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Factors Controlling Availability of Mineral Resources for Mining: An Overview

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ABSTRACT: Mineral deposits are the occurrences of significant concentrations of minerals formed by geologic processes, from where metal(s) or minerals of economic importance can be recovered at a profit from these occurrences.

There is a close relation between the type of mineral resource found in an area and its geologic setting. Thus, the study of Earth gives an idea about where to look for minerals in favourable geologic environments.

The present article discusses various factors controlling availability of mineral resources for mining. These factors include engineering, environmental and economic and geological factors. As population pressures place more demand on land, geologic controls on the distribution of mineral deposits will become increasingly important in mining.

KEYWORDS: Mineral resources, mining, geological factors, engineering factors, environmental factors, economic factors.

I. INTRODUCTION

Ore deposits form when a useful commodity is sufficiently concentrated in an accessible part of the Earth's crust so that it can be profitably extracted. The mineral deposits are immobile by nature, and continue to deplete unlike in agriculture. Ore deposits, localized natural concentrations of some metals, way above their average crustal abundance, have been forming almost from the beginning of earth's history to the present day. Global database reflects their strikingly non-uniform distribution patterns which can be region-specific, time-specific and/or metal specific.

A mineral deposit, in the geochemical perspective, is essentially a segment of the earth's crust with a strong positive chemical anomaly in respect of certain element(s) whose average crustal abundance (called the Clarke value) is very much lower. Every deposit, large or small, is thus a reminder that something very special must have happened there, so that elements with Clarke values in ppm/ppb range have been concentrated in several million tons within a small volume of rock. It is important to consider the range of concentration and the factors that characterize the formation of different types of ore deposit. The metals need to be concentrated by factors in the hundreds in order to form potentially viable deposits. The degree of concentration required for the precious metals is even more demanding, where the required enrichment factors are in the thousands.

The world's population is expected to increase by 25% from 7.7 to nearly 10 billion by 2050. Urbanization is increasing substantially. As populations grow, infrastructure needed to serve demands for reliable power, transportation, housing, clean water, and sanitation increase the need for minerals.

In 2017, the World Bank published 'The Growing Role of Minerals and Metals for a Low Carbon Future', concluding that a low-carbon future will not be possible without minerals. World Bank Group report finds that the production of minerals, such as graphite, lithium and cobalt, could increase by nearly 500% by 2050, to meet the growing demand for clean energy technologies. It estimates that over 3 billion tons of minerals and metals will be needed to deploy wind, solar and geothermal power, as well as energy storage, required for achieving a below 2°C future.

What is it that makes a mineral resource on the planet earth a mineable one? An overview of various factors influencing mineral availability for mining or the factors which translate a mineral resource into a mineable mineral commodity is being presented here.



II. FACTORS CONTROLLING MINERAL AVAILABILITY FOR MINING

Factors controlling mineral availability for mining have got two aspects:

One aspect deals with the availability of minerals for mining or exploitation. Even if rich mineral deposit is located and explored, it may not be exploited till several vital factors are satisfied. The main factors controlling the availability of mineral deposits for mining are engineering, environmental and economic.

Another aspect of factors controlling mineral availability is the natural conditions (the geological factors) which control the presence of a mineral in in space and time. Mineral concentration in the crust of the Earth is produced by the interplay of various geological processes.

Engineering factors

Engineering factors affect mineral availability in two ways, technical and economic. Technical constraints are imposed when we simply cannot do something even if we have sufficient funds to run a mine. The extraction of iron from Earth's core, is not possible by any mining method. Engineering constraints also play a vital role in exploitation even though a mineral deposit is identified. Economically viable ore deposit may not be workable unless certain engineering parameters are satisfied. The engineering properties such as the strength of the host rocks, accessibility, workability of machinery, availability of electricity, water and proper ventilation may be decisive factors in the feasibility of a mineral resource for mining.

The economic aspect of engineering factors includes the cost of machinery and the cost of mine development and operation cost.

Environmental factors:

The extraction of minerals from nature often creates imbalances, which adversely affect the environment. The key environmental impacts of mining are on wildlife and fishery habitats, the water balance, local climates & the pattern of rainfall sedimentation, the depletion of forests and the disruption of the ecology. Various activities involved in mining viz. exploration, construction, operation, maintenance, expansion, abandonment and decommissioning of a mine can impact environmental systems in various ways.

Economic factors:

Before a mineral deposit is exploited, it must be ascertained whether its value is greater than the costs of working, transporting and concentrating the ore. Mineral economics plays the most crucial role in the exploitation of a resource. The ore deposit has to be profitably exploitable. However, exception may be there in the case of strategic minerals. They can be mined at a time of emergency, like, war, without considering economic factors. The price of the commodity effectively regulates the cost of mineral production. Economic factors that control mineral production include those on the supply side, which are largely engineering and environmental costs related to extraction, processing and transportation and those on the demand side, which include commodity prices, taxation, land tenure, and other legal policies of the host government.

Geological factors:

Another aspect of factors governing mineral availability is the natural conditions are the geological factors which control the presence and of exploitation of a mineral resource in space and time.

These factors include

1. The mode of formation of a mineral that is whether the mineral is formed as a product of igneous processes, sedimentary processes or metamorphic processes.

2. The geological factor which governs the mineral availability is localization or dispersion of mineral.

From geochemistry point of view, a mineral deposit is a geochemical anomaly, therefore formation of a mineral deposit at a specific location requires favourable physico - chemical conditions (temperature pressure conditions as well as pH- Eh conditions).

3. Certain specific time periods in the earth history are well known for the presence of mineral deposits all over the world. These specific periods provided all the favourable conditions for the formation of specific type of deposits.

4. A mineral deposit is generally product of certain chemical reactions.

5. Another important geological factor which controls the mineral availability is the availability of favourable site for formation of mineral deposit. This site could be a geological structure such as crest of a fold, shear zone or a fault plane.

6. Certain mineral deposits are associated with specific rock type also.



7. As we all know that the mineral deposits are a product of either primary processes of mineral formation such as magmatic crystallization or they result from secondary processes such as sedimentation, residual concentration metamorphism etc. Therefore, the factors which govern these processes will indirectly control the availability of a mineral deposit.

8. Another geological factor which governs or controls mineral availability is the physical and chemical properties of the mineral itself. For example, minerals such as gold or few other minerals which have very high specific gravity and they are less susceptible to chemical reactions will form mineral deposits at favourable locales under suitable condition.

9. Topography, elevation and geological work of various agencies such as the river, wind, oceans etc also control the mineral availability.

10. When looked from the plate tectonics point of view, from the modern approach towards genesis of or deposits, it has been concluded that certain types of deposit are associated with certain specific type of plate tectonic settings.

The crustal rocks exhibit minute concentrations or quantities of all the metals. Such crustal abundance of metals is expressed in Clarke values, which represents a ratio of a particular element in a rock to the average amount of the element in the Earth's crust. Different geological processes like magmatism, sedimentation, and metamorphism concentrate such discrete metals present in crustal rocks in specific geological settings to form a rich ore deposit. Thus, geological factors play a dominant role in the concentration and availability of mineral deposits for mining.

III. AVAILABILITY OF MINERAL RESOURCES FOR MINING: FUTURE AHEAD

The mineral resources are often viewed as key assets driving socioeconomic development of a nation. Over time and with progressive industrialization, resource use has increased risk of resource depletion. This demonstrates the need to regulate exploitation and use of mineral resources owing to the fact that they are non-renewable. The 1972 UN Conference on the Human Environment held in Stockholm, Sweden, adopted fundamental principles in this regard.

The 5th principle of Stockholm declaration states that non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that benefits from such employment are shared by all mankind.

This warrants an urgent need to plan for exploitation of mineral resources for the future when mineral supply threatens to be inadequate. This planning needs to consider the vulnerable but flexible nature of mineral resources and the global dependence on critical minerals. There has to be a consensus on international targets for global mineral production and monitoring of the impacts of mineral production and consumption. Sustainable mineral resource development involving new mineral extraction technologies is the need of the hour. Marine mineral resources will be the focal point of future mining activities.

IV. CONCLUSION

The availability of mineable mineral resources, being a non-renewable commodity to support a growing human population on planet Earth is definitely a matter of global concern. But the global mineral reserves continue to evolve with enhancement of understanding about geology of mineral deposits, technological advances and economic conditions.

There is a need to adopt a holistic approach to the availability of mineral resources for mining in terms of life cycle of a mineral commodity which takes into account the possibility of reuse & recycling of mineral commodity and blending it with the run off mine. Furthermore, Cost-effective technology minimizing environmental impact will be needed to address the needs of future generations for mineral resources.

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