Geomagnetism and Paleomagnetism

GP51A MCC: Hall C Friday 0830h

Electrical Conductivity and Physical Properties in the Lab and in the Earth I Posters *(joint with S, T, V, DI, MR)*

Presiding: **A Kavner,** University of California, Los Angeles**; C Weiss,** Sandia National Laboratories

GP51A-0979 0830h POSTER

X-Ray Microtomography of Olivine-Basalt Partial-Melts

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Understanding the physical properties of partially molten rocks and developing the ability to infer their existence at depth in the Earth from remote geophysical measurements are of fundamental importance in geology and geophysics. The interconnectivity and tortuosity of the melt phase, in combination with the properties of the individual melt and crystal phases, have bearing on the extractability of the melt, and on the rheology, seismic velocity and attenuation, and electrical conductivity of the bulk material. We have performed synchrotron x-ray computed microtomography to image olivine-basalt partial-melts at the microscale and to evaluate current imaging capability for prediction of transport properties such as permeability and electrical conductivity.

Two different types of samples have been synthesized and imaged thus far: olivine-basalt partial-melts (Fo90) (MMP) and olivine-basalt-sulfide partial melts (Fo90) (BMS). All samples were created in the piston cylinder apparatus. The MMP samples had 5 wt % BaO added to the basalt melt phase to increase x-ray attenuation contrast between the olivine and the melt. There are three different BMS samples with a range of compositions and proportions of silicate and sulfide melts. BMS1 contains both silicate and sulfide melt, BMS2 contains a sulfide melt close to a wetting composition and BMS3 contains a non-wetting iron-rich sulfide melt.

Imaging was performed at Lawrence Livermore National Laboratory (X-ray energies up to 120 keV, $\sim$10 μm spatial resolution), Advanced Photon Source (20-40 keV, 1-6 μm) and Stanford Synchrotron Radiation Lab (10-30 keV, 3.3 μm). Initial processing and reconstruction suggests that pores greater than 10 μm in size are easily imaged but smaller pores and the interconnectness of the melt phases are more difficult to detect. Very high contrast between the olivine and melt phases helps, but it is still not possible to clearly delineate individual interconnecting tubules between larger melt pockets. The attenuation contrast between olivine and sulfide is much greater than between olivine and silicate-melt, and hence the sulfide phase is easiest to detect. The shape of the melt pockets is a strong indication of wetting behavior: wispy star-like shapes are indicative of an interconnected melt phase while spherical blebs are likely isolated. 3-D digital images, when achievable in sufficient resolution, will be used to quantify microstructural properties and predict fluid transport. Coupled with measurements of physical properties such as permeability and electrical conductivity, this will enable the evaluation of empirical and theoretical relationships between electrical conductivity, microstructure, and permeability for partially molten systems.

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GP51A-0980 0830h POSTER

Electrochemical manipulation of apparent oxygen fugacity in a piston cylinder apparatus

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Phase stability of mineral assemblages and their physical properties, especially transport properties, are influenced by oxygen fugacity. Redox effects in earth and planetary systems at high pressure include setting of ferric/ferrous iron ratios [controlling the electrical conductivity of crustal and mantle materials] and possible chemical reactions at the Earths core-mantle boundary. Experimental controls of oxygen fugacity in high-pressure devices have been limited to discrete electrochemical potentials set by buffers such as C-CO, Ni-NiO, and QFM. By contrast, an electric field applied across a silicate sample inside a piston cylinder apparatus establishes a smoothly-varying electrochemical gradient that can be quantified and tied to the oxygen fugacity scale through synchrotron microXANES of polyvalent V and Fe within the silicate.

Fugacity gradient samples were synthesized in a modified Boyd-England piston-cylinder configuration. Platinum electrodes were placed at both ends of a 2-mm cylinder of basaltic composition silicate glass containing $\sim$5% Fe and $\sim$2% V. The sample assembly was surrounded by MgO ceramic, sheathed within a Mo faraday sleeve to insulate the sample from the AC field of the heater, and placed within a 0.5 inch diameter pressure vessel. The assembly was sintered at 800°C for 72 hours to eliminate porosity in the MgO capsule, and then heated to 1400°C for 23 hrs at 10 kbar. At high temperature, a 1V potential difference was applied across the electrodes via an external power supply. The sample was then quenched, potted in epoxy, and polished to a thickness of $\sim$30 μm, and analyzed via optical and scanning electron microscopy.

Vanadium, with oxidation states of 0 and +II to +V, was used as a chemical marker to evaluate the absolute value of the fO_2 conditions across the silicate sample. Synchrotron-based microXANES techniques at GSECARS at the Advanced Photon Source in Argonne, IL were used to measure the pre-edge peak height at the vanadium absorption edge, as a function of distance between the anodic and cathodic electrodes of the recovered piston cylinder experiments. The intensity of the pre-edge peaks varied greatly across the sample, from $\sim$5% near the cathode end to $\sim$70% of the absorption edge level adjacent to the anode. The systematic increase in the pre-edge peak was calibrated to the vanadium valence state and oxygen fugacity by comparison with vanadium microXANES spectra obtained for synthetic komatiite charges (known fO_2; Canil 1997) and basaltic glasses (known fO_2 and oxidation state; Schreiber 1987).

The average vanadium oxidation state varies monotonically from +2.5 at the cathode (reducing) electrode to +4.5 at the anode (oxidizing) electrode, corresponding to an oxygen fugacity varying from 11 to 5 (log units) from cathode to anode. The sample appears reddish at the anode (oxidizing) end and grayer at the cathode (reducing) end, due in part to reducing the iron ferric/ferrous ratio from anode to cathode, in harmony with the V results. In summary, the application of an electric field creates an oxygen fugacity continuum in high-pressure apparati.

GP51A-0981 0830h POSTER

Effect of Water on the Electrical Conductivity of Wadsleyite: Implications for the Water Content of the Transition Zone

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Recent laboratory work has demonstrated that the electrical conductivity profile of the mantle can be reasonably approximated from the measured conductivities of the major mineral constituents such as olivine, wadsleyite, ringwoodite and silicate perovskite. Where the approximation shows lesser agreement with recent geophysical electrical conductivity models, particularly at transition zone depths, consideration of the effects of minor constituents that might affect the electrical properties of minerals is required. For the transition zone, only the conductivities of nominally anhydrous minerals have previously been measured, yet both wadsleyite and ringwoodite, which compose a substantial proportion of the transition zone, can incorporate up to several weight percent water into their structures. Knowing the effect of dissolved water on the electrical conductivities of these minerals may thus provide important constraints on the amount of water in the transition zone. We have obtained preliminary results for the electrical conductivity of hydrous wadsleyite at P,T conditions of the Earth's upper mantle. The sample material was synthesized at 12 GPa and 1100 C in a welded Pt capsule using a multianvil apparatus. The recovered material was cut into 0.5 mm thick disks for in-situ measurement by complex electrical impedance spectroscopy also at 12 GPa in a multianvil apparatus. Pre-and post-run analyses by secondary ion mass spectrometry (SIMS) indicate that the samples lost some water during the high P,T conductivity runs. Post run analyses were 0.40 wt per cent and 0.50 wt per cent H2O, respectively for two conductivity runs performed. We find that the water-bearing wadsleyite is approximately 1/2 to 1 orders of magnitude more conductive than the nominally dry wadsleyite (Xu et al., 2000) over the temperature range 600 to 1050 C and that conductivity increases with water content. The activation energies are independent of water content with values of about 1.0 eV. Furthermore, analysis of nominally dry wadsleyite prepared in the same manner as that of the previous workers yields a water content of 0.16 wt per cent H2O, suggesting that the previous 'nominally dry' results contained a small amount of water. Compared with these laboratory results, Earth conductivity profiles in the transition zone (420-670 km depth) do not require water to be present, but may allow small amounts to be present.

GP51A-0982 0830h POSTER

Novel High Pressure Magnetic Measurements With Application to Magnetite

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We report a novel system designed to measure reversible magnetic susceptibility of micron-sized samples under high pressures (in excess of 30 GPa) in a diamond anvil cell. We find that magnetite reversible hysteresis parameters vary <15% below 0.6 to 1.0 GPa, while at higher pressures significant increases occur in (1) bulk coercivity (Hc) and (2) the ratio of saturation remanent magnetization (Mrs) to saturation magnetization (Ms). The net effect of pressure is to displace magnetite toward a truer single domain state with both higher Mrs/Ms and Hc. Our data, together with the fact that the Curie temperature increases with pressure, suggest that magnetite can account for geomagnetic anomalies related to some subduction zones and potentially to meteorite impact sites on Earth, as well as magnetic signatures observed on some planetary bodies like Mars.

GP51A-0983 0830h POSTER

The controlled-source electromagnetic response of two buried plates, including mutual inductance and interaction with the host medium

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A solution for the response of multiple buried plates in a host medium to controlled-source electromagnetic (CSEM) stimulation has been found. This solution accounts for the interaction between the plates and the host medium. The solution for a plate in free space is well-known and analytic. However, adding a second plate or a conducting host medium increases the complexity of the solution. Time-varying currents induced by the source in the plates and the host medium introduce new magnetic flux to the system that in turn modify the currents via mutual inductance.

This solution is obtained by solving the ($\mathbf{A}$,ϕ) potential formulation of Maxwell's equations using the finite element method. The finite element mesh generator allows for local refinement of the mesh in regions where greater resolution is desirable. This allows finer meshing in the region of the plates, which allows for more accurate modeling of the nuances in the induced currents caused by the interaction between the plates and the host medium.

The effect of mutual induction and the efficacy of the locally refined finite element solution are demonstrated. The response of a model containing two plates within a host medium is compared to the sum of the responses of the two plates modeled separately. The plates are 2 m by 2 m, with a separation distance of 1 m, buried at a depth of 1 m. The plates have a conductivity of 100 S/m, and are within a host medium of conductivity 0.01 S/m. The system is excited by a source with a frequency between 1 and 100 kHz. It is shown that the model response of a two-plate system differs from the sum of the responses of two one-plate systems.

The interaction between the two plates and the host medium must be properly modeled. An accurate model of the interaction of buried conductors excited by a controlled source is necessary to properly discriminate and classify buried targets. This is particularly true in the near-surface region of the earth where complex heterogeneity is common.

GP51A-0984 0830h POSTER

Conductivity Structure of the Upper Mantle Beneath the Southern East Pacific Rise Obtained by Topographic Correction and Anisotropic Inversion of the MELT EM Data

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The Electromagnetic component of the Mantle ELectromagnetic and Tomography (MELT) experiment has previously revealed an asymmetric conductivity structure for the upper mantle beneath the fast spreading East Pacific Rise at 17S (Evans et al., 1999). We present further results obtained by inversion of the MT responses for a transversely anisotropic structure after more complete correction for topographic effects.

The topographic correction of the observed MT responses was carried out using the flattening surface three-dimensional modeling (FS3D) method (Baba and Seama, 2002). FS3D is based on the finite difference method using staggered grids. The algorithm parameterizes seafloor topography as lateral variations in conductivity and permeability in the two layers bounding a flat seafloor. The correction method using FS3D is superior to thin sheet modeling because it doesn't have limitations at short periods and can treat complex, anisotropic structure beneath the seafloor. We use a 2D regularized inversion method to recover an anisotropic conductivity model with the constraint that conductivities in the x, y, and z direction are as close to each other as possible. Dealing with anisotropy is required because independent isotropic inversions of the TE and TM mode data produce distinct conductivity models, and their joint inversion for isotropic models introduces features that are suggestive of anisotropic effects. The model space of the inversion doesn't include topographic change because we invert the responses corrected to a flat seafloor. The combination of the topographic correction and the inversion is iterated several times because of coupling between the topographic effect and mantle structure.

The anisotropic conductivity structure will be compared to previous seismic results and interpreted using end-member melt models.

GP51A-0985 0830h POSTER

Electrical Conductivity and Anisotropy in Pacific Lithosphere: CSEM Results from APPLE

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Emplacement of the sheeted dyke complex and strain associated with plate formation at mid-ocean ridge spreading centers may influence electrical conductivity at various depths in the lithosphere, and may leave an anisotropic fabric frozen in place. By measuring lithospheric electrical conductivity and anisotropy as a function of depth, insight may be gained regarding the formation and evolution of oceanic crust and mantle.

Controlled-source electromagnetic (CSEM) sounding of 35 Ma Pacific lithosphere was undertaken as part of the Anisotropy and Physics of the Pacific Lithosphere Experiment (APPLE), carried out in February/March 2001 approximately 1000 km west of San Diego, California. Twenty seafloor electric field sensors were deployed (and recovered with data) during this experiment. The transmitter (DASI), a 100 m horizontal electric dipole, was deep-towed in a 30 km radius circle around a central core and perimeter array of receivers. An additional radial tow to 70 km total range and a 15 km radius semi-circular tow around a perimeter receiver supplemented the geometry of the main tow. DASI transmitted a 4 Hz square wave throughout the CSEM phase of the experiment.

Smooth (and layered) inversion of short-offset (2-20 km) data, using 1-D isotropic modeling, generates models with upper-crustal resistivities $\sim$10 Ωm, varying by about an order of magnitude across the survey area. Lower crustal resistivities are on the order of 10^3 Ωm. Smooth inversion of the long radial tow data indicates upper mantle resistivities of $\sim 10^4$ Ωm, with an increase in conductivity below 20 km depth. This may be due to thermally-activated olivine conduction, indicating that the base of the lithosphere has been detected. The integrated resistivity-thickness product for the top 100 km of our model is 1.1 x 10^9 Ωm^2.

A factor of two is observed in the electric fields measured during the circular tow, in a pattern that qualitatively resembles forward modeling results over an uniaxially anisotropic halfspace with enhanced conductivity in the vertical and fossil spreading directions. This supports earlier results from the PEGASUS experiment, which advocated dipping ridge-perpendicular mineral lineaments (e.g. oxides, graphite) of enhanced conductivity within the lithosphere.

GP51A-0986 0830h POSTER

Evidence for mid to lower crustal electrical anisotropy at the South Chilean active continental margin

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In late 2000, long period electromagnetic variation measurements have been carried out in the Chilean Southern Andes around 39°S, where the oceanic Nazca plate converges with the South American continent at a rate of approx. 6.5 mm/a. Most field stations are aligned along two profiles running from the coast to the Chilean border with Argentina, both traversing the Recent and Mio-Pliocene volcanic arc, which comprises the more than 950 km long intra-arc resp. trench-parallel Liquiñe-Ofqui-Fault, dividing an obviously due to the subduction obliqueness ($\sim$25°) and, especially to the south, to the indentation of the Chile Ridge at lat. 46° northward moving fore-arc sliver from the continent.

Below and east of the volcanic chain, isotropic 2-D modelling of magnetic and magnetotelluric transfer functions revealed conductivity anomalies of $\sim$10 Ωm in mid to lower crustal depths, which is comparably moderate when compared with anomalies found in the Central Andes. As induction vectors are very uniformly deviated from the perpendicular to the structural axis, magnetic data seem to have clear signature of continental mid to lower crustal horizontal electrical anisotropy. The anisotropy strike is not well constrained, but clockwise oblique to the structural resp. morphological strike, coinciding with the direction of maximum horizontal stress as deduced from the distribution of volcanic flank eruptions at nearby stratovolcanoes. One possible explanation for the proposed anisotropy are conductive magmatic dykes, oriented parallel to the direction of maximum horizontal stress and not just confined to a narrow band below the volcanic arc.

GP51A-0987 0830h POSTER

MT Impedance Estimates at the Kilahuea Volcano Site

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In 1998 a MT survey was carried out at the Kilahuea volcano site, Hawaii to investigate the electrical structures. High noise levels, insufficient sites and the lack of adequate data processing tools resulted in a very poor quality conductivity interpretation..

In an effort to evaluate the possibility to record good quality MT data, a MT feasibility study was performed at the same site, as a collaborative effort between Lawrence Berkeley National Laboratory, Sandia National Laboratories, Electromagnetic Instruments and the USGS Hawaiian Volcano Observatory.

High noise levels where systematically encountered at five different reoccupied sites on the 0.1 to 10 Hz band. The observed low signal to noise ratios are due to abnormal signal levels on the electric components, rather than the expected lack of strength on the natural electromagnetic spectrum on the dead band. As a result, heavily biased MT estimates where obtained when processing the data using traditional least squares stacking, and although the noise on the electric field measurements appears to be incoherent across different stations, the resulting sounding curves are still biased when using a multiple station robust processing technique. This last approach could be tailored by down weighting the electric measurement, which removed the biased and recovered the MT sounding curves.

GP51A-0988 0830h POSTER

A 1D Full Waveform Time Domain Magnetotelluric Inversion

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Conventional frequency domain magnetotelluric (MT) analysis imposes a harmonic model on source fields by extracting the stationary component of a non-stationary signal. This can be statistically inefficient as considerable information is disregarded, and it can lead to biased interpretations unless considerable care is used in extracting the stationary fields. We report on a time domain approach that seeks to model the full waveform of the source field, and through inverse modelling, to determine the time domain response of the best fitting 1D Earth model. This allows the non-stationary components of the Earths natural electromagnetic field to be incorporated into the inversion and dispenses with the usual assumption of harmonic source excitation. The original time series data-sets, typically after low-pass filtration, can be inputted directly into the inversion routine. Ultimately, more efficient use of such data should lead to improved resolution of the Earths interior. Maxwell's Equations for a 1D model space are solved directly for the electric and magnetic fields in the time domain. Initially a harmonic source is considered as the solution can then be Fourier transformed to provide a comparison with the conventional (stationary) frequency domain solution. An inversion based on a linearised conjugate gradient approach is then performed for a synthetic data-set containing multi-frequency components. Finally, anharmonic sources are considered and an inversion performed for a real data-set containing non-stationary components.

GP51A-0989 0830h POSTER

Extracting Dead Band Magnetotelluric Responses From Long Period Array Data.

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Magnetotelluric (MT) systems have traditionally been divided into long period and wide band systems. This has come about because there is a so-called dead band from about 10 seconds to 10 hz in which natural signals are typically weak. Flux gate magnetometers used in long period systems are not sufficiently sensitive in the dead band to detect the natural background. Induction coils used in wide band systems are sensitive to the time derivative of the field and are much better in the dead band, but lose their sensitivity as the period increases.Because long period systems are deployed for several days to several weeks, it is theoretically feasible to extract dead band data by searching for times that the natural signal is above the magnetic sensor noise. With the advent of a new generation of long period systems that can record many days of data at 4 hz or faster, this becomes more than a theoretical possibility.However, standard robust time series techniques for extracting MT responses from such data fail miserably at periods shorter than about 15 seconds. This is because the shorter period natural signal is above system or cultural noise for only a small percentage of the time. It is thus considered anomalous and is rejected. We have, however, had considerable success using Egbert's multiple-station robust code: multmtrn. This algorithm picks out only the signal that is coherent across an array. MT responses from 4 hz data collected for about a week with several NIMS deployed in arrays spanning about 100 km produce responses at 2.5 seconds period that compare favorably in quality to those that long period systems traditionally produce at periods of order 100 seconds.

GP51A-0990 0830h POSTER

Electrical and Petrophysical Parameter Modeling and Inversion of Ferron Sandstone Data

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The dielectric permittivities of fluvial rocks are dependent on frequency, water saturation, and lithology. Complex permittivity measurements were made at three water saturation levels; oven dried, ambient, and fully saturated. The dry samples show very little dispersion. The permittivities vary systematically and are approximately predicted by effective medium models. The effective medium of a real sedimentary rock (rock grains, pore space, and pore fluid) is computed incrementally by adding differential rock grain dielectric permittivity components to a homogeneous background dielectric permittivity until the desired total rock volume is constructed. The dissociated phase (DP) model consists of sand grains (of K^*_m), clay grains (of K^*_n), pore space, and a homogeneous background permittivity of water (K^*_w). An effective medium model containing rock grains coated with water (CG) is more realistic than the DP model for partially saturated sedimentary rocks. In the CG model the effective medium is connected with a continuous unsaturated pore space, and the sand and clay grains are coated with water. The consequences of water layers coating a rock grain are determined by the Stern-Gouy double-layer effect. An inner bound-water layer is strongly bound to the rock grain (and so exhibits lower effective dielectric permittivity than free water) whereas the outer free-water layer is weakly bound to the bound-water layer. DP models and CG models are inverted for water saturation and water permittivity. The first step in the model inversion constrains the dielectric permittivities of the dry sand and clay grains. Dielectric permittivities for oven-dried samples at 50, 60, 70, 75, 80, 90, and 100 MHz are used as input data for inversion with a DP model. The next step in the inversion is to constrain the DP and CG models with the dielectric permittivities of the rock and clay grains and to invert for the dielectric permittivity of water and for water saturation, using the frequency dependent observations from the ambient samples. The average complex permittivities estimated from the DP model are 4.52+0.16j for the sand grains and 6.12+1.78j for the clay grains. Water saturation is estimated to be 9.6% from the DP model and 6.0% from the CG model (water saturation was estimated by weight measurements to be 4.2%). The average dielectric permittivity estimated for bound water is 69.3+50.7j (obtained from the CG model) and compares more favorably with theoretical Stern-Gouy double-layer predictions than does the average dielectric permittivity estimated for free water of 115.5+96.5j (obtained from the DP model). The unphysically high values of K^*_w in the DP model results are a consequence of the physically inappropriate DP model. These results show that the CG model gives a better estimate than the DP model does, of the dielectric constant of water and of the water saturation for low levels of water saturation. A sensitivity analysis of the inversion results is based on an analysis using second derivatives calculated numerically from the effective medium parameters. The effective permittivity of rock has its highest sensitivity to water saturation for low to moderate values of porosity (<20%) and the highest sensitivity of the effective permittivity of rock to water permittivity occurs for high porosity at all values of saturation. It is concluded that the reliability of the estimated bound-water content is much better than that of the estimated bound-water permittivity.

GP52A MCC: 121 Friday 1330h

Electrical Conductivity and Physical Properties in the Lab and in the Earth II *(joint with S, T, V, DI, MR)*

Presiding: **J J Roberts,** Lawrence Livermore National Laboratory**; S Constable,** Scripps Institution of Oceanography**; J A Tyburczy,** Arizona State University

GP52A-01 1340h INVITED

Evolving concepts on the electrical conductivity of the continental crust

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Several decades of geophysical research have established that the middle and lower crust are typically much more electrically conductive than the upper crust and orders of magnitude more so than either dry crystalline rocks or rock-forming silicate minerals at similar conditions. The high conductivities at depth were originally ascribed to the presence of saline fluids. Two problems with this view have emerged: hot water is far too reactive with surrounding rocks to remain for long in the deep crust, and the permeability of hot, ductile crust is too low to account for the observed conductivities. Another possibility is that graphitic carbon exerts the primary control on deep crustal conductivity.

Graphitic carbon can exist in different habits and abundances and influence conductivity on different scales. Buried organic-rich shales form megascopic layers in which carbon is likely to be interconnected over kilometers, but such layers are not common. Graphitic veins formed during metamorphism are probably more common but much less extensive. Carbon also forms films on microfracture surfaces. These have been observed in many crystalline rocks and appear to be ubiquitous; they are also probably extensive and thus may generally account for the crustal conductivity structure. The microcrack network need not be completely interconnected to impart high electrical conductivity. It can exist in series with conductive minor phases such as oxides or sulfides, and it also reduces the size of regions of high resistivity. Regardless of mode of occurrence, that carbonaceous rocks are more abundant in the Phanerozoic than Precambrian records explains why the deep Phanerozoic crust is more conductive than old shield regions.

The control of rock conductivity by carbon in the microfracture network implies that conductivity is in part controlled by microstructure and microfabric and by the chemical state of carbon. Observations of rocks from the KTB borehole indicate that microcrack carbon at the bottom of the hole (9.1 km depth) is relatively pure but at shallower levels contains a higher proportion of hydrocarbon. With uplift of the host rocks, carbon may react with fluids to form less conductive hydrocarbons. This retrograde metamorphism of microcrack carbon may be one reason that shallow crust can be less conductive than deep crust.

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Promotion of Graphite Formation by Tectonic Stress - A Laboratory Experiment

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Graphitisation of less ordered hexagonal carbon was studied under in-situ pressure and temperature conditions on anthracite, black shale and a synthetic calcite/anthracite mixture at upper greenschist facies conditions. Anthracite exhibited a continuous loss of volatiles in the temperature range 100° C up to 850° C (9.9 weight at 450° C) as detected by simultanous Differential-Thermo-Analysis (DTA) and Thermo-Gravimetry (TG). Thus the relative carbon content of the sample was increased by heating up the samples. Energy dispersive X-Ray diffraction (EDX) confirmed this observation by a continuous decrease of the FWHM of the 002 graphite reflection from a broad amorphous peak to nearly perfect crystallised graphitc carbon. The bulk conductivity was increased as a function of time by about three orders in magnitude at constant pressure and temperature conditions (0.7 GPa, 450° C). The frequency dependence of the complex electrical conductivity (AC-IMP) was measured in the frequency range 0.6 up to 100 kHz and was modelled by an Least Squares Refinement exhibiting a continuous decrease of the imaginary part of the impedance. Thus "quasi-metallic" conduction dominates the charge transport in the samples. The application of pressure, shear stress, temperature and time caused an increase in ordering and degree of interconnection of the formerly random oriented hexagonal carbon rings. From these experiments it can be derived that graphitization takes place in nature only with shear at temperatures of the order of 300-500°C and pressures of several 100 MPa. This result corresponds with the occurence of graphite in overthrusts and nappe structures.

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CBEX: Central Baffin Electromagnetic Experiment

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Regional-scale magnetotelluric data were acquired on Baffin Island, northern Canada, during the summers of 2001 and 2002, as part of the Geological Survey of Canada's multi-disciplinary Central Baffin project to study the northern margin of the Paleoproterozoic Trans-Hudson Orogen. Broadband MT (BBMT: 1,000 Hz - 1,000 s) and long period MT (LMT: 20 - 10,000 s) data were recorded at 15 locations equi-spaced along a 300-km NNW-SSE profile during 2001, and BBMT data at 20 fill-in sites, and 10 sites extending the profile 200 km to the NNW, were acquired during 2002. In addition, a short (5 km) profile of data was acquired of six BBMT sites and ten high frequency audio-MT (AMT: 10,000 - 10 Hz) sites across one formation of interest (the Astarte River formation). The primary goal of the survey was to determine the subsurface geometry of major geological boundaries, particularly between Archean rocks to the north and south, and Paleoproterozoic continental margin units in the middle. Within these margin units lies a sulphide-facies iron formation - the Astarte River Formation. Given its likely enhanced electrical conductivity, this formation was a particular target horizon for EM imaging.

Preliminary modelling shows that the Astarte River formation can be mapped as long wavelength syncline/anticline pairs to deep within the crust (>15 km).