GP31C-0767 0830h POSTER

The Beaverhead Impact Structure: Discovery and Investigation of an Allocthonous Impact Structure in SW Montana

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In 1989, Rob Hargraves identified shatter-coned sandstone cobbles in a glacial till in the Tendoy Mts., SW Montana. Subsequent investigations by Hargraves and co-workers discovered shatter cones in Precambrian sandstones and gneisses over a 25x8 km region and pseudotachylites over a more restricted region - thus defining the remains of the 50-100 km diameter, 600M to 1B year old, Beaverhead Impact Structure. Though one of 170+ impact structures identified on Earth, Beaverhead remains distinctive and important for several reasons. First, it is the only example to date of an allocthonous fragment of an impact structure, tectonically dissected and transported eastward by tens of kilometers. Second, it preserves pseudotachylies in several lithologies with varying morphologies and features (such as large vesicles) that suggest they were exhumed very quickly after formation. Finally, the orientation of shatter cones relative to sandstone bedding and cross-bedding suggests that a previously unidentified episode of tectonic deformation predated the impact (the first documented use of shatter cones as an indicator of paleo-orientation of strata). To date, nearly all the impact craters recognized on Earth retain some vestige of their original circular geometry. The discovery of Beaverhead suggests that many more meteorite impact structures may be partially preserved in orogenic belts, and that careful observation of petrologic and outcrop-scale features is the key to their discovery. Hargraves' discovery of Beaverhead (the largest impact structure yet identified in the United States) in a region already extensively mapped and studied by geologists, is only one of many examples of the insight, careful observation, and undogmatic thinking that characterized his outstanding scientific career. By bringing together regional structural geologists, planetary scientists, geophysicists and sedimentary geologists, Hargraves and his co-workers illuminated an unusual and important event in Earth history.

GP31D MCC: Level 2 Wednesday 0830h

Geomagnetic Variations: From Secular Variation to Superchrons I Posters

Presiding: **C G Langereis,** Paleomagnetic Laboratory, Fort Hoofddijk**; L Tauxe,** Scripps Institution of Oceanography

GP31D-0768 0830h POSTER

Modelling the Earth's Magnetic Field Using Wavelets' Frame.

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A new representation of the main field on the sphere is developed, by choosing an approach which always makes a direct relation between the spherical harmonics (SH) and wavelets (Holschneider and *al.*, 2003). Our work is mainly the theoretical description of the wavelets on the sphere in order to use them in field modelling. Our first results in modelling the Earth's magnetic field from observatory data using the wavelet basis underlines the applicability of the method. The comparison with the SH models shows how well the wavelets describe the magnetic field on a global scale. The regional features of the field are also observed in this global representation. Some first results using magnetic satellite data are also presented. Once more, our attempt is to produce two representations, applying the SHA and wavelets to the same satellite dataset. The potential of wavelets to represent geomagnetic field considering an uneven distribution (observatories) or an even one (satellite measurements) is clearly schown.

GP31D-0769 0830h POSTER

The Origin of Geomagnetic Jerks, Revisited

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Over the past two decades, the secular variation of the Earth's magnetic field shows rich temporal behaviour, most obviously the occurrence of magnetic jerks in 1991 and around 2000 observed at magnetic observatories at most locations on the Earth. In addition, a jerk has been identified in 1983 in data from some southern hemisphere magnetic observatories, without being seen elsewhere. This event may be associated with earlier features in the northern hemisphere. The extent, duration and the underlying processes causing these geomagnetic jerks are still debated. We developed time-dependent models for the secular variation and core surface flows for the period 1980 to 2000. These models are based on quiet monthly means and annual means of magnetic observatories and are fixed at the endpoints by satellite main field models. Our field model reveals finer temporal scale secular variation structure than previous models. In this study we also examine how well our flow models represent the characteristics of jerks, particularly those models which invoke core torsional oscillations.

GP31D-0770 0830h POSTER

Time Structure of the 1991 Magnetic Jerk in the Core-Mantle Boundary Zone by Inverting Global Magnetic Data Supported by Satellite Measurements

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New global magnetic data (Gauss coefficients, monthly values) from 1980 to 2000, fitted to global data up to degree and order 5 only and partly based on high-quality satellite vector data (MAGSAT and CHAMP,OERSTED)) are processed with a recent non-harmonic downward continuation method. It solves the related inverse boundary value problem by approximating the solution (e.g. at the core-mantle boundary) of an equivalent Volterra integral equation with a smoothing minimum-norm solution. In an extended version the magnetic field components in the top layer of the fluid outer core can be determined if fluid velocities of special type are prescribed. Using a weakly conducting mantle and the high conducting fluid in the outer core we investigate the temporal structure of the jerk in 1991 at some stations calculating the dY/dt field component at the core-mantle boundary and underneath in different depths of the fluid outer core assuming an angular velocity there.

GP31D-0771 0830h POSTER

Late Quaternary Records of Magnetic Field Excursions From the Southern Hemisphere (ODP Leg 202 - Chilean Margin)

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During ODP Leg 202, shipboard paleomagnetic measurements indicated the existance of three late Quaternary magnetic field excursions at Site 1233 (41°S, Chilean Margin). Two were located in what was estimated to be Stage 3 and one was suspected to occur in early Stage 5. The Stage 3' excursions were also identified at Site 1234 (36°S, Chilean Margin). New u-channel measurements of replicate sections of the three excursions at Site 1233 verify their existence and clearly document their detailed directional and paleointensity variation. A single u-channel record from Site 1233 also indicates the presence of a fourth excursion above the two Stage 3' excursions. Selected oxygen isotope data and AMS radiocarbon dates indicate that all three Stage 3' excursions do occur in Stage Three and that the oldest excursion of the group is synchronous with the Laschamp Excursion (40 ka), as documented in the North Atlantic Ocean/Europe. The youngest excursion (not yet replicated) is apparently synchronous with the Mono Lake excursion (32 ka), and the last excursion occurs about half way between them (36 ka). The Laschamp Excursion equivalent is distinctive in that it is a class II excursion (full polarity reversal, I and D variation in phase). All other excursions are Class I excursions (I and D variation near 90° out of phase). This observation provides clear evidence that the Laschamp Excursion had both Class I and Class II excursions occurring at the same time in different parts of the world. The Class II excursions occurred closer to the poles (tangent cylinder) and the Class I excursions occurred closer to the equator. Overall, this is suggestive of an octupolar excursional state for the Laschamp Excursion itself with an extended (10ky) period of subsequent instability. We will provide computer simulations to provide a unifying conceptual framework for this set of observations.

GP31D-0772 0830h POSTER

Geomagnetic Excursions of the Late Brunhes Chron Detected in a Piston Core Sample (MD012421) from the Western North Pacific off Kashima

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Several records of geomagnetic excursions of the Brunhes chron have been reported from Japan, including a pioneering work in Lake Biwa. It is difficult, however, to investigate detailed features and possible correlation of these reported excursion records at present, mainly because of unresolved issues about chronology and reliability of the older paleomagnetic records. In order to clarify the nature of such geomagnetic excursions, we have made paleomagnetic study of a giant piston core MD012421 obtained during the IMAGES cruise in the western North Pacific off Kashima. Oxygen isotope study along with AMS radiocarbon dating and tephrostratigraphy established high-resolution chronology of this core, covering the time interval from oxygen isotope stage 6 to the present with an average sedimentation rate about 30 cm/ka. We obtained u-channel samples from the entire sequence and subjected them to pass-through measurements of natural remanent magnetization and stepwise alternating field demagnetizations. We also measured anisotropy of low-field magnetic susceptibility (AMS) of discrete cubic samples to investigate sedimentary fabrics. Although the AMS data suggest that the sediments were partly deformed during core recovery, this core provides a high-resolution paleomagnetic record for the last 140

kyrs. Anomalous paleomagnetic directions occur at two horizons between MI events 5.4 and 5.5, yielding VGP paths which are consistent with the Blake excursion reported from Chinese loess-paleosol and volcanic sequences. On the other hand, no significant fluctuations of the paleomagnetic directions correlative to the Mono Lake and/or Laschamp excursions are observed, while the interval around 40 ka is characterized by low paleomagnetic intensity. This result suggests that these phenomena may have caused no anomalous geomagnetic field direction around the Japanese Islands, while the occurrence might be associated with minima of the main dipole field intensity.

GP31D-0773 0830h POSTER

Paleomagnetic Study of Core MD012380 from Banda Sea

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This study presents the paleomagnetic results of core MD012380 taken from Banda Sea during IMAGES VII cruise in 2001. The locality of the coring site is 126o 54.25′E and 5o45.64′S, and the water depth is about 3232m. The total recovered length of this core is 39.9 m. The simulated paleo-intensity pattern is well correlated to that of the SINT 800 (Guyodo and Valet, 1999). Several magnetic events and excursions, such as Blake, Jarmaica, Lavantine, Big Lost Emperor, Delta and B/M Boundary could be identified. These events appeared at the depths of about 13.84 m, 18.05 m, 22.75 m, 31.81 m, 35.89 m, 38.70 m, respectively. Paleoinclination data also indicate that the boundary of Brunhes and Matuyama epochs appeared at the depth of 38.7 m. So, the paleomagnetic result is used to construct the age model of this core. Then, apply it to the studied oxygen isotope pattern and compare to that proposed by Bassinot et al. (1994), they are well correlated. In addition, the LAD of P. lacunosa is found at the depth of 28.4 m, which also supports the proposed age model. Result of magnetic susceptibility (c) shows several high peaks, especially at the bottom portion, which might relate to the volcanic activity in the surrounding area. Generally, high values occurred at the interglacial periods and low values appeared at the interglacial periods. However, magnetic susceptibility has a special increasing trend from stage 8 to the early stage 5. It may be worthy of further study.

GP31D-0774 0830h POSTER

Jaramillo, Cobb Mtn., or Punaruu? - Re-examination of "Cobb Mtn. Event" Lavas at the Coso Volcanic Field, CA.

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Mankinen and Gromme (1982) hypothesized that two flows from the region were erupted during the Cobb Mtn event since they yielded dates of 1.07±0.14 Ma and 1.07±0.12 Ma (Duffield et al., 1980). Given advances in the magnetic polarity timescale, it is now unclear whether to assign these flows to the Jaramillo subchron (0.99-1.07 Ma), the Punaruu Event (1.122±0.010 Ma), or the Cobb Mtn. Event (1.194±0.014 Ma). Therefore, we have undertaken improved radiometric and paleomagnetic studies to resolve this uncertainty and provide additional age constraints to the magnetic polarity timescale. We have dated by Ar/Ar geochronology the four widely separated units (3 basalts, 1 rhyolite) described by Mankinen and Gromme. All ages are reported here at 2 sigma error and relative to the monitor FCs (28.02 Ma) and/or ACs (1.192 Ma). Paleomagnetically, we confirm that two of these are of normal polarity and two reversed, but our age constraints remain as equivocal as before. Fresh glass was extracted from one normal-polarity basalt sample in order to avoid the xenocrysts common in rocks of this suite. The degassing spectrum is discordant, with rising ages at higher temperatures. The isochron age (1.11±0.11 Ma, trapped $^{40}Ar/^{36}Ar$ equal to 298±2, not distinct from atmospheric) yield error bars too large to distinguish between Cobb Mtn., Jaramillo, and Punaruu. Data from the other normal-polarity basalt indicates an age (c.a 0.97 Ma) younger than previously reported. This may correlate with the Jaramillo subchron. The reversed polarity units were also dated in order to bracket the normal polarity flows. One of these ages, 1.140±0.008 Ma, from a rhyolite dome falls between the Punaruu and Cobb Mtn. Events. In short, paleomagnetic data confirm previous results on the polarity of these flows. However, radiometric dating suggests that these units should no longer be referred to as constraints for the Cobb Mtn. Event unless future geochronology shows such a correlation more convincingly.

GP31D-0775 0830h POSTER

Detailed Directional Analyses of the Reunion Subchron (?) Recorded in the Koolau Volcanic Series, Oahu, Hawaii

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In order to investigate the volcanic evolution of the Koolau Volcano (one of the volcanoes that make up the island of Oahu) and the short-term behavior of the geomagnetic field, we have sampled a long volcanic section located on the butressed flank of the Koolau Volcano within the Halawa Valley. Prior paleomagnetic and radiometric investigations of the Koolau Volcano have reported excursional directions within the Koolau Volcanic Series (Site F of Doell and Dalrymple, 1973). The composition of the (100 m) thick sequence of lava flows, easy access, and close geographical proximity to dated flows made these excellent candidates for a detailed paleomagnetic analysis. The flows sampled were bounded between the current K-Ar dates obtained from adjacent lava flows (1.9 ± 0.1 Ma to 2.2 ± 0.1 Ma). At least eight samples were taken of each analyzed flow. Specimens of each sample were stepwise demagnetized by both alternating field (5mT to 100mT) and thermal (from 28^{o}C to 575-650^{o}C) methods, and the mean directions were obtained by principal component analysis. All samples have indicated a strong and stable ChRM trending towards the origin based on no less than seven to nine steps, with thermal and AF results agreeing to a very high degree. Low field susceptibility versus temperature (k-T) analyses were conducted for individual lava flows, and the majority of them show reversible curves. Curie point determinations revealed a temperature close to or equal to 580^{o}C, indicative of almost pure magnetite for most of the flows. The mean directions of magnetization of the entire section sampled indicate that about 10 m of the section are characterized by excursional directions. The calculated corresponding VGPs are located at equatorial latitudes and on the central and south part of Africa with a few of the other ones close to the west part of Australia. These excursional directions place important constraints to the entire volcanic evolution of the Koolau edifice since they might correspond to the Reunion Subchron according to the reported K-Ar age determinations.

GP31D-0776 0830h POSTER

Critical bifurcations among viscous boundary layers of the geodynamo

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An analysis is made of a specific class of solutions to the non-linear mean-field equations of magnetohydrodynamics which approximate the dynamo in the Earth's core. These solutions, obtained after separation of variables, have all of their nonlinearity in one spatial dimension. The resulting enormous numerical economy with which the solutions can be constructed, as compared to more traditional two-dimensional and three-dimensional approaches, enables us to explicitly model the viscous boundary layers on the core side of the core-mantle boundary. In analyzing these solutions we concentrate specifically on the structure of the boundary layers for small Ekman number. Assuming a simple, but geophysically plausible, alpha structure, there is a bifurcation of solutions from the critical alpha number: one solution branch traces super-critical dynamo action, but which has a Hartmann-type force balance, the other, sub-critical branch has the more usually expected Ekman-type force balance. The subcritical branch eventually connects onto a different supercritical branch, but one with solutions having a complicated sandwich of nested Hartmann and Ekman boundary layers. The Ekman-number-dependent scalings of representative solutions on these various branches are explored. The implications for the discovery of these various solution types have significance to dynamo theory, since most simulations assume, a priori, that the boundary layer beneath the core-mantle boundary is of a simple Ekman structure. Yet our results indicate that those are only a subset of the possible solutions, other solutions can have a very different force-balance structure. We are reminded, once again, that boundary layers, albeit thin, can have a global-scale controlling influence on the nature of the Earth's magnetic field.

GP31D-0777 0830h POSTER

ODP Site 1092: Revised Composite Depth Section has Implications for Upper Miocene 'Cryptochrons'

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ODP Site 1092 in the sub-Antarctic South Atlantic produced an Upper Miocene magnetic stratigraphy in the C3r-C5ABn interval (Evans and Channell, 2003). New data from X-Ray Fluorescence (XRF) scanning of half cores at the University of Bremen has led to revised composite depths for the site. This has some implications for the magnetostratigraphic interpretation. Using the shipboard-derived composite section, four polarity subchrons were identified within the normal polarity zone correlative to C5n.2n. The revision of the composite section indicates that there was a duplication of polarity subzones that is an artifact of the miscalculation of shipboard composite depths. Polarity subchrons ("cryptochrons") that were originally labeled C5n.2n-2 (recorded in core 1092A-13H) and C5n.2n-3 (recorded in core 1092C-14H) become a single subchron (relabeled as C5n.2n-2). The resulting modification of the composite section provides new composite depths for polarity zone boundaries at Site 1092 with new age estimates for subchrons not included in the standard geomagnetic polarity timescale (GPTS). Using the ages of the bounds of C5n.2n from Cande and Kent (1992, 1995) and assuming constant sedimentation rate within C5n.2n, the age estimates are C5n.2n-1 at 10.098 Ma, C5n.2n-2 at 10.258 Ma and C5n.2n-3 at 10.803 Ma.Normalized remanence (mean NRM/IRM), used as a proxy for geomagnetic paleointensity in Evans and Channell (2003), can also be well correlated between cores 1092A-13H and 1092C-14H after revision of the composite depths, thereby ratifying the adjustment of the shipboard composite section. The revised number of polarity subchrons within C5n.2n is now three, rather than four, consistent with the number of "cryptochrons" recognized in marine oceanic anomaly data.

GP31D-0778 0830h POSTER

Magnetostratigraphy of Cape Verde Islands Volcanics

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During three field campaigns on the Cape Verde Islands (15N, 24W) in 1998, 2000, and 2003 paleomagnetic collections of several volcanic profiles from 5 of the 9 populated islands of the Cape Verde Archipelago were made. A summary of the paleomagnetic results obtained for some of the islands will be given in the presentation. On the island of Santo Antão paleomagnetic and magnetostratigraphic results from four lava sequences have been obtained: The Tarrafal, Agua Nova, Chä de Morte and Escabecada profiles. From the Tarrafal and Agua Nova profiles, 63 and 43 lava flows were investigated, respectively. Absolute Ar/Ar-ages indicate that the two profiles mainly correlate to the Brunhes Chron, which is in accordance with the normal polarity displayed by the majority of the flows. Some individual lava flows as well as flow sequences with virtual geomagnetic poles deviating more than 45 degrees from the geographic pole are interpreted as geomagnetic excursions, the number of which seem to

be increasing these years. The most noticeable observations are the indications of Brunhes-aged reverse-polarity flows found within the Tarrafal and Agua Nova profiles. From the Chä de Morte and Escabecada lava sequences 21 and 24 lava flows were sampled, respectively. The uppermost flow in the Chä de Morte profile is constrained to the lower part of the Matuyama Chron by an Ar/Ar-age. Except for one flow of intermediate direction (ChM-I), the whole Chä de Morte sequence consists of reverse-polarity flows. The lowermost flow in the Escabecada profile is constrained to the upper part of the Gauss Chron by an Ar/Ar-age. Flows of both reverse and normal polarity are found in the Escabecada profile, corresponding to the lower part of Matuyama and upper part of Gauss, respectively. Two flows with anomalous behaviour, ESC-I and ESC-II, are found in the directional data of this sequence. The uppermost event (ESC-II) most likely recorded the Gauss-Matuyama transition, while the lowermost event (ESC-I) with fully reversed polarity may indicate the presence of a Gauss-Matuyama precursor. Paleomagnetic and magnetostratigraphic results were also obtained from three lava sequences on the island of Santiago, i.e. the Ribeira da Barca, Säo Gonçalo, and Porto Formosa profiles. Samples were collected from 35 independent flow units (110 samples) distributed along the three volcanic lava sequences, which, by use of Ar/Ar-ages, may be correlated with the Geomagnetic Polarity Time Scale. The youngest profile, Ribeira da Barca, consists of normal-polarity flows corresponding to the lower Brunhes Chron. The lowest flow unit in the lava sequence possibly recorded the end of the Matuyama-Brunhes transition (MBT). The Säo Gonçalo profile is dominated by Matuyama-aged flows of reverse polarity, but short sequences of flows with normal and intermediate directions were also recorded in the section. Based on ages available it seems most likely that the normal-polarity zone correlate with the Olduvai Subchron. The Porto Formosa profile is well-constrained to the lower Matuyama, which is consistent with all flows in this section displaying reverse polarity. We are pleased to acknowledge the collaboration with our colleagues in the Danish Working Group on the Geology of the Cape Verde Islands.

URL: http://www.geo.au.dk

GP32A MCC: 3002 Wednesday 1340h

Geomagnetic Variations: From Secular Variation to Superchrons II

Presiding: **C G Langereis,** Paleomagnetic Laboratory, Fort Hoofddijk**; L Tauxe,** Scripps Institution of Oceanography

GP32A-01 1340h INVITED

Global Secular Variation from Satellite to Millennia Time Scales

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Secular variation can be studied on a large range of time scales from direct and indirect measurements of the geomagnetic field. Questions like minimum period and spatial scale of variations originating in the core are investigated with observatory and satellite data. Variations of external origin and mantle filtering are major impediments here. Indirect records of the geomagnetic field from archeo- and paleomagnetic studies provide time series long enough to investigate full periods of secular variation and the underlying core dynamics. While recently first continuous global models on the millennia scale have been developed, dating uncertainties in the individual time series and sparse data coverage challenge their reliability. Here an overview over secular variation features and their implications as determined from global models on decade to millennia time scales is given.

GP32A-02 1355h INVITED

A long-term octupolar component in the geomagnetic field ?

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The hypothesis of a geocentric axial dipole (GAD), which is fundamental to paleomagnetism and plate reconstructions, has recently been somewhat challenged by suggestions that significant long-term octupolar contributions up to 10% (and even 25%) of the GAD may have existed, mainly in the Paleozoic but also since then. For instance, Si and Van der Voo (2001) propose that a value of 6% would account for the low inclinations observed in central Asia in the Cretaceous and early Tertiary. Following and updating our previous analysis of the global paleomagnetic data base Besse and Courtillot, 2002), we attempt to find evidence for octupolar contributions in the 0-200Ma period. An important component of our analysis is the inclusion of data from sites believed to have possibly undergone a tectonic rotation about a local vertical axis (contributing 174 out of 465 data). We analyze the positions of mean poles in 20-Ma windows in common-site longitude, respectively for the northern mid-latitudes, equatorial and southern mid-latitudes, searching for the distinctive antisymmetrical pattern expected for a dipole plus octupole (without quadrupole) field. We next analyze the distribution of "latitude anomaly" (derived from the inclination anomaly, i.e. observed minus expected in case of a pure dipole) versus dipole latitude. Based on these various data manipulations, we find no robust evidence for an octupole and estimate that values on the order of 3% are unlikely to have been exceeded in the last 200 Ma. A preliminary 200 Ma overall mean field has a quadrupole component on the order of 3±2% (i.e. significant) and an octupole of 38% (i.e. not significant). A by-product of the analysis using poles from "free to rotate" sites is clear confirmation of the amplitude of rotations undergone by for instance parts of the Adriatic promontory of Africa or the Colorado plateau. Refs.: Besse, J., and V. Courtillot, J. Geophys. Res., 107, doi:10.1029/2000JB000050, 2002; Si, J., and R. Van der Voo, Terra Nova, 13, 471-478, 2001.

GP32A-03 1410h INVITED

Paleointensity Distributions and the Early Geodynamo

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Sharp increases in geomagnetic intensity are sometimes cited as evidence for the onset of ancient geodynamo activity. High-quality paleointensity measurements, however, do not reveal any drastic increases in the average intensity of the geomagnetic field over the past ∼2.8 Ga. It is therefore necessary to examine other properties of the Precambrian geomagnetic field. We present Thellier paleointensity results (with pTRM checks; corrected for the effects of remanence anisotropy and slow cooling) and stable remanence directions from several Precambian intrusions. We focus on cumulate rocks from 35 sites in the 2.7 Ga Stillwater Complex (Montana, USA) and from nearly that many sites in the 1.4 Ga Laramie Anorthosite. These data, along with the 1.1 Ga Tudor Gabbro paleointensities of *Yu and Dunlop* [2001] are not only reliable records of the Precambrian Earth's mean dipole moment, but also provide information about paleointensity distributions and directional paleosecular variation. For example, the Stillwater mean virtual dipole moment (VDM, 5.1×10^{22} Am^2) is similar to the average VDM of the past 300 Myr, but the distributions of VDMs and of characteristic remanence directions are not what one would expect from the Phanerozoic geomagnetic field. This suggests that, although the Earth had a magnetic field as early as 2.7 Ga, the planet did not develop a "modern" geodynamo until later. Yu, Y., and D. J. Dunlop, Paleointensity determination on the Late Precambrian Tudor Gabbro, Ontario, *J. Geophys Res.*, *106*, 26331-26343, 2001

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Geomagnetic Polarity Timescales and Reversal Frequency Regimes

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An analysis of geomagnetic reversal history is made for the most reliable polarity timescales covering the last 160 Myr. The timescale of Cande and Kent [1995] (CK95) is the optimum representation of Cenozoic and Late Cretaceous polarity history, and the timescale of Channell et al. [1994] (CENT94) best represents the Early Cretaceous and Late Jurassic. The CK95 timescale can be divided into two nearly linear segments at chron C12r. The lengths of chrons in the younger segment have no systematic trend and so this part of the sequence is considered to be stationary for statistical analysis. The mean chron length is 0.248 Myr and the gamma index, k, for the distribution of chron lengths is 1.6 ± 0.4; inserting just 8 additional short subchrons that have been verified from magnetostratigraphic studies as polarity reversals reduces the mean chron length to 0.219 Myr and k to 1.3 ± 0.3. The older segment is stationary if the two long polarity chrons C33n and C33r adjacent to the Cretaceous Normal Polarity Superchron are omitted; in this case the mean chron length is 0.749 Myr and k is 1.2 ± 0.4. The chrons in the CENT94 timescale are stationary with mean length 0.415 Myr and k = 1.3 ± 0.3. The gamma indices of the chron distributions are not significantly different from a Poisson distribution (k = 1), which implies that the reversal process is free of long-term memory. The concept of an inhibition period, in which a new reversal is unlikely for an extended period after a reversal, appears to be unnecessary. However, if the mean chron duration is an indicator of stability of the reversal process, it appears that a long lasting episode of stable behavior may be followed by abrupt change to another stable regime with a markedly different reversal frequency. There is no significant change of the gamma index from one regime to another, although the average reversal rate changes by more than a factor of three. The probability of a reversal per unit time has a constant value within each regime (k = 1), but the value appears to vary from regime to regime in proportion to the reversal rate.

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Was the Ancient Geomagnetic Field Dipolar?

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One of the most useful assumptions in paleomagnetism is that the time-averaged geomagnetic field is closely approximated by a geocentric axial dipole (GAD). This has been found to be true for at least the last 5 million years with the largest non-GAD contribution to the spherical harmonic expansion generally being of the order of 5%. For the more ancient past, it is difficult to test the GAD (or any other field) hypothesis owing to plate motions, rock deformation and accumulating problems of overprinting. Although most paleomagnetic studies make the implicit assumption of a GAD field, several recent studies have called the essential GAD nature of the ancient field into question and have suggested large (up to 20%) contributions of the axial octupolar term to the geocentric axial dipole in the spherical harmonic expansion even in the Cenozoic. In this paper, we develop a new statistical model for the geomagnetic field to diagnose directional dispersion resulting from sedimentary inclination error, a widespread process that plausibly explains many of the observed discrepancies from the GAD field hypothesis. We also present a methodology to correct the resulting persistent shallow bias. Application of this technique to one of the few published studies from the Cenozoic of Asia with adequate data shows that the reported discrepancies from a GAD field in this region are most probably due to sedimentary inclination error rather than a non-GAD field geometry or undetected crustal shortening. Although non-GAD fields cannot in general be strongly rejected (actually, only GAD is a well posed and testable, i.e., refutable, hypothesis), the principle of least astonishment requires us to consider plausible geological mechanisms such as sedimentary inclination error as the cause of persistent shallow bias prior to the very "expensive" option of throwing out the GAD hypothesis.

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Non-Uniform Occurrence of Short-Term Polarity Excursions in the Geomagnetic Field?

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