Mineral Resources: Geology, Exploration, Economics and Environment

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Lecture – 59
Environmental Impact of Mineral Resource Exploitation (Contd.)

Welcome to the today's lecture. So, let us continue on the topic that we have been discussing on environmental impact of exploitation of mineral resources, and in particular reference to mining of multi metal sulphide deposits and the deposits where we have a dominance of pyrite which readily gets oxidized and generates substantial amount of H plus ion and form of H 2 SO 4.

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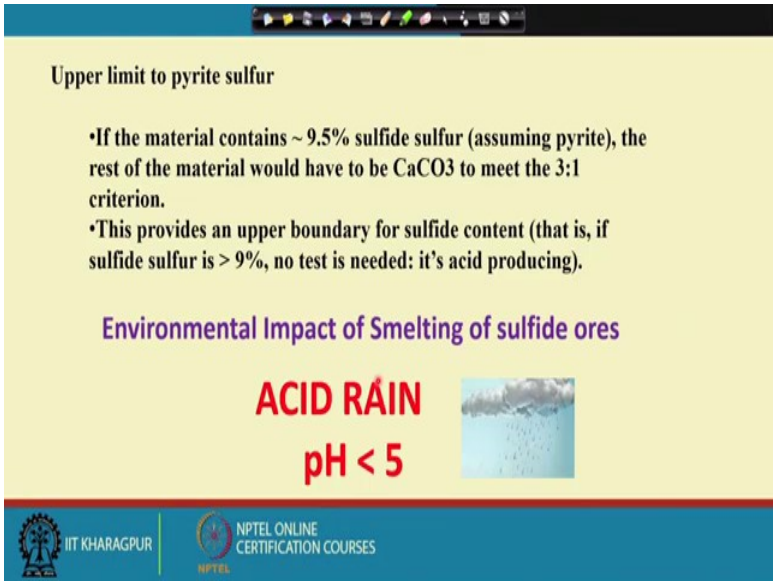

And this acid contaminates the soil and water, hereby affecting the ecology affecting the aquatic life; and in addition to that also indirectly affecting the human life also.

So, just to recapitulate when we were doing the impact assessment through acid mine drainage and bring the acid base accounting. We concluded that if a particular ore body contains more than 9 percent of the sulphidic sulphur then in any case it is going to be net acid producing no matter how much of material would be there in the form of the carbonate, because carbonates are the most efficient materials to neutralize the acid.

Just one more additional point in relation to the exploitation of the mineral resources and in particular the multi metal sulphide deposits is the environmental impact of this melting, because we know that once the sulphide ores are mined from the mine they are concentrated in plants essentially by the process of froth flotation and then the ore is enriched to a level where the ore could be fed into a smelting for extraction of the metal.

And the materials which are discarded in the form of tailings in the form of slurry are deposited in the tailing dam and then the concentrates are essentially fed to the plants which are the smelters where the metals are recovered in the process of smelting.

So, this smelting essentially is a pyrometallurgical process and it producers slags in this process which also have to be disposed off. But more important is the situation which we all know is basically the acid rain. So, in the process of smelting of the sulphide ores a huge amount of sulphur dioxide is distressed to the atmosphere and this sulphur dioxide which is there in the atmosphere gets dissolved in the rain which is precipitated in the clouds.

So, generally the idea about acid rain is that, acid rain is produced by the carbon dioxide in the atmosphere, but essentially the carbon dioxide in the atmosphere which is also soluble and which also renders the rainwater little bit of acidity. But that is always within the range of greater than 5. But the water which can be called as acid water and affecting the aquatic life or causing environmental concerns is generally the water which falls in the form of rain has a pH of less than 5.

There the effects are quite lot and they affect the aquatic life. So, they are in addition to sulphur dioxide where the nitrogen oxides NO2 and the different stoichiometry mostly the nitrogen dioxide it also gets dissolved by the rain and cause acid rain. And they we know that they effect the land, effect the agriculture and affect the aquatic life and as a whole they effect the environment.

So, this could be discussed as one of the salient points on the environmental impact of human resource exploitation in particular reference to the mining of the multi metal sulphide deposits. There are many other environmental problems even though they are a little less known or very little less well known than many such straight forward cases like acid mine drainage.

For example, the dispersion of arsenic or antimony related to gold mining reported in certain cases, and the case of arsenic contamination in groundwater effecting many parts of the Eastern India and the neighbouring country also have been debited a lot and sometimes they are ascribed to geogenic causes. So, whenever we talk about a geogenic cause means we always take it for granted that there are some horizons where there are either arsenic bearing sulphides itself has a pyrite or sulphide minerals with substance with significant concentration of arsenic exposed during the process of their weathering.

And this how they affect the environment and there are many because arsenic is a metal affects only in the plus 3 oxidation state and generally they made precipitated or in the plus 5 states. So, whenever there is a reduction or, the environment is bit reducing the arsenic is released and water is contaminated.

So, many of these is related issues which could not directly be concerned with the exploitation in terms of the mining. There are other situations like the bauxite deposits and the aluminium extraction process causing fluoride contamination in the surrounding areas are also well known and well discussed. We are not getting into any further details on them, so what have been discussed some of the important and the key issues.

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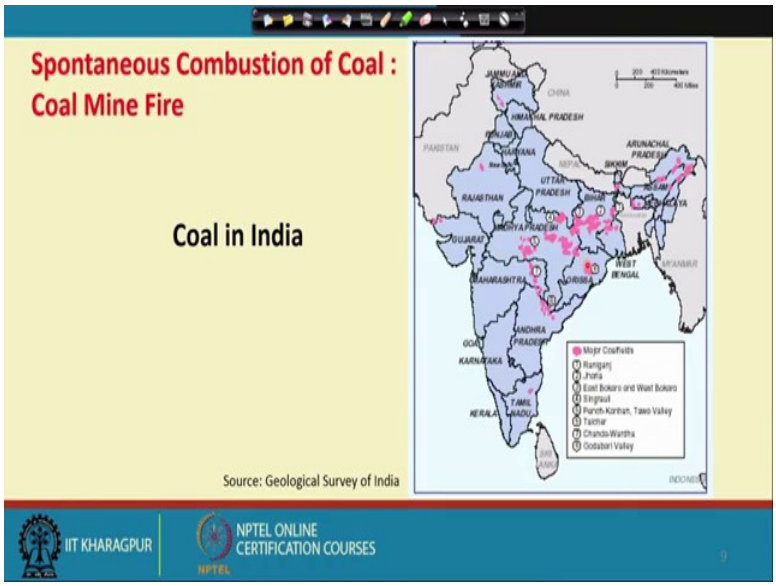

So, a when we come to the environmental impact of mineral resource exploitation if you do not discuss about the issue of the coal or this particular issue which is the spontaneous

combustion of coal or the coal mine fire has been a very important and a critical and burning issue associated with utilisation or exploitation of coal.

Even though we have not discussed about our coal resources, about the geology or the origin of this coal deposits in the country in the world or in particular in the Indian context; But this particular issue which was a little bit of discussion here because, sometimes it is discussed that many some of the coal fields in Eastern India like the Jharia coal field and the coal fields in this region sometimes it is told that the basically this locality they are actually sitting on fire. Now, why is it so?

Because even though we have not discussed much about it let us have a very brief move on the coal occurrences in India, whatever have been marked here in pink. So, this is the Narmada river valley, coal deposits on valley, then the central India, this is the Mahanadi valley, coal deposits in the Godavari valley and we know this coal deposits.

And this is the Raniganj coalfield, this is Jharia, and this the east buckaroo or west Bokaro coal field and these are the Shiroli the coal fields in central India and this is the this is Talcher coal field and we know this is the Mahanadi valley coalfield in Talcher and the IB valley.

So, as we know this coal fields which are there, they are essentially the this the coal fields in the Eastern India or the south Eastern Indian part, are essentially known as Gondwana coal belonging to the permocarboniferrous age and occupy a rift valleys which are now occupied by the distinct river valleys like Son, Narmada, Mahanadi and the Godavari and these are the ones which the coal areas are demarcated here.

So, this coal area is the major coal producing zones in the country mostly producing coals of bituminous kind of variety of coal in majority. And also we see that there are some coal areas in the north Eastern states in the state of Assam and Meghalaya.

So, the essential difference between these two a regions primarily is that the Gondwana coals which were deposited in fluviatile basins, and later on converted in the process of coalification, whereas these coal areas in the north east are the tertiary coals belonging to the mostly Oligocene, Eocene kind of time range. And these are understood to have formed the marine environments and they have a marine origin as against the fresh water origin of most of the Gondwana coalfields.

So, as a simple method of distinction we know that the coals which are freshwater or fluviatile origin of Gondwana coals essentially distinguished from the tertiary coal by some of the parameters as this tertiary coal, richer in the sulphur content as compared to the Gondwana coal.

Now, this in the in the context of spontaneous combustion of coal it is little important because we are find the most the coal areas in the north east state in Asssam and Meghalaya are worked out by open cast surface mining kind of methods. And majority of the coal deposits in this Gondwana coal in the Eastern and south Eastern part in the Dhamodhar valley and the Mahanadi Godavari valley they are mostly worked mostly mined by underground method.

Now, what is observed is that the coal once they are exposed in the mine faces they catch fire they are actually spontaneously combusted what we can call in a group term is coal fire. So, that has been lots of attempt in understanding actually what causes this because people say that this coal fire is not only that there are colossal wastage of resources because huge quantity is a coal are destroyed because of this fire. And also sometimes they pose fate to human lives and there are instances of loss of life because of coal fire in some of the coal fields in the Eastern India.

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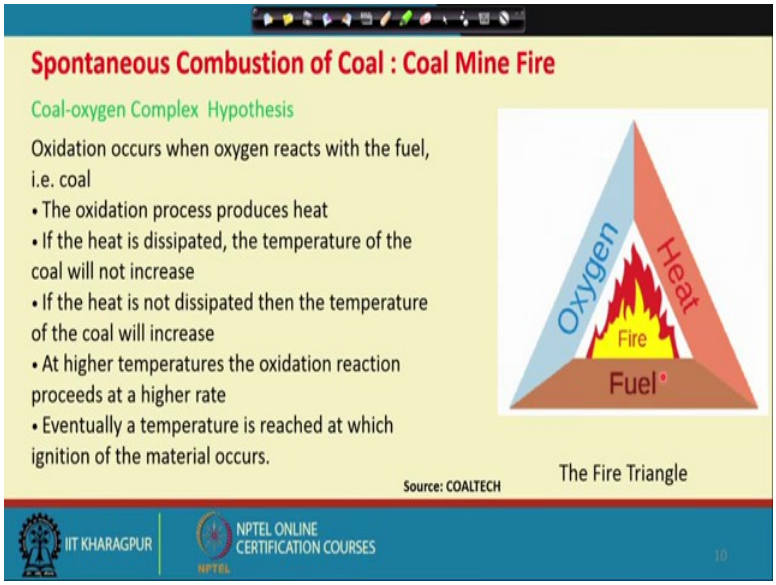

So, we will just see that what is basically understood or what is basically told in the context of this coal fire or the spontaneous combustion of coal mine fire. So, there are

many hypotheses one goes at the coal oxygen complex hypothesis. So this diagram is essentially the schematic diagram showing the fire triangle, the fuel oxygen and heat.

So, it goes by the understanding that once the coal is exposed that comes in contact with oxygen then there is oxidation. This oxidation possibly take place in a complex way by formation of the coal oxygen complexes in between and there is oxidation and it is a very severely exothermic process and generates huge amount of energy in form of heat.

So, if that heat is not dissipated. Essentially it causes a kind of a chain reaction and more and more the oxidation process gets usually kinetically favoured and then each reaction again liberating huge amount of energy in terms of heat and the fire becomes uncontrollable.

As a matter of fact the coal seams or, the coal horizons which are all worked out by open cast mines. Here this supposed to be exposed to the atmosphere where the heat is likely to be dissipated, whereas in case of the underground mine where the heat is not been able to dissipate that very efficiently is basically causing for this reaction.

So, here the process is the oxidation occurs when oxygen reacts with the fuel. Oxidation process produces heat if the heat is dissipated the temperature of the coal will not increase, if the heat is not dissipated then the temperature of the coal will increase. Now at higher temperature the oxidation reaction proceeds at a very high rate and eventually a temperature is reached at which ignition of the material occurs.

Now, if we go by that principle then the open cast mines are less likely to be affected by the spontaneous combustion compared to the underground mine. And then the observation does not actually fully support this because many of the coal areas in the Bokaro coalfields, , Jharia and the Buckaroo coal fields which are affected by this fire some of them also basically being worked out by open cast mining as well as mine always goes.

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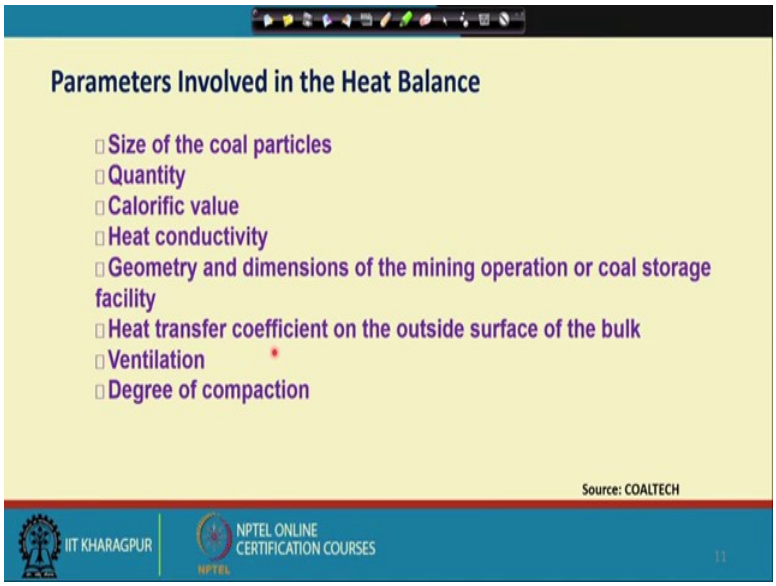

So, now what the parameters did I involved in the heat balance is the size of the coal particles, the quantity of coal, the calorific value, the heat conductivity, geometry and dimensions of the mining operations or the coal storage facility, the heat transfer coefficient on the outside surface of the bulk, ventilation and degree of compaction. So, these are some of the parameters which are known to be the controlling parameters in the spontaneous combustion of coal.

So, the size of the coal particles is an inherent characteristic of the coal, the quantity that is present, the calorific value will come from the fixed carbon content of the coal and the heat conductivity. So, these numbers of parameters which are shown here is a combination of both the inherent characteristic of the coal and the mining processes which both contribute to the coal mine fire.

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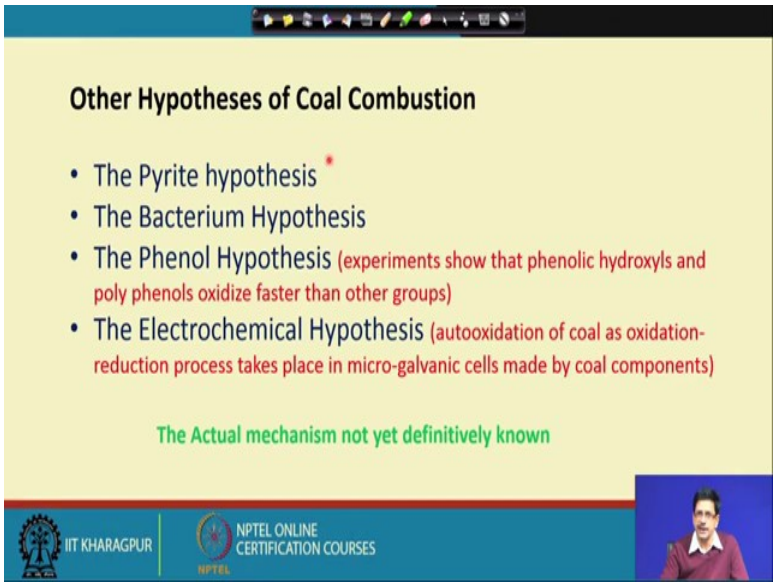

There is some bit of other hypothesis also proposed for this spontaneous combustion of coal. One of them is the pyrite hypothesis. Some people believe that the pyrite as I as I discussed before that the some of the coal are very rich in sulphur, and actually the sulphur is present in the form of pyrite as is observed in many of the coal areas. For example, in the north Eastern coalfields in India where are the pyrite is present in various forms within the intervening sediment as well as the coal seems themselves also contain some amount of pyrite.

So, what we discussed in the context of the acid mine drainage, the pyrite when it gets oxidized, it liberates the hydrogen ion with hydrogen and the sulphide acidic water and in addition to that this pyrite oxidation also generates energy which we discuss that it actually helps the microorganisms to proliferate. This is one of the hypothesis that maybe the energy that is released during the pyrite oxidation which would be one could be triggering the oxidation of coal.

The bacterium hypothesis also goes hand in hand with the pyrite hypothesis that because the bacteria will facilitate the oxidation process and the oxidation of the coal detect this.

The phenol hypothesis says that the experiments show that the phenolic hydroxyls and the poly phenols oxidize faster than other groups. So, they are supposedly present in the in the coal. The electrochemical hypothesis says that the auto oxidation of coal has oxidation reduction process takes place in micro galvanic cells made by the coal

component. So, these are some of the other hypothesis which proposed for the spontaneous combustion of coal.

But if we try to find out the whether this pyrite hypothesis actually holds, we do not see such kind of coal combustion or, spontaneous combustion of coal in the sulphide rich coal seam in northeast as I just said before. Maybe that because they are worked out by open cast mine and most of these are still in a state of a hypothesis and the actual mechanism is not very definitely known.

It may be there some of the coal seems do also contain lots of gases in the form of the coal bed methane and other kind of combustible gases, they also maybe facilitate in the process of a coal combustion, it is not exactly precisely known.

These are the things that we can discuss in terms of the environmental impact of mineral resource exploitation, starting from the thing that there are certain issues which come up because of improper or unsafe mining practices which causes loss of life or some amount of threat to the workers. But then those things could certainly be taken care of by imposing strict safe mining practices.

And then there are certain issues like dust, noise or the change of the landscape which essentially cannot be avoided only with a fact that because as long as we need the mineral resources, we need to exploit them and the best that we could do is that we remain aware about the issues and the way they are affecting the environment. Say for example, in context of the acid mine drainage there are many remedial measures which could be taken for example, use of lime. And then there are recent attempts to use many of the waste material like fly ash or cement slag kind a material to be used in coal mining areas where they could be used for remediation of this acid mine drainage.

So, this remain as the awareness or knowledge that the mineral exploitation process is causing to the environment with the fact that we need this metals and materials for our industrial growth. The issue is that they could be properly compensated.

For example, many of the mining companies it become mandatory for them to, if there is a particular mine area in which the mind lease needs to be deforested for setting of a mine of a particular ore body which is economically very important. Then the mining concern has to compensate by doing afforestation in some in the other adjoining areas,

taking care of the human population or compensating in all possible ways that the mining activity could possibly have done the harm to the environment.

But the fact remains that mineral resources need to be exploited. So, with the only the note of question that remain ever about the environmental impact, and do a proper environment impact assessment, and then attempt adequate remedial measures for restoration of the environment, and also compensating in the form of any other kind of rehabilitation process in the nearby areas, so that the damage that is done to the environment could be somehow controlled or could be compensated.

Thank you. So, we will continue our discussion in the next class.