

SUSTAINABLE MINING AND GEOINFORMATION

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Week – 05

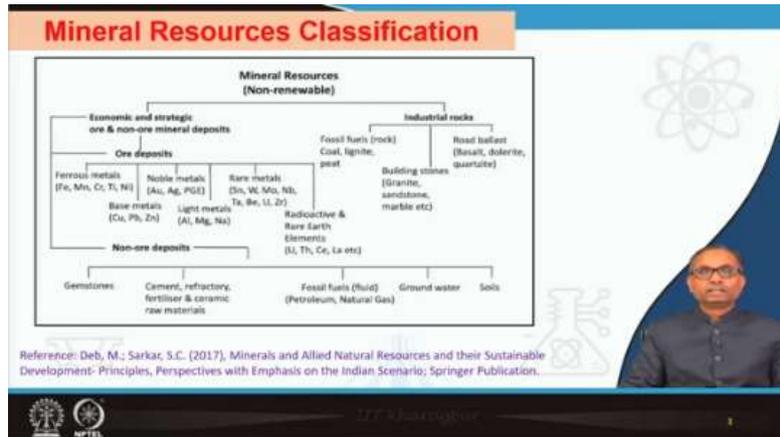
Lecture 22: Minerals, Mining and Society - II

Welcome, students, to lecture 22 of the NPTEL online certification course on Sustainable Mining and Geoinformation. Last class, we discussed the role of minerals in our society and the role of minerals in the growth of our country, the economy of our country, and the role of minerals in the economies of other countries. So, we are continuing today's lecture from where we left off in the last class—that is to say, lectures 21 and 22 are a continuation.

So, today's class we are going to cover the uses of nonmetallic minerals. Also, we will discuss about rare earth elements and rare metals. We will talk about critical minerals. Also, we will talk about atomic minerals. And finally, we will have a discussion about minor minerals, and then we shall summarize what was discussed in the last class and also in today's class.



So, let me take you back to the mineral resources classification. The slide that you can see is taken from the book Dev and Sarkar, 2017, and we discussed this slide in the last class. So, mineral resources are classified into two major types, one is the economic and strategic ores, and the second is the industrial rocks.



Among the economic and strategic ores, we have ferrous minerals or ferrous metals, noble metals or precious metals, rare metals, and radioactive elements. Among the non-ore deposits, we have particularly the gemstones, the raw materials used for the cement, refractory, fertilizer, and ceramic industries. We have one important category, which is fossil fuel, particularly the liquid and the gas. It is also considered a mineral, but we are not discussing that. And among the industrial rock category, there are fuel minerals, particularly coal and lignite, which are very important sectors of mining. Then, apart from that, among the industrial minerals, we have the building stones: granite, sandstone, and marbles.

Other categories of building stones are basalt, dolerite, road ballast, and quartzite; these are counted as minor minerals. So, in the last class, we mostly discussed metallic minerals, and today we shall focus on the non-metallic minerals. Minerals, mostly the non-metallic minerals. So, in the non-metallic mineral type, the most important category of minerals is the fuel mineral. Particularly, in the context of India, we are talking about coal and lignite.

Fuel Minerals: Coal

- Coal is the most important and abundant fossil fuel in India.
- Coal accounts for ~55% of the country's energy need.
- Current per capita commercial primary energy consumption in India is ~ 350 kgoe/yr, well below that of developed countries.
- Hard coal: As per International Coal Classification of Economic Commission of Europe (UNECE)
- Hard Coal: GCV \geq 5700 kcal/kg (23.9 GJ/t) on ash free and moist basis and with a vitrinite reflectance $>$ 0.6.
- Brown coal: with GCV $<$ 5700 kcal/kg and V.M. $>$ 31% on dry mineral matter free basis.
- Coking Coal: when heated in absence of air form coherent beads, free from volatiles with strong and porous mass called coke.
- Non-coking coal: Does not have coking property and is used for power generation.

I would like to emphasize that from a geological point of view, coal, peat, and lignite may not exactly be termed as minerals from a scientific nomenclature, but from the administrative and legal point of view, coal, peat, and lignite are also categorized as minerals. There is this major mineral classification, which is fuel minerals. Coal, peat, and lignite are part of the fuel minerals. In our context, coal is the most important and abundant fossil fuel, which is present in coal, and it accounts for about 55 percent of our country's energy production and energy requirement. Fortunately or unfortunately, India is blessed with a huge quantity, a huge reserve of coal. Most of our energy requirement comes from coal itself.

Now, if you look at the current per capita commercial primary energy consumption in India, which is about 350 kilograms of oil equivalent per year. Now, this is significantly below compared to the primary energy consumption among the developed countries. So, that means, as our economy progresses, economic growth increases or progresses, our primary energy consumption is likely to increase, and most of the energy will come from coal for the near future.

Now, when we talk about coal, there are several types of coal, and as per the International Coal Classification of the Economic Commission of Europe, coal can be classified into two major types: one is hard coal, and the other is soft coal or brown coal. So, when we say hard coal, it refers to that coal which has a gross calorific value (GCV) more than or equal to 5700 kilocalories per kg or, in terms of joules per ton, it is 23.9 gigajoules per ton, and this gross calorific value of 5700 kilocalories per kg is on an ash-free and moist basis. So, also, that same coal should have a vitrinite reflectance of more than 0.6, which means, any coal with a GCV more than 5700 kilocalories per kg and also a vitrinite reflectance of more than 0.6 is termed as hard coal. Now, the other category of coal is brown coal, and when we say brown coal, it is defined as that coal which has a gross calorific value of less than 5700 kilocalories per kg, coupled with a volatile matter of more than 31 percent on a dry and mineral matter-free basis. So, these are the two types of coal: hard coal and brown coal, based on GCV and the vitrinite reflectance or the volatile matter.

Now, as per the use, there are some classifications of coal, particularly in our Indian context. We define coal as mostly of two or three types. So, the two types are coking coal and non-coking coal. So, as we know, some coals have good coking properties. So, what is coking property?

The coal, when heated in the absence of air, forms coherent beads free from volatiles with a strong and porous mass, which is known as coke. So, the You take the coal, heat it in the absence of air, and it forms coke. It is known as coking coal. This coking coal has utility in the steel industry.

We all know that in steel plants, we use coking coal as part of the steel-making process. Now, in the Indian context, out of our huge deposits of coal, only a small portion is coking coal. Particularly, some of the coal found in the Jharia coalfield, under the administrative domain of Bharat Coking Coal Limited (BCCL). So, near Dhanbad and Jharia, these coking coals are found in our country, and the coking coal reserve is not very sufficient. The coking coal production is also not sufficient; it is not meeting our total demand in our country. So, sometimes we also import coking coal from other countries. The second category of coal, as per use, is the non-coking coal. Definitely, the non-coking coal does not have coking property, which means when you heat it in the absence of air, it will not form coke. So, what is its use?

It is mostly used for the generation of power in thermal power plants. These are the two categories: coking coal and non-coking coal. Sometimes, we have a third category of coal, which is known as semi-coking coal. As the name suggests, semi-coking coal has a smaller coking property, so it is situated between non-coking and coking types. Now, you come to the reserve position. The reserve of coal as of 1st April 2024 was 389 billion tons. As you can appreciate, India has been blessed with a huge reserve of coal, and probably, at the current rate of production, we have sufficient coal to last for maybe 200 years or so, or maybe even more than that.



Fuel Minerals: Coal

- Reserve of Coal (as on 1st April 24) was 389 BT.
- Coal occurs in 27 coalfields across India.
- India produced 997.83 MT of coal during 2023-24 (66.6 MT of coking coal and 930.6 MT of non-coking coal)
- **CIL, SCCL** are the major coal producing companies.
- Coking Coal is imported primarily by Steel Industries.
- Power and cement industry are importing non-coking coal.
- India imported 58.8 MT of coking coal and 205.7 MT of non-coking coal during 2023-24.
- Coal was imported from Indonesia, Australia, Russia, South Africa.
- India exported coal to Nepal, Bangladesh and UAE (1.37 MMT in 2023-24).

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Now, this coal occurs across 27 coal fields in India. You might know the Mahanadi coal field or the Damodar Valley coal field. There are 27 coal fields that have been

demarcated across our country. Now, if we look at the production of coal last year, that is, the year 2023-24, India produced almost 1 billion tons of coal. To be exact, it was 997.83 million tons of coal produced by India. Among this coal, the majority was non-coking coal, which was 930.6 million tons of non-coking coal, and only a small quantity, that is, 66.6 million tons of coking coal, was produced.

Now, if you look at the companies that produce coal, mostly they are public sector companies: Coal India Limited and Singareni Collieries Company Limited (SCCL), which is located in Telangana. They are the major coal-producing companies, but apart from these two, we have NTPC and some other companies. Captive companies—other companies that produce thermal power—also have captive mines and produce coal. Now, as I mentioned, our coking coal reserves as well as our coking coal production are not sufficient to meet the demand of our domestic steel industry. The steel industry, for instance, sometimes has to import coking coal from other countries, mostly from Indonesia, Australia, New Zealand, and similar countries. Also, although we have sufficient non-coking coal, sometimes our power companies do not get enough coal and have to import coal from other countries. Power and cement industries also import non-coking coal from other countries. India imported 58.8 million tons of coking coal and 205.7 million tons of non-coking coal during the year 2023–2024. As I mentioned, coal was mostly imported from Indonesia, Australia, Russia, South Africa, New Zealand, and other countries. Now, India also exports a very small amount of coal to neighboring countries like Nepal, Bangladesh, and the United Arab Emirates. So, in the last year, that is, the year 2023–24, 1.37 million metric tons of coal was exported to these three countries. So, this was the position of coal, and the next fuel mineral is lignite. Lignite deposits are mostly found in the states of Tamil Nadu, Gujarat, Rajasthan, and Jammu and Kashmir. Our total lignite resources in India are 47.3 billion tons as of 1st April 2024.

Fuel Minerals: Lignite

- Lignite deposits in Tamil Nadu, Gujarat, Rajasthan, J&K.
- Total lignite resource of India: 47.3 BT (as on 1st April 2024)
- India produced 42.8 MMT of lignite in Yr 2023-24.
- Major uses of coal and lignite: generation of electricity in TPS.
- Other uses of coal: production of coke, cement, steel

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And if you look at last year's production, India produced 42.8 million metric tons of lignite in the year 2023-24. Now, as I mentioned earlier, the major uses of coal and lignite are for generating electricity in thermal power stations. Other uses of coal include the production of coke, which is used in the steel industry. Coal is also used in the cement industry and the steel industry. Sometimes, coal is also used for the production of fertilizers, as the fertilizer industry also uses a lot of coal.

So, that was about the fuel mineral. Now, we will discuss a very critical or crucial mineral, which is extremely important for our infrastructure. In the infrastructure sector, cement is a major requirement, and for producing cement, the basic raw materials are limestone and dolomite. Limestone is a major raw material for manufacturing cement, and some limestone is also used in the iron and steel industry.

Building Minerals: Limestone

- Limestone is the major raw materials for manufacturing of cement.
- It is also used in iron and steel industry.
- India produced 392 MT of limestone in Yr 2020-21 against a demand of 408 MT.
- Limestone reserve of the country is 19 BT (as on 1st April 2020)
- Most L.S. deposits are in Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Chhattisgarh and Tamil Nadu.

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Now, India had reserves of 19 billion tons as of 1st April 2020. This figure needs to be updated slightly, but this is the figure I have. India produced 392 million tons of limestone in the year 2020-21 against a demand of 408 million tons in the same year.

That means our limestone, although we are significantly producing our limestone requirement by our own production. However, there is still a small shortfall compared to our domestic demand.

Now, these limestone deposits are mostly found in the states of Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Chhattisgarh and Tamil Nadu. So, now we will discuss a very important element: the rare earth element. Now, these rare earth elements can also be considered metals, as they are actually metallic elements. Although they are not classified as ferrous metals, they are still metallic elements.

Rare Earth Elements

Periodic Table of the Elements

Image Source: <https://blogs.egu.eu/network/gfgd/2013/05/29/rare-earth-elements-geochemistry-and-geopolitics/> (viewed on 11 Dec 2024)

The image shows a periodic table of elements. The lanthanide series (elements 57-71) is circled in red. Additionally, Scandium (Sc) and Yttrium (Y) are also circled in red. The title 'Rare Earth Elements' is at the top left. A small inset image of a person is visible in the bottom right corner of the slide.

So, for these rare earth elements, you can refer to the periodic table, where I have circled the lanthanide series in red, which includes 15 elements, and at the top, there are two additional elements: scandium and yttrium. These 17 elements are collectively known as the rare earth elements. Why are these rare earth elements important? Now, rare earth elements are a group of 17 metals from the lanthanide series, along with the two additional elements I have shown you in the periodic table.

Rare Earth Elements

- REEs are group of **seventeen metals** from the lanthanide series of elements:
- lanthanum (La), cerium (Ce), praseodymium (Pr),
- neodymium (Nd), promethium (Pm), samarium (Sm),
- europium (Eu), gadolinium (Gd), terbium (Tb),
- dysprosium (Dy), holmium (Ho), erbium (Er),
- thulium (Tm), ytterbium (Yb), lutetium (Lu), along with
- Scandium (Sc) and yttrium (Y).
- The fifteen lanthanide elements have been subdivided into the:
 1. Light-rare-earth elements (LREE)—lanthanum, cerium, praseodymium, neodymium, promethium, samarium, and europium; and
 2. Heavy-rare-earth elements (HREE)—gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.
- Rare Earth Elements (REE) are characterized by **high density, high melting point, high conductivity and high thermal conductance.**

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Here is the list of these 17 elements: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, along with scandium and yttrium. These 17 are known as the rare earth elements. In the lanthanide series, we have 15 elements, which can be subdivided into two categories: the light rare earth elements (LREE) and the heavy rare earth elements (HREE). The LREE includes lanthanum, cerium, praseodymium, neodymium, promethium, samarium, and europium, while the HREE includes gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. Now, these rare earth elements have become very critical due to their applications in high-technology industries and the digital sector.

Now this rare earth element are characterized by their high density high melting point high thermal conductivity and high electrical conductivity so because of these properties they have found lot of application in the high technology areas so they are used in the critical areas such as green energy technology now you know green technology has become very very critical and crucial for our climate change abatement measures. High-tech applications, they are also used in high-tech applications like defense applications, electric vehicles, wind power turbines, computer disks drives for storage of data, missile guidance system.

Rare Earth Elements (REE)

- REE are utilised in critical areas: green energy technologies, high-tech applications in defence, electric-vehicles, wind power turbines, computer disc drives, missile guidance systems, etc.
- Lanthanide elements have magnetic, chemical and spectroscopic properties and have application in a wide range of end-uses.
- Lanthanum has applications in fibre optics and laser.
- Cerium has application in polishing of glass items like lenses & display screens of cathode-ray tubes, liquid-crystal displays & plasma-display panels.
- Principal uses of cerium compounds in the form of nitrate is in the manufacture of incandescent gas mantles and cerium compounds as oxide.

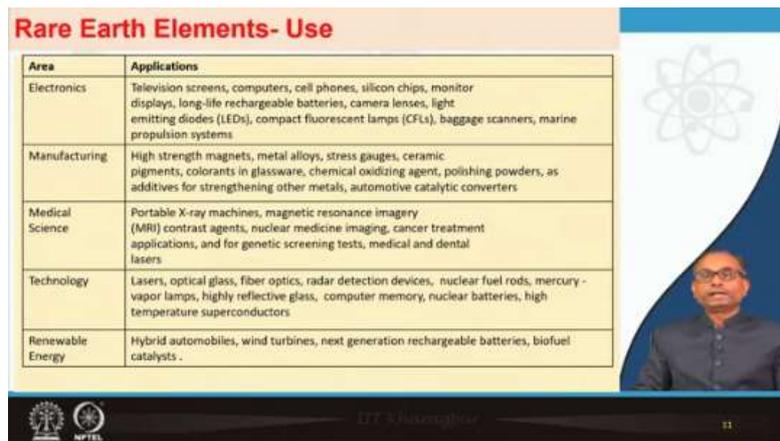
Ref: <https://mines.gov.in/webportal/internationalmineralscenarip> (viewed on 9th Dec 2024)

The slide features a blue and white background with a stylized atomic symbol. A video feed of a man in a dark suit is visible in the bottom right corner. Logos for 'mines' and 'MPTEL' are at the bottom left, and the number '10' is at the bottom right.

So, these REE, they are very useful in the high technology application. That is why these rare earth elements are very very useful and very very crucial for our economy. Now, lanthanide elements have magnetic, chemical and spectroscopy properties and have application in the wide range of uses. Lanthanum has application in fiber optics and laser. Cerium has application in the polishing of glass items, lenses and display of screens like that.

So, you can see this table and the rare earth elements are used in the high technology areas like electronics, manufacturing, medical science. High technology application, renewable energy application. For example, in the electronics, in the television screens, computers, cell phone, silicon chips, LEDs, CFL, like that. In the manufacturing, they are used for manufacturing of high strength magnet, strain gauges, ceramic pigments, lot of important metallic alloys automotive catalytic converters like that.

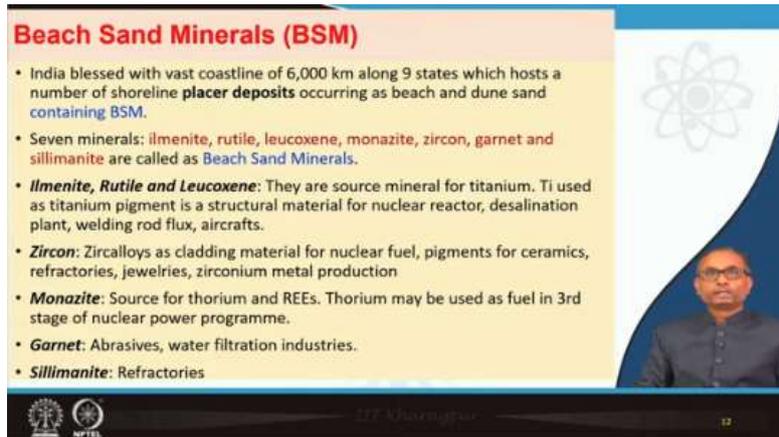
Rare Earth Elements- Use	
Area	Applications
Electronics	Television screens, computers, cell phones, silicon chips, monitor displays, long-life rechargeable batteries, camera lenses, light emitting diodes (LEDs), compact fluorescent lamps (CFLs), baggage scanners, marine propulsion systems
Manufacturing	High strength magnets, metal alloys, stress gauges, ceramic pigments, colorants in glassware, chemical oxidizing agent, polishing powders, as additives for strengthening other metals, automotive catalytic converters
Medical Science	Portable X-ray machines, magnetic resonance imagery (MRI) contrast agents, nuclear medicine imaging, cancer treatment applications, and for genetic screening tests, medical and dental lasers
Technology	Lasers, optical glass, fiber optics, radar detection devices, nuclear fuel rods, mercury - vapor lamps, highly reflective glass, computer memory, nuclear batteries, high temperature superconductors
Renewable Energy	Hybrid automobiles, wind turbines, next generation rechargeable batteries, biofuel catalysts .



In the medical technology domain, this REE, they are used for manufacturing of portable X-ray machines, MRI machines, magnetic resonance imagery machines, nuclear medicine imaging, for they are used for cancer treatment, they are used for genetic screening test, medical and dental lasers. So, very very important uses they have in the medical field. In the high technology domain, these RE are used for making lasers, optical glass, fiber optics, radar detection devices, nuclear fuel rods, mercury vapor lamps, high reflective glass, computer memories, these high temperature superconductors like that. In the renewable energy sector, they are used for hybrid automobiles, wind turbine next generation rechargeable batteries as you know battery is very very important so like this now in Indian context most of this rare earth element you know we are not self sufficient in the rare earth element and as you know China has significant global REE reserve in that country we are not so fortunate to have REE resources but some of the REE resources they are found in what we call the beach sand minerals BSM. So, India is blessed with vast coastline of 6000 kilometer over 9 states and these coastline they host a multi mineral placer deposit in the beach and dune sand. So, these beach sand, they contain seven critical minerals, seven important minerals, which are ilmenite, rutile, leucoxene, monazite, zircon, garnet, and sillimanite. All these seven are known as beach sand minerals.

Beach Sand Minerals (BSM)

- India blessed with vast coastline of 6,000 km along 9 states which hosts a number of shoreline **placer deposits** occurring as beach and dune sand containing BSM.
- Seven minerals: **ilmenite, rutile, leucoxene, monazite, zircon, garnet and sillimanite** are called as **Beach Sand Minerals**.
- **Ilmenite, Rutile and Leucoxene**: They are source mineral for titanium. Ti used as titanium pigment is a structural material for nuclear reactor, desalination plant, welding rod flux, aircrafts.
- **Zircon**: Zircalloys as cladding material for nuclear fuel, pigments for ceramics, refractories, jewelries, zirconium metal production
- **Monazite**: Source for thorium and REEs. Thorium may be used as fuel in 3rd stage of nuclear power programme.
- **Garnet**: Abrasives, water filtration industries.
- **Sillimanite**: Refractories



This ilmenite, rutile, and leucoxene, they are major source of titanium. Titanium has application in the nuclear reactor, desalination plant, for manufacturing of welding rods and for aircraft manufacturing. Zircon is basically it is a alloy which is used for cladding material or coverage material over the nuclear fuel. They are also used in the ceramic industries refractory industries for making jewelry. Monazite: India has a huge Reserve of monazite and this monazite they are source of thorium and other REE. Thorium as you may very well know they are used as fuel in the third stage of our the nuclear program.

And garnet is used mostly as an abrasive and in the water filtration industry. Sillimanite is used in the refractory industries. We come now to what is known as a critical mineral. These critical minerals are not a scientific classification, but from an economic point of view, they are very important. As you know, for economic growth, progress, and strategic reasons, some minerals are very, very important. So the government depending on the geoeconomics, geological reserves available, geopolitical scenarios, trade policies, and other issues, they declare some minerals to be critical, which will play a very important role in our economic growth. So, the Government of India has identified 30 critical minerals.

Critical Minerals

- Critical minerals (CMs) are metals and non-metals which are vital for the economic well-being of society.
- Their supply may be at risk due to geological scarcity, geopolitical issues, trade policy and other factors.
- They occur in mainly by two sources, viz. primary – in ore deposits; secondary – in waste, like the electronic (e)-waste.
- India has identified a set of 30 critical minerals: Antimony, Beryllium, Bismuth, Cobalt, Copper, Gallium, Germanium, Graphite, Hafnium, Indium, Lithium, Molybdenum, Niobium, Nickel, PGE, Phosphorous, Potash, REE, Rhenium, Silicon, Strontium, Tantalum, Tellurium, Tin, Titanium, Tungsten, Vanadium, Zirconium, Selenium and Cadmium. (Ministry Of Mines, June 2023)



13

They are antimony, beryllium, bismuth, cobalt, copper, gallium, germanium, graphite, hafnium, indium, lithium, molybdenum, and so on. You will see there are 30 critical minerals the Ministry of Mines has identified. Now, these critical minerals normally occur in two sources. One is the primary source from the ore deposit, and secondly, they are also recovered from waste materials like e-waste.

These critical minerals, as you might know, are essential for the growth of the digital economy and green technology. For example, electric vehicle batteries are very important, as are the chips used in mobile devices. Some minerals like silicon, lithium, lead, and nickel are very important raw materials for the digital economy. These materials have been identified as critical minerals. Copper, for example, is also very important. Now, some of the critical minerals and their uses.

Critical Minerals

CMs (Atomic No)	Uses
Antimony (Sb, 51)	In batteries and flame retardants
Chromium (Cr, 24)	Primarily in stainless steel and super-alloys
Germanium (Ge, 32)	For fiber optics and night-vision apparatus
Lithium (Li, 3)	Primarily for Li-ion/polymer batteries for electric vehicles; in ceramics and glass industries; nuclear fusion and for many chemical compounds
Nickel (Ni, 28)	For alloys, batteries, coins, cars, mobile phones, jet engines, cutlery and bathroom taps and shower heads
Rubidium (Rb, 37)	For R&D in electronics; in vacuum tubes, manufacture of photocells and in special glasses ; as a propellant in ion engines on spacecraft
Strontium (Sr, 38)	For pyrotechnics and ceramic magnets



14

So, like antimony, it is used in the battery and used as a flame retardant. Chromium, primarily used in the stainless steel, making of the stainless steel. Germanium, it is used

in the fiber optics. Fiber optics, as you know, it is very, very important for our storage and transfer of the data. Lithium for the batteries, for the EV.

Nickel, similarly rubidium, strontium, these are the different critical minerals and our reserve position is not self-sufficient in all the critical minerals. Mostly we are dependent on other countries. So, because we are not self-sufficient, we have to establish the collaboration with African countries, with other countries which are having these deposits. Now, one category of very important strategic mineral, it is the atomic mineral. So, atomic mineral for example, uranite, pitchblende, cophenite, columbioite, tantalite, zircon, monazite, these minerals they contain naturally occurring radioactive elements like uranium and thorium. They have application in our defense, in the nuclear defense, the nuclear medicine, agriculture preservation, food preservation, water desalination and other high-tech industries. Now the Atomic Mineral Directorate for Exploration and Research, AMD, is responsible for exploration of the atomic minerals and they have established a substantial reserve in the Singhbhum belt as well as in the Tumlapally of the Andhra Pradesh. So, we have a reserve of about 1 lakh tons of Uranite.

ATOMIC MINERALS

- Atomic minerals: uraninite, pitchblende, coffinite, columbite-tantalite, zircon, monazite, etc.
- Contain naturally occurring radio-elements of U and Th
- Use in nuclear power, medicine, agriculture, food preservation, water desalination, defence and other hi-tech industries.
- Exploration for atomic minerals by AMD has established substantial reserves of uranium hosted in the vein-type/stratiform deposits of Singhbhum belt and the dolomite-hosted, strata-bound deposits of Tummalapalle.
- Reserve of over 1 lakh tones of U_3O_8 . Low grades ($< 0.1\%$; range $0.02-0.055 U_3O_8$)
- Numerous smaller tonnage deposits (500t - 1500t) such as Bodal, Bhandaritola, Jajawal (in MP), Kasha, Kandi and others (Himalaya).

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Of course, the grade is very low, less than 0.1%, and the range is between 0.02% to 0.055% U_3O_8 . Now, apart from Jaduguda and the Tumlapally region, we have numerous smaller tonnage deposits. These are located in Bodal, Bandaritola, Jajawal in Madhya Pradesh, Kasa, Kandy, and other regions in the Himalayas. In the northeastern region, we also have these atomic mineral deposits. Now, until now, we have discussed the major minerals.

Minor Minerals

- 'Minor minerals' defined in Clause (e) of Section 3 of the Mines and Minerals (Development and Regulation) Act, 1957.
- Minor minerals' includes: building stones, gravel, ordinary clay, ordinary sand, boulder, impure quartz pebbles, lime shell, kankar, and limestone used in kilns for manufacture of lime used as building material, murrum, brick earth, fuller's earth, bentonite, road metal, rehmatti, slate and shale used for building material, stones used for household utensils, marble, quartzite and sandstone.
- 31 more minerals have been declared minor minerals vide Notification S.O 423(E), dated 10th February, 2015,
- Namely, (i) Agate, (ii) Ball Clay, (iii) Barytes, (iv) Calcareous Sand, (v) Calcite, (vi) Chalk, (vii) China clay, (viii) Clay (ix) Corundum, (x) Diaspore, (xi) Dolomite, (xii) Dunite or Pyroxenite, (xiii) Felsite, (xiv) Felspar, (xv) Fireclay, (xvi) Fuschite Quartzite, (xvii) Gypsum, (xviii) Jasper, (xix) Kaolin, (xx) Laterite, (xxi) Limekankar, (xxii) Mica, (xxiii) Ochre, (xxiv) Pyrophyllite, (xxv) Quartz, (xxvi) Quartzite, (xxvii) Sand (Others), (xxviii) Shale, (xxix) Silica Sand, (xxx) Slate and (xxxi) Steatite or Talc or Soapstone.



There is one last category of minerals. That is, the minor minerals. These minor minerals, as defined in Section 3, Clause (e) of the Mines and Minerals (Development and Regulation) Act, 1957, come under the administrative control of the state governments. So, mostly, minor minerals include building stone, gravel, sand, boulder, clay, shell, and similar raw materials used for building roads or houses, such as quartzite, sandstone, and others. So, these come under the state administrative machinery. So, we can summarize what we have discussed over the last two classes.

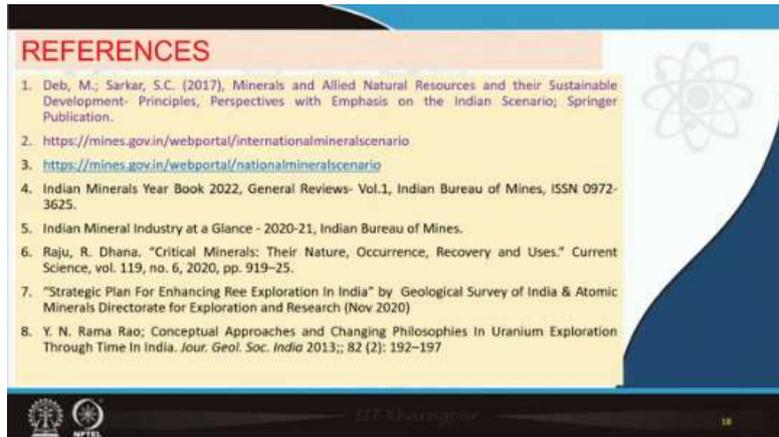
SUMMARY

This lecture session has covered the following:

- Non-metallic minerals
- Fuel Minerals
- REE and critical minerals
- Atomic minerals
- Minor minerals



In the last two classes, we have classified the minerals, discussed the different types of minerals, and in this class, we have covered non-metallic minerals, fuel minerals, REE and critical minerals, atomic minerals, and also provided a brief overview of minor minerals.



REFERENCES

1. Deb, M.; Sarkar, S.C. (2017), Minerals and Allied Natural Resources and their Sustainable Development- Principles, Perspectives with Emphasis on the Indian Scenario; Springer Publication.
2. <https://mines.gov.in/webportal/internationalmineralsscenario>
3. <https://mines.gov.in/webportal/nationalmineralsscenario>
4. Indian Minerals Year Book 2022, General Reviews- Vol.1, Indian Bureau of Mines, ISSN 0972-3625.
5. Indian Mineral Industry at a Glance - 2020-21, Indian Bureau of Mines.
6. Raju, R. Dhana, "Critical Minerals: Their Nature, Occurrence, Recovery and Uses." Current Science, vol. 119, no. 6, 2020, pp. 919-25.
7. "Strategic Plan For Enhancing Ree Exploration In India" by Geological Survey of India & Atomic Minerals Directorate for Exploration and Research (Nov 2020)
8. Y. N. Rama Rao; Conceptual Approaches and Changing Philosophies In Uranium Exploration Through Time In India. *Jour. Geol. Soc. India* 2013;; 82 (2): 192-197

IIT Bombay MPTEL 18

The references have been given in the slides. If you want to read in detail, you can go through these references. There are some books, websites from which I have taken references, and some mineral yearbooks or reports prepared by various agencies of the Government of India, such as the IBM (Indian Bureau of Mines) or the AMD or the Geological Survey of India. So, this is the end of today's class, Lecture 22. In Lecture 21, we discussed the different minerals. The role of minerals in our society, the role of minerals in our economic growth, and the growth of the country.

So, I think this lecture has been informative for you, and I thank you for your very patient hearing. Thank you very much.