Underground Mining of Metalliferous Deposits

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Lecture 01
Metal and Civilization

Welcome to this NPTEL online course on the Underground Mining of Metalliferous Deposits. This is the lecture 1 and we will be focusing on the importance of metals, some general ideas, historical recapitulation and the importance of metals in civilization.

Learning objectives of this lecture:

1. To understand the importance of metal in human civilization
2. To have a brief glimpse of use of metals in ancient times.
3. To have a brief account of mining and metallurgy from pre-historic to modern era.

Let us first focus on the metals of antiquity. These are the metals that were found and being used by the humans in prehistoric time. Some of these metals are very vital for eg. gold, silver, copper, tin, lead, iron and mercury. These metals are right from the beginning, and some of them like gold and silver or gold and copper are available in native form. These seven are the metals from which the modern world was forged.

Apart from copper ore, copper is also available in native form. So, it was very easy to be discovered. Until the discovery of arsenic (now classified as a metalloid) in the 13^{th} century, these were the only known elemental metals, compared to the 91 known today.

Some old remains have been discovered from the famous Harappa and Mohanjodaro. These consists of carnelian belt and gold jewelries in nugget forms, lump gold with thread in between to make it a necklace etc. Copper and mixture of alloys were polished and then give a very shining surface and that acted as mirror. The extensive use of metal for the purpose of utensils can also be seen in the form of glass, plates, cooking pots. Copper and bronze arrowheads can also be found as a tip of the arrow. Bronze is an alloy. But that was also extensively used for the purpose of making arrowheads and sphere heads. That means it used not only for the purpose of

an arrow, but also the spheres. Spheres were very, very important in, as a protective arm, also as for the purpose of hunting. Here also a bigger sphere heads are available from the Mohanjodaro. It is after the book of discovery of J. Marshall. The metals of antiquity are the seven metals which humans had identified and found use in prehistoric times: gold, silver, copper, tin, lead, iron, and mercury. These seven are the metals from which the modern world was forged; Until the discovery of arsenic (now classified as a metalloid) in the 13th century, these were the only known elemental metals, compared to the 91 known today.

Metals are one category of a trio of geological materials on which our present industrial civilization is based. It is a geological material, trio of geo means there are other two also. What are these? The mineral fuels are like coal, petroleum and natural gas one part, and non-metallics, industrial minerals like the stone, sand and gravel, salt and clays. So, these combined that gives the birth to the industrial civilization that means the extension of the geological material, use a coal, petroleum, natural gas and how to best utilize the availability of the stones, sand and gravel, salt and place.

The metallic ore is also a nuclear fuel such as uranium and where metallic ore has alternative applications as an industrial mineral from which the metal component is not extracted.

Since the Bronze Age, our evolving civilization has depended on metals and this will continue in the future, despite the increasing competition metals are now receiving from organic and organometallic synthetics (e.g. plastics, silicone, graphite) and composite materials.
The first metals in human possession came from geological materials: initially from few native metals found in an almost “ready to use” state, then from easy to process ores, followed by complex ores that required advanced technology, and finally from various materials increasingly different from the classical metallic-looking ores (“unconventional ores”).

People could easily identify the shining metals, gold, silver, copper, like that, but the other things slowly people used to understand, like the hematite is not shining, and it is not a native iron. But later on, when people came to know how to use it, how to melt it, iron was found. So, that was

much later, but then that was by that time people could understand there are many things that the nature has given which can be utilized for the advancement of the civilization.

In Indian subcontinent, we have a very rich history. It began prior to even third millennium BCE and continued well into the British Raj. Metals and related concepts were mentioned in various early Vedic age text also. Writing in Rigveda already uses the Sanskrit term Ayas metal.

The Indian cultural and commercial contacts with the Near East and Greco-Roman world enabled an exchange of metallurgical sciences. Now, people recognize that the many knowledge related to metallurgical sciences were provided by the Indian subcontinent, the ancient India, they provided the knowledge to the rest of the world. With the advent of the Mughals much later say foreign Mughal Empire 1526 to 1857 further improved the established tradition of metals.

The copper bronze metallurgy in the Harappan civilization was widespread and had a high variety and quality. See probably it is one of the best and some people say it is the best sculpture in the entire history e.g 10th or 11th century bronze Chola statue of Nataraja.

The early use of iron may have developed from the practice of copper-smelting. That means when they start learning the copper-smelting process, then they may have thought how, if we melt other rock like things or different stones, so will it produce something? So from some what easier process of copper-smelting they slowly diverted their attention towards the iron ore or other things and the use of other metal started.

The question sometimes appears that how these things happened. Smelting iron started in the Indus valley civilization. And some iron items have been unearthed in eight Indus Valley sites, some of them dating before 2600 BCE. The earliest evidence for smelted iron in India dates to 1300 to 1000 BCE.

In the fifth century BCE the Greek historian Herodotus observed that Indian and the Persian army used arrows tipped with the iron. That means they could find out in fifth century that Indian and Persian army, they were having the knowledge and they regularly use the iron tips for their arrows. Indian wootz steel (first form of crucible) was in high regard in Europe and the Indian iron was often considered to be best in Europe.

Zinc was extracted in India as early as in the 4th to 3rd century BCE. Zinc productivity may have begun in India, and ancient northwestern India is the earliest known civilization that produces zinc on an industrial scale. The distillation technique was developed around 1200 CE at Zawar in Rajasthan. The Arthashastra by Chanakya describes the production of zinc. The Rasaratnakara by Nagarjuna describes also the production of brass and zinc. There are references of medicinal uses of zinc in the Charaka Samhita (300 BCE). Now let's see the objects that were made by this metal.

The deepest gold mines of the ancient world were found in the Maski region in Karnataka. There are ancient silver mines in northwest India dated to the middle of the first millennium BCE. Gold and silver were also used for making utensils for the royal family and novelties. So, they were very important metals for the royal families.

Chinese also claim that the prospecting of useful minerals were there in ancient times as coal carvings have been found in ruins of the Fushun coalfield, Liaoning province. Their radiometric age is over 6000 years (Neolithic). The earliest copperware in northern China is also Neolithic, and bronze was widely used during the Shang dynasty (16th to 11th century B.C.)

In 1973, a 3000 year old copper mine with smelting facilities was discovered in Tonglushan and this is also an evidence of the use of metals in ancient times in China. The Daye copper mines in Hubei province have a history going back 2800 years and they are still in production for the very, very historically collectible specimens today. These points indicate that mining activities in China began at least 5000 years ago. Mining in ancient India was far more widespread and had more social relevance than in China. That means the utilization of metals in the ancient Indian society was far more prevalent, and they had far more influence on the other countries like the Euro, Greece and Rome. India had a lot of influence in metal, metal mining and metallurgy in the other part of the world compared to China.

Based on our current knowledge, it is ascertained today that metals like sodium, potassium, magnesium, calcium, iron, manganese, cobalt, copper, zinc and molybdenum are essential for life. Our body must have these in appropriate amounts. So, several metal ions like sodium, potassium, magnesium, calcium, these are essential to sustain biological life. Six additional metals, chiefly transition metals, are also essential for optimal growth, development and

reproduction i.e manganese, iron, cobalt, copper, zinc and molybdenum. They are also equally important.

The oldest known underground mine in the world was sunk more than 40,000 years ago at Bomvu Ridge in Ngwenya mountain, Swaziland, in Africa to mine ochre. Ochre is basically ferric oxide and it is reddish in color with different use and variations. It is used in burial ceremonies and also body coloring. This was used as dye to color different parts of the body. This mine is still visible and it dates back to some 40,000 years.

Now, can we escape from metals? Can you think of a life, a world without metal, no skyscrapers, no railways, no shopping malls, no stadium, no hospitals, no cars, no planes. From safety pin to rockets, there is some metal behind it. So, why not to understand how to best utilize, how to conserve these without wastage, how to mine it, how to do cost effective metallurgy, how to best utilize the metals by reducing wastage and how to recycle these things.

So, absolutely we cannot live without the metals. Everything we depend on today is either made from minerals or relies on minerals for its production and distribution. So, these metals are extremely important and an essential part of human civilization.