5.0 World Deposits

5.1 IMPORTANT COUNTRIES

Iron ore deposits are distributed in different regions of the world under varied geological conditions. They occur in basins of sedimentation, with eroded, deep-seated intrusive and where deep tropical weathering conditions prevail.

Magnetite deposits occur in the deeply dissected regions of plutonic intrusions in North America. Haematite deposits outcrop around the margins of the great sedimentary basin, e.g. from Alabama to New York to Wisconsin and in Newfoundland. The orebodies are abundant and richly concentrated in the Lake Superior region. Residual deposits occur in the eroded Appalachians and in Cuba. In Central Europe, great sedimentary deposits underlie in parts of Loraine, France, Belgium and Germany. There are rich oxide deposits of igneous and metamorphic origin in Sweden. Farther east and north are the extensive deposits of Ukraine and European Russia. In Africa, good quality iron ores lie near the Mediferranear in Morocco and Algeria. There are extensive deposits in Brazil, India and China.

Iron ore deposits are distributed widely in different geological formations. The largest concentrations of ore are found in banded sedimentary iron formations of pre-Cambrian age. These formations constitute the bulk of the world's iron ore resources. Based on the resources, the top ten countries in the world in the order of their iron resources were the Commonwealth of Independent States (erstwhile USSR), Australia, Canada, USA, Brazil, India, South Africa, China, Sweden and Venezuela. Ranking of iron ore producing countries was the Commonwealth of Independent States, China, Brazil, Australia, USA, India, Sweden, Canada, South Africa and Venezuela. Based on the resource criteria, iron ore deposits of the important countries are described in details and summary is given in Table 5.1[1].

TABLE 5.1 : WORLD RESERVES (as on 1.1.1993)

(In million tonnes)

Country	Reserve base
CIS	78,000
AUSTRALIA	28,100
CANADA	25,500
USA	25,200
BRAZIL	17,300
INDIA	12,100
SOUTH AFRICA	9,300
CHINA	9,000
SWEDEN	4,600
VENEZUELA	3,300
FRANCE	2,200
LIBERIA	1,600
MAURITANIA	700
OTHER COUNTRIES	12,500
WORLD : TOTAL	229,000

(Source : Mineral Commodity Summaries, 1993, U.S. Bureau of Mines.)

5.1.1 Commonwealth of Independent States[1] (Erstwhile USSR)

Metamorphosed iron ore deposits are found in the Ukranian shield in an almost east-west trending belt that extends about 700 km from the sea of Azov and Belgorod and includes Krivoi Rog, Kremenchug and Kursk Magnetic Anomaly (KMA) Basin. The shield contains the Karelian deposits of bathic Olenegorsk and the Krivoi Rog iron ore basin (Krivbas), the second largest iron ore reserves in the CIS.

The largest reserves of high grade ores, mostly residual deposits, are found in the Saksagam ore field. In the Northern ore field where the sediments are intruded by Proterozoic granites, silicate-magnetitic and silicate-magnetite specularite, ores are well developed. The total iron ore reserves of the Krivbas are 20,000 Mt. The Kremenchug iron ore region lies on the left bank of the Drieper north of Krivoi Rog and contains eight iron ore deposits, Gorishni-Plavni Lavrikoveskoye, Yeristovskoye, Belanovskoye, Galeshchinskoye,Vasilieveskoye, Kharchenkovskoye and Severnoye (Northern), which form a continuous north-south band of ferruginous quartzites, 45 km long and 0.2 to 0.7 km wide. Kursk Magnetic Anomaly Basin, which contains the largest iron ore deposits in the CIS, is situated in the middle of the Great Russian Plain. Metamorphic pre-Cambrian rocks (1860-1600 million years) containing the iron ores are overlain by 30-600 m sediments. Important iron ore fields include Yakorlevo, Mykhoylovsk, Lebedinskoye and Stoylo.

The Baltic shield where ferruginous quartzite deposits are found includes Olenegorsk and Koslamuksk iron deposits. Magmatic titano-magnetite ores occur within Archaean greenstones and Proterozoic gabbros of the Ukrainian and Baltic shields like Pudozhgova deposit. Sedimentary iron ore deposits are contained within Lower Cambrian sediments around the Baltic Visean and sandy argillaceous Triassic rock in the north of the Great Russian Plain; Middle and Late Jurassic sediments of the northern and central parts of the plain; and in Early Cretaceous sequences of the Black Sea region, e.g. Kerch iron ore basin. Other important deposits are Kovdor iron deposit, Peschansk iron ore skarn deposit, Goroblagodavsk iron ore skarn deposit, Sarbatsk iron ore skarn deposit, Sokoloksk iron ore deposit and Kocharsk iron ore skarn deposit. In Ayat iron ore basin, Alapayevsk iron deposits, Akkermanovsk iron deposit and Lisakavsk iron deposit are important.[1]

Krivoi Rog deposits of the Ukraine occur in syncline zones of lenticular masses of haematite (martite). The iron concentrations occur in the Saksagan Series of Algonkian age, which rests unconformably on the Archaean gneisses and granites. The ferruginous cherts and jaspilites of the Sakagan Series are free from any intercalation of other rocks but, in rare cases, thin partings of thuringite schist occur. The jaspilites contain quartz, iron oxide, generally martite. The iron deposits of the Kerch Peninsula occur along of Ketch strait and the sea of Azov.

In Ukraine, the Krivoi Rog deposits occur in synclinal zones of lenticular masses of haematite (magnetite).

The iron concentrates occur in Saksagan series of Algonkian age, which rests unconformably on the Archean gneisses and granites. Jaspilites of Saksagan contain only two minerals, quartz and the iron oxide generally martite (63 percent iron).

5.1.2 Australia[1]

Australian iron ore occurrences which are mined by opencast methods include Mount Priee, Paraburdoo and Mount Channer Brookman mine which is producing 3 Mt/year of lump and high grade fines for about 20 years. CRA developed Maranderoo mine, 35 km from Mount Tam Price. Other mines are Pibara in the Robe river operation. In the Panawanica deposit, proven reserves are 636 Mt grading 57.2% iron and indicated resources at 2,16 Mt and in the Koolyanobbing mine, about 70 Mt reserve are estimated.

In South Australia, the Iron Monorch, Iron Inhales & associated deposits of the Middle Back Rang contain high grade ore lying about 48 km to the west of the west coast of Spencer Gulf.

The types of the ores vary from hard blue massive to soft, friable or schistose. The orebodies generally stand out as ridges with the ore both on the crests and on the flanks. Small patches are enriched by manganese derived from surface solution. The iron content varies from 64 to 68 percent and the phosphorus from 0.02 to 0.14 percent. There are many small iron ore deposits in South Australia, most of which were formerly worked to provide flux for lead smelters of Port Pirie and elsewhere. They are Adelaide County considered to be a haematite replacement of tilted sedimentary rock and estimated at 500,000 t above the level of the river supplying the Barossa reservoir. Near Cutana, there are a number of scattered limonite bodies derived from the solution of ferruginous limestone. They are estimated at about 800,000 t of about 45 percent iron content. Near Olary railway station, small replacement deposits of Billeroo are estimated at 385,000 t with about 50 percent iron and high phosphorus and the similar Kiol deposits are put at 400,000 t with 66 percent iron and 0.55 percent phosphoric anhydride.

In New South Wales, occurrences are noted of many small deposits of haematite, magnetite and limonite, often of good grade but not large enough to be operated mechanically on the scale required for a modern plant. In the past, a few of them have been worked for the iron at Port Kembla.

(i) The Cadia deposits, west of Milthorpe, are bedded and are considered replacements but entirely enclosed in an andesite. The upper oxidised zone is haematite, chiefly specular with little magnetites and the iron content is 57 to 65 percent.

(ii) Carcoar deposit in south of Cadia is mainly haematite with a little limonite. It is interbedded with Ordovician slate. It is considered to be of replacement origin. Iron contents vary from 52 to 63 percent.

(iii) At Goulburn and in the southern district of New South Wales, certain brown ore deposits are estimated to have total 2.5 Mt reserves.

The large deposits are those of Cadia, estimated at 39 Mt Carcoar, 3 Mt; and Wingellow at 3 Mt. The Wingellow is stated to be an aluminous deposit. In Queensland, the large iron ore deposit is Mount Philp. It is described as altered sandstones, quartzites, schists, slates and crystalline limestones and dolomites. The area is mapped as pre-Cambrian and the deposit seems to be similar to the Lake Superior type. It is haematite dipping vertically along with the sediments, with a general NNE to SSW strike and magnetite is only occasionally present. Silica is high and almost the only impurity. A similar deposit at Mount Leviatan, just west of Clonecurry is estimated at 2 Mt, most of which is silica grade. Other small deposits are Mount Lucy near Almaden, Iron Island in Rock Hampton districts. At Black Mountain near Clonecurry, siliceous deposits of 57 percent Fe occurs. About 2 Mt reserves are estimated in this area.

In Western Australia, older pre-Cambrians widely occur with 95 percent silica and iron oxides. At the surface, the bulk of the oxide is haematite. The most of metamorphosed varieties contain iron-silica minerals, such as grunerite, pyroxene, olivine in addition to magnetites, quartz and garnets. The banded magnetites-grunerite-quartzites are best developed near contacts of intrusive granite. Important known deposits are Tallering Peak at the summit of a range of vertical beds of pre-Cambrian haematite quartzites containing lenses of rich haematite; Weld Range, in the northern part of the Murchisan gold field, and Wilgie Mia deposit estimated at 26 Mt of rich haematite. It contains iron 62.75 %, silica 2.6 %. The orebodies show every evidence of having been derived by leaching of silica from original banded iron formations and its replacement by haematite by action of supergene waters. Mount Hale, Mount Narryer, Mount Masen, North Coolgardie, Mount Gibsen show similar nature of Wilgie Mia. Other deposits are Yampi Sound, Koolyan Bobbing, Rolling Mount Candan, Clockline, Coates Siding Wundowie. Known deposits in Tasmania are Long Plams, Penguin, Beacons - field Launcerton Zeehan Strahan.

Magnetites contain 60 to 70 percent and low phosphorus. The quantities are estimated at 2.9 Mt.

5.1.3 Canada[2]

The most important iron ore deposits are in the region of pre-Cambrian rocks, north and east of the Great Lakes and four areas in the region. Deposits in the Labrador-Quebec area are masses of mixed haematite and goethite in iron formation of the Lake Superior type. The iron ore deposits are located at following places:

Labrador-Quebec; Mosse mountain, Beleher Islands; Nostapoka Islands, Matonipi area, Lake Albanel area, Lake Qunflint area, Goulais River; Atikokan; Mine Centre; Marmora; Radnor; Calalogie; Bristol; Bethurst Kitchener; Zeballos; Quatsino; Matla River, Bannet Plume River, Hart River and Cathedral Creek.

5.1.4 United States of America (USA)[3,4,5]

Numerous agencies are mining iron oxides in USA. In Virginia, Sienna and Umber areas, magnetite is being produced by Hoover Color Corpn., Virginia Earth Pigments Co., and Missouri Pea Ridge Iron Ore Co. The capacity of these operations is 1 Mt/annum of high purity iron ore, about 10 percent of which is the 99 percent grade. Iron oxide has been mined near Cartersville, Georgia. The Cartersville area is underlain by a sequence of metasedimentary rocks divided in ascending order into the Weisner, Shady and Rome formations of Early Cambrian age and the Conaisauga formation of Middle to Late Cambrian age. Deposits of iron oxide consist mainly of finely intermixed limonite and clay with smaller and variable proportions of fine-grained quartz and muscovite. Other important localities are as follows:

Iron deposits in the Lake Superior region occur in the banded formation (oxides, silicates, carbonates or combinations of these minerals) and alternate silica-rich layers (chert or fine-grained quartz). Marquette and Vermilion ranges are other important deposits.

The estimated reserves (measured, indicated and inferred) excluding the teconites are 2,500 Mt. The taconites are estimated to contain 1,700 Mt of concentrate containing 68 percent iron in the magnetite type and a total 20,000 Mt of concentrate including both the haematite and magnetite types.

Minetote-type of iron ore or the Clinton ores have their greatest development in Alabama and outcrop through Tennessee. Kentucky, west Virginia and Virginia to Pennsylvania and New York rank next in importance to the Lake Superior ores. The grade is about 36 percent iron with phosphorus from 0.15 to 0.5 percent in hard ore. The ore beds show gradual transitions to limestones or to ferruginous sandstones in some places and the Clinton formation generally becomes more calcareous westward from Alabama.

The iron ore deposits of magnitnaya-type occur at Iron Springs and Utah in Iron Country. The deposits consist of haematite, magnetite bodies, with minor amount of quartz-chalcedony, calcite, barytes, apatite, pyrite and chalcopyrite. The average grade is about 50 percent iron.

In Cornwall, Pynnsylvania, magnetite occurs in Cambrian limestone. The ore contains about 42 percent iron. It also carries important recoverable by-product of chalcopyrite and pyrite (with 1.25 percent cobalt).

The magnetite deposits of Adirondack are of Kiruna type. The ore sometimes contains much apatite and its iron content is as little as 35 percent. Iron ore deposit of Iron Mountain, Missouri contains compact masses of haematite and some magnetite in andesite phorphyry. The Toberg-type deposit occurs at Lake Sanfold and titaniferous magnetites in Adirondack of New York. It consists of magnetite and ilmenite.

5.1.5 Brazil[1]

Brazil has the largest iron ore reserves of all South American countries. Its most important mining regions are Minas Gerais, north-west of Rio-de-Janeiro, with estimated reserves of about 16,250 Mt, Mata Grosso, close to Bolivia, with a potential resources of some 1,300 Mt and other much smaller centres, such as Amapa to the north of Bahia. The iron ore is derived from the enrichment of the Itabirite formation, which is composed of granular quartz and iron oxide with 45 to 50 percent iron and 25 percent silica. The other important deposits are Piracicaba, Itabira, Cocois Caue Peak, Conceicao, Catas Altas, Aque Quenta, Ouro Preto and Itabirito. These are Bessemer type ores and they are the best quality, best located and largest iron ore reserves not only in Brazil, but on the whole continent. The deposit is pre-Cambrian and the Lake Superior type.

The banded Protore of the Brazilian pre-Cambrian iron formation has a very large development in the remote Uracum region, Mato Grosso, but there is little enriched high grade haematite. The banded haematite jasper is unmetamorphosed and richer than usual in iron (50 to 55 percent).

5.1.6 Republic of South Africa[1]

Important iron ore mines viz. Sishen and Thabazimbi produced 22.9 Mt in 1993 against 22 Mt in 1992. Sishen mine in the mid- northern Cape exports ore through the export terminal on the cape Atlantic Coast. Yellow and red ochres produced in Riversdale deposits are in an area where steeply inclined Bokkeveld shale is overlain by up to 3 m silcrete or gravel of Late Tertiary age. In an area betweeen the towns of Riversdale and Albertinia, alteration of the shale formed zones of iron-enriched shales and also leached zones of soft white clay depleted of iron. The leached out iron was carried downward to be precipitated as bodies of ochre within the white clay. The larger deposits tend to have an irregular somewhat lenticular shape with the longer axis parallel to the strike of the Bokkeveld shale. Commercial output is modest , 2,000 t per year.

Red ochre Is produced along the Baffalo River valley. Natal is from an ochreous phase of the sideritic limestone bed. The product is a soft earth mixture of haematite, limonite and goethite from which various red and yellow ochres can be extracted. The main product is a dark red haematite variety.

In South Africa, large deposits of rich iron ore occurring at the only two areas are stated to be derived from pre-Cambrian banded iron formation which is in northern Transvaal and in the Gamagara Rand, Grigualand West. The Thabazimbi ores lie in the Transvaal system. The ore is hard massive haematite with iron content 66 to 68 percent. The main orebodies stretch almost continuously over a length of 3,300 m. The ores are calcareous with alternating layer of calcite and haematite. The main Gamagara Rand deposits are of later age than Thabizimbi ore and considered to be Late pre-Cambrian. The Gamagara Series haematite contains 60 to 62 percent iron with silica and alumina combined at about 9 or 10 percent.

Very large reserves of oolitic iron deposits occur in the Transvaal system, near Pretoria. There are five main levels in the system, varying in importance, with five different facies around the ovals. The lowest bed is the magnetite-quartzite. It is an arenaceous oolitic ironstone. Higher in the system are two smaller iron-bearing bands, the pisolitic ironstone and clayband. The fourth band belongs to Desporate stage. The lower bed is more important and is the only potential ore with 30 percent iron, but in very large quantities, the upper band is richer in iron up to 53 percent.

5.1.7 China[1]

The main deposits of Lake Superior type in China are those of Liaoning Province, the bulk of which are lean siliceous types. The iron content is 30 to 35 percent (both magnetite and haematite) and the silica from 40 to 50 percent. Minor quantities of rich grade enrichments by leaching contain 60 to 70 percent iron. These deposits have a wide distribution running across the sea to northern Hopeh.

The banded ores contain thin bands of haematite and magnetite alternating with bands of quartz schists, jasper and iron silicates with occasional bands of siderite. In more metmorphosed varieties, hornblende, olivine and garnet are present. Sulphur and phosphorus are low. Concentration is achieved by roasting to reduce the haematite to magnetite, crushing and magnetic separation followed by sintering and briquetting.

The oolitic haematite deposits (minette type) of Sinian of Late Proterozoic and later ages occur in vicinity of Hisuan-hua. In the province of Chahar, the deposits extend in a narrow long outcrop of siliceous haematite. The haematite is dark brown to red, oolitic, each with a minute quartz nucleus. Sulphur is low; phosphorus is about 0.12 percent. The ore contains about 50 percent iron and 20 percent silica. Oolitic haematite is also widely distributed in Human, Kiangsi and Western Hupeh in Southern China. The iron content is 50 to 63 percent and silica about 10 percent, but phosphorus is high.

Chinese iron ore reserves are mineable; 98 percent are of low grade quality (less than 35 percent Fe). Ore output comes from Qianan mining area. Other deposits are Qidashan mine, Jianshan deposits. Reserves of iron ore deposits in Zhangjiawa, Hanwang, Changzhe in Shangdong Province and Huogiu in Auhui Province are about 1,700 Mt.

5.1.8 Sweden[6]

Most of the iron ore deposits are located in a 100-km-wide belt of supracrustal rocks that extend from Caledonides in the west to the Finnish border in the east for a distance of about 200 km. Four main types of iron ores can be distinguished in Morrbotten-apatite-bearing iron ores of the Kiruna types, skarn iron ores, banded iron ores and titaniferous iron ores. Most of them are found in a restricted area around Kiruna and Gallivare. The reserves were estimated by Frietsch at 3,410 Mt - 85 percent of iron ore reserves of Norrbotten individual deposits are large and have an average content of 52 percent Fe. The skarn iron ore and banded iron ore occur mostly in the outer zones of the large volcanic complexes. There are many small occurrences of the skarn type, which together form impressive ore reserves. Banded iron ore is found in long, narrow, persistent zones. The total amount of ore is significant, especially in the Arjeplog area, but the grade is low. It is reported that Kiruna-type apatite-bearing iron ores of Norrbotten are exhalative sedimentary in origin. The rocks are mainly greenstones derived from basalts and andesites. They are associated with acid volcanics, tuffs, graphite schists, carbonate rocks, and jaspilites as well as iron and copper mineralisation. Porphyry dykes play an important role in the northern part of Kirunavaara. The orebody at Kirunavaara is about 4,000 m long, and the width varies between 20 and 200 m. Skarn iron ore deposits are dispersed throughout the ore province from the Caledonides in the west to the Finnish border in the east. The deposits consist of magnetite with occasional haematites; varying amounts of sulphide occur mostly as pyrite and pyrrhotite with minor amount of chalcopyrite.

5.1.9 Venezuela[2]

Important occurrences of iron ore in Venezuela are operated as Cerro Bolivar mine, New San Isidro mine, Elpao mine. The ore is mainly massive haematite, with small quantities of magnetite, and an iron content ranging between 64 and 70 percent. The phosphorus content averages 0.04 percent. The output from Palo mine is around 3.0 Mt per year. The remaining reserves are estimated at 25 Mt. Elpao is the oldest of Venezuela's iron ore mines, and cumulative output has recently exceeded 100 Mt. San Isidro deposit is similar to that of Cerro Colorado faulted synclines and anticlines of itabirite beds in which selective removal of silica by meteoric waters under tropical weathering conditions has led to residual concentration of iron oxides. The deposit principally comprises two types of ores, a hard haematite and a soft ore consisting of black and brown fines (haematite particles agglomerated with quartz and goethite). The proportion of hard and soft ore is 30:70. The proven reserves at San Isidro are estimated at 392 Mt grading on an average 66 percent Fe (dry basis) with some 0.07 percent phosphorus.

There are several other important iron deposits in San Isidro Square. Barraneos is one such important deposit. Maria Luisa is another important deposit of high grade iron ore. Similarly, in Imataca, a mountain range along the bank of the Orinaeo river to the south and east of Cindad Bolivar having the Altamira and Frontera group of deposits resemble Ceroro Bolivar in the vicinity. The Santa Barbara group of deposits consist of San Isidro, San Jauguini Las Paitas and Aguas Calientes orebodies. There are other low grade ores consisting of itabirite ore which forms part of the country's potential reserves, the most important are the Piacoa and Has Castillos deposits.

5.1.10 France[5]

Several beds of oolitic iron ore occur within the Ordovician sedimentary succession. In areas like Arenig of Angou, Llanvirn in Normandy, iron ores are reported from Ordovician rocks. The ferriferous skarns at Framont Grandfontaine (Bas Rhin) supplied about 9,000 t of iron-tungsten ore during the 19th Century. The gulf of Lorraine and Luxembourg was in the Upper Lias, the site of important deposition of oolitic iron ore with 0.5 - 0.7 percent P of the type known as Minatee. The iron district of Lorraine and Luxembourg extends, with an average width of 25 km, for about 140 km, with a north-south trend along the sharp border of the Cote de Mosette. In the Nancy basin, iron formation reaches a thickness of 10 m. In the Metz fault with a throw of 100 m, Orne basin, iron formation reaches 30-40 m thickness. In Landress - Ottange basin, iron formation varies from 30 to 60 m in thickness and continues into Luxembourg through the Esch-Sur-Alzette and Rumelange basin. In the Longway basin, iron formation hardly exceeds 20 m thickness and continues into Luxembourg through the Differdange basin. At its maximum development (in the basin of Landres-Ottanage & Esch-Sur-Alzette-Rumelange), 11 to 12 iron-bearing sequences are found of which only two or three culminate in exploitable beds. These sequences can be grouped into two categoreis:

(i) A siliceous facies, mostly of Toarcian age, represented in Luxembourg and Ardennes in which the ooliths are cemented chiefly by chlorite and silica.

(ii) A carbonate facies mostly of Aalenian age, well represented in Lorraine, in which ooliths are cemented by carbonate.

The ore is composed of ferriferous oolites and grains of quartz bounded by a cement of clay minerals or of chlorites and carbonates. The ooliths consist of iron hydroxides or limonite, with variable proportions of silica, alumina, phosphorus. The chlorites include chamosites, leptochlorites, thuringite and berthierine. Minor amounts of magnetite and pyrite along with baryte, galena are also present.

Lorraines deposits and Ar bed's are the two operating mines of ochre producing in the region of Apt in France with 20 percent iron oxide.

5.1.11 Liberia[1]

The iron ores of Bomi Hill, Liberia, like the Michipicoten deposits have a deceptively close geographical association with pre-Cambrian iron formation. In addition to the iron formation, the country rocks include gneisses, schists, granites and (minor) diabase. The strikes of the orebodies are sometimes in accordance with the iron formation (and other country rock) and sometimes discordant. The high grade ore is magnetite that is partially oxidized at the outcrops to haematite, with minor quantities of silicate minerals, anthophyllite and chlorite. The iron content of the best grade ore is 68 percent, but it is lower in the more siliceous varieties. Reserves are estimated at 50 Mt.

Other similar deposits are known further inland, but have not yet been examined fully. Bong mine, some 80 km north-east of Monrovia, is at present not in operation.

5.1.12 Mauritania[1,7,8]

Kedia and Tazadit deposits are known iron sources. New mining areas are being developed in the country.

Iron ore is produced in north-western Mauritania just east of Fderik from open-pit mines. Both the Kedia d'Idgill and Tazadit deposits are approaching exhaustion. Et-Rhein open-pit mine has 6 Mt per year capacity of concentrate grading 65 percent Fe. High grade deposit at M'Haudat work on a new site has reserves at 80 Mt, most of which is 64 percent Fe grade.

5.2 OTHER COUNTRIES

Apart from the deposits and reserves described under Para 5.1, there are countries which are producing iron ore and some of them are discussed alphabetically.

5.2.1 Algeria[1]

The most important Algerian deposits of Bilbao type are those of Ouenza and the smaller deposit of Bou Kadra. Ouenza deposits occur in Lower Cretaceous (Aptian) limestones folded into the anticline of the Jebel Ouenza. The limestones contain reef masses and the ore appears to favour these, sometimes ceasing abruptly at the junction of the reef and bedded limestones. The ore extends over a length 2.5 km with a maximum width of 400 m, but it is very irregular and occasionally large masses of limestone are enclosed within the ore. The lower part of the orebody is siderite, but above the water table this has been oxidised to haematite and goethite. Quality of the ore Ouenza and Bonkadra is same with iron content 55.5 percent. The low phosphorus and good iron contents, with readily reducibility in the blast furnace, create a demand for the Ouenza ore for the European furnaces. The estimates are not available of the quantities of siderite, but the reserves of oxidized ore may be roughly put at about 85 Mt.

5.2.2 Austria[1]

The known iron deposits of Erzberg, which are irregular masses of siderite and ankerite in Silurian-Devonian limestones, often reef-like skarn-type magnetite deposits, were worked at Kottarun near Geras. At some locations in calcareous Alps, small bodies of manganiferous siderite (with ankerite - dolomite) and their oxidation products were mined.

5.2.3 Belgium[1,2]

The Jurassic Minette ores of Belgium are small and belong to silicious facies of the Lorraine basin with 35 to 39 percent iron. The oolitic iron deposits in the Upper Devonian of the valleys of the Sambre and Mense are estimated at 30 Mt proved with 10 Mt of probable ore.

5.2.4 Czechoslovakia[4]

The sedimentary oolitic iron ore deposits are of marine origin and of Ordovician age. They occur between Prague and Plzen. In Nucice and Zdlice deposits, chamosite-siderite ore occurs. Ejpovice, Krusna Hora, Mnisek and many other deposits contain haematite-siderite ore; only uneconomic concentrations exist in Tremadoc and Arenig.

5.2.5 Egypt[1]

Oolitic iron ore deposits (haematite) occur over an area to the east of Aswan. The deposits are in Nubian Series (Senonian), mainly arenaceous series, lying on a denuded irregular surface of pre-Cambrian schists, granites, etc.

There are four main iron ore deposits in Egypt :

Aswan Iron Ores[1] : These lie to the south of Cairo. The dark red oolitic haematite sedimentary ores from two horizons are separated by ferruginous sandstones and clays of Upper Cretaceous age. The geological reserves are estimated at 15 Mt with an average grade more than 35 percent Fe.

Bahariya Oasis Iron Ore : This deposit occurs at four localities, i.e. EL-Gedida; Masser area; Jebel - Ghorabi, Elattarra. The ore consists mainly of haematite, goethite with pockets of ochre (limonite) and manganese oxides; and the gangue minerals quartz, halite, gypsum, barite and calcite.

Red Sea Hills Iron Ores (Eastern Desert) Five deposits are known in the Red Sea Coastal area of pre-Cambrian age. The total reserves of five deposits are 80 Mt with average of 43 percent Fe.

Fourth type of iron ore in Egypt is represented by black sands in the north of Delta at the area between Rosatta (Rashid) Dimals and northern coast of Sinai Peninsula. These sands contain a small quantity of magnetite because of the other important components of the black sands, such as ilmenite and monazite.

5.2.6 Finland[7]

Pre-Cambrian banded iron formations are seen in Finland in four rock associates. These are (1) Late Archaean occurrences in Eastern and Northern Finland, (2) Early Proterozoic (Lapponi) in Central Finland, (3) Early Proterozoic (Kaichia) Kainnu and (4) Early

Proterozoic (Svecofennia) in Southern and Central Finland. The known iron ore deposits are in Otanmaki, south of Lake Oulunjarvi. The liquid magmatic ilmenite, magnetite ore deposits as in Mustavaara deposit, Misi, Rautuvaara. Svecokarelian, Rautarunkki, Veorokas Honkamaki and Pentinpuro are other important deposits. The Otanmaki iron ore deposits constitute the only real deposit of iron ore in Finland. It is located centrally and the concentrate shows 67 percent iron and 2 percent titanium. The deposits are lens-shaped masses closely connected with pre-Cambrian amphibolitic rocks, and magnetite and ilmenite occur largely as separate grains. The proved reserves are 10 Mt and probable 50 Mt.

5.2.7 Morocco

The deposit of Inri in Tourza (Jebal Ougnat) is 425 km from Ayadir. The deposit is Ordovician oolitic, largely magnetite. In French Morocco, iron deposits of Khenifra occur in Visean limestone conglomerate at the base. In French Morocco, iron mines at Monte Vixan are in Jurassic limestone that is replaced by pyrite at depth and haematite and magnetite at the surface.

5.2.8 New Zealand[9]

Country's potential iron ores are confined to the Parapara limonite at northern extremity of the South Island and the titaniferous iron sands of the west coast beaches of North Island. The total proved and probable reserves have been estimated at over 505 Mt. A series of Ordovician and older rocks, intruded by igneous rocks, ranging from ultrabasic to acidic, were folded into steeply dipping stages and later covered by Tertiaries. Pyrite and marcasite are widely distributed in these Paleozoics. The sulphides from both series were altered to limonites which have replaced some Paleozoic sediments, both siliceous and limestone beds. The Tohar iron sand mine has a producing capacity of 2.5 Mt.

5.2.9 Poland[10]

Most important magmatic-type iron ores occur in Suwalki region and Doggar sedimentary iron ore deposits in the Zarkiczes-Tochona-Klobuck region. Endogenous deposit belongs to the ilmenite-magnetite ore deposit of Krzemianka, and the magnetite quartzite ore deposit of Kowary while exigenous deposits belong to a wide variety of sedimentary deposits including those formed due to weathering. Most important are the Dogger iron ore deposits in Czastochowa-Klobuck and Leczyeat regions.

5.2.10 Portugal[6,11]

In North-Central Iberian zones, detrital and oolitic sedimentary iron deposits are interbedded with the Lower Ordovician Armorican quartzite. The deposits are found around the Middle Galicia-Tras- os-Montes Zone which includes Guadramil, Marao and Moncorvo found in the Trans-os-Montes region of Portugal, but Moncorvo is important. Guadramil is siderite deposit. Marao is magnetite and Moncorvo is haematite deposit. Mineralization occurs in the upper half of the Ordovocian schist-quartzite series. Several small magnetite deposits occur in the Ossa-Morena zone of which Orada near Guadiana River was mined.

5.2.11 Scotland[6]

Magnetite deposit is reported from Scotland Isles and parts of Scottish Highlands fall into this group. In Sandrodgein, northern Scotland old red sandstone is known for old workings. Westphalian ironstones provided a major source for the industrial development of Britain. Siderite (chalybite) (FeO_3) is the principal iron mineral, and the ironstone horizons occur as bands, lenses and tabular masses in the mudstones together with nodules. These are best developed in the lower and middle coal measures in Westphalian. Most of the black band ironstones are demonstrably primary, syngenetic ore deposits. The clay ironstones and nodules are generally non-marine and are believed to be of diagenetic origin.

High grade, low phosphorus iron ore has been mined from the fringe of limestones, mainly of Visean age, which surround the domal structure of the Lake district. In South Wales and forest of Dian, important replacement deposits of iron occur in the Carboniferous limestone. The deposits form irregular lenses and the ore comprises interbanded layers of primary goethite and haematite. Small amounts of magnetite have been obtained from pyrometasomatic deposits of Devon and Cornwall.

5.2.12 Spain[8]

Spanish iron ore deposit is spread in five districts, i.e.

(i) Northern district: Vizcaya-Santander mines, Renteria deposit, Lescaca deposit, Somiedo (Oviedo). Important deposits are situated in areas Ortuella-Somorrostro, south-east of Bidbao, Sopuerta, Hoya Covaron and Dicido.

(ii) North-Western district : Deposits are distributed in arc from Astorga (Leon), towards the south, through Ponferrada, Incio and Villalba to Vivero on the northern Galician coast. Deposits are principally of haematite and limonite. Other deposits are Luarea, Maria, Villaodrid, Coto Wagnar and Coto Vivaldi.

(iii) East-Central district : Deposits of Casila and Aragon are principally in the areas of Sierra Minera and Sierra dol Moneayo.

(iv) South-Western district : Province of iron ore extends from Cordoba, Sevilla, Huelva. Other workings are Cala, Tueler, San Guillermo-Colmenar Santa Justa, Monchi, Cerro de Hierro.

(v) Southern district : Dep of Granada (those of Alquife and Marquesado)

5.2.13 Switzerland[1,10]

The Swiss oolitic iron ore deposits near Chamoson of Collovian (Upper Dogger) age attain their greatest development at Herznach. Fricktal, Aargan, sedimentary Middle Jurassic (or Brown Jara) iron ores are well-known throughout the Central Europe. Other deposits are Chamoson, Wallis; Erzegg, Bern; Mont Chemin, Wallis; Val Ferrera Grisones. The sedimentary oolitic iron deposit near Chamoson lies in the Callovian (Upper Dogger) of the Helvetic morcles nappe. The main oolitic horizon has a thickness of 1 m. Such a small iron deposit merits mention because it is a type locality of the mineral chamosite$(Fe+2Mg, Fe^{+3})_5$ $Al(Si_3Al)O_{10}$ $(OH_2)_{28}$, an iron chlorite well-known in many parts of the world. Total reserves of iron ore at 30 percent Fe are approximately 1 Mt in Erzegg. Bern, the deposit of sedimentary oolitic iron ore, is similar to that of Chamoson. In Mont Chemin, Wallis, several small magnetite lenses occur approximately 4 km south-east of the town Martigny. In Val Ferrera Grison, small iron manganese ore deposit occurs in the folded metamorphic Jurassic quartzites, dolomites and marbles of Penninic Suretta and Schams nappes. These small orebodies, older than the Apline movements, are concordant with folded sediments.

5.2.14 Tunisia

The chief iron deposit in Tunisia of Bilbao type is that of Djerissa near Algerian border and about 400 km south-west of Tunis. Important deposit is Ouenza. The orebodies are irregular, largely in Aptian reef limestones. The chief minerals are haematite, goethite and stilpno siderite with sometimes a little ankerite having iron content average of about 53.6 percent. Other deposits are Douaria and Tamera in Ponth lacustrine beds in northern Tunisia; AP Jebal Ank in the south of Tunisia; and an oolitic iron deposit in Eocene limestone which is being prospected and which promises to contain at least some 16 Mt of 50 percent iron ore.

5.2.15 United German Republic (Erstwhile Federal Republic[1] of Germany and German Democratic Republic)

Iron ores of Jurassic age of Lower Saxary, and to a large extent Lower Cretaceaous Salzgitter ores are of oolitic sediments. The Ordovician iron deposits of Thuringia, Jurassic of Baden and Bavaria (Lias and Dogger ores), Eocene of Kressenberg (Upper Bavaria) are also oolitic deposits. Red iron ore deposits in Lahn-Drill district having a thickness of up to 2 m occur discontinuously in the so called Grenzlegeired iron ore beds at the boundary of the Middle and Late Devonian above the Schalitius or magnetites of the Guvetian and below and between the occasional volcanogenic rocks of deep Adortion are widespread. Red iron ore is achieved from Konigs Zug mine in Dill syncline and Fortuna mine in the Lahn syncline. Other red iron ore deposits are Christiane, Kellorwald, Haingrube, near Bergprechect, Geislingen, Aalen, Wasseral Fingen, Pegritz in Swabian Franconian Alb (Dogger), Namnica, Gifhorn Konrad (Nalm); Satzgitter, Pane-Bulton and Peine, Oberpfalz.[9,1]

5.2.16 United Kingdom[6]

In United Kingdom, occurrences of iron ores are reported from Auglesey and on the mainland. Mining is recorded at Tramado. Most important localities are further north including Llandegri near Bangor, Aber, Bettws, Garnon west of Snowden and minor workings near Bethesda. Small workings/deposits are reported at Tri wyb-y-tal, Llanengan, Pen-yr-Allt Dolgellau.

5.2.17 Yugoslavia[1]

The Triassic siderite-haematite deposits of Vares in middle Bosnia are the largest in Yugoslavia and consist of haematite and limonite ores. Limonite forms at the surface by secondary alteration of the haematite. The siderite-limonite deposits of Ljubija area are the second largest in Yugoslavia. They occur as irregular masses. Ankerite, limestone, pyrite, galena and barytes are associated minerals. Sometimes chalcopyrite and sphalerite occur.

5.2.18 Zimbabwe (Rhodesia)[8]

Concentrations of rich haematite of workable size are reported at Sieppa Leone. These average about 55 percent iron with 6 to 12 percent silica. In northern Rhodesia, known pre-Cambrian iron deposits are in Tanganyilka.

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