rapid to be a viable alternative to the imaging techniques presently in use.

We provide an example that involves the interpretation of an airborne time-domain electromagnetic dataset from an oil sands exploration project in Alberta. The target is the layer that potentially contains oil sands. This layer is relatively resistive, with its resistivity increasing with increasing hydrocarbon content, and is sandwiched between two more conductive layers. This is quite different from the classical electromagnetic geophysics scenario of looking for a conductive mineral deposit in resistive shield rocks. However, inverting the data enabled the depth, thickness and resistivity of the target layer to be well determined. As a consequence, it is concluded that airborne electromagnetic surveys, when combined with inversion procedures, can be a very cost-effective way of mapping even fairly subtle conductivity variations over large areas.

NS22A-04 1115h

An Algorithm for Detecting Feature Lines in Potential-Field Maps

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Areomagnetic or gravity features are vector elements that correspond with local maxima of the horizontal gradient for the respective fields. These features often reflect the boundaries of anomalies, fault zones or other structures. We propose an algorithm based on contour-map to extract areomagnetic or gravitational features automatically. In the case of closed contours, based on the K-L transform,this algorithm also calculates the long-axis direction. The effectiveness of our method is illustrated using several real-data examples. Whereas the original gridded aeromagnetic or gravity data are either in raster format or contours, the set of feature lines as vectors produced by our algorithm can be imported easily into a GIS package as sparse vector elements, facilitating comparison with other types of data.

NS22A-05 1130h

Numerical and Physical Modeling of the Effects of Temperature Change on Ground Penetrating Radar Signals

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Ground-penetrating radar (GPR) is widely used for subsurface characterization in environmental contaminant remediation studies. GPR can be used to detect the extent of the contaminant plume and monitor the remediation process as contaminants are removed. Thermal remediation methods, such as steam injection, are used to mobilize non-aqueous phase liquids (NAPLs) for vapor extraction; these methods cause a temperature change in earth materials, which subsequently causes variations in GPR signal response. When using GPR to monitor a remediation process, it is critical to account for all possible factors that affect GPR signatures for better definition and delineation of contaminant flow and transport. Numerical and physical models were used to quantify the effects of temperature changes and fluid phase changes in a porous medium. The numerical modeling shows that when a porous media is heated, the GPR signal will show both a decrease in traveltime and an increase in amplitude from a reflector. A simplified numerical model of the GPR signal response to a steam injection, characteristic of some thermal remediation methods, was made by comparing GPR signal responses to a water-filled layer and an air-filled (steam) layer within the saturated porous medium. The polarity of the reflected GPR signal is opposite for the water- and air-filled layers. The results from physical experiments conducted in a laboratory-scale sand tank confirm the results obtained from the numerical models.

NS22A-06 1145h

Investigating the Hydrostratigraphy of an Unconsolidated Aquifer using Crosswell Seismic Traveltime Tomography

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Subsurface geologic structure such as sedimentary architecture can have a great influence on the movement of groundwater. For coarse braided stream deposits, computer modeling of contaminant transport has shown that the outcome is largely controlled by the distribution of facies and sedimentary structures (and their associated hydraulic parameters). One method that can be used to image this type of geologic variation in the subsurface is seismic traveltime tomography. Hydrogeologists can either use the resulting velocity image to define aquifer geometry or use the velocities themselves to estimate the values of hydrogeological properties. Seismic tomography can produce useful images in situations where surface seismic reflection has failed. The resolution of crosswell seismic tomography is limited by angular coverage. Synthetic studies have shown that including traveltimes from borehole sources to surface geophones improves angular coverage, and therefore the resolution. In field studies, however, including borehole-to-surface traveltimes has resulted in significant artifacts, such as lateral velocity variations. We have used crosswell seismic traveltime tomography to determine the hydrostratigraphic structure between wells at the Boise Hydrogeophysical Research Site (BHRS), a research wellfield in a coarse alluvial aquifer. We found that we could successfully include borehole-to-surface traveltimes in the tomography by using a reference model that included a large velocity contrast at the water table and weighting the borehole-to-surface data less heavily than the crosswell data. The inclusion of borehole-to-surface data eliminates the X shaped artifact common in crosswell tomograms. The final seismic velocity image agrees well with the existing hydrostratigraphic interpretation of the site.

NS23A CC: 220 C-E Tuesday 1330h

Near-Surface Geophysics: Contaminants II Posters *(joint with H)*

Presiding: **E A Atekwana,** University of Missouri at Rolla**; S S Hubbard,** Lawrence Berkeley National Laboratory

NS23A-01 1330h POSTER

Analysis of the Geoelectrical Stratigraphy of a Controlled LNAPL Release

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Various electrical and electromagnetic techniques are being used to geophysically characterize LNAPL impacted sites. This characterization is dependent on our understanding of the relationship between the geoelectrical stratigraphy and spatial distribution of pore fluids. A numerical model for the geoelectrical stratigraphy of an LNAPL impacted site was constructed using a modified version of the Lenhard and Parker method to predict vertical fluid distributions; Archie's Law and Topp's Equation were used to generate the corresponding electrical conductivity and dielectric permittivity profiles. Both the van Genuchten and Brooks-Corey equations for the fluid content-hydraulic head relationship were considered in the modeling.

The modeling results were compared with geoelectrical data collected during a controlled LNAPL release in a large test cell (3 meter diameter, 1.7 meters depth) containing repacked Borden sand. There are significant differences between the predicted and actual electrical conductivity profiles for both the clean and contaminated cases. The commonly assumed value of 2 for the Archie saturation exponent is too high; a value of 1.6 is more appropriate for matching the low- and high-saturation resistivity data. Furthermore, the Archie saturation exponent varies in a systematic manner over the intermediate saturations for this data set. The predicted and actual dielectric permittivity profiles show some differences for the clean case; however, better agreement is obtained for the contaminated case.

NS23A-02 1330h POSTER

Physical Model Experiment to Test the Sensitivity of GPR to the Presence of Gasoline

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Ground penetrating radar (GPR) measurements were made on a 3-D grid on the surface of a tank filled with sand to measure changes in the vadose zone at three stages during the introduction of water and gasoline. The fluids were introduced into the bottom of the tank, and water table fluctuations were simulated by adding and removing water.

Results from this experiment show the sensitivity of GPR to moisture content and its effectiveness for monitoring small changes in the water table and the capillary fringe. A decrease in reflection amplitudes within the vadose zone occurred as a function of time, after the injection of gasoline into the tank and prior to water table fluctuations. One interpretation of these results is that increasing hydrocarbon vapor pressure displaced redistributed interstitial moisture in the vadose zone, which led to this observed change in the GPR response. The experiment also shows that the GPR response from the water table can be enhanced when residual gasoline is present in the vadose zone. This effect can be interpreted as the result of less attenuation through the medium after the introduction of gasoline into the system.

NS23A-03 1330h POSTER

Characterizing the Hydraulic Components of a Contaminated Basalt Aquifer using Borehole Geophysical and Hydrologic Methods

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Groundwater flow and contaminant transport in basalt aquifers occurs primarily through high permeable interflow rubble zones and interconnected fracture zones. These zones are difficult to identify and characterize because they occupy a small percentage of the aquifer volume and exhibit complex patterns of spatial connectivity. We attempt to characterize these preferential flow zones by integrating information from borehole geophysical logs, optical televiewer (OTV) images, crosswell radar and seismic tomography, hydraulic tests, flowmeter logs, and chemical analysis of water samples. We demonstrate the effectiveness of this integration using data collected in two wells located at the Idaho National Engineering and Environmental Laboratory. The wells are 10 to 15 m apart (varies with depth) and penetrate a saturated 60 m thick sequence of interlayered and fractured basalt within the Snake River Plane Aquifer (64-128 m below the surface). The wells also intersect a trichloroethelene (TCE) plume that is undergoing bioremediation. Caliper logs, neutron logs and OTV images help to identify interflow zones and basalt stratigraphy. The OTV images also provide information about the location, orientation and aperture of fractures that intersect the boreholes. Staining around some fractures is a direct indicator of groundwater flow. Borehole flowmeter logging and hydraulic tests in packed off zones are used to estimate the hydraulic conductivity of different zones. Radar velocity and attenuation tomograms provide information about the continuity between the wells. Zones characterized by low radar and seismic velocities, and high radar and seismic attenuations, tend to be highly permeable zones. Six high permeability

zones (i.e., rubble and extensive sub-horizontal fracturing) were identified through analysis of crosswell radar and seismic data. The most transmissive zone occurs at depths between 94 and 98 m and is correlated to a thick, weathered, rubble zone identified from core and OTV images. TCE concentrations measured at different depths using a straddle-packer show distinct vertical stratification, with higher TCE concentrations at and above these high permeable zones as compared to the dense basalt unit between 98 and 110 m that extends between the wells. We hypothesize that this dense basalt unit is likely limiting the downward migration of TCE.

NS23A-04 1330h POSTER

Interpretation of Quadrature and In-Phase Terrain Electrical Conductivity Responses Observed in Siting and Monitoring Surveys in Glaciolacustrine Soils

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Terrain electrical conductivity (TEC) surveys can assist in the siting and monitoring of landfills and wastewater lagoons. Results of TEC surveys in glaciolacustrine clay-rich soils in southern Manitoba, Canada show how these surveys have successfully mapped subsurface geology, identified heterogeneity in the subsurface, and identified areas of leakage from such facilities.

TEC instruments provide a quadrature response, from which the electrical conductivity of the ground is usually determined, and an in-phase response. In areas of low to moderate electrical conductivity (less than several hundred mS/m) the quadrature and in-phase responses both increase with increasing electrical conductivity. The relationship between the two responses over a uniform half-space is well approximated by a second-order power law. Results from many sites in Manitoba indicate that in some areas this power law is followed whereas in other areas a roughly linear relationship is observed.

At some survey sites, TEC in-phase responses that are spatially uncorrelated with the quadrature response are observed. These observations occur in soils with relatively low electrical conductivity and relatively low magnetization. Results from a number of sites suggest the effect occurs in areas of plowed agricultural land that have undergone long-term exposure to wastewater seepage. We hypothesize that positive in-phase shifts indicate an increase in the electrical polarization in the glaciolacustrine soils caused by their interaction with wastewater. Laboratory studies have shown that the complex conductivity response at the frequency of the TEC measurements is affected by the clay mineralogy; groundwater salinity, acidity, and cation chemistry; and the presence of organic contaminants. In this study we examine a site with enhanced in-phase response in detail. The results reveal increased concentrations of heavy-metals and some variations in soil mineralogy that correlate with the in-phase response, but additional studies are required to identify the clarify the precise cause of the anomaly.

NS23A-05 1330h POSTER

Monitoring of Leachate Recirculation in a Bioreactor Using Electrical Resistivity

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The bioreactor is a concept of waste landfill management consisting in speeding up the biodegradation by optimizing the moisture content through leachate recirculation. Electrical resistivity tomography (ERT) is carried out with fast resistivity-meter (Syscal Pro, IRIS Instruments, developed in the framework of the research project CERBERE 01V0665-69, funded by the French Research Ministry) to monitor leachate recirculation. During a recirculation period waste moisture increases, so that electrical resistivity may decrease, but at the same time temperature and mineralization of both waste and leachate become intermixed. If waste temperature is much higher than leachate temperature electrical resistivity will not decrease as much as if the temperature difference was smaller. If leachate mineralization (i.e. leachate conductivity) is higher than that of wet waste in the landfill, electrical resistivity will tend to decrease. Otherwise for example after an addition of rain water into the leachate storage or in case of very wet waste, the resistivities of each medium (leachate and wet waste) can be almost the same, so that leachate mineralization will not have a great influence on waste resistivity. Resistivity measurements were performed during 85 minutes injection trials (with a discharge of 20 m^3 h^{-1}) where leachate was injected through a vertical borehole perforated between 1.85 and 4.15 m. Three first measurements are made during the injection (3, 30 and 60 minutes from the beginning of the injection) and the two other after the injection period (8 and 72 minutes after the end of the injection). Apparent and interpreted resistivity variations that occurred during injection trials, expressed as the relative differences (in %) between apparent, respectively interpreted, resistivity during injection and apparent, respectively interpreted, resistivity before injection (reference measurement) show the formation of a plume (a negative anomaly: resistivity decreases with increasing moisture content). The positive anomaly could be explained by an increasing of biogas proportion in waste porosity. For this experiment, leachate temperature is relatively cold (between 5 and 10°C, as the injection trials take place at the end of October), leachate conductivity is about 9200 μS cm^{-1} (i.e. a resistivity of 1.1 Ω m) and waste resistivity in the borehole region is about 80 Ω m. This is a situation where the temperature difference between waste and leachate is large and the resistivity difference between waste and leachate is high. The resistivity variation is essentially due to waste moisture increase. ERT method allows leachate diffusion to be seen through the waste mass and the influence zone of the leachate recirculation system to be determined.

URL: http://www.ccr.jussieu.fr/dga/people/Roger%20Guerin/Agu/GrellierAgu04.htm

NS23A-06 1330h POSTER

The Use of Cone-Based Electrical Resistivity Tomography to Image Conductive Contaminants.

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Determining the 3D spatial distribution of subsurface contaminants is a challenging task. Most methods sample small regions immediately adjacent to wells or testing devices, thus providing data which are not representative of the entire region of interest. Furthermore, at many sensitive sites invasive methods that are usually employed to characterize contaminants are no longer acceptable, as the risk for exposing workers and spreading contaminants is too high. By integrating geophysical resistivity imaging with cone-penetration testing, we are developing a technology that addresses both of these issues by being minimally invasive while providing information about the 3D distribution of electrically conductive subsurface contamination.

This new technique, cone-based electrical resistivity tomography (C-bert), involves placing several permanent current electrodes in the subsurface and using electrodes mounted on the cone-penetrometer to measure the resultant potential field while advancing the cone into the sub-surface. In addition to potential field measurements, we obtain the standard suite of cone-penetration measurements, including high resolution resistivity logs; these data can then be used to constrain the inversion of the potential field data.

We recently performed a C-bert experiment to image a salt water intrusion in a fresh water aquifer in Vancouver, British Columbia. A total of nine current electrodes were emplaced at the site and five C-bert profiles were obtained, resulting in approximately 8000 independent data points. Obtaining data at the site proved challenging because of current channeling through the low resistivity salt-water wedge; for certain electrode configurations, this channeling pressed the power limitations of our resistivity unit, resulting in noisy data. In addition, the variation of in-situ resistivity over several orders of magnitude requires specific care be taken with data weighting and model regularization during inversion. To test ways to reduce computational time, we did not explicitly include the effect of the conductive cone in the initial inversion of the data. The inversion results that we obtained, along with forward modeling of the conductive cone, suggest that, for the resistivity structure and measurement geometry at the site, the effect of the cone can be considered second order. We conclude, from this first field test, that this method is a promising new way to image the subsurface.

NS23A-07 1330h POSTER

High-Resolution Flow Logging for Hydraulic Characterization of Boreholes and Aquifer Flow Zones at Contaminated Bedrock Sites

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In the past, flow logging was largely restricted to the application of spinner flowmeters to determine flow-zone contributions in large-diameter production wells screened in highly transmissive aquifers. Development and refinement of tool-measurement technology, field methods, and analysis techniques has greatly extended and enhanced flow logging to include the hydraulic characterization of boreholes and aquifer flow zones at contaminated bedrock sites. State-of-the-art in flow logging will be reviewed, and its application to bedrock-contamination investigations will be presented.

In open bedrock boreholes, vertical flows are measured with high-resolution flowmeters equipped with flexible rubber-disk diverters fitted to the nominal borehole diameters to concentrate flow through the measurement throat of the tools. Heat-pulse flowmeters measure flows in the range of 0.05 to 5 liters per minute, and electromagnetic flowmeters measure flows in the range of 0.3 to 30 liters per minute. Under ambient and low-rate stressed (either extraction or injection) conditions, stationary flowmeter measurements are collected in competent sections of the borehole between fracture zones identified on borehole-wall images. Continuous flow, fluid-resistivity, and temperature logs are collected under both sets of conditions while trolling with a combination electromagnetic flowmeter and fluid tool. Electromagnetic flowmeters are used with underfit diverters to measure flow rates greater than 30 liters per minute and suppress effects of diameter variations while trolling. A series of corrections are applied to the flow-log data to account for the zero-flow response, bypass, trolling, and borehole-diameter biases and effects. The flow logs are quantitatively analyzed by matching simulated flows computed with a numerical model to measured flows by varying the hydraulic properties (transmissivity and hydraulic head) of the flow zones.

Several case studies will be presented that demonstrate the integration of flow logging in site-characterization activities to: 1) delineate aquifer flow zones, estimate zone transmissivity and hydraulic head, and conceptualize the hydrogeologic framework; 2) evaluate cross-connection effects and determine flow-zone contributions to water-quality samples from open boreholes; and 3) design discrete-zone hydraulic tests and monitoring-well completions.

NS23A-08 1330h POSTER

Time-Lapse Imaging of a Bromide Tracer Test in a Coarse Alluvial Aquifer Using Crosswell Radar Attenuation-Difference Tomography

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A tracer test and time-lapse radar tomography experiment was conducted at the Boise Hydrogeophysical Research Site. The goal of the experiment was to investigate the utility of crosswell radar methods for imaging an electrically conductive tracer plume. A multi-level water sampling system down gradient from the tracer injection well and in the radar imaging plane was used to collect detailed fluid electrical conductivity data during the tracer test. We compare the

spatial and temporal position and concentration variations of the plume as indicated by the fluid conductivity data to those suggested by radar level run attenuation differences, shot-receiver attenuation difference crossplots, and attenuation difference tomograms. We find that attenuation differences generally correlate well with changes in fluid conductivity. Where correlations are not so strong, the discrepancies can be explained by the difference in support volumes for the radar and chemistry measurements, and by the effects of regularization in the tomographic inversion procedure. Our results indicate that crosswell radar imaging coupled with tracer testing can provide useful information about subsurface fluid flow and mass transport in complex fluvial aquifers.

NS23A-09 1330h POSTER

Using Spatially Integrated Crosswell Geophysics For Environmental Site Assessment

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Crosswell seismic and radar techniques provide high resolution subsurface images with precise control on depth and quantitative estimates of acoustic and dielectric properties. However, use of multi-well techniques for environmental site assessment has been hampered by (1) the lack of lateral survey continuity between adjacent well-pairs and, (2) ambiguous correlations between measured properties and relevant subsurface attributes such as lithology and fluid content. We present two spatially integrated tomographic strategies for inverting crosswell datasets which include multiple overlapping well pairs. This approach generates consistent velocity images for large site profiles while preserving the high spatial resolution obtained from transmitting signals over shorter distances. Anisotropic Tikhonov regularization is applied to ensure velocity ties at well locations. To compensate for irregular ray coverage and different survey geometries in the various well pairs, we use adaptive methods to control spatially varying model parametrization and regularization coefficients.

We demonstrate these techniques on a curtain of 17 crosswell seismic datasets and several multiwell radar surveys acquired at the former DOE Pinellas site. Using the results of a detailed examination of continuous cores recovered from the site and crosswell velocity images, we construct a high resolution map of lithology with ties to structural and hydraulic features.

URL: http://pangea.stanford.edu/j̃frank/springAGU/index.html

NS23A-10 1330h POSTER

Porous Media Contamination: 3-Dimensional Visualization and Quantification Using X-Ray Computed Tomography

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Non-aqueous phase liquids (NAPLs), if spilled into the subsurface, will migrate downward, and a significant fraction will become trapped in the soil matrix. These trapped NAPL globules partition into the water and/or vapor phase, and serve as continuous sources of contamination (e.g. source zones). At present, the presence of NAPL in the subsurface is typically inferred from chemical analysis data. There are no accepted methodologies or protocols available for the direct characterization of NAPLs in the subsurface. Proven and cost-effective methodologies are needed to allow effective implementation of remediation technologies at NAPL contaminated sites. X-ray Computed Tomography (CT) has the potential to non-destructively quantify NAPL mass and distribution in soil cores due to this technologys ability to detect small atomic density differences of solid, liquid, gas, and NAPL phases present in a representative volume element. We have demonstrated that environmentally significant NAPLs, such as gasoline and other oil products, chlorinated solvents, and PCBs possess a characteristic and predictable X-ray attenuation coefficient that permits their quantification in porous media at incident beam energies, typical of medical and industrial X-ray CT scanners. As part of this study, methodologies were developed for generating and analyzing X-ray CT data for the study of NAPLs in natural porous media. Columns of NAPL-contaminated soils were scanned, flushed with solvents and water to remove entrapped NAPL, and re-scanned. X-ray CT data was analyzed to obtain numerical arrays of soil porosity, NAPL saturation, and NAPL volume at a spatial resolution of 1 mm. This methodology was validated using homogeneous and heterogeneous soil columns with known quantities of gasoline and tetrachloroethylene. NAPL volumes computed using X-ray CT data was compared with known volumes from volume balance calculations. Error analysis revealed that in a 5 cm long and 2.5 cm diameter soil column containing 0.5 ml NAPL (7,080 mg NAPL per Kg soil), the precision of calculated NAPL volumes was ± 0.03 ml (6% error). Residual NAPL saturation in natural soil cores averaged 15% and varied spatially (inversely with porosity) from less than 1% to 70%. These results and others serve as proof-of-concept that a typical medical X-ray CT scanner has the potential to accurately quantify selected NAPLs in natural soils.

NS31A CC: 220 C-E Wednesday 0830h

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

Presiding: **R Knight,** Stanford University

NS31A-01 0830h POSTER

Modeling of Velocity Variations and Water Content Estimations from GPR Measurements in a Controlled Vadose Zone

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Ground Penetrating radar (GPR) is a geophysical method that uses high frequency electromagnetic (EM) waves to image the shallow subsurface. Over the last ten years, the GPR (with other geophysical methods) was successfully used to estimate the water content or hydraulic properties of the soil.

We simulate a vadose zone by injecting water in a sand box that contains buried objects. GPR monostatic profiles (with 1200 MHz monostatic antennae) are performed in order to calibrate and compare the water content estimations with the real water content present in the sand box. We obtain four GPR data sets for different saturation degrees: dry sand, water level at 72 and 48 cm depth and, finally, after draining. For each data set, we performed also two common midpoint (CMP) profiles using the 900 MHz bistatic antennae. No distinguished reflections are observed from the top of the saturated zone, and this is because of the existence of a capillary fringe above the water level. The capillary fringe is the zone in which water rises by capillarity from the water table to the surface.

The mean dielectric constants are calculated from average velocities derived from hyperbolic reflections (or diffractions) coming from the bottom of the sand box (or objects buried in the sand). In general, GPR velocity decreases rapidly with depth and this is primarily a result of increasing water content with depth. Knowing that a layer can be divided in more layers depending on the depth of the reflections (or diffractions) recorded, the sand box is shared into three layers: dry sand, unsaturated (capillary fringe) and fully saturated sand. Afterwards, we convert the average dielectric constants, found previously, into real dielectric constants for each layer.

In order to estimate the volumetric water content (the ratio of water volume to total sample volume) for each layer, we combine the GPR measurements with three relations linking dielectric constant to water content of the sample. From these water contents and knowing the volume of sand considered, we can estimate the water quantity in the sand box for each water level. Subtracting the water volume estimated for dry sand to the water volume obtained for different water levels, we find the variations in water quantities in the sand box, which can be compared to the water quantities injected in the sand box. In spite of the uncertainties in the determination of the average velocities, the variation of water quantities calculated are very close to the water quantities injected in the sand box.

By using a Finite Difference Time Domain (FDTD) modeling method, we try also to model the diffractions coming from three buried pipes: steel pipe, air-filled PVC and water-filled PVC pipes. In order to fit the real data, we use a 3rd order ricker source. The reflections from the pipes are well modeled and the amplitude ratio between direct arrivals and reflections on the pipes is respected. The polarity of the reflection coming from the air-filled PVC pipe is opposed and is not as strong as the signals coming from the steel and water-filled PVC pipes.

URL: http://Phineas.u-strasbg.fr

NS31A-02 0830h POSTER

Seismic Investigation of Glacial and Postglacial Sedimentation for the Evaluation of Local Water Resources in Sudbury, Ontario

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The City of Sudbury in Ontario, Canada, contains 330 lakes that cover a total area of 12% of the City's extent. Lake Wanapitei is the largest (13.28 km^2) and deepest (117 m) and contains approximately 4.9 km^3 of water. Baseline geophysical surveys have been conducted of the geology and substrata of the lake basin to expand our understanding of its origin. Lake Wanapitei occupies a bedrock basin that is considered to enclose a 37 million year old meteorite impact structure, 5 km in diameter, that has been modified by glacial erosion. The basin sits on the border between the Proterozoic Southern Province (Huronian sandstones) and Archean Superior Province (granites), and is transected by olivine diabase dikes 50 to 120 m wide. High resolution 'chirp' seismic surveys of the lake basin show at least 40 m of sediment fill comprising a thick lateglacial glaciolacustrine succession overlain by postglacial sediment. Lateglacial sediments accumulated between 10,500 and 10,000 years ago as the margin of the Laurentide Ice Sheet withdrew northwards leaving a series of moraines (e.g., Cartier and Rawhide Moraines). These moraines comprise large volumes of glaciofluvial sediment, often 'kettled' as a consequence of the burial and melt of dead ice blocks. A large raised delta with a surface at 300 m asl along the northern perimeter of Lake Wanapitei records ponding of a high level ice marginal lake (Glacial Lake Algonquin) and the supply of sediment south into the lake from the retreating ice margin. Seismic data record at least three buried river channels where glaciofluvial sediment was supplied to Lake Wanapitei from the north. The sediment cover is non uniform throughout the lake and shows evidence of differential compaction and slumping over the impact crater. Also evident are several faults recording ongoing neotectonic activity.

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Estimating the Lateral Correlation Structure of the Shallow Subsurface From Surface Georadar Data

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Knowledge of the spatial correlation structure of the hydraulic properties is a key prerequisite for the detailed characterization of aquifers in general and for realistic modeling of flow and transport in particular. Whereas the vertical component of the subsurface correlation structure is often well constrained from borehole information, the nature of the lateral component of the correlation structure is generally largely unknown. The reason for this is that boreholes are generally too far apart to allow for a meaningful lateral information. Georadar data are highly sensitive to variations in the water-saturated porosity structure, which in alluvial aquifers can be regarded as a proxy for the hydraulic conductivity structure. This opens the perspective to the extract the lateral correlation structure from

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