Curie temperature when using temperature dependence of magnetic susceptibility for the Curie (Neel) temperature determination.

GP31B-0757 0830h POSTER

The Magnetics Information Consortium (MagIC)

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The Magnetics Information Consortium (MagIC) is a multi-user facility to establish and maintain a state-of-the-art relational database and digital archive for rock and paleomagnetic data. The goal of MagIC is to make such data generally available and to provide an information technology infrastructure for these and other research-oriented databases run by the international community. As its name implies, MagIC will not be restricted to paleomagnetic or rock magnetic data only, although MagIC will focus on these kinds of information during its setup phase. MagIC will be hosted under EarthRef.org at http://earthref.org/MAGIC/ where two "integrated" web portals will be developed, one for paleomagnetism (currently functional as a prototype that can be explored via the http://earthref.org/databases/PMAG/ link) and one for rock magnetism. The MagIC database will store all measurements and their derived properties for studies of paleomagnetic directions (inclination, declination) and their intensities, and for rock magnetic experiments (hysteresis, remanence, susceptibility, anisotropy). Ultimately, this database will allow researchers to study "on the internet" and to download important data sets that display paleo-secular variations in the intensity of the Earth's magnetic field over geological time, or that display magnetic data in typical Zijderveld, hysteresis/FORC and various magnetization/remanence diagrams. The MagIC database is completely integrated in the EarthRef.org relational database structure and thus benefits significantly from already-existing common database components, such as the EarthRef Reference Database (ERR) and Address Book (ERAB). The ERR allows researchers to find complete sets of literature resources as used in GERM (Geochemical Earth Reference Model), REM (Reference Earth Model) and MagIC. The ERAB contains addresses for all contributors to the EarthRef.org databases, and also for those who participated in data collection, archiving and analysis in the magnetic studies. Integration with these existing components will guarantee direct traceability to the original sources of the MagIC data and metadata. The MagIC database design focuses around the general workflow that results in the determination of typical paleomagnetic and rock magnetic analyses. This ensures that individual data points can be traced between the actual measurements and their associated specimen, sample, site, rock formation and locality. This permits a distinction between original and derived data, where the actual measurements are performed at the specimen level, and data at the sample level and higher are then derived products in the database. These relations will also allow recalculation of derived properties, such as site means, when new data becomes available for a specific locality. Data contribution to the MagIC database is critical in achieving a useful research tool. We have developed a standard data and metadata template that can be used to provide all data at the same time as publication. Software tools are provided to facilitate easy population of these templates. The tools allow for the import/export of data files in a delimited text format, and they provide some advanced functionality to validate data and to check internal coherence of the data in the template. During and after publication these standardized MagIC templates will be stored in the ERR database of EarthRef.org from where they can be downloaded at all times. Finally, the contents of these template files will be automatically parsed into the online relational database.

URL: http://earthref.org/MAGIC/

GP31C MCC: Level 2 Wednesday 0830h

Magnetic Petrology and Its Applications to Tectonics, Remote Sensing, and the Martian Climate Posters *(joint with P, T, V)*

Presiding: **T C Onstott,** Princeton University**; R A Duncan,** Oregon State University

GP31C-0758 0830h INVITED POSTER

The Paleomagnetic Effects of Reheating the Ecstall Pluton, British Columbia

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Current interpretations of paleomagnetic data of plutons from the western Canadian Cordillera vary from thousands of kilometers of cross-latitudinal transport, to in situ tilting, to post-intrusion folding. The Ecstall pluton of British Columbia is ilmenohematite-bearing, and it has a progressive steepening of inclination of magnetic remanence vectors from 16o to 81o [1] between 24 and 12 km west of a thermal boundary with the Coast Mountains batholith (CMB). The CMB was at 700-800oC between 60 and 52 Ma. Our heat flow calculations show that the thermal effects of the CMB on the adjacent 91 Ma Ecstall pluton were enough to reset the thermal chemical remanent magnetisation (TCRM), which occurs at less than 390oC [2]. Reheating to the temperatures necessary for TCRM is supported by K/Ar and Ar/Ar cooling dates on hornblende and biotite. Thus, the progressive shallowing of NRM vectors is attributed to reheating of the Ecstall pluton by the Coast Mountains batholith, following post-solidification cross-latitudinal transport of the pluton. Much of the controversy concerning the amount of translational displacement of the coastal terranes of British Columbia prior to 60 Ma hinges on the interpretation of discordant magnetizations from plutons that may have cooled slowly after emplacement in the mid to lower crust, as was the case for the Ecstall pluton. Many of these plutons contain ilmenohematite as an accessory magnetic phase. Our interpretation for the acquisition of NRM in the Ecstall pluton may have far-reaching implications for understanding of the enigmatic discordant paleomagnetic directions reported from plutons of the western Canadian Cordillera.

GP31C-0759 0830h POSTER

Low-Temperature Magnetometry of Synthetic Titanohematite (y = 0.7): A Way to Get Closer to Resolving the Mechanism of rTRM?

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Rob Hargraves once referred to self-reversed magnetizations as "skeletons in paleomagnetists' closets" and devoted part of his career to understanding this phenomena. He and colleagues (Lawson et al., Science, 213,1372-1374, 1981) were the first to observe by transmission electron microscopy (TEM) the cation ordered and disordered antiphase domains and boundaries in high titanium titanohematites (yFeTiO3·1-yFe2O3). But the mechanism enabling titanohematite to acquire a reversed thermoremanence (rTRM) remains to the present day somewhat elusive. Following the first observation of rTRM in natural rocks in the early 1950's, numerous models have been proposed for the reversal mechanism. Concepts common to all models are: 1) microstructurally, the grain is composed of at least one cation ordered and one cation disordered phase, 2) the phase superexchange coupled to the cation ordered domain generating the rTRM is more Fe-enriched and therefore has a higher blocking temperature than the cation ordered domain. The model dependent concept is whether the phase superexchange coupled to the cation ordered domain generating rTRM is cation ordered and ferrimagnetic (Ishikawa, J. Phys. Soc. Jap., 13(8), 828-837, 1958; Prévot et al., PEPI, 126, 75-92, 2001) or cation disordered and antiferromagnetic (AF) (Hoffman, JGR, 97(B7), 10883-10895, 1992; Nord and Lawson, JGR, 97(B7), 10897-10910, 1992). We attempt to provide experimental validation to these currently proposed models for rTRM by analyzing the magnetic behavior of synthetic titanohematite samples, y = 0.7 (Tc $\approx$ 330 K), that have been annealed and quenched at various temperatures above and below the cation disorder - order transition. Our preliminary results, from remanent and induced magnetization experiments in weak and strong fields and across the temperature range of 3 K to 400 K, clearly show that 370 K is a critical temperature, when approached from above, at which superexchange interactions with the ordered domains commences. Moreover, on cooling through 370 K, magnetic susceptibility increases one order of magnitude in a 30 K interval or less depending on the sample. The larger the cation ordered domains, the sharper and greater is the increase in magnetic susceptibility. The magnetic moment measured in a strong field from 10 K to 400 K linearly decreases by one order of magnitude in the temperature range of 10 K to 400 K, showing no break in the slope at 370 K. This suggests that a low value of the anisotropy energy in the cation ordered domains is associated with the onset of superexchange interactions and critical to the rTRM. The increase in coercivity of remanence, the shape of hysteresis loops and the low values of remanent magnetization and magnetic susceptibility above 370 K suggest that an AF phase with a small parasitic moment is superexchange coupled to the cation ordered domains. This is in greater agreement with the cation disordered AF models proposed by Hoffman, Nord and Lawson.

GP31C-0760 0830h POSTER

Paleomagnetism and Monazite Dating of Grenville Rocks, Adirondack Mountains, NY

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Paleomagnetic studies on three rock units from the Adirondack Highlands, New York State yield stable magnetic directions. Electron microprobe monazite geochronology suggests a strong ca. 1050 Ma signature, corresponding to Ottawan granulite-facies metamorphism. Remnants of older (ca. 1130-1190 Ma) monazite, consistent with early-Grenville tectonomagmatic events are also documented. There is no evidence of younger ($<$ 1050 Ma) events with the exception of partial alteration (with Ca-enrichment) of some monazite. Sillimanite-microcline gneisses (gms) of the far-western Highlands, associated with negative aeromagnetic anomalies, exhibit strong stable magnetization dominated by titanohematite with abundant exsolutions of ilmenite, pyrophanite, rutile and spinel. Mean magnetic directions for 14 sites are I-62.8, D=289.2 and a-95=7.6. Sampled in the central Highlands is the post-orogenic fayalite ferro-hedenbergite Wanakena Granite. Samples contain magnetite with ilmenite oxy-exsolution, occurring as discrete grains and inclusions in silicates. Directions from the Wanakena are steeply negative with westerly declinations (I=-76.4, D=296.7, a-95=4.4, N=7). The Marcy meta-anorthosite was sampled in the central and eastern Highlands, although many of these sites proved unstable. Stable results were combined with unpublished data from Rob Hargraves for 13 sites (I=-64.4, D=286.2, a-95=9.1). Over half of the anorthosites and one gms site have normal directions; all Wanakena sites are reversed. Combined anorthosites and gms units give a pole position of 20S/151E; the Wanakena pole is at -29S/132E. Both poles fall in the southern extent of the Grenville loop. The thermodynamically constrained equilibrium phase diagram for ilm-hem predicts that very fine exsolution, most likely responsible for the stable magnetization of the gms rocks, starts to form around 390C, well below the conditions of granulite grade metamorphism. The abundant lamellae provide a stable NRM through the formation of lamellar magnetism acquired at a late stage in the orogen. Using monazite ages for an upper limit and published age data for the Adirondacks produces a cooling curve yielding 920-900 Ma as time of magnetization acquisition for gms.

GP31C-0761 0830h POSTER

Transmission Electron Microscopy of the Magnetic Mineralogy of the Mt. Stuart Batholith: An Attempt to Better Elucidate the Origin of a Controversial Magnetization

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The mid-Cretaceous Mt. Stuart batholith, north Cascades of Washington, has been the focus of numerous paleomagnetic studies aimed at understanding the tectonic history of the pluton in the context of potential large-magnitude translation of part of the western borderland of North America. These studies have partly demonstrated the complexity of the magnetic mineralogy of the pluton and, in particular, the spatial distribution of different principal magnetization carriers. For example, pyrrhotite has been suggested as an important carrier of the remanence in the batholith (in the northern part of the pluton, a reverse polarity magnetization may be carried by pyrrhotite, implying magnetization considerably after emplacement). A more recent study reaffirms other early investigations that suggested that the remanence in much of the batholith is carried by single-domain magnetite and is of normal polarity, which is consistent with high temperature cooling of the intrusion at ca. 91 Ma. To better understand the carriers of the magnetization(s) characteristic of the pluton, we have inspected representative samples (from numerous sites), using transmission electron microscopy (JEOL 2010, 200 kV TEM with Oxford ISIS EDS). To date our work has concentrated on identifying and characterizing fine, sub-micron particles of magnetite in feldspars, principally plagioclase, in mineralogically fresh samples from the pluton. The paragenesis of pyrrhotite in the batholith, if indeed present, and the possibility that it is of secondary, low temperature origin, remains to be investigated.

GP31C-0762 0830h POSTER

Microstructural Study of Synthetic Sintered Diamond and Comparison with Carbonado, a Natural Polycrystalline Diamond

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The contributions that Rob Hargraves made to paleomagnetism spanned not only great distances (from the Earth to Mars) but a vast expanse in time. His interests in the magnetic character of the Archean Earth led him to compare magnetic polycrystalline diamonds (stewartites) with non-magnetic diamond composites (carbonados). Rob's ideas inspired our attempt to replicate carbonados by sintering diamond powders without metallic catalysts. These experiments employed a multi-anvil press operating at pressures of 6 to 9 GPa, temperatures of 1200°C to 1800°C, and times up to 6 hours. Transmission electron microscopy (TEM) showed that even in the absence of metals serving as solvent-catalysts, sintered compacts were successfully produced for all runs. In all of these compacts, aperiodic slip planes rigorously parallel to 111 consistently emerged in high densities, with lamellar spacings of 3 to 30 nm. In addition, polysynthetic spinel twinning in close association with the partial slip defects were observed in most of the compacts. Compacts compressed at 8 GPa produced some euhedral crystals with very low dislocation densities surrounded by grains in which dislocation densities were quite high. In addition, curviplanar defects loosely constrained to 111 were visible within some specimens sintered at the highest pressures. These textures resembled defect microstructures observed in natural carbonado (De et al. 1998), and the appearance of these features suggests that our experiments at their most extreme pressure and temperature parameters reproduced carbonado-like defect assemblages. The formation of such textures in quasi-hydrostatic experiments indicates that shock metamorphism is not required to produce the periodic defect lamellae observed in carbonado.

GP31C-0763 0830h POSTER

Back to Basics: Allard Lake to Mars

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Rob Hargraves worked on hemo-ilmenites from the Allard Lake area, Quebec for his Ph.D. thesis in 1959 and returned with great interest to these samples in relation to the concept of lamellar magnetism. Because the hemo-ilmenite ores produce large negative magnetic anomalies that can only be modeled with a significant remanent component, they are good analogs for the newly discovered Martian magnetic anomalies. The Allard Lake samples typically have high MDFs, above 100mT, however the hysteresis properties vary significantly with the presence or absence of magnetite. Ms values range from 620 to 23500 A/m, Hc from 3.7 to 169 mT, and Hcr values from 4 to 247 mT. The ratios of Mrs/Ms (0.062 to 0.842) and Hcr/Hc (1.1 to 11.5) reflect the mineralogy, and domain sizes of the exsolution lamellae. Some authors favored a magnetization carried by large multidomain lamellae of hematite, but failed to take the Ilm-Hem phase diagram into account properly. The first coarse generation of titanohematite lamellae, if not further exsolved, would be paramagnetic until appx. 300C. However with further exsolution of ilmenite lamellae, and a Ti-depleted hematite host, magnetic interactions develop at lamellar interfaces between CAF hematite and PM ilmenite, resulting in a chemical remanent magnetization (CRM) that we call lamellar magnetism. Thermoremanent magnetization (TRM) experiments made by Rob years earlier that showed the TRM to be far lower than the NRM, supporting a CRM mechanism, such as lamellar formation, for the NRM. Recent experiments with low-temperature demagnetization of the NRM and SIRM by cooling to 10 K or liquid nitrogen temperatures, and rewarming to room temperature in zero field, indicate a self-reversed magnetization at low temperatures. TEM images show exsolution lamellae down to the nanometer scale. Most small lamellae are fully coherent, which could enhance coercivity greatly. Rob's recent work with the concept of lamellar magnetism appears to provide the most accurate interpretation of the magnetization of the Allard Lake samples and also provides a candidate mineral for Martian magnetic anomalies.

GP31C-0764 0830h POSTER

Rob Hargraves and the External Force in Lamellar Magnetism

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The strong remanence and extreme coercivity of slowly cooled rocks rich in hemo-ilmenite or ilmeno-hematite, poor in or lacking magnetite, was recognized and puzzled over by Rob for 44 years and highlighted in recent studies. Together these are properties neither of paramagnetic (PM) ilmenite nor spin-canted antiferromagnetic (CAF) hematite. The minerals contain fine exsolution lamellae, now shown by TEM to go down to unit-cell scale, suggesting lamellar interfaces as the key. Atomic simulations of PM ilmenite lamellae in CAF hematite show formation of "contact layers" on (001) coherent interfaces that have a hybrid composition between hematite Fe^{3+} layers and ilmenite Fe^{2+} layers. These reduce interface charge imbalance, and, more important, have a magnetic moment coupled anti-parallel to but weaker than adjacent hematite layers. Each ilmenite lamella has an odd number of non-magnetic layers plus two contact layers coupled to hematite. The hematite host has an odd number of layers so magnetic moments of all but one cancel. This, combined with two opposite moments of contact layers (2MC-1MH), gives the moment of one lamella, about 4 Bohr magnetons. The maximum moment per formula unit is the moment per lamella times number of lamellae divided by formula units. One key to achieving a high moment is abundant lamellae. Rob's discussion of etched Allard Lake samples brought attention to the 3-phase cooling reaction in the ilmenite-hematite system, where R3c PM titanohematite transforms to about 20% PM R3 ilmenite and 80% CAF hematite, producing instantaneously the required coupled contact layers and a CRM. Lamellar yields up to 33% are obtained by undercooling below the 3-phase reaction, with eventual very fine nucleation. Long-term heating indicates major loss of the high-coercivity component due to lamellar resorption. A second key to strong remanence is that lamellae be magnetically "in-phase". This is optimized in crystals with (001) parallel to the external force of the magnetizing field during lamellar nucleation, and in nature by having (001) lattice-preferred orientations parallel to the field. Rob demonstrated this, using AMS of Allard Lake samples, where angle from the mean (001) to the Proterozoic magnetic vector is inversely related to intensity.

GP31C-0765 0830h POSTER

The Green Bar: a 2.8 Ga Ultramafic Exhalative or Impactite?

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Drill core samples of an anomalous shale layer in the 2.8 Ga Witwatersrand Supergroup, known as the Green Bar, were analyzed for PGE abundances to determine whether the layer may represent an Archean impactite. The Green Bar occurs in the lower part of the fluvial quartzites and conglomerates of the Johannesburg Subgroup of the Central Rand, approximately 1 to 2 meters above the Au-bearing Carbon Leader. It is comprised of 1 m of chloritoid-rich, laminated to massive siltstone that disconformably overlies a cross-bedded quartz arenite and is disconformably overlain by a cross-bedded quartz wacke. The Green Bar can be correlated over a distance of 10 km in the northern margin of the Witwatersrand basin. DeKock (1949) proposed that the Green Bar might be a volcanic tuff, perhaps not unlike the stratigraphically younger, chloritoid-rich, Bird Reef Marker, interpreted as a volcanic tuff associated with the Bird Amygdaloidal lava. PGE analyses of laminated and massive Green Bar samples yielded Ir concentrations ranging from 0.17 to 0.22 ppb. The concentrations of Ir, Ru, Rh, Pt, Pd and Au normalized to C1 chondrites are consistent with those of ultramafic rocks. The laminated facies exhibited some relative enrichment of Au that may be related to its mobilization during metamorphism. These data are more consistent with an ultramafic exhalative origin for the Green Bar. The presence of ultramafic eruptives during Witwatersrand deposition may also explain the origin of the detrital diamonds associated with some of the conglomerates. An impactite origin is not necessarily precluded by the PGE data if the impact occurred in ultramafic oceanic crust, but it does require some other evidence to support that case. DeKock, W.P. The Carbon Leader on the Far West Rand. Trans. Geol. Soc. S. Africa, 51, 1949.

GP31C-0766 0830h INVITED POSTER

Mantle Roll 30 Years After

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Rob Hargraves, in a pioneering paper published 30 years ago with Robert Duncan, suggested that the mantle has rolled about some independent axis within a lithospheric shell that as a whole is fixed with respect to Earth's spin axis. This work was one of the earliest attempts to use a reference frame based on mantle plumes to assess true polar wander. The status of mantle hotspots as a reference frame and evidence for true polar wander will be discussed on this occasion to honor the seminal contributions of Rob Hargraves.

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 nonharmonic 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.

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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.

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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