Laboratory Practices in Earth Sciences: Landscape Mapping
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Welcome back. So, yesterday we discussed the working principle of GPR and what is the importance of GPR, why we wanted to do it and what were the outcomes. And this was the last slide where we were discussing utility mapping. And as I said that since the infrastructure development is on a very high scale in India, this type of mapping is getting more and more common in most of the regions and wherever. So, we are coming up with smart cities mainly. So, there we need this type of service.

Now, this type of service is required because on most of the occasions we do not have the subsurface utility maps available with us. And if we have to put for example, any flyover and then piers have to be or the columns have to be put there. So, we may not like it, we should know what is the utility under subsurface and that should not be punctured. So, as I said, the beauty of having the 3D profiles is that we can have multiple slicing and at what depth the particular structure or the utility lies that also we can know.

And even we can know the depth at which it goes plus the dimension of the particular utility or a structure. So, further we will just try to see what we have gained in this. So, we have for example, this is another profile which shows the utility at different depths based on the hyperbolas. And as I was mentioning that you can also try to understand what is the direction or the alignment of the utility. For example, here if you take this hyperbola here, this one here and we are having different slices at different intervals in terms of the vertical section.

So, you can connect and then even manually you can do the same thing with your own this thing, but if not then even the software can help you in putting this actually, but you need to identify the features in this region like what I have shown. So, this is one advantage of 3D and also the depth. So, you can easily make out and say that until this depth below this you do not see the utility. So, utility is within this zone actually in terms of the depth of all that. Now, a little bit more about what parameters you can select and depending on the terrain in which you are doing the survey.

So, what is the desired depth? So, depending on your target depth and the area or the terrain in which you are mapping or conducting the survey you can use different modes. So, here for example, in this system and as I said there is another system which is SIR 4000, we can

have different scanning modes actually. So, like data search there is concrete scan, structural scan, utility scan, geology scan. Mostly in this scan, the utility scan structure and concrete there are few very like fixed parameters which have been input by this within the system. But in this one, this is what in 4000, what we say is the expert mode.

So, the data search and the expert mode here are the same. So, expert in data search you can modify your requirements or the parameters which as per your desire and depending on the experience. So, we will briefly discuss what those parameters are while collecting. So, if you see the screen, this is what it will look like actually. So, this is the first stage and then first of all we need to be very careful about what is the vehicle we are getting here that is also known as the O scope.

So, it should not shoot up very outside the range. If such shoot ups are there, then we should try to reduce the gain or we can try to change the parameters like what we are having the dielectric constant and all that. So, in short this is what this is the system you will see and mostly we will try to collect them in continuous mode. So, it will be continuous mode and then another one is that in the middle metric system. So, in meters per we will say and also that is the horizontal as well as the depth section will be in meters.

You can also look at in nanoseconds that you will be able to see here. So, this is what we call the depth scale if you want to see that this is all centimeters, but mostly we take in meters actually. Now the first part which we have to be careful of is what is the frequency range you are using here. It is 400 and the 400 or maybe you can use a 200-megahertz antenna and then another system that we are having is with the 350-megahertz antenna. So, this is one, but usually another one here we can put here is the 400 megahertz also. So, 400 megahertz as I said that this is being used for the shallower that these are slightly deeper and this is also again we can go up to 6 meters or so comfortably.

So, we have different parameters here like radar signals. So, 400 then what is this t rate more distance we will just try to see that. So, other than that the antenna transmission rate in kilohertz that is your t rate transmission rate is there and transmitting high transmit results in fast collection of data. So, if you do that then you in that system allows you to collect in the faster mode and sample here is this one here. So, it goes in a range of like 250 then you are having the 256, 1, 15, 12, 124.

So, this is because each scan curve is made up of numbers of data points known as samples. Samples are directly proportional to the smoothing of curve and vertical resolution. So, this will depend again on what type of data in terms of the resolution you are trying to collect. So, mostly we try to collect in this one if you want to collect very high-resolution data then you can increase this sample per scan, but that will make your system slow and you also

need to move the GPR on the surface very slowly. So, this movement will be restricted if you increase the number of scans per second.

Then the format is fine. 8 bits or 16 bits mostly. We take in 16 bits. It is recommended and the range, as I said, is either you put it in this range mode, which is a time window in nanoseconds, and again you will take in two-way travel time. So, the waves propagated and received back. Now, that will also be a higher range allowing deeper penetration. So, if you increase the range you will be able to penetrate deep, but depending on the terrain one material that you will have to judge based on your wiggle or maybe the scope of what you are getting depending on that you can do that. And the rate is like what we are talking about here.

So, rate is the number of scans that will be recorded per second. So, that also you can again set the rate should be set high in case of using the survey wheel. So, if you are using a survey wheel then the rate has to be higher otherwise there is another method also what we do is the point method. So, for example, you have kept your system here and then you have moved here again and then you have collected the data that is your point mode collection. But mostly if you are connecting the survey wheel then you are going to have like you can keep the rate a bit higher and that will allow you to move faster.

Then we have the usual IIR low pass filters that allow the frequency lower than the entered range. So, it will allow the frequency or the frequency lower than what we have entered. So, mostly in 200-megahertz antennas we take 550 and 600 like that, which is a high pass filter. Then the high pass filter allows the frequency to be higher than the entered one. So, whatever you have entered, the frequency that will be limiting the portion of the data collected.

Now, stacking is also important and that is mainly used for noise reduction. So, high frequency noise reduction techniques, smoothing high frequency features and attenuating low frequency features. So, this is what we do stacking: mostly we put stacking which is around like in 2D around 13 to 14 and if you are taking 3D then we put 9. So, these are the values which we have also with the experience we have fixed up in this type when particular terrain what type of inputs we have to put. So, then dielectric constant this component reflects the velocity of the radar wave moving through the material and dielectric constant is inversely proportional to the depth of penetration.

So, this is again an important point along with the frequency of the equipment. Now, to acquire the better results pre-processing should be done by putting respective equation parameters. So, these are the parameters which we usually use and then as I told you can collect the data in 3D, 2D and 3D. So, 2D if you have the like for example, the surface here

then 2D you will take in one direction whereas, in 3D. So, this is 2D you are taking in 3D. Suppose this is the area you are having, then you finalize the grid I want to do here. Then you measure the grid and then you give x, y and the starting point 0 0 and then keep collecting the data in both directions.

You can also go like you can divide this every 50 centimeter or every 1 meter you can collect the data and you can go in a zigzag way. So, you can collect the data in this fashion and then after finishing this you move in this direction. So, this will give you a pretty good handle like a camera to see what is exactly there in the subsurface. So, this is an instrument with the 400-megahertz antenna. This is the 400-megahertz antenna we are using and again as we are talking about this is the survey wheel actually.

So, this is another one. So, this is the survey wheel and then the data is collected over here. This is the model which we are having, sir 3000. So, this is the part which we did in one of the archaeological sites near Bareilly. Now, I will show a couple of results that we have obtained using the GPR. So, the initial aim using GPR was mapping subsurface deformation. This is what we were doing for the part of like as a geological mapping and then to locate the mostly the ancient structures here.

So, that's what we did. So, for example, this is from Kutch. So, we found some deformational features along the cliff, but we wanted to do this survey here. So, this has been done, the GPR has been moved on the surface and we wanted to go deeper and see what exactly the deformation has to tell us actually here. So, this is the profile which we collected and based on the discontinuous and warped reflections you can easily see this is warping here. So, based on this we mark the faults and this is what the arrows are showing the fault plane.

This is the 2D section we are looking at and then we open up a trench here. So, this black box broken line with the broken line shows the trench area. So, we excavated the trench and this is exactly what we see here. So, you can match easily. So, this one is over here this fault and this fault which is running here is exactly which you can pick up along in the plane here.

So, we were able to match what we see in the GPR. Similarly, another exercise we did in Himalaya on the left bank of the Bias river and here also what we did was that we opened up the trench after doing the GPR part. So, this is the trench section of the GPR where the data was collected initially. So, this has eventually reduced our time frame and also the cost of excavation because we were very then we knew exactly where we wanted to dig and the same case goes for the utility mapping or even for the excavation which may be followed after the GPR survey in archaeological sites. So, this is exactly what we saw this

is the plane here the fault plane is here again the similar type of the conditions we have applied here like we use the warping of the geo radar reflection as well as the sudden discontinuation of the geo radar reflections were been considered to identify or infer the faults fault plane.

And this again the dotted line what we see is the trench section and exactly it matches with what we saw in the GPR. And this place is again in this same area, not exactly the same, but quite a little bit far, maybe 2-3 kilometers away from the first site which I was showing. Now, here the issue came was we wanted to do the geological-like investigations here by digging trenches and all that. Then and according to us this is the fault should probably pass through this area here where the arrows are being marked. And when we were discussing with the local villagers they told us that there is a water pipeline which probably has been put way back in this region.

So, that should not be disturbed otherwise the many villages will face water problems. So, we said we have the instrument which will tell us where the pipe is exactly and then we picked up the pipe. So, this is the reflection of the pipe here and it was not very deep it was kept shallow. So, we avoided this area and we dug the trench over here only in this portion. And this is the part which has been marked here after the topographic corrections.

So, the pipe was way below this curve and then we opened up the trench and you can see that it exactly matches what we see in the GPR profile. We also did 3D of this area and that helped us in identifying which portion of the region should be excavated for better and to get better information that also has been done. So, these are the multiple like profiles which we were able to cut and slice in a vertical section. Then another exercise we did in the archaeological site in Humayun Tomb, Delhi and this is close to the Samudhin railway station. So, probably I am having a few slides of this, but the information which we got and what we wanted us to do is they say that this is the monumental structure here in the center.

And at a particular location they were having the other location earlier they were having the enclosure wall. So, there is a boundary wall, but now there is no signature on the surface. So, that was another aim which they asked us to do. So, we started our survey and at some locations we were able to pick up the signatures of that. So, this is what we found from one of the surveys which shows that there is a platform here and then probably there is a water pathway.

So, what we found was that there is a platform and, on either side, and probably this we interpreted as a water pathway. And these are the most common features in Mughal gardens mainly. And we were also able to fix up at what depth we are able to see this and like up

to 2.5 meters or 3 and below that we do not see this structure, what we have marked the platform and all that. And similarly, so this is whatever interpretation is and this is usually seen in most of the gardens in which were constructed by Mughal.

So, there will be pathways in between and all that. So, probably this is indicative of that. Now, about the enclosure wall, as I said, they gave us the distance that the probable enclosure wall would be there, but on the surface there was no indication. So, what we did was we planned the survey like that considering that if the wall is moving in this direction then we should have the reflections if we cross the wall at this particular portion. But this was again and tentative measurements with that gave.

So, we did GPR and we were able to pick up a clear indication of this hyperbola and flat plateau and then sloping reflections and this was not only at one location all profiles what we did we were able to pick up this, but this was not enough for us. So, we tried with 3D and we were able to see clear indications of prominent reflections that indicated that this is a wall structure which extends in particular direction and depth. So, we interpreted that this is an enclosure wall which they wanted to identify and this goes up to 1.5 1 meter or so and around 2 meters we were not able to see that actually. So, this is how this could be in this type of enclosure wall that was there in the past.

Now, another part we were also able to pick up the crisscross relationship of the structures because one we were able to see here is the wall structure here, but another one was here. So, the next interpretation if you see that is what we have marked. So, probably this was another wall along with this lump wall or maybe the brick beds we see here. So, it might have collapsed and that is one of the reasons why we see this crisscross again. We were able to see at the depth that it does not extend. Now, the last one part which I would like to mention here was Aichatra and in Ahichhatra we did not at multiple locations, but one of the locations here where we did outside the fortified structure and Ahichhatra is an very old ancient site which flourished till 1200 to 1300 A D.

And so here we did outside the structure and the initial without processing the raw profile we were able to pick up something like this, but after processing what we saw is a very clear cut depression here and with that the excavation has been done and you can see that both were compared. So, this is the feature you see over here. So, this is what the best you can do with the GPR and you are applying for different reasons because it is a non-invasive technique you do not need to go for digging initially, but at least you can mark precisely your utilities and the structures which are present subsurfaces. So, with this I will end this lecture and you will learn more during the practical.

So, the lab part which we will do we will record that. Now, one more lecture which I will

be giving will be on the OSL dating part and that again will be followed by the lab. So, till then goodbye take care. Thank you so much.