Early Cambrian (Nemakit-Daldynian) time. The intrusions represent the youngest known Iapetan rift-related magmatism for Laurentia, extending the period of final 'Iapetan' rifting magmatic activity to more than 80 myr. Characteristic paleomagnetic (reversed) directions from both intrusions are easterly and shallow, and the Mont Rigaud intrusion also carries some antipodal normal-polarity directions. The combined preliminary result from 12 sites places the Montreal region at 24° ± 8° S paleolatitude at 534 Ma, in good agreement with Middle and Late Cambrian paleomagnetic results from Laurentia. Laurentia likely resided at low southerly paleolatitudes throughout the Cambrian, ruling out a major inertial-interchange TPW event for Early to Middle Cambrian time. A comparison with Early to Middle Cambrian paleomagnetic results from Gondwana implies that by Early Cambrian time a large paleolatitudinal gap existed between the high latitude proto-Andean margin and its presumed conjugate rift margin Laurentia, likely corresponding to a wide Iapetus Ocean between them. The Late Neoproterozoic apparently rapid latitudinal motion of Laurentia from the south pole at 570 Ma to low paleolatitudes by 550-534 Ma remains enigmatic.

GP24A-04 1620h

An equatorial Laurentia at 550 Ma confirmed by Grenvillian inherited zircons dated by LAM ICP-MS in the Skinner Cove volcanics of western Newfoundland.

Joseph Hodych[1] (jhodych@mun.ca)

Richard Cox[1] (icpmslab@uvic.ca)

Jan Kosler[2] (kosler@natur.cuni.cz)

[1]Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NL A1B 3X5, Canada

[2]Department of Geochemistry, Charles University, Albertov 6, Prague 2 CZ-128 43, Czech Republic

Volcanics of the Skinner Cove Formation of western Newfoundland carry a primary remanence acquired at 550 Ma at a paleolatitude of 19°S. There has been doubt that this represents the latitude of the Laurentian margin at 550 Ma, because the Skinner Cove Formation is allochthonous. We present new evidence from inherited zircons in the volcanics that should remove this doubt. Zircon crystals extracted from an ankaramite flow and a trachyte flow were dated individually using a laser ablation microprobe (LAM) linked to an inductively-coupled-plasma mass spectrometer (ICP-MS). Most of the zircons from the ankaramite are concordant and yield a 550±5 Ma date indistinguishable from the 550+3/-2 Ma date previously reported using multi-grain thermal ionization mass spectrometry. About half of the zircons from the trachyte are also concordant yielding an overlapping date of 556±5 Ma. The other half cluster at ∼ 1000 Ma and at 1500-1600 Ma, which are characteristic ages of the Grenvillian basement exposed nearby in the Long Range Inlier. These zircon xenocrysts were very likely picked up as the Skinner Cove magma ascended through Grenvillian basement of the Laurentian margin. There can now be little doubt that the ∼19°S Skinner Cove paleolatitude represents Laurentia's southern margin at 550 Ma.

GP24A-05 1635h

Neoproterozoic Juvenile Crust Development in the Peri-Rodinian Ocean Coeval With Grenvillian Orogenesis: Accreted Terranes in Late Neoproterozoic Orogens

J. Brendan Murphy[1] (902-867-2481; bmurphy@stfx.ca)

R. Damian Nance[2] (740-593-1107; nance@ohio.edu)

J. Duncan Keppie[3] (55-5-622-4290; duncan@servidor.unam.mx)

Jarda Dostal[4] (902-420-5747; jarda.dostal@smu.ca)

[1]St. Francis Xavier University, Department of Earth Sciences, P.O. Box 5000, Antigonish, NS B2G 2W5, Canada

[2]Ohio University, Department of Geological Sciences, 316 Clippinger Laboratories, Athens, OH 45701, United States

[3]Universidad Nacional Autónoma de México, Instituto de Geología, México, D.F 04510, Mexico

[4]St. Mary's University, Department of Geology, Halifax, NS B3H 3C3, Canada

The supercontinent Rodinia is thought to have been formed by 1.2 to 1.0 Ga continent-continent collisions and to have dispersed between 0.75 and 0.6 Ga. The existence of Rodinia implies the presence of a Panthalassa-like peri-Rodinian ocean between ca. 1.0-0.75 Ga within which juvenile crust developed. Although the vast majority of this crust was later subducted, vestiges are preserved in terranes that accreted to the leading edges of the dispersing continents following the breakup of Rodinia. These terranes are recognized by their ca. 1.2 to 0.75 Ga Sm-Nd T(DM) model ages, coeval with the life of Rodinia. They include ca. 0.9 to 0.8 Ga ophiolites and ensimatic arc complexes, and ca. 0.8 to 0.6 Ga recycled mafic to felsic arc complexes. Formed within the peri-Rodinian ocean, these terranes were accreted to their respective continental margins in the Late Neoproterozoic. For orogens in which subduction culminated in Late Neoproterozoic continental collision (e.g., Southern Yangste margin, Brasiliano, Trans-Saharan), vestiges of peri-Rodinian crust became cratonized within the suture zones between the colliding cratons. In accretionary orogens, in which subduction was not terminated by continental collision (e.g., Arabian Shield, peri-Gondwana), terranes were subsequently involved in Paleozoic orogenesis. More generally, crustal formation in Panthalassa-type oceans and the subsequent recycling of this crust can be recognized by Sm-Nd depleted mantle (TDM) model ages that overlap with the life-span of the supercontinent.

GP24A-06 1650h INVITED

Geochronological Constraints on Neoproterozoic Glaciations, the first appearance of Metazoans, and the Cambrian Explosion.

Samuel Bowring[1] (617 253 3775; sbowring@mit.edu)

Dan Condon[1] (617 2532505; dcondon@mit.edu)

Jahandar Ramezani[1] (617 2531384; ramezani@mit.edu)

Paul Myrow[2] (pmyrow@coloradocollege.edu)

Ed Landing[3] (elanding@mail.nysed.gov)

[1]Massachusetts Institute of Technology, Department of Earth, Atmospheric and Planetary Sciences, 77 Massachusetts Ave, Cambridge, MA 02139, United States

[2]Colorado College, Department of Geology, Colorado Springs, CO 80903, United States

[3]New york State Museum, State Education Department, Albany, NY 12230, United States

Studies of Neoproterozoic climate fluctuations, plate reconstructions, biological evolution and their interrelationships have been hindered by a lack of high-precision geochronological constraints. The correlation and estimates of duration for Neoproterozoic glaciations has relied on physical/chemo-stratigraphy, and thermal subsidence models respectively. New geochronological constraints from Neoproterozoic successions worldwide have sharpened the debate as to the number, synchroneity, and duration of glacial episodes and the relationship, if any, between Metazoan evolution and global glaciation(s). Crucial to the debate are correct interpretation of geochronological data that range from U-Pb zircon studies of intercalated volcanic ash-beds, U-Pb detrital zircon studies, Re-Os from black shales, Rb-Sr from clay-rich rocks, U-Pb and Pb-Pb from carbonates and phosphates, and Lu-Hf from phosphates. Development of a highly resolved Neoproterozoic timescale will require integration and cross-calibration of multiple dating techniques and consideration of what is actually being recorded by each chronometer. A review of available geological and geochronological data indicate that there were at least three and perhaps as many as five periods of Neoproterozoic glacial deposition including rocks from United States (Idaho and Virginia), Newfoundland and the Northwest Territories of Canada, Namibia, and Oman. What must be evaluated is how the paleogeographic distribution of glaciated regions varied with time during the Neoproterozoic. Do Neoproterozoic glacial successions distributed worldwide record a small number of globally synchronous, long-lived glaciations, or numerous diachronous glacial epochs, or a combination of both? At present, the duration of only one glacial deposit, the ca 581 Ma Gaskiers Formation (Newfoundland), is known and it is on the order of 1 Ma, at odds with a long-lived global glaciation predicted by the snowball Earth hypothesis. Other major issues are the timing of the first appearance of animal fossils (south China and Newfoundland) relative to the last global glaciation and whether a major extinction occurred at the Cambrian/Precambrian boundary. These important issues will only be resolved by the integration of high-resolution geochronology and stratigraphy.

GP31A CC: 220 C-E Wednesday 0830h

Geomagnetism and Paleomagnetism General Contributions Posters *(joint with T, V, NS)*

Presiding: **K P Kodama,** Lehigh University**; M A Hamilton,** University of Toronto

GP31A-01 0830h POSTER

MAGNETIC MODEL TRAP FORMATION OF VOLYN

Mykola V. Yusypiv (+380 (44) 424-2452; yusypivm@igph.kiev.ua)

Institute of Geophysics, NAS of Ukraine, 32 Palladin Avenue, Kiev 03142, Ukraine

Abstract In the article technique of magnetic modelling trap formation of Volyn (north-west Ukraine) is considered. It is investigated magnetic properties of rock trap formation, anomalous magnetic field and connection of these parameters with a technique of maning model. The model of a magnetic field was made. The comparative analysis with others trap formations of the world was carried out. Introduction Study of trap magnetism constantly attracts attention of geoscientists throughout the world and may be determined, on the one hand, by connection of a number of important mineral products (copper-nickel, iron and other ores) with trap formations, and on the other hand, has a great importance for solution of general and vital theoretical problems of geosciences.The works of the last ten years' [1-3] study of trap magnetic parameters make it possible to obtain information of magnetism age, geological structure of the territory. Investigations related to making of trap models are of great interest. Making of Volyn region trap formation magnetic model Model 1. The lower limitation is an upper reflection of a ground M. Magnetization of a basalt layer is changed laterally from 1,0 SI units to 5,5 SI units. The field selected in that way is different from the initial field to 30-40 nTl that can be sufficient for modelling of a regional field. Model 2. The lower limitation of a magnetoactive layer is a lower reflection of the M limit. In this case the changes of a lateral magnetization were received from 1,0 to 4,5 SI units. Conclusion. The approach of a model making proved a true possibility for use of a magnetic field not only for traditional study of a near-surface but also deep zones of the earth's crust in conditions of platform areas, zones of spreading of trap formations. The evaluation of contribution of the upper part of the earth's crust to the anomalous field made it possible to mark a regional component of the field by geotraverse II related to the deep parts of the earth's crust. References. 1. Glevasskaya A., Kravchenko S., Mikhaylova N. Vendian geomagnetic poles of East-European platform (EEP) based on paleomagnetic studies of West-Ukrainian sections. JAGA Abstr. boocs. Sec. 1.11. - Upsala, 1997. - P.59 2. Yusypiv M. To creation of magnetic model of trap formation of Volyn. International Geophysical Conference "Geophysics of the XXI Century - Leap into the Future" .Abstr. boocs. Sec. OS 9. - Moscow, 2003 3. Yusypiv M. Features of the magnetic properties of trap formation Volyn in connection with construction of their magnetic model. IV International Geological-Geophysical scientific and technical conference of young scientists and specialist. Abstr. boocs. - Sankt-Petersburg, 2003. - P. 229

GP31A-02 0830h POSTER

Quipus and System of Coordinated Precession

Teodosio Chavez Campos[1] (0511-2250520; tchavez@uni.edu.pe)

Israel Chavez Sumarriva (0511-4764714; tchavez@uni.edu.pe)

[1]Teodosio Chavez Campos, Av. Pablo Carriquiry 451 Lima-27, Lima 0511, Peru

The Incas of ancient Peru possessed no writing. Instead, they developed a unique system expressed on spatial arrays of colored knotted cords called Quipus to record and transmit information throughout their vast empire. In their thorough description of quipus, Ascher & Ascher observed that in two cases the numbers registered in their strings have a very special relationship to each other. For this to occur the numbers must have been obtained through the multiplication of whole numbers by fractions or decimals, operations apparently beyond the arithmetic knowledge of the Incas. The quipus AS120 and AS143, coming from Ica (Peru) and conserved in the Museum of Berlin has the suitable characteristics previously. In the AS143 there is a the relationship with the systems of coordinated precession (tilt of Earth's spin axis (40036); eccentricity of Earth's

orbit (97357); and precession of equinoxes (between 18504 and 23098)). For the history of the Earth are necessary an chronometer natural to coordinate and to classify the observations and this chronometer comes to be the vernal point, defining the vernal point as" a sensitive axis of maximum conductivity" as itdemonstrates it the stability of the geomagnetic equator (inclination of the field is zero grades), in the year 1939 calculated with the IGRF from the year 1900 up to the 2004 and that it is confirmed with tabulated data of the Geophysical Institute of Huancayo (Peru),from that date until this year (2004) and this fluctuating between the 12-14 South.,on the other hand in the area of Brazil it has advanced very quickly toward the north, and above to 108 km. approximately it is located the equatorial electrojet that is but intense in the equinoxes in South America. And this stability from the point of view of the precession of the equinoxes this coinciding with the entrance of the apparent sun for the constellation of Aquarius, being this mechanism the base to establish a system of coordinated precession where it is also considered tilt of Earth's spin axis; eccentricity of Earth's orbit; and precession of equinoxes:Together these, yield a complex curve for the solar cónstant at different latitudes,as first suggested by Croll(1875) y Milankovitch (1920, 1930), Zeuner (e. g. 1945), and other.

GP31A-03 0830h POSTER

Magneto-Petrological Database of Mexican Host Rocks and Fe-Ore Minerals: Geophysical and Genetic Implications

Luis M. Alva-Valdivia[1] (52-55-56224237; lalva@geofisica.unam.mx)

Jaime H. Urrutia[1] (52-55-56224122; juf@geofisica.unam.mx)

Avto Goguitchaichvili[1] (52-55-56224230; avto@geofisica.unam.mx)

[1]Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Av. Universidad 3000 Instituto de Geofisica, UNAM Copilco, Mexico, DF 04510, Mexico

We present a detailed magneto-petrological database from the major Mexican Fe iron-ore deposits. Intensity and direction of the natural remanent magnetization and magnetic susceptibility values are used to constraint the magnetic anomaly interpretation. This will largely reduce the uncertainty implicit in the magnetic processing, resulting in a more realistic interpretation of the proposed bodies since the geological point of view. Several techniques to observe the opaque minerals directly were used: microscopy, microprobe, magnetic force microscopy and Mössbauer spectroscopy. Results of these observations together with rock magnetic properties and magnetic anomaly interpretation were used to propose hypothesis about the possible origin of each Mexican Fe-ore deposit studied.

URL: http://www.agu.org

GP31A-04 0830h POSTER

Magneto-Mineralogical and Physico-Chemical Characterization of the Peña Colorada Iron-Ore, México: Genetic Implications

Maria Luz Rivas[1] (52-55-56224235; mlrivas@geofisica.unam.mx)

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

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

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

[1]Instituode Geofisica, UNAM, Av. Universidad 3000 Copilco, Mexico, DF 04510, Mexico

Peña Colorada iron-ores represented by massive-disseminated ore and intergranular magnetite ore. Mössbauer spectroscopy shows differences in both magnetite-ores. Magnetite of massive-disseminated ore has a stable structure, with Fe in oxidation state III (Fe2O3) and Fe in oxidation state II (FeO). Magnetite of intergranular ore has a micro-margin of replacement with particular properties, because have radicals (OH-) in positions corresponding to oxygen, shifting alternatively Fe II by Fe III. Chlorite associated to intergranular magnetite is classified as chamosite (berthierine variety). Berthierine presents structural differences by X-ray diffraction at 550 oC temperature loosing its cristallinity becoming amorphous. Differential and gravimetric thermal analyses of berthierine show typical endo-thermal reactions at 430 oC and 510 oC by dehydratation, and endo-thermal reaction at 980 oC by structural change. We propose contact metamorphism and a hydrothermal phase, pursued by disseminated-massive magnetite deposition as the main processes acting in the formation of the Peña Colorada iron-ore deposit. Intergranular ore is sedimentary exhalative origin deposited together with berthierine. Massive-disseminated and intergranular ore have similar geochemical evolution and different conditions of deposit. Curie temperatures are mostly 580 $\pm$ 5°C typical of magnetite. Hysteresis parameters indicate that most samples present PSD to MD behavior. AF demagnetization and isothermal remanent magnetization (IRM) acquisition curves show that NRM and laboratory remanence are carried by MD magnetite in iron ores and PSD-SD magnetite in host rocks. Magnetic Force Microscope images for both ore minerals show good and diffuse magnetic domain definition, respectively. Lack of clarity of the intergranular ore image is due to environment, temperature and formation conditions related to magnetostatic changes and magnetocrystalline anisotropy of grains.

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GP31A-05 0830h POSTER

Age of Tectonic Brecciation and MVT Mineralization in the Pillara Zn-Pb Deposit, Lennard Shelf, Western Australia

David T.A. Symons[1] (519-253-3000 x2493; dsymons@uwindsor.ca)

Dennis C. Arne[2] (dennis.arne@bigpond.com)

[1]Department of Earth Sciences, University of Windsor, Windsor, ON N9B 3P4, Canada

[2]Western Australian School of Mines, Curtin University of Technology, Kalgoorlie, WA 6433, Australia

Pillara is the largest of several known Mississippi Valley-type (MVT) deposits on the Lennard Shelf. Paleomagnetic data from 294 specimens from 23 sites in the mine have yielded a characteristic remanent magnetization (ChRM) direction of D= 20.6°, I= $-$27.5° (N= 23, α95= 5.3°, k= 34.1). Thermal step demagnetization and isothermal remanence analyses show: 1) that the ChRM is carried mostly by single to pseudosingle domain pyrrhotite; and, 2) using artificial specimens of Zn and Pb concentrates and of tailings mixed with a ceramic matrix, that the pyrrhotite is carried by sphalerite and galena and not by the gangue minerals. The ChRM's pole position gives an age of 358 $\pm$ 5 Ma, which agrees with previously published Rb-Sr sphalerite, U-Pb ore-stage calcite, and paleomagnetic ages for Lennard Shelf deposits. Separation of ore and barren wall rock ChRM directions, combined with a negative paleomagnetic breccia test on tectonic clasts, indicates that the faulting that created the breccias predated the mineralization event by $\sim$5 Ma.

GP31A-06 0830h POSTER

Paleomagnetic dating of kimberlites: Siberian essay

Vadim A Kravchinsky[1] (+1-(780) 492-5591; vkrav@phys.ualberta.ca)

Konstantin Kabin[1] (kabin@phys.ualberta.ca)

Konstantin M Konstantinov[2] (ubinin@mail.ru)

Jams I Savrasov[3] (museum@alrosa-mir.ru)

[1]Physics Department, University of Alberta, Edmonton, AB T6G 2J1, Canada

[2]Amakinskaya Expedition, ALROSA, Aikhal 678190, Russian Federation

[3]Botuobinskaya Expedition, ALROSA, Mirniy 678170, Russian Federation

We studied diamond bearing Udachnaya, International and Obnazhennaya kimberlite pipes from Siberian platform. Absolute dating for the kimberlites is quite scattered in the area and gives very wide age intervals. We began with reanalyzing of the available paleomagnetic poles from the database to compose up-to-date Apparent Polar Wander Path (APWP) of the Siberian platform for Paleozoic and Mesozoic. New paleomagnetic poles calculated for kimberlites as well as host sediments and sediments from the baked contact zone are statistically different from each other and compared with the APWP of Siberia. On a basis of this comparison we estimated age of the kimberlite magmatism with primary magnetization and age of possible remagnetization events. The distances between the analyzed pole and every point of the APWP have been calculated in order to find the best fitting distance and determine the age. An accuracy of the dating was estimated. Main kimberlite events took place in Middle Paleozoic (Western and Eastern Udachnaya pipes) but there are also Middle Mesozoic kimberlites (Obnazhennaya pipe). The pipes of Malo-Botuoba field (International and earlier studied Mir pipes) were likely remagnetized by Permo-Triassic flood basalts (Siberian traps) about 245 Ma.

GP31A-07 0830h POSTER

Paleomagnetism of the Weaubleau-Osceola impact structure, SW Missouri

Shannon A Dulin[1] (405-325-3253; sdulin@cox.net); Kathryn B Gardner[1] (405-325-3253; kyanitekat@ou.edu); Richard Douglas Elmore[1] (405-325-3221; delmore@ou.edu); L. A. Totten[1]; Kevin R. Evans[2]; J. F. Miller[2]; C. W. Rovey[2]

[1]School of Geology and Geophysics, 100 E. Boyd St. University of Oklahoma, Norman, OK 73019, United States

[2]Dept. of Geography, Geology and Planning, SW Missouri State University, Springfield, MO 56804, United States

The Weaubleau-Osceola impact structure consists of a 19-km circular feature that contains deformed Mississippian limestones and a fall-back breccia. The age of the structure is stratigraphically constrained between deposition of the deformed Osagean limestones and the overlying undeformed Pennsylvanian (Desmoinesian) Cherokee Group sandstones. Paleomagnetic samples were collected from the tilted Burlington-Keokuk formations inside the structure, the fall-back breccia, and the undeformed Burlington-Keokuk outcrops from well outside of the structure. Stepwise thermal and alternating field (AF) demagnetization of tilted limestone samples reveals a magnetization with southeasterly declinations and shallow to moderate positive inclinations that has median destructive field of 20-30 mT and maximum unblocking temperatures of 450^{o}C. The magnetization is post folding, and the pole falls very close to 309-365 Ma mean pole on the apparent polar wonder path. The AF treatment of the fall-back breccia removes a weak southeasterly and shallow component similar to that in the limestones. Subsequent thermal demagnetization removes an apparently Modern component that resides in hematite. The undeformed limestones contain a Modern component residing in magnetite. The magnetization in the deformed limestones is interpreted to reside in magnetite. Because the magnetization is post-deformational, it is likely not a shock magnetization and is tentatively interpreted to be related to thermo-chemical processes such the action of hydrothermal fluids or other diagenetic processes associated with the impact. We are currently conducting studies to determine the mechanism of remagnetization, whether the magnetization is localized in the impact structure, and if it can be distinguished from the widespread Late Paleozoic chemical remanent magnetization that is found in many Paleozoic limestone units.

GP31A-08 0830h POSTER

Chicxulub's Cretaceous-Tertiary Boundary Twin Crater. Was There a Double Impact in the Yucatan Peninsula?

Antonio Z. Camargo[1] ((52) 228-8135757; ancamazn@xal.megared.net.mx)

Julian S. Juarez[2] ((52) 993-3155563; jjuarez@pep.pemex.com)

[1]Petroleos Mexicanos (Retired), Mendelssohn 29, Indeco-Animas, Xalapa, Ver 91190, Mexico

[2]Petroleos Mexicanos, Cerrada R. Priego 6,Col. P. Elias Calles, Villahermosa, Tab 86190, Mexico

In 1980, Alvarez and co-authors proposed that the K/T extinctions were caused by the effects of a celestial body falling on Earth. After a long search for the impact site, the 1981 work by Penfield and Camargo on a 170 km structure in the Yucatan Peninsula got the attention of the specialists, and it was later proved that it was the crater created by the impact of that celestial body. New data suggests the existence of a second impact crater close to Chicxulub, both being of the same age and created by two fragments of the same celestial boby. A new magnetic map plotted as a color-coded shaded relief surface, reveals a feature not evident before: two interlaced ringed anomalies of about 100 and 50 km diameters, the larger one related to the magnetic signature of the Chicxulub Crater, and the second located at its E-SE edge. The 50 km anomaly, with morphology similar to Chicxulub's, is interpreted as also corresponding to an impact crater, centered at about 89 Deg. Long. W and 21 Deg. Lat. N, close to the city of Izamal. The anomaly size indicates that the diameter of the IZAMAL CRATER is about 85 km. The Chicxulub Crater, being buried under several hundred meters of Tertiary carbonate rocks, is not visible from the surface or from space; although some surface expression of its morphology has been reported. The best known is the ring of cenotes (sink holes) at the crater's rim, visible on satellite images and photographs. The JPL/NASA image PIA03379, is a color-coded shaded relief image of terrain elevation in which the topography was exagerated to highlight the Chicxulub Crater rim. On this image, a semi circular arc of dark spots

is also visible immediately to the E-SE of the Chicxulub Crater rim. These spots are interpreted as large irregular karstic depressions, similar to the ones along the cenote ring of Chicxulub. On the evidence of the spatial relationship of the magnetic anomalies and the satellite image features, we tested how well the proposed Izamal Crater would fit the karstic depressions E-SE of the Chicxulub crater. We found that an 82 km diameter circle fits well the semi circle of dark spots, and interpret it as a portion of the rim of the IZAMAL impact crater. The interpreted relationships and origin of the Chicxulub and Izamal craters are: The Chicxulub crater was created after Izamal. They were created by two different impact bodies. The craters are of the same age. They were formed by two parts of the same celestial body, the MAYA BOLIDE. The diameter of the fragment impacted in Izamal is estimated to be about 4 km. This finding has implications on studies related to the K/T extinction event. Some scientists argue that the Chicxulub crater is somewhat small to account for the global K/T extinction all by itself. The double impact may account for the observed effects. Also, multiple impacts at sea may have put into the atmosphere much more sea water salts capable of dissociating into damaging chlorine compounds. Furthermore, the impact sequence may help explain the origin of the K/T boundary glasses from Haiti and better define the ballistic trajectories of the impacts ejecta and its effects on the extinctions. And the Maya Bolide orbit can be investigated to define its origin and characteristics as a comet or asteroid.

GP31A-09 0830h POSTER

An Investigation of Thermal Heating Effects on Magnetic Fabrics

Yongxiang Li[1] (yol5@lehigh.edu)

Kenneth P. Kodama[1] (kpk0@lehigh.edu)

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

Magnetic fabrics have been widely used to characterize petrofabrics of rocks and provide unique constraints on interpretations of sedimentation/compaction, paleocurrents, stress/strain state, and magmatic flow patterns. Oblate fabrics, characterized by the minimum axis perpendicular to the bedding, is typically formed during depositional and/or compactional processes, and the presence of oblate fabrics is often used as an indicator of depositional remanence. However, the oblate fabrics alone may not always warrant a primary remanence for rocks that are suspected to have undergone thermal heating after their formation. Both synthetic and natural samples were measured to determine whether the oblate fabrics uniquely indicate a depositional/compactional remanence. Synthetic samples, a mixture of magnetite particles and non-magnetic cement, were first compacted to generate oblate fabrics. After the anisotropy of magnetic susceptibility (AMS) and anisotropy of anhysteretic remanence (AAR) were measured, the laboratory compacted synthetic samples were then heated up to 600°C for one hour and cooled in a 50 microtesla field, emulating a thermal remagnetization. Following the thermal treatment samples were measured for AMS and AAR to examine if the magnetic fabrics have been altered during the heating process. Comparison of magnetic fabrics of samples before and after being heated indicates that although the intensities of AMS and AAR were reduced during heating, the oblate fabrics of AMS and AAR were retained. Baked sedimentary rocks near a diabase intrusion in the southeastern Newark Basin in Pennsylvania were collected, and their AMS and AAR fabrics were measured. These rocks are known to have undergone thermal alterations (Kodama et al., 1994). The AMS data of these rocks show complex fabrics, probably due to mineral transformations during heating. The AAR results indicate well-clustered principal axes with predominately oblate fabrics. Both synthetic and natural samples exhibit oblate fabrics of AAR, suggesting that depositional fabrics could survive through a thermal remagnetization.

GP31A-10 0830h POSTER

New Early Triassic Paleomagnetic Data from the Yangtze Fold Belt, South China, Suggest Large Clockwise Rotation Caused by Continental Collision Between the North and South China Blocks

Xiaodong Tan[1] (86-20-89023113; xdtan@scsio.ac.cn)

Zhenyu Yang[2]

Bin Wang[2]

Stuart Gilder[3]

Vincent Courtillot[3]

[1]Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology and Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, 164 West Xin Gang Road, Guangzhou 510301, China

[2]Department of Earth Sciences, Nanjing University, 22 Hankou Road, Nanjing 210093, China

[3]Institut de Physique du Globe de Paris, Laboratoir de Paléomagnétisme, 4 place Jussieu,, Paris 75252, France

The Yangtze Mesozoic fold belt shows systematic variations in the fold axis strikes. Published paleomagnetic data have led to controversial interpretations for the changes of fold axis trends. To better understand the deformation mechanisms of the fold belt, we collected 39 block hand samples from four limbs of the East-West trending folds in the eastern middle Yangtze fold belt about 200 km southwest of the indenter corner of the North China Block (NCB). A total of 117 specimens were prepared for systematic thermal demagnetizations. The natural remanent magnetization (NRM) is composed of at least two components. Low unblocking temperature component is distributed around the recent field directions. In half of the specimens, the NRM is dominated by the recent overprint component and more ancient component cannot be revealed. In the other specimens, characteristic remanent components (ChRM) and/or great circles were found at temperatures between 360° and 520°C. The ChRMs are clustered in two groups. Group A is distributed at Dec= 59°, Inc=-9°, α_{95}=24°, κ=10 (n=6), in situ, and Dec= 82°, Inc=24°, α_{95}=7°, κ=124,after tilt-correction. The mean direction of group B is at Dec= 131°, Inc=4°, α_{95}=16°, κ=4 (n=26), in situ, and Dec= 133°, Inc=18°, α_{95}=5°, κ=38,after tilt-correction. Both directions pass fold tests, and their mean inclinations are consistent with published results. The declinations show large clockwise rotation compared with the Early Triassic reference direction of the South China Block (SCB). Our new data may suggest a multiple rotational deformation pattern of the fold belt, which can be explained by the well-known scissors-style collision between the NCB and SCB and indentation of the NCB.

GP31A-11 0830h POSTER

Rock Magnetic Evidence for Inclination Shallowing in the Passaic Formation Red Beds from the Newark Basin and a Systematic Bias of Late Triassic Apparent Polar Wander Path for North America

Xiaodong Tan[1] (xdtan@scsio.ac.cn)

Kenneth Kodama[2] (kpk0@lehigh.edu)

Stuart Gilder[3] (gilder@ipgp.jussieu.fr)

Vincent Courtillot[3] (courtil@ipgp.jussieu.fr)

[1]Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology and Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Key Laboratory of Marginal Sea Geology, South China Sea Institute of Oceanology and Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510301, China

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

[3]Institut de Physique du Globe de Paris, Laboratoir de Paleomagmetisme, 4 place Jussieu, Paris 75252, France

The latest Triassic and earliest Jurassic red beds from the Newark basin showed paleomagnetic inclinations $\sim$10° shallower than the inclination carried by the nearly coeval volcanic rocks. It has been suggested that the difference might be due either to inclination shallowing of the sediments or to remagnetization of the volcanic rocks during a Middle Jurassic hydrothermal event; these two explanations would in turn yield dramatically different apparent polar wander (APW) paths for the Late Triassic and Early Jurassic. Therefore it is important to test these two models. Here we present magnetic anisotropy data for the latest Triassic Passaic Formation red beds, which showed depositional and/or compaction fabrics with 10% anisotropy of high unblocking temperature isothermal remanent magnetization. Inclination correction for the red beds yielded similar directions to that carried by the Earliest Jurassic volcanic rocks, indicating that inclination shallowing is the major cause for the paleomagnetic pole difference between the red beds and volcanic rocks. Comparison of the inclination corrected data with Late Triassic North America APW path showed a systematic error in the APW path caused by inclination shallowing. This error may be more significant in much of the Paleozoic APW path for North America.

GP31A-12 0830h POSTER

New Paleomagnetic Results and Inclination Correction for the Carboniferous Conemaugh Group rocks, Southwestern Pennsylvania

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

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

In order to check the inclination correction of the Carboniferous Mauch Chunk Formation red beds made by Tan and Kodama [2002], the Carboniferous Buffalo Siltstone and Brush Creek Limestone (Conemaugh Group) from southwestern Pennsylvania were sampled so that an inclination correction could be applied to these magnetite-bearing rocks. Paleopoles from the Buffalo Siltstone (BS) and Brush Creek Limestone (BCL) were previously reported by Payne et al. [1981]. Twenty-eight oriented hand samples were collected from 5 of Payne et al.'s 6 sites, predominately from clastic lithologies. A combination of low temperature thermal demagnetization (up to 200°C) followed by alternating field demagnetization (up to 50 mT) allowed characteristic remanences to be isolated in a majority of the samples. A mean direction for 21 samples from 5 sites of D=170.9°, I=23.4°, K=14.0 yielded an uncorrected paleopole at 36.6°N, 111.1°E, closer to the BCL paleopole (36.1°N, 124.3°E) than the BS paleopole (27.4°N, 123.0°E) of Payne et al. In order to make the inclination correction using the anisotropy of anhysteretic remanence (AAR) of the samples, we estimated the individual particle anisotropy (a), by fitting corrected directions to theoretical correction curves as a function of individual particle anisotropy. The best fit suggests an individual particle anisotropy (a value) of about 1.5 should be used; however, the corrected directions have a strongly elliptical distribution. Assuming that a circular distribution of directions would be closer to that caused by random errors in measurement and orientation, a correction using a=2 was made because it gives both an acceptable fit to the theoretical correction curves and a circular directional distribution. The mean corrected direction of D=173.5°, I=42.0° yields a corrected paleopole at 25°N, 106.5°E which agrees remarkably well with a corrected Mauch Chunk Formation paleopole at 26.3°N, 111.2°E. This corrected Mauch Chunk paleopole is different from that reported by Tan and Kodama [2002] since the added constraint of a circular directional distribution indicates that a=1.09, instead of a=1.06, should be used for the Mauch Chunk correction. These corrected paleopoles also agree reasonably well with a preliminary inclination-corrected paleopole (21.6°N, 117.0°E) for the Carboniferous red beds of the Maringouin Formation of New Brunswick, Canada reported at this meeting [Newton and Kodama, 2004]. These results help to validate the inclination correction techniques applied to continental red sedimentary rocks and suggest that this portion of the North American apparent polar wander path should be re-examined, since it is heavily dependent on red bed-based paleopoles.

GP31A-13 0830h POSTER

A Paleomagnetic and Magnetic Anisotropy Study of the Carboniferous Maringouin Formation , New Brunswick, Canada: Possible Evidence for Inclination Shallowing in Continental Red Beds

Michael L. Newton[1] (610-758-3213; mln3@lehigh.edu)

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

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

Continental red sedimentary rocks have stable paleomagnetic signals and have been used extensively to delineate the apparent polar wander path of North America in the Paleozoic. Previous paleomagnetic and rock magnetic work on the Mississippian Mauch Chunk Formation red beds from northeastern Pennsylvania suggests that these rocks have suffered from significant inclination shallowing. The corrected paleopole for the Mauch Chunk lies far from the Carboniferous part of the current North American apparent polar wander path [Tan and Kodama, 2002]. In order to check the validity of this new paleopole for the Mauch Chunk and the prevalence of inclination shallowing in red beds, we conducted a paleomagnetic and magnetic anisotropy study of the coeval, Carboniferous age Maringouin Formation from New Brunswick, Canada. One hundred oriented samples were collected from 11 sites in the Maringouin Formation on the Maringouin Peninsula, New Brunswick. Eight sites were sampled from sea cliffs exposing the south limb of an east-west trending anticline and 3 sites were sampled from the north limb of the fold. Thermal demagnetization was conducted on 5 samples from each site in at least 13 steps up to 675°C. Preliminary thermal demagnetization results

from four sites from the south limb of the fold isolated a mean direction (D=177.4°, I=22.0°, K=8.5) similar to that found in an earlier study of the Maringouin Formation [DiVenere and Opdyke, 1990]. Chemical demagnetization in 3M HCl for up to 6 weeks was also used to isolate the characteristic remanence (ChRM) from 4 samples from each site. Anisotropy of magnetic susceptibility (AMS) was measured at each chemical demagnetization step to determine the AMS of the grains carrying the ChRM. Preliminary results from 3 sites indicate a shallower ChRM was isolated by chemical demagnetization (D=181.2°, I=2.6°, K=13.3), than by thermal demagnetization. The AMS data from 4 sites were used to make a correction for inclination shallowing as proposed by Tan and Kodama [2002] in their work on the Mauch Chunk Formation in Pennsylvania. The thermal demagnetization results from these sites were corrected by the AMS isolated between 3 and 6 weeks of chemical demagnetization. The results from the Maringouin Formation show a 22° steepening of the inclination once it is corrected for shallowing. The corrected paleopole for the Maringouin Formation lies at lat=21.6°N, long=117.0°E, α_{95}=29.9° which is within 13° of the corrected Mauch Chunk paleopole of Tan and Kodama [2002]. It is also reasonably close to a new, inclination-corrected paleopole from the Carboniferous magnetite-bearing Conemaugh Group sedimentary rocks of southwestern Pennsylvaniva (25°N, 106.5°E) [Kodama, 2004]. These results support the need for an inclination shallowing correction on continental red beds. They also may suggest that the North American apparent polar wander path, where it is heavily dependent on red bed-based paleomagnetic data, needs to be re-evaluated.

GP31A-14 0830h POSTER

Paleomagnetism, Geochronology, and Magnetic Mineralogy of Pleistocene Igneous Rocks, Ascension Island, South Atlantic Ocean

Michael J Valentine[1] (253-879-3129; mvalentine@ups.edu); Anna Burke[1] (253-879-3129; banannaburke@hotmail.com); John Devine[1] (253-879-3129; jdevine@ups.edu); Bradley S Singer[2] (608-265-8650; bsinger@geology.wisc.edu); Brian Jicha[2] (608-262-4927); Stephen W Field[3] (254-968-9887; field@tarleton.edu); M. Lee Allison[4] (785-864-3965; lallison@kgs.ukans.edu); Andrew Caruthers[1] (cherylthecat@yahoo.com)

[1]University of Puget Sound, Geology Dept., 1500 N. Warner, Tacoma, WA 98416, United States

[2]University of Wisconsin, Dept Geology & Geophysics, 1215 West Dayton St, Madison, WI 53706, United States

[3]Tarleton State University, Dept Physical Sciences, MS T0540, Stephenville, TX 76402, United States

[4]Kansas Geological Survey, University of Kansas, 1930 Constant Ave., Lawrence, KS 66047, United States

Paleomagnetic samples were collected from 92 sites on Ascension Island in May 2001 and May 2003. Paleomagnetic analyses of samples were performed at the University of Puget Sound paleomagnetic laboratory. Thus far, 43 sites have yielded normal directions, 12 have given reversed directions, and 6 have yielded directions with VGP latitudes of less than 70° (transitional?). Nineteen sites display too much scatter (a95 $> 10°$, k < 100) in paleomagnetic directions to be useful, and 12 sites are still being analyzed. When inverted, the mean direction for all reversed sites is statistically indistinguishable from that for normal directions. The mean value for all inverted reversed and normal sites combined is statistically indistinguishable from the direction expected for Ascension Island assuming a geocentric axial dipole field. Ar/Ar dating of 20 samples was completed at the University of Wisconsin, Madison. Ages range from 50.9±7.9 ka to 1086.2±15.2 ka. Ages and polarities indicate directions for dated units represent the Matuyama Chron, Brunhes Chron, and Jaramillo Subchron. Samples from 68 sites have been examined using reflected light microscopy at Tarleton State University. Optical examination confirms inferences from thermal demagnetization that magnetic mineralogy is largely dominated by titanomagnetite with some units containing significant hematite. Although several sites exhibit extensive post-eruptive alteration, most samples retain sufficient primary titanomagnetite to yield reliable primary, characteristic directions. Xenoliths in many samples exhibiting large scatter may significantly affect paleomagnetic directions. A substantial paleosecular variation (PSV) database has been compiled for the past 5 Ma, but numerous areas, including the South Atlantic, are underrepresented. This study will produce enough magnetic directions from the last million years or more to fill a gap in the PSV database, which can be used to test and refine emerging geodynamo models.

GP31A-15 0830h POSTER

Lineated Near Bottom Magnetic Anomalies Over an Oceanic Core Complex, Atlantis Massif (Mid-Atlantic Ridge at 30N)

Jeff Gee[1] (1-858-534-4707; jsgee@ucsd.edu)

Donna Blackman[1] (dblackman@ucsd.edu)

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

Despite significant effort during the four decades since the Vine-Matthews-Morley hypothesis was first advanced, the relative importance of lower crustal (and possibly upper mantle) sources in generating lineated marine magnetic anomalies remains uncertain. Remanence measurements from samples obtained by drilling or dredging provide the most direct evidence that these deeper layers can be significant anomaly sources. Near bottom anomaly measurements over tectonic exposures of the lower crust/upper mantle can yield valuable complementary information (e.g., patterns of polarity boundaries) as well as provide constraints on the timing and uplift history of these exposures. Here we report results from a near bottom magnetic survey of the Atlantis Massif, an oceanic core complex that formed within the past 1.5-2 Myr at the intersection of the Mid-Atlantic Ridge (30N) and the Atlantis transform fault. Geological and geophysical data indicate the presence of gabbro and peridotite over much of the corrugated central dome, inferred to be the footwall of a detachment fault. A vector magnetometer deployed 25m aft of the deeply towed side scan sonar system allowed measurement of both the total field and horizontal and vertical anomalous fields. Five profiles across the central dome reveal a lineated anomaly low that was not evident in earlier sea surface profiles. The presence of lineated anomalies over presumed gabbro and ultramafic exposures may record the acquisition of remanence as these rocks were exhumed by detachment faulting. Anomaly profiles over the Lost City hydrothermal vent field exhibit a pronounced magnetic low (reversed polarity), suggesting that active serpentinization is not responsible for the overall magnetization pattern. When combined with results from planned IODP drilling at the site, these data should provide significant insights into the importance of gabbro and peridotite lithologies as sources for lineated magnetic anomalies.

GP31A-16 0830h POSTER

Fault and fold interference in the core of an orocline: preliminary paleomagnetic and structural results from the Western European Variscan Belt, NW Iberia

Arlo Brandon Weil (610-526-5113; aweil@brynmawr.edu)

Bryn Mawr College, Department of Geology 101 North Merion Ave., Bryn Mawr, PA 19010, United States

This study reports new paleomagnetic and structural analysis of the inner core of the Western European Variscan Belt (WEVB), northern Iberia in order to test opposing kinematic models for the well-documented fault and fold interference structures formed by late-stage Variscan deformation. Map-scale structural features within the WEVB core have a highly sinuous geometry characterized by transverse and thrust parallel fold systems formed by fault-bend folding over footwall ramps. The intersections of these two fold systems produce steeply plunging interference folds, which are best exposed in the Ponga and Esla thrust units. A total of 110 sites were collected in these units, with emphasis placed on detailed coverage of individual structural domains. Paleomagnetic and structural analysis in the outer horseshoe portion of the thrust belt suggest that the most viable kinematic model for Variscan deformation in northern Iberia is oroclinal bending of an originally linear belt in a two-stage tectonic history. This history represents two regional compression phases (E-W in the Late Carboniferous and N-S in the Permian - both in present-day coordinates), which resulted in the refolding (about steeply plunging axes) of initially north-south-trending thrusts and folds in the hinge zone, and arc tightening due to vertical-axis rotation of the belt's limbs. However, the orocline model has yet to be critically tested in the arc's core where the main structural features are dominated by east-west trending transverse structures that are likely the result of space accommodation during arc formation. Two kinematic models have been proposed for fold and thrust evolution in the core of the arc. The first model proposes that the complex fault and fold patterns result from lateral and frontal hanging-wall ramp interference during initial east-west shortening. Such a kinematic model requires that existing footwall ramp geometries controlled the formation and location of steeply plunging folds, with map curvature being accommodated by rotations around sub-horizontal axes. The second model argues for the modification of pre-existing, west-dipping, frontal hanging wall ramps during late-stage deformation. In this model map-scale curvature is dominated by vertical-axis rotation. Preliminary results from this study indicate that the steeply plunging interference folds found in the WEVB core are best described by late-stage modification of a much more linear fold-thrust system, and not by interference corner folding due to the complex interactions of frontal and lateral ramps. Such a model is in good agreement with the oroclinal-bending model for the WEVB.

GP31A-17 0830h POSTER

Pleistocene Magnetostratigraphy of the Gonghe Basin, NE Tibetan Plateau: Headward Incision of the Yellow River after 1.8 Ma

Maodu Yan[1] (1-734-763-2149; maoduyan@umich.edu)

Josep M Pares[1] (1-734-615-0472; jmpares@umich.edu)

Rob Van der Voo[1] (voo@umich.edu)

David K Rea[1] (davidrea@umich.edu)

Xiao-min Fan[2,3] (fangxm@lzu.edu.cn)

[1]Maodu Yan, Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109, United States

[2]Xiao-min Fang, National Laboratory of Western China's Environmental System, Ministry of Education, & College of Resources and Environment, Lanzhou University, Lanzhou, GS 730000, China

[3]Xiao-min Fang, State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, CAS, Xi'an, SX 710054, China

Headward incision in the upper reaches of the Yellow River is closely related to the uplift of the NE Tibetan Plateau. In the Gonghe Basin, NE Tibetan Plateau, the Yellow River and its tributaries have incised more than 600 m into Neogene sediments. This incision is responsible for a change in the depositional environment of the Neogene strata from a lacustrine internal-drainage system to coarse fluviatile gravel deposition. This transition of sedimentary character (from aggradation stage to degradation stage) represents the arrival of the Yellow River in the Gonghe Basin. Dating the incised sediments will give an age constraint for the (earliest) appearance of the Yellow River in that area. Our two magnetostratigraphic sections in the Gonghe Basin both contain two polarity zones (a reversed polarity zone in the lower part and a normal polarity zone in the upper part), which are through fossils constrained to be post-Olduvai. This means that the normal polarity zone is Jaramillo or even Brunhes. So the gravels and, hence, the appearance of the Yellow River in the basin, are Jaramillo in age or younger. Combined with previous studies in the Lanzhou, Linxia, Guide and Zoige basins, it is clear that, by headward incision, the Yellow River cut through the gorges in between Lanzhou and Guide and reached the Guide Basin at about 1.8 Ma, then cut through the Longyang Gorge from Guide to the Gonghe Basin after 1.1 Ma, and finally incised through the Jungong Gorge to reach the Zoige Basin at about 10 ka.

GP31B CC: 220 C-E Wednesday 0830h

Four Decades of Paleomagnetism in Canada I Posters *(joint with T, V)*

Presiding: **M T Cioppa,** University of Windsor**; M A Hamilton,** University of Toronto

GP31B-01 0830h POSTER

Variation in Magnetization Ages of Devonian and Mississippian Carbonates in the Western Canada Sedimentary Basin

Maria T. Cioppa[1] (519-253-3000 x 2502; mcioppa@uwindsor.ca)

David T.A. Symons[1] (519-253-3000 x 2493; dsymons@uwindsor.ca)

Ihsan Al-Aasm[1] (519-253-3000 x 2494; alaasm@uwindsor.ca)

[1]Department of Earth Sciences, University of Windsor, 401 Sunset Ave., Windsor, ON N9B 3P4, Canada

In the Western Canada Sedimentary Basin (WCSB), reservoir-specific paleomagnetic research has shown