GP21A MCC: Level 1 Tuesday 0830h

Magnetic Interpretation: Continental to Planetary Scales I Posters *(joint with OS, P)*

Presiding: **M E Purucker,** Raytheon ITSS at Geodynamics Branch**; J D Phillips,** U.S. Geological Survey

GP21A-0029 0830h POSTER

Subsurface Structural Imaging Of Esh El Mallaha Area, Gulf Of Suez, Egypt Using Aeromagnetic Data

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This paper presents a case study on the subsurface structural imaging of Esh El Mallaha area. Esh EL Mallaha area is located on the western flank of the Gulf of Suez and it has a great importance due to its hydrocarbon resources. In 1994 the area was covered by aeromagnetic survey conducted by Aero Service Division, Western Geophysical Company of America. The main object of this work to delineate the subsurface structural framework of the area that may assist in hydrocarbon exploration. A 3D analytic signal technique was applied to the aeromagnetic data. One of the most advantages of the analytic signal is that it produces a maximum value over a 2D magnetic source and as a result it enables more accurate location of the magnetic sources. It is also straight forward to determine the depth to the magnetic contacts using a simple formula derived from the analytic signal. Generally, Esh EL Mallaha area is characterized by two basinal structures taking the direction of the NW-SE parallel to the Red Sea rift. Those two basins are separated by long dike igneous rocks bounded by two major faults and taking the direction of NW-SE.

GP21A-0030 0830h POSTER

A Global Crustal Magnetization Model of Mars Based on an $n = 90$ Spherical Harmonic Model

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Using a technique developed by KAW (originally in conjunction with the late Bob Langel) and MEP, a global crustal magnetization model for Mars was estimated using synthetic three–component vector data computed from an $n = 90$ spherical harmonic model. These data were calculated on an approximately equal area grid at 100 km altitude. The areas are two degree squares of latitude and longitude at the equator expanding in longitude poleward similar to the data selection used in the $n = 90$ model. This application for Mars has one less uncertainty than such work on Earth data because there is no need to separate a crustal field from an internal core field, but of course retains the basic ambiguity pointed out by Runcorn regarding the absolute level. A crustal thickness of 40 km was arbitrarily chosen as physically plausible though it has been shown that the thickness is not well resolved by satellite data. A spherical harmonic model computed from this model was also compared with one derived from the data that produced the $n = 90$ model. In both instances the spectrum matches that published by *Cain et al.* (2003) for low degree, but is greatly diminished beyond $n = 20$ as characteristic of a technique whose constraint is minimize the power in the model while satisfying the data. The calculation was implemented in OpenMP on an IBM Eclipse Regatta computing system utilizing 16 parallel processors on one node.

GP21A-0031 0830h POSTER

Martian Magnetization Vectors Estimated from Helbig Analysis Support a Reversing Core Dynamo

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Helbig (1963, Zeitschrift für Geophysik) developed the theory for estimating total magnetization vectors from the moments of measured magnetic component data. Helbig's theory has been tested successfully on aeromagnetic data for several terrestrial locations, where both the induced and remanent magnetizations of sources were known (Schmidt and Clark, 1997, Preview; 1998, Exploration Geophysics). Because Mars no longer has an inducing core field, application of Helbig analysis to the vector magnetic field measured by Mars Global Surveyor permits estimation of crustal remanent magnetization directions and strengths, paleomagnetic pole positions, and reversal characteristics of the extinct Martian core-field dynamo. The results provide an independent test of pole positions estimated from forward modeling (Arkani-Hamed, 2001, GRL) and of magnetization models estimated using inversion (Whaler and Purucker, 2003, The Leading Edge). A Helbig analysis of the n=90 Martian magnetic field model (Cain and others, 2003, JGR), evaluated at 150 km altitude, suggests that most of the stronger sources (average magnetization magnitudes > 4 A/m) have paleomagnetic pole positions within 50 degrees of 195E 50N. This region encloses Arkani-Hamed's (2001) estimated pole position of 230E 25N, based on his analysis of ten semi-isolated anomalies. A smaller number of strongly magnetized sources have pole positions that cluster within 40 degrees of 290E 5N. This cluster may represent either a secondary pole position or a preferred transition path during field reversals. Both normal and reversed magnetizations cluster at these pole positions, supporting the existence of a reversing core dynamo during the early history of Mars. When all estimated magnetic sources are included in the analysis, the weaker sources dominate, and the pole positions cluster along 35N and 35S latitudes. The corresponding source locations are concentrated along lines of longitude in areas of low magnetic intensity. These weak magnetic sources are probably due to orbital noise from external fields and do not represent the Martian crust. The vector components of the magnetization estimated from Helbig analysis resemble the preliminary magnetization model of Whaler and Purucker (2003). The strongly lineated magnetic anomalies on Mars, however, pose a difficulty to both magnetization analyses. For lineated anomalies, only the component of the magnetization perpendicular to the strike can be estimated from the data. The missing magnetization components parallel to strike probably contribute to the large scatter seen in the pole positions.

GP21A-0032 0830h POSTER

Comparing an Empirical Model of the Equatorial Electrojet with CHAMP Satellite Magnetic Measurements

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The longitudinal variation of the EEJ intensity has been reworded, including further ground stations, particularly Baclieu (Vietnam), where an unexpected enhancement is observed. The structure of the ground based longitudinal profile around noon was compared and found to be in good agreement with that obtained from CHAMP data. Confirming the particular behavior of the ionosphere above eastern Asia. The Equatorial Electrojet (EEJ) signatures recorded on board CHAMP satellite have been isolated for 13 passes closely above the west African chain of three stations aimed to accompany Oersted and CHAMP satellite missions, as well as for 19 other passes in three different longitude bands of 15°.The resulted CHAMP EEJ signatures have been compared with the computed EEJ magnetic effects derived from this empirical model of the EEJ, which includes local time and longitude dependences. The model predicted magnetic variations at CHAMP orbit are generally in good agreement with the onboard magnetic signatures. Differences between computed and measured DF peak values are most of the time (69%) less than 10nT. This model will be used to isolate the ionospheric contribution to the Earth internal magnetic field measured by satellite.

GP21A-0033 0830h POSTER

Magnetic Anomalies Associated With Fracture Zones in the Cretaceous Magnetic Quiet Zone in the North Pacific Ocean

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The existence of magnetic anomalies along east-west trending fracture zones in the north Pacific is well known. These anomalies are particularly prominent in the Cretaceous magnetic quiet zone, where no comparable anomalies are observed other than those associated with the Hawaiian Ridge and the Musician Seamounts in a newly compiled magnetic anomaly map. Model calculation was conducted using old magnetic and bathymetric data collected in the Cretaceous magnetic quiet zone. Two-dimensional simple models along north-south lines, which cross the Mendocino, Pioneer, Murray, Molokai and Clarion Fracture Zones, were constructed in order to clarify the sources of these magnetic anomalies. In these model calculations, it was assumed that the source bodies have normal remanent magnetizations with their inclinations of about <ETH>5 (for Mendocino FZ) to -25 degrees (for Clarion FZ), corresponding to the latitudes 40 degrees south of the present locations, as was suggested to have been in the late Cretaceous by some of paleomagnetic studies. This assumption is consistent with the dominance of negative anomalies in the observation. The model calculations suggest that under assumption of 0.5 km thick magnetic source bodies, remanent magnetizations more than 10 A/m should occur below some of the ridges and troughs in these fractures zones. Alternatively, in more plausible models with a remanent magnetization of 3 A/m, the magnetic source bodies should have thicknesses of up to about 5 km there.

GP21A-0034 0830h POSTER

Time-frequency analysis of CHAMP scalar and vector magnetic data

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Wavelet transforms began to be used in geophysics in the early 1980s for the analysis of seismic signals. The advantage of analyzing a signal with wavelets as the analyzing kernels, is that it enables one to study features of the signal locally with a detail matched to their scale. Owing to their unique time-frequency localization property, wavelet analysis is especially useful for signals that are non-stationary, have short-lived transient components, have features at different scales, or have singularities. Unfortunately, many studies using time-frequency analysis have suffered from an apparent lack of quantitative results. We have applied the continuous wavelet transform to analyze 3 years of Fluxgate and Overhauser magnetometer data of the CHAMP satellite mission. We have detected and classified not only artificial source noise (e.g. instrument problems and pre-processing errors) but also high frequency natural signals of external fields (e.g. F-region currents and pulsations). The results of this analysis will be used for: (a) consequent correction and flagging of the data, (b) derivation of a suitable (undisturbed) dataset for the purposes of crustal and main field modeling, and, (c) study of natural signals (e.g. F-region currents, pulsations) contained in the data.

GP21A-0035 0830h POSTER

Axial versus older magnetic anomaly amplitude variations: Evidence for a common origin

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Seafloor spreading magnetic anomalies in the oceans have been used to reconstruct the plate tectonic history of the ocean basins for almost 40 years. Although

the use of magnetic isochrons for the implicit dating of ocean floor remains of primeval importance, the use of magnetic measurements to better understand the fundamental processes of mid-ocean ridge accretion is becoming more and more important. With the increased data density, the higher precision of the observations, both in positioning and sensitivity, as well as the availability of data at different scales and different altitudes relative to the ocean floor, an entire new spectrum of applications of marine magnetic anomalies is opening up. In this contribution, we compare recent observations of Ravilly et al. (JGR, 1998), along the axis of the mid-Atlantic Ridge, with those made many years ago off axis in the Cretaceous magnetic quiet zone (85 - 118 Ma). Ravilly et al. observed that along segments of the mid-Atlantic Ridge, between 20 and 40 N, the axial magnetic anomaly is higher by a factor of about 2 near the segments ends as compared to the segment centres. The preferred explanation is that both variations in the Fe-Ti content resulting from shallow magma fractionation and serpentinisation of shallow mantle rocks near the segment ends are responsible for this variation. One question is then if this signature persists as the crust generating the axial magnetic anomaly becomes older and moves away from the spreading axis by seafloor spreading. The best region to look for such a signature off axis is the Cretaceous magnetic quiet zone, because there the signal is not contaminated by large reversals in the Earth's magnetic field. Collette et al. (1984) observed such an increase in effective magnetization near the ends of segments, which expresses itself as distinctly positive anomalies over the fossil fracture zone valleys, when the magnetic anomalies are reduced to the pole. Hence, we conclude that both observations are consistent and that the processes responsible for the amplitude variations are restricted to the axial region. Hydrothermal processes off axis may be responsible for additional changes in the total magnetic structure of the oceanic crust, but the fundamental 'magnetic' segmentation is preserved.

GP21A-0036 0830h POSTER

Interpretation of the new CHAMP crustal field anomaly maps using a GIS technique

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Reliable global crustal field anomaly maps produced from magnetic data of the first three years of the CHAMP satellite mission now allow for quantitative geological studies of crustal structure and composition. Here, we have developed a GIS based forward modeling technique to infer crustal structure overlain by younger cover. Modeling takes the geologic and tectonic maps of the world as the input and, depending upon the known rock types in each region, an average susceptibility value is computed for every geological unit. Next, the vertically integrated susceptibility (VIS) is generated by multiplying the average susceptibility with the seismic crustal thickness, as given by global models of 3SMAC and CRUST2.1. Starting with this initial VIS model, the vertical field anomaly is computed at an altitude of 400 km and compared with the corresponding CHAMP vertical field anomaly map. Significant geological inferences are made from the agreement and the discrepancies between our initial map and the observed anomaly map. In a subsequent modeling step the poorly known boundaries of buried crustal units are modified until the recomputed map fits the observed magnetic map. By this simple procedure a remarkably good fit to the magnetic anomaly map is be achieved. We conclude that the lateral extent of Archean units in the lower crust can thus be inferred from satellite magnetic anomaly maps.

GP21B MCC: Level 1 Tuesday 0830h

High-Resolution Description of the Earth's Magnetic Field Time Variations Using Paleomagnetism and Archeomagnetism I Posters

Presiding: **Y Gallet,** Institut de Physique du Globe de Paris**; M Korte,** GeoForschungsZentrum Potsdam

GP21B-0037 0830h POSTER

Constraining the geomagnetic field intensity in Western Europe during the 17-19th centuries from French faience shards

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We obtained new archeointensity results for France from the analysis of seven groups of potsherds precisely dated from the beginning of the 17th century to the 19th century. These earthenware shards were found during excavations in Nevers which was an important production center of faience in France during the 17-18th centuries. For our intensity determinations, we used a new variant of the Thellier and Thellier (1959) method. This procedure ("IZZI" method; Tauxe et al., 2003) involves the alternation of pair of heatings in field-zero field ("IZ" steps) and pair of heatings in zero field-in field ("ZI" steps), and was specially designed to detect biased intensity results due to multidomain magnetic grains. The raw intensity values were corrected for TRM anisotropy and cooling rate effects. Our preliminary results do not show strong intensity variations during the 17-19th centuries. In particularly they do not exhibit a rapid intensity decrease during the 17th century as predicted in Western Europe from the global geomagnetic models of Jackson et al. (2000). To constrain their models during the 1590-1840 period, during which directional but no intensity geomagnetic measurements are available, these authors used a backward extrapolation made on the basis of the linear decay of the dipole moment observed since 1840. Our study challenges the validity of this extrapolation and contributes to our knowledge on the recent variation of the dipole moment of the geomagnetic field.

GP21B-0038 0830h POSTER

Archaeomagnetism of some pre-Columbian mural paintings in Central Mexico

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This work investigates the magnetic remanence associated with the mural paintings at three archeological sites in Central Mexico dated between 200 AD and 1450 AD (Cholula, Cacaxtla and Templo Mayor). The remanence of the murals is shown, using X-ray analyses and rock-magnetic measurements, to be carried by both magnetite and hematite. In most specimens, a characteristic magnetization is successfully isolated by alternating field demagnetization. The mean site directions are consistent with the available master curve for Mesoamerica. This work shows that murals from Central Mexico can retain their remanent magnetization for centuries and demonstrates the viability in principle of pictorial remanence as an archeomagnetic tool.

GP21B-0039 0830h POSTER

Absoulte Paleointensities From 21-84 ka Ontake Volcanic Rocks, Japan - Evidence For Excursion At 80 ka

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Tanaka and Kobayashi (2003) reported a paleosecular variation in directions from 21-84 ka volcanic rocks of the Ontake Volcano, Japan. They found two low latitude VGPs from 48 ka (41.9N, 196.2E) and 80 ka (15.9N, 183.3E) lavas, indicating existence of excursions in Japan during the latest Pleistocene. Following this study, we have tried absolute paleointensity measurements on the Ontake volcanic rocks including samples with these two low latitude VGPs. From various rock magnetic experiments, main remanence carrier was judged to be titanomagnetite with minor Ti content. Hysteresis properties suggested that most of the paleomagnetic cores had PSD characteristics, though ratios of Hcr/Hc were beyond the value of PSD-MD threshold (Hcr/Hc=4) for some cores. These evidences indicated that the present samples had ordinary rock magnetic properties for absolute paleointensity measurements. Therefore, we have performed two different methods of the measurements; Coe's version of the Thellier method (Coe, 1967), and double heating technique of the Shaw method combined with low temperature demagnetization (LTD-DHT Shaw method; Tsunakawa et al., 1997; Yamamoto et al., 2003). Until now, the former method has been applied to 71 specimens while the latter to 126 specimens. Each method gave 30 and 54 successful results. Especially, the latter method seemed to be effective for the MD-pronounced specimens. These results ranged from about 10 to 60 ZAm2 in VADM except one site at 84 ka (110 ZAm2). Striking point in these results is that samples from the 80 ka lava with low latitude VGP yielded consistent low paleointensities for both methods; 4.9+/-0.4 uT for the Thellier method (N=4); 5.9+/-0.2 uT for the LTD-DHT Shaw method (N=3). These samples were collected from two outcrops which are 20 m apart across a gully. Since corresponding VDM and VADM is about 12% of the present value, typical for the geomagnetic excursions, the existence of 80 ka excursion is confirmed not only from the paleodirectional evidence but also from the absolute paleointensity data.

GP21C MCC: Level 1 Tuesday 0830h

Extraterrestrial Paleomagnetism: Role of Impact Related Shock I Posters *(joint with P)*

Presiding: **B Lin,** University of California, Berkeley**; D Mitchell,** University of California, Berkeley**; M Fuller,** HIGP-SOEST, University of Hawaii

GP21C-0040 0830h POSTER

Pyrrhotite in Extraterrestrial Materials: Paleomagnetic Implications of its High-Pressure Transition

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In mineralogical and rock magnetic studies of meteorites, pyrrhotite has been somewhat underscored due to misidentification with troilite and to the poor knowledge of its magnetic properties until the nineties. In the common case of pyrrhotite-magnetite (or metal) mixtures, remanence may be mainly carried by pyrrhotite while thermomagnetic curves points toward metal or magnetite. We have now studied 20 (among a total of 28) independent martian meteorites (SNCs) and found that among the 18 strongly magnetic ones (Mrs more than 10 A/m), 9 have their magnetic remanence carried by pyrrhotite. Among the chondrites, rumurutites (R) contain only pyrrhotite, while a number