

Mineral Resources: Geology, Exploration, Economics and Environment
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Lecture – 56
Environmental Impact of Mineral Resource Exploitation

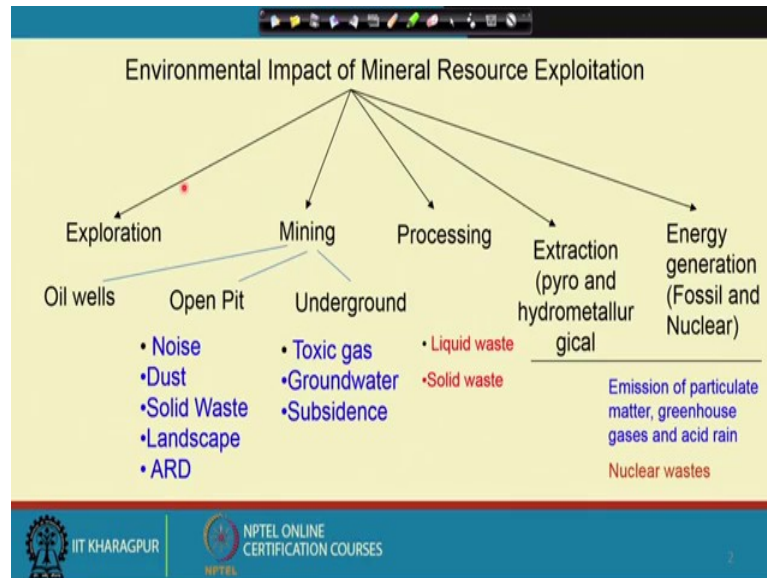
Welcome to today's lecture. So, this is a part of the series, the concluding part of the subject of mineral resources. So, in this part we will mainly be discussing on the environmental impact of mineral resource exploitation. And as I have said earlier that, we now have a more than two centuries of active mineral resource exploitation even though our use of metals can go back to a much distant past in the human civilization. But the active exploitation of mineral resources through the various mining practices and various downstream operations for recovery, beneficiation of the ores and extraction of metals by various hydro and pyro-metallurgical processes that has been going on.

So, gradually we started to realize that, the mineral resource exploitation processes is actually affecting environment, the ecosystem, the life in general and human population in particular. So that is the reason why there has been many statutory bodies there are many stipulations restrictions imposed by government of the different countries in the world. In the name of environmental protection agencies or different governments having their own department of environment and environmental forest and so, right at this point of time for successful exploitation of any particular mineral deposit or even a mining lease is to be granted to any particular agency, there is a very rigorous assessment of the impact that that particular mining activity would create in the surroundings in the ecology.

This kind of study is pretty intensely carried out and a detailed report is produced which is a part of the project evaluation, which we saw before. And many times it is felt that possibly the situation that are being a little bit more than what exactly or the deleterious effect of the mining process is actually it causes.

Nevertheless such practices such processes, I mean have been mandatory to follow. So, in this, say this particular class and the subsequent classes in the end part of this lecture series we will be discussing about the environmental impact of mineral resource exploitation.

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So, let us first have a look. We can possibly subdivide this entire scenario into some 4 or 5 different parts.

So, as we all know that mineral resource exploitation begins with an exploration process, in the exploration for say possibly is not the kind of process which will affect the environment in any serious way. However, the exploration of any unknown area where the detailed exploration work is going on, geophysical exploration work or geochemical exploration work which involves movement of manpower, machinery and creation of the infrastructure in terms of the roads etcetera

which starts the process that might affect the local or the eco system or the equilibrium that is existing in any particular region, where the mineral deposit is occurring. As we know there were locational peculiarities, sometimes they occur in remote areas, forest cover in most of the cases. So, there is a possibility that it will definitely disturb local equilibrium.

But definitely there is no much of a serious effect on the environment from the exploration stage. So, the exploration is followed up once the deposit is discovered and the feasibility studies have all given positive results, the whole body delineated, the quality equal to quantity parameters are estimated; all the evaluation have given all positive result and the whole body is developed and the mining process is beginning.

So, if we can look at the mining even though we have not discussed any hydrocarbon resource we have restricted ourselves to mineral resources. We have not touched upon the occurrence of hydrocarbon the oil fields or the oil pools, but we know that they are exploited by the oil wells because, the oil generally occurs always in the subsurface and certain geological conditions in the form of oil traps or on pools and in several such oilfield in a basin.

So, mining; if we think of in terms of the exploitation of the resource, then we can also take into consideration the mining of the hydrocarbon resources, oil and gas the solid mineral resources they can be mined by two different methods they can be open pit mine or the underground mine, oil wells. We can just briefly consider the drilling and all these recovery processes; drilling is to be done in subsurface sometimes in the offshore area. So, they are likely to affect the environment there.

And one of the important effects that we have seen in the past is the oil well fire, which has occurred in many different parts of the world including India and sometimes it becomes uncontrollable. There are ways; that means to be devised to put out the fire. And other than that sometimes the environmental impact that is caused by the exploitation of the hydrocarbon resources, and in the form of oil spills. When the crude oil is transported a bulk quantity in vessels and there is an accident leakages and there is oil spill created in the sea.

And it seriously affects the biota there in the sea and that is one of the problems which sometimes we get to know. And there are many active research is going on is to how to get rid of this whenever there is an oil spill, how to get the oil spill cleared and how to first detect the extent in which the oil spill is occurred and how to eliminate it. So, we might discuss a little bit about them.

So, the mining is either open pit or underground. So, the open pit mine is the environmental hazards. So, before we go into the environmental impact as essentially we can think of it in two different ways that, what mining causes there could be one of the thing, which can be called as a hazard. Because hazard of the mineral resource exploitation in the form of mining. In most of the cases the hazards may actually be caused by improper mining practice and causing short term or long term injuries to the

miners, the people who work in the mine and those are actually wherever there are some lapses in the proper safety that is to be adopted in the mining it might be.

So, those hazard for example, the water and some of other things which will be discussing here. They would not be exactly be coming under the subject of environmental impact, but they would be definitely coming under the category of hazards of mineral resource exploitation. In terms of the mining practice, how safe or how unsafe the mining practice is and whether it is causing any threat to the health or the life of the miners.

So, when it comes to the environment, we look at when we see the surface mining processes these are the four or five issues; first one is in oil that is the mining process because of the regular processes of release of the ore body through the blasting operations and the movement of huge machineries, wherever there are mechanised mining noise is one of the issues.

Dust is also another issue and the more importantly, the dusts are carried away for longer distances affecting the settlement in the nearby areas of the mining area. And sometimes the particles, the finer particles, which are carried away in the dust because of the higher surface area. They do also undergo certain chemical changes very rapidly and also affect the environment. So, environment essentially we mean air and water and they fall as sediments on the paddy fields or they contaminate the water bodies, surface water bodies and the surface water bodies in turn when it is contaminated it also contaminates the groundwater and so on.

The solid waste because wherever in case of the open pit mining as we have seen before the strip ratio is generally high, because the nature of the ore and as the mining goes deeper they more and more material to be removed as overburden with a very high strip ratio, and there need a space for disposal of the what we call as overburden or the gang.

And sometimes what is discarded as the overburden of the gang, also do contain the ore minerals or the metals in concentrations below their cut off grade, when they are dumped in the form of waste dumps. They also do pose some environmental problems the leaching of the metals through water that precipitates through the rainwater, and they all depending on the geological conditions, there they will eventually contaminate the water, the soil and the groundwater landscape.

So, open pit might actually change the landscape of the area which will be just showing you in a little while; and one of the important fallouts of open pit mine, which is important in context of the metal sulphide deposits where they are worked out by open pit process where the ore body is exposed to the surface. The ore minerals they get oxidized and they release copious amount of low pH water, acid charge water and the name actually is abbreviated as ARD is acid rock drainage or we call it acid mine drainage which will be discussing in a little bit of details in the subsequent lecture.

So, these are some of the issues, which associated with open pit mining and some of the situations for example, because more of the ore body is exposed and there during the process of blasting and the mining operations of the ore body, the dust that is generated also sometimes what we get to know about situations in case of chromites mining for the hexagonal chromium or the chromium, getting oxidized to hexavalent state and causing some health concerns in the nearby areas which will also might discuss.

So, when it comes to underground mining, underground mining of the metal sulphide deposit possibly do not pose that much of a problem like what happens in case of the surface mining in ARD, but again the underground mining in case of the hydrocarbon like coal, is sometimes much more hazardous and affects the environment. One of the situations which happens only in case of the coal mining is the toxic gas, which causes health hazard for the miners and that are many sets histories of miners in different countries in the past they held being affected by getting exposed to this kind of toxic gases in the coal mine, where because of the mining practice or because of not being able to get rid of this toxic gases by proper ventilation.

A groundwater is a one of the issues because most of the underground mining for metals sulphide deposits or any other metallic deposits. For that matter, even uranium deposit or any other metal oxide deposit, which have worked out by underground mining. Because of the depth ranges in which they occur they will invariably be intercepting the water table in the area and there will be slippages of a water in different quantities depending on the nature of the water table, the water table geometry, the hydraulic the hydrostatic head, and the local water table map of the area there could be this problem sometimes could be very acute.

And it does require special measures to be taken for getting rid of this groundwater and in the past we have several such instances in which, there have been serious incursion of the groundwater causing huge loss of life in cool areas in different parts of the world. And in addition to the fact that underground mining, considering the stability issues and other things for the very safe mining operations, which sometimes do cause such kind of hazards to the mining activity and the miners.

Subsidence is another issue where in case of the coal mines coal horizons or the coal layers, which are called the coal seams, which are taken out from the sub surface creating void and they as and when the mining processes continues the coal seams are getting mined out from the sub surface they will cause subsidence of the land.

And this is another one of the major serious concerns as far as the mining is concerned. These are some of the issues that they might come to mind even though it is not a very exhaustive list. And then the mining of the ore when the ore is recovered from the ground, the next step that is followed is for the processing of the ores. There are many different types of ores needing different types of processing. Sometimes even iron ore, which requires some simple washing to get it get rid of the clays and enrichment of the ore to the situation, where we need a very elaborate beneficiation process.

In case of the metal sulphide deposits by use of various chemicals in this process; so this as far as the environment is concerned, the concern arises whenever this processing of the ores. They give rise to two types of waste either could be liquid waste or solid wastes. Take for example, the case of the sulphide ores being subjected to process of froth flotation for the beneficiation, where the froth flotation process uses certain chemicals like the Xanthus which are used as the collectors and the furthers like pine oil.

And many such other different types of chemicals, which are used in this process are also discharged to the surrounding to the water bodies, to the areas and they might also cause some environmental concern. Take for example, the situation with a gold ores; the gold ores are sometimes recovered depending on the mineralogy, depending on the way in which the gold is occurring either as a as inclusions in the sulphide minerals or as invisible gold.

In that case processes like cyanidation for recovery of the gold or amalgamation for the recovery of the gold. They pose a more serious environmental concern because these are

toxic liquid. So, that arise some serious concern for the processing. During the processing, this is the two examples which I could site of. And then the processing also gives rise to lot of solid waste; as we all know during the process of beneficiation of an ore where the primary ore or, low grade primary ore is being processed to increase the grade.

So, it generates waste in the form what we call it the tailings. Tailings are the solid waste which is generated during the process of this beneficiation of the sulphide ores. After the beneficiation, the beneficiation gives rise to the enriched ore which is called the concentrate, and the part that is discarded is called the waste or the tailing and the tailing has to be disposed off in some form which will be seeing them. And then comes the process of extraction, which will be different types of pyro and hydro metallurgical process by which the metals are extracted. So, they also do pose some serious problem to the environment. For example, the sulphide concentrates for the extraction of metal, the process was melting which is carried out as a pyro metallurgical process for extraction of the metal, generates huge amount of sulphur dioxide to the atmosphere, and that sulphur dioxide is a culprit in the sense that into nearby areas it mixes up with the rainwater and what results is a very well known phenomena is called the acid rain. And there are many other processes in which if there are copious release of nitrogen dioxide species, then all they experience this kind of threat to the environment, which is in the form of acid rain which also we will discuss little bit.

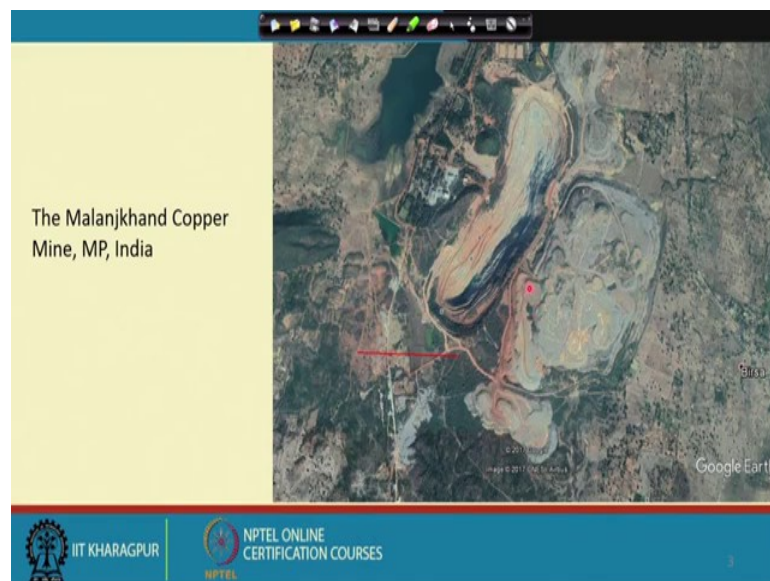
And sometimes there are issues of other metallurgical processes like extraction of aluminium, which using some material fluorine rich material like a kaolinite, which releases lot of fluoride to the atmosphere to the surrounding, and they are one of the major concerns. And we all know there are other issues like sometimes even toxic elements like arsenic getting released to the atmosphere, get to the to the surrounding to the soil and water.

And as far as the extraction also the resources exploitation of the mineral resources is concerned, one of the major issues that comes up in discussion is the hazard of the environmental impact that is caused by generation of energy. Since we have not considered much about the fossil fuel, but we all know about the environmental impact or the deleterious effect of burning of the fossil fuel in terms of increase of the greenhouse gases in the atmosphere causing the temperature to rise and global warming.

And all these things are topics of debate in the current scenario, and the energy generation by use of the energy resources like the uranium, ores uranium thorium ores, they also do give rise to another very important concern which is the nuclear waste disposal, which is a international issue many other countries facing this problem more acutely than what we are. Here we will also discuss a little bit about them.

Because the nuclear wastes in case of a exploitation of the energy resource from the uranium bearing minerals, we know that they also do recovered by the process of enrichment and they also do generate tailings, and then in addition to that the emission of particulate matter, greenhouse gases and acid rain. So, this is even though the list is not that very exhaustive, but it gives a spectrum of issues, which are related to the exploitation of mineral resources and the concerns.

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I will just give a good give an example. Take an example of a situation where I am more familiar with this is a Google map of the Malanjkhand copper mine the smallones copper mine has been operating since 1980.

And now it has almost like a 37 years of history of mining of copper in this particular deposit, which is the Malanjkhand copper deposit what you have seeing here is the open pit which is almost about you see this scale is one kilometre here. So, this length is almost about 2 to 2.2 kilometres and what we see here that when we are discussing about the open pit mining causing the landscape to change. So, it was initially this 2.2

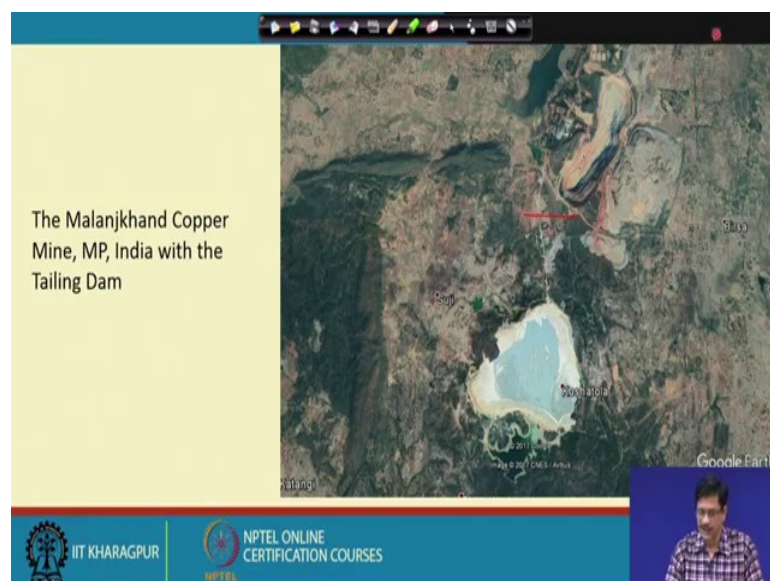
kilometre area was actually made up of string of three or four hillocks, because of the resistant mineralized quartz reef which was in the area.

So, now those quartz reef; it is rising almost to 250 meters from the ground level and about 600 to 700 metres with respect to the mean sea level. And these now what we see here is a huge single open pit, are going to a depth of almost like 300 to 400 meters now starting from 1980 till date. So, what has been done here since it is an open pit mine; it has also generated a lot of overburden and what we see here is that it is possibly represents the limit of the mine release area beyond which it cannot go.

And this 37 years of mining of the copper over here, has given rise to features which are shown here are essentially the dumps. These are the waste dumps which are coming out after the overburden is removed to get the ores and to just remind you this overburden are also not just pure rock, they do also contain the metals in concentration which are below the cut off.

So, along with the country rock which is dominantly the granite here, some amount of low grade ores, the oxidized ore are which are below the cut off are also dumped here. So, definitely these are the situation which has been created, and it can be clearly seen as an environmental issue.

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The same Google map which is taken here in a smaller scale just to show you one important feature here; what you see this fan shaped body; this is the tailing dam. So, the ore body which is mined here is getting enriched by the concentrate by the floatation plant here, which they concentrate in terms of the a enriched ore is transported for further processing of the smelting and the tailing in the form of slurry is transported through pipelines, and is deposited in a place which is making this structure called as a tailing dam.

There are several geological and engineering considerations for the selection of this area, which has to need to be an area where this could be stable even though there are many instance in which there are sometimes this kind of dam also fail. A failure of this dams create a lot of environmental hazards, but even if this situation here is that such kind of discarded material are getting accumulated here and they remain here in the form of tailing dam, they do also by virtue of the presence of the ore minerals, even though in lower concentrations, but also can a potent candidates for affecting the environment there, the soil the water.

So, we will continue discussing on this topic of environmental impact picking of this some of the selected topics. So, we will continue discussing in the next class.

Thank you.