Field Training Report - Day 02 on

Ground Penetrating Radar Survey

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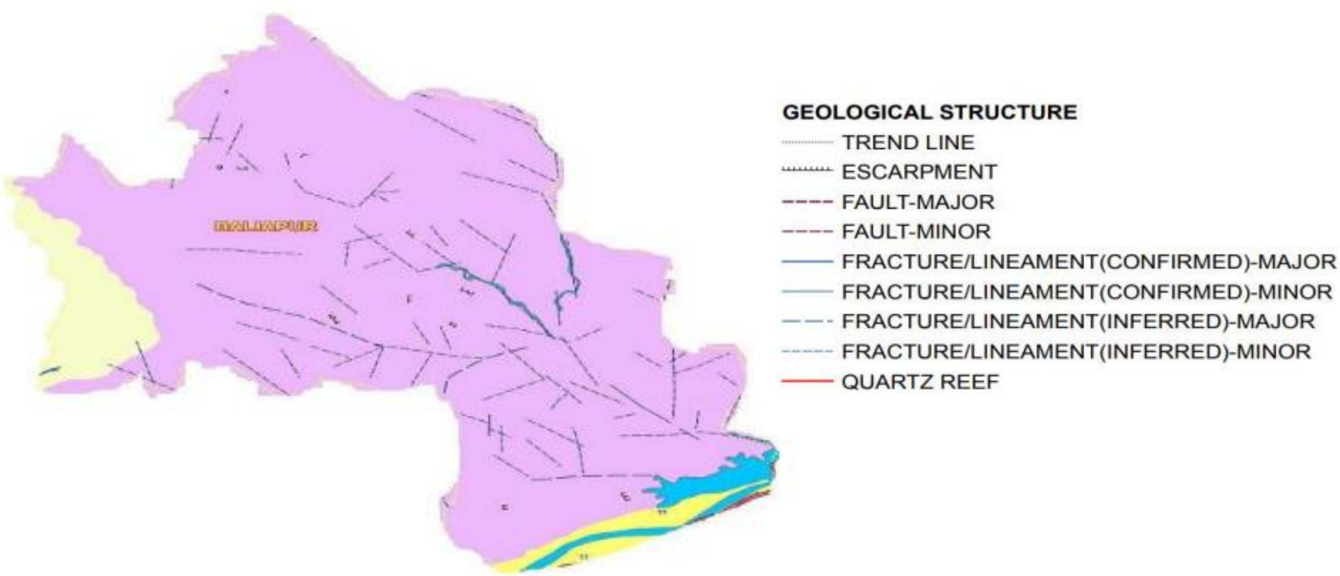
<u>Geology of the Baliapur and its surrounding</u>:

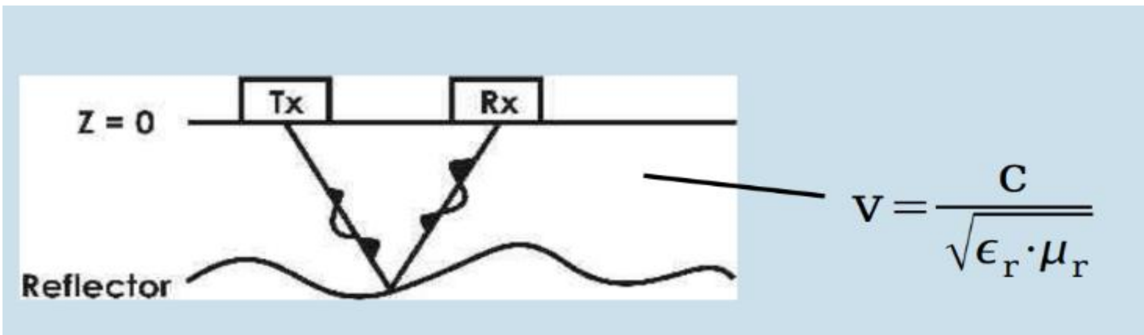
Dhanbad's geological composition predominantly consists of the Chotanagpur Gneissic Complex, which underlies the region encompassing IIT (ISM) Dhanbad. The lithology is marked by metamorphic and igneous rocks, including granites and gneisses. Notably, the Khudia Nala section offers a prime view of these rocks, showcasing gneisses with distinct compositional banding. The Khudia Nala traverse also reveals the rock's deformational history, illustrated by reclined folds. Baliapur CD Block is encircled by Dhanbad and Govindpur CD Blocks to the north, Nirsa CD Block to the east, Raghunathpur II CD Block in Purulia district (West Bengal) to the south, and Jharia CD Block to the west. The lithology and geology structure are shown below figure.



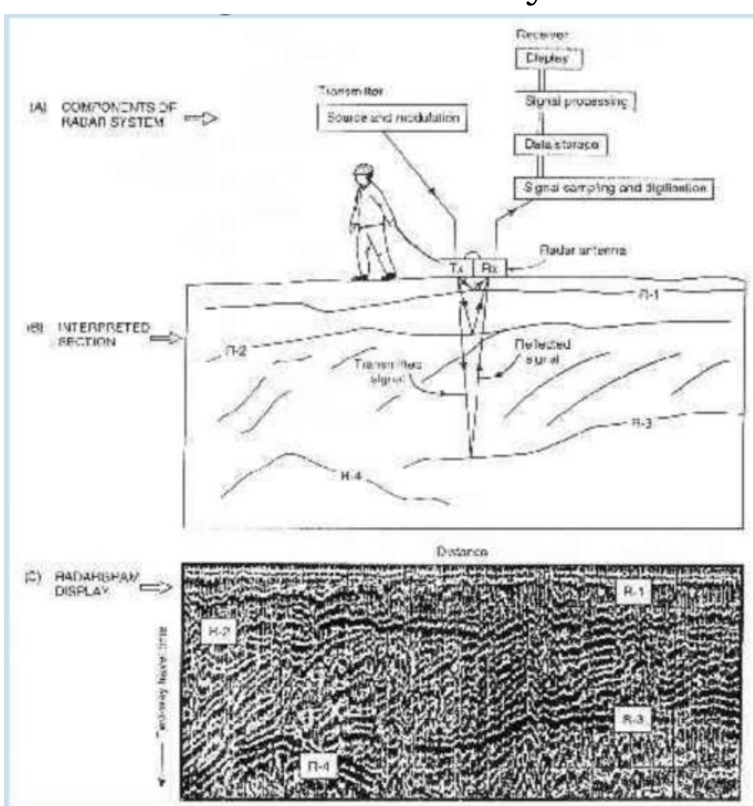
Lithological Map of the Baliapur region, Dhanbad Jharkhand

Theory:

In the GPR method, a short radar pulse in the frequency band 10MHz 1GHz is introduced in the ground. The reflection of electromagnetic waves are observed. Radar velocities are controlled by the dielectric constant where c is the velocity of light in vacuum (3·10 8 m/s), and is the relative magnetic permeability which is close to unity for nonmagnetic rocks.



A radar system comprises a signal generator, transmitting and receiving antennae and a receiver that may have recording facilities.



As radio waves travel at high speeds (in air 300 000 km/s), the travel time is a few tens to several thousand nanoseconds (ns=10 9 s). This requires a very accurate instrumentation to measure the signal.

The antennae used can be in monostatic or bistatic mode. monostatic: one antenna device is used as both transmitter and receiver bistatic: two separate antennae are used with one serving as transmitter and the other as receiver

A contrast in dielectric properties across an interface causes reflection of part of a radar pulse according to the reflection coefficient

$$R=\frac{\sqrt{\epsilon_{r_1}}-\sqrt{\epsilon_{r_2}}}{\sqrt{\epsilon_{r_1}}+\sqrt{\epsilon_{r_2}}}=\frac{v_2-v_1}{v_2+v_1}$$

where and are the relative permittivity (dielectric constants) of the two media separated by the interface and v 1 and v 2 the radar velocities within them. Velocities of geological materials lie within the range 0.060.175 m/ns. Typical value for f=100MHz.

However, energy is lost due to attenuation which is dependent upon the electric ( ), magnetic ( ) and dielectric ( ) properties of the geological medium as well as the frequency of the radar signal.

$$\frac{E_0}{E_x}=\exp(-\alpha x)$$

$$\alpha=\omega\left\{\left(\frac{\mu\epsilon}{2}\right)\left[\left(1+\frac{\sigma^2}{\omega^2\epsilon^2}\right)^{1/2}-1\right]\right\}^{1/2}$$

→ small values for air, ice, granite

→ ideal conditions for GPR

Penetration depth for geo-radar signal:

$$d[m] = \frac{\rho[\Omega m]}{30}$$

small penetration depths for rocks with low resistivities

clay: 0.8 - 1m

saturated sand ≈ 2m

dry sand ≈ 5m

The transmitter and receiver antennae are kept at a small, fixed separation.

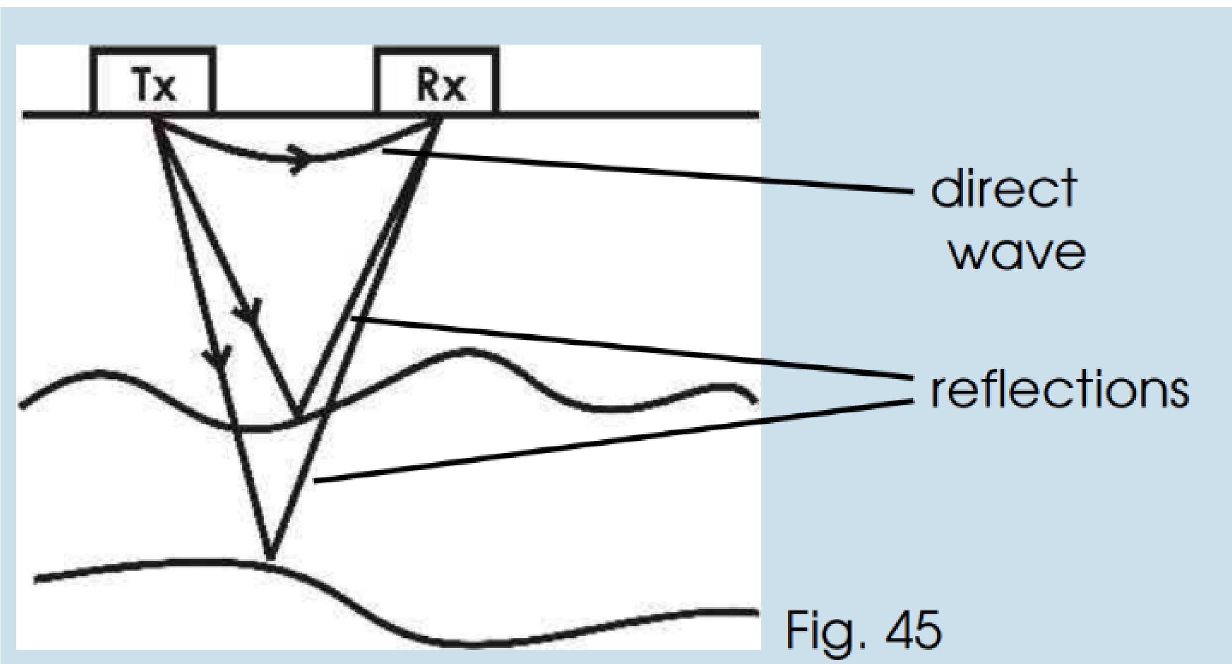


Fig. 45

Travel Time Calculation:

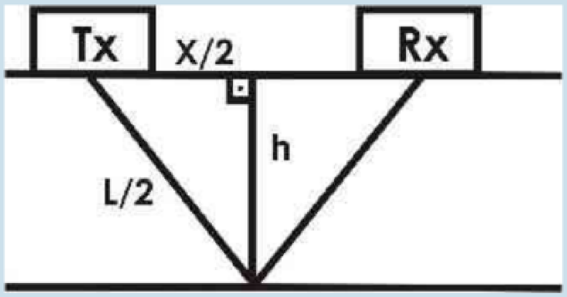


Fig. 48

$$(L/2)^2 = (x/2)^2 + h^2$$

$$\frac{L^2}{4} = \frac{x^2}{4} + h^2$$

$$L = \sqrt{x^2 + 4h^2}$$

$$\Rightarrow t = \frac{1}{v}\sqrt{x^2 + 4h^2}$$

Data Acquisition Methodology:

This feature empowers users to dictate the data acquisition mode, allowing them to choose between Time, Distance, or Point mode. The current mode is conveniently displayed alongside the file name at the top left corner of the screen.

a) Time Mode: In Time mode, data acquisition speed is time-dependent, expressed as scans per second. This mode suits scenarios where data is gathered without a survey wheel or distance measuring instrument (DMI). The SIR 30 collects data at the specified scan rate listed in the Scans/Sec option within the RADAR Config/RADAR sub-menu. The horizontal scan density relies on both the scan rate and the speed of the antenna movement.

b) Distance Mode: Distance mode empowers users to collect data at a specific scan density (entered in Scans/Unit in the Systems Settings display). Users have full control over horizontal scan density and resolution. This mode offers a linear horizontal scale, crucial for accurate results in processing methods like migration.

c) Point Mode: Point mode is ideal for using large, low-frequency antennas or collecting data on rough terrain. In this mode, users collect one radar scan at a time, beneficial for scenarios such as velocity data collection using CMP or WARR methods. Selecting Point mode enables the Static Stacking option in the RADAR Config menu.

d) Stacking Mode: Exclusive to Point mode, Stacking Mode allows users to stack (average) scans, enhancing signal-to-noise ratio and penetration depth. Users can adjust stacking values within a range of 1-10,000.

Additional Configuration Options:

- **SCANS/SEC:** Users can control the data acquisition speed, with the scan rate determined by the Pulse Repetition Frequency (PRF) and the number of samples per scan. Adjusting below the maximum rate activates automatic data stacking, potentially improving data quality at the expense of acquisition speed.
- **SAMPLES/SCAN:** This setting dictates the number of 32-bit samples used to construct the digital waveform. Users must calculate the required sampling value to prevent aliasing. Setting this value too high may result in unnecessarily large files and a lower maximum scan rate.

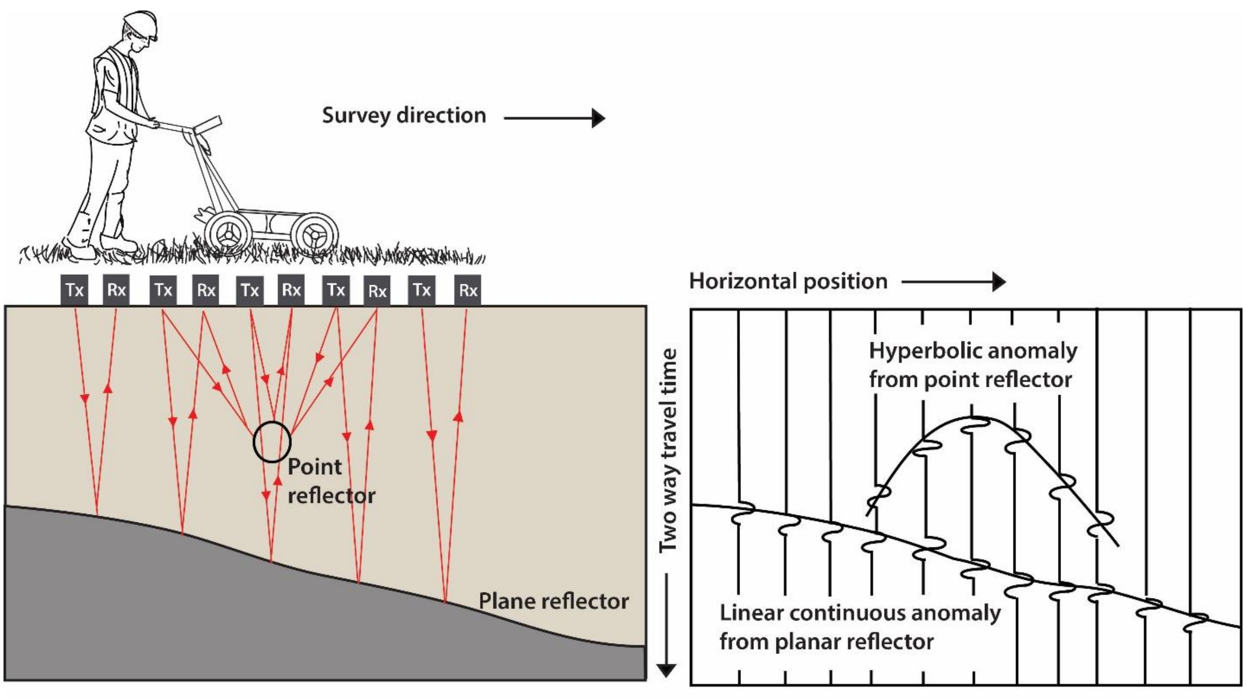
Note: It's crucial to avoid oversampling, as it leads to larger files and a decreased maximum scan rate. The minimum number of samples per scan should be equal to or greater than the calculated value: Time Range (ns) multiplied by Antenna Pulse Width (ns) multiplied by 10.

Instrumentation:

Instruments used in the survey are listed below-

- Primary recievers
- Transmitter
- Console
- Optical cable
- Wires
- Batteries

Field setup:



Data acquisition:

We have taken the data along with the profile.

◆ The profile is made straight by aligning 4 ranging rods.

◆ Proper separation and measurement is done using measuring tape.

◆ There is one transmitter antenna and one receiver antenna, both are separated at 1 meter distance.

◆ Data was acquired at an interval of 25 cm by clicking the transmitter switch.

◆ Each primary antenna frequency: 20 MHz

◆ Each secondary antenna frequency: 15 MHz

Interpretation technique:

A Ground Penetrating Radar (GPR) transmitter emits electromagnetic energy into the ground. When this energy encounters a buried object or a boundary between materials with distinct permitivities, it undergoes various interactions such as reflection, refraction, or scattering, ultimately returning to the surface. In GPR sections, observable events like diffraction and reflections emerge, providing valuable information for interpreting the characteristics of the subsurface target.

We observed the starta along the survey profile mostly horizontal.