Non-invasive investigation of permafrost along a planned route of pipeline, road or airstrip in cold regions involves the use of effective methods for detecting, characterizing, mapping and monitoring permafrost conditions on various spatial and temporal scales. Among the available near-surface geophysical methods, the electrical resistivity imaging is probably the most suitable method since the resistivity contrast between unfrozen and frozen ground can be one or two orders of magnitude.

Induced polarization (IP) profiling was carried out to study the spatial distribution of ground ice in two permafrost mounds near Umiujaq in Nunavik, Canada. A dipole-dipole array was used to perform the IP profiling. Pseudo-sections of electrical resistivity and chargeability giving a misrepresented cross-section of the sub-surface were first draw. The inversion of IP profiling was also performed using DCIP2D developed by UBC-GIF for estimating the spatial distribution of electrical properties in the ground to create realistic models of sub-surface resistivity and chargeability cross-section. The inverse models show clearly the presence of ice-rich core in the permafrost mounds. The ice-rich cores are underlined by high resistivity values while the unfrozen zones show low resistivity values. The localisation of the permafrost table is highlighted by a strong contrast of resistivity while the permafrost base is marked by a transitional change in resistivity. In the hollow between the permafrost mounds, the models show low resistivity values characteristic of unfrozen zone. A synthetic resistivity sounding built from the most acceptable inverse model correlates well with electrical resistivity logging carried out in the permafrost mound during cone penetration tests. The inversion of IP profiling is fundamental for defining realistic models of sub-surface resistivity and chargeability.

Electrical resistivity imaging is a appropriate near-surface geophysical method for permafrost investigation such as detecting the absence/presence of permafrost, assessing the cryostratigraphy, mapping the lateral changes in permafrost conditions, estimating the ice/unfrozen water content, determining the permafrost base for shallow permafrost occurrences and monitoring seasonal variations in permafrost conditions from electrical resistivity imaging carried out at regular interval. Electrical resistivity imaging can be used for the delineation of ice-rich zone in frozen ground along major transect such as the route of pipeline, road and airstrip in cold regions.

## NS41B CC: 220 C-E Thursday 0830h

**Near-Surface Geophysics Posters: Evaluation and Management of Water Resources** *(joint with H, GC, PP, ED)*

***Presiding:*** **R Knight,** Stanford University

### NS41B-01 0830h POSTER

**Poster Component of Near-Surface Geophysics: Evaluation and Management of Water Resources II.**

Near-Surface Geophysics (noe-mail@xxx.xxx)

Near-Surface Geophysics, Posters From the Oral Session NS41A

A list of the abstracts and authors that will be presenting posters in this session can be found in session NS41A. The authors are each giving a 5-minute overview of their poster in the session Near-Surface Geophysics: Evaluation and Management of Water Resources II. The presentations start at 0830h in Room 516B on Thursday.

## NS43A CC: 516 B Thursday 1330h

**Near-Surface Geophysics: Evaluation of Transportation, Building and Energy Infrastructure, and Related Resources I**

***Presiding:*** **L Pellerin,** Green Engineering, Inc.**; M Chouteau,** Ecole Polytechnique

### NS43A-01 1330h

**How Much Gravel? Use of Ground Penetrating Radar for Aggregate Resource Evaluation**

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Ground penetrating radar (GPR) was tested in two gravel quarries in eastern Newfoundland, Canada, to determine its usefulness for aggregate resource evaluation.

In Mercer's Pit, near Tors Cove, GPR profiles show irregular, discontinuous reflections that extend to depths of more than 30 m. Boulders are common at depth (identified on the profiles by numerous individual diffractions). The area is interpreted as a much thicker gravel deposit than had been estimated by previous methods, however, the presence of boulders could indicate a lower quality resource. Analysis of a peat bog near the pit shows a prominent contact on the GPR profiles. It is interpreted as the hummocky surface of the gravel deposit (continuous, high amplitude reflections), which underlies a much weaker reflective zone of peat.

At Snow's Pit, near Bay Roberts, a series of overlapping diffractions at depth are interpreted as representing the bedrock surface, which varies from 5 to 15 m below the surface. Aggregate deposits overlie the bedrock (irregular, discontinuous reflections) and contain very few boulders. This deposit also was found to be larger than previously thought, and is low in boulder content throughout.

GPR was found to be an effective tool for delineating the extent and volume of aggregate resources in these examples. It provides a detailed view of the subsurface and large amounts of information are gathered quickly and easily. GPR can be used to revise volume calculations of quarries already in operation and to estimate the volume of potential new deposits. It is also useful for planning pit development and analysing prospective areas that quarry operators do not yet own or have rights to, with virtually no environmental impact on the land surveyed.

### NS43A-02 1335h

**Electrical Resistivity Imaging for Investigating Slope Stability, Fort St. John, British Columbia**

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The Peace River District of northeastern British Columbia is characterized by steep river valleys that have been incised up to 300 m deep in poorly consolidated Cretaceous and Quaternary sediments. Since the area is a major producer of oil and gas, numerous pipelines and roads transect these valleys. Slope stability has been a major problem at several locations and will continue to pose a problem for future development in the area. Understanding the mechanisms of slope stability will allow better assessment of the risks to infrastructure. The Geological Survey of Canada is conducting studies to determine the role that groundwater infiltration and flow have in controlling slope movements. Near-surface geophysical surveys provide a quick non-invasive method of investigating ground conditions. Since moisture content of the underlying strata plays an important role in slope stability, electrical methods are particularly suitable. For this study, two-dimensional electrical resistivity imaging was conducted along three pipeline route slopes in the Fort St. John area during July 2002. An automated electrical resistivity imaging system was used to acquire continuous Wenner array images up to 1300 m in length. The system used 48 electrodes spaced 5 m apart, to obtain a high-resolution image of the subsurface with an exploration depth of approximately 40 m. Two-dimensional inversion software was used to obtain topography-corrected electrical resistivity models for each slope. Borehole information was incorporated in the interpretation of the results. Electrical resistivity imaging proved to be a fast and effective method for investigating the extremely steep slopes encountered in the Fort St. John area. The results indicate that the method is very useful in identifying seepage zones and extending hydrostratigraphy from borehole observations. These studies will assist modeling of groundwater flow by confirming areas of predicted groundwater discharge and by delineating areas where moisture content changes are taking place.

### NS43A-03 1340h

**Assessment of Continuous Resistivity Profiling for the Characterization of Paved Roads**

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We have assessed the continuous resistivity profiling method using towed arrays as a diagnostic NDT method for the evaluation of pavements. Whether the pavement consists of a sequence of asphalt, concrete slab and subgrade layer (rigid pavement) or a layer of asphalt overlying a subgrade and grade base layers (flexible pavement) defects within those different layers can cause pavement deterioration that must be identified. We first examine the response of the method to the various problems using numerical modeling. It is shown that with an optimally designed system the method allows the determination of the thickness and the location of cracks in the asphalt cover. It is also sensitive to the presence of cracks, internal defects and chloride ions (de-icing salt) within the concrete slab below. For reinforced concrete it is possible to estimate the concrete resistivity related directly to its composition (quality) and the thickness of the top coating over the level of rebars. A low resistivity of concrete will usually be diagnostic of advanced stage of rebar corrosion and delamination could occur. However it is shown that the rebars cause current channeling and the depth of investigation is limited then to the depth of the first row of rebars. Finally heterogeneities within the foundation reflecting subsidence, bad drainage, frost-defrost cycles or cavities can be mapped. The optimal design is based on a system with 10 to 20 receiver dipoles and one transmitter dipole (first or last of the array) with a dipole length typically of 10 cm that can be used in equatorial or in-line mode. Static resistivity measurements have been carried out at the laboratory scale over concrete slabs built to verify results obtained from the numerical modeling. Observed data fit very well the modeled data and validate the overall conclusions. Tests have been performed in December 2003 in some selected streets (6 visited, 3 re-visited) of Montreal using a CORIM system (Iris Instruments, France), a capacitively-coupled resistivity towed equatorial array that continuously record data collected with six receiver dipoles and one transmitter dipole. Typical acquisition sampling and velocity were 0,20-0,50 m and 1 to 2 km/h respectively. Although the system is not optimally designed for the applications described above it provides useful diagnostic information about the state of deterioration of pavement. Data have been imaged using 2D resistivity inversion. In general it shows a high resistivity for the shallow depth related to the asphalt layer and a decreasing resistivity with depth related to the concrete slab first and the granular foundation below. Lateral variations appear to be correlated with degradation of the concrete slab.

### NS43A-04 1345h

**Near Surface Characterization Of Concrete Structures Using Rayleigh Waves**

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The deterioration of the near surface concrete minimises the structural behaviour, capacity, and working lifespan for civil engineering structures and dams. Repair strategy and maintenance require careful examination and determination of the degraded depth. In this aim, dispersive properties of Rayleigh waves are used to detect concrete stratification and cracks. Current work focuses on an experimental study and application of multichannel Rayleigh wave methods on high concrete volumes. The method considers a wavefield in the frequency-wavenumber domain to separate existing Rayleigh modes and determine the appropriate shear wave velocity profile. The classical phase unwrapping analysis technique is also used to localise near surface cracks and defects. This new way in concrete nondestructive testing lead to a best evaluation of near surface stiffness and properties from the surface of concrete structures.

### NS43A-05 1350h

## The Influence of Soil Properties on the Cross-Coupling Coefficient Governing the SP Response to Seepage

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Internal erosion is one of the most prevalent modes of failure in earthfill dams. Consequently, early detection and prevention of anomalous seepage and piping is the focus of embankment dam safety surveillance. Self-potential (SP) is a geophysical technique currently being used to assess seepage conditions in embankment dams. Fluid flow in the subsurface and across zones of differing soil properties generates streaming currents through the electrokinetic phenomenon of streaming potential, which can be characterized using the SP method. However, further investigation of this method is necessary to link the geophysical anomalies with changes in soil or fluid properties within the embankment, and to evaluate its capacity to delineate zones of anomalous seepage or internal erosion. Numerical modelling techniques are instrumental in evaluating and interpreting SP data, but the level of knowledge of the physical properties that govern the geophysical response limits the value and effectiveness of any modelling procedure.

A laboratory system was designed and developed to study the streaming current cross-coupling parameter linking electrical current flow to the hydraulic gradient in soils. The influence of changing soil properties on the cross-coupling coefficient was investigated for a range of samples. We present the results of this laboratory study and discuss the implications for numerical modelling studies of the streaming potential phenomenon.

### NS43A-06 1355h

## Induced Polarization Surveying for Acid Rock Screening in Highway Design

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Highway and pipeline construction agencies have become increasingly vigilant in their efforts to avoid cutting through sulphide-bearing bedrock that has potential to produce acid rock drainage. Blasting and fragmentation of such rock increases the surface area available for sulphide oxidation and hence increases the risk of acid rock drainage unless the rock contains enough natural buffering capacity to neutralize the pH. In December, 2001, the New Brunswick Department of Transportation (NBOT) sponsored a field trial of geophysical surveying in order to assess its suitability as a screening tool for locating near-surface sulphides along proposed highway alignments. The goal was to develop a protocol that would allow existing programs of drilling and geochemical testing to be targeted more effectively, and provide design engineers with the information needed to reduce rock cuts where necessary and dispose of blasted material in a responsible fashion.

Induced polarization (IP) was chosen as the primary geophysical method given its ability to detect low-grade disseminated mineralization. The survey was conducted in dipole-dipole mode using an exploration-style time domain IP system, dipoles 8 to 25 m in length, and six potential dipoles for each current dipole location (i.e. n = 1 6). Supplementary information was provided by resistivity and VLF-EM surveys sensitive to lateral changes in electrical conductivity, and by magnetic field surveying chosen for its sensitivity to the magnetic susceptibility of pyrrhotite.

Geological and geochemical analyses of samples taken from several IP anomalies located along 4.3 line-km of proposed highway confirmed the effectiveness of the screening technique. IP pseudosections from a region of metamorphosed shales and volcaniclastic rocks identified discrete, well-defined mineralized zones. Stronger, overlapping, and more laterally extensive IP anomalies were observed over a section of graphitic and sulphide-bearing metasedimentary rocks. Attempts to use spectral IP characteristics to determine relative abundances of sulphides and graphite were not conclusive. The overall effectiveness of the screening technique however encouraged NBDOT to apply it to an additional 50 km of planned rock cuts along the corridor selected for the new Trans-Canada Highway.

### NS43A-07 1400h

## Power Line Noise in Transient Electromagnetic (TEM) Data: Identification and Removal in a Practical Field Study.

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INTRODUCTION: To evaluate the appropriateness of TEM in mapping deep groundwater tables (in Mars analog environmnets), a field study was carried out in the desert 30 miles SW of Tucson, Arizona. The study was also designed to observe effects of powerline noise on TEM data. The clay-rich soil in the area is quite conductive. The study consisted of 40 in-loop TEM stations, divided into 3 lines, for 4 line-km of data. The survey was carried out by a crew of one person, with square Tx wire loops 100 m on a side, and a ferrite-core magnetic coil Rx antenna in the center of each Tx loop. Maximum useful depth of investigation achieved was 600 m.

TEM DATA: The field area is surrounded by powerlines on all 4 sides: Line 1 has the outside of the first Tx loop under the powerline to the West; Line 2 starts with the powerline to the North passing above just inside its first Tx loop, and ends with the outside of the last stations transmitter loop 20 m shy of the powerline to the South; finally, Line 3 starts 50 m East of the powerline to the West, and runs parallel to the powerline to the South along its entire length, at a separation distance of 70 m. Line 3 was placed largely in an effort to obeserve powerline noise. The decay curve for the first station on Line 1(Line 1/Station 50) is raised above the other curves from Line 1. This is due to the charge (noise) from the adjacent powerline, which is at a distance of 50 m from the Rx coil. In effect, the transient decay is recorded as being slower than it would be without the presence of the powerline. This also artficially lowers the apparent resistivity, readily observed in Line 1/Station 50 data. These effects are present to a lesser extent (lower magnitude noise) in the data from Line1/Station 150, the second station on Line 1. On the smooth-model inversion cross-section of the data from Line 1, the effects of the powerline noise appears as a pulling up of the low-resistivity water table contact towards the surface under the first two stations. Line 2/Station 50 data shows the same artificially slow decay and lowered apparent resistivity, compare to Line1/Station 50. Lower magnitude noise in Line 2/Station 150 data compares to Line 1 data. On the cross-section the effect is again a pulling up of the low-resistivity water table. The effects of the powerline noise on Line 2/Station 1550 data (last station) is mostly reflected in the fact that this data runs into noise at an earlier decay time than the data from other stations on Line 2. The last two stations do show shallower depths of investigation than the bulk of Line 2. Data from Line 3 uniformly runs into noise at earlier decay times than Line 1 and Line 2 data. Line 3 data achieves shallower depths of investigation than those possible along Line 1 and Line 2, and the water table contact is modeled at an artificially shallower than real depth along Line 3. Both of these effects are observable on the resistivity cross-section of Line 3 data.

CONCLUSIONS: Line 1 and Line 2 observations are in good agreement. Effects observed in raw data include artifically slow decay and correspondingly low apparent resisitvities. The powerline noise lowers signal to noise ratios and depths of investigation. An artificial pulling up of the low-resistivity water table towards the surface is observed under affected stations in model cross-sections. There are a few ways in which to deal with this sort of noise in practical terms: remove noisy data at the end of each decay curve; throw out data from affected stations; keep data from affected stations, but be keenly aware of noise source locations and their effects on the data; and if at all possible, record data 200+ m from any powerline noise source.

### NS43A-08 1405h

## Ground penetrating radar survey and lineament analysis of the West Pearl Queen carbon sequestration pilot site, New Mexico

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The potential for leakage of injected CO2 at carbon sequestration sites is a significant concern in the design and deployment of long term carbon sequestration efforts. Effective and reliable monitoring of near-surface environments in the vicinity of these sites is essential to ensure the viability of sequestration activities as well as long term public and environmental safety. This study reports on near-surface geological and geophysical characterization efforts conducted at the NETL West Pearl Queen carbon sequestration pilot site in southeastern New Mexico and their use in uncovering possible mechanisms facilitating escape of small amounts (10e-13 liters) of tracer injected with the CO2.

In this pilot test, a small amount of CO2 (2100 tonnes) was injected into the Shattuck sandstone member of the Permian Queen Formation early in 2003. Tracers injected with the CO2 were detected within a few days of injection and continued to escape for several months following injection. Geological and geophysical characterization of the near-surface environment in the vicinity of the injection well incorporated lineament interpretations and a detailed ground penetrating radar survey conducted over a circular area extending out 300 meters from the injection well. The near-surface geology consists of a few-feet thick veneer of late Pleistocene and Holocene sand dunes covering the middle Pleistocene Mescalero caliche. The lineament study incorporated interpretation of black and white aerial photos from 1949, digital orthophotos, and Landsat TM imagery.

Analysis reveals distinct northeast and northwest trending lineament sets. The GPR survey defines the presence of a nearly continuous blanket of caliche beneath the area. However, the thickness of the caliche zone varies significantly, and it is disrupted by numerous fault-like features, amplitude anomalies, and reflection gaps. Some of these disruptions are traceable over distances of 25 to 200 meters and their aerial distribution shows some association with the distribution of tracers detected in the near-surface across the site. The observations suggest that the caliche has undergone significant karstification and could provide pathways along which CO2 could migrate through the near-surface from a leaky well casing or, less likely, along more extensive vertical migration pathways.

### NS43A-09 1410h

## Delineating the Tuwu porphyry copper deposit at Xinjiang, China with seismic-reflection profiling

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The Tuwu deposit is one of a series of recently discovered porphyry-copper deposits in the Eastern Tian Shan range of Xinjiang, China. Since its discovery in 1997, more than ten boreholes have been drilled and a suite of geophysical surveys has been acquired to delineate the deposit. As part of the geophysical program, a set of 8 seismic-reflection profiles was acquired in 2000, followed by a physical rock-property study in

2001. The ores are characterized by slightly higher density and significantly higher P-wave velocity than the dioritic host rocks. The seismic surveys used 0.6 to 0.9-kg shallow dynamite sources, with a 24-channel end-on spread and offsets up to 350 m. The host orebody and associated igneous layers dip steeply toward the south, so careful processing of the seismic data was required. Weak reflections from stratigraphic contacts are visible on most of the profiles, including the top of the intrusion and base of the orebody. Since the observed reflections include a significant out-of-plane component, we developed a simple 2.5-D migration procedure. This method was applied to line drawings of the seismic profiles, providing the basis for delineation of the orebody in three dimensions. Synthetic seismic sections computed using the inferred bounding surfaces of the ore deposit are in reasonable agreement with observed reflections, even for along-strike lines not used to build the model. The ability to verify interpreted reflections using line intersections was critical to the development of our model. The results of this work establish the viability of seismic methods as an exploration aid for mapping the flanks of shallow, moderately dipping porphyry copper orebodies and associated strata.

## NS43B CC: 220 C-E Thursday 1330h

### Near-Surface Geophysics Posters: Evaluation of Transportation, Building and Energy Infrastructure, and Related Resources *(joint with S, ED, MR)*

***Presiding:*** **L Pellerin,** Green Engineering, Inc.**; M Chouteau,** Ecole Polytechnique

#### NS43B-01 1330h POSTER

### Near-Surface Geophysics Poster Component of the Session on Evaluation of Transport, Building and Energy Infrastructure, and Related Resources I

Near-Surface Geophysics (noemail@xxx.xxx)

Near-Surface Geophysics, Poster Presentations

A list of the abstracts and authors that will be presenting posters in this session can be found in session NS43A. The authors are each giving a 5-minute overview of their poster in the session Near-Surface Geophysics: Evaluation and Transport, Building and Energy Infrastructure, and Related Resources I

#### NS43A-10 1415h

### Applications of Near-surface Geophysical Techniques for Earthquake Soft-soil Response in Eastern Ontario

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There is ample evidence for significant paleoearthquakes in the geological record of soft Holocene soils in Eastern Ontario (Champlain Sea sediments). Widespread, penecontemporaneous, large retrogressive earthflows in sensitive clays as well as other soil disturbances are attributed to ground motion amplification. Factors contributing to soft soil amplification include soil thickness, shear wave velocity-depth function, seismic wave attenuation, and the nature of near-surface acoustic impedance boundaries (e.g. buried bedrock valleys). In some circumstances these factors can yield a combined effect of velocity-gradient amplification, resonance amplification and 3-dimensional focusing which can exceed the shear strength of the cohesive soils and generate liquefaction in non-cohesive earth materials.

Several near-surface geophysical techniques have been adapted and tested as part of a project to develop new methodologies to apply to geotechnical hazard assessments of landsliding in sensitive marine clays of the Ottawa Valley. These include: surface compressional and shear seismic refraction and reflection methods, downhole compressional and shear wave velocity measurements, conventional borehole logging sondes and surface electrical and electromagnetic techniques. Examples of the application of these technique are given for areas of eastern Ontario where detailed geological studies of earthquake-induced deformation phenomena in thick Holocene soils are well documented.

Near surface geophysical techniques have been shown to be cost-effective tools to support geotechnical evaluations of critical geological controls on earthquake-induced soft soil deformation and landsliding. These techniques can be applied elsewhere in thick soft soil areas of the St. Lawrence Lowlands of Eastern Canada.

## NS44A CC: 516 B Thursday 1530h

### Near-Surface Geophysics: Geophysical Implications of the Anomalous Temperature Effects on the Thermophysical and Electromagnetic Properties of Vicinal Soil Water *(joint with H, C, GC, PP)*

***Presiding:*** **S A Grant,** Cold Regions Research and Engineering Laboratory**; S A Arcone,** Cold Regions Research and Engineering Laboratory

#### NS44A-01 1530h

### Conversion of Bouguer Gravity Data to Depth, Dip, and Density Contrast With Complex Attributes Analysis Technique in the Area of Greece.

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The complex attributes analysis is an operator used in the extracting parameters of the buried structures with susceptibility and density contrasts distributions, which lead to the gravity and magnetic anomalies in the region of interest. In this paper is presented the complex attributes analysis of gravity field filtered for wavelengths lower than 50 km in the territory of Greece. The area o Greece has a complex tectonic history and fault system dominated by the subduction of the African plate beneath the Euroasia. A Low-pass filter is used on the Bouguer Anomaly to cut off wavelengths lower than 50Km in order to delineate the major faults structures of interests at big depths. The complex attributes technique aids in interpretation of potential field anomalies, because it can delineate the edges of concealed targets. In obtaining the source parameters from the complex attributes like the local depth, strike and dip, the assumption of sloping contact for the subsurface model is used. The estimated local parameters are in agreement with results obtained by previous interpretations. They can be used in combination with other method to interpret the anomalous field.

#### NS44A-02 1545h

### Anomalous Thermal Expansion of Confined Aqueous Solutions

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The thermal expansion coefficient of water and aqueous solutions is greater in small pores than in bulk liquid. This phenomenon, first reported by Derjaguin et al. [J. Colloid Interface Sci., 109, 586, 1986], has been systematically studied in a series of porous glasses with different pore sizes. We find that the expansion begins to increase when the pore diameter is less than 15 nm. Near room temperature, the thermal expansion coefficient of pure water rises by about a factor of 1.8 in pores with 3.1 nm diameter. The maximum in the density of water is shifted downward from 4 degC in bulk to about 7 degC in 7.4 nm pores. Expansion of a series of salt solutions was measured, and the enhancement was comparable to that of pure water, so there was no indication of an influence of the size of the hydrated ion on the magnitude of the expansion in pores as large as 3.1 nm. Molecular dynamics studies, as well as a variety of spectroscopic measurements, reported in the literature indicate that one or two molecular layers are densely packed against the pore wall. We interpret the high thermal expansion to result from a change in the proportion of molecules included in those layers; as the thermal energy decreases during cooling, more molecules are attracted into the dense layers, and the thermal contraction is therefore enhanced. The layered structure is also supported by measurements of the permeability of the porous glasses. The permeability of a given material decreases as the size of the liquid molecule increases, because the layers bound on the surface reduce the effective pore volume. We find that the permeabilities of our samples can be predicted by assuming that two monolayers are immobilized on the pore wall. Measurements made on saturated cement paste show that the thermal expansion is about 1.6 times greater than that of bulk water, and increases as the permeability decreases, indicating that the expansion is dominated by the smaller pores in the size distribution.

#### NS44A-03 1600h

### Dielectric properties of wet sediments versus temperature at 10-6,000 MHz

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Knowledge of the dielectric properties of sediments is important to studies of subsurface radiowave propagation, especially as it applies to ground-penetrating radar (GPR) operating in the 50-1,000 MHz bandwidth. In areas contaminated by nuclear waste and in desert environments, water within the soils can be unusually warm, with temperatures ranging up to 50°C. For the GPR bandwidth, past results suggest that relaxation effects may cause significant dispersion and loss of the radar signal within the subsurface. To this end, we have employed a network analyzer-based system with a modified HP805 coaxial-type sample holder to investigate sand and silt at water contents ranging from 0% to 30% and temperatures ranging from 0°C to 50°C. The correct operation of this system has been verified with methanol, ethanol, and isopropyl alcohol which are dispersive in the GPR frequency range.

Preliminary results suggest that dry sand and silt, which have relatively constant dielectric response across our frequency range of interest, experience no enhanced dispersion at elevated temperatures. With increasing water content, however, we find increasing dispersion at higher temperatures: for nearly saturated sand and silt, the real part of the complex dielectric permittivity decreases by up to 25% at frequencies above 100 MHz while it decreases less, or even slightly increases, below this frequency. Other than the low frequency peak in e" due to conductivity effects, there are no additional imaginary dielectric loss peaks at elevated temperatures or water contents for sand and silt-sized materials. Further investigations are planned