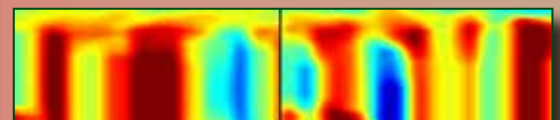
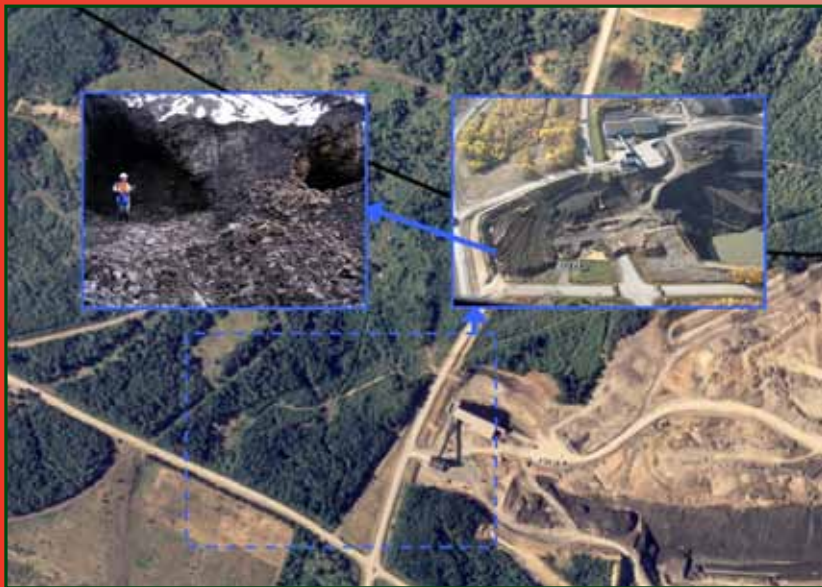


Mapping and Detecting Abandoned Mines with Geophysics



Also in this issue . . .

- NovCare 2009
- 2009 EEGS Award Winners and Elections
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- Call for Nominations: Frank Frischknecht Leadership Award

. . . and more!

Detecting a buried pipe





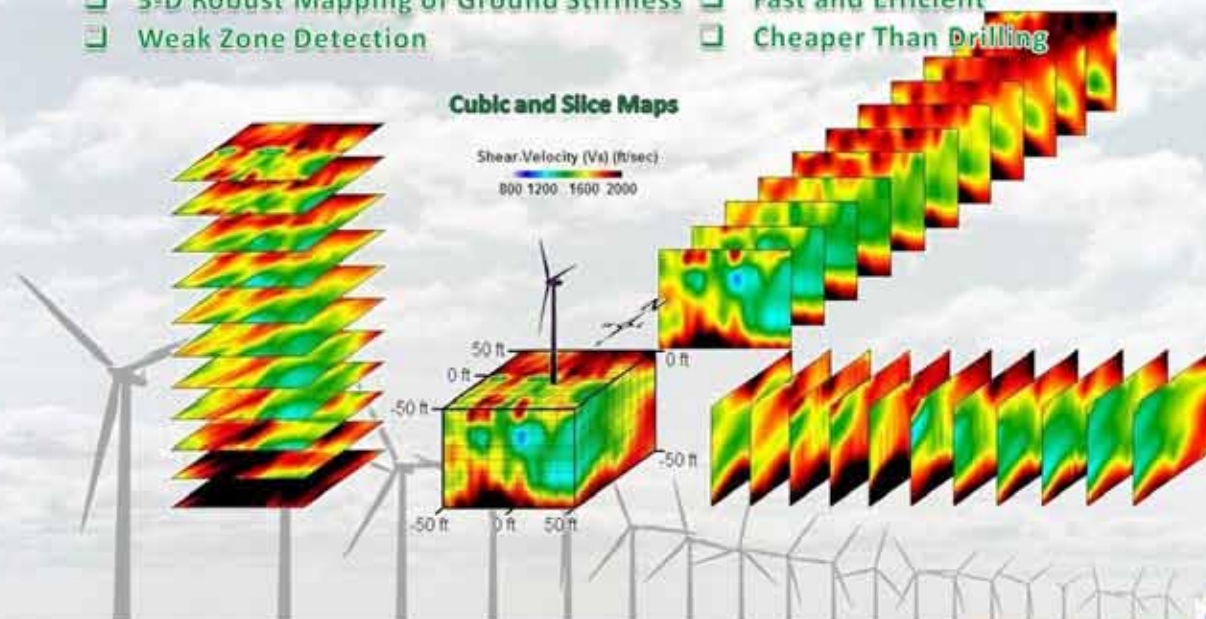
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On the Cover

Abandoned mines present unknown hazards for mining operations and land usage. They impact the public's safety and the environment. Advanced geophysical instrumentation and techniques play a pivotal role in detecting the location and extent of an abandoned mine, as well as to assess the subsurface condition. **Top left and right:** Stellerton mine and seismic velocity images of the site (page 21). **Lower right:** detection of a buried pipe using the LASI ellipticity system (page 27).

What We Want From You

The **FastTIMES** editors appreciate most any geophysical contribution. The suggested topic for the September 2009 issue is Agricultural Geophysics. We also welcome 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 August 21, 2009 to ensure inclusion in the next issue.

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FastTIMES

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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 student membership with a **JEEG** subscription (\$20 without **JEEG**), and \$650 to \$3750 for various levels of corporate membership. The membership application is available at the back of this issue, from the EEGS office at the address given below, or online at www.eegs.org. See the back for an explanation of membership categories.

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The next **FastTIMES** will be published in September 2009. Please send articles to a member of the editorial team by August 21. Advertisements are due to Jackie Jacoby by August 21.

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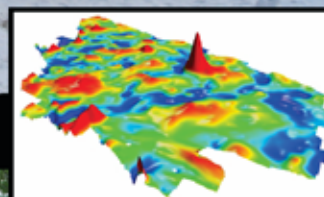
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Calendar

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

2009		October 18–21	<u>Geological Society of America Annual Meeting</u> , Portland, Oregon
August 16–19	AAPG/SEG/SPE <u>Hedberg Research Conference</u> , Geological Carbon Sequestration: Prediction and Verification, Vancouver, British Columbia	October 25–30	<u>SEG International Exposition</u> and 79 th Annual Meeting, Houston, Texas
September 7–9	<u>Near Surface 2009</u> : 15 th European Meeting of Environmental and Engineering Geophysics, Dublin, Ireland	2010	
September 7–11	<u>ISEG 2009</u> : 10 th Symposium on Environmental Geotechnology and Sustainable Development, Bochum, Germany	August 22–26	<u>ASEG/PESA 2010</u> : 21 st International Conference & Exhibition of the Australian Society of Exploration Geophysics, Sydney, Australia
September 8–10	<u>Bouyoucos Conference for the Advancement of Geophysical Technologies Applied to Agroecosystems</u> , Albuquerque, New Mexico	September 5–10	<u>IAEG 2010</u> : 11 th Congress of the International Association for Engineering Geology and the Environment, Auckland, New Zealand
October 12–14	<u>9th Symposium</u> , Society of Exploration Geophysicists of Japan, Sapporo, Japan		

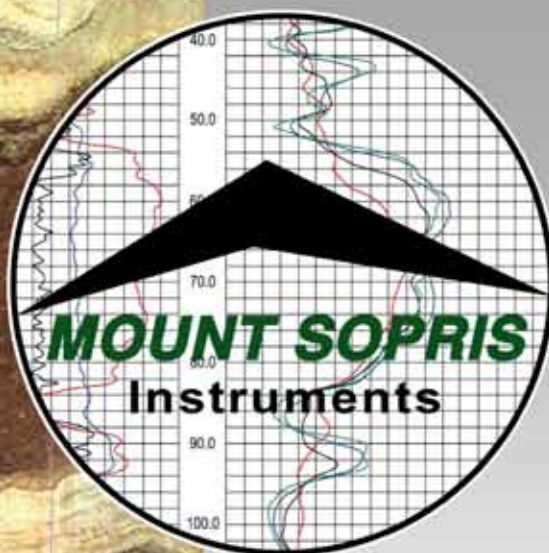


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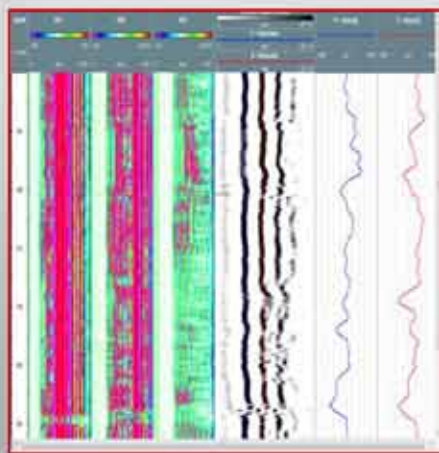




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President's Message: EEGS and the E-word

Jonathan Nyquist, President (nyq@temple.edu)

EEGS has two E-words, of course, but I am going to focus on "Environmental." I have heard more than one EEGS member lament that when they hire a student with a geology or engineering degree they know what they are getting. Not so when they hire a graduate of an environmental science program. One friend told me he routinely discards environmental science résumés because these students are all, "a mile wide and an inch deep," meaning that they have taken introductory classes in many disciplines, but few advanced classes.

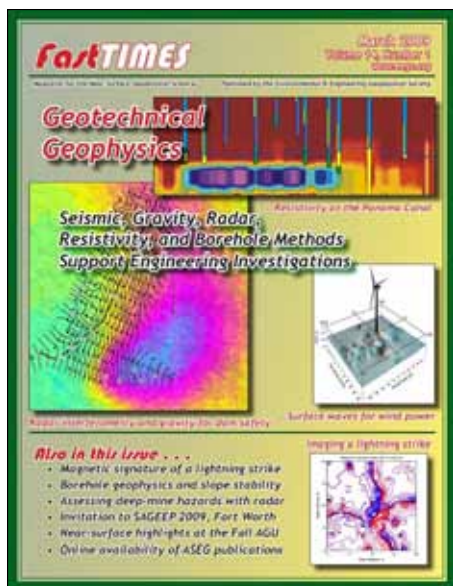
Despite such complaints, student demand is continuing to drive higher education away from traditional geology and toward environmental studies.

There are now 840 degree-granting programs at 652 colleges and universities, offering a total of 1183 different interdisciplinary degrees. And this does not include environmental tracts within geology programs. Traditional geology programs are becoming the exception. My own department recently joined this nationwide trend, changing its name from Geology, to Earth and Environmental Science. This is not just a trend in higher education. High school students can take Advanced Placement Exams in biology, chemistry, physics and environmental science, but there is no AP exam in geology.

The curriculum, not the degree name, is the real issue. (A geologist by any other name would still have muddy boots?) What do environmental science students learn? I recently returned from a meeting of the Council of Environmental Deans and Directors (<http://ncseonline.org/CEDD/>), where the results of a comprehensive survey of U.S. environmental curricula were presented. According to this report, environmental programs train students in three broad categories. Roughly 33% produce "Environmental Citizens." These programs, housed largely in liberal arts colleges, emphasize the social and political aspects of environmental issues. The "Environmental Problem Solvers," (45% of the programs) are trained in a more equal mix of science and social science, and are purportedly ready to "problem solve using disciplinary integration and a systems-thinking approach." (Please do not write me to say that scientists and engineers solve problems too. I was not involved with this report.) This brings me to the third category. Roughly 22% of the programs surveyed trained "Environmental Scientists." These programs emphasize hard science, requiring classes such as calculus, statistics, physics, organic chemistry, hydrogeology, and remote sensing/GIS.

My message to EEGS members is threefold. First, if you are an employer, take the time to read the degree transcripts. The coursework, not the degree name is what matters. Graduates from the "Environmental Scientist" category of programs would likely have sufficient depth to meet my friend's employment criteria. But beware: an "environmental science" program may have fewer science requirements than a program of "environmental studies." Second, if you are a student, think carefully about your employment goals. Many states have a Professional Geologist exam that will be difficult to pass without the requisite coursework. Third, and finally, EEGS should become more involved in shaping education. The call for SAGEEP 2010 papers and sessions is going out. I would like to see a discussion of geoscience education be a component of this conference.

One final thought. Bewildered by the current variety of environmental programs? Just wait. The new buzzword in higher education is "sustainability." Colleges are already launching new degrees in sustainability science. My advice: keep your eye on the transcript.



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 (March 2009, cover image at left) has been downloaded more than 15,000 times through June, 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.



From the Editor's Desk

Moe Momayez (moe.momayez@arizona.edu)

I am very pleased and honored to take my place as the new editor of **FastTIMES** - sincere thanks to all for your support and well wishes. During this transition period, I am especially grateful to Jackie Jacoby, Managing Director, at the EEGS business office, for her enthusiasm and professionalism, to Jeff Paine, our outgoing editor, for his expert guidance and help, and to associate editors Roger Young and Brad Isbell for all their support.

I believe that being the editor of **FastTIMES** gives me a unique opportunity to collaborate with a group of dedicated individuals, to be involved in gathering and disseminating know-how among a league of respected engineers and scientists, and to help shape a magazine that will cover a wide range of topics and solutions of interest to the near-surface geophysics community. My own efforts in the field of near surface geophysics are focused on the development of technologies to characterize geomaterials, and I hope to share some of my findings in a later issue.

I strongly believe in the value of hard work, collaboration, sharing knowledge and knowledge management. I equally believe in creativity. Geophysical engineers and scientists are fortunate enough to practice all of those things every day, whether we spend our time in the field or at the office. I cannot help but think of the old anecdote where a mathematician, a geologist and a geophysicist are all asked the following question: how much does two plus two equal?



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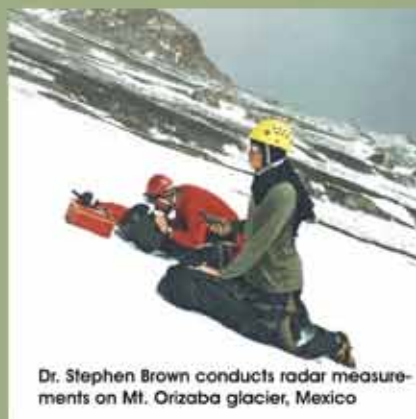


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Dr. Stephen Brown conducts radar measurements on Mt. Orizaba glacier, Mexico

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The mathematician answers four; the geologist responds, 'between three and five'; and the geophysicist enquires, 'How much would you like it to be?' The answer given by our fellow geophysicist, I believe, pays testament to the passion we all share about our discipline.

Later this year, I would like to propose a theme that will require the collaboration from those of you involved in the creation of new software tools. This year's last issue will include a review of new developments in open source code in use by the community. This initiative, supported by you, will keep us abreast of the latest innovations in data analysis, and may also provide an opportunity for some of us to embark on larger collaborative projects.

I am excited about working on every issue and look forward to receive your articles, contributions, news of upcoming events, reports, suggestions as well as constructive criticism on how the magazine is put together and where we should take it.

2009 EEGS/Geonics Early Career Award

About the Award

The Early Career Award, sponsored by Geonics Limited and awarded by the Environmental and Engineering Geophysical Society, is intended to acknowledge academic excellence and encourage research in near-surface geophysics. The award, presented annually to a full-time faculty member who is within ten years following completion of the Ph.D., acknowledges significant and ongoing contributions to environmental and engineering geophysics. The award was presented at SAGEEP 2009 in Fort Worth, Texas.



Kamini Singha, 2009 Awardee

Professor Kamini Singha is the 2009 recipient of the EEGS/Geonics Early Career Award. Receiving her PhD only four years ago from Stanford University, she has already built an impressive record of accomplishment. Kamini, who is presently Assistant Professor in the Department of Geosciences at Pennsylvania State University, has focused both theoretical and applied research on the development and demonstration of geophysical methods for hydrologic and environmental characterization and monitoring. Her novel applications of these methods have required careful, field-scale monitoring of ionic tracer tests using electrical-resistivity tomography. Her work in this area

has truly revolutionized the field by demonstrating the implications of tomographic resolution, survey design, and inversion parameter choices on the information content of tomograms.

In addition to pursuing an ambitious research agenda, Dr. Singha is also a dedicated teacher and adviser to both graduate and undergraduate students, working with undergraduates in challenging research projects, both laboratory- and fieldbased. She uses active-learning strategies in class and in field laboratories and has published a description of a classroom demonstration she uses. Dr. Singha also finds time and energy to pursue community serviced projects with tangible societal and humanitarian benefit, including her interdisciplinary research work in Ghana seeking an understanding of health effects of small-scale gold mining and improving the lives of subsistence miners by educating them in the use of chemical test kits to measure contamination in water. She was recently named the

first Faculty Fellow of the Penn State Alliance for Earth Sciences, Engineering, and Development in Africa (AESEDA) for this work.

2009 EEGS Gold Award

About the Award

The EEGS Gold Award was established to recognize an individual who is deserving of special recognition due to exceptional contributions made to the engineering and environmental geophysics community and to EEGS. Such contributions include development of educational tools or curricula, innovation in outreach efforts, or creating communication methods and opportunities with other professional disciplines that comprise potential geophysical end-users. The award was presented at the 2009 SAGEEP in Fort Worth, Texas.



William E. Doll, 2009 Awardee

William Doll (Bill) is a research geophysicist with Battelle. He leads a team of professionals conducting research in the area of airborne electromagnetic (EM) and magnetic systems for detecting and mapping UXO. He also led the development of complementary airborne EM systems for use where geologic conditions or non-ferrous ordnance impedes magnetic system performance. His team's research has also focused on the evaluation of seismic methods for shallow imaging and integration with multi-electrode resistivity data and other geophysical data sets.

Bill is a rare breed; his varied background has included a focus on EM and magnetic methods as well as seismic techniques. He has held teaching a faculty position as Assistant Professor at Colby College and taught a short course at the University of Tennessee. Prior to his position at Battelle, Bill was in a similar position at Oak Ridge National Laboratory, leading a team of research geophysicists. He has been involved with EEGS, with the Near Surface Group (NSG) of the SEG, and with AGU. He served in several positions of the NSG between 1996 and 1999, including President. His publication list of refereed publications, articles, abstracts and extended abstracts is extensive and prolific, approaching 100, in venues such as *Geophysics*, *The Leading Edge*, *SAGEEP*, and *SEG* to name a few. He and his team routinely provide several papers to *SAGEEP* every year.

Bill served as EEGS President from 2003-2004, and greatly supported the outgoing EEGS President and leadership during a challenging period of transition to our present successful management team at Whiting. Bill was always level-headed and provided competent direction during the transition.

Always a forward thinker, Bill initiated several ideas and programs with EEGS that have impacted the value of the society to our membership. He sought to make EEGS more engaged with domestic and international near-surface organizations, helping EEGS to be more involved with our Asian counterparts, and serving as a Keynote speaker at the ICEEG meeting in China in 2004. He helped institute a new award given by EEGS, the EEGS/Geonics Early Career Award. This award acknowledges academic excellence, encourages research in near-surface geophysics, and appreciates significant and ongoing contributions to the discipline of environmental and engineering geophysics. He has been instrumental in the formation and development of the recently established EEGS Foundation to more fully support the growth and outreach of EEGS, and he is currently serving as the foundation's first President.

2009 EEGS Board Elections

EEGS maintains a balance of experience and fresh ideas on its Board of Directors by having annual elections for roughly half of the positions, staggering multi-year terms, and having key positions serve an apprenticeship year in an “Elect” position. The past presidents assemble a list of qualified and willing candidates for each open position, including those of President Elect, Vice Presidents Elect for SAGEEP and Committees, and two of six Member-at-Large positions. The 2009 nomination committee, chaired by Past President Jeffrey G. Paine, carried on the tradition of identifying highly qualified individuals who are willing to donate their time and effort to help EEGS continue to grow and prosper.

Winners of the 2009 elections, held in January and February, are John Stowell, President Elect; Douglas Groom, Vice President Elect, SAGEEP; John A. Dunbar, Vice President Elect, Committees; and Members-at-Large Dale Werkema, Melvyn E. Best, and Soheil Nazarian. These newly elected Board members (photographs below) began their terms at the close of the 2009 SAGEEP in Fort Worth, TX.

At SAGEEP 2009, Jonathan E. Nyquist continued his extended term as President, Charles Stoyer became Vice President, SAGEEP, and Bruce Smith became Vice President, Committees, and Barbara Luke became Past President. Continuing their terms as Members-at-Large are Gregory S. Baker and Mike Powers. Micki Allen continues in her ex officio position as international society liaison. Concluding their terms on the EEGS board were Susan Pullan, Jennifer Holt, William Doll, Doug LaBrecque, and Jeff Paine. These individuals have generously donated much time and effort to EEGS and deserve our sincere appreciation.

Please consider nominating yourself or another qualified, positive, and enthusiastic member for the 2010 EEGS Board elections. You may send your nomination to Past President Barbara Luke, the current chair of the nominating committee, at barbara.luke@unlv.edu.

Please visit the EEGS website (www.eegs.org), where you can choose the “About EEGS” tab to see the complete 2009–2010 Board of Directors.



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Melvyn Best
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Dale Werkema
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Renew your EEGS Membership for 2009

Be sure to renew your EEGS membership for 2009! In addition to the more tangible member benefits (including a print subscription to **JEEG**, **FastTIMES** delivered to your email box quarterly, discounts on EEGS publications and SAGEEP registration, and benefits from associated societies), your dues help support EEGS's major initiatives such as producing our annual meeting (SAGEEP), publishing **JEEG**, making our publications available electronically, expanding the awareness of near-surface geophysics outside our discipline, and enhancing our web site to enable desired capabilities such as membership services, publication ordering, and search and delivery of SAGEEP papers. New this year is an opportunity to donate to the EEGS Foundation during the renewal process. Members can renew by mail, fax, or online at www.eegs.org.

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 the Denver area. Contact Jon Nyquist (nyq@temple.edu) for more information.



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The *JEEG* Page

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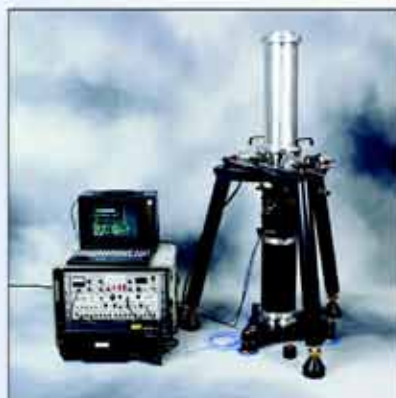
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EAGE's Near Surface Geophysics Journal, June 2009

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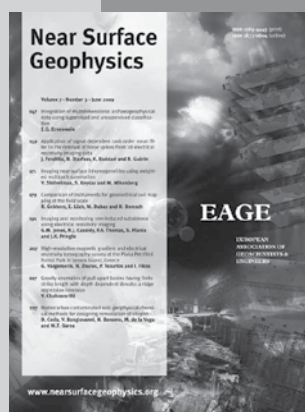
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FastTIMES welcomes short articles on applications of geophysics to the near surface in many disciplines, including engineering and environmental problems, geology, soil science, hydrology, archaeology, and astronomy. In the articles that follow, the authors illustrate how noninvasive geophysical methods have been applied to locate underground abandoned mines.

Finding Near-Surface Abandoned Mine Openings: A Case Study

by S.D. Butt, Faculty of Engineering and Applied Science, Memorial University, St. John's, NL, Canada (sdbutt@mun.ca)

A joint university-industry project headed by Professor Stephen Butt at Memorial University is focused on the development of near-surface seismic methods to assist with locating abandoned mine openings. The project is focused on methods that can be used to do a first-pass survey of a site to identify targets for follow-up investigation or to fill-in between known cavity locations. This project has involved researchers at Memorial University and Dalhousie University in Halifax, NS and has been funded by the Atlantic Innovation Fund (AIF), the Natural Sciences and Engineering Research Council (NSERC), and Conestoga Rover & Associates (CRA) Ltd, with industrial collaboration with C-CORE, the Nova Scotia Department of Natural Resources, and Pioneer Coal Ltd.

The project is based on multichannel spectral analysis of surface waves (MASW) methods (e.g. Park et al., 1999) but with survey procedures, data analysis methodologies and inversion techniques optimized to highlight localized anomalies such as those associated with abandoned mine openings. The data analysis methods are focused in several key areas: i) identifying gaps in dispersion fields which can localize the relative depth of mine openings, ii) processing seismic waves using short sensor array subsets to localize the horizontal position of mine openings, iii) processing data in the f-k domain to highlight the surface and body wave reflections from openings identified from negative velocities, iv) and incorporating front and back shots to isolate the signature of openings from the influence of laterally homogenous horizontal or dipping geological features. To further aid with planning seismic surveys to target localized



Figure 1. Aerial photograph of the Stellerton Mine expansion block before mining (dashed box), after the start of mining in Fall 2005 (inset, upper right) and openings mapped in the pit end face (inset, upper left).

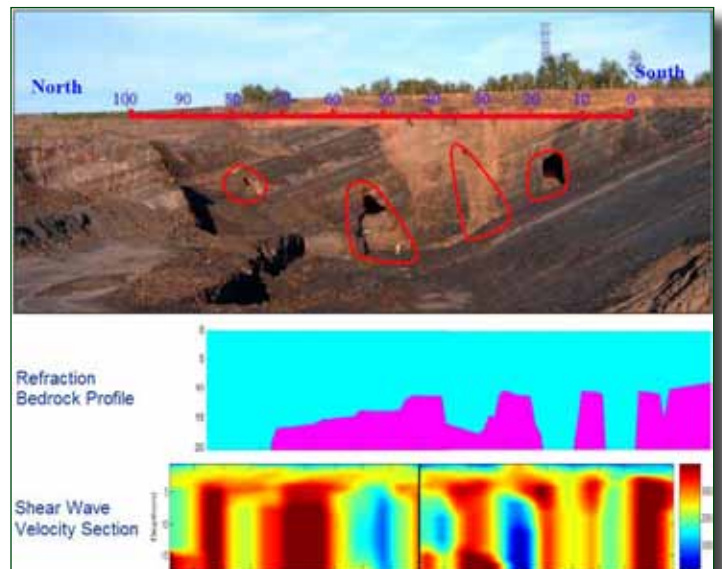


Figure 2. Photograph of the endwall of the Stellerton Mine Field Site and refraction and velocity seismic images from an August 2006 field trial. The seismic line and existing openings and collapse structures are highlighted in red on the photograph. Station numbers are in meters.

anomalies of particular depth or dimension (which are either stiffer or softer than the surrounding material) sensitivity and parametric studies using finite difference wave propagation models have been done (Sharma et al., 2008, 2009).

Field trials of the survey methods were conducted at abandoned mine sites in Nova Scotia over several field seasons (Butt et al., 2005; Xu and Butt, 2006; Xu et al., 2008). One of these field trials was conducted at the Stellerton Coal mine, which is an active surface coal mine exploiting seams previously mined using underground methods during the 1800's and early 1900's. Figure 1 is an aerial shot during a mine expansion phase, showing some of the mine openings that were uncovered during the excavation. Figure 2 is a photograph of the final end wall of the mine expansion showing the location of mine openings or collapse zones over mine openings and the results of the seismic survey that was conducted along the end-wall crest. In this figure, all of the mine openings or collapse zones are identified as low velocity anomalies in the shear-wave velocity section whereas some, but not all, of these features are shown in the refraction bedrock profile. Figure 3 shows the results of an automated wave-field inversion code which correctly determines the number and location of the mine openings (S. Sharma, unpublished PhD research). Overall, the project has demonstrated that surface wave seismic surveys need to be carefully planned in terms of source frequency bandwidth, geophone spacing and overall geophone string length to ensure the greatest likelihood of identifying the targeted mine openings.

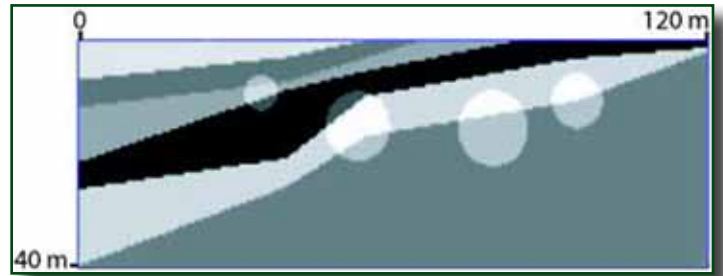


Figure 3. The results of an automated annealing inversion, which determined the approximate size and location of mine openings (shown as grey circles) overlain on the corresponding geological section.

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- ✚ Preparing Work Plans for geophysical surveys/mapping in support of investigation projects.
- ✚ Preparing purchase requisitions for geophysical survey and mapping
- ✚ Evaluating geophysical data relative to presence and extent of buried military munitions
- ✚ Supervising geophysical activities and providing quality control of surveying and mapping
- ✚ Day to day management of up to 8 field workers, performing varying tasks.
- ✚ Monitoring schedules for geophysical activities
- ✚ Capable of communication with USACE Project Managers, Subcontractors and other Prime Contractors.
- ✚ Reviewing geophysical survey reports and presenting quality control data.
- ✚ Candidate shall possess a B.S. or M.S. degree in Geophysics, Geology, or related field.
- ✚ 6+ years experience in working in geophysical surveys
- ✚ 5+ years experience in detection and discrimination of buried military munitions
- ✚ 6+ years experience working on government projects
- ✚ Knowledge of UXO geophysical sensors (EM-61, Magnetics) and positioning systems (RTK GPS).
- ✚ Microsoft Word, Excel, PowerPoint and Access skills required.
- ✚ ArcGIS, Oasis Montaj and Matlab skills required.
- ✚ Good communication skills, self starter, quick learner.
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- ✚ Manage projects in site investigation and remediation services
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- ✚ Exceptional oral and written communication skills
- ✚ Ability to handle difficult and stressful situations with a sense of humor and grace
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Supports project managers in development of environmental investigation and remediation project work plans, reports, and project statusing. Supervises SKY personnel and subcontractors in daily field operations. Familiarity with standard practices and procedures within the environmental industry. Experience with environmental soil sampling required. Must possess excellent communications skills. Capable of making independent decisions based on site and project specific conditions. Flexibility and a willingness to perform a variety of tasks ranging from field work to planning, document preparation, and field execution is a must.

-  Minimum of 2 – 5 years environmental munitions project
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-  Bachelors degree in Geology/Chemical or related field
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Job Responsibilities and Requirements:

The Remote Sensing Scientist Lead is responsible for managing airborne remote sensing research and development programs. The candidate will work closely with the flight operations team for project scheduling and aircraft modification. They will be responsible for directing technical teams and will lead efforts to develop the next generation of civilian and military remote sensing instrumentation and methodologies. The Remote Sensing Lead will also work with other senior staff to expand the base of business in this area. The candidate should have a strong understanding of detectors and detection processes.

- ✚ Act as technical lead
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- ✚ Represent Sky Research in professional forums and client meetings
- ✚ Promote Sky Research remote sensing and other capabilities both domestically and internationally Masters or PhD in technical or scientific field
- ✚ 5 years experience in airborne remote sensing preferred
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- ✚ Demonstrated adaptability, flexibility, perseverance, and a positive attitude required

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Compensation: Salary (D.O.E.)

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Other Criteria

Travel Required: Yes

Telecommute: No



Electromagnetic Geophysics Techniques for Location of Abandoned Underground Mines

by Ben K. Sternberg, Laboratory for Advanced Subsurface Imaging, University of Arizona, (bkslasi@email.arizona.edu)

Introduction

The Laboratory for Advanced Subsurface Imaging (LASI) at the University of Arizona has been involved in the development of electromagnetic geophysics techniques for location of abandoned underground mines and other subsurface voids and tunnels since 1992. I have prepared this short paper in order to review some of the technology that we have used, as well as discuss a series of case histories, which illustrate the capabilities of these methods. Some of this material has been previously presented at a workshop in Tucson, Arizona in 2004, organized by the Interstate Technical Group on Abandoned Underground Mines.

The LASI ellipticity system

With Department of Energy funding, we developed an electromagnetic imaging system in the frequency range from 30 kHz to 30 MHz. The primary applications for this system were in imaging the location of buried waste and contaminated ground water. With Department of Defense and Bureau of Mines funding, we developed an electromagnetic imaging system in the frequency range from 1 kHz to 1 MHz. The primary applications for this system were in imaging the location of abandoned mine workings and subsurface voids. The details of the ellipticity system have been published in Sternberg (1999), Sternberg et al. (1999), and Sternberg and Birken (1999).

In these systems, a transmitter generates a swept-frequency signal in one of the two frequency ranges. We record the ellipticity of the magnetic field at a receiver. The received magnetic field over the earth traces out an ellipse as a function of time. The ellipticity is defined as the ratio of the minor axis to the major axis of this ellipse. The ellipticity provides diagnostic responses over earth structures of interest. Figure 1 shows the transmitter system mounted on an all terrain vehicle (ATV). Figure 2 shows the receiver system mounted on a second ATV. During operation, these two ATVs move along a profile line, recording the ellipticity versus frequency. We then invert these data to cross sections of resistivity versus depth using various modeling programs. The depth of investigation varies with the resistivity conditions and will be shown for specific targets in the following case histories.



Figure 1. Photograph of the transmitter all-terrain vehicle with the transmitting antenna suspended from the boom in the front of the ATV.

Tunnel at the Avra Valley Geophysical Test Site

We have developed a test site west of the University of Arizona campus known as the Avra Valley Geophysical Test Site (Sternberg et al., 1991). It is located approximately 3.8 km west of Ryan field

on Ajo Way. The site contains a wide variety of buried targets, including various metal containers simulating buried waste and water injection basins. The site has been used by many groups to test geophysical techniques and can be made available to other interested researchers.

Figure 3 shows a buried concrete pipe or tunnel, approximately 1 m diameter, and buried 3m to the center of the pipe. Figure 4 shows the recorded 8 kHz ellipticity data over this pipe/tunnel (from Sternberg and Poulton, 1995). There is a strong response over this concrete pipe, i.e. much larger than the background variations in the soil.

Tunnel at the Nevada Test Site

The next test was over a deeper tunnel, located at the Department of Energy's Nevada Test Site. The tunnel is approximately 30 m deep. It is currently being used as an access tunnel for tests on the suitability of the site for storage of high-level nuclear waste. The tunnel contains many metal pipes. We used a sheet modeling program to model the data (Sternberg and Yang, 1999). Figure 5 shows the model that was used for the theoretical electromagnetic response calculations. Figure 6 shows the measured 4 kHz ellipticity data over the tunnel and the sheet model calculations (Sternberg and Poulton, 1996). There are significant variations in the measured data due to the normal variations in rock resistivity but there is still a distinct anomaly visible that is due to the tunnel. The calculated model data agree well with the measured data.



Figure 2. Photograph of the receiver all-terrain vehicle with the receiver antenna suspended from the boom projecting behind the ATV. In normal field operation this receiver ATV leads and the transmitter ATV follows along the profile line.



Figure 3. Photograph of the tunnel constructed at the University of Arizona, Avra Valley Geophysical Test Site.

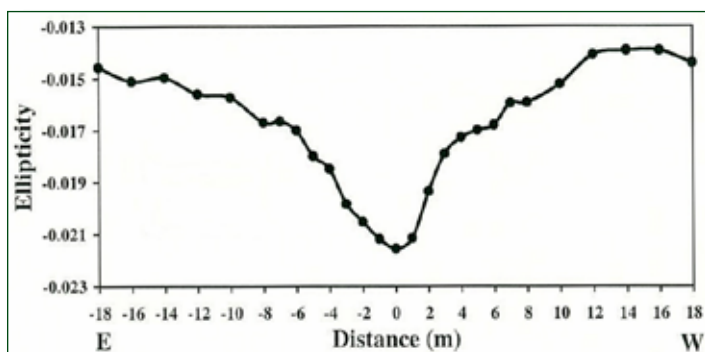


Figure 4. 8m broadside array over empty tunnel, 8 kHz.

Tunnel at the Nevada Test Site

The next case history was from a survey sponsored by the U.S. Bureau of Mines (Poulton and Sternberg, 1995). The survey was over the abandoned Union Pacific #9 coal mine near Rock Springs, Wyoming (Figure 7). A portion of the mine is subsiding due to a fire in the coal seam. Figure 8 shows the results of one of our ellipticity survey lines. In this case, the ellipticity data were converted to a resistivity versus

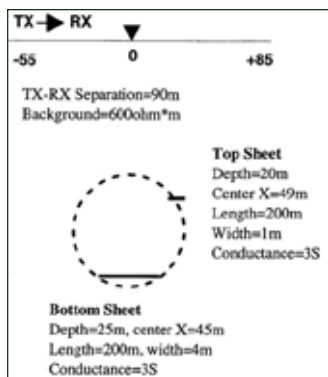


Figure 5. Model used for calculations of the EM response for the Nevada Test Site (NTS) Tunnel. Note, depth not to scale.

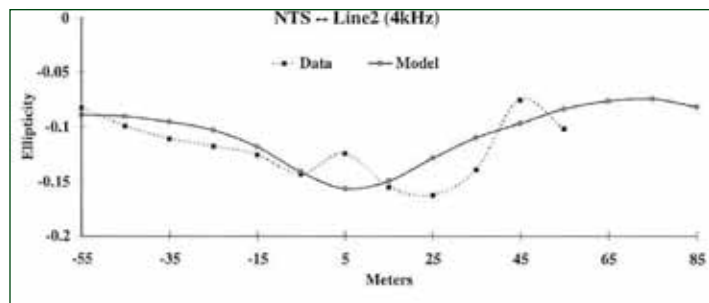


Figure 6. Comparison of data and theoretically calculated model ellipticities at the Nevada Test Site Tunnel.

depth cross section. A locally one-dimensional modeling code was applied at each measurement location. The resulting resistivities versus depth were then contoured to produce this map. The green color on the left in this plot shows the normal background resistivity for the rocks in this area. The dark blue color on the right shows anomalously low resistivities. These low resistivities are interpreted to be due to water-containing fractures caused by the subsidence zone above the burning coal mine. This region correlates well with the known extent of the currently burned coal mine area.

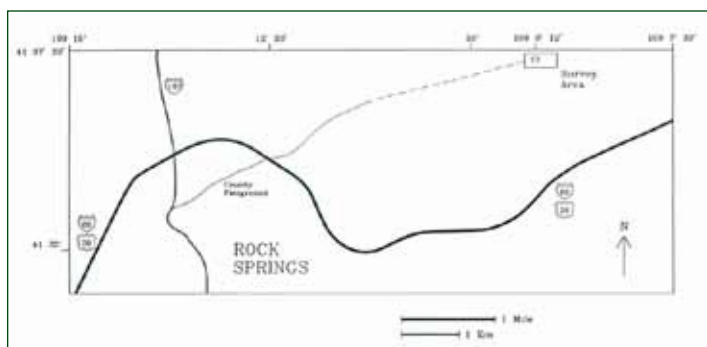


Figure 7. Location of the field survey near Rock Springs, Wyoming.

Figure 9 shows the location of the survey in Tombstone, Arizona. Figure 10 shows the results of the GPR survey at Toughnut Street (Henley and Sternberg, 2000). The warmest colors show the areas of highest reflection signal strength. The cool colors show the normal background signal strength. The time scale has been converted to depth based on velocities determined from the normal move-out of the deep reflecting horizons. The top part of this record is dominated by reflections from above-ground targets, such as cars, buildings, and utility lines. We were able to verify that the deep reflections, i.e. below 100 nsec or 4 meters, are from within the

Ground penetrating radar survey at Tombstone, Arizona

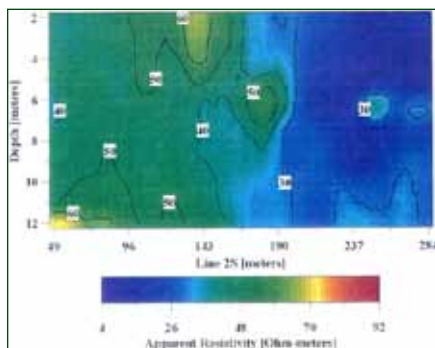


Figure 8. Resistivity section for line 2S created from apparent resistivity inversion results.



Figure 9. GPR survey locations at Tombstone, Arizona.

earth based on a velocity analysis using the data on the sections. The circled region labeled “1” on this cross section is the area of highest reflection strength. This region correlates well with the known mine workings in this area.

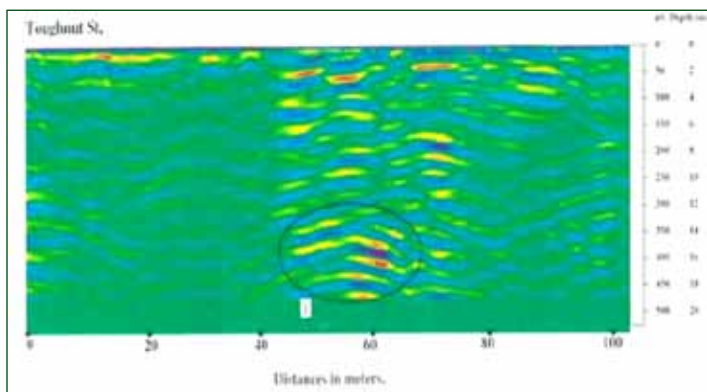


Figure 10. Toughnut St. GPR profile.

nature. These plots are based on measurements of samples made in the LASI Lab by Dr. Levitskaya and are from some of the areas where we have run surveys. The “W” values listed on these plots are the weight percent water contained in the sample. The attenuation is lower and the depth of penetration is greater at lower frequencies, in all cases, which is why we designed the LASI ellipticity system to operate at lower frequencies than most GPR systems. The samples from Brookhaven are clean sands and have very low attenuation values, i.e. similar to the Tombstone rocks. The Avra Valley samples are representative of most soils and rocks in the southwestern U.S. and have too high an attenuation for effective GPR surveys at depths of interest for many abandoned underground mine problems, using antenna center frequencies of 100s of MHz.

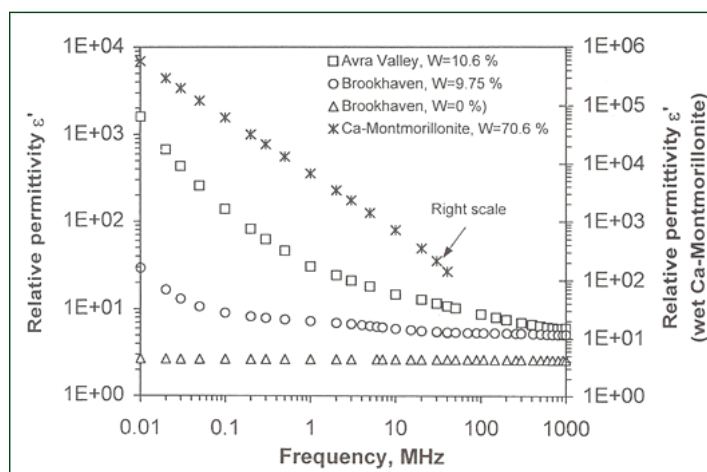


Figure 11. Relative permittivity.

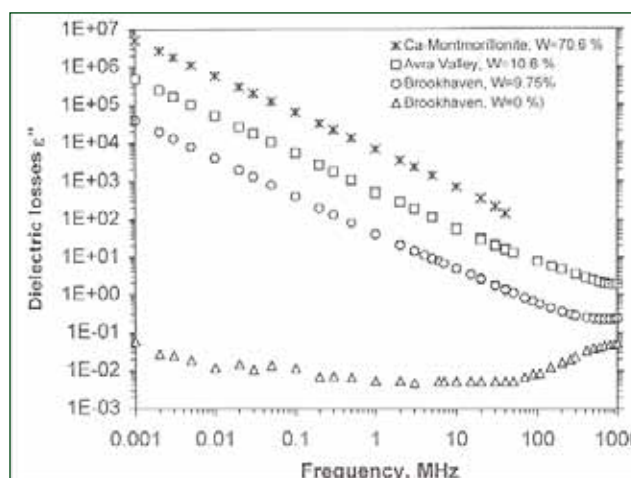


Figure 12. Dielectric losses.

A new approach in subsurface imaging

The Federal Communications Commission has enacted new regulations that apply to GPR and other ultra-wideband transmissions in the radio frequency spectrum. All new GPRs must meet these requirements. Manufacturers of GPR equipment have found that they are able to use sufficient shielding

and low enough transmitted power at frequencies above approximately 100-200 MHz to meet these requirements. The manufacturers have said that they do not see any way to meet these regulations for frequencies below 100 MHz and with the power levels that are needed in these frequency ranges. We have therefore been working on an alternative transmission strategy below 100 MHz. Table 1 lists frequencies known as Industrial, Scientific, and Medical (ISM) frequency bands. It is possible to transmit relatively large powers without a license in these frequency bands. These are narrow bands but are distributed well throughout the region between 1 and 50 MHz. With support from the National Science Foundation, we have studied ways to use these ISM frequencies for effective sounding in the 1 to 50 MHz frequency range as well as at low frequencies (10 Hz to 10 kHz).

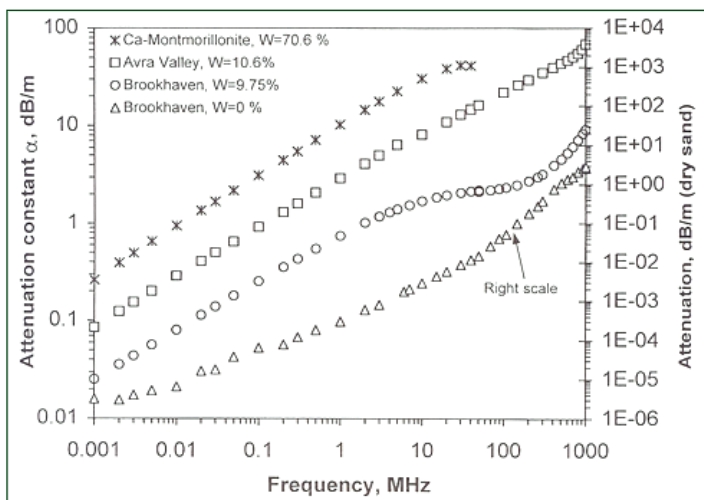


Figure 13. Attenuation constant.

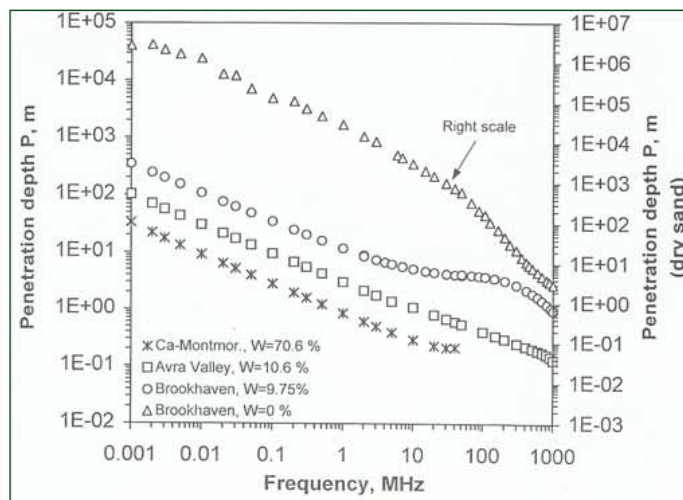


Figure 14. Penetration depth.

Table 1. Characteristics of the ISM frequency bands.

Center Frequency (MHz)	Bandwidth (kHz)	Bandwidth (%)
6.78	+/- 15	0.44
13.56	+/- 7	0.10
27.12	+/- 163	1.20
40.68	+/- 20	0.10

Some of our early results in the 10 Hz to 10 kHz frequency range have been published in Sternberg et al., 2008 and Krichenko et al., 2008. These papers describe a method for making very high-sensitivity measurements, which we call the Alternating Target Antenna Coupling (ATAC) method. The system uses a beam containing orthogonal antennas and rotation of the beam about its axis to preserve the primary coupling while changing the target coupling. The beam may be either vertical (a) or horizontal (b), as shown in Figure 15.

A major limitation of existing technology is the drift of the sensors during the course of measurements. Current commercial instruments of this type may show drift rates of 100s of ppm over typical survey times. Figure 16 shows the drifts before ATAC rotation (400 ppm) and after ATAC rotation (0.1 ppm). Removal of this drift eliminates false anomalies and provides much higher sensitivity for small and deep targets.

We have built a prototype system for testing and proof of concept. The prototype system currently has a usable dynamic range of 134 dB. With a larger TX moment, similar to current commercial systems, we expect that the ATAC system will have a usable dynamic range of >200dB. We have used the prototype system to sense a number of shallow targets including a 2" steel pipe, which has been used as a standard target for testing other systems. We see a diagnostic response at depths of 2m. The maximum depth of investigation for current commercial systems is about 1.5m for this target. With a larger TX moment, similar to current commercial systems, the ATAC system should be able to detect this target at a depth of 9m, i.e. 6X better than current systems. We have found that the ATAC method is also highly effective for imaging subsurface anomalies that are off to the side of the survey line, thus providing survey capabilities in restricted areas or areas with widely spaced survey lines.

Our plans are to adapt the ATAC method to the ISM frequency bands in the 1 to 50 MHz range. We will apply this capability to mapping abandoned underground mines, as well as similar targets.

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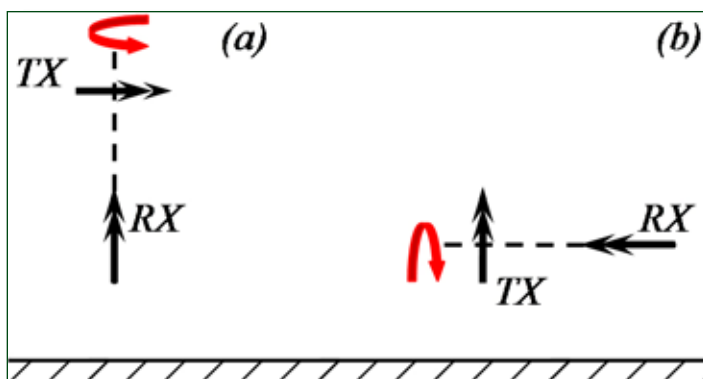


Figure 15. Diagram of the ATAC orthogonal antenna arrays in vertical (a) and horizontal (b) orientations above the surface of the earth.

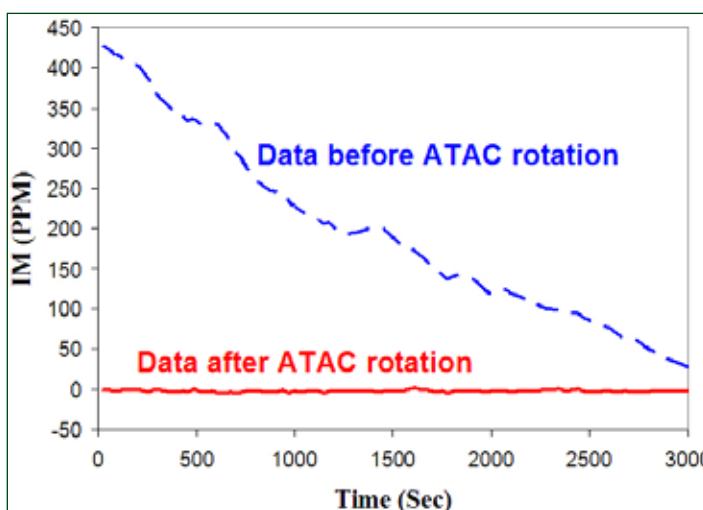


Figure 16. Example of the reduction of measurement errors due to temporal drift in the nulling circuit.

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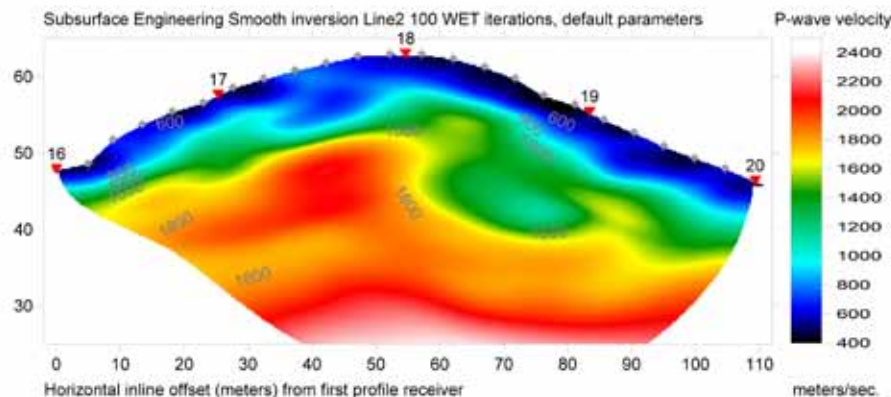
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Above: six-sensor cart with concatenation box and GPS

Left: dual sensor horizontal gradiometer

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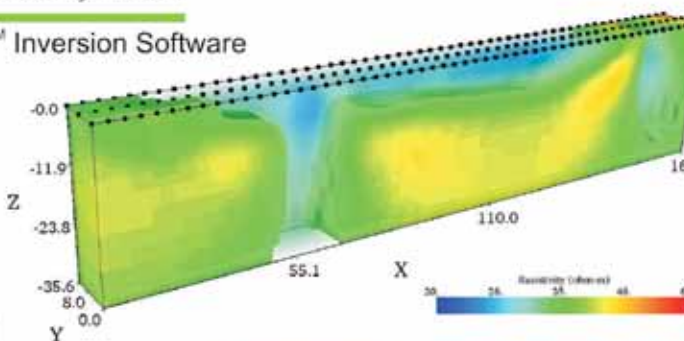
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Near-Surface Community News

FastTIMES publishes contributions from societies and individuals with an interest in near-surface geophysics. Representatives of the Australian Society of Exploration Geophysicists contributed the item below, which first appeared in the March 2009 issue. An abridged version is reprinted below. Contributions from others are always welcome.

Publications of the Australian Society of Exploration Geophysicists Free Online to ASEG/SEG/EAGE/NSG/EEGS Members

by Michael Asten, ASEG President-Elect, and Phil Schmidt, ASEG Chairman of Publications

The ASEG is pleased to announce that all publications (**Exploration Geophysics**, **Preview**, ASEG Conference Extended Abstracts, and Special Publications) are now available online at www.aseg.org.au (select Publications>Exploration Geophysics and follow the prompts).

A period of free access to full pdf downloads, for the year 2009, is being offered to members of the professional geophysical societies listed above.

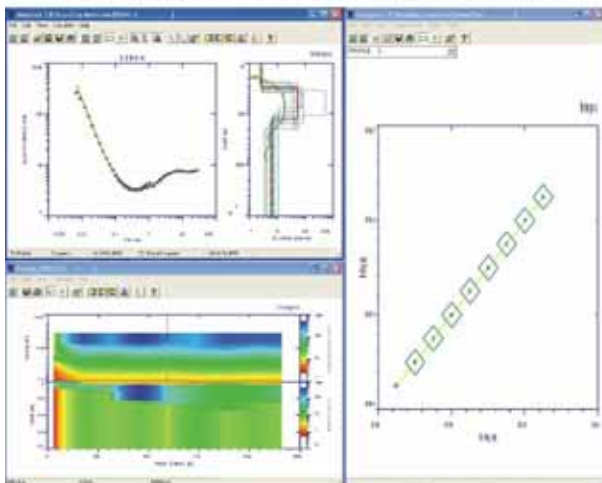
Exploration Geophysics also welcomes submissions of papers from geophysicists world-wide.

All ASEG material is also being incorporated into the SEG Digital Cumulative Index at <http://segdl.org/journals/doc/SEGLIB-home/dci/searchDCI.jsp> (can use tick boxes at the base of the webpage) but the SEG webpage organization and tabbing of ASEG publications is still under development.

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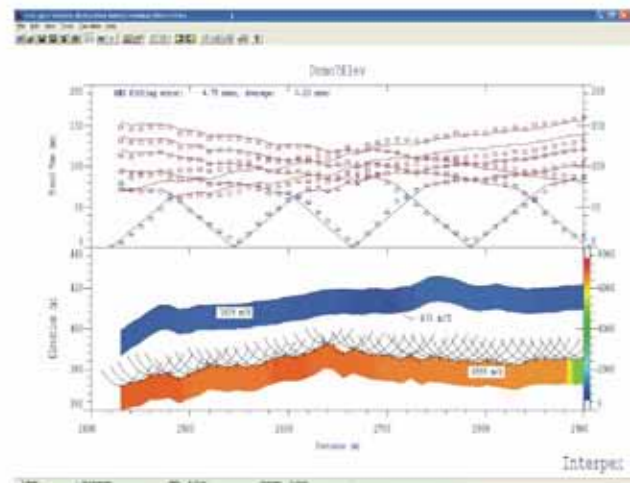
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Coming Events

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

Near Surface

2009

EAGE Near Surface 2009

September 7-9, 2009, Dublin, Ireland

Organised by the European Association of Geoscientists and Engineers, the conference has special themes each day this year, starting with a workshop on Archaeogeophysics on the Sunday followed by related papers on Monday, a day of Engineering and Geotechnical applications on Tuesday and Ground Water and Glacial studies on Wednesday, all in parallel with other geophysics issues. Two field trips are also offered on the Thursday. Visit the EAGE website at <http://www.eage.org> for more information.

Bouyoucos Conference for the Advancement of Geophysical Technologies Applied to Agroecosystems

September 8-10, 2009

Albuquerque, New Mexico

Conference Overview

This unique conference will bring together participants, with agricultural and non-agricultural backgrounds, who have an interest and/or expertise in geophysical technologies. The conference program will promote the advancement of agricultural geophysics through special topic sessions led by invited speakers, and a poster session where the latest agricultural geophysics research is presented.

Conference Hotel

The conference will be held at the landmark Hotel Albuquerque. Rooms have been reserved at the nightly rate of \$89.00 + tax. (<http://hbandr.com/albuquerque.php>) The hotel itself is ideally located within easily walking distance of the museum quarter and all the restaurants, shops, and galleries of the "Old Town" historic district. (<http://www.albuquerqueoldtown.com>)

Conference Program

1st Special Topic Session - September 8 - Afternoon
Geophysical Techniques Presently Used in Agroecosystems and Potential New Applications

Reception and Poster Session - September 8 - Evening

2nd Special Topic Session - September 9 - Morning
New Field Survey Procedures and the Potential Utilization of Geophysical Techniques Currently Not Extensively Employed for Agriculture

3rd Special Topic Session - September 9 - Afternoon
New Agricultural Geophysics Data Analysis Methods

4th Session - September 10, 2009 - Morning
Wrap-Up (includes White Paper and Web Site Development, Specialized Cutting-Edge Research Topic Groups, Regional Project Teams, Establishment of Ties Among Scientific Societies, and International Outreach)

Conference Registration

Registration begins May 15, 2009 and ends August 15, 2009. The general registration fee is \$100.00 (USD), but for graduate students, there is a reduced cost of \$50.00 (USD). The registration form can be completed online at the conference website. (www.ag-geophysics.org)

Call for Abstracts

The deadline for poster session abstracts (300 words or less) is August 1, 2009, and the abstract submission fee is \$50.00. Extended abstracts (four to six pages) need to be submitted by October 15, 2009 in order to be published in the conference proceedings. Abstract submission can be completed online at the conference website.



Conference Coordinators

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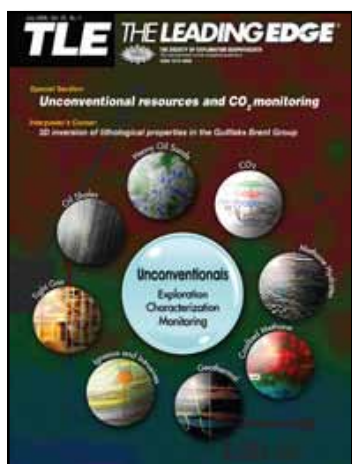
GSA 2009 Annual Meeting & Exposition

October 18-21, 2009, Portland, Oregon

The Geological Society of America is pleased to be holding its 2009 Annual Meeting and Exposition, October 18-21, 2009 in Portland, Oregon, USA. GSA is one of the oldest and most prestigious scientific societies in the world, and many of our members are your employees, colleagues and friends.

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GSA is growing in service and value to geoscientists, and we encourage you to join over 200 other leading businesses and organizations that are choosing to be a part of it! For more information, please call Cindy Lu Thompson, GSA Exhibits Management, at (303) 914-0695. You may also get up-to-date details online at <http://www.geosociety.org/meetings/2009/exhibits.htm>.



Call for Papers: The Leading Edge

October 2009

As many of you are aware SEG's The Leading Edge (TLE) publishes special sections each month highlighting emerging or active areas of applied geophysics. Coming in October the near surface community will have the opportunity to enlighten the entire geophysical community on the high quality and innovative nature of their work in hydrogeophysics. A hydrogeophysics special section is scheduled for the October 2009 issue of TLE. The deadline for submitting paper to be considered is June 18, 2009. If you have any questions, or would like to submit a paper for consideration, please contact Rick Miller rmiller@kgs.ku.edu.



ASEG/PESA

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Visit the ASEG / PESA web site at <http://www.aseg.org.au> for more information.



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.

First International Conference on “Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice - NovCare 2009”

by Remke L. van Dam, Geological Sciences, Michigan State University, East Lansing, Michigan (rvd@msu.edu)

As societal concerns about the sustainability of ground-water resources mount, there is a critical need to improve our understanding of the subsurface and to better monitor and characterize natural and anthropogenic-influenced systems. To address pressing issues of groundwater quality and quantity, the environmental research community increasingly finds itself in need of investigation methods that have high accuracy and resolution across a range of spatial and temporal scales. Ideally, such methods should be able to identify, quantify, and parameterize relevant physical and biochemical processes through space and time, leading, for example, to improved models for subsurface transport. In recent years, several new technologies have been developed for cost-effective, minimal-disturbance, and high-resolution characterization and monitoring of the subsurface. Most of these methods, however, are not yet widespread.



To discuss the opportunities presented by newly-developed and refined field methods, novel applications of existing methods, and new concepts for subsurface characterization and monitoring, the First International Conference on “Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice - NovCare 2009” was held at the Helmholtz Center for Environmental Research – UFZ in Leipzig, Germany from May 13-16, 2009. This conference, which provided researchers and practitioners an opportunity to exchange ideas on how to tackle the challenges of subsurface characterization and monitoring, was supported by the Hydrogeology Section of the German Geological Society (FH-DGG), the Helmholtz Interdisciplinary Graduate School for Environmental Research (HiGrade,) and the Helmholtz Center for Environmental Research – UFZ.

The conference had a strongly interdisciplinary and international character with 124 participants from 14 countries. Several companies and institutes had information booths or gave field demonstrations of novel equipment designs and tools. In total, 64 talks and 19 posters were presented. Ten invited speakers gave talks of specific relevance to one of the five focus areas (see below). The conference started with a word of welcome from the conference chair, Georg Teutsch of the Helmholtz Center for Environmental



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Research – UFZ, and a thought-provoking presentation by Graham Fogg of the University of California at Davis on the interdependence of models and data.

Innovative site characterization – Keynote presentations were given by Mark Kram of Groundswell Technologies and Stefan Trapp of Denmark Technological University. Kram described single mobilization solutions for contaminant flux monitoring based on direct-push technology, while Trapp described investigations using tree core samples to rapidly monitor pollutants in groundwater across large areas. Field demonstrations of novel direct-push and sonic drilling methods were given by leading equipment manufacturers. In addition, a number of talks and posters focused on new developments of direct push probes for physical and chemical characterization of the shallow subsurface.



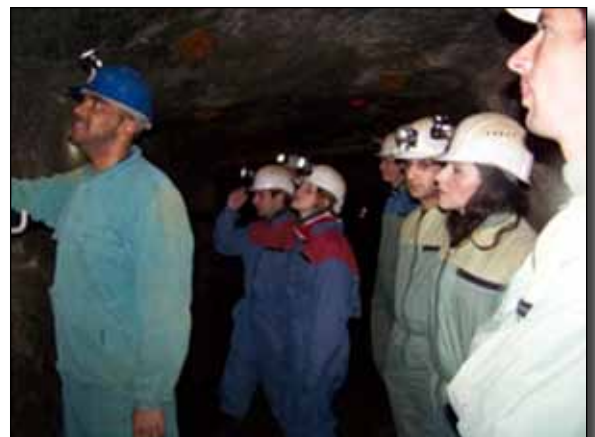
Monitoring – Keynote lectures were given by Alessandro Corsini of the University of Modena and Giorgio Cassiani of the University of Padova. Corsini discussed monitoring processes of relevance for slope stability in mountainous regions and unstable terrain, while Cassiani provided an overview of hydrogeophysical methods for characterization and monitoring of subsurface processes across different spatial and temporal scales.

Watershed characterization – Keynotes addresses were given by Peter Grathwohl of the University of Tuebingen and Stefan Kollet of the University of Bonn. Grathwohl presented results of the EU-funded AquaTerra project, while Kollet discussed new advances in the simulation of coupled subsurface-land surface processes. Also, several talks on the large-scale programs in the 7th framework Program of the European Commission were given. These talks included efforts to develop novel multi-sensor platforms for soil characterization and watershed-scale remote sensor networks.



Groundwater-surface water interaction – Keynote presentations were given by Steven Loheide of the University of Wisconsin Madison and Peter Huggenberger of the University of Basel. Loheide discussed thermal methods for characterization of stream-aquifer interactions with an emphasis on remote sensing approaches, while Huggenberger discussed scientific and societal issues related to flooding and contamination produced by riverine processes.

Subsurface transport – Chunmiao Zheng of the University of Alabama concluded the conference with the 2009 Bird-sall-Dreiss Lecture in which he described the quarter century of research on solute transport in the highly heterogeneous aquifer at the Macrodispersion Experiment (MADE) site in Columbus, Mississippi, and new efforts to character-



ize spatial variations in hydraulic conductivity within that aquifer.

The lively discussions during the formal sessions and the accompanying social events demonstrated the enthusiasm of the characterization, monitoring, and modeling communities for forums in which researchers and practitioners can come together. A second conference, NovCare 2011, will be held in the United States, and has tentatively been scheduled for May 2011 in Boston. Plans for this workshop will be regularly updated on the NovCare website (<http://www.ufz.de/novcare/>).



Jim Butler – Kansas Geological Survey, University of Kansas

David Hyndman, Remke van Dam – Michigan State University

Peter Dietrich – Helmholtz Center for Environmental Research – UFZ

Carsten Leven – University of Tuebingen

2009 SAGEEP Note

March 29 - April 2, 2009, Forth Worth, Texas

by Doug Laymon, 2009 SAGEEP General Chair, Tetra Tech Corporation (Doug.Laymon@tetrattech.com)

As General Chair of the 2009 The Environmental and Engineering Geophysical Society's (EEGS) 22nd Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), I would like to express my deepest thanks to everyone that attended and every one that had a hand in putting the 2009 program together making this a great conference. Dwayne Butler (Technical Chair), the program committee, EGGs Board, and many others worked together to make the 2009 meeting a success. It truly is a team effort to make SAGEEP happen. Fort Worth was a wonderful host city with the Renaissance Worthington Hotel located in a great downtown area. The meeting highlights included a fun Segway tour of downtown, walking tour of the Trinity River redevelopment project, a very good technical program, a full exhibit hall, outdoor equipment demonstrations at the world famous "Billy Bobs", and well attended short courses. It seems like yesterday that we were planning the 2009 meeting and here we are looking forward to 2010. With that I hope to see everyone at Keystone in 2010.

EEGS/NSG Frank Frischknecht Leadership Award

Nomination Deadline: September 15, 2009

The EEGS/NSG 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 Frischknecht 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 and Kenneth Stokoe.

The award alternates on an approximately 18-month interval between EEGS' SAGEEP and the SEG-NSG Section's annual meeting. It will be given next in October 2009 at the SEG-NSG meeting in Houston.

Send nominations to Barbara Luke, chair of EEGS' Nominations and Awards committee, by email to barbara.luke@unlv.edu or call her at (702) 895-1568 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 15, 2009 for full consideration.

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The MPT DAS-1 Electrical Impedance Tomography system is a fully autonomous, integrated induced polarization (IP) system, with 8 channels and a 24-bit A to D converter per channel. It is capable of collecting 3-D subsurface images using Electrical Resistivity Tomography (ERT) or Electrical Impedance Tomography (EIT).

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The EEGS / Geonics Early Career Award

Nomination Deadline: October 31, 2009

The Environmental and Engineering Geophysical Society and Geonics Limited are pleased to announce that nominations are now open for the 2010 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 five members (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 45-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 2010 in Keystone, Colorado. 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
(T) 250.658.0791
(E) 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

The deadline for submission of nominations is October 31, 2008. Questions should be directed to Dr. Best at the address listed above.

Industry Corner

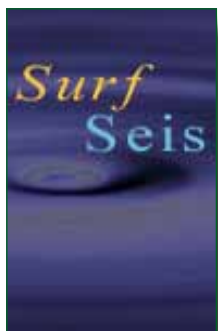
FastTIMES accepts timely and relevant news items from companies as well as brief company profiles. Send your submissions to the editors for possible inclusion in the next issue.



EGA Listed as One of Houston's Largest Environmental Companies

Environmental Geophysics Associates (EGA) has been listed in the Houston Business Journal as one of the "Largest Environmental Companies" in 2008 in the Houston area, Texas.

EGA was founded in 1994 to provide environmental, engineering, and shallow oil and gas geophysical services. EGA provides a complete range of geophysical services to a diverse list of clients throughout the United States and overseas. For more information, visit www.environgeophysics.com.



KGS Announces Impending Release of SurfSeis 3.0

New features in SurfSeis 3.0 software not in version 2 include: utilization of higher modes of the Rayleigh wave, inversion using *a priori* density information, friendlier dialogs, new menus complementing the existing interface, known bugs removed, and improved compatibility with all existing and future KGS seismic software (WinSeis, SeisUtility, SeisTomo, SeisModel, and others).

For more information visit our website at www.kgs.ku.edu/software/surfseis/index.html or call Mary at (785) 864-2176.



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- ☐ \$20 Student Member without JEEG Subscription (submit copy of current student ID).

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- ☐ \$1,800 Partner
- ☐ \$3,950 Benefactor

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Questions? Call (303) 531-7517

*Payments are not tax deductible as charitable contributions although they may be deductible as a business expense. Consult your tax advisor.



Membership Information

EEGS welcomes membership applications from individuals (including students) and businesses. The membership application is available from the EEGS office or online at www.eegs.org.

Individual \$90

Member receives annual subscriptions to **JEEG** and **FastTIMES** along with discounts for EEGS publications, SAGEEP registration, and other EEGS functions.

Student \$50

Member receives annual subscriptions to **JEEG** and **FastTIMES** along with discounts for EEGS publications, SAGEEP registration, and other EEGS functions.

Student (without JEEG) \$20

Member receives annual subscriptions to **FastTIMES** along with discounts for EEGS publications, SAGEEP registration, and other EEGS functions.

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Member receives 2 individual memberships, 2 exhibit booths at SAGEEP, marketing inserts in SAGEEP delegate packets, a link on the EEGS website, listing in **FastTIMES**, advertising discounts in **JEEG**, **FastTIMES**, and the directory.

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and advertising discounts in **JEEG**, **FastTIMES**, and the directory.

Corporate Donor \$650

Member receives 1 individual membership, 1 registration to attend SAGEEP, a link on EEGS website, and advertising discounts in **JEEG**, **FastTIMES**, and the directory.

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SAGEEP PROCEEDINGS

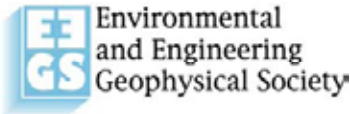
	0026	2009 (CD-ROM)	\$75	\$100			0016	2004 (CD-ROM)	\$75	\$100
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SAGEEP Short Course Handbooks

	0027	NEW 2009 - Principles and Applications of Seismic Refraction Tomography (Printed Course Notes & CD-ROM) - William Doll	\$125	\$150
	0028	NEW 2009 - Principles and Applications of Seismic Refraction Tomography (CD-ROM including PDF format Course Notes) - William Doll	\$70	\$90
	0007	2002 - UXO 101 - An Introduction to Unexploded Ordnance - (Dwain Butler, Roger Young, William Veith)	\$15	\$25
	0009	2001 - Applications of Geophysics in Geotechnical and Environmental Engineering (HANDBOOK ONLY) - John Greenhouse	\$25	\$35
	0011	2001 - Applications of Geophysics in Environmental Investigations (CD-ROM ONLY) - John Greenhouse	\$80	\$105
	0010	2001- Applications of Geophysics in Geotechnical and Environmental Engineering (HANDBOOK) & Applications of Geophysics in Environmental Investigations (CD-ROM) - John Greenhouse	\$100	\$125
	0004	1998 - Global Positioning System (GPS): Theory and Practice - John D. Bossler & Dorota A. Brzezinska	\$10	\$15
	0003	1998 - Introduction to Environmental & Engineering Geophysics - Roelof Versteeg	\$10	\$15
	0002	1998 - Near Surface Seismology - Don Steeples	\$10	\$15
	0001	1998 - Nondestructive Testing (NDT) - Larry Olson	\$10	\$15
	0005	1997 - An Introduction to Near-Surface and Environmental Geophysical Methods and Applications - Roelof Versteeg	\$10	\$15
	0006	1996 - Introduction to Geophysical Techniques and their Applications for Engineers and Project Managers - Richard Benson & Lynn Yuhr	\$10	\$15

Miscellaneous Items

	0021	Geophysics Applied to Contaminant Studies: Papers Presented at SAGEEP from 1988-2006 (CD-ROM)	\$50	\$75
	0022	Application of Geophysical Methods to Engineering and Environmental Problems - Produced by SEGJ	\$35	\$45
	0019	Near Surface Geophysics - 2005 Dwain K. Butler, Ed.; Hardcover Special student rate - 71.20	\$89	\$139
	0024	Ultimate Periodic Chart - Produced by Mineral Information Institute	\$20	\$25
	0008	MATLAB Made Easy - Limited Availability	\$70	\$95
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T-shirt (XX-Large)			\$10	\$10	Sold Out
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