GPR technology
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Subsurface Views

Sensors & Software Inc.

pulseEKKO® PRO: Advanced Survey Techniques

Multi - Polarization or Polarimetric GPR

GPR signals are measurements of electromagnetic (EM) fields. Many GPR users may not realize that EM fields are vector in nature.

A vector field has a direction as well as an amplitude. A common example is

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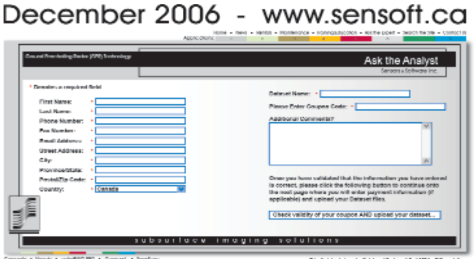
Introducing a NEW Service:

Ask - the - Analyst

December 2006 - www.sensoft.ca



Have you:

- *obtained odd looking GPR data and wondered what it meant?*
- *no GPR experience and wanted advice on data you collected? or*
- *needed a second opinion on data interpretability?*

Ask-the-Analyst is just for you. Submit a data set and our analysts will provide a report on your data.

New system owners and short-course attendees receive complimentary vouchers. If you have on-going needs, a fee-for-service option is available. ▪

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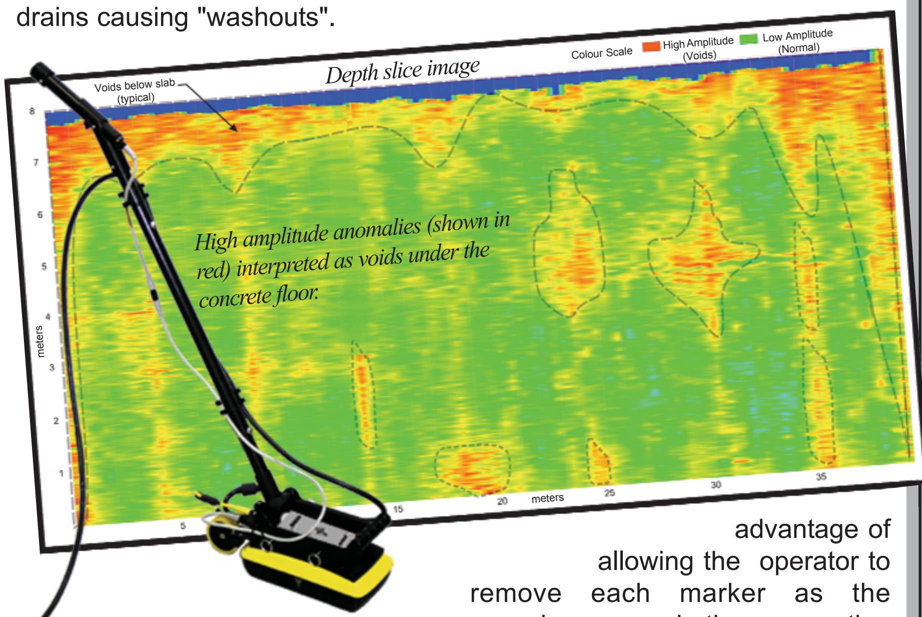
From our customers files:

Mapping Concrete Voids

Voids below concrete floor slabs are a common problem. They can be the result of lack of support at construction joints, consolidation of the sub-base or sub-grade or, most commonly, the result of broken drains causing "washouts".

Parallel lines can be collected by setting markers set at the required intervals or using a laser line set to guide the user. Where the distance to be traversed is relatively short, the marker system is usually more efficient and has the



advantage of allowing the operator to remove each marker as the scanning proceeds thus preventing errors in duplicate scanning.

The spacing between lines is also important and should be a maximum of 500 mm.

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The Noggin 1000 is capable of detecting these voids and displaying them as cross-sectional images using EKKO_View or scaled depth slice images using the EKKO_Mapper software.

The secret to radar imaging in concrete is accurate positioning. In most cases a reasonable approximation of the void location and its area are all that is necessary. All lines should start from a known datum line so targets from adjacent survey lines line up properly when depth slice images are created.

In This Issue

Multi - Polarization or Polarimetric GPR

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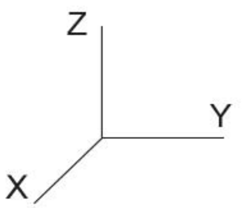
the compass which indicates north-south direction by aligning the compass needle with the magnetic field direction.

GPR's normally measure a single EM field component. Furthermore, GPR transmitting antennas do not excite fields in all directions. Therefore, GPR responses only contain part of the total potential information available.

Targets will respond and remit EM signals depending on the direction of exciting field, their geometry and material properties. The field detected at the receiver will be a function of both the excitation orientation and the target characteristics.



A full description of a target response needs a GPR with the ability to change the excitation field direction and also to detect all of the components from the response of the target. Such GPR systems are called Multi-Polarization or Polarimetric GPR's. The physical nature is depicted in Figure 1.

Does this sound complicated? It can be! Does this mean the traditional GPR is useless? No!

Many applications are satisfied by a single polarization measurement. When necessary, antenna orientations can be changed and repeat measurements can be taken.

Figure 2 and 3 show single polarization responses from a reinforced concrete slab. The excitation and detection polarizations are indicated. Only reinforcing elements aligned with the field direction respond.

In general thin wire metal structures only respond when the electromagnetic field is parallel to the wire direction. The full response can be obtained by combining both polarizations as shown in Figure 4.

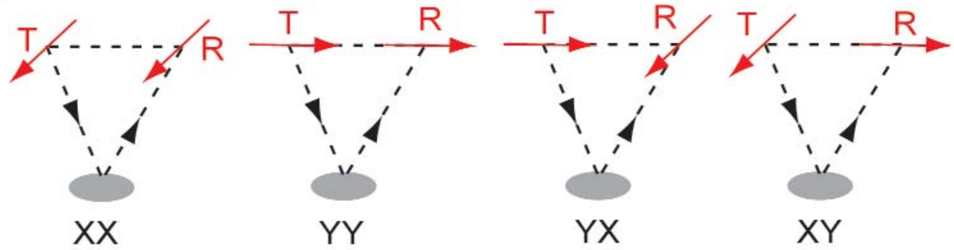


Figure 1: *Illustration of multi-polarization measurement. Transmitter T, and Receiver R, sensing direction in two orthogonal directions help to fully characterize a target response.*

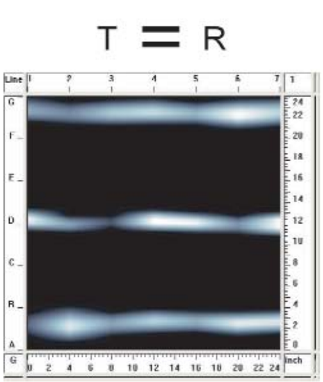


Figure 2: *XX data from a concrete slab with reinforcing steels in 2 perpendicular directions. Only steel bars in the X-direction respond.*

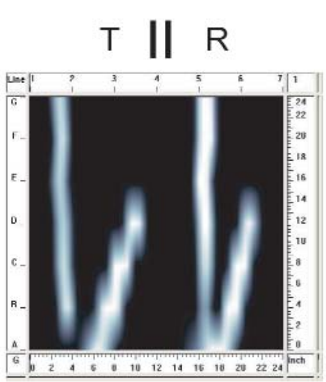


Figure 3: *YY data from same slab as Figure 2. Only Y -direction bars respond.*

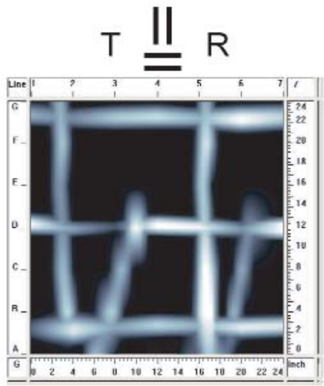


Figure 4: *The result from combining the two polarization data sets in Figure 2 and 3.*

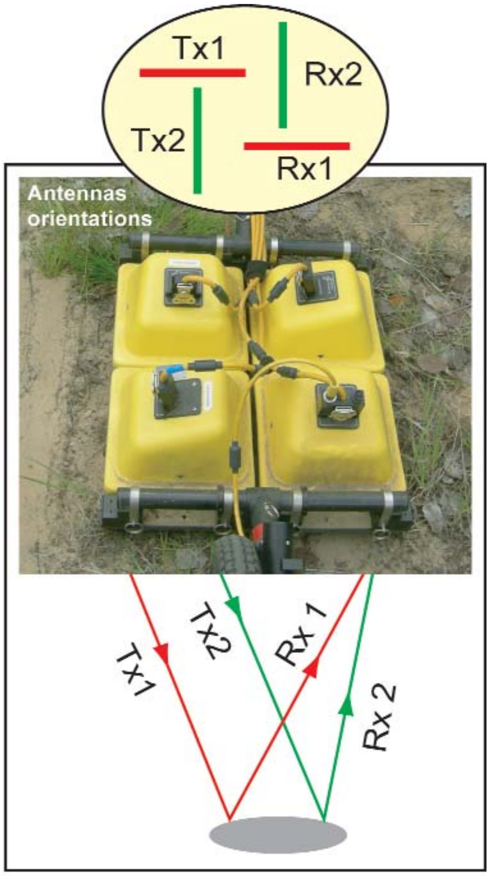


Figure 5: *Photos of a multi-channel pulseEKKO PRO configured for 1000 MHz polarimetric GPR measurements.*

New Multi-Channel pulseEKKO PRO systems allow simultaneous measurements of multiple polarizations with systems such as depicted in Figure 5.

While traditional GPR will continue to be useful for many applications, some advanced applications will be better addressed with Polarimetric GPR's. ■

Mapping Concrete Voids

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The anticipated spatial extent of the void is also important.

Complications arise when there are fixtures which obstruct scanning the lines. These can be handled two ways. The first and preferred method is to measure the distance of the scan line blocked by the fixture and advance the Noggin by turning the odometer until the correct distance is noted on the DVL screen. The second method is to start a new file but change the start point to the correct position on the floor.

Cross sectional views of the data are seen during data collection and voids under concrete are often seen as a high amplitude reflection at the bottom of concrete interface (Figure 1).

Once data have been collected and transferred to a computer, the EKKO_Mapper software is used to generate depth slice images. In the depth slices images, voids, if present, can usually be seen as high amplitude signals (see the depth slice image on page 1). The image can later be refined by selecting a single slice and a precise band of thickness.

Images can be easily imported into AdobePhotoshop or CorelDraw to add annotations for final reports.

The case study shown here is a warehouse floor where settlement of engineered fill was known to have occurred. The Noggin 1000, used in the manner described above, produced accurate images of the voiding below the slab and enabled cost effective repair procedures of drilling at the void locations and pumping in low strength grout.

In this example, since the concrete floor did not contain rebar, higher amplitude reflections from the voids are easy to see and map. Finding voids under concrete with reinforcing bars is more difficult because the strong reflections from the rebar often mask the more subtle reflection from the void. With careful analysis the amplitude anomaly associated with the void will still be visible and can be mapped (Figure 2).

Data and site description courtesy of Ron Grieve, Tekron Services.

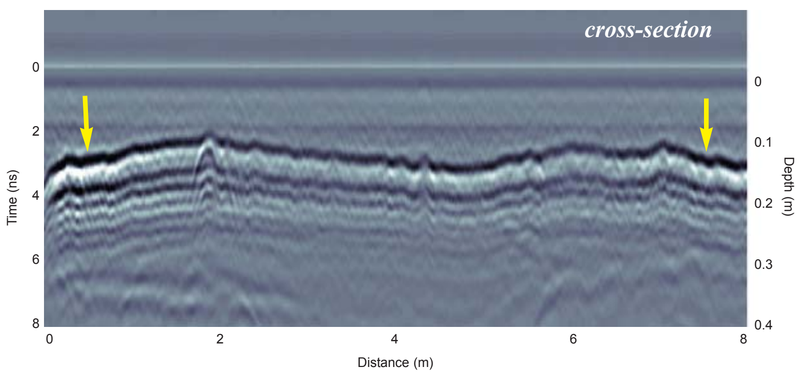

Figure 1: *Voids under concrete appear as high amplitude anomalies.*

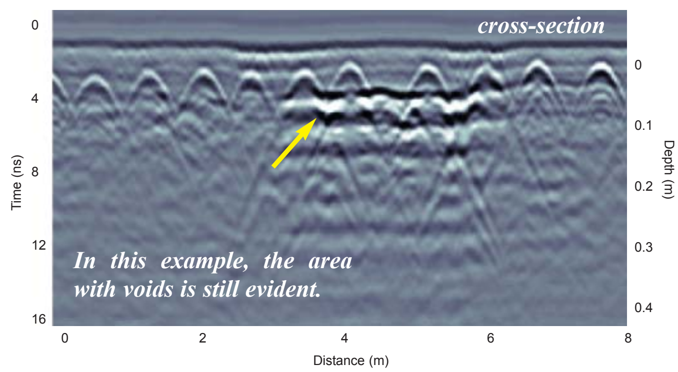

Figure 2: *The high amplitude anomalies caused by voids under concrete can be more difficult to detect when the concrete contains rebar.*

Ask-the-Expert

Why doesn't 500 MHz work well to profile through ice to the bottom of a fresh water lake or river?

GPR bathymetry surveys through ice are usually more successful when using lower frequencies like 50 or 100 MHz. Several factors reduce the effectiveness of 500 MHz signals.

1) Reflection Coefficient: The ice/water boundary has a large dielectric contrast (3.2 to 81) which produces a very large reflection coefficient of -0.67. This means most of the GPR energy reflects back from this interface and limits the energy travelling into the water to reflect from the bottom. Further, energy that does reflect upwards from the water bottom again encounters the water/ice interface which further reduces the energy transmitted through the ice to the GPR receiver.

2) Clutter Dimension: When GPR wavelengths are shorter or similar in dimension to the objects encountered, volume scattering and internal reverberation occurs. A 500 MHz signal has a wavelength in ice of about 0.3m so if the ice thickness has a similar dimension, a lot of energy gets trapped in the ice layer. A lower frequency GPR signal with a wavelength much longer than the ice thickness transmits more energy into the water.

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Recent Technical Papers

1. Exploring linkages between coastal progradation rates and the El Nino Southern Oscillation, Southwest Washington, USA, Geophysical Research Letters, Vol. 30, No. 9 (1448). By: Moore, L.J., Kaminsky, G.M., Jol, H.M., 2003 ***ref 350***

2. Ground penetrating radar as an alternative to radiography, Insight, Vol. 47, No. 7 (July 2005), p. 414-415. By: De Souza, T., 2005 ***ref 351***

3. What Lies Beneath: Modern Technologies Revamp Underground Investigations, CE News, February 2005, p. 30-33. By: Childers, J., 2005 ***ref 354***

4. Time domain reflectometry of glass beads/magnetite mixtures: A time and frequency domain study, Applied Physics Letters, Vol. 86, Letter 224102-2. By; Mattei, E., De Santis, A., Di Matteo, A., Pettinelli, E., Vannaroni, G., 2005 ***ref 356***

Upcoming GPR courses

One Day Noggin® Short Course
January 8, 2007
March 5, 2007

Our Noggin® short courses are offered throughout the year to anyone interested in learning more about GPR and subsurface imaging.

One Day Conquest™ Course
January 9, 2007
March 6, 2007

Our Conquest™ courses are offered to anyone interested in learning more about our concrete imaging instrument.

See us at ...

World of Concrete
Las Vegas, NV
January 23 - 26, 2007
www.worldofconcrete.com

Underground Construction Technology
Houston, TX
January 30 - February 1, 2007
www.uctonline.com

Utility Construction Expo
Las Vegas, NV
February 11 - 14, 2007
www.nuca.com

CGA Excavation Safety Conference
Orlando, FL
March 6 - 8, 2007
www.cgaconference.com

Information Request

Please check off information required below and fax or Email back:

- ☐ pulseEKKO® PRO
- ☐ Conquest™
- ☐ ConquestView
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- ☐ Noggin® Systems
- ☐ EKKO Mapper
- ☐ EKKO_View
- ☐ Rental Information
- ☐ 3 Day GPR Short Course
- ☐ 1 Day Noggin® Short Course
- ☐ Image Concrete with GPR
- ☐ Other (please specify) ____________

Ask-the-Expert

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3) Attenuation: Water starts to absorb EM energy more and more as frequency increases above 500 to 1000 MHz, which reduces GPR signal penetration.

4) Lower Detectable Signal: Higher frequency systems have smaller detectable signals because antenna cross-sections are physically smaller than low frequency systems.

Signal amplitude follows an inverse square law dependence with frequency.

In summary, tailoring the GPR frequency to the application is important as this response illustrates ■

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