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Application of Ground Penetrating Radar for Hydrogeological Study of Bicholime Mine, GOA

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अन्तर्राष्ट्रीय बाजार में प्रतिस्पर्धा के लिये भारतीय खनन उद्योग को लागत में कमी, उत्पादकता में वृद्धि और सुरक्षा के उच्च मानक को प्राप्त करना होगा। बेहतर कार्य प्रणाली, जो खनन से पहले ही भूवैज्ञानिक संरचनाओं का पता कर अवमिश्रण को कम करने में और भूमिगत संरचनाओं का प्रबोधन कर सुरक्षा बढ़ाने में सहायक हो, आज की माँग है, इससे खान से इष्टतम प्राप्ति की योजना बनाने तथा कम लागत पर अधिक उत्पादन करने में सहायता मिलेगी।

गोवा की बिचोलाइम खान एक लौह अयस्क खान है जो चारों तरफ से गावों एवं छोटे कस्बों से घिरी हुई है। अतः यहाँ से अत्यधिक मात्रा में लौह अयस्क का उत्पादन स्थानीय भूजल स्तर को प्रभावित कर भूजल में कमी का कारण बनेगा। यह प्रभाव क्षेत्र विशेष के भूवैज्ञानिक शैलसमूह और खनन तकनीक पर निर्भर करेगा। अतः, खान के स्वामी मे. डेम्पो माइनिंग कार्पोरेशन लिमिटेड में होने वाले खनन से आस-पास के भूजल संसाधनों पर पड़ने वाले प्रभाव के अध्ययन के लिये केन्द्रीय खनन अनुसंधान संस्थान को नियुक्त किया है।

इस उद्देश्य के लिये बिचोलाइम खान, गोवा के खुलीमुख खान में लाइथोलोजिक प्रणाली पर खनन के संभाव्य प्रभाव के अध्ययन हेतु अति आधुनिक परिष्कृत संयंत्र "ग्राऊण्ड पेनेट्रेटिक रडार (GPR) का उपयोग किया गया है।

इस आलेख में बिचोलाइम खान, गोवा में सर्वेक्षण करने के उपरांत प्राप्त परिणामों तथा अन्य भूभौतिकीय विधियों की तुलना में (GPR) के महत्व पर प्रकाश डाला गया है।

INTRODUCTION

There is pressing need for better means of exploring ground conditions ahead of mining and tunnelling. Exploration drilling suffers from the drawbacks of high cost and a seriously restricted sampling zone. Traditional geophysical exploration methods including gravity, magnetic, resistivity, induced-polarisation, and inductive electromagnetic techniques have been used with some success underground, but all suffer from poor target resolution relative to range, since they depend upon the minor distortions of a potential force field.

Much greater ratios of resolution to range can, in principle, be obtained by employing radiation as the exploring agent. This is because propagation time delays can be used to measure range accurately and to separate the small effect of a distant target from the much larger effects of nearer targets and of the transmitter. There are only four types of radiation capable of substantial penetration through rock : neutrinos, hard cosmic rays, seismic waves, and electromagnetic waves. The first two are not easily controlled and a technology for their application to exploration has not yet been developed. Seismic waves have long been used with great success in exploration for petroleum, but the development of underground seismic methods is in its infancy. Electromagnetic (radar) waves have been very successfully used for detection and location through the air and outer space, and have also explored through polar icecaps more than a mile thick. Unfortunately, the bodies of water and the soil mantle covering most of the earth are essentially radar-opaque because of their high electrical conductivity. It is generally not realised that below the soil many rocks are somewhat radar-transparent and that electromagnetic waves can be used for exploring such rocks, once a quarry, a mine, a borehole, or other means of access has been opened.

Electromagnetic waves are reflected by any boundary or object where they encounter a pronounced change in electrical properties. In rocks, the usual cause of such a change is a difference in moisture content. Hence, radar waves passing through tight dry country rock are reflected by a fault filled with gouge clay or with wet broken rock.

Due to these advantages, Ground Penetrating Radar (Geo-radar) based on electromagnetic waves propagation is used for hydro-geological study of Bicholime mine, Goa.

METHODOLOGY

Reflection technique, the most common method of Geo-radar survey has been applied for the hydro-geological study in the Bicholime mining area. The study has been conducted to scan the subsurface areas between the open pits and surrounding villages and Mayem lake. Different sections have been scanned. The scan sections have been interpreted for the occurrence of various strata by utilising the borehole data and sections along the lines supplied by the Dempo Mining corporation Limited. The results have been analysed to interpretate any hydro-geological connection between the open pits and surrounding villages and Mayem lake.

RESULTS AND DISCUSSIONS

Ground Penetrating Radar survey has been carried out along 1 Top and 2 Top in Bicholime Mine during January, 1998 for Hydro-Geological study of the mining area. A total

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of eight sections (A – A1 to H-H1) have been covered around the 1Top Pit (Sec. A–A1 to E–E1) & 2 Top Pit (Sec. F–F1 to H–H1). Survey sites are marked on the plan as shown in Fig.1.

In 1Top, GPR survey has been carried out along section A–A1. Radar signatures for subsurface features along section A–A1 is shown in Fig. 2.1. Most of the places solid layers (dark black line) are existing upto the depths of 10m–13m. After correlating with borehole sections (supplied by Dempo Mines), these layers are indicating Laterites. At some places Laterites layers are extending from surface to about 22 metres at positions ; 0–10m, 90m–125m and 150m–170m respectively. Water saturated Zones in clay layers are present at surface positions ; 15m–20m, 60m–80m, 125m–140m, 170m–228m respectively. Clay layers are existing at position 25m–55m starting from the depth 8m to 22m.

Another survey has been carried out along section B–B1 in 1Top, Hanging wall side, near tailing pond. In this case, solid layers are present from surface to the depth of 22m and from surface positions 60m to 215m; 15–20m and 30–40m respectively. Clay layers are existing at surface positions; 0–10m, 20m-30m and 40m–60m respectively and the depth varying from 12m–22m. Solid layers are observed as Laterite layer after correlating with borehole sections. These Radar signatures are shown in Fig. 2.2.

Again survey was continued along the Section C–C1 in 1 Top, Foot wall side, towards Mayem lake. In this area, solid layers are present from surface to the depth varying 10–17m. Most of the places clay layers are dominating at the depths varying from 10m–22m. Surface positions for clay are observed at; 0 –12m; 20m–24m; 32m–36m; 48m–56m; 80m–84m; 92m–108m; 120m–144m; 148m–168m; and 180m–198m respectively. Water bearing zones in clay layers are existing at positions; 60m–76m; 108m–120m; 144m–148m and 168m–172m respectively. Radar signatures for this section is shown in Fig. 2.3.

GPR survey was continued for another Section D–D1 along 1 Top, Foot wall side, towards Mayem lake. Solid layers are existing upto the depths of 10m–12m. These layers are found Laterite layer when correlation is established with borehole data. Most of the places clay layers are existing at depths varying 10m to 22m except at surface positions 8m–16m, where water bearing strata are dominating. Radar signatures for subsurface features along section D–D1 is shown in Fig. 2.4.

At last GPR survey is continued in 1 Top, Foot wall side, towards Mayem lake along the Section E–E1. In this area, Solid layers are existing upto the depth varying from 11m to 15m. Clay layers are found at surface positions; 0–10m; 47m–55m; 77m–85m; 90m–108m and 123m–140m respectively. Water containing strata are present at surface

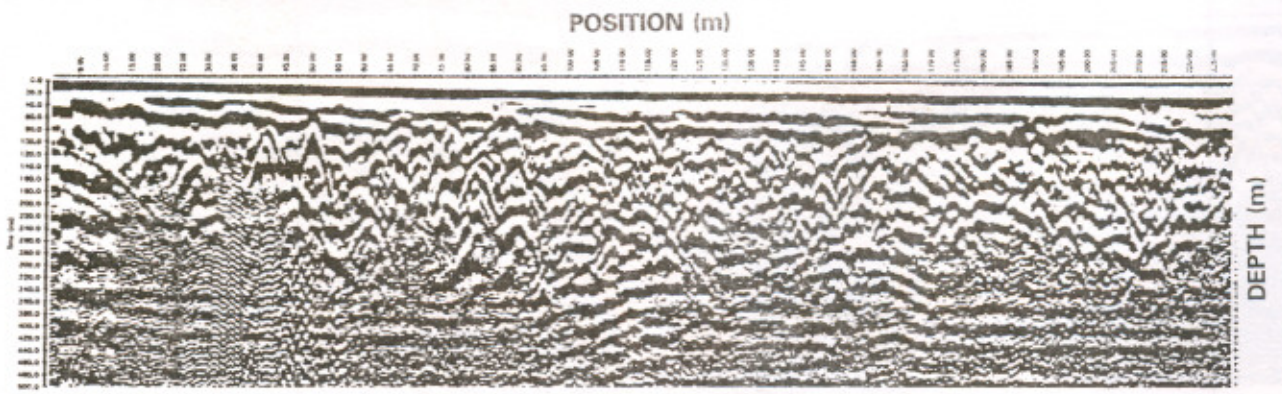

Fig. 2.1 : Geo-Radar signatures along section A – A_1 (1 Top, Hanging wall side)

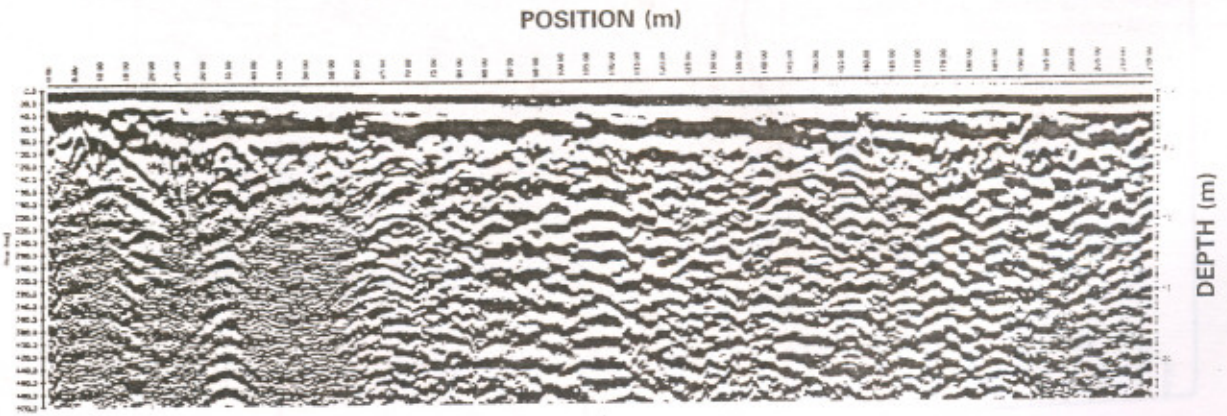

Fig. 2.2 : Geo-Radar signatures along section B – B_1 (1 Top, Hanging wall side, Near tailing pond)

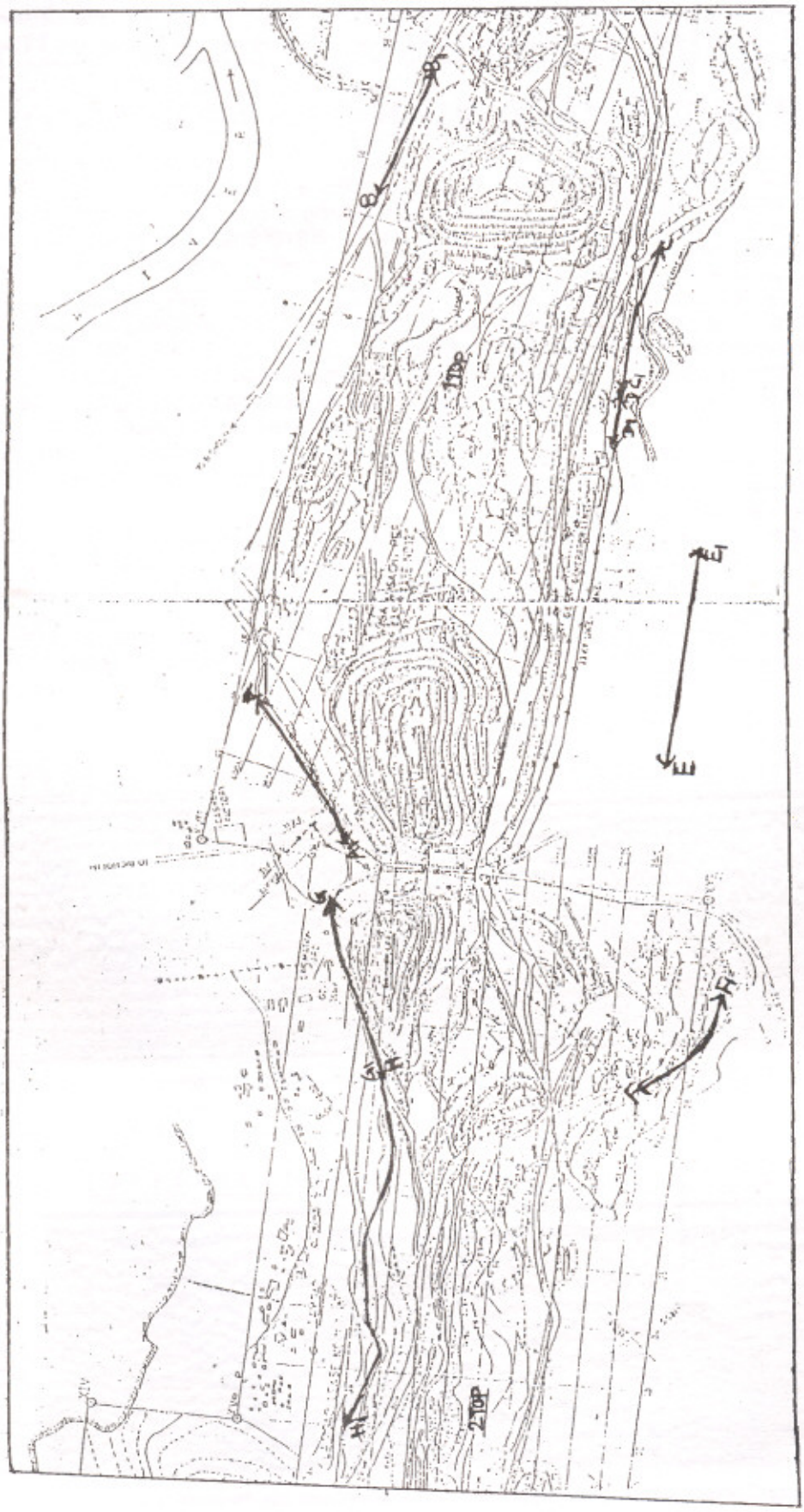

Fig. 1 : Location of Geo-radar study sections

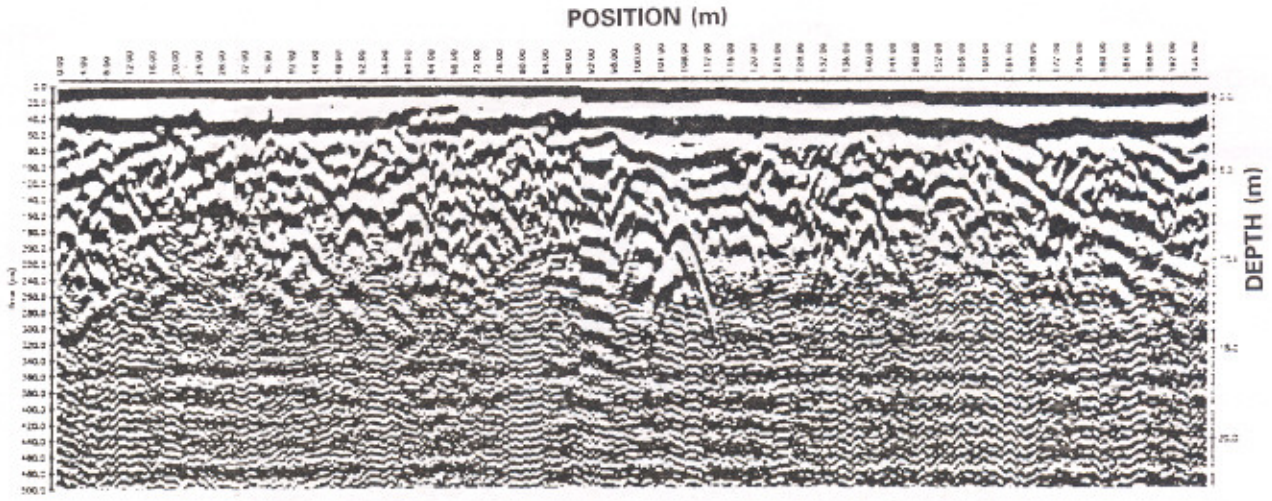

Fig. 2.3 : Geo-Radar signatures along section C – C_1 (1 Top, Foot wall side, Towards Mayem lake)

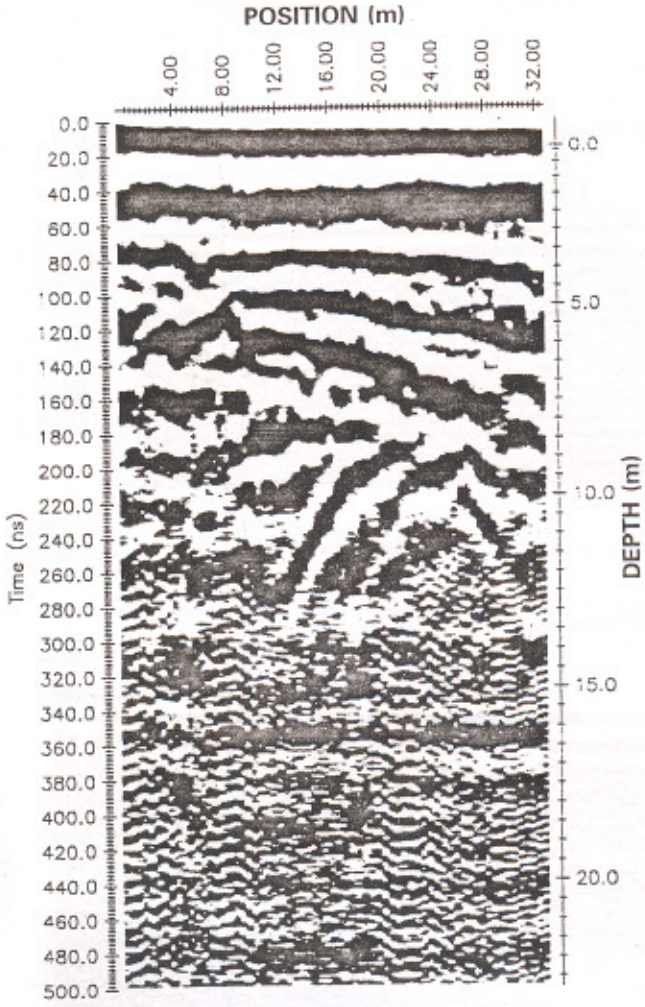

Fig. 2.4 : Geo-Radar signatures along section D – D_1
(1Top, Foot wall side, Towards Mayem lake)

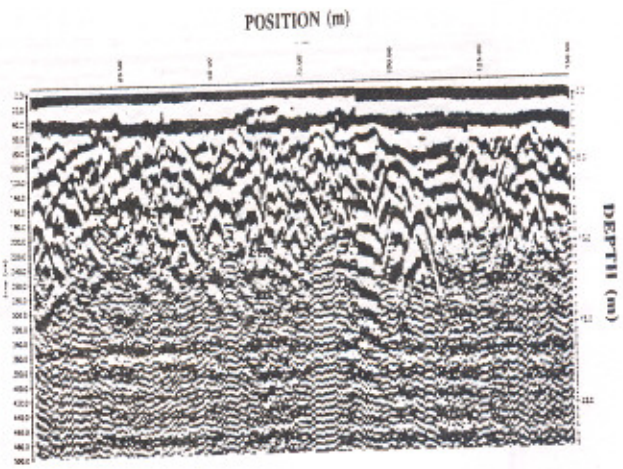

Fig. 2.5 : Geo-Radar signatures along section E – E_1
(1 Top, Foot wall side, Towards Mayem lake)

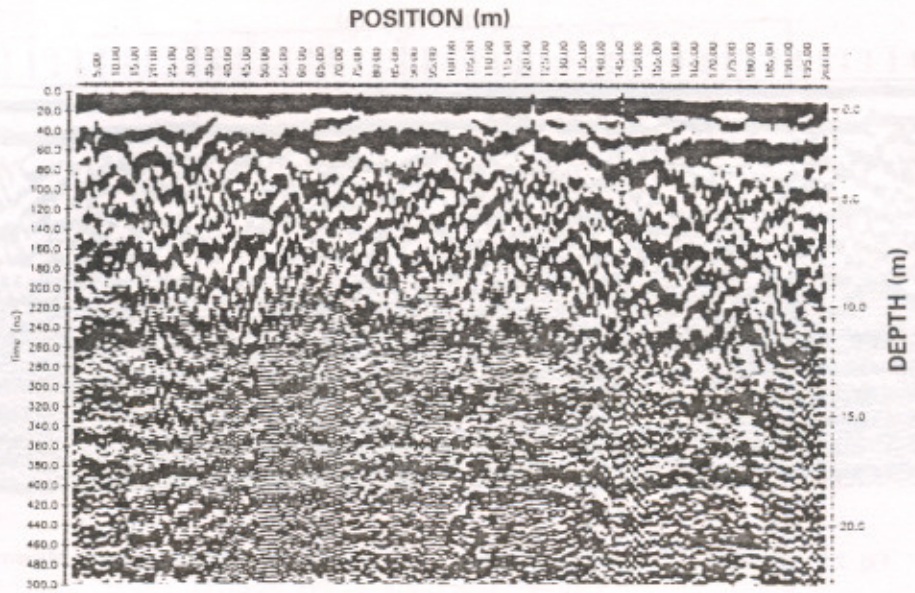

Fig. 2.6 : Geo-Radar signatures along section F – F_1 (2 Top, Near NSP and Stock yard)

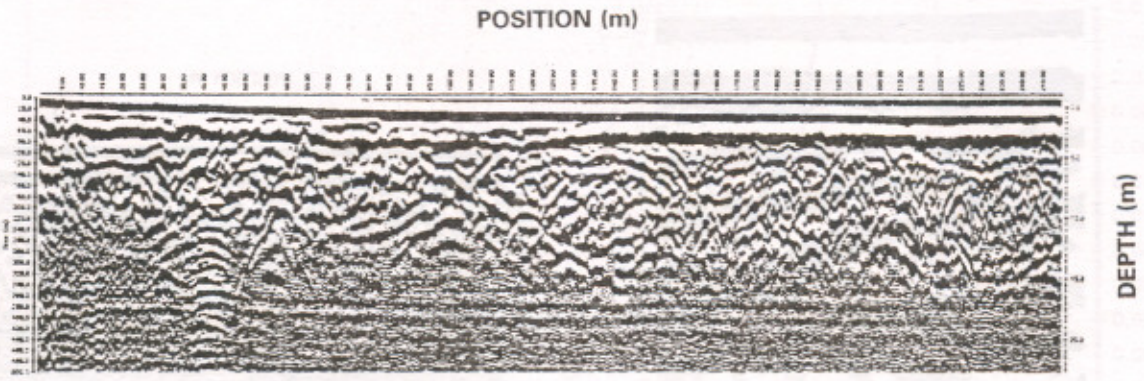

Fig. 2.7 : Geo-Radar signatures along section G – G_1 (2 Top, Hanging wall side)

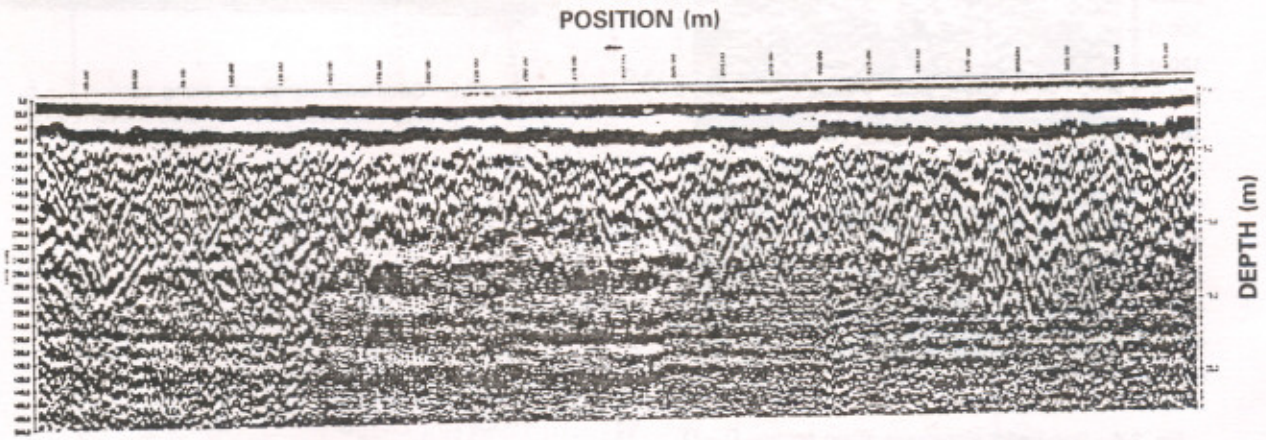

Fig. 2.8 : Geo-Radar signatures along section H – H_1 (2 Top, Hanging wall side, Near Lamgaon Village)

positions 10m–47m; 55m–77m; 108m–123m and 140m–149m respectively. Surface solid layers are found Laterite after correlating with borehole data. Radar signatures for this area are shown in Fig. 2.5.

Now GPR survey has been carried out along Section F–F1 in 2 Top, near NSP and Stock yard. Solid layers are present upto the depths of 10m to 14m from the surface. These layers are representing Laterite layers after correlating with borehole data. Most of the places clay layers are present at the depths varying from 12m to 22m eccept some places where water saturated zones are found as shown in Fig. 2.6. Water saturated zones in clay layers are at positions; 170m–190m; 105m–110m; 75m–80m and 20m–40m respectively.

GPR survey was continued along Section G–G1 in 2 Top, Hanging wall side. Radar signatures are shown in Fig. 2.7. In this area, Solid layers are present at the depths varying from 11m to 15m from the surface except at one place where solid layers are extending from surface to 22m in depth at surface position; 40m to 50m. Most of the places clay layers are found at the depths varying from 11m to 22m. Solid layers are also found Laterite as correlated with borehole data supplied by Dempo Mining.

At last GPR survey is continued along Section H–H1 in 2 Top, Hanging wall side, near Lamgaon Village. Radar signatures for this area is shown in Fig. 2.8. Most of the places, Solid layers are also found at the depth of 11m except at the surface position from 0–145m where solid layers are present upto the depth of 22m from the surface. Water bearing strata are present at the surface positions; 170m–320m and from depth varying from 11m to 22m. Clay layers are found at surface positions; 320m–400m and 425m–587m respectively upto the depth of 22m from the depth of 11m. In this area, surface layers (solid layers) are also found as Laterites when correlated with borehole data.

CONCLUSION

After conducting GPR survey in Bicholime mine, Goa, it may be concluded as follows :

1. Laterite layers are existing there form surface to depths varying from 10m to 14m.
2. Most of the places clay layers are present there at depths varying from 10m to 22m.
3. At some places water bearing stratas are dominating at depths varying 12m to 22m, which may be due to occurrence of perched water table; and
4. Since the clay layers are impervious, mining and dewatering in the lease hold areas may not effect the surroundings hydrolocical regime.

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