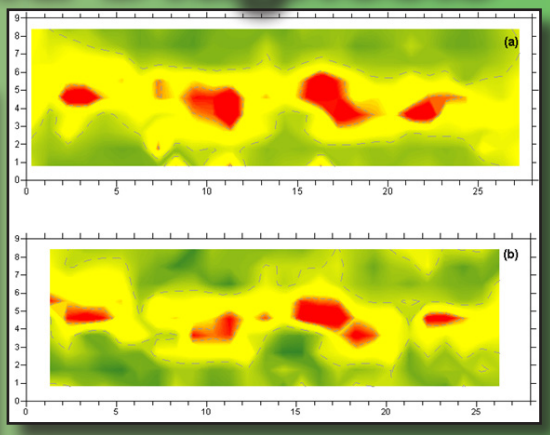
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July 2010
Volume 15, Number 2
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Civil Infrastructure Health Monitoring and Diagnosis



Half-Cell Potential Map



P-Wave Velocity Tomography



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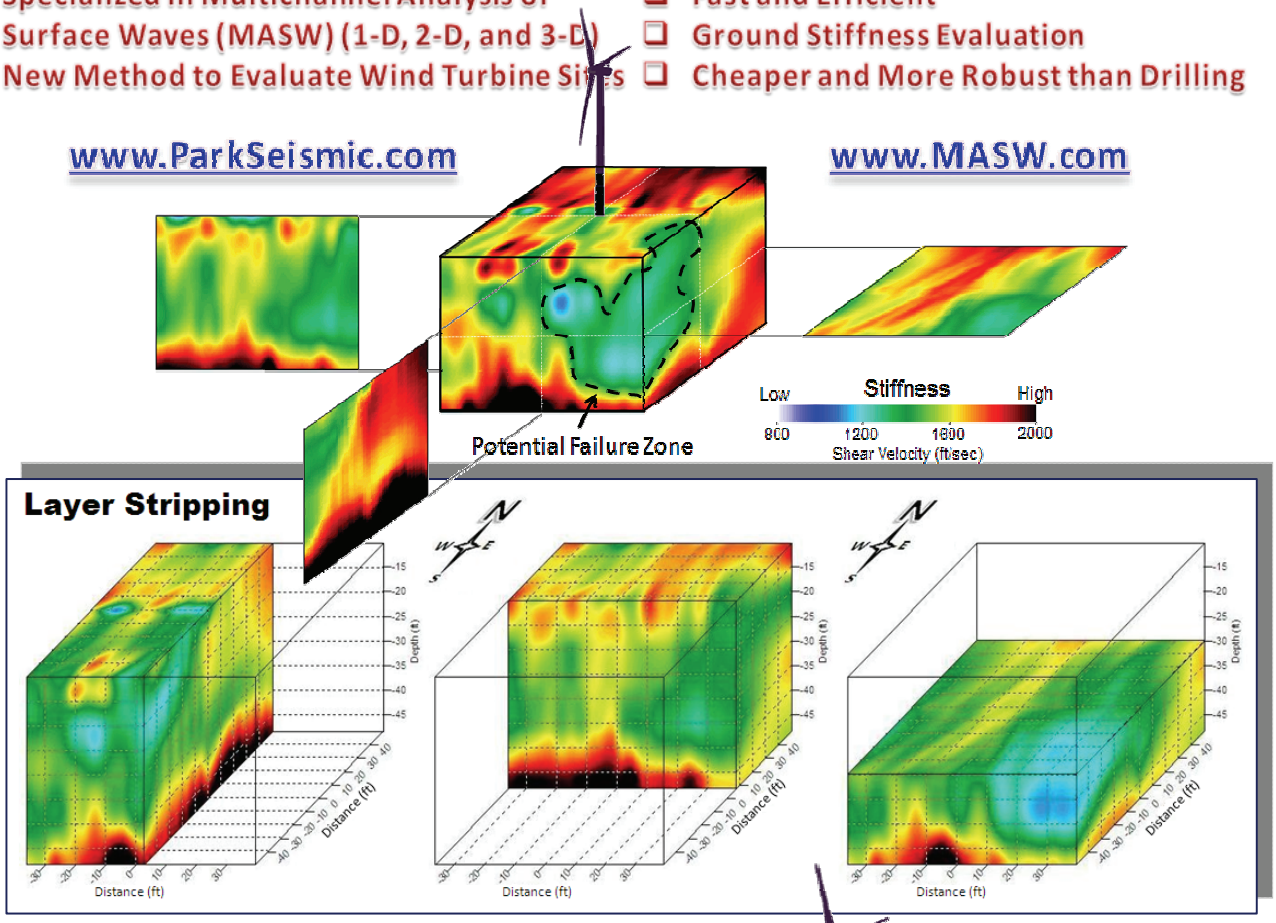
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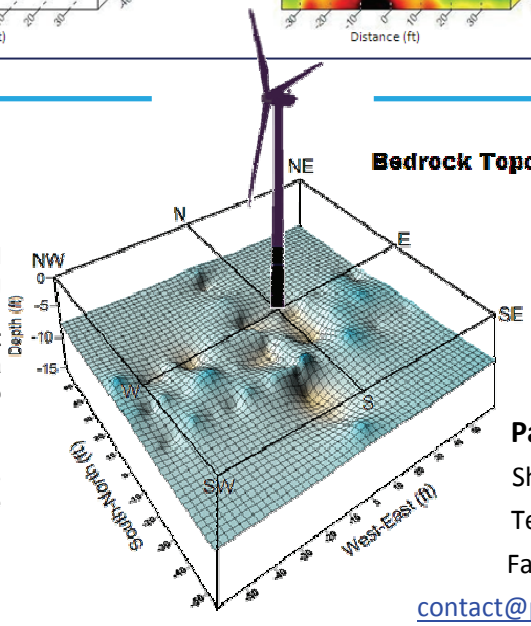
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On the Cover

This issue features geophysical techniques for investigating the health of civil engineering structures. **Upper right:** Half-cell potential map showing the extent of corrosion in reinforced concrete. **Lower left:** Result of compressional wave velocity tomography survey conducted on the vertical section of a gravity dam. **Lower right:** John Stowell, EEGS and Mount Sopris President, demonstrates borehole geophysical instruments at Penn State's hydrogeophysics field camp.

What We Want From You

The ***FastTIMES*** editorial team welcomes contributions of any subject touching upon geophysics. For the upcoming issue of ***FastTIMES***, the editors accept technical papers and general reviews related to geophysical investigation of subsurface phenomenon. ***FastTIMES*** also accepts photographs and brief noncommercial descriptions of new instruments with possible environmental or engineering applications, news from geophysical or earth-science societies, conference notices, and brief reports from recent conferences. Please submit your items to a member of the ***FastTIMES*** editorial team by September 15, 2010 to ensure inclusion in the next issue.

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FastTIMES

FastTIMES (ISSN 1943-6505) is published by the Environmental and Engineering Geophysical Society (EEGS). It is available electronically (as a pdf document) from the EEGS website (*www.eegs.org*).

About EEGS

The Environmental and Engineering Geophysical Society (EEGS) is an applied scientific organization founded in 1992. Our mission:

"To promote the science of geophysics especially as it is applied to environmental and engineering problems; to foster common scientific interests of geophysicists and their colleagues in other related sciences and engineering; to maintain a high professional standing among its members; and to promote fellowship and cooperation among persons interested in the science."

We strive to accomplish our mission in many ways, including (1) holding the annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (**SAGEEP**); (2) publishing the ***Journal of Environmental & Engineering Geophysics (JEEG)***, a peer-reviewed journal devoted to near-surface geophysics; (3) publishing ***FastTIMES***, a magazine for the near-surface community, and (4) maintaining relationships with other professional societies relevant to near-surface geophysics.

Joining EEGS

EEGS welcomes membership applications from individuals (including students) and businesses. Annual dues are currently $90 for an individual membership, $50 for a retired member $20 for a student membership, $50 developing world membership, and $650 to $4000 for various levels of corporate membership. All membership categories include free online access to JEEG. The membership application is available at the back of this issue, or online at *www.eegs.org*. See the back for more information.

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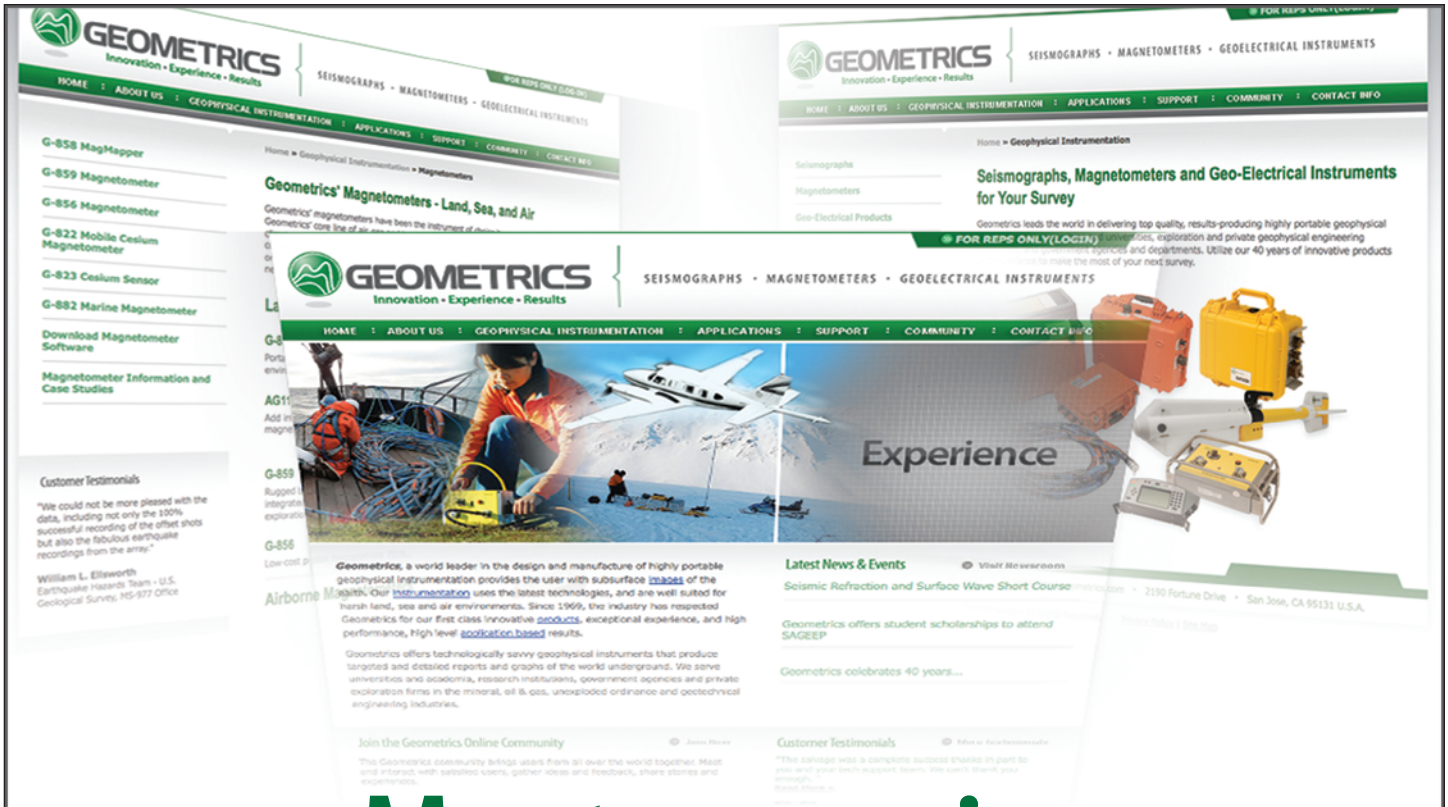
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FastTIMES is published electronically four times a year. Please send articles to any member of the editorial team by May 31, 2010. Advertisements are due to Jackie Jacoby by May 21, 2010.

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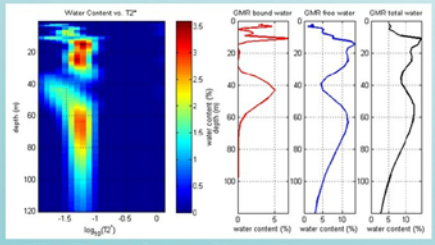
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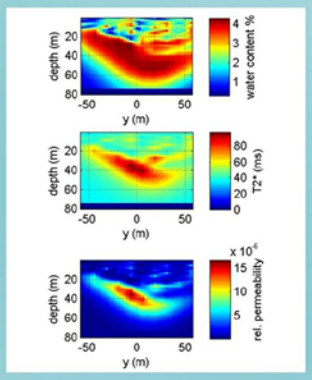
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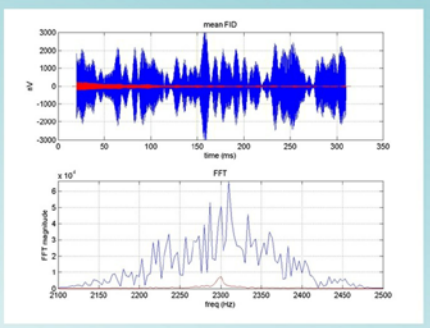
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Calendar

*Please send additions, errors, and omissions to a member of the **FastTIMES** editorial team.*

2010	
August 22-26	*ASEG/PESA 2010*: 21st International Conference & Exhibition of the Australian Society of Exploration Geophysics, Sydney, Australia
August 31	Deadline for submission of articles, advertisements, and contributions to the September issue of *FastTIMES*.
September 5–10	*IAEG 2010*: 11th Congress of the International Association for Engineering Geology and the Environment, Auckland, New Zealand
October 17–22	State-of-the-Art in Multi-Dimensional Electromagnetics: A Special Session in Honor of Gerald W. Hohmann, Denver, CO
November 30	Deadline for submission of articles, advertisements, and contributions to the December issue of *FastTIMES*.

2011	
January 10–14	*12th Multidisciplinary Conference on Sinkholes and Engineering and Environmental Impacts of KarstTM*, St. Louis, Missouri
February 28	Deadline for submission of articles, advertisements, and contributions to the December issue of *FastTIMES*.
April 10–14	SAGEEP 2011: Symposium on the Application of Geophysics to Environmental and Engineering Problems, Charleston, SC





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Notes from EEGS



President's Message: SAGEEP 2010 Recap

John Stowell, President (john.stowell@mountsopris.com)

The 2010 SAGEEP, held in Keystone, Colorado proved to be an extremely interesting and successful conference. The venue, the Keystone Conference Center, located in the high Colorado Rockies, is a first class facility. The program, crafted by General Chair Vic Labson and Technical Chair Jim LoCoco, along with support from the local organizing committee, covered a wide scope, with special sessions drawing participants from new disciplines to our conference. The keynote speaker, Dr. Robert Grimm, Director of the Department of Space Studies at Southwest Research Institute, enthralled the audience with his presentation on extraterrestrial near-surface geophysics. Our early career award winner was Dr. Niklas Linde, from the Institute of Geophysics at the University of Lausanne. Dr. Linde's presentation highlighted work being done at the Institute in joint inversions of various data types applied to hyrogeophysics.

With nearly 300 participants, a sold-out exhibit hall, 4 well attended short courses, and a workshop on Airborne Geophysics, there was never a dull moment. For extra-curricular activities, the social program and nearby ski-slopes provided excellent diversions.

During the last full day of the conference, members of your EEGS board, the 2010 SAGEEP committee, the 2011 SAGEEP committee, and representative from WMR met to review SAGEEP 2010 and begin the process of presenting SAGEEP 2011. Next year's meeting will be held at the Marriott Downtown, in Charleston, South Carolina from April 10-14. Mark this on your calendars now, and be ready for the call for sessions, which will be forthcoming in June. General Chair Bill Doll and Technical Chair Greg Baker have already started moving forward with the program. We are excited about 2011 because we will be collaborating with the Near Surface Groups from both AGU and SEG to bring new and exciting content to our meeting. Participation by these two societies can only increase the technical level of our conference, and make our conference a "must attend" event for geoscientists working in the near surface. I urge all members to begin planning for 2011, as SAGEEP is our "raison d' etre". Working together with AGU and SEG should make this conference one not to be missed.

Be sure to check on the new EEGS web site for updates on SAGEEP 2011. The web site should be up and running by the time you read this issue.

Sponsorship Opportunities

There are always sponsorship opportunities available for government agencies, corporations, and individuals who wish to help support EEGS's activities. Specific opportunities include development and maintenance of an online system for serving SAGEEP papers from the EEGS web site and support for the 2010 SAGEEP conference to be held in Keystone, Colorado. Contact Jon Nyquist (nyq@temple.edu) for more information.

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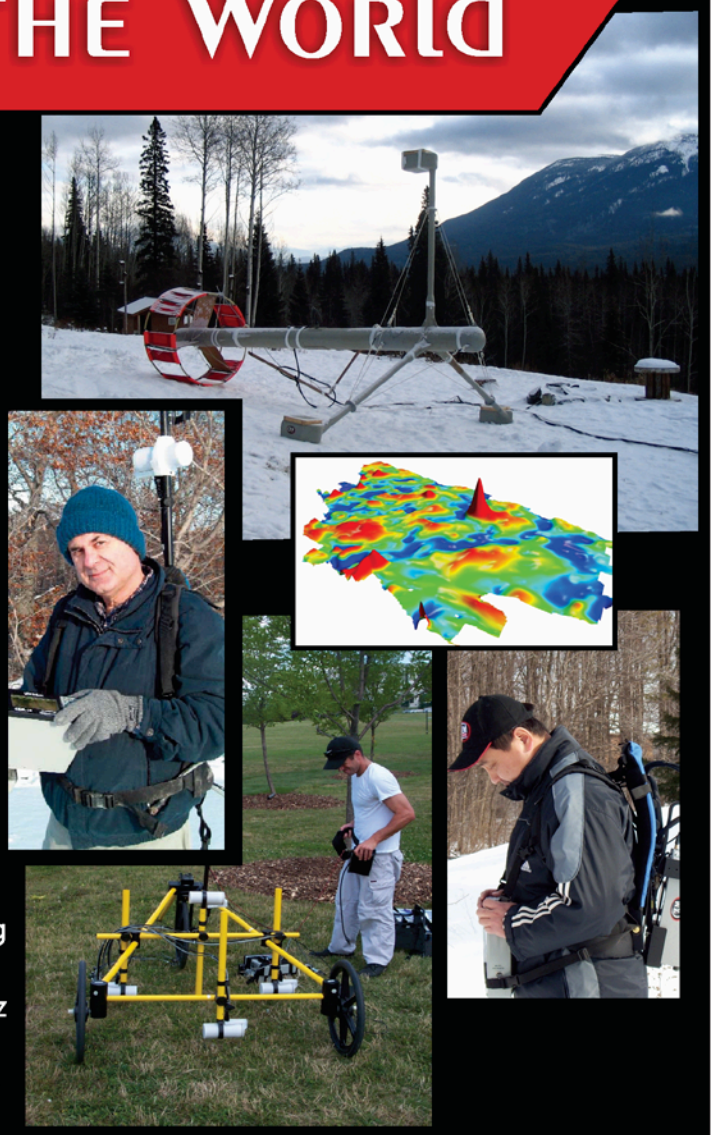
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EEGS Announces Changes in Membership

It's time to renew your membership in EEGS – we've added options and increased benefits!

EEGS members, if you have not already received a call to renew your membership, you will – soon! There are a couple of changes of which you should be aware before renewing or joining.

Benefits - EEGS has worked hard to increase benefits without passing along big increase in dues. As a member, you receive a Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) registration discount big enough to cover your dues. You also receive the Journal of Environmental and Engineering Geophysics (JEEG), the *FastTIMES* newsletter, and full access to the EEGS research collection, which includes online access to all back issues of JEEG, SAGEEP proceedings, and SEG extended abstracts. You get all of this for less than what many societies charge for their journals alone.

Dues Changes - EEGS has worked hard to hold the line against dues increases resulting from inflation and higher costs. Instead, EEGS leadership sought ways to offer yesterday's rates in today's tough economic climate. Therefore, you can continue your EEGS membership without any rate increase if you opt to receive the JEEG in its electronic format, rather than a printed, mailed copy. Of course, you can continue to receive the printed JEEG if you prefer. The new rate for this membership category is modestly higher reflecting the higher production and mailing costs. A most exciting addition to EEGS membership choices is the new discounted rate for members from countries in the developing world. A growing membership is essential to our society's future, so EEGS is urging those of you doing business in these countries to please encourage those you meet to take advantage of this discounted membership category, which includes full access to the EEGS research collection. And, EEGS is pleased to announce the formation of a Retired category in response to members' requests.

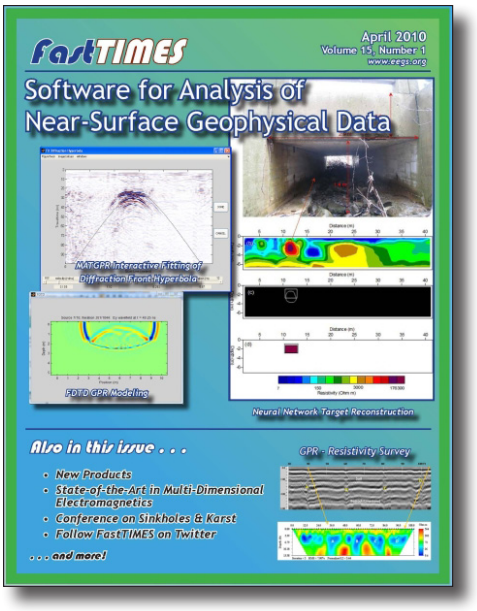
Descriptions of all the new membership options are outlined on EEGS' web site (*www.eegs.org*) in the membership section.

Renew Online - Last year, many of you took advantage of our new online membership renewal (or joining EEGS) option. It is quick and easy, taking only a few moments of your time. Online membership and renewal application form is available at *www.eegs.org* (click on Membership and then on Online Member Application / Renewal).

EEGS Foundation - EEGS launched a non-profit foundation (*www.eegsfoundation.org*) that we hope will enable our society to promote near-surface geophysics to other professionals, develop educational materials, fund more student activities, and meet the increasing demand for EEGS programs while lessening our dependence on membership dues. A call for donations (tax deductible*) to this charitable organization is now included with your renewal materials and can be found on the online Member Resources page of EEGS' web site (*www.eegs.org/pdf_files/eegs_foundation.pdf*).

Member get a Member - Finally, since the best way to keep dues low without sacrificing benefits is to increase membership, please make it your New Year's resolution to recruit at least one new EEGS member. If every current member recruited even one new member to EEGS, we could actually consider lowering dues next year!

*As always, seek professional advice when claiming deductions on your tax return.



From the FastTIMES Editorial Team

FastTIMES is distributed as an electronic document (pdf) to all EEGS members, is sent by web link to several related professional societies, and is available to all for download from the EEGS web site at www.eegs.org/fasttimes/latest.html. The most recent issue (April 2010, cover image at left) has been downloaded more than 28,000 times as of June 2010, and past issues of ***FastTIMES*** continually rank among the top downloads from the EEGS web site. Your articles, advertisements, and announcements receive a wide audience, both within and outside the geophysics community.

To keep the content of ***FastTIMES*** fresh, the editorial team strongly encourages submissions from researchers, instrument makers, software designers, practitioners, researchers, and consumers of geophysics—in short, everyone with an interest in near-surface geophysics, whether you are an EEGS member or not. We welcome short research articles or descriptions of geophysical successes and challenges, summaries of recent conferences, notices of upcoming events, descriptions of new hardware or software developments, professional opportunities, problems needing solutions, and advertisements for hardware, software, or staff positions.

The ***FastTIMES*** presence on the EEGS web site has been redesigned. At www.eegs.org/fasttimes, you'll now find calls for articles, author guidelines, current and past issues, and advertising information.

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EEGS Foundation makes great strides in its first years.

Since the launch of the EEGS Foundation, there are numerous accomplishments for which we can all be proud: Establishing and organizing a structure that serves the needs of EEGS; underwriting the legal process, achieving tax-exempt status; and soliciting and receiving support for SAGEEP. In addition, the Foundation helped underwrite the SAGEEP conference held this spring in Keystone.

These are only a few of the tangible results your donations to the Foundation have enabled. We would therefore like to recognize and gratefully thank the following individuals and companies for their generous contributions:

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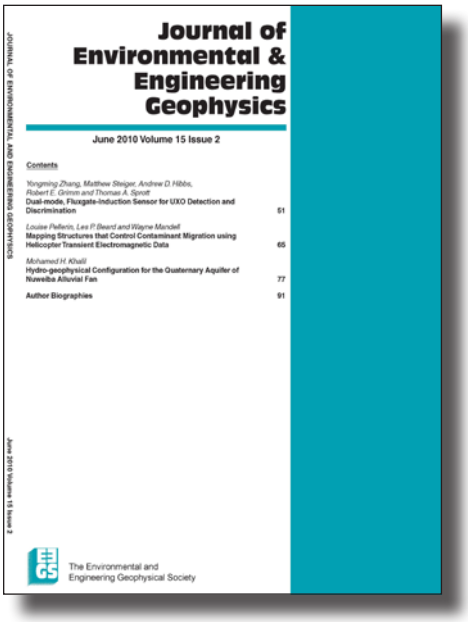


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Contents of the June 2010 Issue



Journal of Environmental & Engineering Geophysics
v. 15, no. 2, June 2010

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Mapping Structures that Control Contaminant Migration using Helicopter Transient Electromagnetic Data
Louise Pellerin, Les P. Beard, and Wayne Mandell

Hydro-geophysical Configuration for the Quaternary Aquifer of Nuweiba Alluvial Fan
Mohamed H. Khalil



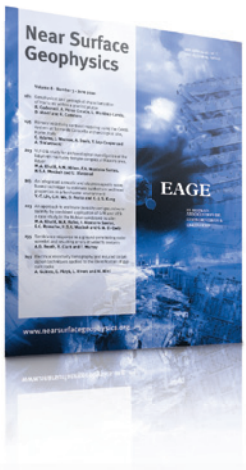
Editor's Scratch

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The ***Journal of Environmental and Engineering Geophysics (JEEG)*** is the flagship publication of the Environmental and Engineering Geophysical Society (EEGS). All topics related to geophysics are viable candidates for publication in ***JEEG***, although its primary emphasis is on the theory and application of geophysical techniques for environmental, engineering, and mining applications. There is no page limit, and no page charges for the first ten journal pages of an article. The review process is relatively quick; articles are often published within a year of submission. Articles published in ***JEEG*** are available electronically through GeoScienceWorld and the SEG's Digital Library in the EEGS Research Collection. Manuscripts can be submitted online at www.eegs.org/jeeg/index.html.

EAGE's Near Surface Geophysics Journal, June 2010

*As a courtesy to the European Association of Geoscientists and Engineers (EAGE) and the readers of **FastTIMES**, we reproduce the table of contents from the August issue of EAGE's **Near Surface Geophysics** journal.*



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FastTIMES welcomes short articles on applications of geophysics to the near surface in many disciplines, including engineering and environmental problems, geology, soil science, hydrology, archaeology, and astronomy. In the article that follows, the author presents examples of structural health monitoring using different geophysical techniques.

Geophysical Investigation of Civil Engineering Structures

Jamal Rhazi, Department of Civil Engineering, Université de Sherbrooke, Sherbrooke, (Québec), Canada (Jamal.Rhazi@USherbrooke.ca)

Introduction

Most of civil engineering structures (e.g. bridges, roads, tunnels, dams) are made of concrete. This relatively low cost construction material is a mixture of cement (usually Portland cement), stone aggregate and water. Typical concrete mixes have high resistance to compressive stresses (about 28 MPa) but are weak in tension and any appreciable tension (e.g. due to bending) will cause cracking and separation of the concrete (Neville, 1996). For this reason, concrete is reinforced with steel rebar to give it extra tensile strength; without reinforcement, many concrete buildings would not have been possible.

The aging and degradation of concrete structures is an international problem whose consequences on the safety of users can be very serious (Wearne, 2000). Some structures are relatively new and already show signs of deterioration sometimes alarming because of a lack of regular maintenance. Owners of these structures must make repairs to keep them in safe operating condition

Some concrete structures have reached the life for which they were originally designed and they are still in apparent good condition. This is the case of some major structures such as nuclear power plants. The owners of these structures want extend their period of operation, which is economically very profitable. But first, they must ensure these structures are really in good condition and safe.

In still other situations, the regulations or operating conditions have changed over time. Existing structures and older must meet more stringent requirements than had been originally intended. It is notably the case of highway bridges subjected to traffic loads that increase in intensity and frequency. In this case, the owners want to know if these structures are able to meet these new service requirements.

So, at one time or another, and for one reason or another, the owner of a structure has to wonder about its capacity to function properly. The owner must know the current status of his structure and possibly his remaining service life to determine whether to make renovations or upgrades it and when to proceed with this work.

Owners are not necessarily civil engineers, and have no particular knowledge in the field of aging and deterioration of structures. These are generally managers whose main purpose is to maintain structures in good working condition and with minimal cost. These owners will therefore give the responsibility to make the diagnosis of their structures to structural engineers.

The objective of the diagnosis of a structure is to specifically answer questions raised by the owner. The engineer must confirm the satisfactory condition of the structure if the structure appears in good condition. If the structure is degraded, the engineer must provide all relevant information for decision

making. He must determine the causes of deterioration, the extent and severity of these impairments, the appropriate repair techniques, the cost and duration of these repairs.

The diagnosis of a structure is based on its evaluation (ACI, 2007). By definition, the evaluation is the process that determines whether a structure (or part of a structure) satisfies the functions for which it was built. The evaluation requires knowledge of a number of information on the structure. These informations relates mainly to the following:

- Quantification of the properties of the material, whether physical properties (e.g. density, moisture, porosity, diffusion coefficient), chemical (e.g. chloride concentration) or mechanical (e.g. compressive strength)

- Recognition of the geometry of a part of the structure (e.g. thickness of a concrete slab, length of foundation, location of steel rebar)

- Detection of defects (e.g. cracks, voids, rebar corrosion)

- Characterisation of these defects (e.g. width of crack, surface or volume of voids, progress of rebar corrosion) to allow an engineer the assessment of the impact of the defects on safety and serviceability of the structure

- Qualification of the operating mode of the structure (e.g. verification of mechanical transfer efforts by strain measurements or constraints)

The information that engineers need to make the evaluation of concrete structures are related to physical, chemical, mechanical or geometric properties. These properties are obtained by means of auscultation techniques (ACI, 2007). These techniques include visual inspection, instrumentation and non-destructive testing (NDT) techniques

Visual inspection of concrete structures is an important activity in the management of these structures. This inspection allows the detection of about 80 % of degradations. However, these degradations are detected only when they are visible, and thus when they reach an advanced stage. Figure 1 shows the visual appearance of the underside of a concrete slab of a parking garage. The analysis of this image indicates that the corrosion of reinforcement is probably active in the area where there are signs of moisture. However, this image does not allow us to assert that corrosion is not active at the location indicated by the arrow where the concrete surface appears dry. To confirm the visual observations, the engineers take some concrete samples by coring. This procedure is destructive and the information obtained is local and does not give reliable information on the condition of the structure.

Instrumentation consists to install a number of measuring instruments at strategic locations of a structure to continuously monitor the behaviour of the structure and its development so as to detect, in real time, any drift dangerous in the long term. The instruments are selected based on the information sought. This can be deformation, stress, displacement or other parameter.

NDT techniques provide additional and complementary information to those collected by instrumentation. For example, the instrumentation can be used to determine openings and closings of surface cracks, but unlike NDT techniques, does not determine what the extended depth of the cracks is.

The principle of NDT techniques is similar to that of geophysical techniques. It consists to induce a disturbance (mechanical, electrical, electromagnetic or thermal disturbance) in the material investigated, and register its response to this excitation. The treatment of this response is then used to estimate

the properties of the material (e.g. compressive strength, water content, porosity) and to detect and characterize internal defects.

In the following sections, we outline two applications of NDT techniques in civil engineering. One concerns the evaluation of the quality of concrete by seismic tomography, and the second the detection and characterization of the reinforcement corrosion by the half-cell potential technique.



Figure 1. Visual appearance of the underside of a concrete slab.

Evaluation of the concrete quality

The actual trend in NDT techniques applied to civil engineering structures is the use of imaging techniques. Among these, the seismic tomography technique is one of the most Interesting (Pla-Ruck et al., 1995). This approach involves reconstructing a cross section or slice through a medium using measurements made outside the medium perimeter of energy that has passed through it. The two-dimensional tomographic image, i.e. a tomogram, shows the internal structure and properties of a medium located between a set of measuring points. Thus, this technique makes the material "transparent" and allows bet-

ter detection of zones that require further analysis and/or rehabilitation.



Figure 2. View of the downstream side of the gravity dam.

The tomographic survey described herein was performed as a part of an investigation undertaken on a concrete gravity dam measuring 5 m in height. The structure was built during the 1940's and has visible deterioration signs (concrete spalling, leaching of hydratation products, etc.). The problem which had required the evaluation of the dam was due to a horizontal construction joint at 2.6 m depth (Figure 2). This joint has been weakening with time leading to water seepage in some areas across the dam.

According to the Quebec law on dam safety, each dam must be periodically evaluated for its safety. This evaluation involves checking the condition, stability and functionality of the dam. So, the objective of the tomographic survey was to characterize the concrete quality of the dam and to gain some information about the integrity of the concrete around the construction joint.

Description of the tomographic tests

A vertical section of the dam was used to perform the tomographic measurements. Seismic waves production was done by means of electrical detonators from an existing vertical borehole (diameter: 0.075 m) filled with water and located at the upstream side of the dam. On the downstream side, a set of accelerometers were laid-out at 0.2 m interval to pick-up transmission characteristics of acoustic signals in concrete. In total, twenty-one source locations and twenty receiver locations were used which enabled 420 travel times' measurements.

The inversion program that has been used to process the data is 3DTOM (Jackson et al., 1996), a three-dimensional tomographic imaging software that uses the simultaneous iterative reconstruction technique (Gilbert, 1972) to invert travel-time data and produce maps of P-wave velocity.

Results and discussion

The tomography result is shown in Figure 3 and indicates the P-wave velocity variation inside the target section. Furthermore, the Rock Quality Designation factor (RQD) of the concrete samples extracted from the borehole is also indicated on the left side of this figure. The RQD is defined as the cumulative length of core pieces longer than 0.10 m in a run divided by the total length of the core run. This factor, expressed in percent, is commonly used in the field of rock mechanics as an indicator of material

quality and discontinuity spacing (Deere, 1989).

In the upper part of the tomographic image, the velocity variation falls in the interval 2000 m/s - 2500 m/s, and the RQD (13 %) confirms that this concrete is in very poor condition. From 2 m to 3 m, the value of P-wave velocity is between 2500 m/s – 3000 m/s and the RQD is 53 %. Below the construction joint indicated by a dashed line in Figure 3, the image reveals that the concrete has better stress-wave propagation properties (V > 4000 m/s) and the RQD is equal to 66 %. Thus, the velocity increase from the top to the bottom of the dam agrees well with the RQD values.

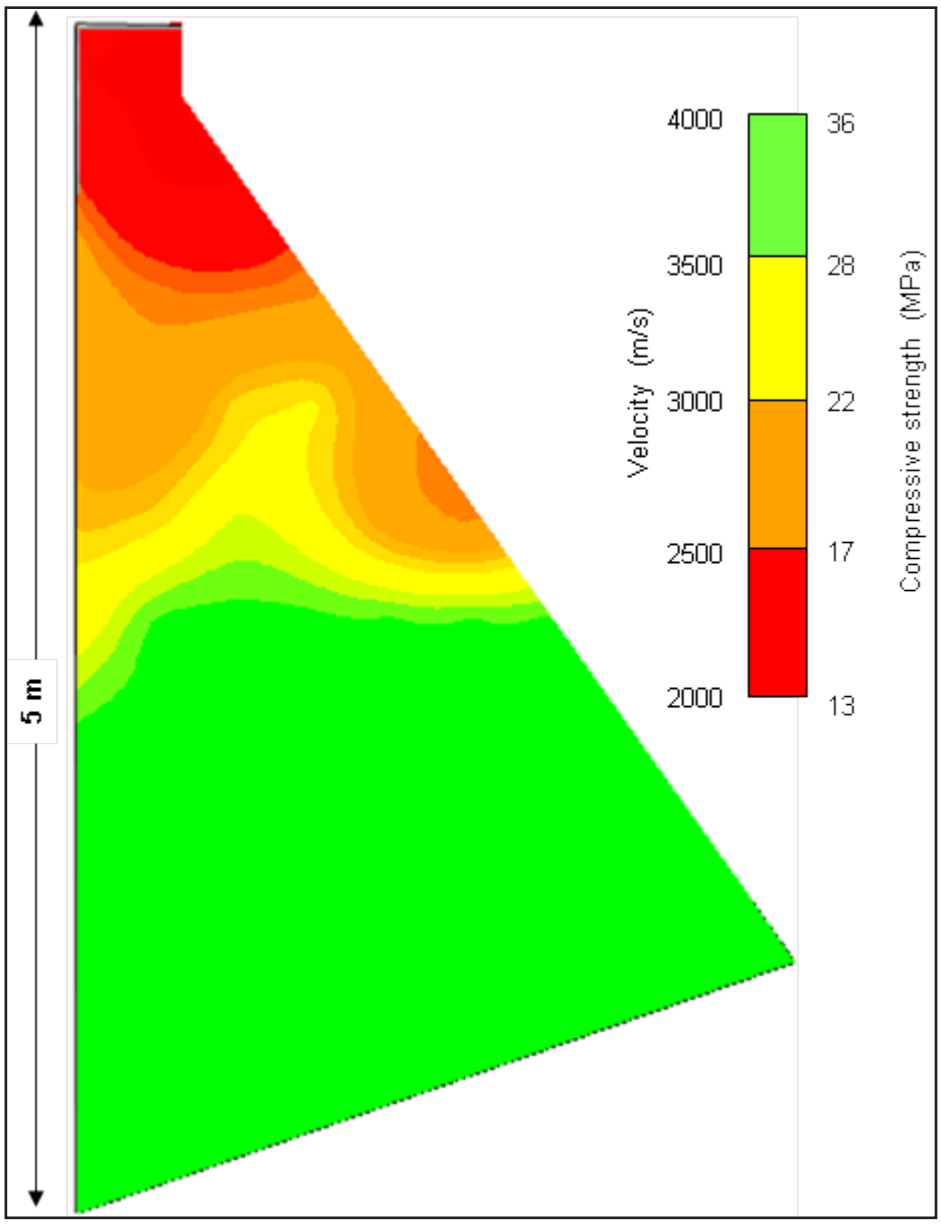


Figure 3. Tomography result.

The tomography result suggests that the two concretes on both sides of the joint were probably of different initial compositions. Accurate measurement of the mechanical properties of the concrete samples extracted from the borehole was not possible. Indeed, the aggregate size of the concrete (≈ 0.08 m diameter) was of the same order than the cores diameter (0.075 m). However, on the basis of the correlation between concrete properties and P-wave velocity observed in another case study (Rhazi, 2006), it can be advanced that the Young modulus and the compressive strength of the concrete above the construction joint (V < 3000) are probably lower than 14 GPa and 18 MPa, respectively. The concrete bellow the construction joint (V > 4000 m/s) has a Young modulus and a compressive strength higher than 19 GPa and 26 MPa, respectively.

Finally, it can be noted that the joint at 2.6 m depth induces a velocity anomaly in the tomographic image (Figure 3). This anomaly is more pronounced on the downstream side of the dam (V < 2500 m/s) than on its upstream side (V ≈ 3000 m/s). The intensity of the velocity field is higher in the inside of the section (V ≈ 3500 m/s). This leads to the conclusion that the joint is likely closed in the center of the surveyed section. This result is corroborated by the fact that there was no water seepage through the dam at that location.

The seismic tomogrpahy method allows a large volume of material to be surveyed compared to conventional nondestructive testing technologies. The benefit of this technique is that it gives an indication of the properties of one part relative to another one in a given structure. Laboratory tests on cored samples taken from the structure investigated can help to interpret the tomograophic image in term of mechanical properties. However, the difficulty when interpreting a tomographic image is certainly the ability to distinguish a cracked area from another area where the concrete exhibits high porosity and degradation. Some initial knowledge on the condition of the structure is therefore necessary since both types of defect have often similar tomographic signatures, i.e. low velocity field.

Corrosion Testing of Reinforced Concrete Bridge Decks

Bridge decks are generally concrete slabs about 0.20 m thick. These slabs are reinforced with two mats of steel rebar located 5 cm from the upper side and lower side respectively. The spacing between rebar is typically 0.15 m and their diameter is about 0.016 m.

The corrosion of steel rebar is the principal cause of degradation of concrete bridge decks. This degradation occurs according the following two-stages (Amleh et al. 2002):

- Stage 1 consisting of chloride ingress and onset of corrosion over the “corrosion initiation time” when steel suffers depassivation due to partial or extensive loss of the protective cover. This stage of corrosion initiation can constitute the serviceability limit state beyond which the corrosion rate and the associated damage would increase significantly.

- Stage 2 consisting of corrosion propagation with on-going steel cross-sectional area until a limiting damage state is reached. This involves progressive delamination, spalling of the concrete cover and loss of bond at the steel-concrete interface until finally failure occurs.

The impact of corrosion damage on safety and serviceability of reinforced concrete bridge decks must be assessed carefully. Bridge engineers frequently use the half-cell potential (HCP) test to evaluate the corrosion activity of the reinforcements, its extent and its severity (Elsener, B., 1995). In this method, the electrical potential difference between the upper steel rebar and a standard portable reference electrode in contact with the concrete surface is measured (Figure 5a). Since most concrete bridge decks have waterproofing membranes and are asphalt covered, this contact is done by water filling a hole (diameter: ~1 cm) drilled through the asphalt and the membrane. The reference electrode is connected to the negative end of the voltmeter and the steel reinforcement to the positive. A grid pattern (~1 m x 1 m) is used to identify locations where the half-cell is to be placed to obtain potential measurements. The HCP values are then plotted on schematic diagram of the structure investigated as an equipotential contour map.

Figure 4 gives the result of a half-cell potential test on a reinforced concrete bridge deck. The horizontal axis is the length of the deck and the vertical axis its width. The ASTM standard C876-09 “Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete” provides general guidelines for the interpretation of the HCP data. According to these guidelines, the probability of corrosion of the rebar is less than 10% if the potential is greater than -200 mV, whereas potential values lower than -350 mV indicate a high probability (> 90%) that corrosion is active. The HCP values between these limits indicate areas where the corrosion activity is uncertain.

The test results are relevant because they allow engineers to determine the locations where corrosion is active, the area of the bridge deck that should be repaired and the cost of repair.

The HCP test has however certain disadvantages. First, the test is carried out from the upper-side of the decks and requires the closing of the lanes to collect the data. This is obviously very problematic in the great urban centres such as Montreal or Toronto. Second, the holes drilled through the asphalt overlay to establish the electrical contact between the reference half-cell and the concrete destroys the waterproofing membrane and accelerates the deterioration of concrete. This is obviously not acceptable.

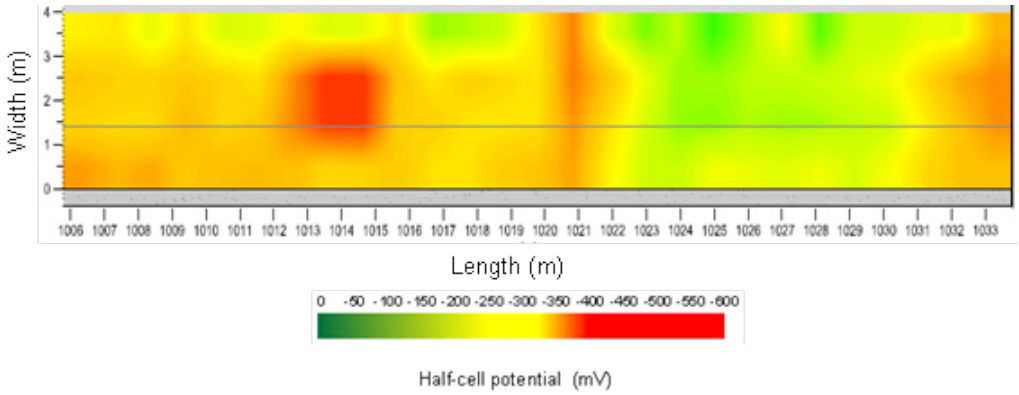


Figure 4. Example of HCP test results.

One of the ways of proceeding to avoid this problem would be to collect the half-cell potential data from the lower-side of the bridge decks. However, the adequate evaluation of the corrosion activity of the upper rebar from the HCP measurements carried out from the lower-side of the decks requires the knowledge of the difference between the measurements collected from the lower and upper sides.

This section presents the results of an investigation recently carried out to determine the possible correlations between the HCP measurements relative to the upper rebar and collected from the upper-side to those collected from the lower-side of the decks.

Description of the HCP tests

The half-cell potential data were collected on a reinforced concrete bridge deck which was built in 1963. Its length is 27.6 m, its width is 9.16 m and its thickness is 0.17 m. The HCP measurements were carried out with a copper-copper sulphate reference electrode according to nine lines in the longitudinal direction of the bridge. The distance between these lines as well as the distance between the points of measurements on each line was equal to 1 m.

The HCP measurements were done in 243 locations. For each location, the data were collected from the upper-side of the bridge deck, while taking as reference the upper rebar mesh (Figure 5a), and from the lower-side of the bridge deck, while taking as reference the upper rebar mesh (Figure 5b).

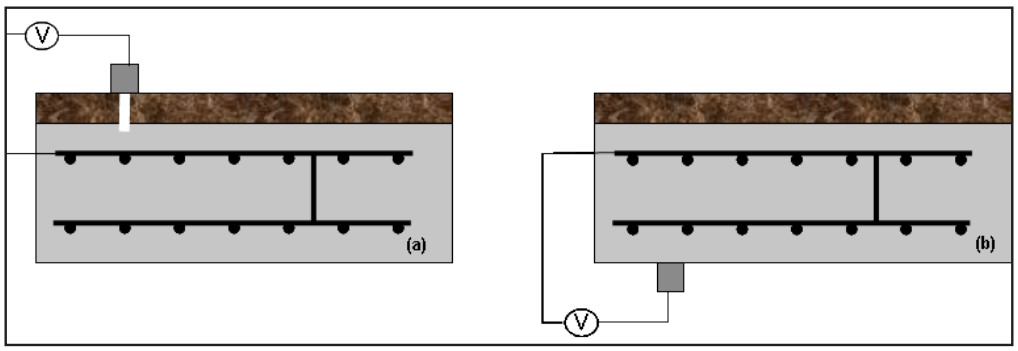


Figure 5. Configuration of the HCP tests.

As recommended by the ASTM C876, the electrical continuity of the reinforcements was verified prior to the HCP measurements. For this purpose, two coring (diameter = 0,10 m) spaced ten meters were done in the deck, and the measurement of electrical resistance was done between the rebar of the upper mesh in theses holes. The electrical resistance was low (1 Ohm) indicating that the electrical

continuity between the rebar was good. In addition, the electrical resistance between the upper rebar and the lower rebar was also measured. This resistance was also low indicating an electrical contact between the two set of rebar by metallic wires. This is a common construction procedure to keep the upper and lower rebar in place during pouring concrete into the formwork.

Results and Discussion

Figure 6 give the HCP results. These results are given in the form of color maps indicating the probability of corrosion of the reinforcements. Figure 6a relates to the measurements taken from the upper side of the deck according to the configurations in Figure 5a. This figure shows that the probability of corrosion of the upper rebar is weak along the northern and southern edges of the deck and is uncertain in the center of the deck. The probability of corrosion is high in four areas in this slab.

Figure 6b relates to the measurements taken from the lower-side according to the configuration indicated in Figure 5b. Since the electrical resistance between the upper rebar and the lower rebar is negligible, this figure describes the corrosion activity of the lower rebar because it is the closest to the reference half-cell.

The HCP map of the lower rebar mesh (Figure 6b) resembles to that of the upper rebar mesh (Figure 6a). In particular, the four zones in Figure 6b where the probability of corrosion of the reinforcements is high are also present in the cartography of the corrosion activity of the upper reinforcements (Figure 6a). This result can be explained by the infiltration in these places, of water and ions chloride through the full thickness of the slab. The visual inspection of the lower-side of the deck confirmed these facts.

Figure 6a and 6b are similar but they are not identical. Figure 7 gives the HCP values obtained from the upper side versus those obtained from the lower side. It shows that the relation tends towards a linear relation, but the dispersion of the results is not negligible.

Usually, bridge engineers use HCP measurements from the upper side to determine the top surface of decks to repair and to estimate the cost of the repair. The top surface to repair expressed as a percentage of the total surface of the deck is taken equal to the percentage of the HCP data corresponding to high probability of corrosion of the rebar (potential < -350 mV).

In the present case, the percentage of the data corresponding to high probability of corrosion is about the same for the measurements from the upper side (9%) and the lower side (8%). However, if the ingress of water and chloride ions was limited to the upper rebar level, the HCP data from the lower-side should underestimate the percentage of high corrosion probability areas. Moreover, if the infiltration of humidity and chloride ions is done from the lower side, this will induce an overestimation of the percentage of high corrosion probability areas. It is therefore important to consider all these possibilities in the analysis of results.

Conclusions

NDE techniques have the potential to satisfy at least some of the needs of civil engineers. These techniques have been used successfully on a variety of reinforced and post-tensioned concrete structures, notably highway and reservoir structures. However, there is a general lack of confidence in the techniques because there is very little independent advice on their applicability, capability, accuracy and reliability. The information obtained by techniques such as RADAR, ultrasonics, stress wave and radiography appears qualitative rather than quantitative and there is concern that NDE procedures lack the necessary

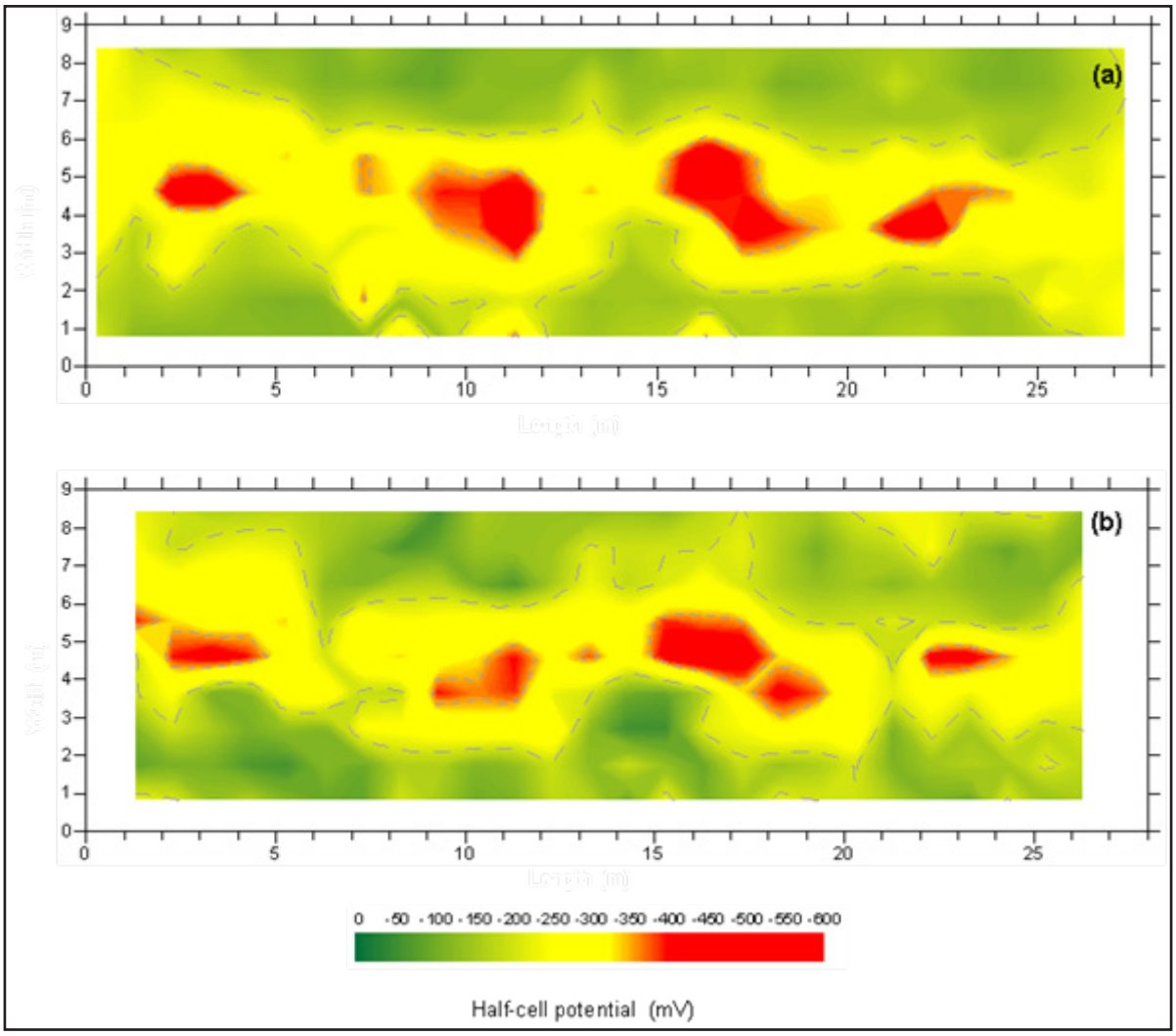


Figure 6. Results of the HCP tests.

qualification to permit their use on safety critical structures. The quantification of the capabilities of NDE techniques is seen as a priority area for development. The provision of authoritative documentation in the form of Standards is desirable. Moreover, many engineers have limited experience, if any, with most of these NDT techniques. Qualification is important to the successful deployment of NDE techniques and will need to be considered when addressing this issue.

Acknowledgments

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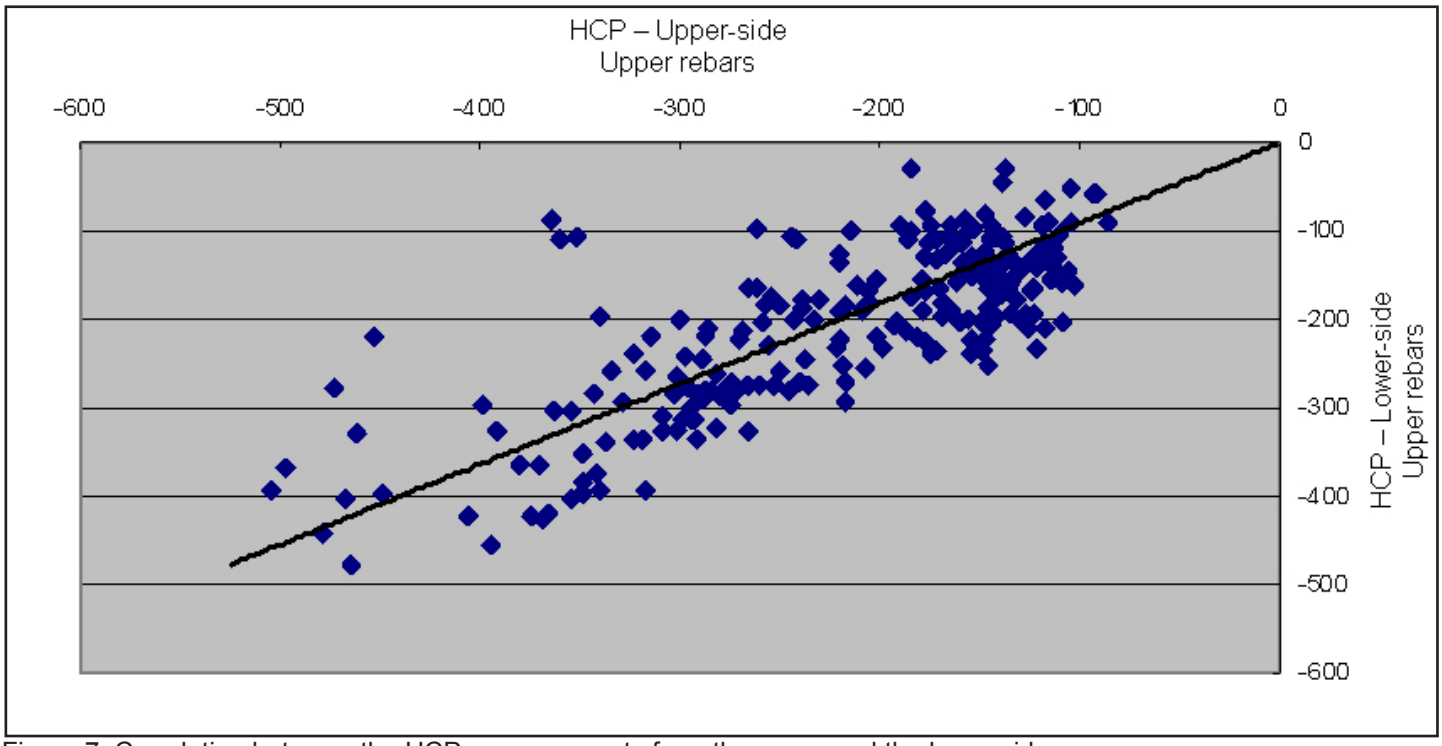


Figure 7. Correlation between the HCP measurements from the upper and the lower sides.

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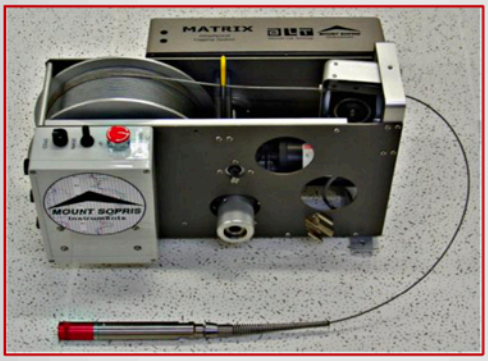
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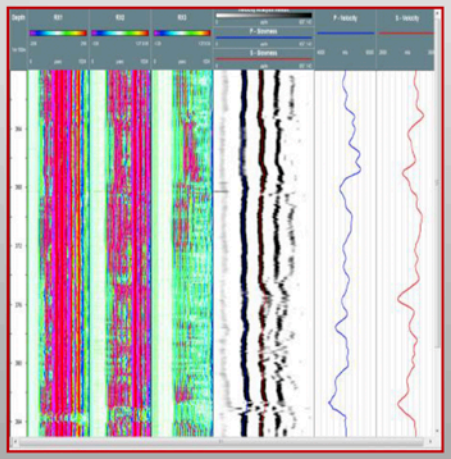


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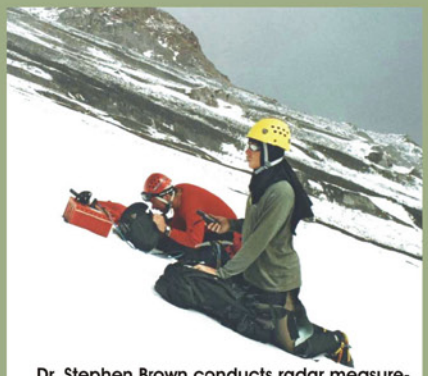


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The **Frank Frischknecht Leadership Award** is established to recognize an individual who shows extraordinary leadership in advancing the cause of near surface geophysics through long-term, tireless, and enthusiastic support of the environmental and engineering geophysics community. Such leadership is often boldly displayed by an invention, a new methodology or technique, a theoretical or conceptual advancement, or a unique innovation that transforms the nature and capabilities of near surface geophysics. The Frank Frischknecht Leadership Award is presented jointly by EEGS and the Near Surface Geophysics Section of the Society of Exploration Geophysicists (NSG-SEG). Past recipients of the joint award are Susan Pullan, Robert Corwin, Kenneth Stokoe and Susan Hubbard.

The award alternates on an approximately 18-month interval between EEGS' Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) and the SEG-NSG Section's annual meeting. It will be given next in April at SAGEEP 2011 in Charleston, South Carolina, USA.

Send nominations to Jonathan E. Nyquist, chair of EEGS' Nominations and Awards committee, by email to jonathan.nyquist@temple.edu or call him at (215) 204-7484 to discuss other means of submission. The nomination should contain the name, title and affiliation of the candidate along with a statement describing the reasons for the nomination. Nominations should be **received by Monday September 20, 2010** for full consideration.

To learn about additional past recipients of the Frank Frischknecht Leadership Award or information on other EEGS awards, please visit the EEGS web site www.eegs.org/about/awards.html.

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Web: www.eegs.org

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The EEGS / Geonics Early Career Award

Nomination Deadline: October 29, 2010

The Environmental and Engineering Geophysical Society and Geonics Limited are pleased to announce that nominations are now open for the 2011 EEGS / Geonics Early Career Award, which acknowledges academic excellence and encourages research in near-surface geophysics. The award is presented annually at SAGEEP to a full-time university faculty member who, by the nomination deadline, is

• fewer than five years beyond the starting date of his or her current academic appointment;

• within ten years post-completion of his or her PhD.

The award acknowledges significant and ongoing contributions to the discipline of environmental and engineering geophysics. The recipient may have any specialty that is recognized as part of the environmental and engineering geophysics discipline. This specialty is not restricted to departments, colleges, or geographic regions (international applicants are welcome). A committee of four or five members (two or three university faculty, one corporate or consulting representative, and one government laboratory representative), appointed by the EEGS Board, is responsible for selecting the awardee.

The award carries the following benefits:

• Free registration to the SAGEEP conference at which the award will be presented

• A plaque, suitable for display

• A $1000 cash award

• A 30-minute time slot to present the awardee's research and vision at SAGEEP

• The citation and, if available, the awardee's presentation, is published in FastTIMES and distributed to cooperating societies

The awardee will be expected to be present during the technical core of SAGEEP 2011 in Charleston, South Carolina. Nominations should be sent electronically to:

Dr. Mel Best, Chair of the Early Career Award Committee

3701 Wild Berry Bend

Victoria, B.C. V9C 4M7 CANADA

(250) 658-0791

best@islandnet.com

Nomination packages must include:

• A comprehensive vitae for the candidate

• A letter of recommendation outlining the candidate's qualifications for the award

• Copies or PDF files of three representative publications

Environmental and Engineering Geophysical Society

SAGEEP 2011 Announcement

New to SAGEEP: Online Session Proposals

Now Being Accepted

The Environmental and Engineering Geophysical Society (EEGS) invites you to submit your proposal for a session(s) at the 24th Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (**SAGEEP**) being held in historic Charleston, South Carolina USA **April 10-14, 2011**.

In order to meet the evolving need of our membership-and to attract new members-EEGS will be launching a new approach for technical session development, abstract preparation, and submission for SAGEEP 2011. Listed below are key changes:

Session Proposals - SAGEEP 2011 Technical Chair Gregory S. Baker has announced the opening of the SAGEEP 2011 online session proposal web site (click here to access the online proposal submission site). Sessions may be proposed **through September 6, 2010** and will require a brief description and list of potential speakers. Once accepted, session proposers will be responsible for developing the session by soliciting papers from individuals in the subject area. Session topic areas are divided into three categories: Applications, Methods and Tools/Components/Other (scroll down for the list of session topic areas). Session proposers are invited to serve as Session Chairs. Also new this year is the opportunity to "invite" one paper, which may be longer in duration than the others. The Technical Program Committee will consider proposals on a rolling basis, so conveners will be notified of the status shortly after submission. For further details, click here for "Guidelines for Proposing a Session", which fully outline the requirements and the new session proposal submission process.

Session Proposals are Due by Monday, September 6, 2010.

Abstract Length Requirement Modified - Expanded, multi-page abstracts for the proceedings will no longer be required, but will instead be optional, based on the desires of the participant. Abstracts will be short (300 words max), and a format template will be prescribed. Submission of an abstract will constitute a commitment to attend the conference, and a $50 fee will be charged upon submission (applicable toward conference registration). Abstracts will be reviewed for both scientific relevance and absence of commercialism, and notices of

acceptance or rejection will be sent in late 2010.

Abstract Submission Deadline is Friday, November 19, 2010.

Change in Proceedings Format - Authors of accepted papers will then have the option of submitting an expanded abstract, if they choose. These optional, expanded abstracts may range in length from a few pages to ten or more pages, and will retain the format of previous SAGEEP proceedings. They must be submitted by **Friday, January 14, 2011**, to be included in the abstract volume that will be distributed at the conference.

Mark your calendar with these important deadline dates:

Sept. 6, 2010	Deadline for SAGEEP '11 Session Proposals
Nov. 19, 2010	Deadline for Abstract Submissions
Jan. 14, 2011	Deadline for Extended Abstracts (optional)

Please address any questions regarding these changes to the SAGEEP 2011 Technical Chair, Dr. Gregory Baker (gbaker@tennessee.edu) or General Chair, Dr. William Doll (dollw@batttelle.org). Consult the EEGS website, www.eegs.org, (click SAGEEP 2011 button) for online session and abstract submission site access, a current list of accepted sessions and the latest information on the conference.

Proposed Session Topic Areas:

Applications:
Agriculture
Archaeology
Biogeophysics / bioremediation
Contaminants
Earth Hazards
Engineering
Environmental
Forensics
Geotechnical
Humanitarian Geophysics
Hydrogeophysics / Hydrogeology / Groundwater
Lake and Coastal Marine Applications
Mining
Resources
Transportation
Infrastructure
Dams, Levees, Reservoirs, & Bridges
Cavities (Karst) and Tunnels
Salt-Water Intrusion
Military Uses of Geophysics
Extraterrestrial Near-Surface Geophysics
Unexploded ordnance / munitions and explosives of concern (UXO /MEC)

Methods:
Electrical
Electromagnetic (EM)
Gravity
Magnetics
GPR /Radar
Airborne and remote sensing
Seismic
Integrated Techniques
Surface Technique(s)
Borehole and Cross-hole Technique(s)
Lab/Column Experiments
Petrophysics
Rock Mechanics

Tools/ Components/ Other:
Acquisition
Data Integration, Management, and Visualization
Computational Modeling
Data Processing
Education
Fractals and multifractals
Interpretation
Inversion
Monitoring Concepts and Applications
Neural nets
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USGS Job Opening

Application Deadline: August 20, 2010

The Geophysical Unit of Menlo Park, US Geological Survey just opened a term position for an operational geophysicist, who in a recent grads. To view the announcement and apply, go to the http://www.usajobs.gov website, search for geophysicist in Menlo Park, CA for job announcement (WR-2010-0440).

OPEN PERIOD:	Friday, July 30, 2010 to Friday, August 20, 2010
SERIES & GRADE:	GS-1313-07/09
POSITION INFORMATION:	TERM Full-Time
SALARY RANGE:	$45,923.00 - $73,019.00 /year
DUTY LOCATIONS:	1 vacancy(s) in Menlo Park, CA

Key Requirements:

- Applicants must be U.S. Citizens.
- Suitable for Federal employment, as determined by background investigation.
- Overnight travel of 1-5 nights per month may be required.
- Must have a valid state driver's license and a good driving record.
- More requirements are listed under Qualifications and Other Information.

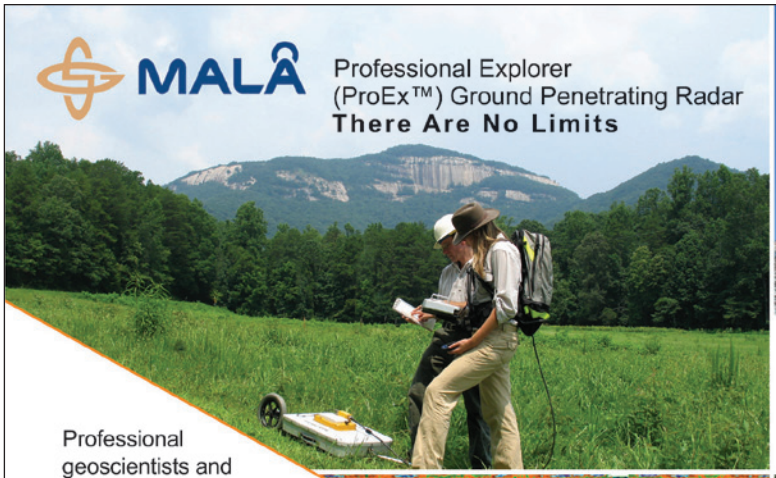
Major Duties:

As a Geophysicist within the Geology & Geophysics Science Center, some of your specific duties will include:

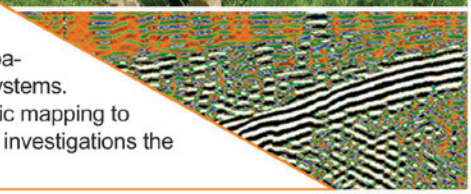
- Plan and conduct the collection and processing of geophysical data, primarily gravity, magnetic, paloemagnetic, and electrical data.
- Use existing and new analytical techniques to characterize spatial patterns in geological and geophysical data.
- Author and co-author informational data and professional reports, abstracts, and presentations conveying interpretive results and new analytical methods related to geophysical studies and geological mapping.
- Operate government 4 wheel drive vehicles in off-road remote areas.

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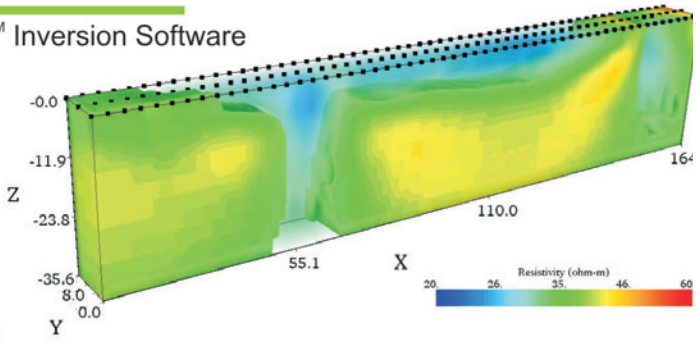
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Coming Events

***FastTIMES** highlights upcoming events of interest to the near-surface community. Send your submissions to the editors for possible inclusion in the next issue.*

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Darling Harbour, Sydney, Australia
22–26 August 2010



www.aseg-pesa2010.com.au

State-of-the-Art in Multi-Dimensional Electromagnetics: A Special Session in Honor of Gerald W. Hohmann

October 17-22, 2010, Denver, CO

This special session honoring the late Gerald W. (Jerry) Hohmann invites contributions that focus on the role of advanced multi-dimensional forward modeling, inversion and field methods in geophysical applications of electrical and electromagnetic methods. The session covers implementation of new field systems and procedures to achieve dense lateral coverage, and the use of modern analytical and numerical techniques for interpretation or inversion of EM field data. Applications can range from hydrocarbon, mineral, geothermal and groundwater exploration, to environmental monitoring and carbon sequestration studies.

This announcement is for anyone considering, or who has completed, the submission of a paper to the SEG meeting. The SEG online system does not have a special-session selection feature. If you would like your paper to be presented in this session, please inform Louise Pellerin (*pellerin@ak.net*) and she will coordinate with SEG. Depending on the number of submissions both an oral and a poster session are possible. Deadline for abstract submission is April 7, 2010, at 5:00 p.m. Central Daylight Time.

Gerald W. (Jerry) Hohmann (Ph.D. 1970, University of California at Berkeley) was Professor of Electromagnetic Geophysics at University of Utah from 1977 until his untimely death in 1992 at age 51. Jerry was a pioneer in quantitative analysis of electromagnetic methods, and together with his mentor and fellow professor Stan Ward, built a world-class research effort in applied geophysics at this institution. Jerry's exacting standards were coupled with an easy-going nature that induced students to high achievement in a supportive environment.

This session is being organized by the Gerald W. Hohmann Memorial Trust for Research and Teaching of Applied Electrical Geophysics. The Trust sponsors career achievement awards and student scholarships with the SEG, and holds quadrennial international symposia on EM modeling and inversion.

12th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst™

January 10-14, 2011, St. Louis, Missouri

This is the 12th in this series of highly successful interdisciplinary conferences which were first organized by the Florida Sinkhole Research Institute in 1984 as a means for geologists and geographers, who study how and where karst develops and how sinkholes form, to interact with engineers, planners and others, who must apply this information to build and maintain society's infrastructure and protect our environment. Since the first meeting in 1984, these biennial conferences have grown into the single most important international professional meeting concentrating on the practical application of karst science.

The goal of this conference is to share knowledge and experience among disciplines by emphasizing scientific and technological aspects of karst that have practical applications, together with case histories of those applications. Since karst topography impacts ground and surface water resources, waste disposal and management, highways and other transportation facilities, structural foundations and utilities and other infrastructure, civil, geotechnical and environmental professionals should all attend this most relevant conference.

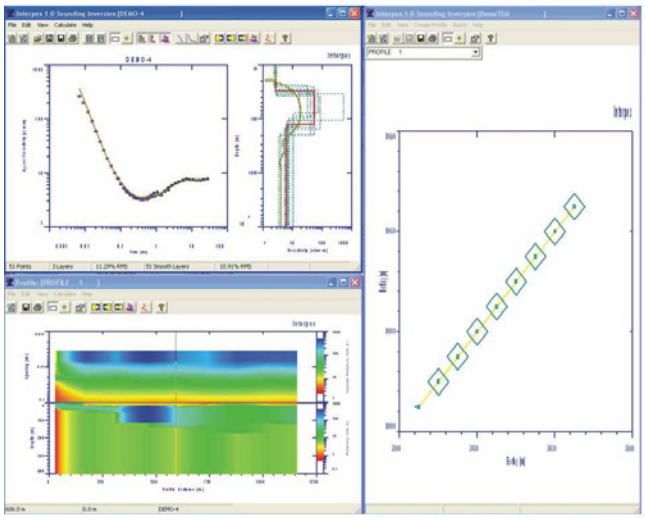
For more information please visit the conference web site at *http://www.pela.com/sinkhole2011.htm*

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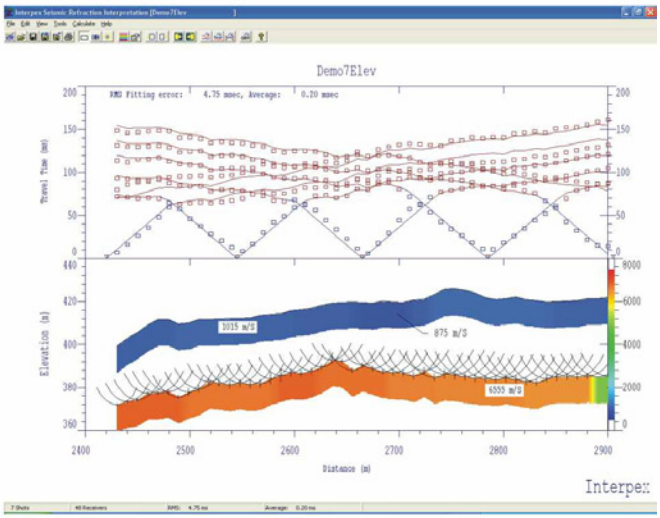
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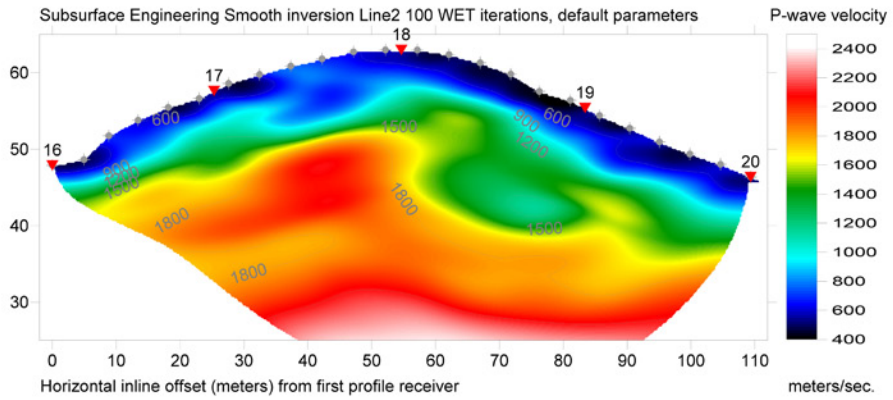
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Recent Events

***FastTIMES** presents contributed summaries of recent events to inform readers who were unable to attend. As a service to others, please send the editors summaries of events you attend for possible inclusion in future issues.*

Hydrogeophysics Camp Returns for Second Year at Penn State

by Kamini Singha, Department of Geosciences, Pennsylvania State University, University Park, PA (ksingha@psu.edu)



This summer, nine undergraduate students participated in the Hydrogeophysics Field Experience with Dr. Kamini Singha from May 17 to June 4. Four students from Penn State, two from Jackson State University in MS and three from Fort Valley State University in GA took part in the program. These students combined field experimentation, data analysis, and numerical modeling with in-class instruction during the three-week program to develop and test hypotheses regarding the processes controlling solute transport. The Shale Hills Critical Zone Observatory near Shaver's Creek Environmental Center is the "home base" for this field camp due to its proximity to the Penn State campus and its facilities.



Environmental consultants, government employees, and researchers from small companies visited the field camp to demonstrate hydrogeophysical field equipment and highlight jobs in environmental fields. The students learned the basics of pumping tests, tracer tests, and slug tests. In addition, they were involved in hands-on exposure to geophysical techniques such as electrical resistivity, wireline logging, and ground-penetrating radar.

Groundwater Resources Association of California

The Groundwater Resources Association of California presented its' 4th Symposium on Tools and Techniques entitled Geophysics at the Beach from May 24th-26th in Santa Ana California. This three day event included a full day short course on borehole geophysics related to groundwater, and was divided into two sessions, basic principals and methods, followed by advanced techniques. The second day of the symposium featured speakers from government, industry, and water districts, with 18 technical papers and 3 posters. EEGS was a co-sponsor of this event, and several EEGS members were present, including Doug Groom, John Stowell, Norm Carlson, and Ned Clayton. The final day of the meeting moved to Peninsula Park at Newport Beach, where manufacturers and vendors demonstrated the latest in geophysical equipment. Attendees were able to talk to experts and learn firsthand about the acquisition and processing of geophysical data. This session allowed participants to handle the gear and learn how it is used in the field.

Best of SAGEEP 2010 Presentations

Compiled by Jim LoCoco – Technical Chair

1. Sue Pullan / Spullan@NRCAN.gc.ca / 613-992-3483 / Update on recent observations in multi-component seismic reflection profiling
2. Tim Munday / Tim.Munday@csiro.au / +61-86-436-8634 / AEM data for assessing irrigation channel leakage a meritorious approach in an australian setting
3. Choon Park / choon@parkseismic.com / 347-860-1223 / Roadside passive MASW survey - dynamic detection of source location
4. Kristen Swaim / kswaim@usbr.gov / 303-445-3037 / Borehole geophysical investigation: Seminoe dam, WY, characterization of internal fracturing & dynamic moduli reduction of concrete mass
5. Lee Slater / lslater@andromeda.rugers.edu / 973-353-5109 / Use of IP to characterize the hydrogeologic framework of the zone of surface-water/groundwater exchange at the hanford 300 area
6. Estella Atekwana / Estella.atekwana@okstate.edu / xxx-xxx-xxxx / Investigating the effect of bio-clogging on electrical and flow and transport properties of porous media
7. Andre Revil / arevil@mines.edu / 303-975-6780 / How useful is spectral induced polarization?
8. Burke Minsley / bminsley@usgs.gov / 303-236-5718 / Calibration and filtering strategies for frequency domain electromagnetic data
9. Jared Abraham / jdabraha@usgs.gov / 303-236-1318 / Using airborne geophysical surveys to improve groundwater resource management models
10. Paul Bauman / paul.bauman@worleyparsons.com / 403-247-5727 / Geophysical exploration of the former extermination center at Sobibor, Poland

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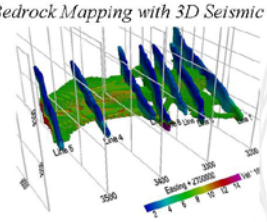
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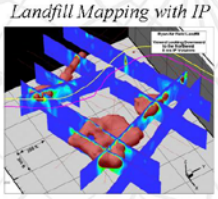
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- *Groundwater Basin Mapping*
- *Archeological Investigations*
- *Contaminant Tracking*
- *Time-lapse Monitoring*
- *UXO/MEC Detection*

Landfill Mapping with IP



Field Surveys

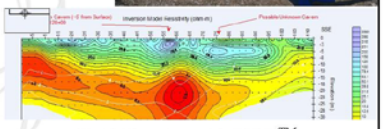
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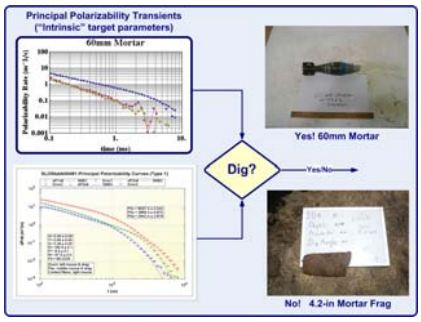
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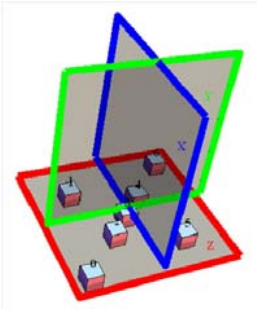
COMMERCIALIZING THE RESULTS OF PRIVATE AND GOVERNMENT RESEARCH PROGRAMS

From Bark Hoekstra, Product Manager, Geometrics

The MetalMapper, supported in its development by several major governmental agencies including SERDP/ESTCP and NAVEODTECHDIV, is geared towards reducing the high cost for cleaning up sites contaminated with unexploded ordnance (UXO). A major emphasis of these groups is the commercialization of the technologies developed under these programs.



The MetalMapper system is a step forward in the discrimination of Unexploded Ordnance (UXO) from other buried metallic scrap. It uses the proven methods of Time Domain EM (TDEM) to identify buried metal, but has significantly more capabilities than existing commercially available systems. The TDEM method works by inducing currents in the ground. Currents in the soils quickly decay away, but if there are metallic objects in the ground the currents decay much more slowly. The MetalMapper system measures the magnetic fields caused by the currents in the metallic objects and then uses that information to compute the size and shape of the buried object.



The system consists of 3 orthogonal transmitter loops that are 1m x 1m in size. There are 7 (seven) 3-component receiver coils mounted within the horizontal transmitter coil. The receiver coils are wire wrapped on 10 cm x 10 cm cubes

The system can be used in two different modes. The first is a dynamic mapping mode where only the horizontal transmitter coil is used and a shorter recording window is employed. The second mode is a static mode where once a target has been identified the array is placed on top of the target. In this mode all three transmitter coils are fired sequentially and a longer recording window is employed.

The system is controlled by a compact PC, running software that controls the acquisition parameters, logs the data and also provides feedback to the operator on the positioning of the system and data quality. The system is highly configurable allowing the operator to vary almost every data acquisition parameter including decay length, number of decays averaged, transmitter coils used and others. The displays available to the operator are equally flexible, so the operator can see the information necessary for whatever type of survey is being performed.

This is a map *(Image 3)* derived from the MetalMapper data. The targets are identified by bright pink features in the data. Similar production rates to currently used systems are obtainable, but the MetalMapper has increased positional accuracy because of the multiple small receiver coils instead of a

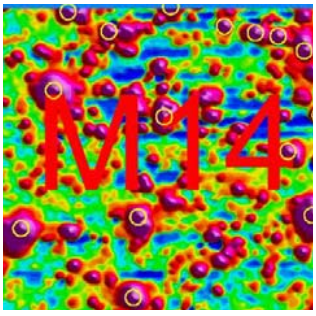


Image 3

single large coil. Further research is currently being conducted to provide the ability to determine the size and depth of the objects from dynamically collected data.

The results from the latest demonstration of the MetalMapper at a site in San Luis Obispo, California showed that the MetalMapper can provide information that is a huge leap forward in the ability to discriminate UXO objects from other metallic objects. The receiver operating curves (ROC) shown in *(Image 4)* show that all UXO objects would be excavated with a minimal number of pieces of scrap metal.

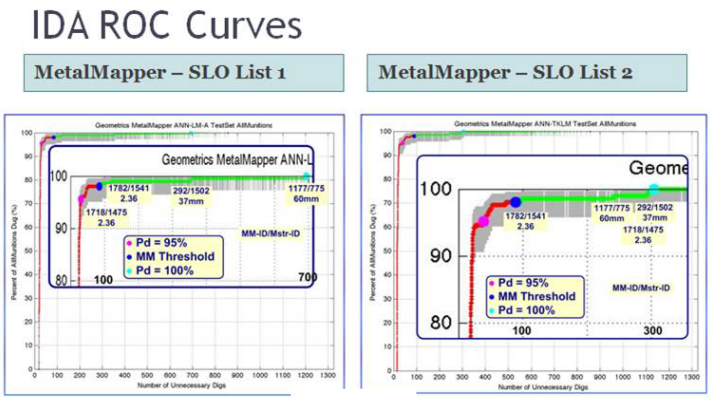


Image 4

Instead of digging thousands of metallic scrap items to find one or two UXO items, which is typical of most UXO remediation projects, the MetalMapper identified all the approximately 200 UXO objects while only selecting 90 metallic scrap objects. This type of information allows a UXO remediation to proceed much quicker and at lower cost, allowing valuable property to be used productively.

Software is provided with the MetalMapper to directly import the MetalMapper files into commonly used software packages such as *Geosoft Montaj*. In addition a .Net library is provided to allow other programs to easily access the data..

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Application Review – TEM

terraTEM System

The terraTEM is a new transient electromagnetic survey system designed and constructed in Australia. It incorporates a 10 Amp transmitter and a true simultaneous 500 kHz 3-component receiver. The unit is powered by an external 24 V battery pack system allowing 6-8 hours of continuous operation. An inbuilt GPS is mounted on the front panel, allowing location information to be automatically recorded with soundings. All connectors are external to the case allowing easy transportation without having to shutdown between sites.



The user interface comprises a 15" colour LCD panel and a touch-screen. Menus are designed to allow intuitive and rapid transition between critical acquisition parameters and data display. Spectral analysis, combined with DSP options, allows the user to design specific filters to suit local site conditions. A diagnostic menu provides access to a spectrum analyser as well as time-domain views of the input signal for rapid troubleshooting or optimisation of acquisition parameters to ambient site conditions.

Data is stored in an expandable 1 GByte solid-state memory, this provides the user with essentially unlimited storage space (up to 500,000 soundings), making the terraTEM system ideal for rapid, high-resolution surveys. System parameters are stored automatically with each sounding for post-survey quality assurance. Data is transferred using a USB flask memory stick. The terraTEM is packaged with data reduction and processing software and can generate on-site standard profile and decay plots, apparent conductivity pseudo-sections, and contour plan maps. Images can be saved as bitmaps and inserted directly into reports. All data in this brochure was derived from the internal terraTEM software. Synchronisation with an external transmitter is optional.



The terraTEM has been developed and manufactured by Monash Geoscope and distributed worldwide by Alpha Geoscience.

For more information, contact:

Ron Bell
Consulting Geophysicist

303-462-1466
rbell@igsdenver.com

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The Founders Fund has been established to support costs associated with the establishment and maintenance of the EEGS Foundation as we solicit support from larger sponsors. These will support business office expenses, necessary travel, and similar expenses. It is expected that the operating capital for the Foundation will eventually be derived from outside sources, but the Founder's Fund will provide an operation budget to "jump start" the work. Donations of $50.00 or more are greatly apreciated. For additional information about the EEGS Foundation (an IRS status 501 (c)(3) tax exempt public charity), visit the website http://www.eegs.org and click on Membership, then "Foundation information". You may also access the EEGS Foundation at http://www.eegsfoundation.org.

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