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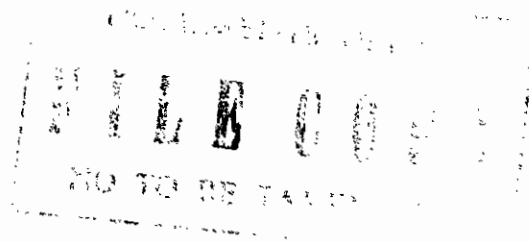
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MINERAL RAW MATERIALS IN AFRICA

TITANIUM

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TITANIUM RESOURCES IN AFRICA

1. Background

Titanium is obtained commercially from two titanium-bearing mineral ores, namely, rutile (TiO_2) and ilmenite ($Fe TiO_2$). The ores of these minerals occur as placer or rock deposits. Placer deposits are located almost always at or near the coast, in which rutile and ilmenite very often occur together, although in certain cases they may be separate. In rock deposits ilmenite is the principal titanium ore-forming mineral with rutile occurring only as an accessory.

The bulk of the titanium produced in the world is obtained from placer deposits with only a small proportion coming from rock sources. In fact there are only four mining operations in the world involving the exploitation of titanium rock deposits^{1/}. These are Allard Lake in Canada; Tahawms in USA; Tellnes in Norway; and Otanmaki in Finland.

The titanium resources of Africa occur as placer deposits in certain areas along the coast of the continent as beach or coastal dune sands and as alluvial deposits in river beds inland and also as ilmenite in titanomagnetite accumulations in magmatic intrusive ultra-basic rocks.^{2/}

Titanium is mainly used as a pigment and in the making of titanium sponge, welding rod coatings and carbides and in ceramic and glass formulations (see section 8b).

2. North Africa

Titanium resources in North Africa have a limited distribution and many of the occurrences are too small to be of economic value except in Egypt where in fact there was some exploitation for ilmenite from the beach sand deposits of Rosetta and Damietta in the Nile Delta during 1932 and 1955, but have since ceased production.

In Morocco, another north African country, titanium mineralization is found in beach sands as ilmenite at Azemmour, Mogador and Agadir^{3/}. These occurrences are, however, too small to be of economic value.

1/ 'Titanium' - MCP-18 Mineral commodity profiles: United States Bureau of Mines, August 1978.

2/ 'Titanium' - The Mineral Resources of Africa by Nicolas de Kun 1965, p. 508-510.

3/ 'Titane' - Notes et mémoires No. 87 Géologie des gîtes minéraux marocains 1952, p. 236.

In the Sudan, indices of titanium mineralization occurring as ilmenite in beach sands are also found in the Dirbat area^{4/}.

3. West Africa

All the West African countries possess some economic potential of titanium resources which occur either as ilmenite or rutile or both in beach sands in many places along the Atlantic Coast, especially in the countries lying between and including Mauritania in the north and the Ivory Coast in the south-east.

(a) Gambia

In Gambia, a belt 15 km-long and 200-m wide beginning from Banjul southwards has been shown to consist of considerable amounts of mineral beach sands. Investigations by the geological organization of the country have so far delineated resources amounting to 100,000 contained heavies of mainly ilmenite, rutile and zircon. More investigations are currently continuing to delineate more resources.

(b) Guinea

At Bokè, Coyah and Conakry, along the Atlantic Coast in Guinea there are potential resources of mineral beach sands containing ilmenite, rutile and zircon^{5/}. Very little detailed work has however been carried out on the resources to determine their economic potential.

(c) Guinea Bissau

In the Varela area along the Atlantic Coast in Guinea Bissau there exist mineral beach sands accumulations containing ilmenite, rutile and zircon^{6/}. However no detailed work has been carried out on the resources to determine their economic potential.

(d) Ivory Coast

Titanium mineralization in the Ivory Coast is widely distributed mainly in mineral beach sands along the Atlantic Coast and in river alluvial deposits

^{4/} 'Titanium' - The Geology of the Sudan Republic by A.J. Whiteman, 1971, p. 248.

^{5/} Commission Economique des Nations Unies pour l'Afrique: Rapport de mission effectuée en Angola, Guinée-Bissau et Guinée dans le Cadre de la préparation de la première conférence régionale sur mise en valeur et l'utilisation des ressources minérales en Afrique, Février - Mars 1979.

^{6/} Ibid.

inland^{7/}. All the occurrences appear to have been derived from igneous intrusive rocks. Several localities in-land with significant titanium mineralizations have been found mainly as ilmenite in the river alluvia. For instance at Daloa grades of 70 per cent ilmenite contained in heavy minerals have been found. At Torogue, grades of 10 kg/m³ of ilmenite have been indicated. At Cruiglo, ilmenite grades of 35 to 80 per cent of the heavies, accompanied by zircon, monazite and rutile have also been found. In the flats of Toulèpleu grades of 1.5 per cent ilmenite have been found in the alluvials and potential resources at Toulèpleu estimated at 3,300 tons contained ilmenite.

Regarding beach mineral sands three important areas in the Ivory Coast have been delineated. These are Tabon where grades of 3 to 4 per cent and sometimes rising to 10 per cent ilmenite have been recorded. Potential resources are estimated at 116,000 tons of ilmenite containing ore. The mineralization is accompanied by zircon and monazite. At Sassandra unestimated resources grading 1.5 per cent of ilmenite are known to exist and at Addah and Grand Lahou potential resources are estimated at 200,000 tons of contained ilmenite. The mineralization also carries rutile, monazite and gold.

(e) Liberia

In Liberia, large deposits of beach mineral sands containing ilmenite, rutile and zircon exist along the Atlantic Coast especially near Greenville. One company, the Liberia Beach Sands Exploitation Company which has been involved in exploration work on beach sands for a number of years at Greenville has been hampered in its efforts to develop the resources because the area lacks a developed infrastructure and the company has yet to secure markets for the products^{8/}.

(f) Mauritania

A large potential of ilmenite mineralization exists in the beach and dune sands in Mauritania, especially those located in the Cape Timiris area where potential resources are estimated at 200,000 tons of contained ilmenite^{9/}. Other areas of interest are Arguin Island, El Mahara, Lensid and Gendert^{10/}.

^{7/} 'Ilmenite' - Atlas des indices minéraux de la Côte d'Ivoire, Société pour le développement minier de la Côte d'Ivoire (Sodemi), Secrétariat d'Etat chargé des Mines, décembre 1975, p. 25.

^{8/} 'Liberia Beach Sands Exploitation Company' - Ministry of Lands and Mines Annual Report 1977, Republic of Liberia, p. 40 - 41.

^{9/} La minéralisation d'ilmenite côtière - Mise a jour des possibilités minières de la République Islamique de Mauritanie: Société Nationale Industrielle et Minière (Suim) 1973, p. 277-281.

^{10/} 'Titanium' - The Mineral Resources of Africa op.cit.

(g) Nigeria

In Nigeria indices of ilmenite and rutile occur in a number of alluvial deposits in river-beds inland and in beach sand deposits along the Atlantic Coast. But none of the known occurrences has been investigated in detail to determine their economic potential.

(h) Senegal

There are four areas along the Atlantic Coast in Senegal with beach mineral sand accumulations of economic importance. These are from south to north Casamance, at the mouth of river Saloum, Rufisque and Kayar-Lompoun lying in between Dakar and St. Louis^{11/12/}. Although data regarding potential resources at Casamance, Saloum and Rufisque are not available, they are presumed to be considerably large. However, potential resources at Kayar-Lompoun are estimated to be 10 million tons of contained ilmenite, rutile and zircon combined.

Exploitation of beach sands in Senegal has taken place intermittently at Rufisque and Casamance where mining for beach sands began respectively in 1912 and in 1923 and ceased sometime during the 1920s. At Saloum, reports indicate that mining of beach sands by Societe Gaziello ceased in 1965 as a result of exhaustion of reserves and difficulties of securing markets^{13/}. Production by Societe Gaziello of ilmenite, rutile and zircon combined averaged about 25 tons of concentrates annually.

(i) Sierra Leone

Sierra Leone is richly endowed in titanium mineralization which occurs mainly as rutile in the old drainage courses running over hypersthene gneisses which contain rutile. The material derived from the rutile-bearing hypersthene gneisses was carried by water differentially and re-deposited in certain places along the courses of the streams where rutile placers grading 1 to 10 per cent rutile now occur^{14/}. The rutile is now found mostly in lateritic encrustations along the old

^{11/} 'Senegal' (Republique de) - Les ressources minerales de l'Afrique, par Raymond Furon, 1961, p. 237-238.

^{12/} 'Ilmenite et Zircon' - Ministère des travaux publics de l'habitat et de l'urbanisme, Service des Mines et de la géologie, République du Senegal; Bureau de recherches géologiques et minières (BRGM) 1962, p. 25.

^{13/} 'Minerais de titane et de zirconium' - United Nations Economic Commission for Africa unpublished report entitled Ressources minerales du Senegal par N.M. Shukri, Octobre 1965, p. 11-12.

^{14/} 'Rutile' - Mineral Resources of Sierra Leone, Ministry of Mines and Lands, June 1976, p. 3.

river courses and because of this mode of occurrence technical difficulties have arisen in the exploitation of these deposits.

The main rutile resources in Sierra Leone are found at Gbangbama in the Moyamba district where reserves amounting to 110 million tons with a rutile content of 1.8 per cent have been delineated^{15/}. Other rutile resources exist in the old drainage courses at Rotifunk and have been investigated by Bayer-Peussag Mining Group of West Germany^{16/} and also in the beach sands found along the coast in the south-western part of the country towards the Liberian border.

The property at Gbangbama was originally owned and operated by Sherbro Minerals Ltd. The company was a creation of British Titan Products Co. Ltd. and Pittsburgh Glass Co. of the USA who respectively owned 20 per cent and 80 per cent of the equity. Production of rutile at Gbangbama began in 1967 but for technical reasons Sherbro Minerals ceased operations in 1971. Production for the period 1967 to 1971 was as follows:

	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
Tons	25 142	13 390	28 403	44 058	11 933

Sources: Mineral Resources of Sierra Leone, Ministry of Mines and Lands, June 1976.

In 1976 Sierra Rutile Ltd. took over the Gbangbama property and after intensive studies regarding the extraction and concentration of rutile from the lateritised rutile-bearing alluvial deposits the company began production in mid-1979. Production is expected to reach 100,000 tons of rutile concentrate grading 95-96 per cent TiO_2 annually when operations attain designed capacity during the 1980s.

The operations at Gbangbama involve ^{17/}mining by a bucket down operating at 1100 tons per hour and concentration of the ore in scrubbers and screens, followed by gravity separation and electrostatic and electromagnetic separation. Then the material which is at this stage about 50 per cent TiO_2 is further up-graded by tabling and drying to obtain a product grading 95-96 per cent TiO_2 . All production is exported.

^{15/} 'Sierra Rutile Products' - Mining Journal Vol. 292, No. 7503, 8 June 1979, p. 445.

^{16/} 'Rutile' - Mineral Resources of Sierra Leone ... op.cit.

^{17/} 'Sierra Leone: Rutile production begins' - Industrial Minerals No. 142, July 1979, p. 14.

Sierra Rutile Ltd. is owned 85 per cent by subsidiaries of Bethlehem Steel Corporation and 15 per cent by Nord Resources Corporation of Canada. Sierra Rutile Ltd. has an agreement with the Government of Sierra Leone for it to pay the Government royalty of \$US 4 per ton produced together with 50 per cent of the profits made^{18/}.

(j) Upper Volta

At Tin Edia, Gomba, Gountouala, Pwiga and Kolel lying to the north-east of and about 250 km from Ouagadougou there exist titanium resources occurring as ilmenite in titanio-vanadium - magnetites bands associated with magmatic intrusive rocks^{19/}. Potential resources are estimated at about 50 million tons grading on average 40 to 55 per cent Fe, 3 to 13 per cent SiO₂, 3 to 14 per cent TiO₂, 2 per cent MgO, 3 to 6 per cent Al₂O₃, 0.5 to 1.15 per cent V₂O₅. Because these resources are remotely located from the coast and because of an absence of a developed infrastructure they have received minimal attention.

4. Central Africa

Potentially economic titanium resources in Central Africa have only been found in the United Republic of Cameroon. The resources are found as rutile and ilmenite in beach sands along the Atlantic Coast near the Nigerian border at Nkambe, Mbalmayo and Akonolinga^{20/},

Between 1935 and 1957 there was some exploitation for ilmenite and rutile and in 1944 reports indicate that 3,300 tons of rutile and ilmenite concentrates were produced. Production ceased in 1957 due to exhaustion of the most accessible reserves.

Other potential ilmenite and rutile resources existing at Kribi and Duala were investigated by Bureau de Recherches Géologiques et Minières (BRGM) in 1964. Resources at Kribi are estimated at 140,000 tons grading 5 per cent ilmenite and at Duala 330,000 tons grading 4.6 per cent ilmenite. None of these resources have been exploited to date.

^{18/} 'Rutile: Sierra Leone' - African Research Bulletin, Vol. 16, No. 2, 31 March 1979, p. 5032.

^{19/} Les gîtes de magnetite vanadifères d'Oursi - Le potentiel minier de la République de Haute-Volta: Direction de la Géologie et des Mines, 1973, p. 5-6 and 1975, p. 40-41.

^{20/} 'Rutile and Ilmenite' - Rohstoffwirtschaftliche Länderberichte, IX, Gabun, Vr Kongo und Kamerun: Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, April 1976, p. 65.

5. East and Southern Africa

Titanium resources are widely distributed in the countries of East and Southern Africa, especially in Tanzania and Mozambique where both placer and rock deposits occur in large quantities.

(a) Ethiopia

In Ethiopia only indices of titanium mineralization exist ^{21/}. They occur as alluvial ilmenite and rutile accumulations at Carrara along River Fafan and at Chiri near Dire Dawa in Harrar Province. In Sidamo Province alluvial ilmenite and rutile accumulations exist near Urdicha in the Dawa Valley. In Wollega in the alluvia of a number of rivers in the Gambela - Dambidollo area ilmenite and rutile accumulations have also been found but no detailed investigations have been carried out on any of these titanium occurrences to determine their economic potential.

(b) Kenya

In Kenya, titanium indices are widely distributed throughout the Basement System occurring as sporadic crystals and aggregates of ilmenite in pegmatites ^{22/}. But the mineralization in the pegmatites is distributed too sparsely and erratically to be of any economic value. Further detailed investigations of the alluvia along a number of rivers inland and at the river mouths along the Indian Ocean Coast have so far revealed only uneconomic accumulations of ilmenite accompanied by some rutile and zircon.

(c) Madagascar

In Madagascar, large unexplored titanium resources occurring as ilmenite in beach sands are found along the coast between Foulpointe and Pointe Larre ^{23/} in the north-east of the Island and also along the south-western coastline near Marombe ^{24/}.

Reports indicate that a company called Montedison carried out exploration work over the ilmenite resources situated at Tanatave in the 1970s and put up a

^{21/} 'Titanium' - Mineral Occurrences in Ethiopia by Danito A. Jelene, 1966, p. 416-422.

^{22/} 'Titanium Ores' - The Geology and Mineral Resources of Kenya, Geological Survey of Kenya, Bulletin No. 9, 1967, p. 30.

^{23/} 'Titanium' - The Mineral Resources of Africa ... op. cit.

^{24/} 'Minéralisations des plages' - Annales Géologiques de Madagascar, Fascicule No. XXXV, 1 Les Terrains Sédimentaires, 1972, p. 429-430.

pilot plant at Tamatave which began functioning in 1976^{25/}. However no data is available as to whether or not the Tamatave experiment has developed into a full-production operation.

(d) Malawi

In Malawi, titanium resources occurring as residual concentrations of ilmenite and rutile accompanied by garnet and magnetite exist at Tengani in Nsanje District^{26/}. Reserves are presumed to be very large and grades of 0.05 to 3.48 per cent TiO₂ have been reported. Other resources are found as beach sands at Monkey Bay along Lake Nyasa. Reserves amounting to one million tonnes and grading 20.5 to 46.1 per cent ilmenite have been delineated. But because Malawi is land-locked with undeveloped energy resources and has no industrial base, the known titanium resources in the country have to date remained unexploited.

(e) Mozambique

In Mozambique, titanium mineralization is widely distributed. The mineralization occurs as placer or rock or vein deposits^{27/}. In the Tete district the titanium mineralizations occur as rutile in quartz veins and pegmatites and in the alluvia of rivers draining the areas where the quartz veins and pegmatite occur. Other important titanium resources in Mozambique occur as ilmenite in the titanono-vanadiferrous magnetite bands associated with magmatic ultra-basic gabbroic intrusives. In many localities in the Tete district this type of mineralization is found. Also other important ilmenite accumulations are found in the sand dunes of the coastal areas and in the beach sands along the coast.

The data regarding tonnage of potential titanium resources in the titanono-vanadiferrous magnetite is now available but is presumed to be very large. Regarding the resources in the dune sands in the coastal areas, only those located at Moebane have been investigated in some detail. They are reported to be 2 million tons of contained heavies grading on average 70 per cent ilmenite 2 per cent rutile, 13 per cent zircon, 5 per cent monazite and 2 per cent other minerals.

Regarding the beach sand deposits, those located in the Pebane region are the most important and grades of 70-85 per cent of contained heavies have been recorded.

^{25/} 'Madagascar: Mines' - EUROPE-OUTRE-MER REVUE ANNUELLE 1979, p. 143.

^{26/} 'Titanium minerals' - Bulletin No. 6: The Geology and Mineral Resources of Malawi, Geological Survey Department, Malawi, 1973, p. 51-52.

^{27/} 'Titano' - Mozambique: Direcçao dos servicos de Geologia e Minas, Carta de Jazigos e Occorrencias Mineraiis, 1974, p. 27-28.

(f) Somalia

In Somalia, the only known occurrence of titanium mineralization of interest is found in the delta area of the Juba (or Giuba) river. The concentrates obtained from the sand from this area have been found to grade about 15 per cent TiO_2 ^{28/}. However, no systematic work has been done on these resources to determine their economic potential.

(g) Tanzania

In the United Republic of Tanzania, titanium mineralization occurs mainly as ilmenite in the massive titano-vanadiferous magnetite mineralization bands associated with intrusive magmatic ultra-basic rocks. Examples of this type of titanium mineralization are the Liganga magnetite deposits and those located to the north-west of Liganga through Upangwa and Ukinga^{29/}. Ore reserves at Liganga are estimated to be 49 million tons grading on average 50 per cent Fe, 1.3 per cent SiO_2 , 13 per cent TiO_2 and 0.23 per cent V_2O_5 ^{30/}.

The second type of titanium mineralization in Tanzania consists of rutile occurring as small masses inter-grown with quartz in quartz reefs. Such types of mineral occurrences are found in the Milembule area, Ufipa district.

The third mode of titanium mineralization in the United Republic of Tanzania occurs as beach sands along the coast. Grades of 55 per cent ilmenite and from 5 to 15 per cent rutile have been reported south of Bangamoyo, Kunduchi and Mbweni near Dar es Salaam.

Regarding the possibility of exploiting Tanzanian titanium resources, the Liganga deposits are under investigation and may form a basis for the establishment of an iron and steel industry in Tanzania as well as a source of titanium and vanadium. The Milembule quartz reefs are too small and remotely located to be of any economic value at present. And as regards the beach sands, no systematic work has been carried out to determine their economic potential.

^{28/} 'Titanium' - The Mineral Resources of Africa op. cit.

^{29/} 'Titanium minerals' - Memoir No. I: Summary of the Geology of Tanganyika, Part IV: Economic Geology, Geological Survey of Tanganyika, 1961, p. 139.

^{30/} Development of the Iron and Steel Industry in Tanzania 1975-1995 by D. Williams November 1973 (Unpublished report of the Tanzania Government).

6. South Africa

South Africa is by far the biggest producer of titanium minerals as well as the metal and titanium products on the continent of Africa and ranks first in identified titanium resources in Africa. The largest resources occur as beach sands along the eastern and western coastlines^{31/}. On the eastern coast in an area stretching from Richards Bay to Durban, a distance of about 180 km. and further southwards to East London, a distance of about 600 km. from Durban, large resources of titanium are known to exist as rutile and ilmenite in beach sands. Less important titanium resources are found on the western coast in the beach sands in the Vanrhynsdorp district 250 km. north of Cape Town.

During the 1950s the exploitation of the beach sands at Umgababa about 40 km. south of Durban began and this operation remained the only relatively large-scale undertaking in the country until the Richards Bay Minerals project came on stream in July 1977. At Umgababa, ilmenite, rutile and zircon are produced by mining the beach sands using dredges. Processing involves gravitational concentrating and magnetic and electrostatic separations to obtain high grade concentrates of ilmenite, rutile and zircon.

At Richards Bay, the operations are carried out by two companies. These are Tisand (Pty) Ltd. which carries out the extraction and initial beneficiations, and Quebec Iron and Titanium Corporation (QIT) which undertakes the smelting and final metallurgical operations^{32/33/}.

Mining is carried out by two dredges operating from a pond. Also in the pond and on floating pontoons is the concentrator. The heavy mineral concentrates are pumped to an on-shore stockpile. At this stage the concentrates grade about 90 per cent of heavy minerals.

From the stockpile the concentrates are carried in trucks to a permanent concentrator site (the dry mill). Here by using low intensity drum magnets the magnetite is removed. Then by using high intensity wet magnetic separators, ilmenite is removed and by using electrostatic separators, rutile is removed from this non-magnetic fraction. What remains now is mainly zircon and by using high tension roll separators followed by high intensity dry magnets a very pure zircon concentrate is obtained.

^{31/} 'Titanium' - The Mineral Resources of Africa ... op. cit.

^{32/} Beach Sand Project for South Africa - Mining Magazine, November 1976, p. 425-433.

^{33/} Production builds up at Richards Bay Minerals Project - South Africa Mining and Engineering Journal, October 1977, Vol. 88, No. 4133, p. 27-377.

The ilmenite obtained is smelted into high titania slag and low manganese pig iron. The smelting is carried out in open arc electric furnaces using anthracite brought in by rail from Natal. The ilmenite is reduced to metallic iron and titania slag, each of which is tapped off at regular intervals. The slag contains 85 per cent TiO_2 .

The rutile (95 per cent TiO_2) and the titania slag are exported mainly to the pigment industry consumers and to the manufacturers of welding, electrode-coating equipment and fluxes mainly in the USA and Europe. The zircon is also mainly exported to steel producers as a moulding sand and as a raw material in refractory brick manufacturing. The pig iron produced is also mostly exported.

7. World Titanium Reserves and Resources

World titanium reserves and total identified resources contained in rutile are estimated at 72.65 and 165.35 million tons respectively (see table 1)^{34/}. Africa accounts for about 4 per cent of world titanium reserves and 11 per cent of world total identified resources contained in rutile.

The world titanium reserves and total identified titanium resources contained in ilmenite are estimated at 164.2 and 537.1 million tons respectively (see table 2)^{35/}. Africa accounts for about 6 per cent world titanium reserves and total identified resources contained in ilmenite.

When the titanium contained in rutile and ilmenite is considered together, (see table 3) it is found that Africa's share in world titanium reserves and total identified resources are respectively about 5 per cent and 23 per cent and of these South Africa alone accounts for 80 per cent of titanium reserves and 71 per cent of total identified titanium resources. The other African countries with significant titanium resources by world standards are and in percentage world share, Sierra Leone 2.3 per cent, Mozambique 1.8 per cent and Egypt 1.3 per cent.

The top ten countries in the world in titanium reserves are in descending order and percentage share of the world, Brazil 23.4 per cent, Canada 18.8 per cent, India 16.4 per cent, Norway 15.3 per cent, Australia 8.5 per cent, USA 7.5 per cent, South Africa 4.4 per cent, USSR 2.1 per cent, Finland 1.4 per cent, and Italy 1.0 per cent. When total identified titanium resources are considered it is noted that the top ten countries are and in percentage share of the world, India 19.6 per cent, South Africa 16.6 per cent, Brazil 15.9 per cent, USA 12.7 per cent,

^{34/} 'Titanium' - MCP - 18 Mineral Commodity Profiles - op. cit.

^{35/} Ibid.

Canada 11.1 per cent, Norway 5.0 per cent, Australia 4.5 per cent, USSR 3.0 per cent, Sierra Leone 2.3 per cent and Mozambique 1.8 per cent. It is significant to note here that although Africa has total identified titanium resources amounting to 164.0 million tons, only about 8 per cent are considered as reserves. While in North America, South America, Europe, Asia and Oceania the share of reserves to total identified resources are higher which are respectively 36 per cent, 48 per cent, 65 per cent, 28 per cent and 53 per cent, indicating that in these countries the level of the development of their titanium resources is much higher than is the case in Africa.

Table 1:

Estimate of Identified World Rutile Resources
(In thousand tons of contained titanium)

	Reserves	Other identified resources	Total identified resources
AFRICA			
Botswana	-	1 000	1 000
Namibia	-	(1) ^{2/}	(1) ^{2/}
Senegal	-	90	90
Sierra Leone	1 630	14 510	16 140
South Africa	1 270	270	1 540
TOTAL AFRICA	2 900	15 860	18 760
NORTH AMERICA			
Canada	-	180	180
Mexico	-	2 630	2 630
USA	1 360	1 630 ^{1/}	2 990
TOTAL NORTH AMERICA	1 360	4 440	5 800
SOUTH AMERICA			
Brazil	54 430	54 430	108 860
Uruguay	-	(1) ^{2/}	(1) ^{2/}
TOTAL SOUTH AMERICA	54 430	54 430	108 860
EUROPE			
Italy	2 450	4 000	6 450
USSR	1 450	1 360	2 810
TOTAL EUROPE	3 900	5 360	9 260
ASIA			
India	4 350	10 800	15 150
Sri Lanka	180	90	270
TOTAL ASIA	4 530	10 890	15 420
OCEANIA			
Australia	5 530	1 450	6 980
WORLD TOTAL	72 650	82 700	155 350

1/ Mainly anatase deposits

2/ Less than 50,000 tons

Source : Titanium: CP - 10, Mineral Commodity Profiles, United States Bureau of Mines, August 1970.

Table 2:

Estimate of Identified World Ilmenite Resources
(In thousand tons of contained titanium)

	Reserves	Other identified resources	Total identified resources
AFRICA			
Egypt	10	3 150	3 070
Mozambique	-	11 700	11 700
Senegal	-	1 310	1 310
Tanzania	-	3 630	3 630
Upper Volta	-	3 630	3 630
South Africa	9 070	105 150	115 220
Others	-	210	210
TOTAL AFRICA	9 980	135 970	146 060
NORTH AMERICA			
Canada	44 450	33 570	78 020
Costa Rica	-	10	10
USA	16 330	6 360 ^{1/}	22 690
TOTAL NORTH AMERICA	60 780	104 340	165 120
SOUTH AMERICA			
Argentina	-	510	510
Brazil	110	1 620	2 730
Uruguay	-	1 320	1 320
TOTAL SOUTH AMERICA	110	4 450	5 460
EUROPE			
Finland	2 730	10	3 630
Norway	35 210	4 540	40 830
USSR	2 630	14 510	17 140
TOTAL EUROPE	40 570	19 160	62 600
ASIA			
India	34 470	88 000	122 470
Indonesia	-	910	910
Malaysia	-	910	910
Sri Lanka	10	10	1 020
Others	-	10	10
TOTAL ASIA	34 480	99 020	127 020
OCEANIA			
Australia	14 510	10 000	24 450
New Zealand	-	6 350	6 350
TOTAL OCEANIA	14 510	16 350	30 860
WORLD TOTAL	164 200	372 500	537 100

^{1/} Includes perovskite deposits in Colorado.

Source: ICP - 17, Mineral Commodity Profiles; United States Bureau of Mines, August 1970.

Table 3:

Estimates of Identified World Ilmenite
and Rutile Resources

(In thousands tons contained titanium)

	Reserves	Other identified resources	Total identified resources	World reserves Percentage Rank	World identified resources Percentage Rank
AFRICA					
Egypt	910	8 160	9 070	0.38	1.29 11
Mozambique	-	12 000	12 000		1.83 10
Senegal	-	1 900	1 900		0.27
Sierra Leone	1 630	14 510	16 140	0.69	2.3 9
South Africa	10 340	106 420	116 760	4.36 7	16.62 2
Tanzania	-	3 630	3 630		0.52
Upper Volta	-	3 630	3 630		0.52
Others	-	910	910		0.13
TOTAL	12 800	152 040	164 820	5.44	23.40
NORTH AMERICA					
Canada	44 450	33 750	78 200	18.77 2	11.13 5
Costa Rica	-	910	910		0.13
Mexico	-	2 630	2 630		0.37
USA	17 630	71 490	89 130	7.47 6	12.69 4
TOTAL	62 140	108 700	170 820	26.24	24.33
SOUTH AMERICA					
Argentina	-	910	910		0.13
Brazil	55 340	56 250	111 530	23.36 1	15.00 3
Uruguay	-	1 820	1 820		0.26
TOTAL	55 340	58 900	114 320	23.36	16.27
EUROPE					
Finland	2 720	910	3 630	1.45 9	0.52
Italy	2 450	4 000	6 450	1.03 10	0.93 12
Norway	36 290	4 540	40 830	15.32 4	5.91 6
USSR	5 000	15 570	20 550	2.14 8	2.98 8
TOTAL	46 540	25 400	71 940	19.05	10.24
ASIA					
India	38 020	98 890	137 710	16.39 3	19.6 1
Indonesia	-	910	910		0.13
Malaysia	-	910	910		0.13
Sri Lanka	1 090	1 000	2 090	0.46	0.3
Others	-	910	910		0.13
TOTAL	39 910	102 620	142 530	16.35	20.29
OCEANIA					
Australia	20 040	11 430	31 470	2.46 5	4.42 7
New Zealand	-	6 350	6 350		0.9 13
TOTAL	20 040	17 780	37 820	8.46	5.30
WORLD TOTAL	236 050	465 600	702 450		

Source: From tables 1 & 2.

8. World titanium production, consumption and utilization

(a) Production

Despite the fact that Africa possesses about 23 per cent of the world's identified titanium resources (see table 3) its contribution to world titanium production is very insignificant with production confined to only two countries at present, namely South Africa and Sierra Leone. However, there is hope that when South Africa's Richards Bay Mineral Project and Sierra Leone's Sierra Rutile Project located at Gbangbama attain full production capacity, Africa's titanium production will become important in the world.

Australia is by far the biggest producer of titanium from primary sources contributing about 35 per cent to world production (see table 4). It is followed in percentage share by Canada 19.1 per cent, Norway 14.2 per cent, USA 13.6 per cent, USSR 7.8 per cent, India 3.3 per cent, Malaysia 3.2 per cent, Sri Lanka 1.4 per cent and Brazil 0.2 per cent. It is significant to note that the biggest producers are the developed countries followed by the more developed of the developing countries, namely India, Malaysia, Sri Lanka and Brazil which between them possess about 36 per cent of the world's identified titanium resources.

Table 4: Estimated world titanium capacity and production, 1977 (thousand tons of titanium content)

	Ilmenite		Rutile		Rutile, Synthetic		Sponge		Pigment	
	Capacity	Production	Capacity	Production	Capacity	Production	Capacity	Production	Capacity	Production
Africa:										
South Africa	-	-	-	-	-	-	-	-	13	n.a.
Sierra Leone	-	-	-	-	-	-	-	-	-	-
Egypt	-	-	-	-	-	-	-	-	-	-
Total:	-	-	-	-	-	-	-	-	13	n.a.
North America:										
United States	390	214	11	n.a.	54	33	19	13	544	363
Canada	475	302	-	-	-	-	-	-	38	n.a.
Mexico	-	-	-	-	-	-	-	-	21	n.a.
Total:	866	516	11	n.a.	54	33	19	13	603	n.a.
South America:										
Brazil	5	4	(¹ / ₂)	(¹ / ₂)	-	-	-	-	10	n.a.
Europe:										
France	-	-	-	-	-	-	-	-	105	n.a.
Germany (West)	-	-	-	-	-	-	-	-	174	n.a.
Norway	254	223	-	-	-	-	-	-	12	n.a.
United Kingdom	-	-	-	-	-	-	4	2	150	n.a.
USSR	112	108	18	15	-	-	38	35	27	n.a.
Other	46	33	-	-	-	-	-	-	269	n.a.
Total:	412	364	18	15	-	-	42	37	737	n.a.
Asia:										
India	72	48	5	4	15	9	-	-	15	n.a.
Japan	2	1	-	-	29	10	10	6	130	93
Malaysia	60	50	-	-	9	2	-	-	-	-
Sri Lanka	41	21	2	1	-	-	-	-	-	-
Other	-	-	-	-	15	9	-	-	5	n.a.
Total:	183	120	7	5	60	30	10	6	150	n.a.
Oceania:										
Australia	490	363	372	187	24	22	-	-	33	n.a.
World Total:	1 956	1 367	400	207	146	93	71	56	1 554	

- No or insignificant production.

1/ Less than $\frac{1}{2}$ unit.

Source: MCP-18 Mineral Commodity Profiles: Titanium; United States Bureau of Mines, August 1978, p. 2.

(5) Consumption and utilization

As observed earlier in section one, the principal use of titanium is as pigment which accounts for about 95 per cent of titanium production. The titanium dioxide finds use in paints, varnishes and lacquers. It is estimated that about 52 per cent of the titanium dioxide pigment is used for these applications annually.

The second important area where titanium dioxide pigment finds use is in paper coatings and as paper fillers accounting for about 21 per cent of the annual dioxide pigment production.

The third area where titanium pigment is used is in the plastics industry in the manufacture of polyethylene, polyvinyl chloride, polystyrene and polyolefin-type plastics.

Other applications of titanium pigment and other titanium compounds are in rubber tyres, floor coverings, printing ink, etc. and in welding-rod coatings, glass fibres, ceramic capacitors and in carbide cutting tools containing 8 to 35 per cent titanium carbide with or without tungsten carbide in a matrix of molybdenum, nickel or cobalt.

As a metal, titanium is used in the manufacture of specialty alloys which find important applications in aerospace industries, electro-chemical processing, in power plants and other industries.

Data on titanium consumption by country are not readily available. However, since titanium-consuming industries require a high level of technological development and are generally found in developed countries, the highest consumption of titanium is therefore to be expected in those developed countries. Africa's consumption of titanium with the exception of South Africa is thus minimal, appearing only in imported titanium-bearing goods and equipment and machinery.