

## Phoenix AMT for Tunnel Survey

**P**hoenix MTU-5A equipment has been used successfully for a 300-site AMT survey in Ecuador.

The six-month survey, performed by two Italian geophysical firms, Techgea Servizi and GDTest, ran from September 2010 until February 2011; it was part of a feasibility study for a hydroelectric power development plan that includes several deep tunnels (500m to 1000m) and an underground power station.

The survey objective was geological prediction for deep tunneling with a tunnel boring machine (TBM). TBMs are used as an alternative to drilling and blasting in rock and conventional “hand mining” in soil. A fundamental requirement of successful tunnelling is accurate prediction of rock type and conditions along the tunnel route.

The specific objectives of this survey were to identify the main geological contact between soft rock (volcanic tuffs) and hard rock (granodiorite intruded in schists and quartzitic schist) as well as to detect the main faults (some of them with water circulation and fault gouge).

The 300 AMT soundings were closely spaced (50 or 100m apart) on a line along the discharge tunnel route (2D data processing) and on a regular grid above the underground power station location (3D data processing). Difficult terrain conditions (dense vegetation, slippery clayey soil and irregular ground surface) coupled with the tropical weather (rain for most of the time) slowed the survey, but the lack of noise allowed short time data acquisition with very stable data.

Data was processed with Winglink, and



provided consistent 2D resistivity sections. Resistivity of soft rock was usually fairly low ( $< 200$  ohm-m), while hard rock (granodiorite and metamorphic rocks) showed higher resistivity. Lower resistivities were also measured in the fault zones, due to water content and rock softening.

From their experience in the Ecuador project, the Italian team drew the following conclusions about the use of AMT in geotechnical/engineering studies:

- AMT is useful for such deep investigations. The small-footprint system provides a significant logistic advantage. AMT uses a natural source, so there is no need to inject energy into the ground; this is a significant cost saving.

Dense vegetation, slippery trails and almost constant rain slowed down the survey; the MTU-5 is under a plastic sheet and leaves.

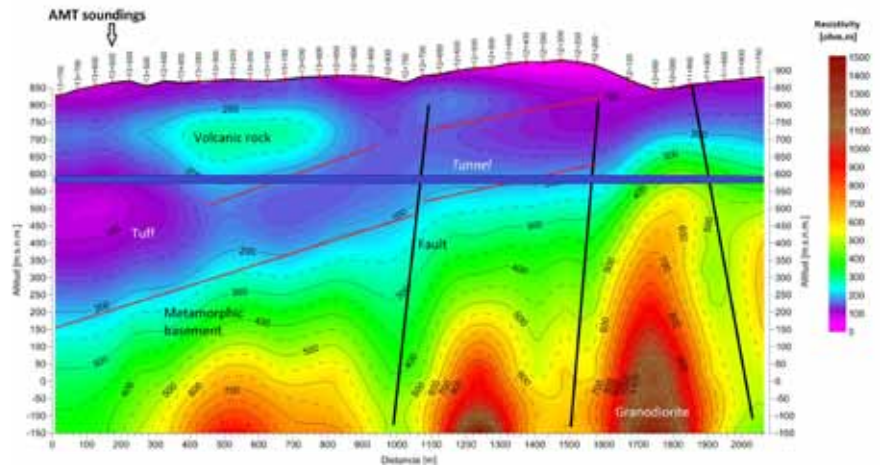
### CONTENTS

- 2 Tunnel Survey cont'd
- In Memoriam
- Welcome
- 3 Around the World
- 4 On the Road
- Around the World
- Coming Up

*(Continued on page 2)*

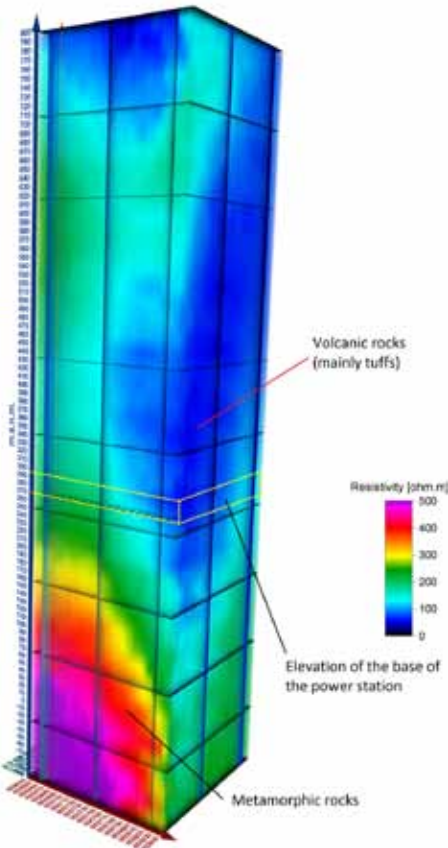
## Tunnel Survey *continued from front*

- In difficult terrain such as that encountered in Ecuador, or in places where blasting is forbidden, AMT is a useful alternative to the seismic reflection method.
- Depending upon the resistivity contrasts expected, AMT could be useful in any similar project that involves deep tunneling.



**Above:** The AMT section above the “tunel de descarga” (discharge tunnel) shows a thick cover of tuffs atop the metamorphic basement. The tuff cover is gently inclined (15-20 degrees), probably due to tectonic tilting. According to the geophysical model (calibrated with some deep boreholes), tunneling will mostly be in soft rocks (tuffs).

**Left:** The ~3D model (obtained from parallel 2D lines) for the “casa de Maquina” (underground power station). This model, calibrated with a 600m borehole, indicates the underground power station will be only in soft rocks (tuffs), with resistivity ranging from 100 to 250ohm.m.



## WELCOME

Carolyn Moore attended Durham College, Oshawa, where she played varsity fastball for three years and graduated with an accounting diploma. After working as a cash room clerk for a security firm, Carolyn joined our production department in May 2010. She is an assembly technician building MTU-5As. Outside work, Carolyn enjoys camping and playing hockey and baseball.



Marc Nolan joined the Phoenix Geophysics production department last November, just days before he and his wife Shauna welcomed their first child, Carrick Matthew Michael Nolan, born November 6. Marc has travelled extensively and studied a variety of subjects including history, culinary arts and biodynamics. He trains in various martial arts and remains a competitive athlete who plays baseball and basketball. In his free time he loves to cook and be with his family.

## In Memoriam

The founder of Scintrex Geophysics, Dr. Harold O. C. Seigel, died July 13, 2011 at Toronto. Dr. Seigel was a world renowned geophysicist but “a prospector at heart”. In 1995, he was inducted into the the Canadian Mining Hall of Fame.

For more about Dr. Seigel’s accomplishments:

[http://mininghalloffame.ca/inductees/s-u/harold\\_o.\\_seigel/](http://mininghalloffame.ca/inductees/s-u/harold_o._seigel/)



Photo: Jenny Chen

For the second year, Phoenix employees pulled a FedEx cargo jet to raise money for ORBIS; again our team had the fastest pull, besting 37 other teams by moving the 57,800kg Boeing 757 a distance of 3.65m in just 6.129 seconds. Phoenix matched the funds raised by employees for a total donation of \$7,714.



## Canada

Phoenix completed a 3D Oil and Gas MT survey in eastern Quebec in June and July. Braden Fox snapped this photo of some of his fellow field crew members. **Right:** From left to right are Alexander Golyashov, Murat Urakov, Doris Labrecque, Charles Samson and Jean-Phillippe Proulx. In the background is Percé Rock in the Gulf of St. Lawrence. One of the largest natural arches in the world, the massive limestone stack is 433m long, 90m wide and 88m at its highest point.



## Australia

A regional survey with Phoenix equipment was performed to investigate the crustal architecture of the Southern Yilgarn Craton of Western Australia. The project was sponsored by the Centre for Exploration Targeting at the University of Western Australia. Thanks to Shane Evans for the great photographs. **Left:** Digging the vertical are, left to right, Luis Gallardo (University of Western Australia), Mike Dentith (University of Western Australia), Shane Evans (Moombarra Geoscience) and Aurore Joly (University of Western Australia). **Inset left:** a thorny devil, an Australian lizard, visited the survey. Although it looks fearsome with its dinosaur-like profile and a body covered with conical spines, it is slow-moving, small (about 15cm) and eats only ants.

## Colombia

In May and June, Alex Golyashov and Carlos Guerrero were in Bogota for training and acceptance at INGEOMINAS, Colombia; the Institute took delivery of the first two Phoenix systems in the country. The equipment will initially be used for geothermal exploration and later for mining applications. **Right:** Surrounded by INGEOMINAS employees are Carlos Guerrero, centre, with Alex Golyashov to his left and, to his right, Wilson Quintero Camacho, Project Manager of INGEOMINAS.



## Costa Rica

Our client ICE (Instituto Costarricense de Electricidad) has ordered a substantial upgrade to their pool of Phoenix equipment.

## Iceland

ISOR has expanded their system and Phoenix has a new client, Reykjavik Geothermal, that is initially using our equipment in Ethiopia.

## ON THE ROAD

**Botswana** Tes Haile (far right) visited the Geological Survey of Botswana earlier this year; with him are Principal Geophysicist Mojaboswa Hilary Kocketso and Director Tiyapo Hudson Ngwisanyi, both of whom earned their M.Sc. in Geophysics in Canada.

**Russia** In May, Olex Ingerov attended an EM seminar in St. Petersburg where he chaired a session and gave two scientific lectures. In June, he attended MIOGE 2011, the Moscow International Oil and Gas Expo. **Right:** In our booth with Olex (left) is Professor Zaytsev, an expert in magnetic observatories at the Institute of Earth Physics, Russia Academy of Science.

**Brazil** In August, Carlos Guerrero and Leo Fox attended the Brazilian Geophysical Society meeting in Rio de Janeiro.



## PHOENIX AROUND THE WORLD



**Brazil** Geologists Hudson Coslop and Isabella Giesta and geophysicist Patricia de Lugaõ, all with Stratimage, set up site parameters for 100-site MT survey over a 3D grid to evaluate dip extension of an orebody already in production. The survey area experienced high levels of noise from the mining operation and nearby villages and powerlines, but data quality was good. Stratimage is also conducting a pilot survey along a pre-existing seismic line for Petrobras.

## COMING UP

- **October 5– 8:** Phoenix will have a booth in the Canada Pavilion at KIOGE, the 19th Kazakhstan International Oil and Gas Expo held in Almaty.
- **October 10–13:** GEM, Beijing, China. Our agent will have a booth at this international workshop on electrical and magnetic methods and their applications.
- **October 17–18:** St. Petersburg, Russia, SPMI EM seminar
- **November 18–20:** our China agent, Hengda, will have a stand at the 10th China Geo-electromagnetic workshop, Beijing, China.



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