ENGINEERING GEOLOGY
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LECTURE – 03
Geologic Maps and Stratigraphic Sections

Hello, every one and welcome to session three of the video course on engineering geology. In this session, we are going to talk about geologic maps and stratigraphic sections. But as is the practice; before going into the subject matter of this presentation, I am going to first discuss the answers of the questions that were asked in the previous presentation.

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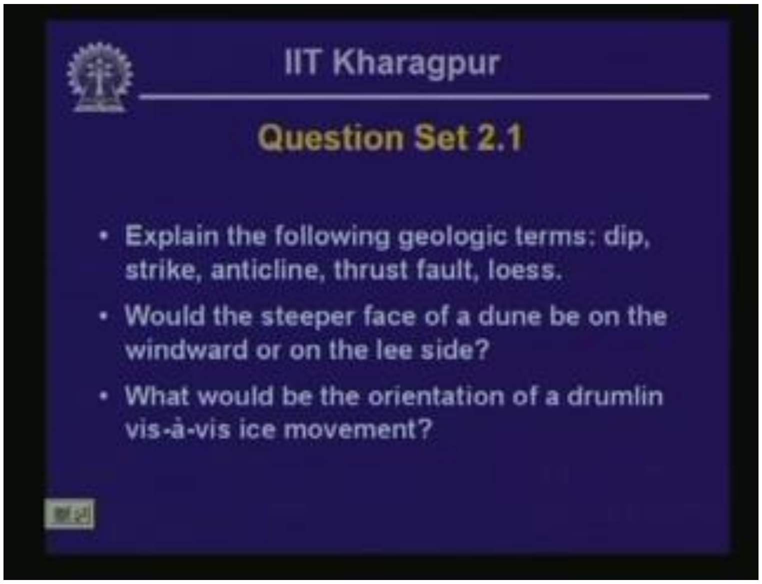

The first question that we were trying to answer was the explanation of the following terms; dip, strike, anticline, thrust fault and loess. Now, the meaning of these terms was clear from the presentation of the last lecture. To restate what I did in the last lecture time; for example, let us take an example of a fault and the fault looks like this.

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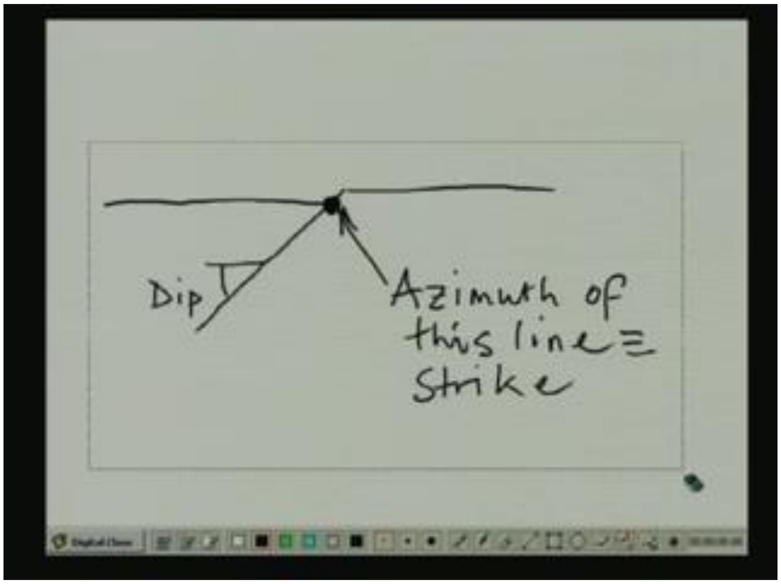

So, in this case, deep of the fault is that angle there, strike of the fault is the orientation of this line perpendicular to the plain of this paper; I mean the Azimuth of that line is going to be giving the strike, Azimuth of this line is equivalent to the strike of the fault. So, that is what we mean by the terms deep and strike.

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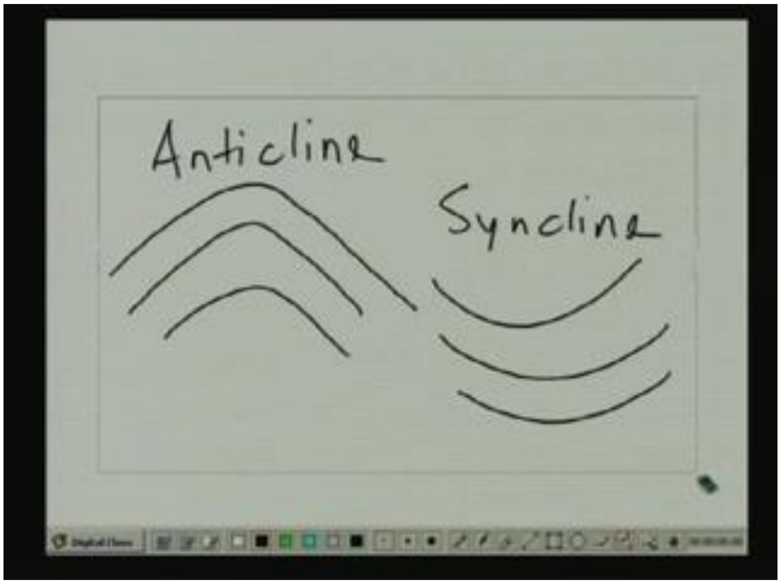

Then by syncline and anticline, what we mean is if you have got a fold like this, then that one is called an anticline and the reverse is a syncline.

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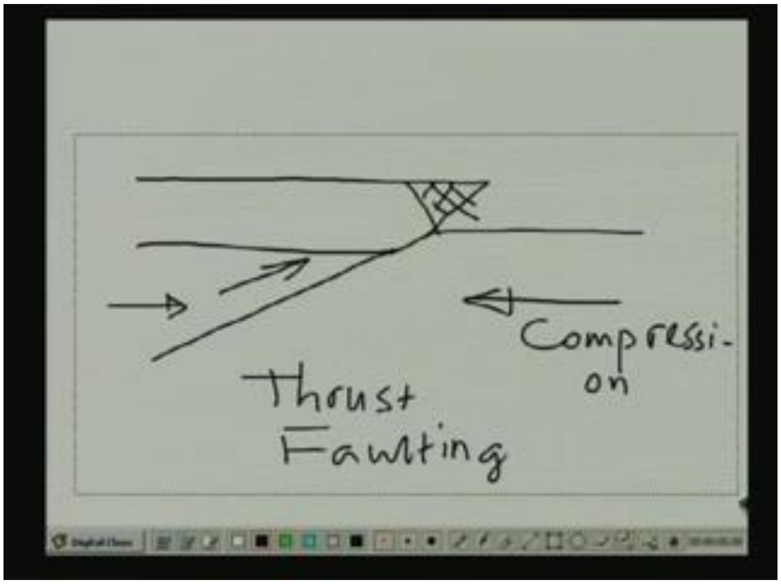

Getting back again; thrust fault, what we mean by thrust fault is say, you have got a fault which is essentially a shallow angle fault and we subject this one, these two blocks actually to a compressive load like that, then this block is going to try to ride on top of the other block and eventually take a shape like this and this block is going to get eroded out and this kind of faulting is called a thrust faulting.

And, the other one that we asked is about loess, about the deposit called loess. Loess is essentially a silt size soils composed of sill sized particles and that is essentially transported by the action of wind. Now, the second question that we asked was; would the steeper face of a dune be on the windward side or on the lee side? Actually, steeper face of a dune is essentially going to be on the lee side.

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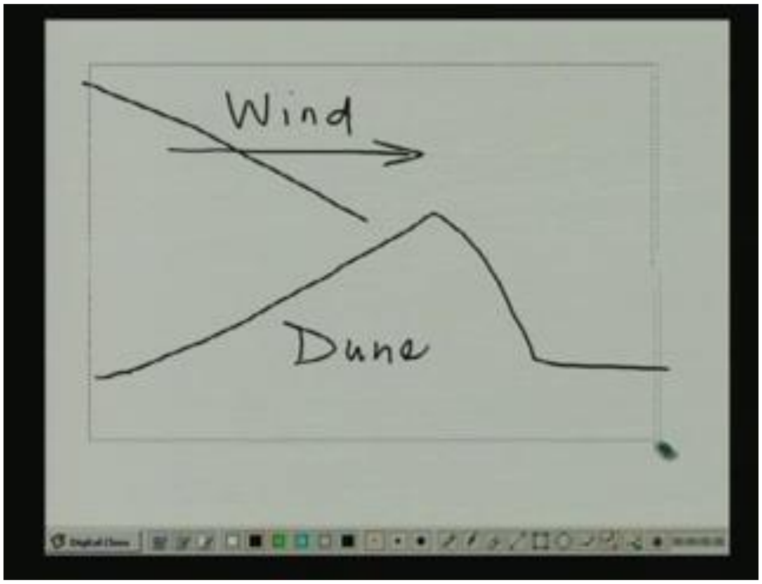

In other words, if you think about vertical section, if you think about a vertical section of a dune, it typically is going to take this kind of shade and the direction of wind is going to be like this. So, this is the dune that we are considering here so that is the other solution.

The third question that we asked was that what is the orientation of a drumlin vis-à-vis the direction of ice movement? So, this is actually going to be parallel to the direction of ice movement.

Let us take or let me draw a sketch here and say, you have got the direction of ice movement like this, so this is the ice movement direction.

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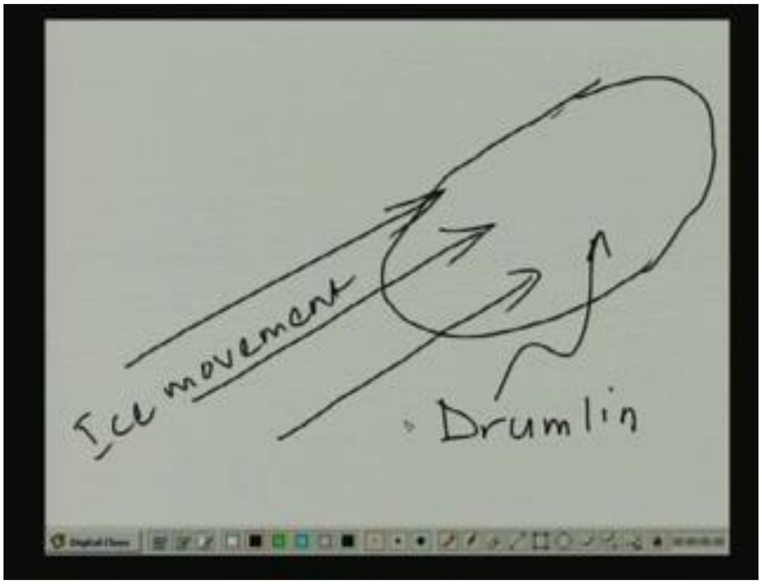

So, in this situation, drumlins are going to form in this manner; so this going to be our drumlin. We are looking at a plan view that means we are considering, we are taking a view looking upside down. So, drumlins are essentially humped like features on the surface of the earth and the orientation of the hump is in the direction of ice movement. So, that kind of takes care of the problems that we asked in the last presentation.

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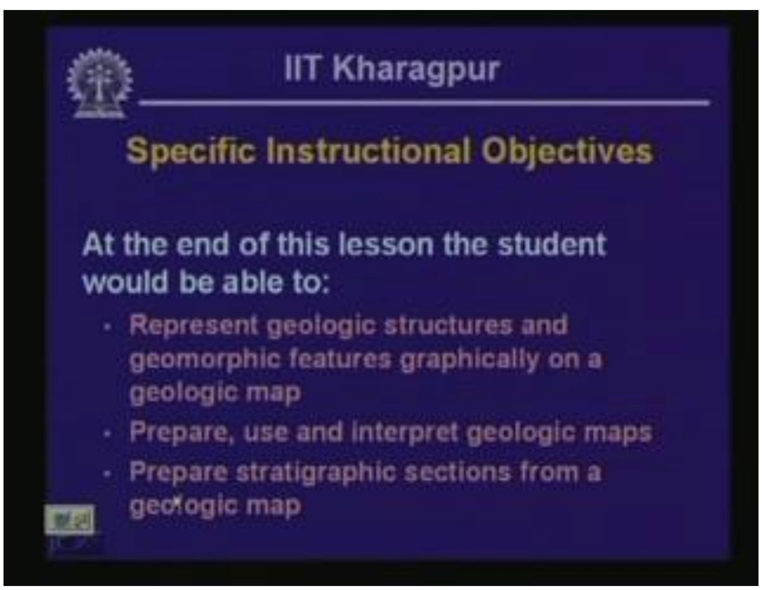

And now, we get on to the subject matter of this presentation. What we are going to learn in this session? We are going to learn about how to represent the geometry of different geologic structures and landforms onto a geologic map. So, that is the basic purpose of this course and we are also going to try to learn about the procedures that will enable us to prepare interpret; prepare as well as interpret available geological maps and prepares stratigraphic sections that may or may not be available in the same package which we receive from existing achieve of information. So with that stated, we get on with the actual subject matter.

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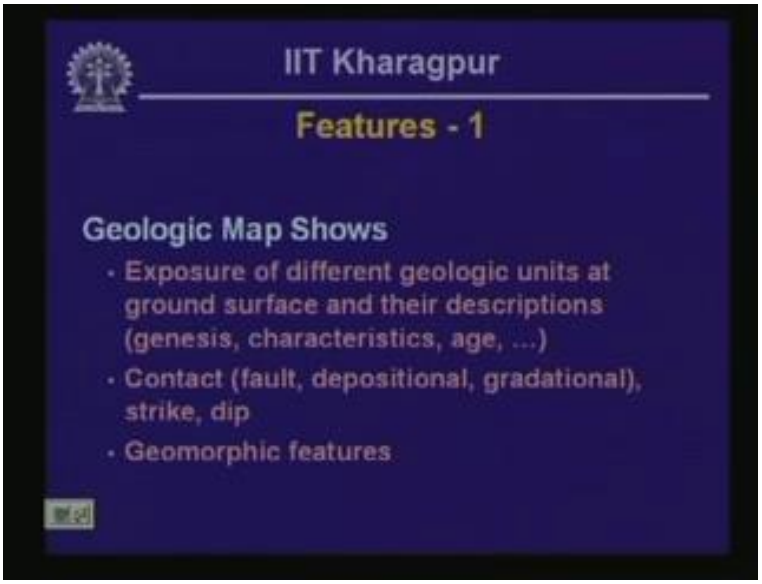

What is going to be shown on geologic map? Geologic map essentially is going to present as I stated just in the previous slide; geologic map is going to include structural features giving, showing the geology showing the different types of landforms that might be there in a particular area and also sometimes it also shows the contact between different geologic units as well as the like other information like deep Azimuth of the strike of a particular feature whether there is anticline or syncline and so on and so forth.

We are going to take an example of geologic map in the next little bit but before doing that, let me also say, also list a few features that may be included on the geologic map but not always.

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This features actually include stratigraphic contours; what do I mean by stratigraphic contours are essentially the lines through equal, through the top of a stratigraphic layer which are at the same elevation. Then it also may include topographic contours; topographic contours are the contour lines or the lines through equal elevation points on the surface of the earth and also stratigraphic sections which are essentially vertical slices through selected locations across the map that is being considered.

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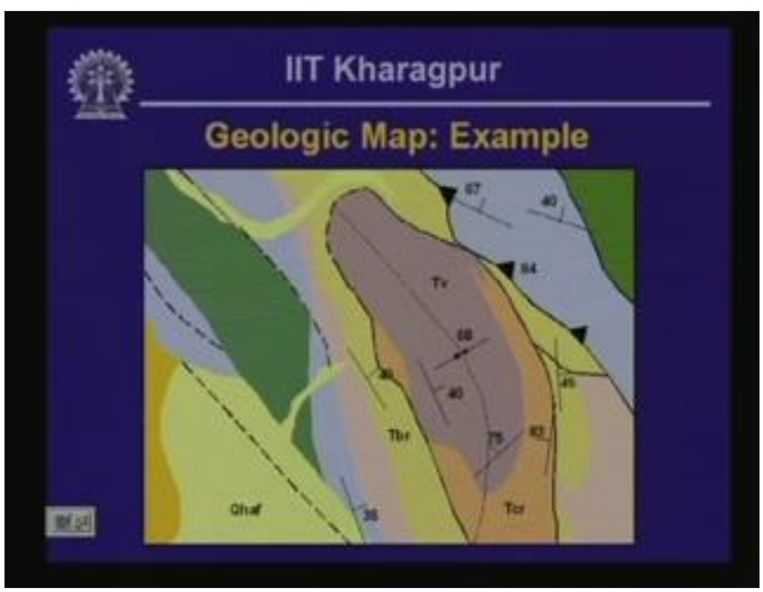

Now, let us take an example of a geologic map in order to try to see what kind of features one might expect on a geologic map. These maps are normally available from existing archives of agencies like geological survey of India or United States geological survey or it can be prepared by an engineering geologist in house for the use of a particular project.

Now, let us see an example of a geologic map. The slide here shows the surface exposure of different geologic units in different colors. For example light yellow color; the unit to the bottom left of the map in light yellow color labeled Qhaf is essentially indicating that area is underlain by some quaternary deposit. That means deposits, soil deposits of relatively recent origin. Whereas, the geologic unit shown in purple color, light purple color near the center of the map labeled Tv is essentially an out crop of a bed rock from the classic edge.

Now, you look at that out crop at the center of unit Tv and you can see a dotted line going top to bottom across this particular, I mean, along the length of this particular unit, dotted line and this dotted line is actually is essentially a syncline which has got a dip of 68 degree as marked by 2 inward arrows shown near the center of this particular unit, geological unit.

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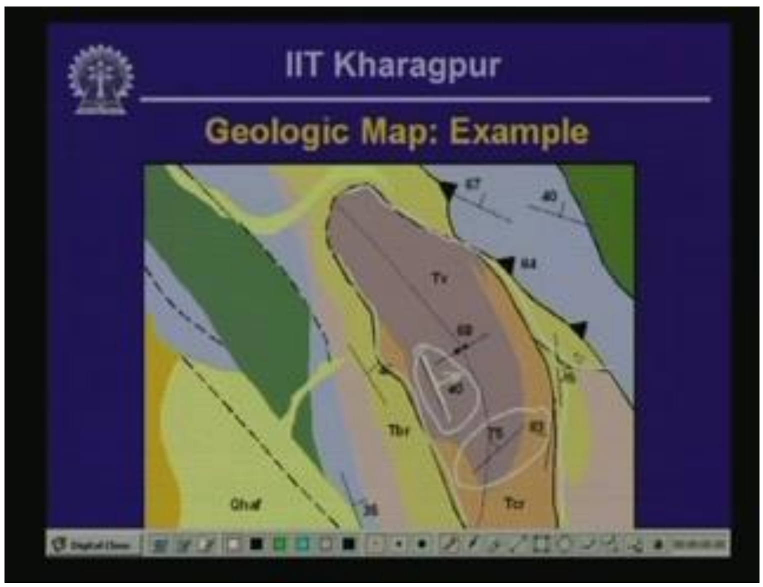

Also shown on this unit are features like these; they are indicative of the dip at different locations of this particular unit. For example, the strike of this out crop is in this direction at this location whereas, it is going to dip, it is dipping at 40 degree in the other direction, in a direction perpendicular to it. So, these are essentially true dips.

Now, there are other lines, actually the thick lines shown here indicate that there are faults in this areas, these are the strikes of different faults. They are all strikes of different faults. So, solid thick lines indicate strikes of faults whereas, dashed lines likes this, like this are indicative of faults inferred fault location about which the geologist to prepare this map is quite sure. Whereas, lines like these indicate faults, these are dotted lines actually, thick dotted lines, they indicate faults about which there is no form information but these are actually inferred from the direction, from the orientation of this fault at location nearby to this area.

Now, this feature here to the right of this geologic map shows essentially a fault, a thrust fault that is dipping at 54 degree angle. So, these are the kind of information that you might actually expect when looking at a geologic map and sometimes these map are going to available to you when you are incharge for a particular project in order to decide the optimal location of different project activity or rooting of different linear developments as we discussed earlier.

In other times, particularly in important projects like dam projects or a tunneling project, the engineering geologist working for that particular project, himself is going to be in charge of developing a geologic map like this to a scale which is larger than the scale of geologic maps that are normally available from the agencies that I talk about of the shelf.

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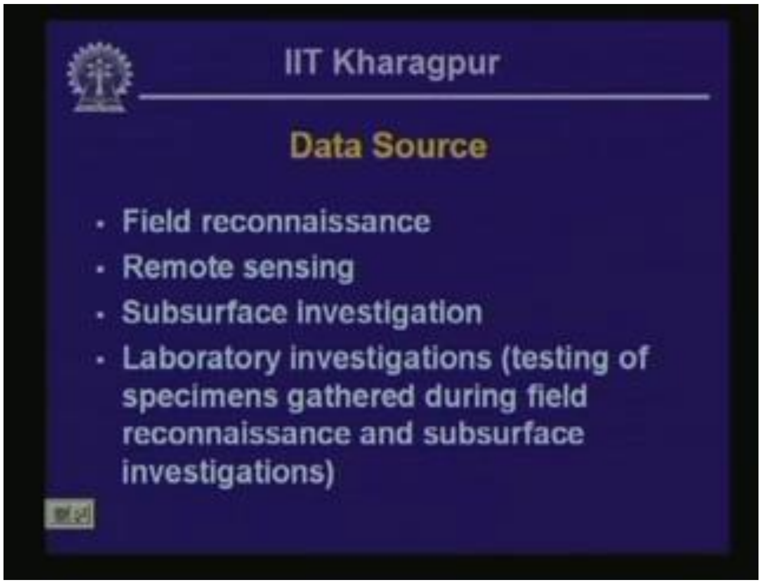

The maps, geological maps available from USGS or geological survey of India typically will be at a map scale or may be one in 20,000 to about one in 100,000. Whereas, in important projects, one might need a map of a much larger scale like one in 5000 or one in 10,000; in that situation, there is no option than to carry out a geological investigation within the project area and prepare a map like the one that was shown in the previous slide.

Now, we have to then ask ourselves what are the sources of data from which a geologic map can be combined. Now obviously, the data source includes field reconnaissance in which an engineering geologist essential goes around in the country side which is going to be forming the map area. Then additional information could be available from remote sensing and subsurface investigation also may be required in some situations, as well as laboratory investigation which include testing of specimens that were gathered during field reconnaissance and subsurface investigations in the previous steps that we listed there.

So, these all things together actually form the activities that required to be undertaken for the construction of a geologic map. Now, let us consider what we do in field reconnaissance? In field reconnaissance, essentially a trained geologist actually roams around the countryside typically to try to identify different types of, out crops of different types of rocks and soils on the surface of the earth at different locations within the project area.

It also includes, the activities also includes the, one must also include the information when carrying of reconnaissance, the information about the dip of this features or different types of structural landforms, outline of different types of structured landforms that may be there within the area that is being mapped.

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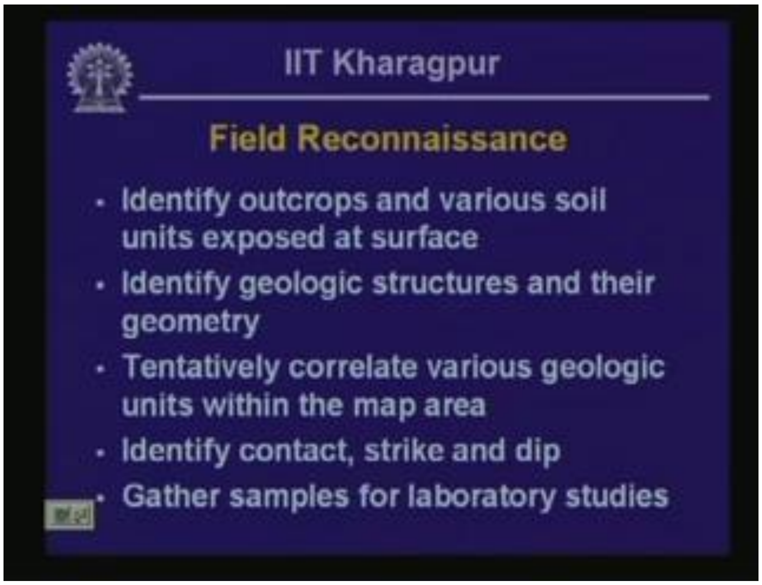

In addition, one will have to identify tentatively, identify tentatively the edge of different geologic units within the map area. Then the responsibility lies in identifying contact, strike and dip of these different geologic units and also samples must be gathered from the outcropping units for laboratory studies because although tentatively various geologic units might be correlated with each other, confirmed correlation can be available only based on some former, some more précised information that can only be available from laboratory studies.

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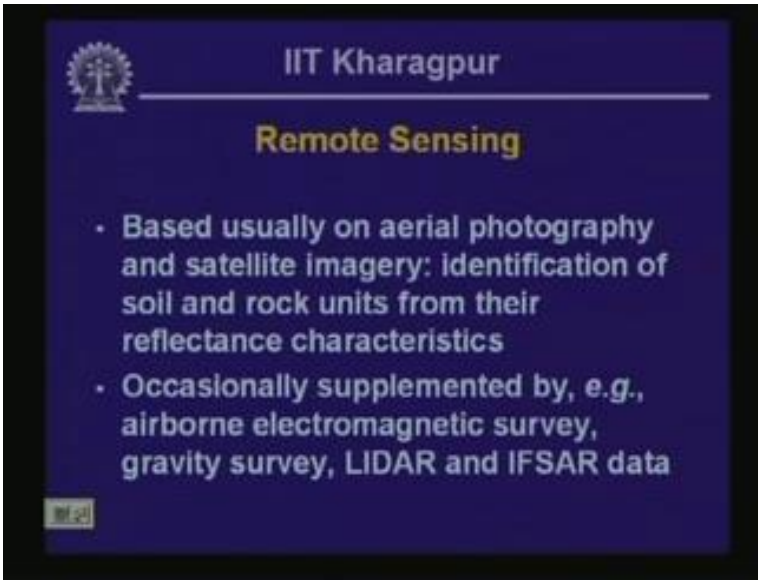

Let us understand what we mean by each one of these things when we consider an example of field data in the next little bit. Also included in the list of data sources that we discussed earlier is remote sensing. Now, in remote sensing, what we do? Essentially we try to look at reflectance, we try to identify different features, different outcrops from the differences in their reflectance characteristics.

The remote sensing procedures that are normally undertaken in preparing geologic map is electromagnetic survey, it could be gravitational survey and as well it could just simply include LIDAR and IFSAR which we are going to discuss in one of the later presentations of this series of lessons in greater detail.

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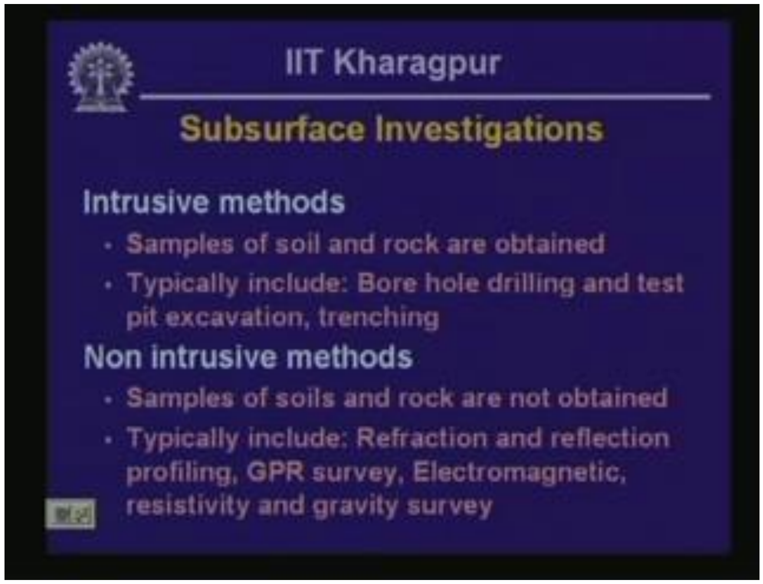

Then we have to also carry out subsurface investigations to get more precise information about the elevation and the topography of the different study graphic units that are not visible at the ground surface. And also, in this activity, samples of different types of geologic units are obtained for subsequent laboratory testing. These subsurface investigations scan include intrusive methods in which a bore hole is drilled typically into the through different geologic units or it could include test pit excavation and trenching and by looking at the different features on the walls of the test pit and trenches, one could correlate different geologic units.

Alternatively, subsurface investigations could also include non-intrusive methods in which no bore hole is excavated or drilled or a test pit excavated through the geologic units. In these testing procedures, samples of soils and rock are not obtained and typically these procedures include refraction and reflection survey; we are going to talk about these different procedures again in greater detail later on in this course.

Then, non-intrusive methods also include GPR survey in which ground penetrating radars are used or as in the previous procedure of recognizance, detailed electromagnetic resistivity and gravity survey can be undertaken in the non-intrusive method in greater details. Recognizance is essentially something to do with getting a quick but wide spread idea about the entire map area, whereas sub surface investigation includes procedure that gives more precise and more detailed information about the subsurface stratigraphy.

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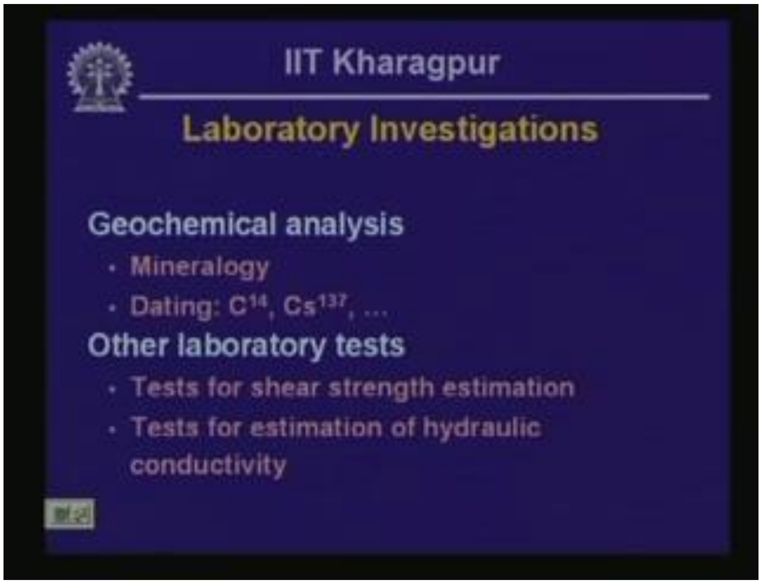

Then, the other activity that goes before the map, before a geological map could be prepared is laboratory study. In laboratory study, typically, geochemical analyses are carried out in which we try to identify the mineralogy of different geologic units. These actually allow us to correlate two different outcrops at two different locations to each other; like for example if we find that the mineralogy of two different deposits are quite comparable, although there far apart, we would inferred that they might be either connected through a fold are some other manner throw the intervening distance.

Then also, geochemical analysis includes dating to identify or to estimate, what is the age of that particular geologic unit and I mean, dating could include radiocarbon dating, carbon - 14 dating in fact or cesium 137 dating or there are several other procedures for dating of particular geologic unit.

Then the other laboratory tests; these include test for shear strength estimation or test for the estimation of hydraulic conductivity of a particular deposit. But these things typically are within the rearm of engineers, geotechnical or geological engineers and not very commonly used in geologic mapping. So, geologic mapping essentially will include identify in the mineralogy of a geologic unit and dating to understand, what is the age of a particular unit.

Now, we have more or less gone through the skeletal details of; what are the different, what is the different activity that needs to be undertaken before we can hope to put together a geologic map? Now, we look at a typical example of a data set those summarizers the activity of a recognizance done within an area interest by an engineering geologist.

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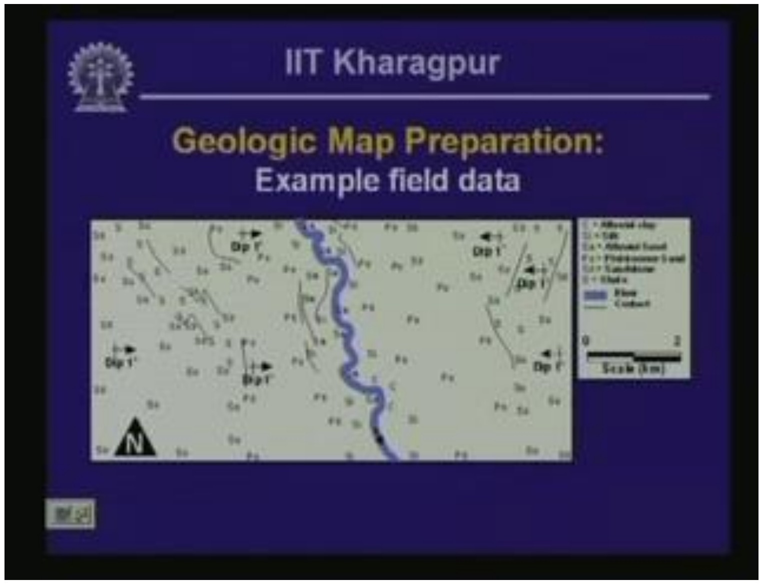

Now, you can look, the sketch shown on this particular slide actually summarizes the notes taken during the recognizance by an engineering geologist. These units you can notice that the engineering geologist has identified different types of outcrops as shown here as well as the engineering geologist has identified the contacts shown by these lines between different outcrops.

Then the other think that he or she has done is to look at the dip, apparent dip actually of different geologic units in a certain direction as indicated on the summary of his or her notes shown there. Then the geomorphologic features are also on the map, like a river has been identified at this location and the flow direction of the river has also been identified.

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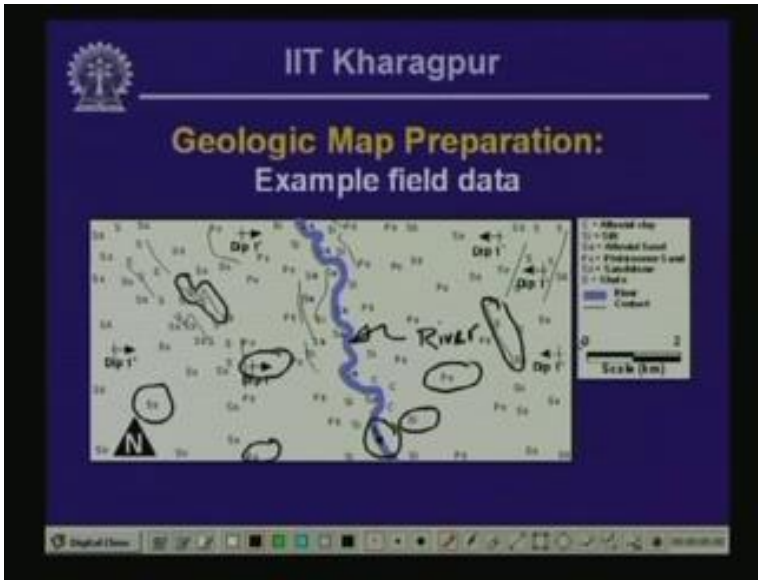

Now, the legend on the write of the sketch here actually shows, actually tells you what these different geologic units mean. For example, the outcrops or the unit, the exposure marked by capital C indicates alluvial clay, Si on the other hand means silts, then these are actually sandy areas indicated by Sa, Ps on the other hand indicates pleistocene sand which dates back to an earlier geologic edge whereas Sa is relatively recent.

Then S, geologic units marked with an S, capital S indicates shell, it is essentially type of clay stone and Ss, although Ss is indicated here, these areas are essentially sandstone outcrops and also shown on the map is the scale, approximate scale of the map area.

What is not shown here is the topography contour and typically topography contours are obtained, large scale contour maps are either obtained from existing archives like from survey of India or they are constructed for the specific purpose of a particular project. Now, this is essentially a summary of the data obtained by an engineering geologist during a field recognizance.

Now, we are going to show in the next slide how the data that is summarized in the previous slide is interpreted to prepare a geologic map. This slide here actually shows the interpretation of the data that was available in this previous slide.

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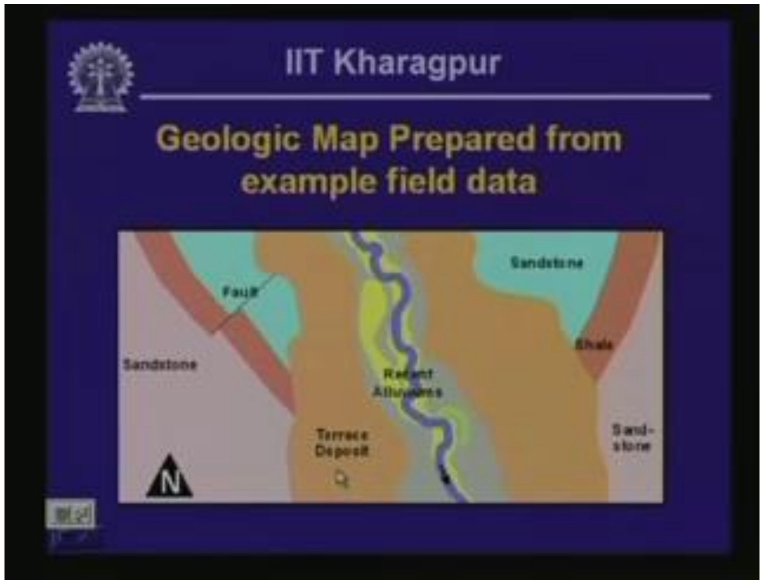

And here, what has been identified are the map areas covered by different geologic units; like you can see the sandstone outcrop to the fringes to the left and right of this particular map, as was identified by the engineering geologist from the recognizance survey.

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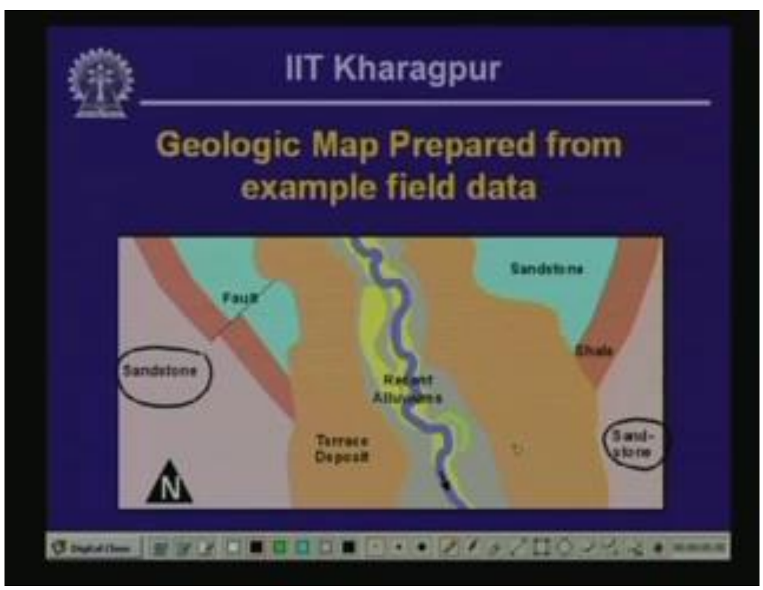

Another interesting feature that was not confirmed actually in the engineering, from the recognizance was this feature here; there was the engineering geologist marked a contract which showed a remarkable kink, you might recall and this kink was later interpreted to be actually a fault, then the older deposits dating back to the pleistocene has been identified here as a terrace deposit and then the recent deposits are shown in this particular area and that is comprised of channel deposits, sands, channels sands, then there are silty unit shown by gray color and there are even finer grained deposits underneath an old oxbow lake which we saw in the presentation of last lesson. So, that is the interpretation of the recognizance survey that was carried out for this particular project by an engineering geologist.

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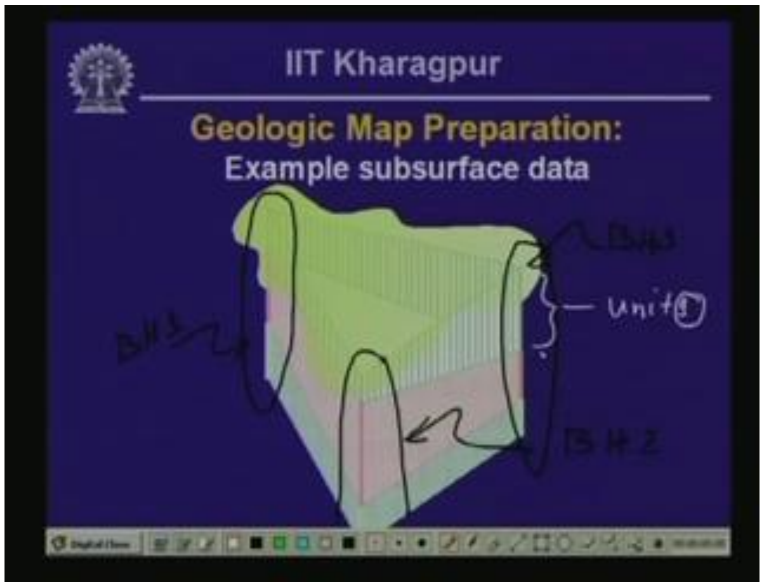

Then we try to look at how we prepare, how we get or we consider an example subsurface data set and we tried to look at how this kind of data set is typically interpreted. What is shown on this sketch are three bore holes; one bore hole is here, we may call this bore hole as bore hole 1, then there is another bore hole at that is location, call this one bore hole as 2 and another one, another bore hole at this location which is bore hole 3.

Now, what is done when we try to get subsurface information through dealing a bore hole is a bore hole is drilled using a mud rotary technique or any other appropriate technique that might actually appropriate for a particular geologic area and we tried to identify the location of the contact between different geologic units.

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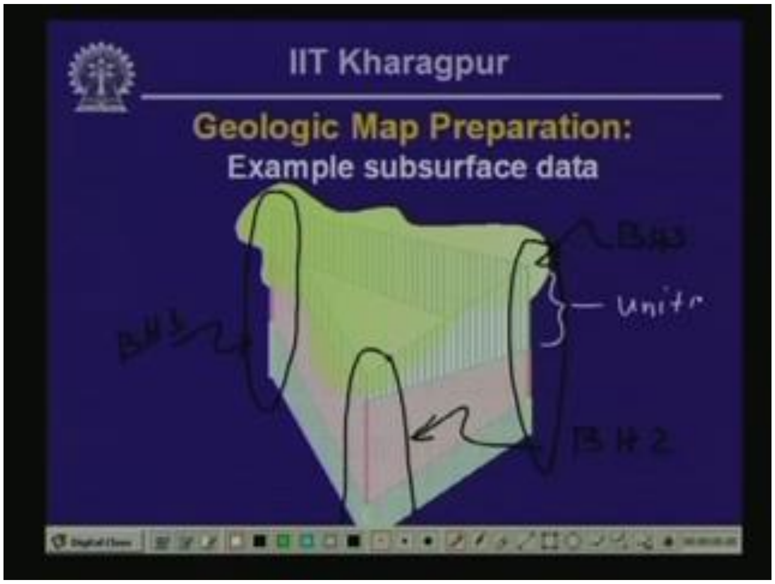

For example, let us consider bore hole 1 and in this one bore hole 1, what we got is this one is unit one, it could be a surface soil; then there is a unit two, this one could be a soil of an earlier age and then there is unit three. This is the simple geologic stratigraphy and you might realize that this is just for an illustrating proposes and the stratigraphy actually, a real life stratigraphy could be much more complicated than the one that is shown there.

Now, on the other side in bore hole 1, we have got unit one here, then we have got a relatively thinner unit two and underneath that we have got unit three as earlier. And similarly, in case of bore hole 3, we have got unit one here, unit two at this location and underneath the unit two is unit three. You should also realize that it is not necessary to get the same units in all the bore holes that are drilled to cover the project area. For instance, it appears that unit one may actually pinch out if one moves a little bit further towards you, compared to bore hole 2.

So, if we actually come further, if you come further near from bore hole 2 towards you, in this direction, then it might so happen that the surficial unit - unit one, actually may disappear altogether and that is called pinching out of a particular geologic unit. So, what we need to, what kind of information we need to get from this kind of subsurface investigation?

We need to find out we need to find out what are the elevations of the contacts between different geologist units. So, we need to for instance know; what is elevation one? What is elevation two that actually separates geologic unit one from unit two and unit two to unit three respectively and these elevations, we need for all the individual bore holes that are drilled within particular project area? How do use these informations?

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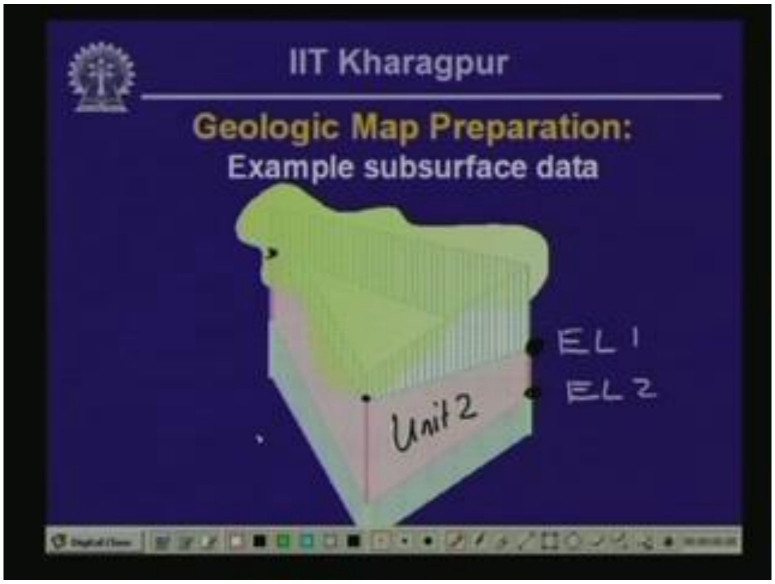

We can actually try to find out or we can actually try to plot a contour through the surface of different geologic units from these informations. For example, from the elevations at the top of unit two, if you recall, this one here is unit two; so we take the top elevations in all the three bore holes of unit two and from these three elevations, we can try to develop a contour map which will show us what is the top or what is the geometric of the top of unit two.

Similarly for unit one, unit one, the top of the unit one is going to give you the topography, the surface topography of that particular area and then unit three is going to give you another side of stratigraphic contours. So essentially, we can develop stratigraphic contours using the information like this for all the individual different layers that we might encounter within a particular project area and the sketch that was shown in the slide that we saw before is called a fence diagram.

Now moving on, we now would like to be able to prepare a stratigraphic section through a particular, through a map area along a particular direction which might be of our interest. For instance, we could we could try to develop a stratigraphic section through an alignment along which a tunnel or a pipeline is proposed because for digging a tunnel, we might have to penetrate different geologic units and how easy or what kind of instruments that you might need to penetrate a particular geologist unit will depend on what are the properties of that particular geologist unit.

For example, the tunnel boring machine that is going be used for sand and gravel may not be suitable for penetrating a hard rock layer. So, these are the objective, actually these or the reasons why one might actually have to prepare stratigraphic sections through different alignments within a particular geologic map.

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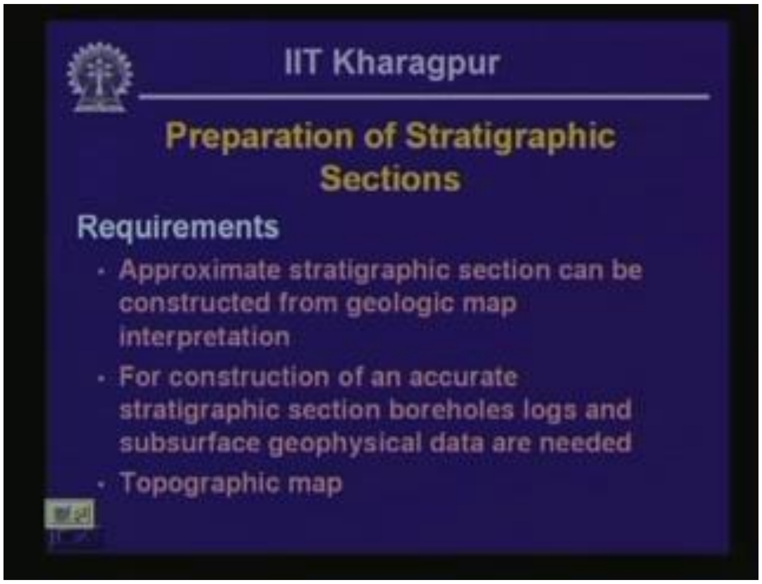

Now, for preparing stratigraphic sections, as we have noticed earlier, we can use the information based on which we constructed the geologic map in the first place and we can also use the information from the interpretation procedure followed by the engineering geologists while preparing the geologic map. Now for construction, I mean that is going to give you a very approximate stratigraphic section though. Now, if you need to construct an accurate stratigraphic section, then bore holes need to be drilled and accurate logs identifying different stratigraphic units within the bore holes will have to be identified.

And also, in this context, one might use subsurface geophysical data in which one can see different stratigraphic I mean, different stiffness, stiffness properties, stiffness contrast of different stratigraphic units underground and together with all these things, we will need to use the topographic map of a particular area and that topographic map as I mentioned earlier could be off the shelf topographic map from existing achieves or it might have to be prepared for a particular project area to an appropriate scale.

Now, we try to look at the rules that are used, typically thumb rules used by engineering geologists for interpreting the information that are obtained for preparing a geologic map.

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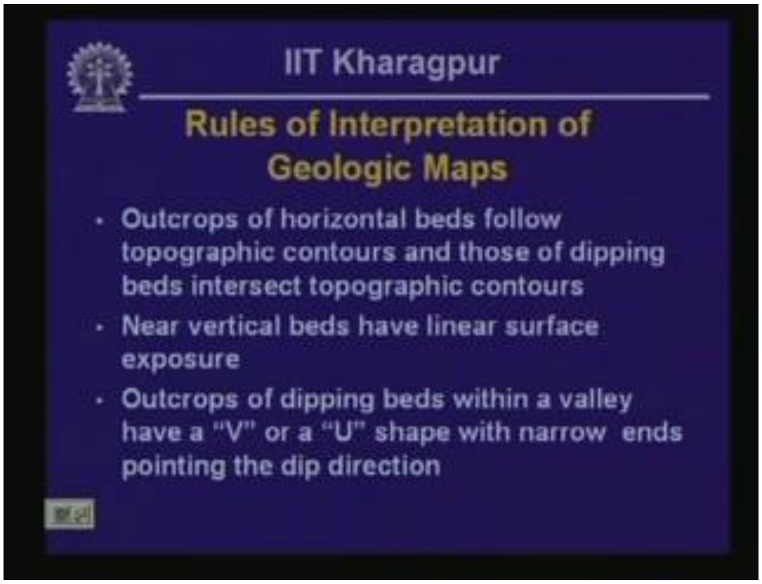

Now, what we look at typically are a set of three or four different thumb rules and the origin of it becomes very clear if you quickly try to follow through the reasons or try to visualize the geometry of different layers and the rules are, let me state the rules in order; outcrops of horizontal beds follow topographical contours and those of dipping beds intersect topographic contours. We are going to illustrate this one with a picture in one of the next slides.

Then secondly, near vertical beds have linear surface exposure, linear or linear surface exposure. That does not mean that it is going to be straight line but there could be a curvilinear surface exposure as well depending on what is the lay out of that particular vertical bed.

And then, the third one is that outcrops of the dipping beds within a valley typically has a shape of a V or an U with the narrow end pointing out to the direction of the dip irrespective of the slope of that particular valley. Now let us consider, let us try to explain what we mean by that in the next slide.

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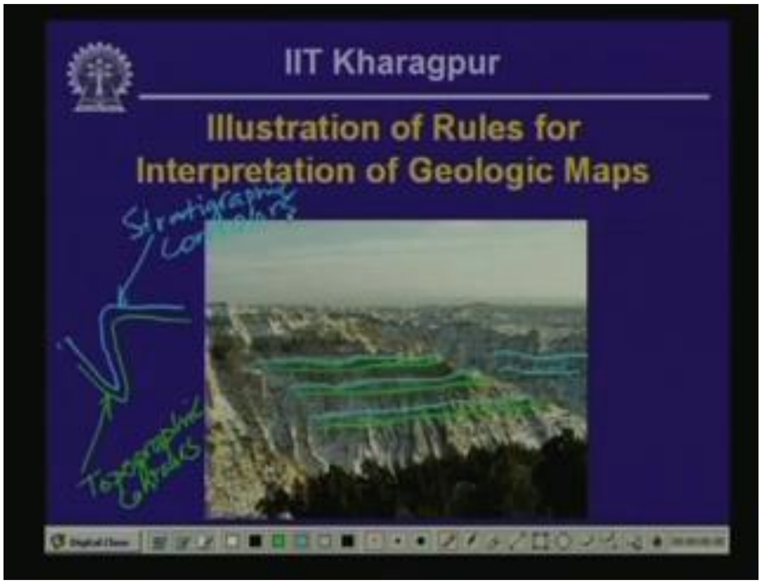

The next slide here shows the photograph of a canyon in the United States and you can see in this slide that the rock layer, the stratigraphic of the rock units are near horizontal and these things are I am trying to mark out approximately and you can see that the topographic contours of this particular geometry, this particular area, this particular canyon is also going to follow a very similar pattern.

If you look at the plan of this area, then what you might see actually is the area is perhaps like this, the topographic contours are going to be like this; whereas, this stratigraphic contours in this case are going to be somewhat like that. So, these are the stratigraphic contours. What we mean? Actually, this feature here, this feature actually is same as this portion in which that rock outcrop is jutting out and this area indicates that area. So, that kind of source that the topographic contour is going to be followed by the stratigraphic contours when the bedding I mean, the surface of the bedding is near horizontal.

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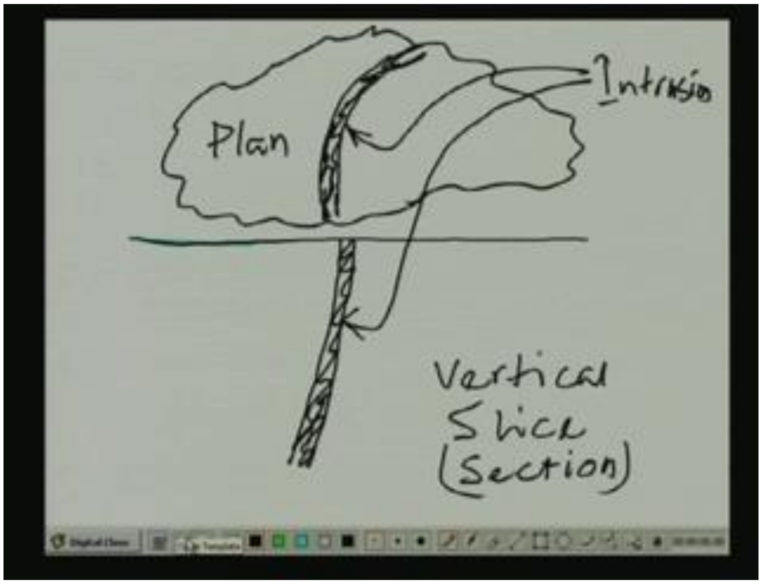

Whereas, if you have got if you have got near vertical surface, let us say we have got a ground surface like that and in which we have got an intrusive layer that is shown like that; in that case, if you look at the plan, then the plan might, so this is the vertical slice or the section whereas in plan, this area might actually, this intrusion might actually look like that. So, this is the area that we consider here and the intrusive layer is shown here; so that is an intrusion, this one here is plan and the bottom one is elevation.

Let us move on to the next slide.

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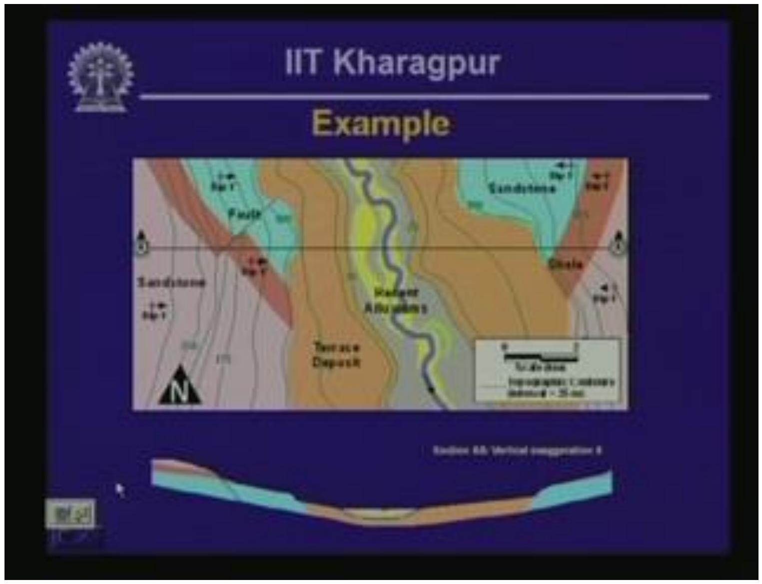

That one gives, that one actually looks at the same geologic map that was prepared earlier and in this case, we try to prepare section AA across the river which might actually show, which might actually follow the alignment of a bridge site that might have to connect the two banks of the river.

Now, the stratigraphic section AA is shown on the bottom, shown at the bottom of this particular slide and the way this particular section is prepared, we are going to look at more detail when we go to the first laboratory session of this particular series of presentations. We will try to get hands on experience about how a stratigraphic section can be prepared from a geologic map shown like that.

Now, we try to summarize what we learnt in this presentation.

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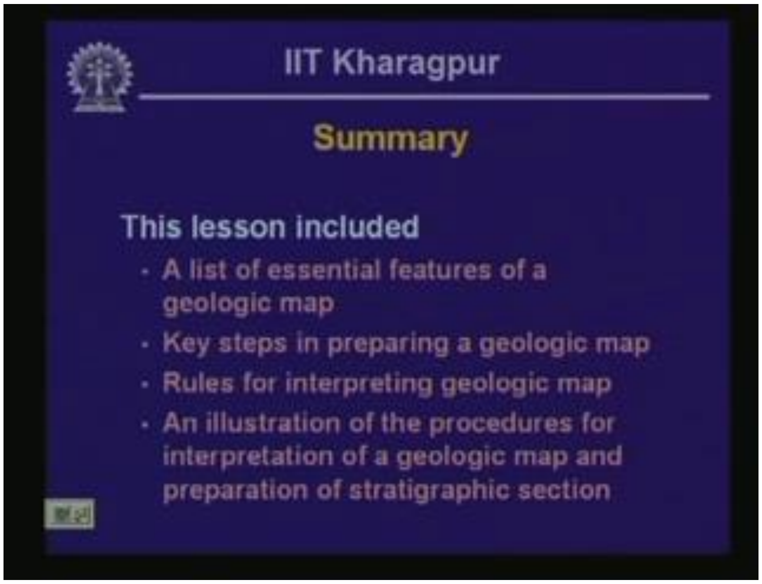

What we did here is we tried to list the essentially features of a geologic map, we looked at the skeletal details about the key steps involved in preparing geologic maps, we also looked at how we can interpret subsurface information and from subsurface information and from subsurface information and interpreted data from recognizance survey while preparing geologic maps, how we can prepare geologic sections.

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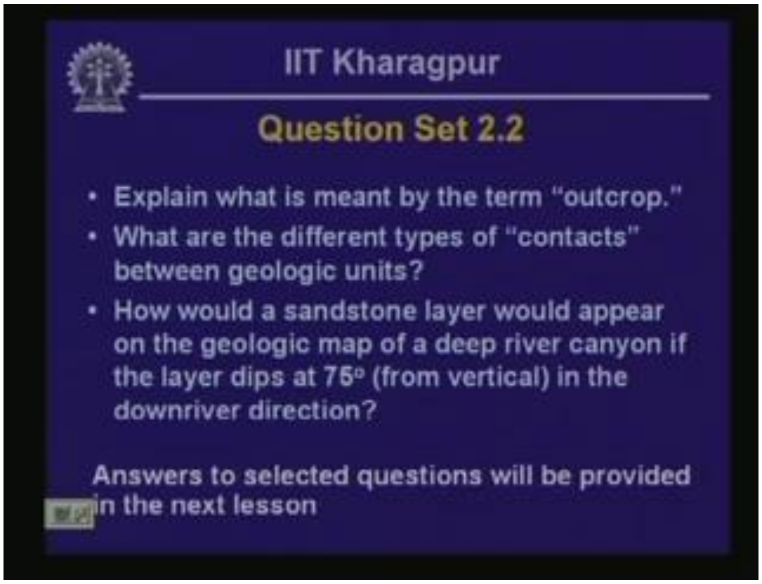

Now, we finish this presentation as usual with the question set and you should try to answer these questions at your leisure. The questions are, the first one being; what is meant by the term outcrop? Then, what are the different types of contacts between geologic units? And thirdly, how would a sandstone layer appear on a geologic map within a river canyon, deep river canyon where the layer dips at 75 degree angle from the vertical in the down river direction?

We are going to provide the answers to these questions when we meet in the next section and with that said, I am going to conclude this presentation and when we meet again, we are going to look at the answers of the questions and we are going to proceed with the next presentation.

Bye for now, until we meet for the next time.

Thank you very much.

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Hello everyone and welcome to session four of the theoretical discussion on remote sensing applications in engineering geology. So, in this lesson, we are going to just cover the principles, essential principles of different procedures of remote sensing that are normally used in different applications particularly geologic mapping that we considered in the last session. But before we proceed with the discussions, subject matter of this particular lesson; we are going to discuss the questions that I asked in the previous presentation.

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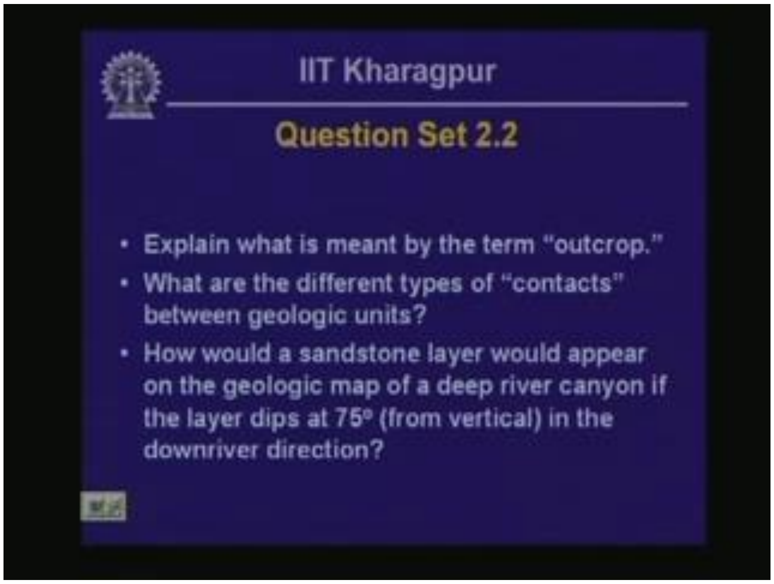

The, first question that I asked was what is meant by the term outcrop? Outcrop is essentially, it essentially is a body of bed rock that is exposed at ground surface. Then the second question that I asked was that what are the different types of contacts between geologic units? We discussed this one in great detail in one of the previous presentations and the types of contacts that we considered at that time were conformal contact, non-conformal contact and one of the types of conformal contacts was considered or we discussed a type of contact called gradational contact. So, these are the three different types of contacts we discussed earlier.

Now, contacts can also be classified depending on whether the contact is through the plain of a fault or not. So, the contact could also be classified as a fault contact or depositional contact depending on whether or not contacts between two different geological units is across the plain of a fault or through surface of deposition.

The third question that I asked was how would a sandstone layer appear on a geologic map of a deep river canyon if the layer dips at 75 degree in the down river direction? Now, recall from what we discussed in the previous presentation, previous classroom presentation was that when there is dipping layer going across a valley, then the outcrop of that particular layer takes the shape of a V or an U.

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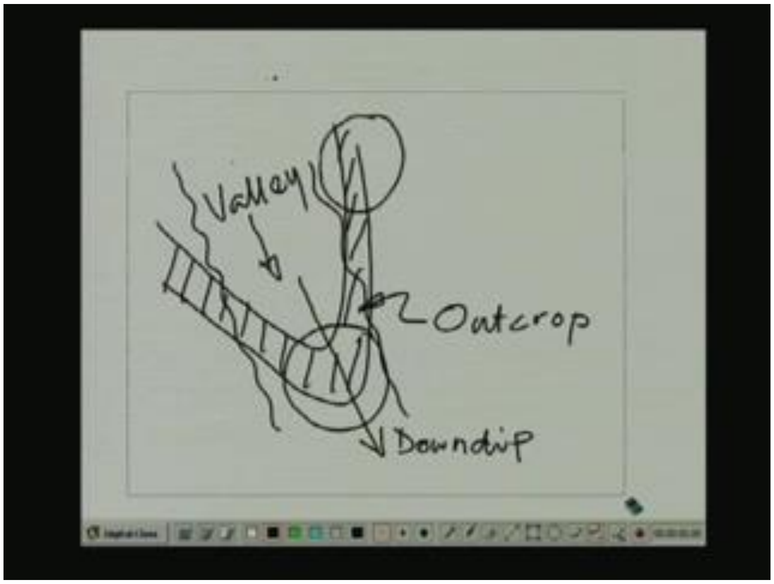

So, this is the outcrop of the layer seen on the plan view that means we are looking at this particular map upside down from an elevation looking down. Now, this is the outcrop of the geologic unit that we are looking at. Now in this case though, and the reason why the outcrop actually takes a shape of a U or a V inside the valley is because near the valley bottom, at the point where the outcrop is at the lowest level, lowest elevation, that is going to proceed in the down deep direction.

So, at this location, the outcrop elevation is the lowest compared to the elevation of the outcrop at the planks of the of the V shape. That is the reason why the tip of the V always shows or points towards the down deep direction irrespective of the surface topography within the valley. So the valley could be, could either slope in this direction or this is the valley, this could be the valley slope or the valley slope could be the other way around. Irrespective of the direction in which the valley slopes, the down dip is going to point or the down dip direction is going to be pointing towards the sharp corner of the V if we have got a dipping layer crossing a particular valley.

So, in this case, though the dipping, the dip angle is quiet near vertical; so you may not get a pronounced V shape as shown on that particular figure. But what you might get is a shape like this.

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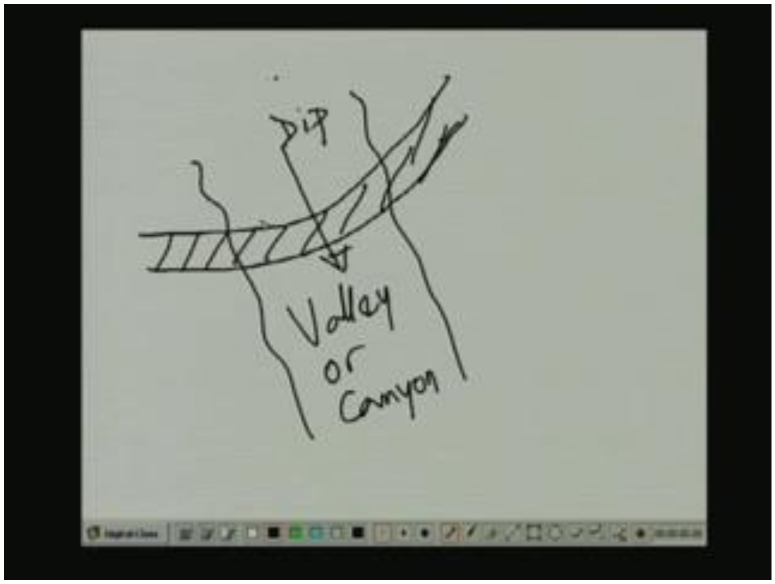

So, this is the valley or canyon … (56:23) from these two way return times of the laser pulses.

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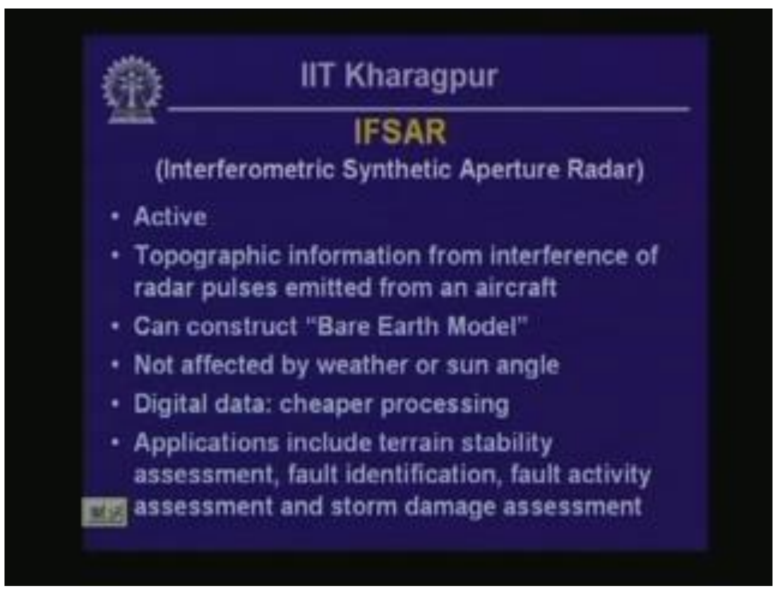

Another procedure commonly used is called the IFSAR. IFSAR is an imaginary in the RADAR band like the RADAR sat image, this is also another active remote sensing procedure and here what is done is we use the interferometric principle to develop the topographic details of a particular area and again, both LIDAR and IFSAR, they can be used to construct a bare earth model that means if there is a vegetation cover, we can formulate a topographic information of the surface of the earth that is underneath the vegetation cover.

Now, we have actually more or less covered in a nut shell, what are the different types of remote sensing techniques used in engineering geology and how the information that are obtained from these different techniques are used in remote sensing in different fields of engineering geology.

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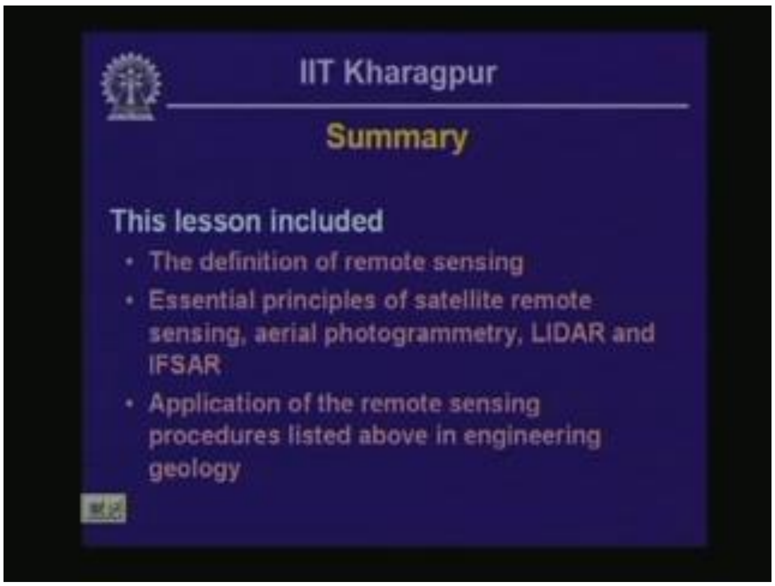

We explained how satellite images are obtained? How the satellite images are interpreted? Aerial photographic, the principles of aerial photogrammetry, LIDAR and IFSAR, what are the uses of these procedures and we looked at the application, essential very simple applications of these techniques in remote sensing, these techniques of remote sensing in engineering geology.

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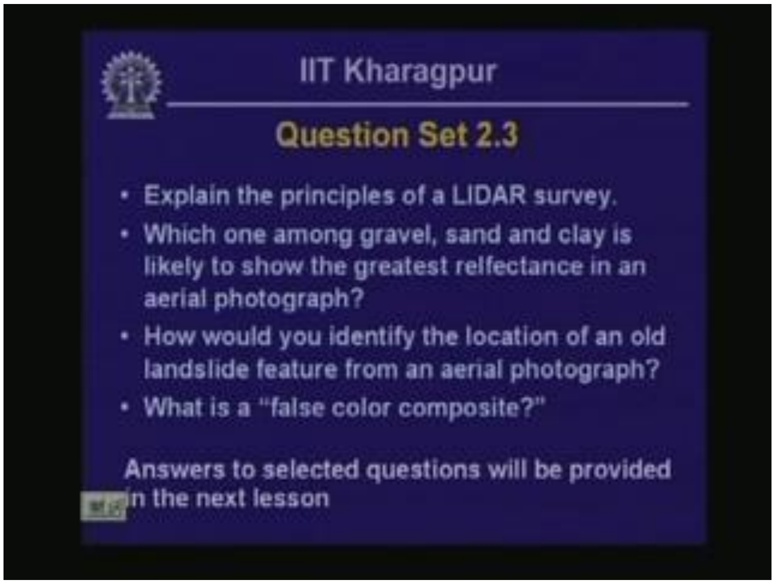

We finally end this section with a question set that is shown on the slide there. I asked you to explain; what are the principles of a LIDAR survey? Which one amongst gravel, sand and clay is likely to show the greatest reflectance in an aerial photograph? Then the third question is how do you identify the location of an old landslide feature from an aerial photograph and finally, what is a false color composite in connection with satellite remote sensing multispectral image?

These answers will be provided when we meet again in the next session. So, until then, you try to answer these questions and I will see you again when we meet with the next session of this course.

Thank you very much.