Essential Readings in Light Metals: Alumina and Bauxite.
Edited by Don Donaldson and Benny E. Raahauge.

1. BAUXITE

Owing to the high concentration of aluminum in bauxite, the relative ease with which the bauxite can be mined and the aluminum compounds separated, this remains the most widely used raw material for alumina production. With the current global aluminum metal production of around 50 million tons per annum, some 200–300 million tons of bauxite needs to be mined to meet the demand for metallurgical grade alumina.

Most bauxites are found in tropical regions and relatively close to the surface. Typically these bauxites contain between 30 and 60 wt-% aluminum oxides (mainly in the form of the tri- or monohydroxides: gibbsite, nordstrandite, boehmite, and/or diaspore); with iron, silicon, and titanium compounds making up the main part of the remainder. However, the physical properties and mineral composition of bauxite vary widely, which makes the classification of bauxite difficult, and also often requires recovery—and beneficiation—as well as digestion processes to be tailored to a specific resource. One of the most important aspects of the mining operation is to produce a homogeneous material with respect to available aluminum and amount of reactive silica.

The papers included in this section are aimed at addressing the variable mineralogy and structure of bauxite and the impacts this can have on Bayer plant operations. The section also contains papers on mining sustainability and mine rehabilitation, an equally important aspect of the operation. The novel approach to build an over-land bauxite slurry pipeline for transporting the mineral from the mine to the refinery is included as an example of the sometimes challenging logistics of the mining operation. The list of recommended readings contains additional papers on the use of specific bauxite resources and the sometimes required beneficiation and pre-treatment of the mined bauxite to improve the extraction or further processing, which can extend the mine life substantially.

Linus Perander

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BAUXITE - ITS TECHNICAL AND ECONOMICAL HISTORY DURING THE LAST HUNDRED YEARS

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INTRODUCTION

It is a well known fact that bauxite was discovered in France near the village of "Les Baux de Provence" in 1822, by a chemist named Berthier, who found an ore which was rich in alumina and poor in iron. But only a few know that the original name was "Beauxite" after the name of the village which at that time was "Les Beaux". This word was used for the first time in 1847 by A. Dufresnoy. The name of the village was changed to "Les Baux" around 1885, and finally, it was Sainte Claire Deville who, in 1862, made the name universally accepted to designate the aluminum ore.

Although fairly recent, the history of bauxite is now over one century old. I will now discuss its development, particularly remarkable since the end of World War II, which makes it today the main non-ferrous metalliferous ore.

A distinction must be drawn, mainly, between three periods :

1. from the origin of the mining until the first world war (1914),
2. between the two world wars (1919-1939),
3. from the end of world war II (1945) until today.

PERIOD 1860-1914

The noticeable fact during this period lasting 54 years, is the major role played by France in the world production of both the ore and metal. This explains why, despite other industrial countries being more powerful in other fields, aluminum was then called the "French metal". I will split this period in two equal periods, the mid-point being the application patent for the Bayer Process in 1887.

Period 1860-1887

Mining of bauxite began around 1860, in the region of Auriol in the "Bouches du Rhône" department in the south of France, from which the ore was transported to Marseille by carts. The ore fed the Salindres plant (founded in 1855) in the "Gard" department near Nimes, which at that time was the only plant in the world regularly producing alumina, using the Deville process, and chemical aluminum between 1860 and 1890.

From 1873 the plant received bauxite from the Herault region, where a deposit was discovered incidentally in the town of Villeveyrac during the cutting-through of a railway tunnel.

The production remained low and mainly concentrated in the Herault (to feed the Salindres plant) and started very slowly in the Var department at the end of this period.

The following figures are given for information :

1860	a few tonnes
1870	1,500 tonnes
1880	2,000 tonnes
1887	7,500 tonnes.

Exportation of the ore, which is essentially produced in France, begins at the end of this period. Indeed, two alumina plants consuming bauxite were erected in Germany :

1880	Goldschmischen near Breslau - Chemische Fabrik H. Bergius
1885	Ludwigshafen Giulini.

These two companies produce alum and alumina sulfate and need bauxite to produce alumina. Hence they import from French producers.

It must be noted that white bauxite (low iron content) is strongly sought for the production of alumina sulfate.

Mining is mainly carried out on a small-scale from outcrops.

Period 1887-1914

The registration of the Bayer patent in 1887 followed by the process applied at industrial scale simultaneously with the creation of the Hall-Heroult electrolysis process in 1886, both stimulate the production of metal and, consequently, the mining of the ore. However, the industrial development is concentrated in four countries only :

. in Europe : France, Germany, Great Britain,
. in America : U.S.A.

- Three new alumina plants are erected in France :
  . Gardanne in 1893,
  . La Barasse, near Marseille, in 1908,
  . Saint Louis des Aygalades in 1908.

- A plant is erected in Great Britain in Larne, receiving local bauxite.

- The erection of the Martinswerk plant also begins in Germany at the end of this period in Bergheim near Cologne.

- Finally, in the U.S.A. the HALL process necessitates alumina which is produced from local bauxites found in 1887 in Arkansas, and in 1902 the East Saint Louis plant is erected in Illinois.

During this period production increases rapidly as indicated by the figures below.

	World production	French production	%
1887	8,000 tonnes	7,500 tonnes	92
1890	20,000 tonnes	15,000 tonnes	75
1900	88,000 tonnes	58,000 tonnes	66
1910	355,000 tonnes	196,000 tonnes	56
1913	450,000 tonnes	310,000 tonnes	67

With more than two thirds of the total tonnage France is then a leading producer and is the recognized supplier of the European industrial countries (Germany, Great Britain, France), the U.S.A. being the other producer.

Throughout this period the French mining of bauxite developed in the Var department, around Brignoles where new deposits are mined as early as 1890. This department will subsequently produce the major part of the exported bauxite (75 %).

	French Production	Exported French Bauxite	%
1900	58,500 tonnes	40,000 tonnes	68
1910	196,000 tonnes	114,315 tonnes	58.3
1913	310,000 tonnes	169,000 tonnes	54.6

The Var bauxite is exported via the ports of Saint Raphael, Toulon, Marseilles, and the bauxite produced in Herault is exported via the port of Sete. This exportation is destined to the following countries : Germany - Great Britain - Holland - U.S.A.

France produces a karstic (seam walls are calcic) monohydrate bauxite, whereas the U.S. produce a lateritic trihydrate bauxite.

In France, the mining which is now widely developed is no longer the monopole of a few independents. Various industrial companies, controlled by aluminum producers, are the main operators. Such as to name but a few :

- British group	:	Union des Bauxites (U.B)
- US group	:	Société des Bauxites et Alumines de Provence (SABAP)
- French group	:	Société Electro-métallurgique Française
- Germano-swiss group	:	Bauxites de France.

Unfortunately, no concession can be granted for the mining of bauxite which is therefore covered by the regulations for quarries. Thus this leads to parcelling out to a large number of small mines. Hence, in 1913 in the forty quarries of the Var 258,000 t were produced, which corresponds to an average yearly production of 6,450 tonnes per site. Since seven hundred and fifty workers working ten hours per day are employed, the production is 300 t/man/year. Partial unemployment is already noted then, and 1903 is a dark year which shows a noticeable recession in the production as a result of large stock-piles.

The cost price is 12 F to 14 F (gold franc) per ton and the selling price delivered in French plants or shipping ports is 18 to 20 F/t, i.e. 245 F (1986) or 36 US$.

FIRST WORLD WAR PERIOD 1914-1919

The first world war upsets the hierarchy of the producers. France, which supplied 2/3 of the production before the war dropped to 20 % during the war, to rise again to 30 % only in 1920. On the contrary, to compensate for the allies bauxite production drop, the U.S.A. increases its production as early as 1915 and thus ensures three quarters of the world production. In becoming the leader in the production of bauxite, the U.S.A. stimulates the prospection in the occidental hemisphere and took interest in the deposits of British Guyana, discovered in 1914, and of Dutch Guyana. Hence, in 1917, a small scale production is noted in British Guyana, which will become one of the large suppliers to the U.S.A. between the two world wars.

Table 2 and figure 2 illustrate the evolution of the production during this period which is therefore marked by the major role of the U.S.A., the decline of France, and the timid rise of British Guyana.

PERIOD BETWEEN THE TWO WORLD WARS (1920-1939)

The first world war provides the U.S.A. with the opportunity to assume the leadership of bauxite production.

This production will more than double during the first en years (1919-1929) after the war, as new producers appear :

In Europe :	Italy	in 1920
	Yugoslavia	in 1920
	Greece	in 1924
	Hungaria	in 1926.
In America :	Britistish Guyana	in 1923
	Dutch Guyana (Surinam)	in 1930.

A noticeable fact of this period is the U.S. production drop that will stabilize near 300,000 tonnes, while the world production increases rapidly. Except for the war years (1942 to 1944), the U.S. production will no longer account for much (less than 10 % in 1939).

On the contrary, the production increases regularly in France, making this country the worlds's largest producer at the time of the 1929 crisis (more than one third of the world production). However, France will soon face strong competition in Europe from Italy (Istria region acquired after the war) in 1920, Yugoslavia in 1920, and Hungary in 1926. The Italian production is mainly from the Istria deposits near Trieste. In Yugoslavia, bauxite is exploited in Montenegro, Croatia, and Dalmatia. In Hungary, bauxite was found in the forest region of Bakony near the Balaton lake and the large deposit of Gant is extracted by open-face mining in 1926. Finally, in Greece, bauxite is found in the Parnasse region near Distomon in 1924.

It was a German state-run company, V.A.W. founded in 1917, which undertook prospection works and acquired interests in the mining of bauxite in Italy (Istria), in Yugoslavia (Croatia) and in Hungary.

On the American continent, Britisch Guyana appears as a major producer and becomes the supplier to the U.S.A. and Canada. An affiliate branch of ALCOA the "Demerara Bauxite Company" starts open-face mining of high-quality bauxite deposits. Another affiliate branch of ALCOA, the "Surinamsche Bauxite Maatschapping" starts mining bauxite in Dutch Guyana in the thirties. Just before the second world war, these two countries are the suppliers to U.S.A. and Canada.

This period is characterized by the fact that the bauxite deposits found and mined are controlled by aluminum producers who want to ensure their own supply and do not wish to rely on more or less important mining companies. Each aluminum producer wants to have sufficient bauxite reserves to cope with the development of the production of aluminum. This is the case for ALCOA, then ALCAN on the american continent, and sometimes european producers such as Alais Froges and Camargue (PECHINEY), AIAG (Swiss group), V.A.W. (German Group) and British Aluminum.

Mining sites become larger, particularly open-face mines, and the mechanization of work appears.

Of course, the 1929 crisis is strongly felt in the development of bauxite mining, since the world production only returns to its level in 1936. The cost price varies with the type of sites, the selling price at the plant is 110 F (1939 value), i.e. 231 F (1986) or 34 US$. This tends to indicate that the cost of bauxite had only slightly decreased during this period.

WORLD WAR II PERIOD (1939-1945)

This period witnesses the changing of the aluminum production leadership from Europe to North America. Figures clearly illustrate this fact :

Years	Aluminum world production in Kt	North American production in Kt	%	European production in Kt	%
1939	687	223.5	22.7	374.5	54.5
1943	1950	1284.5	65.9	447.9	23.0

There are three reasons for this shift of the aluminum production from Europe to the North American continent :

a) the european bauxite and aluminum productions fall under German control.

b) european allies cannot meet their bauxite requirements and look to the U.S.A. and Canada.

c) the extraordinary american war effort (particularly the building of 305,000 aircraft necessitating 1.54 millions tonnes of aluminum) requires a huge quantity of aluminum, hence of bauxite.

This war effort is imposed on the two producers ALCOA and ALCAN (founded in 1926), who control the British Guyana and Arkansas deposits. It must be noted that a siliceous bauxite is extracted there and processed using the "Sinter Process" to meet the enormous demands. It is essentially the appearance of the bauxite production overseas and its transport by sea that will increase ceaselessly. This transport will be vital and will come into confrontation in 1942-1943 with the german submarines, numerous in the Atlantic Ocean. Twenty thousand tonnes ore ships are constructed at this time to transport bauxite in the Gulf of Mexico for the U.S.A. and to Port Alfred in Canada. It must be remembered that in 1942/1943 21 % of the ore ship fleet is sunk during the battle of the Atlantic.

The Caribbean zone appears already as a major bauxite producer with an important role that will continue to grow. On the other hand, bauxite is found in Jamaica, Haiti and Saint Domingue in 1942.

This period is marked by the development of mechanization in open-face mines (mainly British Guyana) ; meanwhile in Europe the technique stagnates in the mines which are mainly underground.

PERIOD AFTER THE WAR (1946-today)

This 40 year period, which witnessed the prodigious development of the production of bauxite related to that of aluminum, must be divided into two distinct sections :

a) Period 1946-1973

This twenty five year period ends in 1973, date of the foundation of OPEP and which indicates the beginning of the crisis through which we have been struggling for 14 years. The production of bauxite is multiplied by 20.

b) Period 1974-1987

This period, which begins with the creation of IBA is characterized by the end of the progression and even by a certain crisis in the eighties, crisis that we all know too well now.

Period 1946-1973

This is the golden years for the production of bauxite, period during which production increases at the incredible rate of 8 % per year.

Although production starts again easily at the end of world war II, it stagnates between 1948 and 1950, like the rest of the world economy. The Korean war will be the origin of the new development of the bauxite production.

The development between 1945 and 1950 takes place mainly in the Caribbean (British and Dutch Guyana), the process being slow in Europe. The Caribbean, who played a primordial role during the war as bauxite producers, will mark this period and become the almost exclusive supplier to North America (U.S.A. and Canada). Prospection was intensely carried out in this entire zone during the 1945-1950 period following the discoveries of deposits in Jamaica, Haiti and Dominican Republic. It appears at that time that logistic requirements to transport the bauxite from these areas to the U.S. plants located on the shores of the Gulf of Mexico are easier and cheaper (shorter distances and no trans-shipment in Trinidad).

Owing to the results of the prospections known at the beginning of the fifties and to the economical recovery particularly after the Korean war, projects mushroom in various places. This is especially the case for the Canadian company ALCAN which suffered from the transports of bauxite from Guyana and which strongly envisaged its implantation in Jamaica by erecting two plants. This would offer the following advantages :

- elimination of the bauxite transport with all its inherent problems ;
- no need to modify the existing plants in Arvida to process this bauxite ;
- creation of an alumina industry in a country about to gain its independance ;
- exoneration of import duties of alumina in Canada.

It must be pointed out that the transfer of bauxite from the producing countries to the consuming countries during the 1945-50 period concerned mainly the Caribbean zone : transport by ore ship of the bauxite mined in Guyana and Surinam to U.S.A. (Louisiana - Texas).

This amounts nevertheless to half the world production which is as such transported to industrial countries. This trend will diminish slowly.

From the fifties on, the production progresses rapidly as shown on table 6. In twenty years, the production is multiplied by approximately seven, which is more than doubling every ten years.

Jamaica appears first in 1952 and is the largest bauxite producer as early as 1960. A little less than half the production is processed locally, the other part of the production being shipped to the U.S.A. to feed plants in Louisiana and Texas.

Africa comes next with the mining of bauxite in Guinea, in the Island of Loos as early as 1950 and the start up of the Fria plant in 1960. Large deposits are found in the Boké region, indicating that Guinea owns 30 % of the world bauxite reserves.

Australia enters the scene at the beginning of the sixties, with the mining in Queensland of the Weipa deposits (1963) feeding the Gladstone plant, and the Darling Range deposits in Western Australia, the same year. Previously, the Gove deposit, in the Northern territories had been found in 1952.

But Australia becomes a major producer in 1970/1972 with the mining of the Weipa deposits in Queensland, of Darling Range in Western Australia, and of Gove in the Northern Territories. In 1972, Australia becomes the first producer and has held this position ever since.

In Western Europe the development of the production of bauxite continued, mainly in France, in Greece and in Yugoslavia, although it only amounts to a little more than 12 %. Eastern European countries with planned economies have also participated in the production increase, mainly in Hungary and in USSR, but the share of the world production still remains around 15 %.

The largest producers are the Caribbean countries, and more particularly Jamaica, with their clients located mainly on the North American continent (U.S.A., Canada).

Asia comes on the market with productions in Malaysia, in Indonesia (feeding the Japanese plants) and in India where an aluminum industry is developed by north america producers.

The tonnage of transported bauxite, that is the tonnage transported by ore ships, represents the same percentage (approximately 40 %) but its absolute values has remarkably increased and is no longer limited to the Caribbean sea.

Since there is a bauxite deficit in West Europe, these countries start importing bauxite in the late sixties : australian bauxite from Weipa (1966) then Gove (1972), then african bauxite mainly from Boké (1973). Hence three zones of producing countries appears (see table and figure 7) :
- the Caribbeans,
- Australia,
- Africa (mainly Guinea),

which export to three zones of industrial countries :
- North America (Canada and U.S.A.),
- Europe,
- Japan.

The flow Africa-Europe starts at the end of this period when the Australia-Asia flow, heavy at the end of the sixties, starts diminishing in favor of the Australia-Europe flow. The important point to note is that bauxite withstands long journeys (45 days for the Australia-Europe route).

During this period techniques evolve considerably owing to mechanization on the one hand, and to the capacities of the mining sites on the other hand. In the fifties 3 MT/year open-face mines are in operation in Jamaica and Surinam, followed, in the late sixties, by a 8 to 10 MT/year sites in Australia (Darling Range and Weipa). European underground mines, particularly in France, must adapt to keep up with the trend and remain competitive. They achieve remarkable results owing to the roof bolting support technique, enabling the opening of large galeries and the mechanization of all production operations using large excavating and loading machines. It is then possible to multiply the productivity by four.

Prices of bauxite are mainly determined by the characteristics of the deposits (open-face or underground mining, low or large production) and by their geographical position. Mining costs range from 1 to 4 US$ for open-face mines and from 7 to 10 US$ for underground mines.

Period from 1974 until today

This period is marked essentially by the economical crisis, still present today, caused by the petrol shocks.

The production continued to increase during the first half of this period, but at a much slower pace than before (50 % in ten years that is less than half). It reached its peak in 1980 with slightly more than 92 millions tonnes. However, unlike the preceding years, not all countries benefited from this progression, the production even decreased in some countries.

At the beginning of this period, more precisely in 1974, eleven bauxite producing countries (Australia, Dominican Republic, Ghana, Guinea, Guyana, Haiti, Indonesia, Jamaica, Sierra Leone, Surinam, Yugoslavia) representing 2/3 of the world reserves, found an international group called I.B.A. (International Bauxite Association) similar to the OPEP model. The purpose of this association is first of all to set up a price policy for bauxite, approved by all member countries in order to obtain acceptable revenues. As such it was decided to levy fiscal taxes for exported bauxites, taxes which are included within a wide rande : 1 to 2 US$ for Australia, 8 to 9 US$ for Guinea, 18 to 21 US$ for Caribbean countries (Jamaica, Surinam, Guyana). This sharply increases the price of bauxite from 1975 on and aluminum producers look for a substituting raw material on the one hand, and consume the cheapest bauxites on the other hand.

Table 8 illustrates the progression of the bauxite production worldwide call for the following remarks :

1. The mining of bauxite in Guinea progresses, thus making this country the world's second producer from 1980 on.

2. Australia remains by far the first producer with 30 % of the world mining.

3. Brazil becomes an important producing country as early as 1980.

4. Caribbean countries (Jamaica - Surinam - Guyana) are no longer the sole suppliers of the North American continent. Production decreases continuously, mainly in Jamaica (in 1985 its production was half its 1974 level). This comes from fiscal taxes which incite the U.S.A. to replace bauxite from Jamaica or Surinam with bauxite from Guinea.

5. The production remains stable in West and East Europe.

However, since 1980, a production record year, the world bauxite production is affected by the aluminum and alumina crisis and has had to be reduced by 5.6 % in 1982 and by 16 % in 1983 to deplete the constant bauxite stokpiles kept by the aluminum producers.

The American continent production is the most affected one : production interrupted in Haiti and Dominican Republic, production halved in Jamaica, Surinam. Furthermore, the mines are operated at approximately 85 % of their capacity.

On the other hand, it must be mentioned that the bauxite transfer on the western market, which reached 31.5 MT in 1980 and 23 MT in 1983, is in regression as illustrated by figures 8. This stems from the reduction of Latin American exports to North America. This trend clearly demonstrates the higher competitivity of alumina plants located immediately near large bauxite desposits, and this trend will continue in the years to come.

Foreseeing bauxite price trends is made difficult by large differences in quality between ores and by the fact that bauxite is usually the subject of very long term contracts. However, it can be noted, although with a certain delay, effects similar to those in the aluminum and alumina markets, that is to say a drop in prices despite efforts from I.B.A., the members of which must work out a compromise between a drop of prices (in other words lower export taxes) which lower incomes and the risks of a final disappearance of consuming plants.

I wish to point out that in France, the regular bauxite production drop is governed by a plan set up in 1973 and based on the adjustment of the economic mining of existing reserves with respect to the existing manpower which progressively diminishes naturally.

The French production must stop in 1990 and it has remained competitive with respect to large tropical mines (Australia : Weipa, Guinea : Boké, Brazil : Trombetas) only owing to the implementation of high performance mining methods and machinery. Hence it was possible to increase the productivity (multiplied by 5).

Finally, let's say that if we show on a same table (see table 9) the reserves and productions of the main producing countries, we can see that the first three producers (Australia, Guinea, Brazil) are also the owners of the first three largest reserves, with two third of the world reserves. It is quite normal to find them as the first three producers. In the long run, there will certainly be a production transfer from Australia to Guinea, the country best situated for export.

The last period is therefore marked by the crisis of the aluminum industry in the western world. Most affected are the non-integrated bauxite or alumina sites, with the disappearance in Japan, U.S.A., and Europe of several small or obsolete alumina plants.

Three large mining centers are now in evidence :

1. Australia with three main regions :	
. Queensland - Weipa deposit	10 MT/y
. West Australia - Darling Range	12 MT/y
. Northern Territories - Gove	5 MT/y
2. Guinea with the Boké deposits	10 MT/y
3. Brazil with the Trombetas deposits	5 MT/y

CONCLUSIONS

Although bauxite remains the perfect aluminum ore, it is used for other applications, and this also for more than a century. I should mention calcined bauxite for the industry of abrasive products (corundum) on the one hand, and the industry of refractory products on the other hand. Also worth mentioning are the so-called chemical quality bauxites used for the production of alumina sulfate, and finally the bauxites used in the cement industries (Portland cement and high-alumina cement). These bauxites with non-metallurgical use amount to 5 % of the world production (4.4 MT/y), and Guyana plays a major role in this domain (see table 10).

In fact bauxite is the only raw material from which alumina can be obtained using the Bayer process. Its remarkable development during the last hundred years makes it by far the first non-ferrous ore. The first fifty years during which mining increased at a slow pace were characterized by the major position of France as the sole supplier of European countries. This position was still effective in Europe between the two world wars.

However, from 1945 on, Europe and other highly industrialized countries (U.S.A. - Canada) still show a deficit of bauxite. The latter is extracted in large quantities in Australia and in developing countries (Caribbean - Africa) for which bauxite is often the only way to acquire strong currencies.

The crisis which has affected the aluminum industry of the western market since 1980, leads to a low number of alumina plants. Only approximately ten large plants consuming imported tropical bauxites (Guinea, Brazil) should remain in operation. The production of bauxite will therefore progress first of all in tropical countries and concentrate in large mines (8 to 10 MT/y) owing to low operating and transport costs, more particularly in countries with integrated sites.

Table I : Bauxite production in tons

	World	U.S.A.	France	% France
1860	600	-	580	97
1870	1 800	-	1 800	100
1880	2 000	-	2 000	100
1887	4 000	200	3 800	95
1890	5 000	1 000	4 000	80
1895	50 000	14 000	36 000	72
1900	88 000	27 000	60 000	68
1910	350 000	151 000	196 000	56
1913	450 000	141 000	309 000	68,6

FIGURE 1

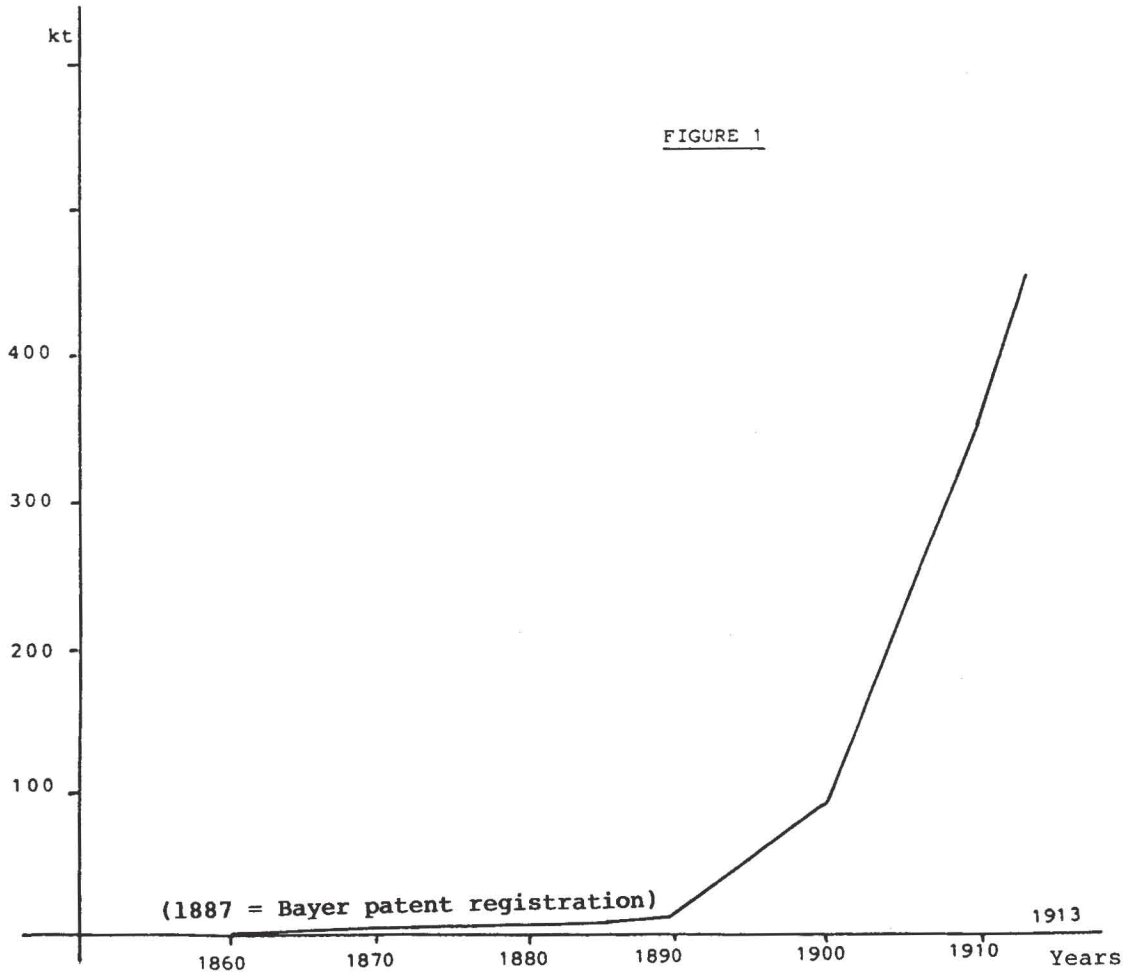


Table II : 1913-1920 bauxite production in kt

	World Production	U.S.A.	%	FRANCE	%
1913	450	141	34	309	68,6
1914	485	223	46	250	51,6
1915	376	302	80	80	21,3
1916	561	432	77	106	18,9
1917	701	578	80	121	17,2
1918	663	615	97	140	21,2
1919	563	383	68	159	28,2
1920	886	530	61	267	30,8

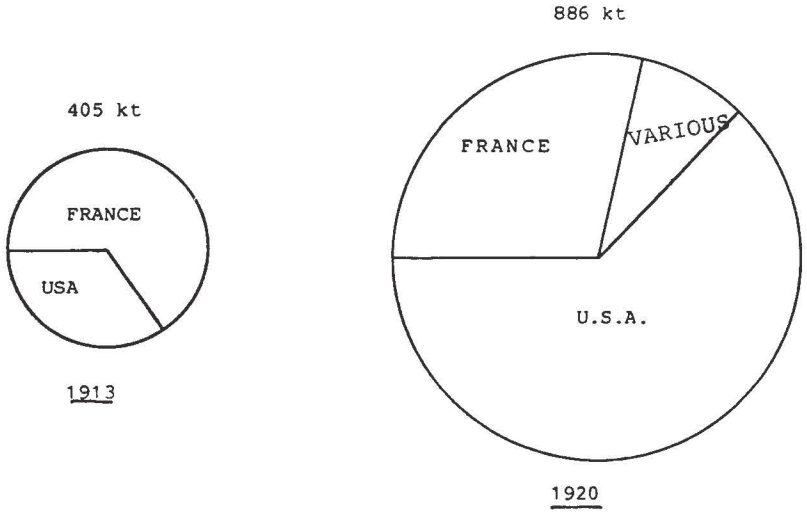


Table III : bauxite production in kt

	WORLD PRODUCTION	U.S.A.	%	FRANCE	%	REMAINING EUROPEAN COUNTRIES Yugoslavia Hungaria	%	WEST INDIES Guyana Surinam	%
1920	886	530	61,0	267	30,8	69	8,0	32	3,7
1925	1 384	322	23,0	502	36,3	278	20,0	282	20,4
1929	2 128	372	17,5	666	31,3	692	32,0	400	18,8
1930	1 706	336	19,7	609	35,7	290	17,0	386	22,6
1935	1 785	249	13,9	513	28,7	616	34,5	407	22,8
1936	2 856	386	13,5	650	22,8	1 013	35,5	760	26,6
1937	3 713	432	11,6	688	18,5	1 410	38,0	1 040	28,0
1938	3 930	316	8,0	682	17,4	1 475	37,5	1 150	29,2
1939	4 272	381	8,9	800	18,7	1 475	34,5	1 250	29,2

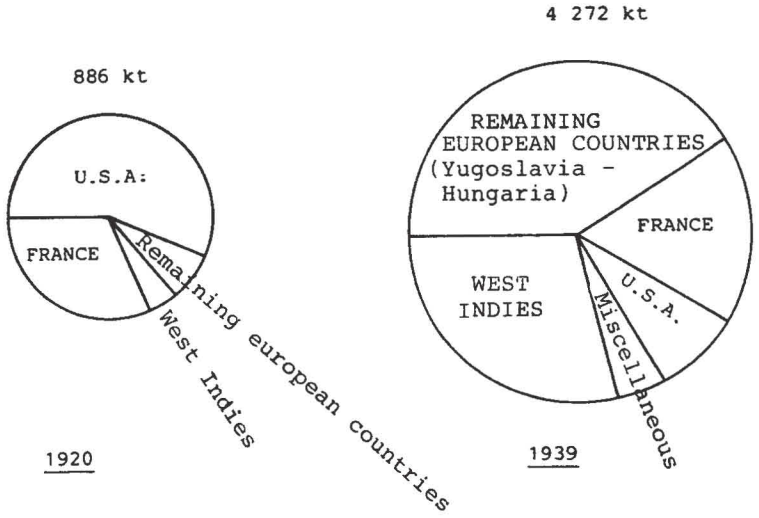


Table IV : bauxite production in kt

	WORLD PRODUCTION	U.S.A.	%	EUROPE	%	WEST INDIES	%
1939	4 272	381	8,9	2 275	53,0	1 250	29,2
1940	4 345	446	10,3	2 042	47,0	1 250	29,0
1941	6 210	952	15,3	2 125	34,2	3 010	46,8
1942	8 400	2 644	31,5	2 247	26,8	3 220	37,2
1943	13 966	6 333	45,3	2 234	16,0	4 300	31,0
1944	7 353	2 869	39,0	1 575	21,4	2 909	40,0
1945	3 716	997	26,8	423	11,4	2 300	69,0

Table V : bauxite production in kt

	WORLD PRODUCTION	U.S.A.	%	EUROPE (except USSR - Hungaria	%	WEST INDIES	%	EUROPE + USSR
1945	3 716	995	26,0	423	11,4	2 300	69,0	
1946	4 563	1 122	24,8	569	12,5	2 500	53,0	
1947	6 306	1 221	19,4	961	15,2	3 117	43,7	
1948	8 476	1 481	17,5	1 140	13,4	4 053	49,4	
1949	8 542	1 167	13,8	1 275	14,9	3 913	45,8	
1950	8 413	1 356	16,0	1 816	21,6	3 700	44,0	600

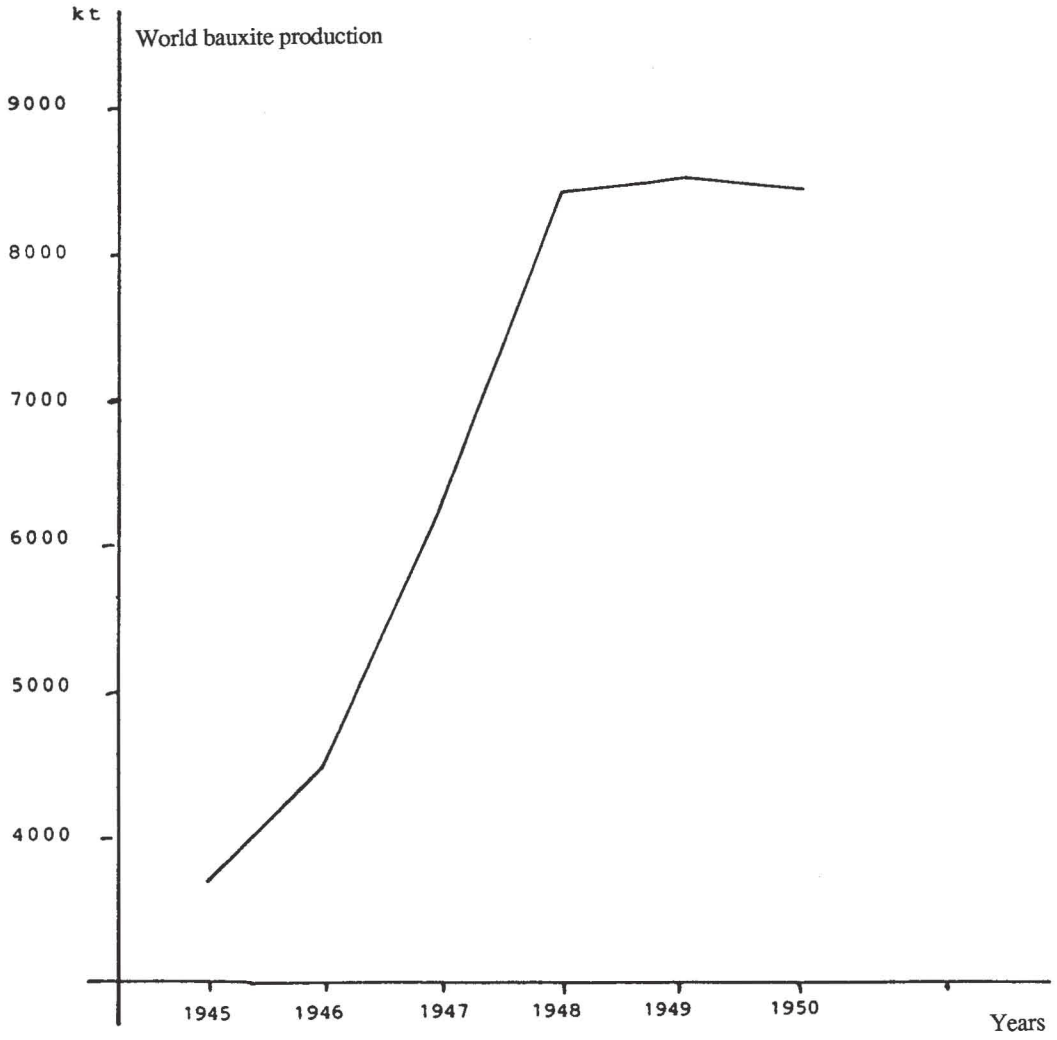


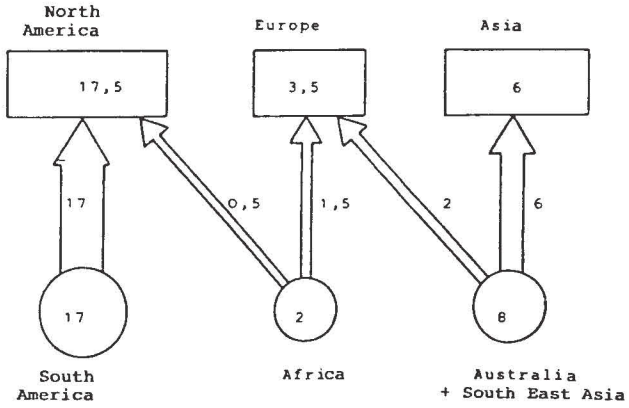
Table VI : production (kt)

Years	1950	%	1955	%	1960	%	1965	%	1970	%
EUROPE	1 255	15,0	3 142	19,5	4 343	16,3	5 585	15,1	7 656	12,5
France	806		1 500		2 038		2 660		3 050	
Greece	77		500		935		1 274		2 292	
Yugoslavia	200		790		1 025		1 574		2 099	
NORTH AMERICA	1 368	16,3	1 817	11,0	2 020	7,5	1 682	4,5	2 115	3,5
SOUTH AMERICA	3 709	44,4	7 562	45,8	12 229	45,5	16 348	43,5	24 702	40,7
Brazil	18		50		100		300		510	
Jamaïca	-		2 688		6 000		8 722		12 010	
Surinam	2 080		2 700		3 455		4 420		6 022	
Guyana	1 608		2 203		2 510		3 000		4 400	
AFRICA	135	1,7	650	4,0	1 608	5,8	2 150	5,8	3 288	5,4
Guinea	14		500		1 376		1 433		2 490	
ASIA	597	7,2	1 100	6,6	1 829	6,8	2 920	7,8	3 795	6,3
AUSTRALIA	4		7		34		1 176	3,2	9 256	15,3
TOTAL WESTERN WORLD	7 068	84,7	14 278	86,4	22 063	82,3	29 761	80,0	50 812	83,7
PLANNED ECONOMY COUNTRIES	1 280	15,3	2 260	13,6	4 760	17,7	7 531	20,0	9 898	16,3
TOTAL WORLD	8 348	100	16 538	100	26 823	100	37 292	100	60 710	100

Table VII

in Kt	1973	%
EUROPE	7 945	10,5
France	2 970	
Greece	2 748	
Yugoslavia	2 167	
NORTH AMERICA	1 909	2,5
SOUTH AMERICA	26 935	35,7
Brazil	847	
Jamaica	13 600	
Surinam	6 976	
Guyana	3 622	
AFRICA	4 847	6,4
Guinea	3 800	
ASIA	3 975	5,3
AUSTRALIA	17 596	23,3
TOTAL WESTERN WORLD	63 207	83,8
PLANNED ECONOMY COUNTRIES	12 200	16,2
TOTAL WORLD	75 407	100

1973 TRANSFER



Total	Consuming countries	Producing countries
	27	27

Figure 7

1973 PRODUCTION

in Mt

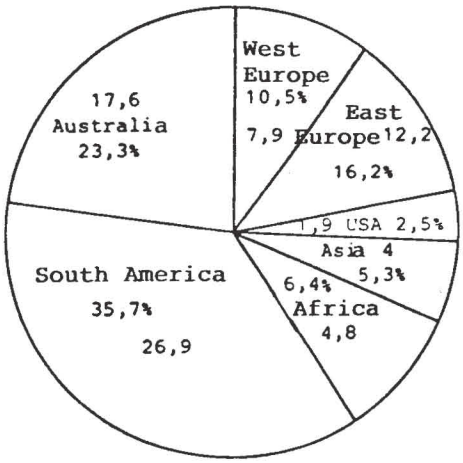


Table VIII : bauxite world production (in kt)

	1970	1975	1980	1985
EUROPE OUEST	7 656	7 916	8 349	7 154
including France	3 051	2 563	1 892	1 530
Greece	2 292	3 006	3 286	2 367
NORTH AMERICA	2 115	1 800	1 559	674
SOUTH AMERICA	24 702	22 409	25 120	18 029
including Brazil	510	969	4 152	5 842
Jamaïca	12 010	11 570	12 025	6 239
Surinam	6 022	4 549	4 903	3 738
AFRICA	3 288	9 508	14 282	15 624
including Guinea	2 491	8 466	13 311	14 325
ASIA	3 795	3 349	4 326	3 659
AUSTRALIA	9 256	21 034	27 178	31 178
TOTAL WESTERN WORLD	50 812	66 016	80 814	76 318
EAST EUROPE PLANNED ECONOMY COUNT.	9 898	11 269	11 750	11 691
TOTAL WORLD	60 710	77 285	92 564	88 009

Table IX

RESERVE in billions of tonnes		% total	1985 PRODUCTION en millions of tonnes	% total
GUINEA	8	32,0	14,3	16,2
AUSTRALIA	5,2	20,8	31,0	35,2
BRAZIL	2,8	11,2	5,9	6,7
JAMAICA	1,5	6,0	6,0	6,8
INDIA	1,5	6,0	2,1	2,4
SURINAM	1,5	6,0	3,7	4,25
CAMEROON	1,0	4,0	-	-
VARIOUS	3,5	14,0	25,0	28,45
TOTAL	25,0	100	88,0	100

Table X

Non-metallurgic bauxite production

	MT raw bauxite
I - Calcined bauxite	
a) for abrasive products 600 000 i.e. Guinea - Surinam - Australia	1.2
b) for refracotry products 1 000 000 i.e. Surinam - Australia - Guyana	2.0
II - Chemical bauxite	
Guyana	0.4
III - Bauxite for cement industries	
Greece - China	0.8

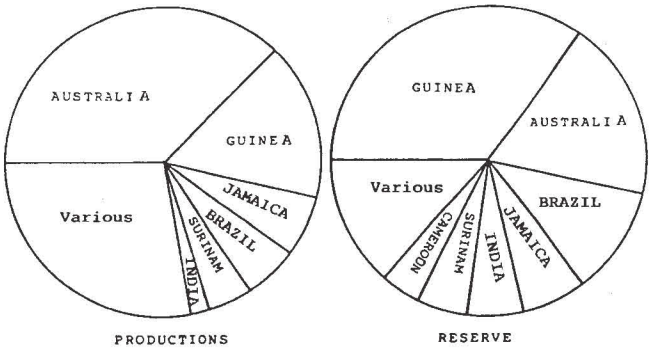
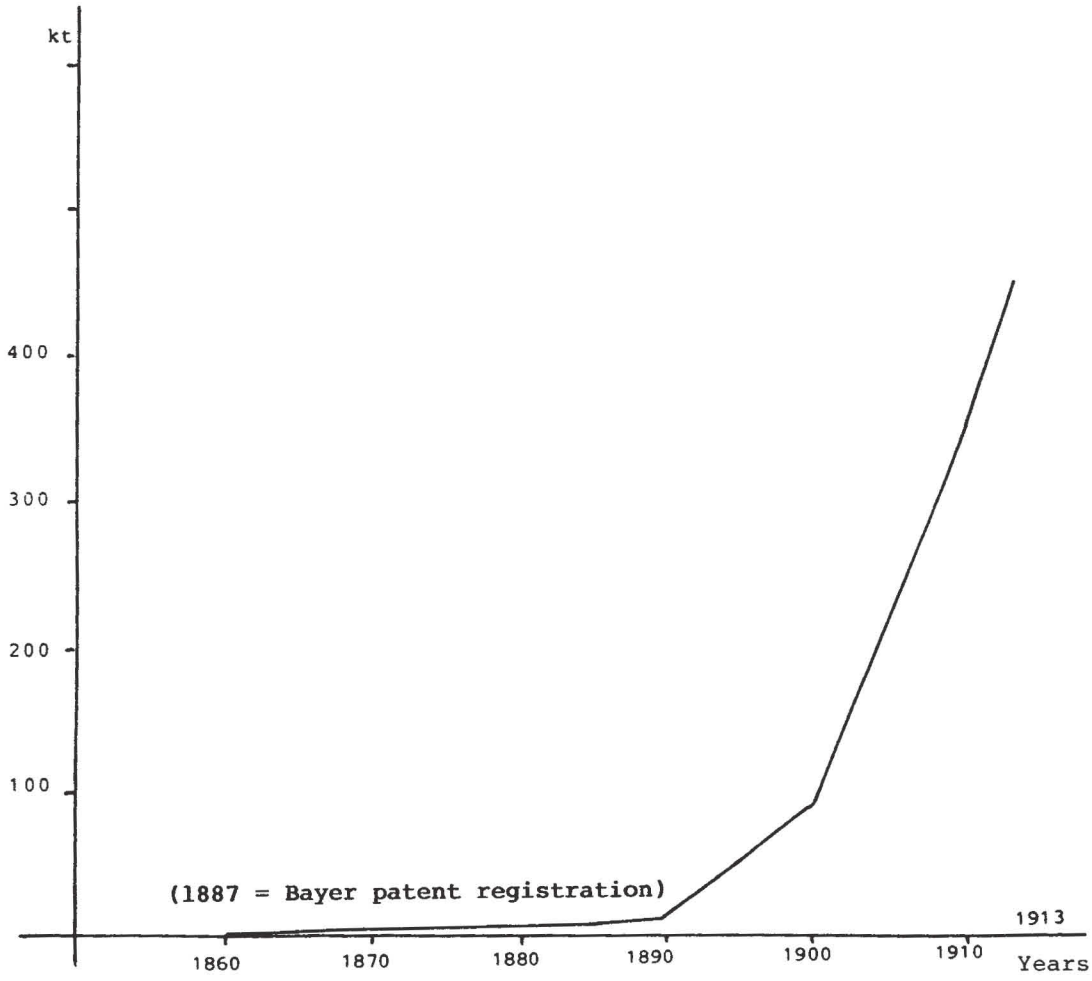


FIGURE 1


kt
400
300
200
100
(1887 = Bayer patent registration)
1913
1860
1870
1880
1890
1900
1910
Years

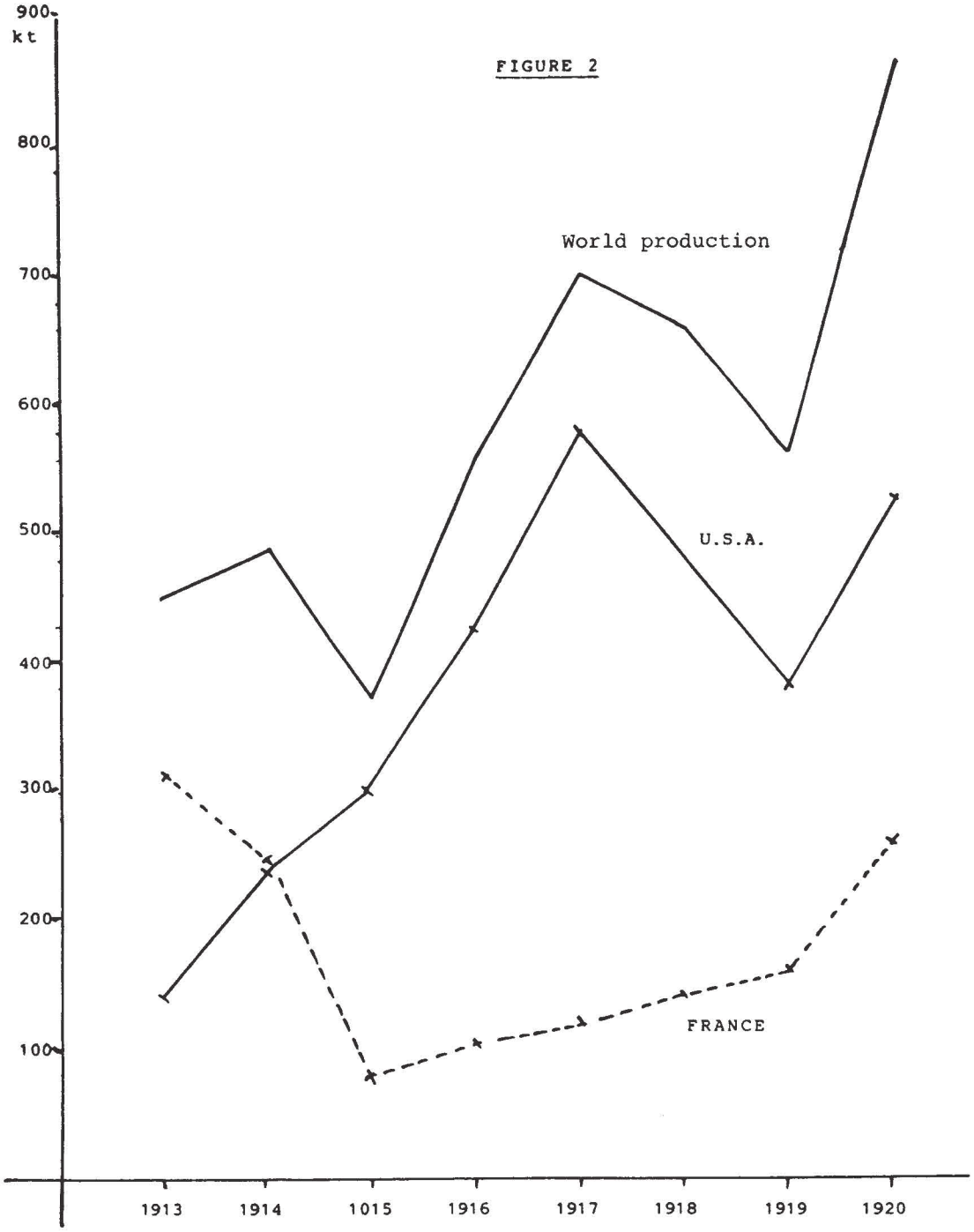
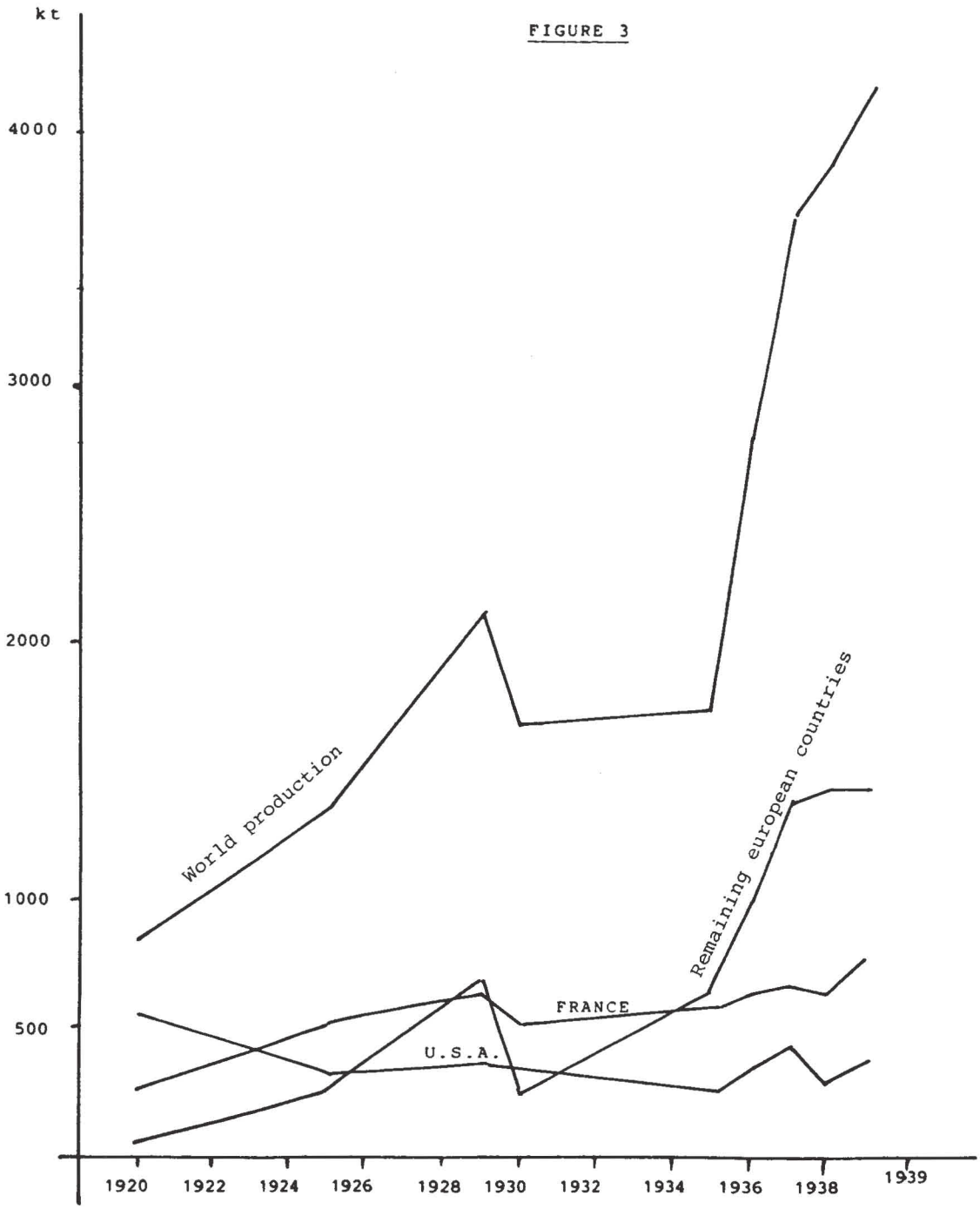

900
kt
800
700
600
500
400
300
200
100
World production
U.S.A.
FRANCE
1913
1914
1015
1916
1917
1918
1919
1920

FIGURE 2


kt
FIGURE 3
4000
3000
2000
1000
500
World production
Remaining european countries
FRANCE
U.S.A.
1920
1922
1924
1926
1928
1930
1932
1934
1936
1938
1939

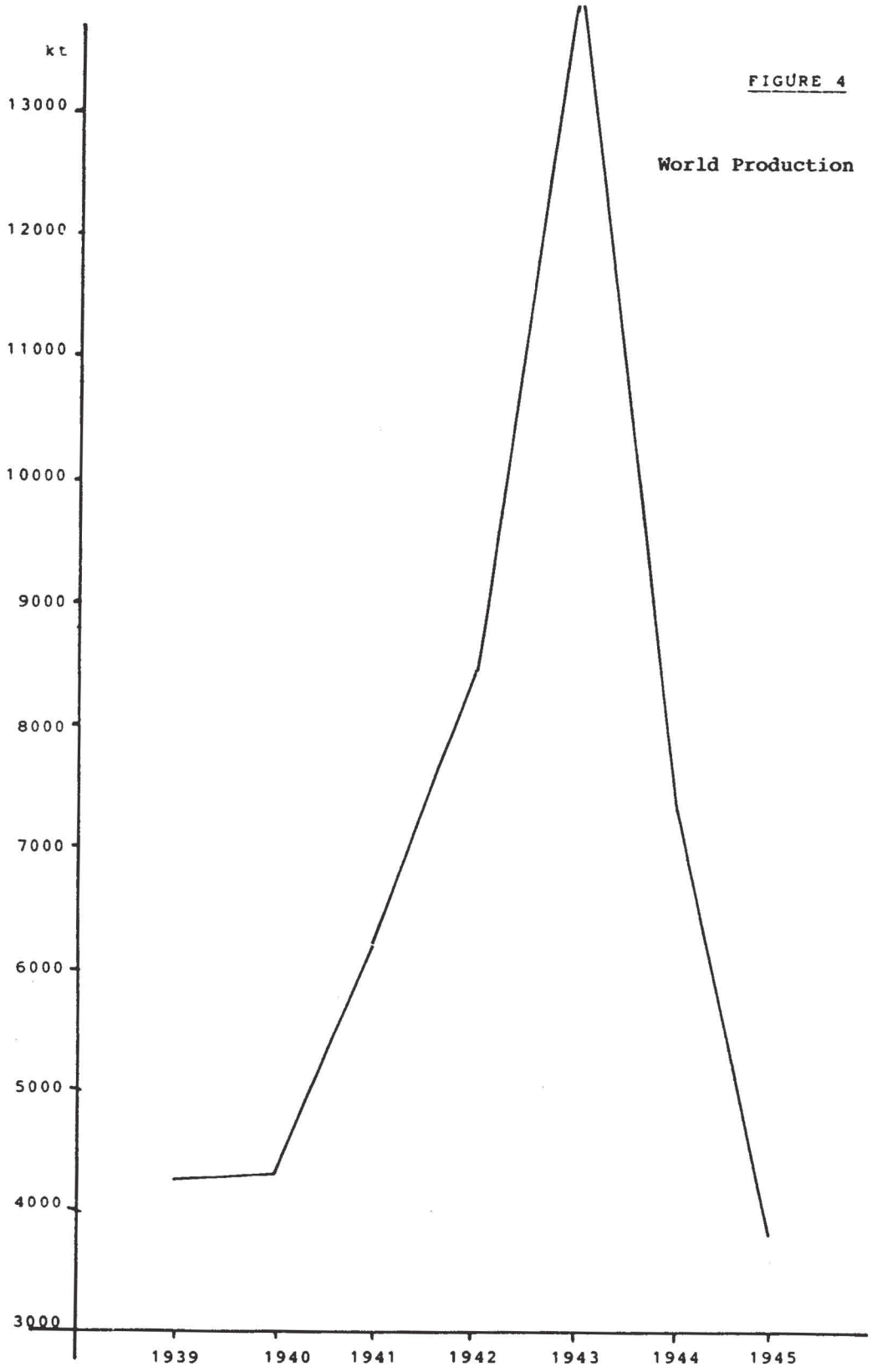
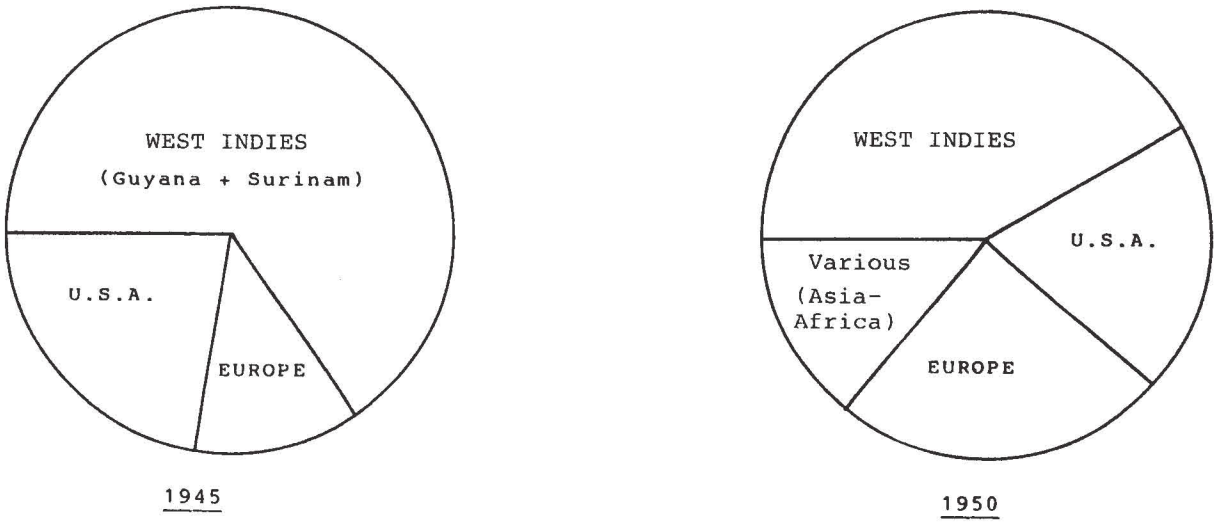


FIGURE 4

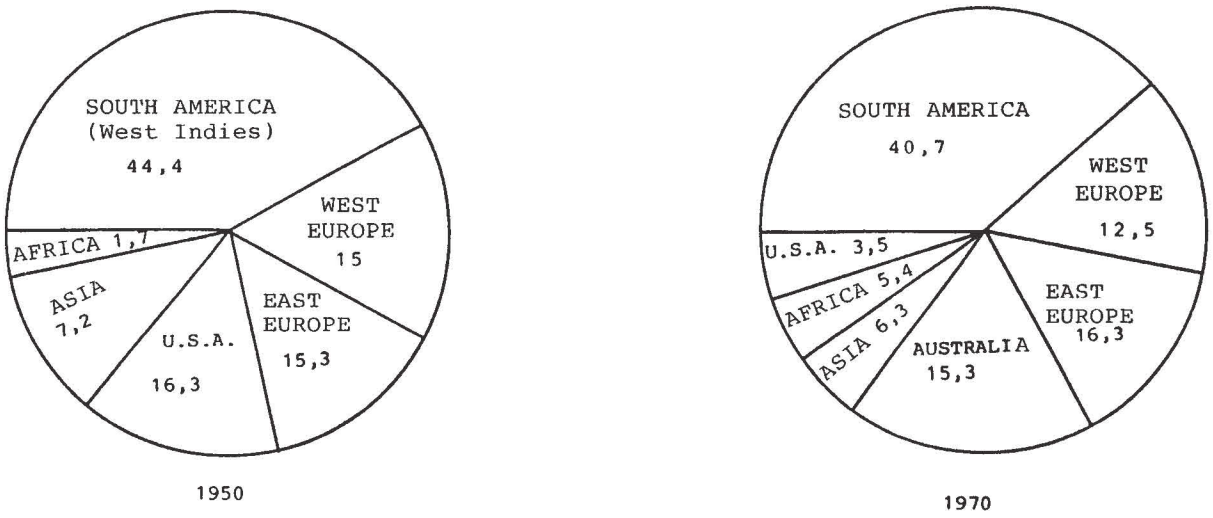
World Production

FIGURE 5



BAUXITE WORLD PRODUCTION

FIGURE 6



BAUXITE WORLD PRODUCTION

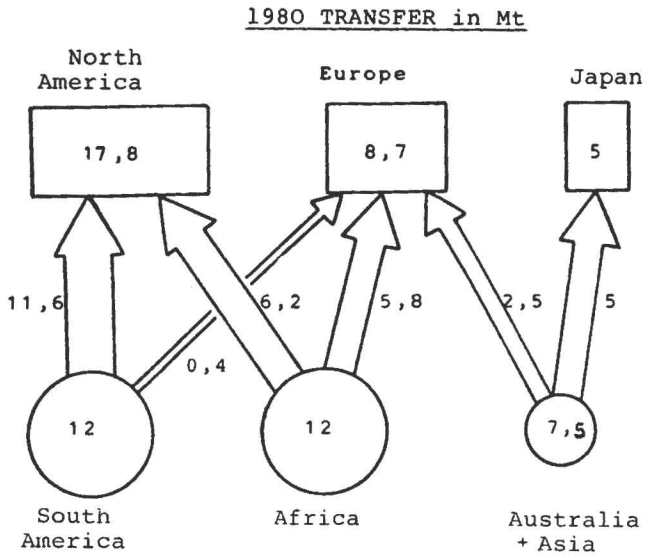
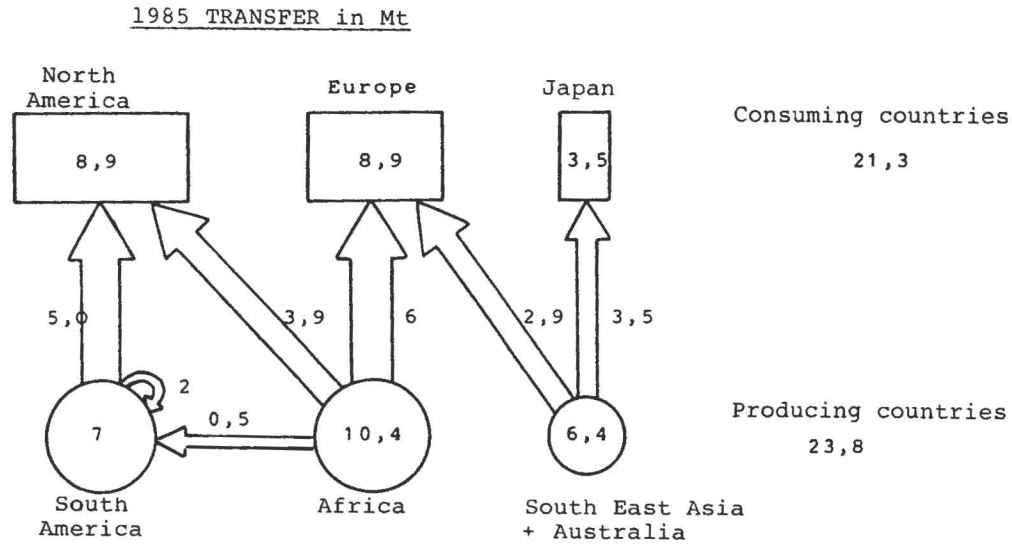

1980 TRANSFER in Mt
North America
Europe
Japan
17,8
8,7
5
11,6
6,2
5,8
2,5
5
0,4
12
12
7,5
South America
Africa
Australia + Asia
Consuming countries
31,5
Producing countries
31,5

FIGURE 8


1985 TRANSFER in Mt
North America
Europe
Japan
8,9
8,9
3,5
5,0
3,9
6
2,9
3,5
2
0,5
7
10,4
6,4
South America
Africa
South East Asia + Australia
Consuming countries
21,3
Producing countries
23,8

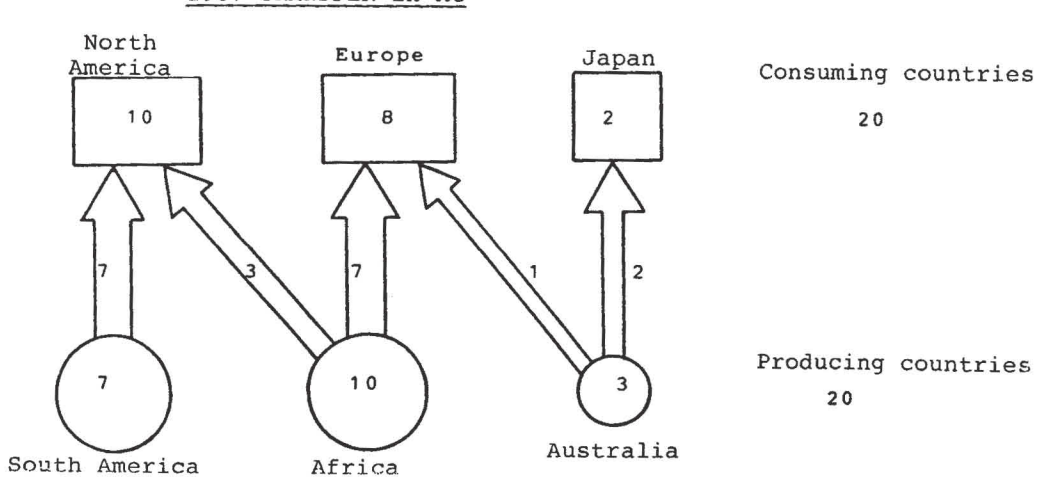

1987 TRANSFER in Mt
North America
Europe
Japan
10
8
2
7
3
7
1
2
7
10
3
South America
Africa
Australia
Consuming countries
20
Producing countries
20

FIGURE 9

BAUXITE TRANSFER in Mt