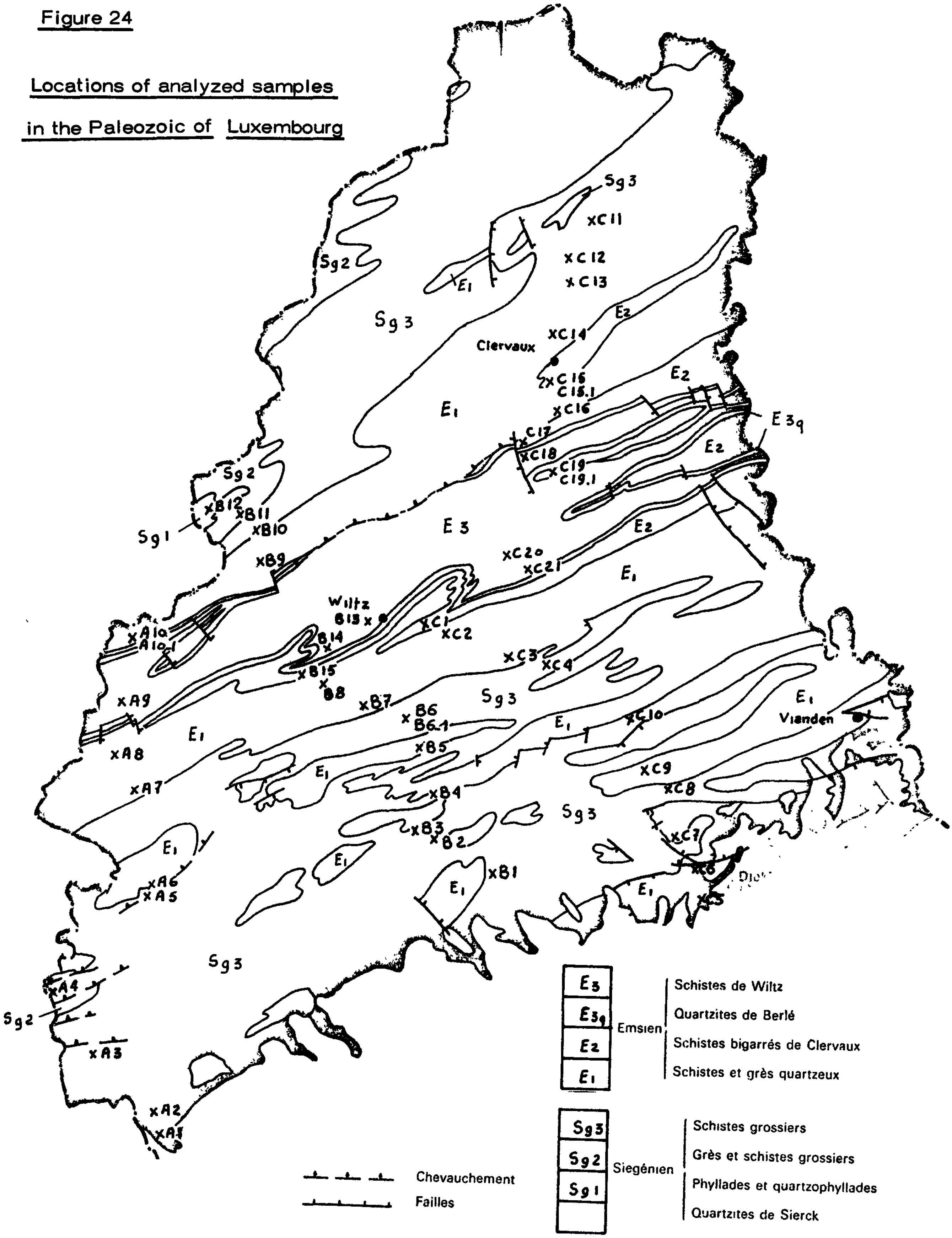
According to Dr. Bintz of the National Geological Survey, the Middle Siegenian exhibits, in the north-western part of the country, argillaceous weathering over 10 to 20 m, reaching locally as much as 40 m thickness. This weathering is also found in Belgium in the area of Bastogne, where the clay is worked on an industrial scale for brickmaking.

It has not been possible to obtain data on the chemical composition of this clay.

The lower part of the Upper Siegenian (SG 3a) consists, near the western border and in the North of the country, of a local facies of highly fissile phyllites which are mined for slate. The two samples analyzed are from waste tips of former workings in the neighbourhoods of Perlé and Martelange.

Figure 24

Locations of analyzed samples in the Paleozoic of Luxembourg



Mean chemical compositions of various Devonian formations of Luxembourg

Geological formation	Sg 1	Sg 2	Sg 3a	Sg 3	E 1a	E 1b	E 2	E 3
Number of samples	1	1	2	13	11	10	6	6
SiO_2	61.74	67.76	53.36	63.30	65.78	66.34	66.44	59.90
Al_2O_3	18.11	14.97	18.93	15.95	15.96	14.88	14.86	17.96
Maxi/Mini			19.27/18.60	19.41/7.27	20.19/6.80	21.63/6.17	19.54/6.23	19.20/14.53
Fe_2O_3	7.35	6.95	8.94	7.66	6.64	5.80	7.75	7.90
CaO	0.33	0.30	2.28	0.67	0.47	0.50	0.49	1.05
MgO	2.37	1.29	3.49	2.48	1.94	1.78	1.43	2.30
K_2O	3.23	3.00	3.89	3.05	2.03	2.88	2.13	3.34
Loss on ignition	4.34	3.34	6.77	4.75	4.22	4.52	4.25	5.49

Earlier documentation gives the mean chemical composition of slates, the number of which is not stated, from Haut-Martelange and Asselborn. These analyses were carried out in 1923 by the Government Agronomic Station at Ettelbruck.

In the north, near Asselborn, three "veins" are being worked to obtain grey slates. Intercalated formations yield locally some black slates, the lower quality of which is probably due to lower-grade metamorphism.

	1	2	3
SiO_2	53.72 %	60.40 %	57.22 %
Al_2O_3	18.29 %	19.41 %	21.41 %
Fe_2O_3	8.47 %	8.98 %	9.75 %
CaO	3.53 %	0.60 %	0.75 %
MgO	3.19 %	-	-
K_2O	3.25 %	-	-
Na_2O	2.48 %	-	-
SO_3	0.87 %	-	-
Loss on ignition	6.20 %	3.98 %	4.35 %

Origin:

1: Haut-Martelange slates

2: Asselborn grey slates

3: Asselborn black slates.

The quantities of waste which could be available at the various workings are not stated.

- Upper Siegenian (Sg 3). P.M.
- Lower and Middle Emsian (E 1a, E 1b, E 2): These exhibit similar chemical characteristics and relatively low alumina contents. The heterogeneous nature of these formations, owing to the occurrence of sandstone seams, is responsible for very substantial variations in alumina contents, which may differ by a factor of two or three.

Very different results are however obtained for the weathering facies developed on the Stolzemburg phyllites (E 1a) (See "Observations et recherches à propos de l' altération météorique des schistes de l'Emsien d'Oesling", M. Lucius, Luxembourg, 1953).

The following analyses have been carried out by the Luxembourg Bridges and Highways Authority:

	1	2	3	4	5	6	7
SiO_2	60.00 %	61.90 %	57.20 %	61.40 %	61.60 %	65.60 %	52.10 %
Al_2O_3	25.13 %	24.10 %	27.90 %	23.20 %	25.30 %	21.11 %	25.04 %
Fe_2O_3	5.17 %	5.50 %	2.40 %	3.80 %	3.70 %	3.45 %	3.36 %
CaO	0.60 %	0.80 %	0.90 %	1.60 %	0.80 %	0.76 %	1.00 %
MgO	2.42 %	2.46 %	2.57 %	2.89 %	2.17 %	1.72 %	2.74 %
Loss on ignition	4.41 %	4.05 %	5.58 %	5.78 %	3.78 %	5.20 %	4.30 %

Origin:

1 - Nikolausberg borehole No. 1 - Core sample, depth 7 m.

2 - Nikolausberg borehole No. 5 - Core sample, depth 11 m.

3 - Mean of 25 samples taken along the railway line at Goebelsmühle, between "km 58.4" and the bridge at km "59.4"

4 - Mean of 25 samples taken above the railway line at Goebelsmühle over a distance of 100 m (km 58.4)

5 - Mean of 25 samples - Trench for the new road immediately south of Clerf

6 - Mean of 25 samples - Railway cutting south of Clerf

7 - Mean of 25 samples - Railway embankment north of Mecher.

Weathering of these phyllites has led to a relative increase in alumina contents and decrease in silica and iron contents.

- The Upper Emsian (E 3) would appear at first sight to be the most homogeneous, or the least sandy, shale formation, with alumina contents ranging from 14.5 to 19.2 %.

These results highlight the potential interest of weathering clays developed on various shale horizons, with particular reference to the Middle Siegenian and Lower Emsian; also, to a lesser degree, the Martelange, Perlê and Asselborn slates and the Wiltz shales.

SECTION A

ANALYSES GIVEN BY THE GEOLOGICAL SURVEY OF LUXEMBOURG

Sample No. Section A and Formation		CaO %	Fe_2O_3 %	MnO %	TiO_2 %	P_2O_5 %	SiO_2 %	MgO %	Al_2O_3 %	Loss on ignit. %	CO_2 %	Na_2O %	K_2O %
SG3	A 1	o,41	7,85	o,19	o,82	o,1o	59,78	2,82	18,51	4,65	< o,ool	o,68	3,88
SG3	A 2	o,31	7,8o	o,o7	o,73	o,1o	64,74	2,76	15,o9	4,o6	< o,ool	o,76	3,2o
SG3a	A 3	2,3o	9,15	o,15	o,82	o,1o	52,6o	3,5o	19,27	6,86	1,87	o,99	3,99
SG3a	A 4	2,26	8,74	o,12	o,81	o,o9	54,12	3,48	18,6o	6,69	1,87	1,o4	3,8o
SG3	A 5	1,22	7,7o	o,14	o,81	o,1o	59,66	3,o9	17,19	5,15	1,19	1,o5	3,64
El a	A 6	o,31	7,6o	o,1o	o,86	o,12	59,76	2,82	18,41	4,78	< o,ool	o,93	4,o3
El a	A 7	o,14	8,45	o,19	o,93	o,11	57,12	1,98	2o,19	5,7o	< o,ool	o,87	4,o1
Elb	A 8	o,35	6,39	o,11	o,87	o,12	66,2o	1,93	15,1o	4,25	< o,ool	1,37	3,o1
E3	A 9	o,16	7,6o	o,1o	o,92	o,1o	61,3o	1,52	18,34	5,73	< o,ool	o,39	3,69
Elb	A 1o	o,12	4,3o	o,12	o,71	o,o2	73,47	o,18	13,92	3,33	< o,ool	o,85	2,71
Elb	A 1o/1	o,15	2,75	o,o4	o,39	o,o3	86,6o	o,14	6,17	1,74	< o,ool	o,41	1,3o

SECTION B

ANALYSES GIVEN BY THE GEOLOGICAL SURVEY OF LUXEMBOURG

Sample no. Section B and Format.		CaO %	Fe_2O_3 %	MnO %	TiO_2 %	P_2O_5 %	SiO_2 %	MgO %	Al_2O_3 %	Loss on ignit. %	CO_2 %	Na_2O %	K_2O %
SG3	B 1	0,27	6,85	0,11	0,67	0,07	67,19	1,99	15,57	3,68	0,10	0,74	2,58
SG3	2	0,25	6,30	0,04	0,80	0,07	65,37	1,95	16,74	4,06	0,17	0,76	3,34
SG3	3	0,51	8,15	0,13	0,83	0,08	59,83	2,71	17,72	5,38	0,52	1,05	3,42
SG3	4	0,65	8,80	0,24	0,76	0,11	60,40	2,96	16,86	5,11	1,01	0,95	3,08
Ela	5	0,83	5,65	0,11	0,63	0,07	71,64	1,92	12,72	3,66	0,69	1,25	1,30
SG3	6	0,33	5,20	0,18	0,41	0,07	78,03	1,96	7,27	3,03	0,69	1,38	2,00
SG3	6/1	0,31	7,65	0,16	0,77	0,07	62,86	2,62	16,30	5,11	0,86	0,67	3,32
Ela	7	1,08	6,50	0,12	0,64	0,08	76,55	1,80	6,80	3,97	2,29	1,10	1,08
Elb	8	0,34	6,85	0,05	0,97	0,12	60,53	2,50	18,97	5,38	0,10	0,30	3,58
Elb	8/1	0,25	3,89	0,05	1,02	0,05	59,00	1,80	21,63	8,12	0,17	0,23	3,77
Ela	9	0,18	2,98	0,05	0,59	0,05	80,60	0,42	10,29	2,17	0,10	0,60	1,85
SG3	10	0,12	10,53	0,18	0,88	0,08	56,40	2,20	19,41	5,33	0,10	0,78	3,68
SG2	11	0,30	6,95	0,21	0,72	0,06	67,76	1,29	14,97	3,34	0,10	1,10	3,00
SG1	12	0,33	7,35	0,24	0,94	0,12	61,74	2,37	18,11	4,34	0,10	1,01	3,23
E3	13	2,90	7,35	0,16	0,81	0,04	54,49	3,45	18,17	7,61	1,76	0,85	3,94
E3	14	1,23	7,90	0,10	0,91	0,05	58,58	2,12	19,20	5,19	0,34	0,78	3,83
E2	15	0,31	6,40	0,05	0,97	0,08	61,66	2,08	18,27	5,48	0,17	0,62	3,84

SECTION C

ANALYSES GIVEN BY THE GEOLOGICAL SURVEY OF LUXEMBOURG

Sample no. Section C and Formation		CaO %	Fe_2O_3 %	MnO %	TiO_2 %	P_2O_5 %	SiC_2 %	MgO %	Al_2O_3 %	Loss on ignit. %	CC_2 %	Na_2O %	K_2O %
E2	C 1	0,36	8,50	0,08	0,92	0,10	60,18	2,08	18,73	4,49	0,10	0,75	3,30
E1b	2	0,85	6,08	0,12	0,76	0,04	70,00	2,35	12,88	3,58	0,53	1,20	1,80
E1a	3	0,34	7,30	0,12	0,83	0,09	63,70	1,14	17,36	4,54	0,35	0,88	3,08
SG3	4	1,26	7,70	0,13	0,88	0,08	58,38	2,56	19,04	5,55	0,68	0,80	3,28
E1b	5	1,18	6,40	0,11	0,96	0,07	60,52	2,64	18,49	5,36	1,02	0,60	3,38
E1a	6	0,31	5,63	0,06	0,97	0,07	62,66	2,10	19,23	3,95	0,51	1,06	3,70
E1b	7	0,62	6,95	0,09	0,86	0,08	61,23	2,46	18,41	4,82	0,35	0,80	3,45
SG3	8	1,04	7,21	0,28	0,54	0,08	71,76	2,02	9,99	4,22	1,92	1,18	1,40
E1a	9	1,02	6,87	0,18	0,75	0,09	65,20	2,63	15,51	3,99	0,87	1,06	2,35
SG3	10	2,11	7,85	0,14	0,83	0,03	58,51	2,69	17,63	6,41	2,47	0,68	2,90
E1b	11	0,46	7,00	0,11	0,84	0,08	63,87	2,25	17,43	3,85	0,68	0,85	2,83
E1a	12	0,30	7,50	0,13	0,90	0,08	60,60	2,29	19,77	4,13	0,17	0,80	3,17
E1a	13	0,40	6,88	0,05	0,82	0,14	65,03	2,02	17,33	3,85	0,10	0,63	2,70
E1a	14	0,23	7,75	0,11	0,98	0,09	60,76	2,27	17,97	5,65	0,10	0,52	3,18
E2	15	1,66	5,53	0,36	0,56	0,06	79,68	1,00	6,23	2,72	0,86	1,20	0,80
E2	15/1	0,27	8,30	0,15	1,00	0,07	58,90	2,28	19,54	5,45	0,18	0,81	2,98
E1b	16	0,17	7,35	0,20	0,94	0,08	62,03	1,58	18,67	4,73	0,18	0,94	3,03
E2	17	0,17	5,50	0,11	0,88	0,07	67,70	0,42	17,07	3,89	0,18	1,06	2,90
E3	18	0,52	8,60	0,23	0,73	0,05	66,00	2,14	14,53	3,99	0,18	0,73	2,04
Qte Berlé	19	0,22	4,55	0,06	0,67	0,05	77,56	0,79	10,40	2,72	0,34	0,65	2,09
E2	19/1	0,17	12,31	0,16	0,59	0,08	70,53	0,72	9,36	3,49	0,17	0,50	1,88
E3	20	0,61	8,16	0,13	0,94	0,09	59,62	2,37	18,76	5,08	0,10	0,75	3,20
E3	21	0,92	7,80	0,10	0,94	0,08	59,42	2,23	18,75	5,33	0,35	0,88	3,36

IX. FEDERAL REPUBLIC OF GERMANY

In the Federal Republic of Germany, there exists only one great Paleozoic massif: the "Rheinisches Schiefergebirge", comprising, from north to south, the Westerwald, the Eifel and the Hunsrück - Taunus mountains.

Permian, Triassic and Jurassic aureoles surround this unit to the South and the East. They are limited to the South and to the North by the Tertiary basins of Bavaria, Cologne and Northern Germany.
The Cretaceous occurs sparsely near the crystalline massifs of the Czech border; it is comparatively extensive in the Hanover area and, South of the Jurassic horst of Osnabrück, it forms the great Munster syncline, transgressive on the Carboniferous of the Ruhr.

The information supplied by the B G R (Bundesanstalt für Geowissenschaften und Rohstoffe), who has made no specific study of silico-aluminate materials, consists of a list of potential subjects and of a few analyses.

1) Paleozoic shales

1.1 "Rheinisches Schiefergebirge"

Devonian: The "Rheinisches Schiefergebirge" consists almost exclusively of Devonian formations. The Lower Devonian (Siegenian - Emsian) extends from Wiesbaden to the latitude of Cologne. The Middle Devonian (Eifelian - Givetian) occurs as a broad fringe in the north of the massif.

By analogy with what is known of these series in France, Belgium and Luxembourg, shaly horizons will be present in the following stages:

Upper Siegenian: the equivalent of the Asselborn shales and slates (Eifel Siegenian Stufe).

Lower Emsian: the Nasinger Schichten flyschoid series (the equivalent of the Stolzembourg phyllites).

Upper Emsian: aluminous shales represented by the Wiltz shales in Luxembourg and the Obere Koblenzstufe in the Eifel.

Middle Devonian: mainly calcareous; the only two shaly formations are represented by the Emmanuella shales and Spirifer shales.

Other Paleozoic formations (Upper Devonian, Ordovician and Silurian), are little represented:

The Upper Devonian is limited to a fringe in the northern part of the massif, but its shaly lithology within the Ardennes system makes it of interest.

The Ordovician and Silurian form two small outcrops near Wiesbaden and in the northern part of the massif.

Grade

The following are two analyses supplied by the BGR.

	a	b
SiO_2	56.0 %	58.0 %
Al_2O_3	22.8 %	21.1 %
TiO_2	0.83 %	1.00 %
Fe_2O_3	7.72 %	7.47 %
CaO	0.37 %	0.10 %
MgO	2.91 %	3.58 %
MnO	0.06 %	0.06 %
Na_2O	0.66 %	0.09 %
K_2O	2.59 %	3.27 %
Loss on ignition	5.46 %	5.46 %
Total:	99.40 %	100.13 %

a) Plettenberg banded shales - Ordovician

b) Hunsrück shales - Devonian.

1.2 Ruhr Valley - Carboniferous

The Carboniferous extends very widely throughout the Ruhr valley. Its interest resides in the possibility of employing colliery spoil, particularly from coal washing plants, and this has attracted the interest of Government bodies. Prompted by the Ruhr Raw Materials Supplies (Rohstoffsicherung) Committee set up by the Ministry of Research and Technology (Bundesministerium für Forschung und Technologie), an application for a subsidy with a view to the recovery, as from 1 st January 1978, of alumina and titanium from colliery spoil has been made by Bergbau Forschung (a mineral prospection company) in conjunction with VAW.

Each colliery in the Ruhr has its own waste tips, but the present-day trend is towards joint tipping facilities (e.g. the Emscherbruch and Grosses Holz central deposit).

Tip sizes are limited by the Bureau of Mines and vary from 1 mt to 30 mt.

The quantity of spoil transferred to tips in 1976 by the Ruhr Coal Authority (Ruhrkohle) was 53 mt as against a net output of 60 mt.

Grade

Four analyses of calcined samples, supplied by the BGR, are as follows:

	c	d	e	f
SiO_2	52.2 %	53.5 %	66.2 %	64.8 %
Al_2O_3	45.4 %	43.69 %	23.8 %	24.6 %
TiO_2	0.5 %	-	-	-
Fe_2O_3	1.0 %	0.88 %	6.4 %	3.74 %
CaO	0.25 %	0.87 %	0.53 %	1.19 %
MgO	0.05 %	0.47 %	0.74 %	2,16 %
Na_2O	0.38 %	-	2.40 %	2.77 %
K_2O	0.13 %			
Total:	99.91 %	99.41 %	100.07 %	99.26 %

c) clay of the Grauverk layer (Charlemagne mine)

d) clay of the Erda layer (Prince Leopold mine)

e) Shaly clay of the Dorsten formation (Schlegel and Eisen mines)

f) Shaly clay, footwall of the Girondelle layer (Wiendahlsbank mine).

2) Mesozoic and tertiary argillaceous formations

2.1 Argillaceous layers only

- Mesozoic: Argillaceous sediments are very largely represented in the Mesozoic formations of West Germany.

They include:

- The Opalinidae clays and Posidonidae shales of the Jurassic
- the Hauterivian - Barremian (Cretaceous) clays of North Germany.

Resources would appear to be very substantial, but nothing is known either of grades or tonnages accessible to open-pit mining.

- Tertiary: Argillaceous sediments (clays), certain of which are employed for the ceramics industry, are present in the following areas:

- "Lower Rhine bay" ("Niederrheinische Bucht")
- Westerwald
- Lower Bavaria and Upper Palatinate
- Rhine graben (Grünstadt)
- Wetterau (neighbourhood of Bad Nauheim)
- Kassel stage
- Hunsrück (Argillaceous formations due to the weathering of shales, west of the "Rheinisches Schiefergebirge").

The relative importance of these various formations and their chemical compositions remain to be determined.

2.2 Lignite and clay basins

The clay/lignite associations in the Tertiary basins (Westphalia, Helmstedt, Hessen and Bavaria) constitute subjects of particular interest in that the lignite could supply part of the energy required for processing purposes.

Production of lignite in West Germany amounted to 134 mt in 1976.

CONCLUSION AND RECOMMENDATIONS

A preliminary and limited survey of the occurrences of aluminium raw materials suitable for the acid processes in the countries of the European Community has lead to the following conclusions and recommendations.

Silico-aluminous rocks are abundant in the EEC countries, either as in situ open-pit mineable clays or shales from large sedimentary formations, or as waste materials rejected by mines in activity (kaolins, slates, etc.).

In particular, the clays or shales rejected by the lignite or coal mine operations, or more generally associated to fossil fuels, should retain the utmost attention. These materials are believed to be well distributed in the EEC and in sufficient quantities to support an aluminium industry; moreover they contain a residual thermic value, presently lost as these materials are disposed as waste, but recoverable if they were processed as an aluminium ore.

It should be recognized that very little is known concerning reserves and qualities of silico-aluminous rocks in the EEC countries.

It is therefore recommended that a comprehensive inventory of aluminium raw materials be undertaken in consideration of the prospects of their availability in the EEC. This assessment should also be conducted in consideration of the raw materials amenability to the most promising processes with regard to their degree of development, their energy consumption and their overall economy.

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SPECIALIZED REPORT II

ON ALTERNATIVE ALUMINIUM ORES:

LEUCITE-BEARING ROCKS AND ALUNITES,

AND THEIR UTILIZATION AS ALUMINIUM RAW MATERIALS.

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SUMMARY

1) Leucitic rocks

Deposits-General

When considering the location and extent as well as the chemical, physical and mineralogical character of the various leucite deposits in EEC countries, it appears that the only deposits lending themselves to industrial exploitation occur in Italy, when the recovery of both Al_2O_3 and K_2O is desired.
In Germany, where the reserves of potassium salt are quite large, leucite rocks seem hardly worth considering as a source. When it comes, however, to recovering Al_2O_3 alone (and provided this is economically justifiable by the use of adequate processes), industrial exploitation of the leucite deposits located in some West German areas may deserve consideration.

Deposits of leucitic rocks are known in other countries, principally in the United States, Africa and Australia. The same comments made regarding Germany apply to the United States. In Africa and Australia, the existence of impressive bauxite deposits render such a comparison futile. However, the leucitic rocks occurring in Australia could be utilized for the production of potassium salts.
There are two leucite deposits in Italy that provide very considerable reserves: the leucitic lava deposit at Civita Castellana (near Viterbo) and the deposit of leucitic tuffs at Ciampino (near Rome).
The Civita Castellana recoverable reserves amount to over 500 x 10^6 t (excluding the built-up zone) from which about 140 x 10^6 t of leucite could be extracted.
The tuff deposit at Ciampino also has reserves amounting to some hundred million t; unfortunately it is located in the expansion area of Rome.
In addition to these well-known deposits, there are others that, with further prospecting, might prove to be equally important sources of Al_2O_3 and possibly K_2O. A table showing some data is given below.

Leucite deposits in Italy

Locations	Estimated reserves t	Expected output t	Type of ore	Leucite %
Civita Castellana (near Viterbo)	900×10^6	545×10^6	Leucitic rock	25.5
Canonica Sugano (near Orvieto)	$300 - 400 \times 10^6$		Leucitic rock	28.0
Sessa Aurunca (near Naples)	5×10^6	about 1×10^6	Leucitic rock	25 to 30
Ciampino (near Rome)	some hundred millions	$100 - 200 \times 10^6$	Leucitic tuff	16.0
Caldera di Vico (near Rome)	some hundred millions		Leucitic tuff	25 to 30

Mining costs

The cost of mining leucite from lava, including removal of the overburden (tuff and weathered lava), crushing, grinding, magnetic separation and waste disposal, is currently Lit. 10,000/t (11.95 u.a.), equivalent to about Lit. 61,000/t (68.77) of Al_2O_3 produced.

Processes for the recovery of Al_2O_3 and K_2O from leucite

Among the various processes for the recovery of Al_2O_3 from leucite that have been suggested during the last 50 years, three will be described briefly: an acid process using H_2SO_4; an acid process using HCl ; and a dry alkaline process (the same type of process as has been adopted in the USSR to produce Al_2O_3 from nephelines).
As the last named process seems to be particularly interesting owing to the chemical composition of the leucite (a potassium-aluminium silicate), details of some of its features (attack, by-products output etc.) will also be supplied. In particular it should be noted that 1 t K_2O and about 10 t of residue (yielding 13 t of Portland cement) are produced per t of Al_2O_3. The other steps of the process are not described, as they are very similar to the Bayer process operations.

Where the recovery of K_2O is not desired, the following processes may be considered:

- direct chlorination,
- direct thermal reduction, yielding Al/Si alloys with a high aluminium content (70 %).

A description of this process will be given in an appendix.

The markets for potash fertilizers and Portland cement in EEC and other countries.

The data supplied relate to potash fertilizers and Portland cement production, consumption, exports and imports, in respect of Italy, other EEC countries and the world through 1975; similar data, for a hypothetical plant producing 400,000/500,000 t/y Al_2O_3 from leucite (dry alkaline process) are also given; from such a plant the output of Portland cement would be equivalent to 15 % (18.75 %) of the 1975 Italian capacity and to 10.7 % (14.0 %) of the estimated Italian capacity in 1978 (5 - 6.25 % of the 1975 EEC capacity). Its output of K_2O would correspond to 200 % (over 200 %) of the Italian consumption, and to 10.5 % (13 %) of the consumption in EEC countries.

2) Alunitic rocks

Deposits

Numerous deposits of alunitic rocks occur all over the world. Their content in alunite varies from 15 % to 50 % and higher. The utilization of alunite for the recovery of Al_2O_3 and K_2O, yielding H_2SO_4 (also gallium and vanadium) as a by-product, has been recently taken into consideration.

There are numerous alunitic deposits in Italy, two of which, the Tolfa (Latium) and the Montioni-Allumiere (Tuscany) deposits, provide reserves of 20 to 30 million t with an alunite content of 10 to 20 %. However, these deposits are not large enough to lend themselves to the economic recovery of Al_2O_3 or to meet domestic or EEC requirements, but other deposits, as yet undiscovered, probably occur in volcanic zones.

A table showing the prospective alunite deposits is given below.

Alunite deposits in Italy

Locations	Mineralized area m^2	Exploitation area m^2	Estimated reserves t	Percentage of alunite %
St. Severa (near Civitavecchia)	8×10^6	small		
Caldera di Bolsena e Latera (near Viterbo)	6×10^6	1×10^6	50×10^6	
Tolfa and Allumiere (near Civitavecchia)	15×10^6		30×10^6	30 to 60 10 to 15 (average)
Montioni-Allumiere and Poggio Saracino (near Grosseto)	13×10^6	1×10^6	$30 - 50 \times 10^6$	10 to 20
Torniella (near Grosseto)	$4 - 5 \times 10^6$			10 to 12
Monte Rosso (near Viterbo)	23×10^6	1×10^6		

From the available literature, it does not appear that deposits of the extent required (permitting exploitation for at least fifty years and production of 400,000 to 500,000 t Al_2O_3/year) are known to occur in EEC countries.

The most important alunite deposit in the world, which was discovered only in 1970, is located in the Wah Wah mountains, Southern Utah, USA. The deposit is the property of Earth Sciences - National - Southwire Corp., and has probable reserves of 800 x 10^6 t of ore with 39 % alunite. The use of this mineral is currently under study at a pilot plant with a capacity of 1.2 t Al_2O_3/hour (Alumet process).

An industrial plant is scheduled to start up early in 1978 to produce annually 500,000 t Al_2O_3, 250,000 t K_2SO_4 and 480,000 t H_2SO_4 at costs competitive with those of the Bayer process.

Another deposit having reserves of 116 x 10^6 t, with an alunite content of between 25 % to 50 %, is found in the State of Guanajuato, Mexico. Examination of the utilization possibilities for this mineral is in progress at a pilot plant (U.G. process).

Moreover, important deposits are found in Australia (250,000 x 10^3 t at Pidinga, still larger reserves at Chandler) and in the USSR. The largest occurrence in the USSR is the one at Zaglik, with 50 % alunite. This deposit prompted the authorities to set up the Kirovabad plant, near the Caspian Sea. The plant, in operation since 1966, was to reach a capacity of 500,000 t Al_2O_3/year by 1974. In Japan, alunite deposits providing reserves of the order of 10 - 30 x 10^6 t are very numerous.

Mining costs

An ore enrichment treatment such as that used for leucites is not required for alunitic rocks, both because alunite generally occurs in dispersed nonhomogeneous form in the gangue (which makes an ore enrichment process very costly) and because it seems sufficient to wash it with water in order to remove the fine particles of clay, and then to grind and screen it to separate the coarse quartz.

The estimated cost for the mining and treatment as indicated is Lit. 7,200/t (8.12 u.a.) of alunite to be processed. This gives a cost of about Lit. 31,000/t (34.95 u.a.) of Al_2O_3 produced on the spot (i.e. excluding costs of installation, etc.).

Processes for the recovery of Al_2O_3

The following major processes are briefly described:

1) The Alumet process, based on alkaline attack of the roasted mineral, followed by a modified Bayer process

2) The U.G. process, developed to treat the ore mined from the deposit in Mexico. It is based on wet treatment with NH_3 of the roasted mineral, followed by acid attack with H_2SO_4; this process is rather elaborate.

3) The process used at Kirovabad, USSR, based on: roasting in a reducing atmosphere after the addition of free sulphur, alkaline attack of the roasted mineral, modified Bayer process.

The most suitable among these processes seems to be the one proposed by Alumet.

It is believed that the treatment of alunitic rocks containing up to 38 - 40 % alunite can compete with the Bayer process, provided that adequate markets are found for secondary products too (0,27 t K_2SO_4 and 0.95 t H_2SO_4 are produced per t of alumina).

It appears that the extent of the alunite deposits discovered in EEC countries so far is not such as to justify their exploitation. However, as this mineral offers great promise for the aluminium industry, we suggest further search for new deposits. This prospecting should be carried out chiefly in Italy, where the presence of many volcanic zones offers good prospects.

Note: all tonnages are expressed in metric tons

1) LEUCITIC ROCKS

1.1 Deposits - General

Leucite, a mineral with the formula $K_2O.Al_2O_3.4SiO_2$, consists of 21,5 % K_2O, 23.5 % Al_2O_3 and 55 % SiO_2 in its pure state. Among the rock-forming silicate minerals, it is the richest in potassium.

Thus some igneous rocks containing a high quantity of leucite (up to over 30 %) have an elevated content of K_2O; moreover, other potassium minerals such as sanidine are often present along with the leucite.

Leucitic rocks, represented both by lava and volcanic tuffs, are all effusive igneous rocks and petrographically belong to the same family as phonolites, tephrites, leucites and leucitic basalts.

Frequently leucite in these rocks is present in the form of large phenocrysts which in the lava - coherent rocks - are immersed in a generally microcrystalline groundmass, whereas in the tuffs - incoherent rocks - they are free and distributed more of less regularly among other crystals and fragments.

Where leucite is present in the rock in the form of large crystals, it is possible to separate it from the rock by physical systems of beneficiation which are relatively simple and thus not excessively costly. For this reason some types of leucitic rocks have in the past been studied and experimented on to determine processes for their utilization as sources of leucite which can then be used in chemical plants as raw material for the production of alumina and potassium salts.

A great deal of research on leucitic rocks has been done in Italy (which is particularly rich in leucite rocks) during the past fifty years, and various deposits have been located. They will be described in the following paragraphs. These deposits are the only ones, in the present situation, from which recovery might be economically feasible.

1.1.1 Deposits of leucitic rocks in Italy

Among the products of post-Pliocene volcanic activity in various zones of peninsular Italy, leucitic lavas and tuffs are frequent. In many areas they consist of beds and layers of vast extent and considerable potential.

The region where these rocks are most widespread is Latium, where all the volcanic systems (Vulsini, Cimini, Sabatini, Laziali) have produced leucite rocks during one or more phases of their activity.

Leucitic rocks of Campania were formed during the initial active period of the Roccamonfina volcano.

Leucitic rocks of Latium and Campania, which are commonly indicated as "leucitophyres", have a higher content in potassium than similar rocks in other areas (e.g. the leucitophyres of "Rhenisch Prussia" and of the Kaiserstuhl, Baden).

Both the leucitic lava and the leucitic tuff formations have been the object of geographic surveys. In some zones - those with the greatest number of favourable characteristics - exploratory mining was carried out with approach cuttings, winzes, tunnels and drillings. In some cases there followed tests for mining and for recovery of aluminium and potassium from the mineral.

In some cases leucite was also produced on an industrial scale, as will be indicated later on.

The surveys revealed various deposits of leucitic lavas, of which the most interesting are the following (see figure 1):

- Canonica-Sugano deposit near Orvieto, Tuscany
- Civita Castellana deposit near Viterbo, Latium
- Carbognano deposit near Lake Vico, Latium
- Sessa Aurunca deposit in the province of Caserta, Campania

Regarding the volcanic leucitic tuffs, deposits have been located in the following areas (see figure 1):

- Ciampino deposit near Rome, Latium
- Lake Vico deposit, Latium

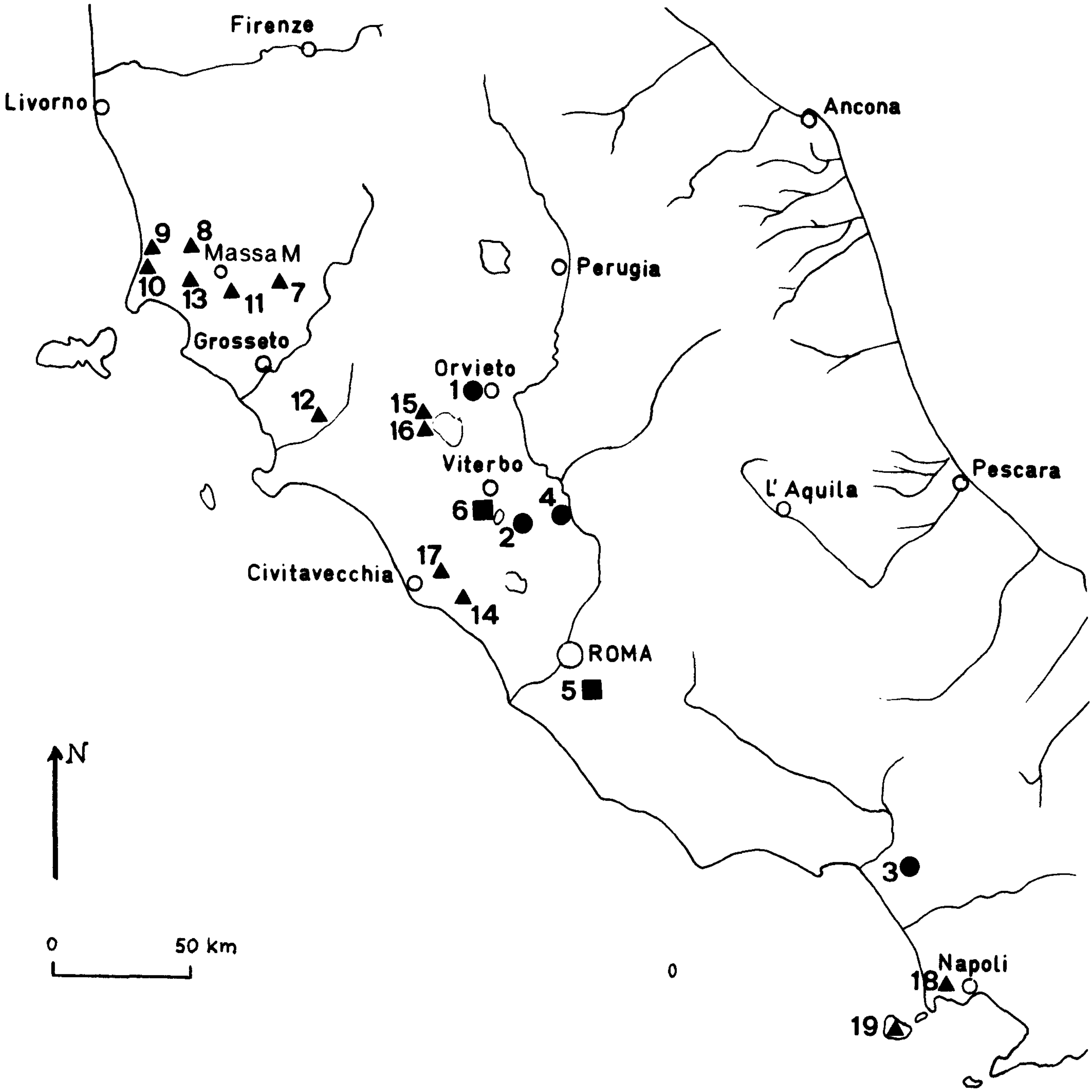
All these deposits lie near national roads and railway stations.
The nearest harbours are:

- S. Stefano, 90 km from Orvieto
- Civitavecchia, 75 km from Civita Castellana
- Anzio and Nettuno, 40 km from Ciampino - Casal Rovere
- Gaeta, 40 km from Sessa Aurunca.

Of all the deposits listed above, the one which presents the best characteristics is the Civita Castellana deposit, which will be described in detail. In the following paragraphs, there is also some information about the other deposits.

Figure 1

Deposits of leucitic and alunitic rocks in Italy



Leucitic lava: 1-Canonica Sugano; 2-Carbognano; 3-Sessa Aurunca; 4-Civita Castellana

Leucitic tuffs: 5-Ciampino; 6-Lago di Vico

Alunitic rocks: 7-Torniella; 8-Frassine; 9-Poggio Acquaviva; 10-Lumiere; 11-Canove; 12-Pereta; 13-Montioni-Allumiere; 14-S.Severa; 15-Latera; 16-Bolsena; 17-Tolfa; 18-Pozzuoli and Agnano; 19-Ischia.

1.1.1.1 Canonica-Sugano deposit near Orvieto

This extends from Santa Trinita (on the Viterbo-Orvieto highway, 6.5 km from this locality to the village of Sugano).

It consists of a bank of leucitic lava which rests on pliocene clays and is covered by layers of volcanic tuffs among which is inserted a flow of basalt.

The leucitic lava consists of a light grey groundmass into which are immersed numerous leucite phenocrysts and very small amounts of augite and feldspars.

Microscopic observation reveals that the groundmass consists of a felt of feldspar microcrystals, pyroxenes, magnetite, leucite and apatite. This is a rock with characteristics very similar to those of the lava which constitutes the Civita Castellana deposit, which will be described in detail in the chapter concerning that deposit.

Research done in about 1930 by "Società Anonima Leucite Potassio Alluminio" (drillings, tunnels and treatment tests) indicated that the reserves of useful rock amounted to several million t of leucitic lava. The content of leucite phenocrysts in the rock averaged 28 %, of which about 82 % was recovered by beneficiation.

Once the research had been completed, the same company applied for and received a mining concession. It then opened a quarry and put a small magnetic enrichment plant into operation which produced a few thousand t of leucite each year.
This mineral, once ground, was used directly as fertilizer or as an additive for chemical fertilizers.

The production activity of this plant as well as of similar ones which had been put into operation by other companies in other zones had a brief life because it was very quickly verified that, being insoluble even when very finely ground, leucite does not yield its potassium back to the soil.

1.1.1.2 Carbognano deposit

Flows of leucitic lava occupy a vast zone between Carbognano and Fabrica di Roma. The lava, which is observed only by cuttings in the ground (since it is covered everywhere by a layer of volcanic tuffs a few meters thick), presents petrographic, mineralogical and chemical characteristics similar to those of the leucitic lava of the Civita Castellana deposit.

The characteristics of the Carbognano deposit are favourable in the following respects:

- the leucite content in the rock is high
- the overburden is incoherent, which means that it is easily removable
- the ratio of the thickness of the soil overburden to the lava flow is less than one
- the reserves are very considerable

However, mining this deposit is not possible at this time because the zone contains numerous farms, villages, houses and roads and the cost of the land is very high.

1.1.1.3 Sessa Aurunca deposit - Campania, in the district of Caserta

The west slopes of the Roccamonfina volcano, facing the Carigliano river, are made up in great part of leucitic lava produced during the first period of the volcano's activity.

Research done by "Società Italiana Leucite (S.I.L.E.)" in 1957/58 indicated a zone where the leucite lava had a very high leucite content (from 25 to 30 %) and where the general conditions (roads, availability of labour, availability of water, topographic situation etc.) were favourable.

In view of the fact that mining was not possible in many zones (owing to the existence of roads and built-up areas) or was not economically feasible owing to an excessive thickness of overburden, the available resources seemed relatively modest - of the order of about five million t of leucitic lava. Since it takes about four 4 t of lava to produce 1 t of leucite, the leucite reserves would amount to slightly more than one million t, therefore excessively limited. Nevertheless this amount was judged sufficient to justify production and S.I.L.E. asked for a concession (which was granted in 1959), annexing to the request a programme for the installation of extraction and treatment systems and of a chemical plant for the production of potassium salts and alumina.

1.1.1.4 Deposits of leucitic tuffs at Ciampino Falcognana (Rome)

The deposits of leucitic tuffs in this area are incoherent or only slightly coherent rocks consisting of crystals of leucite, augite, magnetite and feldspars associated with fragments of volcanic glass, volcanic scoriae and lava.

These tuffs were formed in a period of explosive activity of the Latium volcano, which took place when the magma had the same characteristics as those which gave rise to the formation of leucitic lava flows at the Carbognano deposit.

Particle size of the tuffs varies in different zones within the following limits:

Class mm	Weight Min.	Percentage Max.
0 - 0.5	35	50
0.5 - 2	12	16
2 - 8	25	30
8 - 20	10	20

The leucite crystals are present in the rock in an average amount of 16 %, almost always in the granulometric fractions between 0.5 mm and 8 mm (8 % between 0.5 mm and 2 mm; 7 % between 2 mm and 8 mm).

Rock moisture varies between 10 % and 20 % according to the seasons.

Research projects (approach cuttings, winzes and drillings), which have been carried out on several occasions up to 1962, show that the reserves of leucitic tuff are of the order of several hundred million t. However, excluding from the evaluation the zones where mining was not possible for reasons of public interest (zones of urban development, zones of industrial development, zones declared as national monuments, farms, roads, etc.), the reserves were reduced to slightly more than 100 million t. Today, fifteen years later, not only have the zones where mining of the tuff was possible been further reduced, but for environmental reasons - mostly concerning landscape - it seems likely that the authorization to open a quarry in the area will never be granted. On the other hand, tests conducted by other specialized companies have shown that the treatment process for extraction of the leucite calls for 7 t of tuffs and great quantities of water for each t of concentrated leucite. Supplying the necessary water would constitute an almost intractable problem and would certainly be costly.

1.1.1.5 Deposits of leucitic tuffs at Lake Vico

Along the southern and western borders of the Caldera di Vico in the area included between S. Martino al Cimino, M. Fogliano and Casaletto, banks of incoherent tuffs are seen. They are generally grey and contain numerous crystals of leucite. Covering the tuffs are flows of leucitic lava, generally thin and weathered. The thickness of the tuff banks varies from zone to zone between ten and twenty m. No mineralogical or chemical studies have been carried out on average samples of this rock; observation of a few samples taken from various localities shows that a rock similar to the leucitic tuff at Ciampino is present, but it seems to have a higher content of leucite.

It would be useful to carry out mining research projects to determine the reserves and the physical, chemical and mineralogical characteristics of the tuffs in the zone; in fact, as to both leucite production and use of the untreated rock in chemical plants for the production of alumina and potassium salts, the volcanic tuffs might in some respects be a better proposition than the lavas. This is not only because the mining of the tuffs, which are incoherent, is less expensive than the mining of lava, but because the crushing of tuffs is more economical.

Many of the unfavourable conditions existing in the Ciampino zone do not exist in the area under examination and therefore from this point of view utilization of the leucitic tuffs at Lake Vico could be economically more advantageous than utilization of the lava, even in the case of remarkable lava deposits such as the one at Civita Castellana. A programme of studies and experiments geared to up-dating and precisely defining the problem of utilization of the leucitic rocks must include a research programme to determine the characteristics of the Lake Vico leucitic tuffs.

1.1.1.6 Leucitic lava deposit at Civita Castellana

The vast flow of leucitic lava in the Civita Castellana area (province of Viterbo) has been known for a long time and the first researches there were conducted in 1925.

In 1928 the Società Anonima Vulcanica obtained two mining concessions ("Rio Corverino" and "Case Ciotti") and combined with the Società Italiana Potassa to develop a programme of studies, during which a part of the lava flow was studied by various methods including drilling. Their research indicated that in the explored area alone the reserves amounted to over 270 million t of leucitic lava with a leucite content of 28 %.

Treatment tests for the production of leucite were also carried out with promising results. Later, in 1929, Società Prodotti Chimici began the construction of a plant for the chemical utilization of leucite according to a process developed by Professor C.A. Blanc (attack by nitric acid). This plant was situated at Aurelia about 6 km from the port of Civitavecchia.

The concessions remained with Società Italiana Potassa who in 1948 constructed a small leucite-extraction plant near the station of Borghetto, about 7 km from Civita Castellana, with a productive capacity of about 700 t of concentrated leucites monthly. Upon leaving the treatment plant these leucite concentrates had a particle size of 0 - 2 mm. They were passed to a pulverizing plant which reduced 95 % of the mineral to less than 150 mesh.

Between 1960 and 1962 further studies were carried out by Edison, and later on (in 1966) the Montedison company (because of the Edison-Montecatini association) asked for three research licences, one of which ("I Prataroni") was granted.

Montedison carried out vigorous research (plottings, geological and topographical surveys, soundings and drillings tests, and sample collection and analysis) which enabled it to define the characteristics of the deposit.

Location

The flow of leucitic lava at Civita Castellana extends over an area of about 2,000 hectares enclosed by the Tiber river, on the Northwest by the line of connection, the built-up areas of Civita Castellana and Borghetto on the south and the north and by the valley of the river Treia. This area, situated 60 km north of Rome, is included in the southwest part of the Viterbo province, at the western extremity of the Cimino volcanic centre.

Access

Along the western limit of the deposit runs state road N° 3 (via Flaminia). At the western border lies the railway line between Rome and Florence, with a stop at Borghetto about 2 km north of the deposit. At the eastern border lies the motorway A1 (" del Sole "), with Magliana Sabina exit about 5 km from the deposit along the via Flaminia.

The mining body

The flow of leucitic lava rests on volcanic tuffs which in turn rest on Neogene sediments composed of clays, sands and conglomerates (see fig. 2.). Almost everwhere the flow is covered by volcanic tuffs similar to those underlying it. The thickness of the cover tuffs varies from 0 to 10 m and exceeds that value only rarely and in limited areas.

The lava flow consists of a large level bank, whose upper surface has an average altitude of 120 m above sea level. The base of the flow descends gradually towards the north-west, dropping from about 100 m above sea level to 75 m at the extreme north-west.

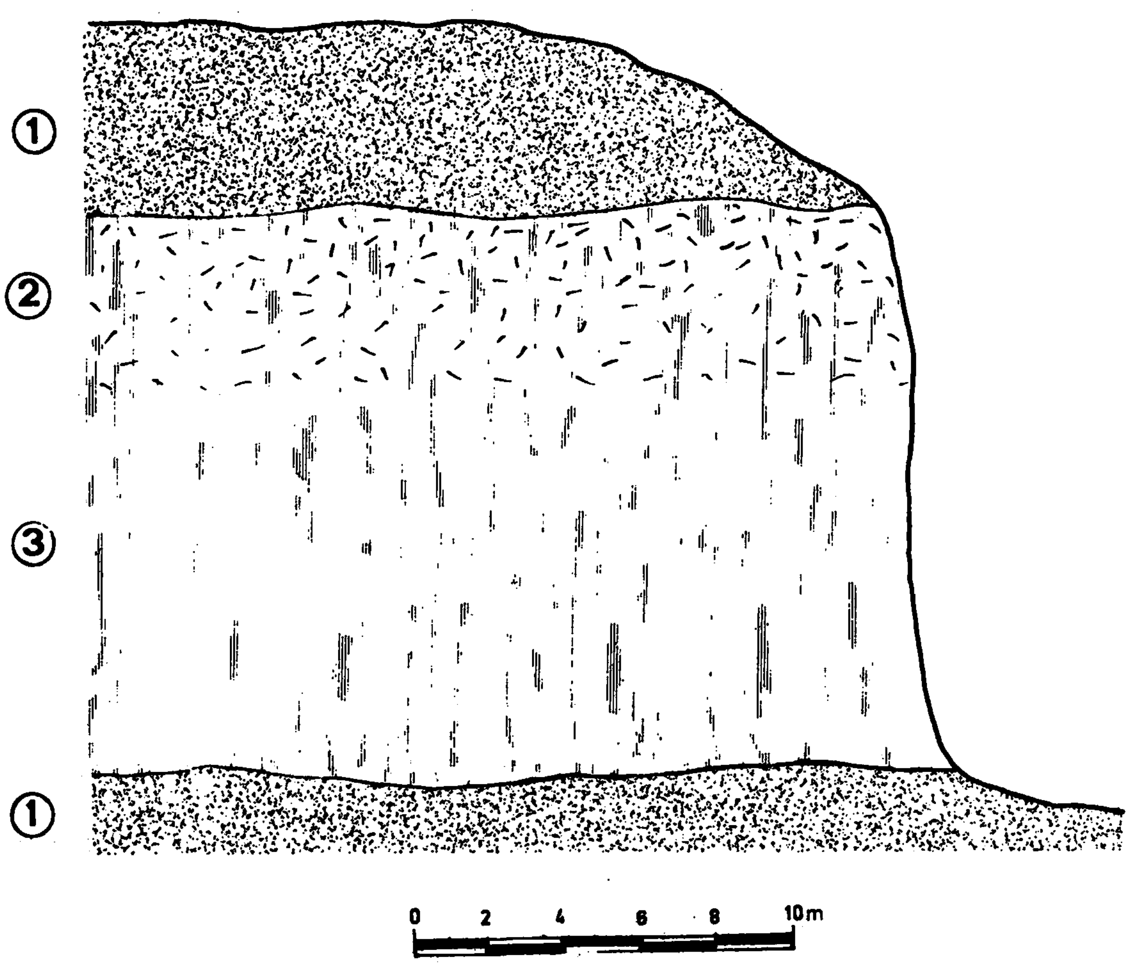
As the water table is always below the base of the flow, water will not interfere with possible mining operations.

The thickness of the lava bank varies from a few m to over 30 m. The variations in thickness are due to the irregularity of the surface of the underlying tuffs and to erosion of the flow by surface waters both before and after deposition of the cover tuffs.

The bank of lava is affected by predominantly columnar jointing.

Figure 2

Schematic section of the bank of leucitic lava at Civita Castellana



1) Volcanic tuffs

2) Weathered leucitic lava

3) Unweathered leucitic lava

In the upper part of the bank, the lava has been more or less deeply weathered over thicknesses which vary depending on the degree of fracturation of the rock and the thickness of the cover tuffs; locally erosion by surface waters has removed the weathered parts and sound rock is exposed.

The thickness of the weathered zone varies from zero to a maximum of ten m. On the average the ratio between the thickness of the non-weathered flow and the thickness of overburden (weathered lava and tuffs) is 2 : 1.

Macroscopic and microscopic characteristics of leucitic lava - Mineralogical compositon

The lava under examination is an effusive igneous rock with the chemico-mineralogical composition of a leucite phonolite. It consists of a grey microcrystalline groundmass in which numerous phenocrysts of leucite and a much smaller number of plagioclases and augites are immersed.

In unweathered rock, leucite crystals are clear, transparent and have a glassy brightness. In weathered rock they are white, opaque, often powdery and have a low potassium content because of the leaching caused by surface waters. The dimensions of leucite crystals vary from 0.5 to over 20 mm. Large crystals are generally well-formed whereas smaller ones almost always have irregular shapes.

Leucite has always been subject to fracturation on cooling, which has also caused separation of the external borders of leucite crystals from the groundmass which contains them. For this reason the grinding process produces few mixed grains, a characteristic conducive to high-quality concentrates. In contrast, the plagioclase and augite crystals form a lot of mixed grains, both because they are smaller than the leucite crystals and because they are strongly bound to the groundmass. They are eliminated by the beneficiation treatment.

Microlites of other minerals (plagioclase, biotite, sanidine, apatite) are included in the leucite crystals.

The groundmass is composed of small crystals of sanidine, augite, basic plagioclase, magnetite, apatite and leucite. Table 1 shows the percentages of the various minerals contained in the rock and their dimensions.

Chemical composition of leucitic lava

Various chemical analyses have been conducted, both on small quantities of rock and on average samples obtained from the grinding of considerable quantities.

Table 1

Mineralogical compositon of the lava at Civita Castellana and average sizes of the constituent minerals

	Minerals	Percentage	Average size mm
Groundmass (about 70 %)	Sanidine	37.4	0.02
	Augite	14.0	0.01
	Basic plagioclase	5.0	0.03
	Biotite	4.5	0.05
	Magnetite	7.0	0.02
	Leucite	3.0	0.005
	Apatite	Submicroscopic needles	
Phenocrysts (about 30 %)	Leucite	25.5	8
	Basic plagioclase	3.0	1
	Augite	2.0	1

The percentages of oxides in the various analyses sometimes differ noticeably, as can be seen by comparing the analyses by various authors (see table 2). However, one must keep in mind that analyses 1 and 2 relate to samples obtained from small quantities of rock, whereas the others relate to average representative samples which were collected by means of different methods and in different zones. This accounts for the difference between the various analyses. In addition to this, some of the analyses concern samples taken at the surface where weathering and alkali loss occur.

Table 2

Chemical analyses of the leucitic lava

from Civita Castellana

in %

	1	2	3	4	5
SiO_2	56.19	55.10	54.27	54.94	54.73
Al_2O_3	20.75	18.65	21.07	22.77	21.10
Fe_2O_3	1.71	2.92	4.08	5.35	4.74
FeO	2.19	3.18	-	-	
CaO	3.53	3.55	5.86	4.06	3.72
MgO	1.14	1.31	-	1.49	1.30
K_2O	10.47	10.95	10.28	8.88	9.94
Na_2O	2.86	2.56	2.67	2.75	2.91
P_2O_5		0.40			0.41
TiO_2		0.64			0.56
ZrO_2		0.04			0.05
MnO		0.12			
BaO		0.12			
SO_3		0.07			
Cl_2		0.02			
i.l.		0.17			

It is believed that the average chemical composition of great quantities of rock can be assumed to be as follows (in %):

SiO_2	54.5	CaO	4.0
Al_2O_3	21.5	MgO	1.5
Fe_2O_3 + FeO	4.5	P_2O_5	0.5
K_2O	9.5	TiO_2	0.5
Na_2O	2.5	i.l.	0.5

Also present in small quantities or traces are:

Mn, Ba, S, Zr, Cl, Sr, Pb

Chemical composition of the leucite

From the chemical formula of leucite one can deduce that the various oxides should be present in the following percentages: SiO_2 = 55.0 %; Al_2O_3 = 23.5 %; K_2O = 21.5 %.

In fact, the leucite crystals which make up the rocks have a chemical composition which is different from the stoichiometrical one, especially in the case of the large crystals, because of the presence of microcrystals of other minerals included in the leucite. Table 3 shows analyses of leucite crystals extracted from rocks of various origins.

Table 3

Analyses of leucite from various sources

in %

	1	2	3
SiO_2	54.30	56.39	55.81
Al_2O_3	20.08	23.10	22.92
Fe_2O_3	1.01		
FeO	0.14		
MnO	traces		
MgO	0.21		

Table 3 (continued)

	1	2	3
CaO	0.46	0.27	
Na_2O	0.30	2.17	2.12
K_2O	20.69	18.05	19.10

1. Leucite from leucitic rock at S. Venanzo ("venanzite")
2. Average sample of 14 leucite crystals from Vesuvius
3. Fragments of pure leucite from leucite crystals extracted from the lava at Civita Castellana

As we shall see in the chapter relevant to the treatment for the extraction of leucite from lava, the concentrates of leucite have a composition which does not differ substantially from the one quoted above (table 3), because with magnetic separation one obtains concentrates with a high leucite content and because almost all the "sterile" barren minerals which pass in small quantities into the leucite concentrate have an Al_2O_3 and K_2O content little lower than that of the leucite.

Weight/volume[x)] of the rock and specific gravity of leucite

The weight/volume of the rock, determined by measuring numerous samples, is 2.46 g/ml. Among the rock-forming minerals, only leucite has a specific gravity practically equal to this value.
The other minerals have a specific gravity greater or very much greater than this value (for example, augite has a specific gravity greater than 3.0 g/ml). The low weight/volume of the rock is due to the porosity of the groundmass which influences both the weight of the rock and its mechanical strength.

Leucite content in the lava

The leucite content in the lava varies considerably in various zones of the flow. Numerous measurements carried out on the samples of lava extracted by drillings show that the values vary from a minimum of 21 % to a maximum of 30 % by volume. As the rock and leucite have the same specific gravity (2.46 g/ml) the above volume percentages coincide with the weight percentages. The average (by weight) of the values measured has shown that the lava has an average leucite content of 25.5 %.

[x)] Bulk density

Mineral reserves: thickness of workable lava and sterile cover

Besides the roof tuffs, it is necessary to eliminate the upper weathered part of the flow; the following values have been calculated for the workable mineral (sound leucitic lava), the sterile cover to be eliminated (tuffs and weathered lava), and the leucite content.

	Mineral	Sterile content
Surface area	$20 \times 10^6 m^2$	$19.6 \times 10^6 m^2$
Average depth	18.45 m	9.15 m
Volume	$319 \times 10^6 m^3$	$179 \times 10^6 m^3$
Weight/volume	2460 kg/m^3	1900 kg/m^3
Reserves	907×10^6 t	
Leucite	25.5 %	
Leucite reserves	230×10^6 t	

As some parts of the deposit cannot be worked, owing to the presence of roads, farms, built-up areas, long-distance lines, etc. and since it would be convenient to site the ore-dressing plant within the deposit in order to reduce transportation costs, actual ore reserves would be smaller than those indicated above. Bearing in mind also the uneven base of the flow, it appears that only 60 % of the ore would be workable. Thus the estimated ore reserves are 545 million t, with a leucite content of 140 million t.

1.1.2 Formations of leucitic rocks in EEC countries and in the world

The leucitic rock formations, in Italy, have been studied for their high potassium content which led several companies to attempt industrial exploitation.
In other countries leucitic rocks have been studied only from the petrographical viewpoint.
Data relative to the characteristics of the deposits are therefore few.

1.1.2.1 Leucite rocks in EEC countries other than Italy

Leucite rocks of some importance are found in several areas of Germany:

- Perlerkopf near Olbruck, where one observes leucitophyres. They are constituted of phenocrysts of leucite (0.5 - 2 mm), aegirine-augite and nosean, immersed in a microcrystalline matrix of aegirine-augite, sanidine, nepheline and garnet. The chemical composition (in %) is as follows:

SiO_2 =	48.85	CaO =	6.42
Al_2O_3 =	18.43	Na_2O =	6.51
FeO =	8.19	K_2O =	6.90
MgO =	1.43	H_2O^+ =	1.79

The potassium content is considerably lower than in the leucitic rocks of Latium (Italy). The content of iron and calcium is considerably higher. The phenocrysts of leucite represent about 15 % of the rock.

- Leucitophyres with similar character are found in the Eifel (Laacher See).

- Kaiserstuhl, where leucite tephrite is found, composed of phenocrysts, garnets and alkali pyroxenes in an amorphous matrix containing plagioclase microlites. Even in this rock, the potassium content is considerably lower than in the leucitic lavas in Italy, whereas the iron content is very much higher.

- In Bohemia, Mittelgebirge, there exist leucitic basalts.
  The leucite is present as phenocrysts which are few and generally small.
  The iron content is very high.
  Concerning these deposits there is very little information, particularly about their extent.
  More generally, the different types of rock present the following compositional variation:

SiO_2	45 - 48	MgO	2.5 - 5.5
Al_2O_3	16 - 18	FeO	3.5 - 5.0
K_2O	6.5 - 8.5	TiO_2	0.3 - 0.8
Na_2O	2.5 - 4.0	P_2O_5	0.05 - 0.35
CaO	8.5 -12.0	i.l.+H_2O	0.8 - 1.2
Fe_2O_3	4.5 - 7.5	traces of ZrO_2 and BeO	

From the above-listed leucitic rocks it would be difficult to obtain concentrates of leucite, first because the crystals of that mineral are so small and secondly because magnetite is absent or present only in small quantities in the groundmass. This would not permit magnetic separation of the leucite, a method which gives the best results with leucitic rocks in Italy. Because of the nature of the mineral in the rocks, other treatment methods would be complex and costly and result in a low recovery of leucite. Nor would it be convenient to utilize the rock as it is, because of the low content of potassium and aluminium and the high iron content.

1.1.2.2 Leucitic rocks in other countries

Leucitic rocks are found in the United States, Africa, Australia, Brazil, Asia Minor, South Nova Scotia, and in the islands of Cap Verde.

The United States has leucitic phonolitic lavas with phenocrysts of leucite at Leucite Hills (Eifel, Wyoming); Navajo (Arizona); Hamburg (New Jersey); Magnet Cove (Arkansas); Absaroka Range (Wyoming); and Highwood and Bearpaw Mountains (Montana).

In Africa there is lava with phenocrysts of leucite:

- in the Tafna valley, district of Oran, Algeria: leucitic basalts
- on Mount Mikeno near Lake Kivu, Congo: leucitite (mikenite)
- in the Nyamunuka crater and at Bufumbira, Uganda: potassium-ankaratrite at Nyamunika and leucitite at Bufumbira
- near Nyiragongo, Congo: leucitite.

Neither the entity of the leucitic formations nor their chemism are known.

In Australia the following types of leucitic rocks occur:

- wolgidite in West Kimberley: this is a rock with phenocrysts of leucite (0.1 - 0.2 mm), also containing manganous amphibole, olivine, phlogopite and small prisms of rutile in a serpentine groundmass.
- cedricite in West Kimberley: a rock with phenocrysts of leucite (0.2 - 0.5 mm) and small crystals of diopside and phlogopite in a groundmass made up of microcrystals of rutile, perowskite, amphibole with manganese, phlogopite and zeolites.

Australian leucitic rocks are rich in potassium, magnesium, titanium and barium and have a low sodium and aluminium content. According to Australian petrographers, these ores are higher in leucite than any other leucite ores known in the world, excluding Italy.

1.1.3 Observations concerning the leucitic formations found outside Italy

In Germany, where reserves of potassium salts are large, there is little point in examining leucitic rocks as possible sources of alumina as a substitute for bauxite. Other rocks offer better possibilities for that purpose, such as the clays (low extraction cost; utilization of the rocks as found,without any grinding) or possible deposits of alunitic rocks (low extraction cost and facility of digestion in the chemical processes).
The same considerations apply in the United States.
In Africa, where numerous large deposits of bauxite occur, there is no need to consider extracting alumina from leucitic rocks.

In Australia, where there are likewise no problems of bauxite supply, leucitic rocks could be used for the production of potassium salts and other useful elements that are contained in those leucitic rocks (such as titanium; however this exists abundantly in Australia). But alunites offer better possibilities for this purpose: these rocks are used for the production of sulphate in Australia. It seems that only the leucitic rocks of Italy are worth considering for the production of alumina and K_2O. Where the recovery of Al_2O_3 alone is desired, however, the German deposits might prove worthwhile after more thorough investigation.

1.1.4 Nepheline syenites

We should note here that the nepheline syenites of Norway, Canada and Russia are similar enough to the leucites, regarding chemical composition. In Norway they are utilized by Norsk Nephelin Soc. of Elkem Spiegerwerket.
For the moment this company is the only one existing in Western Europe for utilization of this mineral. (In Norway, Labradorite is also utilized; labradorite is a plagioclase: Na and Ca silico-aluminate).

The mineral is processed in the island of Stjernöy in the far north of Norway (Altafjord). The extent of the deposit is such that about 215,000 t/y are extracted now. By 1978 the Company hopes to be able to mine 330,000 t. The mineral is made up of a mixture of

- potassium feldspar $K_2O \cdot Al_2O_3 \cdot 6SiO_2$
- albite $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$
- nepheline $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$

The impurities present are biotite, hornblende, pyroxene and magnetite. The mineral, after magnetic separation and grinding, is used generally in the glass and ceramic industries; it has the following composition: Al_2O_3 = 24 %, K_2O = 9 %, Na_2O = 8 %, Fe_2O_3 = 0.1 %.

1.2 Extraction processes. Mining, beneficiation and treatment of leucitic rocks

Leucitic rocks, wherever the deposit, consist of mineral bodies of similar form and dimensions, since they are only found in sub-horizontal banks.

1.2.1 Mining of leucitic rocks

As to leucitic lava, we shall consider the mining of the Civita Castellana deposit, because its characteristics are well known; here the tuffs must also be included, for the reason already explained. As to tuffs, the type of deposit located at Ciampino will be presented as a hypothesis, even though further working may not be permitted. Other deposits that might be taken into consideration would present similar characteristics.

1.2.1.1 The mining of leucitic lava

On the basis of our previous industrial experience, we are able to give the principal data concerning leucite lava extraction.

Let us assume that a million t of leucite must be produced annually, even though, as we shall see, we ought to envisage not less than 2.25 - 2.8 million t/y. As each t of extracted lava yields 0.24 t, the quarry must produce 4.2 million t/y of lava (1.000.000 t/y of leucite: 0.24, percentage of extractable leucite in the lava) (1).

Given the lava weight/volume of 2.46 g/ml, 1.70 million m^3 of lava/y must be extracted (4,200,000 t/y : 2.46 t/m^3).

As the lava flow at Civita Castellana has an average depth of 18.45 m, each year 840,000 m^3 of tuff and weathered lava must be removed (92,000 m^2 : 9.15 meters). (2)

Removal of sterile cover

The cover tuffs and weathered lava are approximately equal in thickness. Thus 420,000 m^3 of tuffs and 420,000 m^3 of weathered lava must be removed annually. The tuffs can be removed by using motorscrapers and Caterpillar tractors. For the weathered lavas preliminary digging is necessary.

In the initial stage of operation, over a period of about six months, the sterile cover must be removed and transported to a distance of 800 m, collected once again and transported to the quarries, after the magnetic treatment waste products have been discharged into the already mined zones. After the first six months the sterile cover is removed and unloaded directly into the zones already mined. The distance must be kept to 800 m in this phase as well. It will be necessary to provide for construction and maintenance of the tracks.

By calculating 230 days a year and 1 work shift, it would be possible to remove 3,655 m^3 of sterile cover/day (840,000 m^3/year: 230 days/year).

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(1) The raw material contains 25.5% leucite and the ore enrichment yield is about 94%.

(2) Total surface to be worked: 1.70 x 10^6 : 18,45 = 92,000 m^2.
9.15 m is the average thickness of the sterile cover.

This means about 460 m^3/hour. To attain this rate of production the following equipment is required:

- 4 motorscrapers (for example Caterpillar 631 C with a load capacity of 36 t)
- 1 tractor (for example Caterpillar D9H)
- 2 tractors with ripper (for example Caterpillar D9H)
- 1 compactor (for example Caterpillar 815)
- 1 motorgrader (for example Caterpillar 12G)

The hourly cost of these engines, including labor costs, wear and tear, depreciation and interest are[x)]:

. motorscraper	Lit. 50,000/hour (56.37)
. tractor	Lit. 40,000/hour (45.10)
. tractor with ripper	Lit. 50,000/hour (56.37)
. compactor	Lit. 20,000/hour (22.55)
. motorgrader	Lit. 14,000/hour (15.784)

The removal cost of each m^3 of sterile cover is Lit. 810 (u.a. 713). To this must be added the costs for supervision of the work area, general and unforeseen expenses (15 %). Thus the total cost reaches Lit. 930/m^3 (1,048). As each m^2 of surface has 9.15 m^3 of sterile material which rest on 45.39 t of useful lava (18.45 m x 1 m x 2.46 t/m^3), the incidence of the removal of sterile material is Lit. 190 (0.169) per ton of useful lava (9.15 m^3 x 930 Lit/m^3, : 45.39).

Bringing down the lava

To obtain a production of 4,200,000 tons of leucitic lava/year, in 230 workdays, the daily production of the quarry must be 18,260 tons (7,425 m^3 of solid rock/ day). As the maximum thickness of the lava flow at Civita Castellana rarely exceeds 30 m, the blasting can be done in one step only. As an average depth, we shall consider the value of 20 m.

By drilling 76 mm diameter holes, it will be possible to blast a three-metre shoulder with each shot. Thus the length of face which must be brought down daily is 124 m (7,425 m^2/20 m x 3 m). The perforations can be located 3.5 m apart. Thus in all 37 holes of a length of 21 m must be drilled, making a total length of 777 m.

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x) From here onwards we place between brackets the corresponding "unit of account", average between January and June 1976.

From the vast range of drilling machines adapted to the type of work under consideration, it is advisable to choose those which require the least employment of labour even if their cost is higher. Assuming the use of tracked hydraulic rock drills with automatic gear-change which require only one operator (for example the Atlas Doc 810H), three machines would be sufficient for the intended task of drilling 777 m.

The amount of explosive must be maintained rather high in order to prevent the formation of oversized blocks, which can easily happen because of the columnar jointing of the lava. For example, by using type ANFO 5, it is calculated that at least 400 g are necessary for every m^3 of rock to be blasted down. Based upon the data mentioned above, the blasting process will cost Lit. 175/t (0.197) for each m^3 of lava, which - augmented by 15 % - becomes Lit. 210/t (0.236).

Transport of lava to the treatment plant

Transport can be effected by dumpers with 20 m^3 load capacity (for example Caterpillar 769B) and a front loader with a 4.5 m^3 bucket (for example CAT 988). Allowing a 10 minute cycle (loading: 4' + transport: 2' + unloading: 2'), 120 m^3/hour can be loaded and transported. It is advisable to effect the transport in two shifts so as not to overload the stock area at the treatment plant, which operates in three shifts.

Each dumper, which theoretically transports 120 m^3/hour, will be able to transport 1,280 m^3 of bank in 16 hours (120 x 16 hr) (50'/60' effective work time) (0.8 bulking factor). This corresponds to 3,160 t of lava/day. Thus 8 dumpers (6 + 2 reserves) and two front loaders are necessary for the loading and transport of 18,200 t/d (20.75) of lava. The cost per hour of the dumpers is Lit. 37,500 (42.28), and of the front loaders Lit. 35,000 (39.46); the transport cost is Lit. 325/h (0.366). To this (which includes work, wear and tear, depreciation and interests) one must add 15 % for supervision of the work area, general expenses and unforeseen expenses. Thus the total cost amounts to Lit. 375/t (0.423).

We have calculated the transport of lava to the plant plus the return of the empty dumpers in order to evaluate the cost of lava to be utilized "as is" in the chemical plant. However, where the lava is used for the production of leucite, the same dumpers which carry the lava to the plant can carry the treatment wastes on the return trip. In such a case one must keep the following factors in mind:

- the time necessary to move from the lava-dumping area to the loading area for the waste products;
- the time for loading and unloading;
- the time necessary to move from the waste product unloading area to the lava-loading area.

It has been worked out that five minutes are more than sufficient for these operations. Consequently the cycle increases to 15 minutes, and the transport capacity is reduced from 120 m^3 to 80 m^3/hour. Thus one arrives at 860 m^3 of lava/day (80 m^3 x 16 hours x 50'/60' x 0.8) which corresponds to 2,115 t/day. The 18,200 t of lava which must be transported to the treatment plant thus require only 11 dumpers, but the number of front loaders remains unchanged. The material to be transported consists of lava (4.2 million t/y) and waste products from the treatment plant (3.2 million t/y), for a quantity of 32,000 tons/day by the dumpers (18,200 tons/day to the plant and 14,000 tons/day from the plant). By proportionnally subdividing the number of dumpers and keeping in mind the fact that the front loaders are used only for the loading of the lava, one arrives at the following costs:

- loading and transport of the lava to the treatment plant:Lit. 300/t (0.338)
- loading and transport of the waste products to the quarry:Lit. 220/t (0.248)

Cost summary for leucitic lava extraction

Summarizing for both situations, the following figures are obtained:

		Lava used "as is" (Lit./t)	Lava used for production of leucite (Lit./t)
Removal of waste		190	190
Bringing down rock		210	210
Transport		375	300
	Total	775	700 x)
		(0.873)	(0.789)

x) The cost for the transport of waste rock to the quarry is indicated in the section "treatment".

1.2.1.2 The mining of leucitic tuffs

We shall consider the hypothesis of mining a deposit such as the one at Ciampino, where the sterile cover consists of a rather thin layer of agricultural soil, the removal cost of which would weigh very little on the cost of mining the tuff.

Mining the tuffs can be done with scrapers and caterpillars without the necessity of using rippers. The cost of a tonne of brought-down tuff is less than the cost which has been calculated above for the removal of the overburden, even with an average transport distance of 1,000 m rather than 800 m.

Seven million t of tuff must be extracted and transported each year (30,500 t/day). With two work shifts, 10 motorscrapers and 3 caterpillar tractors, the cost would be Lit. 365/t (0.411), which with a 15 % increase would reach Lit. 420/t (0.474). This is the cost when using the tuff "as is" at the chemical plant. Where the tuff is used for the production of leucite, the motorscrapers could take the treatment waste products from the plant back to the quarry (amounting to 6 million t/year, or 26,000 t/day). In this case the load-transport-unload cycle would increase from 11 minutes to 16 minutes. Fifteen motorscrapers would be necessary for the extraction and transport of 30,500 t of tuff/day, whereas the number of caterpillar tractors would remain unchanged. In this case the costs become the following:

- mining and transport to treatment plant Lit. 280/t (0.316)
- transport of waste products Lit. 215/t (0.242).

1.2.2 Treatments for the recovery of leucite from leucitic rocks

We shall examine the processing of leucitic lava and leucitic tuffs separately, as they have completely different treatment requirements.

1.2.2.1 Beneficiation of leucitic lavas

The fractures to which the leucite phenocrysts are subject and their poor adherence to the groundmass (the characteristics of which can be observed microscopically) cause the rock to yield medium-sized fragments with a low content of very fine particles when it is ground with the appropriate machinery. This is also due to the fact that the leucite is less fragile than the small crystals in the groundmass. The sizes of the small crystals of magnetite (which have average dimensions of 20 microns) are such that in cases where the fragments of groundmass from the grinding process have a dimension greater than 100 microns, there is a very high probability that at least one crystal of magnetite is included. Since the magnetic susceptibility of the magnetite (800,000 x 10^{-6} cm^3/g) is far higher than that of other minerals which make up the rock (from 5 to 70 x 10^{-6} cm^3/g) the fragments containing at least one magnetite crystal have a much greater magnetic susceptibility than the leucitic crystals, and can therefore be easily separated even by separators which do not have a very intense magnetic field. The "concentrate" produced therefore contains a high fraction of leucite (over 80 %, with 23.5 % of Al_2O_3 and 21.5 % K_2O) whereas the waste product is almost completely made up of fragments of other phenocrysts which are contained in the rock, that is, sanidine (with 18.4 % Al_2O_3 and 16.9 % K_2O) and basic feldspar (with 30 % Al_2O_3). Thus the alumina content of the concentrates is almost the same as that of the original rock, whilst the potassium content is much greater.

As to limited production of very fine particles (which are not very susceptible to magnetic separation) and the concentration of leucite particles in the intermediate granulometric fractions, the best results are obtained by a preliminary crushing followed by a secondary impact crushing with appropriate regulation of the distance between the rotor and hammers of the crusher. By crushing the mineral under 40 mm in a jaw crusher the particle size distribution shown in Table 4 is obtained. (Table 4 also shows the percentage distribution of potassium). The distribution of alumina and silica is practically uniform in the various fractions.

Table 4

Results of primary crushing

Particle size distribution	Weight (%)	Content in K_2O (%)	K_2O distribution (%)
40 - 20	57.90	9.75	55.25
20 - 10	14.41	9.50	13.40
10 - 3	13.34	9.62	12.56
3 - 2	3.90	13.54	5.17
2 - 1	4.24	13.95	5.78
1 - 0.5	2.80	14.06	3.86
0.5 - 0.3	1.26	13.54	1.67
0.3 - 0.1	1.18	12.30	0.42
0.1 - 0.037	0.78	9.30	0.71
under 0.037	0.19	9.65	0.18

The grain-size class below 0.1 mm should be eliminated, as its very low content of potassium causes the yield from magnetic separation to be unsatisfactory. The leucite contained in the size classes between 0.01 mm and 3 mm is sufficiently free to allow these to be passed directly on to magnetic separation. The size classes greater than 3 mm are made up of mixed grains and thus must undergo further crushing.

The process of magnetic treatment must therefore be performed as indicated in the diagram in figure 3.

The results of concentration by the method indicated are shown in Table 5, from which it is seen that the treatment of t of rock yields about 0.24 t of leucite concentrates.

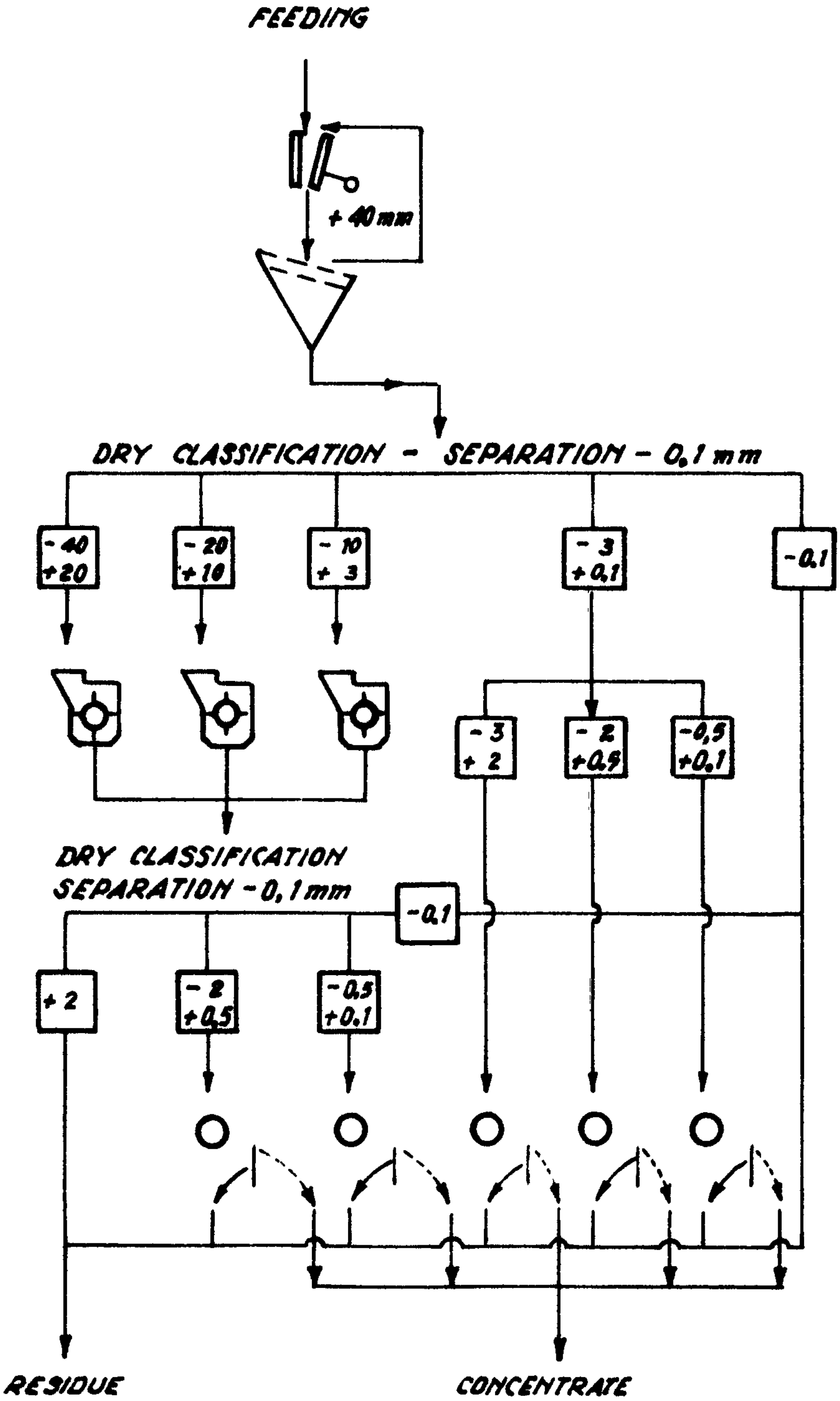


FIG. 3 - TREATMENT SCHEME OF THE LEUCITIC LAVA OF CIVITA CASTELLANA (from Massacci).

Table 5

Results of magnetic treatment of the lava from Civita Castellana

Classes of products		Weight (%)		
F.1[x]	less than 0.1 mm	0.97		
Ref.1[xx]	40 mm - 20 mm	24.64		
	20 mm - 10 mm	6.59		
	10 mm - 3 mm	5.11		
Mag.[xxx]	3 mm - 0.1 mm	6.36	(from primary crushing)	
	2 mm - 0.1 mm	21.17	(from crushing 40 - 20)	
	2 mm - 0.1 mm	5.61	(from crushing 20 - 10)	
	2 mm - 0.1 mm	5.68	(from crushing 10 - 3)	
Non-mag xxxx	3 mm - 0.1 mm	7.02	(from primary crushing)	23.87 %
	2 mm - 0.1 mm	12.09	(from crushing 40 - 20)	
	2 mm - 0.1 mm	2.21	(from crushing 20 - 10)	
	2 mm - 0.1 mm	2.55	(from crushing 10 - 3)	

x Refuse after primary crushing
xx Refuse after secondary crushing
xxx Magnetic product (waste)
xxxx Non-magnetic product (concentrates of leucite)

Table 6 shows the chemical composition of the concentrates (in %).

Table 6

SiO_2	54.2 - 54.8	Na_2O	0.8 - 1.0
Al_2O_3	22.2 - 23.4	P_2O_5	0.05 - 0.15
Fe_2O_3+FeO	0.5 - 1.0	TiO_2	0.1 - 0.25
CaO	0.5 - (1.0) - 1.3	MnO	tr.
MgO	0.3 - 0.6	i.l.	0.4 - 0.6
K_2O	18.2 - 19.0		

When comparing the chemical composition of leucite with that of the original rock, it can be observed that:

- the silica content remains practically unaltered
- the alumina content varies little (10 % higher in concentrates)
- the content of iron and titanium decreases considerably because practically all the magnetite (in which iron and titanium are contained) goes with the waste products
- calcium and magnesium decrease considerably because practically all the minerals that contain them (augite, basic feldspar and biotite feldspar) go with the waste products
- the potassium content is almost doubled and is slightly less than the potassium content in the leucite. This is because sanidine (which has a high content in potassium) is abundant in the waste products that accompany the leucite in the concentrates.

A treatment plant built according to the diagram in figure 2 is composed of machines which require very little supervision and maintenance, and therefore for a large amount of production the labour requirement is moderate. Supposing a production of 1 million/t of concentrated leucite annually, 4.2 million/t of leucitic lava must be treated each year. The cost of treatment for a ton of lava is estimated to be about Lit. 1,650/ton (1.86). To this must be added the costs of settlement of the waste products from the treatment process, which have been calculated at Lit. 220/t (0.248), as well as the cost of disposing of the waste at the dump: Lit. 40/t (0.045). Thus the total cost for transport and disposal of the wastes amounts to Lit. 260/t (0.293).

The total cost for treatment of each ton[x)] of leucite produced is therefore Lit. 7,600 (1650 x 100/20 + 260 x 100/31) (8.67).

1.2.2.2 Treatment of leucitic tuffs

For the treatment of leucitic tuffs primary crushing is not necessary, as the rock is made up of fragments which are sufficiently minute. Based upon a series of treatment tests it has been possible to establish the necessary steps for the separation of leucite as follows:

- a log-washer is used to eliminate the very fine particles with a particle size of less than 0.5 mm. By this operation 50 % of the feed material is eliminated, with a negligible loss of leucite;
- the preconcentrate thus obtained is screened to separate the 8 mm - 2 mm class (33 % in weight) from the 2 mm - 0.5 mm class (16.7 %)

[x)] For every t of leucite produced, 4.2 t of lava are treated and 3.2 t of waste products must be eliminated

- the two above-mentioned classes are passed on the jigs where another 12.5 % of waste is removed;
- the remaining 37.5 % is ground in a rod mill and passed on to a rake classifier. In this way another 4.5 % of waste is removed;
- the remaining 33 % is dried, classified granulometrically and passed on to magnetic separation which separates the magnetic (waste: 19 %) from the non-magnetic (concentrate of leucite: 14 %).

The material which is disposed of as waste (a total of about 86 % of the feed material) has a 3.5 % content in leucite. The concentrates contain about 92 % leucite, therefore 80 % of the leucite is in the concentrates.

The waste which accompanies the leucite in the concentrates is primarily represented by sanidine, and therefore the concentrate of leucite obtained from tuffs is slightly richer in alumina and potassium than the concentrates obtained from the treatment of leucitic lava. The alumina generally exceeds 23 %, and K_2O, 19 %. The differences are minimal, however, and one can therefore consider the concentrates obtained from the treatment of lava as equivalent to those obtained form the tuffs.

In order to obtain 1 t of leucite it is necessary to treat 7 t of tuff and eliminate 6 t of waste. As the water consumption is considerable (about 4 m^3/t of tuff treated) the cost of supplying the water can seriously affect the total cost. Where there is no water shortage the cost of treating 1 t of tuff can be considered to be around(Lit. 770 (0.868). To this must be added the cost of transporting the waste material Lit. 215/t (0.242) and the cost of their disposal in the quarry, which has been evaluated at Lit. 35/t(0.0394). The total cost thus becomes Lit. 7,000/t (770 x 100 : 14 + 250 x 100 : 16.6) (7.89).

1.2.3 Summary of mining and treatment costs

Cost of the rocks used "as mined"
(Lit/t)

	Lava	Tuff
Removal of sterile cover	190	-
Bringing down and transport	585	420
Total:Lit.	775 (0.874)	420 (0.474)

Cost of the concentrates of leucite

(Lit/t)

		Lava	Tuff
Removal of waste, bringing down and transport		2,920	2,000
Treatment and disposal of waste products		7,690	7,000
	Total:	10,610	9,000
		(11.95)	(10.15)

1.2.4 Conclusions

Thus, summing up for an initial estimate, based upon the production of 500,000 t/year of Al_2O_3 (1,515 t/day in 330 days) and on the following:

Al_2O_3 content in the concentrate	22.1 %
Minimum mining yield of Al_2O_3	80.0 %
Ratio between rock and concentrate	4.2

The values to be envisaged are:

Rock to be treated/t Al_2O_3	23.8 t (about 24 t)
Mining of leucitic rock (lava)	36,000 t/d
Production of concentrate	8,560 t/d

Expressed in t/year these figures become:

Ore to be treated	11,000,000 t/year
Leucitic concentrate	2,830,000 t/year

Considering that the utilizable reserves at Civita Castellana amount to 545 million/t of rock (140 million/t of leucite), exploitation could very probably last for 50 years.

The mining and production cost, expressed in t of leucite, is 61,000 (68.77). To this figure must be added the cost of the buildings and land. On-site utilization is foreseen. In the case of tuffs, the mining and ore enrichment cost is lower in spite of the larger quantity of ore to be treated. On the other hand, since we have had no experience in their use that would enable us to anticipate their yields of Al_2O_3, we cannot supply the relevant calculations.

1.3 Recovery processes

1.3.1 General

In the last 50 years a great number of processes have been put forward for the exploitation of leucites and the recovery of both Al_2O_3 and the alkali or of one of the two fundamental components, sometimes only as experiments on a pilot scale and sometimes on an industrial level. However, they have always had more or less negative results both from the economic and the technical point of view.

The best-known processes are as follows:

- Attack with HNO_3 + HCl (Italian patent 536793 - 1925, property of Soc. It. Potassa). Impractical because of numerous inconveniences and the high cost of the acid. (See further point 1.3.2.3)
- Attack with CaO at 1,000 - 1,400^{o}C (French patent 527066 - 1920; English patent 195084 - 1923; F. Jourdan's French patent 693074 - 1930; and another English patent 342617 - 1930)
- Hot attack with $NaNO_3$ solution under pressure (J.H. Frydlender - Rev. Prod. Chim. 28/1925/221)
- Wet attack with $Ca(OH)_2$ under pressure. Devised only for the recovery of KOH. French patent 556994 (1922)
  Owner: Société pour l'utilisation des leucites.

Three more recent proposals, however, seem to have greater prospects.

- a process of attack with H_2SO_4
- a process of attack with HCl
- a dry alkaline process which is similar to the "Russian" process of attack of nephelines.

We want to outline the first two proposals and pay particular attention to the last one.

1.3.2 Acid processes

1.3.2.1 The sulphuric acid process

- acid attack using H_2SO_4. Figure 4 a shows the basic scheme

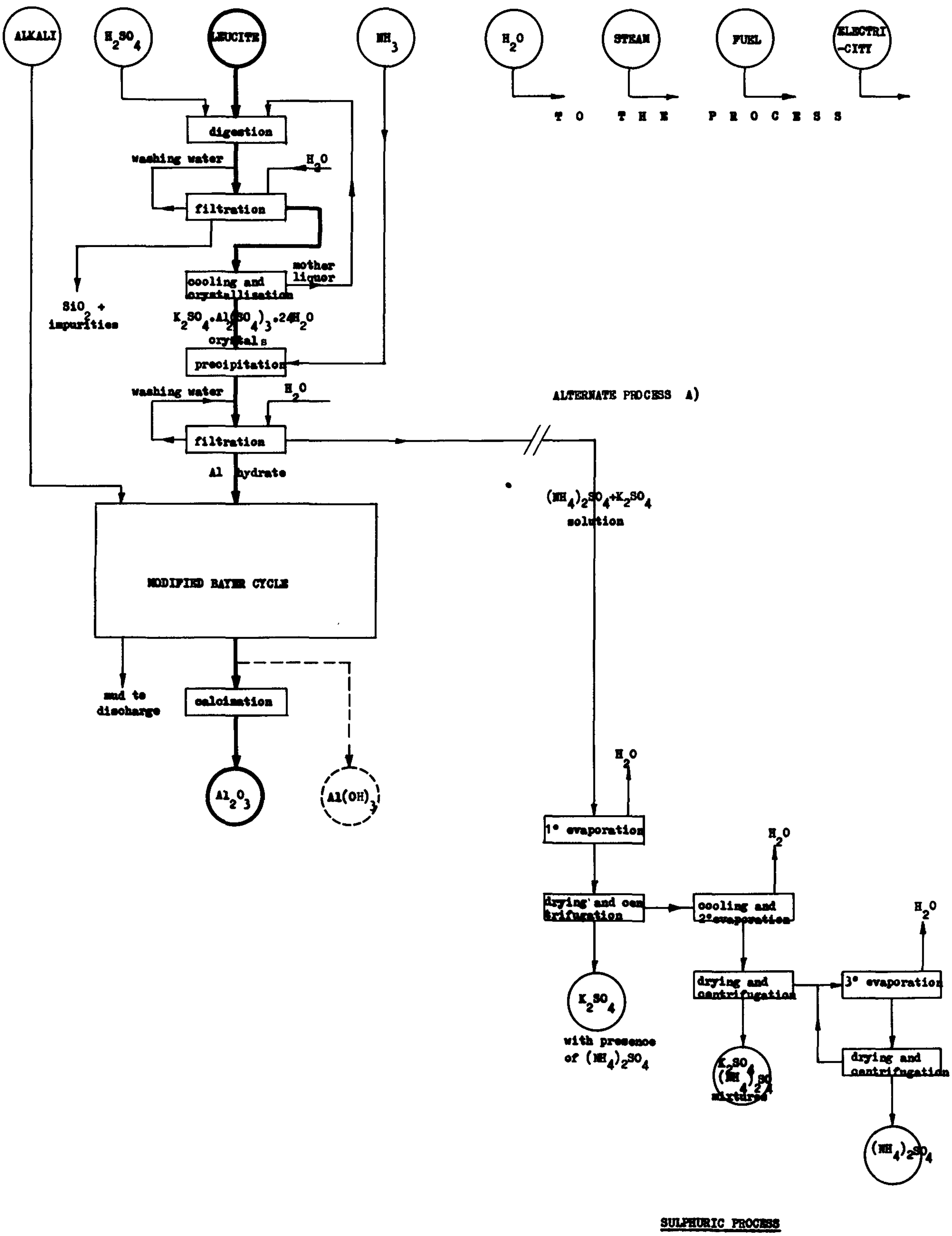

ALKALI
H2SO4
LEUCITE
NH3
H2O
STEAM
FUEL
ELECTRI-CITY
T O T H E P R O C E S S
digestion
washing water
H2O
filtration
cooling and crystallisation
mother liquor
SiO2 + impurities
K2SO4.Al2(SO4)3.24H2O crystals
precipitation
washing water
H2O
filtration
Al hydrate
ALTERNATE PROCESS A)
(NH4)2SO4+K2SO4 solution
MODIFIED BAYER CYCLE
mud to discharge
calcination
Al2O3
Al(OH)3
H2O
1° evaporation
drying and centrifugation
K2SO4
with presence of (NH4)2SO4
cooling and 2°evaporation
H2O
drying and centrifugation
K2SO4 (NH4)2SO4 mixture
3° evaporation
H2O
drying and centrifugation
(NH4)2SO4
SULPHURIC PROCESS

Fig.4 a

ALTERNATE PROCESS B)

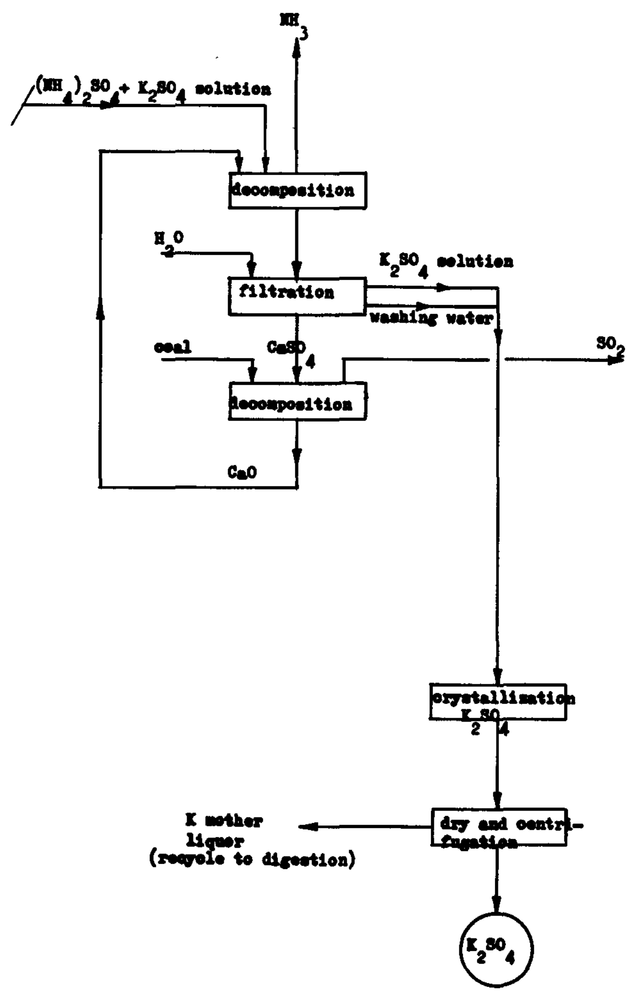


Fig. 4 b

ALTERNATE PROCESS c)

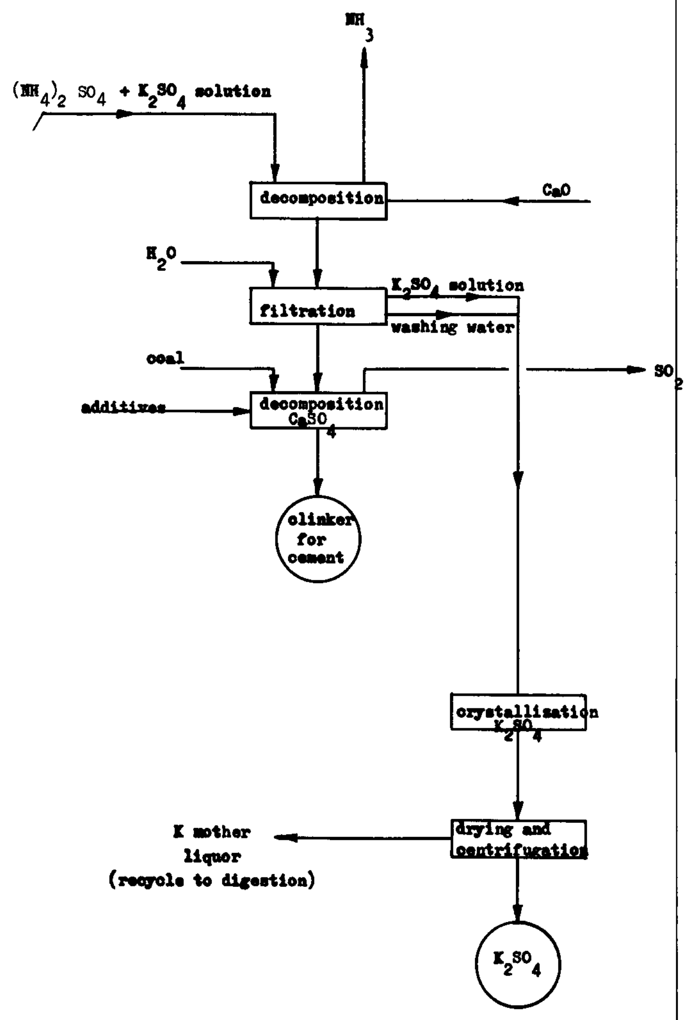


Fig. 4 c

ALTERNATE PROCESS D)

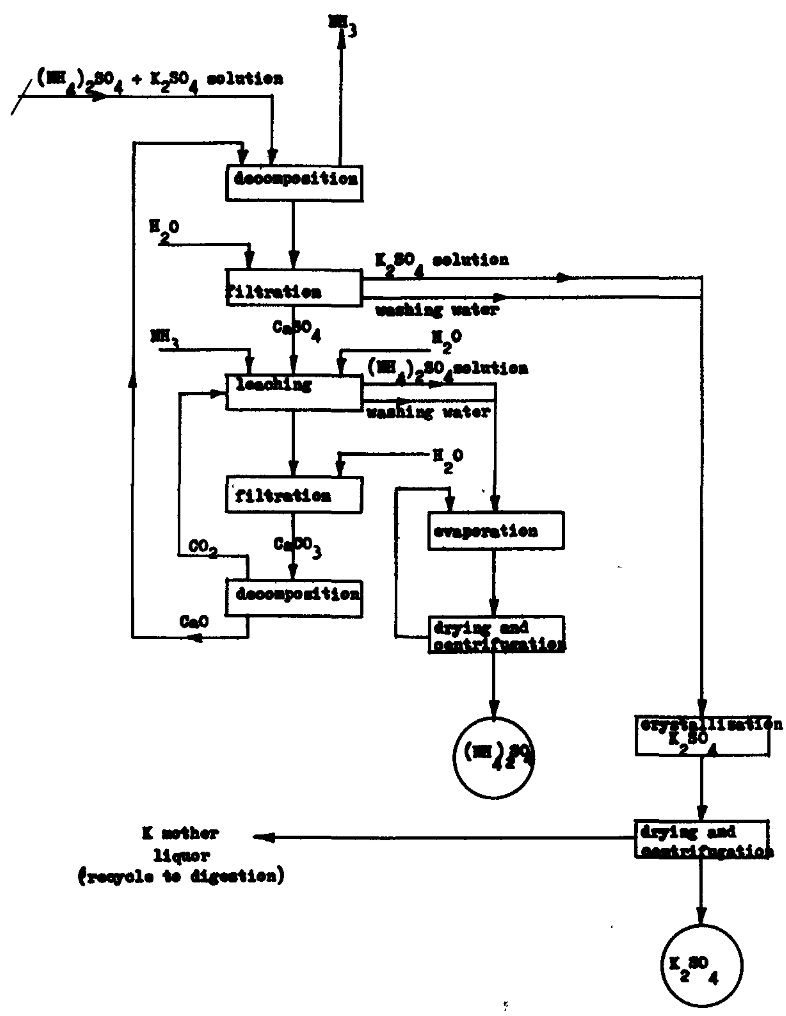


Fig. 4 d

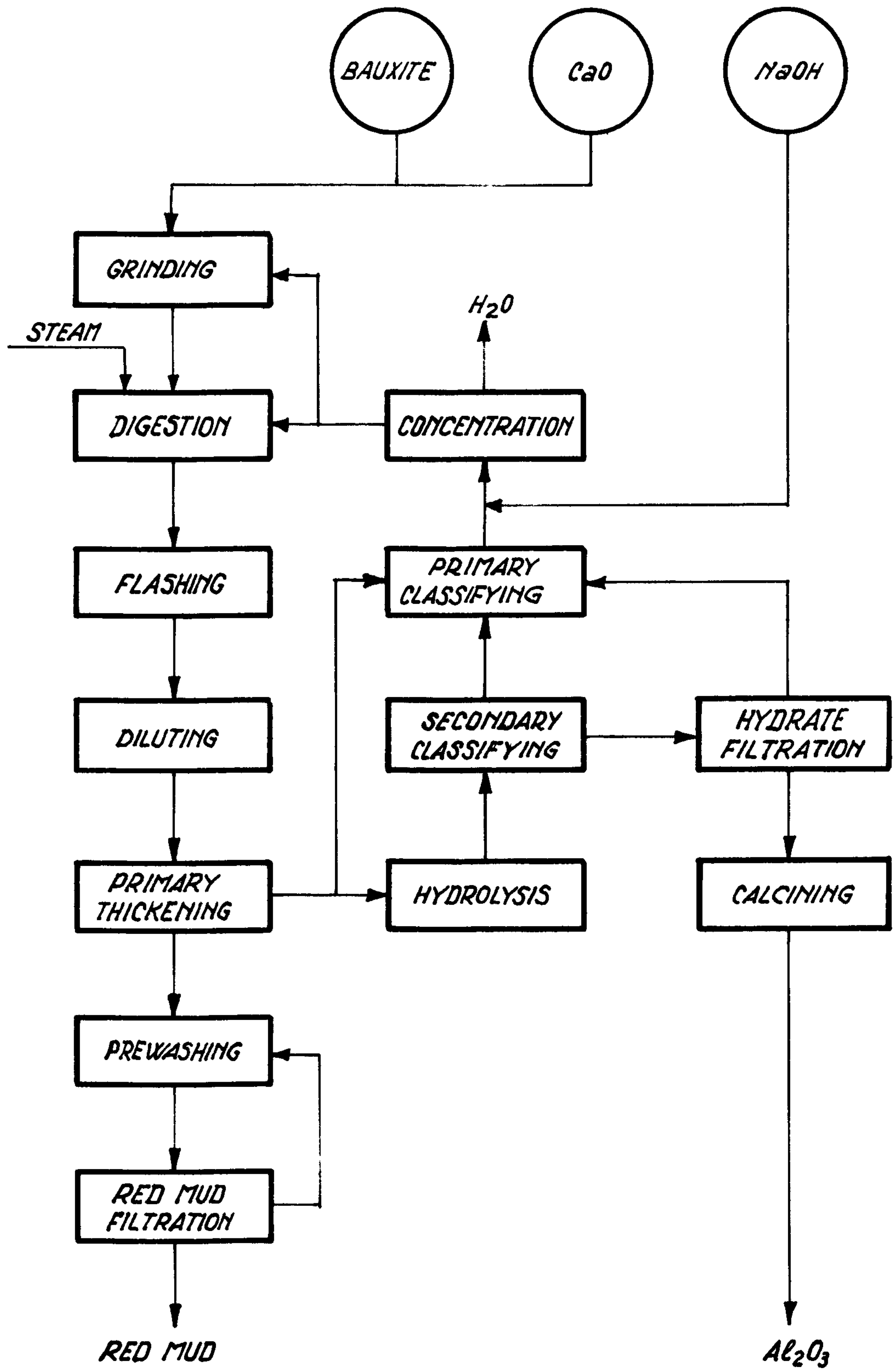


Fig. 5 BASIC BAYER SCHEME

The basic diagram proposes various final alternatives:

a) precipitation with NH_3 - Production of K_2SO_4 - Al_2O_3 - $(NH_4)_2SO_4$

b) recycling of NH_3 - treatment with CaO - Production of K_2SO_4 and Al_2O_3

c) recycling of NH_3 - treatment with CaO - Production of K_2SO_4 - residue for cement - Al_2O_3

d) production of K_2SO_4 - $(NH_4)_2$ SO_4 - $(2CaSO_4 \cdot H_2O)$ - Al_2O_3
(see diagrams 3b - c - d)

Basic scheme

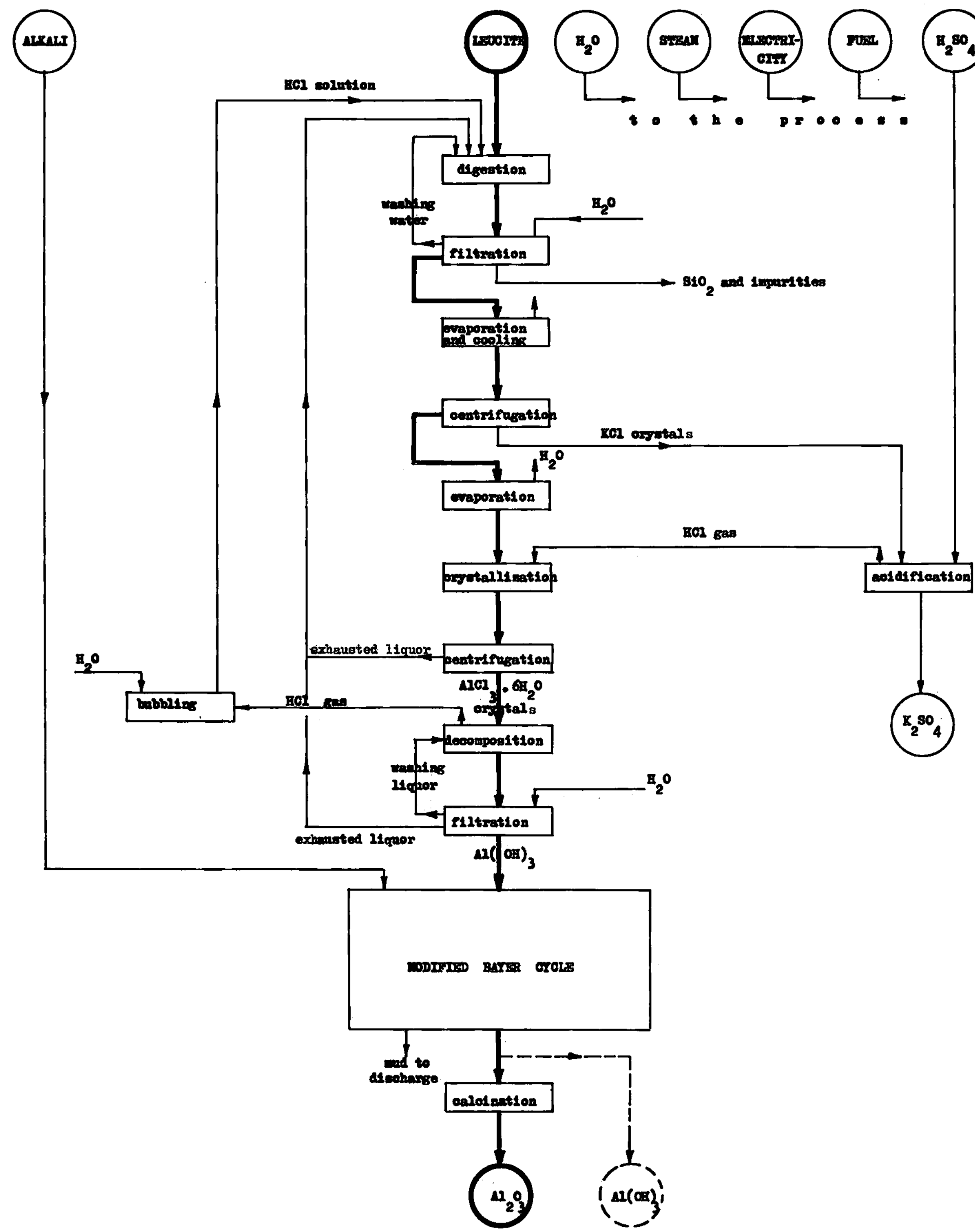
The main steps are the following:

- leaching with a solution of H_2SO_4. Salts of Al and K pass into solution along with Fe and other possible impurities
- filtration of the residue
- cooling and crystallization of the potassium alum: K_2SO_4, Al_2 $(SO_4)_3$, $24H_2O$. Separation of the solid by centrifugation
- dry treatment of the alum with NH_3. The reaction is strongly exothermic. $(NH_4)_2$ SO_4 and Al $(OH)_3$ are formed. The K_2SO_4 remains unchanged
- dissolution with H_2O at 120°C. $(NH_4)_2$ SO_4 and K_2SO_4 pass into solution. Al $(OH)_3$ is separated by filtration
- Al $(OH)_3$ is very impure because of iron and other metallic compounds and must be redissolved in NaOH in order to be retreated according to the Bayer scheme (see the diagram of figure 5).
- cooling and concentration of the solution containing the sulphates of ammonium and potassium at several stages. $(NH_4)_2$ SO_4 and various mixtures of potassium and ammonium sulphates which are directly utilized as fertilizers are obtained.

1.3.2.2 Hydrochloric attack (see the diagram of figure 6)

The process consists of the following steps:

- leaching of the concentrate with HCl. $AlCl_3$, KCl, iron chlorides, calcium chlorides etc. are formed. A residue chiefly composed of SiO_2 is separated.
- cooling and concentrating under vacuum. For crystallization, most of the KCl is formed and centrifuged.
- treatment of the salt with SO_3 at 500°C in a fluid bed. The reaction must be conducted in such a way that all the H_2O present in the salts as humidity reacts. K_2SO_4 and anhydrous HCl are formed, which recycle to the attack



CHLORHYDRIC PROCESS

Fig. 6

- the solution containing $AlCl_3$ and other impurities is treated with HCl; $AlCl_3$, $6H_2O$ precipitates. The aluminium chloride is separated by centrifugation. The mother waters return to the attack. The resulting aluminium chloride is strongly contaminated by $FeCl_3$, KCl etc.
- the aluminium chloride is brought to 300°C in a fluid bed reactor. Hydrolysis takes place with the formation of $Al(OH)_3$, various active semi-anhydrous aluminas and HCl, because of the reaction with the water of crystallization. The hydrochloric acid goes to recycling
- the contaminated aluminium hydrate is washed with H_2O for the purpose of removing KCl, any $AlCl_3$ that did not react, and the other soluble impurities (to recycle)
- the aluminium hydrate goes to redissolution in NaOH according to the Bayer process.

1.3.2.3 Observations

Independently of any economic evaluation, the acid attack presents primarily the following drawbacks:

- the necessity of operating with equipment resistant to the attacks of acids (generally in concentrated solutions and at high temperatures in order to separate the silica as much as possible and to diminish the problems of filtration)
- difficulty of separating the non-solubilized silica, as the silica is, at least in part, present in form of gel which is very difficult to filter.
- necessity of separating the other components, particularly iron, which have passed into the solution along with the alumina.
- necessity of resorting to fractional crystallizations (or to thermic fractional decompositions which are even more difficult to control). Among the various attacks, the hydrochloric attack permits a greater passage of iron in solution and a greater attack of the plant, but the silica is generally crystalline and is therefore easier to filter.
- considerable difficulty in the thermal decomposition of the aluminium salts, owing to the presence of water of crystallization in which they dissolve. Following the dissolution of the salts in their mother waters, they form hard crusts during calcination.
- necessity of recycling the acids to the attack; generally in this phase there are considerable losses of this costly raw material.
- there are sometimes problems during the electrolysis of Al_2O_3, as the alumina coming from thermal decomposition still often contains considerable quantities of water of constitution.

- necessity of having to provide for elimination of the residue coming from the acid attack, a residue fundamentally composed of SiO_2 which is partly in gel form. Certainly this is a problem which is not to be neglected nowadays, in view of the attention being given to the discharge of residues and to environmental problems in general.

On the other hand, in alkaline attack, the problem is how to eliminate the calcium silicate. But this residue should go, at least in part, to the production of cement.
In any case it should not entail any special environmental problem.

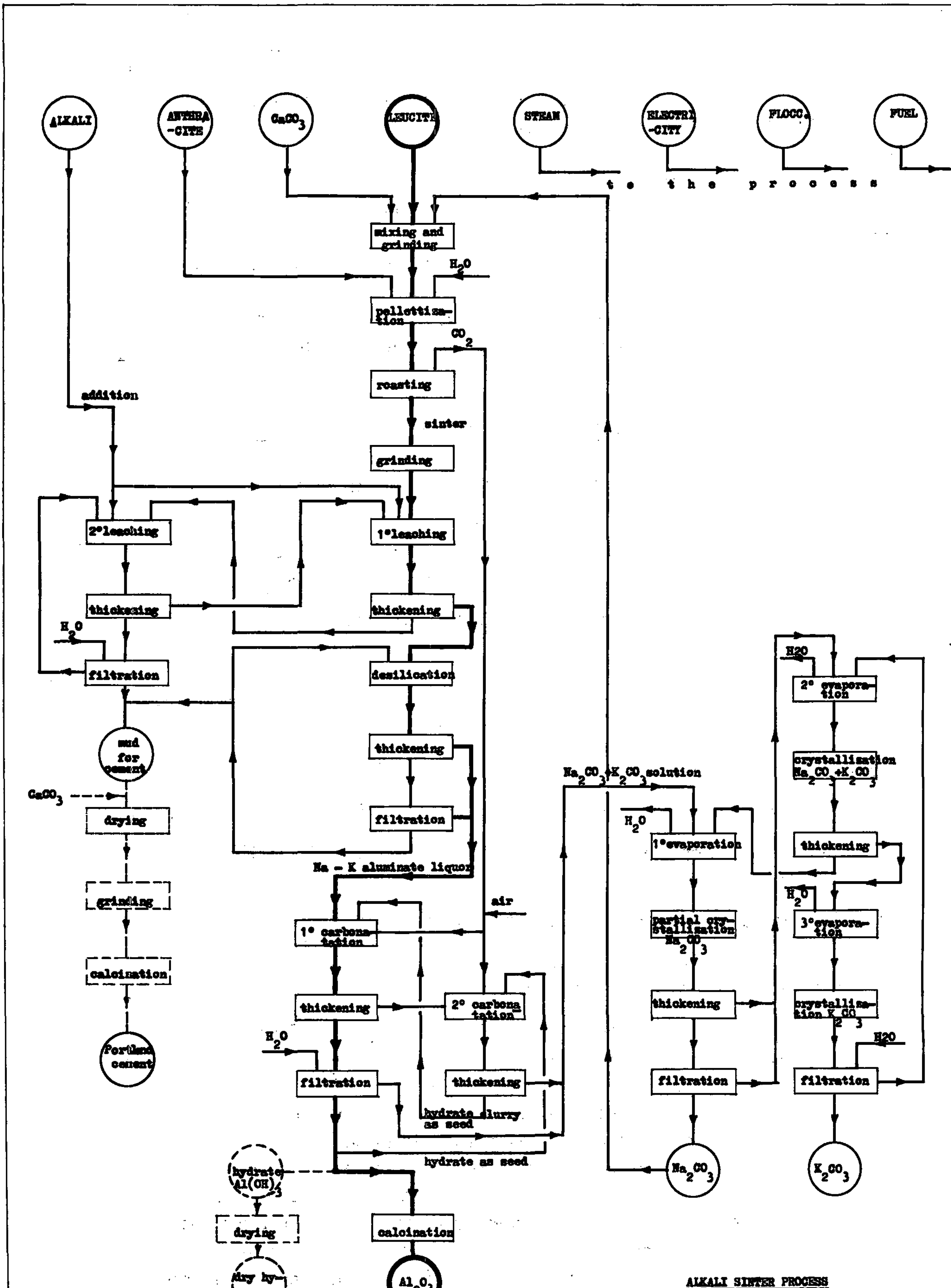
Naturally there are a vast number of techniques, all quite complex, for avoiding the inconveniences indicated. (See, as an example, the H^+ process)

1.3.3 Dry alkaline attack and recovery of secondary products

The process (see figure 7) consists of the following steps:

- preparation of a highly homogeneous mixture consisting of concentrate of leucite, $CaCO_3$, anthracite, Na_2CO_3 and recycled powders;
- granulation, forming grains with dia. 1 - 1.5 cm
- pre-drying of the pellets
- calcining in either a rotary or shaft oven to a maximum temperature of 1300 - 1350° C. Duration of the total reaction about 30 minutes
- wet grinding of the sinter
- leaching with recycled alkaline solution at 90°C for 30 - 40 minutes
- thickening and separation of the residual sludge which will be used for the production of cement
- desilication of the aluminate solution in two stages
- decomposition of the aluminate by recovery of CO_2.
  Separation of the aluminium hydrate
- concentration and separation of Na_2CO_3 and K_2CO_3 in three stages.
  The Na_2CO_3 returns to the attack.

As can be seen from the foregoing, it is a question of choosing between two alternatives, one being a process that achieves separation of the silica as such and carries all the other components (iron, titanium, magnesium, sodium, potassium etc.) in solution - that is the acid attack, and the other being a process which leaves most of these components unaltered and separates the silica in the form of an insoluble compound (calcium silicate). The choice obviously depends primarily on the raw materials which are available.


ALKALI
ANTHRA-CITE
$CaCO_3$
LEUCITE
STEAM
ELECTRI-CITY
FLOCC.
FUEL
to the process
mixing and grinding
H_2O
pellettiza-tion
CO_2
roasting
sinter
grinding
addition
2°leaching
1°leaching
thickening
thickening
H_2O
filtration
desilication
thickening
mud for cement
$CaCO_3$
filtration
drying
grinding
calcination
Portland cement
Na – K aluminate liquor
air
1° carbona-tation
thickening
2° carbona-tation
H_2O
filtration
thickening
hydrate slurry as seed
hydrate as seed
hydrate $Al(OH)_3$
drying
dry hy-drate
calcination
Al_2O_3
$Na_2CO_3+K_2CO_3$ solution
H_2O
1°evaporation
partial cry-stallization Na_2CO_3
thickening
filtration
Na_2CO_3
H20
2° evapora-tion
crystallization $Na_2CO_3+K_2CO_3$
thickening
H_2O
3°evapora-tion
crystallization K_2CO_3
H20
filtration
K_2CO_3
ALKALI SINTER PROCESS
Fig. 7

Generally one has:

- raw materials with a so-called acid character (argillaceous shales,etc.): the acid attack; or
- raw materials with a basic character (silico-aluminates, alkalines and earth alkalines, which includes anorthosites, leucites and nephelines): an alkaline attack with recovery of the alkali. In the specific case of leucite, therefore, it is our opinion that it is preferable to orient operation towards dry alkaline attack.

In this direction we have already made many experiments. Our starting point was the study undertaken in this field by the Russians and ourselves with regard to highly siliceous bauxite ores. The technology adopted was selected with the purpose of using leucite alongside bauxite as far as possible.

The most important aspect of the process which we tested over many months is the dressing of a granulated raw material, with 1 - 1.5 cm diameter, consisting of leucite concentrate, limestone, anthracite, and recycled alkalis and aluminate liquors, and its roasting at about 1350°C in a preferably continuous kiln.

When leaving the kiln, the granules crumble apart and show no melting spots. This technique should obviate a number of inconveniences connected with the use of horizontal kilns, including the loss of potassium by evaporation, less recycling of powders and formation of scaling.
Furthermore, it should allow better heat recovery than does calcining with pans or belts.

The stages subsequent to the sintering, that is, leaching, desilicating, carbonation and crystallization should not notably differ from the processes studied for nephelines and would permit the use of the same apparatus as for bauxites.

On the basis of the tests carried out on a small pilot plant at our Research Centre in Porto Marghera, we will give the most important data regarding the process and the plant, obtained when operating with a concentrate of leucite.

1.3.3.1 Dry alkaline attack: process data and extraction yields

Composition of the leucite concentrate used:

i.l.	0.46	CaO	1.26
SiO_2	54.18	MgO	0.56
K_2O	18.73	TiO_2	0.25

Al_2O_3	22.11	P_2O_5	0.15
Na_2O	0.86	CO_2	0.10
Fe_2O_3	0.98	SO_3	0.46

$\frac{\text{alkali}}{Al_2O_3}$ ratio 0.962

Specific data, t/t Al_2O_3:

leucite	5.7	sludge to cement	
anthracite	0.3	production	9.5
$CaCO_3$	10.0	K_2O extracted	1.0
$Na_2O + K_2O$	0.12	Na_2O	0.04
H_2O (to attack)	3.5		

Extraction yields:

Al_2O_3	min.	80.0 %
K_2O	min.	95.0 %
Na_2O		76.5 %

The cost of treatment for 1 t of Al_2O_3 is always greater than that with the classical Bayer system, fundamentally because of the greater consumption of energy, the reason for which is greater use of material.

Assuming equal cost for the raw material (transport cost of the bauxite could practically be compensated for by the fact that the mineral would be used on site), this greater incidence should be offset simply by the recovery of the secondary raw materials (cement and K_2O).

1.3.3.2 Fundamental equipment for a pilot plant

The following list indicates the fundamental items that constitute a pilot plant for the production of about 3 t/day of Al_2O_3, 3 t/day of K_2O and 28 t/day of residue for cement.

- ball grinder
- pelletizer (about 2.5 t/hour)
- shaft furnace (height about 7 m, dia. about 5 m⁻ temperature: 1500°C)
- leaching reactor
- 4 decomposers (about 100 m^3 each)
- concentration plant
- 2 filters
- silos, tanks
- pumps and valves
- instrumentation
- panel and electric system

We calculate that such a pilot plant will cost not less than Lit. 500 million.

1.3.3.3 Recovery of secondary materials

1.3.3.3.1 Portland cement

The residue from dry attack of the mineral cannot be utilized as it is. One must add CaO so as to obtain a CaO: SiO_2 ratio of 3 : 1.

Keeping in mind that the residue has the chemical composition and the mineralogical composition indicated as follows, it is calculated that for each t of residue it is necessary to add 0.27 t of CaO.

Chemical composition in %		Mineralogical composition in %	
SiO_2	32	2. CaO.SiO_2	40
K_2O	0.57	2. CaO. SiO_2	40
Na_2O	0.12	2. CaO. Al_2O_3.SiO_2	15
Al_2O_3	2.60	3. CaO. Al_2O_3. nSiO_2 (where n 3)	5
Fe_2O_3	0.60		
CaO	61.15		

Thus for every t of Al_2O_3 produced, we shall have 13 t of residue for cement (9.5 + 0.27 x 9.5).

This material is subjected to:

- drying
- grinding
- sintering at 1200 - 1300°C in a rotary furnace
- grinding

For a total production of 400,000 t/y of Al_2O_3, one must calculate a production of 5,200,000 t of cement which presumably should be used not too far from the place of origin. For a total production of 500,000 t/y Al_2O_3, this quantity increases to 6,500,000 t.

Cement market

The production of cement in the Cembureau countries for the first six months of 1975 and 1976 is shown in table 7. Data for 1973 and 1974 are given in "Industria Italiana del Cimento", 1/1975, p.40. Prices of cement in Europe up to 20/10/1975 are listed in "Industria Italiana del Cimento", 3, 1976, p.152.

Keeping in mind the eventual local production of cement from leucite residue, in tables 8 and 9 we show the data relative to imports and exports (1975, first six months 1976) in Italy[x].

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x) Useful additional data can be found in various issues of "Industria Italiana del Cimento". In particular:

- Italian imports and exports in 1974, and evolution 1975/74: n°. 4/1976, p. 210
- 1975 production of cement in each region of Italy: n°. 4/1976, p. 209
- world largest producers: 1970 - 1974: n°. 2/1975, p. 111
- world production 1970 - 1974: n°. 2/1975
- main destination of italian exports in 1973: n°. 2/1974.

Table 7

Production of cement in Cembureau countries
January - June 1975 and 1976
("Industria Italiana del Cimento",3/1976 p. 168)

Countries	1976 (1000 t)	1975 (1000 t)	Variation %
E E C and Cembureau countries			
Italy	17,883	17,199	+ 4.0
France	15,769	15,871	- 0.6
Germany	15,641	15,435	+ 1.3
United Kingdom	8,231	8,772	- 6.2
Belgium	3,613	3,513	+ 2.8
Netherlands	1,744	1,831	- 4.8
Denmark	1,104	907	+ 21.7
Ireland	765	718	+ 6.5
Luxembourg	149	163	- 8.6
Total	64,899	64,409	+ 0.8
Other Cembureau countries			
Spain	12,474	11,972	+ 4.2
Turkey	5,916	4.951	+ 19.5
Greece	4,175	3,728	+ 12.0
Austria	2,607	2,593	+ 0.5
Portugal	1,845	1,665	+ 10.8
Switzerland	1,610	1,743	- 7.6
Sweden	1,326	1,671	- 20.6
Norway	1,301	1,341	- 3.0
Finland	853	1,026	- 16.9
Iceland	49	52	- 5.8
Total	32,156	30,742	+ 4.6
General Total	97,055	95,151	+ 2.0

The exported clinker is included.

Table 8

Imports in Italy: 1^{st} half 1976
in tons
(From: "Industria Italiana del Cimento"; 10, 1976)

Months	Cement			Clinker		
	1976	1975	76/75	1976	1975	76/75
January	4,107	4,631	- 11.3	24	-	-
February	4,920	6,091	- 19.2	-	-	-
March	6,195	4,306	+ 43.9	-	-	-
April	5,787	5,818	- 0.5	24	-	-
May	4,848	3,225	+ 50.3	-	1,045	-
June	3,595	3,605	- 0.3	-	229	-
1^{st} half year	29,452	27,676	+ 6.4	48	1,274	-96,2
July		5,092			796	
August		4,509			299	
September		3,792			45	
October		4,958			-	
November		4,977			-	
December		5,866			-	
Total		56,870			2,414	

Table 9

Exports from Italy: 1^{st} half 1976
in tons
(From: "Industria Italiana del Cimento"; 10, 1976)

Months	Cement			Clinker		
	1976	1975	76/75	1976	1975	76/75
January	22,461	24,086	- 6.7	14,811	6	-
February	11,003	12,054	- 8.7	35,934	6,183	+ 481.2
March	26,984	19,277	+ 40.0	46,310	47,483	- 2.5
April	25,277	21,217	+ 19.1	34,635	73,528	- 52.9
May	66,878	29,140	+129.5	11,950	16,242	- 26.4
June	61,335	29,868	+105.4	12,198	7,122	+ 71.3
1^{st} half year	213,938	135,642	+ 57.7	155,838	150,564	+ 3.5
July		77,520			12,888	
August		39,265			63,333	
September		32,882			40,170	
October		24,099			24,132	
November		21,103			33,956	
December		17,444			70,717	
Total		347,955			395,760	

The production of cement in Italy in 1975 was 34,595,000 t (34.6 million t/year) against a productive capacity of 45 million t/year and a predicted increase to 48.5 million t/year in 1978.

The quantity of cement originating from residues of leucite, with the capacity indicated - 500,000 t/year Al_2O_3 - would be about 19 % for 1975 and about 13.5 % of the 1978 forecasts.

Still referring to 1975, if we look at the available data on cement production in the Common Market countries, the percentage amounts to 6.20 %. There - fore this production should be able to be absorbed.

1.3.3.3.2 Potassium salts

For a potential of 500,000 t of Al_2O_3/year, the production of K_2O is about 500,000 tons.

The salt is in the form of carbonate, which must obviously be transformed into other salts. Chloride is the most demanded. The transformation of carbonate into chloride requires a fairly simple treatment.

The carbonate solutions are treated with CO_2 (recycled). Then the precipitate is washed with an aqueous solution of NaCl. The following reaction takes place:

$$K_2CO_3 + CO_2 + 2NaCl \longrightarrow 2\ NaHCO_3 + 2KCl$$

The monosodium carbonate is heated to 300°C. The result is the generation of CO_2 and the formation of Na_2CO_3, the latter serving to make up losses of alkali. The filtrated solution containing KCl is concentrated to separate KCl.

Potassium salts market

Data on production, export, import and consumption, expressed in t K_2O, are taken from "Annual Fertilizer Review" (F.A.O., Rome)x).

x) useful comments on the potash fertilizer trend can be found in "Annual Fertilizer Review", 1975, p. 6 - 7.

Table 10

in t K_2O

(From: "Annual Fertilizer Review" (F.A.O., Rome), 1976

	Production		Consumption		Import		Export	
	74/75	75/76	74/75	75/76	74/75	75/76	74/75	75/76
Denmark	-	-	159,690	171,300	194,228	159,100	-	-
Germany Fed.Rep.	2,658,896	1,848,447	1,170,459	1,099,003	81,391	85,709	1,209,969	819,414
France	2,078,500	1,734,000	1,390,300	1,314,200	337,000	270,500	884,100	616,600
Italy	165,616	142,050	231,405	275,747	201,280	221,591	53,211	51,804
Belgium Luxembourg	-	-	179,700	148,500	308,866	281,900	-	-
Netherlands	2,601	3,085	112,355	101,069	203,167	186,043	-	100
United Kingdom	12,000	34,000	373,000	399,000	476,000	410,000	-	-
Ireland	-	-	111,100	144,250	140,100	117,700	-	-
Europe	8,162,200	7,292,900	7,999,700	8,198,200	5,638,600	5,592,900	4,322,400	3,399,700
W.Europe	5,298,200	4,273,900			3,041,800	2,569,800	2,233,400	1,647,700
World total	23,698,400	23,476,800	19,646,400	21,337,100	12,975,700	12,174,100	12,974,700	11,887,700

The forecast production capacities for the five-year period 1975 - 1980 are the following (these data relate to Western Europe):

1975/1976	6.19 million t
1976/1977	6.59 million t
1977/1978	6.94 million t
1978/1979	7.19 million t
1979/1980	7.34 million t
1980/1981	7.44 million t

We add two further observations regarding Italy, the only country chiefly interested in the exploitation of leucites. Italy imports KCl from Israel, Russia and USA, and imports small quantities of K_2SO_4 from Germany. New plants for the production of potash fertilizers are not foreseen in the next few years in Europe. A new plant for complex fertilizers with a productive capacity of 16,000 t P_2O_5 has been forecast only in Bulgaria.
Alongside to 500,000 and 400,000 t/y production of Al_2O_3 from leucite one would practically have a corresponding production of K_2O. This quantity amounts to:

215	and	173 %	of	consumption in Italy in 1974 - 1975
250	and	200 %	of	Italian imports in 1974 - 1975
13	and	10.45 %	of	consumption in EEC countries
10.2	and	8.14 %	of	production in the same countries
25	and	20 %	of	total imports

The incidence on Western Europe figures would be as follows:

7.54	and	9.44 %	on production
8.24	and	10.30 %	on consumption
12.95	and	16.30 %	on imports

2) ALUNITES

2.1 Deposits - General

Alunite is a basic sulphate hydrate that can be expressed with the formula $K_2Al_6(OH)_{12}\ (SO_4)_4$ or K_2SO_4, $Al_2(SO_4)_3$, 4 Al $(OH)_3$, where - in the pure state - the various components are present in the following percentages: SO_3 - 38.6 %; Al_2O_3 - 37,0 %; K_2O - 11.4 %; and H_2O - 13.0 %.

Deposits of alunitic rocks have been mined (in Italy ever since the Middle Ages) for the production of potassium alum, but this activity has at present come to an end. In recent times the alunite deposits have been reconsidered for the production of potassium sulphate and, as byproducts, alumina, sulphuric acid, V_2O_5, etc.[x)]

The alunitic formations in the world are numerous, but compared with other types of deposits they have been subject to little mining research. Systematic studies of some deposits have been carried out only recently, especially in Russia, the United States, Australia and Mexico.

Alunitic deposits were formed by the action of acid solutions on alumosilicate rocks, owing to the alteration and substitution of constituent minerals

Alterations can occur:

a) by substitution due to ascending sulphuric hydrothermal solutions genetically connected with magmatic intrusions.
Generally the rocks subject to substitution are acid or intermediate magmatic rocks. Deposits of this kind are found in Russia (Zaglik) and China (Fanchan and Taifou);

b) by substitution due to sulphuric solutions or ascending hydrothermal solutions, genetically connected with effusive magmatism. These rocks are almost always lavas and acid or intermediate tuffs. A deposit of this type is the one at Ugusu in Japan. The fluid mineralizers may also be gas, vapours, or thermal waters, acid because of their content in H_2SO_4, genetically connected with solfataric, fumarolic or geyseric post-volcanic activities. The deposit at Ebeko (Kurile Isles) is of this kind.
When post-volcanic fluids flow on the bottom of crater lakes, alunite may be formed through chemical precipitation (as happens in Lake Kipyashcheye in the island of Kunashir, Kuriles, for example);

c) through the action of descending acid solutions derived from the leaching of altered sulphide products. A deposits of this type is the one at Tolfa in Latium;

d) through dissolution and redeposition of the alunite already formed by one of the above-mentioned processes. The alunite can be carried in solution by hydrothermal fluids and by acid surface waters. In this case, the secondary alunite is made up of veins, seams or shoots in which the content of alunite can be very high (up to 90 %).
A site where deposition of considerable quantities of secondary alunite has occurred is the one at Marysvale, Utah.

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x) Gallium, too, can be present in alunitic minerals. Analyses performed on five samples from Russian deposits showed an average content varying from 0.02 to 0.03 % Ga.

In all types of deposits, the alunite is associated with minerals that were formed because of alteration of constituent minerals in the alunitized rocks. Such minerals are those of the kaolin group (kaolinite, dickite), opal, pyrophyllite, sericite, etc.. The quartz which often accompanies the alunite deriving from the alunitization of acid volcanic rocks is in great part quartz which has resisted the alteration of the rock which originally contained it.

In the known deposits, high-grade reserves (in seams and shoots) are generally rather small, whereas deposits where impregnation minerals are diffused in the rock can contain huge reserves. Since large quantities of alunite are required for an alumina producing plant in order to make the operation economically viable, only deposits with large reserves of mineral are worth working for the production of alumina.

2.1.1 Deposits of alunitic rocks in Italy (see fig. 1 on page 3)

The considerable development of recent volcanic activity in Italy gave rise to numerous formations of alunite rocks, especially in Tuscany, Latium and Campania. There are also rather small deposits of alunite of no practical interest on the island of Lipari and in the Alps (near S. Vigilio di Marebbe in Alto Adige). In Campania alunite was formed by the action of gas, vapours and solfataric solutions on volcanites at Pozzuoli and Agnano near Naples and in the island of Ischia. The Pozzuoli and Agnano deposits are manifestations of moderate extent. At Agnano the alunite is present in small pockets with high content, which were mined in the Middle Ages (activity ceased in 1500). The alunitic formations in Campania do not present any practical interest.

2.1.1.1 Deposits of alunite in Latium

Alunitic manifestations are found inland from S. Severa (community of S. Marinella, Civitavecchia), about 16 air km south east of Civitavecchia. In this zone there are vast beds made up of rhyolitic ignimbrite that in various areas are kaolinized owing to the action of post-volcanic acid solutions. Locally, in connection with kaolinization of the feldspar of the ignimbrite, the formation of small quantities of alunite has occurred.

The alunitic mineralizations in the zone of S. Severa are all of very moderate extent and do not present any practical interest.

There are also alunitic manifestations in the "calderes" of Latera and Bolsena in the Viterbo province. Here too, the mineralizations are of limited extent.

Alunitic formations which cover a fairly extensive area are found in the Tolfa area. Characteristics of these formations, which have been subject to mining activity of some importance in the past, are little known because no mining studies geared to determining their features have been conducted. The few available data follow.

- Alunitic formations at Tolfa (fig. 8-9-10 a and 10 b)

They are found in northwest Latium at about 12 km northeast of Civitavecchia. The alunite is found in various areas (Allumiere, Conca, Trinità, Cave Vecchie and La Cavaccia) where mining activities on a varying scale have been carried out at different times in the past, with both open - cast workings and tunnels. The alunite is always found associated with silica and kaolin in rhyolitic ignimbrite, in the zones where these rocks are hydrothermalized.

According to some authors the Tolfa alunite was probably formed by the action of descending acid solutions (as described in c) above). On the contrary, according to a recent study, the formation of alunite through the action of supergene sulphatic ions should be excluded from consideration. In the first case mineralization could not extend very deeply, an event which would, on the contrary, be possible if alunite had been formed through the action of ascending acid solutions.

The mining bodies consist of:

- breccia zones in relation with faults cemented by alunite
- pockets or small shoots where the altered rock is in great part replaced by alunite
- diffuse impregnations of alunite in the rock.

The breccia zones and shoots have a high content of alunite (from 30 % to 60 %) and those are the zones which have been mined. In the zones with diffuse impregnation, the alunite is present in a very much lower quantity, but sufficient data are not available to be able to evaluate either the average content or the extent of the reserves. Judging from what can be seen on the walls of the old stopes, it seems that the alunite content varies around 10 - 15 %, with considerable oscillations around this value in the different zones.

An analysis of a sample of the mineral with an alunite content of about 35 % has given the following results:

SiO_2	56.0	Na_2O	0.3
Al_2O_3	17.0	K_2O	4.2
Fe_2O_3	3.0	SO_3	13.2
FeO	0.3	H_2O +	7.0

Figure 8

Map of the alunite veins of La Tolfa and Allumiere
Scale 1 : 3000

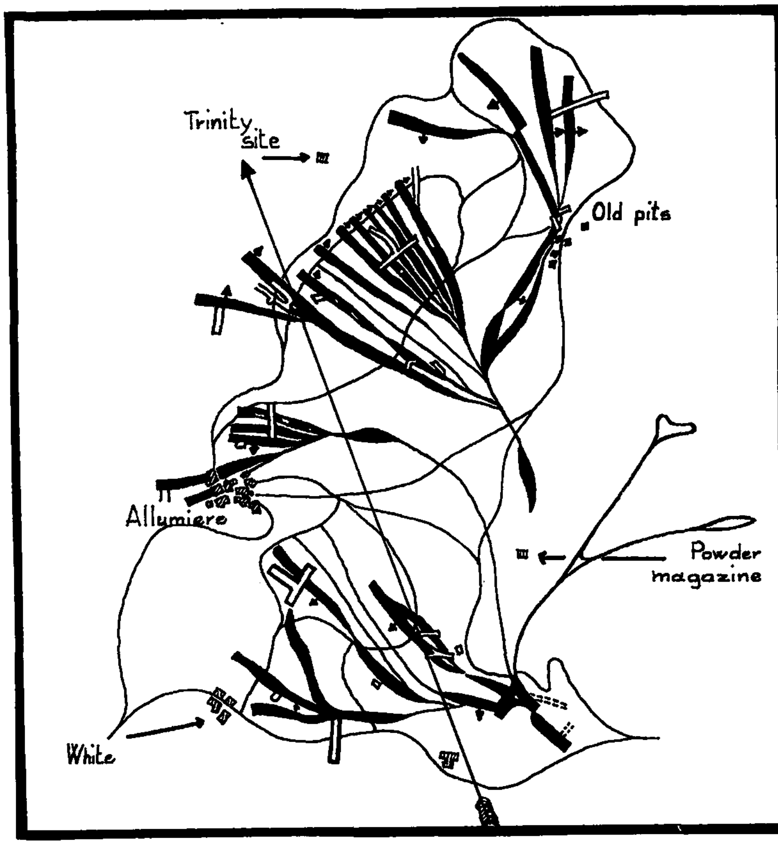
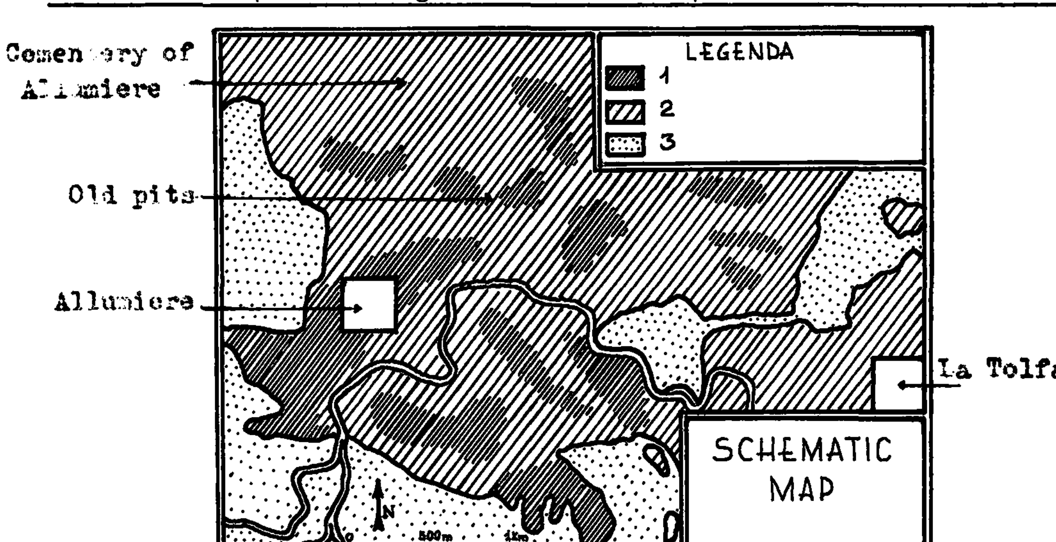


Figure 9

Schematic map of the largest alunitic outcrops at Allumiere and La Tolfa



1) Alunitic and quartzitic-alunitic rocks
2) Liparitic and quartzitic volcanites (mostly metasomatized)
3) Sedimentary soils

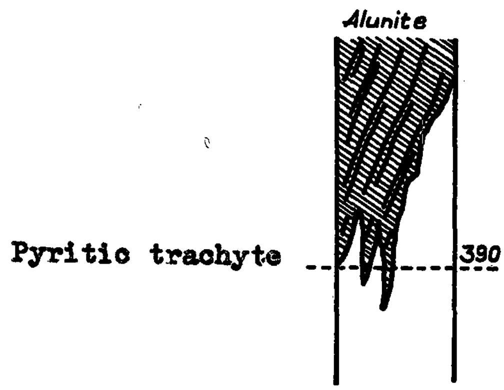


Figure 10a

Theoretical cross-section of the vein Providenza, La Tolfa

Figure 10b

Theoretical longitudinal section of the vein Providenza, La Tolfa

Figure 8 from: De Launay - Traité des gites mineraux et métallifères - (1913) p. 248

Figure 9 from: G. Lombardi - Ricerche su rocce alunitiche del settore d'La Tolfa - Allumiere (da Negretti-Lombardi e Morbidelli) - Periodico mineralogico - Roma 36 -(1967) p. 401

Figure 10 from: De Launay - Traité des gites mineraux et métallifères-Alunite-Gisement de La Tolfa - (1913) p. 249

Italcementi owns a mining concession in the zone and is extracting limited quantities of mineral which are used in the cement factories at Civitavecchia.

In 1951 Montecatini performed geological surveys in the zone, which was held to be of some interest; but no further studies were carried out because the mineralized area lacks the water necessary for treatment of the mineral.

2.1.1.2 Alunite deposits in Tuscany

Alunitic manifestations of very limited size are found at various localities (Frassine, 12 km northwest of Massa Marittima in the province of Grosseto; below Poggio di Acquaviva at the west foot of Monti di Campiglia; Lumiere near Campiglia Marittima in the province of Livorno; Cavoni near the Fenice Capanne mine, 4 km south of Massa Marittima; and Pereta in Val d'Albegna). In all these areas, the alunite was formed by the action of acid solutions deriving from the leaching of sulphide alteration products on alumosilicate rocks of the "Tuscany series" (slaty shales at Frassine; Upper Triassic argillaceous shales at Campiglia Marittima, and marls and Eocene argillaceous shales at Fenice Capanne). In most of the above-mentioned sites, with the exception of Pereta, small-scale mining activity in the zones where the alunite constituted lenses or pockets with high content has been carried out in the past. Zones of diffuse impregation with low content are not large.

Other deposits, of considerable extent, are found at Torniella, 7 km north of Roccastrada in the province of Grosseto, and at Montioni-Allumiere in the district of Severeto at the boundary between the provinces of Livorno and Grosseto.

- Torniella

  The alunite is formed in liparitic and trachytic ignimbrites and is always associated with kaolin, silica and micas. It generally forms the filling of small fractures in the ignimbrites. In the past this zone was mined only for kaolin. Neither the reserves of alunitic minerals nor its content are known, but in all probability the mineral content is not high.

  The analysis of a sample taken from the walls of one of the old mines gives the following composition:

SiO_2	66.33	MgO	0.27
Al_2O_3	22.49	K_2O+Na_2O	1.30
Fe_2O_3	1.21	i.l.	8.38 (of which 3 % SO_3)
CaO	0.22		

Assuming that the rock which contains the alunite is completely altered and therefore that all the sodium and potassium are bound as alunite, the alunite fraction would be slightly more than 10 %.

- Montioni-Allumiere

  The area affected by mineralization is located about 22 km northeast of Piombino. The alunite has formed by action of acid solutions derived from alterations of sulphides (mostly pyrite) on Eocene alumosilicate rocks (argillitic shales and marls). The mineral consists of siliceous layers deriving from the silicification of Eocene rocks, often breccia like, with geodes of quartz in which lenses of alunite and kaolin are enclosed. This area has an extent of a few km^2. There is already a mining concession in the area (Società SOMIT - gruppo EFIM). Further prospecting will be necessary to define the character of this mineralization. However, available reserves are said to amount to over 10 million t (perhaps up to 30 million t) of ore containing 10 % to 20 % alunite. They seem to be at present the most interesting in Italy.

2.1.2 Deposits of alunite in other countries

As can be seen in figure 11, where the distribution of known alunite deposits in the world is shown, deposits occur in certain zones in the earth's crust, particularly in mobile zones in geosynclinal districts. Among the indicated deposits, the most interesting are those found in the United States, Mexico, Australia, Japan, Russia, China, Spain and Korea.

- The United States

  Alunitic mineralizations are found in the district of Goldfield (Nevada), a part of the large gold-bearing territory which, besides Nevada, includes the adjacent states of California, Utah and Idaho. The mineralizations, primarily composed of alunite and quartz, are adjacent to veins of gold-bearing quartz, emplaced in volcanites of lower Tertiary age (andesites, dacites and latites), hydrothermally altered.

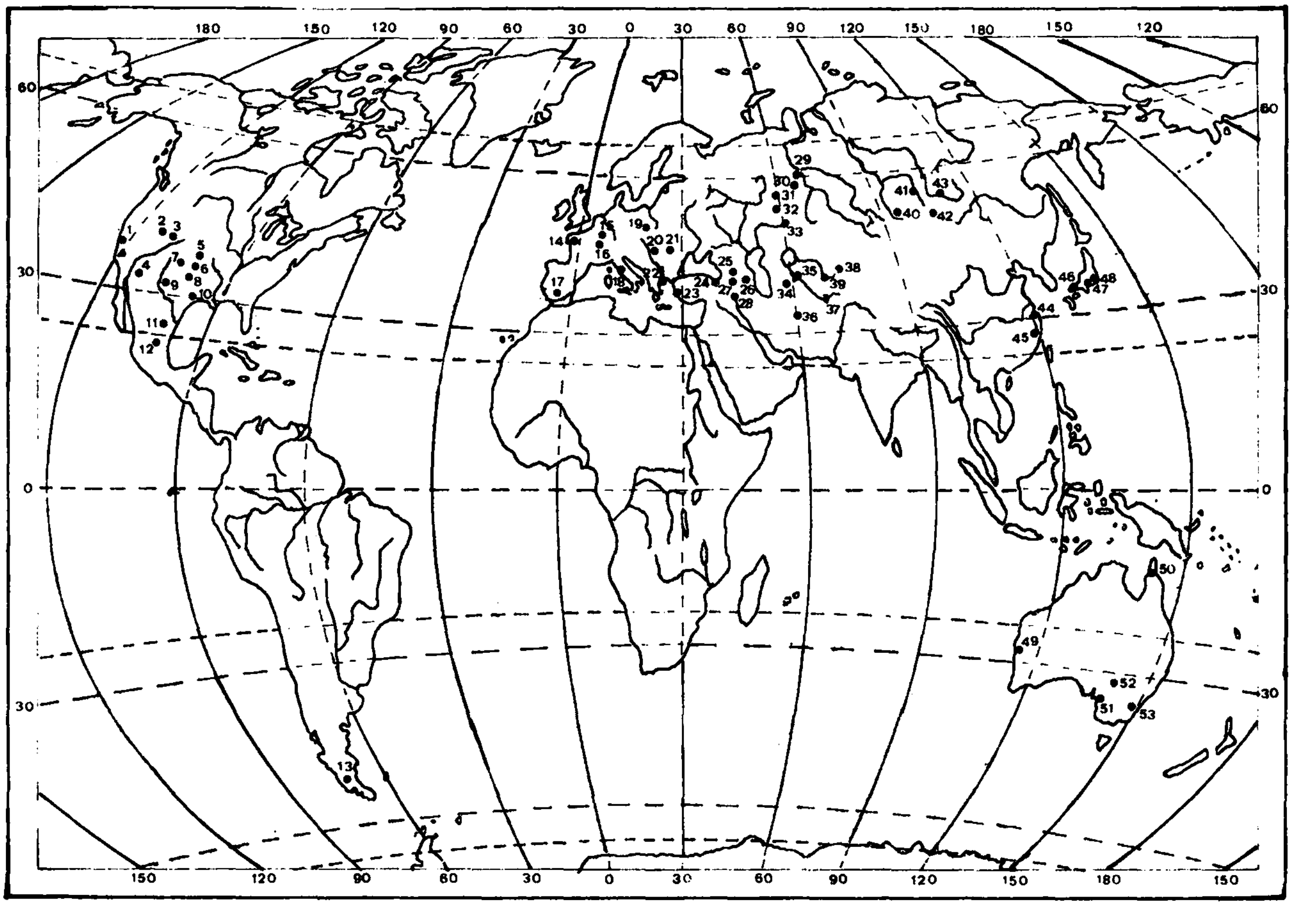
  Southwest Utah: the largest deposit of alunite discovered to date lies in the Wah Wah Mountains (Figure 12).

  The deposit, discovered in 1970, is the property of Earth Sciences Inc. which formed a new company with National Steel Corp. and South Wire Co. for exploitation of the area.

  The available ore reserves are said to range from 800 million to 1,000 million t, with an amount of alunite between 35 % and 40 %, the average being 39 % (Al_2O_3 = 13 % to 14.75 %).

Figure 11

World distribution of alunite deposits

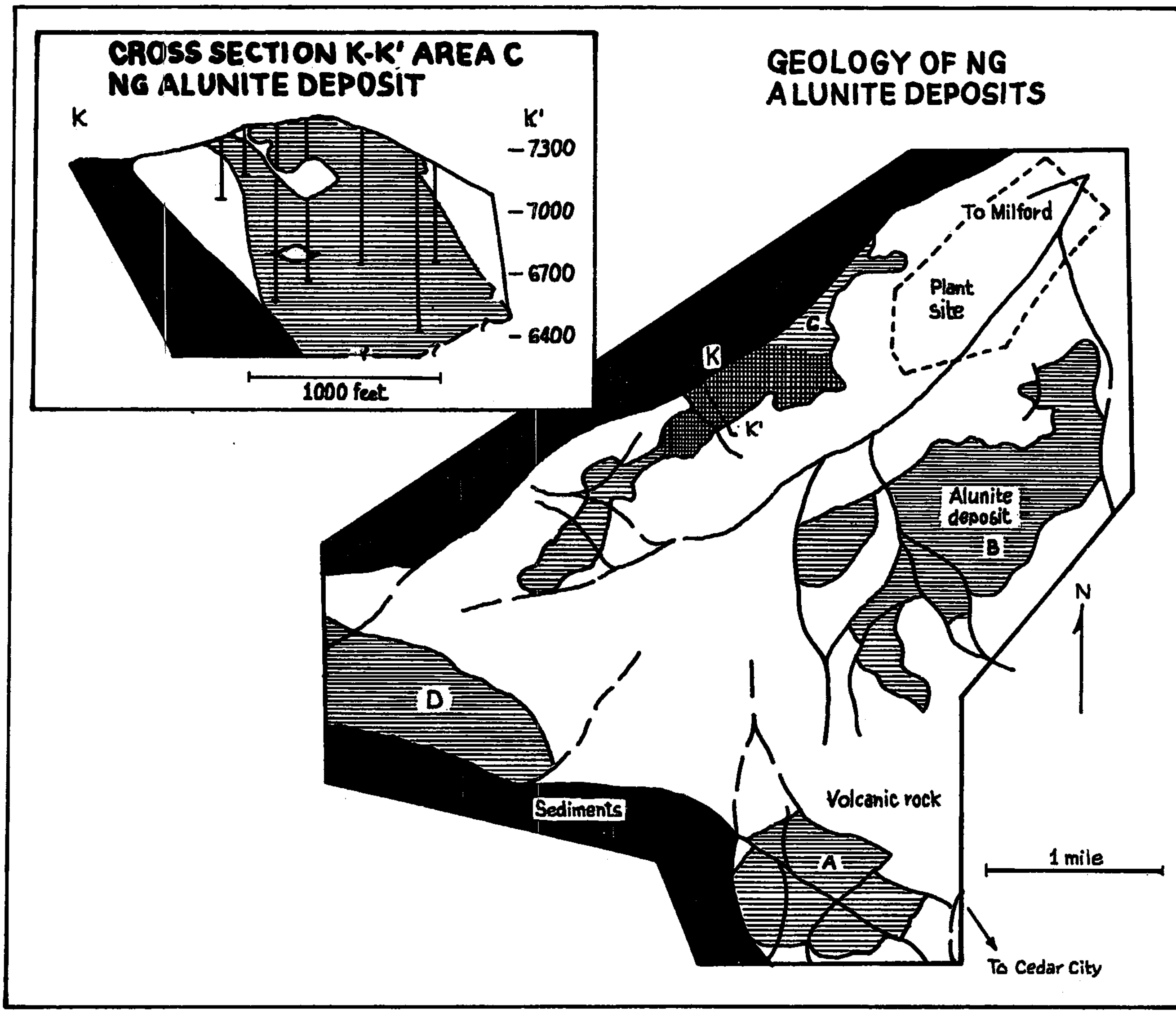


1 + 12	North America	13	South America
14 + 16	France	17	Spain
18	Italy (see fig. 1)	19	Germany
20	Czechoslovakia	21	Roumania
22	Greece	23 + 24	Turkey
23 + 27	USSR	28	Iran
29 + 43	USSR	44 + 45	China
46 + 48	Japan	49 + 53	Australia

from: M.A. Kashkay - Alunite deposits, their classification and associated processes. Izvest. Akad. Nauk SSSR, Ser. Geol. (1960) p. 58

Figure 12

Geology of alunite deposits in the Wah Wah mountains, Utah



From: E/MJ, August 1974, p. 78

Three zones are distinguished in the deposit:

- a zone of intense silicification or opalization consisting of massive silica replacement of the original volcanic rock;

- a zone of quartz and alunite mineralization containing 30 % to 70 % alunite and 30 % to 70 % silica (quartz and opal).

- a clay zone comprising kaolin and a smaller quantity of quartz, alunite and sometimes montmorillonite.

Alumina and potassium sulphate are expected to occur in the following percentages: Al_2O_3 = 14.5 %, K_2SO_4 = 8 %.
K_2O sometimes is replaced by Na_2O.

In the region of White Horse, 4.5 miles northeast of Marysvale, Utah, alunite occurs in veins, shoots and replacement bodies in the altered zone of the upper part of a vesicular lava bed(quartz latite).The alunite which is present as minute lace and flakes has formed by the action of sulphatic solutions and is associated with kaolin and quartz. The ores constituting replacement bodies, veins and seams, have the following composition:

	Replacement bodies %	Veins and seams %
SiO_2	47.88	13.40
TiO_2	0.62	0.77
Al_2O_3	20.33	31.55
Fe_2O_3	0.97	0.56
FeO	-	-
MnO	-	-
MgO	-	-
CaO	-	-
Na_2O	0.10	0.79
K_2O	4.59	8.64
H_2O+	6.82	10.64
H_2O-	0.10	0.08
CO_2	-	-
P_2O_5	-	-
SO_3	19.60	33.80

The ore in replacement bodies contains 48 % alunite, that in veins and seams contains 85 % alunite.

Alunite is also found at Wickenburg, Maricopa County, Arizona, three miles west of Morriston. The mineral, which occurs in various outcrops associated with clay minerals, has formed by the action of hydrothermal fluids on acid volcanites (rhyolites).
This deposit is expected to contain 30 % alunite, unfortunately accompanied by a large amount of reactive silica. Some copper minerals seem to be present in the lower part of the deposit. Probable ore reserves: 200 million t.

Another deposit is found in the Red Mountains at Hinsdale County, Colorado. The ore reserves are 250 million t, with not less than 30 % alunite, disseminated in a very homogeneous way. This is the most promising deposit in Colorado. Other small deposits occur in Nevada. Alunite associated with small quantitities of kaolin und halloysite is found in the Aspen Mountains, Southwest Wyoming; the alunite content sometimes is 90 %.

- Central America - Mexico

A deposit found near the town of Juventino Rosas, in the State of Guanajiuato, consists of 116 million t of ore with an alunite content ranging from 25 % to 50 % in a silica gangue (Al_2O_3 = 10 %, K_2SO_4 = 4.3 %).

- South America

There is a large deposit in Patagonia, Argentina; other large bodies of alunitic rocks constitute the upper parts of copper deposits in the Andes in Argentina, Chile and Peru.

- Australia

Deposits of alunite are found at Pidinga in the west margin of the Nullarba Plain (South Australia) and in the district of Chandler (Western Australia). In both these deposits the alunite, in fine grain associated with kaolin and quartz, occurs in Tertiary clays. In the Pidinga deposit the mineral has 7.5 % K_2O (about 65 % in alunite). The reserves amount to 250,000 t. The Chandler deposit is larger and is exploited for the production of potassium sulphate.

- Japan

Large deposits of alunite are found in all the late Mesozoic and Tertiary volcanic districts. The most important are those at Ugusu (in the prefecture of Shizuoka) with reserves of 30 million t; at Nishina (in the peninsula of Izu) with reserves of 8 million t; and Fukuyama with 10 million t. The alunite was formed by the action of hydrothermal sulphatic solutions. Chemical compositions of various ore samples from these deposits range as follows:

SiO_2	0.51 - 62.18	Na_2O	0.66 - 1.82
SO_3	6.92 - 27.61	K_2O	1.26 - 8.66
Al_2O_3	10.60 - 37.55	H_2O^+	6.40 - 18.36

- USSR

In Russia there are deposits which are connected with intrusive magmatism, effusive magmatism and post-volcanic activity. They are said to be the most important deposits in the world.

In the metallogenic district of Dachkensan there are alunitic deposits at Severo-Zapadnal, Kivar-Kar, Alunitdarskoe and Zaglik, all connected with magmatic intrusions. The contact aureoles of these intrusions are formed by ferriferous skarns in the vicinity of magmatites and by alunitic mineralizations of a different kind at increasing distances. In the Zaglik deposit, the farthest from the magmatites, the mineral contains about 50 % alunite (but the average is probably about 40 %). In the basin of the river Arman, north of the Ohkotzk Sea, there are deposits connected with effusive magmatism. In the lava and liparitic tuffs altered by the action of acid hydrothermal solutions, veins of alunite were formed; there has also been a diffuse impregnation of alunite and dickite over a thickness of 20 m in one bank of tuffs.

Solfataric and hydrosolfataric activity of the most southern of the Kamchatka volcanoes has produced alunitization and kaolinization of lava, basaltic and andesitic tuffs,as well as the formation of alunitic muds on the bottom of a sulphatic lake. Sedimentary lacustine alunite of sulphuric origin was also formed in crater lake Kipyshcheye, in the island of Kunashir, Kurile Is. The alunitic muds that are deposited on the bottom of the lake consist of 35 - 40 % alunite in small rhombohedra and splinters with dimensions of 0.005 mm to 0.008 mm associated with kaolinite, sulphur, opal, quartz, pyrite, marcasite and fragments of plagioclases and pyroxenes.
Superacid waters produced by hot springs and geysers of the Ebeco volcano in Kurile Is, have caused alteration of the volcanites and the formation of alunite.

Of all the deposits known in the USSR the most important seems to be Zaglik at Kirovabad near the Caspian Sea. This deposit, of some 100 million t, justified the installation of the plant which has been in operation since 1966. It uses an alkaline process and was due to reach a capacity of 500,000 t/y of Al_2O_3 by 1974.

These alternative sources would enable the USSR to develop a far greater production of Al from alunite than it has at present.

- China

There are deposits of the same type as the USSR Dachensan deposit. They are located at Fanchan and Taifou where the alunite has formed on acid volcanites, and amount probablyto2 billion t of alunitic rocks.

- Europe

Very little information is available. Some deposits are said to occur in France in the Puy de Dome department but nothing is known about their extent.
In Spain, at Segovia, there is a deposit of supergenetic origin; it seems that it will be commercially developed, but no data are available so far.
In Greece too, it is possible that some deposits exist in the Milo island. These deposits could perhaps be commercially developed. Some other deposits are too small. Some deposits of little or not yet known extent occur in Roumania, Bulgaria, Hungary, Czechoslovakia.

- Middle East

Iran: 100 million t of alunitic rocks are said to occur 150 km WNW of Teheran. No information is available as to the grade of this ore. An agreement has reportedly been signed by Iran and USSR for the joint exploitation of this deposit.
Pakistan: In the volcanic area lying NW from Pakistan near the frontier with Afganistan there probably exists a deposit. Good deposits are expected to exist because of the presence of native sulphur and of "copper porphyries".

Turkey: Alunitic rocks are present in three districts, the most important of which should amount to 33 million t with 22 % alunite.

<u>Composition of alunite extracted from typical deposits in various countries</u>

	ITALY (Tolfa)	USA (Marysvale)	USSR (Azerbajan)	ITALY (Tolfa sodium alunite)
SiO_2		0.22	0.10	2.57
Al_2O_3	39.65	37.10	36.82	36.07
K_2O	10.02	10.46	7.91	4.30
Na_2O		0.33	2.40	3.51
Fe_2O_3		traces	1.08	0.63
CaO		traces	0.10	0.39
SO_3	35.50	38.34	29.00	36.80
P_2O_5		0.58		
i.l.	14.83	12.90	13.40	15.26

2.1.3 Observations

Alunitic ores can constitute an excellent source of Al_2O_3 and its derivatives. As has been seen, world alunite occurrences are said to amount to many million t, probably 10 billion t, although this figure has never been verified.

Unfortunately the situation in EEC countries is unsatisfactory, so far as present knowledge goes. The fact is that 50 million t of alunitic ore containing 25 % alunite, with 37 % Al_2O_3, are equivalent to 9 million t of bauxite with 50 % Al_2O_3. Therefore to replace 45 million t bauxite, alunite ore reserves as high as 250 million t would have to be available within the EEC.

Though alunite deposits of such extent are not likely to occur in EEC countries, it is felt all the same that no effort should be spared in carrying out further investigation and prospecting,directed towards discovering additional occurrences and assessing their nature and extent.

Italy, with its volcanic regions, should be a good field of exploration.

2.2 Extraction processes - General

Unlike leucitic deposits, each alunitic deposit has its own peculiar features as to form and dimensions of the ore body and as to the character of the ore. The cost of mining (and beneficiation) should be calculated for each individual deposit and even then only for those deposits that have been thoroughly investigated.
As that is not the case with the deposits we know of, particularly in Italy, only general accounts will be given concerning mining and treatment.

As already said in regard to leucite, it is useless to plan the exploitation for Al_2O_3 of any alunite deposits that cannot be guaranteed beforehand to yield sufficient raw material, over at least 40 - 50 years, for the production of 400,000-500,000 t of Al_2O_3/year. With an average 30 % alunite content (which is not high) corresponding to 37 % Al_2O_3, and assuming an 80 % mining yield of Al_2O_3, the deposit should amount to at least 225 million t of rock.

This stated in advance, another essential factor for economic treatment of the rock is that the alunite be uniformly distributed. Extremely vast deposits occur in the world (several hundred million t), but they contain alunite distributed very unevenly and which is not pure.

Since alunite is almost always pretty well dispersed in the matrix, even when in a uniform manner, the concentration (beneficiation) treatment of alunite rocks is considered a process so costly as to make this mineral non-competitive from the outset against other sources of Al.

Therefore the only pretreatment generally given is crushing before dispatch to the digestion plant (see, for example, at Alumet - USA). In the USSR, on the other hand, for the poorer rocks a flotation process is adopted with the use of synthetic tannin (Syntan n° 5) or sodium polyphenolsulphite.

An analysis of a concentrate (from Russian alunite) shows the following composition:

Al_2O_3	30.00	Fe_2O_3	1.70
K_2O+Na_2O	7.70	CaO	0.75
SO_3	29.00	TiO_2	0.40
SiO_2	18.45	i.l.	12.00

In general one can say that washing with water and crushing the material to an appropriate grain size should permit the separation of the heavier particles (quartz) from the very fine ones (clay).

2.2.1 Mining of alunitic rocks

To evaluate the costs of mining of the alunitic rocks, we will consider as an example the type of deposit at Tolfa (Latium), Italy. In this deposit the mineralized rock consists mainly of quartz, kaolin and alunite. The alunite content that would result from total mining of the whole area, that is the zone of diffuse mineralization with a low alunite content and the zone with high content, would be probably around 15 %.

Mining

Mining can be carried out by the use of motoscrapers, rippers and caterpillar tractors. Let us assume that the reserves amount to 30 million t; as compared with the mining of leucitic tuffs the cost is slightly higher because the mining zone is not located on level ground. We have evaluated the cost per t of mineral transported to the treatment plant to be 320 Lit. (0.360).

Beneficiation

Treatment tests of the mineral in question have never been performed; however, we believe that a treatment can be achieved by following the phases indicated below:

- elimination of the kaolin (which is present in very fine grains) by a log-washer;

- grinding of the mineral. As alunite has a hardness of less than 4 and is very brittle (quartz is rated at 7), by choosing an adequate crushing method it should be possible to reduce most of the alunite to fragments considerably smaller than the quartz fragments;
- screening to separate the alunite from the quartz.

However, such a process can be adopted only in cases where the concentrate obtained has a 70 % alunite content.

To obtain 1 t of 70 % concentrate, 5.85 t of ore must be treated; as the extraction yield of alunite is about 80 %, and the original ore has a content of 15 %, 4.85 t of waste must be disposed of per t of concentrate.

Assuming that the treatment cost is around Lit. 700/t (0.789) and the transport cost is Lit. 250/t, the total cost for 1 t of alunite concentrate at 70 % (with a production of 340 000t/y) would be Lit. 7 200 (320 x 5.85 + 700 x 5.85 + 250 x 4.85) (8.117).

2.2.2 Summary of costs

One can calculate the following figures for 1 t of Al_2O_3:

- Al_2O_3 content		25.9 %
- Al_3O_3 recovery rate		90 %
- ratio of concentrate to Al_2O_3	about	4.30 t/t
- mining cost of alunitic rock		7,200 Lit./t (8.117)
- rock to be treated / t Al_2O_3 (4.3 x 5.85)		25 t/t
- cost of the raw material/t Al_2O_3 (4.3 . 7,200),(4.3 . 8.117)		31,000 Lit./t (34.95)
- rock to be treated for the production of 500,000 t/y Al_2O_3		12.5 million t

A deposit of 30 million t would be exhausted in less than three years.

2.3 Recovery processes

Some of the best-known processes for the exploitation of alunite are described below.

2.3.1 The Alumet process

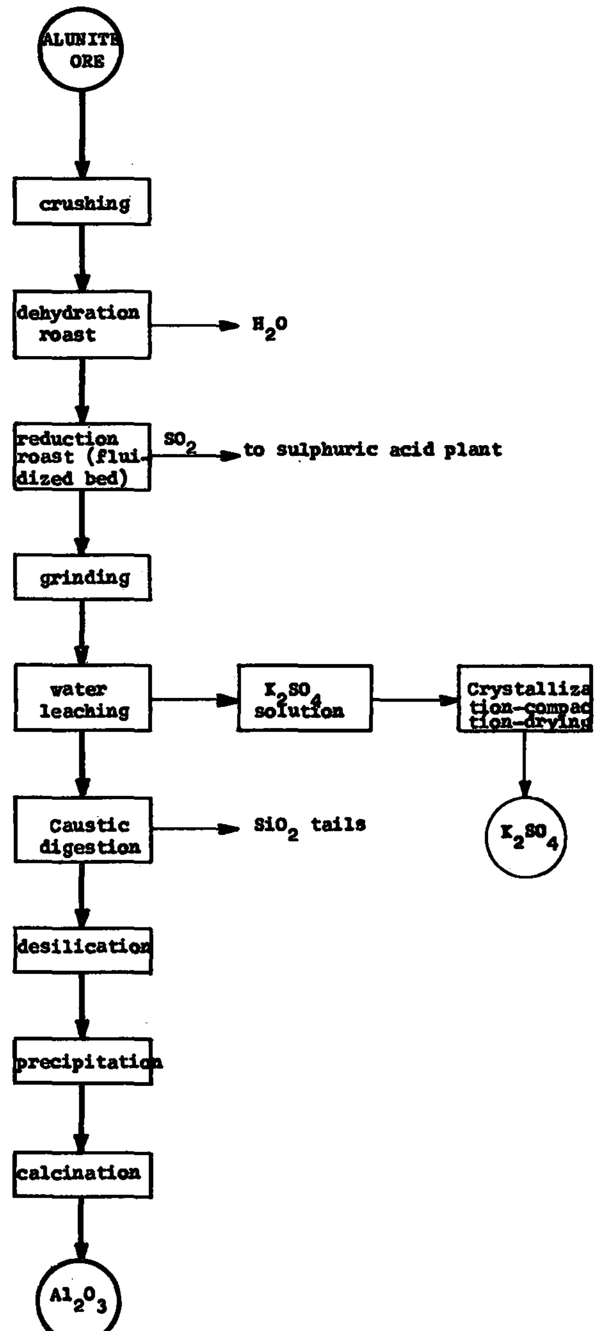
(The Earth Sciences - National Steel Corp. and South Wire Co.)

The process, which at present is being tested in a pilot plant built in 1973 at Golden, Colorado, with a capacity of 12 t/h of rock (that is, about 1.2 t/h Al_2O_3) is based upon the alkaline leaching of the roasted material, followed by a modified Bayer process.

The diagram in figure 13 shows the most important steps of the process. These are:

- on-site crushing to about 1 inch with jaw chrusher;
- further grinding at the plant to a particle size of 1/8 inch;
- dehydration in a rotary kiln at 400 - 700° C (the temperature must never be beyond that necessary to release SO_2);
- feeding to a wet fluid bed reactor with input of reducing gas (for example recycled NH_3). Under these conditions the aluminium sulphate reacts by decomposing, with release of SO_2 that is carried off to a H_2SO_4 plant and from there to the production of fertilizers;
- the roasted material is ground to 14 - 16 mesh (1.5 - 0.25 mm) and then is leached with water. The potassium sulphate, K_2SO_4, goes rapidly into solution. The solution is filtered and sent to a crystallization plant, where it is concentrated and the salt dried out;
- the residue, consisting of quartz and gamma Al_2O_3, is subjected to alkaline attack. Digestion takes place under atm.pressure, at 95°C. The alumina goes rapidly into solution and forms sodium aluminate which is treated in accordance with the Bayer process (hydrolysis with seed,or input of CO_2).

The process, based on the production of 500,000 t/y Al_2O_3, 250,000 t/y K_2SO_4 and 480,000 t/y H_2SO_4, should be competitive with the Bayer process. The plant should go into operation at the end of 1977 or at the beginning of 1978. The capital investment is estimated at 120 million dollars.



ALUMET PROCESS

From E./MJ-August 1974

Fig.13

Three particularly important aspects are the following:

- use of a domestic raw material;
- absence of red mud residues, therefore no environmental problems;
- attack of Al_2O_3 under atmospheric pressure, thus no need for equipment that has to work under pressure; consequent saving of capital and operating costs.

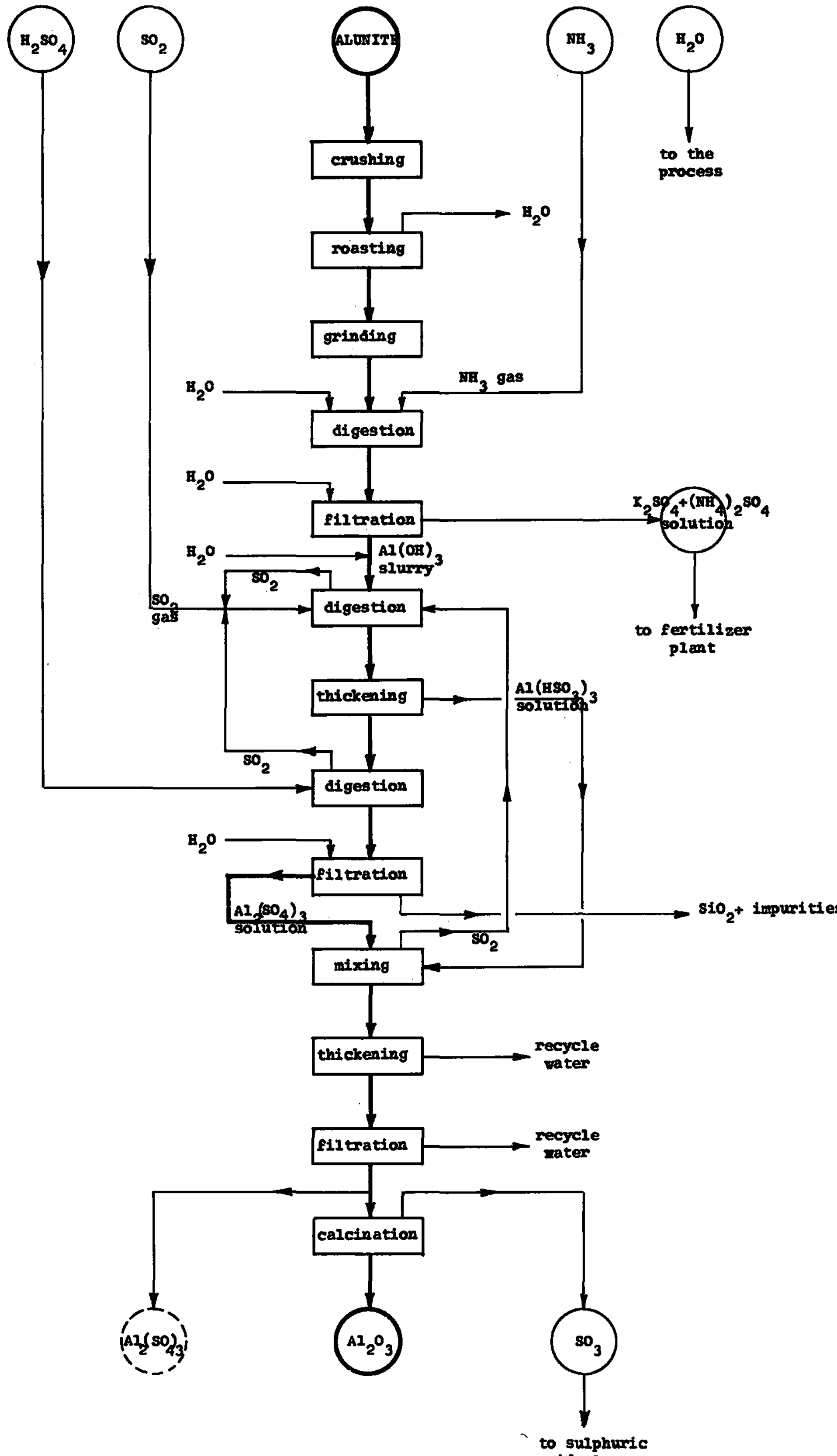
2.3.2 The UG process, University of Guanajuato, Mexico

The process, called "UG", is being carried out in a pilot plant. It was designed and developed expressly for rocks with an alunite content lower than that of the Utah ore or the ores existing in Australia, USSR or Argentina.

The process consists of the following steps (see block diagram in figure 14[x]):

- crushing in two stages to a diameter of 1 inch;
- roasting in a rotary kiln at 750°C (elimination of the water of constitution);
- grinding in a ball mill to a particle size less than 20 mesh (8.5 mm);
- NH_3 and H_2O addition at boiling temperature; $(NH_4)_2SO_4$ is formed, K_2SO_4 is dissolved; SiO_2 and Al (OH_3) remain insoluble;
- filtration of the residue from the solution. The solution is sent to the concentration and crystallization plant, where the salts destined for the production of fertilizers are formed;
- forwarding of the residue, together with water, to a second reactor. Here the slurry is brought to react with SO_2 at about 80°C. An acid solution containing Al $(HSO_3)_3$ is formed.

x) This is the basic process. Recently two alternative ways have been proposed.



H_2SO_4
SO_2
ALUNITE
NH_3
H_2O
to the process
crushing
H_2O
roasting
grinding
H_2O
NH_3 gas
digestion
H_2O
filtration
$K_2SO_4+(NH_4)_2SO_4$ solution
to fertilizer plant
H_2O
$Al(OH)_3$ slurry
SO_2
SO_2 gas
digestion
thickening
$Al(HSO_3)_3$ solution
SO_2
digestion
H_2O
filtration
$Al_2(SO_4)_3$ solution
SiO_2+ impurities
SO_2
mixing
thickening
recycle water
filtration
recycle water
calcination
$Al_2(SO_4)_3$
Al_2O_3
SO_3
to sulphuric acid plant

Fig. 14

- some concentration of the residue composed of unreacted Al $(OH)_3$, sulphites, SiO_2 and so on;
- the thickened residue is sent to a third reactor where it reacts at boiling temperature with H_2SO_4; $Al_2(SO_4)_3$, which goes into solution, is formed. The sulphites decompose, releasing SO_2 which recycles. The silica remains insoluble and is eliminated by filtration;
- mixing of the $Al_2(SO_4)_3$ solution with the Al $(HSO_3)_3$ solution in an appropriate reactor at boiling temperature. Depending on the proportions of the mixture either a basic sulphate of aluminium (for example, Al (OH) (SO_4)) or a mixture of basic sulphate and aluminium hydrate is formed.
  The impurities - Ti, Fe, Ca, etc. - remain in solution, whereas the basic sulphate precipitates in a reducing and weakly acid medium (pH 2)
- concentration and separation of the precipitated salt;
- calcination in a kiln at $T > 1{,}300\ ^{\circ}C$; alpha Al_2O_3 and SO_2 are formed. As an alternative one can obtain aluminium salts.

The industrial plant, for the production of salts of Al, would be constructed at Salamanca by "Guanos y Fertilizantes de Mexico" for a fairly small production: 5,000 t/y $(NH_4)_2SO_4$ - 2,260 t/y K_2SO_4 and 3,990 t/y Al_2O_3.

2.3.2.1 Specific operating data

The specific data which have been communicated, based on a capacity of 30,000 t/y alunite, are the following:

- alunite	t/t finished product	2.673
- NH_3	" " "	0.118
- S	" " "	0.0134
- CH_4	" " "	0.1089
- steam (70 psi)	" " "	3.95
- H_2O (recycled)	m^3/t " "	25.7
- H_2O (process)	" " "	9.32
- Kwh	/t " "	146
- labour	h/t " "	6.17

Distribution of final products/t:

- Al_2O_3	0.356 t
- $(NH_4)_2SO_4$	0.444 t
- K_2SO_4	0.201 t
- SiO_2 (waste)	0.00154 t

The Al_2O_3 recovery rate should be 90 - 92 %

The alkali recovery rate should be 94 - 95 %

Here too, the work is done at atmospheric pressure.
Each reaction lasts from 10 to a maximum of 35 minutes.

2.3.3 The "Russian" process

The process is performed at Kirovabad in the Republic of Azerbajan. It uses the alunite occurring at Zaglik.

The crushed ore is subjected to roasting and then to hydrothermal treatment. Al_2O_3, K_2SO_4, Ga and V are produced.
Leaching of the roasted ore follows the alkaline route and not the acid one used in Mexico.

The ore is said to have the following typical analysis (in %):

Al_2O_3	21.1 (19.2 % of which bound as alunite)
SO_3	20.1
K_2O	3.6
Na_2O	1.4
SiO_2	40.5
Fe_2O_3	5.1
H_2O	6.5

It undergoes processing in the following steps:

- grinding;
- roasting at 450° C in a reducing atmosphere, with addition of elementary S;
- sending of the output gas, containing about 30 % SO_2, to the H_2SO_4 production plant;

- leaching of the ore containing the reduced alunite with a caustic solution at 85°C. One obtains a solution of aluminate with an Al_2O_3 concentration of 100 - 120 g/l and a C.R. of 1.8 - 1.9;
- separation of the insoluble silica by means of thickening and filtration
- desilication of the aluminate solution and decomposition by hydrolysis with formation of Al $(OH)_3$;
- concentration of the exhausted solution, separation of the sulphates K_2SO_4 and Na_2SO_4 and recycling to the leaching unit.

The recovery yield of Al_2O_3 is 90 % and the production of K_2SO_4 with a titre of 51 % and H_2SO_4 with a titre of 99.9 % is obtained. The process also includes recovery of Ga and V_2O_5.

As a modification of this method, a method of simultaneous treatment of alunite and nepheline has been proposed, or rather, a process that entails mixing the aluminate solutions that originate from alkaline digestion of the two minerals.

Some additional comments concerning the "Russian" process

For the reducing roasting of alunite, vertical kilns are being increasingly used with a series of 5 - 6 gratings arranged in a cascade fashion with an angle of inclination greater than the angle of slide of the material; the alunite is granulated. This type of kiln seems to ensure better contact with the reducing gas and a more uniform temperature distribution. The optimum temperature lies between 520 and 580°C.
The average reduction yield is 90 - 93 %.
The amount of SO_2 in the exhaust gas is 30 - 47.5 %.

2.3.4 The acid process

Finally we shall mention the acid process employed by Kalunite Inc. during the Second World War for the alunite at Marysvale (Utah).
The process was based on direct attack with H_2SO_4 and consisted of the following steps:

- crushing and grinding;
- roasting at 560°C for 60 minutes;
- leaching with a dilute solution of H_2SO_4 (about 6 N) at 90 - 95°C for 60 minutes with direct production of alum.
  This attack is said to give a better recovery yield than that obtained with NaOH;
- re-roasting with decomposition of the aluminium sulphate into gamma Al_2O_3 and SO_2. The SO_2 goes to recycle;

- leaching in order to separate the potassium sulphate (which is sent to the production of fertilizers) from Al_2O_3.

2.3.5 Observations on the processes here described

From our review of these processes it seems that if it is decided to exploit the Italian alunites or any (as yet undiscovered) alunites present in the Community countries in sufficient quantity, then the alkaline route, for example the "Alumet" process, should be employed for the following reasons:

- the process and plant are relatively uncomplicated;
- it would be possible to use at least some of the Bayer equipment: filters, thickeners, concentration units, etc.;
- part of the process could be linked to the Bayer process;
- with acid digestion, which carries into solution even iron compounds, the raw materials have to be completely free from Fe_2O_3 in order to avoid laborious purification treatments.

3) Comments and conclusions

If we examine the current situation regarding bauxite reserves and the present and future possibilities of using bauxites in the EEC countries, the following fundamental points emerge:

In the next few years the world resources of bauxite should be sufficient. As a matter of fact, available data differ widely, the figures ranging from a minimum of 10.10^9 t to a maximum of 30.10^9 t of mineral. This notable difference is probably due to the inclusion or omission of low-grade (high silica and/or low alumina) bauxites as well as to uncertainties in evaluating the actual extent of the deposits.
On the other hand, seeing that most of the high-grade deposits were discovered only recently (for example the Australian deposits were discovered at the end of the 1950s), it is reasonable to suppose that further reserves will still be found. It is obvious that this particular distribution carries with it two questions, expecially for EEC countries:

- what will the cost of the mineral (including transport costs) be in the future?
- will supply sources always be available?

It is not easy, perhaps not even possible, to make forecasts about the costs, considering the number of factors involved. We can only cite a relatively recent example: in 1974 the incidence of the Jamaican bauxite price on the USA ingot price increased suddenly from 6 % to 11 %. Of course, besides ensuring easily

available supply sources, discovery in the EEC countries of alternative minerals which might compete with bauxite in the future would also have a deterrent influence on the price policies of bauxite-supplying countries. It is felt, for instance, that some of the poor minerals occurring in EEC countries (such as leucites or alunites) can provide significant alternative sources.
On the assumption that aluminous minerals other than bauxites are several hundred times more abundant than bauxites, the moment will certainly come when bauxites will no longer be considered irreplaceable.

Meanwhile, the fact that a very rich deposit of alunite was discovered as recently as 1970 in the Wah Wah Mountains, Utah, gives us reason to be optimistic regarding further discoveries during the next few years as a result of new prospecting.
In this connection it is interesting to note, according to forecasts made in the United States, that clays will be used for the production of alumina by 1983, whilst anorthosites might come into use in about the year 2000, plus or minus 10 years.

At present, the estimated specific cost for anorthosites is twice as high as for bauxites (and higher than it is for clays.)

Two more points should be considered:

- if poor minerals are used in the future, the increased consumption of raw materials and thus of energy will no longer play such an important role because the less expensive nuclear energy will be available;

- the use of non-bauxite sources will permit either to utilize process residues or to eliminate them; the problem of red mud disposal (about 20 to 50 % of the bauxite) would therefore be partially solved.

As far as the exploitation of non-bauxite sources in EEC countries is concerned, there are very good prospects in Italy, first of all for leucitic lava and tuffs, and probably for alunites.

The deposit of leucitic lava at Civita Castellana (amply described in the report) could ensure for over 50 years the supply of enriched ore to a plant with a capacity of 500,000 t/y of Al_2O_3 and 500,000 t/y of K_2O, and for much more than 50 years the supply of ore for the production of Al/Si alloys.

Another extensive deposit is the one at Carbognano. However, in spite of its favourable characteristics, it unfortunately does not appear to be exploitable at present because of the extensive buildings, public works, etc. in the area.

Other deposits of leucitic lava and tuffs probably occur in nearby zones (further prospecting would therefore be advisable). The leucitic tuff deposits near Lake Vico (Latium) seem to offer good prospects for the near future; these deposits have also been amply described in the report.

Up to the present, no exhaustive mineralogical or chemical studies of these deposits have been carried out. However, on the strength of the ore samples examined as well as on the ore characteristics assessed so far, it seems advisable to carry out further research directed to ascertaining:

- the existing mineral reserves
- the physical, chemical and mineralogical characteristics of the tuffs
- the most suitable enrichment process in view of industrial exploitation. In fact it is quite possible that more detailed studies will prove the use of tuffs to be more economical than that of lavas (mainly because of the friability of the tuffs which results in simpler mining processes), contrary to the current belief.

In order to render the process of Al_2O_3 recovery from leucites or alunites competitive with the Bayer process, it is necessary also to exploit the secondary products, K_2O and residue for cement production.

If a plant producing 500,000 tons/y Al_2O_3 were installed, an equal production of K_2O and 13 x 500,000 t/y of cement should be taken into account.

In the case of Italy, this output of cement would be equivalent to about 19 % of the 1976 production (and to 13.5 % of the expected 1978 production), whilst the K_2O production would meet the whole fertilizer import requirement and leave as much again for export.

Other methods can be investigated however, that could allow of producing aluminium or its alloys directly from non-bauxite minerals, without going through the stage of Al_2O_3 production and probably with a saving of energy.

The problem of how to exploit secondary products (K_2O and cement) would thus be eliminated.

The most promising techniques seem to be the chlorination process or the direct reduction process to produce aluminium in the form of Al/Si alloys.

As regard alunite-based rocks, the known deposits are not reported to be sufficiently large to justify exploitation for the production of alumina (and aluminium). Nevertheless it is quite probable that deposits yet undiscovered exist, particularly in volcanic zones.
A preliminary study in this direction would be desirable.

Data on bauxite supplies to Italy and on Italian aluminium production have been given as follows:

	1974	1975	1976	1977
	1000 t			
- Italian production	212	190	206	
- Bauxite supplied to Italy				1,840