East and West provide a good spatial coverage to study the WFOL in detail. Also seismic investigations have been carried out along both profiles. Explosions in 500m spacing were recorded with 180 seismic sensors (100 m spacing).

The MT results at some sites in the vicinity of the Fault are strongly affected by 3D effects - we observe high skews, phases over 90^{o} and a strong correlation of parallel electric and magnetic field components for long periods. We explain most of the observed effects with generic 3D models which suggest current gathering. Applying Propagation Number Analysis (PNA), we obtain an image of the conductivity distribution by plotting current ellipses. They indicate that the WFOL is not a narrow fault, but a wider fault zone extended to the North with a strongly preferred direction of current flow running parallel. A wider fault zone is in agreement with the seismic results. The tomographic inversion of the direct P- and S-wave travel time data reveals the complex velocity structure of the shallow (<1km) subsurface. The WFOL is imaged as a region of decreased velocities.

GP21A-0251 0830h POSTER

Fast Three-Dimensional Interpretation of Magnetotelluric Data.

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In this paper we present the results of the comparative study of two techniques for 3-D magnetotelluric (MT) data interpretation: the iterative Born inversion and the quasi-analytical inversion. The Born iterative method is based on the fact that the EM inverse problem is actually a bi-linear problem, a special case of a general nonlinear problem (Chew, 1990; Portniaguine and Zhdanov, 1999). Since the problem is linear to anomalous currents, and the currents are the product of the total electric field by anomalous conductivity, the inverse problem becomes linear with respect to conductivity if the total fields are fixed. The total electric fields, in turn, are connected to anomalous conductivity via the corresponding integral equation (IE). Using these properties, one can construct an iterative process whereby the linear inverse problem is solved first for anomalous currents, assuming the total electric fields are fixed. Second, the values of the total fields are updated using the found values of anomalous currents. These new values of the total fields are used in the next iteration of the inverse problem, etc. Another method uses the quasi-analytical approximation for forward modeling (Zhdanov and Hursan, 2000; Zhdanov, Dmitriev, Fang, and Hursan, 2000). This approximation provides fast but accurate technique for electromagnetic forward modeling operator and for the Frechet derivative calculations, which simplifies dramatically the forward modeling and inversion.

Iterative Born method and quasi-analytical inversion technique are implemented using the focusing inversion, which provides both smooth and focused images of the geoelectrical structures. The comparative numerical study demonstrates that both 3-D methods work extremely fast and produce reasonable images of the subsurface geological formations. They give us a possibility to invert on a PC within less than half an hour massive magnetotelluric survey data using fine discretization grids, with several tens of thousands of cells. The comparative study of two 3-D inversion methods were conducted using model data and the observed MT data collected by INCO Exploration.

GP21A-0252 0830h POSTER

Initial-Value Approach to the Electromagnetic Induction in a Heterogeneous Sphere

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We present an initial-value (IV) approach to the forward problem of large-scale electromagnetic induction in a heterogeneous sphere with 3-D conductivity structure, excited by an external source current. The formulation in the time domain is suitable to study the Earth's electromagnetic response to arbitrary variations of the external source currents, in particular to transient signals, which are difficultly treated by the traditional frequency-domain approach.

The parabolic partial differential equation of electromagnetic induction is reformulated in the weak sense. The magnetic field is parameterized by vector spherical harmonic functions in lateral coordinates and by piecewise linear finite elements in radial coordinate. A semi-implicit Euler scheme is applied for the time integration. The terms containing the radial conductivity profile are treated implicitly, while the effect of lateral variations is taken explicitly from the previous time step.

Conductivity models consisting of multiple homogeneous off-axis nested spheres are used to test the IV method and computer code against the known semi-analytic (SA) solutions for periodic external source signals. The differences between the results of IV and SA solutions can be attributed solely to the numerical errors and diminish as the spatial and temporal resolution is increased.

The ability to treat arbitrary external source signals, which is the most important advantage of the IV approach over the frequency-domain methods comes at the cost of two drawbacks. Firstly, an initial magnetic field has to be specified in the whole sphere.Secondly, the common concept of frequency-dependent skin-depth can not be directly employed,because frequency is not introduced at all.

GP21B MC: Hall D Tuesday 0830h

External Magnetic Fields *(joint with SM)*

Presiding: **K Glassmeier,** Technical University of Braunschweig

GP21B-0253 0830h POSTER

A Study of Geomagnetic Indices at the Ile-Ife Observatory, Nigeria.

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The Ile-Ife station in Nigeria is situated within the Equatorial Electroject zone. The station began operation in 1991 and vector measurements of geomagnetic field variations obtained between August 1992 and December 1994, using a Proton Vector magnetometer donated by the British Geological Survey, had been used to derive a K-Scale for the Ile-Ife station (Famutimi E. O. 1998). More recent field measurements have however shown higher ranges and this paper presents a new K-Scale with the corresponding K and Ak indices between the period 1992 and 1996 for the Ile-Ife station.

GP21B-0254 0830h POSTER

Location of Magnetic Dipoles in Chongcho Lake, Republic of Korea

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Magnetic dipoles were located in Chongcho Lake, Sokcho, Korea, using an adaptation of the SOAPFI (Shape-of-Anomaly Potential Field Inversion) program. Approximately 90 km of magnetic-field profiles were recorded in this 1-km2 lake. The lake bottom contains archeological artifacts and unexploded ordnance. Many of these objects were modeled as dipoles with induced magnetization along the direction of the geomagnetic field. Dipole strengths and locations were automatically derived from anomalies of the total magnetic field. These anomalies were filtered along profiles to pass high-wavenumber signals. "Profile-adaptive" filters of the modeled dipole's field matched filters of the observed field within intersecting and overlapping profiles. This procedure allowed simultaneous inversion of data with and without subtraction of a base stations field. For each data window, one or two dipoles were modeled. The shape-of-anomaly criterion minimizes differences between shapes of modeled and observed gravity or magnetic fields using an L1- or L2-(least-squares) norm. In a general application of this criterion, the SOAPFI program automatically shifts the position of a user-supplied initial model, or seed. The seed is generally much smaller than the actual causative body. The shape-of-anomaly criterion then allows the inverse model to grow from that seed until the modeled and observed fields are precisely matched. For applications of the SOAPFI program to magnetic dipole modeling, fewer values of the observed field were used to compute the trial values of dipole moments than to compute the objective functions that were minimized to obtain dipole locations.

GP21B-0255 0830h POSTER

Parametric models of the magnetosphere during geomagnetic polarity transitions

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Parametric magnetospheric models provide a convenient means to estimate high-energy particle flux variations due to paleomagnetic field changes. We consider a purely spherical magnetopause as well as a cylindrical one topped with a half-sphere. The cylindrical-shaped model has been generalized from the present-day dipole situation to arbitrary dipole and quadrupole field configurations. The model allows to study effects of the currently observed decrease in dipole strength and increase of the quadrupole moment on the magnetospheric configuration. In particular we are interested in variation of the magnetic field topology concerning the open and closed field lines, cusp regions and zero lines, where cosmic particles can reach the inner magnetosphere.

GP21B-0256 0830h POSTER

Possible relations between the anomaly of daily variation in geomagnetism and seismicity in Taiwan

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According to previous studies, several days before and after the Chi-Chi earthquake, the greatest plasma frequency foF2 and total electron content (TEC) in the ionosphere observed around Taiwan were severely perturbed. Those developments encourage us to examine the numerous geomagnetic data in Taiwan. It has widely known that it is difficult to figure out the anomaly of the original geomagnetic data directly, which is correlated with the larger earthquake. In an attempt to eliminate large-scale disturbances in geomagnetic field, a method has been used to analyze the amplitude of daily variation in geomagnetism. In this study, we have collected the geomagnetic data of Lunping (LP) and Tsengwen (TW) stations. The LP station, as a reference station, is preferably located in a seismically quiet area. The unequivocal anomaly of daily variation in geomagnetism between two stations was found. This result implies that the TW geomagnetic station is located nearby the higher seismicity or crustal activity area in southwestern Taiwan.

GP21B-0257 0830h POSTER

External Geomagnetic Variations During Polarity Transitions

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During geomagnetic polarity transitions the surface magnetic field of the Earth decays to about 25 % and

less of its present day value. This implies a shrinking of the terrestrial magnetosphere and causes the question whether external magnetic field variations scale in the same manner. Different from previous estimates we conclude that the ring current magnetic field decreases with decreasing internal field. However, deriving a scaling relation for the equatorial and polar electrojet magnetic fields and conclude that the associated external magnetic fields increase with decreasing internal field as the ionospheric electric conductivity approximately scales with M^{-1}, while the ionospheric electric field varies with $\sqrt{M}$, where M is the magnetic dipole moment. Thus, the ratio between external and internal field contributions may be significantly enhanced. First estimates for this ratio are derived indicating that future work is worthwhile to study whether such large external field contributions can be detected in paleomagnetic data.

GP21B-0258 0830h POSTER

The Irregular Variations of the External Geomagnetic Field From INTERMAGNET Data

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The INTERMAGNET program published each year a CD-ROM containing homogeneous series of the magnetic field recorded in some 80 observatories. These series are the definitive one-minute values of the three componenets of the geomagnetic field. We transform these series using a simple nonlinear analysis tool (the average absolute first differences of the three magnetic componenets). Resulting time series appear to be similar for the three componenets and for all the observatories. The geometry of the coorresponding field at the Earth's surface can be investigated; it appears to be a remarkable simple activity field, whose space and time variables separate. We discuss the space and time properties of this field.

GP21B-0259 0830h POSTER

MHD simulations of the paleomagnetosphere

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The Earth's magnetosphere is controlled by the internal geomagnetic field which varies significantly on geological timescales. The most dramatic events are geomagnetic polarity transitions where at times higher-order multipoles are likely to dominate the internal field. We focus on the quadrupole part and investigate the resulting magnetospheric structure by means of the University of Michigan MHD simulation code. Two topologically distinct classes of quadrupole fields are considered, namely, (1) axisymmetric quadrupoles and (2) fields which exhibit neutral lines. It is found that the magnetospheric structure varies not just quantitatively but qualitatively with the orientation of the quadrupole fields. New topological features arise which are not known from dipolar magnetospheres. Some implications of these results for particle precipitation during geomagnetic field reversals are discussed.

GP21B-0260 0830h POSTER

Fluid Core Turbulence; What can we Learn From Time Spectral Features of the Geomagnetic Field ?

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The geomagnetic field is sustained within Earth's outer core by dynamo action, which involves vigorous convective motions. Direct observations of the fluid motions are unfortunately impossible and consequently the picture of the core turbulence is usually painted by theoretical reasoning. Here, we investigated the time spectral features of the main geomagnetic field fluctuations in the range from 0.5 yr-1 to about 0.02 yr-1, using the geomagnetic field annual means recorded at 18 observatories. The average magnetic field spectrum has been found to be in agreement with a power-law, characterized by a spectral exponent approx. -11/3, on time-scales longer than 5 yr. This result is discussed in connection with a non-traditional turbulent nature of the fluid core motions in the outer layers of the Earth's liquid core.

GP22A MC: Hall D Tuesday 1330h

Advances in Hydrogeophysical Investigations of the Near-Surface II

(joint with H, T, MR)

Presiding: **M E Everett,** Texas AM University**; D P Lesmes,** Boston College

GP22A-0261 1330h POSTER

Improved Characterization of the Vadose Zone with Time-Lapsed Ground-Penetrating Radar

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Outcrop studies are increasingly performed to develop realistic heterogeneous subsurface models for application to water resources issues (e.g., agricultural, contaminant transport). Such studies have helped identify goal-specific characterization targets such as fast paths which can accelerate contaminant breakthrough, or sand-rich regions which are responsible for retardation of reactive contaminants in the saturated zone. The use of ground-penetrating radar (GPR) as a means for delineating such subsurface structure has recently received much attention. It has been shown that GPR field data is strongly affected by non-uniform water saturation in addition to structural heterogeneity. GPR data is, therefore, potentially rich in information about both water content and subsurface structure, though these combined effects can lead to non-unique interpretations of data.

In this study, variably saturated flow and GPR are simulated simultaneously to investigate the relation between transient fluid flow in the Vadose zone and the resulting time-lapsed GPR response; the model used for this purpose is based on an outcrop analog site located at a gravel quarry in South-West Germany where colocated hydrologic and geophysical data are also available. Temporal changes in water content, and therefore in electrical parameters, are seen to be related to soil type, and even more so to the spatial sequence of permeability. For example, open-framework gravel (with permeability higher than in the surrounding lithologic units by several orders of magnitude) drain almost instantaneously and typically underlie regions of ponded water, characterized by an increased water content and slow drainage (as compared to underneath the gravel). However, the rate of drainage is also highly dependent on two-dimensional permeability effects such as the slope and continuity of the lithologic units and adjacent permeability structure. Synthetic time-lapsed GPR data are examined and shown to be valuable for improved detection of lithologic units in the Vadose zone and for incorporation into hydrologic parameters inversion methods.

GP22A-0262 1330h POSTER

Seasonal Variations in the Electrical Properties of Alluvial Sediments Near the Rio Grande, West Texas

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We conducted DC resistivity and conductivity studies (EM-31) on a bimonthly basis over a 14-month period at two alluvial sites along the Rio Grande near El Paso, Texas. Our goal was to document how soil salinity and soil moisture content change seasonally due to variations in irrigation and precipitation. Borehole information and cores at each site were used to determine grain size, bedding, salinity, and moisture content variations across the sites. Other shallow geophysical surveys (i.e. magnetics, ground penetrating radar, seismic refraction, spectral analysis of surface waves) were conducted at the sites to help correlate the geology between boreholes. The first site, located east of the Rio Grande, consists primarily of an abandoned river channel. Sediments within the channel are relatively homogeneous, but there is a strong contrast in sediment properties at the edge of the channel located in the eastern portion of the study area. The second site, located west of the Rio Grande, consists of a horizontally and vertically varying sequence of crevasse splay, distributary channel and flood plain deposits with much higher clay contents than found at the eastern site. The largest variations in resistivity/conductivity at both sites occurred following an overbank flooding event along the Rio Grande in August 1999. The flooding remobilized salt within the upper 20-40 cm of the soil, and its movement could be tracked for over 4 months. In addition to the flooding event, seasonal variations in the resistivity of the near surface layers approached 50%. This scale and level of variation explains previous difficulties we had in attempting to interpret deeper resistivity soundings for monitoring groundwater quality changes.

GP22A-0263 1330h POSTER

Characterization of Clastic Dikes Using Controlled Source Audio Magnetotellurics

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A site consisting of 3D geology on the Hanford Reservation in Hanford, Washington, has been surveyed using Controlled Source Audio Magnetotellurics (CSAMT) to determine the methods ability to detect clastic dikes. The dikes are fine-grained, soft-sediment intrusions, formed by the buoyant rise of buried, unconsolidated, water rich mud into overlying unconsolidated sediment. The dikes are of major importance because they may act as natural barriers inhibiting the spread of contaminants, or as conduits, allowing the contaminants to be quickly wicked away from the contaminant storage tanks that may be located in close vicinity of the dikes. The field setup consisted of a 33 meter by 63 meter receiver grid with 3 meter spacing in all directions with the transmitter positioned 71.5 meters from the center of the receiver grid. A total of 12 frequencies were collected from 1.1kHz to 66.2kHz. The CSAMT data is being analyzed using a 2D CSAMT RRI code (Lu, Unsworth and Booker, 1999) and a 2D MT RRI code (Smith and Booker, 1991). Of interest is examining how well the 2D codes are able to map 3D geology, the level of resolution that is obtained, and how important it is to include the 3D source in the solution. The ultimate goal is to determine the applicability of using CSAMT for mapping these types of features at the Hanford Reservation site.

GP22A-0264 1330h POSTER

Geophysical Imaging Using Electrical Resistance Tomography (ERT): Controlled Laboratory Sensitivity Studies

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