Laboratory Practices in Earth Sciences: Landscape Mapping

Dr. Javed N Malik
Department of Earth Sciences
Indian Institute of Technology, Kanpur

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Hello, hello everyone. So, today we will be discussing the geophysical method that we will use to image the subsurface, near subsurface geology for the region. So, till now we have already seen the surficial topographical mapping of the region using the total station and RTK. So, today this is the geophysical instrument that is very handy and we can easily take it into the field and perform a survey. And so, the basic principle behind the instrument that we will be discussing today is ground penetrating radar , the short form is GPR. So, the basic principle behind this instrument is that the high frequency radio electromagnetic waves are transmitted into the subsurface and which get reflected from the target due to the difference in the electrical properties of the subsurface and that is once again detected by the receiver and that signal that we get from the subsurface that is displayed in the into the radar gram.

So, the basic principle behind the electromagnetic wave propagation deals with the Maxwell equations. So, there are a total of four equations that deal with the propagation of electromagnetic waves so I hope you all must be aware of the Maxwell equations and the Faraday laws. So, for the better understanding of the basic principle behind it you all must read about it properly and so that you can easily understand the basic working of the GPR. So, today the purpose of the lecture will be that the topics which we will cover in the lecture is how GPR works.

Secondly, we will discuss about what we can detect through the GPR, what is the penetration depth of the GPR and what are the parameters that we should keep in mind during the acquisition of the GPR profiles and how to acquire 2D and 3D data set in the field and what are the advantages and disadvantages of the GPR technique. So, one by one we will discuss all these things. So, the first thing is how GPR works. So, as I have also mentioned earlier that we emit the GPR emits high frequency that is that range is from 10 megahertz to 2600 megahertz into the subsurface and due to the dielectric properties, that is we call as the dielectric constant or the dielectric permittivity of the subsurface there should be the contrast between the medium and the target material that we are targeting. The electromagnetic waves will reflect back to the receiver and these signals we capture it and we analyze it into the radar gram and the dielectric properties I mean to say is that the property dielectric permittivity is the property of the material that which defines as

which defines as how much electrical charge it can hold.

So if there is completely like suppose if there is metallic the our target material is metallic part and the medium property like the subsurface soil. So, there will be a drastic contrast between the target and the medium. So, that can be easily captured through the GPR. So, the material that we can easily detect through the GPR are like I said metallic wires, metallic pipes, plastic pipes and the geological variation in the subsurface although there will be a very minute change but if there is a drastic change in the geology that we can easily detect from the GPR and other things are like if there is some excavation part that has been done and that the refill part can also be easily detected from the GPR radargram. Apart from that we can also detect the concrete part or the concrete like that can be used in the archaeological surveys.

So that we can find out the buried walls, wall structure or concrete structure. So, it has a huge application in the archaeological geological and geotechnical surveys. So, basically the resolution of the GPR if we talk if we talk about the resolution. So, it is a rule of thumb that at least the target layer that we are trying to detect should be at least one-fourth of the wavelength of the incoming wavelength that the frequency that we are using as a GPR. So, the wide range of frequencies that we can use through the GPR, that is I mentioned that we can use from 10 megahertz to 2600 megahertz.

So, for today's lab we will be using 350 megahertz GPR. So, this is this we can see that this is 350 megahertz GPR it is having it is easily we can move it through the cart it can be easily used at any area that we can use that we want to map and in this you can see that in this unit this is the shielding. So, the electromagnetic waves that are generated cannot go into the atmosphere and within this shielding or the case there is a transmitter and receiver. So, through this into the subsurface the electromagnetic waves are propagated and received back to this receiver and the whole result is transferred the signal transferred to the TUF pad that we are having that I will show you in a short time and once on the right side of this wheel we are having there is an odometer fitted in this. So, it can clearly indicate how much distance you have covered and how much area you have covered through this.

So, now I will show you the different components of the GPR. So, this is our TUF pad. So, it can be easily latched onto the cart. So, I will show you this TUF pad. So, this is a mini computer kind of thing.

So, the whole data that we are acquiring is getting transferred to this TUF pad and we can easily analyze and interpret through this display or the computer. So, to latch it we can fix it and through this we can latch easily onto the screen and it can be easily taken for the survey. So, to start with, this is the case in which our receiver and transmitter is there. So,

the components I was discussing about the components of the GPR. So, in this you can easily see that this is a GSSI 350 hyper stacking stacking.

Hyper stacking is the frequency that is given and hyper stacking is the number of data or the scans that it will be capturing, that is the number of stacking is very high. So, the level of noise will be reduced using the hyper stacking feature of this and this is specialized for the utility scanning and as this is the slot for the battery. So, this kind of battery is attached to this and this cable that we are seeing that goes to the, this is for the odometer and the connection to it is going to this wheel. So, the odometer is connected to this wheel and the connections, if I can tell you, are for communication. So, from the data that we will be receiving in this unit that will be transmitted to our TUF pad using this port and this cable will go from this unit to the TUF pad and similarly this is for the power.

So, this will connect to the battery and this will be connected to this power port. So, I will attach this. So, we have connected the cables and I will now be connecting the battery battery and this is for the communication. So, using this cable we can communicate with the TUF pad. So, here we are having a port.

So, this will be latched to this port for the connection. So, I have connected all the cables and the communication in the GPR unit. So, as you can see right now there is no light blinking in this and as soon as I power on the screen the TUF pad as soon as I power on the TUF pad. So, as you can see that the power light has been popping out and as soon as the communication will be connected to between the GPR unit and the TUF pad. So, blue light will pop out.

So, as we can see now our unit is ready for the survey. So, and this is the shielding this is very important because from the outside of the surrounding region. So, there will be the input electromagnetic waves which can interfere between the frequency of GPR. So, the shielding is very important. So, this now we can see that this now we can latch it out and it should be noted that the GPR unit that is the receiver and the transmitter it should be in constant contact with the ground.

So, the distance between the receiver, the unit and the ground should be very minimum. So that the maximum part of the energy gets into the subsurface and we can get the high resolution GPR radargram. So, as you can see this is the starting screen of the GPR survey unit. So, you can see that this is utility scan for dual frequency and utility scan hyperstating. So, we are having a 350 hyper stacking unit that is the frequency of the antenna and this is for the power button and the symbols this we can see this is for the battery of the unit this is showing and this is the space that is there in this storage of the tough pad and this symbol is for the battery of this tough pad and if this is blinking this will be blinking

orange.

So, that means the battery is low. So, at least around 4 hours it can easily go if it is fully charged and to start we can see that press A1 to start. So, as soon as we press this. So, we can see that there is a green tick that means there is a proper communication between the unit and the tough pad.

The mode is 2D. So, currently the mode is in 2D . We can change the mode through this mode button. As we touch it, it will change the mode to 3D. So, currently we will show you how we can acquire the 2D data. So, the other tab that is showing that is the playback only. So, if we want to see or preview the previous data that is stored in the system that we can view through the playback only menu. Other is the new project. If we want to create a new project then we can click on this tab and a new project will be created and if we want to see our last project and its setting we can choose this from this tab.

So, right now we will choose the new project. So, here we can see that the whole directory has been opened and we will give a new data path. And this is the keypad and we can give lab practice 2D. So, we can see now our GPR has been started and the name of the lab and the data that will be stored is the name of the file is lab underscore practice underscore 2D. So, this is the typical radiogram that we can see.

So, these are the signals that we right now are acquiring and until and unless we press the start it will not record it, but right now it is running. So, to save the file or the start the survey you can press on the start tab to start the survey. So, I will not start right now. So, this is the oscilloscope that we will say or the Weigle plot. So, this Weigle plot means how much energy is getting transmitted to your subsurface.

So, this is the quality of the signal that is transmitted within the subsurface that can be accessed through this plot. So, this is kind of showing the electromagnetic wave and its positive and negative polarities. So, the positive polarity will be plotted as blue color and the negative polarity will be plotted as a red color. So, this is the propagation of the wave that we can see. So, it is the overall propagation is combined to one scan that we are able to see on this.

So, we have to adjust the signal within this portion. So, our signal should not cross this portion that is the plus 2.25 and minus 0.25 bar that we are seeing. So, adjust us for the better interpretation or the better acquisition of the signal.

We have to adjust this to between these bars. So, if we can do so here we have few options. So, we can adjust this Weigle using the signal processes and another tab which we are

having, that is the output options and system options. So, one by one we will go through all these. So, in the signal process we can see scan, gain, filter, line track and maintenance.

So, to give the input parameters to our system as I have talked about the target depth, the penetration depth and the dielectric constant and the or the dielectric permittivity. So, that can be adjusted using the scan tab. So, based on the target depth that we want to acquire the data we can change it. So, the maximum depth through this unit is 10 meters that we can use, but as soon as we go deeper, that is the 10-meter depth. If you want to get the resolution, the single will get attenuated and the resolution will be less. So, the purpose of this unit is specifically to give high-resolution data up to 4 to 5 meters.

So, we will keep it at 4 meters for this and dielectric constant. You should be aware before getting into the survey that you should be knowing about the overall geology of the region. At least you should know what kind of lithology I am going to encounter roughly. So, based on that we can give the dielectric constant. So, as I have mentioned previously, there should be a clear-cut dielectric contrast between the target material and our medium.

So, medium is our soil as of right now. So, the dielectric constant of soil is a very important parameter for the survey. So, as we can see this is some kind of wet soil that we have. So, the wet soil will be having a dielectric constant of around 9 or 10. Similarly you can customize also. So, based on that you can the dielectric constant of some known parameters are given.

So, if there is ice or snow. So, if we select this snow or ice. So, our dielectric constant will change automatically. So, you can see it has been changed to 3 or if there is dry sand then the dielectric constant is 4 and if we take the average soil dielectric constant it is around 14. And if it is wet soil then dielectric constant is around 25, but as you can see the top layer is showing the more that the signal is getting out of this bar and beyond that the signal is getting completely attenuated.

So, this is not an ideal vehicle. So, we have to adjust it based on our type of soil that we can encounter. So, we can take average soil or you can customize the dielectric constant and you can keep it to your own value if you want to give. So, if I am giving dielectric constant as 9 then you can see that the vehicle is more or less fine, but some data is getting spilled out of the bars. So, other things are the scan density. So, there are two options: scan density normal and high.

So, obviously to get a high-resolution data the scan density should be high but the thing is the number of spaces that the quantity of space it will take will be more and the auto save file should be on and off. So, we should keep it on. So, I have shown you the scan

parameters now we can go to the gain. So, gain is particularly enhancing your data. It is with the help of the whole this vehicle is divided into few based on what the number of points is. So, in this we have divided the whole vehicle into four parts.

So, by changing the values of the input signal we can adjust the vehicle through this option. So, if right now gain mode is auto if I change it to manual. So, I can change it. So, for the first part that will be through, suppose this is divided into four parts.

So, the first part will be the G p 1 gain point 1. So, I can adjust it through this point and now you can see the vehicle is completely adjusted between this bar by just simply adjusting a few values. So, the gain point has been adjusted filters if you can if you know that there is some noise from the background or something. So, you can remove the background removal by giving some values, but it will be if we do this during the processing part of the data because we do not want to lose any kind of the target signal. So, if you give some value to this it will lose out on your data. Similarly, this will be giving you the signal floor.

So, how much signal it is getting the real time signal it is it can be accessed through this green histogram that is getting developed peaks that is getting developed through this migration. So, if there is a dipping stratum that we can encounter within the subsurface. So, to migrate the dipping data to the horizontal data that we can be that can be done through the migration that can also be done through during the processing part of the data and this is a Hilbert transform this is a kind of a filter that we can apply to improve our data and this is that we have seen now line track. Line track is the special feature that is given to this model which can detect the live cable within the subsurface. Suppose, there is a live electrical cable within the subsurface.

So, when we turn on this, we will use it through the power mode. So, there will be two frequencies that are 50 hertz or 60 hertz; typically we should keep it on the 50 hertz. So, it can easily detect the live cable that is there that is lying within the subsurface. So, as of right now we are not having that target. So, I am keeping it off and similarly maintaining that there is a built-in GPS, but in this unit, we do not have GPS.

So, this feature will not work and apart from that if we go to the output options. So, display how we want to display our result that can be adjusted through this window. So, there are different color tables as I told you that the positive will be shown in the blue color and the negative will be shown negative polarity will be shown in the red color. So, that can be changed through this we can change it through our requirements. So, now we have changed the color screen and by adjusting this we can actually differentiate different kind of target material according to our, but best is so best is this that we can that and other thing is the

color stretch if you want to stretch the color table through this that is fine and the color should be the black on white or white on black that is different and we can manage our file.

So, we can go to the data path where our file has been we can change the data path where our data is stored or we can add a new data path through this file and we can copy or move our data to the USB drive using this steps and we can also delete the files using the delete file tab. So, till now we have seen the basic principle of GPR how GPR works and what is the resolution that we can get through the GPR and the different components of GPR that is the receiver transmitter and the control unit and we have also seen the parameters that we can use while the acquisition of the data. So, I will stop here and we will continue to the next lecture in the next lab and in that lab, we will show you how to acquire 2D and 3D data into the field. Thank you.