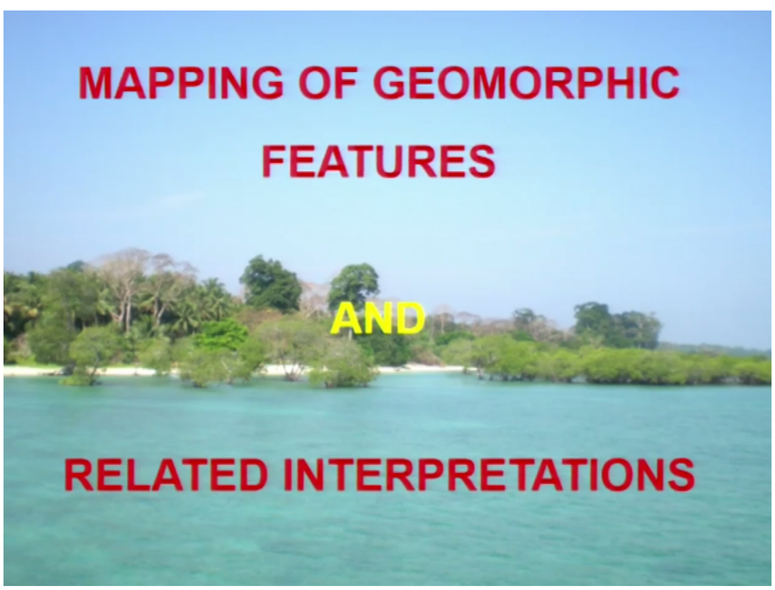
Photogeology in Terrain Evaluation (Part – 2)
Prof. Javed N Malik
Department of Earth Sciences
Indian Institute of Technology – Kanpur

Lecture – 18
Exercise on Identification of Tectonic Features and Geomorphic Mapping Using Satellite Data

Hi, welcome all of you again in the second part of the course photogeology in terrain evaluation. So as in the first part we have learnt something about the theory of this course and in the second part we mostly learned about the applications of this course. So, application of photogeology in terrain evaluation. So in this part I am going to explain you some practical information, some I am going to present some practicals on identifying geomorphic features and identifying some geological structures, some landform related to coastal, Aeolian, fluvial and other type of environments.

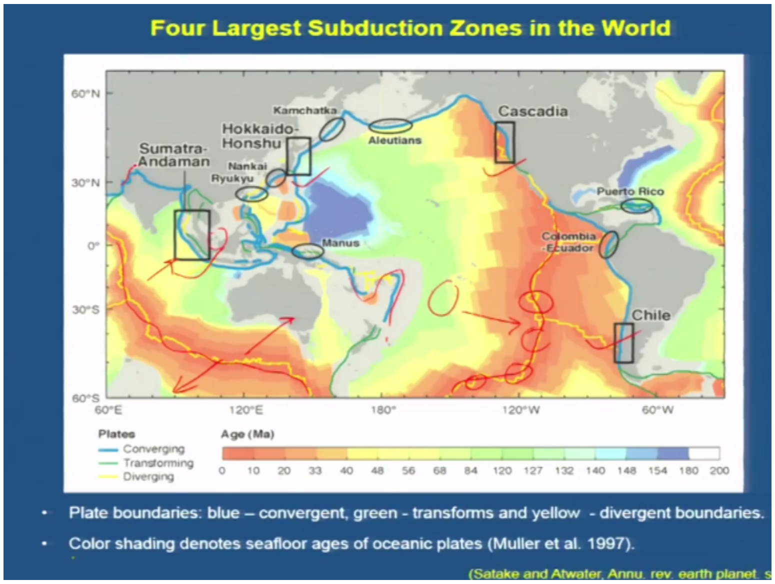
So in this lecture particularly I will move from the small scale images to large scale images. First I will show you a larger version of the Indian map. Then we will move to some smaller areas. So how to identify different type of geomorphical landforms and geological structures or how to identify the deformation pattern and the impact of some events in the regions like some earthquakes, some tsunami sort of events.

(Refer Slide Time: 01:54)



So in this part first I will explain you about the subduction zones of the world. Then we will move to some particular regions like Indian Ocean in that Sumatra-Andaman subduction zone. So let us go ahead with the first slide.

(Refer Slide Time: 02:06)

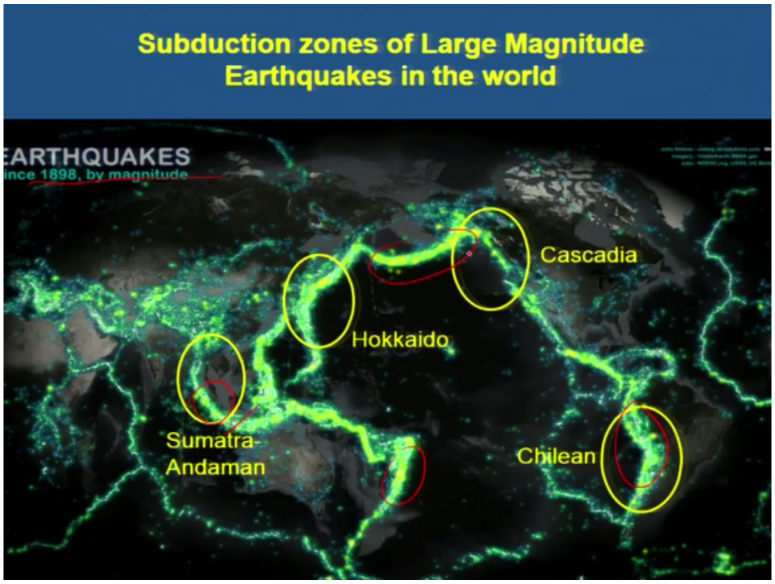


So these are the 4 largest subduction zones of the world most of know about these things. So first is Sumatra-Andaman subduction zone. Second is Hokkaido-Honshu. Third is Cascadia and the fourth is Chilean subduction zone. So these 4 are the largest subduction zone however they also have some minor type of plate boundaries which have convergence or divergence in between these 4 subduction zones.

So like here the blue line is indicating the convergence margins, convergence plain boundaries and this yellow line shows the mid oceanic regions where the lava continuously erupt over the surface of the ocean in the submarine portions and their solidify and form the ridges or rocks at these regions which are called the mid oceanic ridges. So that is why here the material which is solidified here those materials are of younger age and which are away from this region those are of the older ages.

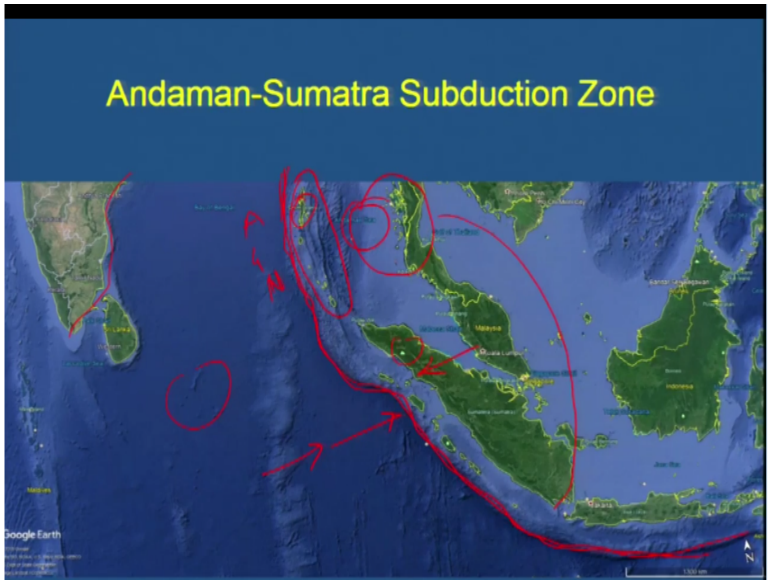
So this green, yellow, and red colours are showing the ages of the sea floor. So here if we can see that green part is representing the older sea floor and red as you move towards the mid oceanic ridge you will find some younger material. Similarly, this blue line is indicating the convergent plate boundaries. So here there is a convergence between the Indian Oceanic plate and this continental plate which is known as Sunda plate. Here this is the Himalayan range. So I will show it on the broader view.

(Refer Slide Time: 04:12)



So what is meant by subduction zones? Here the maximum seismic activity is responsible for the large magnitude earthquakes and on this map you can see the parts which are brighter which have higher intensity of lights. So those regions are indicating the zone of large magnitude earthquakes or the highest seismic activities. So these are the earthquakes in 1898. So this is the Andaman Sumatra as I already explained, this is Hokkaido-Honshu. This is Cascadia and this is Chilean subduction zone. So that is the reason for the large magnitude earthquakes along these subduction zones.

(Refer Slide Time: 05:05)



Now if we see the aerial coverage of these subduction zones like if you are having Google app access then you can see these subduction zones on the Google earth and you can see very prominent features along the subduction zones where 1 plate is subducting beneath the other plate. So those prominent features can be easily identified on the Google earth images also, because Google earth images are the satellite images.

And other types of satellite images like Landsat, IRS, and different types of satellite images you can identify these because these are the largest features on the surface of the earth. So here this line is very prominent on this image. You know that this is the Indian continent landmass. This is the Indian Oceanic plate and this is Sumatra, this is Andaman-Nicobar island. Andaman and Nicobar so this is the channel of Andaman Nicobar Islands.

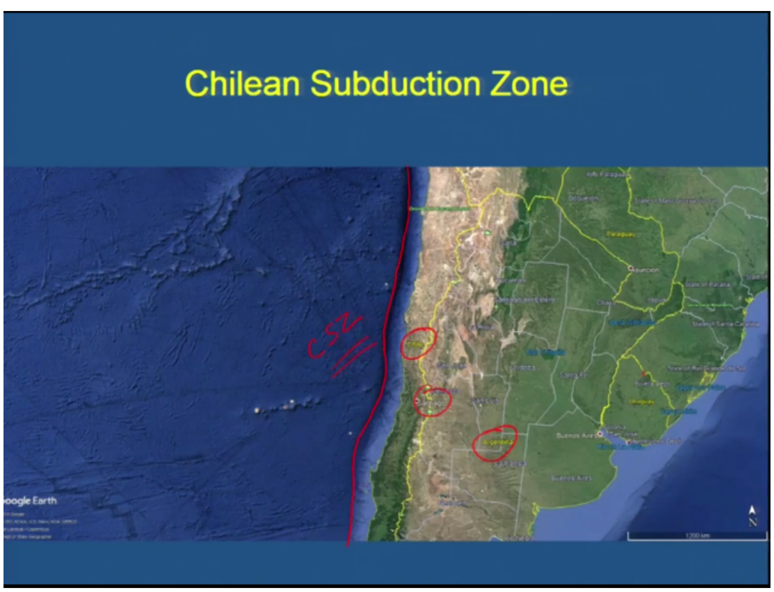
This is Andaman sea and this subduction zone. This red colour subduction zone is between the Indian Oceanic plate and Sunda plate. So this plate, this oceanic plate is subducting beneath the continental landmass. So this continental landmass is continuous from here to here. This is here you can see this is Burmese microplate and this is Sumatra, here Malaysia, Thailand. So all these made up the Sunda plate.

(Refer Slide Time: 07:02)

Similarly, this is another subduction zone Hokkaido-Honshu. Here also you can demarcate a very clear boundary between the oceanic and continental landmass. So this is the oceanic plate and which ocean, this is the Pacific Ocean. This feature is very typical shape of the Japan. Japan itself is a large island, but it is a country. So this whole island represents Japan and the 2011 Tokyo earthquake and tsunami was resulted in this subduction zone and caused a very wide spread Tsunami that affected the whole country.

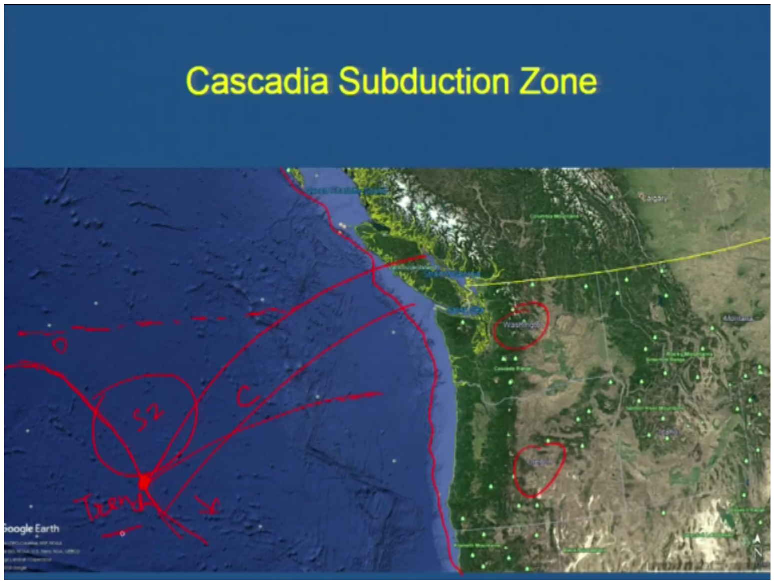
And there was a transoceanic tsunami and affected all these rounding regions along this Hokkaido-Honshu subduction zone.

(Refer Slide Time: 08:14)



Similarly, the third one is Chilean subduction zone. Here you can see the countries like Chile, San Diego, Argentina, and all these some US countries and this line is very prominent on this image is the subduction zone. So this is called the Chilean subduction zone. This was responsible for one of the largest magnitude earthquake in the history.

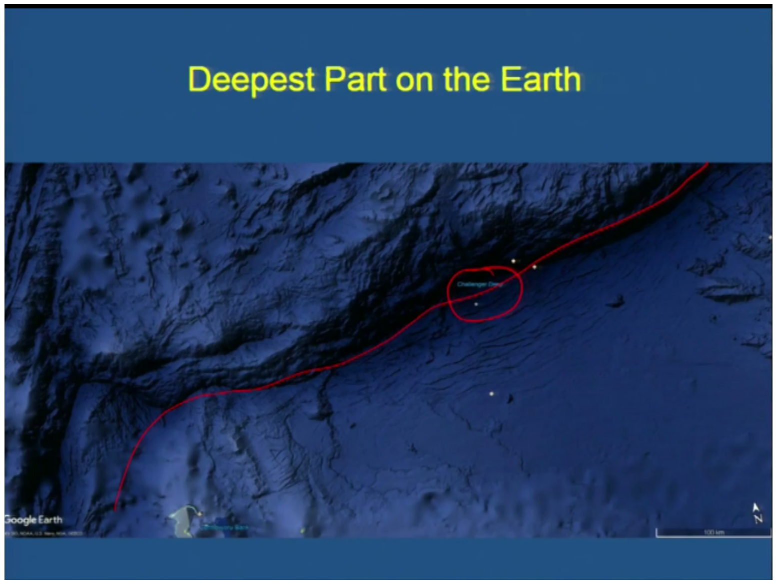
(Refer Slide Time: 08:52)



Another subduction zone that is Cascadia subduction zone. Here also we can see some countries, some cities aligning along this subduction zone that is Washington Oregon State and this prominent line here is representing the subduction zone. So how these subduction zones are formed. So suppose this is the continental plate and this is the oceanic plate and this is subducting beneath this.

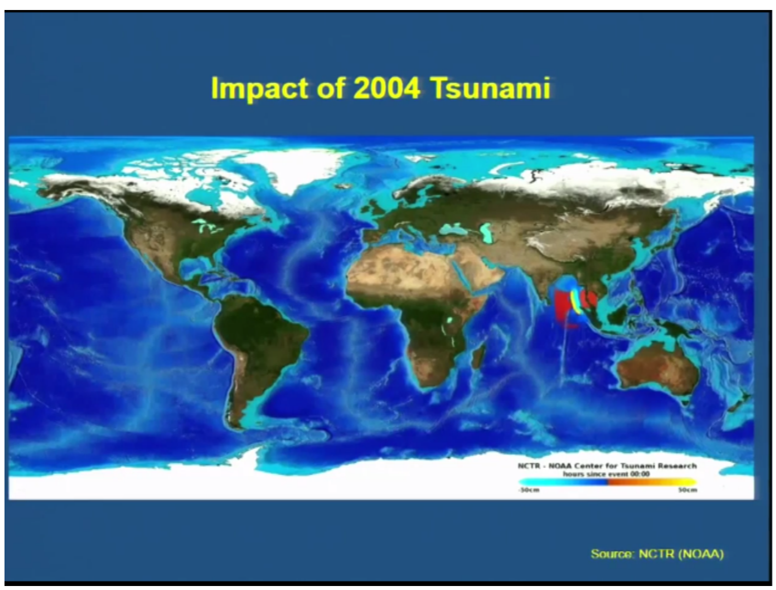
So this region basically forms the subduction zone and this point this suture zone is called the trench. Mariana trench in the world is the deepest part on the earth surface.

(Refer Slide Time: 09:50)



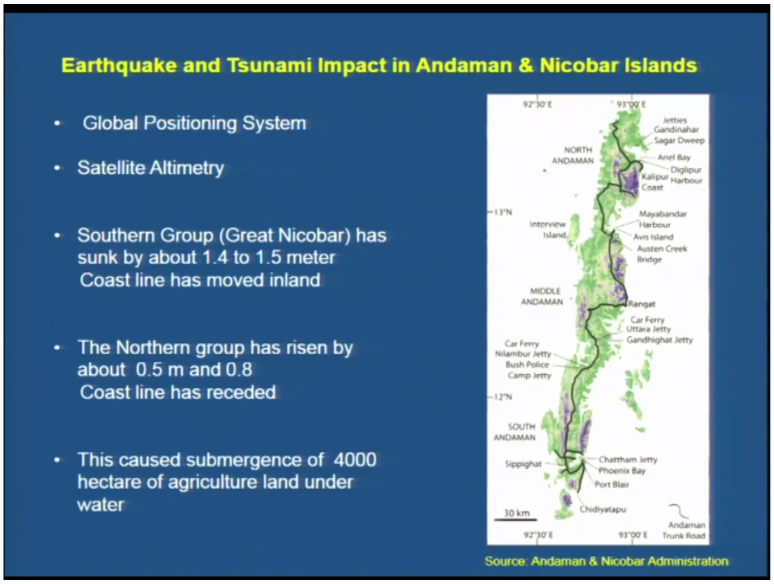
Here you can see this is the challenger deep and it is related to the deepest part of the earth and the highest part as you know that is the Mount Everest on the surface of the earth. So all these fed light images so we can easily identify large scale features like subduction zones, the mountain ranges, the oceans, and their transition zones and different type of environments like coastal environments and all that with the help of some associated landforms and features.

(Refer Slide Time: 10:39)



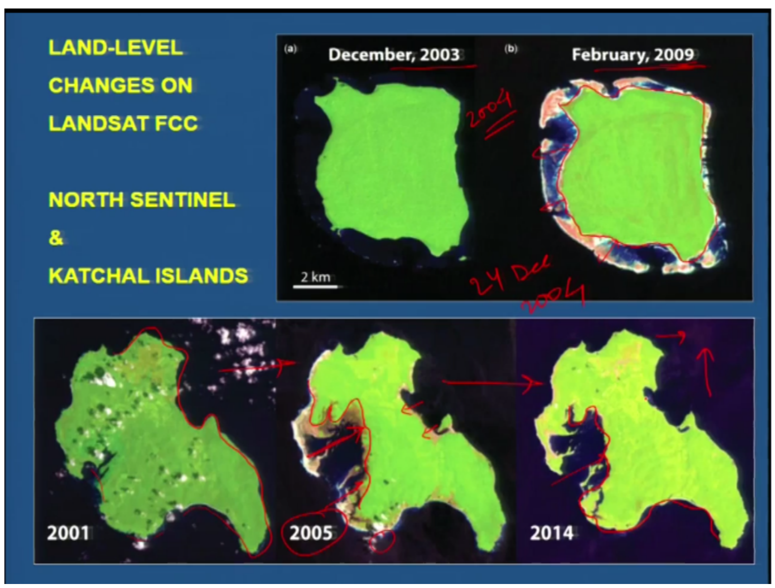
So now what happened during 2004? So why I am talking about the subduction zone because subduction zone are responsible for the largest magnitude earthquakes and do the earthquakes cause the changes in the landscape as well as its changes on the surface morphology?

(Refer Slide Time: 11:01)



So the names which are given here on this map are showing the areas which were affected in terms of uplift and subsidence and in terms of tsunami waves impact.

(Refer Slide Time: 11:19)

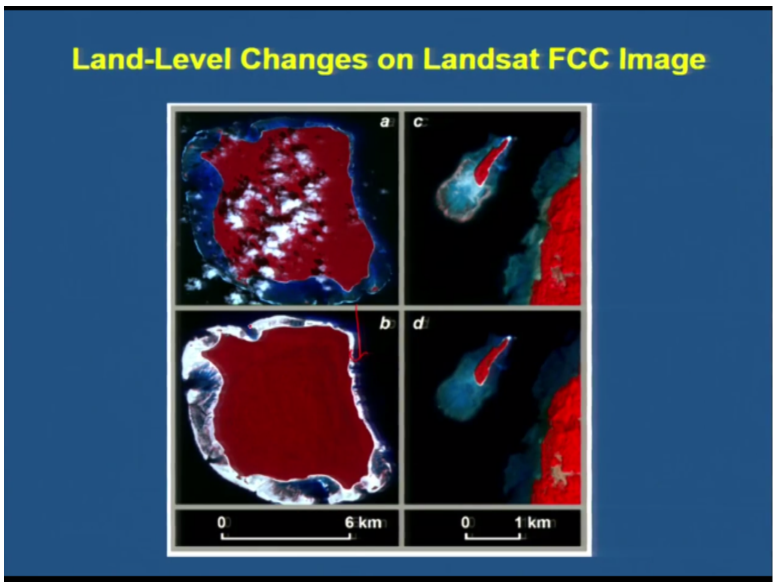


So this Landsat image shows that the north sentinel island was uplifted because you can see here there is a gaining of some land, some new reeves or some new ridges and some shore platform. So the island area shown in the first image is represented by the green colour and all other areas surrounding this green colour are gained due to uplift. So this is image of 2003 before the happening of 2004 event. So the earthquake occurred in 24 December 2004.

So this was the image during 2009 of the same island captured by Landsat image Landsat satellite. So in the similar way we can see another island it is Katchal Island. This has some type of submergence. This island shows submergence and it has lost most of the lands which are lying along the shore line or the coast line. So as you can note down here the area of this island has decreased in this image which was captured in 2005 and in 2014 it again shows that the area which was lost during the 2005 or post 2004 earthquake so that is maintained here.

So now the GPS reading also shows that there is increase in the elevation vector and that means the island is again gaining the land, gaining its lost area.

(Refer Slide Time: 14:20)



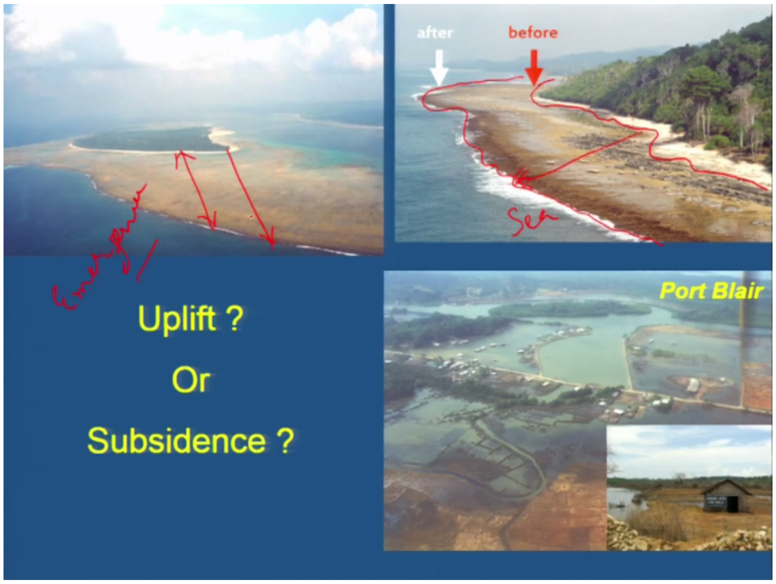
This is again the false colour composite image of the north sentinel island and some other smaller islands. It also shows that it has gained the land. This white patches represent the fresh sand or the fresh sandy reef or ridges all along the original area in red colour of this island.

(Refer Slide Time: 14:53)

So here if I will ask you tell me what is the land level change here in this image uplift or subsidence? So if you have an aerial photograph or a satellite image of a particular area can you define in your terms where there is subsidence or uplift so we can see here as in the previous slide when the island gains the land.

Then it means there is uplift and when it loses the land it means there is subsidence and subsidence causes submergence. Because sea level rises and the shore line moves towards the inland due to which an island loses its area or land. We can see that this bridge was submerged after the earthquake while this bridge is still there it means that it is at some higher elevation than this bridge.

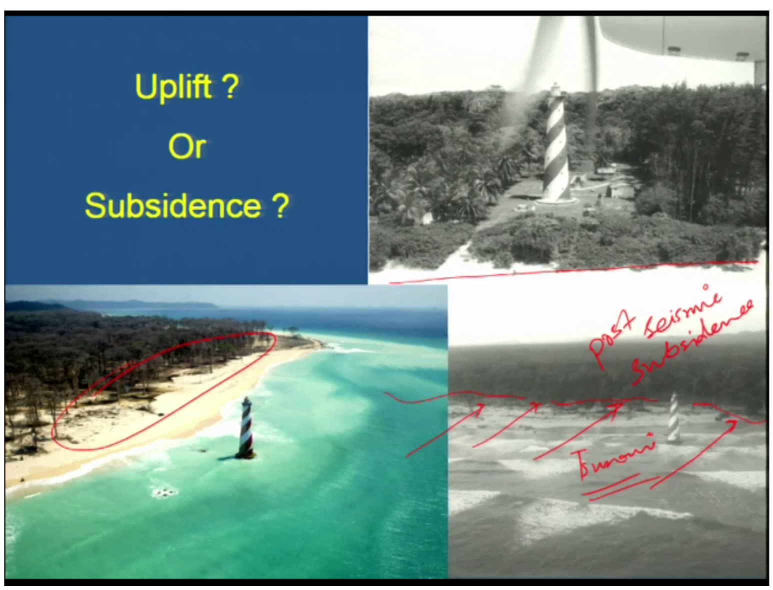
(Refer Slide Time: 16:34)



Similarly, tell me in this image is there uplift or subsidence. So you can see here that the fresh sand is at the base of this island so it represents that the shore line must be there before the event. Now shore line has moved towards the sea. Now this is the present shore line after the event. So it indicates that this island was uplifted.

Here again like in the previous image we can see the submergence of this area due to which indentation causes the water logging into this area and due to which the agriculture farming and the settlements have been affected. Similarly, in this image we can see there is extension of the land so here we can say also emergence of the land or emergence of the wave cut platform.

(Refer Slide Time: 18:14)

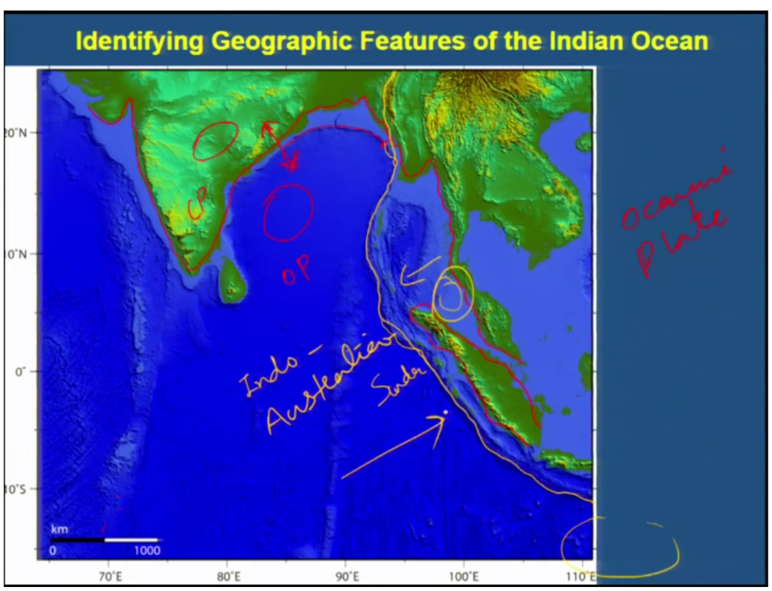


Similarly, another oblique photograph showed the Indira point at the Nicobar Island. This is the lighthouse and before the earthquake we can see that it was surrounded by the lavish green vegetations and all the settlements, but after the earthquake there was a subsidence due to which all the matter up to the present a shore line was swiped off also some most of the things were swiped off during the tsunami and the remaining parts of the vegetation and the settlements were gone up during the post seismic subsidence means the subsidence occurred after the event.

So see the colour photograph again the aerial oblique aerial photograph which shows the original view of the colourful view of this area at the present day how it looks like. So everything has gone. So these are the affects of the earthquake and tsunami which you can map on the images or the satellite data or if you are having some vertical and oblique aerial photograph you can demarcate the boundaries of the affected regions.

And you can prepare the hazard map on the basis of the past events and their affects in a particular region. So these methods and techniques are also very helpful for hazard mapping and zonation.

(Refer Slide Time: 20:47)



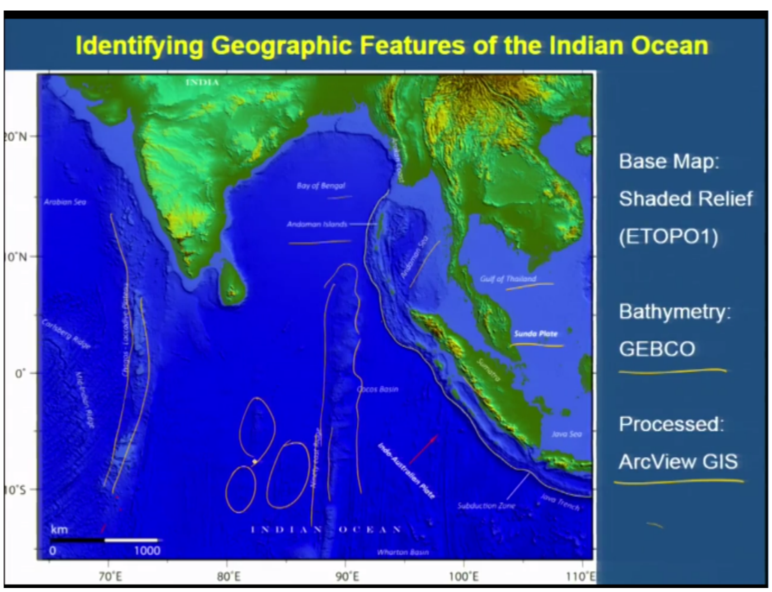
So now let us move ahead towards mapping. So this is SRTM image and here if you look at this image you can have idea of the most prominent features and the well known land mass like India I draw the boundary of this landmass so this will show the continental landmass and this bluish part shows the oceanic plate. Suppose here there is an Indian continental landmass and this is the Indian oceanic plate.

So this is the continental plate, this is the oceanic plate, but there is no break between these 2 because the land which is exposed above the sea level those are the continental landmass or the continental drift and the land which is below the sea level that is the oceanic plate. This is the continental plate. Similarly, there is no break up to this point, but this let us take another colour. If you see this feature, if you say that this is something a gap between these 2 plates because this is forming a deeper trench between these 2 plates and how this is going, this is going like this.

If you see the broader view of the world map, then you will be able to sort out this plate boundary. So this plate boundary is called the subduction zone. The subduction zone it is somewhere it is termed as Sumatra Andaman subduction zone, Sunda subduction zone because the plate the name of this plate is Sunda. So this is the Indo-Australian plate because there is some Australian plate also because the Australian land mass is here somewhere here.

So Indo-Australian plate and this is the continental land mass. This plate is subducting beneath this Sunda plate.

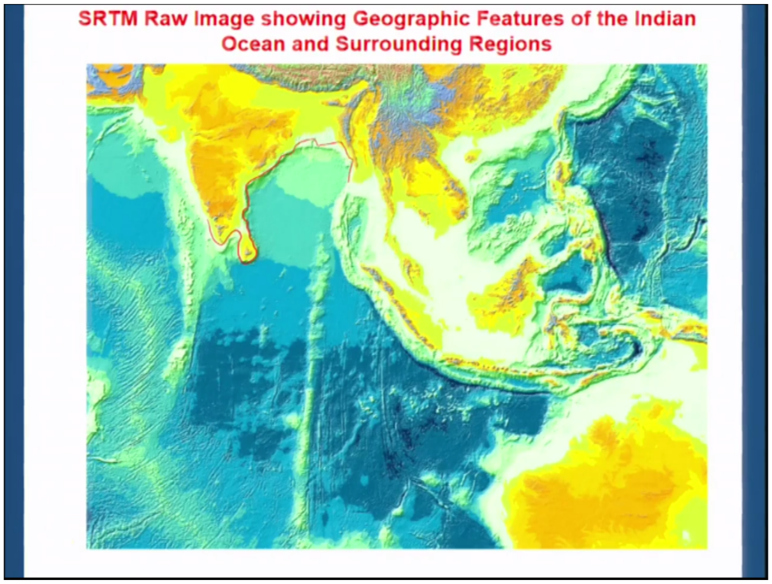
(Refer Slide Time: 23:32)



So this yellowish line demarcates the subduction zone and this here you can see Arabian sea, Bay of Bengal, Andaman Island, Andaman sea then 90 east reach, Sumatra, Sunda plate, and Gulf of Thailand features on this image. So this image is processed in Arcview GIS and the bathymetric data has been taken from the GEBCO. So what is Bathymetric data this because the Bathymetry is also highlighted on this image.

You can see the ridges, the submarine ridges and all the features, elevated features beneath the Indian Ocean and this map is called the shaded relief ETOPO.

(Refer Slide Time: 24:28)

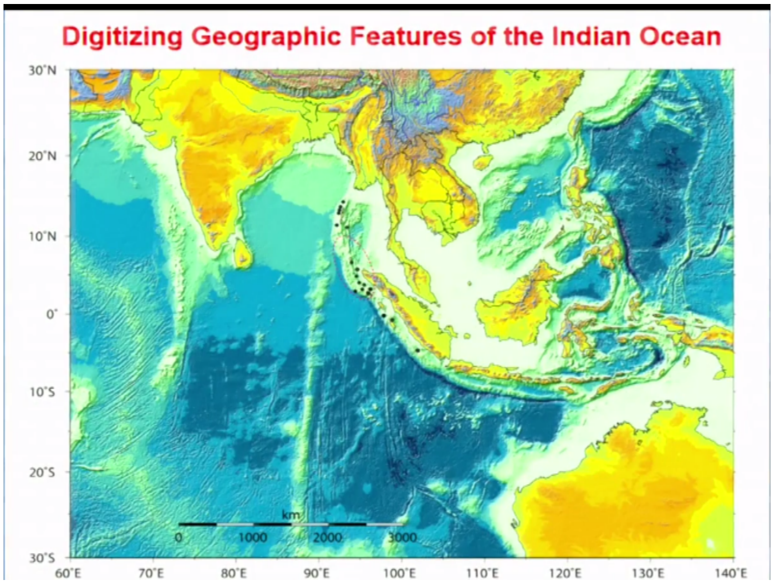


Similarly, this is SRTM raw image of this region which is covering from India, Arabian Sea to this part this is Hokkido-Honshu subduction zone, this is Japan and this is the Pacific Ocean. So now if you see this image you will be able to extract only the most obvious information about the continental landmasses and oceanic regions, but how to make this map more informative. So for this we have to trace the important features.

What we are able to look on this map. So here first we have to trace all the features to make this map more informative. Then we collect some other information about this region from other sources also so that this map becomes informative and we can extract maximum information out of that. So digitizing, the word is known as digitizing.

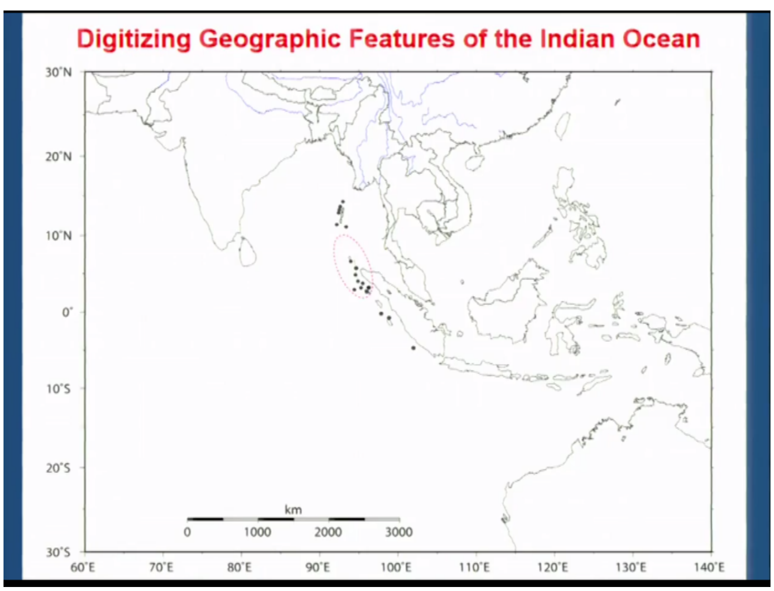
Suppose if we are able to see the boundary of this landmass then you highlight this boundary is called digitization digitizing the map to highlight the boundaries which are obvious or which are doubtful but can be confirmed from other sources like Google earth some other satellite images. So after doing all these exercises what we have?

(Refer Slide Time: 26:32)



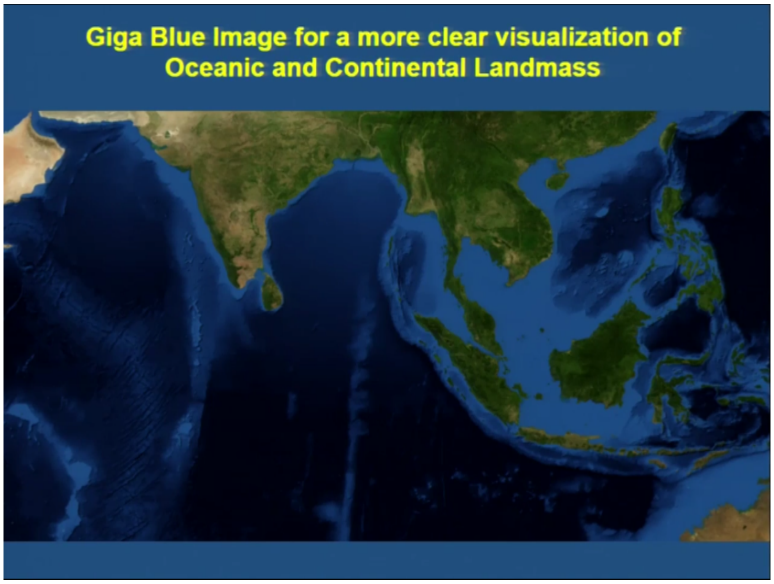
Now look at this image, this is the same image in the previous slide and now this is changed completely. You are able to demarcate all these things. On this mage, we are highlighting the information and there is a separate layer in which we have digitized this map so what is that layer.

(Refer Slide Time: 27:02)



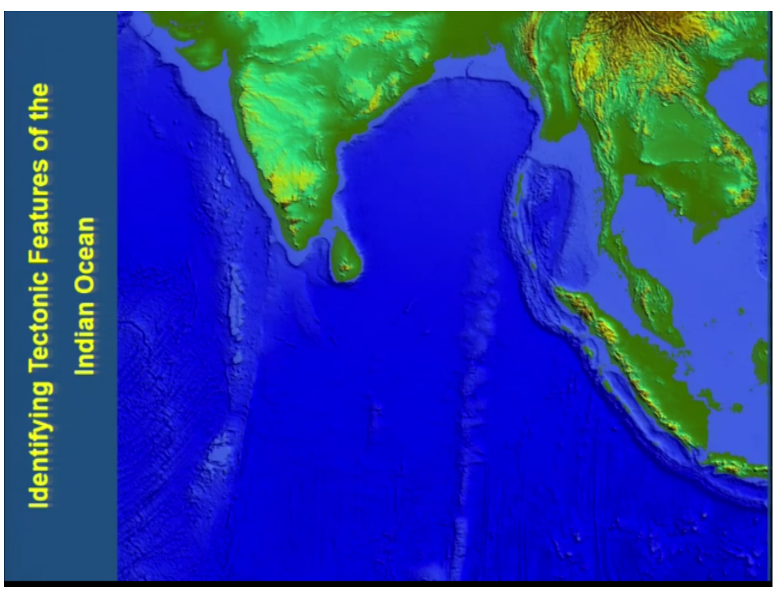
This is the layer. This layer contains only the traces and the exercise what you have done to digitize this image or to make this image more useful and more informative. So how this has changed? This was like this and now it has changed to this image.

(Refer Slide Time: 27:32)



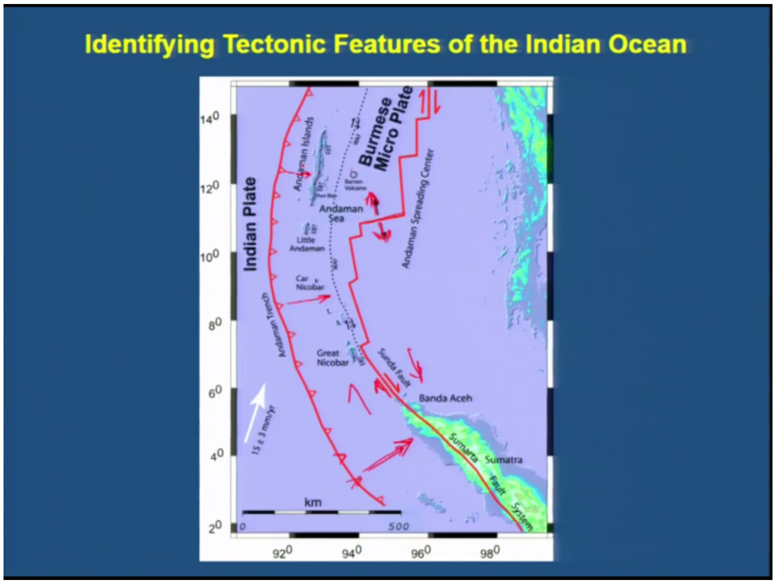
So moving ahead this is a Giga Blue image and you can use these kind of images for a more clear visualization of the land mass from the oceanic regions and if you want to read the elevation information for the land mass then.

(Refer Slide Time: 27:49)



You should go for some Topo maps or some kind of the SRTM map or the maps which are the image is which contains the information of the elevation also. So that long elevation. So by highlighting the elevation information we are able to highlight the areas of higher altitude when you see the image of Himalaya so you would be able to see how at what elevation Himalayas are and how they are differ from the plainer areas. So this I will show on the Google earth images in the next Lab.

(Refer Slide Time: 28:57)



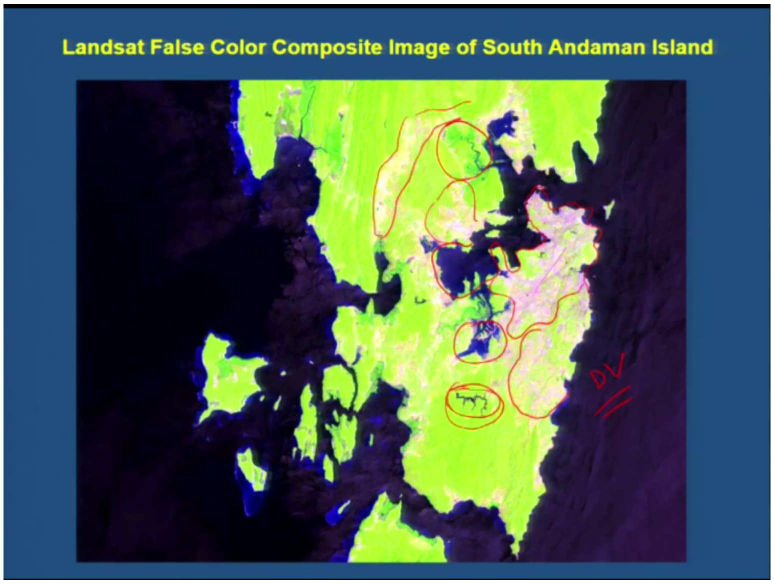
So after reading all this information so we can prepare the tectonic map also. So tectonic map means to highlight the information of the faults including the minor faults as well as the larger scale faults and subduction zones and the direction of subduction and the some from volcanic information like there is some volcano or some other kind of tectonic feature like linear mends and folds so all this information we can put combinedly on a tectonic map.

So as for this region you can see that this line this red line demarcates the subduction zone and these triangles are showing the direction of subduction. If you see here the direction changes a little bit, if you see here the direction changes a little bit. So direction of subduction and this is showing this spreading ridge. Spreading ridge means, it is a sort of where the lands are becoming where the lands are separated from each other they do extensional tectonic regime.

So here there is a presence of extensional tectonic regime and this is Sunda fault and you can see the sense of motion on this fault is like this. So this part is going up. This part is going down and similarly you can see here barren volcano. There is a volcano around the middle part of the

Andaman and this is Andaman sea, this is the capital of Andaman, Port Blair and WA is West Andaman fault and this is Car Nicobar. This is great Nicobar and this is the rate of subduction so at this rate 15 + - 3 mm per year Indo-Australia layer is subducting beneath the Sunda plate.

(Refer Slide Time: 31:30)

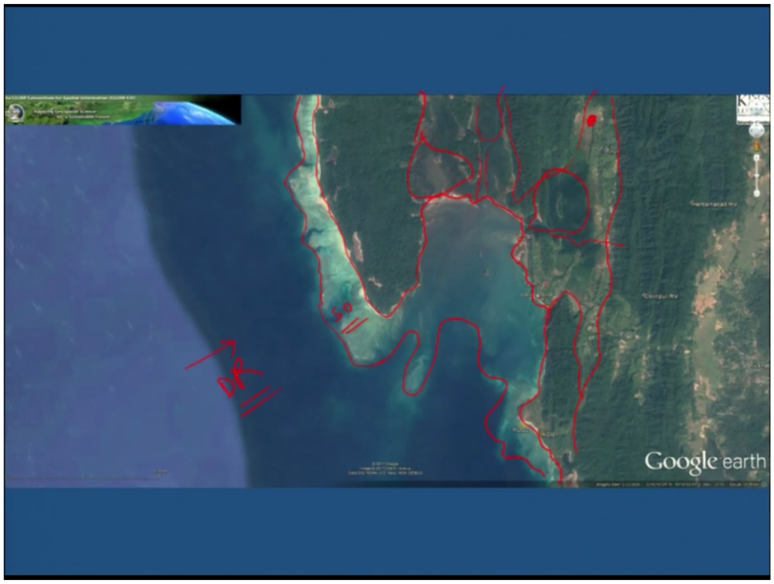


This is the Landsat false colour composite image and on this image you can also highlight some features like here you can see a very linear feature is shown that is the airport. This is the Port Blair air split and this is here first the greenish part. Let us move from the major to the minor. So the greenish part comprises most part of the image which is the dense vegetation. It shows the dense vegetation and mixed type of generals and this part is forming a Bay region and here you can see this stream which has formed some water body.

So stream ponding is also a common feature of the islands. Here also you can see the same thing stream ponding and tidal estuary there is a channel coming from here. So all these things combinedly we can map and mapping all type of features like the main land. These are the settlements. These pinkish regions are showing the settlements on this image. So we can demarcate all these very easily so preparing such a map is called the geomorphic categorizing geomorphic landforms or some land use map.

So we can prepare some land use map and some geomorphic map with the help of this image. I am going to explain how we can do geomorphic mapping of this area.

(Refer Slide Time: 33:36)

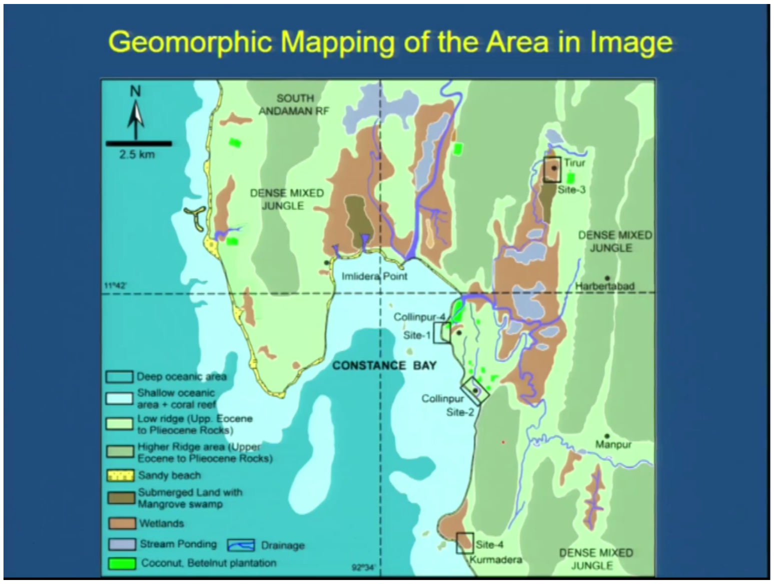


Suppose, we take this region, where we are interested to make a geomorphic map. This region is known as the Constance bay. So these are relocations of our sites 1, 2, 3, 4. In the previous map, I have shown the sides so those 4 sides were located here, 1 side is also here.1, 2, 3, and 4. So now here you can see there is a tidal channel going inside. So we are interested in preparing the map of geomorphic map of this region.

So first we will classify the most prominent features on this map. Those are the coastal, the shore line, the most prominent. So then we can able to demarcate the fresh end part which is the shallow oceanic region. These regions are showing the shallow oceanic part and these are depressed part, deeper regions. So these shallow regions we can classify like this. We can also map some red lines here, some tidal channels, some wet lands here also.

Some channels and some ridges like this is a ridge, this is another ridge and this another ridge. here is some other minor ridge. So I mean to say first we need to classify the major features like which are very easier for us to demarcate. Then we can move towards the small scale features like some small scale coastal land forms, cliff, headlands, sea notches like this.

(Refer Slide Time: 36:06)



So with the help of this we can prepare such kind of geomorphic map. So as on the previous slide I explained there another thing which I missed on the slide that is a narrow steep of beach. A beach must be following the shore line. So there is a very narrow steep of beach along this island which is following the shore line. So that we can also demarcate. So by combining all the features and all the information extracted on the previous slide we can prepare this map.

And we should also compare our geomorphic map with the Topo sheet because Topo sheet gives the information of some contours and some prominent bench marks which we can use and which we can incorporate while we are preparing our geomorphic map. So it is a combined approach by taking some data from the Topo sheet and some data from the satellite images and some data from our own area and like from the photograph which we have captured during our surveying.

So in this map you can see that, we have demarcated the deep oceanic areas and shallow oceanic areas which also have the coral reef. Then these parts are showing some lower elevated reefs and these ridges are at the higher elevation. So these are the higher ridges and are forming some dense mixed jungles over the ridges and here are some strings and these regions are the wet lands and so on.

We will continue in the next lecture with some large scale geomorphic mapping and we will explain you how to map region at a higher scale. So, that you can expect maximum information. So thank you so much.