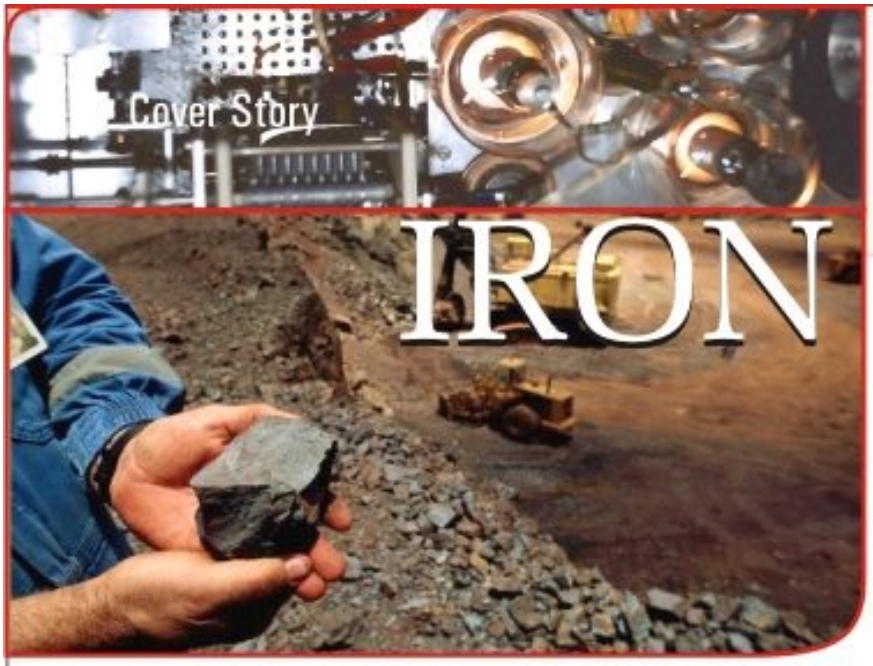

IRON ORE : The Magnet of Industrial Prosperity

- Vaishanavi Naik

To make iron, begin with **iron ore**. Iron ore is simply a rock that happens to contain a high concentration of iron. One thing that gave certain countries an edge between the 15th and 20th centuries was the availability of iron ore deposits. For example- England, The United States of America, France, Germany, Spain and Russia all have good iron ore deposits. When you think of the historical importance of all of these countries, you can see the correlation!

Common iron ores include:

- Hematite - Fe_2O_3 - 70 percent iron
- Magnetite - Fe_3O_4 - 72 percent iron
- Limonite - $Fe_2O_3 + H_2O$ - 50 percent to 66 percent iron
- Siderite - $FeCO_3$ - 48 percent iron

Usually, you find these minerals mixed into rocks containing silica.

The name iron is from an Old English word 'isaern' that can be traced back to a Celtic word, 'isarnon'. In time, the "s" was dropped from usage. Iron (Fe) is a metallic element and composes about 5% of the Earth's crust. When pure it is a dark, silvery-gray metal. It is a very reactive element and oxidizes (rusts) very easily. The reds, oranges and yellows seen in some soils and on rocks are probably iron oxides. The inner core of the Earth is believed to be a solid iron-nickel alloy. Iron-nickel meteorites are believed to represent the earliest material formed at the beginning of the universe. Studies show that there is considerable iron in the stars and terrestrial planets. Mars, the "Red Planet," is red due to the iron oxides in its crust.

Iron is one of the three naturally magnetic elements; the others are cobalt and nickel. Iron is the most magnetic of the three. The mineral magnetite (Fe_3O_4) is a naturally occurring metallic mineral that is occasionally found in sufficient quantities to be an ore of iron. The principle ores of iron are Hematite, (70% iron) and Magnetite, (72 % iron). Taconite is a low-grade iron ore, containing up to 30% Magnetite and Hematite.

Hematite is iron oxide (Fe_2O_3). The amount of hematite needed in any deposit to make it profitable to mine must be in the tens of millions of tons. Hematite deposits are mostly sedimentary in origin, such as the banded iron formations (BIFs). BIFs consist of alternating layers of chert (a variety of the mineral quartz), hematite and magnetite. They are found throughout the world and are the most important iron ore in the world today. Their formation is not fully understood, though it is known that they formed by the chemical precipitation of iron from shallow seas about 1.8-1.6 billion years ago, during the Proterozoic Eon.

Taconite is a silica-rich iron ore that is considered to be a low-grade deposit. However, the iron-rich components of such

deposits can be processed to produce a concentrate that is about 65% iron, which means that some of the most important iron ore deposits around the world were derived from taconite. Taconite is mined in the United States, Canada, and China.

Iron is essential to animal life and necessary for the health of plants. The human body is 0.006% iron, the majority of which is in the blood. Blood cells rich in iron carry oxygen from the lungs to all parts of the body. Lack of iron also lowers a person's resistance to infection.

Iron Ore

About 98% of iron ore is used to make steel - one of the greatest inventions and most useful materials ever created. While the other uses for iron ore and iron are only a very small amount of the consumption, they provide excellent examples of the ingenuity and the multitude of uses that man can create from our natural resources. Major producers of iron ore include Australia, Brazil, China, Russia, and India.

Mining

World consumption of iron ore grows 10% per annum on average with the main consumers being China, Japan, Korea, the United States and the European Union. Iron ore mining methods vary by the type of ore being mined. There are four main types of iron ore deposits worked currently, depending on the mineralogy and geology of the ore deposits. These are magnetite, titanomagnetite, massive hematite and pisolitic ironstone deposits.

Smelting

Iron ore consists of oxygen and iron atoms bonded together into molecules. To create pure iron, the ore must be smelted to remove the oxygen. Oxygen-iron bonds are strong, and to remove the iron from the oxygen, a stronger elemental bond must be presented to attach to the oxygen. Carbon is used because the strength of a carbon-oxygen bond is greater than that of the iron-oxygen bond, at high temperatures. Thus, the iron ore must be powdered and mixed with coke, to be burnt in the smelting process.

However, this is not entirely as simple as that; carbon monoxide is the primary ingredient of chemically stripping oxygen from iron. Thus, the iron and carbon smelting must be kept at an oxygen deficient reduced state to promote burning of carbon to produce CO and not Co_2.

Air blast and charcoal (coke): $2C + O_2 \rightarrow 2CO$.

Carbon monoxide (CO) is the principal reduction agent.

Stage One: $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

Stage Two: $Fe_3O_4 + CO \rightarrow 3FeO + CO_2$

Stage Three: $FeO + CO \rightarrow Fe + CO_2$

Limestone fluxing chemistry: $CaCO_3 \rightarrow CaO + CO_2$

Sources

It is estimated that worldwide there are 800 billion tons of iron ore resources, containing more than 230 billion tons of iron. It is estimated that the United States has 110 billion tons of iron ore representing 27 billion tons of iron. Among the largest iron ore producing nations are Russia, Brazil, China, Australia, India and the USA. In the United States, great deposits are found in the Lake Superior region. Worldwide, 50 countries produce iron ore, but 96% of this ore is produced by only 15 of those countries.

Iron ore is the raw material used to make pig iron, which is one of the main raw materials to make steel. Due to the lower cost of foreign-made steel and steel products, the steel industry in the United States has had difficult economic times in recent years as more and more steel is imported. Canada provides about half of the U.S. imports, Brazil about 30%, and lesser amounts from Venezuela and Australia. 99% of steel exported from the USA was sent to Canada.

Usable Iron Ore Production, by Type of Product

In 1988, the first commercial Corex plant was commissioned at Pretoria in the Republic of South Africa. Many of the technical problems associated with the startup of this 300,000- metric-ton-per-year demonstration plant have since been solved, and several steel companies are now considering building

much larger units in the United States and Western Europe. The proposed Corex plants are still significantly smaller than existing blast furnaces but can be brought up to full operation much quicker with less cost. A key feature of the Corex process is that it uses untreated raw coal in place of coke. The ability to operate without coke gives the Corex plant two environmental advantages over the conventional blast furnace. First, because coke ovens are not needed, all of the problems associated with the generation of benzene and other coal tar byproducts are eliminated. Second, the dust problems associated with blast furnaces are also eliminated because the offgas is used as fuel. Joint COREX and DRI plants are now on the drawing board, with the offgas from the Corex plant being used to fuel the adjoining DRI plant. Direct steelmaking, a much more revolutionary process, is still in the early stages of development. A pilot plant, funded by the American Iron and Steel Institute and the U.S. Department of Energy, has been operating near Pittsburgh since 1990

Uses

In the United States, almost all of the iron ore that is mined is used for making steel. The same is true throughout the world. Raw iron by itself is not as strong and hard as needed for construction and other purposes. So, the raw iron is alloyed with a variety of elements (such as tungsten, manganese, nickel, vanadium, chromium) to strengthen and harden it, making useful steel for construction, automobiles, and other forms of transportation such as trucks, trains and train tracks.

While the other uses for iron ore and iron are only a very small amount of the consumption, they provide excellent examples of the ingenuity and the multitude of uses that man can create from our natural resources.

Powdered Iron

used in metallurgy products, magnets, high-frequency cores, auto parts, catalyst.

Radioactive iron (iron 59)

In medicine, tracer element in biochemical and metallurgical research.

Iron blue

In paints, printing inks, plastics, cosmetics (eye shadow), artist colors, laundry blue, paper dyeing, fertilizer ingredient, baked enamel finishes for autos and appliances, industrial finishes.

Black iron oxide :

As pigment, in polishing compounds, metallurgy, medicine, magnetic inks, in ferrites for electronics industry.

Substitutes and Alternative Sources

Though there is no substitute for iron, iron ores are not the only materials from which iron and steel products are made. Very little scrap iron is recycled, but large quantities of scrap steel are recycled. Steel's overall recycling rate of more than 67% is far higher than that of any other recycled material, capturing more than 1-1/4 times as much tonnage as all other materials combined.

Some steel is produced from the recycling of scrap iron, though the total amount is considered to be insignificant now. If the economy of steel production and consumption changes, it may become more cost-effective to recycle iron than to produce new from raw ore.

Iron and steel face continual competition with lighter materials in the motor vehicle industry; from aluminum, concrete, and wood in construction uses; and from aluminum, glass, paper, and plastics for containers.

Estimated Iron Ore Production In Million Metric Tons For 2006-07

Country	Production
Australia	270
China	520
Brazil	300
India	150
Russia	105
Ukraine	73
United States	54
South Africa	40
Canada	33
Sweden	24
Venezuela	20
Kazakhstan	15
Iran	20
Mauritania	11
Other Countries	43
Total World	**1690**

Source: U.S. Geological Survey