CHAPTER 8

MINERAL RESOURCES

The solid crust of the earth is made up of rocks. The rocks, in their turn, can be defined as the aggregates of minerals. The minerals, therefore, are the smallest geological units forming the crust and are themselves substances of inorganic nature. Minerals are, moreover, characterized more or less by their fixed chemical composition and exhibit perfect geometric shape and have an internal atomic structure. To be designated as a mineral species, a substance must have the following three characteristic features :

(i) a mineral must be found in nature,

(ii) a mineral must be of inorganic origin,

(iii) a mineral must possess a definite chemical characteristic and a distinctive atomic formation.

Most minerals have a crystalline structure. Substances like coal, petroleum and natural gas etc, though gifts of nature, are not minerals, because these are derived from organic substances.

Minerals have long been considered as the basis for the development of human civilization through times. The Stone Age had been distinguished as the time when stones formed and fashioned the life and activities of the ancient men. At this period, the weapons and the essential crude implements of the man were made of stone. Copper Age began as man discovered copper from the mines and learnt its utility. Then came the Bronze Age, when people developed a stronger and more durable metal by mixing copper and tin in suitable proportion. Historians are of opinion that about thousand years before Christian Era the Bronze Age was replaced by Iron Age. More recently, the Iron Age has given way to Steel Age of our modern times.

The real and massive exploration of the earth's hidden treasure or minerals started with the advent of Industrial Revolution in England, more than a century ago. Within this relatively short span of time minerals have become, at an ever-accelerating rate, the essential basis of industrialisation.

A dramatic change of the economic scenario of any region or country may take place following the exploration of minerals. Saudi Arabia is, perhaps, the best example. The country was simply a barren waste of desert even before World War II. But, following the emigration of the people from the West, oil exploration started leading to overall economic upliftment of the country. Thus, within a period of about four decades, the country emerged as a developing nation.

Some minerals can be obtained easily and cheaply than others because they lie at the surface of the earth. Others lie buried at depths of thousand metres beneath the earth's surface. They can be explored by digging deep underground. In the present time, mining is the basic factor for industrial development, because it alone provides means for advanced industrial operations. Minerals enable man to increase his productivity. Man utilises various

minerals to minimise his labour. In effect, minerals enlarge the versatility of a man's hand and multiply the power of his muscles.

In contrast to agriculture or forestry, mining is a kind of robbery or plundering economy because a mineral once mined is lost for ever as a natural resource. The natural replacement of minerals depends entirely on geological events. It is, therefore, the prime objective of different nations to utilize the mineral resources in the best possible way.

Mining and the processing of minerals exert tremendous impact on the economic well-being of a country in a number of ways which can be summarized as follows :

(a) They provide employment opportunities.

(b) They attract population to be settled around the mining sites.

(c) They stimulate the development of transportation.

(d) They open new scope for export earnings.

(e) Minerals extend the scope for the development of domestic industries.

Minerals are very unevenly distributed in different parts of the world. The countries having suitable geological formations are vastly endowed with different grades of minerals. No country in the world, whatever be its size and location, is completely self-sufficient in every mineral resource. The countries like the China or the United States of America have become industrially developed because of the presence of abundant mineral resources within their own territory. The ever-increasing demand of minerals, to sustain the present form of industrial civilization, has caused the world to explore and consume more minerals within the period embracing the two World Wars than in all previous history of mankind. History reveals that the countries like Germany, Japan and Italy became aggressor nations because they were notably lacking in most critically important mineral resources. Minerals are non-renewable resources, and, thus, more a country becomes industrially advanced the more rapidly it exhausts its own mineral deposits and is bound to import from other countries. Japan lacks in most of the mineral resources, so she imports minerals from different corners of the world.

8.1 THE OCCURRENCE OF MINERALS

Minerals generally occur in four main ways depending on the geological set-up under which they are formed :

(a) **In lodes and veins** : Cracks and fissures in different types of igneous intrusions become veins and lodes of metallic minerals of significant economic importance. Areas studded with ancient crystalline rocks that have greatly suffered from repeated tectonic movements often contain veins and lodes in great numbers, enriched with valuable mineral deposits. Minerals may be found in the metamorphic aureole of some metamorphic intrusions. Many of the major metallic minerals like tin, silver, copper, zinc and lead are obtained from veins and lodes.

(b) **In sedimentary beds** : Some minerals occur in horizontal layers or strata. Coal and different iron are formed in this way, and are accumulated as a result of long periods of compression. Some other minerals like gypsum, potash salt and sodium salt are formed through evaporation. Petroleum also occurs within the sedimentary beds of oceanic origin.

(c) **In alluvial deposits** : Alluvial deposits also contain minerals, usually at the bases of hills or in valley bottoms. Minerals like gold, tin, plantinum are resistant to

weathering and are thus carried downslope and deposited within alluvial deposits at the based of hills.

(d) **In weathering products :** Deep weathering products also contain some of the valuable mineral deposits. Bauxite is formed by the deep-seated weathering of rocks under hot and humid tropical climate, having a distinct rainfall regime. Other minerals such as iron, nickel and manganese may also occur within weathering substances but are of little economic significance.

8.2 PHYSICAL AND ECONOMIC CONDITIONS OF MINING

A great many physical and economic factors affect the exploration of mineral resources in various parts of the world. These are equally important because a country may have good physical setting for mineralogical exploitation but may be deficient in the essential economic environment. Africa is still a backward continent not because of its adverse setting for mineralogical exploitation but more importantly because of its economic backwardness, lack of capital, dearth of technological skill etc. Thus, the physical and economic conditions necessary for mining can be grouped in the following way :

A. **Physical Conditions :**

(i) The size of the deposit.
(ii) The depth of occurrence.
(iii) The structural formation.
(iv) The richness of deposits.
(v) The location of deposits.

B. **Economic Conditions :**

(i) The cheap and abundant supply of labour.
(ii) The availability of capital.
(iii) The method of exploitation of minerals.
(iv) The existing method of transportation and its efficiency.
(v) The nature of demand of minerals both within the country and abroad.

8.3 CLASSIFICATION OF MINERALS

The wide variety of minerals that have been explored by man to satisfy his needs may accordingly be classified into the following groups :

(i) Power minerals : coal, petroleum and natural gas.
(ii) Precious metallic minerals : gold, silver and platinum.
(iii) Industrial metallic minerals : iron ore.
(iv) Ferro-alloy metallic minerals : manganese, molybdenum, vanadium, cobalt, nickel.
(v) Non-ferrous metallic minerals : copper, tin, aluminium.
(vi) Non-metallic minerals ; salt, sulphur, potash, asbestos.
(vii) Building materials and stones : sandstone, limestone, marble.

8.4 IRON ORE (Fe)

Iron ore is, by far, the most widely available mineral on earth. It is the back-bone of modern civilization. Historical evidences revealed that iron has been explored since very ancient times. Iron ores are very widely distributed and the countries which are industrially

advanced have been some sources of iron ore deposits. The present trend of iron use distinctly reveals that total consumption is declining drastically, still its international trade is considerable. In the years following World War II, the demand of iron had greatly increased and continuous efforts had been made to supplement the demand. Regarding quality and its use, a great many varieties of iron ore types exists. High grade ores also yield good quality scrap metals which enhance the growth of industries.

Keeping in view the metallic content of different grades of iron ores, it can broadly be classified into four major groups :

(a) **Magnetite :** Magnetite (Fe_3O_4) is the richest iron ore with a very high proportion of metal. It contains about 72 per cent of iron and is especially suitable for electrical industry because of its magnetic property. Magnetite is dark in colour and varies between dark brown to black. This is mainly obtained from veins and lodes that occur in igneous or metamorphic rocks.

(b) **Haematite :** Haematite (Fe_2O_3) is the most widely used iron ore in spite of its relatively low metal content than Magnetite. The average ferrous content of haematite range, between 60 to 70 per cent, include a high proportion of impurities known as gangue and thereby the economic significance of the ore is greatly reduced. Haematite is mostly red in colour, although it may be black or bluish-black in colour. Haematites are derived from the sedimentary rocks.

(c) **Limonite :** Limonite ($2Fe_2O_3.3H_2O$) is the commonest of the iron oxides. This is brown in colour and, therefore, is known as 'brown ore'. Limonite occurs in great thickness within the sedimentary rocks and contains nearly 50 per cent of iron. Because of its low metal content, limonite is not extensively mined, except in the areas lying close to the market or in the countries which are deficient in high grade ore deposits.

(d) **Siderite :** Siderite ($FeCo_3$) is a carbonate of iron and unlike limonite it is also a residual ore. Siderite is ash-grey in colour and contains abour 38 per cent of iron.

8.5 WORLD DISTRIBUTION OF IRON ORES

The distribution of iron ore is most diffused all over the world, yet nearly 80 per cent of the global output of it is obtained from nine major countries which include the CIS (24%), Australia (11%), USA (10%), Brazil (8%), China (7%), Canada (6%), India (5%), Liberia (5%) and Sweden (4%). The following table shows the distribution of global iron ore production.

Iron Ore Production in Major Countries 1973-92

[In million tonnes]

Country	*1973*	*1978*	*1983*	*1988*	*1992*
China	55·9	70·0	71·12	105·0	194·0
Brazil	50·5	84·98	88·71	145·04	146·0
Australia	84·82	83·13	71·03	96·08	117·17
Former USSR	216·09	246·24	245·19	251·0	
a. Rusian Federation					82·5
b. Ukraine					75·7

USA	89·07	82·89	38·16	57·52	55·59
India	35·56	38·84	38·8	52·32	54·0
Canada	50·21	41·75	33·49	38·74	34·14
South Africa	10·95	24·20	16·6	25·25	28·23
Venezuela	23·11	13·51	9·72	18·79	22·00
Ten Countries : Total					809·32
World Total					929·75

Source— World Resources— 1994-95.

8.5.1 Iron Ore Mining in North America

The United States of America, Canada and Mexico are the three leading iron ore producing countries of the continent. For a long time the USA has retained its supremacy in iron ore production, but the production is declining in the recent years. In contrast to the USA, the other two countries are steadily increasing their output. However, these three countries still account for nearly 17 per cent world output of iron ore. Iron ore mining in the continent has been intensified following the rapid industrialization in the North-Eastern part of the continent.

(a) **The USA :** Iron ore is mined in as many as 22 States in the country but Lake Superior district outranks all other regions, accounting nearly three-fourths of the country's output. Four important iron ore producing regions can be distinguished in the country, namely :

(i) **The Lake Superior District :** The Lake Superior district is, by far, the most important iron ore producing region in the country, where the rich deposits of iron ore occur in six major regions or ranges. These ranges include Mesabi, Vermillion, Cuyuna, Menominee, Gogebic and Marquette Ranges. Of these six ranges, Mesabi is the most important and has maintained its superiority since 1909. Even after 81 years of intensive exploitation, the deposits seem to be inexhaustible. Mesabi yields predominantly hematite ores that usually occur in long low ridges. The regional superiority of the Mesabi Region is due to a number of factors, such as : vast deposits of high grade iron ore; shallow depth of the iron bearing strata favouring open pit mining; high degree of mechanization; easy means of transhipment of ores to the consumption centres, etc. The mines remain closed during the winter months of the year because of heavy snowfall and, therefore, the production is restricted in the summer months. This has adverse bearing on the bulk output of the region. Other ranges in the lake region mine soft hydrated hematite.

Because of long exploration, the deposits are nearing exhaustion more specifically in Gogebic and Cuyuna mines and require artificial treatment for large-scale industrial utilisation. This increases the cost of production and favours import.

(ii) **The North-Eastern District :** The North-Eastern region contains some of the oldest iron ore mines in the country, where iron is mined from two principal areas, namely—Adirondacks region of New York and Cornwall area of Pennsylvania. Bulk of the ore of New York is mined from open pits and is mainly magnetite of very high quality. Most of the deposits of the region lie very close to the iron ore smelting centres of Pennsylvania and New York that facilitate exploitation.

(iii) **The South-Eastern Region :** Birmingham, Alabama is the only important mining area of the South-Eastern region. Alabama alone accounts for nearly 10 per cent of country's iron ore. Hematite and limonite are the principal grades of ore. The region as a whole is favourably located near the South Appalachian coalfields and nourish the iron and steel centres of the Birmingham itself.

(iv) **The Western Districts :** The Western district include many dispersed fields in Western United States—in the States of Nevada, Utah, Wyoming and California. The region produces nearly 14 per cent of the country's output. The mines in this region are relatively new and yield high grades of ores for the local manufacturing industries. Some amount of ore is also sent to Japan from this region.

(b) **Canada :** In Canada, iron ore deposits are mainly concentrated around the Lake Superior region at Ontario. Significant deposits of high grade ore also occur at Qubec-Labrador trough in Newfoundland region. The ore mined in the Newfoundland region is of hematite grade that contains nearly 51 per cent of metal on an average. The coastal location of the fields greatly favour the export to the countries like Great Britain, Germany and Japan. In Ontario, there are several fields that lie to the North and East of Lake Superior. The deposits are moderate in size and produce ores of varying grades. Steep Rock Lake and Michipicoten are two most important fields of the region.

Canada is one of the leading exporters of iron ore in the world market. Nearly 86 per cent of her output is meant for export. The USA is the largest buyer of Canadian ore though a substantial amount goes to Japan and many European countries.

8.5.2 Iron Ore Mining in Europe

Iron ore is mined in nearly every country of Europe but her output has declined in the recent years. The European countries are increasingly depending on exports from non-European sources to cater their huge demand. Incidentally, all the industrially advanced nations of Europe consume nearly 40 per cent of world export of iron ore. The principal iron ore producers of the continent include France, Sweden, Germany, Great Britain, Spain and Luxemburg.

(i) **Sweden :** Sweden is by far the largest European iron ore producer, contributing nearly 4 per cent of the world output. The largest deposits occur at Kiruna and at Malmberget mine near Gallivare. Sweden produces very high grade of magnetite ore that contains nearly 60 to 65 per cent of iron.

The mines at Kiruna are very old and both open pit and modern underground mining methods have been adopted there. The reserves are really vast by any standard and meant for export to other European countries. Sweden earns a sizeable revenue through the export of iron ore, mainly to the neighbouring countries like France, Germany, Holland and Spain. There are numerous other small mines in Sweden, which produce considerable iron including Dannemora and Grangeborg. The ores of these mines are of very high grade with low phosphorous content but the output is lowered because of difficult shaft tunnel mining method. Most of the output of the region is used within the country.

(ii) **France :** Next to Sweden, France is the second largest producer of iron ore in Europe that yields nearly 3 per cent of global iron ore. The chief producing region of iron ore in France is the Lorraine district that ranked second only to the Lake Superior region during the pre-War years. The Lorraine ore is known as minette

and is of inferior grade which contain about 40 per cent of iron. The deposits occ in gently inclined sedimentary rocks and favour easy mining. One of the ba advantage of Lorraine ores lies in the fact that ores are of self-fluxing variety a therefore, the cost of smelting is saved to a great extent. Mining centres principally located at Briey, Longwy and Metz-Thionville, but the production gradually declining. France has to import increasing amount of high grade iron mainly from Sweden, which is mixed with poor Lorraine ore to upgrade its quali Other small and scattered deposits also occur in Normandy and Pyrenees.

(iii) **Germany :** The Western part of the newly united Germany has rich ore depos to the South-East in the Sieg and Lahn river areas. These deposits lie very close the rich coal deposits of the Ruhr region which is an added advantage of the regi favouring intensive industrialization. However, the ores are of a low grade, with average metallic content of less than 30 per cent. Iron seams usually occur at great depth, making mining expensive. Many of the mines have been abandoned the recent years both because of high production cost and inferior grade. Germa has to import a very large quantity of iron ore to meet her demand.

(iv) **Great Britain :** Despite the fact that the iron ore deposits of the country ha been exploited for a long time and the majority of the economically workab deposits have already been exhausted, Great Britain still manages to produce nea 30 per cent of her demand. The rest of the demand is met by imported ores. Nea the total output of Great Britain comes from two important areas : South of lower Humber River in the Northern part of Lincoln and in a belt from South Lincoln through Rutland, Northampton, and into North Oxford. The country yie low grade ore which has only 20 percent of iron. Deposits occur at relatively gr depths that also hinder production. The country has to import nearly three-fou of her demand from different countries of the world.

(v) **Belgium, Luxemburg and Netherlands :** Being located very close to famous ore deposits of Lorraine, Belgium and Luxemburg produce small quan of iron ore. These industrially advanced countries require huge quantity of Belgium has no significant ore deposits while Luxemburg is virtually devoid coal. Luxemburg's share comes from the Lorraine field which yield low grade fluxing ore. In Belgium, the major iron and steel works are located at Charleroi Liege regions which obtain ores from the foreign sources. The Netherlands import ores to meet her demand.

(vi) **Spain :** For many years Spain has been an outstanding producer of iron ore Western Europe. Rich deposits of iron ore occur around Bilbao, Santander Oviedo. The deposits occur at a shallow depth that favour easy opencast min The fields are located very close to the coast, making ore handling easier.

8.5.3 The CIS

The CIS now ranks first in the world production of iron ore in the world. The cou deserves special mention in regard to her iron ore production because of at least two dis reasons : Firstly, the country accounts for about 25 per cent of the global output of iro and secondly, the Russian iron ore mining extends over either part of the country - Euro and Asiatic. The iron ore output of the country has been almost doubled since 1965. CIS output is increasing at an incredible rate and it seems quite probable that her pos will remain unchallenged for many years to come.

In the years before the Communist Revolution the country was a rather insignificant producer holding the fifth position in iron ore resources, estimating about 2,000 million metric tonnes. The Great October Revolution not only changed the economic infrastructure of the country but also the people's attitude towards resource development. As a result of which, the country today accounts for about 40 per cent of the estimated ore reserves of the country. Iron ore in the CIS is widely distributed. Nevertheless, the following four important regions may be identified.

The largest iron ore deposits of the European part of the CIS include the Krivoi Rog and Kerch Basins and the Kursk Magnetic Anomaly.

Soviet Iron Ore Production 1982

(Millions of metric tonnes of usable ore)

Rank	*Region*	*Output*	*Percentage of Soviet total*
1	Krivoi Rog	105	43
2	Kursk Magnetic Anomaly	40	16
3	Kazakstan	25	10
4	Urals	24	10
	Sub-Total	215	88
	Soviet total	244	100

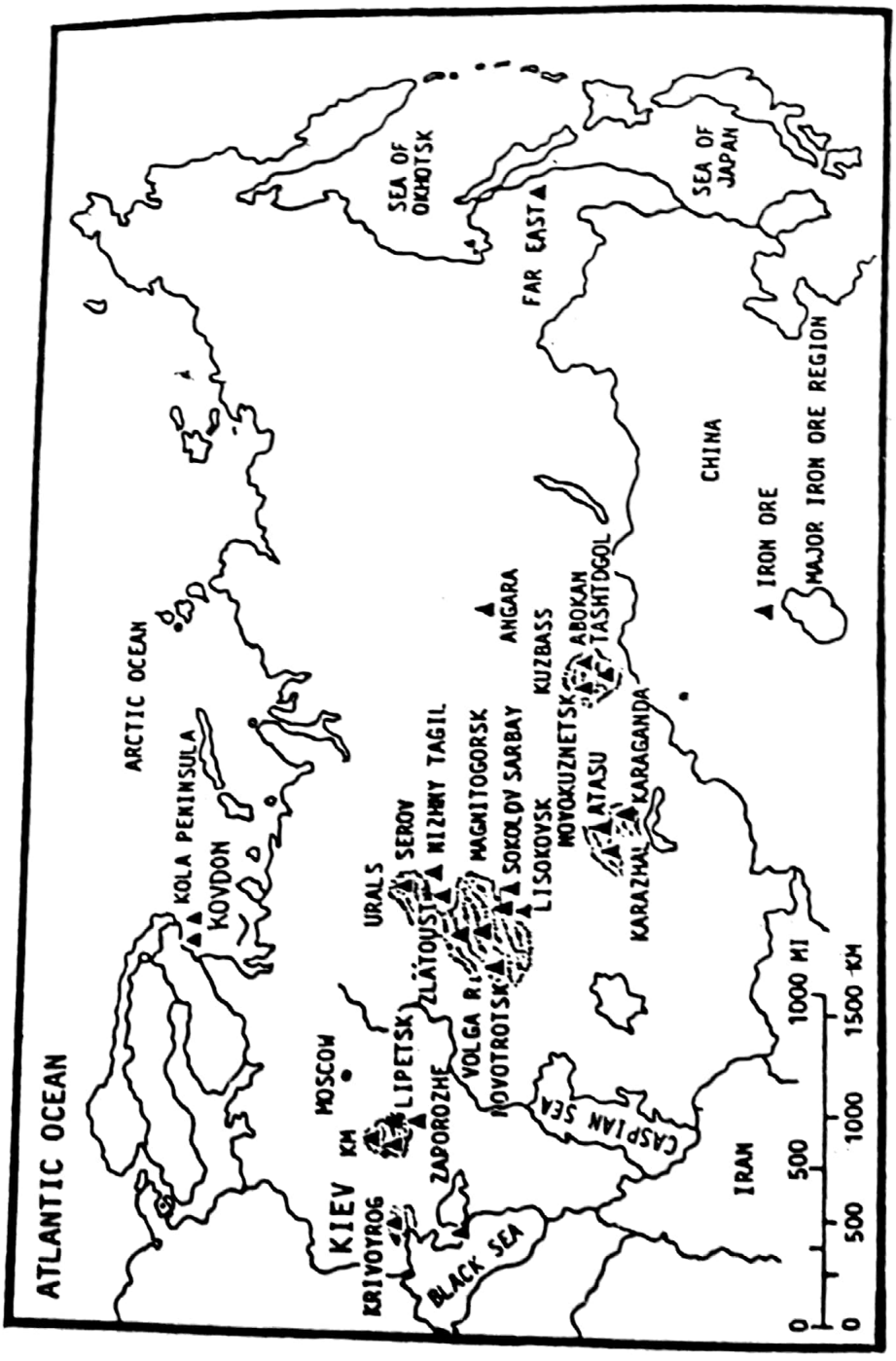
Source : Shabad, Theodore, 'Soviet Geography Review and Transition.

The Krivoi Rog region of the Ukraine is the largest iron ore producing region in the country with an estimated reserve of about 8,000 million metric tonnes. Iron ore in Krivoi Rog belt occurs at varying depths of 300 to 1,500 mts and has more than 300 deposits differing in form, size and gross output of ores. A number of associated factors, like its advantageous geographical position, with regard to efficient transportation network, proximity to coal and rich manganese deposits with the resultant development of intensive heavy metallurgical industries, have greatly contributed to the development of iron ore mining in this belt besides its excellent grades of ore. In recent years. the quality of ores has greatly declined and also the present output of the region. Nevertheless, the Krivoi Rog area on the Dniper River in the Ukraine still accounts for nearly 50 per cent of the country's output.

The Kerch iron ore basin, lying to the north-eastern part of the Kerch Peninsula, has substantial deposits of iron ore. In fact the Kerch iron ore contains other minerals like manganese, phosphorous, vanadium and arsenic and thereby reducing the proportions of iron content to a rather uneconomic percentage of about 25 per cent to 35 per cent. Here, shaft tunnel method is followed, instead of open pit mining method for the extraction of ores. The Kursk Magnetic Anomaly area has emerged as an important iron ore producing region in recent time. The region lies to the South-West of Moscow and covers an area of about 100,000 sq km. It includes the leading iron ore mining areas like Kursk, Belgorod, Bryansk, Orel, Voronezh and Kaluga. The region's output is expected to increase in the future.

In contrast to the European iron ore deposits, the Asiatic deposits are of recent development especially during the Soviet time. The iron ore deposits of the Eastern areas of the CIS are located in three main regions : the Urals, Eastern Siberia and Kazakstan.

The Ural iron ore field stretches for a much wider area in a belt from North to South, parallel to the Ural mountains. The region accounts for about 10 per cent of the country's total output. The most important iron ore deposits of Northern Urals include Bogoslovsk groups of deposits; in the Central Urals—the Baikal, Zigazino-Komarovskoye, Orsk-Khalilovo groups of deposits. In Kazakstan, a large number of iron ore deposits has been discovered. The region accounts for about 16 per cent of the country's ore deposits and 10 per cent of the total output. Extensive deposits of iron ore occurs at the Ayat Iron Ore Basin and Lisakov-ka area. The Kazakstan deposits are very extensive and will dominate the national output in future.



The Eastern Siberian deposits are distributed over an extensive area and yields a number of grades of ores. The most important deposits of the region are the Abakan, Irba, Tei and Krasuo-Kamenskoye groups in Krasnoyarsk Territory, the Angarallim iron ore belt in Irkutsk region and the South Alden deposits.

8.5.4 Iron Ore Mining in Southern Hemisphere

The countries of Southern Hemisphere are also notable both for their deposits and production of iron ores. The most important producers of Southern continents are: Australia, Brazil, Venezuela, Chile, Liberia, Angola etc.

Australia : Amongst the countries of Southern Hemisphere, Australia ranks first and is the third largest iron ore producer in the world. The country is noted both for her output and reserves. The bulk of the Australian output comes from the fields of Western Australia which include the mines like Mt. Goldsworthy, Mt. Whaleback, Mt. Bruce, Mt. Tom Price and Yampi Sound. These mines, however, have greatly increased their output in recent years. Iron is also mined in substantial amount at iron Knob in South Australia. Because of low internal demand the bulk of the output is exported, mainly to Japan.

Brazil : Brazil is noted for her vast ore deposits that lies mostly near the surface and has moderate to high metal content. The principal iron ore deposits in Brazil occur in Central Minas Geraes and in Western Mato Grosso near Crumb. The ores from the Minas Geraes meet the demand of local iron and steel mills and the large integrated steel plant at Volta Redonda in the Pariba Valley. The famous Itabira mines of the district exports millions of tonnes of iron ores through the newly established port at Vitoria. The iron ore deposits of Western Mato Grosso cater the demand of new pig-iron plant at Corumba. Brazil has surpassed the output of both USA and Australia with an estimated annual output of around 75 million metric tonnes of iron ore.

Venezuela : Next to Brazil, Venezuela ranks second in iron ore output in South America and has emerged as an important contributor to international iron ore trade in relatively recent years. The country is fortunate for having large deposits of high grade iron ores which occur in Guiana Highlands to the South of the lower Orinoco river. The bulk of the output comes from two most important fields—El Pao and Cerro Boliver. Venezuelan exports supplement the demand for the American iron and steel industry.

Chile : For a very long time Chile retained her position as the third largest South American iron ore producer. All the three large iron ore deposits in the country are found at La Serena. Chilean output of iron ore is very fluctuating in nature and the majority of it is meant for export.

Peru and Argentina : These two countries, though having relatively poor deposits of iron ore, are significant contributors to the South American total. These two countries together produce about 10 million metric tonnes of iron ore.

8.5.5 Iron Ore Mining in China

China's emergence as a leading iron ore producing country of the world is spectacular. J. S. Lee once commented—"China can never be an iron producing country of any importance". China has baffled the statement in every possible aspects and is now the fifth largest producer of iron ore in the world. The material transformation of China's economy, since Liberation, has significant bearing upon the nature and extent of mineralogical exploitation of the country. The gradual increase in the Chinese output of iron ore bears the testimony of such changes.

Being a highly mountainous country, China's principal iron ore deposits are highly dispersed in nature and complexities in geological structure are very common restricting the

large scale mineralogical exploitation to a great extent. In China, three principal iron ore producing regions can easily be distinguished :

(a) The Lower Yangtze Valley between Tayeh and Nanking which has numerous deposits of iron ore. The region has enriched magnetite and hematite ore deposits that contain 40 per cent to 52 per cent of metallic iron and a relatively small percentage of sulphur.

(b) The Shantung Peninsula, near Chinglinchen, has high grade ores containing about 60 per cent metallic iron and very poor percentage of sulphur. The ore is self fluxing in nature and occur in thick deposits. Proximity to Poshan coalfield makes the iron ore deposits of Shantung peninsula more valuable.

(c) Manchuria has fairly large deposits of moderate to low grade iron ores which required large scale treatment before use.

8.5.6 Iron Ore Mining in India

India is fortunate for having enormous deposits of iron ore. The estimated reserve stands at about 21,000 million tonnes. This vast reserve enables India to become one of the richest nations in the world in regard to iron ore. Indian ores are of very high grades containing mostly haematite and magnetite types and thus comprise of nearly 60 per cent of metallic iron which is substantially high as compared to any foreign ores.

Despite the fact that iron ore deposits are very widely distributed in the country, near about 90 per cent of the national output is contributed by the States of Goa, Madhya Pradesh, Orissa, Bihar and Karnataka. Maharashtra and Andhra Pradesh are other notable producers of iron ore.

Extensive deposits of high grade haematite iron ores occur in the Singhbhum districts of Bihar, Keonjhar, Bonai, Mayurbhanj and Sundargarh districts of Orissa; Durg, Bastar and Jabalpur districts of Madhya Pradesh; Ramgiri and Chanda districts of Maharashtra; Hyderabad and Kurnool districts of Andhra Pradesh; Bellary and Dharwar districts of Karnataka; Jhunjhunu and Sikar districts of Rajasthan and Mahendragarh district of Haryana. Significant deposits of high grade hematite ore has been discovered recently in the Kozhikode district of Kerala.

India has also high grade magnetite iron ore deposits which mainly occur in the Nellore and Guntur districts of Andhra Pradesh, Mandi district of Himachal Pradesh; Shimoga, Hassan and Bangalore districts of Karnataka, Salem and Tiruchirapalli districts of Tamil Nadu and Palamau district of Bihar.

Indian ores are generally of very high grade and, therefore, have high export value. India is, in fact, a surplus country so far as the production of iron ore is concerned and, thus, a substantial proportion of ore is exported each year. Japan is the largest buyer of Indian iron ore.

8.5.7 Japan

Japan has very small isolated deposits of iron ore estimating only about 40 million metric tonnes which is very insignificant in comparison to her demand. Moreover, Japanese ores are of very low grade and contains very low or negligible percentage of metal. Iron ore is mainly mined in Kamaishi and Senin of Honshu Island and Muroran of Hokkaido Japan's

low and poor deposits of iron ore have compelled her to import huge amount of iron ores and scrap iron from India, the USA, Australia, Philippines, and also some Latin American or South American countries.

8.5.8 Iron Ore Mining in Africa

In North Africa, Liberia, Algeria, Morocco and Tunisia are the leading producers of iron ore. Liberia is, by far, the largest producer accounting about 40 million tonnes per annum on an average. Because of the paucity of coal and other power resources, the bulk of the Liberian output is exported to the West European countries like the UK, France, Belgium and Germany.

In South Africa, the Union of South Africa has moderate to high grade of iron ore deposits that mainly occur in Transval. Following the development of new iron and steel centres in the region, the bulk of her output is consumed within the country with occasional exports.

8.6 IRON ORE RESERVES OF THE WORLD

"A survey of world iron ore deposits is so great a task that it can be undertaken only once in a great while, in the meantime the world moves on. Demand expands or contracts, the centre of economic gravity shifts, political borders shift and new regimes mean new politics and laws, transportation conditions change, new areas are explored, new processes are invented that turn the dust of the yester-year into the ore of today, and vice versa." This masterly statement by Zimmermann amply justifies the everchanging pattern of iron ore reserves of the world. The future hope for the existence of balance between the demand and supply of iron ore has brightened up, to a great extent, following the recent geological discoveries of new iron ore deposits in various parts of the world, which were unknown even sometimes ago. At present world reserve of iron ore is estimated at about 150,000 million tonnes.

8.7 INTERNATIONAL TRADE IN IRON ORE

It has roughly been estimated that about 30 per cent of global output of iron ore is meant for export and import. The countries leading in the production of iron ore are virtually the leading exporters in the world market. The exporting countries are Australia, Canada, Brazil, Sweden, Liberia, Venezuela, India, Mauritania, Chile and France. In 1900, the Australian Government imposed ban on export of iron ore considering the low reserves of the country. But following the geological explorations in recent years, the country's potential reserves have been proved to be much larger and the country's potential reserves have been proved to be much larger and the country re-entered in the arena, most gloriously, in 1971 and since then she has retained her supremacy in the export trade. The main customer of the Australian ore is Japan. Much closer location of these countries have greatly helped to establish long-term trade connections between them. Such agreement, however, has adversely affected India's export of iron ore to Japan. The following table shows the relative positions of the major exporting and importing nations of iron ore in the world.

Rank	Nation	Value	Percentage of world total
1	Brazil	1,800	27
2	Australia	1,500	22
3	Canada	789	12
4	India	474	7
	Sub total	453	68
	World total	6,455	100

Leading Iron Ore Importing countries, 1983
(Millions of US Dollars)

Rank	Nation	Value	Percentage of world total
1	Japan	3,245	45
2	West Germany	967	14
3	United States	631	8
4	Great Britain	355	5
5	Italy	349	5
6	France	312	5
	Sub total	5,859	82
	World market economy total	6,925	100

Source : UN Year Book of International Trade, 1985.

It is evident from the export data that Brazil has lowered down Australian supremacy in world export trade in the more recent years. This has been made possible as a result of discovery of iron ores in the Caragas region of Brazil, which has, perhaps, the world's largest high grade iron ore deposits. The bulk of the Brazilian export goes to the United States of America. Other major iron exporting countries include Sweden and Canada. Iron ore deposits in many of the underdeveloped countries are highly scattered in nature and is of secondary importance as an export commodity. In West Africa, however, iron ore is of great importance as a source of income from export, especially in Liberia and Mauritania.

As is revealed from the import data, Japan outranks all other countries, as the country's share of import is about 45 per cent of global total imports. West European countries are also heavily dependent on imported iron ores to run their industries. Because of the exhaustion of good deposit of iron ore in the country, the USA is gradually depending on high grade imported ores mainly from Canada and Brazil.

8.8 COPPER (Cu)

Copper was the first metal to be used by man though its importance declined greatly with the advent of the Bronze age. It recovered its lost glory again in the relatively modern

age following the development of electrical energy which uses copper as the principal metal. Copper is specially valued for its conductivity, ductility and resistance to corrosion. Copper is also used in great quantity as an alloy metal in the making of bronze, brass and cupronickel. Ductility makes possible the fine copper wire which has now become essential in electrical equipment. It has been noted that electrical industry alone consumes nearly 30 per cent of the global copper production. The automobile industry, too, consumes a significant proportion of copper.

Copper ores vary greatly from native copper to complex chemical combination and are obtained from rock formations of nearly all geologic ages. In comparison to the iron minerals, copper minerals are more complex and usually occur in veins within the country rocks. Moreover, it contains a very high percentage of impurities known as gangue. It has been seen that even the most important mines yield copper which contain less than 1 to 3 per cent of metal. This is for its low recovery percentage, the copper smelters are mostly concentrated within the closest proximity of the copper mines so that the transportation cost is greatly minimised.

8.8.1 World Distribution of Copper

Copper is found in several countries, though over 80 per cent of the global output is obtained from seven major countries widely scattered from each other. The following table shows the present pattern of copper production in the important countries.

Copper Production in Major Countries 1977-1992

[In '000 metric tonnes]

Country	*1977*	*1982*	*1987*	*1992*
Chile	1,056·5	1,242·2	1,412·9	1,940·0
USA	1,364·8	1,147·0	1,243·6	1,760·5
Canada	780·9	612·4	794·1	764·2
Zambia	652·2	574·5	463·2	440·0
Poland	284·8	376·0	438·0	387·0
China	99·8	175·0	250·0	375·0
Russian Fedeation				375·0
Peru	350·1	353	417·6	368·1
Kazakhstan				350·0
Australia	220·1	245·3	232·7	326·0
Ten Countries Total	5,666	5,286	5,882	7,085·8
World Total	7,716·4	7,622·3	8,306·3	9,289·6

THE UNITED STATES OF AMERICA

The United States is one the most important producers of copper in the world today and accounts for nearly 17 per cent of the world output. In a country like the United States with so much of diversities, both in physical setup and geologic formation, the significant copper deposits are eventually scatteredly distributed. Yet, five States, namely Arizona, Utah, Montana, Nevada and New Mexico, jointly produce nearly 90 per cent of the country's

output of copper and, therefore, outranks all other States in this regard. Other States with significant output are Michigan and Tennessee.

Arizona is the outstanding copper producing state of the United States, with an annual output of 500,000 to 600,000 tonnes. The greatest concentration of copper mining is seen in the South-Eastern part of the district from the Mexican border northward, beyond Tucson. The leading copper mining areas in the State are Morenci, Globe, Miami, Bisbee and Ajo. Apart from these districts, copper is also mined in a number of smaller districts. It is because of the joint output of both the large and small districts of the states that have enabled Arizona to retain its unquestioned supremacy among the copper producing states in the country.

Next to Arizona, Utah ranks second where copper is mined from the Bingham Canyon district, which is the single major copper producing district of the United States. It yields very low grade ore with an average recovery percentage of less than 1 per cent. The output of the region has declined greatly in the recent years, particularly since the World War II.

Montana has retained its position for a long time and is the third important copper producing state in the country. In Montana, copper mining is most important at Butte, where workings are underground and are also very large in size.

Nevada, New Mexico, and Michigan are the other important copper producing States of the country and are almost of equal importance. Nevada and New Mexico are relatively new areas in this regard, while Michigan is an old producing district which was once the most important producer of copper in the country prior to the rise of the Arizona region.

Canada : Like the United States, Canada too, is characterized by widespread occurrences of copper ores, from Newfoundland and Nova Scotia to British Columbia and the North-West Territories.

The most significant copper producing regions of the country include the mines of the Sudbury Basin of Ontario and Quebec, which together account for about 83 per cent of the country's total output. The nickel-copper mines of the Sudbury basin usually produce about 50 per cent of Canadian output and is, by far, the single largest producer of copper in the country.

In Western Quebec Province, copper is mainly mined from Noranda and some other small deposits. This is the second-m Th important copper producing region of the country and yields copper that contain nearly 5 per cent of metal. Copper is also mined from the Gaspi Peninsula, the Flin Flon and other mines of northern Manitoba-Saskatchewan regions, where copper is mined along with zinc, lead, gold, silver etc. Availability of cheap hydro-electric power from the Southern part of the Laurentian Shield has facilitated copper mining in this part of the country. Canada is an important exporter of copper in the global market, the bulk of which goes to the United States and the West European countries.

COPPER MINING IN SOUGH AMERICA

Despite the fact that copper is mined in a number of countries of South America, Peru and Chile are, by far, the most important producers of copper in the continent.

Chile has a very rich heritage in the history of copper mining, though great modern expansion of the industry took place only in the years following the World War I (1914–1918). Chilean mines are widespread in their locations and yield substantially high grades of

ore. The bulk of the output comes from the three big mines that account for nearly 90 per cent of the country's total output. The Chuquicamta mine alone supplies about 50 per cent of country's output. This field is located within the desert at an altitude of 3,000 metres. This causes a great problem for the further expansion of the region.

The other important copper mining areas of Chile include El Teniente and Potrerillos. Like Chuquicamta, El Teniente too is located within the high rugged mountains which adversely affect the output of the region. El Teniente has an abundant reserve of copper of comparatively high grade. Chilean mines are being explored by British, French and Japanese companies. Most of the output is exported.

Peru : Peru is long known for its copper output and presently is the second largest South American producer that accounts nearly 4 per cent of global output. Cerro do Pasco in the Central Cordillera, Morococha in the Western Cordillera and Casapalca on the western side of the Western Cordillera are the principal copper producing regions of Peru. These mines are operated by the Cerro Corporation, which has more recently opened a new mine at Toquepala in the desert of Southern Peru. Peruvian output is also meant for export.

AFRICAN COPPER REGIONS

Africa is distinctly marked with a number of important copper producing countries that include : Congo Republic, Northern and Southern Rhodesia and Republic of South Africa.

Messina, Nabadeep and Phalaborwa are the principal copper producing regions of the Republic of South Africa. Much of Africa's increasingly large copper production comes from the world's greatest copper region, a 500 km long belt extending from the northern part of northern Zaire, north-west across Katanga province of the Congo Republic. Formerly the Katanga and Rhodesian output was handicapped by distant location and the high cost of road transportation.

Zambia is a notable contributor to global output, accounting for nearly 10 per cent. The main mining centres are Nechanga, Kitwe and Mufulira in Zambia. Zambian ore is of very high grade and is easily mined by simple open-pit method. Almost all the African output is exported.

COPPER IN THE CIS

Copper production in the former USSR has greatly increased in the years following the Communist Revolution. The country is fortunate for having substantially large deposits of copper that have been discovered more recently during the Soviet time. Large deposits of copper occur in Central and Northern Kazakhstan, Urals and Eastern Siberia. Small but economically important deposits also occur in Uzbek and Armenia.

The Urals produce very high grades of pyrite ore from the deposits like Degtyarsk, Krasnouralsk, Kirvograd, Sibai, Uchaly, Gai and Blyava. The Ural region has retained its supremacy for a very long time though most of its easily workable deposits have been exhausted. With the decline in output of the Ural region, Kazakhstan has emerged as the most important copper producing region where the significant deposits occur at Kounradskoya and Bozshakul regions. In Uzbek and Armenia, copper ores are obtained from Almalyk, Kazharan and Agaraki deposits respectively. The Siberian output mostly comes from Norilsk that produces copper from very low grade ores of complex composition. Some copper is recovered as a by-product of nickel production on the Kola Peninsula.

COPPER PRODUCTION IN EUROPE

Europe is insignificant both in regard to deposits and output of copper in the world. Yet copper mining has been carried on for more than 2,000 years in Southern Spain. Spain still produces from the Rio Tinto area North-East of the port of Huelva. Other important copper producers of Europe are former Yugoslavia, Finland, Germany (Harz area) and Sweden. The total European output, except the CIS, is very insignificant.

OTHER IMPORTANT COPPER PRODUCERS

Japan is the principal Asian producer of copper followed by the Philippines, Turkey and Cyprus. Philippines has achieved a fast rate of growth of its output in the recent years. Cyprus is one of the most ancient centres of copper mining but presently yield a small amount. In India, copper mines are very scatteredly distributed in a number of States. The principal copper belt of India is located in Singhbhum and Hazaribagh districts of Bihar. Other important areas include Agnigundala in Andhra Pradesh, Malanjkhand in Madhya Pradesh, and Khetri and Dariba in Rajasthan. Because of her very low output, India has to import copper to meet her increasing internal demand.

THE OUTLOOK

In view of the recent trends in the pattern of copper consumption in different parts of the world, especially in the most advanced nations like the United States, producers are gradually becoming concerned with developing new uses of copper to counteract the keen competition of aluminium, steel and plastics.

It may pose a great problem in the future to meet the expanding needs of the growing population and of rising industrialization and electrification of the less developed countries of the world. To satisfy such demand it will be necessary to find new deposits; to develop more modern devices to extract copper from the inferior grades of ores; to find ways of minimizing the use of copper, and to encourage the use of alternatives or substitutes.

INTERNATIONAL TRADE

Copper is subject to a substantial geographical movement both intranational and international, since the majority of the producing areas lie far away from the great industrial nations. Amongst the leading buyers of copper Japan ranks first, accounting over 70 per cent of the global imports. Germany ranks second with only 13.5 per cent and the USA third with about 4 per cent.

Exact export data for copper are still lacking. Yet, according to the UN Source, Canada is the most important exporter followed by the Philippines, Chile, Australia, Indonesia and others.

8.9 BAUXITE

Bauxite is the chief source of aluminium, highly abundant metal, and constitutes nearly 6 per cent of the earth's crust. Bauxite is not a pure mineral and therefore, tends to be associated with clay limestone rocks. Bauxite is formed as a function of deep seated weathering of country rocks which is a very common feature of the tropical and sub-tropical latitudes. The heavy and uninterrupted downpour in tropical and sub-tropical regions leads to rapid leaching of silica and finally give rise to hydrated oxide or bauxite. It is interesting to note that a rock with low silica content may transform into bauxite than a rock with high silica

The vast majority of the bauxite deposits occur, therefore, within the tropical latitudes. Here leaching causes removal of silicious materials from the top layer to the bottom. Many of the present day bauxite deposits also occur in areas where, in the geologic past, the climate was, perhaps, more hot and humid than it is at present. The presence of bauxite in the United States (Arkansas), France, Hungary exemplifies the fact that they must have had warm tropical climate in the past.

As it has been noted earlier that bauxite does not occur pure in nature, it contains about 55 to 60 per cent of aluminium oxide. Even oridinary clays account for nearly 20 per cent of aluminium, but the lack of modern technology hinders the exploitation from such deposits.

USES OF ALUMINIUM

Aluminium plays an important role in the present-day civilization. It is the most commonly used metal after steel because it is tough but light and malleable. Aluminium is a good conductor of heat and, therefore, can be used as an important substitute for copper. It has a wide range of uses.

(a) Industrial uses : Aluminium, derived from the bauxite ores, is light, cheap and tough; that enables aluminium to be used for various structural purposes where lightness of the fabricated goods is of utmost importance. Aluminium is, therefore, used in the construction of aircraft, automobilies, rail wagons, household appliances, ships etc.

(b) Elecctrical Engineering : Aluminium is a good conductor of heat and electricity which permits it to be used in electrical engineering industry. Since aluminium is cheaper than copper, it is rapidly replacing copper in the electrical industry.

(c) Paint : Aluminium is very resistant to corrosion which favours its use as a protective layer to many metals including iron. Anodized aluminium is largely used in the fabrication of doors, windows etc. Aluminium paint is also used to fight against corrosion.

(d) Aluminium alloys : When mixed with other metals, aluminium produces different grades of alloys which are of great commercial significance. Such alloys are being used in increasing amount for a number of fabrication jobs.

WORLD DISTRIBUTION OF BAUXITE

It has been noted earlier that climate plays a decisive role in the occurrence and distribution of bauxite deposits. So, most of the world's greatest bauxite deposits occur in the tropical and sub-tropical lands.

The most important bauxite producing area is seen in and around the Caribbean Sea, although Australia, lying far away from this region, is the most outstanding producer of bauxite in the present-day world. Australia alone accounts for nearly 30 per cent of global output, followed by Jamaica (15 per cent) and Guinea (14 per cent). Other significant producers include Surinam, the CIS, Guyana, Hungary and the USA.

The following table shows the production of bauxite in some of the important countries of the world.

Bauxite (Aluminium) Production in Major Countries 1977-1992

[In '000 metric tonnes]

Country	*1977*	*1982*	*1987*	*1992*
Australia	23·3	23·6	34·1	39·95
Guinea	10·11	11·83	13·5	13·77
Jamaica	10·21	8·38	7·66	11·3
Brazil	·89	6·29	8·75	10·8
India	1·35	1·85	2·74	4·48
Russian Federation	—	—	—	4·00
Surinam	4·29	4·2	2·6	3·25
China	1·07	1·5	2·4	3·00
Guyana	2·44	1·78	2·78	2·3
Greece	2·66	2·85	2·47	2·1
Ten Countries Total				94·95
World Total				103·62

BAUXITE MINING IN AUSTRALIA

Australia ranks first in the global production of bauxite and accounts nearly 30 per cent of the world output. The country is fortunate to have nearly 40 per cent of world reserves of bauxite. The most important deposits occur near Weipa, on Cape York Peninsula. Here lies the world's largest bauxite deposits which is nearly 3 to 8 ms. thick and extends over a large area. Because of light over-burden, bauxite is mined by simple open cast method. Bauxite exploration in the region started under the leadership of Commonwealth Aluminium Corporation whose prime objective was to produce alumina for export. Apart from the Cape York Peninsula, significant proportion of bauxite is also obtained from the deposits of North-Eastern New South Wales and Perth in Western Australia. The bauxite of these regions is of low grade. Australia is also a leading exporter of aluminium in the world market. The notable buyers of Australian aluminium include the highly industrialized countries like Japan, the United States of America, Canada and France. Nearly two-thirds of her output is exported.

BAUXITE MINING IN SOUTH AMERICA

Some small countriess of tropical South America around the Caribbean Sea are also the significant producers of bauxite in the world. Such countries include Jamaica, Surinam and Guyana. Jamaica has emerged as a leading producer of bauxite within a comparatively short span of time and presently supplies nearly 15 per cent of global bauxite output. Much of the Jamaican ores lie at a very shallow depth that favours surface mining. Jamaica outranks all other countries in the world so far as the export of bauxite is concerned. Bulk of the Jamaican export goes to the United States and Canada. Two other Caribbean Islands, namely Haiti and the Dominican Republic, produce smaller quantities of bauxite.

In South America, bauxite mines are concentrated in Surinam and Guyana. Bauxite ores are found within the igneous and metamorphic rocks that constitute the basement of the Guyana Shild. The seams of bauxite ores stretch into Brazil and Venezuela as well. Throughout the region, climatic conditions are very much favourable for the formation of bauxite and thus the region has substantial deposits of high grade bauxite ores; but, owing

to very low local demand, much of the region's bauxite reserves remained unexplored even in the recent past. The situation is better now compared to the past, as the bulk of the output enters export market.

BAUXITE MINING IN WEST AFRICA

In West Africa, large reserves of bauxite have been discovered in Guinea and Ghana. Of these two countries, Guinea is more important producer and ranks third in production of bauxite in the world that accounts nearly 14 per cent of the world output. Guinean production started in late fifties and by 1962 the country emerged as an important bauxite producer. The output of these two countries is expected to increase by many times in near future.

BAUXITE MINING IN THE CIS

Amongst the light metallic metals bauxite is of paramount importance in the CIS. The country accounts for about 5 per cent of the world total. Deposits of bauxite in the CIS have been found in the Urals (the Severouralsk deposit in Sverdlovsk Region, Chelyabinsk) Kazakstan (Turgai deposit), the North-West (Tikhvin deposit), Western and Eastern Siberia. Soviet bauxite deposits now yield much lesser grade of bauxite and, therefore, she feels the necessity of importing high grade ores of bauxite. Guinea, incidentally, serves as a major bauxite supplier to the CIS together with Former Yugoslavia and Greece. The country also imports alumina from Hungary and Caribbean sources.

BAUXITE MINING IN THE UNITED STATES OF AMERICA

The United States of America has virtually very low proportions of world reserves of bauxite, amounting to only 1.2 per cent and produces about 7 per cent of bauxite. The deposits are scattered in their locations and the majority of the country's output comes from Arkansas, that alone produces about $\frac{2}{3}$ rd of country's output. A small percentage of country's output is obtained from Georgia and Alabama. In comparison to the country's domestic output, the demand for bauxite is very high; therefore, the country has to import good quality bauxite from the adjoining countries.

BAUXITE MINING IN EUROPE

Europe has very small reserves of bauxite. The important European producers include—France, Hungary and Yugoslavia. France has substantially large deposits of high grade bauxite ores at Brignoles, north-east of Tulon. The country produces near about 2 per cent of world total. Hungary is also important for bauxite production as she contributes about 5 per cent of the global total. European countries are notable for imports of bauxite mainly from African and Latin American sources.

BAUXITE MINING IN INDIA

India is self-sufficient in respect of her bauxite deposits and production. India has an estimated reserve of about 250 million metric tonnes, the bulk of which are located in Palamau and Ranchi districts of Bihar; Surguja, Shahdol, Jabalpur and Bilaspur districts of Madhya Pradesh; Salem, Madurai and Nilgiri districts of Tamil Nadu; Kolhapur, Ratnagiri and Kulaba districts of Maharashtra; Jamnagar, Kutch and Surat districts of Gujarat; Kalahandi and Sambalpur districtrs of Orissa; and Poonch, Raisi and Udhampur districts of N.W.India.

8.10 FERRO—ALLOY METALS

Chromium

Chromium is an important Ferro-Alloy metal. It occurs mainly in the form of iro chromate or chrome iron ore. Characteristically, chromium is hard, silvery in colour an metallic in lustre. It constitutes a very insignificant proportion of only 0-02 per cent of th earth's crust. It takes a very high polish and does not gather rust. It is, therefore, mo widely used in the metallurgical industry.

Being an important ferro-alloy, metal chromium's main uses are as follows :

(a) Chromium is an essential element for making stainless steel that contains nearly 1 per cent of chromium and 8 per cent of nickel. Chromium steel is used, in turn, in makin kitchenware, household fittings, surgical apparatus and chemical equipments. Chrome stee is also largely used in manufacturing various sophisticated grades of engineering items.

(b) Chromium is also used for plating on nickel or iron and steel plate to improve thei durability and resistance to corrosion and rust. Such chromium-plated items are used in grea proportions in automobile industry.

(c) Superior grades of alloys, such as nickel-chromium alloys, are also produced by using chromium as an important raw material.

(d) It has been noted earlier that chromite occurs mainly in the form of chromate o iron, which is used for making refractories for lining furnaces of steel plants.

(e) Chromium salts and compounds are important raw materials for manufacture o paint pigments. Chromates are also used in leather industry as a tanning element.

DISTRIBUTION OF CHROMIUM

Chromium deposits are widely scattered in different parts of the world of which two countries—namely the South Africa and the CIS—are most important. These two countrie jointly account for nearly 50 per cent of the global output. Other important producers o chromite are Turkey (8 per cent), Alabania (9 per cent), Brazil (8 per cent), Finland (5 pe cent), India (4 per cent) and Philippines (4 per cent).

South Africa presently ranks first in chromium production that accounts for nearly 3 per cent of the global output. The principal chromite deposit occurs at Rustenburg. I Zimbabwe, high grade of chromite is obtained from Selukwe and Kildonan. Because of low domestic demand, the bulk of the output is exported.

The CIS is also an important producer of chromite. The country is vastly endowed with chromite deposits of which the most significant deposits occur in the Ural region and i Kazaksthan.

India is also important for chromium production. It produces nearly 4 per cent of the global output. The principal deposits occur in Cuttack and Keonjhar districts of Orissa Bhandara and Ratnagiri districts in Maharashtra, Singhbhum districts of Bihar, Mysore and Hassan districts of Karnataka. Other important deposits also occur in Krishna district o Andhra Pradesh and Salem district of Tamil Nadu.

The United States of America, once a leading producer, is not so important so far as the output of chromite is concerned. It has very small deposits that yield inferior grades of ore Incidentally, the United States imports nearly 30 per cent of world output of chromite, the bulk of which comes from the South African countries.

TUNGSTEN (W)

Like chromium, tungsten too has become almost essential in present day metallurgy, more specifically in the manufacture of alloy steels. It is a heavy metal and melts at a very high temperature of about 3,375°C. In present day, industrial world importance of tungsten cannot be ignored. Due to high hardness and corrosion resistance power, its use is gaining momentum day after day.

Wolfram or Wolframite is the chief source of tungsten, that mainly occurs in veins in association with tin cassiterites. Scheelite and hubnerite are the other chief sources of tungsten.

Tungsten is very tough and, therefore, it is most widely used in making steel alloys for the manufacture of very high speed cutting tools. Tungsten carbide is much harder and is used in the cutting edges of machine tools, razor blades and armour plates etc.

Generally, the most known use of tungsten is as a filament in electric (light) bulbs. Tungsten is highly resistant to electric shock and has very high melting point that enables it to convert electricity into light most efficiently. It is important to note that no satisfactory substitute for tungsten in this regard has yet been discovered.

DISTRIBUTION OF TUNGSTEN

Geologically, tungsten ores occur only within rocks where mineralization has taken place under both high pressure and temperatures. Geographically, the principal deposits of tungsten are found in nearly 40 countries of the world, of which only five countries are of outstanding importance. Countries like China, the CIS, the Korean Republic combine to produce nearly 75 per cent of the output of usable tungsten.

China has long been noted for its supremacy in tungsten production and accounts for nearly 22 per cent to 25 per cent of the global output. The output mostly comes from the wolframite grade of ores that yield tungsten of very high quality. Initially the bulk of the country's output used to be obtained from the veins and placer deposits, which has been currently replaced by underground mines. The majority of the deposits occur in the Nanking Mountains of Southern China. The Hunan and the Kiangsi provinces are the most important regions. In 1980, China produced about 11,000 metric tonnes of tungsten. The country is using increasing proportions of tungsten for the production of high grade steel alloys. The country is fortunate to have very large reserves and it is expected that the country will probably retain its supremacy for some decades to come.

Next to China, the CIS ranks second in tungsten production that accounts for nearly 20 per cent of the world output. The most important tungsten deposits in the CIS occur in Eastern Siberia, Central Asia, Kazakhstan and North Caucasus regions. The bulk of the output is consumed within the country.

The United States of America presently ranks third along with Bolivia and South Korea in tungsten production. Each of these countries accounts for nearly 7 per cent of the world production of tungsten. In the United States, the major tungsten deposits occur in the following important regions :

(a) The Climax Mine, Colorado, where tungsten occurs in association with molybdenum.

(b) Mill city, Nevada.

(c) Tungsten ore at Pine Creek mine near Bishop, California.

(d) Hamme mine in Vance country, North Carolina, where tungsten is mostly obtained from wolframite.

(e) Calvert mine, Beverhead country, Montana and lastly,

(f) Other scatteredly located deposits.

The country's demand for tungsten is very high. So, the USA imports substantially high amount of tungsten from the countries of South America.

In South America, the principal deposits of tungsten occur in the countries like Bolivia, Argentina and Brazil. Bolivia produces about 7 per cent of the world output of tungsten. In Bolivia and Argentina, tungsten mostly comes from the wolframite mines high in the Rocky Mountain region. Mountainous location, adverse climate, lack of efficient transport network are some of the important reasons behind the backwardness of tungsten mining in these countries.

In South Africa, tungsten mining is important in the countries like Zaire, Rwanda and Burundi. These countries are the important exporters of tungsten in the world market.

In recent years, Australia has emerged as an important producer of tungsten in the world. It produces nearly 5 per cent of the global production. In Australia, because of its advanced economic condition, most of the tungsten mines are highly mechanized. Australian output mostly comes from the King Island where tungsten is obtained from the scheelite ores. The country is also a leading exporter.

In Europe, tungsten mining is important in Spain, Portugal, France and Sweden. Of these countries, Portugal is the most important one which yields nearly 5 per cent of world tungsten output.

NICKEL (Ni)

Nickel is a hard metal that constitutes about 0.005 per cent of the earth's crust. It is also believed that nickel makes up majority of the earth's inner core. Nickel is a silvery metal which does not gather rust. It is, therefore, very much useful for plating purposes. Nickel, as such, possesses some important properties like high hardness, high malleability etc. Pentlandite, a complex mixture of nickel, iron and sulphur, is the principal ore from which nickel is usually obtained.

Nickel is useful because of its diversified uses. The bulk of the output is consumed to make stainless steel. In the United States, nearly 40 per cent of her output is used for making stainless steel and other nickel steels. A little addition of nickel to steel makes it very tough and nickel alloy is largely used in manufacturing constructional machinery and transport equipments. High nickel steels, that contains about 35 per cent of nickel, is very resistant to heat and acid. It is important to note that the nickel steels are adapted to a wide specturm of uses, from cooking utensils and precision instruments to armour plates.

Invar is a special type of nickel alloy made up of iron and 36 per cent of nickel. This alloy has the property of minimum expansion at substantially high temperatures which makes it suitable to very high range of expansion. Nickel is also used for making coins. Nickel is resistant to corrosion and thus nickel plating is used extensively in the manufacture of food containers. Other important uses of nickel include the manufacture of radio transformers, telegraph relay parts, flame tubes, batteries and also space research articles.

DISTRIBUTION OF NICKEL

The distributional pattern of nickel is very localized in character than that of most other minerals. About 20 countries mine nickel in different corners of the world but only four countries supply about nine-tenths of the world nickel output. The following table shows the pattern of nickel production in the major countries of the world.

Nickel Production in Major Countries

[Output in '000 metric tonnes]

Country	*1977*	*1982*	*1987*	*1992*
Former USSR	144·3	165·2	272·0	
Russian Federation	—	—	—	215·0
Canada	235	88·6	189	192
New Caledonia	109	60	56·9	113
Indonesia	14	45·9	57·8	78
Australia	85·8	87·6	74·6	64
China	—	12	25	37
World	772·8	621·6	892·5	921·9

Source : UN Statistical Year Book.

It is quite evident from the above table that important countries for nickel production are widely separated from each other. Of these countries, Canada ranks first, accounting nearly 29 per cent of the world's nickel production. The CIS ranks second which produce about 21 per cent followed by New Caledonia (14 per cent) and Australia (10 per cent). The other important producers include Cuba, Philippines, Dominican Republic, South Africa and Indonesia.

Canada is the leader in nickel production in the world; that retained its supremacy since 1900. Even some decades ago Canada used to supply about 60 per cent of the global output, but following the development of nickel mining in different parts of the world, especially after World War II, Canadian output has declined to a great extent and the country presently produces nearly 30 per cent of the world's nickel. The Sudbury district of Ontario, Canada, is by far the most important nickel producing region from where the bulk of the Canadian output comes. Incidentally, this region is the world's largest nickel-producing area which is about 58 km long and 26 km wide. This region has about 20 active mines whose deposits are large enough to cater the world's needs for few more decades to come. It is worth-mentioning that due to the vastness of nickel reserves, Canada also dominates the world trade of nickel. The bulk of her nickel output is exported to the USA. Other important nickel mining areas are Lynn Lake region, Hope and Thompson-Moak regions in northern Manitoba.

Next to Canada, the CIS ranks second in nickel production and the country as a whole produces about 21 per cent of nickel. In the CIS nickel deposits are widely separated from each other. The main deposits of nickel ores are concentrated in the Murmansk, Orenburg, Chelyabinsk regions and in the Kazakh S.S.R. In the CIS the bulk of the nickel output comes from the magmatic-copper-nickel deposits. Norilsk (Krasnoyarsk Territory), Zhdanovsk, Kaula (Murmansk Region) and the Ukrainian S.S.R. are the principal regions

for magmatic nickel mining. Since the Second World War the Soviet Nickel output has greatly increased. The major nickel smelters are located adjacent to the nickel mines.

New Caledonia in the Pacific is the third largest producer of nickel in the world. This region emerged as an important producer only following the development of Sudbury district, Canada. New Caledonian reserves are supposed to be very large though they yield very low grades of ores. The bulk of the country's output is exported. Smaller but significant deposits occur also in a number of countries of tropical latitude where secondary deposits of nickel are formed by the laterization under very hot and humid climates. Such countries include Cuba, Brazil, Venezuela, the Celebes, Australia and others. Of these countries, Cuba and Australia are most important. Cuban output mostly goes to the CIS, while Australia exports to the United States as well as to many European countries.

Nickel is one of the most valuable metals as an alloy for ferrous and non-ferrous metallic products and is considered as a vital strategic metal for ordnance purpose. Of the super powers, the CIS is perhaps vastly endowed with nickel deposits, the bulk of which is supposed to remain explored. It is, therefore, believed that the country will probably retain its supremacy in the coming decades too. While, on the other hand, the countries which lack in the deposits of nickel ores will probably depend solely on imports.

MANGANESE (Mn)

Manganese is by far the most important ferro alloy metal and is essential to the production of high quality carbon steel. Manganese is also used to remove the oxide formed by the smelting of the iron. It has been estimated that manganese is one of the most abundant element in the earth's crust. Manganese is silvery in colour and occurs within iron ores. There are two important grades of commercially exploitable manganese ores. These are (a) Pyrolusite (MnO_2) and (b) Psilomelane, hydrated oxide of manganese. It is also found in nodular deposits on the continental shelves but only a very few advanced nations, including India, are in a position to exploit them. Manganese is derived from the ores by means of electrolytic process. In more recent years, manganese ores are being explored from the continental shelves which occur mainly in the form of polymetallic nodules.

MAJOR USES OF MANGANESE

Manganese, being an important ferro-alloy mineral, is used for a number of metallurgical purposes :

(a) The main use of manganese is as a ferro-alloy. Manganese, in fact, acts as an important cleanser in the manufacture of steel. Moreover, it adds to strength and toughness of the steel. It also helps to resist abrasion and, therefore, it is used in great quantities in making switches, railway lines, mining crushers etc.

(b) Manganese compounds are used in making disinfecting liquids, it is also used for making bleaching powder. The industries engaged in the manufacturing of electric batteries, potteries, tiles and bricks also use manganese.

(c) Manganese is also used in making copper alloys.

WORLD DISTRIBUTION OF MANGANESE

Amongst the principal non-ferrous metals, manganese has perhaps the most widespread pattern of distribution. It is found almost in every continent of the world though certain regions enjoy superiority over the others. The following table shows the production trend of manganese of the major countries of the world :

Manganese Production in Major Countries — 1971-93

(In '000 Metric Tonnes)

Country	*1971*	*1980*	*1993*
The former USSR	2,552	2,904	–
South Africa	1,368	2,348	2,810
Gabon	954	953	1,345
Brazil	1,264	1,268	1,235
Australia	374	862	1,160
India	681	668	1,875
China	303	300	–
Mexico	96	186	–

The data showing the production trend of manganese in major producing nations of the world clearly indicates that the former USSR, South Africa, Brazil, Gabon, Australia, India, and China are the most important contributors to world output of manganese. The other important producers include Mexico, Zaire and Morocco.

The CIS is one of the largest producer of manganese in the World. Manganese ores are mined mainly in two principal areas : Chiatura in Georgia, and Nikopol in Ukraine. The famous Bolshoi Tokmak manganese ore deposit has been explored near the city of Nikopol; this deposit equals in reserves to those of Nikopol deposit. Manganese is also obtained from a number of scattered deposits located in the eastern part of the country : Marsyaty, Polunochnoye, Nove-Beryozovskaye and Yurkino in the Urals; Dzhezdy in Kazakhstan, Usinskoye in Western Siberia, and the Malykhingan area in the Far East. Russian manganese ore is of moderate quality. The country accounts for about 30 per cent of world total.

South Africa ranks second with about 23 per cent of the global total. The bulk of its output comes from the Cape province. South African output is steadily increasing in the recent years. The majority of the producing areas lie far from the coastal area.

Brazil is also an important producer of manganese. Lafayette district is the principal manganese-producing region of the country. The Brazilian ores are low in metal content. Over three-fourths of Brazil's output is exported.

India is the sixth largest producer of manganese. India is fortunate in having extensive deposits of manganese, scattered in a number of states which include Madhya Pradesh, Maharashtra, Orissa, Andhra Pradesh, Karnataka, Bihar, Rajasthan and Goa.

At present, Orissa ranks first among the Indian States in manganese production. The principal manganese producing regions in Orissa are located at Gangupur, Bonai, Keonjhar and Sundargarh. In Madhya Pradesh, the principal deposits are located at Balaghat, Jabalpur, Chindwara and Jhabua. In Maharashtra, manganese is raised from Nagpur, Panch Mahals, Chhota Udaipur and Bhandara. Srikakulam and Vishakhapatnam in Andhra Pradesh; Bellari, Shimoga and Chitradurg in Karnataka, Kalhan, Singhbhum and Chaibasa in Bihar are important producers. Goa also produces huge quantities of manganese. India's output of manganese has gone up to a great extent in recent years following the establishment of a

9.15 COAL—THE PRINCIPAL POWER RESOURCE

Amongst the most well-known sources of energy, coal has long enjoyed a supreme position. It is rather difficult to say now whether man discovered coal only by chance or through a systematic means of exploration. But the record from history revealed that, relative utility of coal was perhaps known to the ancient Greek and Roman people. The real glorious journey of coal, as the chief source for generating heat and power, began following the invention of steam engine by James Watt in the 18th century. The mechanical or Industrial Revolution was, undoubtedly, made possible through the most rapid utilization of coal by the leading countries of the world, rich in coal reserve, namely the Great Britain. Even today, when we are technologically so sound to derive energy from a number of more efficient sources, coal still plays the pivotal role in the sphere of energy generation. It becomes customary to draw some correlation between the amount of reserves of coal and the degree of economic development of a country. Incidentally, with the exception of Japan, all other economically advanced nations in the present world, namely the United States of America, the CIS, Great Britain, France, Germany etc., have vast deposits of coal. The astonoising material progress made by these countries has depended more upon coal than any other source of energy.

There is no doubt about the fact that the relative importance of coal, at least as the main source of power, has substantially declined in the recent years, especially in the more economically advanced nations of the world where the other conventional sources of energy have also been developed. But in the underdeveloped or developing nations of the world, the relative importance of coal has hardly declined. So, there is a significant disparity in the relative importance of coal and its utilization pattern.

9.16 COAL—NATURE AND MODE OF ORIGIN

Coal can simply be defined as a solid, amorphous substance of organic origin comprising mostly of carbon of varying amount, and is mostly black in colour. The origin of coal dates back about 250 million years in the Carboniferous period. Geologists are of opinion that, during that time a kind of highly luxurious and dense vegetation was present in the wetter segments of the then Earth. Following the fluctuation in the sea level, the trees and plants were submerged leading to the heavy downpouring of silt, sand, mud and other substances of both organic and inorganic origin. It is also believed that, this process of submergence and emergence continued for a very long period until some successive layers of silt and decayed vegetable matters were formed. This, in fact, led to subsequent earth movements and thus the layers of buried vegetation substances were compressed very hard, and were changed into coal through the expulsion of oxygen and water. It is important to note that coal is a sedimentary rock and, therefore, it is found only within the sedimentary rock layers such as sandstones, limestones, and shales. Coal is neither found in highly compacted metamorphic rocks nor in igneous rocks. The bulk of the world's major and highly productive coal reserves are found within the gently folded sedimentary rocks.

9.17 MAJOR COAL TYPES

Coal is a carbonaceous rock and, therefore, the varying amount of carbon within a rock species can be considered as the basis for classification of coal. Accordingly, coal can broadly be classified into the following main categories :

1. **Peat** – Peat represents the most inferior grade of coal that has been formed only through the very limited degree of decomposition. It is fibrous in character and contains only

about 30% of carbon and a much higher proportion of moisture and other volatile matters. Thus, peat generates very little heat and plenty of smoke.

2. **Lignite Coal** – Lignite is popularly known as 'brown coal' because of its light brown colour. In fact, lignite represents only the second phase of coal development and, therefore, contains slightly higher proportions of carbon, which usually varies between 45% to 65%. Lignite also contains substantially high proportions of volatiles that delimits its industrial importance to a great extent. Moreover, it is rather difficult to tranship lignite to a very long distance, since it slacks readily when exposed to air. Following the exhaustion of more important grades of coal, lignite is being used in great quantities both for domestic and industrial purposes.

3. **Bituminous Coal** – Bituminous is the most widely used and available grade of coal that contains a much higher proportion of carbon, ranging between 60-80%. Bituminous illustrates the more advanced stage of decomposition and thus it is hard, compact and black in colour. The relative proportion of carbon may vary most significantly within bituminous rock leading to recognition of a number of sub-types such as steam coal, bunker coal, canal coal and coking coal. Bituminous shares nearly $\frac{4}{5}$ th of the global output of coal.

4. **Anthracite Coal** – Anthracite, however, represents the best quality of coal so far as the relative percentage of carbon is concerned. Anthracite usually contains more than 90% of carbon and almost little smoke. Anthracite deposits account for only 5% of global coal output.

9.18 ECONOMIC IMPORTANCE AND LEADING USES OF COAL

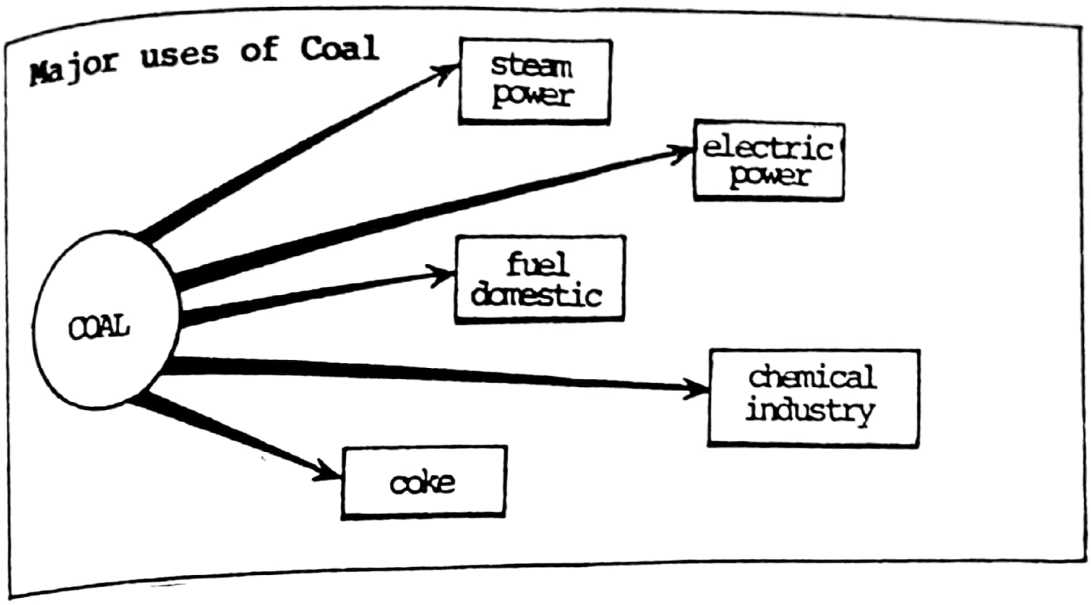
Coal is an indispensible source of energy. From the very earliest days of the Romans and the Greeks coal has been most successfully used as a domestic fuel, but following the rapid development of industries since the Industrial Revolution of 18th century, the magnitude of coal utilization increased substantially and the other ways of economic utilization of coal thus became apparent. The relative importance of coal in industrializing the human society can hardly be exaggerated. It has rightly been called the "mother of modern industry", It is highly questionable whether the advent of modern industrial societies would have been at all possible without coal. Even today, when the alternative sources of energy are very much known to us, the importance of coal can hardly be denied. The principal uses of coal can briefly be outlined in the following paragraphs.

(a) **Steam Energy** : Since invention of steam engine by James Watt, coal has become the prime source for generating steam in a great range of industrial production. In the initial phases of industrial development, coal had to play more important role than at present, because of the fact that almost all the machines were operated by coal. Transportation system, too, was dependent upon coal since railway locomotives and steam-ships used huge quantity of coal.

(b) **Electric Energy** : Coal is largely used to generate thermal electricity. In India, the bulk of the electricity is derived from coal. Coal is also used to produce coal-gas both for domestic and industrial purposes.

(c) **Domestic Energy** : Right from the beginning, coal is being used as a popular domestic fuel, though in the recent years its relative importance as a domestic fuel has greatly declined in most of the urban areas.

(d) **Metallurgical Coke** : Coal's relative importance as metallurgical coke is yet irreplaceable. Availability of coking coal is still considered as an essential pre-requisite for the development of iron and steel industry.



(e) **Chemical Raw Materials** : Besides its role as a major source of fuel, power and coke, coal provides us with some of the essential raw materials for chemical industry which include coal gas, coal tar, benzole, sulphate of ammonia etc. These, in turn, can produce a number of chemical raw materials essential for the development of certain branches of chemical industry. A great many by-products which are derived from coal include creozote, napthalene, anthracene, fertilizers, explosives, antiseptics etc.

9.19 COAL—GLOBAL PATTERN OF DISTRIBUTION

The principal coal-producing regions of the world are marked by a very uneven distributional pattern. Coal mining has become almost exclusively the monopoly of the countries of the Northern Hemisphere. Keeping in mind the location of the major coal mining areas and their spatial pattern, we can identify the following important regions :

(a) **European coal mining areas**— The great European coal trough extends from the United Kingdom across Northern France and Belgium through Germany and South Poland. The coal-fields of Spain, Central Plateau of France, the Saar Basin and Czechoslovakia. These are relatively small in size but are of great national importance.

(b) **The CIS**— The CIS is the world's leading coal producer and is, perhaps, the richest nation so far as coal resource is concerned.

(c) **The South-East Asian coal mines**— This region is comprised of the four important producers—China, India, Korea and Japan. Of these important Asian producers, China ranks first amongst the Asian nations and third in the world.

(d) **The North American coal belts**— The United States of America is the most important producer contributing about 85% of the continent's output. Other countries include Canada and Mexico.

The following table gives the coal reserves and production of the leading nations of the world.

World Coal Reserves and Production

(In 000,000 metric tons.)

Country	Reserve	Production 1980	Production 1992
China	1,600,000	490	1,095
USA	2,285,763	604	907·4
CIS	–	–	307·1
India	80,953	106	227
S.Africa	44,339	86	175
Australia	111,865	73	165
Poland	45,741	186	132
UK	162,814	122	87
Germany	230,304	90	72
Canada	–	–	32
World	**8,134,374**	**2,528**	

(Source : United Nations Monthly Bulletin, 1994.)

(c) **The coal belts of the Southern Hemisphere**—As noted earlier, the coal-fields of the Southern Hemisphere are not only small but also yield inferior grades of coal when compared to those of the Northern Hemisphere. Of the main producers, Australia ranks first. The other countries of significance include South Africa, Southern Argentina, South-Eastern Brazil, Central Chile and Colombia.

9.20 COAL MINING IN SELECTED COUNTRIES

9.20.1 The USA

The USA is one of the leading producers of coal and ranks second in current production with many widely scattered coal-fields having an estimated reserve of 2,285,763 million metric tons. The coal mining in the USA started much earlier than others, but the country emerged as a leading producer only in the 20th century.

The Coal-producing regions of the United States may be categorized into six major provinces. They include :

(a) The Eastern Districts.

(b) The Interior Region.

(c) The Gulf Coast Districts.

(d) The Northern Great Plains.

(e) The Rocky Mountain Region.

(f) The Pacific Coast.

(a) **The Eastern Districts** : The Eastern Province outranks all other coal-producing regions of the United States both in production and quality. It comprises of four of the five leading coal-producing states of the country : Pennsylvania, West Virginia, Kentucky and Ohio. Dominating coal producing sub-regions are :

(i) *The Pennsylvania anthracite field* – The North-Eastern Pennsylvanian field is the most productive coal region accounting nearly half of the global output of anthracite coal. In the past, production of this region was very high which has decreased substantially in the recent years. Largest production comes from Schuylkill and adjacent Luzerne countries, where the towns like Pottsville, Hazelton and Wilkes Barre are famous for coal mining. Small amounts are mined in part of Northumberland country and Lackawanna country. The bulk of the coal output is consumed within the region. The relative importance of this region has declined in the present time mainly because of the closure of marginal mines and also because of high cost of mining.

(ii) *The Appalachian bituminous fields* – The Eastern Province owes its economic superiority, however, to the extent of the Appalachian bituminous field and the high quality and accessibility of the coal deposits there. This region accounts for more than 50% of the USA's annual output. Three distinct sub-areas are recognized :

(i) The north part of Appalachian region contains some good quality coal mines. However, the early glory of this region as coal producer has gone. The region is now an insignificant producer.

(ii) The Central Appalachian field, resembles the Northern Appalachian in many respects and ranks second in output. This region lies mainly in Kentucky and West Virginia and clusters around Grand Kanawha.

(iii) The Southern Appalachian fields are scattered in Alabama and Tennessee and yield all the important grades of bituminous coal which has favoured the growth of iron and steel industry at Birmingham.

(b) **The Interior Region** : This is a major coal-producing region in USA, covering wide and extensive region. Entire coal belt may be sub-divided into two principal regions, namely Eastern Interior and Western Interior field.

Eastern fields comprise the coal-fields of Kentucky and Indian provinces. In the northern end of the mine zones are the Michigan coal mines. These coal mines have a relative advantage of a nearby market. The adjoining industrial cities provide ready market to the entire coal production. The Great Lakes and the Mississippi river provide easy transportation of the coal to the foreign markets.

The western interior fields produce better quality coal than its eastern counterpart. Like eastern coalfields, numerous types of coal are available here. In most of the coal seams, high grade bituminuous coal is intermingled with anthracite variety. The major concentrations of coal have been noticed in Iowa, Kansas, Oklahoma, Missouri and Arkansas. Compared to other coal regions of USA, here coal mining is very difficult. Due to high degree of past tectonic activities, most of the coal seams are inclined.

(c) **The Gulf Coalfields** : In the south-east, adjacent with Mexico border and Gulf of Mexico, this coal mining region stretches through Texas, Louisiana, Mississippi and Alabama. The average quality of the coal is not up to the mark.

(d) **The Rocky Mountain Region** : Comprising the Rocky Mountain and Northern great plains. Most of the coal deposits are of high grade bituminous, situated very near the surface. The coalfields are situated within Colorado, Wyoming and Washington.

(e) **The Pacific Coast** : This region is to the west of the Rockies. The western-most states of Oregon, Nevada and northern California mines provide some amount of coal. The total amount of coal extracted from these fields is insignificant.

At present, minimum amount of coal is extracted from Appalachian mines of the eastern province. The combined output of Kentucky, West Virginia and Pennsylvania accounts for about 46 per cent of the US output. The Rocky mountain area contributes one-fourth and the rest by western fields.

9.20.2 The CIS

The Former Soviet Union surpasses all other countries in the world in regard to its reserves and ranks third, next to the China & USA, in global coal output, which accounts nearly 20%. The Former Soviet coal mining industry has achieved a spectacular rise in the years since Revolution. Coal output has gone up steadily from less than 30 million tonnes in 1914 to 224 million tonnes in 1953, 420 million tonnes in 1967 and almost 500 million tonnes in 1980.

Presently coal is mined in nearly all economic areas of the country. At the same time the coal output of the Eastern Republics is increasing at a very fast rate. These mines of the East played very significant role during the Great Patriotic War when most of the important European coal mining areas were occupied by the Fascist invaders. The temporary loss of the important coal bases stimulated the growth of coal industry even in the sparsely populated Eastern territories. The major CIS coal-fields are as follows :

(a) The Donetz or Donbas Coal Basin.

(b) The Moscow-Tula Coalfields.

(c) The Kuznetsk or Kuzbas Coal Basin.

(d) The Karaganda Coalfield.

(e) Other Minor Coalfields.

Distribution of Total Explored (Balance) Coal Resources

As on January 1988

Major coal basins and deposits	*Share in total Soviet resources (%)*	*Major coal basins and deposits*	*Share in total Soviet resources (%)*
Donetz	25·9	Ekibustuz	4·7
Moscow	3·8	Ubagan	4·3
Pechora	2·8	Central Asia	2·3
Dneiper	1·6	Irkutsk	3·2
Urals	2·4	Kansk-Achinsk	11·2
Kuznetsk	20·1	Minusinsk	1·3
Karaganda	5·0	Bureya	1·1
		Sakhalin	1·2

(Source : The Former USSR Ministry of Geology and Protection of National Resources).

(a) The Donetz Coal Basin : Though the relative importance of the Donetz basin as a major coal producing region has declined in the recent years, it still remains the most productive coal producing region in the Soviet Union. The region lies to the north of the Black Sea and the Sea of Azov and produces coal of very high grades that include both

anthracite and bituminous. This region is famous for its metallurgical coal that accounts nearly 60% of the country's output. This coal basin is linked up with the major industrial centres of the region which obtain cheap coal from the Donetz basin.

(b) **The Moscow-Tula Coalfields** : This region is an insignificant producer of coal both in regard to output and quality. The region yields low grade brown coal or lignite which is locally consumed for gassification and electricity generation.

(c) **The Kuznetsk Coal Basin** : The Kuznetsk coal basin or Kuzbas has been developed in the more recent years following the socialist reconstruction of the regional economic-infrastructure. This region produces very high grade coking coal, the bulk of which is consumed for the metallurgical purposes. The region enjoys the benefit of good transportation networks, as a result of which coal can easily be transported to the adjacent economic areas of Western and Eastern Siberia and the Urals.

(d) **The Karaganda Basin** : The Karaganda Basin in Kazakhstan, explored and extensively exploited, has become one of the most important Soviet coal bases. The region plays a leading role in the production of coking coal for the rapidly expanding metallurgical industries of the Uralkuzbas complex. The coal is of superior quality and can be mined easily.

(e) **Other Small Coalfields** : In a country like the Soviet Union coal deposits are widely scattered all over the country. Such deposits include the coal mine areas of the Ural mountains, Pechora Basin, the Siberian coal basin and the Ekibastuz Coal Basin. Of these coal basins, the Pechora Basin region is the most important and hence, plays a significant role in supplying coal to the North-Western economic areas. In Siberia, there are the virgin coal deposits of the Tungus and Lena basins and the rapidly expanding fields of Kansk-Achinsk (Kransnoyarsk Territory), Irkutsk and Bukachacha regions.

9.20.3 China

China is one of the richest countries in the world in coal reserves and ranks first in the world, both in estimated reserves and in annual output. Like the former USSR, China has also made tremendous progress in regard to mineralogical exploitation, especially in coal, following the Communist Revolution.

The coal reserves in China are widely distributed and are found in 27 of the 29 provinces. Nearly 90% of the coal reserves are located to the North of the Quinling Mountains and the Huai River and 60% in North China. North-West, South-West and North-East China each accounts for about 10% of the national total.

Shanxi Province, in the North, has the largest coal reserves in the country. Eighty per cent of the Province's counties have coal deposits, which are found in a total coal bearing area of 58,000 sq kms. Significant coal deposits occur in Datong, the Western Hills of Taiyuan and Yangquan. The region lies in the middle of the country, therefore, the coal produced here can easily be transported to various parts of the country.

Inner Mongolia ranks second in coal reserves and accounts for about 25% of national output. Complexity in geological formations has greatly hindered coal mining in this region. Moreover, the region lies far from the populous parts of the country that limits its utility to a great extent. The principal deposits occur at Fenhe Valley, Ningwn, Datong, Kansu and Honan.

The Manchurian coalfields in the north, confined in the provinces of Jiliu, Liaoning and Heilongkiang, are famous for their high grades of coal. The mines have fostered the growth

of heavy industries in the adjoining regions. Scattered but significant deposits of coal is also found in the Sichuan Basin. Here the coal seams are sufficiently thick and lie at a relatively great depth. They support a wide variety of thermal-based industries. Insignificant deposits are there in the Province of Yunan, Guizhou, Jiangxi and Hunan that cater only to the local demand.

9.20.4 Great Britain

Great Britain, the pioneer of modern coal mining, is presently languishing in a humble state of existence. For many years, Great Britain enjoyed supreme position in the sphere of coal production. British coal deposits are small and discontinuous, though they yield very high grades of coal. The major coal mining areas are in the following regions : (a) the Scottish lowlands; (b) the Pennine flanks; (c) Southern Wales. The important coal mining areas include : (i) the Scottish lowlands, (ii) Northumberland Durham, (iii) Yorkshire, (iv) Nottingham-Derby, (v) South Wales, (vi) West Midlands, (vii) Lancashire and (viii) North Wales and Cumberland.

Compared with the coal seams of the Northern Appalachian field, coal seams of Great Britain are handicapped by number of unfavourable factors like (a) smaller reserves, (b) thin beds and (c) geological constraints in the form of faults that offset the coal seams. The factors that had once stimulated the British coal industry include : (i) high grade of coal, mostly bituminous and anthracite, (ii) proximity to the transhipment points favouring export, (iii) early start of the modern manufacturing industries, favouring rapid growth of coal mining.

Coal constitutes nearly 90% of the value of all minerals raised in Great Britain and supports about 10% of the population through direct employment in the mines. Coal production in Great Britain reached its all-time peak of 287 million metric tonnes in 1913, but since then the output has declined for a number of reasons :

(a) Development of coal mines in many new areas causing the proportionate decrease in British coal output.

(b) Development of alternative fuels, especially hydro-electricity in many countries which were previously importaing the British coal.

(c) Increasing cost of production due to high wage rates.

(d) Increasing utilization of different types of fuels, like petroleum, natural gas, nuclear power.

9.20.5 Europe

Almost every European country produces some amount of coal but the prominent producers are Germany, France and Belgium in Western Europe and Poland in Eastern Europe. Most of the European countries are suffering from some common problems and, therefore, their output remains either stationary or declined in the last few years.

Germany

Germany is the largest coal producing nation in Western Europe after Great Britain. Her rich coal deposits, varying in grade from lignite to high-grade bituminous, favour rapid industrialization.

The famous Ruhr and Westphalia coal range contributes major portion of German coal output. After a continuous exploitation of several decades, it still produce huge amount of good quality coal. A large agglomeration of industries were developed on the basis of Ruhr

and Westphalia coal. Many of the older mines of the region have been abandoned in the recent years because of their poorer deposits and high cost of production. Most of the coal output of the region is consumed locally in the metallurgical industries.

The Aachen field is small and continues North-Westward. This field is no longer important. On the French-German border lies the famous Saar basin. It produces high quality coking coal from substantially large deposits.

Large lignite or brown coal deposits occur in Saxony, particularly in the Leipzing-Magdeburg area, Cologne and Bavaria. Of these three regions Saxony is the most important, which until recently was under East German occupation. Lignite is used for electricity production and for household purposes.

France

France has small deposits of coal and its output is declining day by day. The majority of country's output is obtained from Pas de Calais and Nord, in north-eastern part. Alsace-Lorraine field is yet another important coal-producing region though the output is small. French coal mines are very old and, therefore, most of the easily workable deposits have been exhausted. Small coal deposits are also found in Central Massifs. The country has to import coal to meet the demand of her industries.

Belgium

Belgium is an important West European producer of coal but her production is declining rapidly. The largest coal deposits are in Franco-Belgian coalfield. Like their French counterparts, most of the mines in this region have the same characteristic features : thin, badly faulted coal beds, and high cost of production. Many old mines have been closed down. Newer deposit like Kempenland or Campine coalfields are yet to gain importance.

Poland

The Silesian coalfield is the most significant producer of coal in Poland and ranks only second to the Ruhr region of Germany both in reserves and in output. The Silesian coal is of good coking variety and thus favours the growth of heavy metallurgical industries. In contrast to the other European producers, Poland's coal industry has ample scope for further expansion and, therefore, the output is increasing day by day. Poland is also an important exporter of coal, mainly to the European countries.

9.20.6 Other Producers

The remaining European coal producers include Spain (Ovied in Northern part), Bulgaria, Yugoslovia, Czechoslovakia and Hungary. Of these countries, Spain and Czechoslovakia are worth mentioning.

India

India ranks second amongst the Asian countries, surpassed only by China, both in reserves and in annual output of coal. The coal mining industry in the country started as early as 1774 and since then the industry developed at a relatively faster rate, especially in the post-Independence period.

In India, coal deposits are found mostly in two different geological formations namely : (i) the Lower Gondwana series and (ii) the Tertiary formations. Of these two distinct formations, the Lower Gondwana is of overwhelming importance since it contributes about 98% of the total reserves and 99% of the country's output. The Lower Gondwana coal

deposits are distributed mainly in the valleys of the Damodar (Bihar-West Bengal); the Son (Madhya Pradesh-Bihar); the Mahanadi (Madhya Pradesh-Orissa) and the Godavari and Wardha (Maharashtra-Andhra Pradesh). This covers an area of about 77,700 sq km.

In contrast to the Gondwana system, the Tertiary coal in very scattered deposits are found in the states like Assam, Meghalaya, Nagaland, Arunachal Pradesh and Jammu & Kashmir.

The Indian coalfields are located in the interior parts of the country that hinder easy haulage. From the view-point of utilization, the Indian coal can be divided into five groups :

(i) Metallurgical coal available mainly in Jharia, Ranigunj, Bokaro and Giridih.

(ii) High grade steam coal, found primarily in Ranigunj, Bokaro, Karanpura, Talcher and Singareni fields.

(iii) Low-grade steam coal found in most of the fields.

(iv) Tertiary coal is available in the North-Eastern States.

(v) Lignites of Tamil Nadu.

India's coal output increased from mere 35 million tonnes in 1951 to 227 million tonnes in 1992. Apparently this rise seems to be spectacular, but, as compared to China, it is far from the expectations. Measures have been taken to increase the production. It is interesting to note that about 35 per cent of the country's coal output is consumed by the railways; 11 per cent used for power generation and 10·5 per cent for iron and steel industry. Other important consumers include cement factories, cotton mills, paper mills etc.

Despite its bright prospects, India's coal output is not increasing because a number of problems are associated with this industry. Such problems include :

(i) Unrestricted production of low grade coal in excess of their demand.

(ii) Transportation problem of coal from the mines to the centres of consumption.

(iii) The problem of filling up mined spaces in the coalfields.

(iv) Lack of modern mining techniques.

(v) Outdated machineries.

(vi) Uneducated miners.

(vii) Short supply of power.

(viii) Lack of proper conservation policies.

(ix) Unscientific management.

(x) Fire in the coal mines.

Japan

Japan is not an important producer of coal and she has to import good coking coal to meet her demand. Japan's annual output of coal is declining rapidly in the recent years and comprises mainly of low grade bituminous. In Japan, coal seams are thin, distorted and scattered in location which hinder greatly the exploitation of coal from the mines. Significant deposits of coal are in the regions like Chikugo coalfield in North-Western Kyushu, Ishikari fields of Hokkaido and Joban and Ube fields in Honshu. Most of the mines are very old and their deposits are almost becoming exhausted making the cost of production very high.

Other Asian Coalfields

The other Asian countries which have very small deposits of coal include : South Korea, North Korea, Vietnam, Indonesia, Malaysia, Philippines and Thailand. Coal in all such countries is found in very small, scattered deposits and are of little commercial importance.

In the recent years, all-round efforts are being made to increase the output of coal in all these countries. It is expected that the region will contribute more significantly to the global output of coal in the future years.

9.20.7 The Southern Hemisphere Producers

In comparison to the countries of the Northern Hemisphere, the countries of the Southern Hemisphere are poorer both in regard to deposits and output. Most of the output comes from Australia and South Africa.

Australia

Australia is the most outstanding producer of coal in the Southern Hemisphere. Coal output of the country has been greatly expanded in the last two decades following the rapid industrialization. Australian coal mostly comprises of bituminous and lignite variety. The most famous coal-producing region in the country lies in the New South Wales area that accounts for nearly 80 per cent of Australia's coal. Coal mined in this region is supplied to the rest of the country by means of efficient transport systems. Other important coal deposits have been found in Queensland (Ipswich), Victoria (Gippsland), Tasmania (Fingal). Much of the Australian output is exported to other countries.

South Africa

Africa, in general, is an insignificant producer of coal, because of its typical geologic formations, comprising of crystalline rocks virtually devoid of fossil fuels like coal. Actually all of the continent's coal is concentrated at Vereeniging, Middleburg and Withbank. Small quantity of coal is obtained from Zimbabwe (Wankie), Zaire, (Luena), Mozambique (Manianba), Zambia (Nkandabwe and Mamba) and Nigeria (Enugu). Backward economy, poor industrial development and lack of proper technical skill to exploit coal from the mines ate the other factors for Africa's small output.

South America

South America, too, is poor in coal reserves and in annual output. Rugged terrain represented by the high Andean ranges, unfavourable rock formations, scattered location and economic underdevelopment are the main reasons for the continent's low output of coal. Coal seams are thin and low in extent. Low grades of coal occur in Central Chile, South-Eastern Brazil, Western Argentina, Peru and highlands of Colombia.

Note : For maps and details see Group C, mineral resources of USA, Former USSR, China and Japan.