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MINERAL RAW MATERIALS IN AFRICA

IRON ORE

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IRON-ORE RESOURCES IN AFRICA

1. INTRODUCTION

(a) Economic iron minerals

The most important iron minerals are the oxides - magnetite and haematite - and to a lesser degree the hydrated (water-containing) oxides - limonite and goethite. Iron carbonate (siderite) is also exploited economically. The iron sulphides - pyrite and pyrrhotite are mainly exploited for their sulphur content, but in some cases the iron is obtained as a by-product. The different minerals, together with their formulae and their iron content are listed below:

Mineral	Formula	Fe content (percentage)
Magnetite	Fe_3O_4	72.4
Haematite	Fe_2O_3	70.0
Limonite	$Fe_2O_3 . nH_2O$	48-63
Goethite	$FeO.OH$	62
Siderite	$FeCO_3$	48.3
(Pyrite	FeS_2	46.6
(Pyrrhotite	FeS	63.6)

(b) Classification of iron-ore resources

Iron-ore resources can be classified on the basis of their origin as sedimentary, igneous or metamorphic, but because origin is disputed in certain iron-ore occurrences, a grouping by reference to a few well-known types (together with indications of origin where there is some measure of general agreement) has been adopted in this report. 1/ On this basis, iron-ore resources can be divided broadly into bedded and massive types. The bedded iron-ore resources include the Lake Superior types and the oolitic (and non-oolitic) minette types. The massive division includes three iron-ore types, which can be considered as representing a continuous series: Magmatic segregations (Kiruna and Taberg types), contact metamorphic (Magnitnaya types), and hydrothermal replacement in limestone (Bilbao types).

There are, however, other iron-ore resources which are residual in origin, having been formed by the decomposition of the underlying rocks, e.g., laterites, or by precipitation in river-beds and surface depressions. These iron-ore types are classified here as residual deposits.

(i) Bedded iron-ore resources

a. Lake Superior type

The bedded iron formations of the Pre-Cambrian age (Lake Superior type) supply the bulk of the world's iron-ore. They occur in all four continents. The iron formations are usually 30-600m in thickness and cover areas of several thousand square kilometres. The ore-forming minerals are usually magnetite and/or haematite and the gangue minerals are usually quartz, and silicates and carbonates of iron. The Lake Superior type iron formations usually grade 20-40 per cent Fe. Examples of these iron-ore types occur in all the subregions of Africa.

1/ Survey of World Iron-ore Resources (ST/ECA/113, 1970, and ST/ECA/27, 1955).

Secondary enrichment of the primary iron-ore formations, involving oxidation of ferrous minerals to haematite and accompanied by the removal of silica, may sometimes take place. Such iron-ore resources are referred to as residual and are usually earthy and porous and contain up to 60 per cent Fe. Very often, however, the removal of silica may be accompanied by the introduction of additional iron oxide and the iron ores are then referred to as replacement iron ores. Replacement iron ores are usually dense and massive and contain 64-68 per cent Fe. Examples of such iron-ore accumulations in Africa are those at Fort Gouraud in Mauritania and Shishen in South Africa.

b. Oolitic ironstones (minette types)

The sedimentary oolitic (and sometimes non-oolitic) ironstones of Palaeozoic or late Pre-Cambrian to Tertiary age differ from the bedded Pre-Cambrian iron-ore resources in a number of respects. Although they grade usually 20-40 per cent Fe, like the Pre-Cambrian bedded iron-ore resources, they rarely exceed 48 per cent Fe. They are usually less than 15 m thick. The ore-forming minerals are very fine grained haematite, often accompanied by quartz, chamosite, siderite and calcite, all occurring in varying proportions. In certain cases the calcite content is such that the iron ore is self-fluxing. It often has a high phosphorus content.

(ii) Massive iron-ore resources

a. Magmatic segregations

Massive accumulations of magnetite thought to be of igneous origin have been found to occur, in Pre-Cambrian rocks in certain countries, as irregular or layered masses; these appear to have formed by segregation of magnetite crystals in the magma. Such iron-ore accumulations contain upto 60 per cent Fe and 15 per cent Ti. Magmatic magnetite iron-ore accumulations with a high titanium content are classed as Taberg types, after the famous titano-magnetite iron-ore deposits of Taberg in Sweden. Those with no or very little titanium are referred to as Kiruna type, after the magmatic magnetite iron-ore deposits at Kiruna, also in Sweden. Examples of magmatic magnetite iron-ore occurrences in Africa are found in the Bushveld Igneous Complex of South Africa at Liganga and Pudo in the United Republic of Tanzania, in Ghana and elsewhere.

b. Massive replacements in limestone (Bilbao types)

Metasomatic replacements of limestone by iron may sometimes lead to economic accumulations of iron ore. The ore-forming mineral is usually siderite ($FeCO_3$). When the siderite is exposed to weathering processes, massive iron oxides comprising limenite (goethite) and haematite may form near the surface, while the siderite in the zone below the water-table (reducing zone) remains unchanged. The iron oxides derived in this manner give rise to high- and low-phosphorus iron ores. The Ouenza (Algeria) and Djebel Djerissa (Tunisia) iron-ore deposits located in the Ouenza Massif are examples of Bilbao-type iron-ores.

c. Contact metamorphic iron formations (Magnitnaya type)

The contact metamorphic iron-ore resources are concentrations of magnetite that have replaced bodies of rock such as limestone where, or near where, they have come into contact with an intrusive igneous rock. Such iron accumulations may ocontain upto 65 per cent Fe, depending on the extent of replacement. Garnet and other silicate minerals are common accessories.

(iii) Residual iron-ore resources

Residual iron-ore resources in Africa are represented by lateritic ores, formed mainly under conditions of tropical weathering during the Tertiary period from basic rocks rich in iron. The Conakry iron-ore deposits are the best known in Africa. These deposits were derived from the underlying iron-rich dunite under lateritic weathering conditions.

2. NORTH AFRICA SUBREGION

Iron-ore resources are found in all the countries of the North Africa subregion. They occur widely in the Interior Meseta - High Atlas zone, in the Rif and Tell Alpine zone of Morocco and Algeria, and in the Eastern Atlas, which extends across the border between Algeria and Tunisia. In Algeria, more iron-ore resources are found in the extreme south-western part of the country close to the Moroccan-Algerian border. In the Libyan Arab Jamahiriya, large iron-ore resources have been delineated at Usu el Kabir.

In Egypt, the important iron-ore resources occur at Aswan, at Baharia Oasis and in the Sinai peninsular. In the Sudan, iron-ore resources are known to occur at Wadi Halfa, Paloic-Wabari, Darfur and Kordofan.

(a) Algeria

The principal iron-ore resources in Algeria are found in association with Triassic, Jurassic and Cretaceous limestones in the Alpine zone and in the Lower Palaeozoic rocks in the Gara Djebilet area in the extreme south-western part of the country.

More than 40 iron-ore deposits have been delineated in the Alpine zone of Algeria. They are usually siderite/goethite haematite Bilbao-type replacements in Triassic, Jurassic and Cretaceous limestones. They are widely distributed in Algeria but the most important occur at Ouenza and at Bou Khadra.

The Gara Djebilet iron-ore resources are located in the occidental Sahara close to the border with Morocco. The nearest port is **Tarfaya**, on the Atlantic coast of Morocco, which lies about 400 km west of Gara Djebilet. In 1973 an agreement was reached between Morocco and Algeria for the joint exploitation of the Gara Djebilet deposits. 2/ A railway was to be built from Gara Djebilet to Tarfaya, but the project was never implemented because of the political tensions that developed between the two countries. It has been reported that Algeria is planning instead to build a railway entirely within its own territory from Gara Djebilet to La Macta on the Mediterranean coast, a distance of 1,100 km. 3/

The iron-ore deposits at Gara Djebilet are associated with a lower Palaeozoic sedimentary rock series. 4/ The iron-ore deposits consist of three separate ore bodies: the western, central and eastern. Of these, the western ore-body is 10 km long and about 4 km wide on average, the central ore-body is 20 km long and 4-5 km in width, and the eastern ore-body is 7 km long and about 1 km in width. All three ore-bodies are, however, geologically continuous from one to another, and almost horizontal. Stratigraphically, and going from top to bottom, each ore-body consists of:

2/ "Opening up Algeria's Djebilet", Metal Bulletin, No. 5816, 13 July 1973, p. 28.

3/ "Maghreb - Europe: mineral ores", Mining Journal, 16 June 1978, p. 450.

4/ Etude d'investigation dans les branches mécaniques et électriques et dans les industries en amont en vue de déterminer les capacités de sous-traitance actuelles et à moyen terme dans et entre les pays du Maghreb (Tanger, Centre d'Etudes Industrielles du Maghreb, 1974), pp. 4-29.

(i) a thick crust of ironstones 4 to 8m in thickness; (ii) a low-grade zone of haematite alternating with shale bands 5 to 15m in thickness; in this zone the iron ore grades on average 40 to 50 per cent Fe; (iii) a band of oolitic magnetite 6 to 10m in thickness, grading on average 56 to 65 per cent Fe; this oolitic magnetite band is the richest of the four iron mineralization zones; (iv) a low-grade zone of oolitic haematite 0 to 3m in thickness; and finally (v) argillites which, form the base of the overlying bedded iron formations.

Reserves in the oolitic magnetite band, both for the western and central ore-bodies, are estimated to be 1 000 million tonnes grading on average 57 per cent Fe. Reserves in the non-magnetite haematite zone, for the western and central ore-bodies, are estimated at 2,245 million tonnes grading on average 50 to 57 per cent Fe. Iron-ore reserves for the eastern ore-body have not yet been determined, but potential reserves are estimated to be 500 million tonnes grading on average 45 per cent Fe. It should be noted, however, that the iron-ore resources at Gara Djebilet have an abnormally high phosphorus content (up to 0.8 per cent P). Studies have shown that the phosphorus occurs in two forms, namely as apatite and as intergrowths with the iron-ore minerals. While it has been shown that the apatite can be removed by gravitational separation, that part of the phosphorus found as intergrowths with the iron-ore-forming minerals cannot easily be removed by conventional methods and is expected to cause difficulties during steel-making.

Total Algerian iron-ore reserves are estimated at 1,848 million tonnes of contained iron (details are given in table I.1).

(i) Exploitation of iron-ore in Algeria

Iron ore is exploited in Algeria by La Société Nationale de Recherches et d'Exploitatic d'Exploitations Minières (SONAREM), a state company created to run all mining operations in the country following the nationalization of the minerals industry in 1966.

Before 1976 Sonarem operated six iron mines. These are:

(i) Saf in the Province of Tlemcen;
(ii) Zaccar closed in 1976 in the Province of El Esnam;
(iii) Timezrit in the Province of Setif;
(iv) Khanguet El Mouhad in the Province of Annaba;
(v) Ouenza in the Province of Annaba;
(vi) Bou Khadra in the Province of Annaba.

a. Saf iron mine

The Saf iron mine is located near the port of Beni Saf. It is a small underground mine whose average annual production is 180,000 tonnes of iron-ore concentrate. The iron-ore mineral is haematite and the ore grades 51 to 56 per cent Fe. About 7,000 tonnes of the iron-ore concentrate produced annually at Saf are used locally in the Oran Cement Factory and the remainder is exported to Europe. The mine employs about 600 persons.

b. Zaccar iron mine

Before its closure in 1976 the Zacoar iron mine had an annual production of 200,000 tonnes of iron-ore concentrate and employed about 600 persons. The mine is situated near the city of Miliana, lying about 150 km west of Algiers. It is connected by a narrow-gauge railway to the Oran-Algiers railway line. While the mine was in operation, all the ore produced at Zaccar was transported by rail to the port of Algiers and exported to Europe.

Some iron-ore reserves, mainly of siderite and amounting to 1.2 million tonnes grading 50 per cent Fe, still remain at Zaccar but have an abnormally high silica content. This is one of the many reasons that led to the closure of the mine.

c. Timezrit iron mine

The Timezrit iron mine is situated about 35 km south-west of the port of Bajaia on the Mediterranean coast. The mine lies on the Bajaia-Algiers railway line. Annual production averages about 125,000 tonnes of iron-ore concentrate and is all exported, mainly to European steel-makers. In 1972 it had a labour force of about 550 persons.

The iron ore obtained from the Timezrit mine is very friable with more than 40 per cent fines. For this reason Sonarem has had difficulties in marketing it.

d. Khanguet iron mine

The Khanguet iron mine is located in the Tebessa region close to the Tunisian border. It lies about 150 km south-south-east of the port of Annaba, to which it is linked by a railway line. Mining at Khanguet is by open-cast methods and the mine has an annual production of about 200,000 tonnes. It employs about 170 persons.

All the iron-ore produced (supplemented by ore obtained from the Bou Khadra and Ouenza mines) goes to the El Hadjar Iron and Steel Complex.

e. Ouenza iron mine

The Ouenza iron mine is located about 190 km south-south-east of the port of Annaba and is connected to it by an electrified railway line. Mining is by open-pit methods and is highly mechanized. Annual production averages 2.5 million tonnes of haematite iron-ore concentrate which is self-fluxing and therefore in great demand both in Algeria and in Europe.

About 700,000 to 800,000 tonnes are used by the El Hadjar Iron and Steel Complex annually, while the remainder is exported to European consumers. The mine employs about 2,500 persons.

f. Bou Khadra iron mine

Bou Khadra iron mine is located about 35 km south of Ouenza mine on the edge of the Ouenza massif. Geologically, Ouenza and Bou Khadra in Algeria and Djerissa iron mine in Tunisia form one continuous sedimentary Bilbao-type iron-ore mineralization. The Bou Khadra iron-ore deposits have, however, a higher grade (58 per cent Fe) than the Ouenza deposits (55.5 per cent Fe).

Mining is by open-pit methods and, as at Ouenza, mining operations are highly mechanized. Average annual production is about 500,000 tonnes of iron-ore concentrate.

The Ouenza and Bou Khadra iron-ore mines have a potential combined annual production capacity of up to 5 million tonnes of iron-ore concentrate and plans were put in hand for a limited expansion of the two mines in 1975 5/ as the capacity of 5 million tonnes cannot be attained because of inadequate rail transport; the Ouenza -- Annaba railway line serving the mines also serves the important phosphate mines lying to the south at Djebel Onk.

(ii) Algerian iron-ore production and exports

Iron-ore production in Algeria increased from 3.1 million tonnes in 1968 to 3.8 million tonnes in 1974. Since 1974, however, iron-ore production has been on the decline, as showin in table II.1, due to a decline in world industrial activity.

For the period 1968-1973, as shown in table III.1, Algerian iron-ore exports decreased from 3.2 million tonnes in 1968 to 1.2 million tonnes in 1973. This decrease was due mainly to the after-effects of nationalization, which necessitated the drawing up of new sales contracts with consumers. In 1974, however, there was an increase of 146 per cent in iron-ore exports as compared with the previous year in response to increased world demand for iron ore during the same period. This increase in demand did not last long, for in 1975, 1976 and 1977 iron-ore exports fell to 1.5, 1.8 and 1.55 million tonnes respectively.

(iii) Iron and steel industry in Algeria

Since 1967, when the minerals industry was nationalized, a policy of integrated mineral development has been followed, so that ore extraction is followed by processing and the manufacture of finished or semi-finished products. For instance, the El Hadjar iron and steel complex with a capacity of 400,000 tonnes per year began production in 1973. 6/ Another integrated iron and steel facility is under development at Oran, while a special steels plant and a special welded pipe plant are being developed at Jijel near Annaba and Ghardia respectively. Also a 10 million tonnes per year integrated iron and steel plant is on the drawing board for La Macta on the Mediterranean coast; this will obtain its ore feed from the Gara Djebilet iron deposits, 1,100 km deep in the occidental Sahara. Production is expected to commence during the 1980s. 7/ Over the eight-year period from 1969 to 1976, as indicated in annex IV.1, production of pig-iron and ferroalloys has grown from 172,000 tonnes in 1969 to 413,000 tonnes in 1976.

5/ "Iron Ore: Algeria", African Research Bulletin, vol. 12, No. 2, 31 March 1975, p. 3435.

6/ "Industrialization: Algeria", African Research Bulletin, vol. 11, No. 3, 30 April 1974, pp. 3066-3069.

7/ Etude d'investigation dans les branches mécaniques et électriques et dans les industries ....

(b) Egypt

Egyptian iron-ore resources occur at Aswan (southern part of the Nile Valley), in an area south-west of Quseir in the Central Eastern Desert, at Baharia Oasis in the Western Desert and in the Sinai peninsular.

In the Aswan area several horizons of minette-type iron mineralization occur within the Nubian formation. Among the many horizons that exist, only the upper horizon is important economically. It consists of dark red, compact, oolitic haematite 0.1-3.5 m in thickness. This haematite band has been traced over an area of 50 km^2. The iron ore at Aswan grades on average 31.2 per cent Fe, 5.3 per cent SiO_2, 3.0-10.0 per cent Al_2O_3, 0.04-3.5 per cent P, 0.01-1.06 per cent TiO_2, 0-1.4 per cent Mn, 0.25-9.0 per cent CaO, 0.08-1.80 per cent MgO and 0-0.30 per cent S. 8/ Reserves are estimated at 140 million tonnes.

In the central part of the Eastern Desert region, south-west of Quseir, a number of metamorphosed potential iron-ore resources (Lake Superior type) occur. The iron mineralization takes the form of bands and lenses of magnetite and haematite. Quartz is the commonest gangue mineral. The bands and lenses may extend for several tens of kilometres in length along the strike and vary from a few centimetres to 5 m in width. The average composition of these potential iron-ore resources is 31.9-52.34 per cent Fe, 19.32-37.2 per cent SiO_2, 0.17-0.61 per cent P, 0.23 per cent Mn, 0.27 per cent Ti and 0.1 per cent S. Workable reserves are estimated at 39 million tonnes.

The Baharia Oasis iron-ore deposits in the Western Desert were discovered in 1962. They occur in Eocene sedimentary beds associated with haematite and goethite mineralization. Reserves are estimated at 250 million tonnes. The largest iron-ore deposit in the area is located at El Gidida (134 million tonnes) and grades on average 54.8 per cent Fe, 1.06 per cent Mn, 0.91 per cent S, 0.23 per cent P and 0.94 per cent Cl. 9/ The other three iron-ore deposits at Baharia Oasis area are Gabal Ghorabi (54 million tonnes grading on average 46.8 per cent Fe), Nasser (26.6 million tonnes grading on average 43.7 per cent Fe) and El Harra (33.7 million tonnes grading on average 42.0 per cent Fe).

The iron mineralization occurring in the Giddi area, Sinai Peninsula, and lying 60 km east of the Suez Canal was discovered in 1969. It is very similar to the Baharia type. Reserve estimates and grade are not available. A summary of the tonnage and chemistry of the known iron-ore resources in Egypt is given in table I.2.

(i) Exploitation of iron ore in Egypt

Iron ore mining in Egypt is carried out by the State Iron and Steel Company, which began operations at Aswan in 1957. The iron ore mined at Aswan, currently running at 70,000 tonnes per year, is transported both by rail and by water to the Helwan Iron and Steel Complex located 16 km south of Cairo.

8/ Studies of Some Mineral Deposits in Egypt (Geological Survey of the UAR, 1970), pp. 5-7.

9/ Ibid.

In 1973 the Iron and Steel Company began exploiting the El Gidida iron-ore deposits at Baharia Oasis. The ore mined at El Gidida is transported on a 346 km railway to the Helwan Iron and Steel Complex. Production is currently running at 1 million tonnes per year and could be increased to 3.5 million tonnes, but storage facilities are lacking. 10/

The Helwan Iron and Steel Complex, built with technical aid from the USSR, started production in 1958 with a capacity of 300,000 tonnes per year. It has since been expanded to 1.7 million tonne capacity steel. The complex is being linked with the Abu al Gharadiq gas field so that the coking coal previously imported from the USSR and Poland can be replaced by gas. 11/

From 1957 to 1972 iron-ore production in Egypt averaged 450,000 tonnes annually, all of it from the Aswan mine. From 1973 onwards, the El Gidida mine started production and since then Egyptian iron-ore production has been about 1.2 million tonnes annually (details of production for the period 1968-1977 are contained in table II.2).

(ii) Iron and steel production in Egypt

All the iron-ore mined in Egypt is used locally in iron- and steel-making, 12/ except for a small proportion used in the manufacture of cement.

In 1968 and 1976 Egyptian pig-iron production (excluding ferroalloys) was 220,000 and 569,000 tonnes respectively (Figures for the intervening years are given in table IV. Pig-iron production has been increasing since 1968 and by 1976 had increased by 61 per cent as compared with the 1968 figure.

(c) Libyan Arab Jamahiriya

The principal occurrences of iron-ore resources in the Libyan Arab Jamahiriya are in the Shatti Valley in the north of Fezzan Province. The mineralization is a minette type associated with Upper Devonian carboniferous rocks. The ores consist mainly of haematite, chamosite and siderite, and have a high silica and phosphorus content. 13/, 14/, 15/ Ore reserves, which amount to 2,514 million tonnes (Fe content) (table I.3), are divided up as follows:

a. 1,755 million tonnes grading 48 per cent Fe, 16 per cent SiO_2, 0.26 per cent S and 3.25 per cent Al_2O_3;

b. 2,554 million tonnes grading 44 per cent Fe, 21 per cent SiO_2, 0.31 per cent P, 0.29 per cent S;

c. 1,378 million tonnes grading 35 per cent Fe;

d. 227 million tonnes grading 29 per cent Fe, 46 per cent SiO_2, 0.39 per cent P, 0.35 per cent S.

10/ "Egypt's expanding Helwan", Metal Bulletin Monthly, No. 79, July 1977, pp. 37-38.

11/ "Egypt", Mining Annual Review, 1978, p. 513.

12/ "Helwan on time" Metal Bulletin, No. 5860, 18 December 1973, p. 29.

13/ "Steelworks plan for Libya", Metal Bulletin, No. 5927, 27 September 1974, p. 39.

14/ Oolitic Magnetite from Wadi Al-Shati, Fezzan: Sedimentary or Metamorphic in Origin - Second Symposium on the Geology of Libya, Tripoli, 16-21 September 1978, p. 58.

15/ Geology and Mineral Resources of Libya - A Reconnaissance, Geological Survey Professional Paper 660, prepared in co-operation with the Ministries of Industry and National Economy of the Government of Libya under the auspices of the Agency for International Development, US, Department of State.

The resources are located deep in the Saharan desert about 500 km from Misurata on the Mediterranean coast.

Other iron mineralizations occur in northern Tripolitania in association with cretaceous sandstone and in the Dor el Goussa area in central Fezzan in association with Cambrian and Ordovician sandstones.

The Government of the Libyan Arab Jamahiriya plans to develop an iron and steel facility at Misurata which will use the Shatti Valley iron-ore resources to produce 2.5 million tonnes of liquid steel from an ore feed amounting to 4.5 million tonnes annually. 16/

(d) Morocco

Iron mineralizations in Morocco occur in rocks of Pre-Cambrian, Palaeozoic and Mesozoic age. They occur in the old African stable southern table-land (Anti-Atlas zone) as minette deposits in Ordovician rocks, Bilbao types in Carboniferous and Permian rocks, and Lake Superior deposits in Middle Pre-Cambrian rocks in the extreme southern part of the country. In the Atlas zone, which covers much of the central region of the country, and the Tell and Rif zone, lying along the Mediterranean coast, iron-ore deposits occur as Magnitnaya types, having been affected by both hercynian and Alpine metamorphism.

The iron-ore deposits located at Imin n'Tourza (in the Jebel Ougnat region), at Ouarzamine Tachila near Agadir, and at Ait Ahmane near Bou Azer in the Ouarzazate region, are some of the most important iron-ore resources occurring in the old African stable table land. The iron-ore resources at Imin n'Tourza and at Ouarzamine are found in host rocks of Ordovician and Lower Silurian age. The ores are either oolitic magnetite or siderite and/or goethite. At Ait Ahmane the iron mineralization is a Lake Superior type associated with stratiform Pre-Cambrian rocks. At Kettara (west of Marrakech) hydrothermal iron-ore resources occur in vein deposits.

The important iron-ore resources located in the Atlas region of Morocco are Bou Ousel (Khénifra region), Boulhaut, Ait Amar and Keradid. The mineralization at Bou Ousel is barytic haematite, a Bilbao-type substitution in Carboniferous limestone. Those at Boulhaut Ait Amar and Keradid are oolitic magnetite minette types associated with sedimentary Ordovician/Lower Silurian rocks.

The iron-ore resources located in the Rif and Tell Alpine zone of Morocco, and in particular those located in the Rif area (at Ouichane, Achara and Setolazar) are the most important in the country. The mineralization occurs as Bilbao substitution in Jurassic limestones in which, during the Alpine metamorphism, much of the mineralization has been converted into Magnitnaya iron-ore types. Total iron-ore reserves amount to 56 million tonnes contained iron (Details of the tonnage and the chemistry of the various iron-ore deposits are given in table I.4).

(i) Exploitation of iron ore in Morocco

The earliest iron-ore deposit to be exploited in Morocco was at Ait Amar. The available records 17/ show that by 1973 iron-ore production had already begun at Ait Amar. Records also show that, before the mine was closed down in 1962, it was a substantial producer of iron-ore concentrate, reaching a peak production of 552,000 tonnes during 1952.

16/ "Libya", Mining Annual Review, 1978, p. 511.

17/ Etude d'investigations dans les branches mécaniques et électriques et dans les industries .....

The centre of iron-ore production in Morocco is now in the Rif region. In 1940 a Spanish Company, Compagnie Espagnole des Mines du Rif, began exploiting the iron-ore deposits at Quichane, Achara and Setolazar.

Mining at Quichane and Achara was by both open-cast and underground methods while mining at Setolazar was entirely underground.

Ore beneficiation at Quichane, Achara and Setolazar involved crushing, grinding, floatation, magnetic separation and calcination to remove sulphur, in particular, present in the ores as pyrite. A concentrate containing 63-65 per cent Fe, and 0.25-0.30 per cent S was obtained.

During the period 1964-1967 the company suffered from operating difficulties, due to the exhaustion of the rich and easily accessible ore reserves, as well as marketing difficulties because of the abnormally high sulphur content of the Rif iron ores. In 1967 the company ceased operation, as a result of which the Government took over the mines. In 1968 Société d'Exploitations des Mines du Rif (SEFERIF) was established by the Government as a branch of the Bureau de Recherches et de Participations Minières, (BRPM) to continue mining at Quichane, Achara and Setolazar.

Seferif carried out intensive geological studies of the Rif iron-ore deposits which led to the discovery of another iron-ore deposit at Iber Kanen, lying between Achara and Setolazar. At the same time the various ores delineated in the Rif zone were intensively studied metallurgically and, as a result, a decision was made to construct a pelletizing plant of 850,000 tonnes capacity at Nador. It began operation during 1973. The principal Moroccan iron-ore mines are listed below:

Mine	Remarks
Quichane	The rich and easily accessible ore deposits have been exhausted.
Achara	Productive, open-cast.
Setolazar	Underground operations stopped in 1967. Plans to resume mining during 1990.
Iber Kanen	Underground mining began in 1975.

(ii) Iron-ore production in Morocco

Iron-ore production in Morocco for the period 1968-1977 is shown in table II.3. As noted earlier, Compagnie Espangnole des Mines du Rif, during the period 1964-1967, suffered from operating and marketing difficulties in respect of the ore from their mines at Quichan Achara and Setolazar, and this led to the closure of the mines in 1967. During the four-year period prior to the closure of the mines iron-ore production had been on the decline, and continued to fall after the Government had taken over the mines. Between 1968 and 1972 for instance, iron-ore production fell by 71 per cent (see table II.3). From 1973 to 1975 there was, however, a gradual increase in production from 375,000 tonnes in 1973 to 554,000 tonnes in 1975. This was due to the coming on stream of the Nador pelletizing plant

(whose start-up date was in 1973); in addition, a new underground mine at Iber Kanen began production during 1975. During 1976 and 1977 production was 343,000 tonnes and 407,000 tonnes respectively. The decline during 1976 and 1977 is attributable to cut-backs in production resulting from lack of demand caused, in turn, by the world recession.

Another minor source of iron in Morocco is as a by-product of pyrrhotite mining at Kettara. After the pyrrhotite has been roasted to remove the sulphur (which is used in the fertilizer industry), the iron cinder produced in the process is stock-piled and will most probably be sintered to be fed to the blast furnaces of the iron and steel plant under serious consideration at Nador. Production of pyrrhotite is currently running at 76,000 tonnes. Production for the period 1968-1977 is shown in table II.4.

(iii) Exports of iron ore from Morocco

Moroccan iron-ore exports have declined since 1968 (table III.2). Thus, in 1968, iron-ore exports were 658,000 tonnes but by 1976 had fallen to 338,000 tonnes. In monetary terms the revenue obtained from iron-ore exports has also declined. The share of iron ore in total mineral exports and total commodity exports, for instance, were 3.5 per cent and 1 per cent respectively in 1968 but by 1976 had declined to 1 per cent and 0.5 per cent respectively. It is likely that, with the coming on stream of the Nador iron and steel facility during the 1980s, iron-ore exports from Morocco will decline still further.

(e) The Sudan

The iron resources in the Sudan occur mainly in rocks of Pre-Cambrian age as bedded deposits and as laterites derived from rocks of various ages. The principal iron resources occur at Fodikwan and Sofaya in the Red Sea Hills and also in the South-central Kodofan, at Kutum in the Wadi Halfa area, at Ingessana Hills in the Blue Nile Province and in the Bahr el Ghazal Province. 18/, 19/

At Fodikwan and at Sofaya (Red Sea Hills) the deposits are associated with Pre-Cambrian basic rocks. The ore-forming minerals are mainly magnetite and minor haematite derived from the alteration of magnetite. The iron mineralization is a Magnitnaya type. Reserves at Fodikwan are estimated at 6 million tonnes grading on average 60 per cent Fe. Those at Sofaya are estimated at 20 million tonnes, also grading on average 60 per cent Fe.

The principal iron resources in the Kordofan province are located at Abu Tulu. The mineralization is a Lake Superior type. Ore-forming minerals are mainly haematite with some magnetite. Potential ore reserves are estimated at 36 million tonnes grading on average 61 per cent Fe and 5 per cent SiO_2.

At Kutum in the Wadi Halfa area, minette-type iron resources occur within the Nubian series (Mesozoic). The ore-forming mineral is haematite. Potential resources are estimated at 10 million tonnes grading on average 51 per cent Fe.

18/ "Ministry of Energy and Mining of Sudan", Mining Journal, vol. 291, No. 7457, 21 July 1978, p. 47.

19/ A.J. Whiteman, the Geology of the Sudan Republic (1971), p. 240.

The laterite iron-ore accumulations occurring in the Bahr el Ghazal Province appear to be the largest iron resources in the Sudan, but no systematic investigations have been carried out on them to determine their tonnage and grade. Total iron-ore reserves are estimated at 16 million tonnes contained iron (see table I.5).

Exploitation of iron ore in the Sudan

The only iron-ore resources to be exploited in the Sudan are those located at Fodikwan and at Sofaya because of their proximity to the sea, but even these have only been intermittently worked and then only on a small scale.

In 1964 the Fodikwan Company Ltd. was established to work the Fodikwan iron-ore deposits. One other mine which is reported to have been in operation is that based on the Sofaya iron-ore deposits. The information available is that in 1962 the lease covering the Sofaya deposits was held by Sudanese nationals who had a contract to supply iron ore to a Yugoslav company. It is reported that, although they shipped some ore to Yugoslavia, the deal fell through because ore specifications were not met. 20/

Production of iron ore in the Sudan is insignificant.

(f) Tunisia

The principal iron-ore resources in Tunisia are Bilbao types with minor minette types occurring in the southern part of the country. 21/ The most important of the iron-ore resources are found in the Tamera-Douria-Bouchiba area, and at Djerissa, Jebel Ank, Nebeur, and Nefza.

The Tamera-Doria-Bouchiba deposits occur in the north of the country. They consist of a number of scattered haematite deposits of Bilbao type substituting for limestone of upper Miocene age. The deposits have a high content of arsenic, lead, zinc and silica. Below the water-table the ores consist of mainly siderite.

Ore reserves at Tamera amount to 10.0 million tonnes haematite grading 52 per cent Fe.

At Douaria siderite reserves amount to 14 million tonnes grading on average 60 per cent Fe.

The Djerissa iron-ore deposits are located in the Province of Kaf not far from the Algerian border and just 30 km east of the Ouenza iron-ore mine in Algeria. The Djerissa iron deposits in Tunisia and the Ouenza and Bou Khadra iron-ore deposits on the other side of the border in Algeria are geologically continuous, for all three lie at the edge of the Ouenza Massif. The ore-forming minerals of the deposits are haematite with siderite occurring particularly below the water-table. Reserves at Djerissa are estimated at 32 million tonnes of haematite ore grading on average 54 per cent Fe.

20/ Ibid.

21/ Etudes d'investigation dans les branches mécaniques et électriques et dans les industries ...

The Jebel Ank iron-ore resources near Gafa are of the oolitic minette type and occur in sedimentary rocks of Eocene age. The ores grade on average 53 per cent Fe and have an abnormally high phosphorus content (up to 0.8 per cent P). Potential resources are estimated at 30 million tonnes.

At Nebour in the Kef region about 10 million tonnes of potential oolitic iron-ore resources have also been investigated. They grade on average 40 per cent Fe and 6-10 per cent SiO_2.

At Nefza, not far from the Tamera-Douaria-Bouchi deposits, potential iron-ore resources amounting to 10 million tonnes and grading 20-27 per cent Fe are known to exist.

Total iron ore reserves are estimated at 23 million tonnes contained iron (see table I.6).

(i) Exploitation of iron ore in Tunisia

a. Tamera-Douria mines

Several scattered iron mines exist in the Tamera-Douaria-Bouchiba area; they have been operated by Scciété du Djebel Djerissa since 1967.

Annual production averages 111,000 tonnes of iron-ore concentrate, half of which is exported and the other half used as feedstock for the El Fouladh and Menzel Bourgiba Iron and Steel works.

As a deliberate national policy, production has been allowed to fall in order to conserve reserves. 22/ The mines employ about 500 persons.

b. Djerrisa mine

During 1971 and 1972 annual production at Djerrisa mine was averaging 800,000 tonnes but has now been allowed to fall in order to conserve reserves. It is current running at 200,000 tonnes annually. The mine is operated both by open-cast and underground methods. More than two thirds of production is exported while the remain supplies the El Fouladh and the Menzel Boughiba Iron and Steel plants.

Over all, for the period 1968-1977, total production has declined from about 1 million tonnes in 1968 and now stands at 0.3 million tonnes, as shown in table II.5

(ii) Exports of iron ore from Tunisia

Tunisian iron-ore exports have declined over the period 1968-1976 and are still declining. In 1968, for instance, iron-ore exports were 654,000 tonnes but by 1976 had fallen to 113,000 tonnes. This follows the 1972 decision to reduce production in order to conserve ore reserves. As a consequence of the decline in iron-ore exports, the share by value of such exports in total mineral and total commodity exports has also declined from 6.3 per cent and 2.5 per cent respectively in 1968 to 0.3 per cent and 0.2 per cent respectively in 1976 (see table III.3).

22/ "Maghreb-Europe: mineral bond", Mining Journal, vol. 290, No. 7452, 16 June 197 pp. 449-451.

(iii) Pig-iron and ferroalloy production in Tunisia

The annual production of pig-iron and ferroalloys over the period 1968-1976 has averaged 130,000 tonnes, as indicated in table IV.3.

There are plans to increase iron and steel production in Tunisia through the use of imported as well as local ore. A direct-reduction plant, probably based on Brazilian ore and local gas, is under construction.

3. WEST AFRICA SUBREGION

All the known iron-ore resources of importance in the West Africa subregion are sedimentary-controlled except for the lateritic Koloun iron-ore deposits of Guinea and the magmatic Agracha iron resources of Western Sahara. The majority of the iron-ore deposits in the subregion are Lake Superior or minette with a few Bilbao types.

(a) Benin

Iron-ore resources in Benin occur as minette types in association with Mesozoic and Tertiary sedimentary rocks. The ore-forming mineral is haematite. The principal iron-ore accumulations are located at Loumbou-Loumbou and Madékali in the Kandi district in the northern part of the country. 23/, 24/ The resources lie about 550 km north of Porto Novo on the Atlantic coast. Potential resources at Loumbou-Loumbou are estimated at 250 million tonnes grading on average 50 per cent Fe, 16 per cent SiO_2, 0.04 per cent S, 0.8 per cent P 5 per cent Al_2O_3 and 0.08 per cent Mn. Potential resources at Madekali are estimated at 40 million tonnes grading on average 58 per cent Fe, 3 per cent SiO_2, 2 per cent Al_2O_3, 0.09 per cent Mn and 0.8 per cent CaO (see table I.7).

(b) Ghana

The principal iron resources in Ghana are the Shieni sedimentary iron-ore deposits, the Opon-Mansi lateritic iron-ore deposits and the Pudo titaniferous magnetite ore deposit. 25/

(i) The Shieni sedimentary iron-ore resources (minette type)

The Shieni sedimentary iron-ore resources occur in the northern region near the borde with Togo. They are associated with the Voltaian formation. The ore-forming mineral is haematite. Reserves are estimated at 1,270 million tonnes with average grade 35-50 per ce Fe, 18-37 per cent SiO_2, 0.33 per cent P and an abnormally high percentage of titanium.

(ii) The Opon-Mansi lateritic iron-ore resources

The Opon-Mansi lateritic iron-ore resources are developed over folded rocks of the Tarkwaian and Birimian. Reserves are put at 150 million tonnes grading on average 52.5 pe cent Fe, 3.6 per cent SiO_2, 0.9 per cent P and 15 per cent Al_2O_3.

23/ Survey of World Iron-Ore Resources .....

24/ "Benin", Mining Annual Review, 1978, p. 497.

25/ Iron-Ore Deposits of Ghana (Ghana Geological Survey, Report No. 75/7, 1975).

(iii) Pudo titaniferous-magnetite iron-ore resources (Taberg type)

The deposit occurs at Pudo in the north-central part of the Upper Region. The ore consists of thin but persistent magnetite bands separated by norite. The magnetite bands are vertical or steeply dipping. Potential resources are estimated at 4.5 million tonnes grading on average 33.5 per cent Fe_2O_3 and 3.9 per cent TiO_2.

(iv) Other iron ore resources or indications in Ghana

Indications of iron-ore have been found at Akpafu in the Volta Region in the form of haematites associated with cherty quartzites and sandstones. The average grade on the few samples analysed was found to be 50 per cent Fe_2O_3 and 38 per cent SiO_2. Other occurrences have been found in the Eastern and Western Regions but no systematic investigations have so far been carried out on them.

Over all the total known iron-ore reserves in Ghana amount to 618 million tonnes of contained iron. The details of the various iron-ore deposits are given in table I.8.

(c) Guinea

Iron-ore resources in Guinea are found at Koloum, Forécariah and Yomboeli, near Conakry, the country's capital, at Tomine near Gaoual, located in the north-western part of the country, and at Simandou and Nimba in the south-east. 26/, 27/

The Koloum, Forécariah, Yomboeli and Tomine iron-ore resources are lateritic types. Reserves at Koloum are estimated at 9 million tonnes grading on average 52 per cent Fe, 1.5 per cent Cr and 0.05 per cent P. Those at Forécariah are estimated at 300 million tonnes grading on average 53 per cent Fe, 1.5 per cent Co and 0.05 per cent P. At Yomboeli reserves are estimated at 2 million tonnes grading on average 40 per cent Fe, and those at Tomine are estimated at 200 million tonnes grading on average 55 per cent Fe, 1 per cent Cr and 0.45 per cent P.

The Simandou and Nimba iron-ore resources in Guinea are an extension north-eastwards of the Nimba iron-ore deposits of Liberia. Simandou lies 15 km north-east of the Liberian Nimba iron-ore deposits while the Guinean Nimba iron-ore resources lie 122 km further on to the north-east. The principal ore-forming mineral at Simandou and at Nimba is haematite, which accounts for about 93 per cent of all the iron-ore-forming minerals. Reserves at Simandou amount to 1,000 million tonnes grading on average 65 per cent Fe, 0.05 per cent P, 0.25-0.4 per cent SiO_2 and 5.8 Al_2O_3. Those at Nimba amount to 700 million tonnes grading on average 67 per cent Fe and 0.04 per cent P. Both the Simandou and Nimba iron-ore resources contain traces of chromium.

The total known iron-ore reserves in Guinea amount to 1,394 million tonnes contained iron. Details of the tonnage and chemistry of the various iron-ore deposits are given in table I.9.

26/ H.R.V. Gaertner, Rapport sur les gisements de minerais de fer en Guinée (Bundesanstalt, für Bodenforschung, 1961), unpublished report.

27/ "Guinea", Mining Annual Review, 1970, p. 360.

(i) Exploitation of iron-ore in Guinea

The Koloum lateritic iron-ore deposits were exploited over the period 1953-1966 by Compagnie Minière de Conakry, owned by British and French interests. The mine was operated by open-cast methods and annual production averaged about 1 million tonnes of iron ore. The history of production annually for the period 1957-1966 is given in table II.6.

The ore was transported on a railway 12 km long from the Koloum peninsula to the port of Conakry for export mainly to Poland, the United Kingdom, the German Democratic Republic, Czechoslovakia and Egypt. Because of competition from other producing countries, however, the prejudice of some consumers against the comparatively low iron content (about 51.5 per cent Fe) and high chromium content (about 1.25 per cent Cr), and the acquisition of some of the equity in the company by the State in 1961, the original owners, who were still operating the mine, allowed it to run down and eventually mining operations ceased in 1966.

(ii) Future projects

In 1966, the Government, together with five international companies, established Mifergui (Guinean Iron-Ore Company) to exploit the Nimba and Simandou iron-ore deposits. The share capital at the time was reported to have been distributed as follows:

	Percentage
Guinean Government	50
Southland Mining of Australia	20
United States Steel	12.5
Finsinder of Italy	7.5
State Steel Company of Yugoslavia	5
State Steel Company of Romania	5

In 1971 it was reported that the British Steel Corporation was also interested in participating in the venture and that Okura Trading Company of Japan had signed a long-term agreement to buy 7.5 million tonnes of the Simandou-Nimba iron-ore. The remainder was to be bought by the five Mifergui participating international companies. 28/, 29/, 30/, 31/, 32/, 33/ Iron-ore production was planned at 15 million tonnes of ore concentrate annually.

(iii) Infrastructure development

The Simandou and Nimba iron-ore deposits lie about 20 km and 120 km respectively to th north-east of the LAMCO Iron Ore Mines in Liberia. The international participants in

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28/ Ibid.

29/ "Guinea", Minerals Yearbook, vol. III Area Reports: International (USBM, 1972) p. 1004.

30/ "Guinea", Mining Annual Review, 1974, p. 571.

31/ "Guinea", Mining Annual Review, 1978, p. 501.

32/ "Guinea: changing direction", African Research Bulletin, vol. 15, No. 10 30 November 1978, pp. 4880-4881.

33/ "Guinée", Afrique Industrie, No. 182, April 1979, p. 20.

Miferqui wanted to build a railway linking the Simandou-Nimba iron-ore deposits in Guinea to the LAMCO rail-head, arguing that it would have been cheaper and have enabled an earlier start to be made on the project than extending the Conakry-Kankan railway to Simandou and Nimba, as proposed by the Government. The Government's view is that the extension would not only serve the iron mines but also open up the entire central region of Guinea by providing an outlet to and from the Atlantic port of Conakry. The Government's wishes ultimately prevailed and studies are now under way on the construction of a rail link between Kankan and Simandou-Nimba.

(d) Ivory Coast

(i) Reported iron resources

Iron-ore resources in the Ivory Coast are widely distributed throughout the country but none is being exploited at present. The commonest iron-ore occurrences are either minette or Lake Superior types. Five of the most important known iron-ore resources in the country are as follows: 34

a. At [illegible] oolitic iron-ore resources (minette-type) occur associated with Miocene-Pliocene sedimentary series. The ore-forming minerals are goethite and hematite. Potential iron-ore resources are estimated at 150 million tonnes grading on average 40 per cent Fe, 23 per cent SiO_2, 0.06 per cent S, 0.25 per cent P and 11 per cent Al_2O_3.

b. At Mamandre oolitic Miocene-Pliocene iron-ore resources also occur. Potential resources are estimated at 45 million tonnes grading on average 42 per cent Fe, 14 per cent SiO_2, 0.05 per cent S and 0.2 per cent P.

c. At Gao Mountain Lake Superior-type magnetite iron-ore resources occur. Potential resources are estimated at 250 million tonnes grading on average 40 per cent Fe and 34 per cent SiO_2.

d. At Segaye Mountain Lake Superior-type magnetite iron-ore resources have been identified. Potential resources are estimated at 43 million tonnes grading 25-48 per cent Fe and with a high silica content.

e. Lake Superior-type iron-ore resources exist at Totro Mountain. Potential resources are estimated at 265 million tonnes grading 25-48 per cent Fe.

f. Lake Superior-type iron-ore reserves amounting to 232 million tonnes grading 25-48 per cent Fe have been delimited at Tia Mountain.

g. Lake Superior-type iron-ore resources located at Klahoyo Mountain have been intensively studied by Société des Mines de Fer de la Côte d'Ivoire (Comiferci). Reserves are estimated at 1,400 million tonnes grading on average 36.3 per cent Fe.

34/ Atlas des Indices Minéraux de la Côte d'Ivoire - Sodemi (Ministère des Mines, 1975).

h. Potential iron-ore resources estimated at many millions of tonnes occur in that part of the Nimba mountains extending into the Ivory Coast. However, very few detailed investigations have been carried out on these resources.

i. In the Dans Massif potential iron-ore resources exist amounting to 5 million tonnes with average grade 40 per cent Fe.

j. At Sipilou potential Lake Superior-type iron-ore resources estimated at 50 million tonnes grading on average 40 per cent are known to exist.

k. The Beti and Tienko Mountains in the Touba region are known to have potential iron-ore resources of Lake Superior-type. Potential resources at Beti are estimated to be 20 million tonnes grading on average 37 per cent Fe and at Tienko 7 million tonnes grading on average 43 per cent.

l. Potential iron-ore resources amounting to 130 million tonnes and grading 40 per cent are known to exist at Kaniasso.

(ii) Massive and residual iron resources

Of massive and residual resources, although occurring in various geological environments in the Ivory Coast, the most important are:

a. As thin titanium-bearing magnetite bands in the Birrimian System, e.g., at Tortiya.

b. As pegmatitic titanium iron minerals, e.g., north Daloa.

c. As secondary titanium iron minerals in laterites, e.g., west of Daloa.

d. As titanium-rich magnetite derived as differential segregations from basic magmatic igneous rocks, e.g., at Samorokaha.

None of these iron mineralization occurrences has been investigated in detail with a view to delimiting ore reserves and grade. However, potential resources are presumably large.

The known iron-ore reserves in the Ivory Coast amount to 448 million tonnes of contained iron. Details of the tonnage and chemistry of the various deposits are given in table I.10.

(iii) Plans to start iron-ore mining at Klahoyo

Comiferci has plans to start producing 12 million tonnes per year of iron pellets based on the Klahoyo iron-ore resources. 35/, 36/, 37/, 38/, 39/ There were two possible ways of transporting the ore to the port of San Pédro. The first involved pelletizing at the mine and transporting the pellets by rail for 376 km. The second was to transport the concentrate suspended in water via a 330 km long pipeline to the port and pelletizing it there. It has been reported recently 40/ that a decision has been taken to adopt the second alternative. The energy required by the mine will be obtained from a hydroelectric dam now under construction on the Sassandra River.

The participants in the project are:

British Steel Corporation (United Kingdom)	20 per cent
Mitsubishi Corporation) (Japan) Sumitomo Shoji Kaisha)	40 per cent
Ore and Metal Co. Ltd. (Oremco) (South Africa)	10 per cent
Usinor (France)	10 per cent
Packands Mather International (USA)	15 per cent
Ivory Coast Government	5 per cent

The cost of the project is estimated at $US 4 billion and because of the huge capital outlay Comiferci is trying to find other companies willing to join the consortium. 41/

(e) Liberia

Iron-ore resources in Liberia occur as haematite and/or magnetite in schists or gneisses and/or quartzites associated with Pre-Cambrian rocks. A few of the known iron-ore occurrences in the country are being exploited but the majority are still being investigated to determine their economic viability. Details of the tonnages and chemistry of some of the most important iron-ore resources in Liberia are given below.

35/ "Ivory Coast venture", Mining Magazine, May 1974, p. 375.

36/ "Klahoyo", Bulletin de l'Afrique noire, No. 250, September 1974, p. 821.

37/ "Côte d'Ivoire", Bulletin de l'Afrique noire, No. 246, May 1974, p. 493.

38/ "Japanese interest in iron-ore project in Ivory Coast", Quarterly Economic Review, No. 4, 1973, p. 12.

39/ Projet de Mines de Fer en Côte d'Ivoire, Ministère de l'économie et des Finances: Secrétariat d'état chargé de Mines, January 1973, unpublished.

40/ "Ivory Coast iron ore ", Mining Magazine, December 1978, p. 639.

41/ "Interest in Ivory Coast iron ore and nickel revives", Mining Journal, vol. 291, No. 746, 18 August 1978, p. 117.

(i) Bomi Hills iron-ore deposits

The Bomi Hills iron-ore deposits occur in association with schists, gneisses, granite and minor diabase of Pre-Cambrian age. The strikes of the ore-bodies are sometimes concordant and sometimes discordant with the general strikes of the country rocks and they are therefore classified as Michicopiten types.

The ore-forming mineral is magnetite that has been partially oxidized to haematite. The grade averages 68 per cent Fe in the high-grade ores and 30 per cent Fe in the more siliceous ores. Iron-ore reserves still to be exploited amount to 65 million tonnes grading on average 45.3 per cent Fe.

Exploitation of iron ore at Bomi Hills Mine

The Bomi iron ore mines began production in 1951. Mining was by open-cast methods. Production was a steady 2.8-3 million tonnes annually until the mine ceased operations in March 1977.

The mine was owned by Liberia Mining Company (LMC) whose equity capital was divided up as follows:

Republic Steel (USA)	60 per cent
U.S. Steel)	
Christie family)	40 per cent

To enable LMC to carry out mining operations at Bomi, the following steps were taken:

(i) A narrow-gauge railway and a road were built to link Bomi with Monrovia.

(ii) A harbour was constructed at Monrovia.

(iii) Social services (housing, water, power, etc.) were provided at Bomi.

All the iron ore produced was exported, mainly to the United Kingdom, Federal Republic of Germany, Italy and the USA. At the time of closure, the mine averaged an annual production amounting to about 0.6 million tonnes and had a labour force of 2,585, of whom 133 were expatriates.

(ii) Mano River iron-ore deposits

The Mano River iron-ore deposits are geologically similar to the Bomi Hills deposits. Ore reserves are estimated at 15 million tonnes grading on average 47 per cent Fe.

a. Exploitation of iron ore at Mano River Mine

The National Iron Ore Company (NIOC) was established in 1958 to exploit the Mano River iron-ore deposits. Its equity was divided up among the following:

Liberia Mining Company (LMC), owned by Republic Steel, US Steel and Christie family	-	15 per cent
The Government of Liberia	-	50 per cent
Liberia Enterprises Incorporated	-	35 per cent

Liberia Enterprises Incorporated is owned by private share-holders (43 per cent American and 57 per cent Liberian). Of the American shares, at least 25 per cent are owned by the Christie family.

NIOC entered an agreement with Mine Management Associated Ltd. (MMA), owned 100 per cent by the Christie family, to run the mine and sell the iron ore. For their services they are paid 3 per cent of the gross sales, tax free, irrespective of the profit made during the year.

Associated Mines Services Ltd. (100 per cent owned by the Christie family) also has an agreement with NIOC for services involving mine purchases, contracting etc.

The LMC railway was extended from Bomi Hills to the Mano River iron-ore mines.

Production began in 1962 and reached 3 million tonnes in 1964, rising to 4 million tonnes in 1970.

b. Marketing of iron-ore production from Mano River Mine

Production, all of which is exported, goes mainly to the USA and Europe. From 1963 to 1969, NIOC bought on average 100,000 tonnes from LMC's Bomi Mines. It is said that this was done in order to mix the ores from Mano River with those of Bomi Hills and thus upgrade them so as to obtain a higher price. Another reason for this procedure is that NIOC's ore was sold to Republic Steel under long-term contracts at a fixed price of $US 6 per tonne. Republic Steel, as noted above, is the principal share-holder in LMC. In 1975, the prevailing world price for iron ore averaged $US 12 per tonne. Thus NIOC was not interested in making a profit as long as it produced cheap ore for Republic Steel to buy.

In 1970 the total labour force at Bomi iron mines was, 1,950, of whom 150 were expatriates.

(iii) Nimba (and Tokadeh) iron-ore deposits

These are located in the north-eastern part of the country near the border with Guinea and are typical Lake Superior types which have been subsequently enriched to form both residual and replacement iron ores. The ore-forming mineral is mainly haematite. Ore reserves at Nimba-Tokadeh amount to 1,636 million tonnes grading on average 63.7 per cent Fe, 4 per cent SiO_2, 0.03 per cent S, 0.03 per cent P and 0.9 per cent Al_2O_3.

a. Exploitation of iron ore at Nimba

In 1953 International African-American Corporation (IAAC), and American company, obtained a 60-year concession agreement from the Liberian Government to exploit the Nimba iron-ore deposits. In 1954 the Swedish Liberian Syndicate (SLS) became a partner in IAAC.

SLS was later joined by Bethlehem Steel (LIBETH) to form Liberian American-Swedish Minerals Company Ltd. (LAMCO). A joint agreement was entered into under which LAMCO had a 75 per cent and LIBETH a 25 per cent interest in the concession.

The concession agreement grants LAMCO the exclusive right and privilege to explore, develop, mine, manufacture, transport, load, ship, sell and export iron ore in iron-ore-bearing minerals, etc.

In addition, neither LAMCO nor LIBETH were required to pay taxes, fees, excise duties, royalties, etc., to the Government.

b. Infrastructure development at Nimba-Buchanan

To enable mining to be carried out at Nimba:

(i) A 260 km railway was built from Nimba to Buchanan on the Atlantic coast.

(ii) Complete harbour facilities were developed at Buchanan for the export of the ore.

(iii) Social facilities for the workers were provided at Nimba and Buchanan.

Production began in 1963. Annual production averages 10 million tonnes. All the iron-ore production is exported, mainly to the USA, Federal Republic of Germany, Italy, France, Spain and the Netherlands.

The labour force is about 4,000, of whom 750 are expatriates.

(iv) Bong iron-ore deposits

The Bong iron-ore deposits are similar to the Bomi and Mano River deposits. The ore-forming minerals are magnetite and haematite. Ore reserves are estimated at 371 million tonnes grading on average 38 per cent Fe, 7-8 per cent SiO_2, 0.03 per cent S, and 0.03 per cent P.

a. Exploitation of iron ore at Bong Mine

In 1958, Gewerkschaft Exploration Ltd. obtained a 70-year concession agreement from the Liberian Government to exploit the Bong iron-ore deposits.

Gewerkschaft Exploration Ltd. is a creation of four steel companies in the Federal Republic of Germany, dominated by August Thyssen Hütte. They were joined by the Italian Finsider Group, the largest producer of steel in Italy. The Gewerkschaft and the Finsider Group then formed the Bong Mining Company (BMC). Gewerkschaft Exploration Ltd. has a consulting agreement with BMC.

BMC is a closed mine, i.e. its owners are also its principal customers. The ore is exported solely to the Federal Republic of Germany and Italy. The Group is therefore not interested in making a profit at the mine. As long as production costs are met, profits will follow in the form of a lower ore price and thus a lower cost for steel.

Annual production is about 7 million tonnes of iron-ore concentrate. The total labour force at the mine is about 2,245, of whom 337 are expatriates.

(v) Wologisi Range iron-ore deposits

These deposits are located in the northern part of the country, very close to the Liberian-Guinean border.

The deposits have been under investigation for a number of years by the Liberian Iron and Steel Corporation (LISCO). They have not so far been exploited because of their remoteness from the coast. Plans are under consideration, however, to construct a railway to link Wologisi Range with the Bomi-Monrovia line. Ore reserves amount to 1,285 million tonnes grading on average 45 per cent Fe.

(vi) Putu Range iron-ore deposits

These deposits are located about 160 km north of the Atlantic port of Grand Cess. The property is owned by the Bong Mining Company.

(vii) Other iron-ore resources in Liberia

These include occurrences at Firestone Harbel, Bassa Hills, Kpo Range, Mount Kitoma and Wantike Mountains. They are being investigated and investigations are quite advanced in a few cases, but in others are only at the preliminary stages.

(viii) Over-all assessment

Liberia, with its 2,055 million tonnes contained iron-ore reserves, is second only to South Africa in iron-ore reserves in Africa. Because the Liberian deposits are close to sea ports, the country's iron-ore production features prominently in world trade.

(ix) Iron-ore production in Liberia

Iron-ore production is in the form of: concentrates (19 per cent), pellets (16 per cen washed lump (6 per cent), washed fines (56 per cent) and run of mine (1.6 per cent); all figures are approximate.

It will be seen from table II.7 that iron-ore production increased from 19.6 million tonnes in 1968 to 25.8 million tonnes in 1974. However, from 1975 to the present, productio has declined and fell to 17.5 million tonnes in 1977. This decline in production is linked mainly to events in the world market for steel. The recession in the industrialized market economies, which became noticeable during 1972-1973, was exacerbated by the oil crisis of 1973-1974 and led to a reduced demand for steel, which in turn resulted in a reduced demand for iron ore. Another reason for the decline in iron-ore production in Liberia is the fact that Bomi Iron Mine, the oldest in the country, ceased operations in March 1977.

(x) Exports of iron ore from Liberia

Iron-ore exports, as will be seen from table III.4, account for about 92 per cent and 70 per cent of total mineral and total commodity exports respectively. The pattern of iron-ore exports for the period 1968-1977 has followed that of production, reflecting the fortunes of the iron-ore market, as noted earlier under iron-ore production.

The principal consumers of Liberian iron ore are the Netherlands, France, Italy, the United Kingdom, Belgium, USA, Greece and Japan.

(xi) Contribution of iron-ore mining to GDP and Governments revenue

The Liberian economy is characterized by a total dependence on iron-ore mining. Thus the iron-ore mining industry contributes about 32 per cent to GDP (see tables V.1 and V.2). However, the real contribution of iron-ore mining to the national income is not high. Although it contributed 33.6 per cent to GDP in 1970, after deduction of foreign factors of production, depreciation and cost of capital, the net value added was only 14 per cent. The reason for this is that the majority of the iron-ore mines depend on loan capital and not on own capital; in addition, a large proportion of the work-force consists of expatriates, who export large amounts of money in the form of foreign exchange to their countries of origin.

Iron-ore mining is also important in Government revenue formation, accounting for 20.4 per cent. It follows, therefore, that any decline in iron-ore production and exports would seriously affect the Government's revenue position, as has indeed happened from 1975 to the present. 42/

(f) Mali

The known iron resources of Mali are located in the south-west of the country. They occur as Bilbao and minette types. The iron-ore resources located at Nioro and Djidian-Kenieba are Bilbao types, with magnetite replacing Ordovician limestones, and those located at Galé are minette types, consisting of goethite and haematite. Potential resources at Nioro, Djidian-Kenieba and Galé are respectively 10 million tonnes grading on average 63 per cent Fe, 2 million tonnes grading on average 65 per cent Fe and 58 million tonnes grading on average 52 per cent Fe and 12 per cent SiO_2. 43/, 44/, 45/ (see table I.12).

42/ Economic Survey of Liberia for 1976 (Monrovia, Ministry of Planning and Economic Affairs, Republic of Liberia, 1977), pp. 24-27.

43/ Survey of World Iron Ore Resources ..... Nicolas de Kun.

44/ The Mineral Resources of Africa (1965), pp. 260-274.

45/ "Pour les mines", Industries et travaux d'outremer, No. 252, November 1974, p. 94

(g) Mauritania

The iron-ore resources in Mauritania are situated in the north-central part of the country in the Kedia Range close to the border with Western Sahara. 46/, 47/, 48/ The principal resources occur in the Fort Gouraud area as huge banded haematite Lake Superior iron-ore types. The banded ironstones, where well developed, may reach a maximum thickness of 2,000 m. The grade of the ore averages 62 per cent Fe and may reach 72 per cent where the mineralization is heavy. The quartzite layers alternating with the haematite bands carry values of iron ore of up to 45 per cent Fe (see table I.13).

(i) Exploitation of iron ore in Mauritania

In 1952 Société de Mines de Fer de Mauritanie (Miferma) was established to exploit the Mauritanian iron-ore resources located in the Kedia D'Idjil range. Production began in 1963. At the time of its establishment Miferma was owned by Usinor and Bureau de Recherches Géologiques et Minières (BRGM), both French companies, with a combined holding of 56 per cent, British Steel Corporation (19 per cent), Finsider Group Italian steel-makers) (15 per cent), Auguste Thyssen Hütte AG of the Federal Republic of Germany (5 per cent) and Mauritanian Government (5 per cent).

To enable the iron-ore resources to be exploited, a railway was built from Fort Gouraud to the Atlantic port of Etienne. In addition, an intensive construction and development programme was embarked on at the mine itself. The harbour was dredged so as to deepen it and allow large vessels to use it.

Production began in 1963, the Tazadit deposits being exploited first, followed by the Rouessa deposits. In 1966 the F'Derik ore-body was opened up. Production began at 7.2 million tonnes of ore concentrate, rose sharply to 8.8 million tonnes in 1969 and reached a peak of 11.9 million tonnes in 1974.

In 1974 the Mauritanian Government nationalized the mines and formed the Société Nationale Industrielle et Minière (SNIM) to run them. 49/

All production is exported to France, the Federal Republic of Germany, the United Kingdom, and the Netherlands. For the period 1968-1977, production averaged 8.5 million tonnes annually (see table II.8).

(ii) Exports of iron ore from Mauritania

In 1968 iron ore exports accounted for about 90 per cent of total commodity exports and iron-ore was the only mineral exported from Mauritania until 1970. It was joined by copper during 1971, but the major commodity exported from Mauritania is still iron ore. It follows, therefore, that the decline in iron-ore exports that has occurred since 1974, has caused serious foreign exchange and fiscal problems for the country.

46/ Survey of World Iron Ore Resources ....

47/ "Mauritania's vast mineral wealth", Mining Magazine, April 1968, pp. 220-227.

48/ "Mauritania iron ore", South African Mining and Engineering Journal, 8 March 1968, pp. 538-542.

49/ "Miferma take over", Metal Bulletin, 3 December 1974.

(h) Niger

The important iron-ore resources in Niger are situated at Say-Diabou and at Kolo-Say-Tamou about 80 km to the south of Niamey on the right bank of the River Niger. 50/, 51/ 52/ They occur as oolitic goethite in association with Miocene sedimentary rocks. Potential resources at Say-Diabou are estimated at 600 million tonnes grading on average 49 per cent Fe, 19 per cent SiO_2 and 1.9 per cent P. Those at Kolo-Say-Tamou are estimated at 80 million tonnes grading on average 42 per cent Fe, 19 per cent SiO_2 and 1.8 per cent P (see table I.14).

(i) Nigeria

Two important iron-ore occurrences in Nigeria have been investigated with a view to establishing an iron and steel industry in the country. One of these deposits is located at Itakpe in Kwara State, lying about 60 km south of the confluence of the Niger and Benue branches of the River Niger, and the other is at Enugu and adjacent areas lying to the west of Enugu in Anambra State. 53/, 54/

The Itakpe iron-ore resources consist of an ironstone crust capping of cellular and concretionary laterite which overlies a bed of oolitic and pisolitic ironstone of Cretaceous age. The laterite ironstone crust capping varies in thickness from zero to 7 m, with an average thickness of 5 m. The underlying oolitic ironstone zone has an average thickness of 9 m. Reserves at Itakpe are estimated at 600 million tonnes grading on average 39 per cent Fe, 0.9 per cent P, 0.08 per cent S, and 16.7 per cent combined SiO_2 and Al_2O_3. Pilot mining is in progress and the iron and steel plant planned for Ajoukta, lying a few kilometers to the south, will obtain its ore feed from the Itakpe iron-ore deposits.

The Enugu iron-ore deposits occur as lateritic ironstones in the high country west of Enugu. Potential resources are estimated at more than 200 million tonnes grading on average 32 per cent Fe. The deposits, although of low grade, are favourably situated close to the collieries, and limestone is available a few kilometers to the east.

(j) Senegal

Significant iron-ore resources in Senegal have been delineated in the headwaters of the River Felémé near Saraya. 55/, 56/ The resources are located about 700 km from the Atlantic coast. The iron mineralization is found in association with early Pre-Cambrian (Dahomeyan) rocks consisting of sandstones, schists and jaspers. The same rocks extend northwards into Mauritania and southwards into Guinea. The iron mineralization is a Lake Superior type with

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50/ Survey of World Iron Ore Resources ....

51/ Nicolas de Kun, op. cit.

52/ "Fer de Say et magnétites vanadifères d'Oursi", Commission économique pour l'Afrique (Organisation des Nations Unies), Autorité de développement intégré du Liptako-Gourma, projet FD/1335: rapport sectoriel No. 1, Géologie et Mines, Bruxelles, juillet 1973 pp. GM-iv-3 to GM-iv-4 and GM-iv-12 to GM-iv-15.

53/ Survey of World Iron Ore Resources ....

54/ Minerals and Industry in Nigeria, Federal Government Pointer, 1957, pp. 23-25.

55/ Notes on Senegal, Mineral Unit (United Nations Economic Commission for Africa, 1972), mimeograph.

56/ "Le minerai de fer de Falémé, Sénégal", Marchés tropicaux et méditerranéens, 21 June 1974, p. 57.

haematite as the principal ore-forming mineral. Reserves are estimated at 700 million tonnes and potential ore resources at 600 million tonnes all grading on average 60 per cent Fe (see table I.16).

(k) Sierra Leone

The important iron-ore resources in Sierra Leone occur at Marampa and at Tonkolili, 80 km east of Marampa, at Great Scarcies River, 80 km north of Marampa, and at Bagla Hill in the southern part of the country. Other iron resources occurring as beach sands exist at Gbangbama (Magbwemo) in the Southern Province. 57/, 58/

(i) Marampa iron-ore resources

The Marampa iron-ore resources occur as haematite-muscovite within the Marampa Schists The resources, although banded, are not of the Lake Superior type sensu stricto but rather an enrichment of the surface rocks in iron by weathering such that the lumpy haematite which has formed in the process is economic to exploit. Reserves that remain to be exploited at Marampa are estimated at 100 million tonnes grading on average 38 per cent Fe

(ii) Tonkolili iron-ore resources

The Tonkolili iron-ore resources occur within the Kambui Schists belt (Pre-Cambrian) covering much of the Sula Highlands. The resources were investigated by Bethlehem Steel of the USA during 1973-1975; it was found that, although the iron mineralization occurs as banded ironstones, the economic zones have been enriched subsequently through lateritizati processes. The ore-forming minerals are martite and goethite. Reserves are estimated at 608 million tonnes grading on average 54 per cent Fe, and 8-9 per cent Al_2O_3.

The resources are important for they are situated not very far from the proposed hydroelectric power station at Bumbuna on the Rockel River.

(iii) The Great Scarcies River iron-ore resources

Iron-ore resources estimated at 15 million tonnes and grading on average 30 per cent Fe exist close to the Great Scarcies River, about 80 km north of Marampa close to the border between Guinea and Sierra Leone.

(iv) Bagla Hill iron-ore resources

At Bagla Hill in the Kanema District, situated in the southern part of the country, iron-ore resources exist in association with the Kambui Schists. The ore-bodies consist of magnetite enclosed in gneisses and quartzites.

57/ The Mineral Resources of Sierra Leone, Report No. G.P. R/1551/76/100/7.76 (Ministry of Lands and Mines, 1976).

58/ "Iron ore and rutile" (Sierra Leone, Ministry of Mines, Mines Division, 1973-1975), unpublished report, pp. 17-20.

Bethlehem Steel Corporation of USA have investigated the deposits and have delineated reserves amounting to 400 million tonnes grading on average 41.6 per cent Fe, 1.58 per cent SiO_2 and 6.6 per cent Al_2O_3 (see table I.17).

(v) Beach sands at Gbangbama (Magbwemo)

Reserves amounting to 172 million tonnes grading 1.75 per cent rutile have been delineated at Gbangbama in Moyamba District by Sierra Rutile Ltd., a company owned by Bethlehem Steel Corporation of the USA, (85 per cent) and Nord Resources Corporation of Canada (15 per cent).

(vi) Exploitation of iron ore in Sierra Leone

a. Marampa iron-ore mine

The Marampa iron-ore deposits were discovered in 1926. About 1930, the Sierra Leone Development Company, a subsidiary of William Baird of the United Kingdom, was formed to exploit those deposits.

A railway was built from Marampa to Freetown, where port facilities were also developed to handle the iron ore.

Mining was by open-cast methods. Production began in 1933 and averaged 2 million tonnes of iron-ore concentrate annually. All the ore was exported to the United Kingdom (32 per cent), the Federal Republic of Germany (35 per cent), the Netherlands (27 per cent), France (4 per cent) and Austria (2 per cent). In 1970 the Government of Sierra Leone acquired a 51 per cent interest in the company. Mining operations ceased in November 1975 owing, it is claimed by the company, to technical reasons. At its peak the mine employed about 5,000 persons, who were all laid off after the closure of the mine.

Iron-ore production for the period 1968-1975 averaged 2.5 million tonnes annually (details are given in table II.9).

b. Beach sand mining at Gbangbama

In 1967 Sherbro Minerals Ltd, owned by British Titan Products Co. Ltd. (20 per cent) and Pittsburgh Glass Co. of the USA (80 per cent), began exploiting beach sands at Gbangbama for rutile, but for technical reasons abandoned the venture in 1971. For the period 1967-1971 production of rutile concentrate (in tonnes) was as follows:

1967	1968	1969	1970	1971
25,142	13,898	28,403	44,058	11,933

In 1976 Sierra Rutile Ltd. took over the property and constructed a dredge and a concentrating plant. Production began in April 1979 and the full capacity of 100,000 tonnes of rutile concentrate annually is expected to be reached during 1980. Sierra

Rutile Ltd. is to pay the Government of Sierra Leone a royalty of $US 4 a tonne produced in addition to 50 per cent of the profits. 59/, 60/, 61/, 62/, 63/

(vii) Exports of iron-ore from Sierra Leone

For the period 1968-1973 iron-ore exports from Sierra Leone averaged about 2.45 million tonnes annually. In 1974, however, the figure was 2 million tonnes and there was a further decline to 1.4 million tonnes during 1975. The Marampa mine was closed in November 1975. In financial terms the country was receiving about $US 14 million annually for the period 1968-1975, which amounted to about 15 per cent and 12 per cent of total mineral and total commodity exports respectively.

(l) Togo

Four years of investigations (from 1964 to 1968) by the Institut géographique national (IGN) together with the Bureau de Recherches Géologiques et Minières (BRGM), both of France, resulted in the delineation of two important iron-ore deposits at Benjél and at Bitijaba in Togo. 64/, 65/ The mineralization is of Lake Superior type with haematite as the principal ore-forming mineral in late Pre-Cambrian (Buem) host rocks. The deposits are located about 460 km from and north of the Atlantic port of Lome. Ore reserves at Benjéli are estimated at 42 million tonnes grading on average 45-54 per cent and those at Bitjabé are estimated at 600 million tonnes grading on average 32-35 per cent Fe, 20 per cent SiO_2, 0.23 per cent P, 0.05 per cent S and 16 per cent Al_2O_3 (see table I.18).

(m) Upper Volta

The known iron-ore resources in Upper Volta occur at Tin Edia, Gouba, Gountouala, Pwiga and Kolel (D'Oursi area) to the north-east of and about 250 km from Ouagadougou, as Taberg-type iron ores. The iron ores occur as magmatic magnetite segregations in gabbro host rocks. The magnetite is rich in both titanium and vanadium. Potential ore reserves are estimated at about 50 million tonnes (table I.19) grading on average 40-55 per cent Fe, 3-13 per cent SiO_2, 8-14 per cent TiO_2, 2 per cent MgO, 3-6 per cent Al_2O_3, and 0.5-1.15 per cent V_2O_5. 66/, 67/, 68/

59/ "Sierra Leone: SRC on the verge", Industrial Minerals, No. 139, April 1979, pp. 13-14.

60/ "Sierra rutile produces", Mining Journal, vol. 292, No. 7503, 8 June 1979, p.446.

61/ "Gabangbama: Sierra Leone", Engineering and Mining Journal, vol. 80, No. 1, January 1979, p. 105.

62/ "Rutile: Sierra Leone", African Research Bulletin, vol. 16, No. 2, 30 March 1979, p. 5032.

63/ "Sierra Leone: Les produits miniers assurent 78.4 per cent des exportations", Afrique industrie, No. 190, 1er et 15 août 1979.

64/ Survey of World Iron Ore Resources ....

65/ "Togo-mineral exploration", Mining Journal, 12 July 1968, p. 25.

66/ Survey of World Iron Ore Resources ....

67/ Les gîtes de magnétite vanadifères d'Oursi - Le potential minier de la République de Haute-Volta (Direction de la Géologie et des Mines, 1975), pp. 179-182.

68/ Fer de Say ....

(n) Western Sahara

About 150 million tonnes of potential (Taberg-type) iron-ore resources are known to exist at Agracha in the Western Sahara. Average grade is 54 per cent Fe and 14 per cent TiO_2 (see table I.20).

4. CENTRAL AFRICA SUBREGION

(a) Angola

Iron-ore resources in Angola occur widely all over the country but only those occurring near the coast or near the Mossamedes - Serpa Pinto, the Benguela - Villa Teixeira de Sousa and the Luanda-Malanje railways have been or are likely to be exploited in the near future. 69/, 70/, 71/

The known iron-ore resources in the region traversed by the Luanda-Malanje railway are located at Dala Tando very close to Villa Salazar and at M'Bassa and Cassala-Quitungo.

The Dala-Tando iron-ore resources are situated near the Champambe hydroelectric dam on the Cuanza River in the Cassala-Quitungo area. The resources are Pre-Cambrian taconites with ore (haematite) reserves estimated at 1 billion tonnes grading on average 32 per cent Fe. Plans are under way to exploit this iron-ore deposit.

The M'Bassa iron-ore resources located about 150 km east of Luanda are titaniferous iron ores, having been formed as magmatic magnetite segregations from basic and ultrabasic igneous rocks intrusive into the Basement Complex. Ore reserves are estimated at 10 million tonnes grading on average 56-60 per cent Fe and 7 per cent SiO_2.

The Cassala-Quitungo Group lie about 40 km east of M'Bassa. They consist of titaniferous magnetite iron-ore types. Ore reserves and potential resources are estimated respectively at 72 and 100 million tonnes grading on average 35 per cent Fe, 44 per cent SiO_2 and 0.4 per cent TiO_2.

The most important iron-ore resources in the vicinity of the Benguela - Villa Teixeira de Sousa railway are situated at Cuima, Chilesso and Teixeira da Silva.

The Cuima iron-ore resources, located about 65 km south-east of Nova Lisboa, consist of haematite-magnetite lenses and residual iron ores. The reserves remaining are estimated to be about 10 million tonnes grading on average 60 per cent Fe.

The iron-ore resources located in the region traversed by the Mosamedes - Serpa Pinto railway are at Cassinga and Sa da Bandeira. The Cassinga iron-ore resources are by far the largest known iron-ore resources in Angola. The resources are Lake Superior types occurring as residual, replacement or primary bedded iron-ore formations. Ore reserve estimates are put at 100 million tonnes of haematite ore, grading on average 61 per cent Fe, and 2 billion tonnes itabirite, grading on average 40 per cent Fe.

69/ Survey of World Iron Ore Resources ....

70/ Ferro: Ocorrências Minerais (Provincia de Angola, Republica Portuguesa, Direcção Provincial dos Serviços de Geologia e Minas, 1965), pp. 23-30.

71/ R.A. Pelletier, Mineral Resources of South-Central Africa (1964), p.242.

The Sa da Bandeira iron-ore resources, like those in the Cassala-Quitungo region, are titaniferous magnetite ores. Estimates of reserves are not available.

The possibility that more iron-ore resources will be discovered in Angola is very good indeed. The only difficulty is that they would be remote from the existing infrastructure. Total known iron-ore reserves amount to 1,218 million tonnes of contained iron (see table 1. 21).

(i) Exploitation of iron ore in Angola

a. Cuima iron-ore mine

Iron-ore production was begun in Angola at Cuima in 1957 by Companhia Mineira do Lobito, a company owned by the Portuguese Government (85 per cent) and German interests (15 per cent). The ore was transported from the mine to Lobito on the Benguela railway and then by sea to the Federal Republic of Germany. 72/ In 1957 shipments of iron-ore concentrate from the mine were 75,000 tonnes but by 1961 had reached 500,000 tonnes. Production at Cuima ceased in 1967-1968 when the richer and larger deposits in Cassinga were brought into production.

b. Cassinga iron-ore mine

Some time during the 1960s Companhia Mineira do Lobito made plans to exploit the Cassinga iron-ore deposits because they were larger than the Cuima deposits and offered opportunities for large-scale operations. They were joined by a consortium of investors possessing large financial resources led by Krupp of the Federal Republic of Germany, who became the managing agents. 73/

Before beginning production, the company built a railway from Cassinga to the deep-water port at Saco de Giraul, 10 km north of Mossamedes.

Production began in 1967 and by 1975, when the Angolan civil war broke out, was averaging 5 million tonnes of iron-ore concentrate.

The principal consumers of Cassinga iron ore were the United Kingdom, the Federal Republic of Germany, France, Japan and Belgium.

Before the civil war, plans had been drawn up to concentrate and pelletize the huge low-grade (35-45 per cent Fe) Cassinga-Sul iron-ore deposits. Kaiser Steel Corporation of USA was to be involved. The project was to be financed by the Industrial Development Corporation and Union Corporation of South Africa (with a combined holding of 51 per cent), Companhia Mineira do Lobito (35 per cent), Krupp of the Federal Republic of Germany, Usinor of France and the British Steel Corporation (combined holding 14 per cent). 74/ The steel producers were to guarantee a market

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72/ "Lobito's iron ore resources", Mining Journal, vol. 264, No. 6766, April 1965.

73/ "Krupp to develop Cassinga", Engineering and Mining Journal, vol. 166, No. 8, August 1965, p. 122.

74/ "Iron ore (Angola)", Mining Annual Review, 1974, pp. 353-354.

for the entire Cassinga pellet production. These plans were shelved as a result of the 1974-1975 FNLA and UNITA versus MPLA power struggle. Reports emanating from Angola during 1978, however, indicate that Energoprojekt of Yugoslavia has been awarded a contract by the Luanda Government to operate the Cassinga mine. 75/

c. Cassala iron mine

Companhia de Manganese de Angola (Portuguese), in addition to its manganese interests, was also engaged in iron-ore mining in the Cassala - Quitungo area. By 1968, however, the high-grade ore at Cassala and Quitungo was becoming depleted and the company hired Kloekner Industrie- Anlagen GmbH of the Federal Republic of Germany to carry out metallurgical studies on the large low-grade ore reserves that exist at Cassala. Kloekner concluded that a concentrate containing 65 per cent Fe could be obtained economically by treatment and agglomeration of the low-grade itabirite ore (about 30 per cent Fe).

In 1973 it was announced that mining was to begin at Cassala and Quitungo by a Portuguese-Japanese firm made up of Companhia de Manganese de Angola, the Portuguese Government and C. Itoh and Co. of Japan. All production was to be bought by Kawasaki Steel. The new investment would have involved: (i) the building of a new 50-km railway and increasing the capacity of the existing 36-km railway; (ii) the development of a large loading facility at Luanda to service the huge Japanese ore carriers (150,000 DWT). In 1975 Companhia de Manganese de Angola announced that the project was to be postponed and it has, in fact, never been started.

(ii) Iron-ore production in Angola

For the period 1968-1975, after which mining ceased, iron-ore production in Angola averaged 5 million tonnes of concentrate annually (see table II.10).

(iii) Exports of iron ore from Angola

It will be seen from table III.7 that iron-ore exports, which were about 3 million tonnes in 1968, rose sharply in 1969 to reach 5.1 million tonnes. For the period 1970-1973, iron-ore exports averaged about 6 million tonnes annually. However, in 1974, iron-ore exports began to fall as a result of the world-wide recession. In 1975, as a result of the civil war, Angola exported hardly any iron ore.

In monetary terms it will be seen that iron ore made a very important contribution to the country's foreign exchange earnings, rising from $US 22.4 million in 1968 to an average annual value of $US 44 million for the period 1969-1974.

Although in 1969 iron-ore exports had a 69.4 per cent share in total Angolan mineral exports and an 11.7 per cent share in total commodity exports, these had fallen to 6.1 per cent and 3.9 per cent respectively by 1974 due mainly to the increase in the contribution made by petroleum exports. With the planned revival of mining operations at Cassinga during 1978 and when the Dalatando project becomes operational some time during the 1980s, it is hoped that iron ore will regain its former place among Angolan mineral exports.

75/ "Angolan mining study", Mining Journal, vol. 291, No. 7470, 20 October 1978, p. 312.

(b) Central African Republic

The iron mineralization belt of the Kilo-Moto region of north-eastern Zaire extends into the Central African Republic. 76/ The iron mineralization is associated principally with Pre-Cambrian rocks, where the ores occur as haematite/magnetite Lake Superior types. East of Ouada, itabirites enclose lenses of haematite. In the M'berri drainage between Rafai and Yaluiga, and also in the eastern part of the country, haematite iron mineralizations occur. At Roandji, in the centre of the country, haematite/magnetite Lake Superior-type iron mineralization predominates. Other localities with significant iron mineralization are Bogoin, Damora and north of Bangui.

(c) Chad

Potential iron-ore resources have been recognized in four regions of Chad. 77/ Haematite veins occur in northern Chad, oolitic laterite iron mineralization has been found in central Chad, and goethite mineralization in western Chad. Finally, in eastern Chad, haematite quartzites are known to exist. Very little attention has been paid to the iron-ore resources in Chad because of their remoteness from ports, and because of the inability of the country to make use of its mineral resources.

(d) Congo

The known iron-ore resources in the Congo occur in three distinct belts. The first is in the Avima-Nabelea region located in the extreme north-western corner of the Republic close to the border with Gabon and the United Republic of Cameroon, 78/ and the second is the north-western central part of the country lying to the south of Avima-Nebebe and close to the Gabon border. The mineralization is a continuation of the Makokou-Mékambo iron belt of Gabon. Significant accumulations of iron ore in this belt are at Mount Keke and at Akana lying a few kilometers to the south; both places lie a few kilometers to the west and south-west respectively of Kelle. The third region with important iron-ore accumulatic is in the western central part of the country close to the southern frontier of Gabon. The principal iron-ore accumulations in this region are situated at Mayoko in Lekouma Mountain and at Zanaga. 79/, 80/

The iron mineralization in all three regions are Lake Superior types with haematite and subordinate magnetite forming the ores. Ore reserves at Zanaga have been estimated to be 100 million tonnes grading on average 43 per cent Fe and 20 per cent SiO_2. Iron-ore reserves at Mayoko are estimated at 30 million tonnes grading on average 56 per cent Fe, 8.3 per cent SiO_2 and 2.05 per cent Al_2O_3 81/, 82/ (see table I.22)

76/ Nicolas de Kun. op. cit.

77/ Survey of World Iron Ore Resources ....

78/ Nicolas de Kun, op. cit.

79/ "Activités minières", Industries et travaux d'outremer, No. 243, February 1974, p. 140.

80/ "Industrie minière: Congo", Industries et travaux d'outremer, No. 250, September 1974, p. 784.

81/ Rapport de la mission fact-finding République Populaire du Congo (Bundesansalt für Geowissenschaften und Rohstoffe, 1977), unpublished report.

82/ Aperçu de l'activité minière en 1976 (République Populaire du Congo, Bulletin d'Afrique noire no.870, 4 June 1977)

(e) Gabon

The iron-ore resources of Gabon occur as Lake Superior types, located in the north and running in an east-west direction, and also in the south-western part of the country. 83/ The principal iron-ore accumulations in the northern region are located at Batoala, Belinga, Boka-Boka, Minkébé, Méleaga, Mela and N'Gana; in the south-western belt only Tchibanga-Mouteli is important. The first four deposits are very often referred to as the Mekambo iron-ore group. Iron-ore resources estimates and chemistry (also see table I.2) of the eight iron-ore deposits are as follows:

- Batoala: 117 million tonnes (ore reserves) grading 66 per cent Fe, 2.9 per cent SiO_2.
- Belinga: 566 million tonnes (ore reserves) grading 64 per cent Fe, 2.2 per cent SiO_2, 0.12 per cent P and 2.5 per cent Al_2O_3.
- Boka-Boka: 194 million tonnes (ore reserves) grading 62 per cent Fe, 3.5 per cent SiO_2, 0.1 per cent P.
- Minkébé: 60 million tonnes (ore reserves) grading 64 per cent Fe, 3 per cent SiO_2, 0.1 per cent P.
- Mébaga: 15 million tonnes (ptential resources) grading 60 per cent Fe, 4 per cent SiO_2
- Méla: 100 million tonnes (potential resources) grading 46 per cent Fe, 30 per cent SiO_2
- N'gana: 50 million tonnes (potential resources) grading 47 per cent Fe, 22 per cent SiO_2
- Tchibanga-Moutéli: 114 million tonnes (potential resources) grading 43 per cent Fe, 27.4 per cent SiO_2, 0.05 per cent S, 0.18 per cent P and 3 per cent Al_2O_3

Although none of these deposits is being exploited at present, there are plans, after the Trans-Gabon railway (570 km long) has been completed, for Société des Mines de Fer de Mekambo (Somifer) to begin exploiting the Mekambo iron-ore resources some time during 1983. 84/, 85/ Before this huge project is finally implemented, however, there are a number of problems to be solved. These are: (i) the procurement of the large financial resources needed for the project; and (ii) the securing of long-term sales 86/ agreements; this is very important in view of the prevailing world-wide recession and the large iron-ore surplus production capacity already in existence.

83/ Fer: Plan minéral, partie principale (Ministère des Mines, République Gabonaise. 1971), pp. 109-114.

84/ 1976-1980 Troisième plan de développement économique et social (République Gabonai pp. 152-153.

85/ "Gabon: State participation in industry", African Research Bulletin, vol. 11, No. 7, 31 August 1974, p. 3205.

86/ "The steel industry metals - Africa", Mining Annual Review, 1974, p. 72.

Another project under consideration in Gabon involving iron ore is the planned production of 85,000 tonnes of ferromanganese at either Grand Poubara or M'Passa. 87/

(f) United Republic of Cameroon

The known iron-ore resources in the United Republic of Cameroon are located in the Mamelle Range between Kribi and Campo on the border with Equatorial Guinea and about 16 km from the sea. 88/, 89/ The resources are associated with early Pre-Cambrian rocks and the ore-forming minerals are haematite with subordinate magnetite. Potential ore reserves are estimated at 150 million tonnes grading on average 38 per cent Fe, 0.2 per cent S, 0.08 per cent P and high silica (see table I.24).

There are, in addition, in several places in the country, potential lateritic iron-ore resources with grades of 50-55 per cent Fe, but these have not been investigated in detail to determine their economic potential.

(g) Zaire

Iron-ore resources are widely distributed in Zaire, especially in Katanga Province, in the Kilomoto region in the extreme north-eastern part of Zaire, and in Kasai Province (eastern Zaire). 90/, 91/ The mineralization is mainly of Lake Superior type although Bilbao types are also present (see table I.25).

The principal iron-ore accumulations in the Katanga region are located at Kisanga-Kambove and Kanunka, both places lying close to the town of Jadotville. The iron-ore resources at Kisanga-Kambove are Bilbao types with haematite and magnetite replacing dolomitic limestone. Ore reserves are estimated at 50 million tonnes grading on average 56 per cent Fe, 9.5 per cent SiO_2 and 0.1 per cent P. The resources at Kanunka are of the Lake Superior type grading on average 54 per cent Fe, 21 per cent SiO_2 and 0.24 per cent Cu. Estimates of potential resources are not available but are presumed to be very large. In a belt stretching from near the town of Bondo on the River Uele eastwards towar Lake Albert (Kilomoto area) a distance of about 500 km, large potential iron-ore resources of Lake Superior type are known to exist. Because the area is remote, few systematic investigations of these resources have been made. However, estimates of potential iron-ore resources are put at 5,000 million tonnes grading on average 45-65 per cent Fe.

In the Luebo area (southern Kasai) potential Lake Superior-type iron-ore resources are known to exist. They occur in ferruginous quartzites. Like the Kilomoto iron-ore resources the Luebo resources have not been investigated in detail because of their remoteness from existing infrastructure. Potential iron-ore resources are put at 100 million tonnes gradin on average 30 per cent Fe.

87/ 1976-1980 Troisième plan de développement ....

88/ Survey of World Iron Ore Resources ....

89/ Eisen: Rohstoffwirtschaftliche Länderberichte, IX, Gabun, VR Kongo und Kamerun (Hannover, April 1976), p. 66.

90/ Survey of World Iron Ore Resources ....

91/ R.A. Pelletier, op. cit., p. 234.

5. EAST AND SOUTHERN AFRICA SUBREGION

(a) Botswana

Iron-ore resources in Botswana occur in three distinct geological environments, namely: (i) the Archaean schist belts - the Tati Schist belt in north-east Botswana and th schists found in the Kapvaal Craton out-cropping in the extreme south-eastern part of Botswana near the South African border; (ii) the Limpopo metamorphic belt; and (iii) the younger Pre-Cambrian sedimentary cover. A number of potentially economic accumulations of iron mineralization have been identified but have not been investigated in detail to determine their economic viability. 92/

(b) Ethiopia

The known iron-ore resources in Ethiopia occur in the north of the country in Eritrea and Tigre Provinces, in an area running in an east-west direction in the centre of the country (Wollega, Showa, Kaffa and Harrar Provinces), as well as in the southern-most province of Sidamo. 93/, 94/, 95/ The known localities with potential iron-ore resources of interest in Ethiopia are listed below:

Location	Potential resources (in tonnes)	Chemistry
Eritrea		
Agametta-Sabub	300 000	58 per cent Fe, 0.04 per cent P 0.02 per cent S
Gumhod	10 000	58 per cent Fe
Falcat	250 000	55 per cent Fe.
Ghedem	325 000	48 per cent Fe, 40 per cent Mn, 0.04 per cent P
Wobi-Terashi	1 370 000	49 per cent Fe, 19-3 per cent MnO
Hamsien	5 000 000	30 per cent Fe.

92/ Resources Inventory of Botswana Metallic Minerals, Mineral Fuels and Diamonds, Mineral Resources Report No. 4 (Geological Survey Department, 1977), pp. 35-39.

93/ Survey of World Iron Ore Resources ....

94/ Iron Ore in Ethiopia, Mineral Circular No. 5 (Geological Survey of Ethiopia, July 1976), unpublished.

95/ Danilo A. Jelenc, Mineral Occurrences of Ethiopia (1966), pp. 125-133, 243-296, 335-339, 415-422, 471, 557-562, 573-592.

Location	Potential resources (in tonnes)	Chemistry
Tigre		
Adwa-Axum-Enticho	5 000 000	30 per cent Fe
Wollega		
Koree	250 000	67 per cent Fe, 0.04 per cent P, 0.15 per cent S
Yubdo	50 000	65 per cent Fe, 0.18 per cent P, 0.05 per cent S
Gordana Katcho	50 000	63 per cent Fe, 0.05 per cent P, 0.04 per cent S
Chago	80 000	64 per cent Fe, 0.08 per cent P, 0.04 per cent S
Nejo	50 000	65 per cent Fe.
Others	13 520 000	
Total in Wollega	14 000 000	33 per cent Fe, 33 per cent SiO_2
Kaffa		
Mai Gudo	75 000	40 per cent Fe, 8 per cent Mn
Shoa		
Entoto	?	?
Sidamo		
Yavello	?	43-70 per cent Fe
Harrar		
Chercher Mountains	?	?
Jijiga	?	?

The important iron-ore resources, however, are those situated at Hamsien in Eritrea and at Adwa-Axum-Enticho in Tigre, and the group of accumulations occurring close to one another near Nekemte in Wollega Province. Details of these three iron-ore resources are summarized in table I.26.

(c) Kenya

The known iron-ore resources in Kenya (table I.27) considered to be of significance are those occurring at Mirma Hill, about 60 km south of Mombasa, at Bukuro, 70 km north-north-east of the provincial town of Kisumu on the shores of Lake Victoria at Uyoma Peninsula 0 km west of Kisumu along the coast of Lake Victoria, Macaulder Mine, 130 km south-south-west of Kisumu and very close to the border with Tanzania, at Ikutha, 50 km north-east of Kibwezi, a town on the Mombasa-Nairobi railroad, and at Taita Hills, about 50 km west of the railway junction of Voi on the Mombasa-Nairobi railway. 96/

96/ Minerals of Kenya, Bulletin No. 11 (Geological Survey of Kenya, 1970), pp. 35-36.

The Mirma Hill iron ore is a soft dust-like material consisting mainly of goethite, having been derived from the weathering of carbonatite. Potential iron-ore resources are estimated at 15 million tonnes grading 7-36 per cent Fe.

The Bukuru iron-ore resources consist of a pyrite ore-body associated with the Nyanzian System (Early Pre-Cambrian). Potential pyrite ore resources are estimated at 17 million tonnes grading about 30 per cent Fe. At Uyoma Peninsula, along the coast of Lake Victoria, mineral beach sands occur. The tonnage present is not known but appears to be large enough to warrant detailed investigations.

At Macaulder Mine (a copper and gold mine now closed) and in the surrounding area, banded ironstones associated with the Nyanzian System are widely distributed. The ores grade on average 38 per cent Fe, 39 per cent SiO_2, 0.1 per cent S and 0.8 per cent P. The area covered by the Nyanzian System is a promising one for the discovery of economic iron-ore resources. The planned follow-up exploration on the ground after the aerial geophysical survey carried out during 1976-1977 by the Kenya Geological Survey could lead to the discovery of economic iron-ore resources in the area together with other minerals.

The iron-ore resources at Ikutha and Taita Hills consist of narrow magnetite veins up to 1m thick, concordant with the strike of the Mozambican (Early Pre-Cambrian) hornblende gneisses. The resources appear to be substantial but have not been investigated in detail.

(i) Exploitation of iron ore in Kenya

The only iron ore exploited in Kenya is at Ikutha, where a small annual production of about 600 tonnes of magnetite concentrate began in 1968. All production is being used locally in the Bamburi Cement Works near Mombasa. Attempts to work the Taita Hill magnetite deposits, which are nearer to the Cement Works than the Ikutha deposits, were made but the ore was found to be very hard.

Interest in the other iron-ore occurrences in Kenya has been limited because energy has not been available, but with the construction of the Tana River upper hydroelectric dam they will probably be investigated with a view to delineating deposits large enough to warrant the establishment of an iron and steel industry in Kenya.

(d) Madagascar

The iron-ore resources in Madagascar are either Lake Superior, lateritic or Magnitnaya types associated with Pre-Cambrian host rocks. 97/ The ore-forming minerals are either magnetite, goethite or haematite, in various proportions. Details of the known iron-ore resources in the country are given in table I.28.

97/ Survey of World Iron Ore Resources ....

It has been reported that a European consortium of steel-makers of which the British Steel Corporation is a member, is interested in exploiting the lateritic iron ores located in the Soalala region. Reserves are estimated to be 300-400 million tonnes grading more than 60 per cent Fe. The feasibility studies on the deposits now in progress are being carried out by the Italian steel-makers Italsider, financed by the European Development Fund. 98/, 99/

(e) Mozambique

The principal iron-ore resources in Mozambique occur in the Tete, Villa Perry, Zambezi and Moçambique districts. 100/, 101/ Of the known iron-ore resources, however, only those occurring in the Tete and Moçambique districts are likely to be of economic significance in the near future.

The main iron-ore accumulations in the Tete district occur at Muande, Machedua, Massamba, Inhantipissa and Txizita. These iron-ore resources occur as magmatic magnetite segregations in a gabbro-diorite complex intrusive into the Umkondo System (Middle Pre-Cambrian). Those in the Moçambique district occur at Anamapa about 160 km north-west of the port of Moçambique. The iron-ore resources here are associated with Cretaceous sedimentary rocks. It will be appreciated that the Cretaceous formation outcropping in the south-eastern part of the country accounts for about one-third of the total surface area of Mozambique. It follows, therefore, that the chances of finding other economic iron-ore resources in this vast area are very good.

The principal known iron-ore reserves in the country occur in six locations; information on them is summarized in table I.29. Total resources amount to 27 million tonnes iron content.

(f) Namibia

Namibia is endowed with considerable iron-ore resources which have not been fully exploited. Lake Superior-type iron-ore deposits occur at Windhoek in the Damaran System. Ore reserves are estimated at 300 million tonnes grading on average 40-50 per cent Fe. At Kaokoveld in north-west Namibia, large Lake Superior-type iron-ore resources exist which are an extension of the Cassinga iron deposits in southern Angola. 102/ The ore-forming minerals, both at Windhoek and Kaokoveld, are specular haematite and magnetite; where the

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98/ "Un gisement de minerai de fer estimé à 400 millions de tonnes: Soalala", Marchés tropicaux et méditerranéens, No. 1509, 11 October 1974, p. 2860.

99/ "Madagascar: Economic review", African Research Bulletin, vol. 15, No. 8, 30 September 1978, pp. 4812-4815.

100/ Survey of World Iron Ore Resources ....

101/ "Une nouvelle loi minière est en cours d'élaboration: Mozambique", Industries et travaux d'outremer, No. 242, January 1974, p. 78.

102/ S.H. Haughton, The Stratigraphic History of Africa South of the Sahara (1963), pp. 141-148.

mineralization has undergone secondary weathering, goethite may be present in significant amounts. Ore reserves at Kaokoveld are estimated at 100 million tonnes grading over 40 per cent Fe and potential resources are estimated at 1 billion tonnes grading slightly less than 40 per cent Fe. The iron ore at Kalkafeld is a Bilbao type with magnetite substituting for dolomite. Potential iron-ore resources are estimated at 10 million tonnes grading 30-50 per cent Fe.

At Okorusu, near Kalkafeld, titaniferous magmatic magnetite iron-ore resources occur, estimated at about 40 million tonnes grading about 45 per cent Fe. Details of the iron-ore resources in Namibia in summary form are given in table I.30.

(i) Exploitation of iron ore in Namibia

Very little is known about mining activities in Namibia following the ban on the publication of trade data from the territory in 1969 by the South African authorities. In 1969 and 1970 production was 56,000 tonnes in each year and in 1971 50,000 tonnes. 103/ It is presumed that all this production came from only one source, namely the Kalkafeld Mine owned and operated by Tsumeb Corporation Ltd., who used the iron ore produced as slag in their silver, copper, lead and zinc smelter. 104/

(g) Somalia

Lake Superior-type iron-ore resources occur in several places along the Bur Range trending N70°E and lying 130 km west of Mogadishu. Of the known iron occurrences in this Range, only those located at Bur Dur and Daimir appear to be large enough to be of economic interest. Other occurrences of iron mineralization are found at Jessoma and Jirta Ggno in southern Somalia in association with the Cretaceous sandstones. Grades of 50 per cent Fe are reported in some of the mineral outcrops. 105/, 106/ Estimated tonnages and grades of the potential resources at Bur Dur and Daimir are put at 170 million tonnes with an average grade of 35 per cent Fe (see table I.31).

(h) Southern Rhodesia

The principal iron-ore resources in Southern Rhodesia are genetically associated with the Bulawayan formation. Resources within the banded iron formations with grades of between 20 per cent and 45 per cent, although very large, are not being exploited at present. In several places within the Bulawayan banded ironstones, however, secondary enrichment has taken place so that economic accumulations of replacement and/or residual iron ores have formed. The iron-ore reserves of deposits of this kind amount to 226 million tonnes of contained iron. Potential resources are estimated to be about 3,300 million tonnes grading 40 per cent Fe (see table I.32).

103/ Roger Murray and others, The Role of Foreign Firms in Namibia: Study Project on External Investment in South Africa and Namibia (S.W. Africa) (1974), pp. 79-99.

104/ Mineral Trade Notes, December 1966, p. 18.

105/ Survey of World Iron Ore Resources ....

106/ Nicolas de Kun, op. cit.

(i) Exploitation of iron ore in Southern Rhodesia

In 1938, the Rhodesian Iron and Steel Corporation was formed by private share-holders to produce iron and steel from scrap. In 1942, the Government, through its Rhodesia Iron and Steel Commission (RISCO), took over the company. By 1956, supplies of scrap had become inadequate and plans were put in hand to use domestic iron ore. In 1957, a consortium of Southern Rhodesian and overseas companies took over the Rhodesian Iron and Steel Commission's operations and formed in its place the Redcliff Iron and Steel Company. The new company investigated the banded iron stones at Que Que and found them suitable for iron- and steel-making. At the same time, they found limestone and dolomite interbedded with the banded ironstones, so that two essential raw materials were available on the spot. Mining at Redcliff (Que Que) began in 1958. One unusual feature at Redcliff is that mining operations are carried out under contract and not by the Redcliff Iron and Steel Company. 107/

Another iron-ore mine, the Beacon Tor, is located not very far from the Redcliff Iron and Steel works mines at Que Que. This mine, which began production in 1962, is operated by Iron and Minerals Development Company, a subsidiary of Mines de Chrome et de Fer SA, owned 80 per cent by Kobe Steel Works of Japan. During the 1960s all production was exported to Japan. It is not clear, however, whether or not the Beacon Tor iron-ore mine is still operating, as the rebel government stopped the publication of mineral trade data after the Unilateral Declaration of Independence in November 1965. 108/, 109/

(ii) Southern Rhodesian iron-ore production and exports

As the rebel Southern Rhodesian Government stopped publication of trade data after the Unilateral Declaration of Independence in November 1965, the figures given in table II.11 should be considered as estimates.

No data are available for iron-ore exports. For iron and steel production, approximate figures for the period 1968-1977 are shown in table IV.4. It will be seen that the output of the country's iron and steel industry has increased from 260,000 tonnes in 1968 to 300,000 tonnes in 1977. The industry has grown because of the need for the country to be self-sufficient in steel products, following the international trade boycott against the rebel regime instituted in December 1966.

(i) Swaziland

The principal iron-ore resources in Swaziland are located at Ngwenya, over the Bonvu Ridge in the north-west of the country near the Swaziland-Transvaal border. 110/ Other resources occur at Gege in south-western and at Maloma in south-eastern Swaziland, and

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107/ "Rhodesian iron and steel", South African Mining and Engineering Journal, 25 October 1968, p. 974.

108/ Minerals of Southern Rhodesia (Natural Resources Board of Southern Rhodesia, 1963), p. 27.

109/ Annual Report (Mines Department, Southern Rhodesia, 1961, 1962 and 1963).

110/ "Swazi iron ore for Japan", Mining Magazine, March 1967, p. 154.

at Forbes Reef in northern Swaziland, a few kilometers north of Ngwenya. 111/, 112/ All these iron-ore resources are associated with banded cherts and ferruginous shales of the Basement Schists (Early Pre-Cambrian). The ore-forming mineral is predominantly haematite, with magnetite occurring as a minor and sometimes a major constituent. Ngwenya, situated about 25 km north-west of the capital city Mbabane, has estimated remaining ore reserves amounting to 50 million tonnes grading on average 45 per cent Fe. At Gege, ore reserves are estimated at 55 million tonnes and potential resources at 90 million tonnes, all grading on average 40 per cent Fe. The Maloma ore reserves are estimated at 75 million tonnes grading on average 30 per cent Fe. The Forbes Reef ore reserves, which consist mainly of siderite, are estimated at 6 million tonnes grading on average 38 per cent Fe. The chemistry and tonnage of all the known iron-ore resources in Swaziland are summarized in table I.33.

(i) Exploitation of iron ore in Swaziland

The existence of economic iron-ore deposits at Ngwenya was brought to the attention of the authorities by the Swaziland Geological Survey in 1946.

In 1958 Anglo-American Corporation of South Africa Ltd. formed the Swaziland Iron Ore Development Company (SIODC) to determine the economic viability of the deposits and to exploit them if economically viable. Other partners in the project were Guest, Keen and Nettlefold (a South African company), who held a 10 per cent interest.

In 1971 the Swaziland Government acquired a 20 per cent interest in the operations.

(ii) Infrastructure requirements necessary for exploitation of Swaziland iron ore

To enable the Ngwenya iron deposits to be exploited, the following projects were undertaken:

a. A railway (3 ft 6 in gauge) was constructed by the Swaziland Government from Ngwerya to Goba at the frontier with Mozambique. At the same time the Portuguese authorities in Mozambique extended the existing railway to Goba, so that Ngwenya was linked to what is now Maputo. Construction began in 1962 and the railway became operational in 1964;

b. In the meantime, port facilities at Maputo were expanded by the Portuguese authorities;

c. Rolling stock was acquired;

111/ "Swaziland", Minerals Yearbook, Vol. III Area Reports: International, (USBM, 1974), pp. 1203-1205.

112/ "Swaziland (iron ores) Ngwenya", Metal Bulletin, 1969, Iron Ore Special Issue, pp. 103-106.

d. Three ships, each of 70,000 tonnes, belonging to General Ore International Corporation (a Norwegian-American Company), were constructed in Japan to carry Swaziland iron ore;

e. Water for the mine was taken from the Mbuluzi River via a 6-km long, 30-cm diameter pipeline;

f. Electricity was provided from a $US 6 million hydroelectric scheme.

Finance for the above-mentioned projects was provided, either alone or jointly, by the Commonwealth Development Corporation, Anglo-American, South African Mutual Insurance Society, South African Iron and Steel Corporation, and the Mozambique and Swaziland Governments, but not until a contract for the sale of 12 million tonnes of iron-ore concentrate over a 10-year period had been signed in 1961 between the Swaziland Iron Ore Development Corporation and two Japanese steel producers, Yawata Iron and Steel Company and Fuji Iron and Steel Company, which later combined to form Nippon Steel.

Production at Ngwenya began in 1964. In November 1977 mining was stopped because the high-grade ore had been depleted. The mine employed about 450 persons. Annual production for the period 1968-1977 averaged 2.3 million tonnes iron concentrate (see table II. 12).

(iii) Exports of iron-ore from Swaziland

The export of high-grade iron concentrate from Swaziland to Japan which began in 1964 was averaging, as table III.8 shows, slightly over 2 million tonnes of concentrate annually until mining ceased in November 1977. There was, however, enough stock-piled ore to continue iron-ore exports until early 1979. 113/ By value, the average of $US 14 million obtained annually from iron-ore exports was a very important contribution to the country's total exports. Thus iron-ore exports, as will be seen from table III.8, accounted for 66 per cent of total mineral exports and 22 per cent of total commodity exports in 1971. By 1976, the figures were respectively 45 per cent and 8 per cent. This decline in the share of iron ore in exports was not due to the decline in the tonnage exported but rather to the substantial increases in value over the same period of coal and asbestos exports. The cessation of iron-ore mining did, in fact, have serious effects on the country's balance of payments.

(j) Uganda

Iron-ore resources in Uganda are found in Kigezi, south-west Uganda, and at Sukulu and Bukusu near Tororo in eastern Uganda. 114/, 115/ Kigezi iron deposits are replacement

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113/ "Swaziland iron ore producer ceases mining", Mining Journal, vol. 289, No. 7420, 4 November 1977.

114/ Survey of World Iron Ore Resources ....

115/ The Mineral Resources of Uganda, Bulletin No. 4 (Geological Survey of Uganda, 1961), p. 55.

haematite Lake Superior types with potential resources estimated to be 30 million tonnes grading on average 78 per cent Fe. The Sukulu and Bukusu iron-ore deposits are residual, having been derived from carbonatite through weathering. Potential ore resources at Sukulu are estimated to be 45 million tonnes grading on average 62 per cent Fe, 1.1 per cent SiO_2 and 2.6 per cent P. The potential resources at Bukusu are estimated at 23 million tonnes grading on average 60 per cent Fe, 10-20 per cent Ti. Details of tonnage and chemistry of the resources are given in table I.34.

It is significant that, during the exploitation of the Sukulu residual soils for apatite, which is the basis for the Ugandan phosphate fertilizer industry, magnetite together with pyrochlore, zircon and barytes were stock-piled. It is highly lilely that at some future date this stock-piled ore will be used in the production of iron and steel. 116/

(k) United Republic of Tanzania

Iron-ore resources in Tanzania have been found in three districts, namely Njombe, Mpanda and Morogoro. In the Njombe District there is a region extending in a north-south direction for about 160 km and lying parallel to and located at about 60 km to the east of Lake Nyasa where several titaniferous magmatic iron-ore accumulations occur. Among these accumulations, those located at Liganga are by far the most important. The mineralization occurs as titaniferous magnetite bodies associated with a belt of gabbroic rocks. Ore reserves at Liganga are estimated to be 49 million tonnes grading on average 50 per cent Fe, 1.3 per cent SiO_2, 13 per cent TiO_2 and 0.23 per cent Va. 117/ In the Mpanda District, magmatic magnetite iron-ore accumulations occur at Mbalala, 60 km north-west of Karema on Lake Tanganyika. The tonnage of potential ore resources at Mbalala is not known.

Iron-ore resources have also been found in the Mpanda District, at Manyoro Michicopiten. The banded ironstones lie at right angles to the general strike of the enclosing anphibolites. Potential iron-ore resources are estimated to be 68 million tonnes grading on average 30 per cent Fe and up to 11 per cent Mn. In the Uluguru Mountains in the Morogoro District at Kundusi, Taberg-type iron-ore resources have been recognized. They are associated with an intrusive meta-anorthositic complex which forms the core of the western Uluguru Mountains. 118/ Potential ore resources are estimated at 8 million tonnes grading 45-55 per cent Fe. A summary of the tonnage and chemistry of the iron-ore resources in the United Republic of Tanzania is given in table I. 35.

116/ D. Williams, Development of the Iron and Steel Industry in Tanzania 1975-1995 (United Republic of Tanzania, Ministry of Planning, 1973), unpublished report.

117/ "Summary of the geology of Tanganyika, Part IV", Economic Geology, 1961, pp. 88-91.

118/ Survey of World Iron Ore Resources ....

There are plans to develop an iron and steel industry in the southern part of the United Republic of Tanzania, based on the Liganga iron-ore resources and either the Mchuchuma-Katewaka or Songwe-Kiwira coal resources. 119/, 120/, 121/

(1) Zambia

Iron-ore resources in Zambia have a wide geographical distribution (see table I.36). A summary is given below of selected deposits which are considered most important. 122/

(i) Chisasa (Lake Superior type), 240 km west of Chingola and 90 km west of Solwezi. 11 million tonnes are reserves, grading 55-60 per cent Fe. Potential resources more than 50 million tonnes grading 35-40 per cent Fe. Ore-forming mineral is predominantly haematite, with minor magnetite.

(ii) Mwinilungu area (Lake Superior type), 360 km west of Chingola. Very large tonnage. Very similar to Chisasa geologically. Grade estimates 50-60 per cent Fe.

(iii) Lufubu (Lake Superior type), 240 km west of Kitwe and 20 km east of Kasempa. Potential ore resources estimated at 60 million tonnes grading on average more than 60 per cent Fe.

(iv) Kahare (Lake Superior type), 330 km west of Lusaka and 30 km south-west of Kaoma. 20 million tonnes of potential ore resources, grading on average more than 50 per cent Fe.

(v) Sanje-Pamba-Nampundwe (Lake Superior type). Three adjoining areas some 50 km west of Lusaka with several million tonnes of potential ore grading 50-60 per cent Fe and a high phosphorus content.

(vi) Namatombwa-Shashikaula (Bilbao type), 115 km west of Lusaka, 15 million tonnes ore reserves grading on average 58 per cent Fe and 0.4 per cent P.

(vii) Nambala-Sonkwe (Lake Superior type) 135 km west of Lusaka, potential resources estimate 50 million tonnes grading more than 60 per cent Fe.

(viii) Mutumbwe (Lake Superior), 185 km north-west of Lusaka and 50 km north-west of Mumbwa. Potential resources 50 million tonnes grading 40-60 per cent Fe.

(ix) Chibote (Lake Superior), near Mansa and 360 km north-east of Ndola. Ore-forming mineral haematite. Potential resources 50 million tonnes grading on average 50 per cent Fe and 1 per cent Mn.

119/ D. Williams, op. cit.

120/ "In Africa: Tanzania", Engineering and Mining Journal, vol. 175, No. 5, May 1974.

121/ "United Republic of Tanzania: Chinese loan for mining", African Research Bulletin vol. 11, No. 3, 30 April 1974, p. 3078.

122/ M.E. Woakes, Iron Ore-type Occurrences in Zambia (Zambian Geological Survey, 1974) unpublished report.

The choice of one deposit for exploitation from among those listed will depend on transport costs, location of the other raw materials necessary in iron- and steel-making, availability of a method of processing the ore so as to meet market requirements, and general political development objectives. Detailed studies are already in progress on the Chisasa iron-ore deposits.

6. SOUTH AFRICA

South Africa is generously endowed with iron-ore resources of various types. 123/ The principal deposits are:

(i) High-grade haematite deposits of the Postmasburg and Thabazimbi Districts (Lake Superior type) with grades averaging 60 per cent Fe. Ore reserves are estimated at 4,300 million tonnes. The principal mines operating in the belt are Shishen, Manganore and Thabazimbi.

(ii) Low-grade deposits in the Pretoria Series of the Transvaal System - Late Pre-Cambrian (minette type). Ore reserves are estimated at 6 billion tonnes grading 40-55 per cent Fe, 19-22 per cent SiO_2, 0.12-0.29 per cent P, 0.01-0.04 per cent S.

(iii) Titaniferous magnetite deposits (Taberg type) of the Bushveld Igneous Complex; these are sometimes vanadium-bearing. Ore reserves are estimated at 2,200 million tonnes grading 42-60 per cent Fe.

(iv) Miscellaneous iron-ore deposits often of good grade but generally occurring as small scattered ore-bodies in both the Transvaal and Karroo Systems.

With 6,928 million tonnes of contained metal, South Africa holds the first place for iron-ore reserves among African countries. A summary of the tonnage and chemistry of the principal deposits is given in table I.37.

(a) Exploitation of iron ore in South Africa

(i) Deposits in the Postmasburg and Shishen area

a. Shishen Mine

Shishen Iron Mine is located in the north-western Cape Province and began production in 1953. The mine is operated by South African Iron and Steel Corporation (ISCOR). The mine initially supplied the Vanderbijl Vecor Steel Works but now also produces for export, and especially for the Japanese market. Mining is by open-cast methods. Annual production averages 8 million tonnes. 124/

123/ R.A. Pelletier, op. cit., pp. 104-109.

124/ "Shishen - 9.2 million tons per year by 1980", South African Mining and Engineering Journal, 28 November 1969, p. 1225.

b. Manganore Iron Mine

This mine, located about 30 km south of Shishen, is operated by Anglo-American Corporation and supplies ore to the Amcor Steel Works at New Castle for the production of ferromanganese. Mining is by open-cast methods.

c. Thabazimbi Mine

Thabazimbi iron mine, located about 130 km north-west of Rustenburg, is the oldest of the large iron mines in the Republic of South Africa. Also owned by the South African Iron and Steel Corporation (ISCOR), it began production in 1931. 125/ Mining is both by open-cast and by underground methods where the depth of overburden is too great to be moved. Annual production averages 2 million tonnes of high-grade ore of which two-thirds is railed to the Pretoria Steel Works and the other one-third to the Vanderbijl Vecor Steel Works.

(ii) Deposits in the Pretoria Series

A number of small mines are located in the Pretoria Series near the Pretoria Steel Works. They supply a small tonnage of iron ore which is mixed with the Thabazimbi and Sheshin ores in order to increase the silica content of the blast-furnace feed.

(iii) Deposits within the Bushveld Igneous Complex

Towards the top of the Main Zone of the Bushveld Igneous Complex, stratified magnetite mineralization occurs and the magnetite accumulations are occasionally large enough to be economically exploitable.

The ore is medium to high grade, 70-85 per cent Fe_2O_3 and 14-20 per cent TiO_2; at Mapoch Mine in Roossenekal (see below) the magnetite ore carries 1.4-1.9 per cent V_2O_5. 126/, 127/

a. Mapoch Mine

Mapoch Mine began production in 1968. The mine is owned by Highveld Steel and Vanadium Corporation Ltd. (an Anglo-American subsidiary) which also operates an integrated iron and steel and vanadium plant near Witbank. This plant uses the Mapoch Mine ore to produce finished steel and vanadium pentoxide slag.

125/ "Low level bombing at Thabazimbi", South African Mining and Engineering Journal 28 November 1969, pp. 1199-1202.

126/ Mapoch mine's millionth ton of magnetite", South African Mining and Engineering Journal, 6 February 1970, p. 255.

127/ "The mineral potential of the Bushveld Complex", Metal Bulletin Monthly Supplement, April 1978, pp. 69-71.

Magnetite ore reserves at Mapoch Mine are estimated at more than 200 million tonnes grading as follows:

Fe	55-57 per cent
TiO_2	12-15 per cent
V_2O_5	1.4-1.9 per cent
Cr_2O_3	0.15-0.3 per cent

(iv) Iron-ore production in South Africa

The Republic of South Africa, with an average annual production of 26.5 million tonnes of iron-ore concentrates ranks ninth in world iron-ore production and could increase its share easily if additional market outlets could be found. Annual iron-ore production is shown in table II.13, for the period 1968-1977.

(v) Production of iron and steel in South Africa

The Republic of South Africa is the leading producer of iron and steel in Africa. Over the ten-year period from 1968 to 1977 production of iron and steel increased by about 80 per cent. It now stands at 6.6 million tonnes per year. Table IV.7 gives detail of annual production over the 1968-1977 period.

As will be seen from tables IV.5 and IV.6 the greater part of South African iron and steel production is exported and only a small proportion is used domestically.

(vi) Exports of iron ore from South Africa

South African iron-ore exports have increased over the ten-year period from 1968 to 1977, as indicated in table III.9. It will be seen that in 1968 the value of South Africa iron-ore exports was $US 26.1 million but in 1976 had reached $US 38.4 million an increase of 47 per cent. Between 1968 and 1972, the period for which data are available, total tonnage exported expressed as percentage of production declined, showing that South Africa iron-ore production was being increasingly used domestically in iron- and steel-making. As noted earlier, much of the iron and steel produced is exported, as shown in table IV.5 and IV.6.

7. THE ROLE OF DEVELOPING AFRICAN COUNTRIES IN WORLD IRON-ORE RESERVES

Before any assessment is made of the role of developing African countries in world iron-ore reserves, consideration should be given to the following:

(i) The term "resources", as defined by the US Bureau of Mines, 128/ means a concentration of naturally occurring solid, liquid or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible;

128/ Mineral Resources Perspective 1975, Professional Paper 940 (US Geological Survey, 1976), pp. 2-6.

(ii) The term "reserves" is defined as a concentration of naturally occurring solid, liquid or gaseous materials in or on the earth's crust in such form that they can be technically, economically and legally extracted at the time of determination;

(iii) It follows from (ii) above that a large part of the iron-ore resources and indeed any other mineral resources in developing African countries, which are very often large and of very high quality, cannot be regarded as reserves at present as defined in (ii) above;

(iv) It should also be noted that, with the exception of Algeria, Egypt, Tunisia, Rhodesia and the Republic of South Africa, none of the other African countries at present possess a domestic iron and steel industry based on primary ore;

(v) The exploitation of iron ore in all African countries, except Egypt, Rhodesia and the Republic of South Africa, was started primarily to supply iron ore to overseas consumers, the iron-ore resources being favourably located with respect to world shipping lanes, so that overland transportation costs are non-existent or minimal;

(vi) It follows from (ii) and (v) above that only those iron-ore resources favourably located for purposes of export, and/or those not so located but currently being exploited for domestic use such as those in Rhodesia, and/or those for which plans for exploitation exist, as in Libya and Algeria -- countries where large amounts of capital are available - strictly qualify as reserves according to the definition given in (ii) above;

(vii) Moreover, some of the iron-ore deposits, although favourably located for exploitation for export, remain unexploited because of lack of capital and technology. 129/ The huge Nimba iron-ore deposits in Guinea and the Wolugisi Range deposits in Liberia are a case in point. Those with both capital and technological know-how, who happen to be the steel-makers in the developed countries, are reluctant to invest in new projects, partly because of over-capacity in world iron-ore production, and partly also, in the case of Guinea, because of doubts as to the advisability of foreign investment in that country. Strictly speaking, therefore, the iron-ore resources at Nimba in Guinea and at Wolugisi in Liberia are not reserves as defined in (ii) above;

(viii) For the purposes of this report, the emphasis on technical, economic and legal exploitation at the time of determination has been minimized. Provided that the boundaries of a particular resource have been reasonably and accurately delineated and that extraction is technically feasible, the resource in question is considered to be a reserve. It is also assumed that the country in which the resource occurs may, in the not too distant future, exploit that resource for its own economic benefit;

(ix) Another factor to bear in mind here is that, in developing African countries, estimates of iron-ore resources cannot possibly be accurate because the geology of those countries is poorly known and the available data do not allow any reliable extimate resources located in them to be made. Because of this, no attempt has been made to compare resources.

129/ L. Lauren, Planned Developments of New Ores or Expansions of Existing Ones - Raw Materials for Iron and Steel in Africa, Present Utilization and Potential for Further Development (United Nations Economic Commission for Africa, 1976), unpublished report, pp. 35-51.

In view of the foregoing, comparisons between the various African countries are limited to reserves, and even these should be regarded as very approximate.

In Africa, the Republic of South Africa leads in iron-ore reserves, with 6,928 million tonnes Fe content, representing 34.3 per cent of the total. It is followed, in decreasing order (in millions of tonnes Fe content and percentage of total African iron-ore reserves) by the Libyan Arab Jamahiriya 3,514 (12.5 per cent), Liberia 2,055 (10.2 per cent), Algeria 1,848 (9.2 per cent), Guinea 1,394 (6.9 per cent), Angola 1,218 (6.0 per cent), Ghana 620 (3.1 per cent), Sierra Leone 537 (2.7 per cent), Gabon 520 (2.6 per cent) and Ivory Coast 448 (2.2 per cent) (see table I.38).

When the iron-ore reserves of the developing African subregions are considered, it will be seen that, in decreasing order (in millions of tonnes Fe content and percentage of total African reserves), the West Africa subregion comes first with 6,282 (31.2 per cent), followed by North Africa 4,638 (23.0 per cent), Central Africa 1,826 (9.0 per cent), and East and Southern Africa 497 (2.5 per cent).

In relation to world iron-ore reserves, the Republic of South Africa holds a 6.0 per cent share and ranks fifth; the Libyan Arab Jamahiriya has a 2.1 per cent share and ranks tenth; Liberia has a 1.8 per cent share and ranks twelfth; Algeria has a 1.6 per cent shar and ranks thirteenth; Guinea has a 1.2 per cent share and ranks fifteenth; Angola has a 1.0 per cent share and ranks sixteenth. Ghana, Sierra Leone, Gabon and the Ivory Coast have each about a 0.5 per cent share of world reserves, or slightly less. The remaining African countries with iron-ore reserves each have less than a 0.25 per cent share of world iron-ore reserves.

Developing African countries have a total of 13,250 million tonnes Fe content iron-ore reserves, equivalent to an 11 per cent share of world iron-ore reserves. Africa as a whole has iron-ore reserves amounting to 20,175 million tonnes Fe content, representing 17 per cent of world iron-ore reserves.

Table I.39 shows that bedded iron-ore resources predominate, as elsewhere in the world; in Africa, they account for about 90 per cent of all the known reserves. Of these, about 49 per cent are of the bedded Pre-Cambrian Lake Superior type, except in the North Africa subregion, where palaeozoic and post-palaeozoic minette types account for about 99 per cent of all the known bedded iron-ore reserves.

8. THE ROLE OF COUNTRIES OTHER THAN THOSE OF AFRICA IN IRON-ORE RESERVES

As shown in table I.38, the USSR ranks first in the world with 31,000 million tonnes Fe content, accounting for 27 per cent of world iron-ore reserves. 130/ It is followed in descending order (in millions of tonnes Fe content, percentage and world ranking) by Brazil 16,000 (14.0 per cent, second); Canada 11,700 (10.0 per cent, third); Australia 10,000 (8.6 per cent, fourth); USA 4,000 (3.4 per cent, seventh); People's Republic of China 3,100 (2.7 per cent, eighth); France 2,700 (2.3 per cent, ninth); Sweden 2,200 (1.9 per cent, eleventh); and Venezuela 1,400 (1.2 per cent, fourteenth).

9. PRODUCTION AND USE OF IRON ORE IN AFRICA AND THE REST OF THE WORLD

(a) Iron-ore production in Africa

Although Africa accounts for 17 per cent of world iron-ore reserves, it contributes only about 7 per cent of world iron-ore production, as is clearly shown by the production figures for the year 1975 given in table II.14. Of this 7 per cent share, furthermore, 78 per cent is produced in only three countries, namely Liberia (40 per cent), Mauritania (16 per cent) and the Republic of South Africa (22 per cent). This low iron ore production on the African continent relative to the known iron-ore reserves, as already observed, is due mainly to the small, and for the majority of African countries, complete absence of local consumption of iron ore in raw form. In addition, the prohibitive cost of overland transport and of shipping to overseas consumers renders exploitation of most African iron-ore resources unprofitable at present. In this connexion, it is significant to note that, with the exception of Rhodesia, the other African iron-ore producing countries have direct access to the sea. Because of their favourable geographical location and because of the development of large bulk carriers, these countries have been able to exploit their iron-ore resources for export in raw form at a profit. Rhodesia, although land-locked, produces iron ore mainly for its domestic iron and steel industry.

(b) Non-African iron-ore producing countries

The biggest producer of iron ore in the world is the USSR, which has approximately a 25 per cent share of world production (see table II.14). It is followed, in descending order, by Australia 12.0 per cent, Brazil 11.5 per cent, USA 9.7 per cent, China 6.4 per cent, Canada 5.4 per cent, India 5.1 per cent, Sweden 3.9 per cent, Venezuela 3.03 per ce France 3.02 per cent, Liberia 2.7 per cent, the Republic of South Africa 1.5 per cent and Mauritania 1.1 per cent. These are followed by Spain, the Democratic People's Republic o Korea and Mexico, each with slighily less than 1 per cent of world production. The other producers each account for much less than 0.5 per cent of world production. It is significant that the developing countries as a whole have about a 35 per cent

130/ "Mineral facts and problems", US Bureau of Mines Bulletin No. 667, 1975.

share of world iron-ore production. While the USSR by itself has a 25 per cent share, the remaining developed countries (of which the majority belong to the Western Block) account for only 40 per cent of world iron-ore production. They thus depend on imported iron ore for their domestic iron and steel industries, and especially on iron ore from the developing countries together with a few developed countries, namely the Republic of South Africa, Australia and Canada. This state of affairs is particularly important when world pig-iron and ferroalloy production are considered. As will be seen from table IV.8, countries and especially those of the West which have no or insignificant iron-ore production are major producers of pig-iron and feroalloys. These countries therefore depend on imported ore. For instance, the United Kingdom, the Federal Republic of Germany and Japan imported respectively 41 per cent, 34 per cent and 63 per cent of the iron ore which they consumed during 1950; in 1975, however, their imports were respectively 77 per cent, 93 per cent and 99 per cent. 131/, 132/ These countries are among the few where iron and steel production began many years ago.

In each of these countries demand for iron ore has tended to outstrip local supply in terms of both tonnage and technical quality requirements. These needs have been met by the development of resources in distant countries - taking advantage of advances in bulk shipping technology - often with consumer participation or finance [(see Sections 3(c), 3(e), 3(g), 3(k) and 4(a)].

(c) Iron and steel production in Africa

Southern Rhodesia, the Republic of South Africa and all the North African countries (excluding the Libyan Arab Jamahiriya and the Sudan) are the only countries in Africa with a domestic iron and steel industry based on primary iron ore. The African share of world iron and steel production is therefore very small. Thus, although Africa had a 7 per cent share of world iron-ore production in 1975 (table II.14), its share in the processing of ore to iron was only 1.5 per cent of the world total (see table IV.8). This is because most of the iron ore produced on the continent is exported to overseas consumers in raw form.

131/ "Iron ore: changing mix", Mining Journal, vol. 792, No. 7495, 13 April 1979, pp. 281-283.

132/ "Steel industry evolution", Mining Journal, vol. 292, No. 7496, 20 April 1979, pp. 288-297.

(d) Non-African iron and steel producing countries

Table IV.8 shows world pig-iron and ferroalloy production, with each country's and each subregion's production expressed as a percentage of world production; in the case of African countries, each country's production is also expressed as a percentage of African production. The positions of all the countries relative to one another have remained practically unchanged from 1975 to the present time. It will be seen further that Eastern Europe with about 28 per cent of world pig-iron and ferroalloy production, ranks first. It is followed in descending order by Asia, with about 27 per cent, Western Europe 22 per cent, and North America 18 per cent, while Oceania (represented by Australia alone) and Africa each account for about 1.5 per cent. The eleven largest pig-iron and ferroalloys producers are in descending order, the USSR with about 21 per cent of world kproduction, followed by Japan 18 per cent, USA 15 per cent, China 6.5 per cent, Federal Republic of Germany 6.2 per cent, France 3.8 per cent, United Kingdom 2.5 per cent, Italy 2.4, Czechoslovakia and Canda 1.9 per cent each, and Belgium 1.8 per cent.

Among the developing countries, Brazil and India are expected to increase their share in the transformation of iron ore into iron and steel because they possess in abundance the essential raw materials needed in steel-making, such as iron ore and mangane Countries such as the Republic of Korea and Saudi Arabia, which depend largely on imported raw materials, will also increase their share of iron and steel production as their steel requirements expand. The erosion of markets for steel products from the old traditional steel-makers, especially those of the West, and the prospect of increased competition in world markets for raw materials pose immense political and economic problems for the developing countries. Thus many of the African developing countries planning to establis their own iron and steel industries are finding it difficult to obtain external finance for this purpose. A case in point is the Nador Iron and Steel project in Morocco, which was delayed for two years by the World Bank. 133/ Another recent example is that of the steel companies and unions in the United States of America, which have started to exert pressure on Congress to end export financing that assists any industry where there is world-wide over-capacity. 134/ Their target, of course, was prospective Third World Steel producers. Together with all these financial difficulties, developing countries have als to face big-power politics as the competition for raw materials increases.

133/ "Iron ore: Changing mix", pp. 281-283.

134/ "Steel: A third world surge", Newsweek, vol. XCIV, No. 18,29 October 1979, pp. 44-45.

ANNEX I

Statistical tables on iron ore resources in African countries

Table I.1: Iron ore resources in Algeria

Deposit	Nearest significant location	Type of deposit	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential ores	Total resources	Current annual production (thousands of tonnes)	Remarks
Ouenza-Bou Khadra	Bone	Bilbao	Haematite siderite	55.5	3.8	0.05		Mn 2 CaO 3.4 MgO 1	130	130	130	73.8	500	630	3 000	80 per cent Algeria's production
Beni Saf	Oran	Bilbao	Haematite goethite	56	5	0.07	0.03	Al_2O_3 0.9 CaO 2.6 Mn 1		2	2	1.2	?	?	180	Small producer
Zaccar	Algiers	Bilbao	Haematite siderite	53	5.7	0.02	0.02	Al_2O_3 0.4 CaO 5.3 MgO 0.4		1.2	1.2	0.6	?	1.2	200	Ceassed production 1976
Timezrit	Bougie	Bilbao	Haematite siderite	57	2		0.01	CaO 0.5 Mn 1.1		2.0	2.0	1.1	?	2	125	Small producer
Khanguet El Mouhad	Tebessa	Bilbao	Haematite goethite	57	3.2		0.02	Mn 1.7 CaO 3.9 MgO 2.3		1.5	1.5	0.75	?	1.5	200	Small producer
Gara Djebilet (Western and Central ore-bodies Magnetite Zone)	Tindouf	Minette	Magnetite	57	4.9		0.8	Al_2O_3 4.3 Ti_2O_3 0.3 MgO 0.3	1 000	1 000	1 000	570		1 000		Under development
Gara Djebilet (Western and Central ore-bodies Haematite Zone)	Tindouf	Minette	Haematite	53.5			0.8		2 245	2 245	2 245	1 201		2 245		Under development
Gara Djebilet (Eastern ore-body)	Tindouf	Minette	Haematite magnetite	40-57			0.8						500	500		Under detailed investigation
Total											3 381.7	1 848.45	1 000	4 379.7		

Table I.2: Iron ore resources in Egypt

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential ores	Total resources	Current annual production (thousands of tonnes)	Remark
Aswan	Aswan	Minette	Haematite	31.2	5.3		3.5	Al_2O_3 6 CaO 5		140	140	43.7		140	450	
S.W. of Quseir	Red Sea area	Lake superior	Haematite magnetite	43	28		0.4	Mn 0.23 Ti 0.27		39	39	11.0		39		
El Gidida (Baharia Oasis)	Baharia Oasis	Minette	Haematite	54.8		0.91	0.23	Mn 1.06		134	134	73.4		134	750	
Gabal Ghorabi	Baharia Oasis	Minette	Haematite goethite	46.8						57	57	26.7		57		
Nasser	Baharia Oasis	Minette	Haematite goethite	43.7						26.6	26.6	11.6		26.6		
El Harra	Baharia Oasis	Minette	Haematite goethite	42						33.7	33.7	14.2		33.7		
Giddi area (Sinai)	Suez	Minette	Haematite	?						?	?	?		?		
Total:										430.3		180.6				

Table I.3: Iron ore resources in the Libyan Arab Jamahiriya

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential ores	Total resources	Current production	Remarks
Shatti Valley (a)	Fezzan	Minette	Haematite	48	16	0.22	0.26	Al_2O_3 3.25		722	1 755	842				Plans under way to start exploitation
Shatti Valley (b)	Fezzan	Minette	Haematite	44	21	0.29	0.31			1 087	2 554	1 124				
Shatti Valley (c)	Fezzan	Minette	Haematite	35						1 378	1 378	482				
Shatti Valley (d)	Fezzan	Minette	Haematite	29	46	0.35	0.39			227	227	66				
Total :										5 914	2 514					

Table I.4: Iron ore resources in Morocco

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Current annual production (thousands of tonnes)	Remarks
Imin Tourza	Ouarzazate	Minette	Magnetite siderite	52	7		1	Al_2O_3 5.9 CaO 2.2 Mn 0.2		40	40	20.8	50	90		
Ouarzamine Tachila	Agadir	Minette	Siderite goethite	35	26		0.05	Al_2O_3 10					20	20		
Ait Ahmane	Bou Azzer	Lake Superior	Haematite	46	24								10	10		
Kettara	Marrakech			52	11.5		0.05	Al_2O_3 1					1	1		
Bou Cusel	Khenifra	Bilbao	Barytine haematite siderite goethite	42	10		0.01	$BaSO_4$ 15 MnO_2 2.3					60	60		
Boulhaut		Minette		46									10	10		
Ait Amar	Oued Zem	Minette		44	14		0.07	Mn 3 Al_2O_3 9		25	25	11		25	500	Operation from 1937 to 1962
Keradid	Settat	Minette		38	28			Al_2O_3 7					80	80		
Ouichane	Nador	Magnitnaya	Magnetite haematite pyrrite	60	7	1.5	0.005				30	18		30		Closed
Achara	Nador	Magnitnaya	Magnetite haematite pyrrite	?	?	?	?				?		?	?		In operation: open-cast
Setolazar	Nador	Magnitnaya	Magnetite haematite pyrrite	54	4	4	0.01				11	5.9				Closed
Iberkanen	Nador	Magnitnaya	Magnetite haematite pyrrite	?	?	?	?				?	?	?	?		In operation: underground
Total												55.7				

Sources: Etude d'investigation dans les branches mécaniques et électriques et dans les industries en amont en vue de déterminer les capacités de sous-traitance actuelles et à moyen terme dans et entre les pays du Maghreb - Centre d'Etudes Industrielles du Maghreb, 1974.

Survey of World Iron Ore Resources, UN ST/ECA/113, 1970.

Table I.5: Iron ore resources in the Sudan

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources
Red Sea Hills	Sofaya	Magnitnaya	Magnetite haematite	60							20	12		20
Podikwan	Sofia	Magnitnaya	Magnitite haematite	60							6	3.6		6
Kordofan (Abu Tulu)	Fula	L.Super.	Haematite magnetite	61									36	36
Wadi Halfa area (Kutum)	Kutum	Minette	Haematite	51									10	10
Bahr el Ghazal	Gabr el Ghazel	Laterite	Goethite	37									large	large
												15.6		72

Table I.6: Iron ore resources in Tunisia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Tamera	Tabarca	Bilbao	Haematite goethite	52	4		0.10	A_2O_3 3.7 CaO 0.3 Mn 2			10	5.2		10		
Douaria	Tabarca	Bilbao	Siderite	60									14	14		
Djerissa	Lekef	Bilbao	Haematite siderite	54	4		0.03	Al_2O_3 0.8 CaO 0.5 Mn 2.1			32	17.3		32		
Djebel Ank	Gafsa	Minette	Goethite siderite	53									30	30		
Nefza		Minette	Siderite	26									10	10		
Nebour Kef		Minette	Siderite	40	8								10	10		
												22.5		106		

Table I.7: Iron ore resources in Benin

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Loumbou-Loumbou	Kandi	Minette	Haematite	50	16	0.04	0.8	Al_2O_3 5 Mn 0.08					250	250		
Madekali	Malanville	Minette	Haematite	58	3			Al_2O_3 2 Mn 0.09 CaO 0.8					40	40		
Total													290			

Table I.8: Iron ore resources of Ghana

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Shieni	Yendi	Minette	Haematite	35-50	18-37		0.33	High Ti			1 270	540				
Opon-Mansi	Dunkwa	Lateritic	Goethite	52	3.6		0.9	Al_2O_3 15			150	78				
Pudo	Pudo	Taberg	Magnetite		33.5			TiO_2 3.9					4.5			
Total:														618		

Table I.9: Iron ore resources in Guinea

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Reserves (millions of tonnes) Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Kaloum	Conakry	Laterite	Goethite haematite	52		0.05		Cr 1.5			9	4.7	9	9	1 000 000	Operational 1953-1966
Tomine	Gaoual	Lateritic	Goethite haematite	55		0.45		Cr 1.0			200	110		200		285 km from Kamsal port 50 km to Benty port
Forecariah	Benty	Lateritic	Goethite haematite	53		0.05		Cr 1.5			300	159		300		
Yomboeli	Benty	Lateritic	Goethite haematite	52							2	1		2		
Simandou	Nzerekare	Lake Superior	Haematite	65	25-40	0.05		Cr traces Al_2O_3 5.8			1 000	650		1 000		800 km to Conakry, 20 km to LAMCO rail head.
Nimba	Beyla	Lake Superior	Haematite	67		0.04		Cr traces			700	469		700		900 km to Conakry, 140 km to LAMCO rail-head
Total :											2 211	1 394				

Table I.10: Iron ore resources in the Ivory Coast

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Monogaga	Sassandra	Minette	Goethite haematite	40	13	0.06	0.25	Al_2O_3 11					150	150		
Sassandra	Sassandra	Minette	Goethite Haematite	42	14	0.05	0.2						46	46		
Gao Mt.	Man	Lake Superior	Magnetite	40	34								150	150		
Segaye Mt.	Man	"	Magnetite	25-48	High								43	43		
Totro Mt.	Man	"	"	25-48	High								165	165		
Tia Mt.	Man	"	Magnetite haematite	25-48	High					232	85			232		
Klahoyo Mt.	Man	"	Magnetite haematite	36.3						1 000	363			1 000		
Nimba Mt.	Man	"	Magnetite haematite										large	large		
Dans Massif	Man	"	Magnetite haematite													
Sipilou	Man	"	Magnetite										50	50		
Beti	Touba	"	Magnetite										20	20		
Tieko	Touba	"	Magnetite										7	7		
Kandanso	Odienne	"	Magnetite										130	130		
Total:											448			1 993		

Table I.11: Iron ore resources in Liberia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Bomi Hills (LMC)	Monrovia	Michicopiten	Magnetite haematite	45.3	0.2 5.8						65	29		65	3 000 000	Closed March 1977
Mano River (NIOC)	Monrovia	Michicopiten	Magnetite haematite	47							151	71		151	4 000 000	In operation
Nimba (LAMCO)	Buchanan	L. Superior	Magnetite	63.7	4	0.03	0.03	Al_2O_3 0.9			1 636	1 042		1 636	10 000 000	In operation
Bong Range (BMC)	Monrovia	Michicopiten	Magnetite	37.9		0.03	0.03				371	141		371	7 000 000	In operation
Wolugisi Range (LISCO)	Monrovia	Michicopiten	Magnetite haematite goethite	33-54							1 285	559	5 000	6 285		Under development
Putu Range	Grand Cess	L. Superior	Magnetite	41.3							516	213		516		
Total:												2 055		9 024		

LMC Liberia Mining Company
NIOC National Iron Ore Company
LAMCO-JV Liberian American Swedish Mineral Company Ltd. - joint venture
BMC Bong Mining Company
LISCO Liberian Iron Ore Company-formerly Kitoma Mining Company

Table I.12: Iron ore resources in Mali

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources in millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Nioro	Kayes	Bilbao	Magnetite	63									10	10		
Djidian-Kenieba	Kayes	Bilbao	Magnetite	65									2	2		
Galé	Kayes	Minette	Haematite goethite	52	12								58	58		

Table I.13: Iron ore resources in Mauritania

Region district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
F'Derik	Fort Gouraud	L.Superior	Haematite	64	4.3	0.01	0.03	Al_2O_3 1.2 CaO 0.2 Mn 0.12			100	64		100		
Rouessa Hamariat	Fort Gouraud	L.Superior	Haematite	64							100	64		100		
Tazadit	Fort Gouraud	L.Superior	Haematite	64							100	64		100		
Azouazite	Fort Gouraud	L.Superior	Haematite	64							100	64		100		
Legleitat	Akjoujt	Bilbao	Haematite	52	8	0.01	0.13				200	104		200		
Kedia d'Idjil	Fort Gouraud	L.Superior	Haematite	37									2 000	2 000		
Akjoujt	Akjoujt	By-product	Magnetite										15			
Total:												360		2 600		

Table I.14: Iron ore resources in the Niger

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Say-Diabou	Niamey	Minette	Goethite	49	19		1.9	Al_2O_3 4.7					600	600		
Kolo-Say-Tamou	Say	Minette	Goethite	42	19		1.8	Al_2O_3 7					80	80		
Total:													680	680		

Table I.15: Iron ore resources in Nigeria

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Itakpe	Lokoja	Minette	Haematite	39		0.08	0.09	Al_2O_3 + SiO_2 16.7			600	234		600		Under development
Enugu	Enugu	Laterite	Goethite	32									200	200		
Total :											600	234		800		

Table I.16: Iron ore resources in Senegal

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Felémé	Saraya	L.Superior	Haematite	60							700	420	600	1 300		
Total :											700	420	600	1 300		

Table I.17: Iron ore resources in Sierra Leone

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (in millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Marampa	Freetown	Bedded not classified	Haematite	38							100	38		100	2 000 000	Closed Oct. 1975
Tokolili	Freetown	Bedded not classified	Maritite goethite	54				8-9 Al_2O_3			608	328		608		
Great Scarcies River	Freetown	Bedded not classified	Haematite	30							15			15		
Bagla Hill	Freetown	Lake Superior	Magnetite	41.6	1.58			6.6 Al_2O_3			400	166		400		
Total:												532		1 123		

Table I.18: Iron ore resources in Togo

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Benjéli	Bassari	Lake Superior	Haematite	49							42	20		42		
Bitjabé	Bassari	Lake Superior	Haematite	33	20	0.05	0.23	Al_2O_3 16			600	198		600		
Total:											642	218		642		

Table I.19: Iron ore resources in the Upper Volta

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Tin Edia	Dori	Taberg	Magnetite haematite ilmenite	58	2.2			TiO_2 12 Mn 0.2 Al_2O_3 1.5 V 0.33					50	50		
Total													50	50		

Table I.20: Iron ore resources in the Western Sahara

Region/ district deposit	Nearest Significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Agracha	Villa Cisneros	Taberg	Magnetite	54				Ti 14					150	150		
Total													150	150		

Table I.21: Iron-ore resources in Angola

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Annual production (in tonnes)	Remarks
Dala Tando (Cassala-Quitungo)	Villa Salazar	Lake Superior	Haematite	32							1 000	320		1 000		
M'Bassa	Luanda	Taberg	Magnetite	56-60	7	0.01	0.1	TiO_2 5			10	6		10		
Cassala-Quitungo	Villa Salazar	Taberg	Magnetite	35	44	0.03	0.06	TiO_2 0.4			72	25	100	172		
Quima	Nova-Lisboa	Massive not classified	Magnetite	60	3.5	0.01	0.05				10	6		10	320 000 (1966)	Closed 1967/68
Chilesso	Villa Salazar	Lake Superior	Haematite	High							?	?	?	?		
Teixera da Silva	Villa Salazar	Lake Superior	Haematite	High							?	?	?	?		
Cassinga	Mossamedes	Lake Superior	Haematite	61			0.1				100	61		100	5 000 000 (1975)	Production interrupted 1975 by Civil War
Cassinga	Mossamedes	Lake Superior	Haematite	40							2 000	800		2 000		
Sada Bandeira	Mossamedes	Taberg	Magnetite	?							?	?	?	?		
Total											3 192	1 218		3 292		

Table I.22: Iron ore resources in the Congo

Region/ District deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Annual production (in tonne)	Remarks
Annan	Dolisie	Lake Superior	Haematite magnetite	43	20					[illegible]	[illegible]		[illegible]		
Mayoko	Dolisie	Lake Superior	Haematite magnetite	56	8.8			Al_2O_3 2.05		30	17		30		
Mayoko	Dolisie	Lake Superior	Haematite hagnetite	35-45	25-45							776	776		
Total										130	60	776	906		

Table I.23: Iron ore resources in Gabon

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured indicated and inferred	Fe content	Potential resources	Total resources	Annual production (tonnes)	Remarks
Batoala	Makokou	Lake Superior	Haematite goethite magnetite	66	2.9					99	117	77		117		Production possible in 1983
Belinga	Makokou	Lake Superior	Haematite goethite magnetite	64	2.2		0.12	Al_2O_3 2.5	516	516	566	362		566		Production possible in 1983
Boka-Boka	Mekambo	Lake Superior	Haematite goethite magnetite	62	3.5		0.1				194	120		194		Production possible in 1983
Minkébé	Makokou	Lake Superior	Haematite goethite magnetite	64	3		0.1			60	60	38		60		
Mébaga	Mitzic	Lake Superior	Haematite goethite magnetite	60	4								15	15		
Méla	Kango	Lake Superior	Haematite magnetite	46	30								100	100		
N'Gama	Mitzic	Lake Superior	Haematite goethite magnetite	47	22								50	50		
Tchibanga-Moutéli	Tchibanga	Lake Superior	Haematite	43	27.4	0.05	0.18	Al_2O_3 3					114	114		
Total											937	597	279	1 216		

Table I.24: Iron ore resources in the United Republic of Cameroon

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Annual production (tonnes)	Remarks
						m										
Les Mamelles	Kribi	Lake Superior	Haematite magnetite	38		0.2	0.08						150	150		

Table I.25: Iron ore resources in Zaire

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Annual production (tonnes)	Remarks
Kisanga-Kambove	Jadotville	Bilbao	Haematite magnetite	56	9.5		0.1			50		28		50		
Kanunka	Jadotville	Lake Superior	Haematite	54	21			Cu 0.24								
Kilomoto area	Kisangani	Lake Superior	Haematite	45-65									5 000	5 000		
Luebo	Lumumbashi	Lake Superior	Haematite	30									100	100		
Total										50		28	5 100	5 100		

Table I.26: Iron ore resources in Ethiopia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of resources (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Annual production (in tonnes)	Remarks
Hamasien	Asmara	Magnitnaya	Haematite	30	10								5	5		
Adwa-Axum-Enticho	Mekele	Lateritic	Goethite	?									5	5		
Wollega	Nekemte	Lake Superior	Magnetite haematite	33	33								14	14		
Total													24	24		

Table I.27: Iron ore resources in Kenya

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Annual production (in tonne)	Remarks
Mrima Hill	Mombasa	Residual Massive	Goethite	7-36									15	15		
Nukuru	Kisumu		Pyrite	30									17	17		
Kyoma Peninsular	Kisumu	Mineral sands	Magnetite ilmenite					TiO_2 13					?	?		
Kutha	Voi	Bedded Massive	Magnetit.												600	ment production
Taita Hills	Voi	Bedded Massive	Magnetite													
Total													32	32		

Table I.28: Iron ore resources in Madagascar

Region/district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Ambatomy-Analamy	Malaranga	Residual Lateritic	Goethite Haematite	46	0.7	0.3	0.1	Al_2O_3 12 Ni_2O_3 0.2 Cr 0.8 Ti 1.7					38	38		
Bekisopa	Fianarantsoa	Magnetitaya	Magnetite	40		0.3	0.2						70	70		
Soalala		Lateritic		+60									300	300		
Betioky	Betioky	Residual Lateritic	Goethite haematite	24									30	30		
Fasintsara	Andasibe	Lake Superior	Magnetite haematite	35			0.15						105	105		
Marorangata-Ambatoloana	Tamatave	Lake Superior	Magnetite haematite	25									8	8		
Total													551	551		

Table I.29: Iron ore resources in Mozambique

Region/district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Muande	Tete	Tabeng	Magnetite	67	0.8	0.01		Al_2O_3 1.3 Ti_2O_3 1.5	6	6	20	13		20		
Machedua	Tete	Tabeng	Haematite magnetite ilmenite	48	0.1	0.02		MgO 2.5 Al_2O_3 5.2 Ti_2O_3 23.9 Va 0.6	12	12	12	5.8	120	132		
Massamba	Tete	Tabeng	Haematite magnetite ilmenite	48	0.2	0.02	0.05	MgO 2.5 Al_2O_3 5 Ti_2O_3 24 Va 0.5	8	8	8	3.8	70	78		
Zumantipissa	Tete	Tabeng	Haematite magnetite ilmenite	50				Ti 22					11	11		
Dxiziga	Tete	Tabeng	Haematite magnetite ilmenite	46	1	0.1		CaO 0.1 MgO 1.4 Al_2O_3 0.5 Ti_2O_3 25	1	1	[illegible]	[illegible]		[illegible]		
Namapa	Mocambique	Bedded - not classified	Magnetite	52	24			MgO 0.1 Al_2O_3 0.7 Ti_2O_3 0.6 Va 0.6					60	60		
Total									27	27	48	26.5	261	309		

Table I.30: Iron ore resources in Namibia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Windhoek	Windhoek	Lake Superior	Haematite magnetite	40-50							300	135		300		
Kaokoveld	Kaoko	Lake Superior	Haematite magnetite	40							100			100		
Kaokoveld	Kaoko	Lake Superior	Haematite magnetite	40									1 000	1 000		
Kalkafeld	Kalkafeld	Bilbao	Magnetite	30-50							10			10		
Okorusu	Kalkafeld	Taberg	Magnetite	40							40			40		
Total:											450	135	+1 000	1 450		

Table I.31: Iron ore resources in Somalia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Bur Dur	Mogadishu	Bedded - not classified	Haematite	39									120	120		
Daimir	Mogadishu	Bedded- not classified		30									50	50		
Total:													170	170		

Table I.32: Iron ore resources in Southern Rhodesia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (in millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Que Que	Salisbury	Lake Superior	Haematite	59	10						200	118		200		
Buchwa	Shabani	Lake Superior	Haematite	63							134	84		134		
Manesi Range		Lake Superior	Haematite	40									3 300	3 300		
Black Mamba and Yank	Gatooma	Lake Superior	Haematite	60							40	24		40		
Nyuni		Lake Superior	Haematite	55-66							4			4		
Chikurubi	Gwelo	Lake Superior														
Mongula and Manyoka		Lake Superior	Magnetite	50-60												
Dorowa and Shawa		Residual carbonate	Magnetite													
Total											378	226	3 300	3 678		

Table I.33: Iron ore resources in Swaziland

Region/district deposit	Nearest significant location	Type of mineral	Principal Fe	SiO_2	S	P	Other significant components	Chemistry of reserves (percentage)	Resources (in millions of tonnes) Reserves: Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Ngwenya	Mbabane	Lake Superior	Haematite magnetite	45			Mn 0.4		50		22	4	50		Production ceased 1
Zege	Lake	Lake Superior	Goethite haematite	40			Mn 0.6		55		22	90	145		
Maloma		Lake Superior	Magnetite	30					75		23		75		
Forbes Reef			Siderite	38					6		2	6	6		
Total									186		69	100	276		

Table I.34: Iron ore resources in Uganda

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (in millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual Production	Remarks
Kigezi	Kigezi	Lake Superior	Haematite	78			0.05						30	30		
Sukulu	Tororo	Not classified	Magnetite	62	1.1		2.6						45	45		
Bukusu	Mbale	Massive not classified	Magnetite	60				TiO_2 10-20					23	23		
Total:													98	98		

Table I.35: Iron ore resources in the United Republic of Tanzania

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (in millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production	Remarks
Liganga	Liganga	Taberg	Magnetite	50	1.3			TiO_2 13			49	25		49		Under study
								V 0.23					8	8		
Hundusi	Hundusi	Taberg	Magnetite										?	?		
Mbalala	Liganga	Taberg	Magnetite										68	68		
Hanyoro	Hanyoro	Micopichen	Magnetite	30				Mn - up to II per cent								
Total:											49	25	76	125		

Table I.36: Iron ore resources in Zambia

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Chisasa	**Chingola**	Lake Superior	**Haematite** magnetite	55–60							11	6		11		
Chisasa	Chingola	Lake Superior	"	35–40									50	50		
Mwinilungu	Chingola	Lake Superior	Magnetite haematite	50–60									Very large	50		
Lufubu	Kitwe	Lake Superior	Haematite	+ 60									60	60		
Kahare	Lusaka	Lake Superior	Haematite	+ 50									20	20		
Sanje–Pamba–Nampunde	Lusaka	Lake Superior	Haematite magnetite	50–60		High							Very large	Very large		
Namatombwa–Shashikaula	Lusaka	Bilbao	Magnetite	58		1.4					15	9		15		
Nambala–Sonkwe	Lusaka	Lake Superior	Haematite	+ 60									50	50		
Chibote	Ndola	Lake Superior	Haematite	50				Mn 1%					50	50		
Total:											26	15	+230	306		

Table I.37: Iron ore resources in the Republic of South Africa

Region/ district deposit	Nearest significant location	Type of ore	Principal mineral	Chemistry of reserves (percentage) Fe	SiO_2	S	P	Other significant components	Resources (millions of tonnes) Reserves: Measured	Measured and indicated	Measured, indicated and inferred	Fe content	Potential resources	Total resources	Average annual production (tonnes)	Remarks
Postmasburg-Thabazimbi																
Thabazimbi	Johannesburg	Lake Superior	Haematite	60							100	60	Very large	100	2 000 000	Operating
Shishen	Kimberly	Lake Superior	Haematite	65-69							4 200	2 814	Very large	4 200	8 000 000	Operating
Pretoria	Pretoria	Minette	Haematite		High						6 000	2 820		6 000		A number of operating mines
Bushveld Ingneous Comp.																
Bushveld Ingneous Complex	Johannesburg	Taberg	Magnetite	42-60							2 200	1 122	Very large	2 200		
Mapoch Mine				55-57				Cr_2O_3 15-0.3 TiO_2 12-15 V_2O_5 1.4-19			200	112		200	1 000 000	Operating
Total:											12 700	6 928		12 700		

Table I. 38 : The role of developing African countries and other countries in world iron-ore reserves expressed as a percentage of Africa and world iron-ore reserves

Subregion/ country	Iron ore resources R e s e r v e s Fe content (millions of tonnes)	Africa Percentage	Africa Rank	World Percentage	World Rank	Potential resources (Millions of tonnes) Fe (percentage)	Total resources Fe content (millions of tonnes)
North Africa							
Algeria	1 848	9.16	4	1.58	13	1 000	40-57
Egypt	181	0.90		0.15		Unestimated	
Libyan Arab Jamahiriya	2 514	12.46	2	2.15	10	Very large Unestimated	
Morocco	56	0.28		0.05		231	35-52
Sudan	16	0.08		0.01		Unestimated	37-60
Tunisia	23	0.11		0.02		Very large 64	26-60
Total North Africa	4 538	22.99		3.97			
West Africa							
Benin						290	50-58
Ghana	620	3.07	7	0.53	17	Unestimated	25-40
Guinea	1 394	6.91	5	1.19	15	Very large Unestimated	25-55
Ivory Coast	448	2.22	10	0.38	20	Very large 761	25-46
Liberia	2 055	10.18	3	1.76	12	+5 000	33-54
Mali						70	52-63
Mauritania	360	1.78	12	0.31		+2 000	37-64
Niger						680	42-49
Nigeria	234	1.16	13	0.20		+ 200	32
Senegal	420	2.08	11	0.36		+ 600	40-60
Sierra Leone	537	2.66	8	0.46	18	Unestimated substantial	41-54
Togo	218	1.0 4	15	0.19		Unestimated small	25-40

Table I.38: The role of developing African countries and other countries in world iron ore reserves expressed as a percentage of Africa and world iron ore reserves (continued)

Subregion/ Country	Iron ore resources: Reserves: Fe content (millions of tonnes)	Reserves: Africa: Percentage of	Reserves: Africa: Rank	Reserves: world: Percentage	Reserves: world: Rank	Potential resources: Million tonne	Potential resources: Fe (percentage)	Total resources Fe content (millions of tonnes)
Upper Volta						+ 50	58	
Western Sahara						+150	54	
Total West Africa	6 286	31.10		5.38				
Central Africa								
Angola	1 218	6.04	6	1.04	16	Unestimated very large	25-50	
Gabon	520	2.58	9	0.44	19	+ 279	46-60	
United Republic of Cameroon						150	38	
Central African Republic						Unestimated very large		
Chad						small		
Congo	60	0.30		0.05		776	35-56	
Zaire	28	0.14		0.02		+5 100	45-65	
Total Central Africa	1 826	9.06		1.55				
East and Southern Africa								
Botswana						Limited		
Ethiopia						24	30-33	
Kenya						32	7-36	

Table I.38: The role of developing African countries and other countries in world iron ore reserves expressed as a percentage of Africa and world iron ore reserves (continued)

Iron ore resources

Subregion/ country	Reserves					Potential resources		Total resources
	Fe content (millions of tonnes)	Africa Percentage	Rank	World Percentage	Rank	Million tonne	Fe (percentage)	Fe content (millions of tonnes)
Madagascar						251	25-46	
Mozambique	27	0.13		0.02		261	48-50	
Namibia	135	0.67		0.11		+1 000	25-40	
Somalia						170	30-39	
Southern Rhodesia	226	1.12	14	0.19		3 300	40	
Swaziland	69	0.34		0.06		96	38-40	
United Republis of Tanzania	25	0.12		0.02		76	30	
Uganda						98	60-78	
Zambia	15	0.07		0.01		280	35-60	
Total East & Southern Africa	497	2.45		0.41		+5 588		
Total Developing Africa	13 247	65.60		11.31		?		
Republic of South Africa	6 928	34.34	1	5.94	5	Very large	25-40	
Total Africa	20 175			17.25		Very large		

Table I.38: The role of developing African countries and other countries in world iron ore reserves expressed as a percentage of Africa and world iron ore reserves

Iron ore resources

Subregion/ country	Reserves					Potential resources (millions of tonnes)	Total resources Fe content (millions of tonnes)
	Fe content (millions of tonnes)	Africa Percentage	Rank	World Percentage	Rank		
North America							
USA	5 000			3.43	7	14 000 (Fe content)	18 000 (Fe content)
Canada	11 700			10.02	3	17 300 (Fe content)	29 000 (Fe content)
Other	400			0.34		200 (Fe content)	600 (Fe content)
Total North America	16 100			13.79		31 500 (Fe content)	47 600 (Fe content)
South America							
Brazil	16 600			14.22	2	12 400 (Fe content)	29 000
Venezuela	1 400			1.20	14	2 500 (Fe content)	3 900
Other	1 400			1.20		16 700 (Fe content)	18 100
Total South America	19 400			16.62		31 600 (Fe content)	15 00

Table I.38: The role of developing African countries and other countries in world iron ore reserves expressed as a percentage of Africa and world iron ore reserves (continued)

Iron ore resources

Subregion/ country	Reserves					Potential resources (millions of tonnes)	Total resources Fe content (millions of tonnes
	Fe content (millions of tonnes	Africa Percentage	Rank	World Percentage	Rank		
Europe							
USSR	31 000			26.56	1	26 000 (Fe content)	57 000
France	2 700			2.31	9	900 (Fe content)	3 600
Sweden	2 200			1.88	11	800 (Fe content)	3 000
Other	3 600			3.08		1 400 (Fe content)	5 000
Total Europe	39 500			33.83		29 100 (Fe content)	68 600
Asia							
India	6 200			5.31	6	2 500 (Fe content)	8 700
Peoples Republic of China	3 100			2.66	8	4 000 (Fe content)	7 100
Other	2 000			1.71		1 000 (Fe content)	3 000
Total Asia	11 300			9.68		7 500 (Fe content)	18 800
Oceania							
Australia	10 000			8.57	4	10 000 (Fe content)	20 000
Other	200			0.17		800 (Fe content)	1 000
Total Oceania	10 200			8.74		10 800 (Fe content)	21 000
WORLD TOTAL	116 675			99.91		Unestimated	Unestimated

Source: Data on Africa derived from tables I.1 to I.37. Rest of world: Mineral facts and probles (resource estimate 1973), USBM Bulletin No. 667, 1975.

Table I.39: Iron ore reserves of Africa - Summation by type of ore deposit
(millions of tonnes Fe content)

	BEDDED					MASSIVE					RESIDUAL			
Country/ subregion	Lake Superior	Michicopiten	Minette	Other and not classified	Subtotal	Magnitnaya	Bilbao	Taberg	Other and not classified	Subtotal	Laterite	Other and not classified	Subtotal	Total reserves
North Africa														
Algeria			1 771		1 771		78			78				1 849
Egypt	11		170		181									181
Libyan Jamahiriya			2 514		2 514									2 514
Morocco			32		32	24				24				56
Sudan						16				16				16
Tunisia							22			22				22
Total North Africa	11		4 487		4 498	40	100			140				4 638
West Africa														
Ghana			540		540			2		2	78		78	620
Guinea	1 119				1 119						275		275	1 394
Ivory Coast	448				448									448
Liberia	1 255	800			2 055									2 055
Mauritania	256				256		104			104				360
Nigeria			234		234									234
Senegal	420				420									420
Sierra Leone	166			371	537									537
Togo	218				218									218
Total West Africa	3 882	800	774	371	5 827		104	2		106	353		353	6 286
Central Africa														
Angola	1 181				1 181			31	6	37				1 218
Congo	60				60									60
Gabon	520				520									520
Zaire							28			28				28
Total Central Africa	1 761				1 761		28	31	6	65				1 826
East & Southern Africa														
Mozambique								27		27				27
Namibia	135				135									135
United Republic of Tanzania								25		25				25
Southern Rhodesia	226				226									226
Swaziland	69				69									69
Zambia	6				6		9			9				15
Total East and Southern Africa	436				436		9	52		61				497
Total Developing Africa	6 090	800	5 261	371	12 522	40	241	85	6	372	353		353	11 635
Republic of South Africa	2 874		2 820		5 694			1 234		1 234				6 928
Total Africa	8 964	800	8 081	371	18 216	40	241	1 319	6	1 606	353		353	20 175

ANNEX II

Statistical Tables on Iron ore production in African countries.

Table II.1 ; Annual production of iron ore in Algeria, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore Concentrate (millions of tonnes)	3 08	2 97	2 863	3 275	3 663	3 136	3 797	3 189	2 756	3 2
Iron content (millions of tonnes)	1 626	1.565	1 524	1 699	1 978	1 7	2 064	1 728	1 49	1 734

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971 (for 1968-1970 figures)
United Nations Economic Commission for Africa (for 1971-1977 figures).

Table II.2: Annual production of iron ore in Egypt, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore concentrate (millions of tonnes)	0 447	0 460	0 451	0 473	0 427	0 64	1 302	1 121	1 243	1 2
Metal content (millions of tonnes	0 224	0 230	0 227	0 236	0 214	0 32	0 651	0 56	0 621	0.599

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971 (for 1968-1970 figures)
United Nations Economic Commission for Africa Statistical Division (for 1971-1977 figures).

Table II.3: Annual Production of iron ore in Morocco, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore concentrate (thousands of tonnes)	807	749	872	623	234	375	534	554	343	407
Fe Content (thousands of tonnes)	501	457	523	374	135	214	324	336	202	247

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1977 (for 1968-1971 figures).
United Nations Economic Commission for Africa Statistics Division (for 1972-1977 figures).

Table II.4: Annual production of pyrrhotite in Morocco, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Production (in tonnes)	-	391 529	291 041	440 549	430 006	215 341	323 521	203 789	76 242	
Local sales (in tonnes)	-	374 169	286 574	445 116	366 909	298 114	355 685	188 305	58 147	

Source: Activités du secteur minier, Royaume du Maroc, 1976.

Table II.5: Annual production of iron ore in Tunisia, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore concentrate (thousands of tonnes)	1 015 7	945 5	773.9	935 8	891	810	795	616	485	344
Fe content (thousands of tonnes)	508	470 5	387 1	468	485	433	422	326	255	181

Source: IGS Statistical Summary of the Mineral Industry, 1967-1971.
United Nations Economic Commission for Africa, Statistics Division (for 1972 to 1977 figures).

Table II.6: Annual production of iron ore in Guinea

	1959	1960	1961	1962	1963	1964	1965	1966
Iron concentrate (tonnes)	342 000	776 000	542 000	700 000	662 000	908 000	755 000	1,600,000
Fe content (tonnes)	171 000	388 000	276 000	350 000	331 000	454 000	378 000	800,000

Sources: IGS Statistical Summary of the Mineral Industry
United Nations Economic Commission for Africa, Statistics Division.

Table II.7 Annual production of iron ore in Liberia, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore concentrate (thousands of tonnes)	19 572	22 867	22 295	24 574	22 152	25 270	25 799	22 203	22 593	17 500+
Fe content (thousands of tonnes)	13 309	15 549	15 161	16 000	12 588	14 360	14 920	13 770	14 010	10 850+

\+ Estimated

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971.
UNECA Statistical Division.

Table II.8 Annual production of iron ore in Mauritania, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore concentrate (thousands of tonnes)	8 045	8 678	9 104	8 457	9 055	10 200	11 860	8 640	9 415	8 400
Fe content (thousands of tonnes)	5 511	5 693	5 903	5 700	5 840	6 580	7 650	5 570	6 070	5 416

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971.
United Nations Economic Commission for Africa, Statistics Division.

Table II.9: Annual production of iron ore in Sierra Leone, 1968-1975

	1968	1969	1970	1971	1972	1973	1974	1975*
Iron ore concentrate (thousands of tonnes)	2 536	2 427	2 427	2 610	2 552	2 272	2 014	1 345
Fe content (thousands of tonnes)	1 521	1 456	1 456	1 566	1 531	1 515	1 269	916

*Production stopped Nov. 1975

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1977.
United Nations Economic Commission for Africa, Statistics Division.

Table II.10: Annual production of iron-ore in Angola, 1968-1975

	1968	1969	1970	1971	1972	1973	1974	1975*
Iron ore concentrate (thousands of tonnes)	3 218	5 478	6 091	6 158	4 608+	5 772+	5 120+	2 560+
Fe content (thousands) of tonnes)	2 092	3 560	3 959	4 003	2 995	3 752	3 328	1 664

*Production suspended in 1975 due to civil war.

+ Calculated using average iron to ore ratio for 1968 to 1971.

Source: IGS Statistical Summary of the Mineral Industry, 1967-1971
1977 UN Statistical Yearbook.

Table II.11: Annual production of iron ore in Southern Rhodesia, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore concentrate	Na	Na								
Fe content (thousands of tonnes)	455	325	325	325	325	352	384	384	384	384

Source : 1977 UN Statistical Yearbook.

Table II.12: Annual production of iron ore in Swaziland, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Irone ore concentrate (thousands of tonnes)	2 051	2 303	2 552	2 886	1 984	2 147	2 077	2 240	1 936	900
Fe content (thousands of tonnes)	1 291	1 451	1 608	1 818	1 270	1 374	1 314	1 417	1 229	574

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971
United Nations Economic Commission for Africa, Statistics Division.

Table II.13: Annual production of iron ore in the Republic of South Africa, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore concentrate (thousands of tonnes)	8 233	8 788	9 193	10 496	11 223	10 955	11 553	12 298	14 655	26 481
Fe content (thousands of tonnes)	4 940	5 273	5 515	6 298	6 734	6 573	6 932	7 379	8 793	15 889

Sources: IGS Statistical Summary of the Mineral Industry, 1967-1971 (for 1968-1971 figures).

Mining Statistics 1973, 1975 and 1977
Department of Mines, Republic of South Africa
(for 1972-1977 figures).

Table II.14: The role of developing African countries (including other producer countries) in iron ore production for 1975, estimated as a percentage of Africa and world production

Country/Subregion	Fe content (thousands of tonnes)	Africa		World	
		Percentage	Rank	Percentage	Rank
North Africa					
Algeria	1 728	5.024	4	0.34	21
Egypt	560	1.628	8	0.11	
Morocco	336	0.977	10	0.07	
Tunisia	326	0.947	11	0.07	
Total North Africa	2 950	8.576		0.58	
West Africa					
Guinea+					
Liberia	13 770	40.03	1	2.7	11
Mauritania	5 646	16.41	3	1.11	13
Sierra Leone++	916	2.66	7	0.18	
Total West Africa	20 332	59.11		4.0	
Central Africa					
Angola	1 664	4.84	5	0.33	22
Total Central Africa	1 664	4.84			
East & Southern Africa					
Southern Rhodesia	384	1.12	9	0.08	
Swaziland+++	1 417	4.12	6	0.28	
Total East & Southern Africa	1 801	5.24		0.35	
Total Developing Africa	26 747	77.75		5.27	
Republic of South Africa	7 648	22.24	2	1.51	12
Total Africa	34 395	99.99		6.78	
North America					
USA	49 035			9.66	4
Canada	27 609			5.44	6
Mexico	3 369			0.66	16
Total North America	80 013			15.76	

Table II.14 : The role of developing African countries(including other producer countries) in iron ore production for 1975, estimated as a percentage of Africa and world production (continuation)

Country/Subregion	Fe content (thousands of tonnes)	Africa Percentage	Africa Rank	World Percentage	World Rank
South America					
Argentina	139			0.027	
Brazil	58 431			11.51	3
Chile	6 772			1.334	13
Colombia	537			0.106	
Peru	5 067			0.998	15
Uruguay	--			—	
Venezuela	15 359			3.026	9
Total South America	86 305			17.002	
Western Europe					
Austria	1 201			0.237	25
Belgium	28			0.006	
Denmark	5			0.001	
Finland	597			0.118	
France	15 309			3.016	10
Federal Republic of Germany	1 053			0.207	27
Greece	817			0.161	29
Italy	259			0.051	
Luxembourg	673			0.133	
Norway	2 662			0.524	19
Portugal	22			0.004	
Spain	4 281			0.843	16
Sweden	19 642			3.87	8
Switzerland	--			—	
Turkey	1 300			0.256	24
United Kingdom	1 143			0.225	26
Total Western Europe	48 992			9.652	
Eastern Europe					
Bulgaria	775			0.153	
Czechoslovakia	468			0.092	
Democratic Republic of Germany	23			0.004	
Hungary	153			0.03	
Poland	376			0.074	
Romania	786			0.155	30
USSR	127 483			25.12	1
Yugoslavia	1 928			0.38	20
Total Eastern Europe	131 992			26.008	

Table II.14 : The role of developing African countries (including other producer countries) in iron ore production for 1975, estimated as a percentage of Africa and world production (continuation)

Country/Subregion	Fe content (thousands of tonnes)	Africa Percentage	Africa Rank	World Percentage	World Rank
Asia					
China	32 500			6.404	5
Democratic People's of Korea	3 760			0.741	17
Hong Kong	94			0.018	
India	26 147			5.152	7
Iran	610			0.12	
Japan	426			0.084	
Malaysia	195			0.038	
Philippines	839			0.165	
Republic of Korea	322			0.063	
Thailand	18			0.003	
Total Asia	64 911			12.788	
Oceania					
Australia	60 860			11.992	
Total Oceania	60 860			11.992	
Total World	507 468			99.982	

\+ Production stopped 1970.
++ Production stopped October 1975.
+++ Production stopped November 1977.

Source: 1977 UN Statistical Yearbook.

Table III.2: Moroccan iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore exports (thousands of tonnes)	658 0	867 696	801 294	457 [illegible]9	308 21	490 035	540 497	293 655	338 482	?
Share of production (percentage)	81.5	115.8	91.9	73.3	131.7	130.7	101.2	53	98.7	?
Value of iron ore exports (thousands of US dollars)	5.019	6.302	5 691	3.455	2.448	4 787	10 618	9 270	6 432	?
Value of total mineral exports (thousands of US dollars	144 677	151 789	154 902	150 632	188 191	243 522	1 035 035	911 823	561 929	586 464
Value of total commodity exports (thousands of US dollars)	450 163	485 103	488 020	499 069	633 552	876 600	1 706 387	1 543 027	1 262 145	?
Share of iron ore in mineral exports (percentage)	3.5	4.1	3.7	2.3	1.3	2.0	1.0	1.0	1.1	?
Share of iron ore in total commodity exports (percentage)	1.1	1.3	1.2	0.7	0.4	0.5	0.6	0.6	0.5	?

Source: UN Yearbook of International Trade Statistica, 1970-1971, 1975 and 1977.

Table III.3: Tunisian iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore exports (tonnes)	653 949	567 463	628 450	612 243	664 100	423 830	526 354	295 611	112 632	
Share production (percentage)	64.4	60.0	81.8	86.2	74.5	52.3	66.2	48.0	23.2	
Value of iron ore exports (thousands of US dollars)	3,879	3.324	3 706	5 398	4 541	3 236	5 574	4 315	1 478	
Value of total mineral (thousands of US dollars)	61 196	67 594	78 128	?	116 534	158 529	450 683	500 948	404 407	
Value of total commodity (thousands of US dollars)	157 770	165 634	182 469	215 817	310 869	385 550	914 242	856 172	788 811	
Share of iron cre in mineral exports (percentage)	6.3	4.9	4.7	?	4.0	2.0	1.2	0.9	0.3	
Share of iron ore in total commodity exports (percentage)	2.5	2.0	2.0	?	1.5	0.8	0.6	0.5	0.2	

Source: UN Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

Table III.4: Liberian iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore concentrate (thousands of tonnes)	?	20 597	23 560	21 235	22 978	25 574	25 592	18 401	19 082+	17 900+
Iron ore production (percentage)	?	90.1	105.7	86.4	1 037	101.2	99.2	8.29	84.4	102.3
Value of iron ore concentrate exports (thousands of US dollars)	118 027	137 049	150 689	160 617	182 709	196 714	262 169	293 589	337000+	?
Total mineral exports (thousands of US dollars)	127 206	146 027	156 549	166 745	189 263	246 357	292 408	312 596	?	?
Total commodity exports (thousands of US dollars)	167 505	195 946	213 733	222 374	244 009	323 789	399 757	393 935	?	?
Share of Iron ore in total mineral exports (percentage)	92.8	93.8	96.3	96.3	96.5	79.8	89.7	93.9	?	?
Share of Iron ore in total commodity exports (percentage)	70.5	69.9	70.5	72.2	74.9	60.7	65.6	74.5	?	?

Source: UN Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

Table III.5: Mauritanian iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore exports (thousands of tonnes)	7 702	8 457	9 221	8 601	8 618	10 296	11 664	8 515	9 664	?
Share of production (percentage)	96.0	97.4	101.3	101.7	95.2	100.9	98.3	98.6	102.6	?
Value of iron ore exports (thousands of US dollars)	64 067	67 700	77 390	74 766	73 345	102 845	124 294	110 690	153 883	?
Value of total mineral exports (thousands of US dollars)	64 067	67 700	77 390	78 703	77 752	133 531	163 961	120 234	163 174	?
Value of total commodity exports (thousands of US dollars)	71 758	77 798	88 849	93 895	119 205	155 318	181 490	174 313	?	?
Share of iron ore in mineral exports (percentage)	100	100	100	95.0	94.3	77.0	75.8	92.1	94.3	?
Share of iron ore in total commodity exports (percentage)	89.3	87.0	87.1	79.6	61.5	66.2	68.5	63.5	?	?

Sources: UN Yearbook of International Trade Statistics, 1970-1971, 1975,1977.
UNECA Statistics Division.

Table III.6: Sierra Leonean iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976
Iron ore exports (thousands of tonnes)	2 535	2 427	2 427	2 610	2 321	2 405	2 064	1 429	-
Share of production (percentage)	100	100	100	100	90.9	105.9	102.5	106.2	-
Value of iron-ore exports (thousands of US dollars)	12 600	11 868	12 641	13 717	13 034	13 776	14 788	14 751	-
Value of total mineral exports (thousands of US dollars)	70 936	83 762	77 890	78 181	98 978	98 842	108 106	85 132	31 792
Value of total commodity exports (thousands of US dollars)	90 874	104 598	99 822	98 482	114 801	128 565	141 390	125 473	111 393
Share of iron ore in mineral exports (percentage)	17.8	14.2	16.2	17.5	13.2	13.9	13.7	17.3	
Share of iron ore in total commodity exports (percentage)	13.9	11.3	12.7	13.9	11.4	10.7	10.5	11.8	

- No exports

Sources: Total value of mineral exports obtained from Ministry of Mines, Sierra Leone. Remaining data obtained from UN Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

Table III.7: Angolan iron-ore exports, 1968-1975

	1968	1969	1970	1971	1972	1973	1974	1975
Iron-ore exports (thousands of tonnes)	2 894	5 110	6 355	5 498	5 073	6 330	5 271	?
Share of production (percentage)	89.9	93.3	104.3	89.3	110.1	109.7	102.9	?
Value of Iron-ore exports (thousands of US dollars)	22 448	38 217	49 728	41 305	37 463	49 262	48 074	?
Value of total mineral exports (thousands of US dollars)	69 993	55 091	188 022	179 924	235 338	378 262	782 676	?
Value of total commodity exports (thousands of US dollars)	271 181	326 627	423 385	422 510	515 592	779 452	1 229 325	?
Share of iron ore in total mineral exports (percentage)	32.1	69.4	26.4	22.9	15.9	13.0	6.1	
Share of iron ore in total commodity exports (percentage)	8.3	11.7	11.7	9.8	7.3	6.3	3.9	?

Source: UN Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

Table III.8: Swaziland iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore exports (thousands of tonnes)	2 050	2 302	2 552	2 886	2 304	1 993	2 481	1 960	1 744	?
Share of production (percentage)	99.9	99.9	100	100	116	92.3	119	87.5	90	?
Value of iron ore (thousands of US dollars)	12 632	13 465	15 443	16 957	12 047	11 420	18 056	16 248	14 457	?
Value of total mineral + exports (thousands of US dollars)				25 583	18 242	21 514	26 772	29 458	13 743	32 446
Value of total commodity exports of (thousands of US dollars)	55 086	58 125	70 511	78 449	79 809	104 877	175 750	179 755	191 316	179 583
Share of iron ore in total mineral exports of (percentage)	?	?	?	66.3	66.0	53.1	67.4	55.2	45.5	?
Share of iron ore in total commodity exports (percentage)	22.9	23.2	21.9	21.6	15.1	10.9	10.3	9.0	7.6	?

\+ Approximate figures

Source: UNECA Statistics Division.

Table III.9: South African iron ore exports, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron-ore exports (thousands of tonnes)	2 426	2 439	2 975	2 659	2 816	?	?	?	?	?
Share of production (percentage)	29.5	27.8	32.4	25.3	25.1	?	?	?	?	?
Value of Iron ore (thousands of US dollars)	26 078	26 745	28 278	26 702	20 813	22 242	18 989	19 370	38 419	?

Source: Data for Republic of South Africa are approximate. They were obtained by subtracting Swaziland iron ore export tonnage and value from Customs Union of South African iron-ore export tonnage and value obtained from Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

ANNEX III

Statistical tables on iron ore exports from African countries

Table III.1: Algerian iron ore exports

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Iron ore concentrate (millions of tonnes)	3.2063	2.8278	2.015506	1.790925	2.387542	1.255168	3.082559	1.5	1.776651	1.55
Share of production (percentage)	104.1	95.2	70.4	54.7	65.2	40.0	81.2	47.0	64.5	48.4
Value	21 786	19 247	17,661	14 693	21 640	11 039	31 034	23 480	26 419	
Value of total mineral exports (thousands of US dollars)	608 211	677 841	736.554	656 640	1 081 799	1 516 479	3 763 870	3 784 405	4 588 620	
Value of total commodity exports (thousands of US dollars)	830 026	933 893	1 008 771	852 241	1 287 307	1 906 037	4.259.586	4 294 478	4 971 855	
Value of iron and steel exports (thousands of US dollars)	—	3 369	25 165	14 648	12 448	12 497	22 717	34 215	18 620	
Share of iron ore in total mineral exports (percentage)	3,58	2.84	2.40	2.24	2.00	0.73	0.82	0.62	0.58	
Share of iron ore in total commodity exports (percentage)	2.62	2.06	1.75	1.72	1.68	0.58	0.73	0.55	0.53	
Share of iron and steel exports in total commodity exports (percentage)	—	0.36	2.49	1.72	0.97	0.65	0.53	0.80	0.37	

Source: UN Yearbook of International Trade Statistics, 1970-1971, 1975 and 1977.

ANNEX IV

Statistical tables on the African production of pig-iron and ferroalloys in African countries
(in tonne)

Table IV.1: Pig-iron and ferroalloy production in Algeria, 1969-1976

1969	1970	1971	1972	1973	1974	1975	1976
172 000	409 000	333 000	394 000	358 000	293 000	399 000	413 000

Table IV.2: Pig-iron production in Egypt, 1968-1976

1968	1969	1970	1971	1972	1973	1974	1975	1976
220 000	300 000	300 000	210 000	331 000	440 000	275 000	420 000	569 000

Table IV.3: Pig-iron and ferroalloy production in Tunisia, 1968-1976

1968	1969	1970	1971	1972	1973	1974	1975	1976
128 000	131 000	125 000	98 000	143 000	158 000	145 000	148 000	103 000

Table IV.4: Pig-iron and ferroalloy production in Southern Rhodesia, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Pig-iron and ferroalloys (thousands of tonnes)	260	270	250	280	290	290	300	310	310	300

Source: 1977 United Nations Statistical Yearbook.

Table IV.5: Ferroalloy production in the Republic of South Africa

Commodity	1960 Tonnes (thousands)	1960 Value (millions)	1964 Tonnes (thousands)	1964 Value (millions)	Growth rate of Period	Growth rate of Tonnes Per annum %	Growth rate of Value Per annum %	1970 Tonnes (thousands)	1970 Value (millions)
Ferromanganese	136.6	12.1	-	-	1960-70	7.1	7.0	302.7	27.4
Ferrochrome	-	-	37.3	4.5	1964-70	16.7	17.9	123.4	18.4
Ferrosilicon	-	-	27.1	2.4	1964-70	-7.0	-7.0	14.9	1.7
Other	35.8	4.2	6.1	0.5	1960-70	-	-	15.8	13.3
Total ferroalloys	172.4	16.3	230.3	20.2	1960-70	10.9	13.8	456.8	60.8

Table IV.6: Exports of ferroalloys from the Republic of South Africa

Commodity	1960 Tonnes (thousands)	1960 Value (millions)	1964 Tonnes (thousands)	1964 Value (millions)	Growth rate of Period	Growth rate of Tonnes Per annum %	Growth rate of Value Per annum %	1970 Tonnes (thousands)	1970 Value (millions)
Ferromanganese	105.1	9.3	-	-	1960-70	7.8	7.3	213.4	19.3
Ferrochrome	-	-	28.6	3.4	1964-70	16.9	18.0	87.0	13.0
Ferrosilicon	-	-	20.7	1.8	1964-70	9.9	6.9	10.5	1.2
Other	27.5	3.3	-	-	1960-70	-	-	11.0	9.2
Total ferroalloys	132.6	12.6	176.1	15.4	1960-70	11.6	14.4	321.9	62.7

Table IV.7: Iron and steel production in the Republic of South Africa, 1968-1977

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Tonnage produced (thousands of tonnes)	4 121	4 355	4 328	4 456	4 899	4 887	5 258	5 925	6 611	

Source: 1977 United Nations Statistical Yearbook.

Table IV.8: World pig-iron and ferroalloy production, 1975
(thousands of tonnes)

Country/subregion	Fe content (thousands of tonnes)	Africa Percentage	Africa Rank	World Percentage	World Rank
North Africa					
Algeria	399	5.53	3	0.08	
Egypt	420	5.82	2	0.08	
Morocco	12	0.17	6	0.002	
Tunisia	148	2.05	5	0.03	
Total North Africa	979	13.57		0.02	
East and Southern Africa					
Southern Rhodesia	310	4.30	4	0.06	
Total developing Africa	1 289	17.87		0.26	
Republic of South Africa	5 925	82.13	1	1.21	18
Total Africa	7 214			1.47	

Table IV.8: (continued)

Country/subregion	Fe content (thousands of tonnes)	Africa Percentage	Africa Rank	World Percentage	World Rank
North America					
Canada	9 309			1.90	10
Mexico	3 082			0.63	22
USA	74 515			15.25	3
Total North America	86 906			17.78	
South America					
Argentina	1 043			0.21	
Brazil	7 308			1.50	15
Chile	417			0.08	
Colombia	293			0.06	
Peru	307			0.06	
Venezuela	535			0.11	
Total South America	9 903			2.03	
Western Europe					
Austria	3 064			0.63	22
Belgium	9 063			1.85	11
Finland	1 356			0.28	
France	18 395			3.76	6
The Federal Republic of Germany	30 330			6.21	5
Italy	11 591			2.37	8
Luxembourg	3 839			0.79	20
Netherlands	3 970			0.81	19
Norway	1 565			0.32	
Portugal	336			0.07	
Spain	7 128			1.46	16
Sweden	3 508			0.72	21
Switzerland	35			0.01	
Turkey	1 369			0.28	
United Kingdom	12 338			2.52	7
Total Western Europe	107 942			22.08	

Table IV.8: (continued)

Country/subregion	Fe content (thousands of tonnes	Africa Percentage	Africa Rank	World Percentage	World Rank
Eastern Europe					
Bulgaria	1 560			0.32	
Czechoslovakia	9 413			1.93	9
German Democratic Republic	2 442			0.50	24
Hungary	2 223			0.45	
Poland	7 926			1.62	13
Romania	6 602			1.35	17
USSR	102 968			21.07	1
Yugoslavia	2 196			0.45	
Total Eastern Europe	135 330			27.69	
Asia					
China	32 000			6.55	4
Democratic People's Republic of Korea	2 900			0.59	23
India	8 558			1.75	12
Japan	89 016			18.22	2
Republic of Korea	1 188			0.24	
Thailand	12			0.002	
Total Asia	133 674			27.36	
Oceania					
Australia	7 598			1.55	
Total Oceania	7 598			1.55	
Total World	488 600			99.99	

ANNEX V

Contribution of mining and quarrying in GDP

Table V.1: Liberia GDP at constant (1971) factor cost, 1970-1976 (millions of US dollars)

	1970	1971	1972	1973	1974	1975	1976
Total GDP	324.7	342.5	354.0	343.4	356.6	343.5	354.3
Mining and quarrying	-	-	-	130.5	134.0	116.2	107.6
Iron-ore mining	109.3	113.7	117.6	118.2	125.0	110.3	103.1
Non-iron-ore mining and quarrying	-	-	-	12.3	9.0	5.9	4.5
Share of iron ore in GDP (percentage)	33.66	33.2	32.2	34.4	35.1	32.1	29.1

Source: Ministry of Planning and Economic Affairs.

Table V.2: Liberia GDP at current prices (1978)

	1970	1971	1972	1973	1974	1975	1976
Total GDP	321.5	341.1	373.0	375.2	459.1	599.1	560.8
Mining and quarrying	115.7	124.8	142.1	129.8	159.0	231.8	184.4
Iron-oreemining	104.7	113.7	129.7	110.9	147.5	224.7	178.0
Non-iron-ore mining and quarrying	11.0	11.1	12.4	18.9 ,	11.5	7.1	6.4

+: Due to major changes in computation methods the years 1970-1972 and 1973/1976 are not comparable.

Source: Ministry of Planning and Economic Affairs.