GPR technology
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Subsurface Views

Sensors & Software Inc.

Rock Noggin for Fracture Detection

Voids and fractures in rock can be effectively detected using GPR. Solid rock is much better than most soils for GPR penetration because it tends to be more electrically resistive, attenuating the GPR signal less.

Figure 1: The Rock Noggin being used to scan the rough wall of a limestone quarry to look for internal cavities and fractures.

This, coupled with the fact that air or water-filled cavities create a large electrical contrast, means that GPR is usually very successful at detecting voids and fractures. The Rock Noggin system is designed specifically for scanning into the rock in mines and quarries.

Figure 1 shows the wall of an old limestone quarry being scanned with a Rock Noggin 500 MHz system. The rough surface of the wall made it impossible to collect data with an odometer so the trigger button was employed for this "point and shoot" survey. Although the surface undulates, the real time data is always displayed as though it were collected (continued on page 3)

pulseEKKO® applications:

Placer Exploration

Ground Penetrating Radar is a valuable tool in placer exploration. Unfortunately, much of this exploration data remains proprietary and is rarely published. This research focused on delineating a buried diamondiferous and gold-bearing placer in the tropical jungles of Guyana's interior (Figure 1). GPR was used to map the buried valley geometry and image the valley-fill sediments.

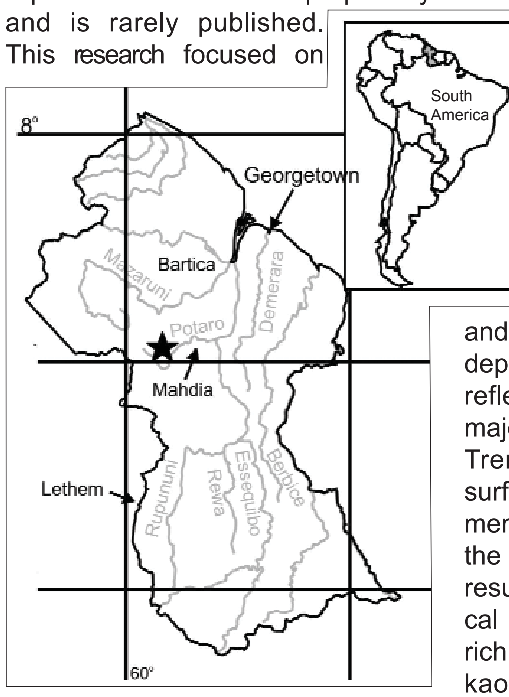

Figure 1: The study area is located in the Potaro Mining District (placer) of Guyana's interior.

In 2000, our GPR survey imaged the fluvial architecture of a buried paleovalley at Maple Creek, Guyana. The survey was part of an MSc. thesis funded by Vannessa Ventures Ltd. at the University of Victoria. The project investigated the local stratigraphy of the valley and interpreted the organization of fluvial elements within the valley-fill sediments.The survey consisted of 44 km of survey lines collected with 100 MHz antennae in the southern part and 50 MHz antennae in the northern part of the study area.

The survey successfully imaged the fill architecture and valley geometry to a maximum depth of over 70 m. Two strong reflectors were interpreted to be major bounding surfaces (Figure 2). Trenching confirmed the lower surface (A) to be the bedrock-sediment interface or the boundary of the paleovalley. This strong reflector results from a contrast in the electrical impedance between the quartz-rich fluvial sand and the saprolitic kaolinized bedrock. The second major reflector (B) occurs at the boundary between the fluvial valley fill and overlying leached, white quartz sand. (continued on page 2)

In This Issue

Placer Exploration

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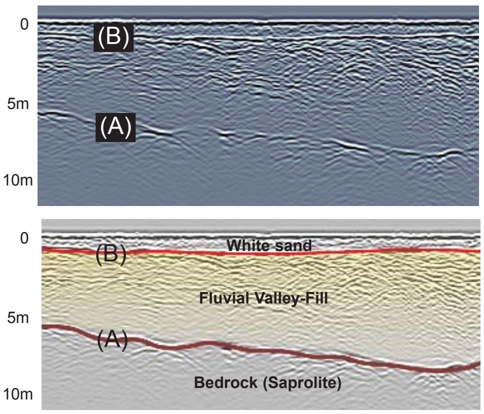

Figure 2*: Two major surfaces (A) and (B) were clearly imaged in the radar survey.*

The underlying fluvial sand is often heavily iron stained and indurate whereas the white sand is typically loose and porous, producing a significant contrast in the electrical properties of the two units (Figure 3). In addition to the two major surfaces, several minor surfaces and their associated internal reflectors were also outlined, resulting in the identification of 21 radar elements. Examples of these elements, interpreted to represent fluvial architectural elements, are shown in Figure 4.

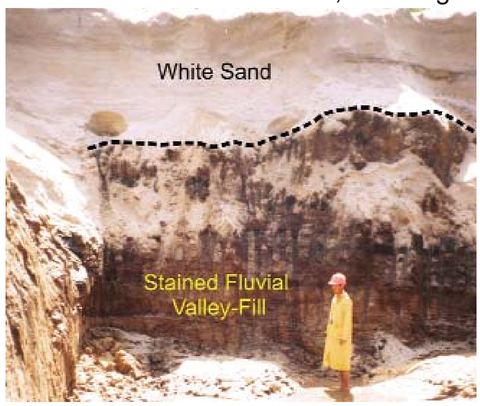

Figure 3: *The boundary between the white sand and underlying fluvial valley-fill sediments is easily recognized in the field, as staining is restricted to the valley-fill material. Because the two units have significantly different electrical properties, the boundary is clearly imaged with the GPR.*

The GPR work was the basis of Mr. Adrian Hickin's MSc. thesis. We are extremely grateful Mr. Hickin's contribution and the permission of Vannessa Ventures Ltd. to allow the example results to be presented. A more extensive description of this work is contained in the article contributed by Adrian Hickin - Ministry of Energy & Mines, Oil & Gas Division, Victoria, B.C.: Hickin, A.S., Bobrowsky, P.T., Paulen R.C. and Best, M (in press) Imaging fluvial architecture using ground penetrating radar, Maple Creek, Guyana; Geological Society of America Special Paper: Advances in Stratigraphic Analysis using GPR.

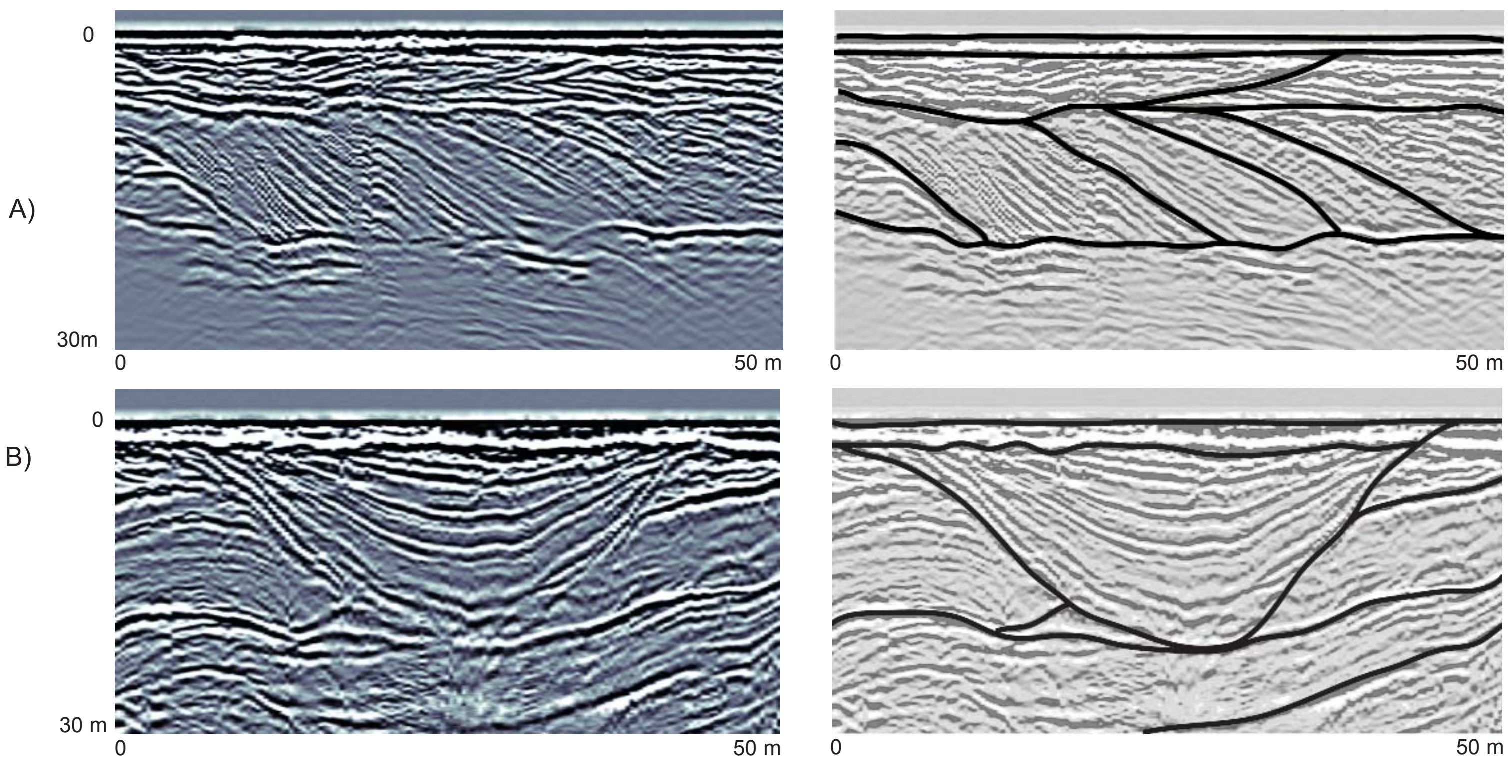

Figure 4: *The GPR survey was successful in imaging the architecture of the valley fill. Two examples are presented here and include: A) Oblique parallel reflectors bounded above and below by laterally continuous reflectors represent a migrating feature such as a large scale mid-channel bar or pool fill; B) Divergent fill that represents an incised channel that has been filled with sediment.*

Rock Noggin for Fracture Detection

(continued from page 1)

on a flat surface (Figure 2). The raw data shows a strong reflector sloping into and out of the rock at points about 2.5 m apart. This reflector becomes easier to interpret when the GPR image is compensated for topography. In Figure 3 the bowl-shaped reflector is transformed into a flat event revealing that this section of rock has started to break away from the wall of the quarry.

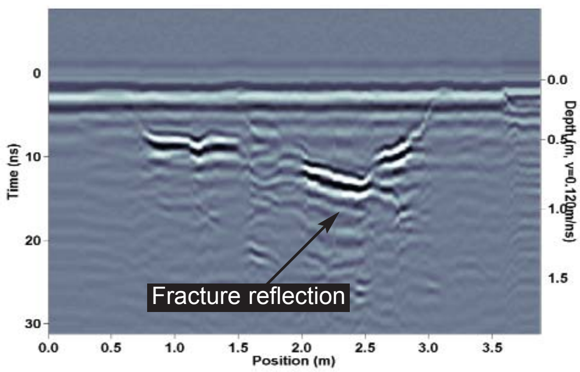

***Figure 2**: The raw, uncompensated 500 MHz data image, showing strong reflectors from fractures.*

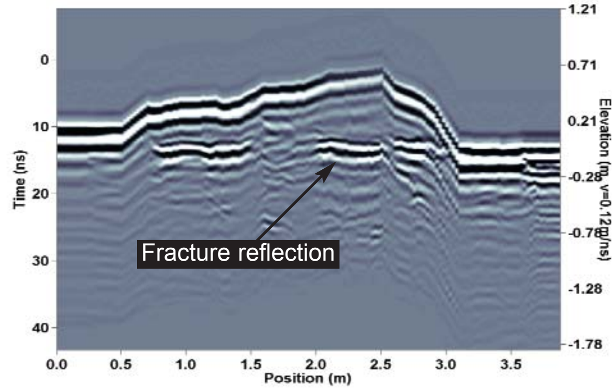

***Figure 3**: The same data as Figure 2 but after compensation for surface topography along the survey line. The strong reflector from a fracture is now a linear event.*

This simple, 2 minute survey shows the power of the Rock Noggin for quickly revealing fractures and a potentially hazardous situation.

Ask the Expert

Is GPR capable of determining ground density and porosity to help locate soil suitable for septic fields?

The short answer to the question is that relative variations in porosity and density can be inferred from GPR velocity changes when the soil character is simple. However, it can be tricky and misleading to depend on GPR velocity to infer porosity and density for highly precise estimates; The correct answer is that the utility of GPR for this application depends on the precision needed and knowledge of other a priori information.

GPR velocity is weakly affected by soil density. In general the bulk dielectric permittivity of a material depends on the electron density in the material. The more dense, the more electrical charge in the bulk volume which increases electrical polarizability which creates bulk permittivity. In dry soils, an empirical estimate of permitivity, K is:

$$K = \rho^{1.92}$$

where ρ is the density in g/cm^3.

In most earth environments, the presence of water has a much larger impact on bulk permittivity. Because of the high bulk permittivity of the water, the more water that can be placed in the pore space of a soil, the higher the bulk permittivity. (*see Topp, G.C., Davis, J.L. and Annan, A.P., 1980, Electromagnetic Determination of Soil Water Content: Measurements in Coaxial Transmission Lines, Water Resources Research, Vol. 16, No. 3, p. 574 - 582.)*

In saturated soil conditions, variations in bulk density translate directly into variations in porosity which in turn map into variations in water content which result in changes in dielectric permittivity and GPR wave velocity. While this sounds indirect, in many situations GPR velocity can provide a good indication of bulk porosity using these relationships.

Tutton's Well - a Further Follow Up

We had additional input from Mr. Kevin Dingley who is chairman of the Friends of Tutton's Well. Mr. Dingley advised that on commencing to build the commemorative well head, they discovered the old well.

The old well was cleared and a clean ground bottom emplaced. The photos below were kindly provided by the Friends of Tutton's Well. More information can be obtained from their website: **www.tuttons-well.org.uk**

Recent Technical Papers

1. **Measuring Soil Water Content with the Ground Penetrating Surface Reflectivity Method: Effects of Spatial Variability,** ASAE Paper Number 03229, Written for presentation at the 2003 ASAE Annual International Meeting, Las Vegas, NV, USA, 27-30 July 2003, in press.
By: Redman, J.D., Galagedara, L., Parkin, G.,
2003 ***ref 299***

2. **Three-dimensional kinematic imaging of borehole radar data,** Exploration Geophysics (2003), Vol. 43, No. 1 & 2, pp. 103-109.
By: Osman, N., Simmat, C., Hargreaves, J., Mason, I.,
2003 ***ref 302***

3. **Finite-difference modeling of borehole ground penetrating radar data,** Journal of Applied Geophysics, Vol. 29, pp. 111-127.
By: Wang, D., McMechan, G.A.,
2003 ***ref 303***

4. **Radar frequency dielectric dispersion in sandstone: Implications for determination of moisture and clay content,** Water Resources Research, Vol. 39, No. 2 (2003), pp. 1-1 - 1-12.
By: West, J.L. and Handley, K., 2003,
2003 ***ref 304***

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