GP43A CC: 519 B Thursday 1330h

Long- and Short-Term Variations of Geomagnetic Field Strength I *(joint with OS, T, PP)*

Presiding: **A Gogichaishvili,** National University of Mexico**; C Carvallo,** University of Toronto at Mississauga

GP43A-01 1330h

What We Really Know About the Long-Term Variation of Absolute Geomagnetic Paleointensity?

Avto Gogichaishvili[1] (avto@geofisica.unam.mx)

Juan Morales[1] (jmorales@geofisica.unam.mx)

Luis Alva-Valdivia[1] (lalva@geofisica.unam.mx)

Jaime Urrutia-Fucugauchi[1] (juf@geofisica.unam.mx)

[1]Laboratorio de Paleomagnetismo y Geofisica Nuclear, Instituto de Geofisica, UNAM, Ciudad Universitaria, 04510 México DF, MÉXICO, 04510, Mexico

Three different trends of the long-term paleointensity variation were recently analyzed. Trend 1 suggests the low paleointensity during almost whole Mesozoic time. Trend 2, which is mainly based on submarine basaltic glass data , supports the relatively high paleointensity since about 0.3 Ma with lower paleointensities prior to that including the entire Cretaceous Normal Superchron (CNS). In contrast, trend 3 suggest that the paleointensity was higher during CNS. In order to estimate the true features of geomagnetic field intensity we re-analyzed almost all paleointensity determinations obtained since early sixties. The variable quality of published paleointensity estimates makes global compilations difficult and extreme care must be taken not to interpret problematic data in terms of geodynamic features.

GP43A-02 1345h INVITED

Long term trends in paleointensity: Are there any?

Lisa Tauxe (ltauxe@ucsd.edu)

Scripps Institution of Oceanography, Geosciences Research Division, La Jolla, CA 92093-0220, United States

After more than nearly five decades of effort, there is still considerable controversy over the long term intensity behavior of Earth's magnetic field. Was there a period of unusually low intensity in the Mesozoic? Was there a period of unusually high intensity during the Cretaceous Normal Superchron? Is there a relationship between reversal frequency and average field strength? Is the present field intensity unusually strong, or about average? The reasons why these fundamental questions are still under debate are that paleointensity data are rare and the acquisition of them is fraught with difficulties. The idea of normalizing one readily measured remanence with another is deceptively simple. Much of the discussion about intensity behavior therefore revolves around approaches to data selection. It is clear that the "best" experimental material would have a remanence carried by tiny (single-domain) magnetic grains that resist alteration during the experiment and whose rate of remanence acquisition can be approximated in the laboratory. Yet a natural material that closely satisfies these requirements, submarine basaltic glass (SBG), is rejected out of hand in several recent compilations. I will discuss the case for paleointensity data derived from SBG and summarize the current state of the paleointensity data set as a whole, including new data from ODP glasses and new experimental designs. I will also examine the case for the CNS intensity high, the Mesozoic dipole low, and the relationship between reversal frequency and average field strength.

GP43A-03 1405h INVITED

400,000 YEARS OF GEOMAGNETIC FIELD INTENSITY AT HAWAII FROM THE LONG BASALTIC CORES

Carlo LAJ[1] (laj@lsce.cnrs-gif.fr)

Catherine KISSEL[1] (kissel@lsce.cnrs-gif.fr)

[1]LSCE, CNRS-CEA Avenue de la Terrasse, Gif-sur-Yvette 91198, France

We present a compilation of paleointensity results from the Hawaiian long basaltic cores HSDP1 (Mauna Loa and Mauna Kea volcanos), SOH-4 and SOH-1 (Kilauea Volcano) and the first results from the aerial part of the new core HSDP2 (Mauna Loa and Mauna Kea volcanos). The results are selected using a set of paleointensity selection criteria (PICRIT-03) we recently proposed for Thellier-Thellier experiments which has been further improved. Case studies relevant to these selection rules will be presented and discussed. Previous results from SOH-4 (0-98 kyr) and HSDP1 (100-420 kyr) have already been re-examined using these criteria, and the results are in press. Here published results from SOH-1 (0-45 kyr) are re-examined and new results from HSDP2 (100-420 kyr) are selected using these newly proposed criteria for the Thellier experiments. Over the time intervals on which the records overlap (0-45 kyr for SOH-1 and SOH-4 and 100-420 kyr for HSDP 1 and HSDP 2) the paleointensity results yield very consistent results. This allows to construct a spliced record of geomagnetic field intensity at Hawaii for the last 420 kyr which we believe to be accurate within +/-15%.

GP43A-04 1425h INVITED

Paleomagnetic and Paleointensity Results from ∼2.45 Ga Matachewan Dikes (Ontario, Canada): Implications for the Early Geodynamo

John A Tarduno[1] (john@earth.rochester.edu)

Alexei V Smirnov[1] (alexei@earth.rochester.edu)

[1]Department of Earth and Environmental Sciences University of Rochester, 227 Hutchison Hall, Rochester, NY 14627, United States

Paleomagnetic and paleointensity studies of Proterozoic-Archean rocks have great potential for providing insight into processes of the early Earth's dynamo. We sampled 20 dikes of the Matachewan swarm emplaced in the Early Proterozoic (∼2.45 Ga). Sampling site locations were chosen so that the dikes contained clear plagioclase crystals according to the classification of Halls and Zhang (1998). Magnetic hysteresis, thermomagnetic, and low-temperature magnetic analyses suggest that PSD to MD magnetite is a dominant magnetic carrier in whole rock dike samples. Paleomagnetic analysis showed the presence of a stable high-temperature (HT) (>500^{o}C) component of natural remanent magnetization (NRM) in the majority of the samples. This component was interpreted to be a primary thermal remanent magnetization (TRM), acquired during dike emplacement. The paleomagnetic directions determined from the HT component are consistent with those reported in previous studies (e.g. Bates and Halls, 1991). After correcting for local tectonic rotations, the between-dike directional variation is consistent with the range of secular variation seen in rocks formed during the last 200 m.y., and hence onset of the geodynamo before the Early Proterozoic. To determine paleointensity we applied the single plagioclase crystal technique, which aims to obtain data less affected by geological and laboratory alteration. Small 1-2 mm size crystals were chosen for analysis (larger, altered plagioclase phenocrysts were avoided). Only ∼3% of plagioclase crystals separated from the dikes were magnetically strong enough (> $5{\cdot}10^{-11}$ Am^2) to be used in paleointensity determinations. Seven successful paleointensity determinations from one dike result in a mean field value of 26.8±2.5 μT, which corresponds to a VDM of $6.8{\pm}0.6{\times}10^{22}$ Am^2.

GP43A-05 1445h

Preliminary Directional and Paleointensity Studies of South African Proterozoic/Archean Minerals Using a CO_2 Laser System

Dorothy G Bauch[1] (db007k@mail.rochester.edu)

Rory D Cottrell[1] (rory@earth.rochester.edu)

John A Tarduno[1] (john@earth.rochester.edu)

[1]Department of Earth and Environmental Sciences University of Rochester, 227 Hutchison Hall, Rochester, NY 14627, United States

Many Archean rocks are characterized by multiple components of magnetizations which may reflect a long history of overprinting when exposed to temperatures between 300 and 400 ^{o}C. In addition, many plutonic rocks available for study contain mineral grains with magnetic carriers having drastically different magnetic domain states (multidomain to single domain). As a result, paleomagnetic measurements of whole rock Archean samples can be expected to reflect a highly complex averaging process, potentially taking us very far from the original field direction and intensity. To address this issue, we report preliminary data using a CO_2 laser system under development at the University of Rochester. Using a Princeton Measurements Corporation Alternating Gradient Force Magnetometer, we are able to identify mineral carriers with optimal (single domain-like) behavior. Using the CO_2 laser system we have been able to isolate both directions and paleointensities from such minerals (e.g. feldspars and quartz from 3-3.5 Ga plutonic rocks of Barberton, South Africa). Further developments and data will be discussed, as well as rock magnetic data on other mineral carriers, including zircons.

GP44A CC: 519 B Thursday 1530h

Long- and Short-Term Variations of Geomagnetic Field Strength II *(joint with OS, T, GC, PP)*

Presiding: **A Gogichaishvili,** National University of Mexico**; C Carvallo,** University of Toronto at Mississauga

GP44A-01 1530h

Has the Next Geomagnetic Field Reversal Already Started?

Angelo De Santis[1] (+39 06 51860327; desantis@ingv.it)

Roberta Tozzi[1] (+39 06 51860389; tozzir@ingv.it)

Johannes Wicht[2] (+49 5556 979 437; wicht@linmpi.mpg.de)

[1]Istituto Nazionale di Geofisica e Vulcanologia, Via Vigna Murata 605, Rome 00143, Italy

[2]Max Planck Institut für Aeronomie, Max Planck Str. 2, Katlenburg Lindau 37191, Germany

Although in the past some speculations about an occurring geomagnetic field reversal were already formulated, only recently this has emerged as a really constructive hypothesis to be better investigated. From Information Content analysis of global models of the geomagnetic field and geodynamo simulations, it results that within 1000-1500 years the geomagnetic field will likely change its polarity. In this work we will present some considerations that support this possibility together with their geophysical implications.

GP44A-02 1545h

Paleomagnetism and Paleointensity of the Michoacan-Guanajuato Volcanic Field, Mexico

Gennaro Conte[1] (52 55 5622 4122; gennaro@geofisica.unam.mx)

Jaime Urrutia Fucugauchi[1] (52 55 5622 4122; juf@geofisica.unam.mx)

Avto Goguitchaivili[1] (52 55 5622; avto@geofisica.unam.mx)

[1]Universidad Nacional Autonoma de Mexico, Instituto de Geofisica, Ciudad Universitaria, Coyoacan, Mexico 04510, Mexico

We report detailed paleodirectional and paleointensity study from 24 volcanic units (Late Pliocene to Present) from the Michoacan-Guanjuato volcanic field (MGVF). The MGVF belongs to Transmexican volcanic belt and contains over 1000 late Quaternary volcanic centers. Almost 90 percent of them are cinder cones. Single component, linear demagnetization plots were observed in most cases. Seven sites yield reverse polarity magnetization while fifteen volcanoes are normally magnetized. Sixteen samples, from three volcanoes, yield reliable paleointensity estimates with the site-mean virtual dipole moments (VDM) ranging from 7.3 to 12.2 x 1022 Am2. Mean VDM obtained in this study is 9.2 ± 0.8 x 1022 Am2 which is slightly higher than present day geomagnetic field strength.

GP44A-03 1600h

Paleointensity Experiments with pTRM and Tail Checks for Multidomain and PSD Magnetites

David J Dunlop[1] (905-828-3968; dunlop@physics.utoronto.ca)

Song Xu[2]

Baoxing Zhang[3]

Ozden Ozdemir[1]

[1]Physics, University of Toronto, Mississauga Rd. N, Mississauga, ON L5L 1C6, Canada

[2]JDL Digital Systems, Andover Park, Seattle, WA 98188, United States

[3]Geology, University of Toronto, Mississauga Rd. N, Mississauga, ON L5L 1C6, Canada

Simulated Thellier experiments using total TRM as NRM were performed on dark minerals (biotite, amphiboles) from a diabase and on 1, 6, 20 and 135 um fractions of crushed magnetite crystals, all annealed and sealed under vacuum. The 135 um magnetite had strong downward curvature of the Arai plot, as predicted by theory. The 20 um and dark minerals samples, which behaved identically, and the 6 um magnetite had progressively less curvature, and the 1 um magnetite behaved almost ideally. Detailed pTRM checks and pTRM tail checks were performed for the 135 um and dark minerals samples. When the laboratory field H was parallel to the NRM, all pTRM tail checks were zero, as reported by Yu and Dunlop (JGR, Nov. 2003), but when H was perpendicular to NRM, pTRM tails were detected after 3rd heatings in zero field. Undemagnetized pTRM residuals were likely present in both cases, but were hidden when pTRM is parallel to NRM. For the 135 um magnetite, pTRM checks for all temperatures were positive. For the dark minerals, pTRM checks grew larger than the original pTRMs as heating temperatures rose. The most deviant of these was rechecked by giving a new total TRM ("NRM") to the sample and replicating this single pTRM. The second pTRM check was closer to, but still larger than, the original pTRM. Two further experiments were undertaken as closer replications of the complete Thellier experiment. The only differences were that the NRM was pre-treated by either 15 mT AF or LTD. In both experiments, seven new pTRMs closely matched original pTRMs. Neither AF nor LTD made the Thellier results much closer to ideal; the treated NRM and pTRMs still gave convex-down Arai plots with initial slopes of 2-2.5 instead of 1. However, our experiments do verify that these strongly curved Arai plots are reproducible and have a purely physical cause. They do not result from irreversible physiochemical alteration. Conventional pTRM checks depend on magnetic history in multidomain samples and do not always reproduce the original pTRMs. Nevertheless the Arai plots are reproducible if the entire Thellier experiment is repeated ab initio.

GP44A-04 1615h INVITED

The Early Brunhes Chron and Matuyama-Brunhes Boundary Interval (500-900 ka) in North Atlantic Drift Sediments

James E.T. Channell[1] (352 3923658; jetc@nersp.nerdc.ufl.edu)

Jason H. Curtis[1] (curtisj@ufl.edu)

Benjamin P. Flower[2] (bflower@seas.marine.usf.edu)

[1]University of Florida, Department of Geological Sciences, PO Box 112120, Gainesville FL 32611, United States

[2]University of South Florida, College of Marine Science, St. Petersburg FL 33701, United States

We compare magnetic and oxygen isotope data for the 500-900 ka interval from Ocean Drilling Program (ODP) Site 984 with those from ODP Sites 980 and 983. These sites from North Atlantic sediment drifts provide high-resolution records for the early Brunhes Chron and for the Matuyama-Brunhes boundary. At ODP Site 984 (Bjorn Drift, Iceland Basin), the mean sedimentation rate in the 500-900 ka interval is 12 cm/kyr based on an age model derived by matching the planktic and benthic oxygen isotope records to an Ice Volume Model. The Matuyama-Brunhes polarity transition at Site 984, as defined by virtual geomagnetic polar (VGP) latitudes less than 40°, has an apparent duration of 7 kyr with a mid-point at 773.5 ka, compared to 772.5 ka at neighboring Site 983. Outside the polarity transition at both Sites 984 and 983, excursions in VGP latitude, to values less than 40°, at 540 ka, 590 ka, 670 ka, 860 ka and 880 ka correspond to troughs in the paleointensity record. The u-channel paleomagnetic data across the Matuyama-Brunhes boundary at Sites 984 and 983 are compared for the different holes from each site, and with back-to-back 1-cm cubic discrete samples. Clusters of VGPs in the South Atlantic and NE Asia in both u-channel and discrete sample records imply that polarity transition fields have characteristics reminiscent the modern field stripped of its axial dipole.

GP44A-05 1635h

Secular Variation and Paleointensity Records From the Eirik and Gardar Drifts (North Atlantic Ocean)

Helen F Evans[1] (352 392 3298; geohelen@ufl.edu)

James E. T Channell[1] (jetc@ufl.edu)

Joseph S Stoner[2] (stonerjs@buffmail.colorado.edu)

Claude Hillaire-Marcel[3] (chm@uqam.ca)

[1]Department of Geological Sciences, University of Florida, PO Box 112120, Gainesville, FL 32611, United States

[2]Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Campus Box 450, Boulder, CO 80309, United States

[3]Centre de Recherche et Geodynamique (GEOTOP-UQAM-McGILL), University of Quebec a Montreal, Case Postale 8888, Succursale Centre-Ville, Montreal, QC H3C 3P8, Canada

Jumbo piston cores and gravity cores collected by the RV Knorr from the Eirik and southern Gardar drifts (North Atlantic) in 2002 have yielded records of secular variation and paleointensity for the last few hundred thousand years. The magnetic data from the Eirik Drift are augmented by results from a 43 m long core (MD99-2227) collected during the 1999 cruise of the Marion Dufresne II, that has a detailed oxygen isotope record. Both the Laschamp (40 ka) and Iceland Basin (190 ka) excursions are recorded in u-channel samples from the higher-sedimentation-rate cores. Paleointensity and magnetic susceptibility records can be correlated to published results from older piston cores (HU90-013-012 and HU90-013-013) from the Eirik Drift collected by the R/V Hudson. On the Eirik Drift, the contrasting glacial/interglacial sedimentation rates between shallower (2500 m) and deeper-water (3500 m) sites are sensitive to changes in the outflow of the WBUC (therefore in the production of NADW) and allow us to develop a composite record with a higher resolution than at any single site. The new magnetic data from southern Gardar Drift sites at 3000 m water depth can be correlated to published results from ODP Sites 983/984 from shallower (<2000 m) sites on the northern Gardar/Bjorn drifts, and to the NAPIS-75 (North Atlantic) paleointensity stack.

GP53A CC: 519 B Friday 1330h

Rock Magnetism and the 40th Anniversary of the Vine-Matthews-Morley Hypothesis I

(joint with G, T, V)

Presiding: **D J Dunlop,** University of Toronto**; J Gee,** Scripps Institution of Oceanography

GP53A-01 1335h

The Origin of the Geomagnetic Polarity Time Scale: an Historical Footnote

Ted Evans (evans@phys.ualberta.ca)

University of Alberta, Institute for Geophysical Research, Physics Department, Edmonton, AB T6G 2J1, Canada

Coincidence sometimes plays an important role in scientific discovery, as, for example, when two individuals happen to come together in a particular institution. Sometimes, however, the coincidence takes place but the discovery doesn't. The geomagnetic polarity time scale - a central ingredient in setting up the Vine-Matthews-Morley hypothesis - grew from the seminal work of Cox, Doell and Dalrymple published in June 1963. This did not result from coincidence, but rather from a program with the clear objective of determining the magnetic polarity and the radiometric age of suitable geological targets. In his excellent book describing these historical developments, William Glen ponders why this major advance was not made in the University of Alberta. After all, Jan Hospers was there, doing palaeomagnetism, and Joseph Lipson was there, building mass spectrometers - in the same department. Everything was in place for a breakthrough. Or was it?

GP53A-02 1355h INVITED

Magnetic Anomalies over the Osbourn Trough in the Southwest Pacific Cretaceous Quiet Zone

Steven C Cande[1] (858-534-1552; scande@ucsd.edu)

Joann Stock[2] (jstock@gps.caltech.edu)

Rob Clayton[2]

Michael Gurnis[2]

[1]Scripps Institution of Oceanography, Mail Code 0220, La Jolla, CA 92093

[2]Caltech, Mail Stop 2521, Pasadena, CA 91125

Detailed surveys of magnetic anomalies over ocean crust that formed during long intervals of predominantly one polarity and that formed at moderate to fast spreading rates, such as anomaly 5 in the Northeast Pacific, often display a pattern of small scale, linear anomalies that reflect a mixture of short polarity events and/or intensity fluctuations of the paleomagnetic field. These tiny wiggles have been mapped in many regions of the ocean representing large portions of the last 180 Ma including the Jurassic Quiet Zones. However, they have not been reported in the Cretaceous Quiet Zones. Although the lack of tiny wiggles in the Cretaceous Quiet Zones might reflect a difference in field behavior during the Cretaceous Long Normal Polarity Interval, it more likely reflects the lack of good surveys in areas where tiny wiggles are most likely to be preserved. The Southwest Pacific Cretaceous Quiet Zone, with its fast spreading rates and high paleo-latitude, is ideally located for preserving small scale anomalies. Recent data collected on transits of the R/VIB Nathaniel B. Palmer reveal a linear pattern of moderate amplitude (+ - 100 nT), short wavelength (10-30 km) magnetic anomalies straddling the Osbourn Trough, an east-west striking fossil spreading center east of the Tonga-Kermadec Trench. Although the age of the Osbourn Trough is uncertain, it is likely to have formed around 95 or 100 MA, in the middle of the Cretaceous Long Normal Period. The magnetic profiles straddling the Osbourn Trough document a magnetic anomaly pattern that is very similar in appearance to classic tiny wiggles; that is, they are not as strongly linear as would be expected for anomalies generated by true reversals, but they are definitely linear and have a unique pattern. They most likely represent a record of paleointensity fluctuations at this time and will help in unraveling the tectonics of this enigmatic region.

GP53A-03 1410h

Magnetic Gradiometer and Vector Magnetometer Survey of the Galapagos Triple Junction

Jeff Gee[1] (1-858-534-4707; jsgee@ucsd.edu); Steven C. Cande[1] (scande@ucsd.edu); Robert L. Parker[1] (rlparker@ucsd.edu); Peter F. Lonsdale[1] (plonsdale@ucsd.edu); Julie Bowles[1] (jbowles@ucsd.edu); Chris Symons (csymons@cox.net)

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

Several fundamental tectonic problems of the equatorial Pacific remain unsolved due to the lack of magnetic anomaly data. A basic limitation encountered with the use of the standard proton precession magnetometer (or any total field instrument) is that total field anomalies over approximately N/S striking bodies are very small at low magnetic latitudes. Another problem encountered with magnetic surveys near the magnetic equator are the diurnal variations associated with the external field. Measurements of the vector anomalous field and total field gradient offer ways to overcome these limitations. Total field gradiometer data allow recognition and removal of time dependent external field variations. Vector magnetic anomalies provide two distinct advantages over total field measurements. Although the total field anomalies are small (typically 50 nT) over most of the equatorial Pacific, the vertical and horizontal components of the anomalous field are 2-5 times larger. In addition, vector anomaly data can be used to evaluate the two dimensionality of the magnetic source since the along track and vertical anomalies are related by a 90° phase shift for a perfectly two dimensional source. To evaluate the advantages of these systems, we conducted a survey of the trails of the Galapagos triple junction using both a high resolution total field gradiometer and a vector magnetometer. The longitudinal gradiometer system consists of two Overhauser sensors (0.01 nT sensitivity) towed 350 and 450m behind the survey vessel. The towed vector magnetometer utilizes a commercial motion reference sensor (0.02° orientation accuracy with three fluxgate sensors) suitable for measuring horizontal and vertical anomalies as small as 30-50 nT. Vector anomalies across Cocos-Nazca crust corroborate the high degree of linearity of these E/W lineations; horizontal and vertical anomalies exhibit high coherence (>0.9) and the expected 90° phase relationship at wavelengths longer than 8km. Vector data from lower amplitude Pacific-Cocos and Pacific-Nazca lineations are more difficult to interpret, with lower coherence at somewhat longer wavelengths (>11km). The lower apparent degree of linearity over these N/S lineations in part reflects the much higher amplitude of any three dimensional sources. The combined use of vector and gradiometer measurements shows considerable promise for mapping magnetic lineations in low latitude regions.