GPR Technology Vol 6, No. 21, January 2010

Subsurface Views

Sensors & Software Inc.

Conquest - Concrete Imaging

Glass Rebar

The failure of bridges and other reinforced concrete structures due to corrosion of rebar is an ongoing problem. To combat this, one solution involves using GFRP (Glass Fibre Reinforced Polymer) rebar. GFRP is made from high strength glass fibres, coated with a vinyl resin. Besides being corrosion proof, it is also one-quarter the weight of steel rebar. This product is seeing increased use in concrete exposed to de-icing salts and marine environments.

Since GFRP rebar is non-conductive and transparent to electromagnetic fields, it is also used in MRI rooms in hospitals and near high voltage transformers and substations.

As a result, Conquest operators are encountering this type of rebar more often. The question is, "What does glass rebar look like when scanned with Conquest?"

From GPR theory, objects are detected based on the difference in electrical properties between the host material and target material. Steel rebar, being electrically conductive, provides a good contrast to the surrounding concrete and is therefore easily detectable.

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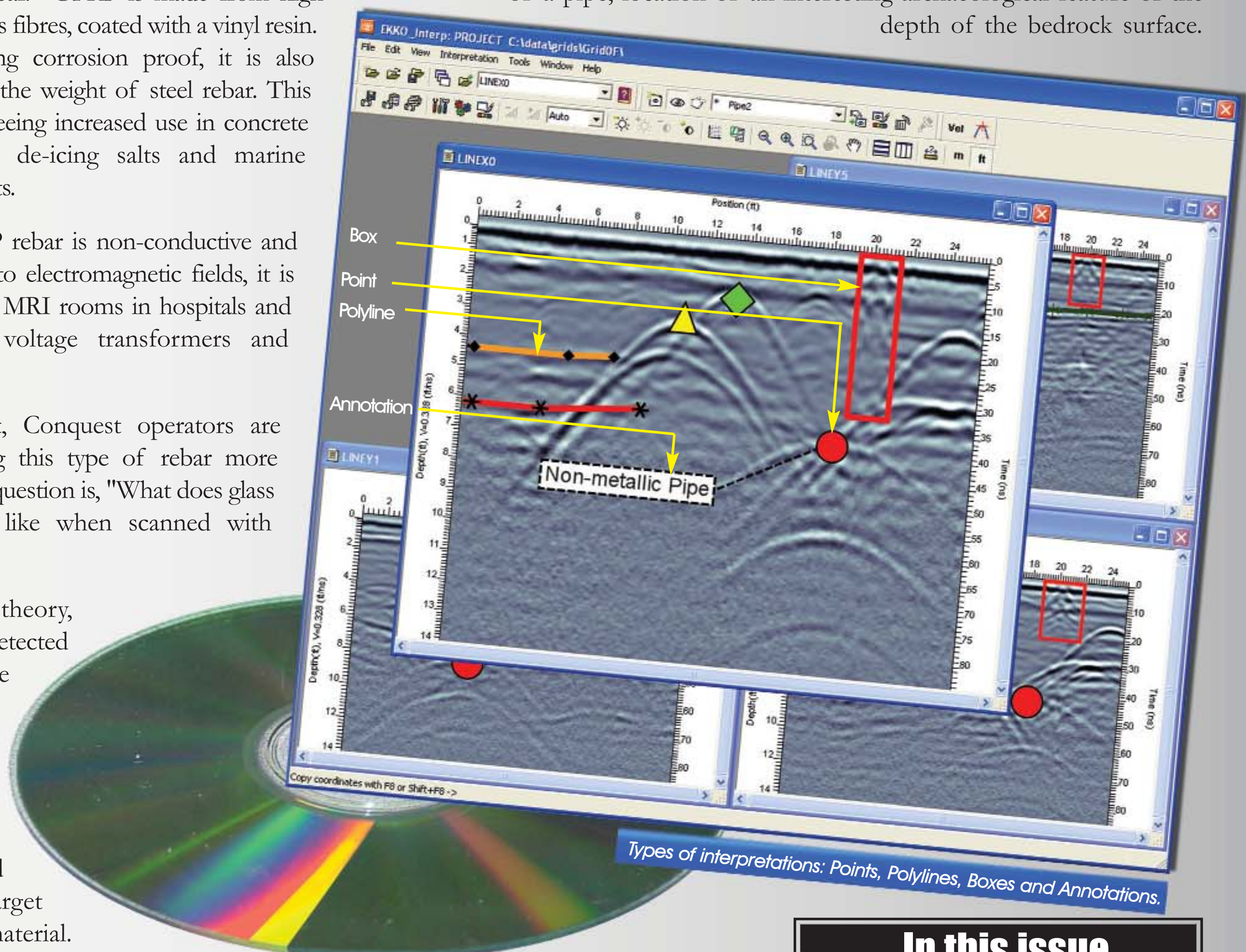
New Reporting Possibilities

EKKO_Interp Software

The value in GPR data is simply this: what it reveals about the subsurface can be used to solve problems. Ultimately, users are not interested in the GPR image itself but the interpretation of the images. Users want to extract quantitative information about the subsurface, be it the location and depth of a pipe, location of an interesting archaeological feature or the depth of the bedrock surface.



Types of interpretations: Points, Polylines, Boxes and Annotations.

EKKO_Interp is a new software package that enables users to selectively pick, label and export GPR feature attributes for a wide range of reporting requirements.

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EKKO_Interp

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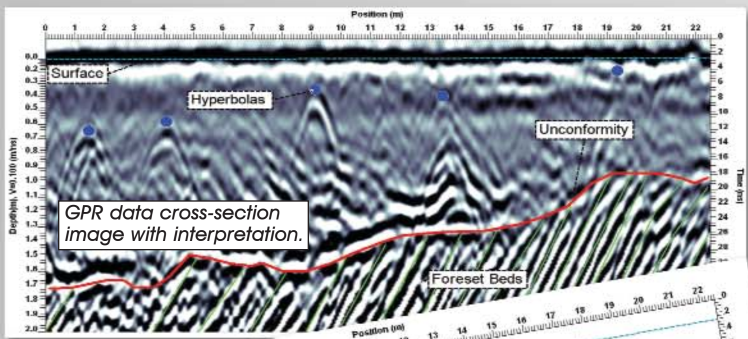
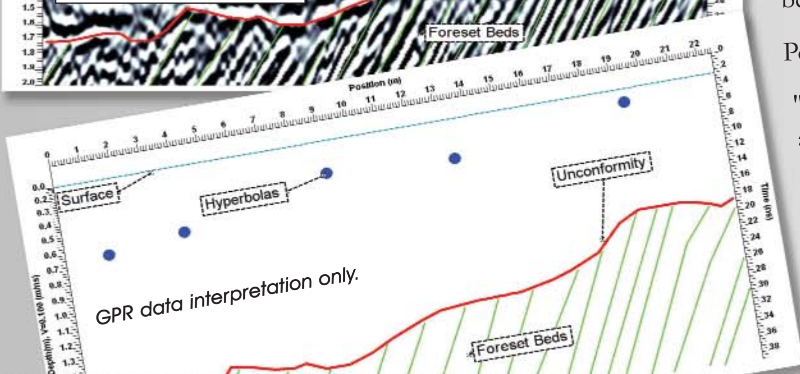


GPR data cross-section image with interpretation.



GPR data interpretation only.

Type	Interpretation	GPR-Line	X-Pos(ft)	Y-Pos(ft)	Depth(ft)	Time(ns)	Elev(ft)	Amp(mV)	Vel(ft/ns)	GPS-Lat(deg)	GPS-Long(deg)
Point	Pipe1	LINEX5.DT1	18.033	0	7.122	43.52	0	6.847	0.328	37.936765	-75.4814433
Point	Pipe1	LINEX0.DT1	18.772	0	6.261	38.28	0	27.044	0.328	37.936765	-75.4814433
Point	Pipe1	LINEY5.DT1	8.337	0	7.528	45.99	0	-2.228	0.328	37.936765	-75.4814433
Point	Pipe1	LINEY1.DT1	9.187	0	8.067	49.27	0	-10.575	0.328	37.936765	-75.4814433
Type	Interpretation	GPR-Line	X-Pos(ft)	Y-Pos(ft)	Depth(ft)	Time(ns)	Elev(ft)	Amp(mV)	Vel(ft/ns)	GPS-Lat(deg)	GPS-Long(deg)
Polyline	Horizon1	LINEX0.DT1	0.146	0	4.233	25.96	0	2.208	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEX0.DT1	5.177	0	4.233	25.96	0	7.338	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEX0.DT1	7.51	0	4.151	25.47	0	1.827	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	0.143	0	2.76	17.06	0	-4.067	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	3.399	0	2.883	17.8	0	-10.312	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	5.653	0	2.883	17.8	0	-1.971	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	7.049	0	2.965	18.3	0	-1.553	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	8.874	0	3.006	18.54	0	-1.698	0.328	37.936765	-75.4814433
Polyline	Horizon1	LINEY5.DT1	8.874	0	3.006	18.54	0	-1.698	0.328	37.936765	-75.4814433

Interpretation Report in CSV format.

Some of the reports possible from various GPR applications include:

Concrete

- Rebar positions
- Cover depth with min, max, average and median
- Thickness variations over a large slab of concrete

Geotechnical

- Depth to bedrock maps
- Quantifying stratigraphic structure
- Fracture zones and Sinkhole locations
- Areas of high GPR signal attenuation

Utilities

- Utility positions and depths
- Trenched areas

Forensics & Archaeology

- Positions of targets and disturbed soil
- Grave locations in cemeteries

EKKO_Interp utilizes GPR Project (GPZ) files; compressed files containing the GPR data files (DT1 and HD) as well as ancillary files such as GPS, Elevation, etc.

The interface is simple and intuitive following the same standard format as the EKKO_View software.

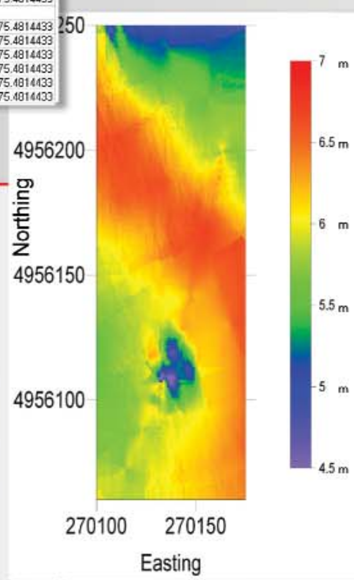
The user interactively creates interpretations on the GPR cross-section data images. Four types of interpretations are available: Points, Polylines, Boxes and Annotations. Each interpretation has automatic or user-defined properties like color, style, markers and marker size which make it easy to distinguish between them. Interpretations are stored in an integrated database.

Points are used to mark hyperbolas and other point targets.

"Polylines" can consist of one or more shorter segments. Boxes are any rectangular shape. Annotations have a line that points to a specific location in the data image.

Editing tools allow the user to easily add, move, delete and insert points, including adding points or a new segment to an existing polyline. Polylines are easily cut or two parts of a polyline can be joined together. Boxes can be resized and Annotations are easily moved to new locations on the image.

Interpretations are not restricted to a single cross-section image; they can span multiple images.



Bedrock surface interpretation plotted in Surfer, a third-party 2D plotting program.

Often-used interpretations can become "templates" so they are available for new projects. For example, if your interpretation is a red-colored polyline called "Bottom of Concrete" and you want to use it with other projects, make it a template.

Interpretations are exported in 3 ways:

- As a graphics image file (JPG, BMP, TIF, etc.) of the GPR data image with interpretations superimposed
- As a graphics image file (JPG, BMP, TIF, etc.) of the interpretations only
- CSV (Comma Separated Values) files with the quantitative values for the interpretations, i.e. positions along the GPR line, GPS (if available), depth, time, signal amplitude etc.

These files are easily included in reports or imported into other software like GIS software.

EKKO_Interp works with all Sensors & Software GPR hardware to provide another dimension in displaying GPR data.

For more information or to receive a demo, contact one of our application specialists at sales@sensoft.ca or visit www.sensoft.ca. ■

Glass Rebar

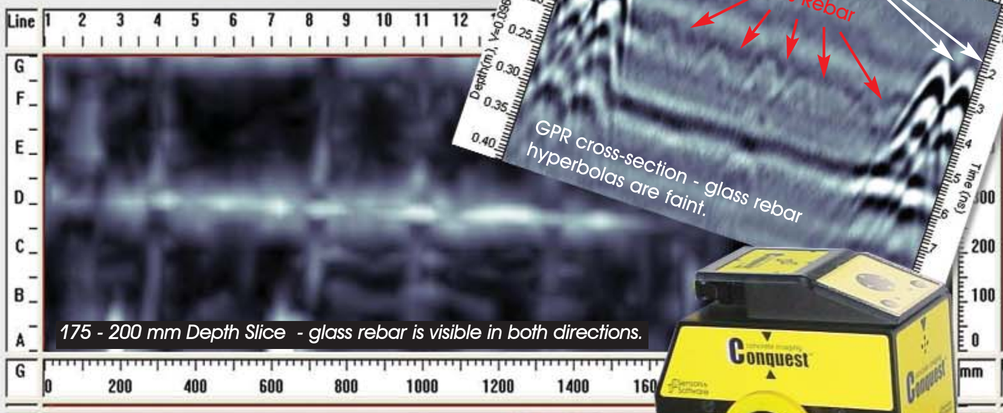
(continued from page 1)

However, the electrical properties of glass are not drastically different from the concrete, so we predict that the responses from glass rebar will be weaker.

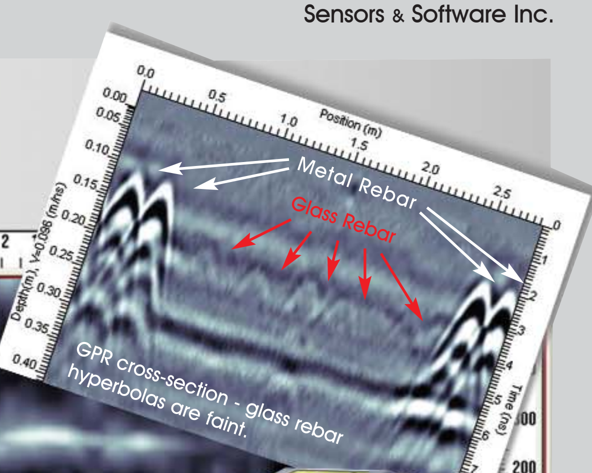
In our case study, a hospital required installation of a cylindrical vessel on a concrete slab containing steel rebar. For electromagnetic considerations, there couldn't be any steel rebar in the vicinity of the vessel. Part of the concrete slab was removed and replaced with concrete containing GFRP rebar. Conquest was subsequently used to scan the concrete slab before further holes were drilled for mounting equipment.

Looking at the cross-section data we see that the hyperbolas are, as expected, very faint when compared with the nearby steel rebar. The Gain value had to be increased to see the response from the glass rebar.

A 0.6 m x 2.4 m grid was laid down on the concrete over the area of glass rebar. In the 175-200 mm depth slice the glass rebar is visible in both directions, though certainly not as sharply defined as steel rebar.



175 - 200 mm Depth Slice - glass rebar is visible in both directions.



GPR cross-section - glass rebar hyperbolas are faint.

Glass rebar

The glass rebar simply does not reflect as much of the GPR signal due to its material properties.

When dealing with such variable contrasts, we highly recommend viewing the data interactively on a PC using ConquestView or EKKO_Mapper software where a large degree of flexibility and iterative adjustments of gain, contrast, sensitivity and colour can be used to extract subtle features more effectively.

For all Conquest data, glass rebar or not, it is important to always look at the raw cross-section data in conjunction with the plan views to ensure that you are seeing everything in the concrete. ■

GPR Tips

Sometimes GPR signals look like they are penetrating to great depth into the subsurface when in fact they are not. The signals seen at deeper depths can be airwaves caused when the GPR signals reflect from objects in the air. Surprisingly, in some cases these signals can be from objects hundreds of feet from the GPR survey line.

Airwave reflectors from above surface objects like trees and metal towers can look like deep subsurface penetration.

Example 1: The GPR shows signals returning from as deep as 18 feet. The deeper signals have a trough-like shape and the operator originally interpreted a sinkhole in the bedrock surface.

A closer inspection of this cross-section image reveals that many of the deeper signals have a hyperbolic shape. When the hyperbola-fitting method is used to calculate the velocity to these reflectors, it is 0.3 m/ns or 0.98 ft/ns; the speed of light (and GPR signals in air).

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Technical Papers & Notes

1. **Subsurface Utility Engineering: An Asset for All Infrastructure Projects.** Water Utility Infrastructure Management, January/February 2009 Issue, pp. 32-34
By: Nicholas M. Zembillas
2009 **ref 395**

2. **Assessment of agricultural drainage pipe conditions using ground penetrating radar.** Proceedings of the Symposium on the Application of Geophysics to Engineering & Environmental Problems, p.913-928.
By: J.D. Redman, B. Allred
2009 **ref 396**

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http://excavationsafetyonline.com/

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Keystone, CO
April 11 - 15, 2010
http://www.eegs.org/sageep/index.html

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

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GPR Tips

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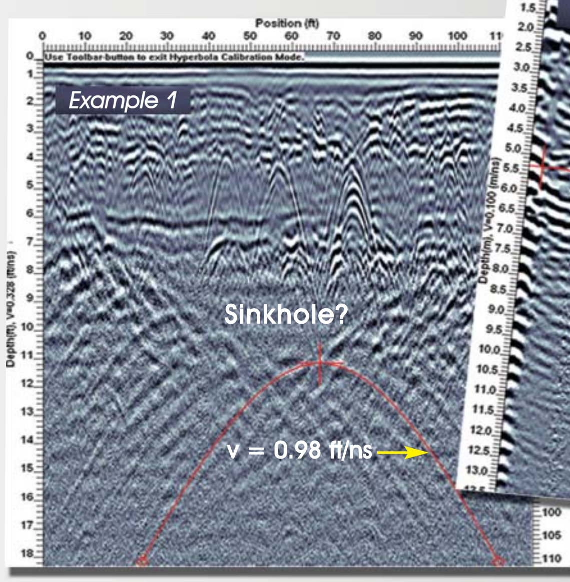
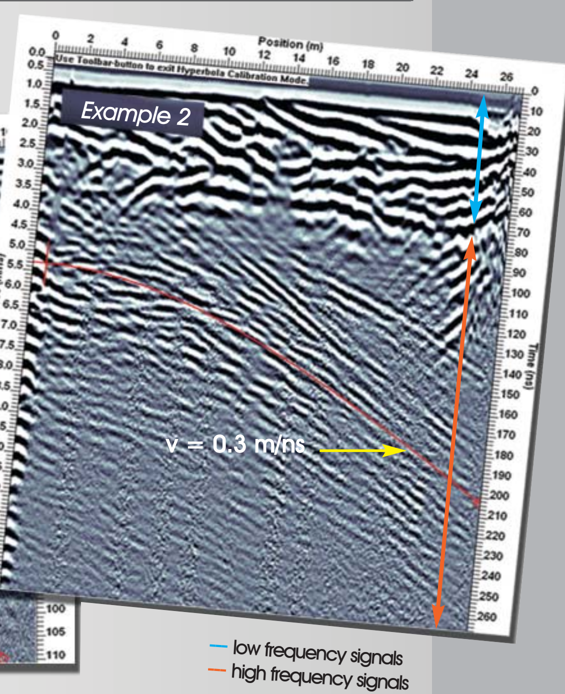
This suggests that the deeper reflections were a result of GPR signals reflecting from multiple above-surface targets (most likely trees) at various distances from the GPR survey line.

Example 2: Again, the operator thought that penetration was about 13+ metres because deep signals are visible but the actual penetration was about 4 or 5 metres. This example provides two clues that the deeper signals are airwaves:
1) Like example 1, fitting a hyperbola with the velocity of air shows that the deeper signals are parallel and therefore airwaves,
2) The deeper airwave signals are higher frequency than the shallower subsurface signals.





Lower frequency GPR signals tend to couple better into the earth. The higher frequencies in the GPR signal are preferentially attenuated by the ground, leaving lower frequencies. In comparison, the airwave signals tend to be higher frequency. You can see this frequency difference by measuring peak to peak (white to white) distances of the shallower ground signals compared to the deeper airwave signals. The shorter distance between the peaks in the deeper signal indicates a higher frequency signal, related to airwaves.

Air waves are more prevalent when using unshielded antennas but can also occur with shielded antennas because shielding is never 100 percent effective. Always look at your data with a critical eye and be suspicious if something doesn't look right. ■

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