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

Monika Korte (+49 331 288 1268; monika@gfz-potsdam.de)

GeoForschungsZentrum Potsdam, Telegrafenberg, Potsdam 14473, Germany

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 ?

Vincent E Courtillot[1] (33144272434; courtil@ipgp.jussieu.fr)

Jean Besse[1] (33144272827; besse@ipgp.jussieu.fr)

[1]Institut de physique du globe, 4 Place Jussieu, Paris 75252, France

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

Peter A Selkin[1] (pselkin@ucsd.edu)

Jeffrey S Gee[1] (jsgee@ucsd.edu)

William P Meurer[2] (wpmeurer@mail.uh.edu)

Lisa Tauxe[1] (ltauxe@ucsd.edu)

Cathy G Constable[1] (cconstable@ucsd.edu)

[1]Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0220, United States

[2]Department of Geosciences, University of Houston, 312 Science & Research Bldg. 1, Houston, TX 77204-5007, United States

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

GP32A-04 1425h

Geomagnetic Polarity Timescales and Reversal Frequency Regimes

William Lowrie[1] (41-1-633-2607; lowrie@mag.ig.erdw.ethz.ch)

Dennis V. Kent[2,3] (1-732-445-7049; dvk@rci.rutgers.edu)

[1]ETH Zurich, Institute of Geophysics, Zurich 8093, Switzerland

[2]Rutgers University, Dept of Geological Sciences, Piscataway, NJ 08854-8066, United States

[3]Lamont-Doherty Earth Observatory, Paleomagnetic Laboratory, Palisades, NY 10964-8000, United States

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.

GP32A-05 1440h

Was the Ancient Geomagnetic Field Dipolar?

Lisa Tauxe[1] (ltauxe@ucsd.edu)

Dennis V Kent[2,3] (dvk@ldeo.columbia.edu)

[1]Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093-0220, United States

[2]Lamon-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, United States

[3]Department of Geological Sciences, Rutgers University, Piscataway, NJ 08854, United States

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.

GP32A-06 1455h

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

Wout Krijgsman[1] (858-534-6531; krijgsma@geo.uu.nl)

Dennis Kent[2] (dvk@ldeo.columbia.edu)

[1]Paleomagnetic Lab. Fort Hoofddijk Utrecht University, Budapestlaan 17, Utrecht 3584 CD, Netherlands

[2]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, United States

We will present new magnetostratigraphic results from DSDP Site 608 in the North Atlantic that reveal the presence of nine short-term polarity excursions in the middle to late Miocene. These polarity excursions do not correspond to subchrons in the most recent GPTS. Four of them correspond to cryptochrons. IRM component analysis suggests that these polarity excursions represent true fluctuations of the geomagnetic field. Comparison with published results from ODP Sites 845 and 1092, and from the continental Orera Composite Section, shows that all nine polarity excursions have been observed in more than one record. A refined criterion for a short-term polarity excursion to qualify as polarity subchron defines five new subchrons in the late Miocene: C4r.2r-1n, C4Ar.1r-1n, C5r.2r-1n, C5r.2r-2n, and C5r.3r-1n. The three events within C5n and the one in C5An.2n qualify better as polarity excursions and are most likely associated with decreases in paleointensity of the geomagnetic field. These results imply that the occurrence of short-term polarity excursions in the geomagnetic field is non-uniformly distributed through time - for example, being relatively more common in the early Late Miocene and the Pleistocene but virtually absent in the latest Miocene and Pliocene - but it remains uncertain if this is related to real behavior of the geodynamo.

GP32A-07 1510h

Deeptow magnetic survey of the Pacific Jurassic Quiet Zone: Implications for the marine magnetic anomaly timescale

Maurice A Tivey[1] (mtivey@whoi.edu)

William W Sager[2] (wsager@ocean.tamu.edu)

Sang-Mook Lee[3] (smlee@kordi.re.kr)

Shipboard Party

[1]Woods Hole Oceanographic Inst., 360 Woods Hole Rd., Woods Hole, MA 02543, United States

[2]Texas A&M University, Department of Oceanography, College Station, TX 77843, United States

[3]Korean Ocean Research and Development Institute, Ansan, P.O. Box 29, Seoul 425-600, Korea, Republic of

We present results of a recently completed near-bottom magnetic survey of the Pacific Jurassic quiet zone located in Pigafetta Basin in the vicinity of ODP Hole 801C. A total of 1550 km of tracklines were completed during 5 lowerings of the DSL120 sidescan sonar system of the National Deep Submergence Facility equipped with two magnetometer systems. The nominal altitude of the vehicle was 100 m above the seafloor with the average sediment thickness 300 meters. We collected simultaneous vector magnetic data from a digital Honeywell HMR2300 magnetoresistor sensor and absolute total field using a Marine Magnetics Overhauser sensor provided by KORDI. The survey had four primary goals: 1) to investigate the presence or absence of magnetic lineations related to seafloor spreading around ODP Hole 801C, 2) to extend the magnetic anomaly mapping south to the Rough-Smooth (RS) boundary, thought to be the limit of the oldest Pacific crust, 3) to extend and confirm correlations of previously collected deeptow results, and 4) to investigate the M33-M34 sequence which can be clearly correlated with the timescale but also shows a period of rapid field reversal. The survey around Hole 801C was navigated within a transponder net whereas the remainder of the surveys were navigated using acoustic layback and bottom-lock doppler. From our results, we confirm that anomalies in the M33-M34 sequence are highly-lineated and well-correlated between adjacent lines with a high reversal rate. We found that anomalies older than M36 become harder to correlate to about M40 where there may be a possible change in trend of the anomaly strike. The anomaly record appears to become more linear again as Hole 801C is approached. Around Hole 801C the anomalies show a clear lineation with a strike direction of 25 degrees, although the correlation is not as consistent as the younger anomaly sequence. The decrease in anomaly amplitude that is seen from M21 through the M36 sequence appears to be low through anomaly M40 and then increases to a higher value thereafter with an average amplitude of 200 nT at deeptow altitude. South of Hole 801C towards the RS boundary we find that magnetic anomalies continue with short-wavelength anomalies superimposed on a longer wavelength anomalies making them difficult to correlate. High amplitude anomalies mark the RS boundary itself. In summary, we find evidence for seafloor spreading anomalies throughout the survey area although there are areas where correlation is difficult.

GP32A-08 1525h

Paleomagnetic data from Late Cenozoic Fort Selkirk Lavas, Yukon,significance for secular variation and tectonics

Ted Irving[1] (250 656 9645; tirving@pgc-gsc.nrcan.gc.ca)

Judith Baker[1] (250 363 6509; jubaker@nrcan.gc.ca)

Rene W Barendregt[2] (403 329 2225; barendregt@uleth.ca)

Neil D Opdyke[3] (352 392 6127; drno@ufl.edu)

[1]Pacific Geoscience Centre, 6000 West Saanich Road, North Saanich, BC V8L4B2, Canada

[2]University of Lethbridge, 4401 University Drive, Lethbridge, AB T1K 3M4, Canada

[3]University of Florida, 137 Turlington Hall, Gainesville, FL 32611, United States

Directions of magnetization in 33 basalt flows from Fort Selkirk, Yukon Canada, of Bruhnes, Matuyama and Gauss (1 flow only) age are well grouped. Normal and reversed magnetizations are present and it is likely therefore that secular variations have been covered. The very high accuracy within-lavas allows a good estimate of the dispersion of secular variation to be made. The circular standard deviation (theta63) of directions is 8.5deg at latitude 62.7deg N. The mean, regardless of sign, differs significantly from the geocentric axial dipole (GAD) field, indicating a 15±6deg counterclockwise rotation. Data from rocks of the same age range from the Western Cordillera of Canada and the NW USA agree well with the GAD. Recent seismic and GPS studies show that the dynamic crust in the Yukon is only 20 km thick and intensely mobile. Heat flow is high, allowing a ductile decollement for the tectonic float to transfer stress more than 1000 km inland to the currently seismic McKenzie Mountains from the indentor, the Yakutat block, which is colliding with North America. Yukon crust is moving NE and rotating counterclockwise with respect to North America as a result of this on-going collision. The geodetically determined general rotation is much less than that suggested by paleomagnetic deviation, indicating that Selkirk area may be moving seperately within the mosaic of the Yukon crust. The deviation from the GAD field is evidently tectonic not geomagnetic.

GP32B MCC: 3002 Wednesday 1600h

Bullard Lecture

Presiding: **L Tauxe,** Scripps Institution of Oceanography

GP32B-01 1610h INVITED

Progress Towards Understanding the Geodynamo from Observations and Numerical Models

Jeremy Bloxham (617 495-9517; jeremy_bloxham@harvard.edu)

Harvard University, 20 Oxford Street, Cambridge, MA 02138, United States

The new generation of magnetic field satellites currently in orbit hold enormous promise for understanding the generation of the Earth's magnetic field. These new data, together with earlier observations, and in combination with numerical models of the geodynamo, are enabling new insights into the dynamo process. Our approach aims to dissect the full range of behavior of the field that is observed: from high-latitude concentrations of flux that persist, at least in the time-average, over periods of several million years, to magnetic jerks, abrupt changes in the field on a timescale of a year or less. We describe a simple dynamical model of the core consistent with these observations. A number of key questions remain. How do reversals fit into this model? Are they simply a more extreme manifestation of secular variation, or do they require some separate explanation? How do we account for the different field morphologies and range of magnetic field strengths observed in the Solar System?

GP41A MCC: 2000 Thursday 0800h

Environmental Magnetism I

Presiding: **T Evans,** University of Alberta**; A Roberts,** University of Southampton

GP41A-01 0800h INVITED

Magnetic Mineral Concentrations of Recent Lake Sediments as Recorders of Climate Variations

Kenneth P Kodama[1] (610-758-3663; kpk0@lehigh.edu)

BangYeon Kim[1] (610-758-3660; bak4@lehigh.edu)

[1]Lehigh University, Department of Earth and Environmental Sciences, 31 Williams Drive, Bethlehem, PA 18015-3188, United States

We have been studying the mechanism by which the variation of magnetic mineral concentrations in recent lake sediments could record local climate variations. Our earliest work showed that magnetic mineral concentrations in lakes of different productivity (eutrophic, mesotrophic, and oligotrophic) from the Pocono Mountains of northeastern Pennsylvania showed a correlation to historic records of regional rainfall over the past 100-200 years. The robustness of these correlations was hampered by the reliance on ^{210}Pb dating of the lake sediments. The varve chronology of sediments from Lake Ely in northeastern Pennsylvania afforded a more accurate downcore comparison between magnetic mineral concentrations and a local historic rainfall record. The observation of a positive correlation between ARM and SIRM and the local rainfall record over the past 60 years suggested a model in which increased precipitation supplied more nutrients to a postulated magnetotactic bacteria population in the lake and enhanced the production of magnetosomes that were preserved in the lake sediments. A detailed study of the mineral magnetism of water filtered from the water column and recent lake sediments of Lake Ely indicates that magnetosomes are definitely present at the oxic-anoxic transition in the water column and in recent lake sediments. Comparison of the ARM intensity of water column filtrate with the ARM intensity of material collected six months later from a sediment trap, does give some support to the rainfall-nutrient model, but the correlation recorded over this short period is not strong and is incomplete. Comparison of the magnetic data to the historic temperature record suggests that the duration of lake ice cover may be a mitigating factor in the magnetic mineral recording of rainfall variation, i.e. colder winters with longer periods of ice cover would minimize mixing of lake waters by wind and allow larger populations of magnetotactic bacteria to develop in the following spring and summer. Based on our studies, the best lake from which to obtain a record of climate variations using magnetic mineral concentration is one with a magnetic mineralogy dominated by magnetosomes, i.e. where the detrital input to the lake has a easily distinguished, different magnetic mineralogy from the magnetosomes or has a much lower magnetic mineral concentration. In addition, the magnetic mineral concentrations may record a combination of precipitation and temperature variations.

GP41A-02 0815h

Toward Modelling Topsoil Magnetic Susceptibility for Demining Activities

Jacqueline A Hannam[1] (hannam@liverpool.ac.uk)

John A Dearing[1] (j.dearing@liverpool.ac.uk)

[1]Environmental Magnetism Laboratory, Department of Geography Roxby Building University of Liverpool, Liverpool L697ZT, United Kingdom

The Landmine Monitor estimates that landmines cause up to 20,000 fatalities and casualties worldwide every year, in over 100 countries affected by landmine contamination. Although detection technologies have become more sophisticated, the metal detector still remains the most widely employed detection system in landmine affected regions. With increased use of minimum metal mines, the performance and sensitivity of metal detectors are increasingly challenged. In addition to mine constituents, depth of burial and orientation, soil properties significantly affect metal detection capabilities. Soils with high magnetic susceptibility, in particular those dominated by viscous components, interfere with the response signal in both frequency and time domain metal detection systems. Using Bosnia and Herzegovina (BiH) as a pilot region, we created an expert system to predict topsoil susceptibility from environmental information within a SOTER data base.