Geomorphic processes: Landforms and Landscapes
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Lecture -38
Tectonic Geomorphology of Kachchh (Part II)

So welcome back. Last we discussed about the landscape of Kachchh. Now quickly we will see what are the signatures which we got from the great Rann of Kachchh and from Dholavira and how we have correlated. Our investigations or the findings with the the events of the landscape change.

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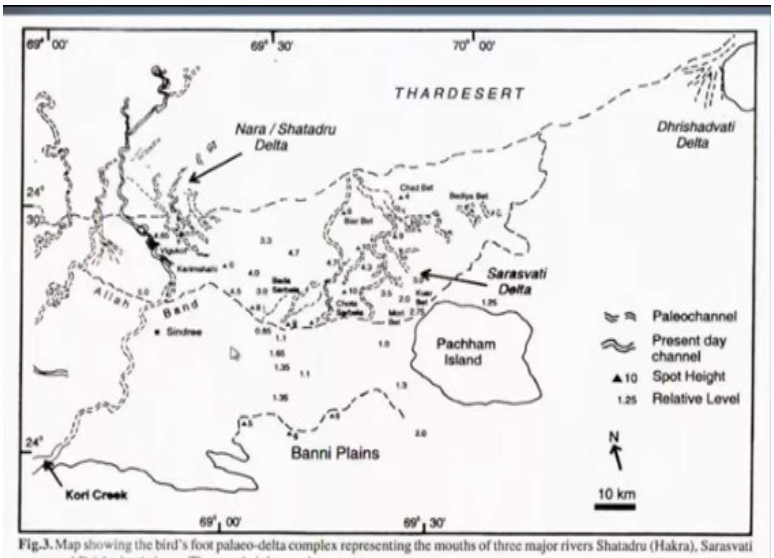

Fig.3. Map showing the bird's foot palaeo-delta complex representing the mouths of three major rivers Shatadru (Hakra), Sarasvati and Drishadvati rivers. The spot heights are in metres. (after Malik et al., 1999)

So, coming back into the part here that what we discussed in the previous lecture. We had three deltas of different rivers one is the Sarasvati delta, the Dhrishadvati delta which is this channel or this river is now known as Luni in Rajasthan and then we had Nara Shatadru delta. And then further west if you go you have the Indus one.

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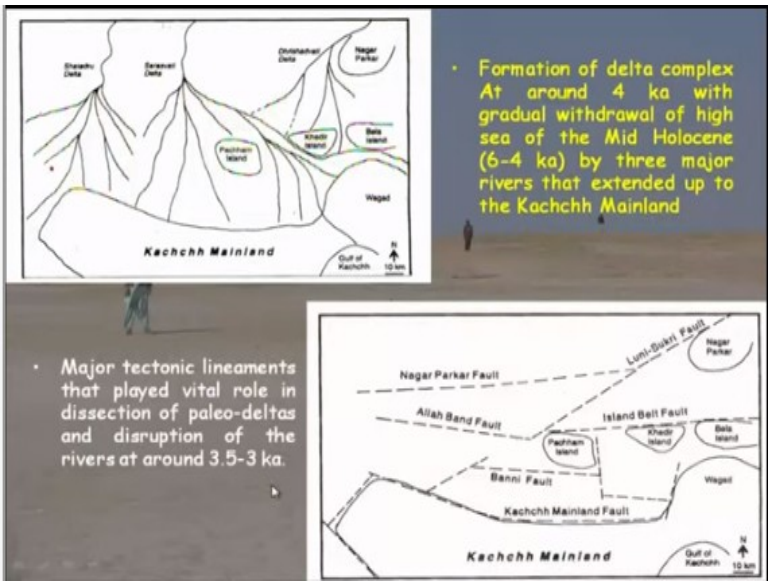

Now this is what we suggested and this is fairly acceptable that when you have the low sea level then the fluvial activities will extend further towards the ocean. And that what we consider that the area are which lies between the Thar Desert and then the low the shallow sea area was occupied by the extended deltas. And during this period the extended deltas within distributary networks had one of the channel which float close to the Khadir Island and this was one of the one the channels of Saraswati channel Saraswati river.

So, this we had Saraswati and then we had towards the the west we have Shatadru and then we had Dhrishadvat. So, we suggested formation of delta complex was at around 4 ka with gradual withdrawal of the sea level. So, climate played an important role which allowed the drainage network extended or extension of the drainage network towards the ocean side further towards the ocean which resulted into the multiple distributary network of multiple deltas.

So, this was around 4 ka and this was because of the gradual withdrawal of the high sea of mid Holocene that was from 6 to 4 ka. So, three major rivers that extended up to the Kachchh mainland. This is again and a thought process but yes of course this give some idea about the sculpturing of the landscape. So we say after this after 4 ka four thousand years the tectonic activity was more intense in this area and that allowed or the reactivation of the fault lines and

disruption of the channels and all that along the different faults like Nagar park fault, Luni-Sukri fault, Allah Band fault, Island Belt fault and all that.

So, this was the the phase when the tectonic activity was quite intense which disrupted the delta complex. So, 4000K was your withdrawal of sea resulted in the extension of the rivers and the distributed network and the disruption at around 3K.

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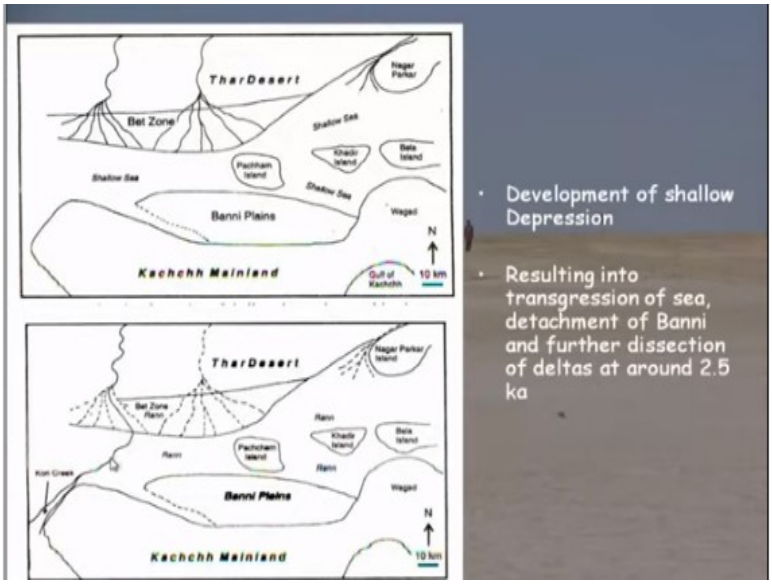

Further this tectonic activities or maybe we can say the landscapes sculpturing because of the ongoing deformation resulted into the development of shallow sea outlet in this region. So, by that time this region was formed and the delta remained confined to this region that is the bed zone that this is known as bed zone slightly elevated area in the marshy region close to Thar Desert.

So, this resulted into transgression of the sea detachment of the Banni and the Banni area is this one actually this is grassland which used to be there but now no more grassland this whole area is under the salt and crestation. But yes of course not salt and crest exactly but this part is the and this still exists but it is not the exactly the grassland now. So, it further dissected and the delta complex at around 2.5K.

Then lastly what we suggested was not this and this is not just based on our hypothesis or the thought process but yes of course in literature it exists that this was connected this channel this Nara channel or Shatadru channel.

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So, and so this is one of the sketches which are available from Lyell 1857 paper publication which talks about that Sindhri fort before the earthquake and after the earthquake this was in **1918** 1819 Allah Bund earthquake.

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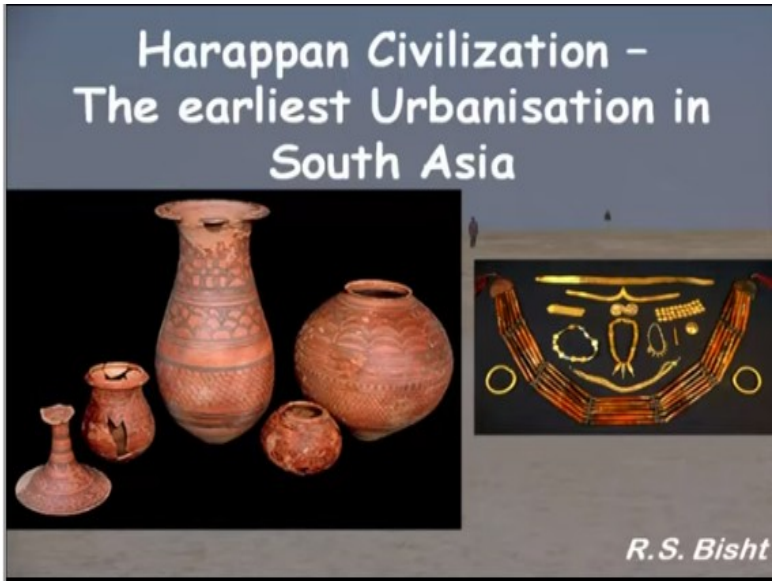

So Dholavira in particularly if you see is the one of the major Harappan civilization site that is what we call the earliest urbanization in South Asia. So, this is an extremely urban settlement and even what we felt was that the usually we see that there is an cultural transferred from one cultural level to another one or maybe we can say the one settlement to another settlements and progressively.

But there is no sort of an connection or connectivity we see on the people who are staying presently in that region Khadir Island and the people used to stay during the Harappan civilization. There is no connectivity because they were quite modern in advance in terms of their trench, network and all that but that has not we can say the culture has not passed on to the next level.

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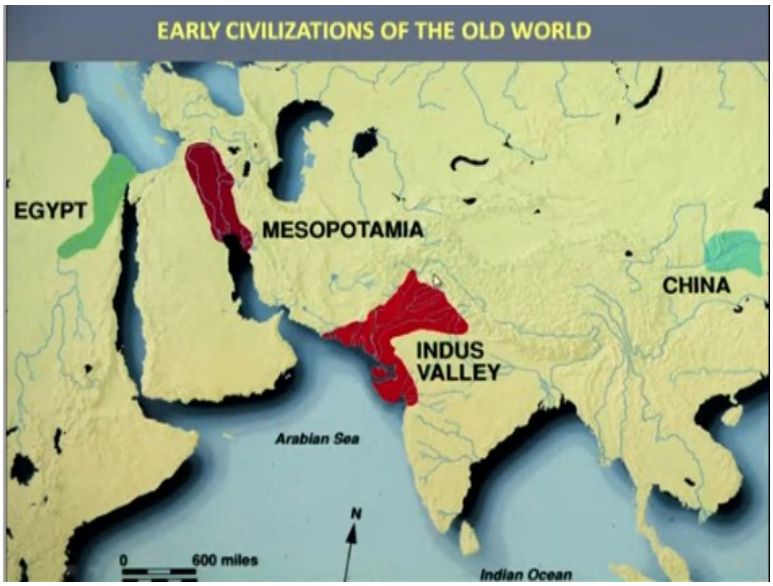

So, this was the area which used the Indus Valley is quite a huge area which used to be like in terms of the cultural extent.

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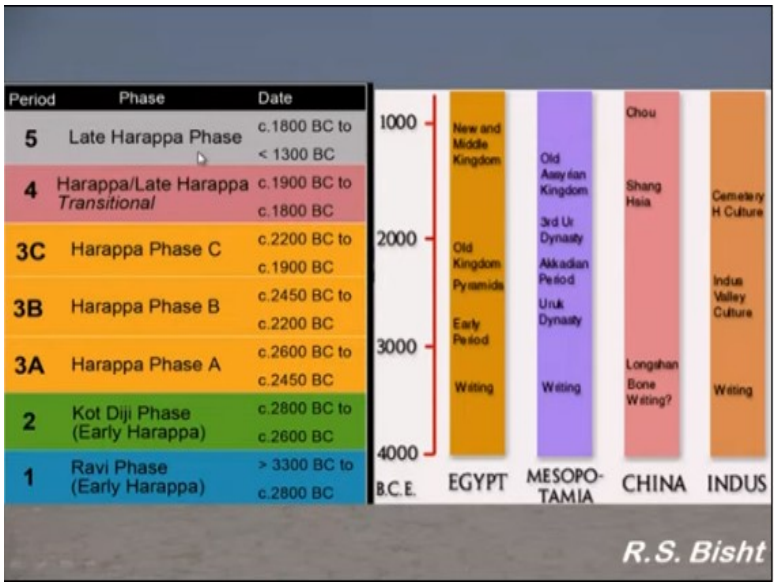

So, you have different phases of the early Harrappans right up to the late phases.

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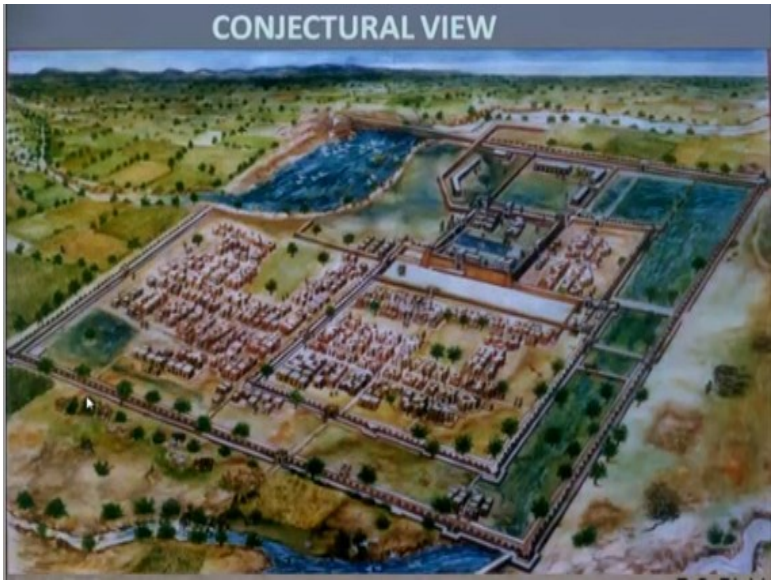

This we have so this is an over conjectural view of Dholavira talks about an of course acts as the climate changed and the landscape got sculptured because of the ongoing deformation and the climate change. The final late Harappans they understood that they will face problems in terms of the water storage and all that .So they have a very good drainage system so we had an influence influent which is the waters coming here and then get stored into different reservoirs and this is an outlet of that.

But of course they had an very good connectivity but right now if you see there is no channel which connects the city. So this is an conjectural outlay of Dholavira and a very well-planned city.

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So, this is where during the excavation that shows about the well-planned streets and shops and houses.

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So this was one of the example which we got the slumping of walls and that was because of were related to the earthquake.

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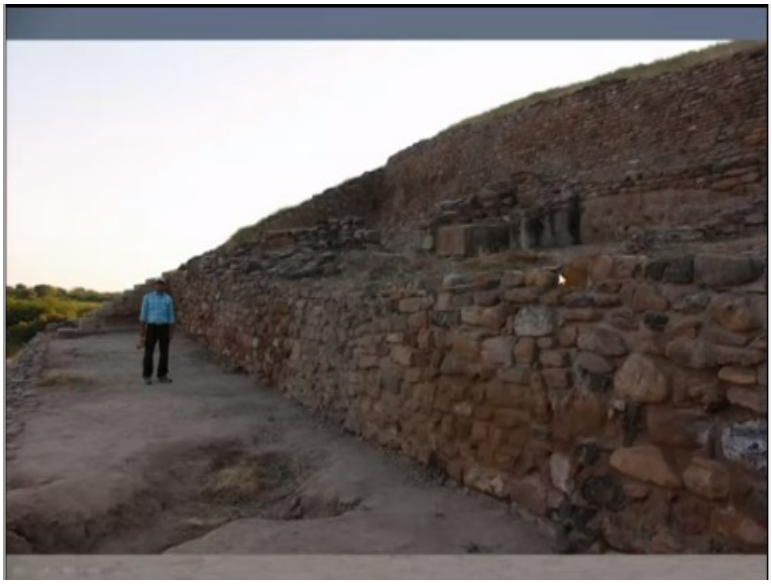

And then waved up walls and one of the side of the gate which is an again example of the earthquake or we can say the seismic wave which has passed through this area.

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So, strong seismic shaking has been experienced tilting of walls so this is from one of the gate where the wall has been tilted.

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So these are all signatures which are the left out signatures of past earthquakes which affected this region. An another one which we inferred was that this area was occupied by (()) (10:42) or we can say reoccupied after the events and this is well understood by the older construction here which is seen here. And then this gate if you look at was been constructed later on and you can see the filling of the material here so this was older one this was younger one and then they use the existing or the ruins not existed at that time.

Again we see some very clear examples of tilting of walls with all set of walls which have been seen in the excavation during an excavation.

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So, again another one example of the tilting of wall in that area.

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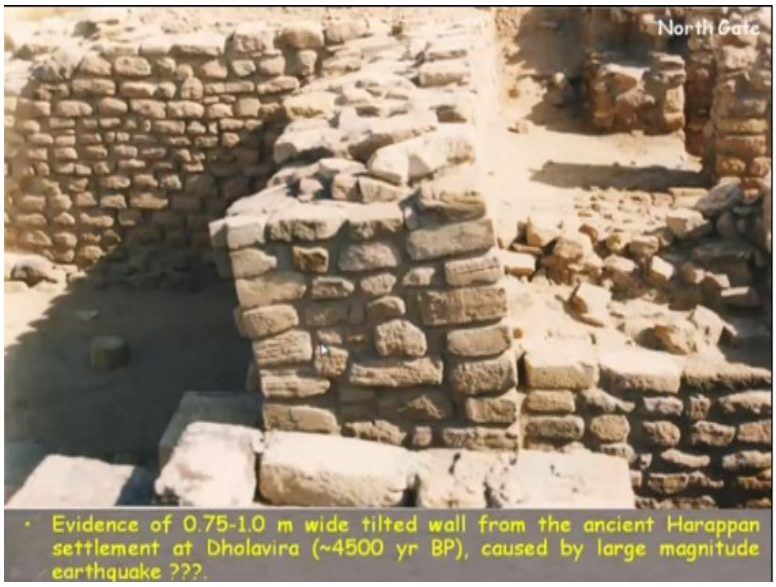

This is a clear example of the strong ground shaking. So, there were few very clear indicators which suggested that Dholavira got affected because of the tectonic moments in that region.

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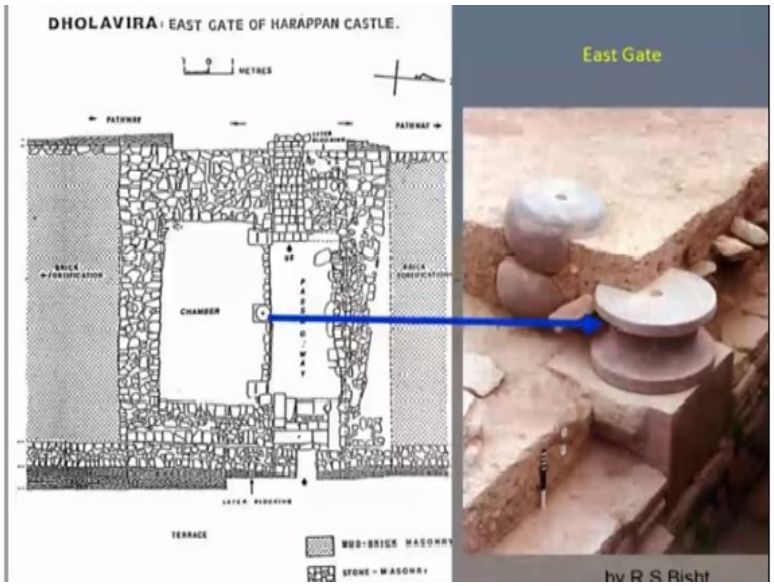

So, these are few pictures were taken by one of the ASI officer Dr. R.S. Bisht who was one of the leading personal in excavation of the site.

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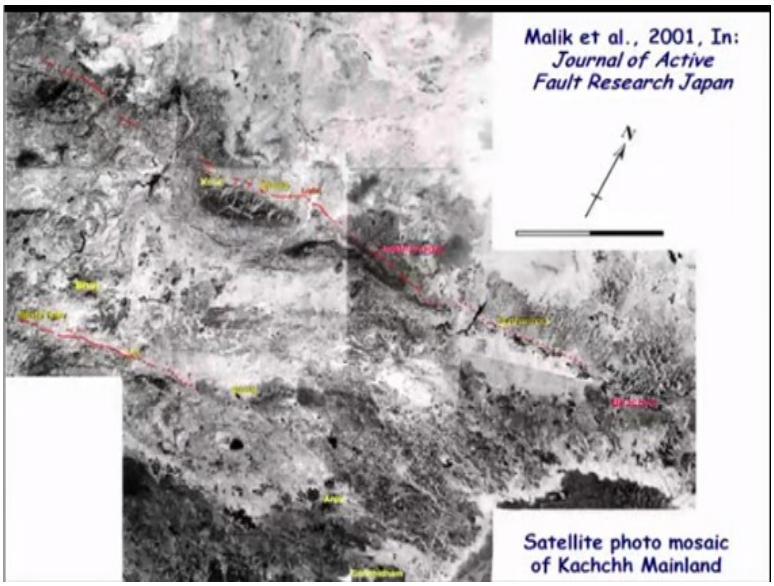

Now, coming back to this again what we found was the there were number of active faults which exists in the in this region.

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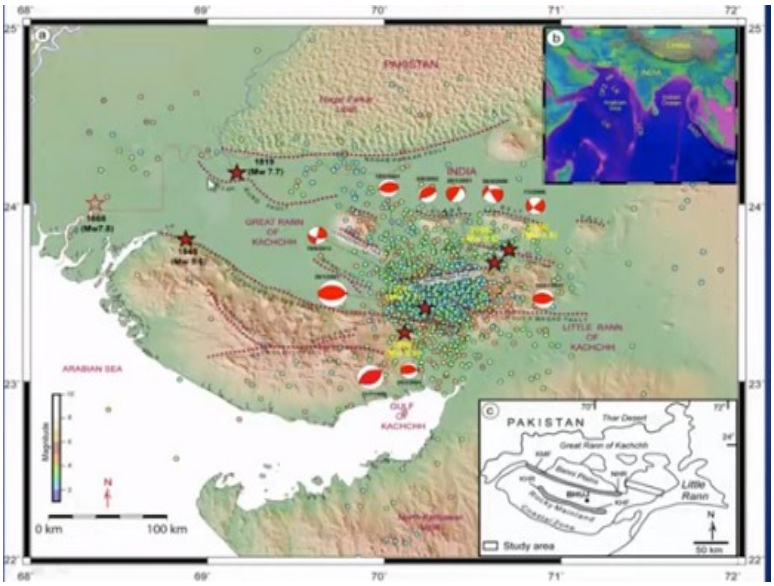

And this faults one of the faults might may be responsible for the damage and all of the Dholavira. So, in 2001 after the like after 2001 which earthquake we concentrated in this area and try to looked at the activity of faults here. But I am not going to discuss this one here and in detail but we will just jump to this area because this is more interesting. But I would like to add

this here that this fault that is in (()) (13:07) fault we identified two earthquakes which were responsible for the damage to the Harappan civilization here.

So I will straight away go to the Allah Bund area here and try to show you the site which existed in recent times that is around thousand years back. But at present you do not see any like the favorable conditions which allows such settlement to come up here in this region.

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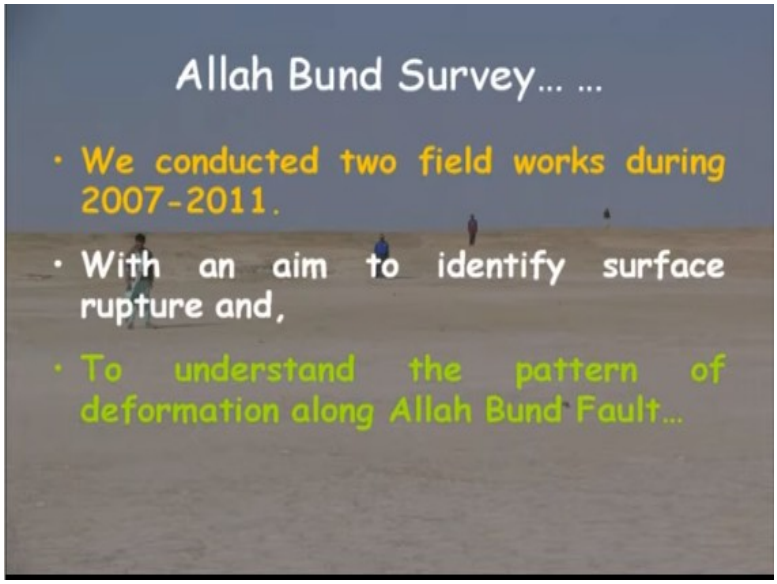

So, coming to the Allah Bund part again Allah Bund terrain is really very interesting terrain in terms of if we see the cultural settlements and if you look at the landscape. And it is sometime difficult to connect between this two but we have tried our best to understand that what might have happened in the past. Now as we talk about the climate change so major climate fluctuation was the lowering of the mid Holocene high sea around four thousand years.

But after that more or less the climate did not get change in this region that is what we understand until now well along with some minor fluctuations. So, if the climate remained unchanged after four thousand years then the why the landscape were changed so much of course we see a sort of an global warming we started talking about the green house effect and all that. But during that period I do not know thing that there was much of the green house effect and all that.

So coming straight away to Allah Bund we conducted the field in 2007 and 2011 with an aim to identify the surface rupture and so this was the idea behind to understand the pattern of deformation of Allah Bund. Then of course this should be connected to the why the landscape got change and why the people were been forced to move from that area.

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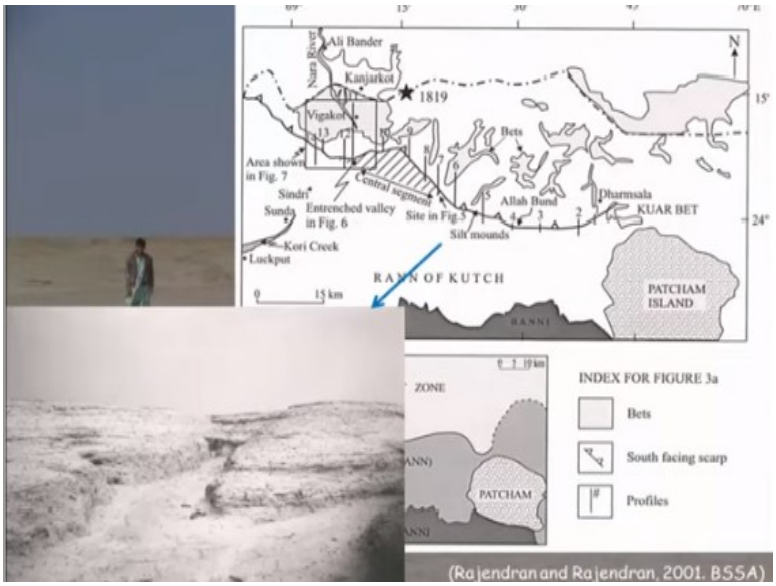

So, this we have already discussed. Now, previous studies before as which people did they talk about that there was multiple events and the they looked at the Allah Bunds Scarp on the lands landform and

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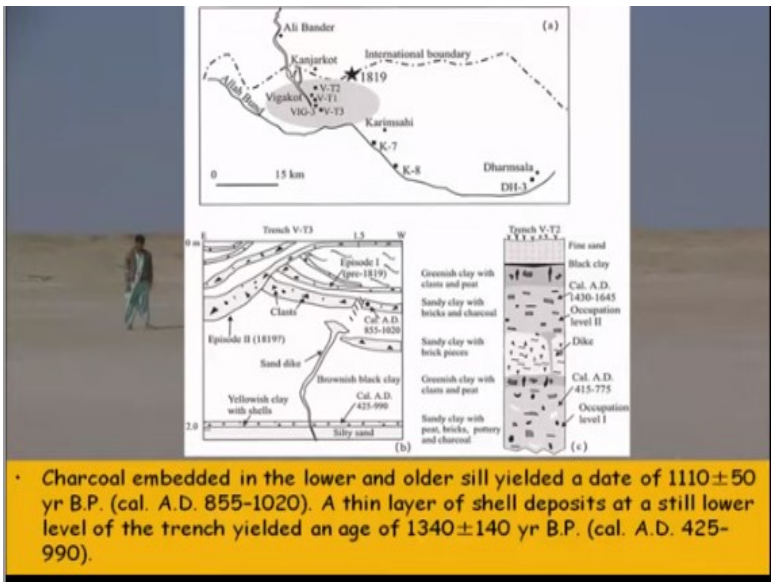

And showed that there were events of liquefaction because of the strong ground shaking may be in different time. So, one was at around like 1100 before present and another one was 1300 before present. So, this 1100 years before present and 1300 years before present so two events have been marked and this was from the Vigukot area. So, we will also been talking about this region in our studies that is Vigukot which was one of the major settlement of that time because it was an well planned city.

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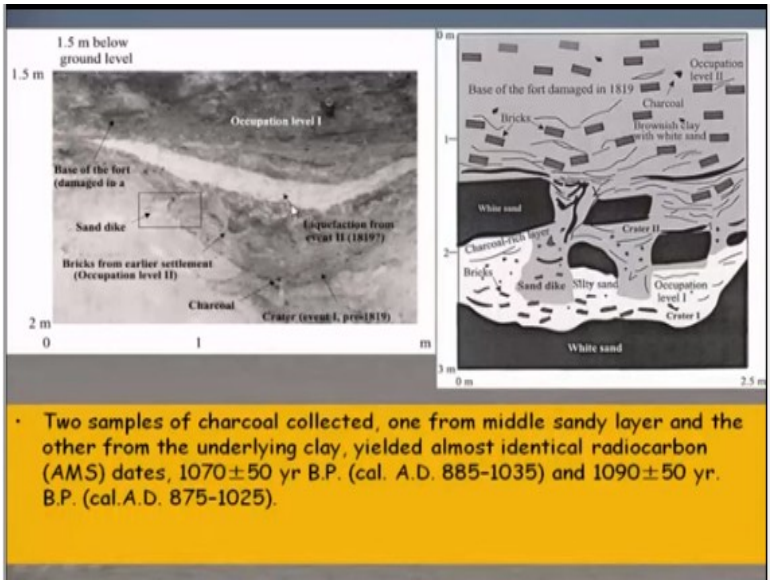

They also found some craters; small craters and the excavations which they correlated usually with the earthquake craters and with this again. Based on the dating of the charcoal they suggested that two events mean around thousand years and another one is around this two events doing almost like during 885- 2035 AD and another one was so the two samples of the charcoal collected one from the middle sandy layer and another from the underlying clay.

So, you have this one so the sand layers and all that this they have will get from event from 89. So, this type of study is basically important when we are talking about the seismic hazard or the earthquake as are in the region and particularly when we are not having the surface ruptures.

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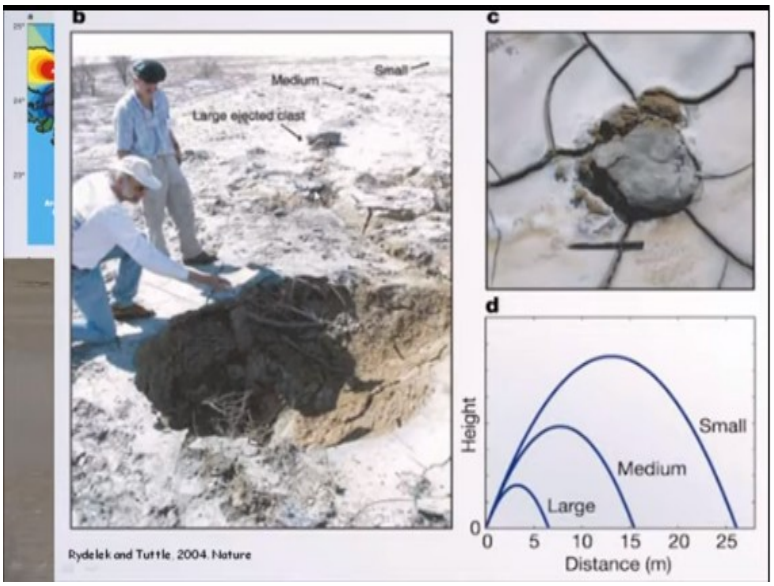

So, in 2001 Bhuj earthquake great Rann of Kachchh people experienced a strong ground shaking and the formation of the craters were also identified. So, what they identified was that during an strong ground shaking and liquefaction such craters will be formed because of the explosions you can say because of the change in the pore water pressure. So pore water pressure increases subsurface and it explodes on the towards the surface or it travels towards the surface and explode the or break the surface.

While doing so it also eject the clast and that what you call ejector. So, if you are having the larger class will sit closer to the crater and the smaller one will be thrown far away. So within the sand will exploded you will also see the ejector.

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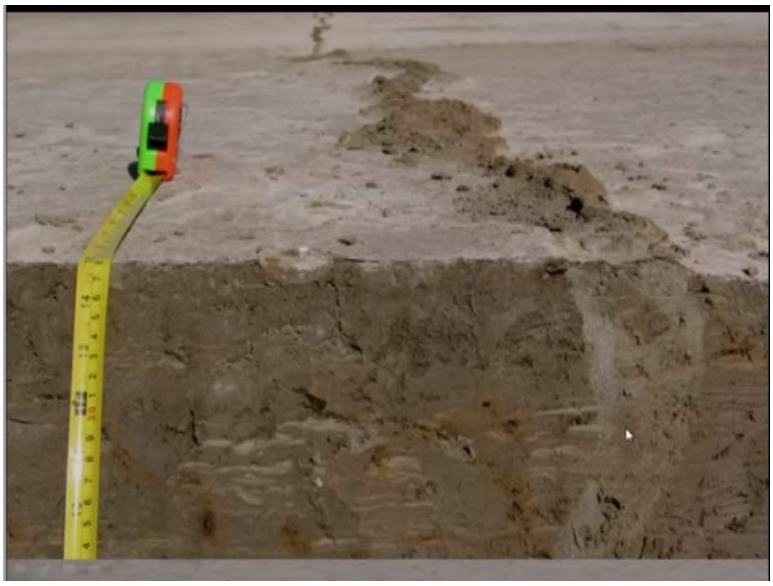

And this is an typical of the liquefaction this we indentified in great Rann of Kachchh where the (()) (19:34) of the sand travelled or pushed up right up to the surface and cutting through the units and on the way of the conduit.

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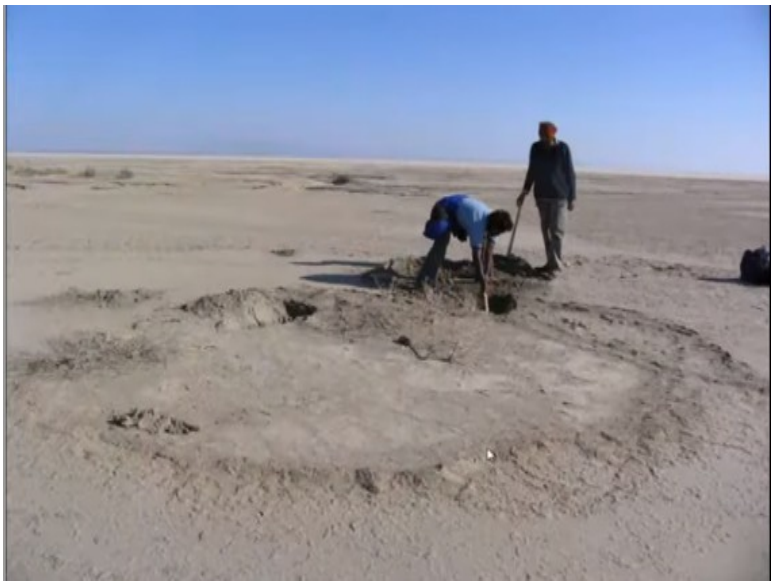

So, liquefaction features certain right crater we have we excavated this and this is what we found is the in two conduits which connects from the bottom and they result into the formation of this sand block.

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The close-up of that and in between what you see here is the clast which are the broken clast of the soil on the way of the sand which traveled through this conduits right up to the surface.

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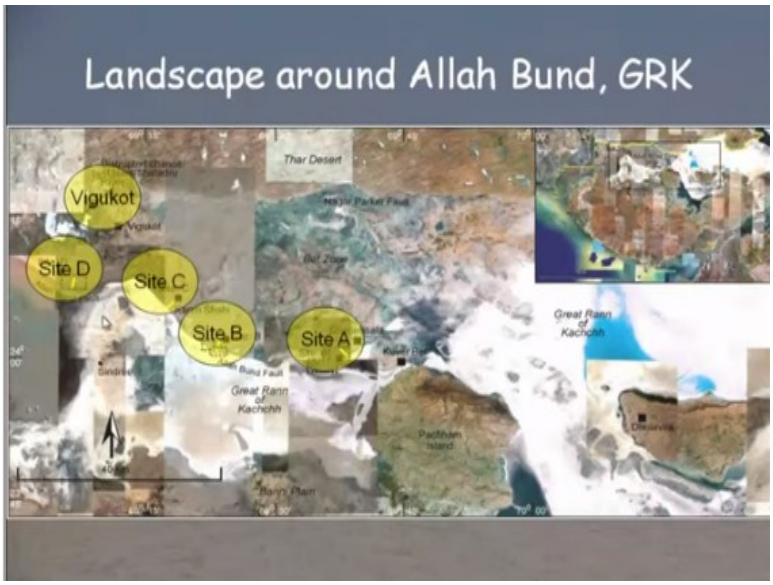

This is one so these are all the data's which we were collecting and finally here heading towards the Vigukot site so we had previous work which talks about the at least two earthquakes in the region and then of course it was Vigukot but we wanted to do an recheck of this and then we also treat the Allah Bund. So the idea was that how this area the channel which is coming and just getting lost in the marshy land and what is the total landscape.

And so we wanted to understand that and what is the landscape here but this one this what we say is uplifted but if you go and feel and see is there is just in a very gentle slope you will be able to see or so. So we what we did we take an topographic mapping across this one at least covering the two kilometers from the from South to North site A, site B, site C and site D we collected and finally we did this survey Vigukot.

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So this is the landscape which you see from South towards North and this portion is your Allah Bund area so this landscape is the uplifted area during an earthquake.

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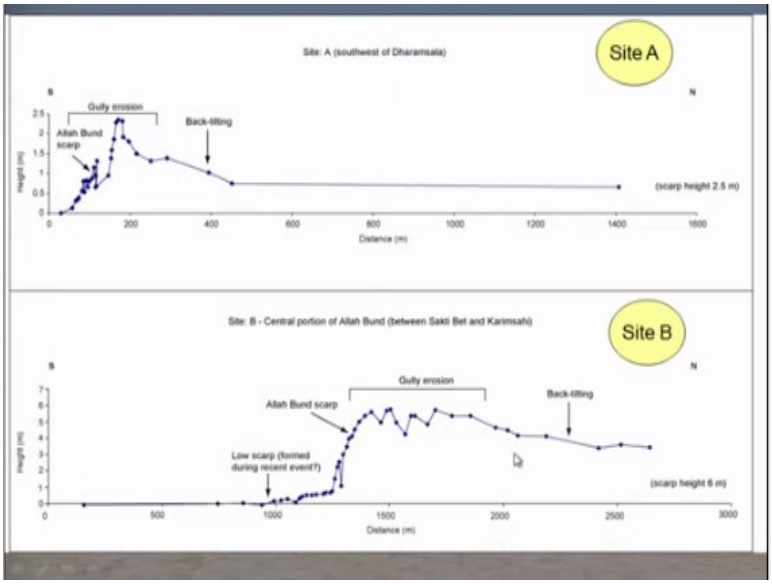

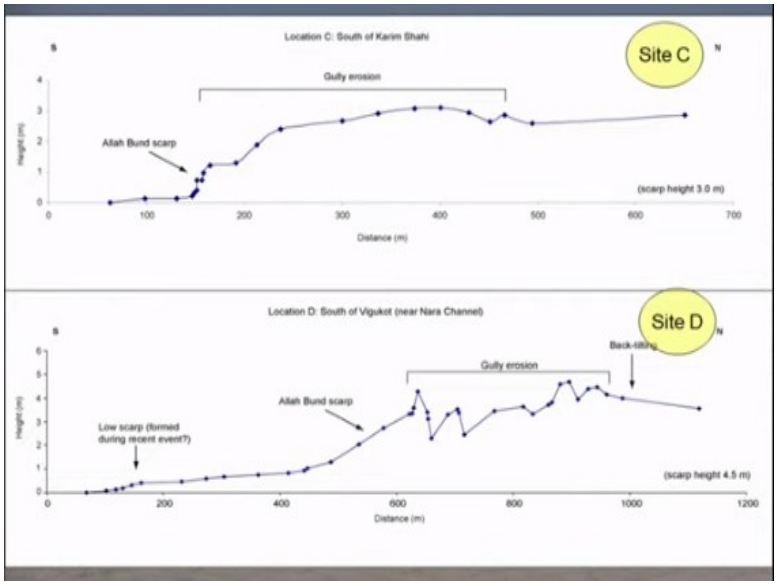

So, we did the mapping at different sites and what we found was that area is of course having and some change in elevation which goes from by ranges from 2.5 meters to 6 meters. And then it has a very gentle slope a back tilting towards north and this is clearly an indication of the ongoing tectonic deformation because the slope usually has been seen towards the ocean it is not towards the land side so this is an typical of tectonic deformation.

And this was one of the reason why it did not allow the Nara channel to flow through this region because the gradient was inverted.

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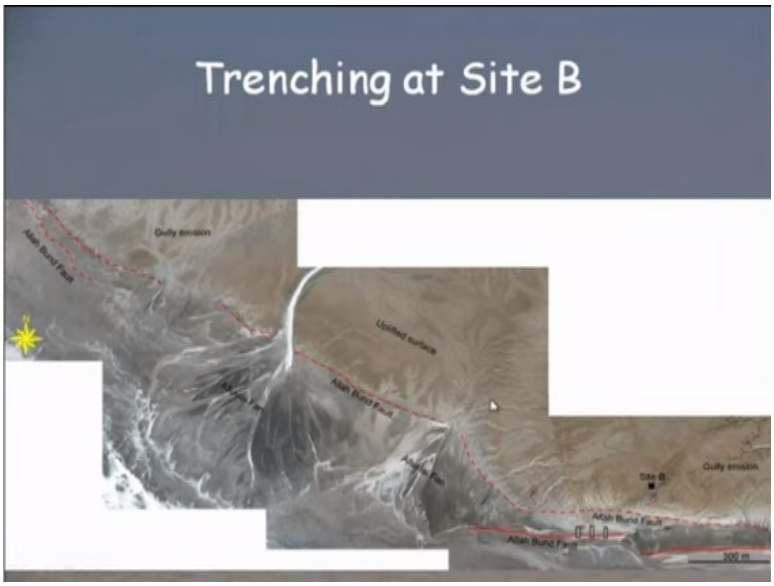

So, similar attri the another two sites we were able to see so the elevation ranged from 6 meter here to almost like 2.5 to 3meters on either side. We chose this area to do our detailed studies and look for the signatures of the sudden change in the land the geomorphic divide. So, this what we so use you can see is an alluvial sand very beautiful land form over here and the drainage which is coming from and getting just having an sharp boundary here.

So change in the elevation here and that what we also saw in the total station studies.

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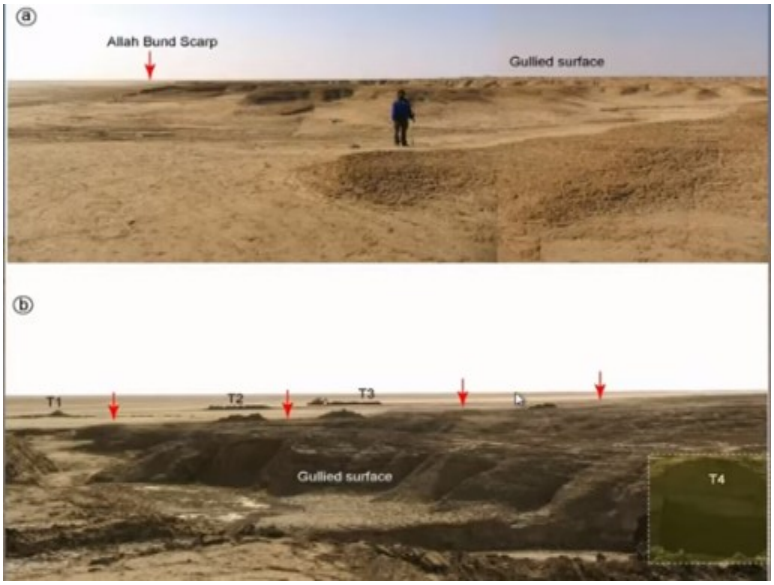

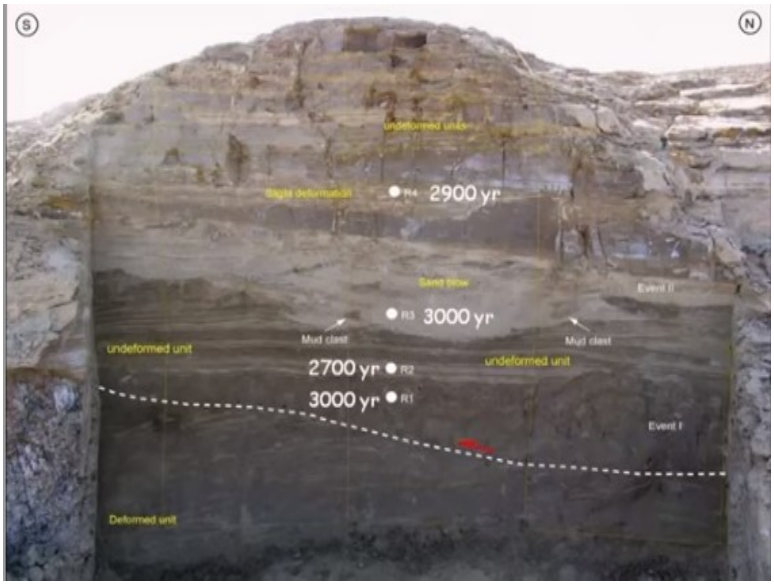

So we did some geological studies and tried to look for some signatures of the liquefaction and the sediments and this is what we saw this an typical of sand glow. As I was trying to show you in one of the slide which we did digging in 2000 of 2001 liquefaction so this is very similar to that but this is an old liquefaction signature. And then we have the fault on this portion has moved over this one and if you want to see the clear signature the next slide will show that probably if I am having.

And these are ages which we have so events have occurred more or less within 2700 years to 3000 years.

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Now this is what do you see the clear-cut contacts and the soft sediment deformation. So this block has moved on this one here along this plain and this is your sand glow**.** So we have deformed, un-deformed layers sequence which sits here.

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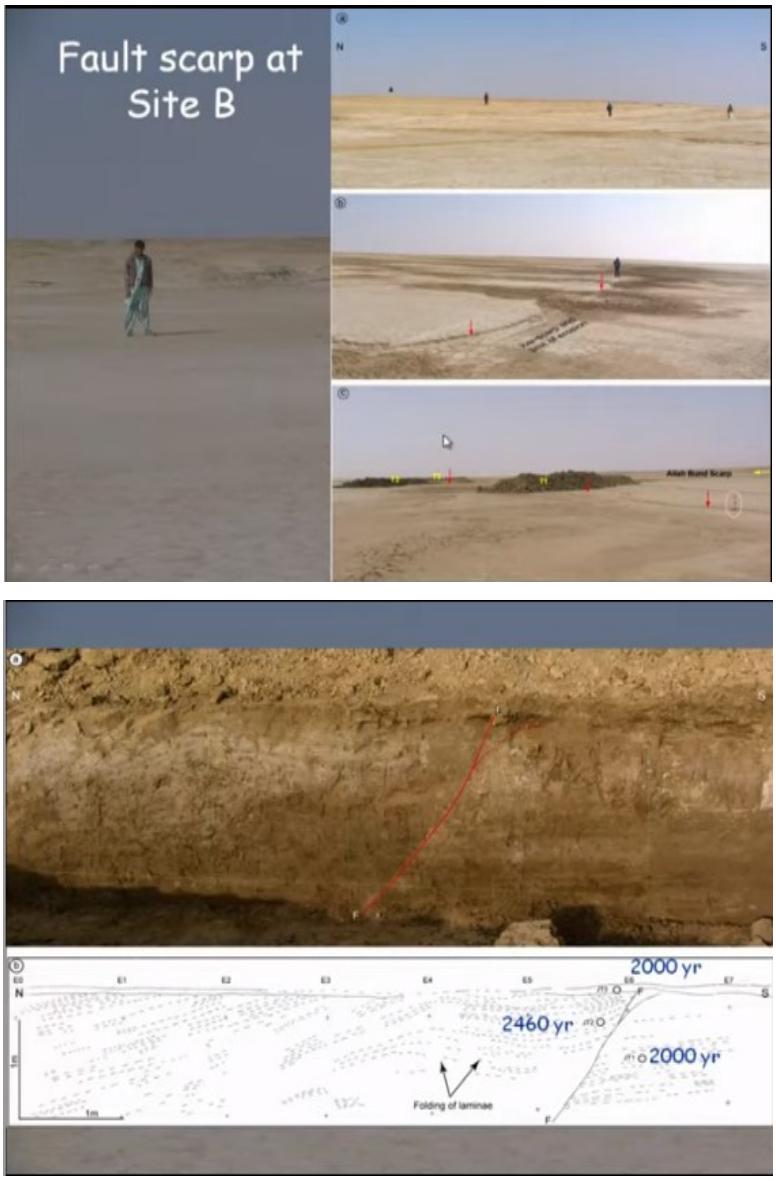

So we did some excavation along this one and we found these are the trenches and we found the signature of the earthquake over here and which dates back to around 2,000 years before present. So, we say that this event was there was an major event on Allah Bund around 2000 years so this probably was one of the events which also affected the Dholavira site.

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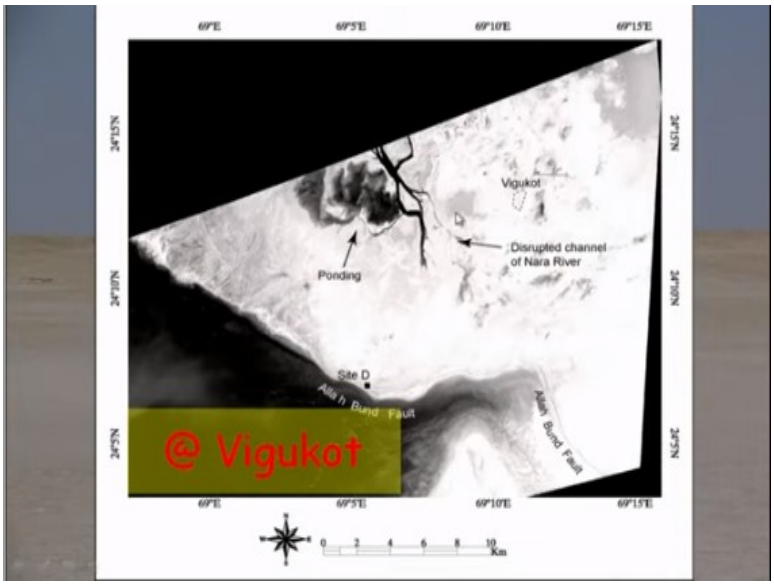

Now coming straight away to the Vigukot area this is what we see the settlement here and the main channel which used to flow through this into the Arabian Sea through Kori Greek but now it just dies out and in this marshy region. And then ponding which I have shown on satellite data is present on the ground photograph was from this area so this an disrupted channel of Nara and this site Vigukot. So Vigukot site is lying or sits on the left bank of Nara channel.

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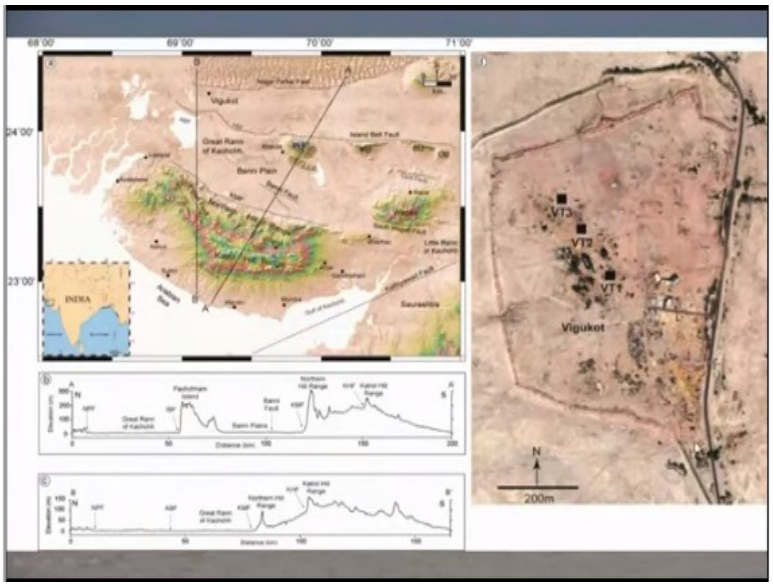

So this is the site which we can see here an fortified lands the site still exists and then some reddish colour which you see here are the brick **pads**.

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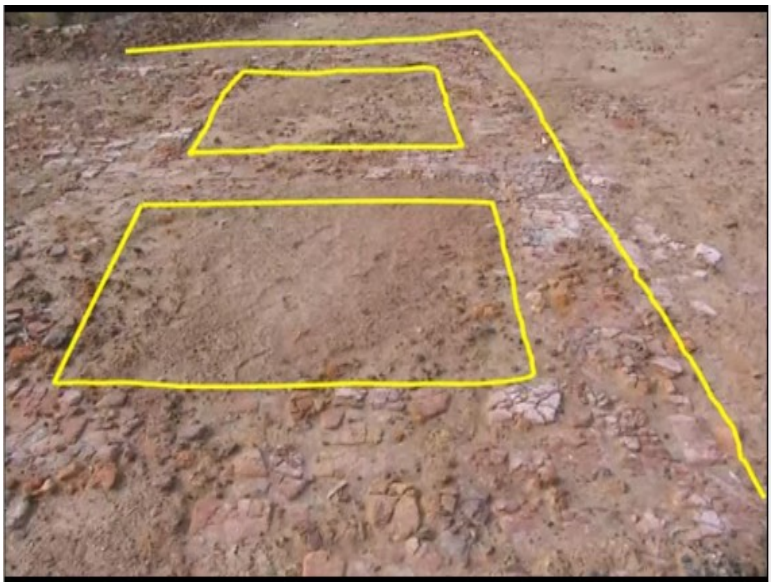

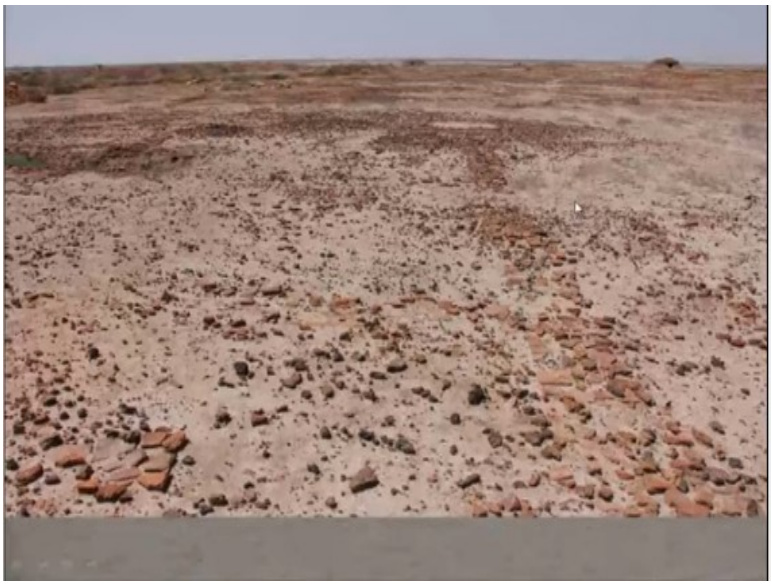

So we excavated couple of trenches in this region to look at what are the signature of past earthquakes. So, on surface what we see as this type of the foundations which still exist and again and north south and east west orientation of the walls well-planned city again. Now, the question is not there was no connectivity of the channel then why the people came here.

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So, what we did what we also did some excavation and we tried to understand that what might have extend happened in the past.

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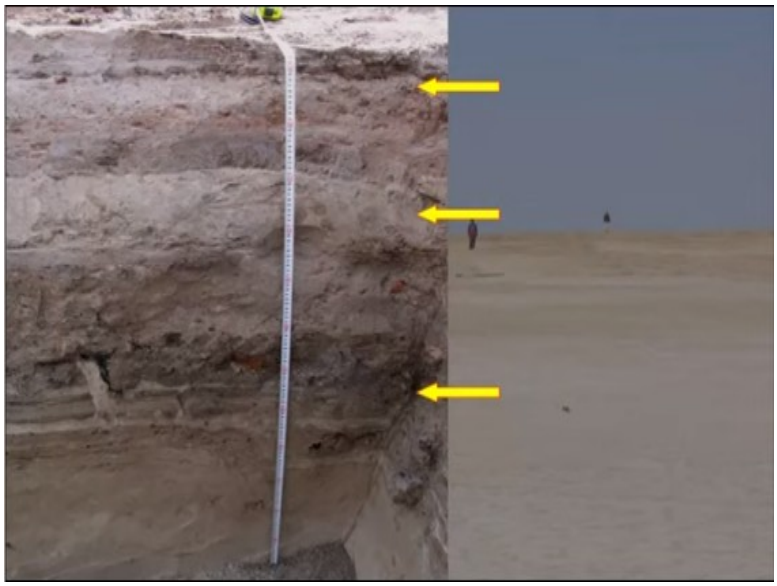

So, if you look at in this trench then this is the portion which is like the color variation is very sharp. So, this portion of the whitish sand as the tidal deposits so the cultural level started from here people came in and settle down in this area after the deposition of this one. And then they they so what we identified was that we had like multiple cultural levels and this yellow arrows are showing the sand layers.

Now this sand layers are very much similar to what I was trying to show the liquefaction features. So we have we got three cultural levels and three and more than a like around three liquefaction layers we have cultural level 1 then 2 here and then 3 here.

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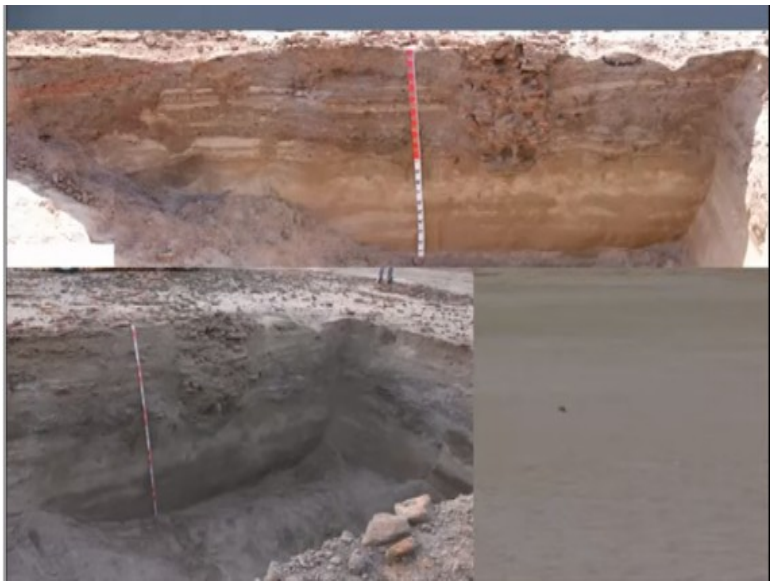

So, we did some excavation final the foundation which you see here is of the last settlement which also collapsed and that we can clearly see over here. So, this is one of the best site to study the what has happened in the past. So what we found was this was that the earthquake cycle or the earthquake in these region did not just start after they came into or occupied this area or but **given before** even before because the ages which we had of this region is around thousand years or so.

So, this settlements which came in this region were not very very old but during Harappan civilizations and all that this area was not occupied and then this may be the phase out of the the Harappan civilization that is we can say the later Harappan civilization. But early civilization did not occupy this one because this was not the the major attraction.

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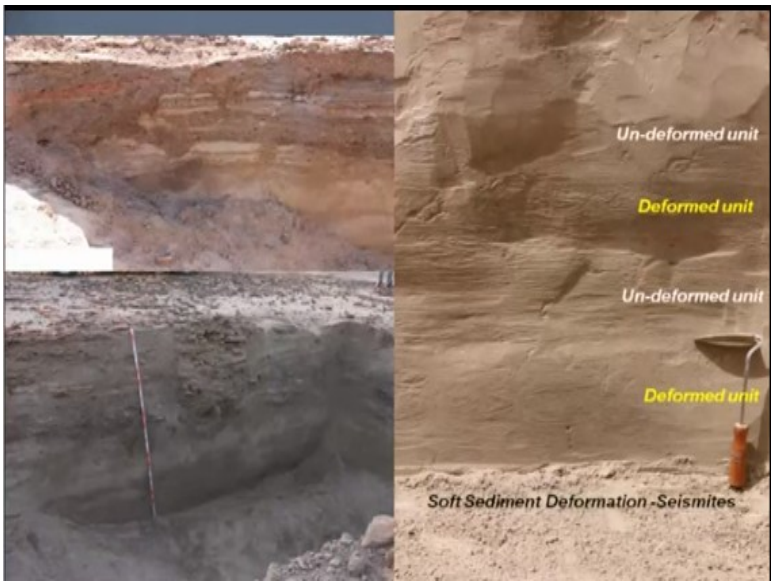

So, what we found where that we had like deformed and deform units and these are within the so these are again an indicators of the past earthquakes in this region.

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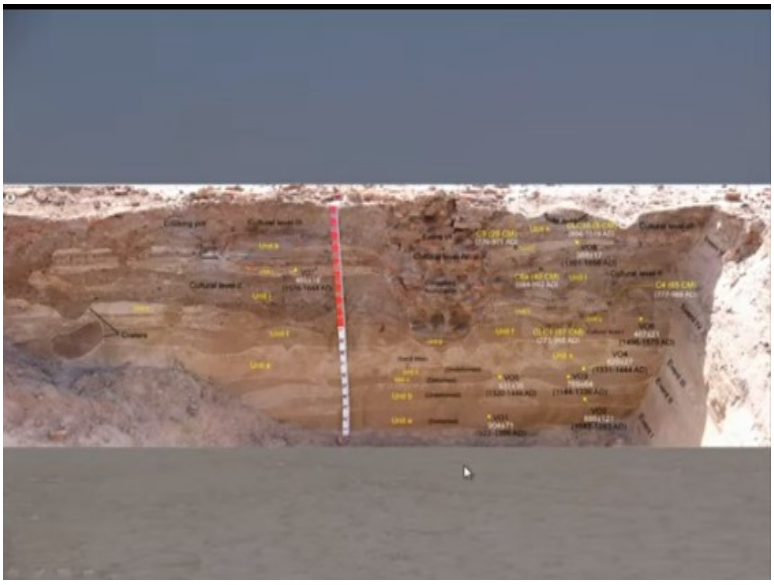

Then we collected number of samples from this and this is what we have marked that we had event one here when before the settlement came in from this area. So we have one event, two event, three event and four and five so and finally these are the ages. So we have the cultural levels one then we have another cultural level over here and then final one is sitting here.

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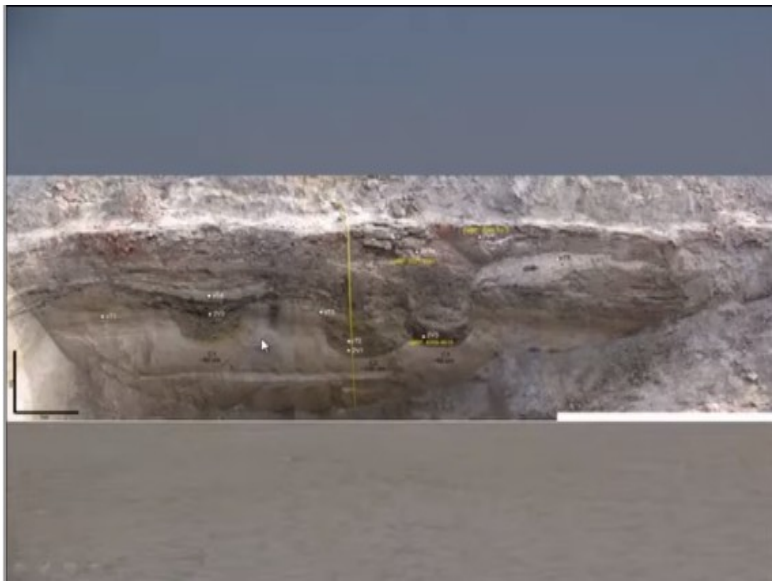

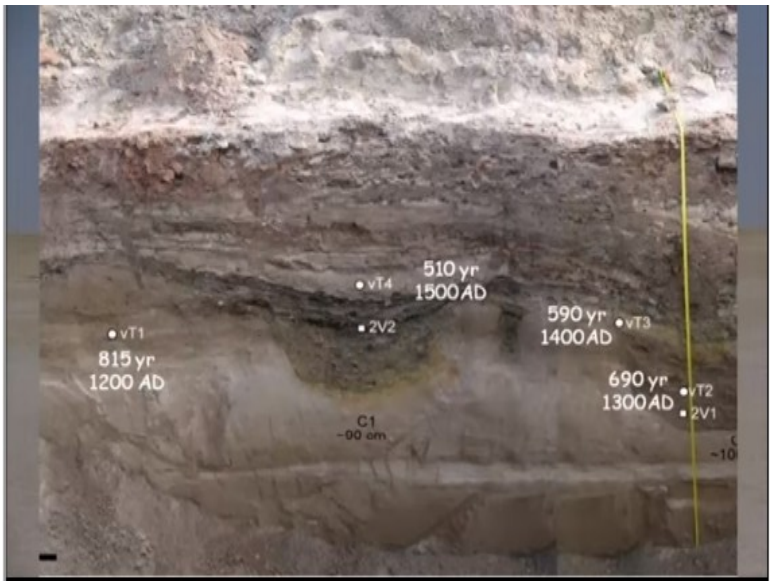

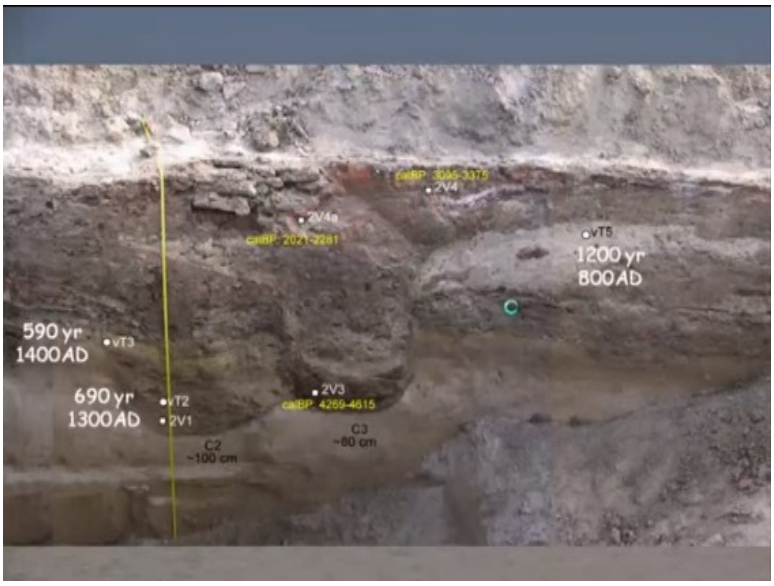

And further these are some examples of the craters which talks about the multiple craters in that area and cross something relationship suggest that at least three earthquakes have occurred in this region. And these are the ages which helped us in identifying the events and also other than that if you look at the close-up of this one then we have the sand glow here and these are the ejector so we have crater and we have the ejector.

So, what I was showing in the people who the group of people who worked in 2001 of the 2001 earth quake the crater and the ejector very much similar in this section.

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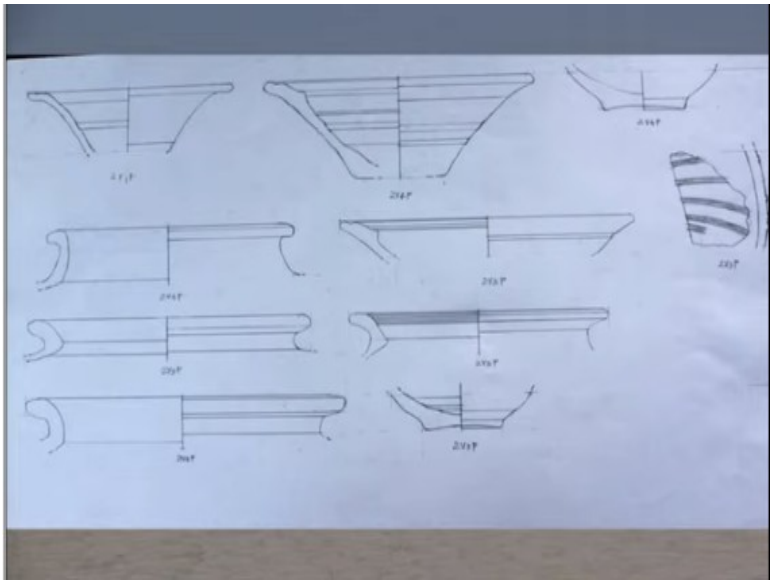

So, we also took help from the Archaeological survey of India which helped us and in understanding the pottery pattern of the pottery. And finally what we suggested that this is the preliminary results and this pottery belongs to a period of first century.

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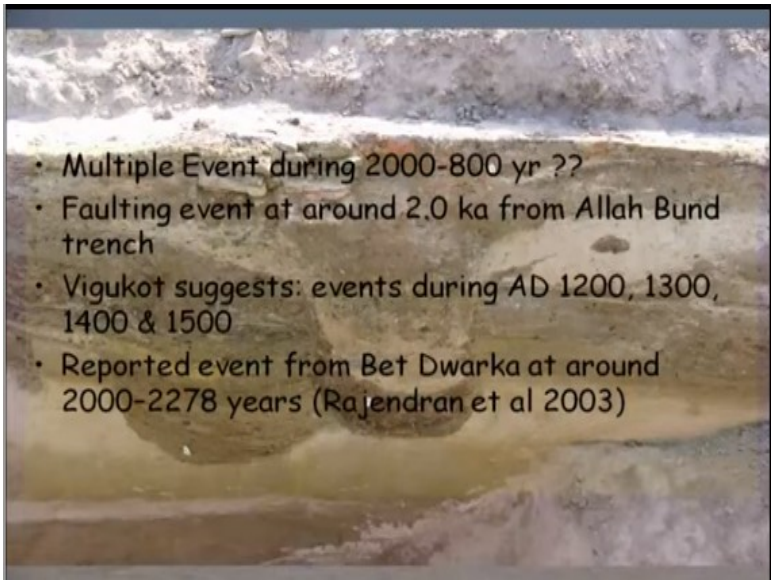

And our interpretation is not multiple events occur during two thousand and eight hundred years before present and there was an earthquake in two thousand years back and Vigukot suggest an events multiple events during 1200, 1300, 1400 and 1500 years e reported events from Bet Dwarka also around two thousand years back.

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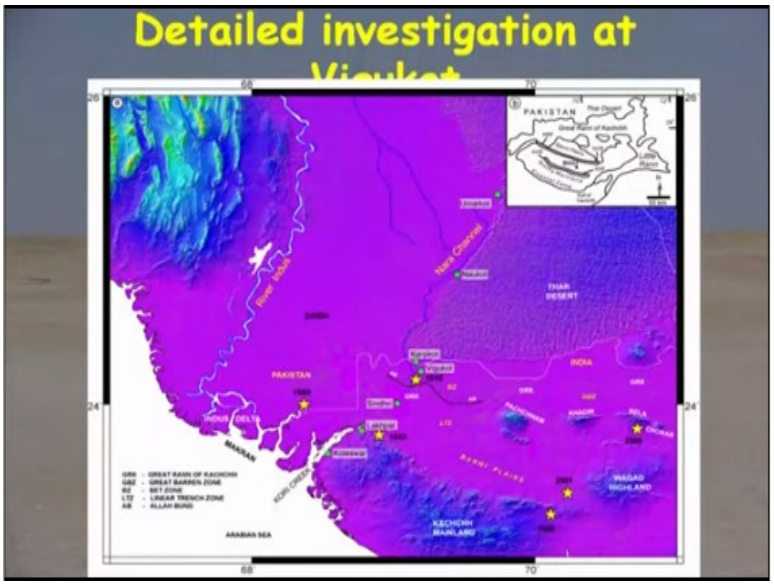

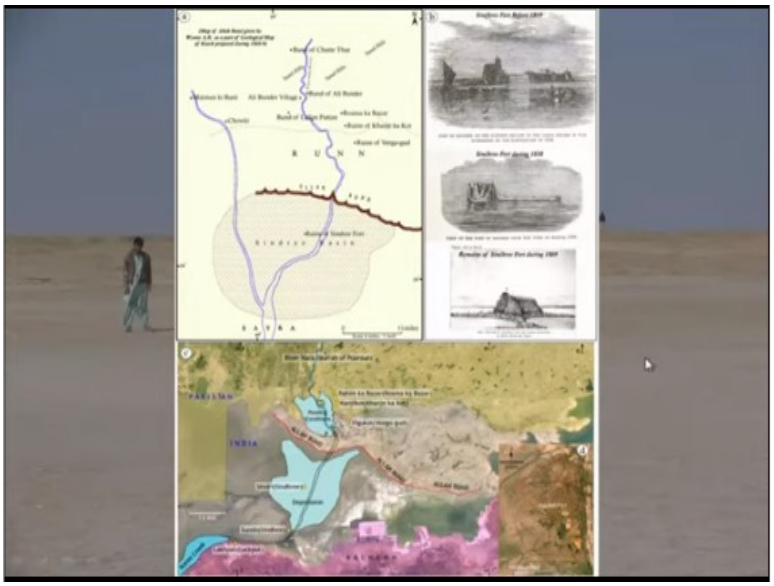

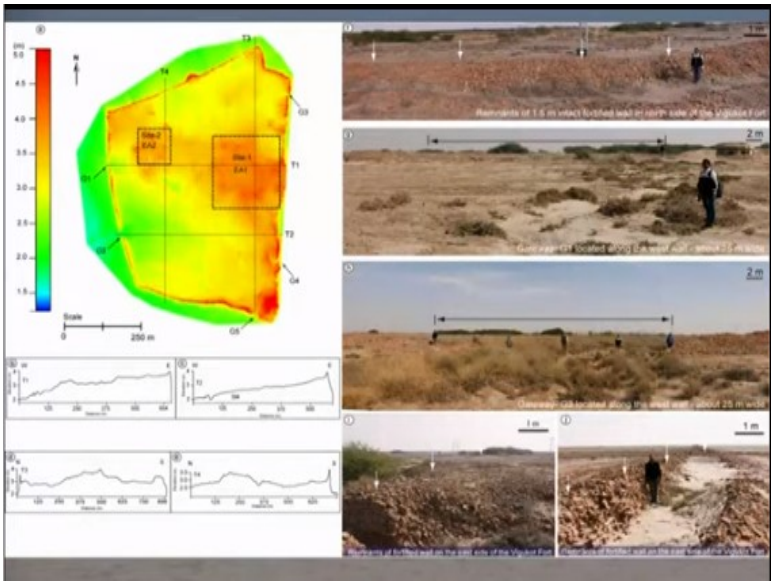

And then finally what we did is detail investigation at Vigukot was that we tried to look at that how the whole area was been like looks like. So, we did in very detailed topographic mapping and what we found where there were three of not three but at least two gates on each side and that is on east and west and one gate was on the south southern side. This with two major gates G1 and G2 and this were on the west side of the town.

And of course this was closer to the Nara channel which existed on the west of the Dholavira and this Vigukot. So and the major settlement or the operatory larger houses were in this area and this smaller one was this and along with these shops. So very well-planned city as you see the fortification. So the question was that if the landscape present landscape we will definitely not allow the people to stay here.

So, from where they had an freshwater connectivity and what was the mode of transportation of course the mode of transportation was through channels or the rivers. So they navigated through the then existing river channels and there is also landscape was not the same what we see here.

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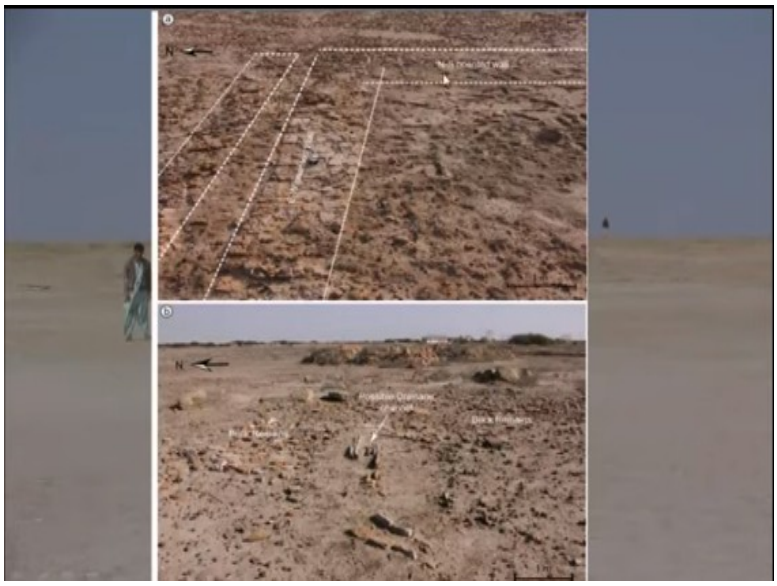

So in just a thousand years the landscape has changed drastically well-planned city, well construction was been done like we the north-south, east-west oriented walls then you have like double walled or bricked possible drainage and the brick remains which you see are also suggestive and even we find some copper coins from this region.

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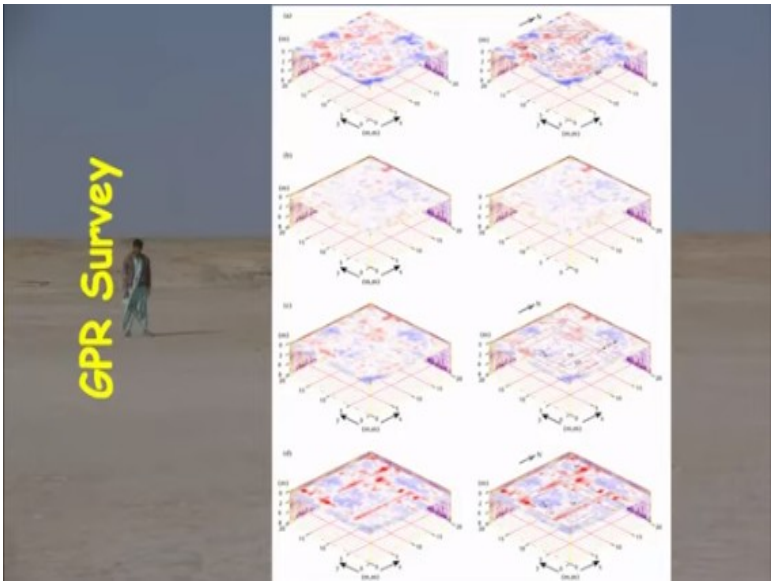

So, we did a GPR survey ground penetrating radar survey to understand that how similar cultural levels exists at the bottom or not that what we see here is an very well planned construction in this region and this was just for the understanding we did of them. So, I will end my lectures here

I wish you all best for the exams and I hope you enjoyed this course. Thank you so much for being with us. Thank you.