the conventional (stationary) frequency domain solution. An inversion based on a linearised conjugate gradient approach is then performed for a synthetic dataset 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.

GP52A-02 1355h

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.

GP52A-03 1410h

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).

The most significant conclusion reached from preliminary analyses and modelling is that Astarte River rocks are not electrically connected to similarly conductive rocks found in the southern part of the profile. This suggests either that Archean rocks mapped in the south are not related to similar-aged rocks to the north, or that tectonic imbrication has disconnected northern and southern segments. Either way, the MT data provide important constraints on crustal geometries and orogen evolution.

Laboratory analyses of rock samples from the type section of the Astarte River Formation show strong electrical anisotropy at hand sample scale, with low resistivities (8-80 Ohm.m) parallel to bedding and 100 times higher resistivities (greater than 2,500 Ohm.m) perpendicular to bedding. In these surface-derived samples, the sulphides do not contribute to enhancing the conductivity – It is the interconnectivity of the graphite that is important. In the bedding-parallel directions there is electrical connectivity, but not perpendicular to bedding.

GP52A-04 1425h

Resistivity Architecture and Physical State of the Great Basin: Separate and Joint Roles of Fluids and Graphite

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Dense profiles of MT soundings in the active Great Basin extensional province and the neighboring stable Colorado Plateau are integrated to provide a view of large scale structure, tectonic activity, fluid state, thermal regime and strength of the crust and upper mantle. Resistivity cross sections were derived from the MT data over the period range 0.005-10,000 s, subjected to strike analysis, using a 2-D inversion algorithm damping model departures against a-priori structure. To first order, Great Basin resistivity structure is one of a moderately conductive, Phanerozoic sedimentary section fundamentally disrupted by intrusion and uplift of resistive crystalline rocks. Early and Late Paleozoic, low-resistivity graphitized shales form important conductive marker sequences in the stratigraphy for unraveling structure. Degree of graphitization and conductance correlates with that of compressional shear deformation and hydrocarbon source maturity. Resistive crystalline core complex massifs adjoin their host stratigraphy across crustal-scale, steeply-dipping fault zones providing pathways to the lower crust for heterogeneous, upper crustal induced, electric current flow. The numerous crustal breaks imaged with MT may contribute to the low effective elastic thickness (Te) estimated for the Great Basin and exemplify the mid-crustal, steeply dipping slip zones in which major earthquakes appear to nucleate. We find the most important domain for graphite in conductivity to be the upper half or brittle regime of the crust with an origin in organic-bearing sedimentary rocks, but with important later remobilization by fluids during thermal events.

Average lower crustal resistivity is low under both central and eastern Great Basin sub-provinces and is quasi one-dimensional. Deep temperatures and volcanic products suggest oxidizing conditions in the lower crust, so high conductivity is interpreted to reflect a low porosity (<1 vol. %) of hypersaline brines and possible water-undersaturated crustal melting. However, lower crust of the central region is strongly anisotropic at the broadest scales with the more conductive direction being NNW, oblique to the current NNE horst-graben morphology. It is parallel to earlier deep crustal trends reflecting orientation of the ancestral Proterozoic continental margin as interpreted from isotopic data and regional mineral belts such as the Carlin Trend. The fluids probably are residual to the mostly Miocene regional extension, but their degree of interconnection and anisotropy is controlled to a large extent by ancient fabric. Mantle resistivity in the central region shows only slight anisotropy at most, and the relatively high values about 100 ohm-m are consistent with temperatures near the global mantle adiabat and not plume-like. Deep crustal resistivity in the eastern Great Basin is lower than even the more conductive direction of the central region, in keeping with the currently active state of the former with probable magmatic underplating and fluid exsolution. Upper mantle conductivity there appears higher than permitted by dry lherzolite and peridotite solidus limits, thus implying probable melting. It stands in stark contrast to the cooler, stable Colorado Plateau to the east where a thin lower crustal conductor is barely observable and lies right at the Moho, sandwiched by a resistive middle crust and upper mantle lid.

GP52A-05 1440h INVITED

Elastic and Anelastic Properties of Porous Rocks: Models and Measurements

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The effective properties of porous polycrystalline rocks are inherently uncertain owing to lack of knowledge of their microstructure. We have constructed models of the elastic and anelastic properties of fluid saturated rocks using a self-consistent effective-medium theory that takes into acount the geometry and connectivity of the pore space. A division of pore space into crack-like and equant pores appears adequate for most purposes. The model identifies regimes of characteristic behavior determined by different limiting cases of fluid pressure equilibration between pores, and allows laboratory results to be interpreted in terms of a minimum number of physical parameters. Introducing distributions of pore shape and connectivity in the model allows comparison with real materials. Results can be obtained for partial saturation and mixed fluid saturation. Extensions of the model to nonlinear response are possible by taking into account the assymmetry of crack closing and opening, as well as frictional sliding on crack surfaces. The modelling scheme is applicable to electrical and transport properties as well.

GP52A-06 1455h

The High-Pressure Melting Temperature of hcp Iron Determined From Thermal Physics

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The melting temperature, $T_{\rm m}$, of hexagonal close-packed (hcp) iron at pressures corresponding to the Earth's core is derived using two thermal physics methods. The first, Gilvarry's rule, follows from the assumption that melting occurs when the root mean squared amplitude of atomic vibration is a certain fraction of the interatomic distance. The second, the Stacey-Irvine formula, follows from assuming that the Gibbs free energy of both solid and liquid phases are equal in value. A crucial pressure is 330 GPa, the pressure at which Earth's solid inner core is in thermal equilibrium with its liquid outer core. We find hcp-iron melting temperatures at 330 GPa of 5905 K or 6050 K when the Gilvarry and the Stacey-Irvine formulae, respectively, are used. These calculations are made possible by the recent experimental determination of the vibrational Grüneisen parameter, $\gamma_{\rm vib}$, and the thermal expansivity, α, up to 360 GPa at 300 K. These $T_{\rm m}$ (330 GPa) values are in near agreement with the value of 5995 K for hcp iron determined using the dislocation-mediated method. The average result of the approaches discussed here, Gilvarry's rule, the Stacey-Irvine formula, and the dislocation-mediated method, indicates that $T_{\rm m}$(330 GPa) = 5980 ± 70 K for hcp iron. This result is consistent with the value of 6000 K for hcp iron sometimes assumed in studies of Earth's core.

GP52A-07 1530h

Salt, Sediments and Seawater: Marine Magnetotellurics in the Gulf of Mexico

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The Smackover and Louann salt formations are distinguishing features of the Gulf of Mexico which not only provide clues to the tectonic evolution of the Gulf, but also play a critical role in the formation of traps for hydrocarbon reservoirs. However, the challenge of mapping these features is only partially met by existing seismic methods: the top of salt (TOS) is usually well resolved while the base of salt (BOS) is remarkably less so. Owing to the high contrast in electrical conductivity between salt and the surrounding sediments, electromagnetic methods such as magnetotellurics (MT) are promising techniques for minimizing the uncertainty in mapping allocthonous salt structures. Futhermore, the high conductivity of the seawater invites speculation on the usefulness of vertical electric field measurements in TOS/BOS characterization. Thus, we present results from a series of 3D numerical modeling experiments of electromagnetic induction over a "realistic" salt body: a 3D seismic–derived volume representing the Gemini salt structure, located beneath 1000m of water in the Mississippi Canyon, Gulf of Mexico. Results are compared to a collection of 34 broadband (T = 1–5000 s) MT datasets collected in three surveys over the structure between 1998 and 2001. Previously obtained 2D inversion results of the observed data are validated by 2D inversion of the fully 3D synthetic model response.

URL: http://mahi.ucsd.edu/SEMC/

GP52A-08 1545h

Preliminary Marine MT Results from the Anisotropy and Physics of the Pacific Lithosphere Experiment (APPLE)

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We present preliminary magnetotelluric (MT) and geomagnetic depth sounding (GDS) results from the Anisotropy and Physics of the Pacific Lithosphere Experiment (APPLE). APPLE included both controlled source EM and MT components in order to provide constraints on the depth and alignment of anisotropic conductivity structure in both the crust and upper mantle. A key goal of the MT component is to provide insights into electrical conduction mechanisms in the mantle, particularly the proposal that hydrogen dissolved in olivine enhances the conduction in the a axis direction. The main survey was located on 30 Ma old lithosphere, about 1000 km west of San Diego, USA. The core location consisted of two long period MT instruments (10^2 - 10^5 s), two broadband MT instruments (10^1-10^4 s) along with four long wire electric field receivers. Around the core eight additional instruments were positioned on a 30 km radius to provide constraints on lateral heterogeneities in conductivity structure that may masquerade as mantle anisotropy. Four long period instruments were also deployed along a transect from the core to the base of the continental slope to constrain the effect of the coast on the data. These were augmented with four broadband sites in 1500 m water on the continental shelf offshore San Diego and six broadband sites in 10-350 m water offshore Torrey Pines Beach, California.

Processing the MT time series yielded impedance responses that are predominantly two dimensional (2D) with large splits between the two principal MT modes (up to a factor of 10 difference in apparent resistivity), with the greatest mode split and most significant GDS response occurring at sites nearest the continental margin. This suggests that much of this first order anisotropy in the MT response is due to the juxtaposition of the conductive ocean and the resistive continental crust, and indeed a 2D inversion that includes bathymetry of the coastline as fixed structure produces a model with lithospheric resistivities in agreement with the controlled source EM results and responses that match the observed split in the MT data. However, MT sites at the core and the surrounding 30 km circle sites, which should all exhibit the same relative coast effect distortions, show differences in both impedance responses and strike directions. Thin sheet modeling shows that despite the relatively small amount of relief (seafloor gradients typically less than 1 degree slope) the MT responses are affected by the subtle variations in seafloor bathymetry. It is clear that in order to estimate how much, if any, mineral scale anisotropy exists in the mantle beneath the deep ocean, the distorting effects of the seafloor bathymetry and the nearby resistive coastline have to be considered.

URL: http://mahi.ucsd.edu/Steve/APPLE/

GP52A-09 1600h INVITED

Enhanced Mantle Conductivity from Sulfides beneath the Sierra Nevada?

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A region of enhanced mantle conductivity (0.03-0.1 S/m) beneath the southern Sierra Nevada, where elevations of over 4000 m are found, has been attributed previously to 3-5% basaltic melt (Park et al., 1996) and to a mix of basaltic and sulfide melt (Ducea and Park, 2000). Because the sulfide melt is assumed to have similar conductivities to its solid counterpart (10,000 S/m), very small amounts ($<$ 0.1%) of sulfide are needed in order to reduce the bulk conductivity from matrix values of about 0.003 S/m or even that of the matrix-basalt melt mix to the values observed. Basaltic melt percentages of less than 1% are needed in the presence of 0.1% sulfide melt in order to match the observed mantle values. Xenoliths from the Holocene basalts in the Big Pine Volcanic Field contain 0.06-0.4% sulfide, so the estimated values are reasonable. Given the lack of evidence for volumetrically extensive, young ($<$ 10 Ma) basaltic volcanism, calculated residence times of approximately 100 Ka for 3-5% partial melt, the short (about 300 Ka) times needed to develop connected pathways for the basalt, and the young extension of the adjacent Basin and Range province, a mixed melt with both basalt and sulfides seems more reasonable.

This conclusion presupposes that the sulfide melt is somehow interconnected in the mantle. Models in which the matrix, the basaltic melt, and the sulfide melt each form interconnected, interlaced networks leads to much higher predictions of mantle conductivity; the sulfide melt fraction must be discontinuous in order to lower bulk conductivity. Petrological studies of sulfide-silicate systems confirm this conclusion; sulfide melts form isolated blebs on the surfaces of olivine within interconnected basaltic melt channels (Holzheid et al., 2000). Simple series-parallel models of 1% continuous basaltic melt and 0.01% discontinuous sulfide melt provide bulk conductivities comparable to the observed mantle values. More complicated equivalent media and Hashin-Shtrikman models provide similar estimates.

The idea that a discontinous, volumetrically small component can alter substantially the bulk conductivity of a rock is counterintuitive. If this hypothesis is true, then the interconnected basaltic melt forms the bridge between the patches of sulfide melt. Laboratory studies are needed to confirm this hypothesis, however. Measurements of sulfide melt at elevated pressures and temperatures are needed, as are measurements of mixed basalt-matrix-sulfide systems.

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Park, S.K., B. Hirasuna, G.R. Jiracek, and C.L. Kinn, Magnetotelluric evidence of lithospheric mantle thinning beneath the southern Sierra Nevada, J. Geophys. Res., 101, 16241-16255, 1996.

GP52A-10 1615h

Electrical Conductivity of Mantle Minerals: A Laboratory View

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Since the work of Lahiri and Price (1939) geophysicists have attempted to interpret electrical conductivity profiles of Earth's mantle. As we now know, the basic materials are olivines, pyroxenes, spinels, garnets, and their high-pressure, high-temperature polymorphs. However, beginning in the late 1940s researchers plunged in by measuring conductivities in ultramafic rocks. As inconsistencies appeared over the next couple of decades, it was necessary to define minerals in terms of condensed matter physics—an approach needed for extrapolation to extremes of mantle conditions not then available in the laboratory. By these standards mantle minerals are insulators, and for insulators electrical transport properties are difficult to measure reliably.

Achieving chemical buffering (principally of oxygen fugacity by Duba and colleagues) in the early 1970s had two big effects: (1) it threw into doubt most of the previous quarter-century of work, and (2) it introduced nearly unprecedented reproducibility. Improved laboratory measurements permitted the role of iron in charge transfer to be defined and interpreted in terms of oxygen-sensitive defect populations. For mantle olivine ($\sim$10% fayalite content) there was actually general agreement among several groups for measurements at mantle temperatures. [In both field and laboratory conductivity measurements half an order of magnitude appears to be the level at which disagreements become academic.] Other advances, measurements of mineral conductivity in multi-anvil devices and diamond anvil cells have become possible at mantle pressures and/or temperatures, and the role of crystallographic phase transitions was elucidated. Attention to chemical buffering has led to other advances. For instance, "water" in its various chemical species appears to enhance conductivity, at least in the uppermost mantle. Elemental carbon could also play a role. Finally, an unusual agreement with geophysical observations has been achieved. However, current successes may be less interesting than some discrepancies that suggest further work.

GP52A-11 1630h

Concentration and Mobility of Electrically-Conducting Defects in Olivine

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We have collected measurements of electrical conductivity and thermopower as a function of temperature and oxygen fugacity (f_{O_2}) on a sample of San Quintin dunite (95% olivine), and measurements of electrical conductivity equilibration after changes in f_{O_2} on Mt.Porndon lherzolite (65% olivine). Both data sets have been analysed using nonlinear parameter inversion of mathematical models relating conductivity, thermopower, and diffusion kinetics to temperature, f_{O_2}, time, and defect concentration and mobility.

From the dunite thermopower/conductivity data we are able to estimate the concentration and mobilities of electrically conducting defects. Our model allows electrons, small polarons (Fe^{+++} on Fe^{++} sites), and magnesium vacancies (V''_{Mg}) to contribute to conduction, but only polarons and V''_{Mg} are required by our data. Polarons dominate conduction below 1300° C; at this temperature conduction, is equal for the two defects at all f_{O_2} tested. Thermopower measurements allow us to estimate defect concentration independently from mobility, and so we can back out polaron mobility as $12.2 \times 10^{-6} \exp(-1.05\ eV/kT)\ m^2V^{-1}s^{-1}$ and magnesium vacancy mobility as $2.72 \times 10^{-6} \exp(-1.09\ eV/kT)\ m^2V^{-1}s^{-1}$.

Electrical conductivity of the lherzolite, measured as a function of time after changes in the oxygen fugacity of the surrounding CO_2/CO atmosphere, is used to infer the diffusivity of the point defects associated with the oxidation reactions. An observed f_{O_2} dependence in the time constants associated with equilibration implies two species of fixed diffusivity, each with f_{O_2}-dependent concentrations. Although the rate-limiting step may not necessarily be associated with conducting defects, when time constants are converted to mobilities, the magnitudes and activation energies agree extremely well with the model presented above for the dunite, after one free parameter (effective grain size) is fit at a plausible 1.6 mm diameter. Not only does this study represent one of the few direct measurements of polaron mobility, but the very good agreement between two independent measurement techniques (thermopower versus equilibration kinetics) and two independent samples (dunite versus lherzolite) provides some level of confidence in the results. We are currently extending these modeling techniques to study olivine defect mobility anisotropy.

URL: http://mahi.ucsd.edu/Steve/olivine.html

GP52A-12 1645h

Heterogeneity of the Transition Zone

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Research on the composition of the transition zone has particulary benefited from collaborations between laboratory and field geophysicists. In laboratory studies, the composition of the samples has been varied until a laboratory based mantle conductivity-depth profile matches the electromagnetic field data. Before 2000, these consisted of tensor magnetotelluric (MT) data at periods below 20.000s and scalar geomagnetic transfer functions (GDS) at longer periods. The overlap period corresponded to 350 - 400 km penetration depth and heterogeneities below that could not be resolved from the scalar GDS data. Recent long period measurements in the Simpson desert, Australia, provided high quality tensor MT data in the 20.000s - 80.000s period range, corresponding to 350 - 600 km penetration depth with indications for strong heterogeneities in this depth range.

GP61A MCC: Hall C Saturday 0830h

Numerical Modeling in Geomagnetism/Paleomagnetism Posters *(joint with NG, P)*

Presiding: **L Tauxe,** Scripps Institution of Oceanography**; J Bloxham,** Harvard University

GP61A-1001 0830h POSTER

Micromagnetic Modeling of First-Order Reversal Curves (FORC) Diagrams for Single-Domain and Pseudo-Single-Domain Magnetite

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A micromagnetic model based on a conjugate gradient algorithm was used to calculate FORC diagrams for isolated grains of magnetite as well as for arrays of grains. In the case of individual elongated grains, we found that the FORC diagram consists of a single peak centered on the coercive force if the grain is single-domain. For a pseudo-single domain grain, we observe multiple peaks on the FORC diagram.

The modelling of arrays of elongated single-domain particles reveals two distinct types of patterns on the FORC diagram depending on the spacing between particles. In a 2×2×2 array a secondary branch on the reversal curves appears if the spacing is less than two times the particle width. This feature translates into the appearance of one negative and two positive peaks on the FORC diagram. In the case of a 3×3×3 array we also observe several secondary branches when the spacing between grains is less than 2.5 times the particle width, leading to the appearance of several peaks on the FORC diagram. Arrays of cubic single-domain grains having random magnetocrystalline anisotropy axes show the same features, the only difference being a lower coercive force. Therefore the presence of symmetrical peaks on a FORC diagram can be an indicator of the presence of magnetic interactions in an ensemble of grains.

GP61A-1002 0830h POSTER

Inverting Magnetic Data Using Parallel Processing

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We have collaborated to develop an innovative method for inverting magnetic data from high-resolution geomagnetic maps. Our method uses parallel computations and asynchronous communication among multiple nodes of a Beowulf cluster to produce geologically constrained 3-D models of magnetic anomalies. This modeling effort comes in response to the current revolution in gathering geophysical data. Interfacing