GPR technology
Vol 2, No. 8
Fall 2006

Subsurface Views

Sensors & Software Inc.

pulseEKKO® PRO: Advanced Survey Techniques

Structure Transillumination

Typical GPR reflection surveys rely on the transmitting and receiving antennas being close together on the surface to collect signals that have reflected from the subsurface.

Borehole transillumination techniques, where signal is sent from one borehole to another or from the surface to a borehole, were described in our previous issue. Transillumination surveys can also be conducted on structures like walls, pillars, monuments, and even dams to image the internal structure and extract material properties.

Transillumination surveys use transmitting and receiving antennas placed on opposite sides of a structure. Anomalous areas are indicated by variations in the travel time, amplitude and period of the GPR signal after it has passed through the structure (see Figure 2 in last newsletter).

An operational transillumination measurement with the transmitting antenna on one side of a structure and the receiving antenna on the other side is shown in Figure 1a. A Zero Offset Profile (ZOP) quickly identifies anomalous zones in rectangular (Figure 1b) or cylindrical structures (Figure 1c).

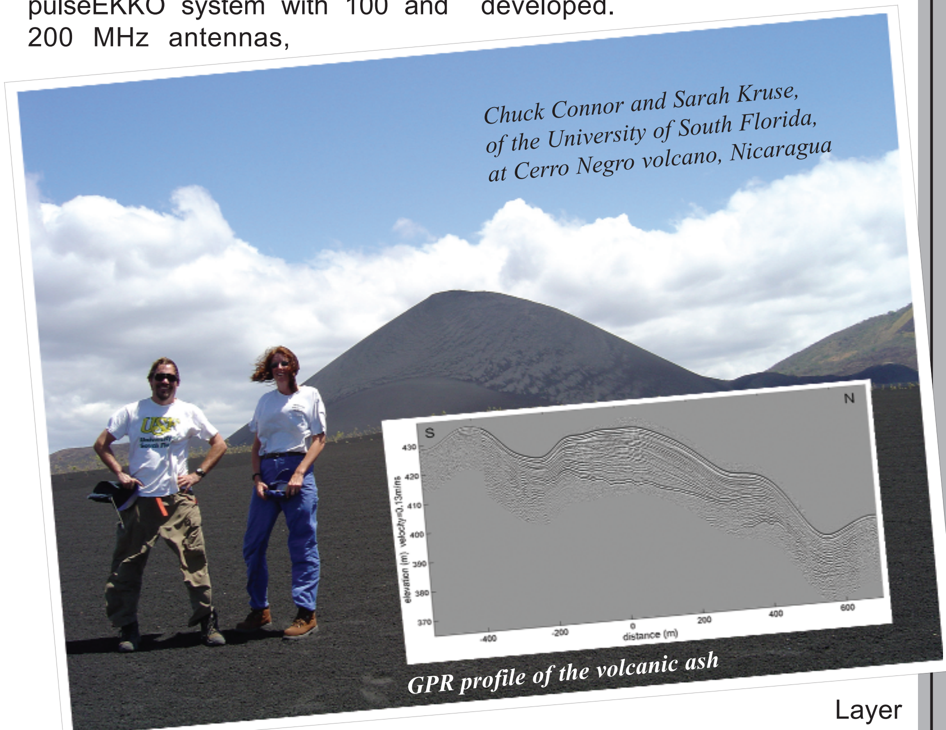
(continued on page 2)

From our customers files:

Volcanic ash imaging

GPR profiling conducted by a University of South Florida team on the Cerro Negro volcano in Nicaragua in 2004 was highly successful. Using a pulseEKKO system with 100 and 200 MHz antennas, data were collected across a blanket of tephra deposits (volcanic material transported through the air) which extends downwind (southwest) from the small cinder cone.

Cerro Negro has erupted repeatedly since 1850, most recently in 1995. Ash from these eruptions impacts León, Nicaragua's second largest city. By imaging the sequence of deposits from various eruptions, Cerro Negro's explosive eruption mechanisms can be understood and constraining models for volcano processes can be developed.



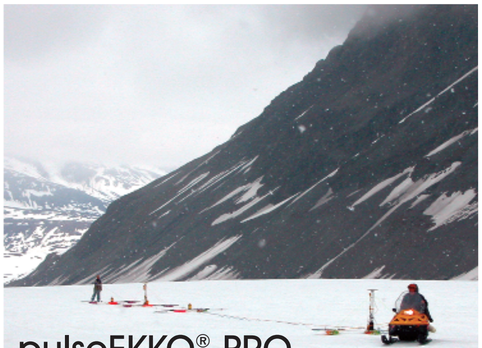
Chuck Connor and Sarah Kruse, of the University of South Florida, at Cerro Negro volcano, Nicaragua

GPR profile of the volcanic ash

Layer thickness from individual eruption events are especially useful for the latter.

(continued on page 3)

In This Issue



pulseEKKO® PRO Multi-Channel

An Alaskan story

Dr. John Bradford and students Josh Nichols and Dylan Mikesel from Boise State University collected a multi-azimuthal, multi-offset 3D survey using a pulseEKKO PRO Multi-Channel system on the Bench glacier in Alaska in June 2006. The data were acquired as part of an ongoing NSF funded project designed to measure the volume and distribution of water in the englacial system. Dr. Bradford will be presenting results of this survey at the American Geophysical Union Conference in San Francisco in December. ■

Multi-Channel Adapter

Visit: www.sensoft.ca to see more details on pulseEKKO PRO Multi-Channel Adapter.

Structure Transillumination *(continued from page 1)*

In the case of an air-filled cavity in the wall, the travel time would decrease because GPR signals travel faster in air than stone, concrete or other materials. The result is a GPR image like Figure 2.

Cross-sectional image reconstruction with transillumination data requires numerous Multiple Offset Gather (MOG) surveys. A MOG is collected by fixing the transmitting antenna at one location and collecting data traces as the receiving antenna is moved to many locations around the structure. This provides traces from as many different angles through the material as possible (Figure 3) and improves the accuracy of the image.

Tomographic analysis of the MOG data produces two-dimensional images of the structure including velocity, attenuation and dispersion. An example from a water tank experiment shows a high attenuation zone resulting from a large metallic cylinder placed vertically in the tank (Figure 4).

Correct positioning of the transmitter and receiver is critical for accurate images from transillumination surveys so odd-shaped structures like statues are challenging to survey. As well, structures like reinforced concrete columns can be difficult to image when there are many metal rebars that strongly scatter GPR signals and reduce direct signal transmission.

Similar to medical images of the body, structure transillumination provides an effective technique for imaging inside structures. Multi-channel systems like the pulseEKKO PRO can dramatically increase data acquisition speed with multiple transmitters and receivers. This, coupled with faster data analysis, opens many possibilities for the quick and accurate non-destructive testing of structures. ■

Figure 1a

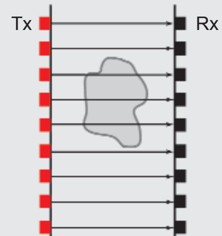


Figure 1b

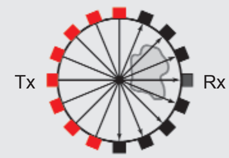


Figure 1c

***Figure 1:** Zero Offset Profiles (ZOPs)*

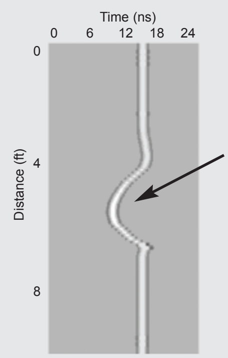


***Figure 2:** ZOP data image from a wall*

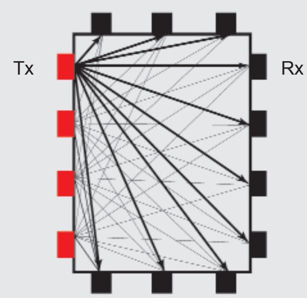


***Figure 3:** Multiple Offset Gather (MOG)*

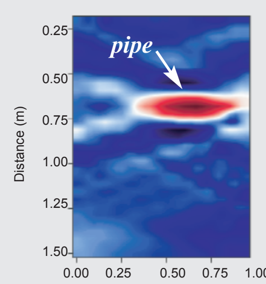
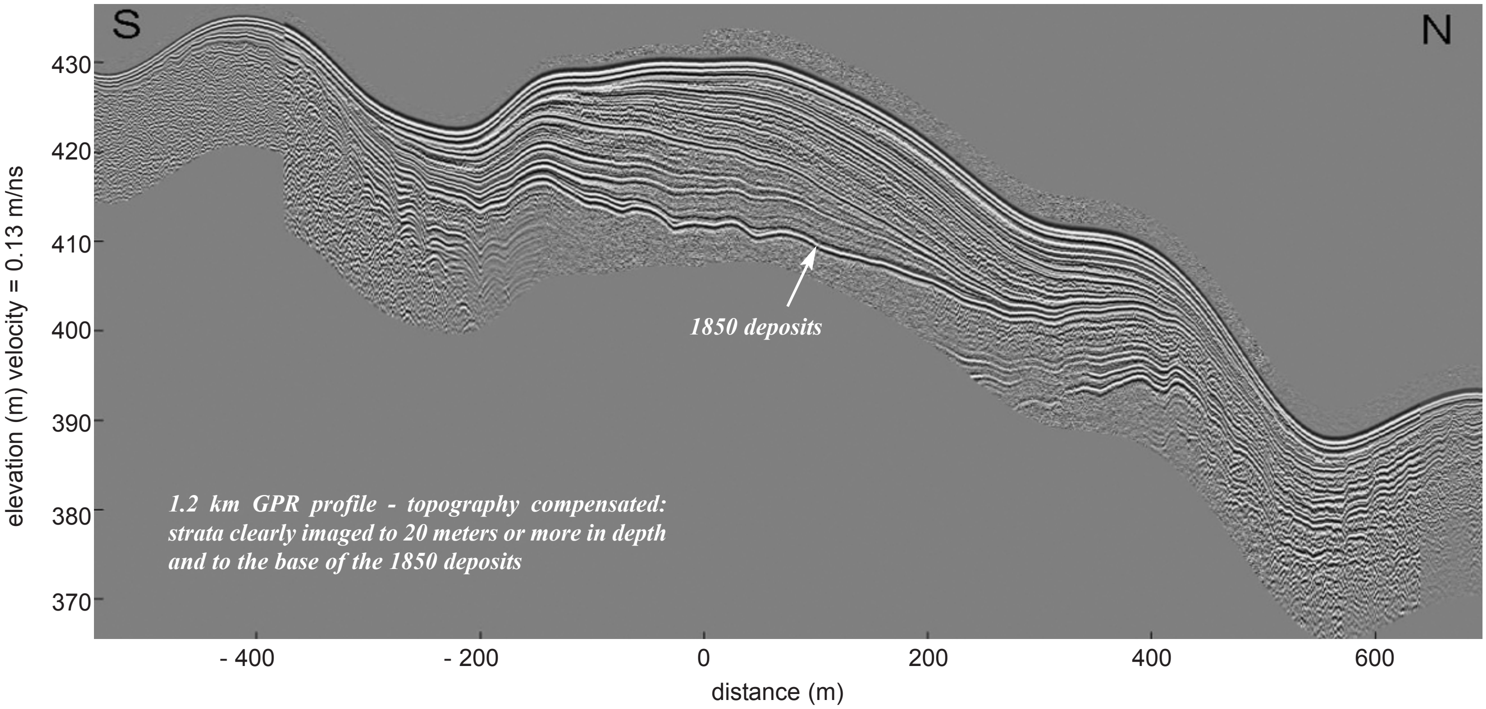


***Figure 4:** Plan view attenuation image from a water tank experiment. The vertical pipe is clearly imaged as an area of high attenuation.*

Volcanic ash imaging

(continued from page 1)



Strong GPR reflecting horizons within the tephra blanket represent the paleosols (old soil) or weathered horizons that formed between distinct eruptions. The data were collected during a dry period and velocities ranged from 0.12 to 0.16 m/ns, based on common-midpoint surveys. Penetration in the dry resistive tephra deposits exceeded 20 meters and the deposits from the 1850 eruption could be imaged.

The Cerro Negro GPR images are particularly valuable because they illuminate otherwise inaccessible terrain. Trenches can be used to estimate the thickness of deposits far from the vent of the volcano, where deposits are thinner. Excavations tend to collapse at depths of more than 1.5 meters making data on the thicker deposits close to the vent hard to obtain. Results from this survey suggest that the current models for tephra deposition from explosive eruptions do a good job of predicting the thickness of deposits far from the vent, but break down close to the vent where the volcanic activity is more complicated. In the future we plan surveys closer to the vent. (Harmonic tremors in the vent at the time of this survey indicated it was not a good time to get TOO close.) With more data, a more complete record of near-vent processes like fire-fountaining and volcanic block ejections will be obtained.

This work is part of a recent resurgence of interest in using GPR in volcanic environments. At the GPR 2006 conference several presentations featured GPR's remarkable imaging of volcanic deposits.

This work was conducted by Sarah Kruse, Chuck Connor and Kristin Martin of the University of South Florida, with field support from the Instituto Nicaraguense de Estudios Territoriales (INETER).

Data and site description courtesy of Dr. Sarah Kruse, University of South Florida.

If you have an interesting GPR story to share, contact us.

Ask the Expert

Can GPR be used to detect coins?

In general, individual coins are too small to be reliably imaged with GPR. In an ideal situation, where a coin is relatively shallow (< 0.3m) and positioned horizontally in a homogeneous material like sand, it can be imaged with high frequency (1000 MHz) GPR. But these situations rarely occur outside of controlled laboratory conditions.

In the real world, a coin at an arbitrary angle would reflect most signals away from the GPR receiver.

(continued on page 4)

Recent Technical Papers

1. Ground-Penetrating Radar Surveys at the West Point Foundry, Cold Spring, NY, Society for Industrial Archeology Newsletter, Vol. 34, No. 1, p. 11-12.
By: Finch, K.
2005 ***ref 342***

2. Early-Time GPR Signal Analysis: Implications for Water Content Measurement, Delft Abstract (to be published).
By: Pettenelli, E., Di Matteo, A., Paolucci, F., Bella, F., Mattei, E. Riccioni, S., De Santis, A., Vannaroni, G., Cereti, A., Del Vento, D., Annan, A.P.,
2005 ***ref 344***

3. Subsurface Imaging Using Non-Intrusive Ground Penetrating Radar, American Cemetery, Vol. 74, No. 6 (June 2002), p. 22, 24, 56.
By: Hutchinson, P.J., Barta, L.S., Young, S.1999
2002 ***ref 349***

4. Concrete inspection with GPR - Advances in Analysis
By: A.P. Annan, J.D. Redman, T.De Souza,
2006 ***ref 362***

Upcoming GPR courses

One Day Noggin® Short Course
November 6, 2006
January 8, 2006

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

One Day Conquest™ Course
November 7, 2006
January 9, 2006

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

See us at ...

SEG New Orleans
New Orleans, LA
October 1 - 6, 2006
http://meeting.seg.org

SEAoT
San Antonio, TX
October 19 - 21, 2006
www.seaot.org

GSA 2006
Philadelphia, PA
Oct. 22-25, 2006
www.geosociety.org/meetings/2006

ASNT Fall Expo
Houston, TX
October 23 - 27, 2006
www.asnt.org

ACI Fall 2006 Convention
Denver, CO
November 5 - 9, 2006
www.concrete.org

Damage Prevention Conference
Phoenix, AZ
December 6 - 7, 2006
www.damageprevention.com

AGU Fall Meeting
San Francisco, CA
December 11 - 15, 2006
www.agu.org

Information Request

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

- ☐ pulseEKKO® PRO
- ☐ Conquest™
- ☐ ConquestView
- ☐ OEM Noggin*plus*
- ☐ RoadMap™
- ☐ pulseEKKO® Borehole GPR
- ☐ 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

(continued from page 3)

Coupled with the fact that typical soils are full of heterogeneities (rocks, roots and other objects) recognizing the reflection from a coin is very unlikely. Customers who have had success using GPR for treasure hunting have done so by: *1) finding larger caches of coins and jewels, 2) locating larger artefacts associated with the treasure or 3) detecting the disturbed soils and trenches related to the burial.*

In an upcoming newsletter, we will have the story of a customer who successfully uses a Noggin for locating buried historical objects. ■

Sensors & Software Inc.
1040 Stacey Court
Mississauga, ON L4W 2X8 Canada
Tel: (905) 624-8909
Fax: (905) 624-9365
Email: sales@sensoft.ca
Website: www.sensoft.ca