Introduction to Remote Sensing

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Lecture 11

Image interpretation of different geological landforms, rock types and structures

Hello everyone and welcome to the eleventh lecture of this course which is Introduction to Remote sensing. In this particular discussion we are going to have discussion on image interpretation and especially we would like to focus on geological land forms, rock types and structures, Because think that once the data has being acquired by a satellite and sensor than it has to be use for some purposes. One example I am going to show here how various land forms which are present on the surface of the earth then we identify and discern very easily using satellite image.

Remember that when we were discussing the advantages of a remote sensing data one of the example it is said about the synoptic view. Especially for geological mapping or things related to the earth sciences. When we go on the ground we see a very small area and we are not vantage point. That means we see very small area just standing on the ground but when we use the satellite data then we are having because of this remote sensing technology, we are having a synoptic view and that providing a data or information about a large area. Information like in our case suppose if I am interested to study the lands forms then large numbers of land forms are available.

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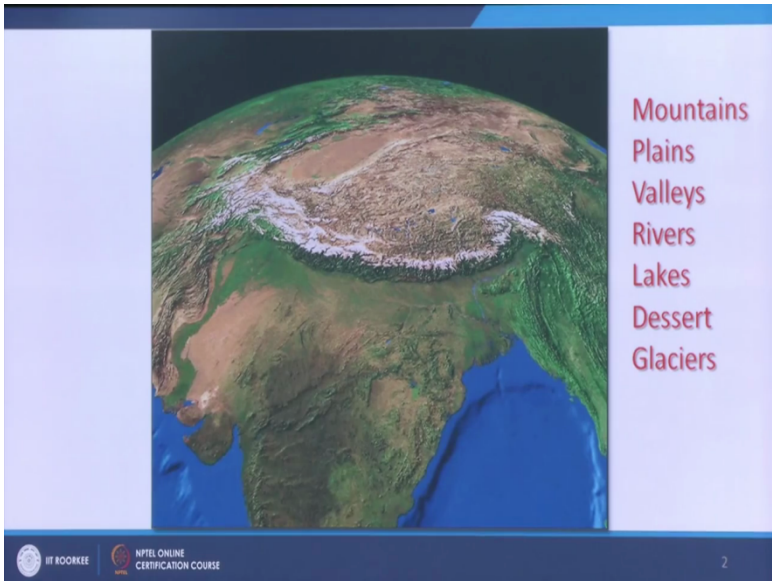

This example is of course is a mosaic in the background it is digital illumination model is there top of it the land set ETM plus images have been draped here and you are seeing a complete seamless mosaic part of India. Especially I would like to focus on major land forms which you can identify where easily or anyone who doesn't have even the background of remote sensing or background of geology or sciences can still identify and because of this 3D prospective view of available through this tele-elevation model or even with single satellite image even the depth perception comes because of the presence of the shadow and orientation of shadow.

With the reference related to the viewer we get the depth perception. So here we can identify the mountain chain, which is the Himalayan Mountain very easily and if we are having some information, some further knowledge we can say these are the highest part of Himalayan Mountain system which are snow and ice covered so we are having snow as well as glaciers part above that and this is the Tibetans plateau is there and on that we can see lot of lakes including our Mansarovar lake as well.

Then we come to the south of this Himalayan we can identify other large land forms like for example the river system the Ganga's river is there, the Yamuna river is there the Brahmaputra river which basically originates from Tibet it is called Tsangpo in Tibet and enters in India through Assam states largely and it goes in the bay of Bengal. And even because of digital

elevation method in the background so even you have seen some information about the land forms which are present in the sea itself.

And specially this north 90 degree range as well, it become the (ah) plateau part of India then we see the different Vindhya ranges and also Aravali's are there and Vindhya's are there Satpura are there Vindhyans are there Satpura are there all kind of mountain system river valleys everything becomes easily identified.

This image is from Google earth where products have been generated we can zoom it and identify objects including the desert part of our Indian desert as well as some part of Pakistan and with agriculture land you can also identify part of Punjab and Haryana and Western UP which you can see some part including Pakistan. On the eastern side what we see different geological structures. We will see the zoom part of it and how the arrangements of different land forms which are projects.

This is because remote sensing is providing data in multispectral so we see thing in color. Remote sensing is also providing data so we can create digital elevation models so we can get the depth perception and also remote sensing is providing data to large area after doing image processing and making mosaic we can see large numbers of various types of land forms identify very easily and that things. So like mountains, plane's we can identify valleys, we can identify lakes, we can identify desert we can identify glaciers, I have already mentioned this part we can identify N's one. This is not exhaustible, this identification of things keep going.

The only problem with the remote sensing of earth is that because earth is having atmosphere sometimes we are having clouds and because of this over cast we do not get a high quality satellite image, if we compare the satellite image of Mars where we don't have much atmosphere very thing atmosphere and therefore satellite images are very clear you can identify each and every type almost every type of landforms on surface of Mars like using images of Mangalyan.

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The zoom part is like for north east India as you can see there is series of these antiform and synform, plunging folds are there and same time you can see Sundarban area, the Brahmaputra is

coming. You can see the concentration of the sediment and that extend and so and so for. You can identify as many as landform which are present in the particular part of the earth very easily.

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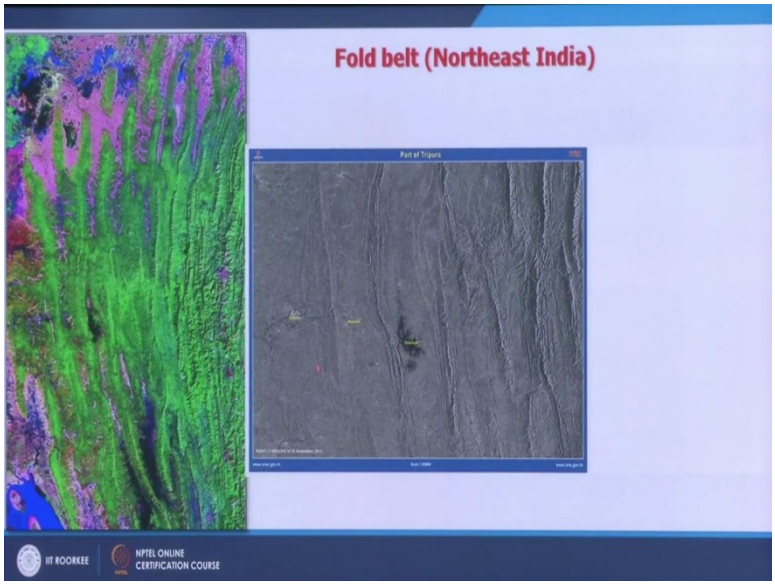

Like for example I will give example of north east India there is series of Host and grievance and plunging folds are present here, this is radar image this is image from Landsar ETM Mosaic and if we combine this two our interpretation and our analysis will improve further. So we will be able to identify more type of land forms, but if we use in a separate form then our limitation become.

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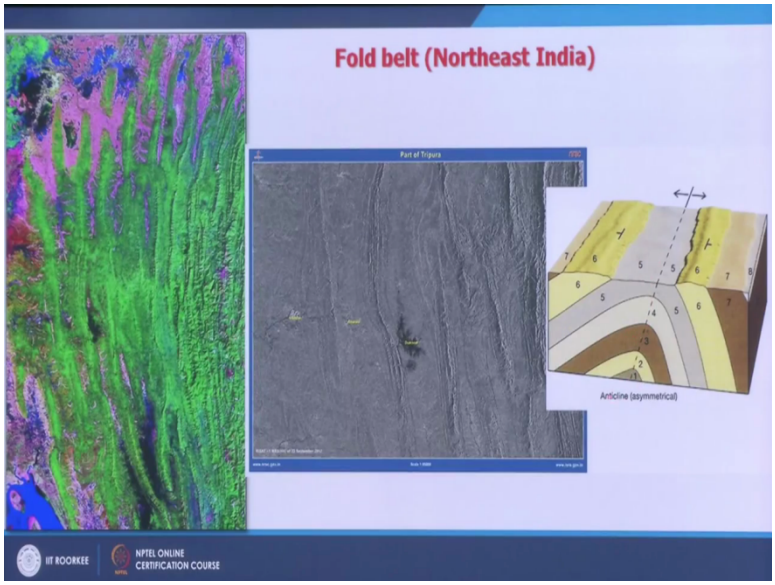

And finally you can reconstruct some models shown the lines which are nothing but the antique lines which are a symmetric and are shown here and we can decent and we can create the model for further understand, Because your purpose in not just only understanding but further exploration, maybe exploration for water, maybe exploration for wild and gas and this part is having quite of these resources. So that is why the analysis interpretation of different landforms becomes very very important.

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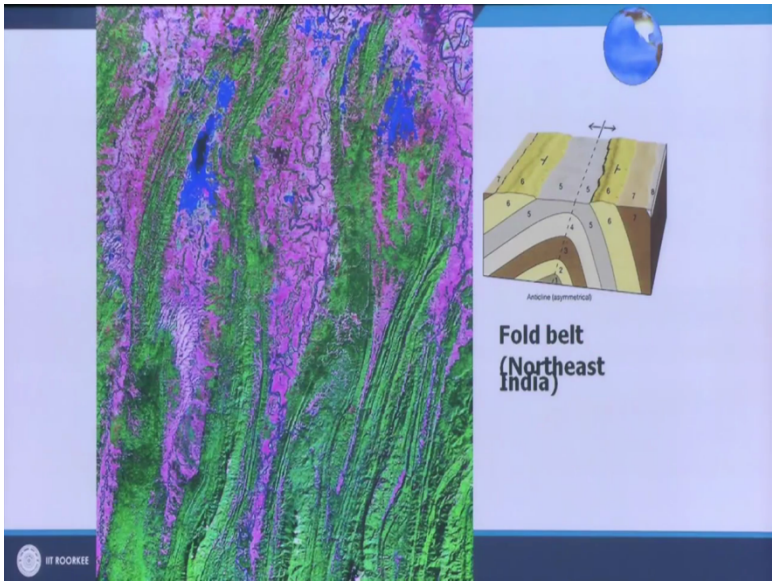

To identify images reconstruct model and try to understand what is beneath the surface though most of the satellite data accept radar data in case of desert area might penetrate may penetrate up to few meters in a dried sand but otherwise remote sensing provide on the sufficient information. Information about the surface of the earth whatever the feature are present whether geological structures, land forms, vegetations and water bodies, glaciers, snow peaks and covered peaks and so on so for this.

But using the help of this earth signs of geology you can create a model which can give us depth information as well, what is beneath that and then this things finally this things can be confirmed by using geophysical method which can give you surface information. So what is happening nowadays any area which have to be explode for anything, for mineral for natural resources, even for natural disaster even for oil or gas whatever first people resort of satellite images and they try to extract as much as possible the information from this satellite images.

So remember that statement a picture a normal picture tells thousand words whereas a satellite image tells 10 thousand words. So that is the advantage that we not only we identify the landforms, not only we identify different features or objects present on the earth, but we try to infer the information. We look that how this landform has formed, what would be the conditions of the surface and if I am looking for ground water then there I can find the ground water and if I am looking for oil which is in a very special circumstances I can find in special geological arrangement then still I can infer that one. Nowadays for all kind of surveys or investigation which involve the land surface of the earth first people will resort satellite images including natural disaster conditions.

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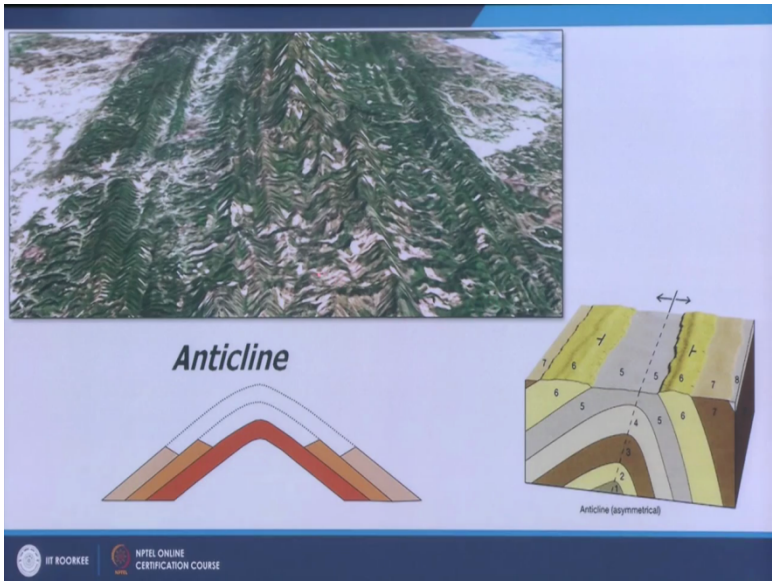

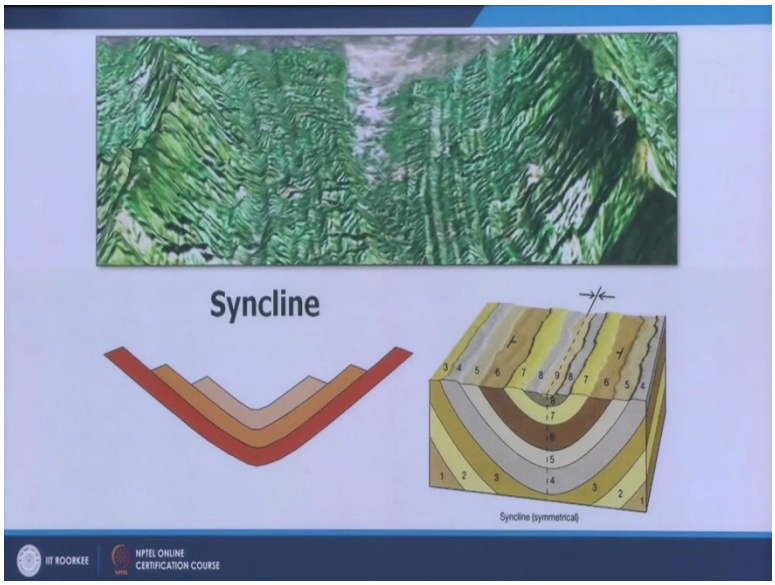

Some examples I am showing here that how asymmetric, anticlines, antiforms can be identified and then infer and then we can estimate how things are in the depth. So syncline are looking synforms are looking there seems through the satellite series of lines but they are basically part of synform whether it is (systa) symmetrical or asymmetrical we can still see we can get information very easily through satellite images and we can reconstruct some models.

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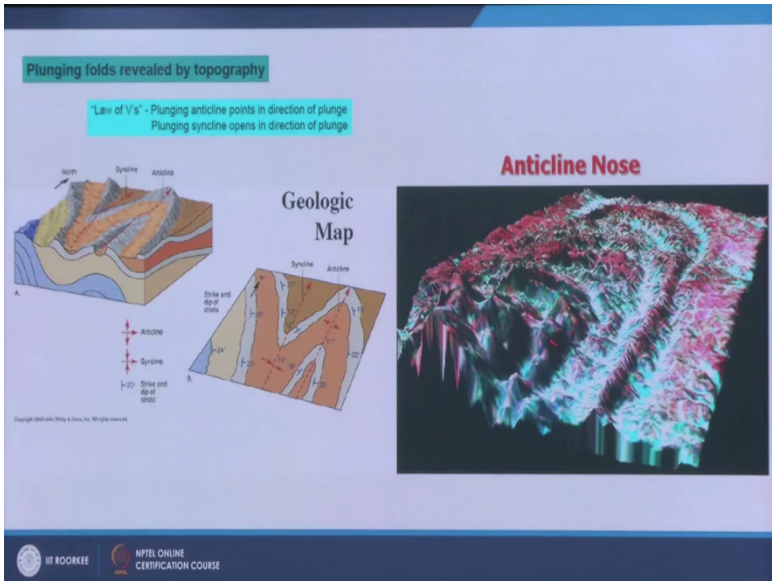

So in a 2D surface this is how it looks but we can construct the 2D surface and see that this construction has been done using satellite image and in the background we having digital elevation model and that model too has been derived from satellite data either using your stereo pair data or using SAR interoferomatric technique. So there are several digital elevation models which have been derived from satellite (ah) based on remote sensing either stereo or SAR interoferomatric, all are available free of cost for that part of the world.

So we can infer we can make our understanding about different landforms different features which are present on the earth implying including in the background the modern digital elevation model as shown in this example. So on surface you see features like this in the surface you see features something like this you can create 3D surface or prospective using digital elevation model and draping over satellite image like this and then finally you can make a model to make full understanding not only on the surface but subsurface conditions as well.

So that makes exploration of oil, gas, petroleum anything is much easier and reliable. This started with a simply surface information then got digital elevation model and then some understanding about some geological area and then finally reconstruction of a model. So this complete detail about things. Now we want further detail more confirmation more reliable information than geophysical and experiments can be done geophysical prospective can be done geophysical techniques can be done when we apply to make things more reliable.

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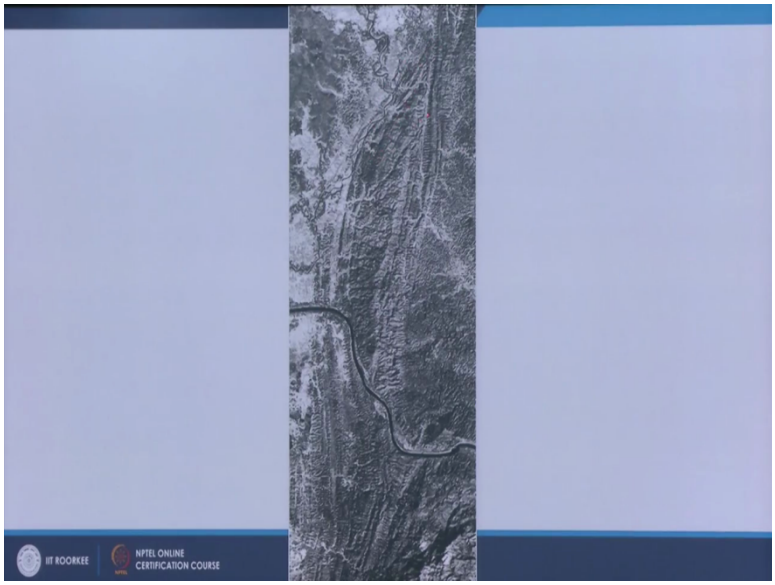

Similarly here what we are seen that how a river crossed all these geological features specially these plunging anticline and so on. So we can, based on this we also infer the age of the fluvial system compared to the geological structure. This is cut across that means these structure was later formed river was there and we can infer so many other.

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So first data acquisition from satellite data then come analysis, interpretation, inferences and basically the replications. So this how the sequence goes. So just images are not sufficient these

has to be analyze this has to be interpritate. And based on the interpretation along with some other data may you know GIF forms you put that along with other data sense and you try to infer the structure, the self surfacing information the surface information and so on for so.

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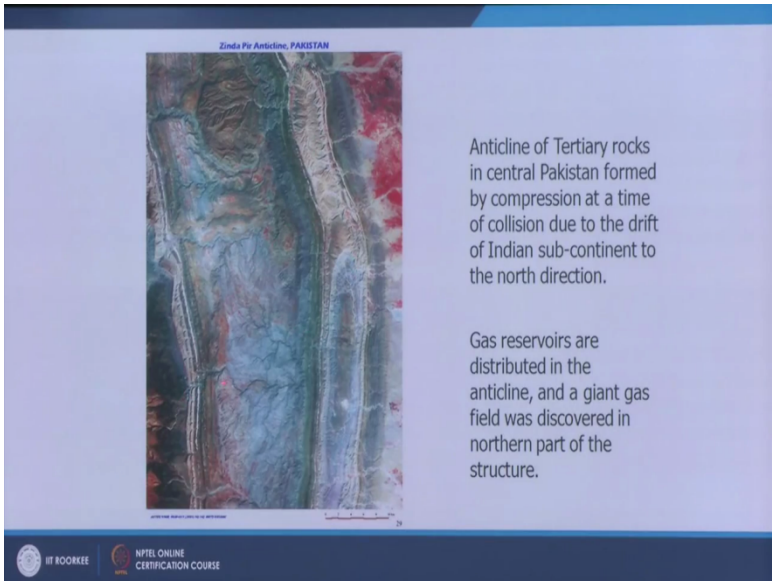

So this is how the geological landforms can be indentified again examples of part of Pakistan because we have less vegetation and therefore all these geological landforms are very very clearly visible. Gas reservoirs are distributed in antiforms or anticline a giant gas field wires are covered in this northern part of the structure here in this part of the structure. So the initial investigation nowadays as I have mentioned always now is starting with the satellite data so if one is looking for oil gas or any other thing it is the best way to starting this thing.

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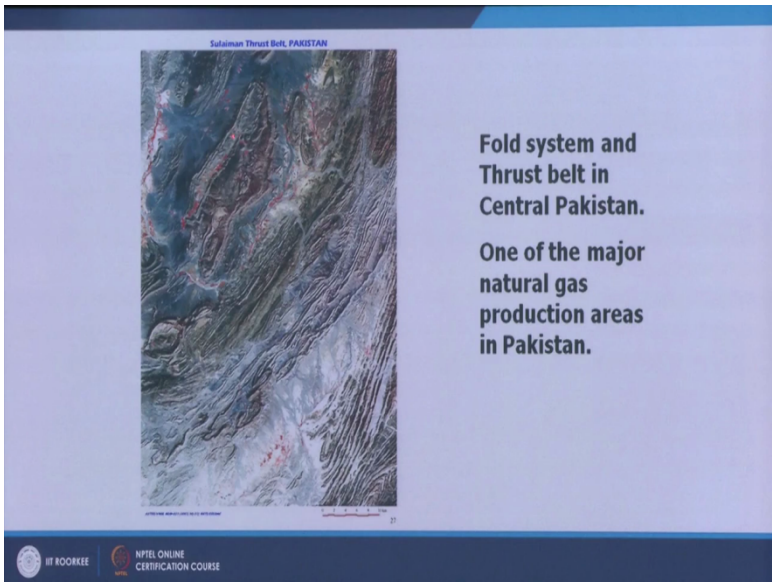

Similarly this folds could traps for natural gas and oil that's why they are important this landforms, the geological landforms which we are seeing there interpretation and there understanding about such surface conditions can give clues about availability of natural resources.

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Again this is about the Zagros mountain fold belt of (satellite) Iran where you can see that there are many several plunging anticline and syncline are there and these area are also having the potential of providing oil and gas.

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And same with this Zagros field another high resolution images 3D prospective is also there so you can get better idea about different landforms that are present. Maybe some idea about the sub surface conditions and may be some idea about the available natural resources of surface condition.

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And like dome structure you get dome structures are also useful for certain kind of resources.

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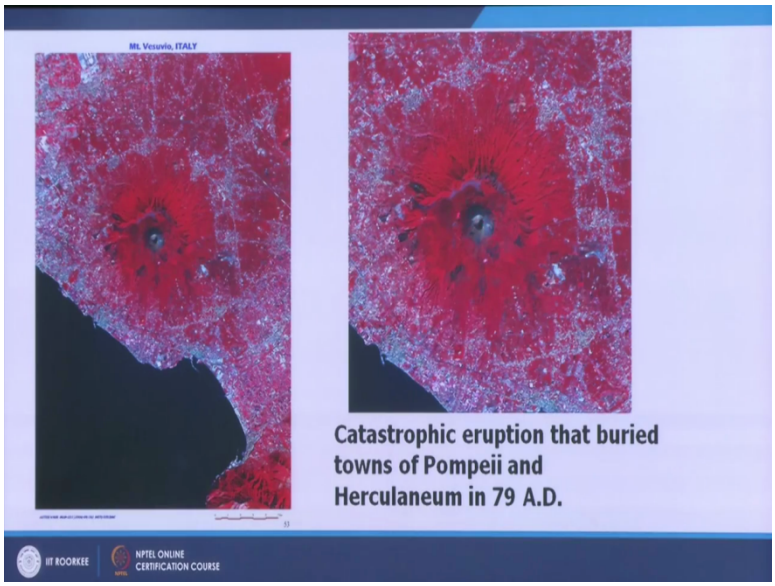

Similarly like this is volcano and this is volcanic neck where you can see easily and then the lava which has come and important thing to note here this is for composite and see the growth of vegetation the lava in few years time get converted into very highly fertile soil and therefore the vegetation you can see. Because false color composite as discussed earlier the infra red channel is assign red color and in infrared channel then vegetation is having highest reflectance and

therefore in false color composite or standard color false color composite the FCC vegetation will appear green it will be high dense or healthy vegetation will appear in false color composite in red and that is why you are seeing.

So in infrared channel it is having highest reflectance but in false color composite it will appear red. So this how the interpretation has to be done. That you are seeing the vegetation in red color which is very healthy and fertile land this what so if there is water available soil is very good and people will go around and do agriculture there.

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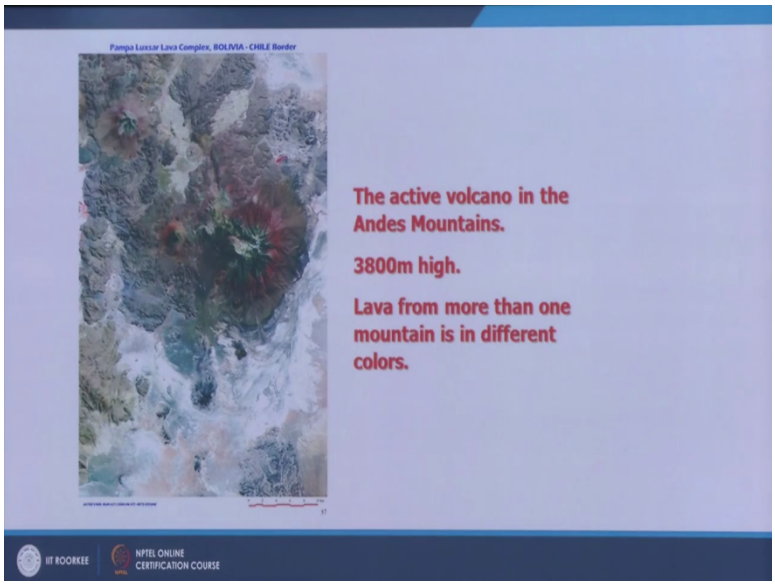

So many volcanoes where the water is available the land becomes very fertile. Though if they are dormant or extent volcanoes it is very good and one of the example from India is the Deccan tribe it is the large basaltic tariff which covers large part of Maharashtra and Madhya Pradesh the soil is again black cotton soil again very fertile land.

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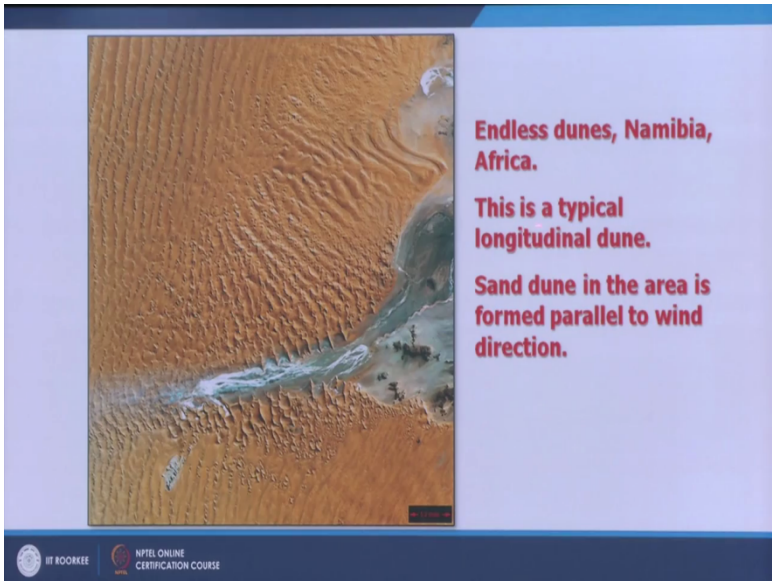

And this is desert landforms which you are seeing sundews of different types of dews you are seeing and different dews of Namibia Africa say longitudinal beans which are you know longer lines which you are seeing here, sand dunes parallel to the area of wind out directions even identify based on this orientation landforms the prevalent wind direction. So one is the image another one is the analysis, interpretation and then the inferences. Inference here you can make what is prevalent to the direction as well

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This is the desert part the image is from Google earth which is having various land set images on the background you are having digital elevation model as you can see this Haryana Punjab is full of this true color image therefore you are seeing vegetation in green, then you are having desert part hardly there is any vegetation in the part of Rajasthan up to the Indo Pakistan border. On the other side there is some desert part there but this Indus river valley you are having good vegetation they are similar to what we are having in Punjab. So desert land forms can also be identified and also you are seeing some part of this Kutch.

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This is ground of feature of ground part of sand dunes how they look on the ground and on satellite images. And the images are taken from the top so they look different.

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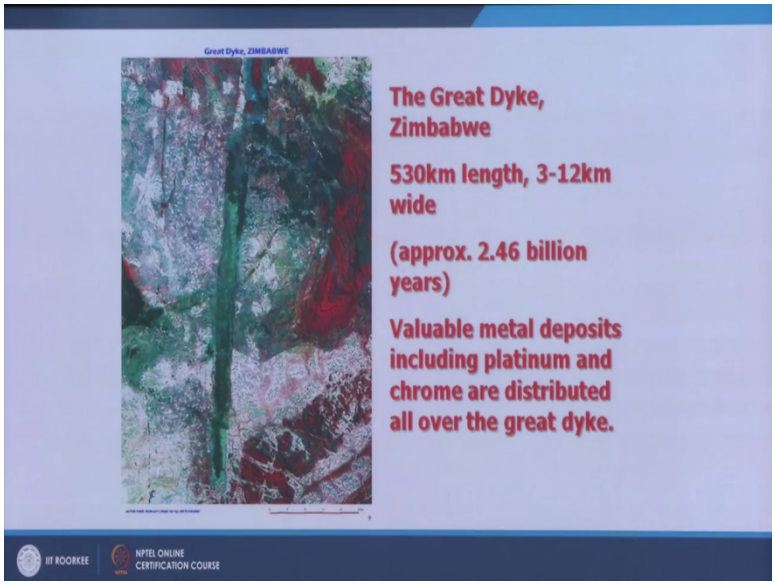

This Great Dyke of Zimbabwe, it is very long Dyke approximately 2.46 billion approximate billion years value will matter deposits. So if you are having satellite image if that area is not explored one can go through the data and can identify the data going the field take the sample and analyze the data and one may find if value will matter data. Here it has been found which is having platinum and chromium and say all over the Great Dyke area.

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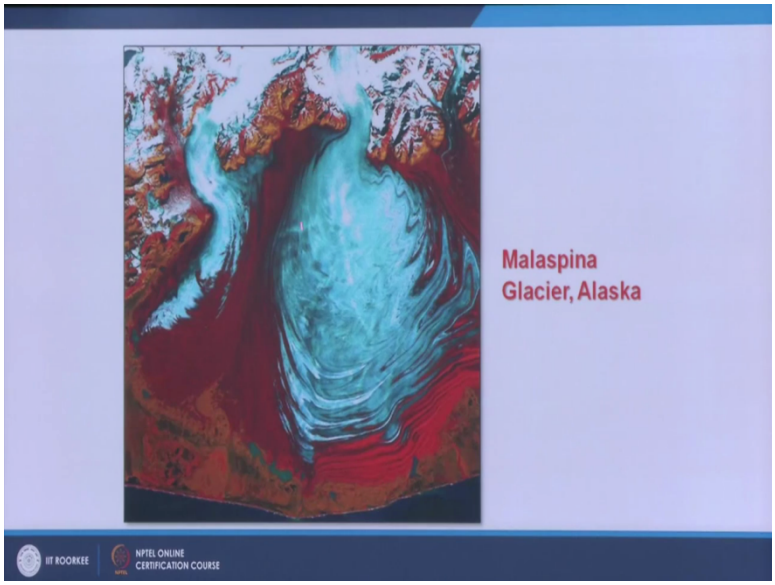

This is a glacier land form Malaspina Glacier, Alaska and this is very unique feature on the surface of the earth where glacier not as a kind of value glacier, it is a kind of alluvial fan kind of glacier in a circular body. There are some value kind of glaciers are also seen. So not only light images you can identify landforms of deserts area or mountain but you can also identify glacier landforms, fluvial landforms and several other types of landforms are there. This is very famous glacier of Alaska Malaspina. In glacier you can also see false color composite, you can also see the lower part the growth of vegetation forest and then water bodies, glaciated lakes and other features can also be seen and sea part is also there interference between land sea can also be identified.

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This is a 3D prospective view of the glacier Malaspina Alaska glacier, valley glacier you can identify. But this is a unique feature which make a fan shape kind of glacier because this like alluvial fan but a glacier because suddenly it is leaving the mountains coming in the plain area but still it is very cold so the ice is there, snow is there therefore it looks like a fan but it is a glacier not typical value glacier as shown here.

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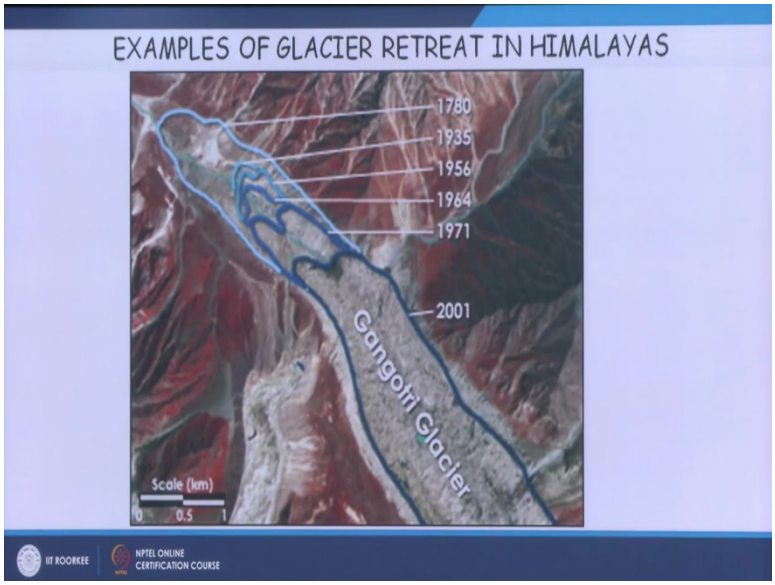

I have been mentioning that remote sensing data especially nowadays is available from 1972 Landsat MSS till 2016 complete time series is available from different censors on board of different satellite. All these archives are now almost available free of cost on net and therefore time series analysis can be done, chain detection analysis can be done and this example is on that.

And a very famous Gangotri glacier where our river Ganges start it originates as you can see this not based on satellite data information, based on some topographic maps and some other ground information that the glacier, the snout of the glacier, the beginning of the glacier the mouth of the glacier was here in 1780 but once we entered here and now this is the era of satellite data and what we see that it has retreated to this extend and you can also see the scale.

So roughly about three or four kilometers up it has gone, it has retreated and it is the situation in 2001, this information in 2001 has of course come through satellite information. If we get a another one say latest 2016 this retreat might be observed here. So if we get the successive images at time series data, first of all what we can see how a landform is changing maybe a glaciated landform maybe a desert landform of fluvial landform doesn't matter, so one thing how things have been changed this thing can be done through the times series or chain detection analysis and what is the speed, the velocity of and how quickly things have been changing.

And it is not necessary that things will change as they have been changing like between 1780 to 1935. The change may be faster or lower depending of the metrological conditions or weather conditions if we talk only about the glaciers or landforms but there are changes which are sudden like related with earthquake. There are changes which occur within few seconds these changes too can be detected by using employing a pre earthquake image and post earthquake image.

Remember when I was discussing the advantages of remote sensing data not only it provides the synoptic view, not only it provides the digital data, not only it provides the regular basis but it also provides the unbiased basis so here the manual input or human input might be biased but based on the satellite data this is more reliable information or inputs which are coming or which are making the understanding about this information about the glaciers.

Maybe a fluvial system how a river are shifting a particular river at a particular section how it is shifting with time and how this land forms are changing? What is the speed of changing one? So by looking the past and the changes, and the way things have changes we can also think about the project, we can project to the future. So if you say this Gangotri glacier the change continues and if we know that how things have changed in past we can also project in future this is now might appear somewhere here.

That prediction and that modeling can also be done after learning through time series data about say any landform or say any changing feature on the surface of the earth. So that is the advantage that the desert are increasing or reducing, a glacier or glaciated part of Himalaya is increasing number of glaciers are increasing or reducing or fluvial system more flooding are occurring.

Everything can be assessed through the time series data, their speed can also be assessed that how the things are changing. And then we can do some modeling we can predict that how in near future things will change. So based on this unreliable synoptic digital data and not many such studies can be done.

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And another example of this you sees this fluvial landform. Fluvial landforms are again very important specially from sediment transport point of view or even normal transport point of view, from ground water recharge point of view and also others like vegetations growth, algae growth and so many other things are there because this keeps changing. So another natural disaster that is flooding so from flooding point of view the study of such fluvial land forms are important. If we are having time series data as of now today then we have 45 years of data we can see how things have been changed in past specially with the fluvial system.

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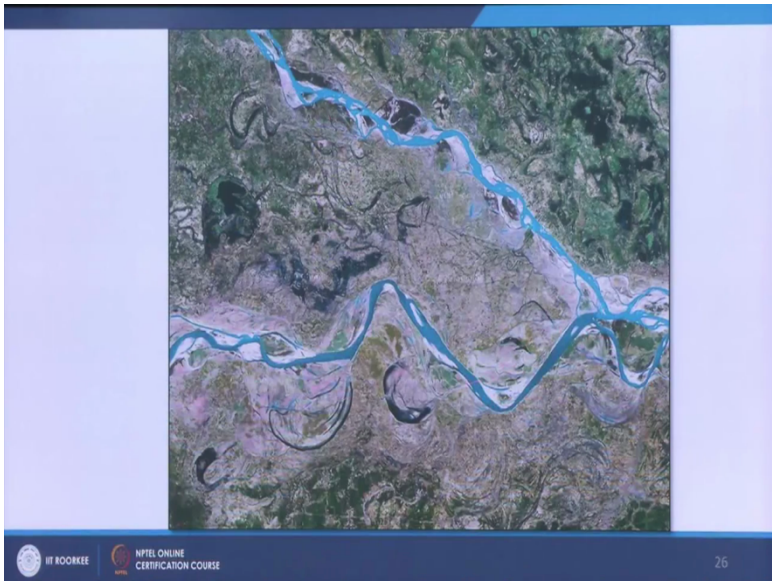

Similarly I am now giving example of our own Indian system this is the Ganges, this is the Yamuna this is Allahabad where there is Sangam and see these palaeo channels there remaining of extent courses of rivers of Yamuna and Ganges so that means what they are telling that few years back Yamuna was flowing somewhere here, few years back Ganga was flowing here. It is shifting how much it will shift in future or whether it will come back.

This can be analyzed, it is being analyzed by employing time series remote sensing data not only for Ganga, Yamuna, Brahmaputra almost all rivers which are having migrating characteristics and they are changing fluvial landforms can be studied and even if we are having much older data we can tell that in which year the river Yamuna was flowing in this part.

And these are all have different name, palaeo channels, oxford lake so these are the palaeo channels Yamuna this is Oxford lake that is water after sometime it will become dry and so on so forth. This fluvial system will keep changing the study is very important that we can assess the flood potential in this area.

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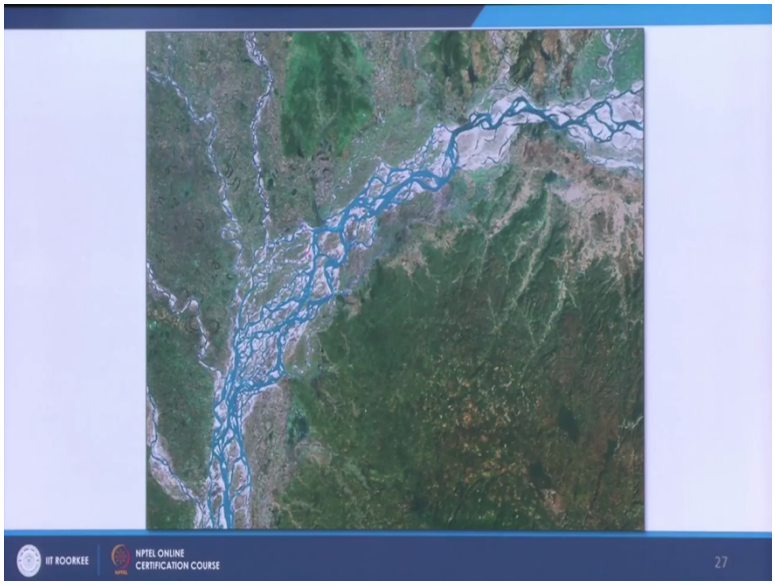

This is the Brahmaputra, this is braided channel of Brahmaputra and several other streams and rivers are also meeting in Brahmaputra and Brahmaputra almost every year is bringing flood, high sediments because of high erosion in Himalaya and high concentration of sediments are coming and the channels are braided there is no single channel and it is in a wide valley creates havoc every year due to flooding. Palaeo channels are there people have studied that how Brahmaputra has moved from one place to another and even can predict how in future things will move in a fluvial system. So that is the advantage of having remote sensing data, if you go there stand on a point you don't see that such a synoptic point view of Brahmaputra, you thinking will be very narrow in that sense.

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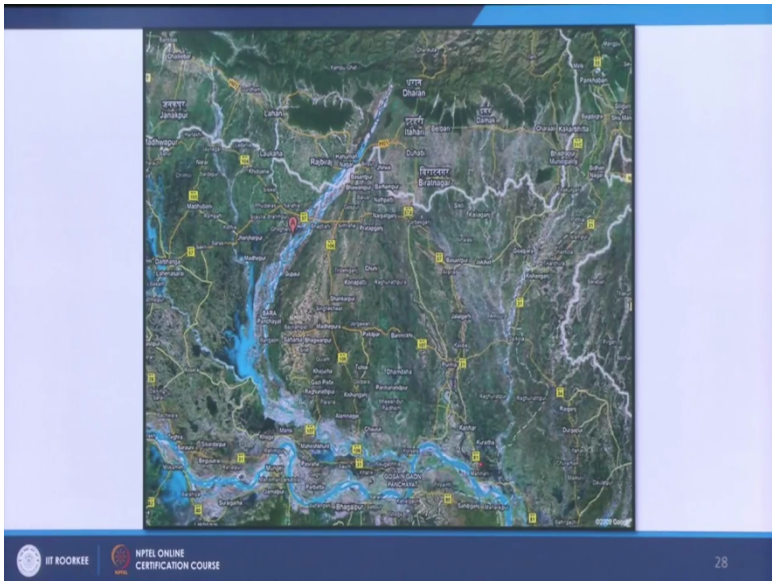

Another very good fluvial feature which is called the sorrow of Bihar which is a Kosi river, you would be surprise to know that about 250 years ago this Kosi river was flowing in this part that means on the eastern side and in this 250 years later and now it is flowing here so this has made a world largest alluvial fan, it has been moving and moving but it has a limit after it cannot go in west part. So one day it will come start coming back again and year almost every year it is bringing flood and it is creating lot of problems in Bihar. Another thing we have study that using satellite data we can study that how it has migrated? What was the speed and what it start coming back and these courses are changing or not?

All these things can be studied through satellite images, so that's the advantage of having remote sensing, specially I have focused on geological land form feature that we see very quickly on satellite images specially like product of Google Earth or some other and then we start interpretation and of course we can make some inferences if we are having old data arc eye or time series data how things have been changed in past and also we can predict about future, we can model the things that how thing will change in future. So thank you very much.