FastTIMES

March 2011
Volume 16, Number 1
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- Message from SAGEEP 2011 Chairman
- Industry News: Pile Dynamics
- CEN Workshop

. . . and more!

SAGEEP 2011 in Charleston

On the Cover

In honor of the upcoming SAGEEP symposium in April 2011, this issue of ***FastTIMES*** features a selection of the best articles from past SAGEEP proceedings.

What We Want From You

The ***FastTIMES*** editorial team welcomes contributions of any subject touching upon geophysics. The theme for our next issue will be the application of EM method for mineral, ground-water and geotechnical investigations. ***FastTIMES*** also accepts photographs and brief non-commercial 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 May 21, 2011 to ensure inclusion in the next issue. We look forward to seeing your work in our pages.

Advertisers

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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 page for more information.

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FastTIMES is published electronically four times a year. Please send articles to any member of the editorial team by February 21, 2011. Advertisements are due to Jackie Jacoby by February 21, 2011.

Calendar

Please send event listings, corrections or omitted events to any member of the ***FastTIMES*** *editorial team.*

2011

April 10–14	SAGEEP 2011: Symposium on the Application of Geophysics to Environmental and Engineering Problems, Charleston, SC
May 9–11	NovCare 2011: Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice, Ocean Edge Resort, Brewster, MA
May 15-19	Proximal Soil Sensing: Global Workshop on High Resolution Digital Soil Sensing and Mapping, McGill University, Montreal, Canada
May 23–26	73rd EAGE Conference & Exhibition: Unconventional Resources and the Role of Technology, Vienna, Austria
May 21	Deadline for submission of articles, advertisements, and contributions to the June issue of *FastTIMES*
May 31	Deadline for submission of abstract to the 10th SEGJ International Symposium, Kyoto, Japan
June 22–24	International Workshop on Advanced Ground Penetrating Radar 2011: presents a wide range of scientific and technical information of high standard to scientists, engineers and end-users of GPR technology. Aachen, Germany
June 28–July 7	IUGG General Assembly: International Union of Geodesy and Geophysics (IUGG) General Assembly invites researchers world-wide to participate in an exciting, multi-disciplinary conference on cutting edge science, Melbourne, Australia
August 21	Deadline for submission of articles, advertisements, and contributions to the September issue of *FastTIMES*
November 21	Deadline for submission of articles, advertisements, and contributions to the December issue of *FastTIMES*
December 5-9	2011 AGU Fall Meeting. San Francisco, CA

President's Message: SAGEEP 2011

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

We hope you will find this issue of FastTimes interesting. Our editor, Moe Momayez and his co-editors have selected the best papers from the last five SAGEEP meetings to showcase the caliber of technical work that is being presented at our annual meetings. SAGEEP 2011, to be held two short months from now in the beautiful city of Charleston, South Carolina, promises to be an excellent meeting, with more papers offered than at any previous event. The exhibition is sold out, and the short course and workshop offerings are filling up fast. We are offering special sessions sponsored by the Society of Exploration Geophysicists, the American Geophysical Union, and a full day devoted to agricultural geophysics.

General Chair Bill Doll and Technical Chair Greg Baker have finalized 2011 program, which includes a liquefaction demonstration of the T-Rex vibroseis unit, a historic Charleston earthquake walking tour, a full day field trip on the USACE's new survey vessel Evans and an exciting social program. By now you should have set aside the week of April 10-14th to come to Charleston and participate in this exciting event.

The society would like to thank corporate sponsor Geometrics, who has offered $500 to 10 students to help offset the cost of attending SAGEEP. It is our stated goal to attract the best and brightest young geophysicists to our Society, and this sponsorship helps us fulfill that goal.

As you read this issue of FastTimes, you will undoubtedly have found your way to the new SAGEEP website, which was launched prior to opening the SAGEEP 2011 registration and distribution of the March issue. Jackie Jacoby of our management group WMR and Moe Momayez, your board member who doubles as Editor of FastTimes and website committee chairman, have worked hard to make a smooth transition from the old website to the new one. The new site will offer dynamic features which we are sure will add value to your EEGS membership experience.

Just a reminder: We have received our first copies of the joint AGU-SEG-EEGS publication Advances in Near-Surface Seismology and Ground-Penetrating Radar. Contact Jackie Jacoby on the EEGS web site to order your copy. This document will be available for purchase at Charleston, during the SAGEEP meeting.

Paid-up members will be receiving ballots and position statements for the 2011 board elections in March. Please be sure to cast your vote during this election. We have been a bit dismayed by the rather tepid response during the last few elections. This process is extremely important to the success of our society, and it is your chance to select the candidates you wish to see lead the charge in the next few years. Results will be announced at SAGEEP-Charleston, along with the winners of our special awards including the prestigious Frank Frischknecht award.

Hope to see you in Charleston!!!

***FastTIMES** is pleased to publish a personal invitation from the Chairman of the 2011 SAGEEP conference.*

INVITATION TO ATTEND

INVITATION

Dear Colleague,

I am truly delighted to invite you to attend the 24th annual SAGEEP in Charleston, South Carolina! Our theme this year is "Geophysical Stewardship", and that theme will resound through several components of the conference. There are several reasons for this conference to be a "must-attend" for geophysicists and engineers who specialize in the near surface environment as well as those who sponsor or contract for our expertise.

Technical Chair Dr. Greg Baker has developed an unsurpassed technical program with support from a devoted group of session chairs and special assistance from Dr. John Bradford as SEG liaison. The call for papers resulted in a new record of 270 papers that have been accepted for presentation at the conference, which required having four simultaneous sessions rather than the typical three, along with 60 poster presentations.

The Keynote Address on Monday will be presented by Dr. John Reynolds, author of the popular textbook "An Introduction to Environmental and Applied Geophysics." Dr. Reynolds has vast experience in near surface geophysics, spanning the academic, government, and commercial sectors. Those who have read his textbook have only begun to understand the breadth and depth of his experience. We are very pleased that he has agreed to 'cross the pond' and join us from the UK.

As usual, several timely short courses will be offered at SAGEEP, and for the second year, we will offer specialized workshops. New short courses this year include a summary of the emerging nuclear magnetic resonance (NMR) methods, and an advanced MASW course. We will also be offering David Fitterman's popular time-domain EM course, and a new course on dams and levees that emphasizes the client's perspective and requirements. Two special workshops will be presented: "Advances in Near-surface Electromagnetic Induction Geophysics", and "Application of Geophysical Technologies to Agroecosystems". The agricultural workshop is paired with a technical session to highlight the growing use of geophysics in agriculture.

A special component of the Charleston SAGEEP will be an EEGS Foundation-sponsored luncheon on Wednesday to promote the Geoscientists *Without* Borders® (GWB) program. Dr. Stephen Moysey, Clemson University, will present results from his GWB project in India. The luncheon will be free to students. A donation of $35 or more is requested from other attendees. Be sure to sign up in advance as a limited number can attend!

The Monday Business Luncheon will feature a presentation on cutting-edge research from the EEGS-Geonics Early Career Award winner, Dr. James Irving. Please join us on Tuesday at this year's Gala event which will be held at the historic Charleston Place Hotel. As with all SAGEEPs, this year's conference will feature an exhibition with about 40 vendors, and an associated outdoor demonstration that will be held across the street from the hotel!

Charleston is recognized for having been the site of one of the largest earthquakes known to have occurred in the continental US - the 1886 earthquake measured a Richter magnitude estimated at 7.3. SAGEEP attendees will have the opportunity to participate in a walking tour of earthquake evidence in downtown Charleston on Sunday afternoon. There will also be a field trip on the Charleston harbor aboard the Corps of Engineers new survey vessel, the "Evans" to learn about the survey systems in real time. The 43-foot Evans supports the latest in dual frequency side scan, multi-beam bathymetric, and single beam sonar.

With Charleston's earthquake past in mind, the University of Texas will be bringing the triaxial vibroseis truck, "T-Rex" to SAGEEP for a liquefaction demonstration at a nearby field site. Transportation to and from the site for the Monday demos will be provided at no cost to conference attendees.

Charleston has a rich history and is spectacular in the springtime. Coincidentally and interestingly, SAGEEP 2011 will convene during the sesquicentennial of the first shots of the U.S. Civil War on April 12 1861, which were fired at Fort Sumter in Charleston harbor. Special events will be offered by local historical groups during the SAGEEP conference. You can visit Fort Sumter, explore the aircraft carrier USS Yorktown, or wander one of the many plantations located nearby. Be sure to explore all that Charleston has to offer while you are there, and bring your spouse!

See you there,

Bill Doll

SAGEEP 2011 General Chair

INVITED SPEAKERS

SAGEEP 2011 KEYNOTE SPEAKER

Monday, April 11, 2011

John M. Reynolds

In his Keynote presentation, '**The Challenges for Near-surface Geophysics to Address Societal Needs**', Professor John M. Reynolds will give a personal view of the challenges facing a number of sectors where geophysicists are well placed to influence not only future exploration but also policy and strategy for the benefit of society. Professor Reynolds asks "Are we doing enough as a scientific community to face up to them and deliver real benefit? We live in a world faced with changing climate, burgeoning populations and over-use of limited resources. Coupled with economic strictures, society is faced with major challenges – how to cope. These challenges are huge." In his presentation, he will explore the questions and his ideas about a requirement to better understand earth processes to facilitate the sustainable management of the resources we have, and to help monitor change and the rate of change. Author, speaker and recipient of an appointment to an Honorary Professorship at Aberystwyth University, Wales, UK, in 2005, Professor Reynolds has broad near-surface geophysics and geosciences experience through 5 years with the British Antarctic Survey (Cambridge), 7 years in academia, and 22 years in various commercial organizations, including over 16 years heading his own geophysical consulting company.

EEGS LUNCHEON

Tuesday, April 12, 2011

EEGS / Geonics Early Career Award Recipient

The 2011 recipient of the EEGS / Geonics annual Early Career Award (ECA), Dr. James Irving, will deliver the EEGS Luncheon talk, "Application of Stochastic Methods in Hydrogeophysics." While much of Dr. Irving's work has been focused on ground-penetrating radar applied to hydrogeophysical problems, it is becoming apparent that the methods he has developed have application across a broad range of problems. The prestigious ECA acknowledges academic excellence that also encourages research in near-surface geophysics. Register early, limited space available.

GEOSCIENTISTS *WITHOUT* BORDERS® LUNCHEON

Wednesday, April 13, 2011

Stephen Moysey, PhD

The Geoscientists *Without* Borders program has created a new opportunity for the near surface geophysics community to participate in solving humanitarian problems around the world. Stephen Moysey, assistant professor in the Department of Environmental, Engineering and Earth Sciences at Clemson University, will offer perspectives on different ways to become engaged in the program based on experiences working in rural India. By sharing these experiences, it is the intent of our luncheon speaker to inspire you to think creatively about how you can lend your personal experience and expertise to make a difference *without* borders. The luncheon is sponsored by the EEGS Foundation. Non-students are encouraged to contribute $35 or more to offset the cost of the luncheon. Students are invited gratis (no charge).

T-REX VIBRATOR LIQUEFACTION DEMONSTRATION

Monday, April 11, 2011

A special viewing of the The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)@UTexas Triaxial Vibroseis ("T-Rex") has been set up with 4 departure times to the demonstration site. The T-Rex introduces a new in-situ liquefaction test that can be used to evaluate the coupled response between excess pore water pressure generation and nonlinear shear modulus behavior. Select your departure/return time on the registration form - space is limited and departure time preferences from the host hotel are not guaranteed.

EARLY-BIRD CONFERENCE REGISTRATION DEADLINE MARCH 18, 2011

Register Online at www.eegs.org and click SAGEEP 2011

SAGEEP 2011 PRELIMINARY PROGRAM

Saturday April 9

All Day — **SC-1: Surface Waves are for Everyone (Active and Passive MASW)**
Instructor: Julian Ivanov, Kansas Geological Survey and Geometrics, Inc.

Sunday April 10

Half Day — **SC-2: Advanced Surface Wave Methods (Active and Passive MASW)**
Instructor: Julian Ivanov, Kansas Geological Survey and Geometrics, Inc.

All Day — **SC-3: Application of Time-Domain Electromagnetics to Ground-Water Studies**
Instructor: David Fitterman, Aviva GeoTech

Half Day — Half-Day Historic Earthquake Walking Tour - Charleston

Evening — Ice Breaker

Monday April 11

	Session 1	Session 2	Session 3	Session 4
Morning	**Awards and Keynote Session:** ***John M. Reynolds*** ***Author and Honorary Professor, Aberystwyth University, Wales, UK***			
	Coffee in Exhibit Hall			
	SPECIAL SESSION: Best of 2010 EAGE/NSGD			
Late Morning Lunch	Late Morning: Shuttle to T-Rex Liquefaction Demo / Lunch on Own			
Afternoon	Seismic Refraction Shootout	Evidence-Based Groundwater Management	Frequency-Dependent Seismic & EM Analyses	Vadose Zone Studies
	Seismic Refraction Shootout (con't)	Evidence-Based Groundwater Management	Geophysics in Rivers & Streams	Vadose Zone Studies (con't)
Late Afternoon	Exhibitors Equipment Outdoor Demonstrations (Brittlebank Park - across the street from hotel)			
Evening	Student Event at Southend Brewery and Smokehouse (downtown Charleston)			

Tuesday April 12

Morning	Airborne Geophysics	Geotechnical Characterization Using Seismic Surface Waves	Classification of Military Munitions Response	Contaminant Studies
	Coffee and Poster Viewing in Exhibit Hall Prefunction Area			
	Airborne Geophysics (con't)	Geotechnical Characterization Using Seismic Surface Waves (con't)	Large-Scale Field & Lab Experiments with NEES	Contaminant Studies (con't)
Lunch	EEGS Luncheon - Speaker: EEGS / Geonics Early Career Award Winner			
Afternoon	Migration of Seismic/GPR; Interpretation of Multiple Methods	Geotechnical Characterization Using Seismic Surface Waves (con't)	Large-Scale Geotechnical Testing with NEES (con't)	Hydrogeophysical Monitoring
	Coffee and Poster Viewing in Exhibit Hall Prefunction Area			
	End User Integration in Geophysical Surveys Trans-portation & Construction	Mining Geophysics	Large-Scale Geo-technical Testing with NEES; Karst Geophysics	Hydrogeophysical Monitoring (con't)
Evening	SAGEEP Conference Evening Event in Downtown Charleston			

Wednesday April 13

Morning	Nuclear Magnetic Resonance	Geophysics in Cold Climates	Archaeological Applications	SPECIAL SESSION: Funding Opportunities in Near Surface Geophysics
	Coffee and Poster Viewing in Exhibit Hall Prefunction Area			
	Nuclear Magnetic Resonance (con't)	Agricultural Geophysics	Biogeophysics of Contaminanted Sites	Geotechnical & Geoenvironmental Engineering
Lunch	Geoscientists *Without* Borders® Luncheon			
Afternoon	Nuclear Magnetic Resonance (con't)	Agricultural Geophysics (con't)	Earthen Dams & Levees	Geotechnical & Geoenvironmental Engineering (con't)
	Coffee and Poster Viewing in Exhibit Hall Prefunction Area			
	Borehole Geophysics	Agricultural Geophysics (con't)	Earthen Dams & Levees (con't)	Geotechnical & Geoenvironmental Engineering (con't)

Thursday April 14

All Day

SC-4: Magnetic Resonance for Groundwater Investigations: Physical Principles and Applications
Instructors: J.-F. Girard, BRGM, A. Legchenko, IRD, Jean Bernard, IRIS Instruments

SC-5: Geophysical Investigations of Dams and Levees, an Engineering Perspective
Coordinators: Mark Dunscomb, PG, Schnabel Engineering and Douglas E. Laymon, PG, Tetra Tech

W-1: Advances in Near-surface Electromagnetic Induction Geophysics
Coordinators: M. Everett, Texas A&M Univ. and C. Farquharson, Memorial Univ., Newfoundland

W-2: Application of Geophysical Technologies to Agroecosystems
Coordinator: B. Allred, USDA/ARS Soil Drainage Research Unit

All Day — US Army Corps of Engineers Charleston District Navigation Section S/V Vessel "Evans" Field Trip

Note: This is a preliminary program and subject to change. Please do not make travel arrangements based on this schedule.

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:

Allen, Micki
Arumugam, Devendran
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"Guiding Technologies Today -Preparing for a World of Needs Tomorrow"

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.

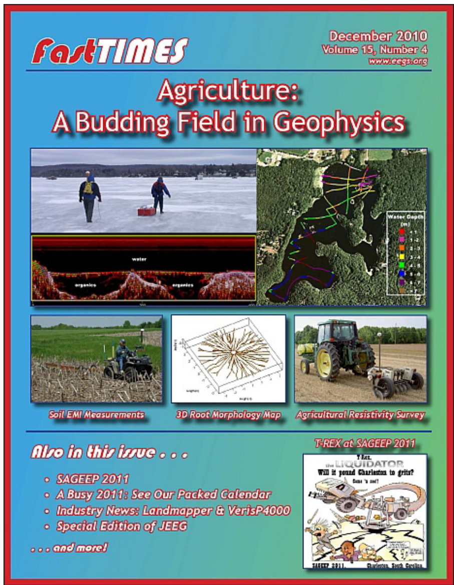
Descriptions of all the new membership options are outlined on EEGS' web site (www.eegs.org) in the membership section.

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, 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 (December 2010, cover image at left) has been downloaded more than 15,000 times as of March 2011, 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.

The JEEG Page

*The **Journal of Environmental & Engineering Geophysics (JEEG)**, published four times each year, is the EEGS peer-reviewed and Science Citation Index (SCI®)-listed journal dedicated to near-surface geophysics. It is available in print by subscription, and is one of a select group of journals available through GeoScienceWorld (www.geoscienceworld.org). **JEEG** is one of the major benefits of an EEGS membership. Information regarding preparing and submitting **JEEG** articles is available at http://jeeg.allentrack.net.*

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Editor's Scratch

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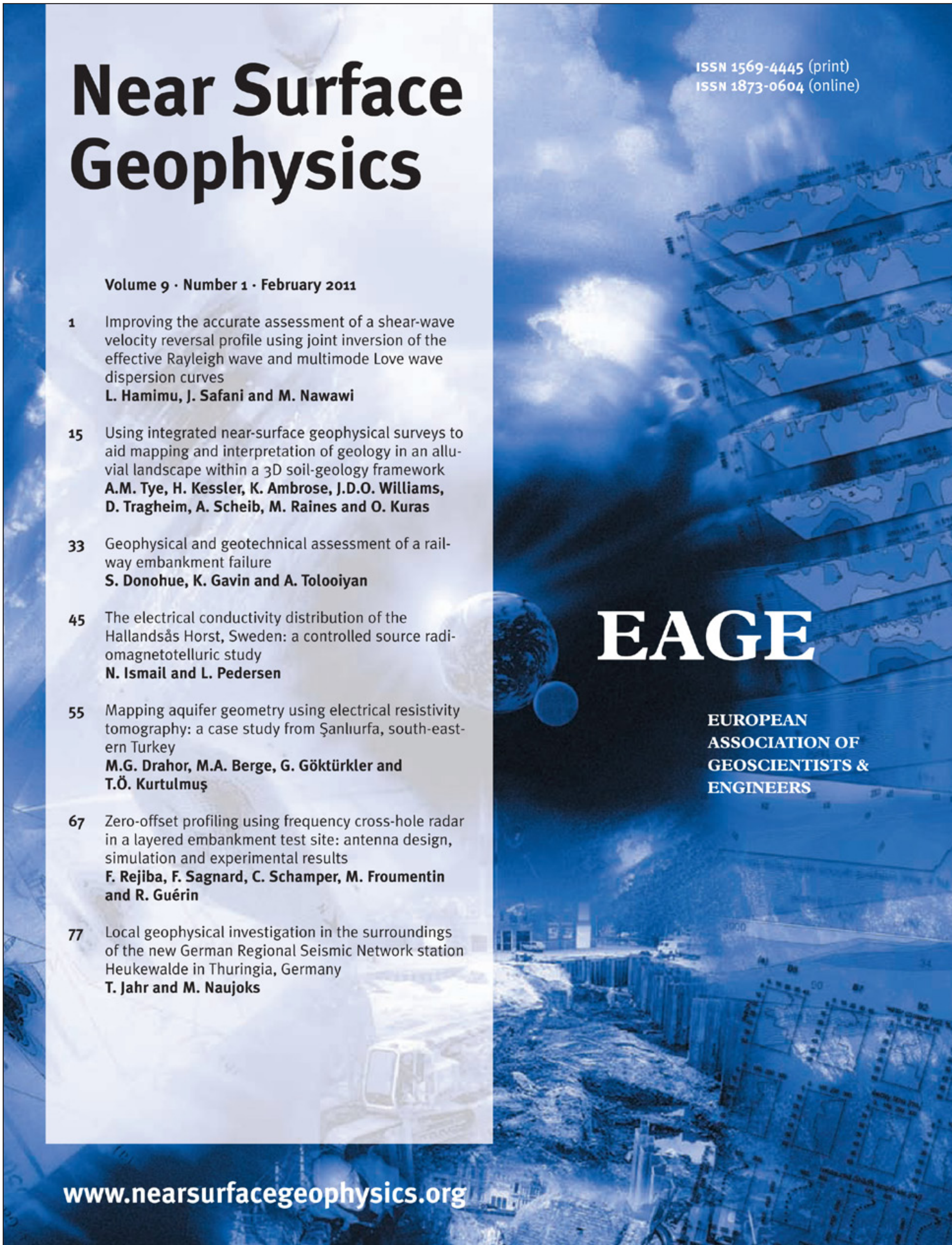
The ***Journal of Environmental and Engineering Geophysics (JEEG)*** is the flagship publication of the Environmental and Engineering Geophysical Society (EEGS). All topics related to geophysics are viable candidates for publication in ***JEEG***, although its primary emphasis is on the theory and application 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, February 2011

*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 October issue of EAGE's **Near Surface Geophysics** journal.*



Near Surface Geophysics

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EAGE
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www.nearsurfacegeophysics.org

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. This issue of FastTIMES presents selected articles from past SAGEEP conference proceedings.

HIGH-RESOLUTION SEISMIC REFLECTION TO IDENTIFY AREAS WITH SUBSIDENCE POTENTIAL BENEATH U.S. 50 HIGHWAY IN EASTERN RENO COUNTY, KANSAS

Richard D. Miller, Kansas Geological Survey, Lawrence, KS

Abstract

High-resolution seismic reflections were used to map the upper 200 m along an approximately 22 km stretch of U.S. 50 highway in Reno County, Kansas, where natural and anthropogenic salt dissolution is known to threaten ground stability. Surface subsidence in this part of Kansas can range from gradual (an inch per year) to catastrophic (tens of feet per second), representing a significant risk to public safety. Primary objectives of this study were to delineate the Permian Hutchinson Salt layer beneath the proposed alignment of the new U.S. 50 bypass around the City of Hutchinson. Of secondary interest were any features with subsidence potential beneath U.S. 50 east of the City of Hutchinson in Reno County, a distance of around 15 km crossing the dissolution front of the salt beds. The high signal-to-noise ratio and resolution of these seismic reflection data allowed detection, delineation, and evaluation of several abnormalities in the rock salt layer and overlying Permian sediments. Locations were identified where failure and associated episodes of material collapse into voids left after periodic and localized leaching of the 125 m deep, 40 m thick Permian Hutchinson Salt member were evident. Anomalies were identified within the salt and overlying rock layers with seismic characteristics consistent with collapse structures. Of particular interest were features with the potential to migrate to the surface in areas where no subsidence has been previously observed. Anhydrite and shale layers several meters thick within the salt are uniquely distinguishable and appear continuous for distances of several kilometers. High noise levels from the heavy traffic load carried on U.S. 50 and maintaining continuous subsurface coverage beneath the Arkansas River presented significant challenges to both the acquisition and processing of these data. Over a dozen unique features potentially related to subsidence risk were identified.

Introduction

Sinkholes are common hazards to property and human safety the world over (Beck et al., 1999). Their formation is generally associated with subsurface subsidence that occurs when overburden loads exceed the strength of the roof rock bridging voids or rubble zones formed as a result of dissolution or mining. Understanding sinkhole processes and what controls their formation rate is key to reducing their impact on human activities, and in the case of anthropogenic, potentially avoiding their formation altogether. Sinkholes can form naturally or anthropogenically from the dissolution of limestone (karst), gypsum, or rock salt, or from mine/tunnel collapse. With the worldwide abundance of limestone, karst-related sinkholes are by far the most commonly encountered and studied. Both simple and complex sinkholes have formed catastrophically and/or gradually, as the result of dissolution of limestone or rock salt, and by natural and man-induced dissolution processes in many parts of Kansas (Merriam and Mann, 1957).

In central Kansas most sinkholes are the result of leached out volumes of the Permian Hutchinson Salt member of the Wellington Formation (Watney et al., 1988) (Figure 1). Sinkholes forming above salt layers have been studied throughout Kansas (Frye, 1950; Walters, 1978) and the United States (Ege, 1984). Studies of subsidence related to mining of the salt around Hutchinson, Kansas (Walters, 1980),

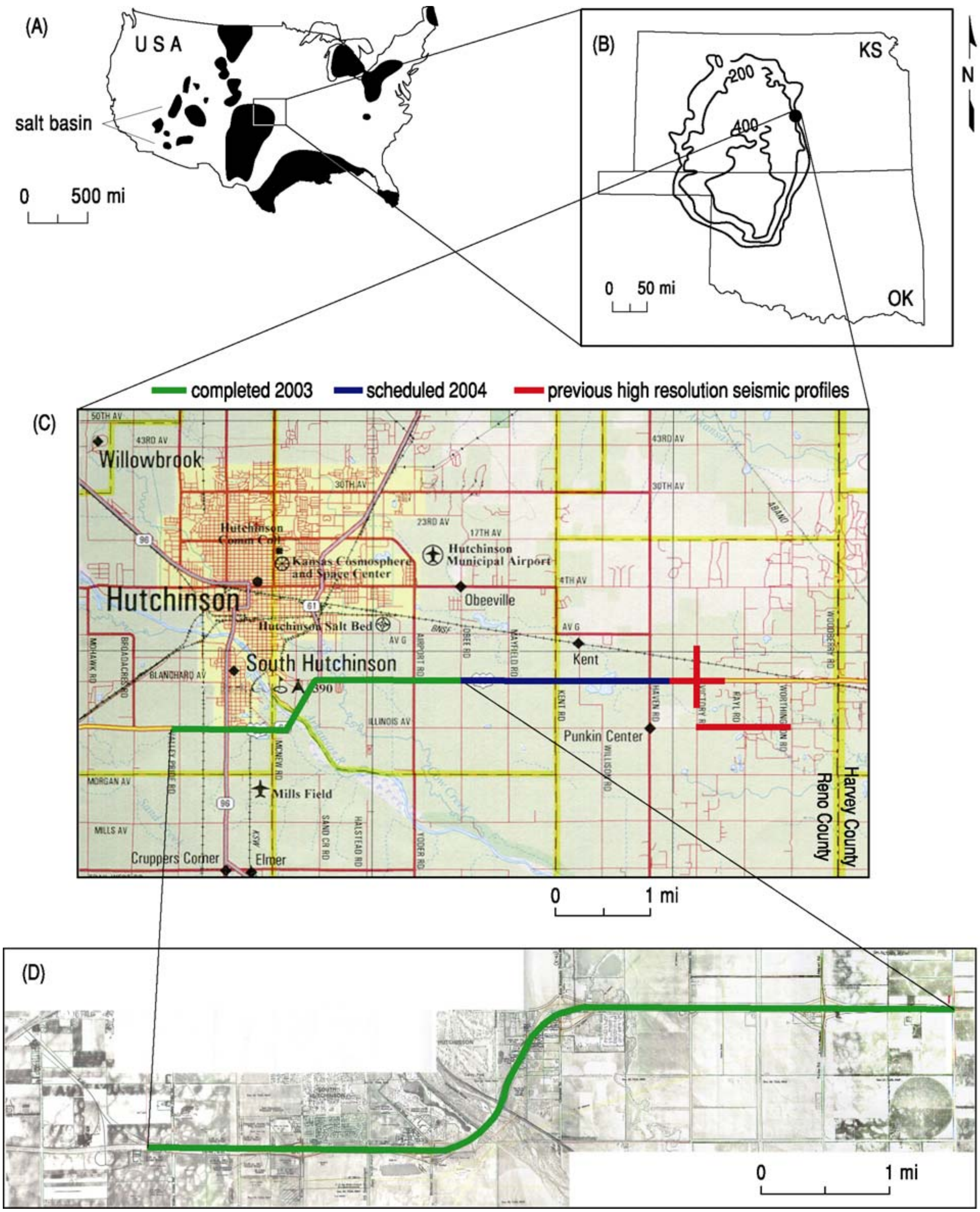

Figure 1: Site map for seismic reflection study along proposed new U.S. 50 bypass around Hutchinson, Kansas. Major salt basins of North America (A). Areas extent and thickness of the Permian Hutchinson Salt member in Kansas and Oklahoma (B). Seismic profiles acquired and planned along and near Highway U.S. 50 and the dissolution front (C). Seismic profile map along the proposed U.S. 50 bypass around Hutchinson (D).

disposal of oil field brine near Russell, Kansas (Walters, 1991), and natural dissolution through fault/fracture-induced permeability (Frye and Schoff, 1942) have drawn conclusions about the mechanism responsible for subsidence geometries and rates based on surface and/or borehole observations. Using only surface observations and borehole data, a great number of assumptions and a good deal of geologic/mechanical sense must be drawn on to define and explain these features and their impact. High-resolution seismic reflection profiling has proven an effective tool in 3-D mapping the subsurface expression and predicting future surface deformation associated with dissolution of the Hutchinson Salt in Kansas (Steeples et al., 1986; Miller et al., 1993; Anderson et al., 1995a; Miller et al., 1995; Miller et al., 1997).

Salt dissolution sinkholes are found in all areas of Kansas where the Hutchinson Salt is present in the subsurface. Sinkholes have been definitely correlated to failed containment of disposal wells injecting oil field brine wastewater using stem pressure tests and/or seismic reflection investigations at a variety of sites throughout central Kansas (Steeples et al., 1986; Knapp et al., 1989; Miller et al., 1995; Miller et al., 1997). Sinkholes that have formed by natural dissolution and subsidence processes are most commonly documented at the depositional edges on the west and north and erosional boundary on the east of the Hutchinson Salt (Frye and Schoff, 1942; Frye, 1950; Merriam and Mann, 1957; Anderson et al., 1995a). The vast majority of published works studying the source of localized leaching of salt in Kansas directly contradict suggestions that recent land subsidence in Kansas is mostly natural in origin (Anderson et al., 1995a).

Natural dissolution of the Hutchinson Salt is not uncommon in Kansas and has been occurring for millions of years (Ege, 1984). Faults extending up to Pleistocene sediments containing fresh water under hydrostatic pressure are postulated as the conduits instigating salt dissolution and subsidence along the western boundary of the salt in Kansas (Frye and Schoff, 1942). Paleosinkholes resulting from dissolution of the salt before Pleistocene deposition have been discovered previously with high-resolution seismic surveys (Anderson et al., 1998).

Subsidence can occur at rates ranging from gradual to catastrophic. Subsidence rates are to some extent related to the type of deformation in the salt (ductile or brittle) and the strength of rocks immediately above the salt layer. As salt is leached, the resulting pore space provides the differential pressure necessary to support creep (Carter and Hansen, 1983). If this pore space gets large enough to exceed the strength of the roof rock, the unsupported span will fail and subsidence occurs (Figure 2). Depending on the strength of the roof rock and therefore the size of the void, characteristics of the failure within and just above the salt will dictate how the void progresses upward until it eventually reaches the ground surface. In general, gradual surface subsidence is associated with ductile deformation that—besides vertically sinking—progresses outward, forming an ever-growing bowl-shaped depression with bed geometries and offsets constrained by normal fault geometries (Steeples et al., 1986; Anderson et al., 1995b). When rapid to catastrophic subsidence rates are observed, failure within the salt is usually brittle with void area migrating to surface as an ever-narrowing cone with bed offsets and rock failure controlled by reverse-type fault planes (Davies, 1951; Walters, 1980; Rokar and Staudtmeister, 1985).

Seismic reflection data targeting beds altered by dissolution and subsidence in this area have ranged in quality and interpretability from poor (Miller et al., 1995) to outstanding (Miller et al., 1997). Interpretations when data quality is poor have unfortunately been relegated to indirect inference of structural processes and subsurface expression (mainly from interpretations of structural deformation in layers above the salt) due to low signal-to-noise ratios. However, data with excellent signal-to-noise ratios and resolution have allowed direct detection of structures and geometries that appear characteristic of complex sinkholes. Resolution potential and signal-to-noise ratio of seismic data from this study are superior to any previously published that have targeted the salt interval. These data provide conclusive images of important structural features and unique characteristics that control sinkhole development.

Concerns for public safety and elevated maintenance costs associated with potential future surface subsidence along a newly proposed four-lane bypass around the city of Hutchinson, Kansas, are

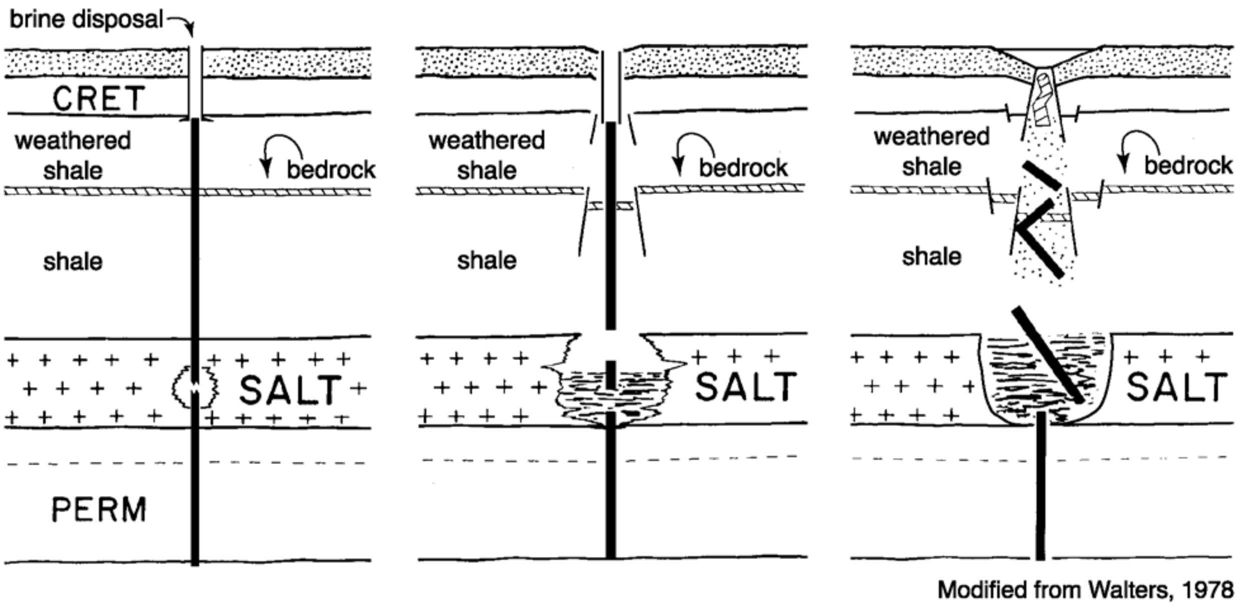

Figure 2: Cartoon of the dissolution and subsidence process across time when instigated by fluids introduced by lost containment in a disposal well.

justified considering the tendency for sinkholes to form in eastern Reno County, Kansas, associated with the natural dissolution front, aging oil field wells, and voids (jugs) remaining from salt dissolution mining practices. As an example, the formation of a sinkhole just 15 km east of the proposed bypass on U.S. 50 has become a nuisance for maintenance crews, vehicle traffic, and public officials trying to calm the concerns of local residence. Subsidence of U.S. 50 below construction grade at its intersection with Victory Road totaled 30 cm when first measured during a 1998 elevation survey. Routine elevation surveys conducted since that time have monitored the pattern and rate of subsidence. At an average subsidence rate of around 20 cm/yr, the highway surface at its centerline has sunk about 1 m since its construction. The current sinkhole is symmetric, with a very regular bowl-shaped geometry around 100 m in diameter that retains water most of the year.

Geologic Setting

Several major salt basins exist throughout North America (Ege, 1984). The Hutchinson Salt Member occurs in central Kansas, northwestern Oklahoma, and the northeastern portion of the Texas panhandle, and is prone to and has an extensive history of dissolution and formation of sinkholes (Figure 1). In Kansas, the Hutchinson Salt possesses an average net thickness of 76 m and reaches a maximum of over 152 m in the southern part of the basin. Deposition occurring during fluctuating sea levels caused numerous halite beds, 0.15 to 3 m thick, to be formed interbedded with shale, minor anhydrite, and dolomite/magnesite. Individual salt beds may be continuous for only a few miles despite the remarkable lateral continuity of the salt as a whole (Walters, 1978).

Rock salt under a depositional load is almost incompressible, highly ductile, and easily deformed by creep (Baar, 1977). Plastic deformation of the salt associated with creep is expected naturally to occur in these salts (Anderson et al., 1995b). Thin anhydrite beds within the halite succession have a strong acoustic response. Considering the extreme range of possible strain rates the salt can experience during creep deformation, these thin interbeds can possess quite dramatic, high frequency folds within relatively short distances.

Redbed evaporites overlaying the Hutchinson Salt Member are a primary target of any study in Kansas looking at salt dissolution sinkhole development and associated risks to the environment and human activity. Failure and subsidence of these evaporite units are responsible for the eventual formation of sinkholes and provide a pathway for groundwater to gain access to the salt. In proximity to the dissolution front fractures, faults, and collapse structures compromise the confining properties of the Permian shale bedrock and put the major fresh water aquifer (Plio-Pleistocene Equus Beds) in this part of southern Kansas at risk. Along the eastern boundary (dissolution front), the salt, which ranges from 0 to over 100 m thick, is buried beneath about 120 m of Permian redbed evaporites.

The eastern margin of the salt was exposed during late Tertiary where erosion and leaching began the 30 km westward progression of the front to its present day location (Bayne, 1956). The ability of the front to migrate while under as much as 100 m of sediments was a direct consequence of ready access to an abundant supply of groundwater (Watney et al., 1988). Subsidence of Permian, Cretaceous, and Tertiary rocks has progressed along the migration front as the salt has been leached away. While this subsidence was going on, Quaternary alluvium was being deposited in volumes consistent with the salt that was being removed. This processes resulted in today's moderate to low surface relief that masks the extremely distorted (faulted and folded—non-tectonic) rock layers within the upper Wellington and Ninnescah shales (Anderson et al., 1998).

Seismically, all Permian and younger reflectors are important to accurate interpretation of the stacked sections. Model studies show significant time delays (static) and geometric distortions that are to be expected below recent subsidence (Anderson et al., 1995b). "Pull downs" in time result from the localized decreases in material velocities within a sinkhole. The velocity structure and small radius of curvature of the synforms, characteristic of salt dissolution and subsidence in this area, can produce diffractions and distort reflections on vertically incident reflection sections. Reflections from beneath the salt will have a subdued expression of the post-salt subsidence. Estimations of subsidence and therefore volume of rock salt removed based on time section estimations alone (without compensation for velocity variability) may exceed actual by as much as 25 to 50 percent in this area. Considering this geologic setting, it is reasonable to compensate for compaction-related static causing this lateral decrease in velocity by "flattening" on the top of the Chase Group.

Most of the upper 700 m of rock at this site is Permian shales (Merriam, 1963). The currently disputed Permian/Pennsylvanian boundary is about 700 m deep and seismically marked by a strong sequence of cyclic reflecting events. The Chase Group (top at 250 m deep), Lower Wellington Shales (top at 175 m deep), Hutchinson Salt (top at 125 m deep), Upper Wellington Shales (top at 70 m deep), and Ninnescah Shale (top at 25 m deep) make up the packets of reflecting events easily identifiable and segregated within the Permian portion of the section. Bedrock is defined as the top of the Ninnescah Shale with the unconsolidated Plio-Pleistocene Equus Beds making up the majority of the upper 30 m of sediment. Thickness of Quaternary alluvium that fills the stream valleys and paleosubsidence features goes from 0 to as much as 100 m depending on the dimensions of the features.

Seismic Acquisition

A continuous profile, a little over 10 km in length was acquired along the existing U.S. 50 highway right-of-way around Hutchinson, Kansas (Figure 1). In moving to meet the ever-growing vehicle load on the current highway, engineers proposed several possible transects skirting the southern edge of Hutchinson intended to accommodate a new four-lane limited access highway generally consistent with the current two-lane road that is there. With the known threat sinkholes in this area represents—both naturally occurring and as a result of dissolution mining—the subsurface between the base of the salt and bedrock beneath the proposed highway transect was examined using high resolution seismic reflection. The objective of this survey was to expose any feature lurking below ground that might someday threaten the stability of the road surface. These data were acquired using a rolling fixed-spread design that eliminated the need for a roll-along switch and extended the range of far offsets available during processing. This survey design provided the wide range of source offsets necessary for detailed velocity analysis, close receiver spacing for improved confidence in event identification, and maximized the range of imageable depths.

Even though no sinkholes were visible at the ground surface, evidence for historical dissolution and subsidence not visible at the ground surface has been observed in several locations around eastern Reno County, Kansas. This historical dissolution and subsidence, referred to as "paleosinkholes," is an indication that fresh water has had access to the salt in this area previously and has found a pathway to carry the dissolved salt away from the dissolution front. Several naturally forming sinkholes in this area have seen resent reactivation and formation of a surface depression. Therefore, looking for paleo-sinkholes and old salt mine dissolution jugs will be critical to final placement of this proposed bypass around Hutchinson.

Acquisition parameters were defined based on experience and walkaway tests near the start of the profile on the western end of the survey. Twin Mark Products L28E 40Hz geophones were planted at 2.5 m intervals in approximate 1 m arrays. Geophones were planted into firm to hard soil at the base of the road ditch in small divots left after the top few inches of loose material were removed to insure good coupling. Four 60-channel Geometrics StrataView seismographs were networked to simultaneously record 240 channels of data. An IVI Minivib1 using a prototype Atlas valve delivered three 10-second, 25-250 Hz up-sweeps at each 5 m spaced shot location. Experiments at this site were consistent with bench tests, which suggested this new rotary valve design will produce up to four times the peak force of conventional valves at 250 Hz. The pilot was telemetried from the vibrator to the seismograph and recorded as the first trace of each shot record. Each of the three sweeps generated per shot station was individually recorded and stored in an uncorrelated format with the ground force pilot-occupying channel 1.

All sweeps were recorded into the fixed 240-channel spread with the source incrementally moving from shot station to shot station through the middle half of the spread. Once the center 120 receiver stations (60 shot stations) were shot through, the back 120 receiver stations were moved to the front and the process repeated. Since all shot records were recorded uncorrelated, QC involved visual inspection of the recorded pilot trace, audio monitoring of the pilot trace on an RF scanner, inspection of the vibrator power spectra after each shot, and review of a correlated shot record after every 5 to 10 shot stations. With the exception of receiver stations not instrumented due to excess or thick gravel or asphalt or stations taken off-line when their offset exceeded 300 m, the survey was recorded with 98 percent live receivers within the optimum recording window (Hunter et al., 1984).

Seismic Processing

A basic common midpoint (CMP) processing flow was used in a fashion consistent with well-established 2-D high-resolution seismic reflection methodologies (Steeples and Miller, 1990). All lines were processed using WinSeis2, beta seismic data processing software (next generation of WinSeis Turbo) from the Kansas Geological Survey. Any reflection data acquired in this highly disturbed subsurface setting will be plagued with static problems and subject to dramatic swings in NMO velocity over relatively short distances; this data set was no exception.

Data were recorded and stored uncorrelated to allow precorrelation processing in hopes of increasing the signal-to-noise ratio and resolution potential (Doll and Çoruh, 1995). Removal of noisy traces and amplitude scaling were precorrelation processing steps that significantly enhanced signal-to-noise and resolution potential. Attempts to improve the data quality precorrelation through frequency filtering, spectral whitening, and frequency-wave number (F-k) filtering were unsuccessful. Storing data uncorrelated also allowed tests to be run with different methods of correlation and correlating with different pilot traces. These data were optimally correlated using the synthetic drive signal. Storing data uncorrelated and unstacked required 30 times more storage space, about 50 percent more acquisition time, and 5 times more data transfer time. Improvements in signal-to-noise ratio and resolution made these increases cost effective.

Emphasis was placed on noise suppression, maintaining true amplitude, and compensating for velocity irregularities. Noise suppression focused on vehicle noise from the highway, livestock along the lines, powerline noise, surface waves, first arrivals, and air-coupled waves. Muting and hum filtering (Xia and Miller, 2000) improved signal-to-noise appreciably. The three individual shot gathers acquired at each shotpoint were vertically stacked after all the noise suppression operations were complete. With the exception of the 1 sec AGC used precorrelation and display gains, only spherical divergence was used to adjust trace amplitudes. With the large depth window of interest, a relatively wide optimum offset window was maintained, which after noise mutes resulted in true trace folds ranging from 1 to a maximum of 30 (Liberty and Knoll, 1998). Velocity was defined in groups of 20 CMPs with at least one control point for each 100 ms time window and a minimum of five points selected in the first 200 ms. Each line is defined by a velocity function with over 400 time/velocity pairs determined with the aid of several iterations of correlation static corrections and velocity analysis.

Even when reflections were interpretable within the noise cone an inside mute was applied after the air-coupled wave to avoid signal degradation of reflection wavelets on CMP stacked sections. Inside mutes are a common practice for shallow (upper 1 km) seismic reflection processing (Baker et al., 1998). It is however, uncommon and counterintuitive to remove confidently identifiable reflection events regardless of where they are relative to other energy arrivals. The likelihood of wavelet distortion sufficient to reduce the resolution potential or lose the trace-to-trace coherency of reflections is significantly increased when surgically muting noise immersed in signal. Analogous to inoperable tumors, attempts to precisely remove just noise—especially air-wave noise—at tolerances of a millisecond or two run the risk of cutting too severely and/or defining mute tapers that are too steep, thereby irreparably altering the reflection waveform. Stacking waveforms into the fold that have been distorted by overly aggressive mutes will compromise the accuracy of the information contained in the waveform, and in some cases produce artifacts that can be misinterpreted as true earth response.

Powerline noise was pronounced on shot gathers where power lines were located along the south side of the road. A complex combination of 60 Hz, 120 Hz, and 180 Hz noise bleeding from overhead power lines masked most of the seismic energy even after correlation along portions of the road. A hum filter was very effective in eliminating powerline noise without affecting the amplitude or phase of the seismic data (Xia and Miller, 2000). This predictive filter produced a noticeable increase in signal-to-noise without loss of resolving potential.

Interpretation

Confidently interpretable reflections on shot gathers are essential to optimizing the acquisition, processing, and interpretation of high-resolution seismic reflection data. Reflections can be interpreted on raw, correlated shot records (scaled for display purposes) from around 50 ms to two-way time depths in excess of 500 ms (Figure 3). Considering the optimum window for these data, it was imperative to keep a wide range of offsets to insure the entire target zone was imaged. Reflections with dominant frequencies of around 200 Hz can be interpreted as deep as 200 ms, while the dominant frequency of reflections at 500 ms have dropped to around 100 Hz. With dominant frequencies of some reflections exceeding 200 Hz, a 2.5 ms static between adjacent traces represents a 180º phase shift and complete cancellation. Therefore, it is critical that static irregularities be compensated for before the data are CMP stacked. Reflection events can be traced through the air-coupled wave and just into the ground roll

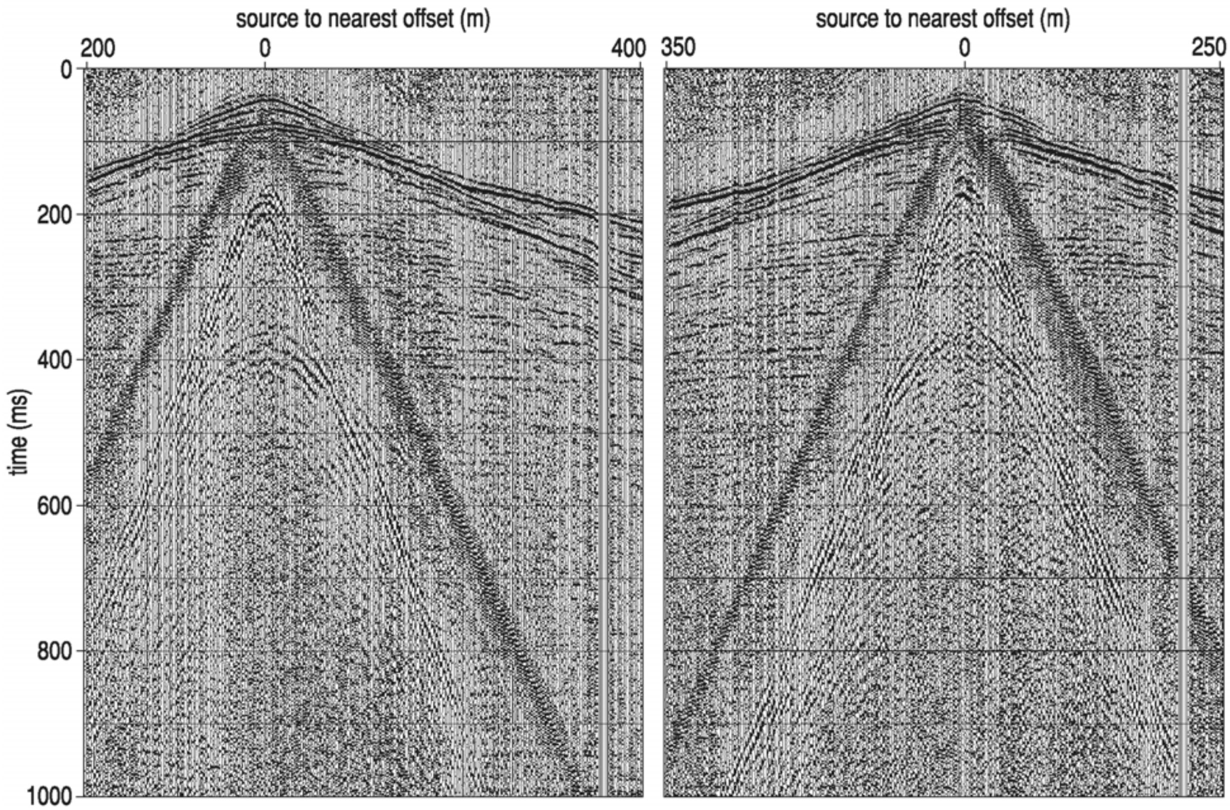

Figure 3: Correlated shot gathers from along profile. Reflection events have diagnostic curvature and high frequency wavelets.

wedge. To avoid any contamination by air-coupled wave, all energy after the airwave was removed during processing.

For quality control reasons it is important that reflections interpreted at two-way times less than 50 ms on CMP stacks can be correlated with equivalent 50 ms reflection hyperbolae on shot gathers. Identification of these reflections on field files and tracking of them throughout the processing flow was necessary to ensure CMP sections were correctly stacked and interpreted. Ultra shallow reflections (< 50 ms) were a critical aspect in discerning the periods since Permian that these sediment-filled sinkholes may have been active.

From interpretations of reflection from raw shot gathers it can be estimated that reflectors from 15 m to over 1 km were imaged by these data (Figure 3). Even under these extremely noisy conditions, contending with wind, vehicles, and power lines along with an extremely variable near surface at ove-rpasses, access road fill, the Arkansas River, and railroad grade, the data are of exceptional quality. Bed resolution using the half-wavelength criteria is around 2 m at the top of the salt unit. Reflections identi-fied on the shot gather extend from the Permian through the upper Pennsylvanian.

CMP stacked section from this 10+ km survey are all of excellent quality (Figure 4). Data from the western extreme of the profile provide an excellent look at the seismic character of a segment of Permian rocks not disturbed by dissolution-induced subsidence. The salt interval has been identified using a combination of nearby well logs and depth estimates from NMO velocity conversions. Two-way travel time to the top of the salt is around 170 ms with a salt interval that is clearly distinguishable on seismic data from the surrounding Permian rocks.

Critical to identifying areas of disturbed salt and any overburden that might be susceptible to collapse due to irregularities within the salt is a clear understanding of how native, undisturbed salt and

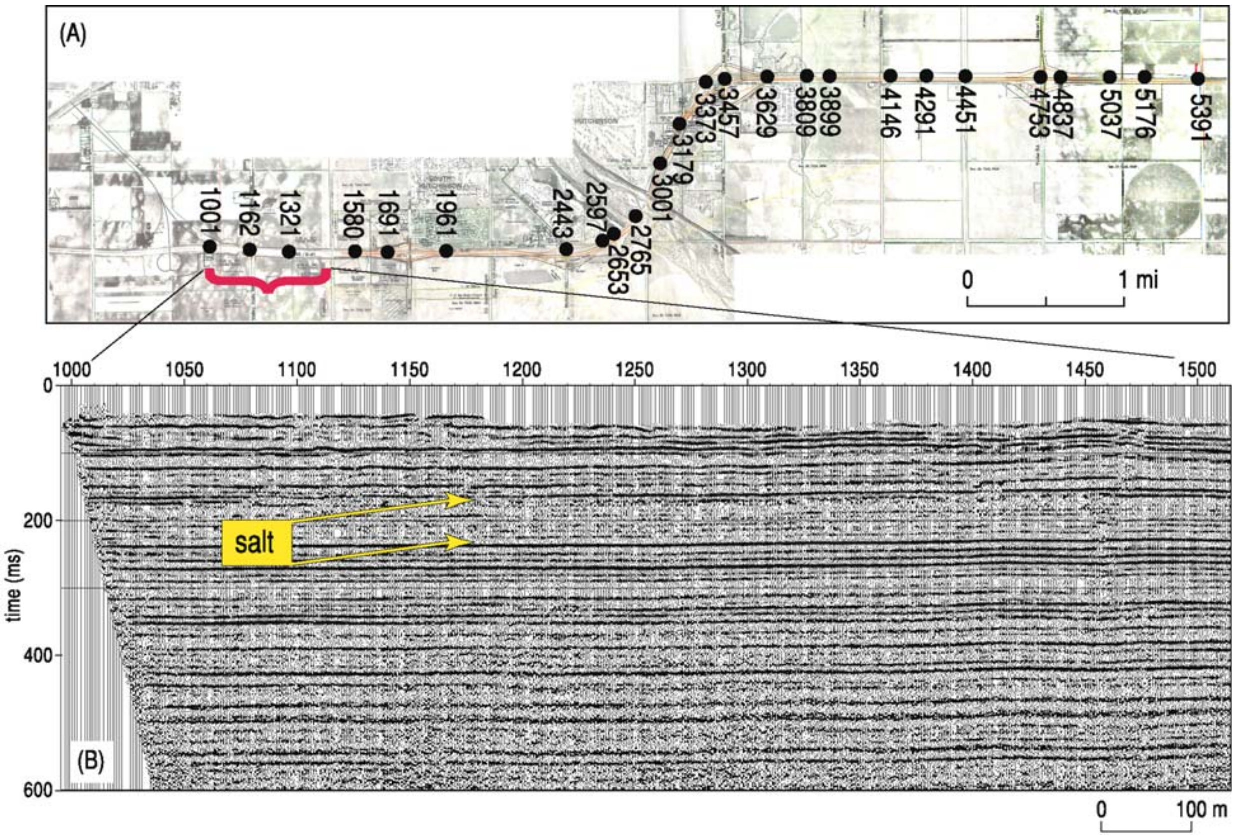

Figure 4: Seismic stations were DGPS located to within ±2 cm (x, y, z) (A). Seismic section from first 1.25 km clearly demonstrates the data quality and signature of undisturbed salt (B).

overburden appear on CMP stacked seismic sections. A strong reflection at about 170 ms interpreted to be the Milan Limestone marks the top of the salt, followed by a subdued set of relatively discontinuous reflections to about 230 ms where another high amplitude reflection, likely the Carlton Limestone, is interpreted to be the basal contact between the salt and surrounding rocks of the Sumner Group (Figure 5). Reflections from within the salt layer possess geometries consistent with channel-cut-and-fill deposition. These intra-salt beds are likely shales and anhydrites.

A somewhat unusual feature interpreted on these seismic data is a small area of disturbed salt with a volume of rock extending upward from the salt to near the bedrock surface that appears to be disturbed and possibly offset with some related subsidence (Figure 6). The disturbed area within the salt can be identified by the loss of continuity of the intra-salt reflections. Immediately below the basal salt contact at about 230 ms is a slightly disturbed zone that increases in area with depth that is likely the shadow effect (scatter and decreased overburden velocity) related to the disturbed reflections within the salt and is an artifact. A chimney feature extending toward the bedrock surface appears to be a fracture zone associated with the anomaly in the salt. Localized layers above the salt and this anomaly appear to form a very subdued syncline. This fracture zone could well be related to salt creep and not dissolution. With the many zones where water is confined in the Permian redbeds between the salt and bedrock surface, this fracture zone could well have allowed water access to the salt, but without an exit point for the saturated brine solution to leave the salt. The leaching process started but was halted before sufficient salt was dissolved to create a void of sufficient size for large-scale subsidence to occur.

The only clearly identifiable paleosinkhole across the 10 km profile was identified near the intersection of U.S. Highway 50 and Kansas state Highway 96 (Figure 7). Reflection characteristics of the salt and overlying sediments across the almost 1 km between the anomaly identified beneath station

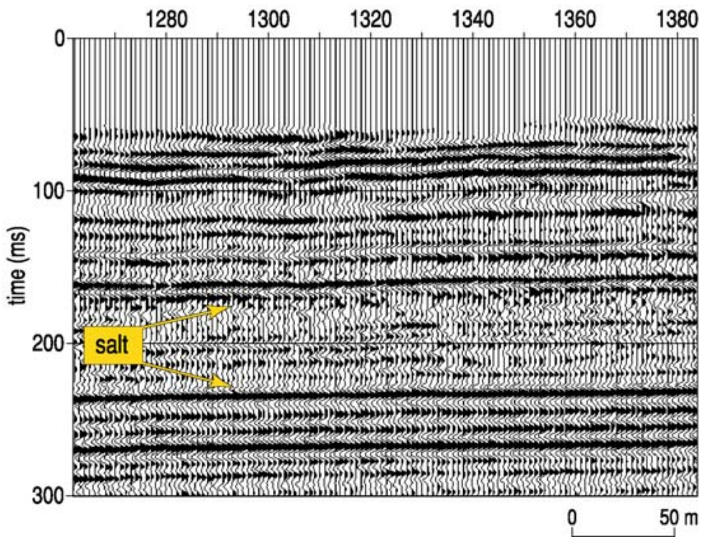

Figure 5: Expanded view of salt interval and layers above and immediately below. Reflections from within the salt are unique in comparison to those from surrounding Permian layers.

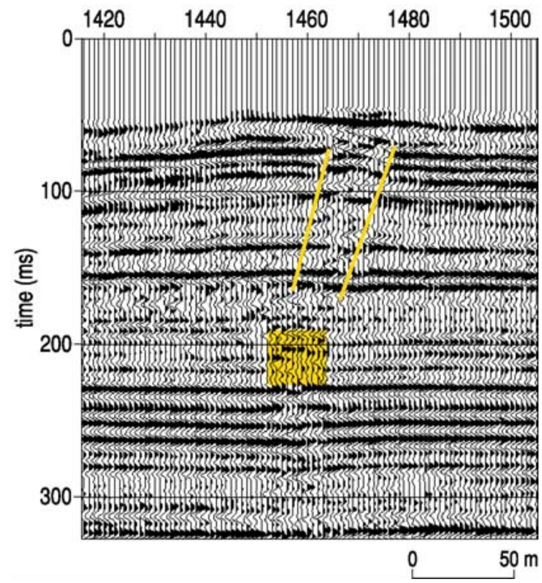

Figure 6: Disturbed area within the salt and associated chimney where rocks between the salt and bedrock appear altered.

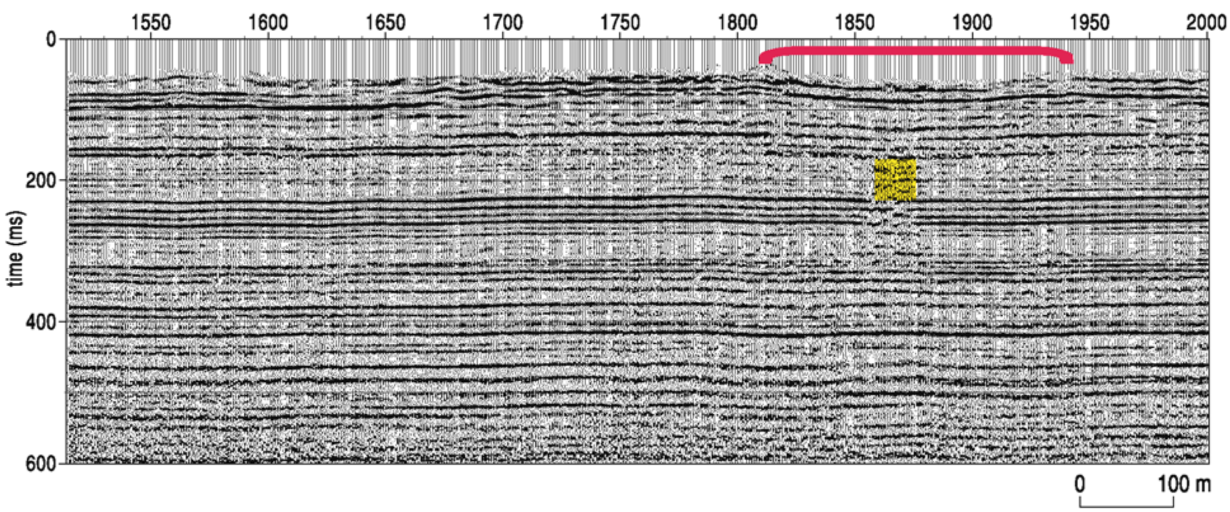

Figure 7: Paleosinkhole evident about 2 km from the beginning of profile and approximately beneath the stretch of highway that includes the overpass of Highway 96.

1470 and 1800 appear very undisturbed with "normal" depositional features interpretable in reflections within the upper 300 m. Between stations 1800 and 1950 a very pronounced depression in the shallower sediments is evident. In general, this anomaly possesses the classical reflection drape above the salt indicative of plastic deformation that occurs as salt gradually dissolves and overlying sediments subside into the void. The only significant faulting evident in this feature is at the edges of the bowl-shaped structure indicative of more brittle deformation.

A close-up of the paleosinkhole beneath station 1870 provides a very intriguing view of this ancient, yet potentially dangerous feature (Figure 8). Clearly all the leached salt responsible for this more than 300 m wide feature at the bedrock surface came from little more than a 50 m wide stretch of salt. Key to this discovery is what appear to be competent layers within the salt that are beneath the

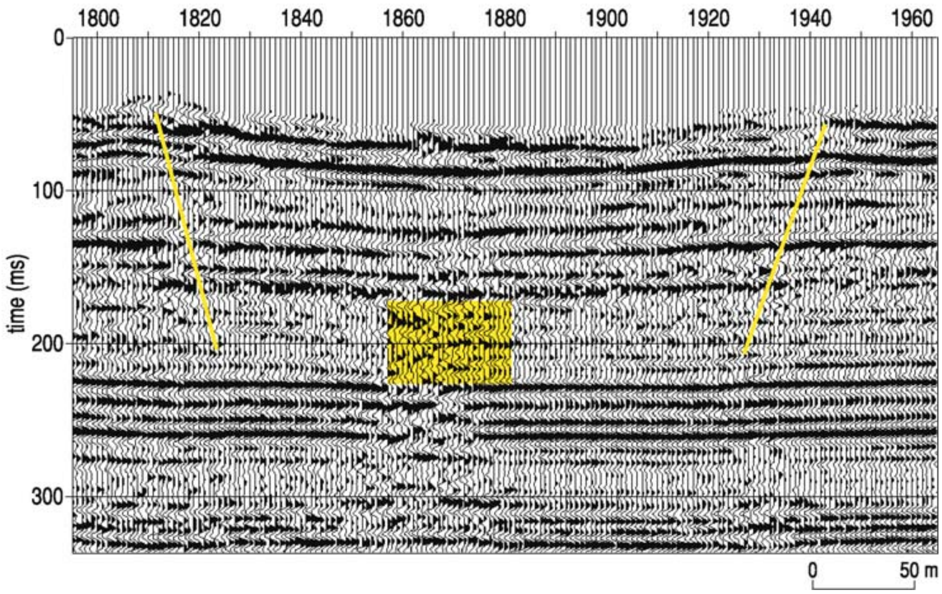

Figure 8: An area of active dissolution from where the salt was previously dissolved, allowing creep and the formation of a much larger surface depression than salt void volume.

bedrock expression of the sinkhole. This implies dissolution occurred within a relatively small volume, then due to salt creep this 50 m wide zone of dissolution reduced the pressure regime and affected salt more than 100 m away. As salt creeped toward this low-pressure area, wide expanses of unsupported roof rock began forming until subsidence occurred, with the edges of salt creep defined by faults that extended to the bedrock surface.

Probably one of the most intriguing, yet least significant feature for highway planners, is what appears to be a large fault zone beneath station 4430 (Figure 9). This fault zone appears to have minimal vertical offset, but possesses a marked change in character of reflections across this zone. The reflection identified as from the top of the salt changes in both frequency and amplitude, as well most events above about 250 ms appear to have changes in character across this fault that range from dramatic to subtle. Below 250 ms the fault zone is still evident but lacks as much change in seismic wavelet characteristics

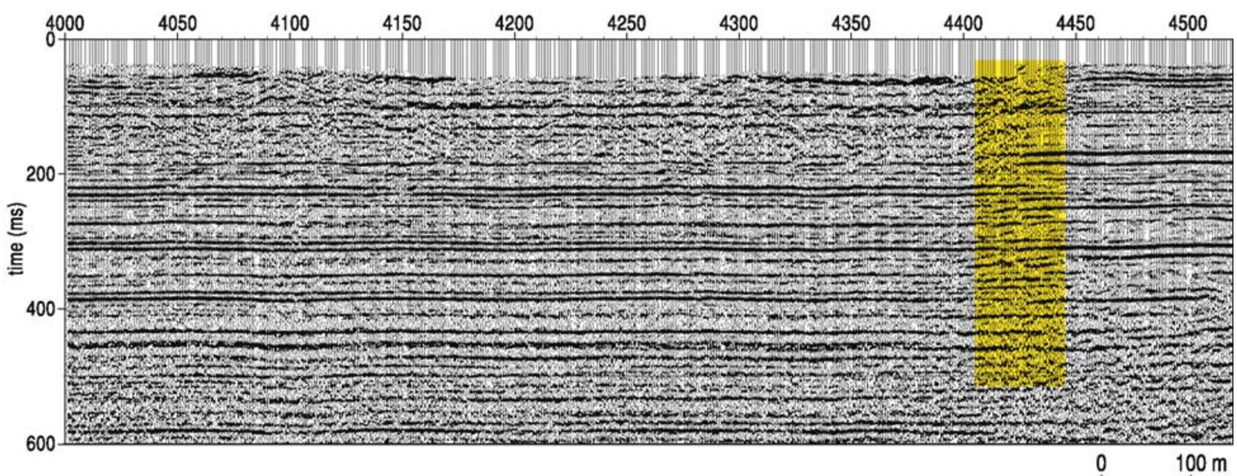

Figure 9: A fault is clearly evident on these data beneath station 4430. An abrupt change in reflection characteristic, diffraction, and apparent bed offset are all key indicators of faulting.

as shallower in the section. From a purely speculative perspective this fault has all the characteristics expected from a predominantly strike-slip fault. Correlations with local geology are not yet complete, but will likely provide key insights into this feature.

Conclusions

High-resolution seismic reflection provided a relatively continuous view of key rock layers above the base of the Hutchinson Salt beneath the proposed new alignment of the U.S. 50 bypass south of the city of Hutchinson, Kansas. Several features with the potential to affect the ground surface along or beneath the future highway were discovered. A paleosinkhole with indications of reactivation since it originally formed represents a risk of gradual subsidence in the highway surface at some point in time. Also, chimney features associated with salt creep are areas for monitoring. A fault intersecting the highway alignment cannot be avoided by the new highway and it has not provided a conduit for fresh water to gain access to the salt at this time. The area above the fault will also require monitoring for any indication of ground subsidence, but does not represent a significant threat to highway stability. Diffraction or scatter associated with bed terminations or point source re-radiation was identified in two locations adjacent to known areas where dissolution salt mining has been active previously. It is not unreasonable to suggest these features might be related to that mining activity. If they are related to dissolution mining activity, they represent the most significant risk of accelerated failure and subsidence in this area. More study of these diffraction/scatter features is needed to better define their source.

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Best of SAGEEP 2007

COMBINING MULTIPLE SEISMIC AND GROUND PENETRATING RADAR TECHNIQUES TO ANALYZE GEOLOGIC CONTROLS OF RIPARIAN MEADOW COMPLEXES IN THE CENTRAL GREAT BASIN, NEVADA USA

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Abstract

Riparian meadow systems in the Central Great Basin are of interest because they support the majority of ecosystem diversity in the region. The riparian meadows are highly dependent upon groundwater levels, thereby making them vulnerable to fluctuations. These systems are actively degrading due to incision of the streams, resulting in a lowered water table and modification of the associated ecosystems. Geologic controls, such as bedrock geometry and sediment variability, are important in the meadows because of their control on the overall system. The current hypothesis is that the sediments associated with side-valley alluvial fans and fault-related bedrock steps interact to constrict ground water flow.

Seismic reflection data and seismic refraction tomography data were collected to analyze bedrock structure and topography from 10 to 80 meters depth, while ground penetrating radar (GPR) data were collected to determine the stratigraphic variability in the upper 10 meters. These data were integrated to provide a comprehensive interpretation of the upper 80 meters of the subsurface. Seismic reflection data were processed to identify the bedrock surface. This surface was then correlated with the seismic refraction tomography to extend the bedrock surface across the meadow complexes. The large volume of GPR data were interpreted by classifying radar facies based on the characteristics of the radar reflectors. These facies (in conjunction with borehole information) confirm and extend areas of alluvial fan related sediment distribution. Integration of these three geophysical techniques is advantageous because they provide more information than could be obtained with the individual techniques.

Introduction

Motivation and Background

Riparian meadow ecosystems hold much importance to researchers as they comprise the majority of the Central Great Basin's ecological diversity, despite their lack of land coverage (Chambers and Miller, 2004). The riparian systems are very dependent upon the water table remaining close to the surface, as they are mesic meadows. Many of the meadow complexes are degrading, or becoming xeric due to a lower water table, with some areas in very poor ecological condition. There are several factors related to the degradation, with the most prominent being anthropogenic disturbances. This can consist of agricultural grazing, roads and recreation. Other factors include climate change, natural disturbances, geomorphic and hydrological changes. The Great Basin Ecosystem Management (GBEM) Project is a large, multidisciplinary effort to understand the processes that drive the formation and function of the upland riparian ecosystems. By gaining a better perception of the ecosystems and the factors that degrade them, it is possible to create more effective maintenance and reestablishment methods. The research presented here is a small part of this larger project, aimed at the objective of understanding formation and function of the meadows. Maintenance methods could change significantly if a meadow had more considerable bedrock control as opposed to sediment control, or vice versa.

Six meadows were selected from four different mountain ranges within the Humboldt-Toiyabe National Forest (Figure 1).

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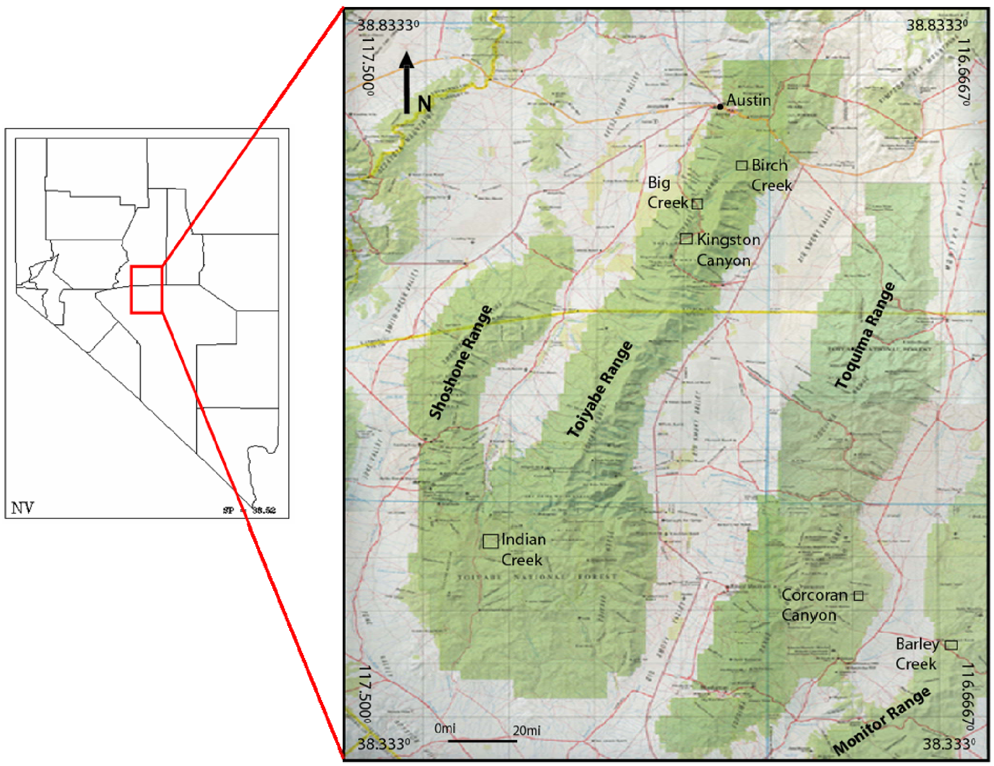

Figure 1: This image illustrates the six site locations within the Central Great Basin. Kingston, Big and Birch Canyons are located within the Toiyabe Range. Indian Creek is located within the Shoshone Range. Corcoran Canyon is located within the Toquima Range and Barley Creek is located within the Monitor Range.

Objective

There are two objectives to this research. The primary objective is to use near-surface geophysical techniques to analyze riparian meadow complexes in the Central Great Basin. This objective can be broken into two smaller tasks, the first being to use near-surface seismic techniques to determine the depth to bedrock and identify structures affecting the top of bedrock in the canyons. The other task is to use ground penetrating radar (GPR) to analyze the sediment distribution within the meadow complex. The current hypothesis for the meadow formation and function is that sediments related to side-valley alluvial fans and fault related bedrock steps interact to change the ground and surface water flow upstream, thereby causing the wet meadows. The secondary objective of this research is to illustrate the usefulness of utilizing multiple geophysical techniques for a more complete subsurface image. By using techniques which target different depths of penetration, it is possible to get a more complete idea of the subsurface, very near-surface (0 – 5 meters) with the GPR technique, and slightly deeper (10-100 meters) with the seismic techniques.

Methodology

Data Acquisition

GPR data were collected in 2005 and 2006, and seismic data were collected in 2003, 2004 and 2005. GPR data collected in 2005 used a Sensors & Software pulseEKKO 100A unit, with 50, 100 and 200 MHz antennas. Antenna were mounted on a piece of particle board at the correct spacing and dragged along profiles to improve data collection efficiency. GPR data collected in 2006 used a Sensors & Software pulseEKKO Pro unit, with both the SmartCart and Full Bistatic assemblies. Only the 100 MHz antenna was used for this data collection. GPR profiles were arranged within the wet meadow complexes, as the antennas were not able to be used in the dense sage outside the meadows. Table 1 shows the parameters of the GPR data collection.

Table 1: GPR data acquisition parameters

GPR Systems	Sensors & Software pulseEKKO 100A unit and pulseEKKO Pro unit, with both the SmartCart and Full Bistatic assemblies
Antenna Frequency	50, 100 and 200 MHz
Step-size	0.10 – 0.50 meters
Time Window	300 ns
Stacking	8

Seismic data were collected in all three years with the same equipment. Data were collected with Mark Products L40A 40 Hz geophones and data were recorded with a Geometrics Strataview R-60 seismograph. The seismic source was the Thunderbolt™ impact source, which produces results similar to a sledgehammer, however this source has a higher consistency between different users. Source spacing was set-up to collect both seismic refraction and seismic reflection data along one profile to increase collection efficiency. Shot locations started at a far offset to the receiver spread, moved through the spread and then on to far offsets beyond the spread. This was to allow enough offset for the first break picks for the seismic refraction tomography. For longer profiles, the spread was “leapfrogged” several times, allowing for higher signal-to-noise ratio along the length of the line. Profiles were arranged both within the meadow complexes and surrounding the meadows. Table 2 shows the parameters of the seismic data collection.

Table 2: Seismic data acquisition parameters

Source	Chris-Nik Thunderbolt ™ post-tamper with a 12 sq. in base pad
Vertical Stacks	3 – 20
Source Spacing	3 or 6 meters
Receivers	Mark Products L40A 40 Hz geophones
Receiver Spacing	1 meter or 1.5 meters
Number of Channels	60
Seismograph	Geometrics Strataview R-60
Sampling Interval	0.125 ms
Record Length	512 ms
Survey Design	Leapfrogging

Data Processing

GPR data were processed with Sensors & Software WinEKKO Pro and EKKOMapper software. Minimal processing were done to the GPR data, mostly involving a dewow filter, conversion from time to depth and the changing of various display parameters. The conversion from time to depth was done using the direct wave velocity from the common mid-point (CMP) gather (Figure 2). Velocities were averaged for each meadow and applied to each of the profiles within the meadow complex.

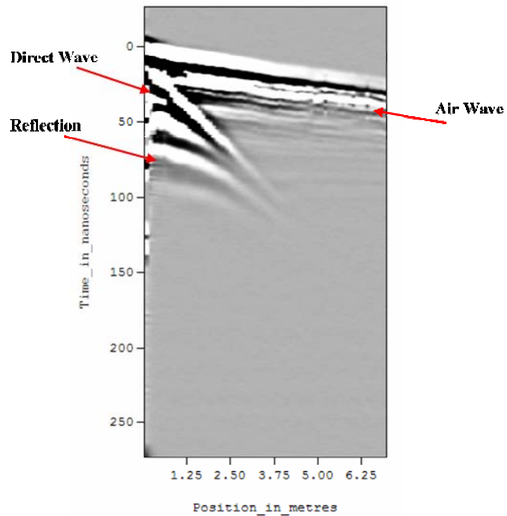

Figure 2: Common mid-point data used for the direct wave velocity

Seismic refraction tomography data were processed using Seisimager 2-D software, following industry techniques. Minimal processing were also done to the seismic refraction data, primarily first break picks and running of a least squares velocity inversion model. First break picks were done using Pickwin95 and velocity tomograms were created using Plotrefa. First breaks were chosen for individual shot gathers (every 12 meters) and were then compiled into one file for the entire profile (Figure 3).

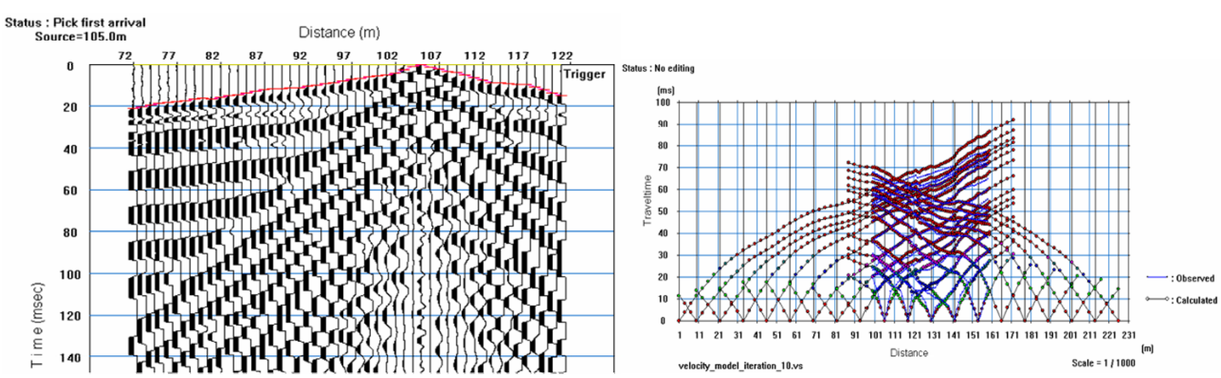

Figure 3: The image on the left illustrates first break picks chosen for a single shot gather, while the image on the right illustrates compiled picks for an entire profile. The blue pick marks are the user's picks, which can be compared to the computer interpolation picks that are colored.

Seismic reflection data were processed using Parallel Geosciences Seismic Processing Workshop (SPW), following the steps outlined in Baker, 1999. Several main processing steps were completed, including shortening the record, muting of refractions and airwave, velocity analysis, normal move-out corrections, stacking and converting from time to depth (Figure 4). Each profile required careful scrutiny for reflections in the raw data, as well as a specially designed flowchart to get the most out the individual profiles and to avoid creating processing artifacts (Steeples and Miller, 1998).

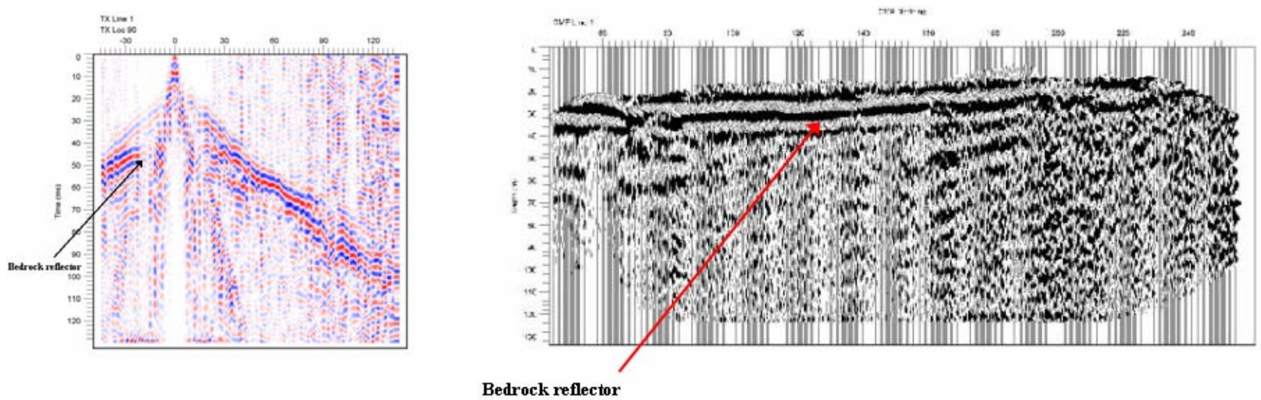

Figure 4: This image shows the bedrock reflector in the original shot gather (left) and the stacked time section (right).

Data Analysis

Due to the large volume of GPR data collected, the interpretations were made by classifying radar facies based on the similar radar reflection characteristics. The radar facies were split into 3 categories, horizontal parallel, sub-horizontal/cross-stratified and chaotic (Figure 5). Each profile was interpreted separately in order to avoid human bias in the classification.

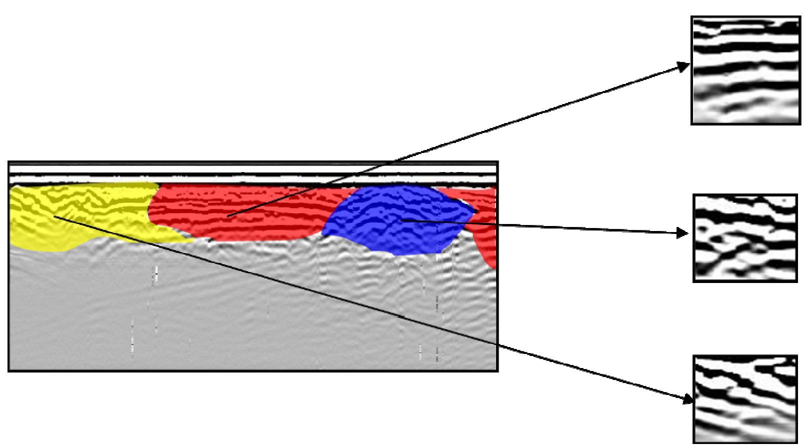

Figure 5: This image shows the different radar facies. The *horizontal facies* are shown in red, the *sub-horizontal* in yellow, and the *chaotic* in blue. Closer images of each interpreted facies are shown in the smaller boxes to the right of the profile.

Seismic data were analyzed using both the reflection and the refraction tomography data. The seismic refraction tomograms were modified into layered models using velocities from the seismic reflection velocity analysis. These tomograms can then be compared to the final stacked depth section from the reflection data to confirm the bedrock surface on both techniques (Figure 6). If the correlation was high, the bedrock layer found in the reflection data could be extrapolated using the seismic refraction tomography.

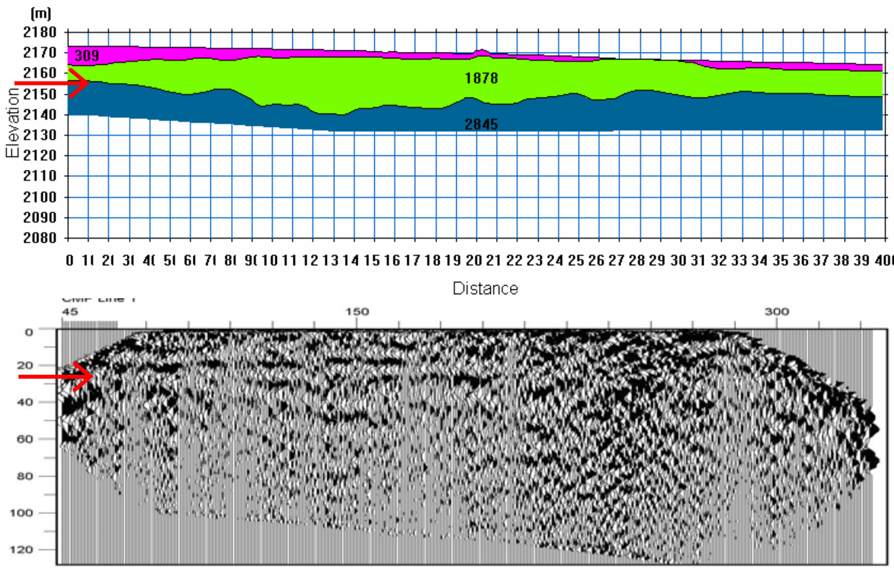

Figure 6: Comparison of seismic refraction tomography bedrock surface (upper) with the seismic reflection bedrock surface (lower), scaled the same both horizontally and vertically. Note the red arrows, which point out the initial bedrock surface in both of the profiles. There is very good correlation between these two models, allowing for interpretations to be made as the next step.

Results

The GPR facies showed excellent correlation across the meadow complexes (Figure 7). The facies also depicted and extended areas of alluvial fan sediments, as well as areas with more layered valley fill. The seismic refraction tomography and seismic reflection data had good correlation of bedrock surfaces, increasing the confidence of both the depth to top of bedrock and the structures affecting the top of bedrock. The structures from the reflection data were overlain onto the refraction tomography and then oriented in fence diagrams to get final bedrock results for each meadow complex (Figure 8).

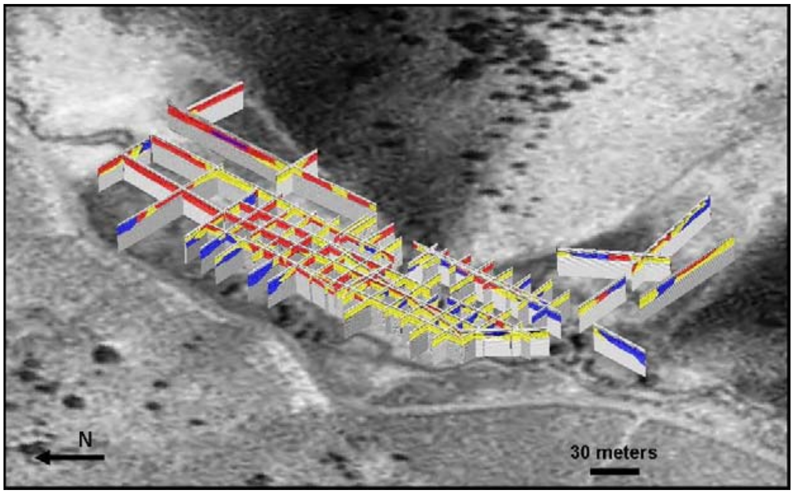

Figure 7: This image shows the radar facies results for Kingston Canyon. The areas of blue correlate to coarser grained sediments, i.e., alluvial fan or colluvium, while the red and yellow correlates to finer grained sediments, i.e., valley fill.

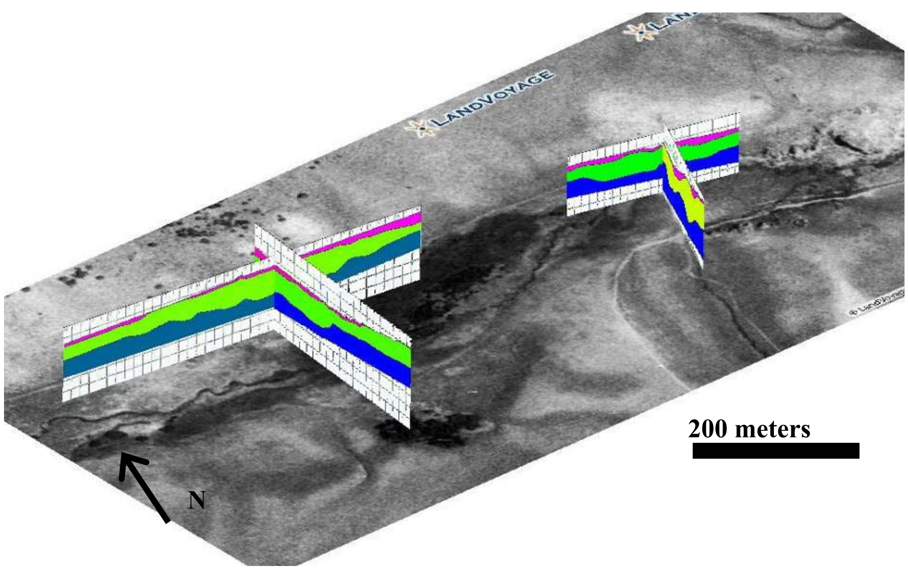

Figure 8: Refraction tomography profiles in Birch Creek. Bedrock layer is shown in the blue layer, the green/yellow layer is saturated sediment and the pink layer is unsaturated sediment or fill.

Conclusions

The methodology of using multiple techniques has already demonstrated an advantage over using only one technique. The comparison of seismic reflection and seismic refraction tomography has verified bedrock surfaces to increase confidence, and the use of the GPR facies method has helped to establish a better understanding of the sediment distribution within the meadows.

Each meadow was classified by its fault relation to analyze bedrock control. Type Ia meadow exhibits faults only at the downstream end of the meadow, suggesting that faulting may control meadow formation. Type Ib meadows have a bedrock high at the downstream end, but the seismic resolution was not high enough to interpret a fault, so there some evidence to suggest a bedrock control but not enough evidence to suggest fault control. A Type IIa meadow which has many faults (some can be at the downstream end); however, it is not possible to declare faulting as a major control of these meadows. A Type IIb meadow which has no faulting present, so faulting cannot be a control on the meadow complex.

Each meadow was also classified by its sediment type. A type I meadow has a distinct set of fan sediments at the downstream end of the meadow complex, and also has horizontal and sub-horizontal facies behind the fan complex. These meadows are obviously influenced by the changes in sedimentation. The Type II meadow has horizontal/sub-horizontal facies in the center of the meadow, and some distribution of chaotic facies around the meadow. They can be either downstream or upstream, or at both ends. This meadow has some control from sedimentation, but the exact cause and location cannot be pinpointed from the data. A Type III meadow is a meadow which has mostly horizontal/sub-horizontal sediments, and it can be implied that the meadow is not influenced by change in sedimentation. If there is some influence, it is undetectable by this method.

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AZIMUTHAL SELF POTENTIAL SIGNATURES ASSOCIATED WITH PNEUMATIC FRACTURING

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Gregory Herman, New Jersey Geological Society, Trenton, NJ

Abstract

Pneumatic fracturing is used to enhance the permeability and porosity of tight unconsolidated soils (e.g. clays) and/or bedrock thereby improving the effectiveness of remediation treatments applied to contaminated soils. A laboratory simulation was performed whereby compressed kaolinite sediments were pneumatically-fractured and subsequently injected with an electrolyte/dye simulating a treatment. Fracture geometry was quantified via fracture strike analysis of visible fractures in the tank walls combined with optical borehole televiewer imaging. Azimuthal self potential (ASP) measurements revealed clear electrokinetic self potentials during injection that correlate with dominant fracture strikes in the clay. Polar plots show that ASP lobes coincide with azimuths of high fracture strike density and that cross plots of SP versus number of fractures display a statistically significant positive correlation. Furthermore, the magnitude of electrokinetic SP scales with flow rate for any particular fracture set, and the positive lobes of the ASP anomaly are diagnostic of the flow direction of the treatment.

Introduction

Previous studies have shown that coupling conventional technologies for the injection of remedial products (e.g. chemical or biological treatments) with the pneumatic fracturing technology can improve mitigation at contaminated sites (e.g. Ding et al., 1999). However, cost-effective methods are needed to characterize the effectiveness of pneumatic fracturing and the progress of the remedial products in the subsurface. Wishart et al. (2006) have shown that azimuthal self potential (ASP) is an effective way to characterize bulk anisotropy and groundwater flow in fractured bedrock aquifers. Here we describe an experiment to investigate whether ASP can be used to characterize anisotropy induced by pneumatic fracturing of unconsolidated (clay sediments) and delineate the migration pathways of remedial treatments added to enhance contaminant cleanup. We describe here an experiment to characterize anisotropy and the migration of an injectate (electrolyte plus dye) through hydraulically-conductive fractures that were mechanically-induced in a laboratory experimental tank model. Our findings suggest that the ASP method proposed by Wishart et al. (2006) for characterization of anisotropy in fractured bedrock aquifers can be adapted to the quantification of bulk fracture-induced anisotropy in mechanically-generated fractures at contaminant sites.

Pneumatic Fracturing

The pneumatic fracturing technology patented in 1991 (Schuring, 1991) has emerged as an effective method for enhancing remediation of contaminated soils and groundwater (Figure 1). Mechanically-induced fracturing is aimed at overcoming inherent transport limitations at many remediation sites for the introduction of beneficial substrates (liquid and solid amendments) to accelerate remediation. During pneumatic fracturing, permeability is enhanced with high-pressured gas injected into consolidated sediments or rocks at pressures exceeding the natural in situ pressures present in the soil/rock interface (i.e. overburden pressure, cohesive stresses, etc.) and at flow volumes exceeding the natural permeability of the subsurface. Fracture orientation during formation is controlled primarily by *in situ* stresses. If compaction exceeds the natural overburden pressure in over-consolidated sediments, fractures tend to propagate in the direction normal to the *least principal stress* in the formation and follow the path of least resistance. Pneumatic or hydraulic fracture propagation is expected to be predominantly horizontal and in most geologic formations the propagation is relatively uniform (i.e. radial) around the point of injection.

Azimuthal Self Potential (ASP)

The ASP method is based on naturally occurring voltages in the earth's surface generated from in situ electrokinetic phenomena relating to charge separation/transport during fluid flow. An electrokinetic potential results from the drag of ions in the diffuse part of the electrical double layer (EDL) exerted by fluid flow in the pore space induced by a hydraulic gradient. The magnitude of the induced electrokinetic potential gradient ($\Delta\phi$) is commonly related to the inducing hydraulic gradient (ΔP) and an electrokinetic coupling coefficient (C'),

$$C' = -\frac{\Delta\phi}{\Delta P} = \frac{\varepsilon\zeta}{\mu F \sigma_b}, \quad (1)$$

where e is the dielectric permittivity, ζ is the zeta potential, μ is the dynamic viscosity, F is the formation factor and σ_b is the bulk conductivity. Wishart et al., (2006) demonstrate that this electrokinetic effect may be used to infer flow direction within a fracture network. As fluid flows in fractured or porous media, excess counterions within the electrical double layer [EDL] of the rock /fluid interface are transported downstream producing a net dipolar charge separation (drag) that (1) is parallel to an electric field, (2) usually positive (depending on pH) in the direction of flow, and (3) produces an electrokinetic potential (Φ) proportional to the applied hydraulic pressure gradient.

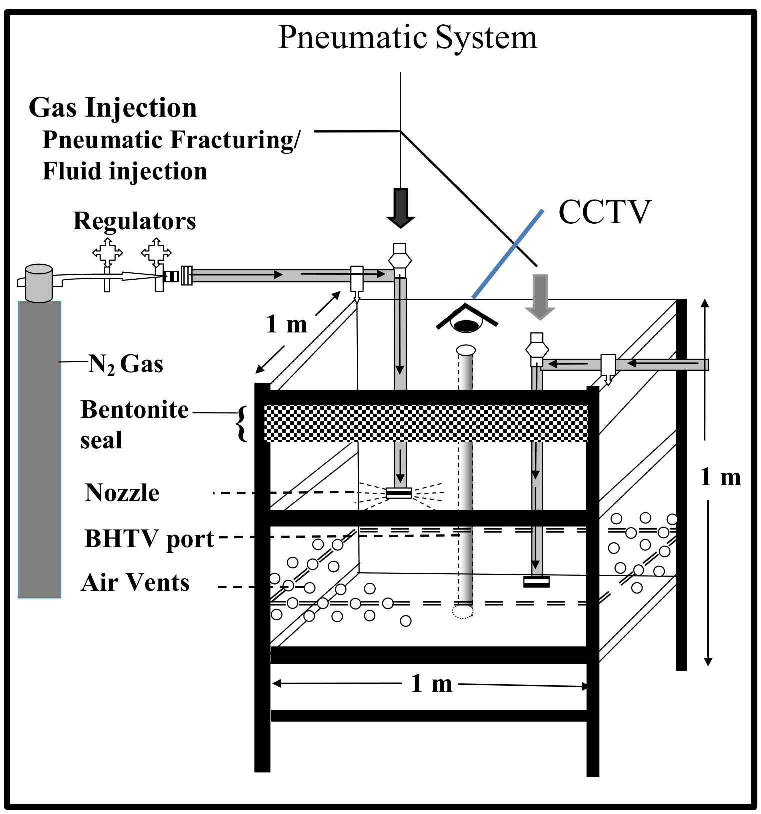

Figure 1: Schematic of tank setup for pneumatic fracturing experiment whereby fractures were

Experiment design and methods

The pneumatic fracturing experiment consisted of a 1.0 m x 1.0 m x 1.0 m glass tank filled with tightly-compressed kaolinite sediments (Figure 1). A clear polycarbonate tube was inserted in the center over a sealable portal in the base of the tank to facilitate optical imaging of the mechanically-induced fractures propagated in the formation using a borehole televiewer (BHTV). The injection point for the entry of compressed N_2 gas was positioned halfway between the central borehole (optical imaging port) and the southwest (SW) corner of the tank at 71.0 cm along the northeast-southwest (NE-SW) diagonal in Figure 1. Electronic biaxial tiltmeters were placed on the soil surface at tank corners to record surface deformation caused by fracturing. Pressurized air used for the fracturing process was controlled by a pressure manifold system consisting of an actuator, regulator, a source to the control panel, valves, pressure transducers, and a compressed gas (N_2) source. Pressure transducers were used to monitor pressures during (1) fracture initiation, (2) propagation, and (3) the re-fracturing process (maintenance). During fracturing, N_2 gas was supplied from one cylinder at a flow rate of 5 psi and injected into the formation through a 1.27 cm diameter Schedule 40 PVC tube, attached to the 0.125 cm SW nozzle (SWN) situated 0.25 m (anticipated fracture interval) above the base of the tank in the southwest quadrant (Figure 1). Fracture characterization (strike, dip, aperture etc.) was performed using (1) BHTV in the central borehole, and (2) compilation of fracture strike orientation data and density characterization of the fractures in the primary 40-80 cm fractured interval. Fracture characterization was done on a grid system by counting the fractures within each section of the grid at 10 cm intervals. A total of 256 fractures, including 13 fracture orientations surrounding the borehole from BHTV, were plotted on a standard Rose diagram.

A mobile-dipole method was used to acquire ASP measurements before and injection of a 0.01 M NaCl electrolyte/red dye solution into the SWN at a range of flow rates. This electrolyte was mobilized by a stream of N_2 over specified time intervals (2 min, 3 min, 4 min, and 6 min). ASP measurements were made with two custom-built, non-polarizable PbCl-$PbCl_2$ electrodes kept at a fixed distance apart and rotated simultaneously at 20º steps through 360º to record electric potential ($\Delta\phi$) with change in azimuth. The diameter of the outer circle of electrodes was 72 cm and the diameter of the inner circle was 46 cm. Electrodes were connected to a precision multimeter (input impedance >10 MOhm).

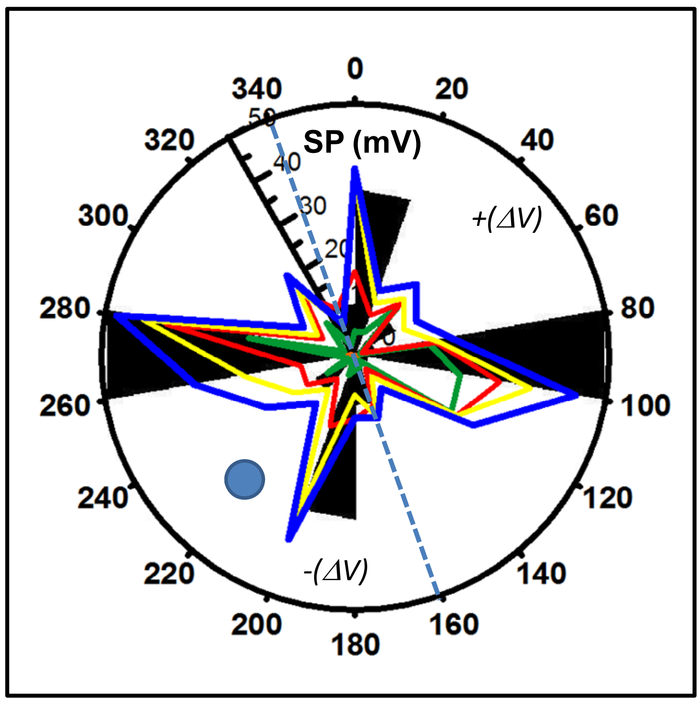

Figure 2: Polar plot of azimuthal self potentials during injection of an electrolyte/dye at four flow rates (green = 0.45 cm^3/s; red = 1.63 cm^3/s; yellow = 1.63 cm^3/s; blue = 3.17 cm^3/s). Blue circle denotes injection location into the tank. Also denoted are the positive and negative hemispheres of the SP signal.

Results

Figure 2 shows the results as a polar plot of ASP superimposed on the rose diagram of the mechanically–induced fractures during injection of simulated treatment into the southwest nozzle at multiple flow rates. ASP signals are strikingly consistent with both primary fracture sets at 10°/190° and 90°/270° whereas weaker ASP lobes coincide with minor fracture sets oriented at 050º, 150º. SP values are negative from 120º to 300º degrees (values being positive in the opposite hemisphere). The minimum $\Delta\phi$ recorded for the lowest flow injection (0.45

fracture sets after post-fracture injections of product is consistent with the proportionality between ASP and hydraulic gradient. Cross plots of self potential versus number of fractures show that the striking visual correlation between ASP and fracture strike is statistically significant. Figure 3 is such a plot, with the SP values normalized to injection rate in order to account for the expected increase in electrokinetic SP with increased hydraulic gradient (Equation 1).

Discussion and Conclusions

Our results confirm findings of previous experiments and demonstrate that ASP is effective in the characterization of bulk hydraulic anisotropy of mechanically-induced fractures in unconsolidated soils, in addition to fractured bedrock as shown previously. Our results suggest that ASP can be used to evaluate pneumatic fracturing at field sites and can assist in tracking the direction of migration of an amendment through an anisotropic induced fracture network. The positive correlation (linearity) between SP signals and the number of fractures (N) along the same azimuth suggests that it is possible to characterize the hydraulic anisotropy induced by pneumatic fracturing. Furthermore, transport directions of the remedial treatment may be inferred from the polarity of the ASP signal, as the positive SP lobe will be parallel to the direction of flow. Further information on progress of the remedial treatment may be obtainable by exploiting the proportionality between the electrokinetic potential and the applied hydraulic pressure gradient, such that the magnitude of the SP signal scales with the flow rate. In summary, ASP can provide very useful baseline information that can help evaluate the effectiveness of a pneumatic fracturing treatment, define the hydraulic anisotropy induced by the fracturing and possibly monitor the progress of remedial treatments injected.

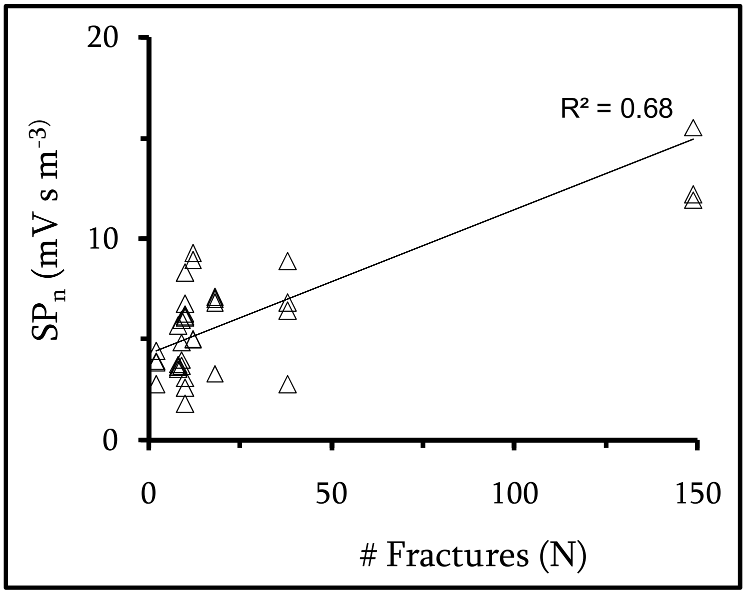

Figure 3: Cross plot of the self potential versus number of fractures for a given azimuth. The self potential has been normalized to the calcuated flow rate during injection in order to plot all values on a single graph.

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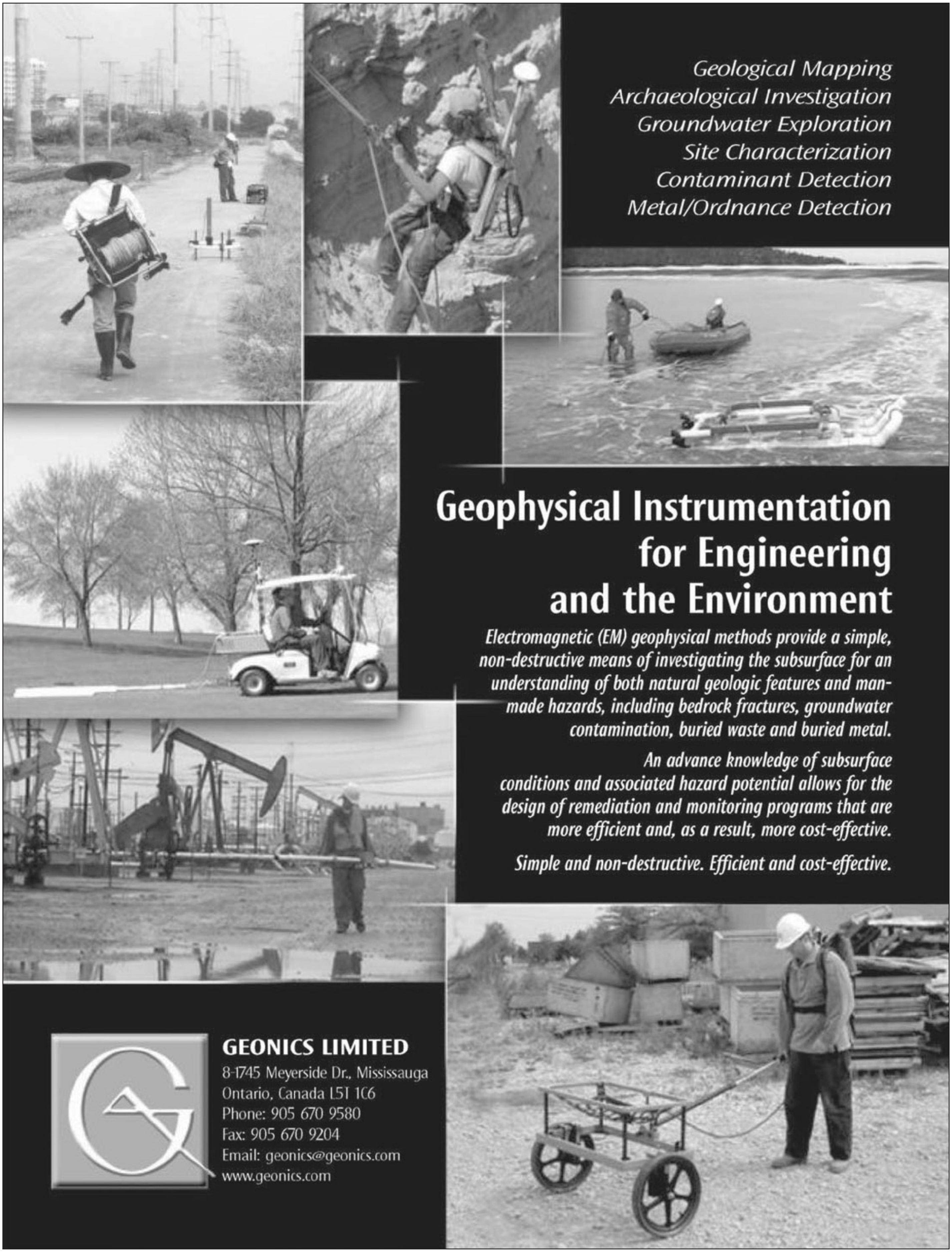
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GEOPHYSICS IN THE SEARCH FOR HOMER'S ITHACA

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Abstract

Identifying the location of the island of Ithaca, legendary home of Odysseus, has been a problem for historians for centuries. The modern island of Ithaki, in the Ionian Sea, does not match the description in Homer's epic poem. In 2003 Robert Bittlestone initiated a study of the Paliki peninsula in western Cephalonia in an attempt to determine whether this was the island that Homer called Ithaca, then separated from the rest of Cephalonia by a sea channel later described by the Greek geographer Strabo.

Ground, airborne and marine geophysical surveys are being used to study the potential for a channel under an area now largely covered by colluvium from the adjacent mountains. Airborne EM and magnetic data provide a regional overview of ground conductivity. Ground EM, resistivity, gravity and refraction seismic surveys are being used to study the proposed channel zone in detail to determine the depth of fill and contours of the buried bedrock surface. Marine seismic has been employed offshore to analyze the drainage patterns at the low water levels of 3000 years ago. High resolution airborne LIDAR mapping provides detailed surficial information. All of these data sets are brought together to build a comprehensive geological model of the proposed channel area and to provide the ultimate test of the classical enigma.

History

The *Odyssey*, the epic poem by the Greek poet Homer, was written about the travels of Odysseus, estimated to be about 1200BC. It was long thought to be just a good story, like its companion poem, the *Iliad*. The tales of Cyclops and men turning into pigs left little doubt that the events described were fantasy, and the poems' locations were also thought to be fictitious. This changed in the 1870s, when the historian and archaeologist, Heinrich Schliemann used the description of Troy in the *Iliad* to narrow down and subsequently discover the location of that fabled city. Since the 19th Century, other archaeologists have verified other facts from these stories. This should be no surprise; the blending of fact and fiction. Many stories told in today's popular media mix fiction and real geography, placing their characters into our real world, to render the story more believable and familiar.

However, the geographical descriptions in these stories are often ambiguous, and locating places can be difficult. So it is with the location of Odysseus's homeland, ancient Ithaca. In the *Odyssey* (chapter 9, lines 21-26) the wandering hero Odysseus describes himself to King Alcinoos thus:

"I am Odysseus, Laertes' son, world-famed
For stratagems: my name has reached the heavens.
Bright Ithaca is my home: it has a mountain,
Leaf-quivering Neriton, far visible.
Around are many islands, close to each other,
Doulichion and Same, and wooded Zacynthos.
Ithaca itself lies low, furthest to sea
Towards dusk; the rest, apart, face dawn and sun."
(trans. James Diggle, in Bittlestone et al., 2005)

Some of the places described are still known, like the island of Zacynthos. The problem with Homer's description of Ithaca is that the modern island of Ithaki (often regarded as the original Ithaca) is not low-lying - it is mountainous. It is definitely not "furthest to sea towards dusk" (west), but rather lies east of the other islands in the group, closer inland. Was Homer wrong, or had the island moved[1]?

Many searchers have translated and re-translated the *Odyssey* and studied the geography of the Ionian islands to determine where Ithaca really was. Heinrich Schliemann and Willhelm Dörpfeld excavated on modern Ithaki in search of ruins of ancient Ithaca and a palace, without success. Dörpfeld later re-interpreted the *Odyssey* and proposed that the neighboring island of Lefkas was the ancient Ithaca. His colleague, A.E.H. Goekoop suggested in 1908 that ancient Ithaca is now the south-western part of Cephalonia, and his grandson, C. H. Goekoop suggested that it was the northern region of Cephalonia, Erissos. Lefkas, however is north of the other islands in the group, and both locations on Cephalonia are in the centre of the group, rather than furthest west. There are many more hypotheses for the location of Ithaca – some in fantastic locations.

Figure 1: Ithaki, Cephalonia and Paliki
Landsat 7 Image courtesy NASA

This paper describes the work of Fugro in support of the hypothesis of Robert Bittlestone, who, working with geologist John Underhill and classicist James Diggle, has put forward a new proposal: that the Paliki peninsula, the westernmost part of Cephalonia, was ancient Ithaca. Their book, Odysseus Unbound, gives a detailed description of the evidence supporting the hypothesis, and the story of its development. There is one major sticking point: Paliki is joined to the larger part of the island of Cephalonia, by an isthmus as much as 180m above sea-level. Figure 1 shows a Landsat 7 image of the islands today, and the Thinia valley fills the isthmus between Paliki and the rest of Cephalonia. The new hypothesis requires a channel through the isthmus, perhaps in the location shown in Figure 2.

The problem of determining whether Paliki was once an island becomes a geological challenge: could a channel have existed at the time of Odysseus, 3200 years ago, and been filled to a maximum depth of 180m in the intervening years? Several pieces of information add support to the idea.

The Greek geographer, Strabo, produced his "*Geography*" at about the time of Christ, describing in remarkable detail and accuracy the geography of the Mediterranean and parts of northern Europe and the Middle East. In it, he described Cephalonia thus:

> *"Where the island is narrowest it forms an isthmus so low-lying that it is often submerged from sea to sea. Both Paleis and Cranioi are on the gulf near the narrows."*

[1] This last suggestion is not facetious – when entire villages move from place to place in ancient times (due perhaps to disaster), they might take their village name with them. And disaster is a definite probability in this part of the Ionian Sea. The group of islands described in the Odyssey lie on the boundary between the Eurasian Plate and the North African Plate, which is slowly forcing its way north under Europe. The area is one of the more seismically hazardous in Europe, as demonstrated by the destructive quake under Cephalonia in 1953 (Bittlestone et al, 2005)

The first impression one gets from pictures of the east side of the Thinia valley is the prevalence of recent loose fill. Long hours of field study and research led Bittlestone and Underhill to determine the only possible location for the channel described by Strabo is in the Thinia Valley (Figure 2). Nowhere else on the peninsula is it possible to trace a line from one side to the other without encountering bedrock outcrop.

Figure 2: Thinia valley with possible channel route and outline of geology map (Fig 3)
Image © 2009 DigitalGlobe

Figure 3 is a surface geological map of the Thinia valley prepared by Underhill, overlain on the topography, looking east toward Mt. Imerovigli. The purple color shows the extent of colluvium, derived in part from the mountain above.

The crux of the problem is: **Does the colluvial fill on surface in the valley, brought down from the hills around by millennia of seismic activity, fill a sea-level channel, or is there bedrock well above historic sea levels**? In 2006 a drill hole was bored at the site marked with a yellow arrow in Figure 2, at the south end of the proposed channel. As shown in Figure 4, the boring passed through 40 metres of unconsolidated fill before entering Miocene marl, lending more support to the filled-channel hypothesis.

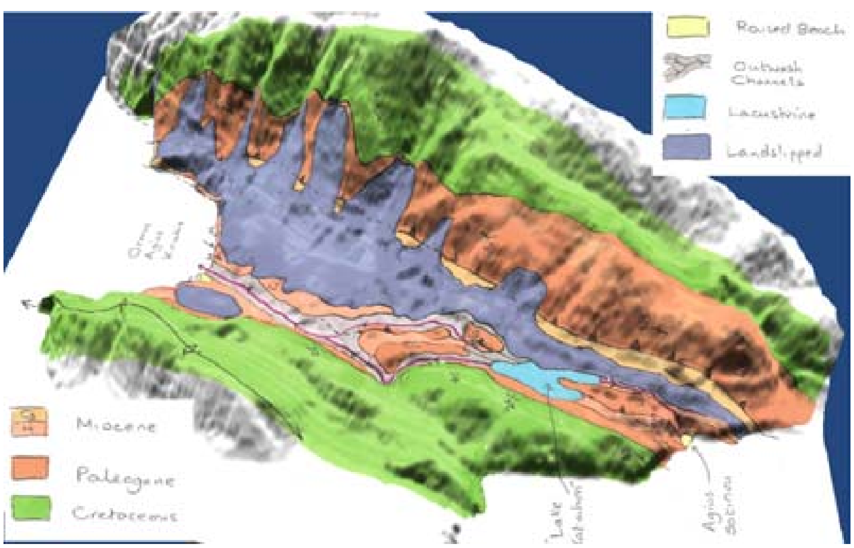

Figure 3: Surface geological map overlain on topography, Thinia valley. (Modified from Underhill, 2008)

Geophysical Surveys

Geophysical surveys can assist in evaluating the buried channel hypothesis, by estimating the depth of the fill across the entire Thinia valley. Fugro entered the project in 2007 as a supporter, agreeing to provide the geophysical services and expertise. As this is a research and demonstration project, it was decided from the beginning to test a wide range of methods on the project.

The plan is for a multi-year, staged approach, starting with an airborne electromagnetic (EM) and magnetic survey, and an airborne LIDAR mapping survey. The EM and magnetic survey were to be used to map the extent of the colluvial fill and examine the depth (to about 100m) in the Thinia valley. In addition, the survey data will be used to evaluate the depth of sediment in the level area of lacustrine sediments (light blue in Figure 3), called “Lake Katachori” by the team, after the nearest town. If these sediments, which onlap onto the colluvium, can be dated, it may constrain the age of the fill on the isthmus. At the head of Argostoli Bay (south of the isthmus) is a low-lying area, probably at one time flooded by the sea. EM may indicate if the sediment is thick enough to suggest that at one time this was flooded deep enough to be an ancient harbor? The magnetic data are generally useful for mapping.

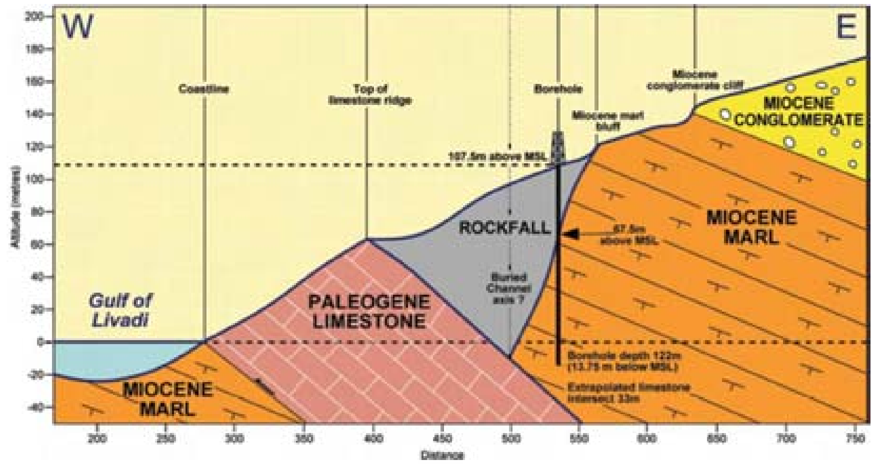

Figure 4: Section at drill hole at southern exit of channel. (From Underhill, 2008)

The high-resolution FliMap LIDAR survey data would serve principally as a detailed topographic base map. A second survey is intended, after a span of years, to map the change in slope contours and possibly give an indication of the rate of soil creep.

Follow-up to the airborne surveys will include DC resistivity surveys, to refine the detail of the airborne surveys, and possibly extend the depth of exploration to the bottom of the fill. Refraction and/or reflection seismic surveys will attempt to map the bedrock surface below the fill. Gravity surveys, principally across the Thinia valley, would be used with the seismic and resistivity surveys to accurately model the bedrock surface.

Marine seismic surveys are being used to examine the depth to bedrock at the south entrance to the proposed channel. The marine surveys will also define the sediment layering in Argostoli Bay, to help define the post-glacial flooding history (when the floor of the bay was exposed by the lowered sea levels).

The geophysical survey results will be used to define the optimal location for drilling. Shallow drilling in the Lake Katachori region and in the sediments at the head of Argostoli Bay will be used to describe the recent history of both areas. Deep drilling in the hypothesized channel itself will be used to prove-up the geophysical results, and possibly be used for down-hole and cross-hole geophysics to further refine the profile of the bedrock sub-surface.

Airborne EM and Magnetic

The airborne EM system used was the RESOLVE frequency-domain system. RESOLVE has 5 coplanar EM channels for layered-earth mapping, with a frequency range from 400Hz to 140kHz. The magnetometer is in the RESOLVE system.

Figure 5 shows the 40kHz apparent resistivity map for the entire survey area, overlain on the local topography. Immediately apparent is the low resistivity (warm colors) throughout most of the Thinia valley, mapping out both the deep colluvium and the Miocene conglomerate and marl. The dark blues generally represent very high resistivity Cretaceous limestone forming the hilltops on the island.

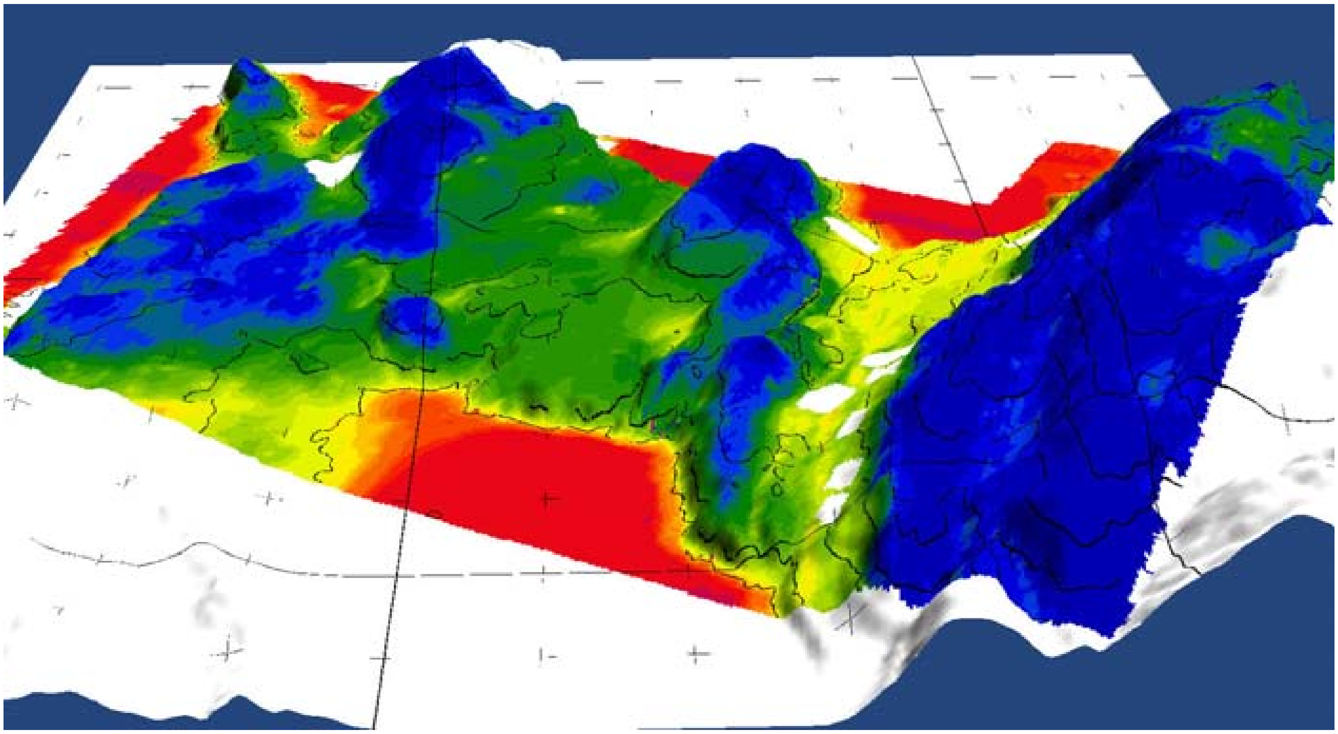

Figure 5: Airborne Apparent Resistivity map (40kHz) on topography.

Figure 6 shows the apparent resistivity data for the Thinia valley, in order, the 140kHz (left), the 8200Hz (middle) and the 400Hz (right). These represent the shallowest, middle, and deepest resistivities. Figure 7 shows (for the same extents) the mapped topography (left), Underhill's geology map (middle) and the magnetic data (reduced to the pole).

At the east edge of the survey, the high resistivities (blue) show the extent of limestone. The weakly conductive zones generally correlate to shallow drainage valleys, and presumably show the shallow fill in these valleys. The contact between the limestone and the marl and fill of the valley is very apparent on all frequencies, as the trend toward more conductive material (green). The contact is clear as a relatively straight line on the lower frequencies. The higher frequency EM shows more variation, mapping the shallow loose fill in the valleys (purple areas on the geology map). Within the colluvium/marl zone, there are distinct zones of lower resistivity, forming channel-like continuous zones. At 8200Hz the zones are still apparent, at about 20m depth below surface. At the lowest frequency, the individual zones are not apparent, most likely because they are too narrow or too indistinct (for the wider footprint at depth) relative to the surrounding material. We can observe, however, that the zone remains resistive, indicating either marl or colluvium exists to approximately 80m depth across the entire isthmus. There is no indication of limestone bedrock to beyond that depth.

An interesting feature in the magnetic data is the strong, linear anomaly coincident with the contact between the limestone and marl. It is most prominent and continuous on the eastern contact, but also apparent on the west contact. At this time, this is unexplained. Also interesting, in the western part of the survey, were relatively strong magnetic anomalies coincident with some valleys. The Terra Rossa soil in these valleys (Bittlestone, pers comm.) is high in iron content, but magnetic susceptibility measurements of the soils at surface indicate that there is insufficient magnetite in the soil to explain the anomaly strength.

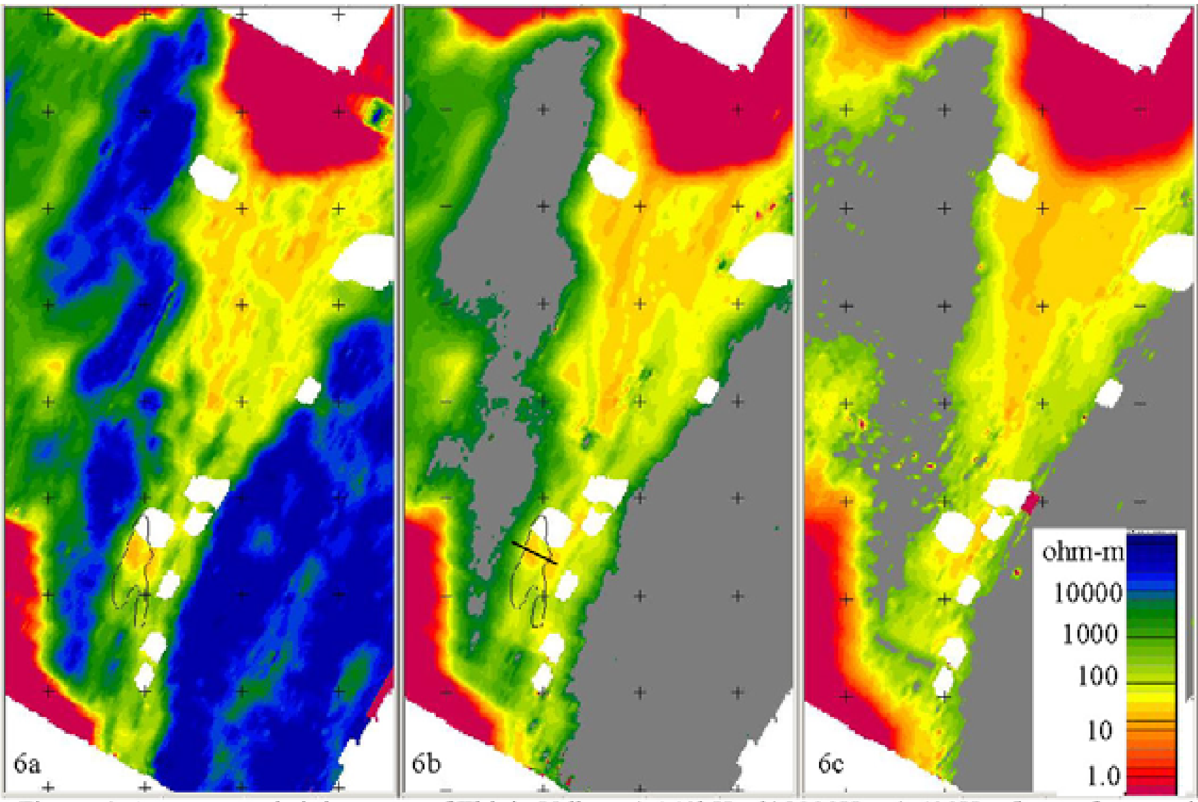

Figure 6: Apparent resistivity maps of Thinia Valley: a) 140kHz, b)8200Hz, c) 400Hz (lower frequencies greyed-out where too resistive) Line indicates location of profile shown in Figure 9.

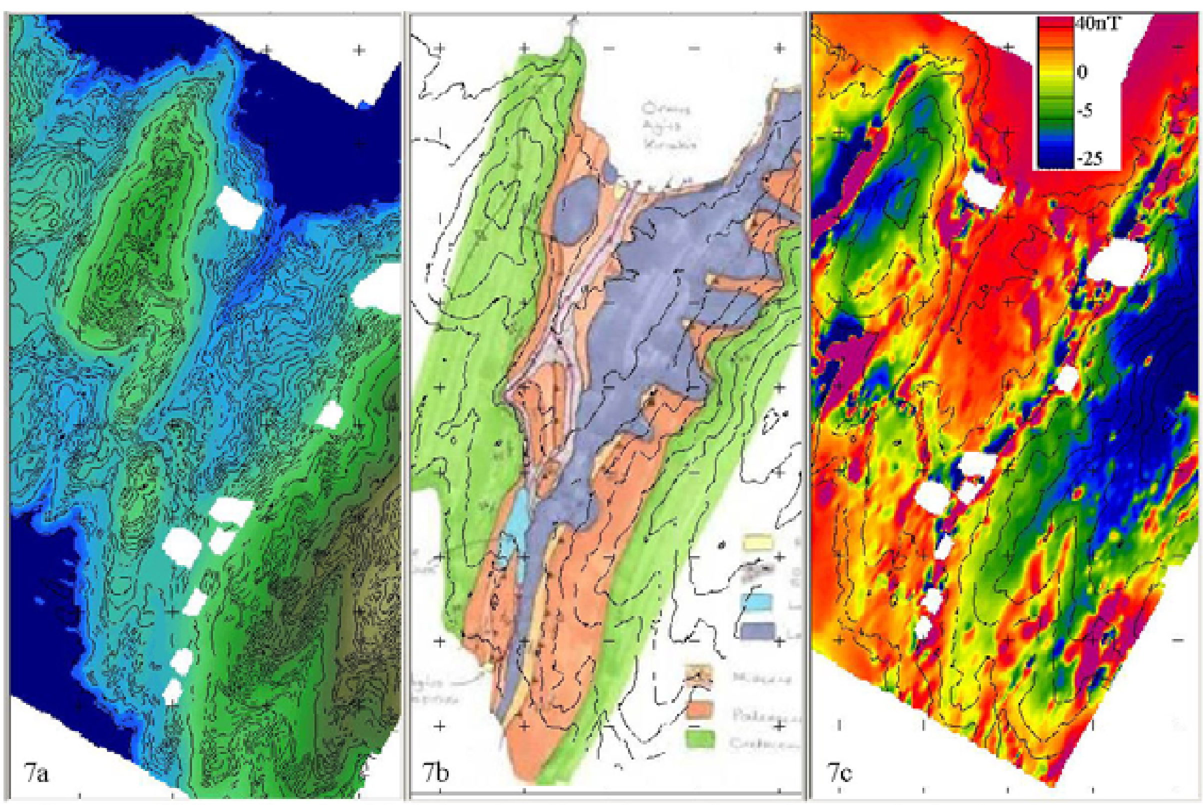

Figure 7: Thinia Valley: a) Digital elevation, b) Surface geology, c) Magnetic data (RTP) Ticks are at 1km intervals, topography varies from sea-level to 1000m.

The Head of Argostoli Bay

Bittlestone et al (2005) hypothesized that the lowlands at the head of Argostoli Bay could have been open water at the time of Odysseus, possibly a harbor. The apparent resistivity appears to map out the thickness, and perhaps the type of sediment in the bay. The 140kHz apparent resistivity shown on the left in Figure 8 clearly shows the shoreline as a consistent, smooth contrast in conductivity toward the bay. These data also show a band of slightly higher resistivity between the most conductive areas of the lowlands and the sea shore, indicating more resistive soils, probably a baymouth bar, now buried. The centre of the low lying area is the most conductive, indicating the greatest depth of sediment. At these resistivities the 400Hz signal is measuring down to about 20m, with no apparent increase in apparent resistivity indicating that the sediment there is at least that deep. The 400Hz data provide a measure of the water depth in the bay itself, as the trend to from shore in the north-west to lower resistivity into the increasingly deep water. The water depth close to the south exit of the channel is definitely deeper than elsewhere.

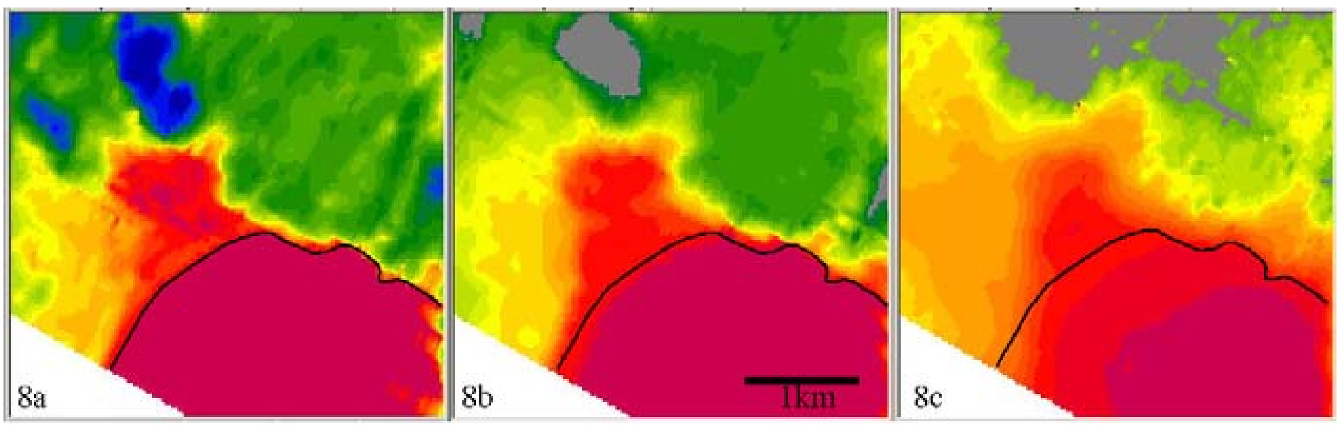

Figure 8: Resistivity at the head of Argostoli Bay (Ithaca Harbor?). a) 140kHz, b) 8200Hz, c) 400Hz Colour range is the same as Figure 6.

Ground Resistivity

The ground resistivity surveys are being conducted as follow-up to the airborne EM mapping, to provide more detail on areas of interest, as well as greater exploration depth. A number of the channels apparent in the airborne resistivity, and the deep sediment in the lake were chosen as areas for initial follow-up with DC resistivity surveys.

The key feature to look for would be high resistivity at the bottom of the section, indicating bedrock, although it is important to keep in mind that the Miocene marl and conglomerates do not appear from the airborne data to be markedly different in resistivity than the valley fill. However, to positively confirm that there is no contrast, the data from resistivity, seismic and gravity need to be correlated to confirm the depth of colluvium where the resistivity depth profile is available.

Gravity

The gravity survey has the potential to be one of the defining measurements of the depth of the valley fill, particularly when allied with the seismic data. While the Miocene sediments may have resistivity fairly close to that of the colluvium, it should have significantly higher density (and seismic velocity). At the time of this writing, the first phase of gravity surveying was completed. Due to difficulties of access, a full, continuous line of gravity was not completed across the entire channel zone. Figure 9 shows one of the gravity profiles across Lake Katachori (see below).

Lake Katachori

Figure 9 shows a map compilation of the data over Lake Katachori (shown as an outline). In the upper left is the 140kHz apparent resistivity, on the upper right is the 8200Hz apparent resistivity (white spaces are villages which could not be surveyed). The lower left is the Bouguer Anomaly gravity, and the lower right the DC resistivity coverage. Immediately apparent is a coincident anomaly of low resistivity (orange) on both the airborne and ground resistivity, and a coincident gravity low. The reduced width of the resistivity low at the greater depth suggests that it is a basin-shaped feature.

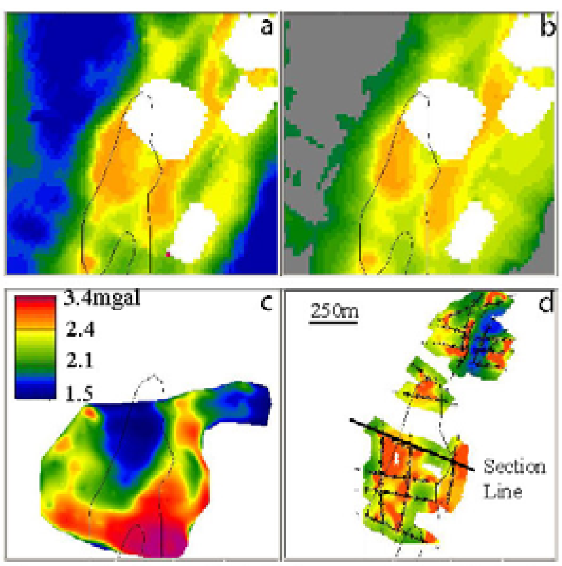

Figure 9. Compiled data over Lake Katachori Airborne Resistivity a)140kHz b) 8200kHz c) Bouguer Gravity d) DC Resistivity Resistivity maps use the color bar of Fig 6

Figure 9a shows a compiled set of sections (DC resistivity on the bottom, airborne next, and the gravity and magnetic profiles on top). The thick clays are apparent on both the airborne and ground resistivity data, with similar resistivity values. The edge of the "lake" sediments is apparent to the west (left) on the ground resistivity, and the high resistivity on the airborne data shows that this is a limestone unit. There is not a strong resistivity contrast at depth in the airborne data, suggesting that to a depth of more than 100m there is no limestone, but rather colluvium or marl, which appear to have similar resistivities. Both the airborne data and ground data show the edge of the conductive lacustrine sediments (at about mid-section) but both the section and map (Figure 6b) show that there is another conductive zone east of the "lake", which is another potential channel.

Seismic Refraction

Only a few seismic lines have been conducted to date. Figure 9b shows the section across the same part of Lake Katachori as the data shown in Figure 9a. The seismic velocities remain low to depth in the center part of the line, rising close to the limestone to the west, and the modestly resistive ridge at the east end of the seismic and ground resistivity sections.

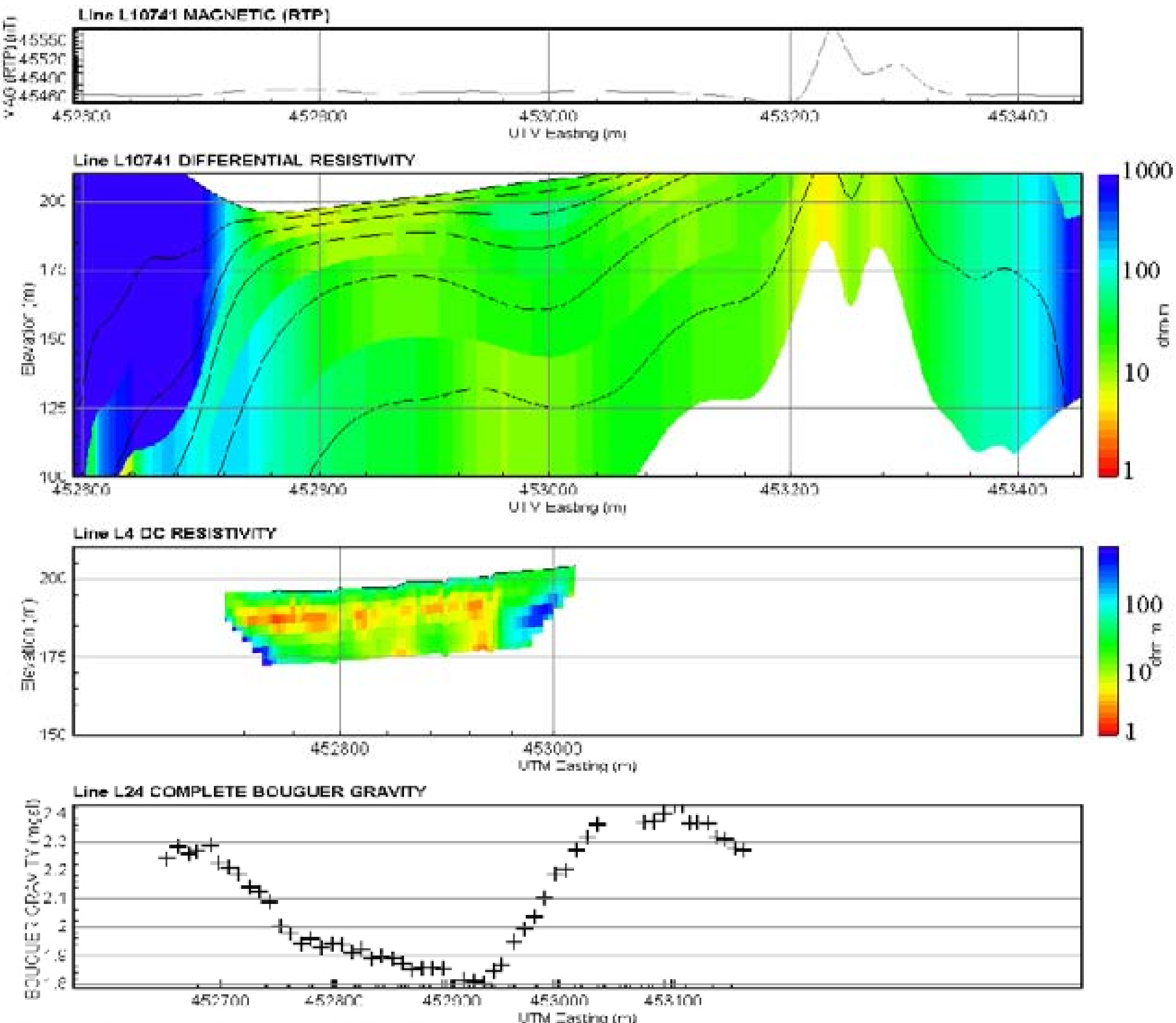

Figure 9a: Profile across Lake Katachori.
Location of profile shown in Figure 6b

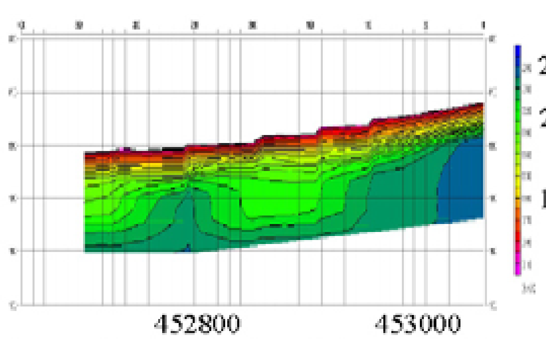

Figure 9b: Refraction Seismic Profile
across Lake Katachori.
Location of profile shown in Figure 6b

Marine Geophysics in Argostoli Bay

The northern part of Argostoli Bay was covered by marine seismic data. The purpose of the survey was to examine the depth of the sediment to define the pre-Holocene bedrock subsurface near the south end of the hypothesized channel, and to give some indication of the post-glacial history of the bay. The post-glacial history is relevant to the drainage in the bay and on the islands around, and on the water level at the time of Odysseus. Lower water levels would have increased the rate of down-cutting by rivers draining from Mt Imerovigli (east of the Thinia valley) through the valley into the sea north or south of the valley, possibly creating the channel.

The line of marine seismic data shown in Figure 10 was conducted across the middle of Argostoli Bay. The data not only demonstrates the significant pre-Holocene erosion surface buried beneath today's seafloor, but also shows the highly folded nature of the Cenozoic sediments beneath, something that has been well demonstrated in neighbouring coastal exposures (Underhill, 1989), but never seen beneath in the subsurface before.

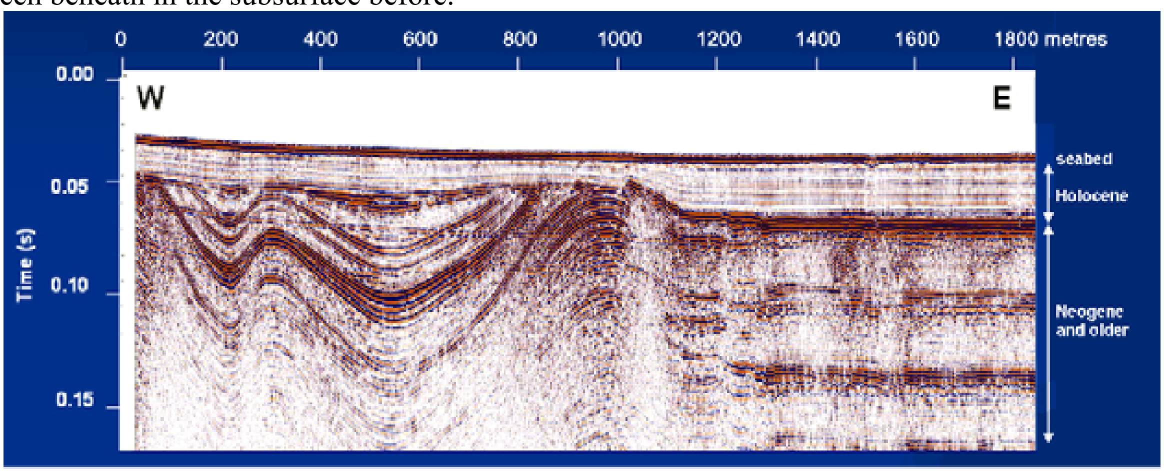

Figure 10: Marine Seismic Profile across Argostoli Bay

FliMap Data

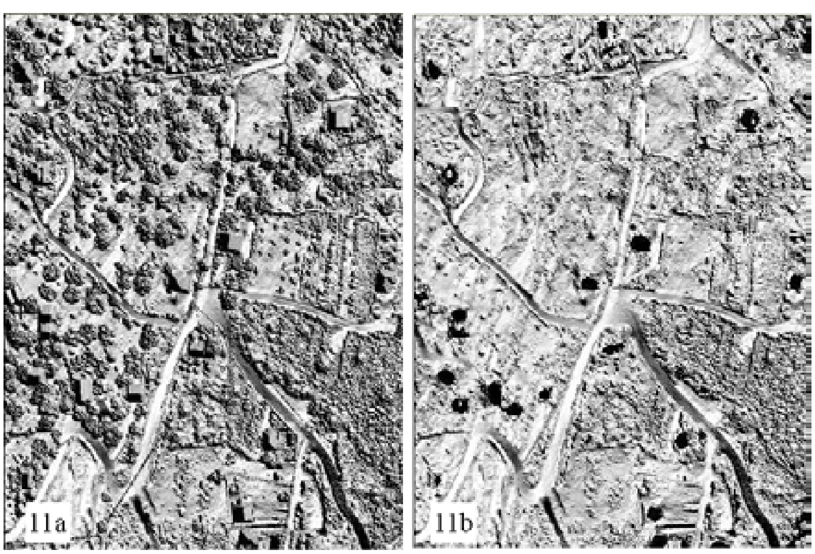

Figure 11: FliMap data, Thinia Valley:
a) Visible Surface, b) Stripped of vegetation and buildings

The FliMap LIDAR data are being used now as a base map and digital elevation model for processing and presenting the rest of the geophysical data. The intent, in the long term, is to fly the survey again and look for changes in slope profile, to map long-term soil creep. This test is aided by the high accuracy (1-2cm, relative) of the FliMap data, and the "stripped" version of the data, with the effect of trees and other cover removed to show the ground surface. Figure 11 shows an example of the data, both original and stripped.

Conclusions

At the time of this writing, the project is not complete. Ground geophysical surveys are on-going, to extend the coverage of the first year, and investigate some of the mysteries found at that time. Confirming the existence of the channel is potentially much more complicated, and requires much more extensive surveying, than demonstrating that bedrock outcrop blocks the channel. However, at this time there has not been conclusive evidence to disprove the hypothesis of the existence of a buried channel at across the Thinia Valley, separating the Paliki Peninsula from the rest of Cephalonia, as hypothesized by Robert Bittlestone.

The current phase of work (on-going at the time of writing) includes gravity and resistivity mapping. Once coverage of the channel zone is complete, the next phase will be deep drilling in the channel itself, and/or borings in the areas of deep, in-situ sediments (Lake Katachori and the head of Argostoli Bay) to analyze the history of these areas, and its relationship to the thesis.

Acknowledgements

The authors would like to thank Robert Bittlestone, first for originating the idea and for his continuing support, and James Diggle for his advice on ancient Greek translation and the context of Homer's epic poems. The on-site work benefited from the support of many departments of the Greek and local governments, including IGME (Institute of Geology and Mineral Exploration), Ministry of Foreign Affairs, Ministry of Culture, and the Dimarcheions of Paliki and Argostoli, as well as the Natural Environment Research Council (NERC) in London. The authors would also like to thank Fugro for their support of the project, and for support in preparation of this paper.

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BOREHOLE GEOPHYSICAL INVESTIGATION: SEMINOE DAM, WY CHARACTERIZATION OF INTERNAL FRACTURING AND DYNAMIC MODULI REDUCTION OF MASS CONCRETE UNDERGOING AAR

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Abstract

Alkali aggregate reaction (AAR) is the general term for a slowly occurring chemical reaction in which highly alkali cement paste reacts with concrete aggregate. AAR is a common problem in concrete poured prior to the 1950's. The reaction leads to the formation of an alkali silicate gel at the interface of the aggregate and cement. This gel product is less dense than the reactants, causing expansion. The gel product also increases in volume with water.

During July of 2009, five six-inch diameter boreholes with varying depths were drilled into Seminoe Dam. Down hole optical and acoustic imaging tools were utilized to locate and characterize fractures within the concrete surrounding the borehole. Data collected from sonic and density logging tools were used to calculate the in-situ dynamic modulus values of the concrete surrounding the borehole wall.

Imaging data was analyzed for fracture dip, orientation and frequency. Sonic data was analyzed for the concrete's compression and shear wave velocities. Concrete density was computed from gamma ray logging data. In-situ shear, bulk and Young's modulus values were determined throughout the depth of the boreholes. Characterization of the fractures and in-situ dynamic modulus values of the concrete are used in comparison with past investigations of Seminoe Dam to gauge the progression and effects of AAR throughout the structure.

Location and background information

Seminoe Dam is a mass concrete arch dam consisting 160,556 m^3 of mass concrete, poured in 1938. Seminoe is the first dam downstream of the head waters of the North Platte River. Its foundation is in a narrow granite gorge. Table 1 summarizes some of Seminoe Dam's important structural and hydrological information. Figure 1 shows locations of the 5 boreholes in plan-view of the dam's crest. Early signs of AAR were first documented at Seminoe Dam in 1951; at that time it was not considered a concern (USBR, 2000). The Bureau of Reclamation has been periodically monitoring the progression of the reaction since, with the first major investigation conducted in 1975, indicating a high degree of deterioration in the top five feet with signs of minor AAR to a depth of 25 feet (USBR, 2000). Seminoe is constructed of mass concrete, which further enhances the AAR affects by providing a larger surface area for the reaction. Volumetric expansion due to AAR within a concrete structure can lead to fracturing and loss of material strength. The dam is also located in a region where it frequently experiences freeze thaw conditions; compounding the deteriorating effect of AAR (Acres International, 2000).

Table 1: Summary of Seminoe Dam's Important Structural and Hydrological Information

Structural Height	295 ft
Crest Elevation	6361.0 ft
Crest Length	530 ft
Crest Width	15 ft
Base Width	85 ft
Radius of Upstream Face	290 ft
Volume of Dam Construction Materials	210,000 cubic yards
Total Water Storage Capacity	1,017,279 acre-ft
Average (median) Reservoir Elevation (since 1970)	6340 feet

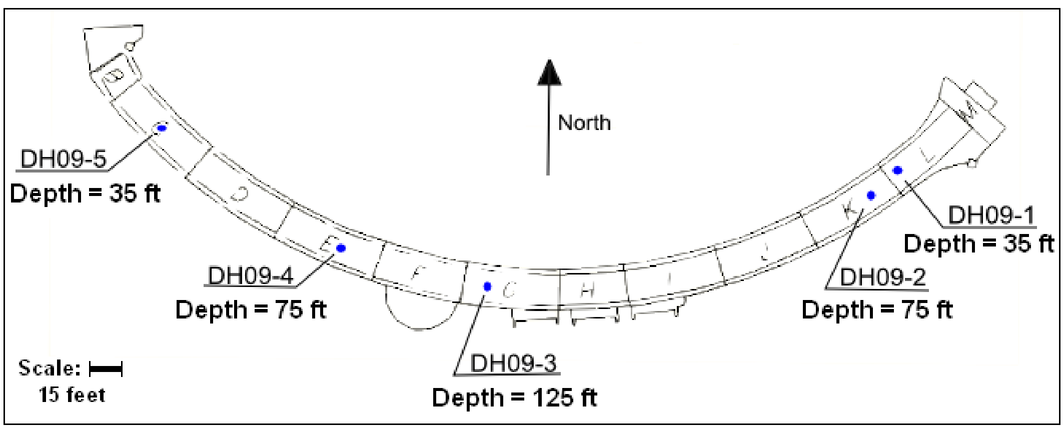

Figure 1: Plan view of the crest of Seminoe Dam. For the purpose of indicating drill hole locations, naming scheme and depths.

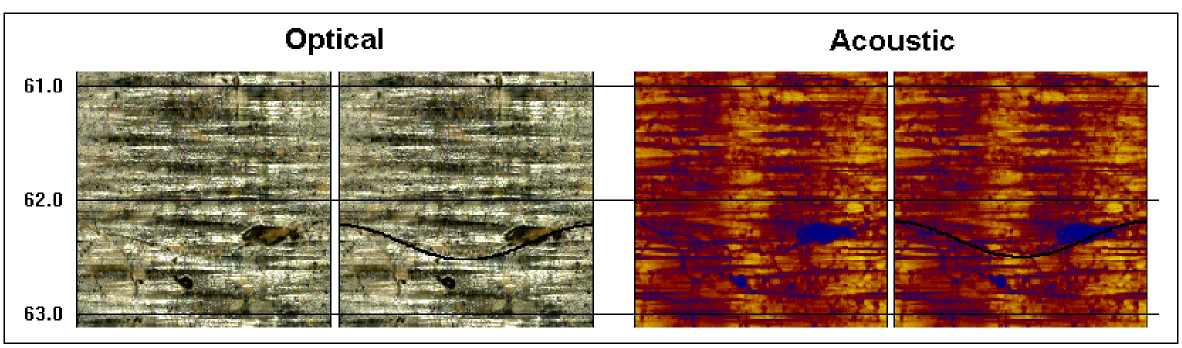

Figure 2: Two foot interval of optical and acoustic amplitude borehole images from DH09-4. Left side is raw data, while the right side shows a fracture pick overlain on top of the image.

Geophysical data collection, processing and data reduction

Optical and acoustic logging data were visually inspected for the entire depth of each borehole to locate fractures. Figure 2 is a two foot interval of both optical and acoustic amplitude data from borehole DH09-4. The figure includes both the raw data and data with a fracture pick overlaid. The oblong darker shape on the right side of each borehole image is indicative of a piece of missing aggregate. The white semi-horizontal stripes on the optical images were caused by scoring of the borehole wall by the drill bit. The imaging tools also record the tools orientation while data is collected so that once a fracture has been picked, both the fracture's dip and orientation can be determined. Polar plots of the fractures for each borehole were created. These plots are included in figure 3.

A four receiver sonic logging tool was used to determine compression and shear wave velocities for the in-situ concrete in the vicinity of each borehole. A dual spaced gamma ray density tool was also used to determine in-situ concrete density. Young's, bulk and shear dynamic moduli were calculated using the density along with the P and S wave velocities. Due to the fundamental differences in testing procedures, static and dynamic moduli values are not equal (Mockovciakova, et al. 2002). Dynamic moduli values tend to be greater than static moduli values (Zimmer, 2005). For this paper, percent reduction of dynamic modulus will be considered, as opposed to the calculated moduli values. Through inspection of the dynamic modulus values and fracture locations, an area in borehole DH09-3 (from depth 75 to 90 feet) contained little variation of the moduli values, suggesting that this portion of the dam has been relatively unaffected by AAR. The moduli values in this zone were arithmetically averaged to find an average unaffected modulus value (AUDMV). The AUDMV was used to calculate the in-situ dynamic modulus reduction. Table 2 lists the AUDMV used for each dynamic modulus. The percent of modulus reduction was plotted versus depth, to illustrate the decrease in modulus values near the crest of the dam. Figure 4 contains these plots.

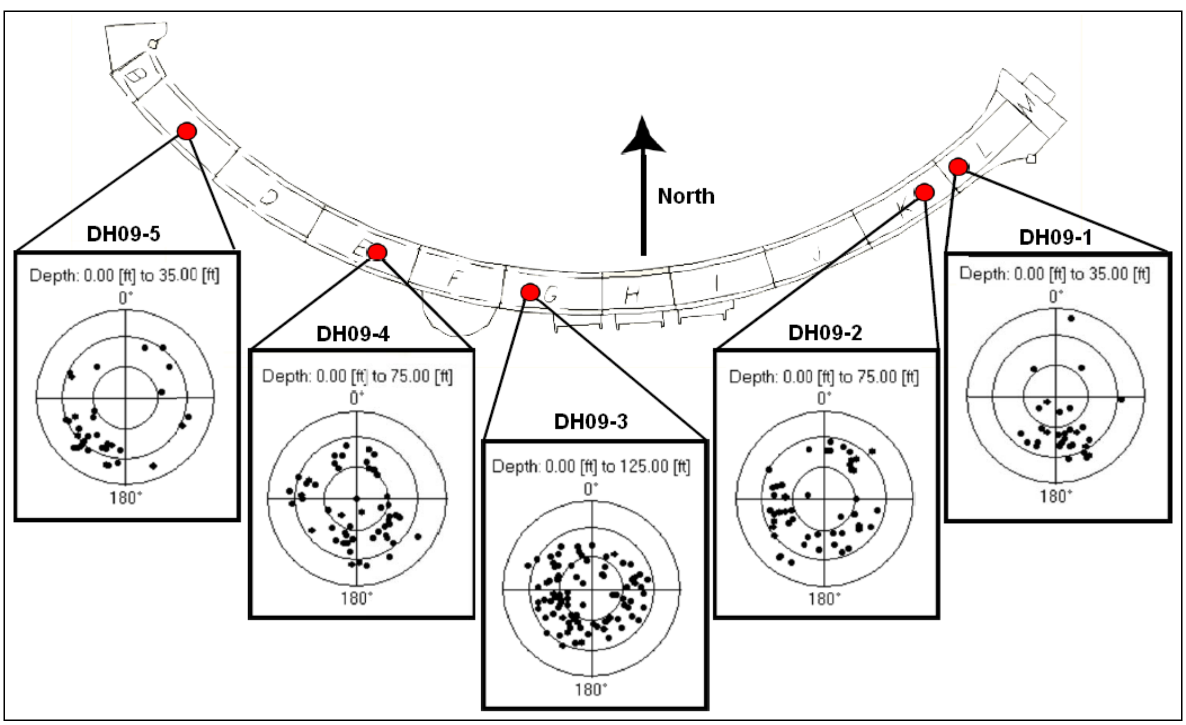

Figure 3: Schmidt [equal area, southern hemisphere] polar projection plot of fractures within the borehole wall, corrected to true north. The radial location of a pole indicates the fracture's angle of dip [center = 0º], the pole's azimuthal location indicates the up gradient direction of the fracture plane.

Table 2: Average unaffected dynamic modulus values (AUDMV) used to calculate dynamic modulus percent reductions in all 5 bore holes.

Dynamic Modulus	Average Unaffected Dynamic Modulus Value		Standard Deviation	
	GPa	Mpsi	GPa	Mpsi
Shear Modulus	18.3	2.66	0.7	0.10
Bulk Modulus	25.4	3.69	0.9	0.14
Young's Modulus	44.3	6.43	1.5	0.22

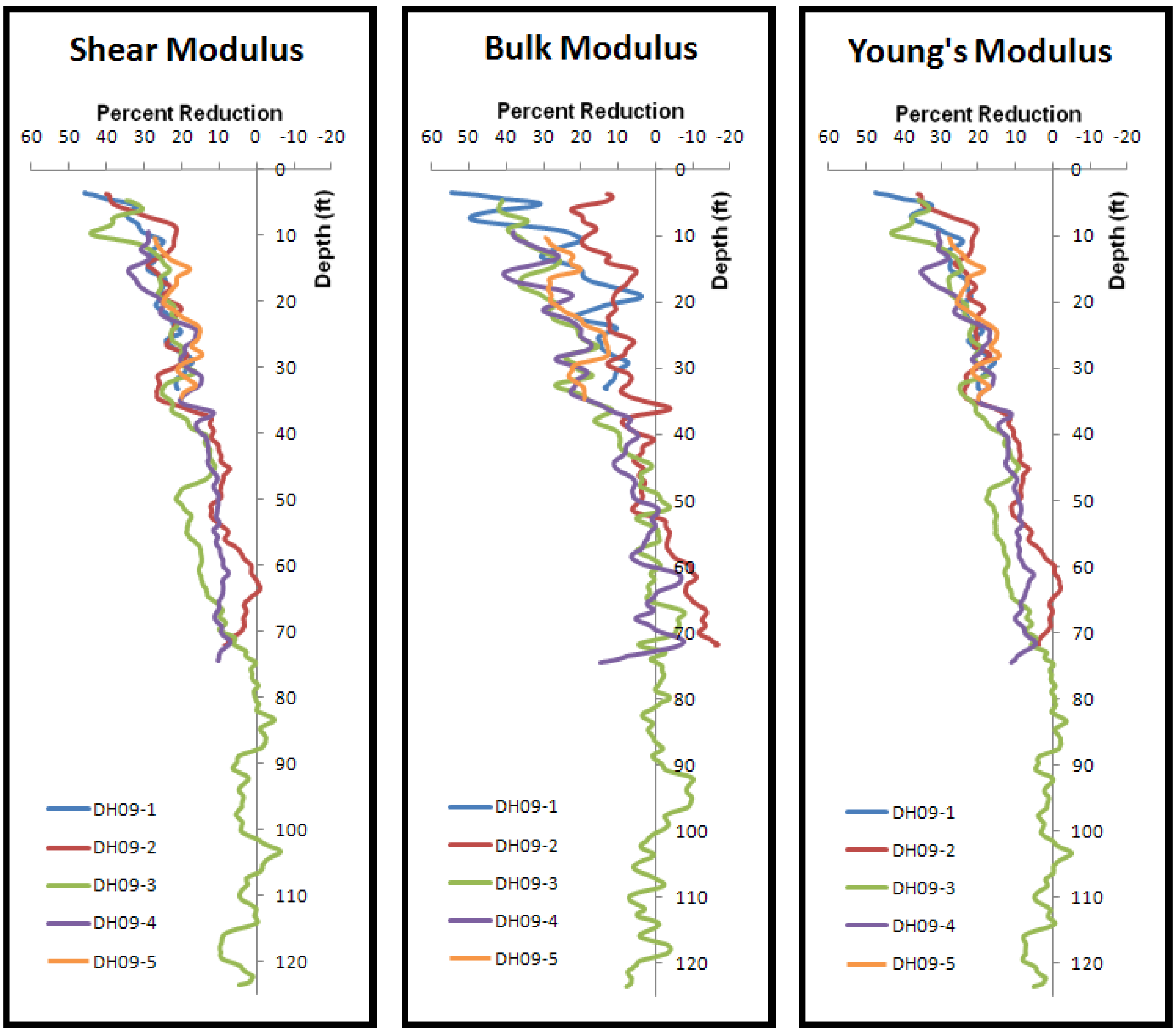

Figure 4: Plots of the percent reduction of bulk, shear and Young's modulus values within each bore hole. Dynamic modulus values were computed from in-situ measurements, percent reductions are derived from AUDMV.

Conclusions

The fracture analysis has revealed that fracture frequency decreases with depth. The fractures tend to dip more steeply towards the dam's abutments. This correlates with the visual inspections at the dam. Figure 5.a is a photograph of the right abutment that was taken in the field during data collection; 5.b highlights the fractures that can be seen on the downstream face of the dam. Fractures near the abutments also have a preferential orientation towards the downstream side of the dam, see figure 3. This trend in fracture orientation was previously unknown and could not be determined without data from within the structure.

Figures 5.a and 5.b: Photographs taken during data collection of the downstream face of the dam, viewing the right abutment. 4.b highlights some obvious fractures, with steeper fractures highlighted in blue and horizontal fractures in green.

Seminoe Dam is experiencing a decrease in all dynamic modulus values, with greater decreases seen at the crest of the dam and leveling to a stable value with less variation at depth, see figure 4. The concrete at the top of the structure is more compressible, as indicated by a lower bulk modulus. The concrete is also becoming more flexible and less rigid, as indicated by the decrease in Young's and shear modulus values, see figure 4. The results from this investigation indicate that the upper 40 feet of the dam is experiencing concrete deterioration associated with freeze thaw and AAR. This is a progression from the previously determined upper 35 foot zone, (Acres International, 2004). Analysis of the data also indicates the effect of AAR extending to a depth of at least 75 feet.

References

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Acres International, April 2004, Seminoe Dam: finite element stress analysis of concrete growth

Mockovciakova, A., Pandula, B., April 2002, Study of the Relation Between the Static and Dynamic Moduli of Rocks

Schimschal, U, USBR Technical Services Center, October 1998, Borehole geophysical investigations Seminoe Dam, Kendrick Project, Wyoming, Technical Memorandum No. D8330-98-036

USBR Technical Services Center, May 2000, Seminoe Dam ASR concrete deterioration issue evaluation data package

Zimmer, M.A., 2005, Comparison of Static and Dynamic Bulk Moduli in Unconsolidated Sands, American Geophysical Union, abstract #NS41B-04

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The University of Toledo
College of Engineering
Tenure Track Faculty Position in Geotechnical Engineering - 962235

The Department of Civil Engineering at the University of Toledo invites applications for a tenure-track Assistant or Associate Professor position in *Geotechnical Engineering*, with appointment beginning as soon as Fall 2011. *Exceptionally qualified research scholars will be considered for tenure at the rank of associate professor.* Successful candidates must have demonstrated abilities in, or evidence of outstanding potential for research and teaching undergraduate courses in Geotechnical and Civil Infrastructure, and graduate courses in Geotechnical Engineering.

The Department is particularly interested in receiving applications from candidates with the potential for a sustained research program in the areas of geotechnology at the interface with energy and the environment, and sustainable civil infrastructure. The successful applicant is expected to develop a strong externally funded research program and relevant collaborations with faculty in the Department, College of Engineering and campus community. Opportunities exist to participate in the Intermodal Transportation Institute, UT-University Transportation Center, Institute for Sustainable Engineering Materials and the Lake Erie Center. Additional resources include the Center for Materials and Sensor Characterization, University Instrumentation Center, the Polymer Institute and several programs for commercialization of new innovations. For more information about the Department and research facilities at The University of Toledo, visit http://www.eng.utoledo.edu/civil/ and http://www.eng.utoledo.edu/.

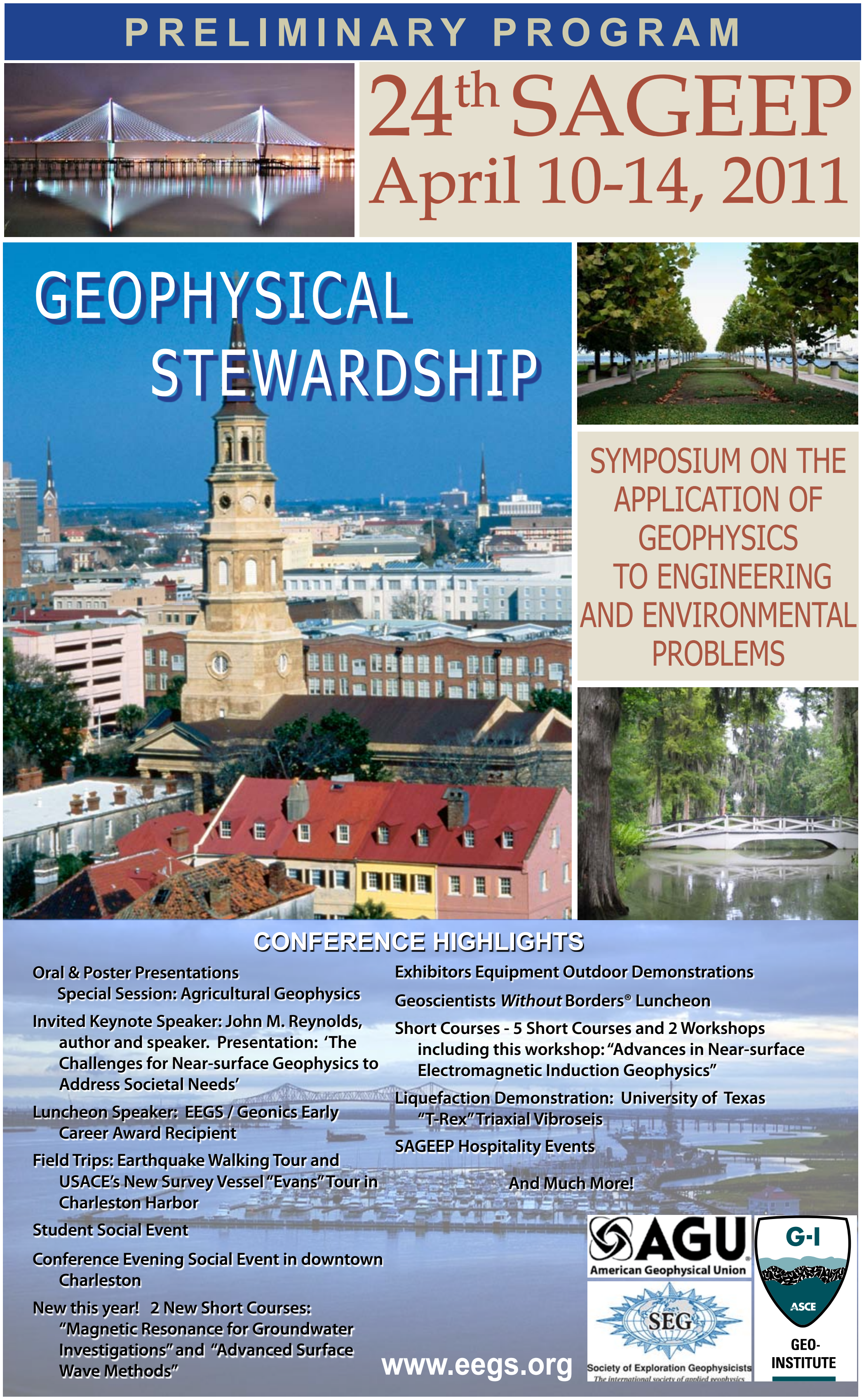
Applicants must have an earned doctorate in Civil Engineering, or a closely related field. One to two years of postdoctoral or research and development experience beyond the Ph.D. degree is highly desirable. Consideration will also be given to candidates who are in the final stages of completing their doctoral programs. Licensure as a professional engineer is expected within three years of appointment. The University of Toledo is one of only seventeen U.S. public universities to offer professional and graduate academic programs in business, education, engineering, health and human services, law, medicine, nursing, and pharmacy. The University is state assisted, with an enrollment of approximately 23,000 students of which about 4,700 are graduate and professional students.

Rank and salary will be commensurate with qualifications and funds are available to establish a research program at the University. Consideration of qualified candidates will begin after January 1, 2011. The position will remain open until an appointment is made. For full consideration, applicants are encouraged to submit the following: a cover letter which addresses the position qualifications; a curriculum vitae; a one-page statement of teaching philosophy and interests; a one-page summary of research philosophy and interests; and the names, addresses, emails and telephone numbers of three references to *UT Geotechnical Engineering Faculty Search,* ***Attn****: Dr. Cyndee Gruden, Search Committee Chair, 3006 Nitschke Hall, MS 307, The University of Toledo, 2801 W. Bancroft Street, Toledo, OH 43606.* Applications will also be accepted by email at civilgeotech@eng.utoledo.edu [please include *UT Geotechnical Engineering Faculty Search* in the subject line].

The University of Toledo is an Equal Access, Equal Opportunity, Affirmative Action Employer and Educator.

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.



2011 CONFERENCE & EVENT INFORMATION

Help EEGS Control SAGEEP Costs!
Make reservations at the host hotel, the Charleston Marriott.

EEGS is not charged for conference facilities if it commits to a minimum number of room nights - please take advantage of the negotiated rates **by March 18, 2011.** Limited government rates available.

TAKE ADVANTAGE OF THESE GREAT RATES!
Single/Double Rate*: $155
Government Rate: $132**

* Special rates are applicable to reservations 3 days prior to and 3 days post conference. Hotel room rates are subject to applicable state and local taxes (currently 12.5% plus a $1 destination tax) in effect at the time of check in. All reservations must be accompanied by a first night room deposit or guaranteed with a major credit card.

** Government rates are available and will require a valid government photo ID at the time of check-in.

RESERVE YOUR ACCOMMODATIONS online or by telephone. Call 1-800-228-9290 (USA Country Code is +1) identify yourself as a SAGEEP attendee and provide the conference code EEGEEGA (or if seeking the government rate, use SAGEEPGOVTBLK). Or, make your hotel reservations online: a special reservation site has been set up with the group code auto populated (EEGEEGA): www.marriott.com/hotels/travel/chsmc?groupCode=EEGEEGA&app=resvlink&fromDate=4/8/11&toDate=4/15/11. If you choose the Government/Military radio dial, enter the group code SAGEEPGOVTBLK. Or, access www.eegs.org, click on the SAGEEP 2011 button, select the Venue/Hotel tab and click on the Charleston Marriott link to go directly to the reservation page.

Reservations must be made **by March 18, 2011** to qualify for the special rates.

CONFERENCE HOTEL INFORMATION
Charleston Marriott/170 Lockwood Boulevard
Charleston, South Carolina 29403 USA
Hotel: 1-800-968-3569 (USA Country Code is +1)/ Marriott reservations: 1-800-228-9290

DRIVING DIRECTIONS (from airport)/TRANSPORTATION
Hotel is 12 miles southeast of the Charleston International Airport. Exit airport onto International Blvd. Take International Blvd. to Montague Ave. Turn left on Montague Ave to I-26 east. Take I-26 east to exit 221A (Highway 17 south) toward Savannah. Highway 17 becomes Spring Street - take Spring Street to Lockwood Blvd. Take a right onto Lockwood Blvd. The hotel is on right, 4 blocks ahead. The hotel does NOT provide complimentary shuttle service to/from airport. Alternate transportation: Taxi $25 or Absolutely Charleston $32 USD (one way).

AMENITIES
Complimentary parking; complimentary access to pool and fitness center and complimentary shuttle transportation between the hotel and the downtown Charleston historic district (5 minute ride one way).

CHARLESTON HISTORIC EARTHQUAKE AFTERNOON WALKING TOUR SUNDAY, APRIL 10 (HALF-DAY)
Join Dr. Levine, a renowned expert in the seismic history of Charleston, SC, on an earthquake walking tour of the city. Many are not aware that Charleston is one of the most active seismic areas in the eastern US. Walk the beautiful landscape of downtown Charleston while viewing damage that persists today in many of historic buildings from the major earthquake that caused severe damage in 1886. A bonus is the wonderful display of azaleas and other botanical treats visible in Charleston in springtime. Tour includes transportation downtown.

SAGEEP CONFERENCE EVENING EVENT TUESDAY, APRIL 12
The Conference Evening celebration will take place in the finest hotel in Charleston – Charleston Place - situated in the heart of the city and within walking distance of the historic center. The evening begins with a reception, hosted by Interpex, celebrating its 25th anniversary, in the beautiful Palmetto Restaurant gardens. A 3-course, southern flavor dinner with wine follows, with soft background guitar music.

OUTDOOR DEMONSTRATIONS MONDAY, APRIL 11
Monday afternoon, the Exhibitors Equipment Outdoor Demonstrations will be conducted at Brittlebank Park (directly across the street from the Charleston Marriott). The event is free to conference attendees; however, please indicate your intention to attend on the registration form (badge required). Light refreshments served.

US ARMY CORPS OF ENGINEERS S/V "EVANS" FIELD TRIP, THURSDAY, APRIL 14
SAGEEP registrants are offered an opportunity to tour the new, state-of-the-art survey vessel, "Evans." Tour includes a short cruise on the Charleston Harbor and a demonstration of the survey systems in real time. Space is limited to 10 persons per trip from 8:30 am to 3:30 pm. Includes tour, demo (cruise) and lunch.

STUDENT VOLUNTEERS/SCHOLARSHIPS AVAILABLE
Students who work two shifts at SAGEEP are eligible to receive a registration fee rebate. Contact EEGS: tel. (303) 531-7517 or e-mail (staff@eegs.org) by February 25, 2011. Geometrics is pleased to offer a limited number of student scholarships: Students in good standing at an educational institution and able to provide an application letter signed by a faculty member can e-mail linda@geometrics.com (e-mail only please).

STUDENT EVENT AT SOUTHEND BREWERY & SMOKEHOUSE MONDAY EVENING, APRIL 11
Students are invited to this top-rated microbrewery for dinner, networking and camaraderie. The center of the building features the beautiful and functional glass encased "brewhouse". Take Charleston's only indoor glass elevator to upper floors for dinner, darts, billiards and good company. Begins after the Outdoor Demonstration. Non-students welcome.

COMBINATION PRICING FOR AGRICULTURAL RELATED TECHNICAL TALKS AND WORKSHOP
Those choosing to attend Wednesday's Agricultural Geophysics sessions and Thursday's workshop W-2: "Application of Geophysical Technologies to Agroecosystems" can take advantage of discounted pricing. Consult the registration form for pricing information.

SAGEEP Workshop on the

"Application of Geophysical Technologies to Agroecosystems"

Charleston Marriot Hotel
Charleston, South Carolina
Thursday, April 14, 8:30 - 4:30 PM

Workshop Overview

Geophysical methods have become an increasingly important tool for agricultural landscape management. The workshop covers past developments, present utilization, and future trends of geophysical techniques within agroecosystem topic areas that include soil salinity measurement, assessment of spatial variations of soil properties, precision farming, forestry research, watershed scale mapping, turfgrass investigations, and considerations for data collection/analysis.

This unique workshop, which ends with a panel discussion focused on future developments, is expected to be highly informative as it brings together the leading authorities on applications of geophysical methods within agroecosystems.

For More Information:
Barry Allred
Barry.Allred@ars.usda.gov
614-292-9806

Sponsored by

2011 Symposium on the Application of Geophysics to Environmental and Engineering Problems

Visit http://www.eegs.org/sageep to register for the workshop and/or the conference.

Historic Charleston, SC

Agenda

8:30 – 9:10 Agricultural Geophysics: Methods Employed, Past Success, and Current Trends
Barry Allred, *USDA – ARS*

9:10 – 9:50 Soil Salinity Monitoring and Mapping
Dennis Corwin, *USDA – ARS*

9:50 - 10:10 **Break**

10:10 - 10:50 Use of Geophysical Methods for Characterization of Soil Spatial Variability
Jim Doolittle, *USDA – NRCS*

10:50 - 11:30 Incorporation of Geophysical Data for Precision Farming
Hamid Farahani*, USDA - NRCS*
Dennis Corwin, *USDA – ARS*

11:30 - 1:00 **Lunch**

1:00 - 1:30 Forest Environment Applications
John Butnor*, USDA - Forest Service*

1:30 - 2:00 Agricultural Geophysics at Watershed Scales
Bruce Smith*, U.S. Geological Survey*

2:00 - 2:30 Turfgrass Geophysical Surveying (golf courses, athletic fields, etc…)
Robert Freeland*, University of Tennessee*

2:30 – 2:50 **Break**

2:50 – 3:30 Considerations for Planning an Agricultural Geophysics Survey, Collecting Data, and Interpreting Results
Ty Ferré*, University of Arizona*

3:30 – 4:30 Panel Discussion and Wrap up "Future Development of Agricultural Geophysics"
Moderator, ***Rick Taylor****, DUALEM, Inc.*

SAGEEP 2011 REGISTRATION FORM

Mail or Fax completed registration form & payment to: EEGS/SAGEEP 2011
1720 S. Bellaire St., #110
Denver, CO 80222-4303 USA
(USA country code is +1)
Tel: 303-531-7517
Fax: 303-820-3844
E-mail: staff@eegs.org

Note: This is a preliminary program and subject to change. Please do not make travel arrangements based on this schedule.

Important Payment Information: Checks from Canadian bank accounts must be drawn on banks with US affiliations (example: checks from Canadian Credit Suisse banks are payable through Credit Suisse New York, USA). If you are unsure, please contact your bank. As an alternative to paying by check, we recommend sending money orders or paying by credit card.

Please print or type. Deadline for Early-Bird Registration Discount is March 18, 2011. Register online at www.eegs.org

A. Delegate Information

Name: ______________________ Email: ______________________

Company/Affiliation: ______________________

Address: ______________________

City/State/Zip/Country: ______________________

Telephone: ______________________ Fax: ______________________

Registration must be received by the close of business on Friday, March 18, 2011 to receive the Early-Bird rates. Payment must be in US dollars and accompany the completed registration form. Please contact EEGS if you have any questions. Cancellation Policy: No Refunds After March 18, 2011. **Pre-registration deadline is March 18, 2011. After this date, on-site registration only.**

Check box if member: ❑EEGS ❑ASCE-GI ❑SEG-J ❑ASEG ❑AEG ❑SEG ❑AGU Member rate is available to EEGS, ASCE-GI, SEG, SEG-J, ASEG, AGU and AEG members. **Please complete a separate form for each registrant. Check boxes and circle appropriate rates to indicate your choices.**

B. Conference Registration

MONDAY ONLY April 11, 2011
Monday Only conference includes: keynote address, oral and poster presentations, exhibits, conference program book and 25% off the purchase of one copy of SAGEEP 2011 Proceedings CD-ROM.

	Early-Bird	On-Site
❑ Member Rate:	$250	$350
❑ Non-Member Rate:	$350	$450

SAGEEP CONFERENCE RATE
Conference rate includes: ice breaker, keynote address, oral and poster presentations, exhibits, conference program book and one copy of SAGEEP 2011 Proceedings CD-ROM.

	Early-Bird	On-Site
❑ Member Rate:	$475	$575
❑ Non-Member Rate:	$575	$675

STUDENT RATE
(Must be able to demonstrate that you are currently enrolled in an accredited science or engineering undergraduate or graduate program or have graduated in the past 2 years.) Includes same as SAGEEP Conference rate.

	Early-Bird	On-Site
❑ Member Rate:	$105	$180
❑ Non-Member Rate:	$155	$230

EXHIBITORS
Exhibiting companies receive one (1) full conference registration and two (2) complimentary exhibit personnel registrations for each paid booth space as well as one copy of the SAGEEP 2011 Proceedings CD-ROM. Additional exhibit personnel registrations may be purchased at the $50 exhibitor registration fee. Exhibitor registration fees include all printed program materials and admission to food and beverage events held in the exhibit hall. Even though the registration fee is complimentary, please complete this form.

	Early-Bird	On-Site
❑ Comp Full Conference Registration (Limit 1 per 10x10 booth) (Limit 2 per 10x20 booth)	$0	$0
❑ Comp Exhibit Personnel (Limit 2 per 10x10 booth) (Limit 4 per 10x20 booth)	$0	$0
❑ Additional Exhibit Personnel	$50	$50

C. Short Courses and Workshops

New! Special combination pricing for signing up for both W-1 and the Agricultural Geophysics sessions on Wednesday.

	EEGS Members Early-Bird	EEGS Members On-Site	Non-Members Early-Bird	Non-Members On-Site
***SC-1:** Surface Waves are for Everyone (Sat)	$398	$498	$498	$598
Student Rate:	$123	$173	$173	$223
***SC-2:** Advanced Surface Wave (MASW) Methods (Sun)	$225	$348	$348	$448
Student Rate:	$ 50	$100	$100	$150
***SC-3:** Time-Domain Electromagnetics to Ground-Water Studies (Sun)	$398	$498	$498	$598
Student Rate:	$123	$173	$173	$223
***SC-4:** Magnetic Resonance for Groundwater Investigations: Physical Principles and Applications (Thurs)	$398	$498	$498	$598
Student Rate:	$123	$173	$173	$223
***SC-5:** Geophysical Investigations of Dams and Levees, an Engineering Perspective Studies (Thurs)	$398	$498	$498	$598
Student Rate:	$123	$173	$173	$223
***W-1:** Advances in Near-surface Electromagnetic Induction Geophysics (Thurs)	$188	$288	$288	$388
Student Rate:	$ 73	$123	$123	$173
***W-2:** Application of Geophysical Technologies to Agroecosystems (Thurs)	$165	$265	$215	$315
Student Rate:	$ 73	$123	$123	$173
***W-2 + Agricultural Geophysics Sessions on Wed:** (Wed and Thurs)	$300	$400	$350	$450

D. Additional SAGEEP 2011 Proceedings

❑ $75 per copy (member): Total Copies ______ $ ______ Total
❑ $100 per copy (non-member): Total Copies ______ $ ______ Total
Shipping & Handling: (# copies x price + Shipping & Handling = Total $)
❑ USA $7 ❑ Canada/Mexico $15 ❑ Other Countries $40

E. Luncheons / Activities

	Early-Bird	On-Site
Student Event at Southend (Mon) Student price/Non-Students	$15/30	$20/35
*T-Rex Liquefaction Demo (Mon) Circle to select desired departure/return time - limited space available: **A.** 10-11:30am **B.** 10:30am-Noon **C.** Noon-1:30pm **D.** 12:30-2:00pm	$0	$0
EEGS Luncheon (Tues) Speaker: EEGS / Geonics Early Career Award Recipient	$40	$45
SAGEEP Conference Evening Event at Charleston Place (Tues)	$80	$85
Geoscientists *Without* Borders Luncheon (Wed) Donations Accepted in Lieu of Luncheon Price Students: No Charge/donation	Suggested Donation:	$35
Exhibitors Equipment Outdoor Demonstrations (Mon)	$0	$0

F. Tours/Field Trips

	Early-Bird	On-Site
*Half Day Historic Earthquake Walking Tour (Sun) Tour includes transportation to downtown Charleston	$30	$40
*Full Day USACE's New Survey Vessel "Evans" Tour (Thurs) Tour includes lunch & transportation to Charleston Harbor	$100	$110

G. Payment Information (US dollars only)

Check # ______________________ (Made Payable to EEGS)
❑ MC ❑ Visa ❑ Discover ❑ Amex
Card Number: ______________________ Exp. Date: ______
Name on Card: ______________________
Signature: ______________________

A. EEGS Membership: $ 90.00 (electronic JEEG) $ ______
$100.00 (printed, mailed JEEG) $ ______

Register for SAGEEP at Member Rates – become a member today! Contact EEGS (online at www.eegs.org) for Corporate Membership information & EEGS Foundation contribution options.

B. SAGEEP Conference Registration
❑ Monday Only SAGEEP $ ______
❑ Full SAGEEP Conference $ ______
❑ Student SAGEEP $ ______
❑ Exhibitor $ ______

C. Short Courses/Workshops
❑ **SC-1** Surface Waves are for Everyone $ ______
❑ **SC-2** Advanced Surface Wave (MASW) Methods $ ______
❑ **SC-3** Time-Domain EM Applied to Ground-Water Studies $ ______
❑ **SC-4** Magnetic Resonance for Groundwater Investigations $ ______
❑ **SC-5 Geophysical Investigations of Dams & Levees** $ ______
❑ **W-1 Advances in Near-surface EM Induction Geophysics** $ ______
❑ **W-2 Application of Geophysical Tech. to Agroecosystems** $ ______
❑ **W-2 on Thurs + Agricultural Geophysics Sessions on Wed.** $ ______

D. Additional SAGEEP 2011 Proceedings $ ______

E. Luncheons/Activities
❑ Student Event at Southend Smokehouse - Mon $ ______
❑ T-Rex/Liquefaction Demonstration (A, B, C or D) - Mon $ ______
❑ Outdoor Demonstrations - Mon $ ______
❑ EEGS Luncheon ECA Speaker - Tues $ ______
❑ SAGEEP Conference Evening at Charleston Place Hotel - Tues $ ______
❑ Geoscientists *w/o* Borders Luncheon (specify donation amt) $ ______

F. Tours/Field Trips
❑ Historic Earthquake Walking Tour - Sun $ ______
❑ Charleston Harbor/"Evans" Demo/Tour - Thurs $ ______

G. Abstract Submission Fee
❑ Check box if you paid an abstract fee(s) and subtract this amount $ ______

TOTAL: USD $ ______

Note: Attendees may be photographed by EEGS for archival and marketing purposes (however, not during scientific sessions).
* EEGS reserves the right to cancel this event if minimum requirements are not met by March 18, 2011. Tours have limited capacity - register early.

NovCare 2011 - Workshop on Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice

May 9-11, 2011, Ocean Edge Resort, Brewster, MA

As societal concerns over sustainability of groundwater resources mount, and 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.

In recent years, several new technologies have been developed for cost-effective, minimal-disturbance, and high-resolution subsurface characterization and monitoring. Most of these methods, however, are not yet widespread. To share insights and knowledge, and to identify key areas for future research and development we announce a workshop to bring together interested stakeholders from a broad range of areas, including research, technology development, consultancy, and government.

The three-day workshop, sponsored by the Army Research Office, will provide a rare opportunity for participants to explore, experience, and discuss the latest science on subsurface characterization and monitoring. Workshop activities include plenary and poster sessions with invited and selected speakers, a social event, and a field trip to the famous Cape Cod Tracer studies on Otis Air Force Base. At this site, vendors will be on hand to present field demonstrations of their latest technologies.

Thematic areas for the conference are: subsurface transport monitoring, contaminant remediation, stream-aquifer interactions, and watershed characterization. Relevant technologies include: direct-push characterization tools, surface and borehole geophysics, adaptive & wireless sensor networks, geotechnical methods and sonic drilling, novel sensing devices, and tracer and other hydraulic testing methods.

Logistics

The workshop will be held at the Ocean Edge Resort, located on Cape Cod, MA, with easy access from Boston and close to the proposed demonstration site on Otis Air Force Base. Accommodation for attendees will be at the conference facilities.

A first call for abstracts will be distributed in November, 2010. More information can be found on http://www.novcare.org.

Organizing committee:

- Drs. David Hyndman, Remke van Dam - Michigan State University
- Drs. Jim Butler, Geoff Bohling – Kansas Geological Survey, Univ. of Kansas
- Drs. Peter Dietrich, Georg Teutsch – Helmholtz Center for Env. Research (UFZ)
- Dr. Carsten Leven – University of Tuebingen
- Dr. Kamini Singha – Penn State University


Second GLOBAL WORKSHOP ON
Proximal Soil Sensing
(Formerly known as Global Workshop on High Resolution Digital Soil Sensing and Mapping)
www.friglobalevents.com/pss
MONTREAL 2011
Dates:
May 15-19, 2011
Venue:
Leacock Building, McGill University, Downtown Montreal, Canada
Format:
Similar to the First Global Workshop on High Resolution Digital Soil Sensing and Mapping held in Sydney, Australia in February 2008.
Focus:
Proximal soil sensor development, equipment, applications, calibrations, signal processing, sensor data fusion, inference systems, (geo)statistical analyses.
INTERNATIONAL UNION OF SOIL SCIENCES
Working Group on Proximal Soil Sensing (WG-PSS):
Chair: Raphael Viscarra Rossel, Raphael.Viscarra-Rossel@csiro.au
Vice-chair: Viacheslav Adamchuk, Viacheslav.Adamchuk@mcgill.ca

The 10th SEGJ International Symposium - Imaging and Interpretation -

Call for papers

京都

November 20-22, 2011（Tentative）
Clock Tower Centennial Hall, Kyoto University
Kyoto, Japan.

Abstract deadline: May 31, 2011 (tentative)

Sessions:
1. Sensors and Acquisition Technologies
2. Seismic/Geodetic Imaging Technologies
3. EM/GPR Imaging Technologies
4. Data Processing/Signal Processing
6. Multi-scale Imaging/Interpretation Methodologies
7. Spatial/Time-Lapse Data Management
8. Reservoir Characterization
9. Shallow/Near-Surface Structural Applications
10. Regional/Global Structural Applications
11. Disaster Mitigation Applications
12. Imaging/Interpretation Frontiers

Chairperson:
SEGJ: Hitoshi Mikada (Kyoto University)

Sponsor:
The Society of Exploration Geophysicists of Japan (SEGJ)

Cosponsors (planned):
The Korean Society of Exploration Geophysicists (KSEG)
The Australian Society of Exploration Geophysicists (ASEG)
The Society of Exploration Geophysicists (SEG)
European Association of Geoscientists and Engineers (EAGE)
Environmental and Engineering Geophysical Society (EEGS)
Vietnam Association of the Geophysicists (VAG)
Society of Petroleum Geophysicists（SPG）

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

CEN Workshop: Best Practice Approach for Electromagnetic Induction (EMI) Measurements of the Near Surface

June 3-4, 2010, Leipzig, Germany

A prerequisite for the application of geophysical measurements for proximal soil sensing are reproducible and reliable data. The procedure of the CEN Workshop of the European Committee for Standardization (CEN) seems to be an adequate framework to introduce standardised procedures into geophysical measurements. Because electromagnetic induction measurements (EMI) are widely used for soil mapping the existence of several problems with the comparability of EMI results, we want to establish a widely accepted voluntary standard for a best practice of EMI with help of the CEN Workshop" Best practice approach for electromagnetic induction (EMI) measurements of the near surface"

The CEN workshop agreement (CWA) will focus on the near surface application of this method, especially related to soil and water. The overall goal of the workshop is to develop a standardized approach for electromagnetic induction measurement in order to ensure that results of different measurements are comparable, in terms of analysis procedures and information content of data. The proposed 'best practice approach' will help to minimize such potential problems of e.g. reproducibility of measurements and will help to improve the comparability of data. This provides the opportunity for reliable interpretation of data in terms of subsurface structures and parameters, as well as for reliable comparability and joint interpretation of measurements gathered at different times and with different instruments.

About 40 participants from most of the manufactures of EMI devices, institutes, universities and SME's from Europe, Asia and America signed for membership. We want to highlight the fact that the four big EMI manufactures such as Geonics, GSSI , Dualem and GSI also signed for membership. The kick-off and a technical meeting took place on June 3-4, 2010 in Leipzig and according to the CEN regulations the 3rd draft is now in the commenting phase.

For more information, contact Dr. Peter Dietrich at peter.dietrich@ufz.de

Industry News

FastTIMES presents articles about commercial products for use in near geophysics investigations. Corporate sponsors are invited to send the editors descriptions of new products for possible inclusion in future issues.

Pile Dynamics, Inc. releases Pile Integrity Tester model PIT-X2

Gina Beim, Pile Dynamics, Cleveland, OH (www.pile.com)

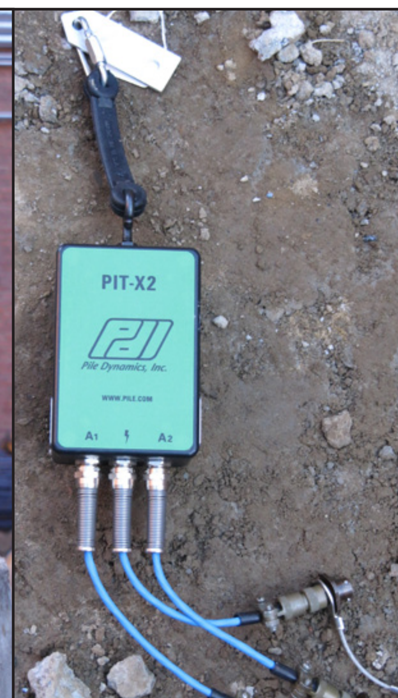
For immediate release

The small and wireless Pile Integrity Tester, PIT-X, was an instant success when Pile Dynamics, Inc. (PDI) released it about a year ago, making integrity assessment of concrete piles by the low strain method more convenient without compromising data quality.

However, those that wanted to use the PIT to test the integrity or evaluate the length of foundations using two accelerometers still had to use the larger, cabled PIT-FV. With the release of PIT-X2, this is no longer the case. While routine integrity tests may be performed with one accelerometer, a second accelerometer becomes necessary to test piles under existing structures, to determine concrete wave speed, to evaluate unknown foundation length or to better analyze the records of relatively large piles.

The PIT-X2 looks exactly like the PIT-X, acquiring data from two accelerometers that are coupled to a wireless transmitter. As is the case with previous generations of PIT, the PIT-X2 works with a small hand-held hammer. A PIT-X2 model that will acquire data from the user's choice of either a second accelerometer or an instrumented hammer (the latter is required by code in some countries and is useful in certain complex pile testing situations) is under development.

In addition to the Pile Integrity Tester, Pile Dynamics produces several other quality assurance and quality control products for the deep foundations industry. The company is located in Cleveland, Ohio, USA, and has commercial representatives in all continents. For more information visit www.pile.com.



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Environmental and Engineering Geophysical Society

Membership Renewal

1720 South Bellaire Street | Suite 110 | Denver, CO 80222-4303
(p) 011.1.303.531.7517 | (f) 011.1.303.820.3844 | staff@eegs.org | www.eegs.org

Contact Information

Salutation | First Name | Middle Initial | Last Name | Nickname

Company/Organization | Title

Street Address | City & State | Zip | Country

Direct Phone | Mobile Phone | Fax

Email | Website

About Me: Interests & Expertise

In order to identify your areas of specific interest and expertise, please check those that apply:

Classify Association

- ☐ Consultant
- ☐ User of Geophysical Services
- ☐ Student
- ☐ Geophysical Contractor
- ☐ Equiment Manufacturer
- ☐ Software Manufacturer
- ☐ Research/Academia
- ☐ Government Agency
- ☐ Other ______

Classify Interest or Focus

- ☐ Archaeology
- ☐ Engineering
- ☐ Environmental
- ☐ Geotechnical
- ☐ Geotechnical Infrastructure
- ☐ Groundwater
- ☐ Hazardous Waste
- ☐ Humanitarian Geophysics
- ☐ Mining
- ☐ Shallow oil & Gas
- ☐ UXO
- ☐ Other ______

Specific Areas Involved

- ☐ Borehole Geophysical Logging
- ☐ Electrical Methods
- ☐ Electromagnetics
- ☐ Gravity
- ☐ Ground Penetrating Radar
- ☐ Magnetics
- ☐ Seismic
- ☐ Other ______

Professional/Scientific Societies

- ☐ AAPG
- ☐ AEG
- ☐ ASCE
- ☐ AWWA
- ☐ AGU
- ☐ EAGE
- ☐ EER1
- ☐ GeoInstitute
- ☐ GSA
- ☐ MGLS
- ☐ NGWA
- ☐ NSG
- ☐ SEG
- ☐ SSA
- ☐ SPWLA
- ☐ Other ______

Interested in Participating on Standing Committees?

- ☐ Government Affairs
- ☐ Research
- ☐ Publications
- ☐ Awards
- ☐ Corporate Affairs
- ☐ Web Page
- ☐ Student

Membership Categories

Circle the desired Membership Category amount.

	Standard (I prefer to access JEEG online and do not wish to receive a printed issue)	Printed (I prefer to receive a printed JEEG)
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Student	$20	$60
Corporate Donor	$650	$660
Corporate Associate	$2,400	$2,410
Corporate Benefactor	$4,000	$4,010
To view the qualification for the New Developing World categories, please access http://www.eegs.org and click on Membership	**Standard** (I prefer to access JEEG online and do not wish to receive a printed issue)	**Printed** (I prefer to receive a printed JEEG)
NEW Developing World Category*	$50	$100

Category Descriptions and Newly Expanded Benefits

Individual and Developing World Category Memberships:

- Access to the **online EEGS Research Collection** resource—online access to the complete *Journal of Environmental and Engineering Geophysics* (*JEEG*) and proceedings archives of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP)
- The option of receiving a printed *JEEG* or accessing an electronic issue
- Subscription to the ***FastTIMES*** Newsletter
- **Preferential** registration **fees** for **SAGEEP**
- **Networking** and continued **communication** on issues of interest to the organization

Retired Membership:

- Includes all the benefits of the Individual Membership category. Applicants must approved by the EEGS Board of Directors. Please submit a written request for the Retired Category, which will be reviewed by the Board of Directors.

Note: This category does not include the option for a printed JEEG - if you wish to receive a printed JEEG, please sign up under Individual Membership Printed

Student Membership:

- Includes all the benefits of the Individual Membership category
- Submission must include current student ID or documentation of graduation date (applies to recent graduates for two years after graduation)

Corporate Donor Membership:

- Includes all the benefits of the Individual Membership
- Full conference registration for the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP)
- A link on the EEGS Website
- Listing with corporate information in *FastTIMES*
- 10% discount on advertising in the *JEEG* and *FastTIMES*

Corporate Associate Membership:

- Includes all the benefits of the Individual Membership for two (2) people
- An exhibit booth at the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP)
- Ability to insert marketing materials in the SAGEEP delegate packets
- A link on the EEGS website
- Listing with corporate information in *FastTIMES*
- 10% discount on advertising in the *JEEG* and *FastTIMES*

Corporate Benefactor Membership:

- Includes all the benefits of Individual membership in EEGS for two (2) people
- Two exhibit booths at the Symposium on the Applications of Geophysics to Engineering and Environmental Problems (SAGEEP)
- Ability to insert marketing materials in the SAGEEP delegate packets
- A link on the EEGS website
- Listing with corporate information in *FastTIMES*
- 10% discount on advertising in the *JEEG* and *FastTIMES*

Foundation Contributions

Founders Fund

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.

Foundation Fund Total: ____________________

Student Support Endowment

This endowed fund will be used to support travel and reduced membership fees so that we can attract greater involvement from our student members. Student members are the lifeblood of our Society, and our support can lead to a lifetime of involvement and leadership in the near surface geophysics community. Donations of $50.00 or more are greatly apreciated. For additional information about the EEGS Foundation (a tax exempt public charity), visit our website at www.eegs.org and click on Membership, then "Foundation information". You may also access the EEGS Foundation at http://www.eegsfoundation.org.

Student Support Endowment Total: ____________________

Corporate Contributions

The EEGS Foundation is designed to solicit support from indivudals and corporate entities that are not currently Corporate Members (as listed above). We recognize that most of our Corporate Members are small businesses with limited resources, and that their contributions to professional societies are distributed among several organizations. The Corporate Founder's Fund has been developed to allow our Corporate Members to support the establishment of the Foundation as we solicit support from new contributors. As such, Corpoate Founders received special recognition for donations exceeding $2500 made before May 31, 2010. These sponsors will be ackowledged in a form that may be posted at their SAGEEP booth for years to come, so that individual members can express their gratitude for the support.

Corporate Contribution Total: $ ____________________

Foundation Total: $ ____________________

Payment Information

Subtotals:

Membership: $ ____________________

Foundation Contributions: $ ____________________

Grand Total: $ ____________________

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Card Number ____________________ Exp. Date ____________________

Name on Card ____________________

Signature ____________________

Make your check or money order in **US Dollars** payable to: EEGS. Checks from canadian bank accounts must be drawn on banks with US affiliations (Example: checks from Canadian Credit Suisse banks are payable through Credit Suisse new york, USA). **Checks must be drawn on US Banks.**

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

Return this form with payment to: EEGS, 1720 South Bellaire Street, Suite 110, Denver, CO 80222 USA

Credit Card Payments can be faxed to EEGS at 011.1.303.820.3844

Corporate dues payments, once paid, are non-refundable. Individual dues are non-refundable except in cases of extreme hardship and will be

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Membership Renewal
Developing World Category Qualification

If you reside in one of the countries listed below, you are eligible for EEGS's Developing World membership category rate of $50.00 (or $100.00 if you would like the printed, quarterly *Journal of Environmental & Engineering Geophysics* mailed to you—to receive a printed *JEEG* as a benefit of membership, select the Developing World Printed membership category on the membership application form):

Afghanistan
Albania
Algeria
Angola
Armenia
Azerbaijan
Bangladesh
Belize
Benin
Bhutan
Bolivia
Burkina Faso
Burundi
Cambodia
Cameroon
Cape Verde
Central African Republic
Chad
China
Comoros
Congo, Dem. Rep.
Congo, Rep.
Djibouti
Ecuador
Egypt
El Salvador
Eritrea
Ethiopia
Gambia
Georgia
Ghana
Guatemala
Guinea
Guinea-Bissau
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India
Indonesia
Iran
Iraq
Ivory Coast
Jordan
Kenya
Kiribati
Kosovo
Kyrgyz Republic
Lao PDR
Lesotho
Liberia
Madagascar
Malawi
Maldives
Mali
Marshall Islands
Mauritania
Micronesia
Moldova
Mongolia
Morocco
Mozambique
Myanmar
Nepal
Nicaragua
Niger
Nigeria
North Korea
Pakistan
Papua New Guinea
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Philippines
Rwanda
Samoa
Sao Tome and Principe
Senegal
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Somalia
Sri Lanka
Sudan
Suriname
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Thailand
Timor-Leste
Togo
Tonga
Tunisia
Turkmenistan
Uganda
Ukraine
Uzbekistan
Vanuatu
Vietnam
West Bank and Gaza
Yemen
Zambia
Zimbabwe

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www.agiusa.com

Allied Associates Geophysical Ltd.
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Exploration Instruments LLC
www.expins.com

Foerster Instruments Inc.
www.foerstergroup.com

GEM Advanced Magnetometers
www.gemsys.ca

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www.geogiga.com

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Geonics Ltd.
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Geophysical Survey Systems, Inc.
www.geophysical.com

Geostuff / Wireless Seismic Inc.
www.georadar.com

GISCO
www.giscogeo.com

hydroGEOPHYSICS, Inc.
www.hydrogeophysics.com

Interpex Ltd.
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MALA GeoScience
www.malags.com

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Northwest Geophysics
www.northwestgeophysics.com

Spotlight Geophysical Services
www.spotlightgeo.com

EEGS Store

Environmental and Engineering Geophysical Society

2010 Publications Order Form

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SAGEEP PROCEEDINGS

Member/Non-Member

	0029	2010 (CD-ROM) **NEW**	$75	$100
	0026	2009 (CD-ROM)	$75	$100
	0025	2008 (CD-ROM)	$75	$100
	0023	2007 (CD-ROM)	$75	$100
	0020	2006 (CD-ROM)	$75	$100
	0018	2005 (CD-ROM)	$75	$100

	0016	2004 (CD-ROM)	$75	$100
	0015	2003 (CD-ROM)	$75	$100
	0014	2002 (CD-ROM)	$75	$100
	0013	2001 (CD-ROM)	$75	$100
	0012	1988-2000 (CD-ROM)	$150	$225
		SUBTOTAL—PROCEEDINGS ORDERED:		

SAGEEP Short Course Handbooks

	0027	Principles and Applications of Seismic Refraction Tomography (Printed Course Notes & CD-ROM) - William Doll	$125	$150
	0028	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
		EEGS T-shirt (X-Large) Please circle: white/gray	$10	$10
		EEGS Lapel Pin	$3	$3
		SUBTOTAL—SHORT COURSE/MISC. ORDERED ITEMS:		

Publications Order Form (Page Two)

***Journal of Environmental and Engineering Geophysics* (JEEG) Back Issue Order Information:**

Member Rate: $15

Non-Member Rate: $25

Qt.	Year	Issue	Qt.	Year	Issue	Qt.	Year	Issue
	1995			**2001**			**2006**	
		JEEG 0/1 - July			JEEG 6/1 - March			JEEG 11/1 - March
	1996				JEEG 6/3 - September			JEEG 11/2 - June
		JEEG 0/2 - January			JEEG 6/4 - December			JEEG 11/3 - September
		JEEG 1/1 - April		**2003**				JEEG 11/4 - December
		JEEG 1/2 - August			JEEG 8/1- March		**2007**	
		JEEG 1/3 - December			JEEG 8/2 - June			JEEG 12/1 - March
	1998				JEEG 8/3 - September			JEEG 12/2 - June
		JEEG 3/2 - June			JEEG 8/4 - December			JEEG 12/3 - September
		JEEG 3/3 - September		**2004**				JEEG 12/4 - December
		JEEG 3/4 - December			JEEG 9/1- March		**2008**	
	1999				JEEG 9/2 - June			JEEG 13/1 - March
		JEEG 4/1 – March			JEEG 9/3 - September			JEEG 13/2 - June
		JEEG 4/2 - June			JEEG 9/4 - December			JEEG 13/3 - September
		JEEG 4/3 - September		**2005**				JEEG 13/4 - December
		JEEG 4/4 - December			JEEG 10/1 - March		**2009**	
	2000				JEEG 10/2 - June			JEEG 14/1 - March
		JEEG 5/3 - September			JEEG 10/3 - September			JEEG 14/2 - Available June
		JEEG 5/4 - December			JEEG 10/4 - December			JEEG 14/3 - Available September
								JEEG 14/4 - Available December

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SUBTOTAL - SAGEEP PROCEEDINGS ORDERED	
SUBTOTAL - SHORT COURSE / MISCELLANEOUS ITEMS ORDERED	
SUBTOTAL - JEEG ISSUES ORDERED	
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T-shirt (Large)			$10	$10	Sold Out
T-shirt (X-Large)			$10	$10	
T-shirt (XX-Large)			$10	$10	Sold Out
EEGS Lapel Pin			$3	$3	
SUBTOTAL – MERCHANDISE ORDERED:					

TOTAL ORDER:

SUBTOTAL – Merchandise Ordered:	
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SHIPPING AND HANDLING (US - $7; Canada/Mexico - $15; All other countries - $40):	
GRAND TOTAL:	

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Card Number: __________ Cardholder Name (Print): __________

Exp. Date: __________ Signature: __________

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THANK YOU FOR YOUR ORDER!

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