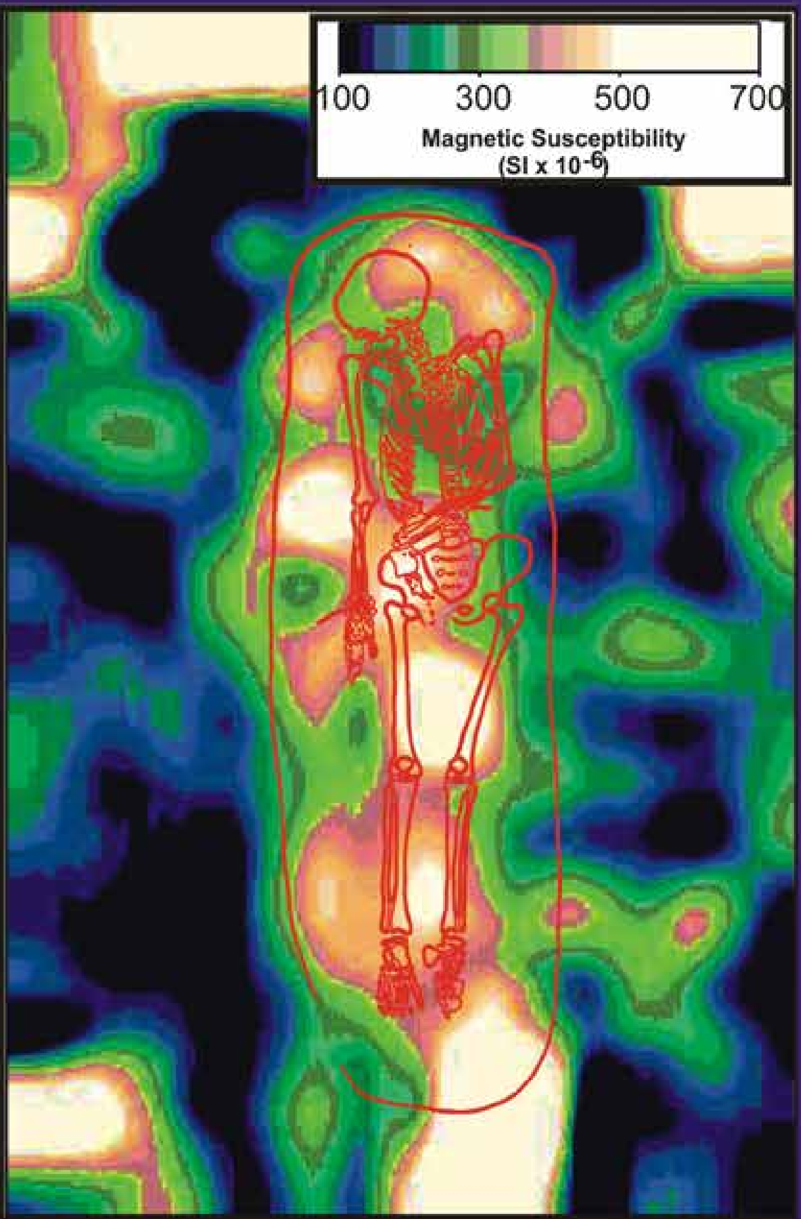
*Fast*TIMES

Forensic Geophysics

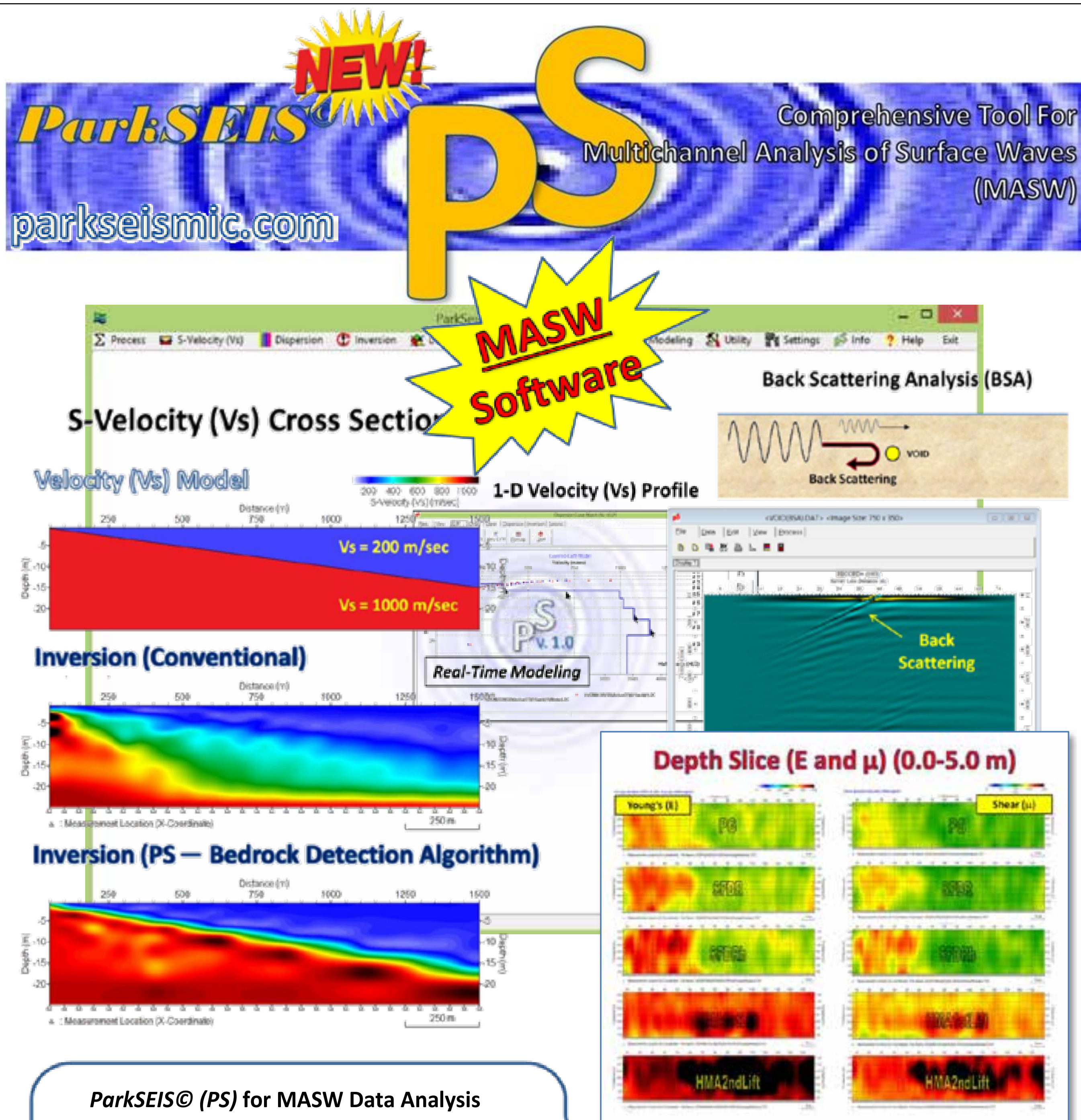


Special Feature:

Canto Flegreo: Sounds from an Active Volcanic Crater

June 2016

Volume 21, Number 2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This issue of *Fast*TIMES is focused on forensic geophysics. Also included is a special feature, "Canto Flegreo: Sounds from an Active Volcanic Crater".

Contents

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Forensic Geophysics Issue

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*Fast*TIMES

*Fast*TIMES (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 *Fast*TIMES, a magazine for the near-surface community, and (4) maintaining relationships with other professional societies relevant to near-surface geophysics.

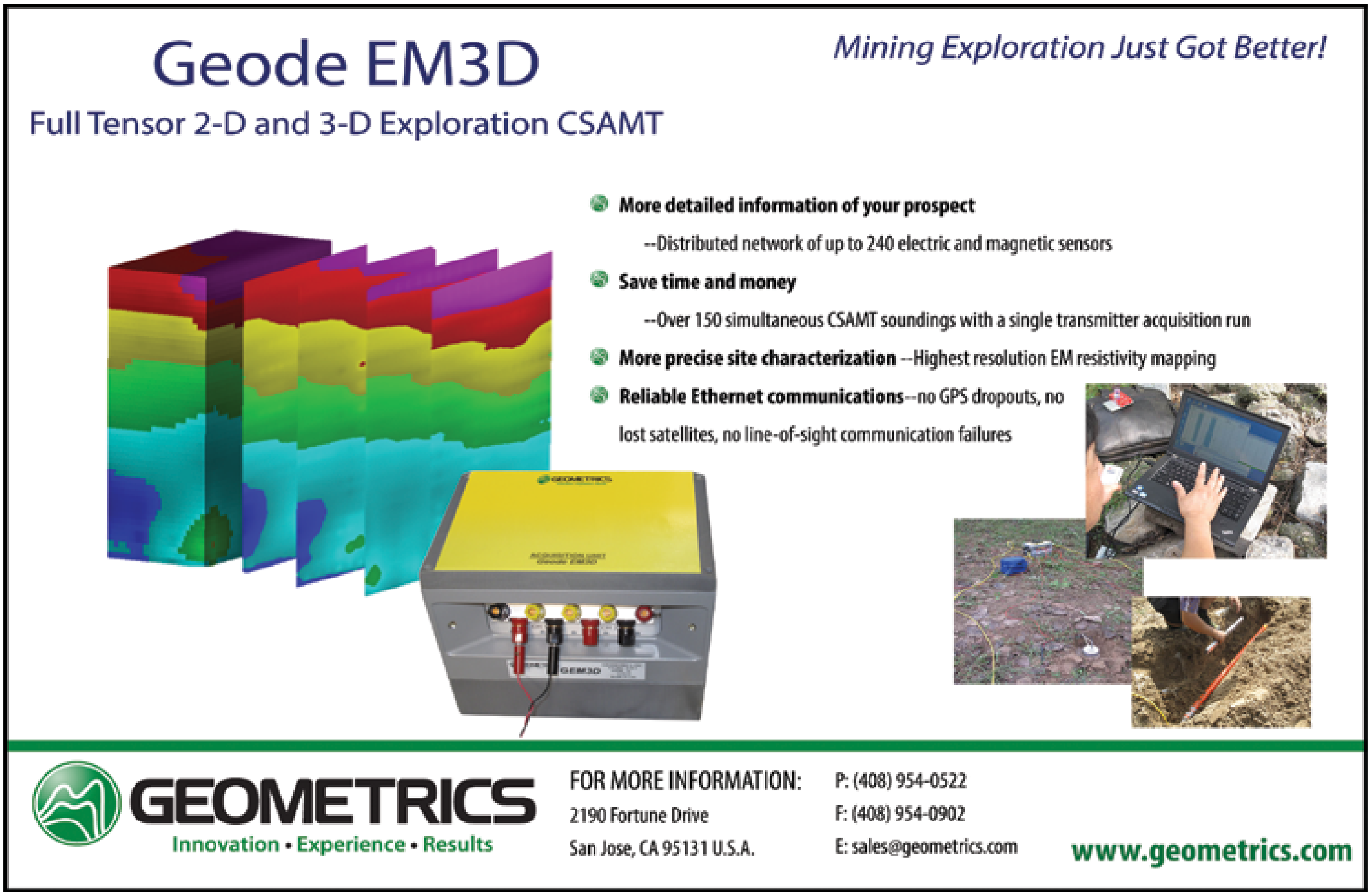
JOINING EEGS

EEGS welcomes membership applications from individuals (including students) and businesses. Annual dues are $90 for an individual membership, $50 for introductory membership, $50 for a retired member, $50 developing world membership, complimentary corporate sponsored student membership - if available, and $300 to $4000 for various levels of corporate membership. All membership categories include free on-line access to JEEG. The membership application is available at the back of this issue, or online at www.eegs.org.

SUBMISSIONS

To submit information for inclusion in *Fast*TIMES, contact a member of the editorial team:

*Fast*TIMES is published electronically four times a year. Please send contributions to any member of the editorial team by September 1, 2016. Advertisements are due to Jackie Jacoby by September 1, 2016.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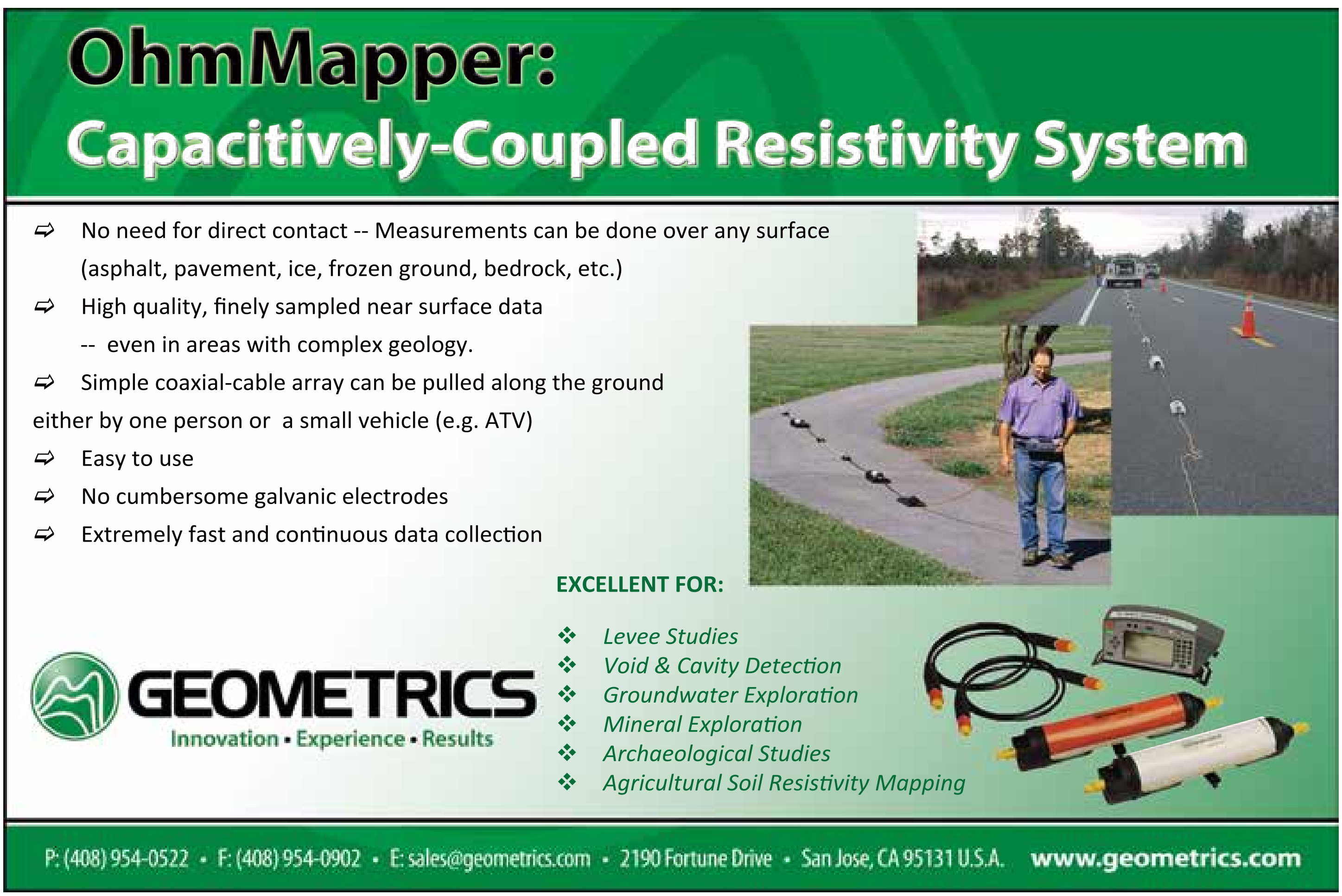
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CALENDAR

2016

August 19	SurfSeis - Multichannel Analysis of Surface Waves (MASW) Workshop (one-day workshop focused on processing and advanced topics) Lawrence, Kansas, USA http://www.kgs.ku.edu/software/surfseis/workshops.html
August 21 - 24	Australian Society of Exploration Geophysicists 25th International Geophysical Conference and Exibition Adelaide, Australia http://www.conference.aseg.org.au/index.html
September 18 - 24	59th annual Meeting of the Association of Environmental & Engineering Geologists Waikoloa Village, Hawaii, USA http://www.aegweb.org/
November 4	Rocky Mountain Geo-Conference Lakewood, Colorado, USA http://www.aegrms.org/2016Geoconf.pdf
December 12 - 16	American Geophysical Union Fall Meeting San Francisco, California, USA http://fallmeeting.agu.org/2016/

2017

March 19 - 23	Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) Denver, Colorado, USA http://www.eegs.org/sageep-2017 (Note: See page XX for additional information.)

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

PRESIDENT'S MESSAGE

Bethany Burton, President

(blburton@usgs.gov)

Time Flies...and Opportunities Arise

I am honored and enthusiastic as I begin my term as President of EEGS. It's hard to believe that it's been fifteen years since I attended my first SAGEEP in 2001 in Denver as a student volunteer. I was just starting my graduate program at the Colorado School of Mines and refocusing my attention to near surface geophysics after a very short time working in the oil and gas industry. I recall having two main impressions from that conference: (1) How excited I was to soak up as much information as I could about so many real-world geophysical applications, and (2) How personable and welcoming the community was to students. After that experience, myself and a handful of students created an EEGS student chapter at CSM, and I later helped with the student event planning for the Colorado Springs meeting. And now, many years later, I've been fortunate to have been involved with the EEGS Board for the last several years.

EEGS exists because of the tireless efforts of so many of its members who serve on the Board of Directors and JEEG and FastTIMES editorial boards, participate in SAGEEP, and are involved with the committees. We are a member-driven, volunteer-centric organization. We need to enlist the help of our great membership, and so I ask of you the following:

- Get involved in a committee. We have several dynamic committees and your involvement doesn't have to require a lot of time. Please visit the committees website to review the committees and to contact the committee chairs to request additional information. Feel free to reach out to me directly as well for any guidance.

- Attend and participate in SAGEEP. We're excited to announce that the 30th Anniversary SAGEEP is returning to Denver and will be co-located with the National Ground Water Association's (NGWA) Hydrogeophysics and Deep Groundwater Conference, March 19 – 23, 2017. Stay tuned for calls for session proposals and abstracts.

- Urge your colleagues to get connected. We all know people who would benefit from being a member of EEGS or from attending SAGEEP, whether they're practitioners or customers of geophysics, and in turn, our membership community benefits as well.

Regarding Board participation, I'd also like to introduce and welcome our incoming 2016 – 2017 Board members:

Daniel Bigman, Bigman Geophysical LLC, Board Member at Large
Katherine Grote, Missouri University of Science and Technology: Board Member at Large
Lia Martinez, Mount Sopris Instrument Company Inc: VP-elect Committees
Darren Mortimer, Geosoft Inc: Board Member at Large
Jeffrey Paine, University of Texas Bureau of Economic Geology: VP-elect SAGEEP.

As a former student member who began her professional society participation as a SAGEEP volunteer to now serving on the Board, EEGS is an organization that provides many opportunities for its members to contribute to the near surface geophysical community. I'm looking forward to a productive year!

Bethany Burton, EEGS President

NOTES FROM EEGS

Renew your EEGS Membership for 2016

Be sure to renew your EEGS membership for 2016! In addition to the more tangible member benefits (including the option of receiving a print or electronic subscription to JEEG, *Fast*TIMES delivered to your email box quarterly, discounts on EEGS publications and SAGEEP registration, and benefits from associated societies), your dues help support EEGS's major initiatives such as producing our annual meeting (SAGEEP), publishing JEEG, making our publications available electronically, expanding the awareness of near-surface geophysics outside our discipline, and enhancing our web site to enable desired capabilities such as membership services, publication ordering, and search and delivery of SAGEEP papers. You will also have the opportunity to donate to the EEGS Foundation during the renewal process. Members can renew by mail, fax, or online at www.eegs.org.

Lifetime Membership

In a move to enable those who wish to join EEGS once and support the organization and receive benefits without renewal, the EEGS Board of Directors approved the formation of a membership category "Lifetime Member." Longtime EEGS member Professor Oliver Kaufmann became the first Lifetime Member this past January. EEGS President Lee Slater welcomed Prof. Kaufmann and said "learning about our first Lifetime Member was one of the high points of my one-year tenure as president of EEGS." President Slater also commended Prof. Kaufmann for his commitment to EEGS and his role in assuring the long-term health and value of EEGS.

Sponsorship Opportunities

There are always sponsorship opportunities available for government agencies, corporations, and individuals who wish to help support EEGS's activities. Specific opportunities include development and maintenance of an online system for accessing SAGEEP papers from the EEGS web site and support for our next SAGEEP. Make this the year your company gets involved! Contact Lee Slater (blburton@usgs.gov) for more information.

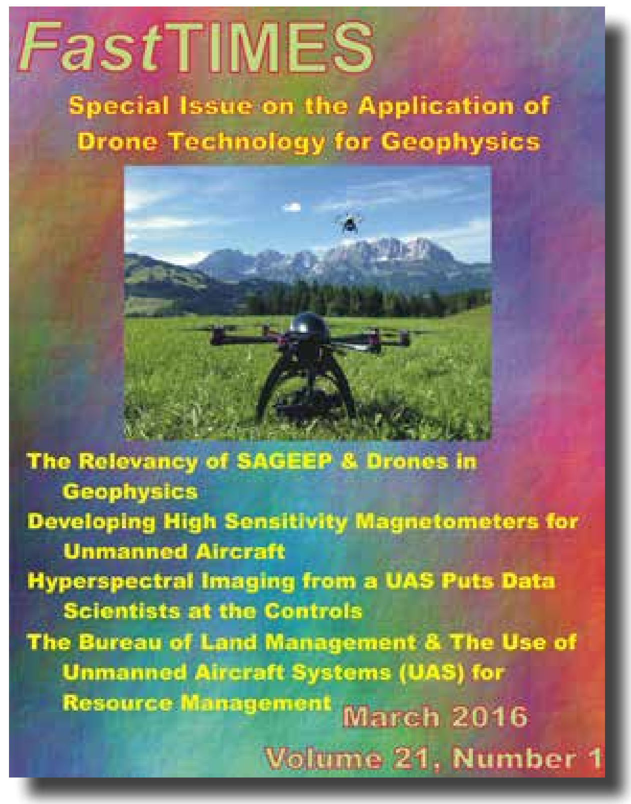
From the *Fast*TIMES Editorial Team

*Fast*TIMES 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 downloading from the EEGS *Fast*TIMES web site (http://www.eegs.org/fasttimes). Past issues of *Fast*TIMES 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 *Fast*TIMES 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 *Fast*TIMES presence on the EEGS web site has been redesigned. At http://www.eegs.org/fasttimes you'll now find calls for articles, author guidelines, current and past issues, and advertising information.

Special thanks are extended to Daniel Bigman for his leadership in developing this issue of *Fast*TIMES with its focus on forensic geophysics.



Submissions

The *Fast*TIMES editorial team welcomes contributions of any subject touching upon geophysics. *Fast*TIMES 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 *Fast*TIMES editorial team by September 1, 2016 to ensure inclusion in the next issue. We look forward to seeing your work in our pages. Note: *Fast*TIMES continues to look for Guest Editors who are interested in organizing a *Fast*TIMES issue around a special topic within the Guest Editor's area of expertise. For more information, please contact Barry Allred (Barry.Allred@ars.usda.gov), if you would like to serve as a *Fast*TIMES Guest Editor.

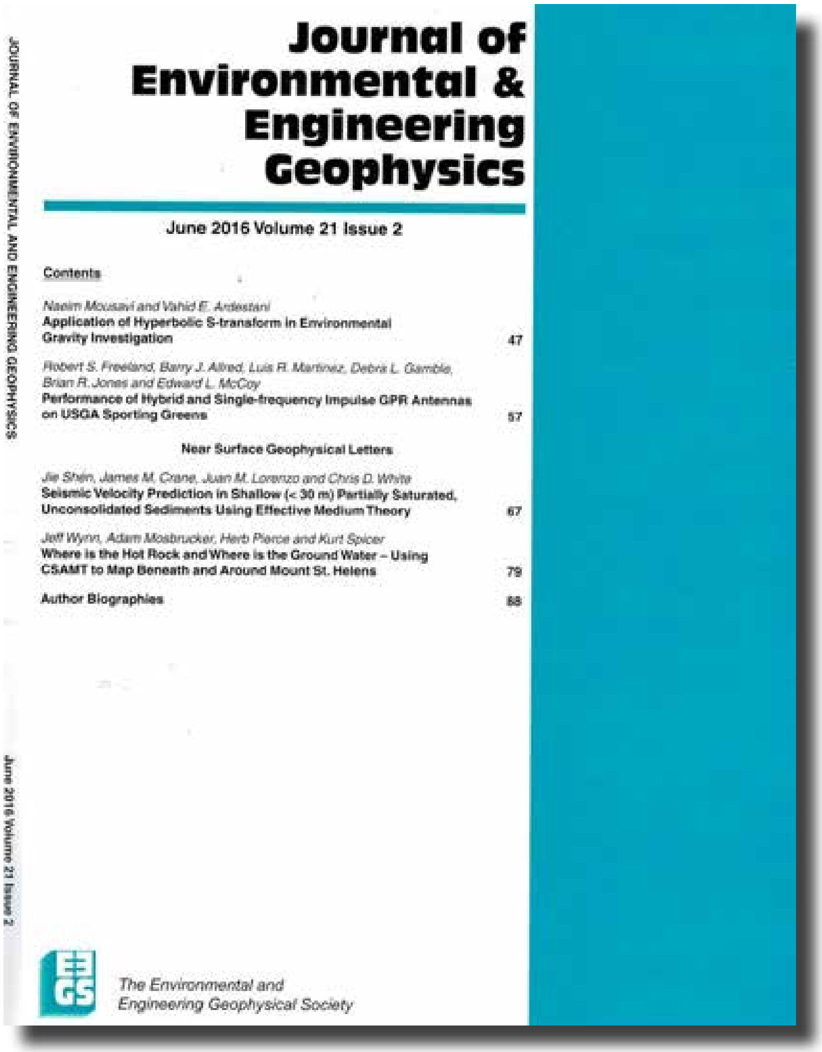
Message from the *Fast*TIMES Organizing Editor of This Issue

Forensic investigations have become an important and popular application of near-surface geophysics over the past 25 years. This application has real life impact on the people involved in crimes and can be the driving methodology for giving grieving families closure from a traumatic experience of losing a loved one. Despite the use of geophysics in forensic investigations over the past quarter century, there is still much to be learned about the effects of body decomposition on geophysical signatures, the effects of various burial sites on instrument performance, and the possibility of real-time data recording to reconstruct activity patterns. The articles in this exclusive issue on "Forensic Geophysics" illustrate the development in recent years in solving these problems. In the first article, Kevin Hutchenson presents the results of research that uses seismic-acoustic wavefield's to differentiate between on site activity patterns such as walking, digging, approaching automobiles, and engine starts. In the second paper, Jamie Pringle and Henry Dick provide an overview of various methods that are often used to investigate forensic scenes and conclude with an applied process for carrying out forensic searches. Finally, Stephen Yerka and colleagues describe experimental research from five test sites where near-surface geophysical surveys were conducted on excavated and reinterred graves, as well as cemeteries with marked and unmarked burials. The goal of this experimental research is to build a comparative database of geophysical signatures for accessible referencing by future investigators. Furthermore, this issue also contains a special feature article from Antonio Menghini describing the conversion of volcanic field geophysical measurements to music, which I'm sure *Fast*TIMES readers will find fascinating.

Daniel Bigman, *Fast*TIMES Associate Editor, dbigman@bigmangeophysical.com

JEEG NEWS AND INFO

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.



JOURNAL OF ENVIRONMENTAL AND ENGINEERING GEOPHYSICS

Journal of Environmental & Engineering Geophysics

June 2016 Volume 21 Issue 2

Contents

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The Environmental and Engineering Geophysical Society

June 2016 - Volume 21 - Issue 2

Editor's Note

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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 http://www.eegs.org/jeeg.

SUCCESS WITH GEOPHYSICS

*Fast*TIMES welcomes short articles on applications of geophysics to the near surface in many disciplines, including engineering and environmental problems, geology, hydrology, agriculture, archaeology, and astronomy. The current issue of *Fast*TIMES is focused on the application near-surface geophysics to forensic investigations and has three articles devoted to this very interesting topic. As always, readers are very much encouraged to submit letters to the editor for comments on articles published in this and previous *Fast*TIMES.

UNDERSTANDING YOUR LOCAL SURROUNDINGS USING THE SEISMIC-ACOUSTIC WAVEFIELD

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Introduction

Geophysics has been used for many years to understand the structure of the earth, the nature of earthquakes, and our climate, and to contribute to civil engineering projects, to name but a few applications. Seismology, a strong field in its own right, has been used for many years to understand impulsive events, particularly, earthquakes and nuclear explosions. Forensic geophysics is a fairly recent application of geophysics to understand events that have happened in the past. For example, the last couple of decades have seen magnetism and electrical methods as well as ground penetrating radar (GPR) make significant contributions to archeology.

Forensic seismology has been used since the middle of the 20th century. The recent coupling of seismology and acoustics has led to further understanding of small events at near distances via the seismic-acoustic wavefield (Arrowsmith et al., 2010). With today's geophysical sensing and data processing capabilities, it is now possible to examine much smaller events in detail to establish a forensic portfolio capable of supporting or refuting allegations in courts of law. Such events include those associated with perimeter breaches, intrusions, or other physical security offenses. Inexpensive vibration sensors in concert with modern, high capacity computing power allow thorough examination of the seismic-acoustic wavefield in their environment for situational awareness around the clock.

A seismic-acoustic wavefield tends to be generated by events near the boundary between the solid earth and atmosphere exciting mechanical waves (Arrowsmith et al., 2010), or by coupling across the boundary. For these applications, vibrational frequencies of interest range upwards from approximately 10 Hz and the wavefield can facilitate an understanding of events occurring within a spherical region surrounding the sensor that includes the air, ground, underground, and, any bodies of water within detection range. Vibrations from events in or on the water couple with the land at

Keywords: Forensic Seismology, Seismic-Acoustic Wavefield, Spectrograms.

the land-water interface much like acoustic waves coupling at the air-land interface. The dimensions of the "sphere" are dependent on source type, source strength, propagation parameters, and system settings, as well as on environmental noise, whether natural or man-made.

For forensic work or physical security monitoring, signals occurring within the region sampled by the sensor help determine what event types are occurring. Algorithms can be developed to classify a number of types of events based on the features and patterns of the signals detected in the wavefield. These features derive from both the time and frequency domains. For example, Figure 1 illustrates how various sources producing seismic and/or acoustic waves can be differentiated into different time-frequency domains. The figure was created empirically by observing different sources and categorizing them by their features of duration and frequency. It is these differences in frequency and duration that help facilitate a classification to be made on the source type. All source types can be broadly grouped as either impulsive, emergent, or as a continuous wave / frequency modulated (CW/FM) signals.

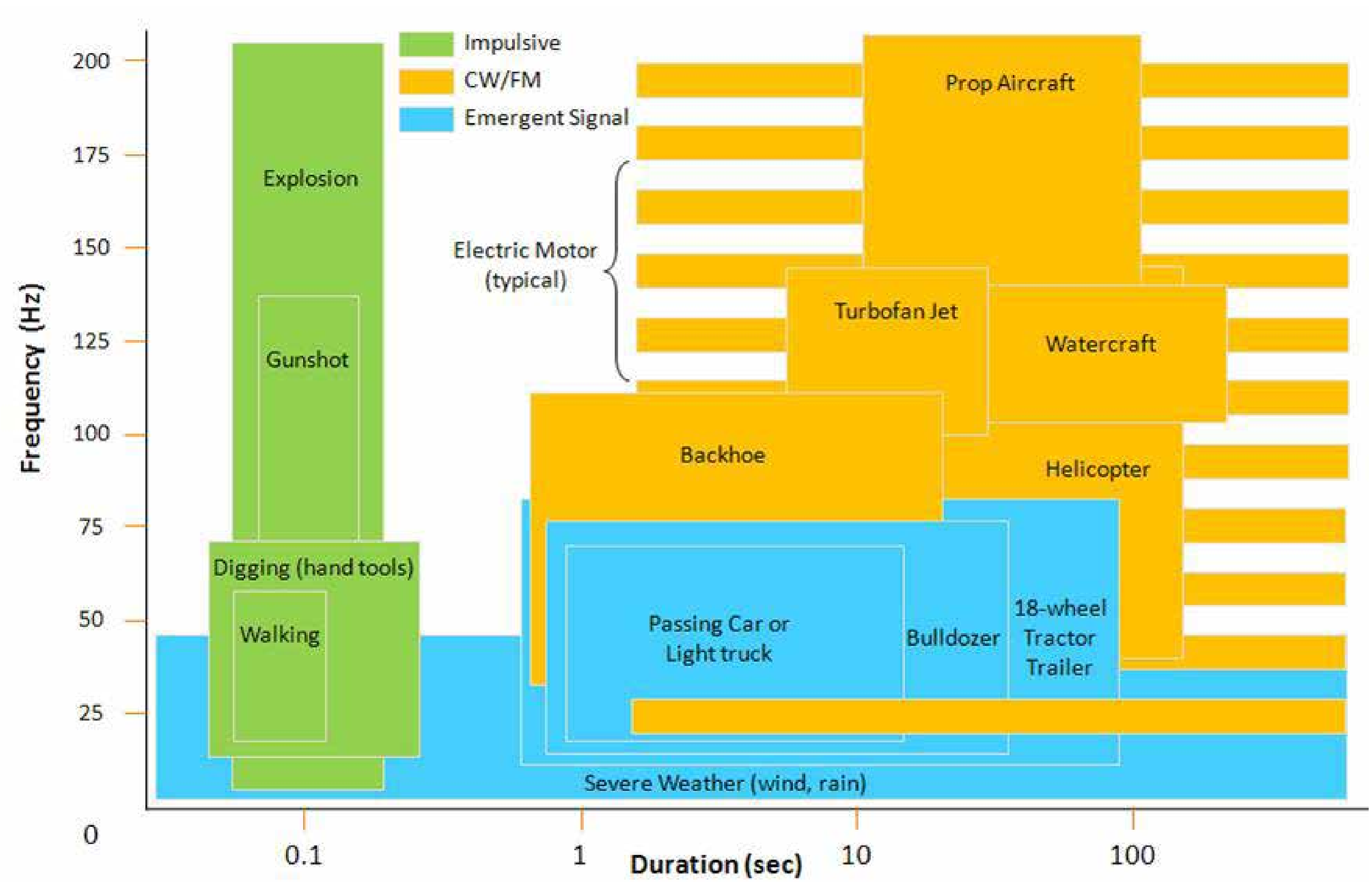

Figure 1: Time and frequency separation of different signals by features.

Description

Several representative examples of the three signal groups using time-frequency graphs, or spectrograms, are shown in Figure 2. These represent real events as observed by field experiments. Impulsive events, such as footsteps or a shovel digging in the ground, have short time duration but a broad frequency range. Emergent signals, shown by the light truck spectrogram, first appear in the low frequency (or longer wavelength) region. As they approach and pass the sensor at the closest point (closest point of approach, or CPA, sometimes referred to as the Point of Closest Approach, or PoCA), the highest frequencies are present. As the vehicle moves away, the reverse happens, the lowest frequencies persist the longest. The group of CW/FM signals is also unique. For stationary machines, such as a generator, the spectral lines are fixed in frequency, but continue in time as long as the machine is "on". Aircraft will have one or several lines changing in frequency as the aircraft changes position with respect to the sensor. Other engines and helicopters have their own unique signals.

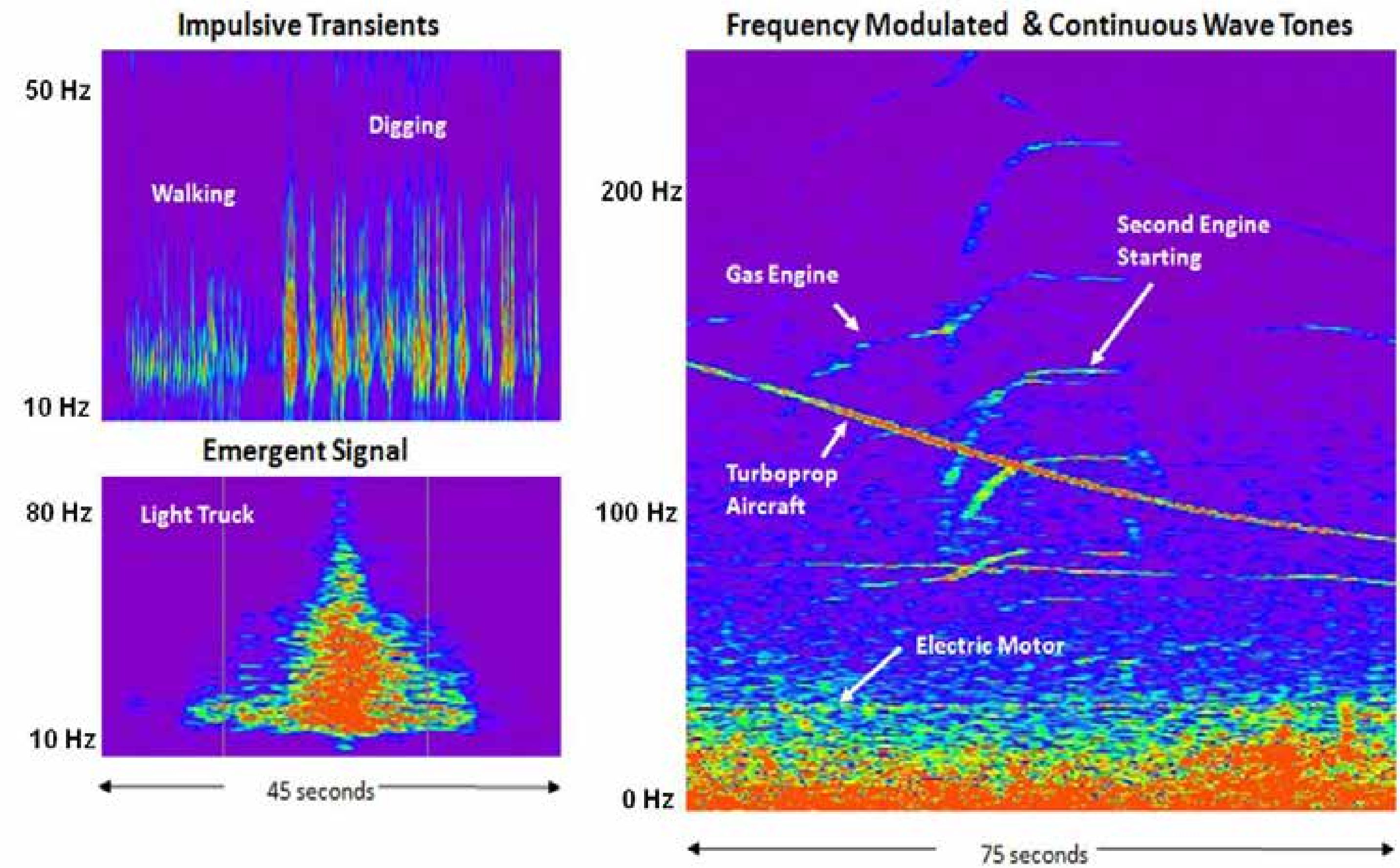

Figure 2: Time and frequency graphs for different sources as provided by the author.

Using different configurations of sensors, the seismic-acoustic wavefield can be sampled in different ways to yield specific information. For instance, a single sensor can be best used for isolated structures or pathways. An example may include a little used access road on a property; in use, a single sensor installed by the road would detect intruding footsteps or a vehicle and either record the alert or radio the alert to a central console. Forensically, a record of the data or alerts will identify the activity, time, and approximate location, should they be later needed for forensic, archival, or prosecutorial purposes. A second approach is to use a number of sensors connected to form a string of sensors. This approach and sufficient separation between sensors makes this a good choice for perimeter protection of an area, facility, or border. A third approach deals with a specific spatial separation of sensors arranged in a cluster, designed for a particular ground velocity and target frequency with specific software to support a more traditional seismic array pattern (Schweitzer et al., 2012). This approach yields a greater detection range than the others, and provides a bearing to each source as referenced from the center of the array for all signals it detects and classifies. Unlike many other physical security systems, such as cameras and radar, sensors designed to sample the seismic-acoustic wavefield can be buried, thus keeping them more clandestine.

Global seismology can observe earthquakes halfway around the world. The seismic-acoustic wavefield for security purposes samples much weaker signals that are originating closer to the sensors. For these signals, it is important to differentiate between the terms "detection" and "classification". Detection implies a signal is observed above the background noise but sufficient features are not available to determine the nature of the source; a signal can be classified when sufficient features are present to determine the source type of the signal, i.e., a footstep or vehicle or some other source.

Typical classification distances from single sensors are very dependent on the source strength of the signal and soil types. Typically, wetter soils propagate seismic signals at the frequencies of interest better than drier soils. Grain shape in the soil may also make a difference. However, airborne acoustic signals are dependent more on atmospheric density and temperature. The one other important factor when extracting the source signal is the level of background noise and clutter. Clutter sources are other signals, not the signals of interest. The problem is much like listening to a person talking when across the room; the speaker is easily heard if only two people are in the room as opposed to the case of a room full of people, all talking about different things.

Typical distances to classify a person of average height and weight walking at a normal pace in a moist soil environment is between 40 to 90 m. Vehicles in the same environment are detected and classified a little further away, typically 90 to 125 m. Normal digging with a shovel or post-hole digger can typically be classified out to distances of approximately 50 m. Typical signals of each source are shown in Figure 2. Drier soils propagate poorly, thus, not as far.

For forensic purposes, a multi-sensor system deployed in a known pattern can also provide other information about the source signal. In a recent study by the author during an electrical storm, the direction of the lightning was determined from the direction of the thunder acoustically arriving across the sensor pattern (Figure 3). Clearly, the acoustic wave of thunder arrived from the southwest, propagating to the northeast. The waveforms are stacked top to bottom from 1 to 15, corresponding to the sensor locations shown on the inset (Figure 3).

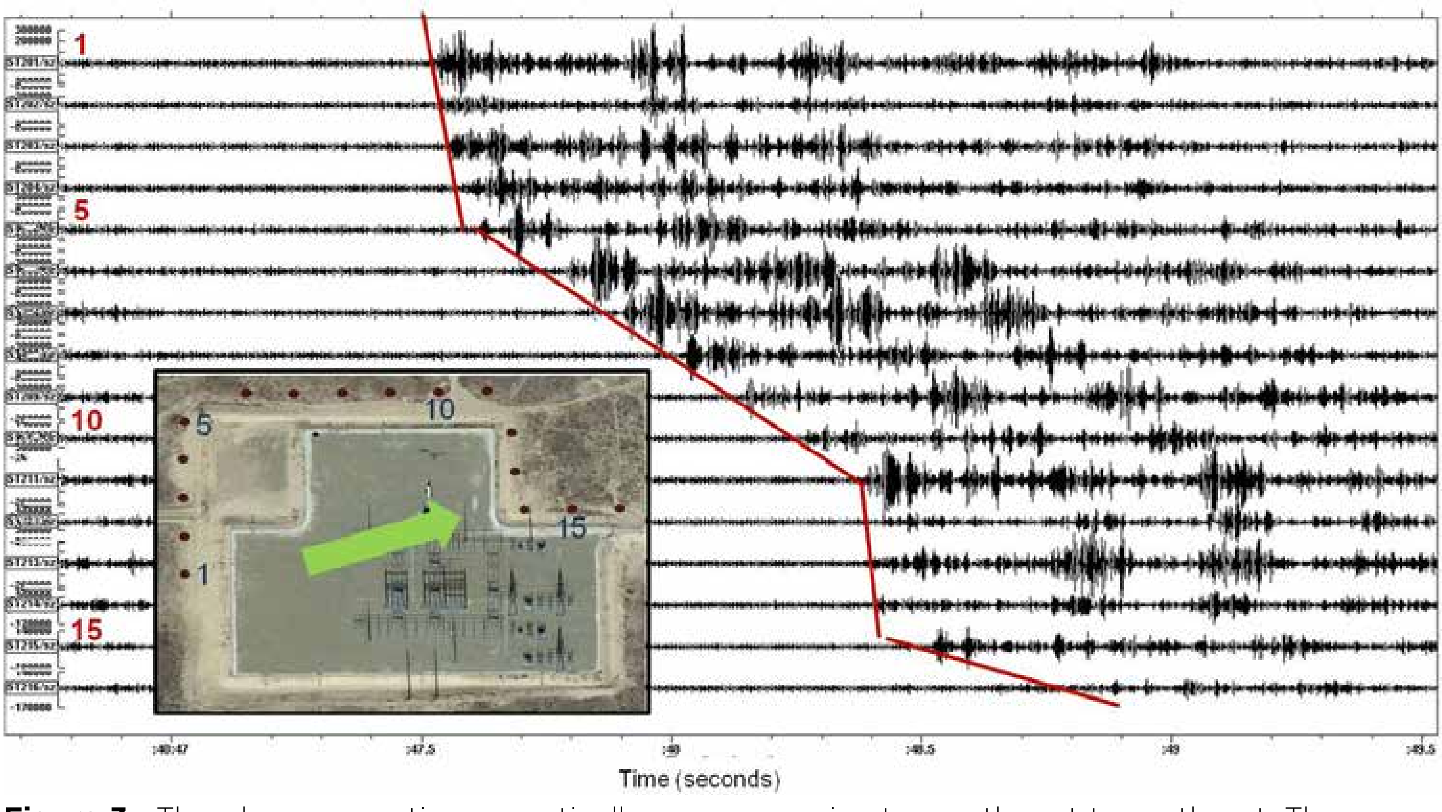

Figure 3: Thunder propagating acoustically across a perimeter southwest to northeast, The sensor layout is shown in the inset. The bottom boundary of the substation is 1080 ft. The acoustic wave velocity was calculated at 337 m/s with the direction shown by the green arrow (Quantum, unpublished study).

A system of sensors deployed in an array pattern provides another dimension from which to obtain features, namely a spatial component, from which signal processing extracts a wavenumber feature and, more importantly, an array-to-source direction. In addition, a small improvement in the signal-to-noise ratio is obtained; a theoretical maximum improvement is the square root of the number of sensors in the array. A seismic-acoustic array is similar to a global seismic array except for the sensor spacing, much closer in this case due to the higher frequencies of interest (Stump et al., 2004). Processing can be accomplished using a beam recipe (pre-determined pattern of slowness and azimuth) approach or frequency-wavenumber (fk) approach; both have pros and cons.

An example of the information provided by an array system generated by the author is shown in Figure 4. In this example, the array pattern contains seven (7) equally spaced sensors in a circular pattern with a radius of 4.88 m (16 ft) with the eighth sensor in the middle, having a 0.5 m (1.6 ft) offset from the center of the array pattern. As a demonstration, two people are walking in opposite directions in a circle around the array at distances of 30-40 m. In addition, a window air conditioner (AC) unit (a clutter source) is running in the west end of the building, just west of North of the sensor array. The resulting spectrogram in the figure also exhibits a strong 60 Hz line, a by-product of the power grid (noise). Using fk processing (Smart and Flinn, 1971), a plot of detected source azimuth vs. time clearly indicates the two walkers as it does the direction of the AC unit.

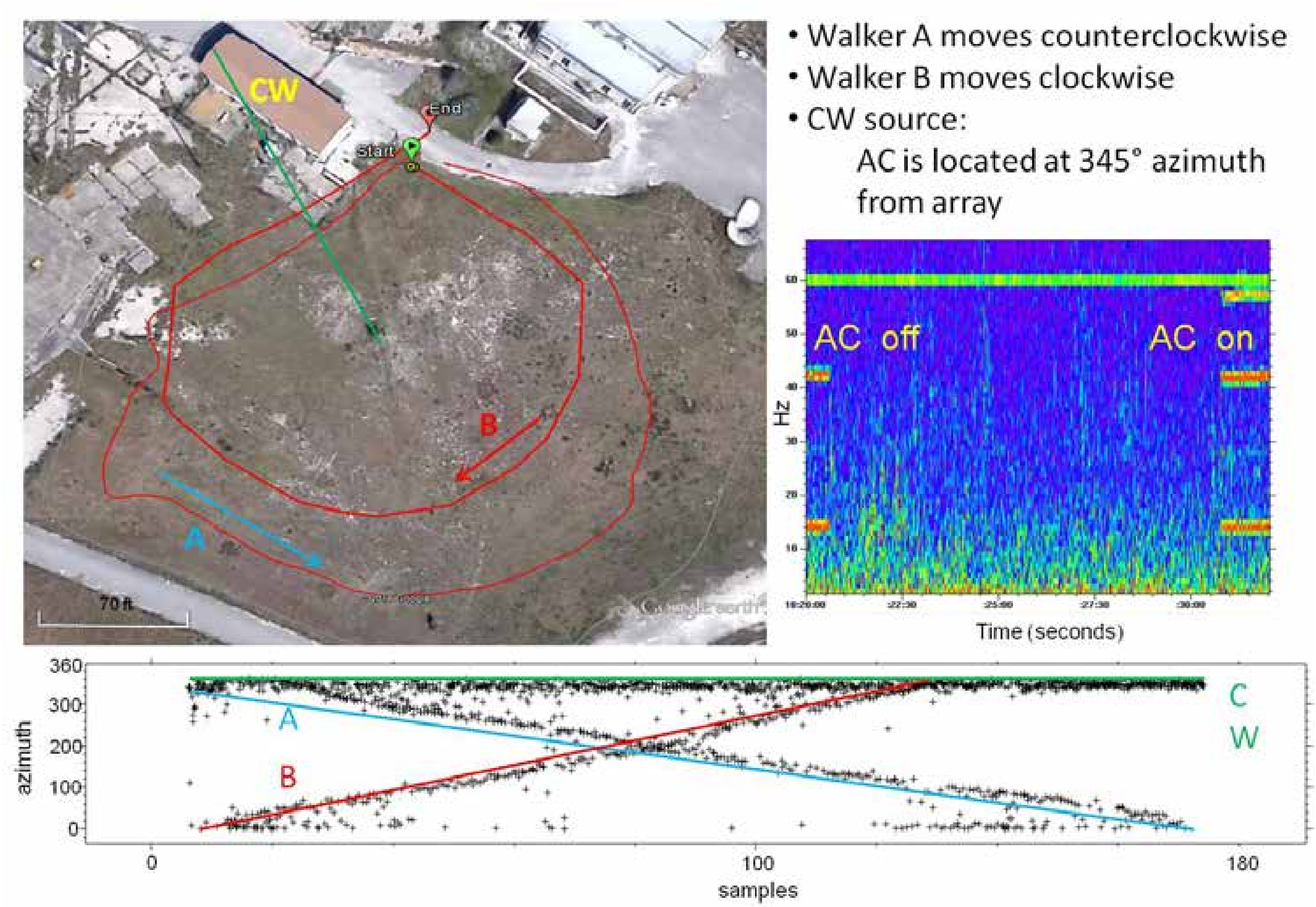

Figure 4: Map view of the sources and paths in the upper left. The spectrogram (middle right) shows the AC unit powering off, then on. The lower plot is the result of an fk trend plot clearly showing the two people walking in a circle around the array in opposite directions. A direction to the AC unit, running during this time period is visible at about 345° as a straight line since it is not moving and maintains a constant bearing.

In another array processing example conducted by the author (Figure 5), a known source is digging at 100 m at an azimuth of 205° from the array. This signal could also be someone hitting the ground with a heavy instrument or some other repetitive but finite source. However, in the background and in the woods towards the north and out of sight, a dirt bike (motorcycle) was cruising through the forest.

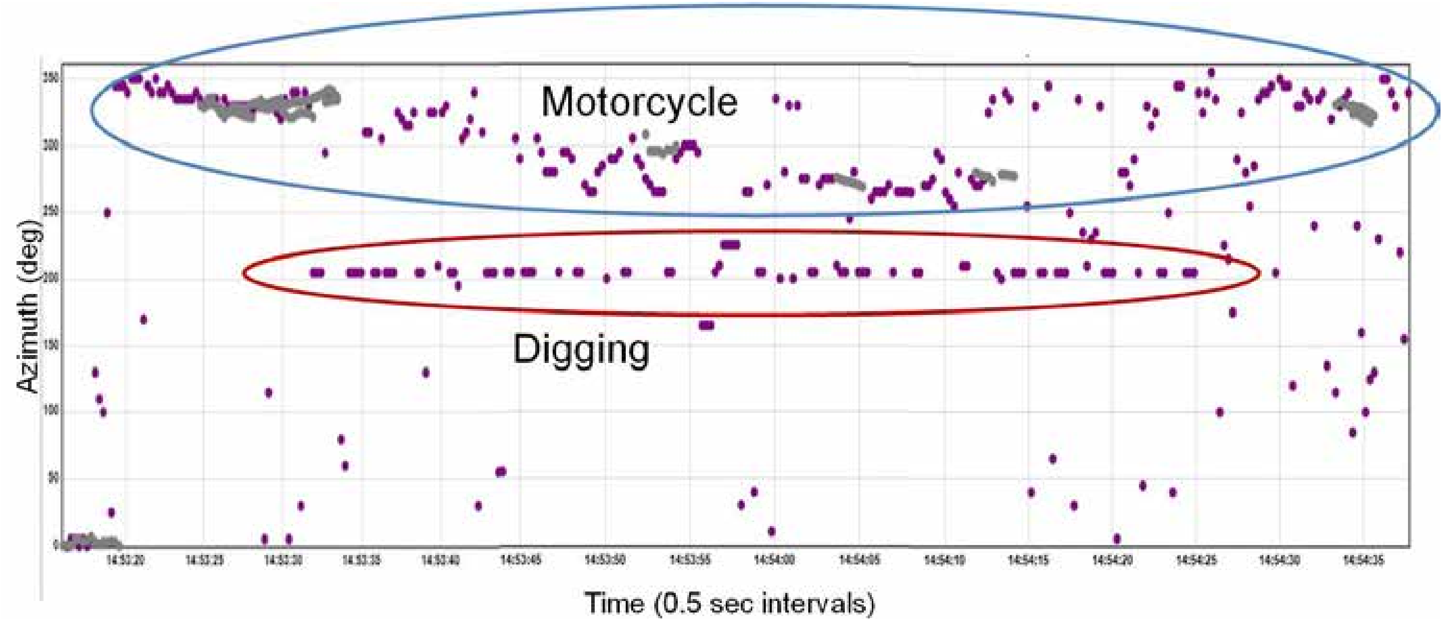

Figure 5: A digging signature is visible as point impulses at the same azimuth over time. Overprinted is a motorcycle in the woods to the northwest of the array.

Characterization of sequential activities is also useful for forensic purposes. Consider a buried sensor placed near a building or access point, such as a gate or road. Figure 6 is a simple example conducted by the author of a car driving down a road next to a buried natural gas pipeline, pulling off and stopping, idling for a period of time, then stopping the engine. The inset spectrogram shows the emergent signal of the approaching car, the stoppage of its motion, continued engine idling, and finally, engine stoppage, all against the background of the active pipeline. Had someone emerged from the car and walked around, there would be a record of footsteps and any other activities, such as digging, and all from an invisibly buried sensor. Also note that line of sight was not necessary for detecting the car as it approached from out of sight behind the trees.

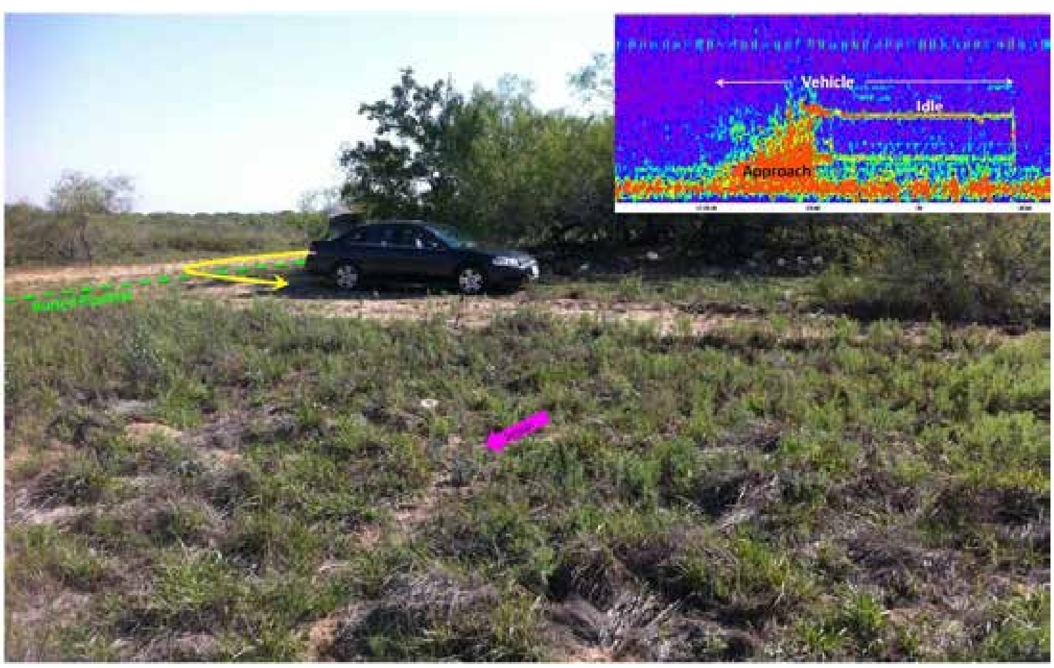

Figure 6: The vehicle approached at 15 mph from behind the trees, turned, stopped, and idled for 55 seconds before shutting down. The initial vehicle detection distance was over 200m. Pipeline activity was also detected.

Conclusion

Geophysics can be used to determine events happening in the world. Several examples have been shown where signals and patterns can be used to forensically sample events in the seismic-acoustic space surrounding a sensor or pattern of sensors and ultimately understand the events from measured features. As we have found, understanding the signals is a learning process. A rule of thumb attributed to Dr. Charles Richter by urban legend states that the training of a seismologist involves looking at 10,000 seismograms. That is certainly a true statement with the plethora of signals at all frequencies in the seismic-acoustic wavefield.

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FORENSIC GEOPHYSICS: ASSISTING LAW ENFORCEMENT AGENCIES IN CLANDESTINE GRAVE DETECTION

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Introduction

Thousands of people are reported missing in the world every year to their respective Police Services, 250,000 annually in the United Kingdom alone (UK Home Office, 2010). In other countries, with larger populations, these figures will be considerably more, for example, the US National Crime Information Center lists 84,136 missing persons cases as of 2013, with ~57,000 currently missing in Colombia (Molina and others, 2016). Where the missing have sadly become homicide victims, their bodies are commonly hidden inside structures (see Ruffell and others, 2014), deposited in water (see Parker and others, 2010) or buried in terrestrial environments (see Pringle and others, 2012). Where these cases are unsolved, they are commonly referred to as 'cold cases' which periodically get revisited every decade or so, where new case information may come to light and/or forensic techniques have been recently developed which may assist with the investigation.

There are various methods used for detection of these victims, with best practice suggesting a phased approach, moving from large-scale remote sensing methods to suggest likely areas, down to ground reconnaissance and control studies of suspect area(s) before full site searches are initiated (see Larsen and others, 2011, Pringle and others, 2012). Full site searches can include a variety of techniques, including forensic geomorphology, scent-trained 'cadaver' victim recovery dogs, chemical analysis of soil/water samples and near-surface forensic geophysics. Near-surface geophysical methods are being increasingly used by forensic search teams to assist them with detecting a variety of forensic-related items of interest.

Forensic Geophysical Methods

Forensic geophysics has been defined as 'the study of locating and mapping hidden objects or features that are underground or underwater' (Dupras and others, 2011) for both civil and criminal court purposes. Geophysical methods should be able to non-invasively, rapidly survey extensive suspected areas; subsequent targeted anomalies can then be investigated using conventional and forensically careful, intrusive methods. Forensic geophysical targets are many, the highest profile of which are both isolated and mass clandestine graves of homicide victims, but other targets, for

Keywords: Forensic Geophysics, Clandestine/Cemetery Burials, Search Program Workflow.

example, weapons used in crimes, drugs and money caches, are also important forensically to locate for criminal and civil courts, with environmental forensics to locate, characterise and, ideally, time the illegal dumping of waste also becoming more common concern (see Pringle and others, 2012).

The dominant near-surface geophysical technique currently utilized globally for terrestrial searches is ground penetrating radar or GPR (Figure 1). It is easily portable, has good resolution (depending upon the antenna frequency being utilized) and penetration (depending upon soil type), and data is able to be both viewed in real-time and GPS positioned. Usually mid-range frequencies (200 MHz – 500 MHz) are mostly used for forensic investigations, on 0.5 m spaced traverses and 0.1 m sample spacings, depending upon the target size being searched for. However, it has been suggested that in some cases, it has been used based on past successes and without consideration of local depositional conditions (see Table 1). It is also particularly used to pinpoint historic and unmarked grave burials (see the FastTIMES article by Lachlab and Zawacki, 2015).

Figure 1: Photograph of a forensic geophysics search site in the United Kingdom to look for a homicide victim. A GPR survey has been undertaken on 0.5 m spaced survey lines, with suspect anomalous areas being marked by yellow flags for investigation teams to intrusively investigate.

Table 1: Generalized table to indicate potential of search techniques(s) success for buried target(s) assuming optimum equipment configurations. Note this table does not differentiate between target size, burial depth/age and other important specific factors (see text). Key: ●Good; ◉Medium; ○Poor chances of success. The dominant sand | clay soil end-types are detailed where appropriate for simplicity, therefore not including peat, cobbles etc., types. Modified from Pringle and others (2012).

Target(s)	**Near-Surface Geophysics**						
Soil Type: Sand / Clay	Seis-mology /	Cond-uctivity	Resist-ivity	GPR	Mag-netics	Metal Detector	Magnetic Suscept-ibility
Unmarked Grave(s)	Poor/Poor	Medium/Medium	Good/Good	Good/Medium	Medium/Medium	Poor/Poor	Good/Good
Clandestine Grave(s)	Poor/Poor	Medium/Medium	Good/Good	Good/Medium	Good/Good	Medium/Medium	Good/Good
UXOs/ IEDs	Poor/Poor	Medium/Medium	Good/Good	Good/Medium	Good/Good	Good/Good	Good/Good
Weapons	Poor/Poor	Medium/Medium	Medium/Medium	Medium/Medium	Good/Good	Good/Good	Good/Good
Drug/Cash Dumps	Poor/Poor	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Medium/Medium	Good/Good
Illegal Waste	Medium/Good	Good/Good	Good/Good	Good/Medium	Medium/Medium	Good/Good	Medium/Medium
Common Depositional Environment							
Woods	Poor	Medium	Poor	Poor	Good	Good	Good
Rural	Good	Good	Good	Good	Good	Good	Good
Urban	Medium	Poor	Poor	Medium	Poor	Medium	Poor
Coastal	Good	Poor	Medium	Poor	Good	Good	Good

Electro-magnetic (EM) methods, which include metal detectors, are also commonly used, often as the initial field geophysical technique, as they are relatively quick. Metal detectors have the transmitter and receiver together and therefore have very good resolution, other EM equipment have these separated, which usually results in them not having as high resolution as other methods, although the penetration depths for the latter are better. EM datasets would be typically acquired on 1 m spaced traverses and 0.5 m sample spacings. Apart from metal detectors, EM surveys are mainly used for detecting disturbed from 'natural' ground (and thus may not be useful in urban searches), metallic items and or waste which are conductive and items that are contained with or beside the target(s) of interest, as well as items left behind by the perpetrator(s). However, caution should be used for intrusive investigation of anomalies in a search site; used before other geophysical techniques, any intrusive investigations created by the detector search teams may then themselves be identified as a target by subsequent geophysical searches (Figure 2). They are also problematic in urban or culturally 'noisy' environments where above-ground EM sources may interfere with results (Table 1).

Figure 2: Photograph of a forensic geophysics search site in the United Kingdom to look for a homicide victim. A metal detector search team have already been onsite and dug up where metal was indicated (water-filled holes). Due to the clay-rich soil type of the site, a fixed-offset, dipole-dipole electrical resistivity survey has been undertaken (in background).

Electrical resistivity (ER) techniques, the inverse of EM methods, have been widely used for ancient burials searches, clandestine grave searches (particularly in clay-rich soils which may preclude GPR to be used – see Figure 2) and for larger targets (see Pringle and others, 2012). Resistivity surveys have the advantage of measuring probes being physically inserted into the ground and are therefore less affected by above-ground sources of interference (Figure 2). Datasets are typically collected on 0.5 m spaced traverses and 0.5 m sample spacings, depending on target size. However search results, whilst useful to pinpoint suspect area(s), may be due to soil moisture content variations in heterogeneous soil rather than due to targets, and thus careful data processing is necessary and potentially other technique(s) may be necessary to confirm if target(s) are present and positions before intrusive investigations are undertaken.

Finally, magnetic methods have also been used in forensic searches, particularly looking to recover metallic weapons, or when metallic objects are left within an unmarked or clandestine grave. Various magnetometers are typically used on 0.5 m spaced traverses and 0.25 m sample positions, with total field magnetometers utilized for big targets, magnetic gradiometry for smaller objects within 1 m of the ground surface, to even magnetic susceptibility surface probe surveys for more subtle targets or to look for disturbed ground (see Figure 3).

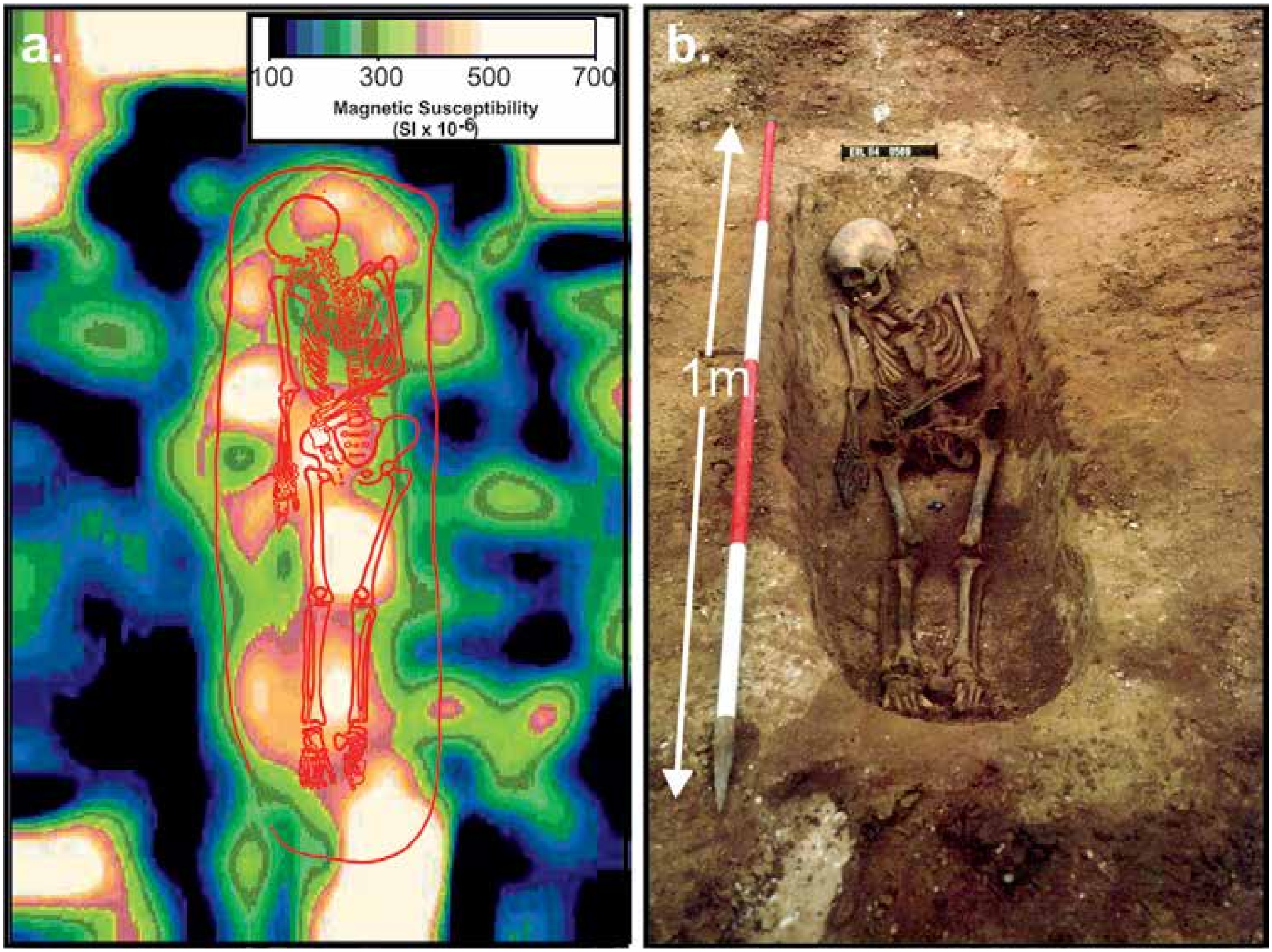

Figure 3: Magnetic susceptibility (MS) surface survey to detect an Anglo-Saxon grave in East Anglia, United Kingdom. (**a**) digitally contoured gridded surface of MS results with subsequent (**b**) excavated skeleton outline superimposed, interestingly not containing any metal. Modified from Pringle and others, 2015.

With the development of faster data acquisition technologies, particularly towed geophysical instrumentation, automated robot surveys, and drone technologies (see FastTIMES March 2016 Special Drone Issue), terrestrial searches using forensic geophysics should become increasingly common. However, considerations need to be given on the individual case, which is where controlled geophysical research comes in.

Controlled Forensic Geophysical Research

Controlled research using simulated clandestine graves have proven critical to determine the optimal geophysical technique(s) and equipment configurations to maximize the potential for target detection success (see, for example, Schultz and Martin, 2012 and Pringle and others, 2016). Controlled research by various authors has also determined the major site variables that affect burial detection. The most important variable is time since burial, over time the disturbed soil over a buried target will compact to leave this target to be more difficult to differentiate from background values. For clandestine burials the style of burial is important, if it is wrapped/clothed it will have a big difference geophysically, wrapping will prevent conductive decompositional fluids from escaping and being detected, but the wrapping itself provides a good radar reflective surface. The local soil type is also important, clay-rich soils, for example, result in rapid attenuation of radar waves and thus usually results in poor penetration so electrical resistivity surveys may be optimal in this scenario. Finally the local depositional environment including surface vegetation is an important variable, dense forests would preclude the use of GPR and electrical resistivity due to them imaging tree roots, thus EM or magnetics may be optimal here. Table 1 details the optimal techniques in different depositional environments.

Clandestine burials are quite different from historic graves in graveyards and cemeteries, the actual target will change depending on the time since burial and decomposition stages; this will then effect which technique should be used. Early decomposition results in lighter than air gases escaping which would make methane probes and search dogs optimal, later stage decomposition would release 'leachate plumes' that could be detected electrically, whilst skeletonised remains would be best detected by GPR (see Figure 4).

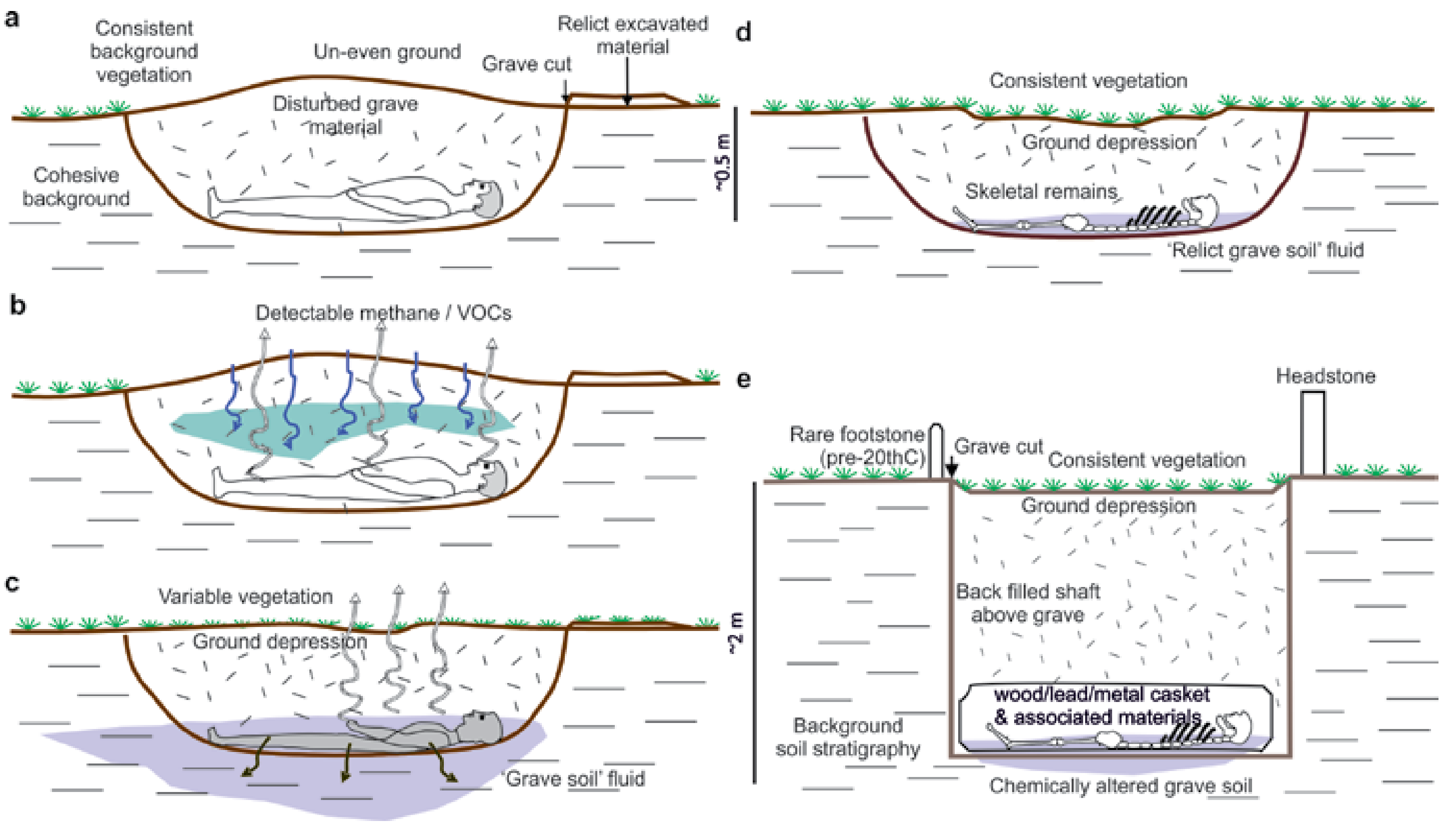

Figure 4: Schematics and potential 'grave' markers of the clandestine and cemetery burial stages. (A) Recent burial, surface expression is most obvious. (B) Early decomposition with forensic geomorphologists (surface changes), search dogs and/or methane probes being optimal. (C) Late-stage decomposition with forensic geomorphologists and grave soil fluids being an ER target. (D) Final skeletonised decomposition with GPR being optimal. These contrast with (E) isolated static graveyard/cemetery burial showing typical geophysical targets including forensic geomorphology, back-filled grave soil, coffin/contents and 'grave fluid'. Modified from Pringle and others, 2016.

Conclusions

Every forensic geophysical search is unique, therefore a good knowledge of the case background and potential suspected site(s) should be gained before a sequential site investigation(s) is initiated. Creating a conceptual target model and continually refining this when new information comes available will assist forensic search teams in developing a detailed and focused search plan. Analysis of large-scale (remote sensing) techniques should be undertaken before ground reconnaissance and control studies are initiated. Key considerations when considering a forensic geophysical survey are exhaustive but should, as a minimum, consider the local soil type and environment, likely time since burial and target size and style. If time is not a factor, certain surveys are optimal in certain seasons, for example electrical resistivity surveys have been shown to be more successful in wetter winter ground conditions. Lastly, a clear written workplan should be created as an exit strategy in case the target is not identified using geophysical methods. Figure 5 gives a generalized typical search program workflow using forensic geophysics.

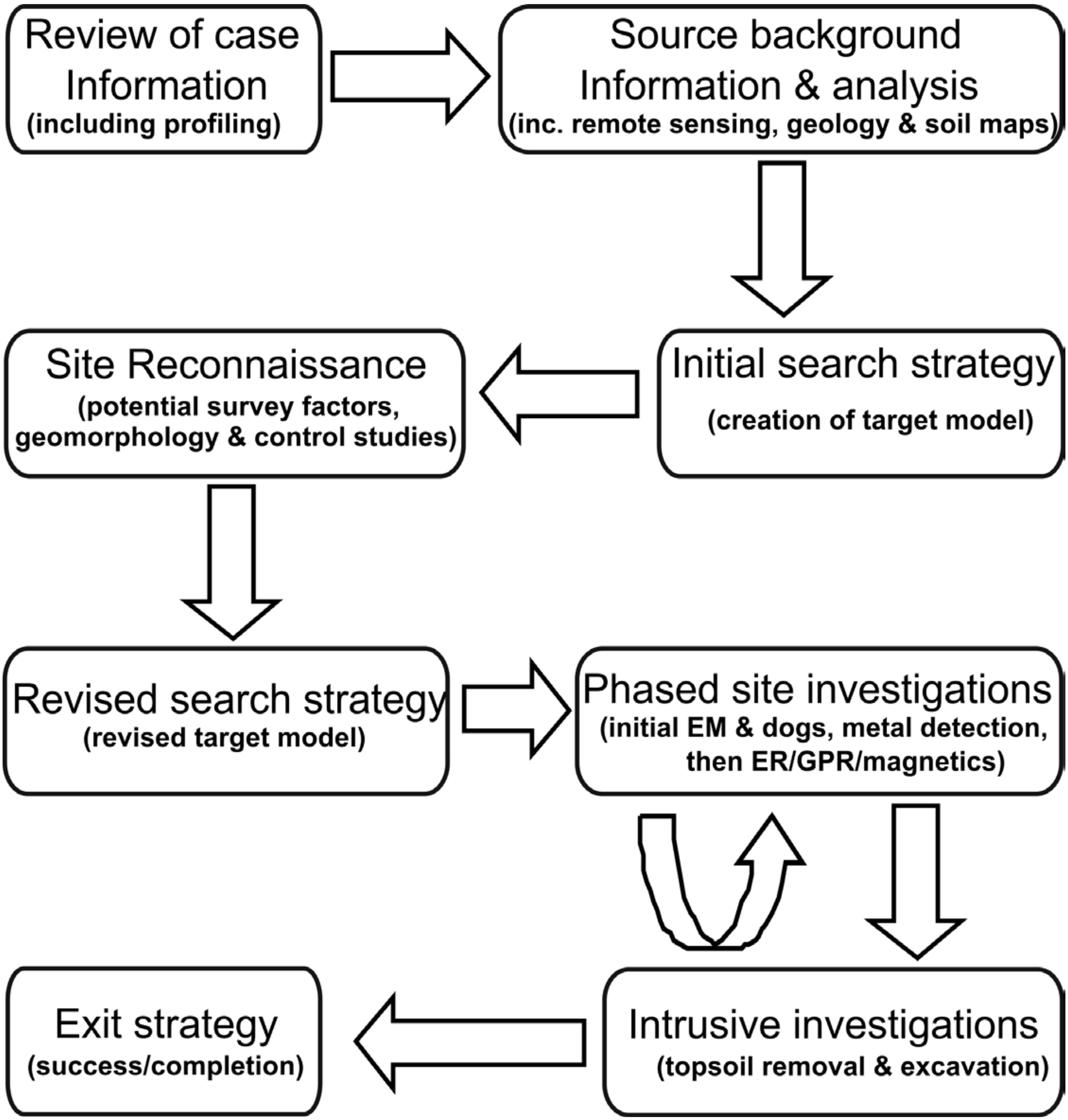

Figure 5: Generalised forensic search program workflow (modified from Pringle and others, 2012).

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AN OPEN ACCESS DATABASE FOR COMPARING NEAR-SURFACE GEOPHYSICAL SURVEY RESULTS OF HUMAN BURIALS

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Introduction

Using remote sensing and geophysics to search for buried human remains is nothing new. Twenty-five years ago Bevan (1991) demonstrated that GPR is an effective technique for detecting burials in archaeological contexts, and the following year France and colleagues (1992) published results from experimental pig burials using multiple geophysical techniques, but over the last decade, geophysical surveying has become increasingly popular for archaeology and forensic investigations (e.g. Dalan et. al. 2010; Pringle et al. 2016).

Basic crime scene and archaeological procedures both dictate that searches for human remains must be appropriate and methodical, aiming to identify evidence while not adversely affecting the scene. Considering near-surface geophysical surveying is mostly noninvasive and essentially capable of documenting subsurface conditions before excavation, it seems a fairly obvious choice for burial recovery. What is not always as obvious is that the detection threshold and identifiable properties of a burial feature can be highly variable and dependent on localized factors like: preservation, sediment characteristics, mode of interment, and a host of other confounding variables. There is no single instrument or technique that is right for every situation. It is important to learn about local field conditions prior to selecting a geophysical technique for a survey.

Keywords: Geophysical Surveys, Clandestine/Cemetery Burials, Open Access Database.

Project Background

This article presents near-surface geophysical surveys of five experimentally replicated clandestine human burials at the Anthropological Research Facility (ARF), University of Tennessee. Additionally, surveys collected opportunistically over the course of several years at cemeteries with areas of both marked and unmarked graves are included as well. In tandem with this publication, the primary geophysical survey data will be available as a digital comparative collection on the web. Both unfiltered and processed versions of the survey data will have stable web identifiers and available in standard geophysical file formats at Open Context, Alexandria Archive Ins. (www.opencontext.org) under the Geophysical Surveys of Burial Anomalies (GeSBA) Comparative Collection Project. All data are provided as-is, and for informational purposes only.

This project began as a pilot study to test whether the available, standard geophysical field instruments could reliably monitor clandestine graves and buried evidence across time and under various conditions. Early into the pilot study, it became apparent that the heuristics developed during archaeological field surveys — where targets of interest produce low contrast anomalies as a rule — could be equally useful to the search for clandestine graves. Below, we share results from the early pilot study and provide open access to the primary data as a sort of comparative collection. The purpose is to inform other surveyors and investigators that are designing or interpreting geophysical survey for human remains.

Near-Surface Geophysical Surveys of Experimental Burials

The experimental site is within the William M. Bass Anthropological Research Facility (ARF) at the University of Tennessee, Knoxville (also commonly referred to as the “Body Farm” in popular media). The ARF is a property situated within a natural environment dedicated to the study of human decomposition. Each calendar year approximately 100 individuals are donated to the facility for use in decomposition studies and law enforcement training. Terrain at the ARF is unmodified and representative of the natural environment of the Appalachian physiographic region, and the eastern United States in general. The facility incorporates wooded and open environments, and soils are generally clay-rich. (Figure 1). Vegetation and thick undergrowth had to be cleared for several of the survey stations. Clearing the area so that a systematic survey can performed is a very important step for obtaining clean survey data. Not only do instruments need room to operate, and the GPR needs to remain in contact with the ground surface, but the operators need safe access to the area. Tripping hazards abound in wooded areas.

Figure 1: Authors collecting resistance data over experimental plot 1. The plot slopes towards the camera, but is a relatively flat plane otherwise. Undergrowth like that in the background of the photo had to be cleared before survey could get underway — an important factor when planning field work.

Experimental Area 1

Experimental Area 1 (ARF 1) is a roughly 10 m by 8 m plot containing a single human interment that was excavated to a depth of approximately 75 cm. This is the typical depth excavated for burials at the ARF. At this depth the remains will be no less than approximately 50 cm below the surface after reburial. The experimental burials represent conditions similar to what might be expected of an expedient, clandestine burial in a shallow grave (Figure 2).

Figure 2: ARF 1 experimental area showing position and depth of burial prior to re-burial and geophysical survey. A distinct boundary in the sediments is visible where the excavation excavates into the clay-rich subsoil.

GPR was collected over ARF 1 using a GSSI SIR 3000 with a 400 MHz center frequency antenna. The most commonly used antennas in archaeological surveys usually have a center frequency between 300 - 500 MHz. This range is capable of imaging the top 1-2 meters below surface with fairly good resolution.

The survey was conducted ~2 years after ARF 1 was established so all signs of recent disturbance had weathered away. All surveys in this study were collected on systematic surveyed grids covering the entire plot with half-meter transverse lines and using an odometer to calibrate distance. Settings for the GPR interface are included with all of the primary data at www.OpenContext.org. Figure 3 shows a colorized, processed radargram with the burial anomaly highlighted.

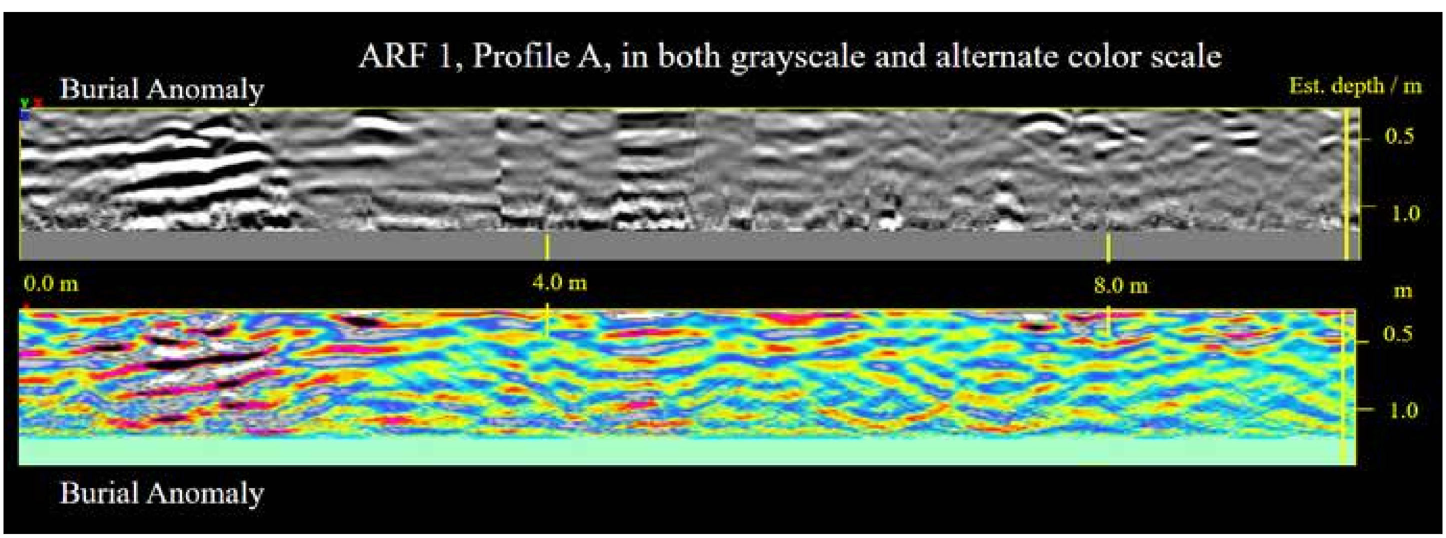


Figure 3: GPR profile showing the response from ARF 1 burial, anomaly representing burial on the left side of image. The same profile is shown here in grayscale and color.

The systematic survey was collected as 3D data as well, and a plan view is shown in Figure 4 of a time-slice that ranges from 4 - 14 nS below surface. Viewing survey data in 3D allows is often more informative than individual profiles for characterizing a burial feature. In Figure 4 the anomaly associated with the burial appears as a fairly regular shape that is about 2 m long by 1 m wide on the left side of the image, while the other anomalies in the data are caused by roots and rocks. Having the gridded GPR survey allows for a more confident selection of an anomaly that is most likely to contain a burial. This type of visual processing is beneficial not for just assessing which anomalies to test excavate, but it also may be more informative than GPR profiles for those unfamiliar with GPR profiles.

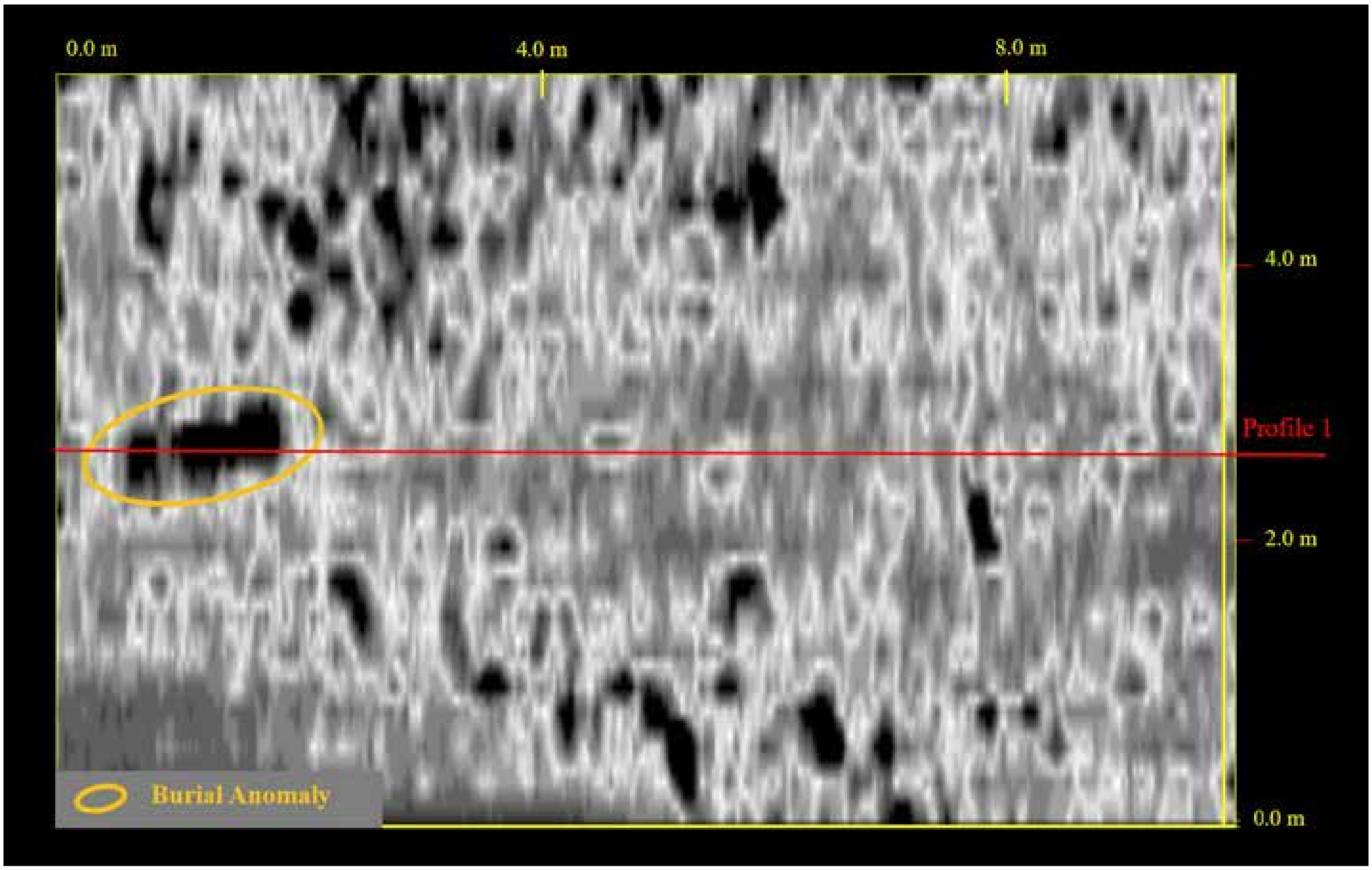


Figure 4: ARF 1 as 3D GPR timeslice (4 - 14 nS below surface). The thin red line represents Profile A shown in Figure 3, the distance marks are in meters. The ARF 1 Burial is labeled on the left side of the image.

Area ARF 1 was also surveyed with a Geoscan MPX-15 soil resistivity meter set-up as a mobile twin probe multiplexed array. The same grid was collected as the GPR on half-meter transects, with four readings per meter down each transect. Four electrodes were mounted on the mobile array with the 0.5 m, 0.75 m, and 1 m spacing. The stationary array was placed in the ground down-slope ~30 m away. The probe spacing was selected to correspond to a depth below surface that would be likely to capture the burial anomaly. In a real-world practice, like in a forensic investigation, if the depth of burial is unknown, then multiple twin-probe surveys with probe spacing at regular intervals up to at least two meters wide may be required. Figure 5 shows the results in gray-scale from the 0.75 cm-spaced probes in units of resistance. The soil resistivity survey clandestine burial responses in the ARF are generally detected as low resistance anomalies directly over the infilled burial trench, and flanked by relatively higher resistance features. One possible explanation is that since the clay-rich subsoils have poor drainage, an intrusive pit will puddle subsurface water and act as a sump for water in the adjacent undisturbed ground.

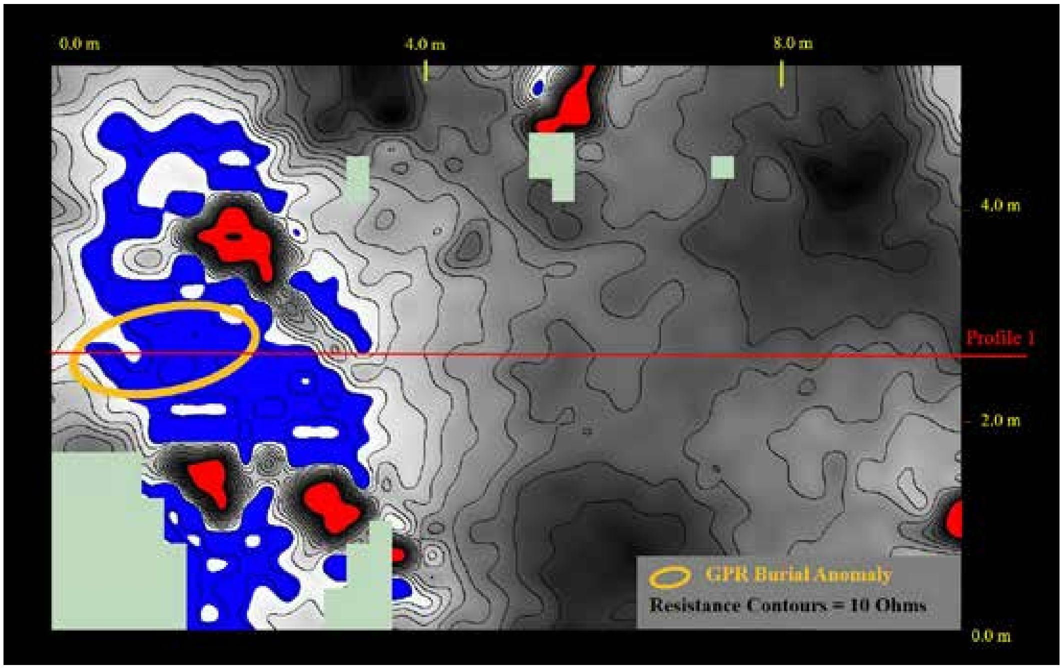


Figure 5: ARF 1 Soil resistance survey with gray-scale range and blue for low-resistance and red for high-resistance features (unshaded = no data). Survey results show a patterned response in shallow burials in clay-rich sediments. These data correlate with the GPR, but also work as two separate types evidence for to distinguish burial features versus some other type of buried targets.

Experimental Area 2

Experimental Area 2 at the facility (ARF 2) is a smaller plot surrounded by limestone boulders limiting the area that could be surveyed (Figure 6). The small plot contains two replicated clandestine burials that are separated by a 0.5 m dirt baulk. The two burials were placed in the ground at different times with one year separating interments dates, and are placed at different depths. GPR results clearly show two burial anomalies at different depths as can be seen in the GPR profile (Figure 7).

The GPR burial anomalies overlap, but are distinct enough that with high resolution sampling they can be distinguished as two separate burials at different depths. Most of the GPR response is captured within 200 samples between ~ 5 nS and 15 nS below ground surface. Employing a dense sample coverage within a reduced range, targets can be parsed into distinctive burial anomalies, and is demonstrated in images in Figures 8 A-C.

Figure 6: Area ARF 2 contains two burials in a small area. The GPR is at the upper left with the 400 MHz Antenna attached to a drag wheel. Numerous roots and boulders are in the plot which is marked with PVC flags.

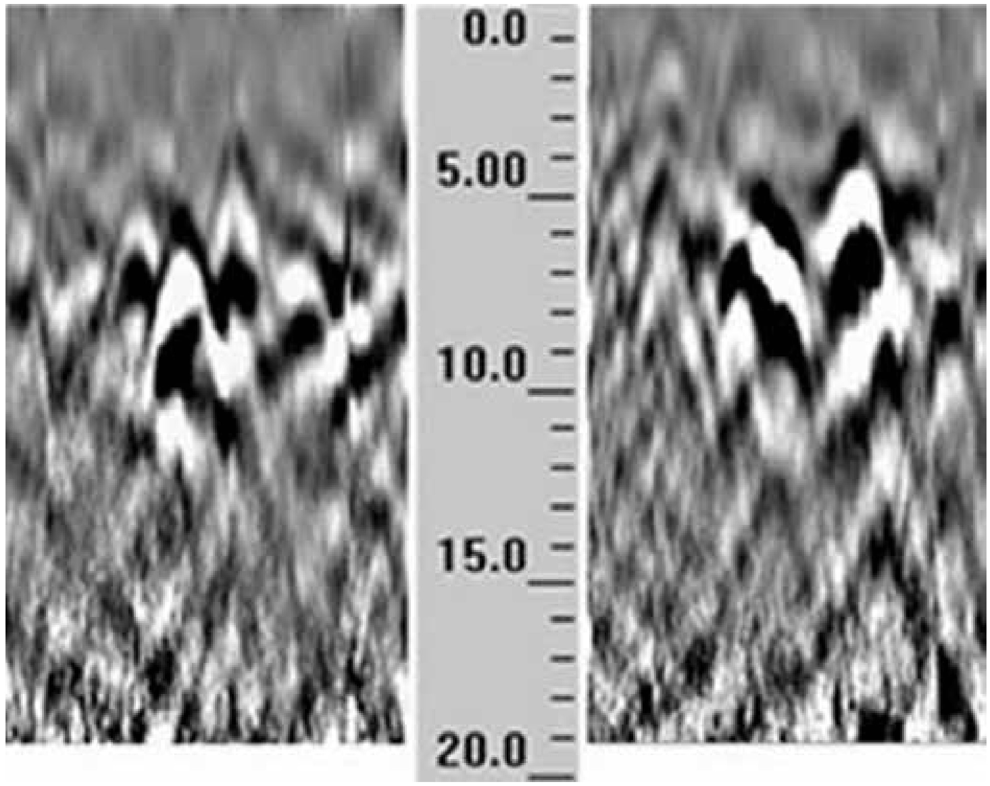
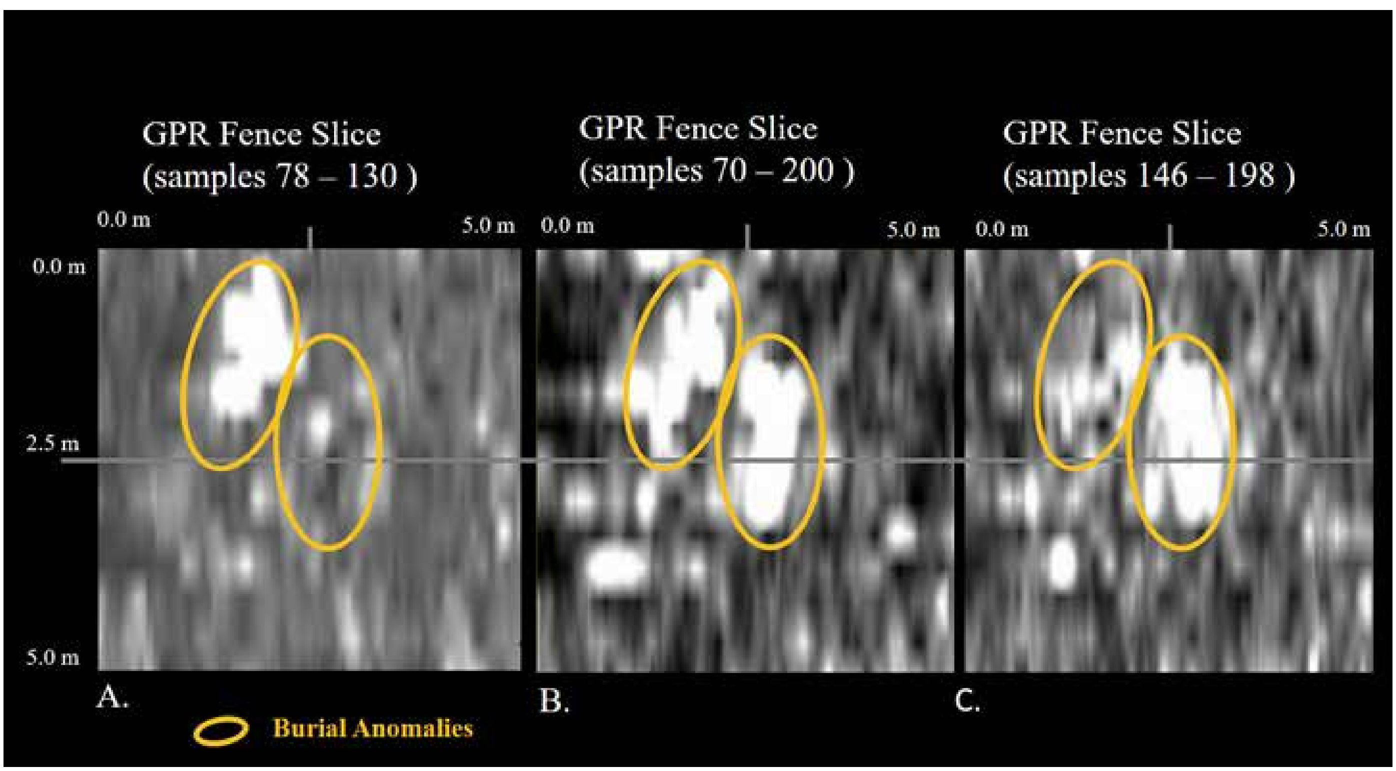


Figure 7: GPR profiles from ARF 2 show overlapping, but distinct targets. In this plot the clay was rather damp, and signals were attenuated quickly after ~18 nS. Profiles have been processed and corrected for surface position. Each profile is three meters wide.



Figures 8 A-C: Time slices showing GPR results over two closely spaced burials interred 1 year apart. More recent burial on right, which in turn was buried 1 year prior to survey. Narrow band time slices show how reducing the range of GPR collection can provide good resolution for distinguishing between complex anomalies.

Experimental Area 3

Experimental Area # 3 (ARF 3) contains the remains of three individuals in an area that is clay-rich with little to no top soil. Two individuals were positioned in a prone position in a close to north south direction. A third individual was positioned in a flexed manner with the torso in a supine position. This plot was surveyed during a period of heavy rain. Because of the saturation level in the very clay-rich soils, 400MHz GPR was attenuated quickly below surface, but the soil resistivity again registered a low resistance anomaly in a halo surrounding the burial feature (Figure 9). The GPR was able to identify differences in the subsurface, but the results were not clear enough to characterize the anomolies with confidence (Figure 10). We include all data in www.opencontext.org.

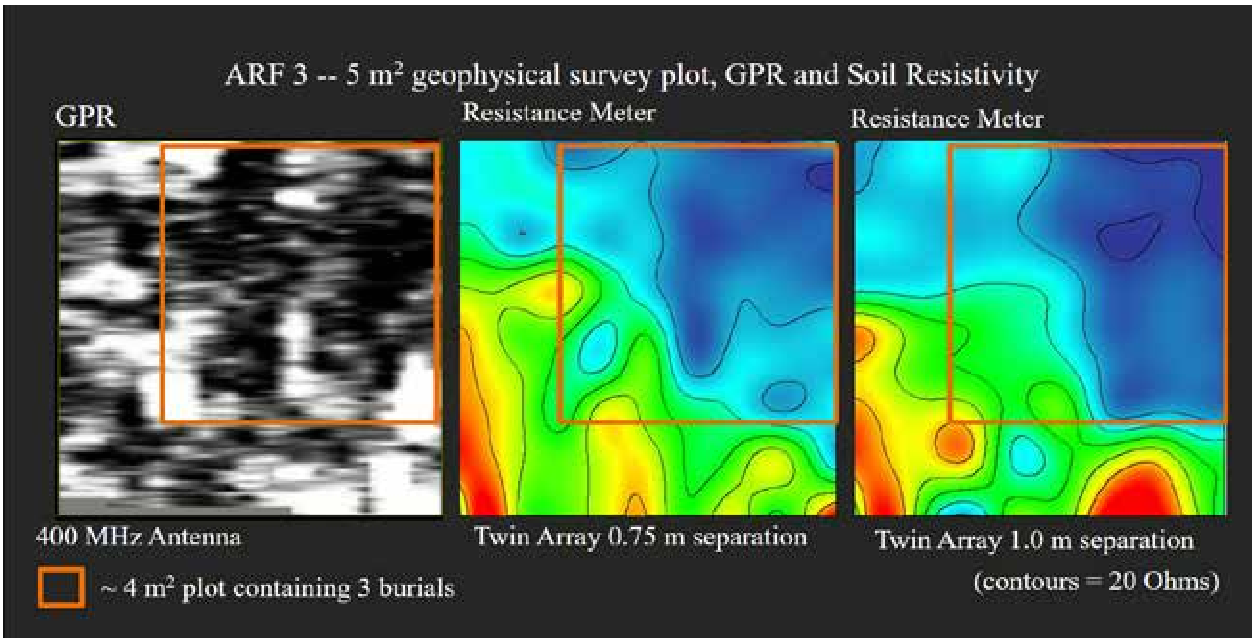


Figure 9: ARF 3 GPR and resistivity results during a rainy period.

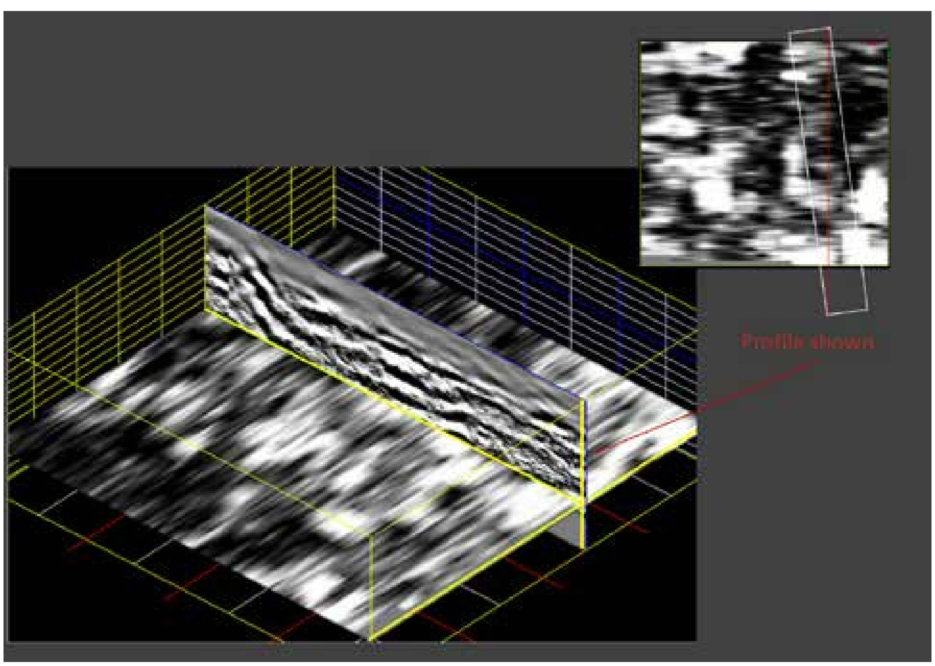


Figure 10: ARF 3 GPR 3D cube showing a profile directly over the burial pit. The edge of the excavation feature was detected, but the signal was attenuated quickly in the wet clay sediments, therefore the feature could not confidently be interpreted as a burial.

Historic Cemeteries with Marked and Unmarked Graves

Multiple historic cemeteries are available in the online collection. Some are extensive covering several acres, while others cover only several small plots. Burials in the historic cemeteries range over the last couple centuries. The cemetery discussed briefly below is one of three such surveys available for the comparative collection, together totaling several hundred cemetery burials. Figure 11 shows large scale survey results at a cemetery that has been continuously used at the Macedonia, Tennessee, United Methodist Church Cemetery. The large cemetery was mapped and every visible headstone recorded. The final results of the survey are presented in a single time slice, although multiple slices could provide more detail.

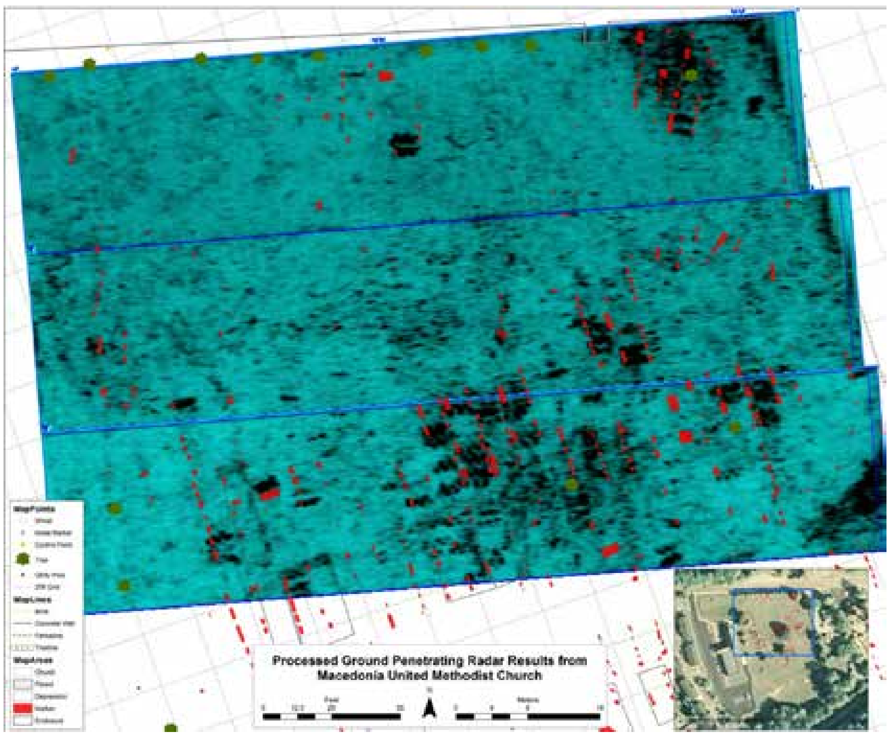


Figure 11: Plan view time slice from a large area GPR 3D survey at an historic cemetery. Monument markers and other above ground features are mapped in red. Burial anomalies are generally appearing as dark oblong features. Multiple areas with unmarked graves are visible.

Historic cemeteries in East and Middle Tennessee provide robust sets of comparative data. Some of the cemeteries like the one in Figure 11 have been continuously used for over 200 years, and provide an opportunity to examine burial contexts with variation in depth, treatment and containment diachronically—in similar soils. Results obtained over known burials are integrated into the survey for unmarked graves whenever possible. Producing a large database of these surveys, made open and available on the web with raw survey data and processed finals, is one of the long term goals of this research group.

Conclusion

The survey data compiled here supports the conclusion that the detection of burial features, within similar deposits/sediments, is predictable to at least some degree. For instance, in clay-rich sediments with poor drainage, a 400 MHz center frequency GPR produces consistent results. GPR results can be further resolved when the receiving antenna range time is reduced, effectively creating more densely sampled "good" data, and ignoring deeper weak responses. Additionally, the added support of soil resistivity provides much better data that are characteristic of ground disturbance and human interment. Final analysis is yet to be completed, but in the experimental settings, soil resistivity produces distinctive anomalies over human burial contexts.

Geophysical surveys can be a productive aspect in many shallow subsurface searches, especially for human remains. Many variables, however, like soil chemistry, morphology and depositional environment will play a major role in the successful imaging of an interment feature. The ultimate goal of this project is to define the variables that contribute to or detract from the detection threshold.

Maintaining a comparative collection of geophysical results over human burials is useful for several reasons. It will assist geophysical surveyors in the field, particularly those working in unfamiliar sediments/deposits during a recovery effort. It can be used by researchers and public officials to cite editorially-reviewed data for reports and other instruments, and it can be used for basic scientific research. The open-access comparative collection will continue grow as the research team and other contributors make surveys available, so that the collection can serve as basic data for computer modeling and simulation.

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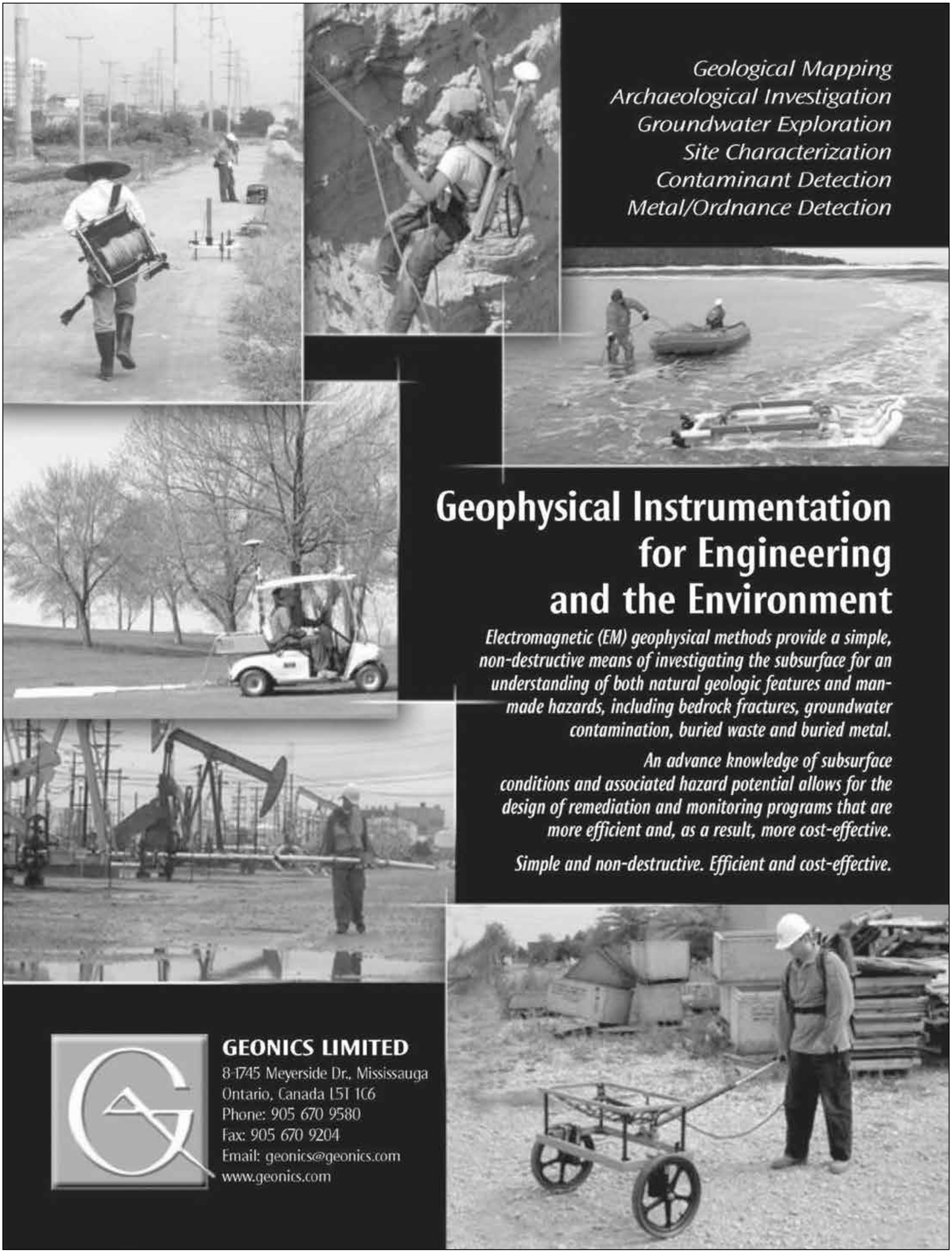
Geological Mapping
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Site Characterization
Contaminant Detection
Metal/Ordnance Detection
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Electromagnetic (EM) geophysical methods provide a simple, non-destructive means of investigating the subsurface for an understanding of both natural geologic features and man-made hazards, including bedrock fractures, groundwater contamination, buried waste and buried metal.
An advance knowledge of subsurface conditions and associated hazard potential allows for the design of remediation and monitoring programs that are more efficient and, as a result, more cost-effective.
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CANTO FLEGREO: SOUNDS FROM AN ACTIVE VOLCANIC CRATER

On 21st May the Solfatara Volcanic Crater, in Phlegrean Fields, Naples (Italy) hosted the first EM concert in the world. This combined scientific-musical event was performed by the E-Mago team (www.emago.earth), thanks to support of the Association of Geologists of Campania and sponsorship by Geostudi Astier. The E-mago project started at the beginning of this year, thanks to the meeting between Antonio Menghini, a geophysicist, and Michele Villetti, a musician, and involves a number of people (geologists, geophysicists, musicians, filmmaker, sound engineer, technicians). The goal was to sensitize people in achieving a right perception of Earth resources, by means of Music; the idea being to extract the effective "sound of the Earth" by using the Transient EM method (as reported by Menghini and Pontani, 2016). With this method, it is possible to enjoy landscapes by adding a sound component, so as to achieve a complete "land art" performance.

The project had a pretty didactic objective, as it is possible to explain in a humorous way to the general public the geophysical laws that govern the EM method. Our aim is also to encourage young students in exploring scientific matters.

The Campi Flegrei ("burning fields") or Phlegrean Fields is a large, 13 km wide nested caldera located under the western outskirts of the city of Naples and under the Gulf of Pozzuoli. It contains many volcanic features (cinder cones, tuff rings, calderas) that have been active during the past 30-40,000 years. The volcanic field has been the site of some extremely violent eruptions in the past, and it is nowadays considered as one of the most dangerous areas in the world. The presence of a still active magma chamber is confirmed by several solfataras, warm springs, gas vent emissions, and by frequent episodes of major ground deformation in the form of large scale uplift and depression of the surface (bradyseism). The Solfatara Crater (Figure 1), where the event took place, was considered the mythological home of the Roman god of fire, Vulcan. Steam can be seen escaping from fumaroles (Figure 2), and there are over 150 pools of boiling mud at last count. Several subsidiary cones and tuff craters lie within the caldera. One crater is filled by Lake Avernus, which was believed to be the entrance to the underworld (as quoted by Virgil in the *Aeneid*).

Figure 1: The rim of Solfatara crater.

Figure 2: One of the gas vents (fumaroles). The orange alterations are due to the precipitation of sulfur crystals.

The TEM sounding was performed by Stefano Floris and Matteo Pelorosso (S.Te.G.A.) with a Geonics Protem 47, a 20 x 20 m Tx loop and a high-frequency receiver coil, having an effective area of 31.4 m^2 (Figure 3). Only the 250 Hz base frequency was collected, so as to sample voltage values until about 0.6 msec. The sounds extracted from the crater of Pozzuoli Solfatara, after data sonification performed by Antonio Menghini and Stefano Pontani (Figure 4) on-site, have produced this musical track: http://www.emago.earth/uncategorized/canto-flegreo/.

Figure 3: Acquisition of TEM data by means of a Geonics Protem 47.

Figure 4: Data sonification step: transforming the voltage response into musical pitches.

It's important to keep in mind that the listening times were expanded by 1 million times, in comparison with the actual recording times of geophysical data. Hence, each time we are speaking of seconds, we should actually refer to as microseconds. Figure 5 shows the transient with the X axis in seconds (after the time expansion). For each time gate, a corresponding musical note was inserted.

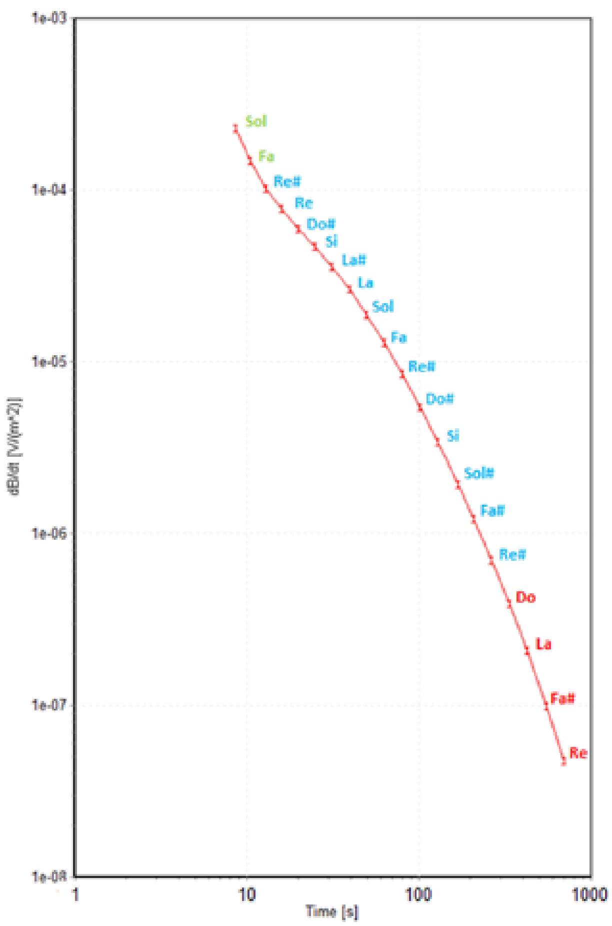

Figure 5: Transient of the TEM sounding performed inside the Solfatara crater. The first two notes (in green) are associated to the shallower pyroclastic layer, affected by fractures and huge gas manifestations. Blue notes are related to pyroclastics saturated by thermal waters. The third layer (resistive volcanic substratum) produces the red notes at the end.

The initial sound has not any relationship with the actual voltage response and has only the scope to provide an idea of the impulse that excites the Earth. The first half of the musical track (about 12 minutes) is referred to the travel of the eddy currents from the surface to the maximum exploration depth (in this case about 80 m), whereas the second half shows the reverse path.

On the basis of the resistivity model we achieved, we can associate the first two notes, until 10 seconds, to the shallower pyroclastic layer, affected by fractures and huge gas manifestations, with a thickness of about 8 m and resistivity of 15 ohm-m. This low resistivity translates into high tone pitches. It must be stated that when the first note arrives, the signal has already went down about 4-5 m. The notes associated with this first layer are highlighted in green.

From here a marked chromaticism can be observed (blue notes), due to the very slow decay of the transient, caused by the occurrence of a highly conductive layer (4 ohm-m), interpreted as pyroclastics saturated by thermal waters. Most of the track develops from this geological formation, as the eddy currents slow down dramatically. The sounds played until 6 minutes and 18 seconds are produced by this second layer, that is present down 31 m depth.

From this point until the end of the first part, a sudden acceleration of the eddy currents' propagation is observed, due to the presence of a volcanic substratum that is more resistive (14 ohm-m), so that in only 4 minutes they cover about 60 m. The musical notes, shown in red, arrange themselves in wider intervals (C, A, F# and D), according to an unforeseeable D7 chord, that we can certainly associate to the third layer. The signal decays more and more, as evidenced by the lowering of audio volume.

This musical base was the same used by the Michele Villetti Quartet (Michele Villetti: drums; Francesco Mascio: guitar; Stefano Battaglia: double-bass; Luigi Tresca: sax) and by Flavio Boltro (trumpet) to play the Canto Flegreo concert (Figure 6). The beginning of the concert can be listened to here: https://www.youtube.com/watch?v=sjnoDX-M0Fg .

Figure 6: The concert performed by Michele Villetti Quartet (from left: Francesco Mascio, guitar - Michele Villetti - drums; Stefano Battaglia - double bass; Luigi Tresca - sax) with Flavio Boltro (trumpet) as special guest. They have improvised over the musical soundtrack provided by the geological setting of the Solfatara crater.

A lot of positive feedback has been received. First, people who did not know anything about geophysics had the opportunity to see instruments at work and to understand how it is possible to recover the subsurface structure, without drilling or excavations. Second, they had the chance to enjoy the suggestive landscape scenario, by adding a natural soundtrack. Last, but not least, it has demonstrated that the dissemination of scientific knowledge can be achieved by an appealing way.
The other E-Mago staff personnel are: Riccardo Scorsino (sound engineer), Giulia Selvaggini (film-maker and photographer), Leonardo Vietri (press and media coordinator) and Riccardo Marini (management, lawyer consultant, and web designer).

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geoDRONE Report

Ron Bell, rbell@igsdenver.com tel: 720-220-3596

The FAA to Release Rules for sUAS Soon!

31 MAY 2016

On Friday, May 27th Marke "Hoot" Gibson, a retired USAF Major General presently serving as a Special Advisor on UAS Integration to the FAA spoke to an audience of nearly 100 UAS professionals based along the Colorado Front Range. The event was hosted by the State of Colorado Office of Economic Development and International Trade and at Metropolitan State University in Denver, CO, which incidentally announced the creation of an aeronautical engineering and advanced manufacturing programs with an emphasis on UAS to their curriculum offerings. In a nutshell, General Gibson's message was simply that the FAA expects to roll out the rules of the use of drones in the National Air Space (NAS) in June 2016 with the likely involvement of President Obama.

According to General Gibson, as of the end of May 2016, the FAA has received more than 12,000 Exemption 333 petitions for sUAS COAs, processed about 50% of them, and awarded 5000+ COAs for companies and individuals. When the rules have been officially rolled out, the system for obtaining a Certificate of Authorization (C.O.A) will be streamlined. A COA is required in order to legally operate a sUAS commercially in the NAS. At present, the FAA requires a minimum of 90 days to process an application for a COA and there have been reports of a 5 to 7 month delay due to the backlog.

SAGEEP 2016 – geoDRONEology short course

On March 20th and again on April 24th, my colleague Rene Perez and I conducted a short course titled ***geoDRONEology©: integrating drones into the geoscientific and engineering workflow.*** The March version of the short course was presented as an educational offering at the SAGEEP 2016 conference and the second (April) event was an educational offering complete with Continuing Education Units (CEU) at the NGWA Ground Water Summit.

NGWA Ground Water Summit – geoDRONEology

Both short courses were well attended and included special presentations by geologists and geophysicists presently using drones in their research or business. All of the participants expressed satisfaction with the course content with many sharing that, as a result of the course, they gained a better understanding of the applicability of UAS technology and developed new ideas about how they will use drones in their business and work.

At both events, sUAS manufacturers and service providers presented on their technology and the current applications of their customers. In addition, a sUAS networking event was held after the end of the geoDRONEology course work.

One March 21st, the presenters in the ***Drones in Geophysics*** session at SAGEEP 2016 meeting highlighted the use of drones for capturing LiDAR, hyperspectral, low altitude L-band, tensor VLF-EM, magnetic, and photogrammetric data.

SAGEEP 2016 - Drones in Geophysics Session

geoDRONEology networking – April 2016

Perhaps, it is time for you to consider integrating a drone into the workflow of your business. If you wish to learn more about what is required to do so, please feel free to e-mail me at rbell@igsdenver.com.

The **geoDRONE Repot** is a mix of reporting and opinion pertaining to the use of robotic systems by geologists, geophysicists, and engineers to the study of the earth and earth processes. If you wish to contribute, contact Ron Bell at rbell@igsdenver.com.

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

April 29, 2016

New Tomography Software for Cross Hole Sonic Logging: PDI-Tomo

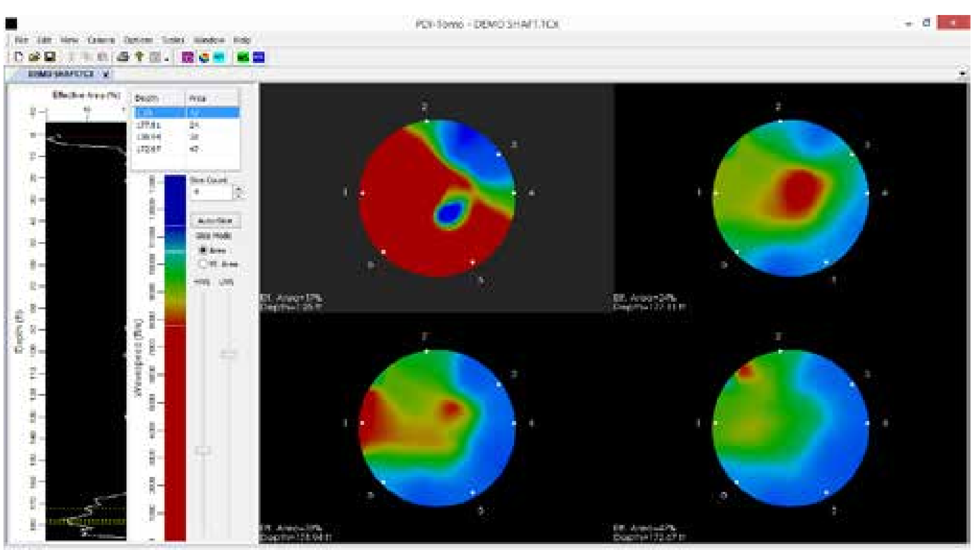
Pile Dynamics has released the new PDI-Tomo software for analysis of Crosshole Sonic Logging (CSL) data. The program replaces an older tomography program, with significant advantages.

Crosshole Sonic Logging evaluates the integrity of the concrete of drilled shafts and other bored or cast-in-place deep foundations. Ultrasonic transmitters and receivers are inserted in the foundation and an instrument such as the Pile Dynamics' brand CHAMP-XV collects the data. Its software CHA-W analyses the propagation of the waves emitted by the transmitters, indicating potential concrete problems.

Tomography Analysis with PDI-Tomo takes the examination many steps further, allowing a better estimate of the extent of irregularities or defects. It combines arrival time data from the scans of all pairs of tubes, analyses the data and displays it in various views.

Once CSL testing is complete and data is processed, the transition from CHA-W to PDI-Tomo is done in one seamless step. PDI-Tomo has been designed for fast data processing, improving the productivity of CHAMP-XV users. Program functions are intuitive and many features are automatic (for example, PDI-Tomo find the depths where data suggests that a detailed investigation of integrity may be warranted). The professional looking PDI-Tomo output is highly customizable to fit the needs of each user.

For more information on this testing system visit www.pile.com/CHAMP. The CHAMP-XV and PDI-Tomo are just one of a growing line of Pile Dynamics Systems for quality assurance and quality control of deep foundations. Pile Dynamics is based in Cleveland, Ohio, USA; its products are sold around the world through PDI's network of representatives.



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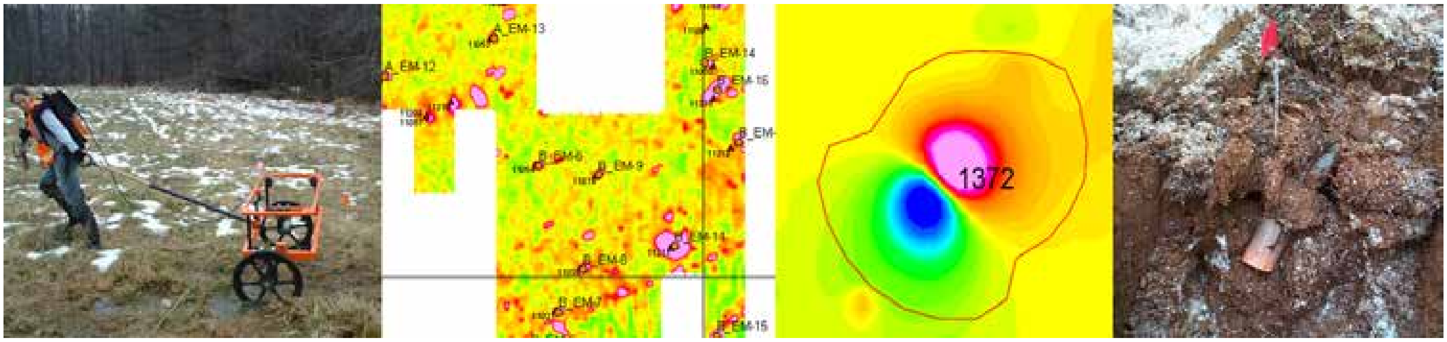
Geosoft Releases UXO Land and Updated UXO Marine



In June, Geosoft is pleased to release UXO Land, a new extension for Oasis montaj that provides a complete suite of tools for working with terrestrial UXO survey data (EM61 and magnetics). UXO Land incorporates the features previously available in the UX-Detect <http://www.geosoft.com/products/software-extensions/ux-detect> and UX-Process <http://www.geosoft.com/products/government-sponsored-uxo-software#ux-process> extensions into a single workflow that takes users through all the steps from survey planning to target identification and analysis. Included in UXO Land are quality control and assurance (QA/QC), processing, visualization, target picking, target prioritization, and target management.

With the expiry of US Department of Defense funding for maintenance and support of UX-Process as of September 2015, Geosoft has agreed to continue supporting customers through merging these two previous extensions into UXO Land. Geosoft will continue the provision, maintenance, testing and ongoing technical support of the UX-Process capabilities as part of UXO Land, for all of its users who currently have a maintained Oasis montaj and UX-Detect license.

The UX-Detect and UX-Process menus are already fully integrated, so supported users will mainly notice branding changes in the licensing information as well as online help and How To guides.

The new UXO Land packaging is complementary to Geosoft's UXO Marine <http://www.geosoft.com/products/software-extensions/uxo-marine/overview> package for working with magnetic data in the marine environment. An updated UXO Marine is also being released in June. Geosoft previewed the new modelling and analysis capabilities in UXO Marine at the Oceanology International 2016 and SAGEEP 2016 conferences in March.

Building on UXO Marine's existing capabilities for magnetic data processing, analysis and visualization the update includes tools that make it easier and more efficient to process data from large gradient sensor arrays, and model targets from magnetic data. Highlights include:

- Improved, automated batch modelling of magnetic data. Supports the sparse data commonly seen in many marine magnetic and gradiometer surveys, and provides output of magnetic moment;

- Rotated maps. When you create a map, you can now rotate the data view in any direction on the map so that north is not necessarily at the top of the page. This enables you to find the best fit for your data to the page or screen. It is also useful for creating maps that have the map boundary parallel to the survey direction or to maximize the coverage of the map for long narrow surveys. It may also increase some processing and visualization speeds by an order of magnitude or more;

- Expanded tools for gradient sensor arrays that accommodate any number of sensors and configurations;

- Calculate the "Analytical Signal" directly from measured vertical magnetic gradients, in surveys where magnetic gradient measurements are dense enough to be gridded;

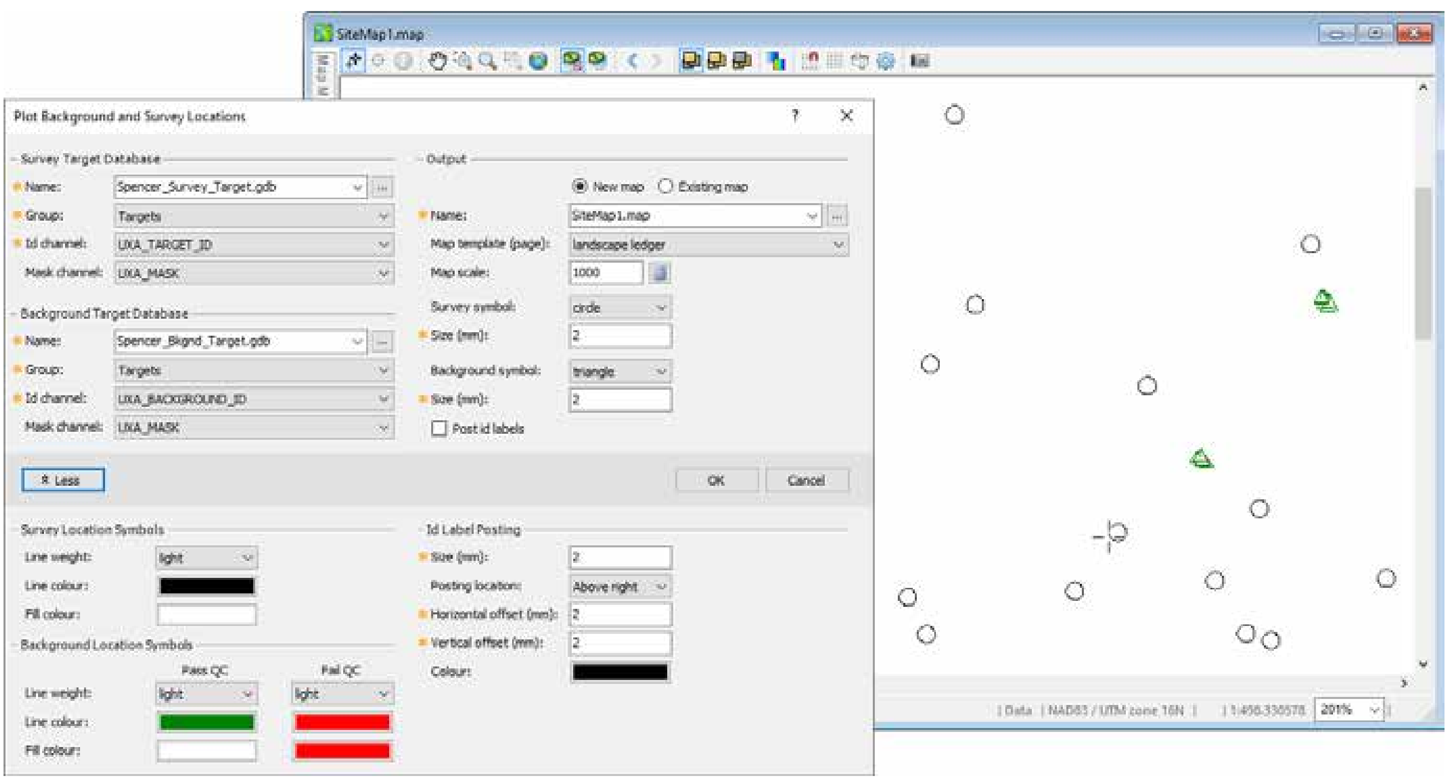
- An improved "Add Target" tool to automatically find the closest peak to the picked location, when picking targets from profile data in the database;

- Additional lag and offset tools to correct the path or location of your survey data;

- Import any number of survey files at once. Avoids having to create batch import scripts for ASCII or raw data imports. The files must all have the same format or structure.
With these new features, UXO Marine will provide a more comprehensive workflow for marine geophysics and address industry requirements for tools to rapidly and reliably process, analyze and map high volumes of magnetic data for accurate target detection within subsea environments.

Both UXO Land and the updated UXO Marine are being released with Oasis montaj v9.0 in June 2016. Here is a comparison<http://www.geosoft.com/media/uploads/resources/geosoft-uxo-product-comparison-chart-aug27-15.pdf> of the current UXO data processing offerings from Geosoft.

Contact us with any questions about UXO Land - UXO Marine: http://www.geosoft.com/contact-us/



WWW.EEGS.ORG/SAGEEP 2017/EXHIBITS

Anniversary SAGEEP 2017

SPECIAL ANNOUNCEMENT

EEGS is pleased to announce that **SAGEEP** and the National Ground Water Association's (NGWA) **Hydrogeophysics and Deep Groundwater Conference** will be held concurrently. Participants will benefit from expanded sessions and additional short courses.

2017 MARCH 19 20 21 22 23

Denver Marriott City Center Downtown
Denver Colorado USA

General Chair
Dale Werkema, Ph.D.
Werkema.D@epamail.epa.gov

Technical Chair
Elliot Grunewald, Ph.D.
elliot@vista-clara.com

Plan to join us in Colorado, site of the first SAGEEP, and help celebrate 30 Years of this iconic near surface geophysics conference.

Call for Session Topics and Abstracts Soon!

Symposium on the Application of Geophysics to Engineering and Environmental Problems

COMING EVENTS AND ANNOUNCEMENTS

SAGEEP 2017

The Conference

SAGEEP is internationally recognized as the leading conference on the practical application of shallow geophysics. Since 1988, the symposium has featured over 200 oral and poster presentations, educational short courses and workshops, a commercial exhibition and field trips. 2017 will be a special SAGEEP: It is the 30th Anniversary **and** NGWA will colocate its Hydrogeophysics and Deep Groundwater Conference in Denver, CO!

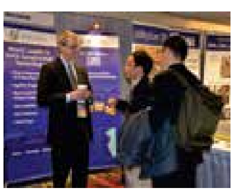
About the City

Denver, the Mile High City, a thriving cultural scene, diverse neighborhoods, and natural beauty is one of the world's most spectacular playgrounds. Located 12 miles east of the "foothills," Denver is situated at the base of the Colorado Rocky Mountains. Since its Wild West beginnings, Denver has evolved into a young, active city - stunning architecture, award-winning dining, unparalleled views year-round and 300 days of sunshine a year. The conference will be held in downtown Denver - the heart of the city.

The Technical Program/Call for Session Ideas

The Technical Program typically features over 200 oral and poster presentations. Authors will be invited to submit abstracts online in late summer. The SAGEEP 2017 Technical Committee will be calling for session topics and a list of planned sessions will be posted to the SAGEEP 2017 web site (click Sessions/Abstracts). Contact: Technical Chair Elliot Grunewald elliot@vista-clara.com.

The Exhibits/Exhibitors Outdoor Equipment Demonstrations



In addition to 14,000 square feet of exhibition space, exhibitors will conduct equipment demonstrations at an outdoor location. The addition of NGWA attendees will result in an even wider audience of geophysics professionals interested in the latest in equipment, software and services - they will find it at SAGEEP 2017.

Sponsorships and Other Supporting Opportunities

Sponsoring an event, luncheon, or conference materials is an effective and economical way to increase visibility for your organization or services, reaching a targeted audience of geophysicists from many disciplines.

Exhibits Manager I Micki Allen I Marac Enterprises I mickiallen@marac.com

WWW.EEGS.ORG/SAGEEP 2017/SPONSORSHIPS

WWW.EEGS.ORG/SAGEEP 2017/EXHIBITS

COMING EVENTS AND ANNOUNCEMENTS

Call for Papers

The 7th International Conference on Environmental and Engineering Geophysics (ICEEG) was held in Beijing from June 26-29, 2016. We plan to publish a special issue in Engineering (the top journal of the Chinese Academy of Engineering) by inviting authors from ICEEG and other scientists who work on near-surface geophysics. You are encouraged to contribute your current research to this special issue. We plan to publish the issue in the early 2017, so the deadline is tentatively set for October 31, 2016. To reduce the possibility of delay, you can send manuscripts directly to Jianghai Xia (jianghai_xia@yahoo.com or jhxia@zju.edu.cn). Any topics related to near-surface geophysics will be given consideration for inclusion in this special issue. Please do not hesitate to contact Jianghai Xia if you have any questions.

COMING EVENTS AND ANNOUNCEMENTS

Letter from Phil Sirles - 2016 Recipient of the John Nicholl Memorial Award

To my EEGS Friends,

It is with a humble heart that I share my thoughts about receiving the ***John Nicholl Memorial Award*** at SAGEEP 2016. I was told a while back I would be asked to write this letter for FastTIMES, and I had a million thoughts about what to say. But then the time comes to put something this meaningful into words, and it not so easy.

John Nicholl meant the world to me. EEGS means the world to me. So, needless to say, this Memorial award means the world to me. John and EEGS / SAGEEP have had an integral part for my career growth in geophysics; one, was just lost too soon. For those of you in Denver this year, you heard me refer to John as a friend, a mentor in life and faith, and 'one hell of a geophysicist'. But the fun part is how Dr. Cathy Skokan introduced me as "having a 30-year career" when honoring me for the award. Little did Cathy, or anyone in the room, know that I could have had a 30 'AND-A-HALF' year career, if not for one Mr. Nicholl! See, John was my very first interview after graduating with a masters from Mackay School of Mines. He told me over the phone that he had an opening. I guess after meeting me in person, he felt differently (the story goes that the funding went away). So, I waited tables for 6 months. For almost 30 years afterward John and I were able to laugh-out-loud about this initial introduction to my career, and how often our careers paths crossed. Beer usually aided the laughter.

The fun really started when my first job at the Bureau of Reclamation meant that I got to hire John as 'my consultant'. This was way cool because, now John worked for me. After that, I was able to conduct projects with and for him as a consultant at MicroGeophysics Corporation. Then, while serving as an officer in EEGS we shared many hours together in the board room. As fate would have it, after my year as EEGS President, in February 2000 I had the pleasure of handing John the gavel at SAGEEP in Washington DC. Yes, there certainly was a grin on my face to hand that EEGS gavel to the gent who turned me down for a job. Yep, he followed me ...as President of EEGS.

All that malarkey and ancient history aside, John's leadership and contribution to EEGS was unparalleled. I was extremely lucky have followed him as the Past-President. Our society... no, our industry was better because of John. It is better because of John. He is worthy of a memorial award. No one who knew John will forget his wide smile, his wit, or his ability to navigate difficult situations. I feel John's strength as a geophysicist, a man, and a leader was rooted in his faith. There too, I was lucky enough to have shared in his faith journey. He would stand tall, talk of his faith, and walk-the-walk; that is what I will most remember about John.

Receiving this Memorial award means everything to me. Seeing my colleagues, John Nicholl's daughter, brother, sister, and mother in the audience when I received it will forever be THE HIGHLIGHT of my career. No job, no 'amazing geophysical solution' or any project will ever compare. The beautiful glass award sits front-and-center on our hearth at home. Sure, it seems like a work- or career-type accomplishment; but for me, this is so much more. Maybe one day the John Nicholl Memorial Award will go to my office, like other tokens received through a career. Nah, just kidding, not this one.

I want to thank so many people. Rather, the phrase "it takes a village" comes to mind. We are that village. Presenting my very first professional paper at the 1988 (1st) SAGEEP, surely kicked things in motion that I never could have imagined. The professionals in this industry, the mentors, the friends and comrades I have had the pleasure to work for- and built friendships with- are all to be given credit for anything I have accomplished. In addition to thanking John for many of the steps in my career, I thank my wife Nora as she put up with me waiting tables until the geophysical career began in 1986 (and the field work ever since!). I truly hope John's memory will live on for you, as it does for me. And that the faith he shared with so many of us, will continue to help us all become better people, leaders, and contributors to EEGS and the near surface community of geophysicists as a whole. So, I recommend you get involved, stay involved, and learn to love and contribute to the societies our industry is made of, because that participation will, indeed, enhance your career.

Thank you all for this honor.

COO / Principal Geophysicist
Olson Engineering, Inc.

Recipient of the 2016 John Nicoll Memorial Award - Phil Sirles

The Nicoll Family with Phil Sirles

COMING EVENTS AND ANNOUNCEMENTS

Note from Andrew Parsekian
2016 Recipient of the EEGS/Geonics Early Career Award

I am humbled and privileged to have accepted the EEGS Early Career Award at this year's SAGEEP meeting in Denver. I recall attending my very first SAGEEP meeting in 2008 as a new graduate student and attending the session when the inaugural instance of this award was conferred. Since that time, I have viewed each subsequent Early Career Award winner as a role model and therefore it is a great honor to now be considered among this group. I am very thankful to those who nominated me for the award, to the EEGS Early Career Award Committee, and to the leadership of EEGS. I also thank my former academic advisors Lee Slater and Rosemary Knight for invaluable guidance that formed a strong foundation on which to build an academic career in near-surface geophysics.

Individual Membership Categories

EEGS is the premier organization for geophysics applied to engineering and environmental problems. Our multi-disciplinary blend of professionals from the private sector, academia, and government offers a unique opportunity to network with researchers, practitioners, and users of near-surface geophysical methods.

Memberships include access to the *Journal of Environmental & Engineering Geophysics (JEEG*), proceedings archives of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), and our quarterly electronic newsletter, *FastTIMES*. Members also enjoy complimentary access to SEG's technical program expanded abstracts, as well as discounted SAGEEP registration fees, books and other educational publications. EEGS offers a variety of membership categories tailored to fit your needs. Please select (circle) your membership category and indicate your willingness to support student members below:

☐ **Yes, I wish to sponsor ________ student(s) @ $20 each to be included in my membership payment.**

Individual Members

Individual members are invited to sponsor student members. Simply indicate the number of students you'd like to support (at $20 each) to encourage growth in this important segment of EEGS' membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Individual	$90	$130

Retired Members

Your opportunity to stay connected and support the only organization focusing on near surface geophysics. Retired members are invited to sponsor student members. Simply indicate the number of students you'd like to support (at $20 each) to encourage growth in this important segment of EEGS' membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Retired (*Must be Approved by EEGS Board of Directors)*	$50	$130

Introductory Members

If you have not been a member of EEGS before, we offer a reduced rate (electronic JEEG option) for new members to enjoy all the benefits of individual membership (except vote or hold office) for one year.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Introductory	$50	$130

Lifetime Members

New! Support EEGS, receive benefits on an ongoing basis and never renew again! Members of this category enjoy all the benefits of Individual membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Lifetime Member	$995	$995

Developing World Members

Those wishing to join this category of EEGS membership are invited to check the list of countries to determine qualification.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Developing World *(List of qualifying countries next page)*	$50	$130

Student Members

Students represent EEGS' future and we offer complimentary membership subsidized by Corporate Student Sponsor Members and those who sponsor students. Student members enjoy all the benefits of individual membership (except to vote or hold office). Available for all students in an accredited university up to one year post-graduation. Please submit a copy of your student ID and indicate your projected date of graduation: ___ /____ (Month/Year). New! Students in year two beyond graduation are offered a special rate for 1 year.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Student up to 1 Year Post Graduation	$ 0	$90
Student - Year Two Post Graduation **(Grad Date: Mo/Yr.: ___/___)**	$50	$90

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 $130.00 if you would like the printed, quarterly *Journal of Environmental & Engineering Geophysics* (*JEEG*) 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-Bissau
GuyanaHaiti
Honduras
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
Paraguay
Philippines
Rwanda
Samoa
Sao Tome and Principe
Senegal
Sierra Leone
Solomon Islands
Somalia
Sri Lanka
Sudan
Suriname
Swaziland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Tunisia
Turkmenistan
Uganda
Ukraine
Uzbekistan
Vanuatu
Vietnam
West Bank and Gaza
Yemen
Zambia
Zimbabwe

1720 South Bellaire Street | Suite 110 | Denver, CO 80222-4303
(p) 001.1.303.531.7517 | (f) 001.1.303.820.3844 | staff@eegs.org | www.eegs.org

Environmental and Engineering Geophysical Society

2016 EEGS Membership Application

Renew or Join Online at www.EEGS.org

CONTACT INFORMATION

Salutation	First Name	Middle Initial	Last Name

Company/Organization	Title

Street Address	City	State/Province	Zip Code	Country

Direct Phone	Mobile Phone	Fax

Email	Website

ABOUT ME: INTERESTS & EXPERTISE

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

Role	Interest or Focus	Geophysical Expertise	Professional/ Scientific Societies	Willing to Serve on a Committee?
☐ Consultant	☐ Archaeology	☐ Borehole Geophysical Logging	☐ AAPG	☐ Publications
☐ User of Geophysical Svcs.	☐ Engineering	☐ Electrical Methods	☐ AEG	☐ Web Site
☐ Student	☐ Environmental	☐ Electromagnetics	☐ ASCE	☐ Membership
☐ Geophysical Contractor	☐ Geotechnical	☐ Gravity	☐ AWWA	☐ Student
☐ Equipment Manufacturer	☐ Geo. Infrastructure	☐ Ground Penetrating Radar	☐ AGU	
☐ Software Manufacturer	☐ Groundwater	☐ Magnetics	☐ EAGE	
☐ Research/Academia	☐ Hazardous Waste	☐ Marine Geophysics	☐ EERI	
☐ Government Agency	☐ Humanitarian Geo.	☐ Remote Sensing	☐ GeoInstitute	
☐ Other	☐ Mining	☐ Seismic	☐ GSA	
	☐ Shallow Oil & Gas	☐ Other	☐ NGWA	
	☐ UXO		☐ NSG	
	☐ Aerial Geophysics		☐ SEG	
	☐ Other		☐ SSA	
			☐ SPWLA	

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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 appreciated. For additional information about the EEGS Foundation (an IRS status 501(c)(3) tax exempt public charity), visit the website at http://www.EEGSFoundation.org.

Foundation Fund Total: $ ____________

STUDENT SUPPORT ENDOWMENT

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Corporate Contribution Total: $ ____________

Foundation Total: $ ____________

PAYMENT INFORMATION

☐ Check/Money Order ☐ VISA ☐ MasterCard

☐ AmEx ☐ Discover

Subtotals

Membership: $ ____________

Student Sponsorship: $ ____________

Foundation Contributions: $ ____________

Grand Total: $ ____________

Card Number **Exp. Date** **CVV #:**

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 001.1.303.820.3844

Corporate dues payments, once paid, are non-refundable. Individual dues are non-refundable except in cases of extreme hardship and will be considered on a case-by-case basis by the EEGS Board of Directors. Requests for refunds must be submitted in writing to the EEGS business office.

QUESTIONS? CALL 001.1.303.531.7517

Environmental and Engineering Geophysical Society	Renew or Join Online at www.EEGS.org
2016 Corporate Membership Application	

EEGS is the premier organization for geophysics applied to engineering and environmental problems. Our multi-disciplinary blend of professionals from the private sector, academia, and government offers a unique opportunity to network with researchers, practitioners, and users of near-surface geophysical methods.

Memberships include access to the *Journal of Environmental & Engineering Geophysics (JEEG*), proceedings archives of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), and our quarterly electronic newsletter *FastTIMES*. Members also enjoy complimentary access to SEG's technical program expanded abstracts as well as discounted SAGEEP registration fees, books and other educational publications. EEGS offers a variety of membership categories tailored to fit your needs. We strive to continuously add value to all the Corporate Membership categories. For the best value, we offer the Basic + Web ad Package Website Advertising opportunities. Please select (circle) your membership category and rate. EEGS is also offering an opportunity for all EEGS members to help support student(s) at $20 each. Please indicate your willingness to contribute to support of student members below:

☐ **Yes, I wish to support ____ student(s) at $20 each to be included in my membership payment.**

Category	2016 Electronic JEEG	2016 Basic Rate (print JEEG)	2016 Basic + Web Ad Package
Corporate Student Sponsor *Includes one (1) individual membership, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES and Sponsorship of 10 student memberships*	$310	$340	$840
Corporate Donor *Includes one (1) individual EEGS membership, one (1) full conference registration to SAGEEP, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$660	$690	$1190
Corporate Associate *Includes two (2) individual EEGS memberships, an exhibit booth and registration at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$2410	$2440	$2940
Corporate Benefactor *Includes two (2) individual memberships to EEGS, two (2) exhibit booths and registrations at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$4010	$4040	$4540
Website Advertising *One (1) Pop-Under, scrolling marquee style ad with tag line on Home page, logo linked to Company web site* *One (1) Button sized ad, linked logo, right rail on each web page*	Purchase Separately $600/yr. $250/yr.	$600/yr. $250/yr.	Package Rates include both website ad locations

Environmental and Engineering Geophysical Society	Renew or Join Online at www.EEGS.org
2016 EEGS Corporate Membership Application	

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☐ Equipment Manufacturer	☐ Geo. Infrastructure	☐ Ground Penetrating Radar	☐ AGU	
☐ Software Manufacturer	☐ Groundwater	☐ Magnetics	☐ EAGE	
☐ Research/Academia	☐ Hazardous Waste	☐ Marine Geophysics	☐ EERI	
☐ Government Agency	☐ Humanitarian Geo.	☐ Remote Sensing	☐ GeoInstitute	
☐ Other	☐ Mining	☐ Seismic	☐ GSA	
	☐ Shallow Oil & Gas	☐ Other	☐ NGWA	
	☐ UXO		☐ NSG	
	☐ Aerial Geophysics		☐ SEG	
	☐ Other		☐ SSA	
			☐ SPWLA	

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Foundation Total: $ ____________

PAYMENT INFORMATION

- ☐ Check/Money Order
- ☐ VISA
- ☐ MasterCard
- ☐ AmEx
- ☐ Discover

Subtotals

Membership: $ ____________

Student Sponsorship: $ ____________

Foundation Contributions: $ ____________

Grand Total: $ ____________

Card Number ____________ **Exp. Date** ____________

Name on Card ____________ **CVV#** ____________

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.

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QUESTIONS? CALL 001.1.303.531.7517

EEGS CORPORATE MEMBERS

Corporate Benefactor

Your Company Here!

Corporate Associate

Advanced Geosciences, Inc.
www.agiusa.com

Allied Associates Geophysical Ltd.
www.allied-associates.co.uk

CGG Canada Services Ltd.
www.cgg.com

Exploration Instruments LLC
www.expins.com

Geogiga Technology Corporation
www.geogiga.com

Geometrics, Inc.
www.geometrics.com

Geonics Ltd.
www.geonics.com

Geophysical Survey Systems, Inc.
www.geophysical.com

Geosoft Inc.
www.geosoft.com

Geostuff
www.geostuff.com

GeoVista Ltd.
www.geovista.co.uk

Interpex Ltd.
www.interpex.com

Mount Sopris Instruments
www.mountsopris.com

Northwest Geophysics
www.northwestgeophysics.com

Ontash & Ermac, Inc.
www.ontash.com

R. T. Clark Co. Inc.
www.rtclark.com

Sensors & Software Inc.
www.sensoft.ca

Scintrex Limited
www.scintrexltd.com

Vista Clara Inc.
www.vista-clara.com

Zonge international, Inc
www.zonge.com

Corporate Donor

Fugro Consultants, Inc.
www.fugroconsultants.com

Geomar Software Inc.
www.geomar.com

Geomatrix Earth Science Ltd.
www.geomatrix.co.uk

Quality Geosciences Company, LLC
www.quality-geophysics.com

Spotlight Geophysical Services
www.spotlightgeo.com

EEGS STORE

Environmental and Engineering Geophysical Society

2016 Publications and Merchandise Order Form

1720 S. Bellaire Street, Suite 110
Denver, CO 80222-4303
Phone: 303.531.7517; Fax: 303.820.3844
E-mail: staff@eegs.org; Web Site: www.eegs.org

Sold To:
Name: ______________________
Company: ______________________
Address: ______________________
City/State/Zip: ______________________
Country: ____________ Phone: ____________
E-mail: ____________ Fax: ____________

Ship To (If different from "Sold To":
Name: ______________________
Company: ______________________
Address: ______________________
City/State/Zip: ______________________
Country: ____________ Phone: ____________
E-mail: ____________ Fax: ____________

Instructions: Please complete both pages of this order form and fax or mail the form to the EEGS office listed above. Payment must accompany the form or materials will not be shipped. Faxing a copy of a check does not constitute payment and the order will be held until payment is received. Purchase orders will be held until payment is received. If you have questions regarding any of the items, please contact the EEGS Office. Thank you for your order!

SAGEEP PROCEEDINGS

Member/Non-Member

	0041	2016 (USB Thumb Drive)	$75	$100
	0040	2015 (CD-ROM)	$75	$100
	0036	2014 (CD-ROM)	$75	$100
	0034	2013 (CD-ROM)	$75	$100
	0025	2008 (CD-ROM)	$75	$100
	0023	2007 (CD-ROM)	$75	$100

Member/Non-Member

	0013, 0014, 0015, 0016, 0018, and 0020	CD-ROMs for 2001, 2002, 2003, 2004, 2005 and 2006 are available upon request (call or email EEGS to check availability and place order)	$75 each	$100 each
	0012	1988-2000 (CD-ROM	$150	$225
SUBTOTAL—PROEEDINGS ORDERED				

SAGEEP Short Course Handbooks

	0039	2013 Agricultural Geophysics: Methods Employed and Recent Applications - Barry Allred, Bruce Smith, et al.	$35	$45
	0038	2010 Processing Seismic Refraction Tomography Data (including CD-ROM) - William Doll	$35	$45
	0037	2011 Application of Time Domain Electromagnetics to Ground-water Studies – David V. Fitterman	$20	$30
	0032	2010 Application of Time Domain Electromagnetics to Ground-water Studies – David V. Fitterman	$20	$30
	0027	2010 Principles and Applications of Seismic Refraction Tomography (Printed Course Notes & CD-ROM) - William Doll	$70	$90
	0028	2009 Principles and Applications of Seismic Refraction Tomography (CD-ROM w/ 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
	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

Books and Miscellaneous Items

	0031	***New Pricing!!*** Advances in Near-surface Seismology and Ground Penetrating Radar—R. Miller, J.Bradford, K.Holliger Special Pricing Available for Limited Time—through March 23, 2017—end of SAGEEP 2017!	$79	$99
	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
	0035	Einstein Redux: A Humorous & Refreshing New Chapter in the Einstein Saga—D.Butler	$20	$25
		EEGS Lapel Pin	$ 3	$3
		SUBTOTAL—SHORT COURSE/MISC. ORDERED ITEMS:		

EEGS STORE

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	To order volumes from		**2006**	JEEG 11/1 - March		**2011**	JEEG 16/4 - December
	to	1995 through 1999			JEEG 11/2 - June		**2012**	JEEG 17/1 - March
	1999	Contact EEGS (call or			JEEG 11/3 - September			JEEG 17/2 - June
		email) for availability			JEEG 11/4 - December			JEEG 17/3 - September
		and to order		**2007**	JEEG 12/1 - March			JEEG 17/4 - December
	2000	JEEG 5/3 - September			JEEG 12/2 - June		**2013**	JEEG 18/1 - March
		JEEG 5/4 - December			JEEG 12/3 - September			JEEG 18/2 - June
	2001	JEEG 6/1 - March			JEEG 12/4 - December			JEEG 18/3 - September
		JEEG 6/3 - September		**2008**	JEEG 13/1 - March			JEEG 18/4 - December
		JEEG 6/4 - December			JEEG 13/2 - June		**2014**	JEEG 19/1 - March
	2003	JEEG 8/1- March			JEEG 13/3 - September			JEEG 19/2 - June
		JEEG 8/2 - June			JEEG 13/4 - December			JEEG 19/3 - September
		JEEG 8/3 - September		**2009**	JEEG 14/1 - March			JEEG 19/4 - December
		JEEG 8/4 - December			JEEG 14/2 - June		**2015**	JEEG 20/1 - March
	2004	JEEG 9/1- March			JEEG 14/3 - September			JEEG 20/2 - June
		JEEG 9/2 - June			JEEG 14/4 - December			JEEG 20/3 - September
		JEEG 9/3 - September		**2010**	JEEG 15/1 - March			JEEG 20/4 - December
		JEEG 9/4 - December			JEEG 15/2 - June		**2016**	JEEG 21/1 - March
	2005	JEEG 10/1 - March			JEEG 15/3 - September			JEEG 21/2 - June
		JEEG 10/2 - June			JEEG 15/4 - December			
		JEEG 10/3 - September		**2011**	JEEG 16/1 - March			
		JEEG 10/4 - December			JEEG 16/2 - June			
					JEEG 16/3 - September			
					SUBTOTAL—JEEG ISSUES ORDERED			

SUBTOTAL - SAGEEP PROCEEDINGS ORDERED	
SUBTOTAL - SHORT COURSE / BOOKS & MISCELLANEOUS ITEMS ORDERED	
SUBTOTAL - JEEG ISSUES ORDERED	
CITY & STATE SALES TAX (If order will be delivered in the Denver, Colorado—add an additional 7.62%)	
SHIPPING & HANDLING (US—$15; Canada/Mexico—$25; All other countries: $50)	
GRAND TOTAL:	

Order Return Policy: Returns for credit must be accompanied by invoice or invoice information (invoice number, date, and purchase price). Materials must be in saleable condition. Out-of-print titles are not accepted 180 days after order. No returns will be accepted for credit that were not purchased directly from EEGS. Return shipment costs will be borne by the shipper. Returned orders carry a 10% restocking fee to cover administrative costs unless waived by EEGS.

Payment Information:

☐ Check #: ________________________________ (Payable to EEGS)

☐ Purchase Order: ________________________________
(Shipment will be made upon receipt of payment.)

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

Important Payment Information: Checks from Canadian bank accounts must be drawn on banks with US affiliations (example: checks from Canadian Credit Sulsse banks are payable through Credit Sulsse 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.

Card Number: ____________________________ CVV# _____
Exp. Date: ____

Cardholder Name (Print) ____________________________________
Signature:____