Letter from the President

Greetings Everyone! The SEG Annual meeting is Sept 23-28, 2007 in San Antonio, TX. The NSG Section meeting and dinner will be held on Tuesday 25th September, 2007 at Rio Rio Cantina in the Estrella Room on the Riverwalk in San Antonio, an easy walk from convention center. The dinner is free to all NSG members. For non-members the cost is $15 which includes the membership fee for the year. We look forward to seeing you all at the meeting.

Technical Chairs Wendy Wempe and Jeff Paine did an excellent job in organizing Near Surface sessions for the SEG Annual meeting. This year we have 36 papers divided amongst three oral sessions and two poster sessions. Thanks to all of the reviewers for their efforts. Visit http://meeting.seg.org/techprog/ for more details on session themes and papers.

In November 11-14, 2007 a Near Surface workshop will be held in Bahrain titled “Unraveling the near surface: So near yet so far”. In addition to seismic the workshop welcomes papers on GPR, EM and potential field applications in near-surface problems. The deadline for paper submission is October 1, 2007. Visit the site: http://www.seg.org/meetings/nsw2007/ for more details.

To honor Dr. Ken Zonge for his tremendous contributions to the field of geophysics, there will be a special symposium, “Advances in IP and Complex Resistivity and related techniques”, organized by Zonge Engineering and Research Organization, September 27-28, 2007, (immediately following the SEG annual meeting) in San Antonio TX. I strongly encourage you to visit our website http://nsgs.seg.org for upcoming events and activities related to near surface geophysics. I would again like to draw your attention to SEG Research committee. This committee organizes workshops events in the annual meeting as well as the summer research workshops. Currently, the representation from the near-surface community is far too low. If you are interested to be part of this research committee please contact us.

Please do not hesitate to contact any of us if you have suggestions about the NSG section or if you’d like to submit an interesting article for the NS Views newsletter. This is my last letter as President of the NSGS. I would like to thank the executive committee and membership for making it such a rewarding experience.

Best Wishes and look forward to seeing many of you in the future.

Partha Routh,
President, NSG Section
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GSSI team member Dan Delea performing a soil salinity survey in Grand Forks, ND using the GSSI Profiler in conjunction with a Trimble AG 132 GPS system.

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Executive Committee Officers

Wendy Wempe, President

Wendy Wempe joined the Schlumberger Water Services team in Sacramento, California, as a Senior Hydrogeologist in 2006, where she works on characterization of hydrogeologic properties using borehole geophysical data. Wendy received a B.S. degree in Earth Sciences from University of California, Santa Cruz, in 1994, and a Ph.D. degree in Geophysics from Stanford University in 2000. While at Stanford University, she developed new theory for constraining aquifer transport properties using geophysical data. Afterwards, she worked as a research associate at the Cooperative Institute for Research in Environmental Sciences in Boulder, Colorado, continuing the development of a new technology that identifies changes in fluid saturation and granular wettability using seismic attenuation data. She then developed and co-taught “Groundwater Law and Hydrology”, an advanced law seminar at the University of Colorado, Boulder. The development of this course led her to providing introductory hydrogeology public short courses and in-house training programs to water lawyers, policy-makers, and resource managers through a retired consulting company she created called Hydro Info.

Partha Routh, Past President

Partha obtained his B.Sc (Hons) (1991) and M.S. in Exploration Geophysics (1993) from Indian Institute of Technology (IIT), Kharagpur, India. In 1999, he obtained his Ph.D. from University of British Columbia (UBC), Canada with the focus in electromagnetic inversion problems. After a post-doctoral at UBC-Geophysical Inversion Facility, he was Senior Geophysicist in Conoco Inc. Upstream research where he worked on potential fields and pre-stack seismic inversion for reservoir characterization of oil and gas problems. From 2003-2007 he was an Assistant Professor of Geophysics at Boise State University in Idaho, USA. Currently he is in a seismic development research group with ConocoPhillips in Houston, TX. Broadly, his interests are in the area of inverse problems and appraisal analysis applied to Seismic, EM/electrical problems. He is active in the area of seismic imaging/inversion, time lapse for reservoir monitoring and multi-scale inversion. He is in the editorial board of Geophysical Prospecting, EAGE. He is an active member of the NSG, SEG, EAGE, AGU, SIAM, SPE and AAPG.
Deborah Underwood, Vice President/Website Editor

Deborah is currently in her 8th year as a Senior Geophysicist at Geometrics, Inc. in San Jose, California. Prior to Geometrics, she worked with the Seismic Hazards Group at the US Geological Survey in Menlo Park, California, and at Landmark Graphics in Denver, Colorado. She earned her M.S. degree in Near-Surface Geophysics, specializing in high-resolution reflection seismology, from the University of California, Santa Cruz in 1998, and her B.S. degree in Geology from the University of California, Santa Barbara, in 1993. Deb has served on the NSG Section Executive Committee for 4 years.

Laurence R. Bentley, Treasurer

Larry received his B.A. degree in Physics from Hamilton College in 1971 and his M.S. degree in Geology and Geophysics from the University of Hawaii in 1974. He worked for 10 years with Western Geophysical Company as a party manager, supervisor and research geophysicist. In 1985, Larry returned to university to study subsurface flow and transport modeling. He received his Ph.D. degree from the Department of Civil Engineering at Princeton University in 1990. After a one-year post-doctoral fellowship at the University of Vermont, he joined the faculty of the University of Calgary in 1991. He is currently a professor in the Department of Geology and Geophysics. His research interests include hydrogeology, groundwater modeling, and near-surface geophysical applications in hydrogeology. He has been a member of the SEG since 1998. Larry has served the NSG Section as Vice President and will begin his second term as treasurer.

James Irving, Secretary

James received his B.S. degree in Earth Sciences from the University of Waterloo in 1997, his M.S. degree in Geophysics from the University of British Columbia in 2000 and, his Ph.D. in Geophysics at Stanford University under the direction of Dr. Rosemary Knight. James’ research interests include the use of ground-penetrating radar for hydrogeological applications. He is currently working as post-doc in Switzerland. James will begin his third term as NSGS Secretary.

Emily Hinz, NS Views Editor

Emily Hinz received her B.S. in Geoscience and Computer Science (2004) and her M.S. in Geoscience (2007), from the University of Texas at Dallas. While her Bachelor's degree focused on geology, her Master's research focused on the application of seismic refraction to archaeological sites and geo-archaeological investigations. She has participated in the Summer of Applied Geophysical Experience (SAGE) as a student and then a teaching assistant for the past four summers. She is currently pursuing a Ph.D. in near surface geophysics at Boise State University in Idaho. Emily is a member of the SEG and EEGS, and has had the honor of being a multi-year SEG scholarship recipient.
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Accounting for Temperature in Time-Lapse Electrical Resistivity Surveys

Kevin Hayley¹, L.R. Bentley, M. Gharibi and M. Nightingale
Department of Geoscience
University of Calgary
Calgary, Alberta, Canada

Author’s Note: This article is a synopsis of a paper submitted to Geophysical Research Letters for publication later this year.

Introduction
The electrical conductivities of rocks and soils are highly dependent on water saturation and ionic concentration within the pore water. Variations in electrical conductivity (EC) are used in the time-lapse electrical resistivity imaging (ERI) studies to track tracer migration [e.g. Daily et al., 1992; Kemna et al., 2002; Slater and Sandberg, 2000] monitor infiltration [e.g. Barker and Moore, 1998; Binley et al., 2002; French and Binley, 2004] and to monitor contaminate transport and remediation. Hauck [2002] used time-lapse ERI to monitor frozen ground and related the observed differences to changes in liquid water saturation and temperature.

Temperature has a strong influence on the EC of the subsurface [Sen and Goode, 1992; Waxman and Thomas, 1974]. Rein et al. [2004] studied the effect of temperature, soil moisture, and temporal variation of the ambient ionic concentration on tracer tests, and concluded that even diurnal temperature variations can have a relatively large effect. Yet in most time-lapse studies, the influence of temperature variations has not been accounted for. Our purpose is to examine the near surface temperature dependence of electrical conductivity, establish a general temperature conductivity relationship, and implement a practical framework to account for temperature effects in time-lapse electrical surveys.

Laboratory experiment
Laboratory experiments were conducted to examine the temperature EC relationship on samples from a site of a time-lapse ERI survey. Material at the site consists of a predominantly fine grained glacial till with sporadic pebbles and cobbles in the sandy clay matrix. A subsurface brine plume is being monitored and remediated at this site and the pore fluid is NaCl dominated.

The experimental apparatus for measuring the EC consisted of a cylindrical non-conducting cell with copper plate electrodes at each end. A filter paper soaked with a 1 molar CuSO₄ solution was placed between the copper electrodes and the sample to assure good electrical contact and to minimize charge build up effects. The cell had an internal thermocouple and was placed in a precision temperature incubator set at the desired temperature for each reading. Four samples from direct push core representing different subsurface levels of salt concentration were homogenized, split and repacked in the cell in order to test repeatability resulting in eight measurements sequences. Resistance measurements were made with a Hewlett-Packard¹⁴ 4262A inductance-capacitance-resistance (LCR) meter following the method described by Wong et al. [2004]. The LCR meter measures resistance, capacitance and inductance at three test frequencies of 120 Hz, 1 kHz and 10 kHz. The 10 kHz measurement values are used, because they have minimal charge build up effects as evidenced by the low measured specific capacitance values (on the order of 10 nF/m). Resistance measurements were converted to resistivity using the geometric factor for a cylinder, and reported as EC.
Figure 1 shows the bulk EC normalized by the respective 25°C measurement as a function of temperature for the four different samples and their duplicates. The normalized data is well described by a linear model:

$$\frac{\sigma_T}{\sigma_{25}} = m(T - 25) + 1$$  \hspace{1cm} (1)$$

where $\sigma_T$ and $T$ are the recorded EC and temperature in degrees Celsius. $\sigma_{25}$ is the electrical conductivity at the conventional reference temperature of 25°C and $m$ is the fractional change in EC per degree Celsius. Equation 1 fit our data with a best fit slope of $m = 0.0183$. The slopes are consistent across a large range of salt concentration and EC.
In a study of the EC of soils and sediments, Scott and Kay [1988] examined the temperature dependence of 91 soil samples from 12 field sites across Canada with variable geologic settings and depths of 0.5 to 10 m. We extracted the data from the 0 to 25°C temperature range and observed that the temperature-EC relationships followed an approximately linear trend. The slope of each 0 to 25°C data set was determined by least squares. The distribution of the derived slopes or \( m \) values is shown in figure 2. This distribution has a mean of 0.021 and a standard deviation of 0.003. Our results are within one standard deviation of the mean. In comparison to our laboratory experiments the procedure used in the Scott and Kay [1988] study was less controlled in terms of saturation, packing and loading of the cell. The spread of \( m \) values from this study may be influenced by the material type, and sample saturation. Moreover, several of the datasets contain only three points so the resulting linear fits would be affected by experimental error. In spite of these issues, the distribution of fitted slopes in figure 2 is narrow. Thus, these values can be used to account for the temperature dependence of a variety of near surface materials over the 0 to 25°C temperature range when an experiment like the one used in this study is not conducted.

**Figure 2.** Histogram of extracted slopes from the analysis of the, Scott and Kay [1988] study. This distribution has a mean of 0.021 and a standard deviation of 0.003.
Field study

Time lapse three-dimensional ERI monitoring of a salt plume was conducted over the same site where the core samples for the temperature study were taken. 4 meters separated the ten parallel lines. Each line had 56 electrodes separated by 2 m. Lines were run with dipole-dipole configurations to a maximum n-spacing of 6. The ten lines of data were combined and jointly inverted with RES3DINV [Loke and Barker, 1996].

The site is being remediated using tile drains installed at 2m depth, and the goal of the time-lapse survey is to image the remediation and natural movement of the plume. The water table was measured at 2.3m depth in a piezometer for the October 2005 survey and 2.6m for May 2006. Data from two tensiometer nest installations and a soil water characteristic curve for a silty clay were used to estimate the saturation. Estimated saturation varied from 0.88 to 0.95 in the upper 0.5m during each survey with similar magnitude variations between the survey periods. So, saturation changes should contribute to only small changes in EC in the upper 50cm. Temperature was recorded at the time of the surveys using two thermocouple installations completed to six meters and in piezometers below the water table. Figure 3 shows the temperature measurements recorded at the field station during the October 2005 and May 2006 surveys. Temperature was recorded at a variety of times and locations, giving an indication of the spatial and temporal variability of the subsurface temperature distribution during the survey collection period. This gives us a measure of the uncertainty in any temperature compensation calculation applied over the survey area. We can see consistent trends showing the seasonal temperature variations penetrating the subsurface, with the temperatures stabilizing at around 6° C at nine meters depth.
In order to remove the temperature effect from the time-lapse images we use the linear temperature dependence model to change the EC to a standard temperature equivalent before we make comparisons between images. The standard temperature we chose for our survey was 6°C to minimize the magnitude of the temperature compensation. We applied the relevant temperature profile shown by the lines in Figure 3 to each of the surveys. Some care has to be taken as all of the linear models use 25°C as the reference temperature, and the slope m is dependant on the reference temperature. In order to convert our data to a 6°C equivalent and to maintain the 25°C convention, we manipulate equation 1 to:

$$
\sigma_{std} = \left[ \frac{m(T_{std} - 25) + 1}{m(T_i - 25) + 1} \right] \sigma_i
$$

(4)

where \(T_{std}\) and \(\sigma_{std}\) are the standard temperature and EC, \(T_i\) and \(\sigma_i\) are the in situ temperature and EC (i.e. taken from the temperature profile in Figure 3 and the resistivity inversion), and \(m\) is the slope calculated using the 25°C convention.

Figure 4A) shows the ERI inversion results of in situ resistivity values and the May 2006 minus October 2005 difference. A negative difference dominates the upper 4 meters. Figure 4B) shows the images after using equation (4) and the temperature profiles in Figure 4 to produce the 6°C equivalent images. The majority of the negative change in the May 2006 minus October 2005 no longer exists in the 6°C equivalent difference image. By removing the temperature effects from the difference image our interpretation of the images is altered from large scale seasonal solute movement and removal by the drain system to subtle effects due to saturation changes in the upper 50 cm, possible solute redistribution, and noise.

**Conclusions**

Our laboratory experiment produced a linear Temperature EC relationship well described by Equation 1. Our best fit temperature dependence parameter was \(m = 0.0183\). In this study and that of [Scott and Kay, 1988] using a variety near surface materials, the slope of the low temperature linear model is quite consistent. At least for Canadian sites, a value between 0.018 and 0.022 can be used if no other information is available.

Neglecting temperature variations when using resistivity to track the movement of solute or soil moisture can lead to errors in interpretation of the geophysical results. Accounting for temperature variations is especially important when attempting quantitative estimates of concentration or moisture content from resistivity data or when comparing long-term time-lapse data images. Only by converting all images to a standard temperature equivalent can the results be compared to isolate solute movement and
saturation changes. Many studies have tried to convert ERI images to solute concentration maps; however, if this is to be meaningful, then temperature variations within the image must be accounted for. Consequently, auxiliary data, such as that derived from the installation of temperature sensors, should be an integral component of any time-lapse survey or any survey seeking quantitative estimates of pore fluid concentration or variations in moisture content.

References

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Figure 4. ERI inversion results from October 2005, May 2006, and the difference between them. A) no temperature compensation. B) 6°C equivalent images.
Research, 28 (5), 1429-1442.
Kemna, A., J. Vanderborght, B. Kulessa, and H. Vereecken (2002), Imaging and characterisation of subsurface solute transport using electrical resistivity tomography (ERT) and equivalent transport models, Journal of Hydrology, 267, 125-146.
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SEG Annual Meeting Near Surface Presentation Schedule

Sunday September 23, 2007
- 4 to 5pm SEG 77th Honors and Awards Ceremony
- 6 to 8pm Icebreaker/Exhibition Preview

Monday September 24, 2007
- NSE P1: Hydrologic Applications of Geophysics
- 6 - 10pm, Student Reception, San Antonio Marriott Rivercenter

Tuesday September 25, 2007
- NSE 1: Seismic Statics
- NSE 2: Seismic Imaging and Soil Characterization

Wednesday September 26, 2007
- NSE 3: GPR, Resistivity, and Magnetics
- NSE P2: Seismic Attenuation, Propagation, and Exploitation

Mark Your Calendar

SEG Annual Meeting
San Antonio, TX
23-28 September

4th International Symposium on Three-Dimensional Electromagnetics
Freiberg/Saxony, Germany
27-30 September

SEG sponsored workshop, “Unraveling the near surface: So near yet so far”
Bahrain
12-14 November

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10-14 December

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Dr. Louise Pellerin, of Green Engineering, has enthusiastically served the geophysics community for many years. Thanks Lu for being an active and committed member of the NSGS executive committee. Your experience and insights will be greatly missed. We wish you the best in your new position as Second Vice President for the SEG.

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NSG Section Business Meeting and Reception
at the SEG 2007 Annual Meeting

Please mark your calendars and plan to join the NSG Section for its annual business meeting and dinner reception. Thank you to Deborah Underwood, NSG Section Vice President, for organizing the event.

When: Tuesday, September 25, 2007 at 6:00 pm

Business Meeting, 6:30 – 7:30 pm

Dinner Reception, 7:30 – 9:00 pm

Where: Rio Rio Cantina, Estrella Room and Patio
421 E. Commerce St. on the San Antonio Riverwalk,
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Near-Surface Geophysics Section of the SEG
Membership Application

The Near-Surface Geophysics (NSG) Section of the Society of Exploration Geophysicists is a professional organization chartered by the SEG to promote the rigorous practice of the science of shallow-earth geophysics. You may read about the origin and goals of the section at http://edge-online.org/pdf/te1209r0922.pdf and nsgs.org.

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Telephone\(^4\): ( ) __________________________ Fax: ( ) __________________________

Email: ..........................................................

Primary application/field of study

____ Engineering Geophysics
____ Environmental Geophysics
____ Groundwater Geophysics
____ Mining Geophysics
____ Petroleum
____ Research
____ Academic/Training
____ Government Admin./Regulations
____ Other

Expertise (check all that apply)

____ Borehole geophysics
____ Electrical
____ Electromagnetics
____ Gravity
____ Radar
____ Radiometry
____ Magnetics
____ Seismic
____ Other

I am currently a member of the SEG: YES or NO. SEG membership is NOT required to join the NSG Section. Note that student SEG membership is free through the Corporate Sponsorship Program. Go to www.seg.org, Membership Services, to learn more. If you are not a member of SEG, provide two NSG Section or SEG sponsors or attach a current resume.

Sponsor 1: ___________________________ Company: ___________________________ Email: ___________________________

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Payment

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I have enclosed my check for $_______ made payable to the “Near-Surface Geophysics Section”

Credit Card

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Signature (only if paying by credit card)

Please print and complete this form and send with your payment and applicable attachments to the below address.

NSG Section, c/o the Society of Exploration Geophysicists (SEG) Business Office, P.O. Box 702740, Tulsa, OK 74170 USA

\(^1\) Geophysicists & SEG member or sponsored by two NSG Section or SEG members. See NSG Section Bylaws III.1.a. for details.

\(^2\) Interest in NSG Section & SEG member or sponsored by two NSG Section or SEG members. See Bylaws III.1.b. for details.

\(^3\) Registered student. Attach a dated statement signed by a professor in your academic department indicating you are a registered student at the time of application.

\(^4\) Please include country and city telephone codes, if applicable.