GRADUATE RESEARCH DAY

Presented By

Beta Iota Chapter

Department of Geosciences
University of Houston

March 25, 1988

GRADUATE RESEARCH DAY

ACKNOWLEDGEMENTS

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Beta Iota Chapter Members and Fellow Travelers

Rick Beaubouef
Karen Boates
Paul Buchanan
Tim Crnkovic
Sean Fitzmaurice
Concepcion Gomez-Moran
Bill Jones
Denise Kane
Rosanne Lindholm
Karen Love
Dave Meaux
Kent Ross
Everett Rutherford
Kristina Skrine
Susan Smith
Art Wahl

We invite everyone for refreshments in Room 315 at 5:00 (following the last presentation).

SCHEDULE OF PRESENTATIONS

REGIONAL GEOPHYSICAL STUDIES
Session Presiders: Concepcion Gomez-Moran, Susan Smith

9:00 **Karen Marks:** Geophysical Investigation of the Australian-Antarctic Discordance Zone
9:15 **Nirmalya Ghosh:** Geophysical Studies of the Lower Nicaraguan Rise, Colombian Basin, Beata Ridge and Northern South America
9:30 **Jason Jonas:** Gravity Anomalies Over Extinct Mid-Ocean Spreading Centers
9:45 **Chunshou Xia:** A Textural Study of Mantle Rocks at 23 N, near the Kane Fracture Zone, Mid-Atlantic Ridge: Implications for the Rheology of the Oceanic Lithosphere

SEDIMENTARY GEOCHEMISTRY AND BIOSTRATIGRAPHY
Session Presiders: Concepcion Gomez-Moran, Susan Smith

10:00 **Janet Rashkes:** Hydrogen Isotope Ratios of Kaolinites in the Lower Cretaceous Dakota Group and Mowry Shale, North Colorado: Evidence for a Tertiary Equilibration Event
10:15 **Ana Perez-Guzman:** Miocene Radiolarian Biostratigraphy and Paleo-oceanographic Reconstruction of Baja California and Tres Marias Islands, Mexico

10:30 --------------- **COFFEE BREAK**

CRUSTAL AND MANTLE GEOCHEMISTRY
Session Presiders: Karen Love, Dave Meaux

10:45 **Yan Liang:** Trace and Major Element Geochemistry of Two Xenolith-Bearing Alkalic Basalts from Xalapasco de la Joya, SLP, Mexico: A Preliminary Report
11:00 **Bill Jones:** Origin of Hornblende Megacrysts and Pyroxenite Xenoliths from Central Mexico
11:15 **Concepcion Gomez-Moran:** Composition of the Lower Crust Beneath the State of San Luis Potosi, Mexico
11:30 **Kent Ross:** Chemical Stratification in Mafic Magma Chambers: Evidence from Ophiolites and Basic Layered Intrusions

SEDIMENTARY PETROLOGY
Session Presiders: Karen Love, Dave Meaux

11:45 **Sean Fitzmaurice:** The Petrography of some Non-Marine Limestones, Palm Park Formation (Eocene), Caballos Mountains, New Mexico
12:00 **Karen Graber:** Barite and Phosphate in the Devonian Slaven Chert: An Example of Deposition in an Oxygen Minimum Zone

12:15 --------------- **LUNCH**

SEISMIC MODELLING AND DATA PROCESSING
Session Presiders: Karen Boates, Bill Jones

1:30 **Dan Ebrom:** Physical Modelling with Shear Waves
1:45 **Michael Gibbins:** Interval Velocity Determination of Physical Models Using the Hilbert Transform Method and Velocity Spectra with Semblance Coefficients
2:00 **Martin Karrenbach:** A New Approach to Three Dimensional Migration of Zero Offset Data

TECTONIC STUDIES OF LOWER PALEOZOIC ROCKS, W. NEWFOUNDLAND
Session Presiders: Karen Boates, Bill Jones

2:15 **Rosanne Lindholm:** The Significance of *Oldhamia* in the Blow-Me-Down Brook Formation, Western Newfoundland
2:30 **Rick Beaubouef:** Cambro-Ordovician N. American APW: Results from Western Newfoundland and Evidence for Late Paleozoic Remagnetization
2:45 **Dave Meaux:** On the Origin of Subophiolitic Basalts from the Humber Arm Allochthon of Western Newfoundland
3:00 **Nazneen Kharas-Khumbatta:** Estimated Composition of the Parent Magma for the BMD Massif, Bay of Islands Complex

3:15 --------------- **COFFEE BREAK**

METEORITES AND TEKTITES
Session Presiders: Tim Crnkovic, Rosanne Lindholm

3:30 **Paul Buchanan:** Grain Size and Texture of Chondrule Populations in Mezo-Madaras
3:45 **Jonathan Sadow:** A Quantitative Petrographic View of Lunar Chondrules and Chondrule-Like Objects
4:00 **Karen Love:** The North American Strewnfield: Intrafield Relations and Parent Materials

STRUCTURE AND TECTONICS
Session Presiders: Tim Crnkovic, Rosanne Lindholm

4:15 **Everett Rutherford:** Some Structural and Stratigraphic Consequences of Palinspastic Restorations in the Southern Appalachian Thrust Belt
4:30 **John Ruhl:** Identification, Geometry, and Movement History of Active Surface Faults in Fort Bend County, Texas
4:45 **Michael Edmunds:** Morphology and Distribution of Venus Coronae: Evidence for an Endogenic Origin

PRESENTED BY TITLE ONLY

Justine Boccanera: A Study of Currently and Recently Active Surface Faults, Brazoria County, Texas
Pat Rush: Diagenetically Altered Stable Isotope Values from Petrographically Pristine Brachiopods: Lower Devonian Helderberg Group, New York State
Pat Rush: HMC as Precursor Mineral for Stromatoporoids: Evidence from Diagenetic Fabrics in Lower Devonian Helderberg Group, New York State

CAMBRO-ORDOVICIAN N. AMERICAN APW; RESULTS FROM WESTERN NEWFOUNDLAND AND EVIDENCE FOR LATE PALEOZOIC REMAGNETIZATION.

Richard T. Beaubouef, Department of Geosciences, University of Houston, Houston, Texas 77004.

Most models for the development of the Appalachian Orogen in Newfoundland require the formation and subsequent destruction of an Early Paleozoic ocean, the Iapetus Ocean. Determination of the paleolatitudinal position of the N. American margin of this ocean, both prior to and during its destruction, is important to these models. Paleomagnetic investigations of rocks within the Appalachian Orogen can be used to document the timing of deformation, relative motions, local rotations (if any), and original latitudinal position of units associated with the closure of this ocean. Unfortunately, geological phenomena related to such tectonic/orogenic events are often seen to have partially or completely obscured the paleomagnetic record of rocks in question. In particular, the age of remanence aquisition often differs substantially from the formation age of the rock due to remagnetization events in the Late Paleozoic.

To obtain a Cambro-Ordovician paleomagnetic pole position for North America, and to determine the paleolatitude of its margin of the Iapetus as represented in W. Newfoundland, a study of Upper Cambrian and Lower Ordovician carbonates from Port-au-Port Peninsula, W. Nfld. is in progress. 75 specimens from 6 sampling sites across the boundary between the Late Cambrian Petit Jardin Formation and the Tremadocian aged St. George Group have been analyzed. The NRM of these rocks is seen to be the resultant of three distinct paleomagnetic directions; 1) a steep downward component observed in the low temperature range (room temperature - 250°C) present in virtually all specimens, roughly corresponding to the present day field direction, 2) a stable component with a southerly declination and a shallow-intermediate negative inclination (Dec=175, Inc=-17) usually seen in the range of 450°-600°C, found in 40% of the specimens, and 3) a stable southeasterly, shallow-intermediate, positive component (Dec=156, Inc=+34), generally blocked in within the ranges of 350°-550°C and 400°-600°C, observed in another 40% of the specimens. The remaining 20% were found to be either directionally unstable to thermal demagnetization or completely overprinted by the present day component and therefore excluded from further analysis. The type 2) directions yield a reversed paleo-pole position at 49.8°S and 50.7°W (in situ; d_p=4.66, d_m=9, $alpha_{95}$=8.7, k=11.16, colat=98.36) which falls close to reported poles of Permo-Carboniferous age. The type 3) directions also yield a reversed pole located at 19.2°S and 35.1°W (tilt corrected; d_p=4.76, d_m=8.31, $alpha_{95}$=7.26, k=18.11, colat=71.55) which is in good agreement with recently reported Cambro-Ordovician poles from Western Newfoundland and elsewhere. Based on these observations it is concluded that the type 3) directions are a pre-folding, pre-Acadian remanence and that the resulting pole position is representative of North America during Early Ordovician times. However, lack of a fold test and gentle regional structure make this interpretation tentative. The type 2) directions probably represent a post-folding Late Paleozoic overprinting event possibly associated with the Alleghenian Orogeny.

A STUDY OF CURRENTLY AND RECENTLY ACTIVE SURFACE FAULTS, BRAZORIA COUNTY, TEXAS. Justine A. Boccanera, Department of Geosciences, University of Houston, Houston, TX 77004.

This study is being conducted over the 1422 square miles of Brazoria County, Texas, an area previously unexplored for surface faulting.

For reconnaissance of the county, several generations of high resolution false-color infrared and low altitude black and white aerial photographs are being utilized to identify surface lineations. Extensive field investigations are conducted to determine the nature of the lineaments observed, and finally, well logs and seismic data are used to study the growth history and three dimensional geometry of selected faults in the subsurface.

The test area chosen for the subsurface investigation is the Arcola Oil Field. The study has thus far shown the prominent Arcola and Iowa Colony Faults to be, respectively, a major down-to-the-coast growth fault, and a relatively young antithetic structure. Several previously unidentified faults can be included as part of this system. They are relatively minor synthetic and antithetic features, and an earlier generation antithetic to the Arcola, the Stevens Road Fault.

Most faults within the Arcola-Iowa Colony system exhibit growth character. Expansion indices indicate three major events for this system: a decrease in movement rate on the Arcola since the Oligocene corresponding to a concomitant decrease in sedimentation rate; initiation of the Stevens Road Fault as the major antithetic to the Arcola in Upper Vicksburg time; and activation of the Iowa Colony Fault as the primary antithetic to the Arcola in earliest Miocene time.

Bounded by this fault system, structure contour maps show that successful wells in the Arcola Oilfield are located on the closure developed by rollover into the Arcola and Stevens Road Faults. Dry holes along the Arcola-Iowa Colony rollover anticline suggest this younger feature is not a hydrocarbon trapping structure.

The major faults in this system are listric in shape with initial 70° dips decaying to approximately 54°-59° at 8000' depths. Application of the Gibbs model (1983) to describe the listric shape of these faults does not account for the observed geometries. Predicted fault dips and "depth to detachment" were much too shallow. However, a model invoking sediment compaction as the principle factor determing growth fault geometry is found to be rather suitable.

GRAIN SIZE AND TEXTURE OF CHONDRULE POPULATIONS IN MEZO-MADARAS.

Paul C. Buchanan, Dept. of Geosciences, University of Houston, Houston, TX 77004

Introduction. The unequilibrated ordinary chondrite, Mezo-Madaras (L3), is described as a polymict accumulation breccia (1), i.e. it includes xenoliths of a number of different types in a minimally metamorphosed, chondritic host (4). Hence, it is excellent material for studying accretionary processes in meteorites. Previous work describes chemical composition and texture of both host and xenoliths (2,3,5,6,7). The present study attempts to document textural variability within the meteorite by petrographic analysis of individual petrogenetic elements (fluid-drop chondrules, lithic chondrules, lithic inclusions, etc.).

Chondrule Types. Mezo-Madaras includes a diverse assortment of material; fluid-drop and lithic chondrules are mixed with lithic inclusions and fragments. Concentrations of chondrule types were calculated for three representative thin-sections (USNM 4838-1, USNM 4838-2, and EAK-1). Fluid-drop chondrules varied significantly between sections from 4.4 chondrules/cm^2 in USNM 4838-2 to 23.6 chondrules/cm^2 in EAK-1. In contrast, concentrations of lithic chondrules are similar in all three sections, ranging from 25.7 to 28.0 chondrules/cm^2.

Chondrules and inclusions also display a diverse assortment of internal textures: granular, porphyritic, barred, radial, microcrystalline, fine-grained, fibrous, spongy, etc. Particularly interesting are proportions of the two dominant types, granular and porphyritic, within different areas and populations of the meteorite; Table 1 documents these proportions for the three thin-sections discussed above. In all cases, lithic inclusions are dominated by porphyritic textures, while the majority of near spherical, fluid-drop chondrules are granular.

Chondrule Sizes. Maximum apparent diameter in phi units of fluid-drop and lithic chondrules is plotted against a probability ordinate for the three thin-sections considered above (Figs. 1-3). USNM 4838-2 shows a continuous range of values plotting as a slightly curved line. By contrast, section EAK-1 displays a striking discontinuity between 0.0 and 0.5 phi units. Though difficult to interpret, USNM 4838-1 probably includes a discontinuity at 0.0 phi units with another possible at 1.0 phi. These plots indicate significant heterogeneities in size-frequency distributions of chondrules in different volumes throughout the meteorite.

Conclusions. Two types of processes seem likely to affect chondrule populations in Mezo-Madaras: 1)primary chondrule-forming or chondrule-altering processes and 2)secondary processes associated with accretion of the polymict accumulation breccia. The increase in proportion of granular to porphyritic elements as sphericity increases seems to be relatively consistent throughout Mezo-Madaras and may result from the first type of process. Variations throughout the meteorite in concentrations of fluid-drop chondrules and grain size-frequency distributions of chondrules may, however, result from secondary accretion processes.

References

(1) Wahl, W., 1952, Geochim. Cosmochim. Acta, 2, 91;
(2) Dodd, R. T. and Van Schmus, R., 1965, J. G. R., 70, #16, 3801;
(3) Dodd, R. T., et al., 1966, The American Mineralogist, 51, 1177;
(4) Van Schmus, W. R., 1967, Geochim. Cosmochim. Acta, 31, 2027;
(5) Kurat, G., 1967, Geochim. Cosmochim. Acta, 31, 1843;
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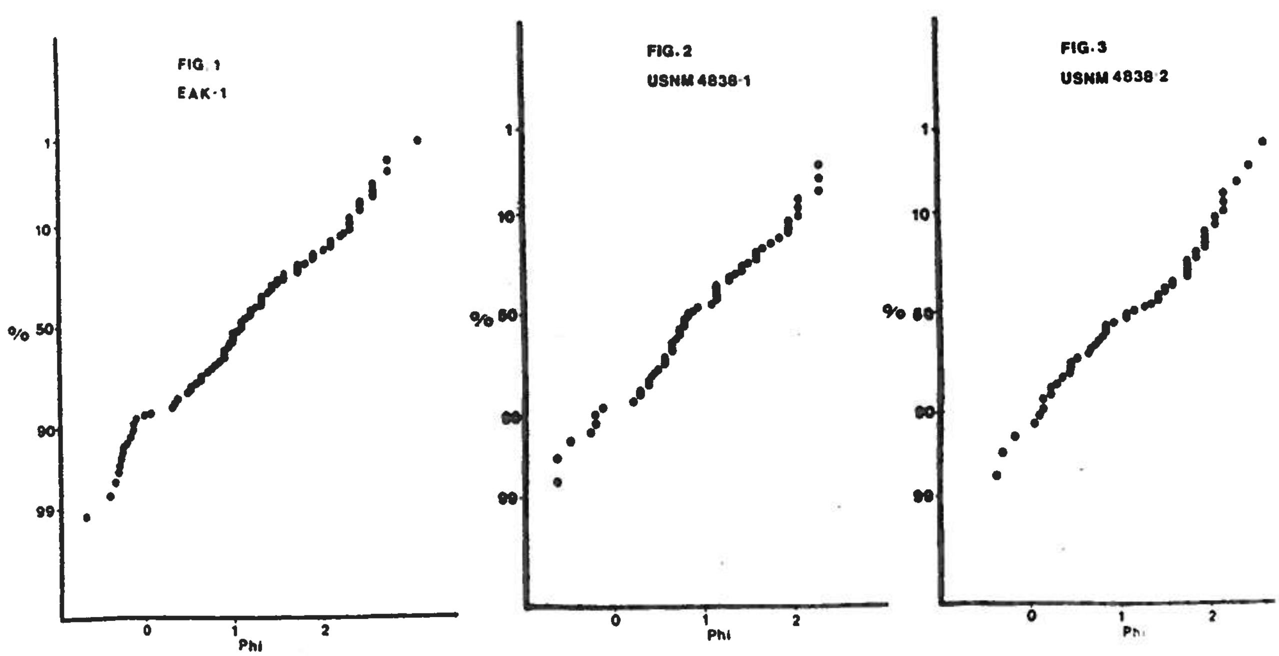
(7) Topel-Schadt, J. and Muller, W. F., 1985, Earth and Planetary Science Letters, 74, 1.

TABLE 1.

Numbers of chondrules
by type and internal textures

	EAK-1		USNM 4838-1		USNM 4838-2	
	granular	porphyritic	granular	porphyritic	granular	porphyritic
fluid-drop chondrules	24	13	6	5	6	0
lithic chondrules	23	30	27	10	30	9
lithic inclusions	32	40	21	28	32	36



PHYSICAL MODELING WITH SHEAR WAVES

Dan Ebrom, Dept. of Geosciences, Univ. of Houston, Houston, TX 77004

Shear transducers utilizing cross-cut piezo-electric crystals have been successfully used in obtaining time sections that include both compressional and shear events. The transducers have been calibrated for polarization, allowing the acquisition of either SH (cross-line polarized) or SV (in-line polarized) shear sections, or any polarization of S-waves between SH and SV. Transmission seismograms through a homogeneous medium (Plexiglas) illustrate the complexity of elastic wave propagation for even a simple model, with distinctions being especially prominent between SH and SV transmission experiments. An unexpected discovery was the existence of a linear event that appears to be a mode-converted SV to P wave that travels along the interface. This sort of conversion is predicted in Booth and Crampin (1985). The SV to P arrival would be observed in the field given a down-hole shear source and an offset surface geophone. Obviously, transmission seismograms in homogeneous media are not directly relevant to exploration work; however, the homogeneous medium case serves as a reference point from which to start when acquisition is done over more complicated media.

As an example, acquisition can be done over anisotropic media. Systems of transverse isotropy are among the most common examples of anisotropy observed in the actual earth, and the most straight-forward to model physically. Our model simulates vertical fractures in an idealized fashion by horizontally stacking thin Plexiglas plates under compression, with water between the plates. The plates are 0.16 cm thick, or about one eighth of a wavelength wide for shear waves at a frequency of 120 kHz. The transducers were placed on opposite sides of the model to reduce surface wave noise problems. One transducer was kept stationary as the other transducer was moved along a line, measurements being made at intervals of 0.12 cm. The signal was in the range of 20 kHz to 150 kHz, and the temporal sampling rate ($0.1\mu sec$) well exceeded the Nyquist criterion. The data were collected along three separate lines: one parallel to the cracks between the plates, one perpendicular to the the cracks, and one 45^o between the first two lines. Both in-line and cross-line polarized sources were used for each line, with both in-line and cross-line polarized receivers recording the signal for each source polarization. The direct travel times were measured and were analyzed to determine the effect of crack orientation upon shear wave velocities. Shear wave splitting was observed, with velocity differences in excess of 20%.

References

Booth,D.C. and Crampin,S., 1985, Shear-wave polarizations on a curved wavefront at an isotropic free surface: Geophys. Jour. Roy. Astron Soc. **83**, 31-45.

MORPHOLOGY AND DISTRIBUTION OF VENUS CORONAE: EVIDENCE FOR AN ENDOGENIC ORIGIN; Michael S. Edmunds, Department of Geosciences, University of Houston, Houston TX 77004.

Coronae are large concentric structures first identified on Venera 15 and 16 radar images of the northern hemisphere of Venus. They are characterized by a series of concentric ridges from 200 to 600 km in diameter and exhibit low to moderate relief. Their interiors are generally lower in elevation and complex with low domes, with and without summit pits, linear ridges and flow-like morphologies. Domes and flows also occur exterior to the concentric ridges [1,2]. They have been attributed variously to exogenic (modified impact craters) as well as several endogenic processes (e.g. ring complexes, modified domes or volcanoes, and mantle diapirs). We have examined 33 coronae and determined their morphologic, topographic, and spatial characteristics to constrain their origins.

The majority of these features occur within the lowlands and upland rolling plains units of Masursky et al. [3] and are adjacent to Ishtar Terra, the large continent-like highland in the northern hemisphere. It is noted that with few exceptions they occur in three clusters with approximate centers at 67^{o}N, 115^{o}E (Tethus cluster); 66^{o}N, 280^{o}E (Mnemosyne cluster); and 40^{o}N, 20^{o}E (Fortuna cluster). Coronae are observed between the elevations of -1.0 to 2.0 km (referenced to 6051 km radius) with a peak at ~0.6 km (Figure 1). While 14 coronae in our sample have topographic expressions of < 200 m, relief of up to 1.2 km is observed (Figure 2). The positive correlation of relief with surface elevation indicates a link between corona generating processes and those responsible for maintaining regional topography and suggests to us that coronae are initially regions of substantial positive relief which become less distinguishable as the sustaining thermal anomaly decays. Those features expressing low relief occur at various elevations and could indicate a population of old, degraded, or inactive coronae. Approximately 70% of the coronae in our sample are elliptical. This ellipticity appears to be primary in many coronae, but low resolution and poor image quality make this observation difficult in other coronae. Since elliptical structures caused by low angle impact are rare it can be argued that coronae are not produced by impact.

We looked on Earth for similar features and found that comparisons with African hotspots show several interesting similarities; the African features are of comparable size and relief and are also typically elliptical [4]. Thiesson polygons have been used to define a set of convection cells beneath Africa and indicate thes cells are roughly equidimensional with an average separation distance of slightly less than 8^{o}, which corresponds to ~900 km measured along the surface [5]. Construction of Thiesson polygons for the three clusters of coronae on Venus yields cells with geometries and scales remarkably similar to those in Africa (Figure 4); average separation distance is just over 8^{o} or 840 km measured along the surface. These results for Earth and Venus correspond favorably with experimental models of mantle convection beneath a stationary upper layer that has been scaled up to a 700 km depth of convection [6]. The African plate appears to be stationary relative to the underlying mantle and has been so for ~25 m.y. [see references in 5]. The elliptical forms of African hotspot expressions, therefore cannot be attributed to migration of the lithosphere over a mantle plume, but instead appear to reflect assymetries in mantle upwelling [4]. Elongation directions of coronae within individual clusters show diverse orientations [7], and do not appear consistant with patterns produced by plate movements.

The results of this study lead us to believe that coronae, like their African analogues are structures produced by volcanic and attendant tectonic modification of the lithosphere associated with mantle upwelling. Additionally, the morphology and distribution of there features seems to indicate that the lithosphere around Ishtar Terra is virtually stationary with respect to the ensuing mantle reference frame.

REFERENCES: [1] Barsukov et al., Proc. Lunar Planet. Sci. Conf. 16, D378-D398, 1986. [2] Basilevsky et al., Proc. Lunar Planet. Sci. Conf. 16, D399-D411, 1986. [3] Masursky et al., J. Geophys. Res. 85, 8232-8260, 1980. [4] Burke and Whiteman, Implications of Continental Drift to the Earth Sciences, Tarling and Runcorn eds.,735-755, 1973. [5] Thiesson et al. Geology 7, 263-266, 1979. [6] Richter and Parsons, J. Geophys. Res. 80, 2529-2541, 1975. [7] Edmunds et al., Lunar and Planetary Science XIX,294-295, 1988.

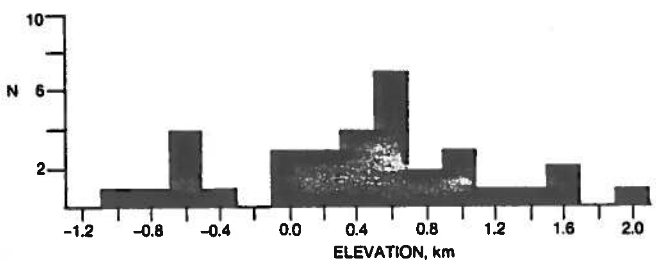


Figure 1

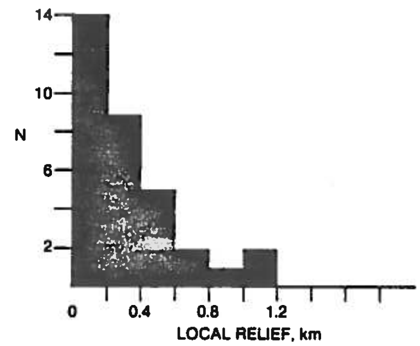


Figure 2

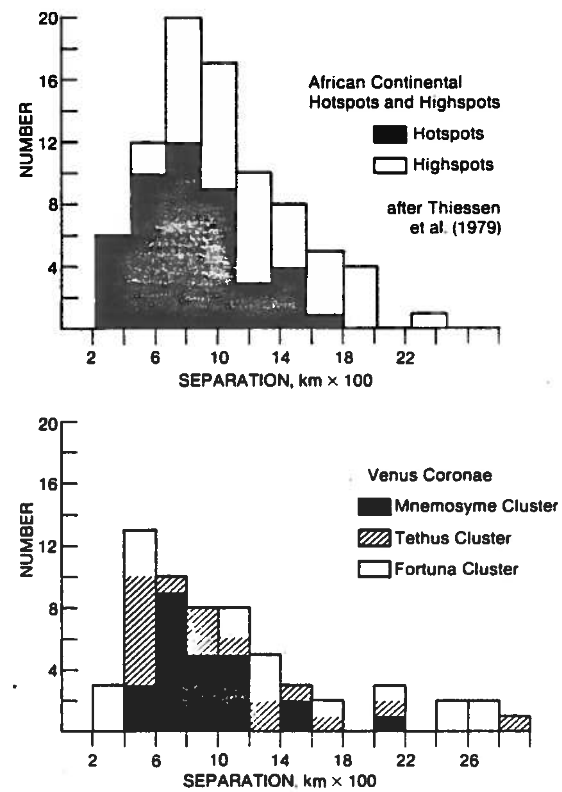


Figure 4

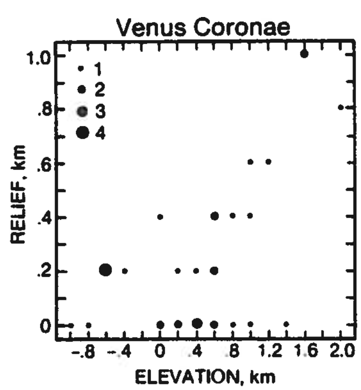


Figure 3

THE PETROGRAPHY OF SOME NON-MARINE LIMESTONES, PALM PARK FORMATION (EOCENE), CABALLOS MOUNTAINS, NEW MEXICO. Sean Fitzmaurice, Department of Geosciences, Univ. of Houston, Houston, Texas 77004.

Non-marine limestones, approximately 45 million years old, crop out in the foothills of the Caballos Mountains in southcentral New Mexico. Sampling and description of these limestones has revealed a variety of features indicating deposition occurred primarily in shallow, fresh-water environments. Environments ranged from rapidly precipitated travertine mounds near spring orifices to carbonate buildups consisting largely of algal micrites in adjacent lacustrine deposits.

Petrographic analyses shows the limestones to consist largely of packed intramicrites and intrasparites, with intraclasts consisting dominantly of fragments of coated grains. The carbonate coating covers plant stems, siliciclastic grains, limestone fragments or any convenient object. Casts and molds of reeds and palm fronds give evidence for high rates of carbonate precipitation, rapid enough to engulf the surrounding biota. Other evidence of organic activity is encased in many of the samples. Oncolites that range in size from one to one hundred millimeters in diameter are found at several locations. Forms vary from strange oblong-shaped oncoids to more spherically shaped blue-green algal oncoids. Compound oncoids consisting of an agglutination of several smaller, single oncoids are also found. Light and dark laminated limestones associated with spring orifices contain small (15 micron diameter) threads of probable algal origin in the lighter layers. The darker layers consist of sparry calcite, lack the algal filaments, and appear relatively free of organics. These alternating light-dark laminations may reflect a seasonal growth pattern, with the sparry inorganic calcite precipitating during the dormant season for the algae, and the lighter, more micritic calcite precipitating during and possibly in response to algal growth. Dendritric crystals occur in the layers containing filaments. Branches of these crystals range from bare to sharp-leafed. A yellow halo occurs in the spar cements surrounding the dendrites. Filaments or threads of probable organic origin can be observed in intimate association with dendrite branches, possibly influencing their growth and morphology. Fan or shrub-like cements are found in other samples of the light-dark rhythmically laminated limestones, representing variations of the dendritic cements. Other cements found include fibrous radiating botryoidal crystals, isopachous, bladed void lining spar, and crusts consisting of fibrous to equant spar crystals. Cathodoluminescence (CL) microscopy has shown many generations of cements not readily discernible under ordinary light. Non-luminescent to brightly luminescent areas document different generations of cements. Under CL, a non-luminescent ghost of prêcursor micrite allows differentiation of areas of primary micrite and spar. Late stage diagenetic fluid evidence, not visible under plain light, appear as strongly luminescent canals cross-cutting both micrite and spar, including earlier stage luminescent, zoned spar cements.

Environments of deposition of the Palm Park limestones include: travertine mounds, found around spring orifices; shallow, horizontally laminated ponded travertine deposits, containing ooids and other coated grains, found adjacent to the travertine mounds; and farther removed from the area of the spring orifices, lake-fill deposits that represent areas of accumulation of travertine detritus and lacustrine algal micrite buildups.

GEOPHYSICAL STUDIES OF THE LOWER NICARAGUAN RISE, COLOMBIAN BASIN, BEATA RIDGE AND NORTHERN SOUTH AMERICA. **Nirmalya Ghosh, Department of Geosciences, Univ. of Houston, Houston, Tx 77004.**

The Colombian Basin is one of the three major ocean basins of the Caribbean-sea, the Lower Nicaraguan Rise appears to be a crustal block west of the basin and separated from it by the Hess Escarpment. The Beata Ridge appears to be a compressional structure on the east of the basin. The origin and tectonic evolution of the Colombian Basin, the Lower Nicaraguan Rise and the Beata Ridge is not well understood. Neogene development of the Caribbean plate has been described and discussed in elaborate details recently, because of clear relationships to present plate boundary configuarations and relative movements. Cretaceous and Paleogene development prior to mid Cenozoic plate reoganization, is more problematic and most authors treat this period in a cartoon form showing the present Colombian Basin and Venezuelan Basin forming as one unit as part of an 'Eastern Pacific Plate'. This cartoon treatment results due to lack of definitive evidence from the Colombian Basin its similarities or differences, if any, with the Venezuelan Basin and it's development. Further two opposing plate tectonic models for the Colombian crust have been proposed, 1) the crust generated in-situ by a roughly east-west trending spreading center and 2) the crust originated in the equatorial Cretaceous Pacific Ocean Basin and was subsequently translated northeast.There is a lively controversy on the tectonics of northern South America, according to one group the Caribbean crust has been underthrusting South America for the last 40 my, according to the other group the Caribbean crust is moving eastward relative to the Americas with a right lateral strike slip motion on the northern part of South America. There is an ongoing debate whether the Hess Escarpment, which is a sharp bathymetric discontinuity, is a fracture zone or a boundary between two different crustal types. The origin of the magnetic signatures over the Beata Ridge is also controversial, are they due to magnetic reversal, which is characteristic of the oceanic crust, or are they a manifestation of the near surface volcanic material or structural variations of a magnetic basement. The tectonic evolution of the Colombian Basin, Hess Escarpment, Beata Ridge and northern part of South America is not well understood, a knowledge of their geologic evolution is required to better constrain the plate tectonic reconstruction of the Caribbean region.

The objectives of the research are, 1) to compile the ship and air-borne magnetic data 2) to compare and contrast the nature of magnetic field over the Colombian Basin, Lower Nicaraguan Rise and the Beata Ridge 3) to better define the structure and depth to magnetic basement 4) to integrate these results with SEASAT and GEOS-3 derived gravity data, available seismic results, compiled ship borne gavity and geologic studies in the region 5) compare the results of Colombian and Venezuelan Basins 6) develop an evolutionary model of the western Caribbean Region 7) develop constraints on the existing models for the northern part of South America from two-dimensional gravity modeling.

INTERVAL VELOCITY DETERMINATION OF PHYSICAL MODELS USING THE HILBERT TRANSFORM METHOD AND VELOCITY SPECTRA WITH SEMBLANCE COEFFICIENTS.

Michael G. Gibbins, Department of Electrical Engineering, Seismic Acoustics Laboratory, University of Houston, 4800 Calhoun Road, Houston, Texas 77004.

Seismic reflection experiments were conducted with three physical models at the Seismic Acoustics Laboratory: Thinning Wedge (SALTHN), Model 53 (Salt Ridge), Basin Model (SALBAS). Acoustical reflection data were collected for the purpose of determining interval velocities and reconstructing the velocity distribution of the models.

The raw data were computer processed and displayed as seismic record sections. All data were corrected for Dip Moveout (DMO) and Normal Moveout (NMO). DMO data panels were generated by creating replacement traces corrected for dip angle and smearing of Common Midpoints (CMP) gathers. The DMO correction is independent of velocity. NMO transforms hyperbolic moveout curves to straight line reflections. A correct pre-determined velocity must be used to correct for NMO.

Velocity scans were created from partial stacks of DMO panels using a pre-determined suite of velocities. Each DMO panel was split into two halves, all traces in each half were stacked, resulting in a pair of partial stacked traces for each velocity used.

Interval velocity is determined by visual inspection and detection of zero phase angle shift in the trace pairs. A true velocity will properly correct for NMO, producing a zero phase shift and a local maximum signal amplitude.

Velocity spectral plots are an expression of interval velocity as a function of semblance and traveltime. High semblance values indicate true interval velocities and apparent velocities. Semblance is the sum trace energy divided by the mean energy of the components of the sum.

The velocity scans and velocity spectra produced from these experiments are in general agreement with each other and documented values of scaled acoustic velocity in the modeling materials.

COMPOSITION OF THE LOWER CRUST BENEATH THE STATE OF SAN LUIS POTOSI, MEXICO. Concepcion Gomez-Moran, Department of Geosciences, Univ. of Houston, Houston, Tx 77004.

In the state of San Luis Potosi, Mexico, several phreatomagmatic craters of possible Pleistocene age characterized by the presence of crustal and mantle xenoliths have been described by Labarthe [1] and Aranda-Gomez [2].

Major and trace element whole rock analyses of xenoliths from two localities (Xalapasco de la Joya and Laguna de los Palau) display a wide range of compositions from ultrabasic to acidic very similar to those reported from Central Massif, France, [3] and Algeria [4]; they extend toward more silicic compositions than those reported from South Africa [5], Australia [6, 7] and West Germany [8, 9]; and they confirm the presence of rocks derived from sedimentary and igneous protoliths.

Whole-rock rare earth element abundances of selected xenoliths from Xalapasco de la Joya define four major groups: (1) charnockites which are characterized by the presence of a large positive Eu anomaly and Light-REE enrichment; (2) plagioclase-rich cumulates, also characterized by a positive Eu anomaly and Light-REE enrichment; (3) pyroxene-rich cumulates which are Light-REE depleted; and (4) liquids crystallized at high pressure and cumulates characterized by a Light-REE enrichment and either a lack or the presence of a negative Eu anomaly. Group (4) can also be subdivided into (4a) which is characterized by an almost flat REE pattern and slight negative Eu anomaly; (4b) which is characterized by a La/Ce > 1; and (4c) characterized by a La/Ce < 1.

On the basis of the major, trace and REE compositions a common origin is inferred for several of the high-pressure crystallized liquids and cumulates however, this origin cannot be extrapolated for the rest of the samples.

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BARITE & PHOSPHATE IN THE DEVONIAN SLAVEN CHERT: AN EXAMPLE OF DEPOSITION IN AN OXYGEN MINIMUM ZONE.

Karen K. Graber & Henry Chafetz, Department of Geosciences

Bedded barite and phosphate within the Slaven Chert in East Northumberland Canyon, Toquima Range, Nye County, Nevada formed within an oxygen minimum zone during the Late Devonian. East Northumberland Canyon deposits are a part of the Roberts Mountains allochthon which was overthrusted onto eastern carbonate shelf deposits by the Late Devonian-Early Mississippian Antler Orogeny.

Petrographic and stratigraphic analyses of the barite/chert beds indicate that they formed as sedimentary and early diagenetic precipitates. The barite occurs as layers of fine crystals and/or nodules. The finely crystalline beds lack matrix chert and probably formed at and/or above the sediment-water interface. In contrast, barite nodules often contain abundant radiolarian fossils, phosphate, and silt grains; and are located within chert and/or fine-grained barite. These data suggest that the spherulites grew within deposited fine-grained barite and/or chert sediment as an early diagenetic mineral.

High organic matter concentrations (up to 6%), well preserved microfossil skeletal hash, and phosphate in barite and chert deposits, indicate that the rocks formed in an anoxic environment. REE values of phosphate from the Slaven Chert resemble patterns of phosphorites formed in zones of coastal upwelling at low lattitudes versus phosphate formed in non-upwelling areas (Coles, 1984). These facts suggest the barite, chert, and phosphate formed within an oxygen minimum zone associated with coastal upwelling currents.

GRAVITY ANOMALIES OVER EXTINCT MID-OCEAN SPREADING CENTERS. Jason M. Jonas, Stuart A. Hall, and John F. Casey, Department of Geosciences, Univ. of Houston, Houston, TX 77004

Gravity fields over mid-ocean ridges display long wavelength free-air gravity highs with short wavelength lows superimposed over the spreading axis. These axial lows across slow spreading active ridges are typically 30-70 mGal in amplitude with wavelengths of 40-60 km but decrease in amplitude and wavelength with increasing spreading rate until, at fast spreading centers, the anomaly is positive (10-20 mGal) with wavelengths of about 20-30 km. The free-air gravity lows are also observed over extinct spreading ridges and typically show the same paleo-spreading rate dependency as active ridges, suggesting that a large component of the anomaly is not dynamically maintained. Calculation and removal of gravitational effects from basement topography and sedimentary rocks leaves a residual axial gravity low at the extinct ridges analyzed here, even though all the thermal effects associated with active spreading have diminished and no longer produce such short wavelength gravity lows. The amplitude of the residual low at slow paleo-spreading rates are 25-40 mGal with half widths of about 25-45 km, and decrease in amplitude and wavelength with increasing rate to about 5 mGal amplitude and 10-15 km half-width at fast paleo-spreading ridges. Most of the previously proposed models of mid-ocean ridge structure are unable to explain these anomalies and many are inconsistent with at least some aspect of the large body of knowledge currently available for mid-ocean ridges. This research provides a further constraint on these geometric models of accretion, since most of the models predict vastly different gravity fields. These results are, however, indicative of a frozen-in low density accretionary structure confined to within about 10 km of either side of the axis, which is consistent with the presence of a low-density gabbroic root situated at typical mantle depths beneath the ridge axis. This root tends to narrow with increasing spreading rate, producing the required residual gravity field variation.

ORIGIN OF HORNBLENDE MEGACRYSTS AND PYROXENITE XENOLITHS FROM CENTRAL MEXICO: A WORK IN PROGRESS. Bill Jones, Department of Geosciences, Univ. of Houston, Houston, TX 77004.

A variety of lower-crustal and mantle derived fragments are found in low-relief tuff rings about explosive craters in the state of San Lois Potosi, Mexico. La Joya Prieta Maar is one such crater, located about 75 km NE of the more extensively studied Xalapasco de la Joya Honda (see abstracts by Liang *et. al.* and Gomez-Moran, and references therein, this volume). La Joya Prieta is somewhat unique among the craters in this region by virtue of the dominance of large (1-2" length) hornblende crystals in the xenolith population, as well as the presence of a large number of pyroxenite fragments. Determining the origin of these high-TiO_2 hornblende megacrysts and their possible relationship to the pyroxenites containing hornblendes of similar composition is the motivation behind this study. The main problem to be resolved is whether these rocks are of magmatic or metasomatic origins.

The first line of attack is microscopic examination of the rocks in thin section. Four distinct morphologies of hornblende megacrysts (all analyzed as kaersutite) are present when viewed down the long ("c") axis of the crystal. All varieties exhibit well-developed external crystal faces parallel to c, and most are rounded on the ends due to melting in transit to the surface. Most common are megacrysts with a deep red-brown color. Similar in their possession of good internal cleavage are those megacrysts with a golden-yellow color. Both of these groups have a variety of fluid inclusions present, which commonly are aligned in planes within the crystals, and often are decrepitated. Ilmenite rods in common alignment are also present. A third group of kaersutites exhibit a swarthy, criss-cross type of appearance, with no obvious internal cleavage planes present. The fourth group lacks any internal orientations, and appears to consist of microcrystalline "beads" of hornblende.

Two major groups of pyroxenites are dominant. First are those comprised mainly of clinopyroxene and kaersutite (usually red-brown), accompanied by about ten modal percent of spinel and/or ilmenite (minor amounts of orthopyroxene and olivine are present in a few of the samples). The kaersutites poikilitically enclose clinopyroxenes, and opaques are most commonly located in the center of kaersutite grains. Three of these samples have all clinopyroxene in optical continuity, while the kaersutite consists of one to three grains in optical continuity. Other samples have a more random orientation of clinopyroxene and hornblende grains. The second major textural group consists of more evenly balanced percentages of clino- and orthopyroxenes. These two minerals comprise 99+ percent of the rocks in this group, which commonly display a mosaic texture, with only trace amounts of hornblende present. Nontheless, all but one of the hornblendes are analyzed as kaersutite.

Bill Jones

Microprobe analyses of these xenoliths allows them to be classified as members of the "Al-augite" or "Type II" groups (Frey and Prinz, 1978). Type II xenoliths are commonly modelled as crystallizing from liquids similar in composition to the basalt fragments with which they are commonly found. As discussed by Liang *et. al.* (this volume), melting of mantle peridotites is often proposed as the source of alkaline magmatism. At the same time, many workers propose mantle metasomatism as the likely source for hydrous phases in mantle xenoliths (see Boettcher, 1984, for a concise review). The question then becomes one of resolving a magmatic origin for pyroxenites with a metasomatic one for the hornblendes contained therein. But what of the large hornblende megacrysts, of similar major, minor and trace element composition to the hornblendes in the pyroxenites? These are not as easily describable in terms of veining or replacement of preexisting rock. Preliminary instrumental neutron atomic activation at Johnson Space Center of the megacrysts and whole-rock and clinopyroxene and hornblende mineral separates from the pyroxenites indicates overlapping trace element patterns and abundances for hornblendes from either source. Whole-rock patterns appear to be controlled by clinopyroxene and hornblende. Although INAA is still underway, it appears likely that rare earth element patterns are enriched in the light elements and depleted in heavies. This type of pattern is compatible with crystallization from liquids derived from melting in the garnet-lherzolite stability region of the mantle. Completion of INAA and subsequent modelling of trace element data should serve to complete this study. Studies of stable and radiogenic isotopic composition would further enhance our understanding of processes involved in the formation of these rocks.

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A NEW APPROACH TO THREE DIMENSIONAL MIGRATION OF ZERO OFFSET DATA Martin Karrenbach, Department of Geosciences, University of Houston, 4800 Calhoun, Houston, TX 77004

Three dimensional migration of zero offset data can be performed using Fourier transforms of time slices. The migration process is carried out entirely in the two dimensional spatial Fourier domain. The algorithm consecutively shifts and adds time slices of the 3D data volume in a way that is equivalent to adding energy along the diffraction surface of a point. Operating in the 2D Fourier domain allows that a time slice is imaged completely after one summation.

Let x,y,z be Cartesian coordinates with the origin at the surface of the earth. A single scattering point (x_1,y_1,z_1) in the subsurface has an arrival time T for coincident shot and receiver,

$$T = \{T_0^2 + \frac{4}{V^2}\left((x-x_1)^2 + (y-y_1)^2\right)\}^{\frac{1}{2}}, \qquad (1)$$

with the time $T_0=\frac{2z_1}{V}$. For a constant propagation velocity the surface is a hyperboloid of revolution. The time slice $T=const$ cuts the diffraction surface in a circle with center at (x_1,y_1) and radius $R = \frac{V}{2}\{T^2 - T_0^2\}^{\frac{1}{2}}$. Hence, scattering points give rise to circular events in time slices.

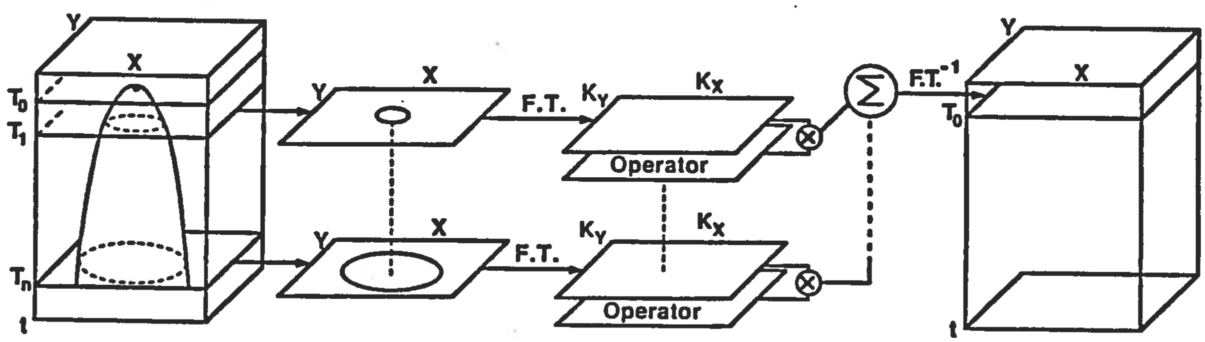
In order to sum energy along the diffraction surface of a scattering point, it has to be summed along circles in the time slice representation of a 3D data volume. This process can be carried out by multiplying the 2D Fourier transform of each time slice by the cosine factor

$$CSF(K,L) = cos\{2\pi R\sqrt{K^2+L^2}\}, \qquad (2)$$

where R is the radius of the intersection of the time slice with the diffraction surface in equation (1) and K and L are the spatial frequencies. Thus, the circular event is approximately collapsed to a point. In practice a trace in a 3D data volume is recorded in equal increments in time, but it is more useful not to filter and sum these already existing equally spaced time slices. Instead time slices, which represent equal increments in diffraction radius are used. This is advantageous, because the cosine factors can be calculated more rapidly. By repeating the filtering process for all slices which contain these diffraction circles and summing up all the slices, the energy will build up at the true location of the scattering point. During the summation of the time slices the amplitude at all these points stack in phase and accumulate the diffracted energy, noise stacks out of phase and therefore averages to a small number. Figure 1 illustrates the process of filtering and adding schematically.

The advantage of this migration scheme is that the summation does not have to be carried out for each point in the time slice, instead a time slice can be migrated as an entity. This feature together with the vectorizability of the process can save computation time and eventually lead to future interactive applications.

Migration Algorithm



ESTIMATED COMPOSITION OF THE PARENT MAGMA FOR THE BMD MASSIF, BAY OF ISLANDS COMPLEX. Nazneen Kharas-Khumbatta, Department of Geosciences, University of Houston, Houston, TX 77004.

In recent years, great importance has been given to studies aimed at inferring the compositions of primitive and even primary magmas for oceanic rocks. Since direct sampling of oceanic lithosphere is not readily possible, the study of ophiolites assumes great importance in this problem. Ophiolites represent slices of obducted oceanic lithosphere where crustal sections have been formed by the fractionation of primary melts derived by partial melting of the upper mantle.

Two opposing views are commonly expressed for the composition of the primary magma. Some workers feel that primary melts are generated by partial melting of upper mantle at shallow depths (<10 Kbars) below mid ocean ridges and compositions are represented by MORBs with 9-11 weight % MgO [1-3]. An alternate origin for primary basalts having 17-20 weight % MgO has been postulated, indicating these are melts segregating from the upper mantle at high pressures (15-25 Kbars) and have undergone variable degrees of fractionation before erupting on the earth's surface [4-7].

Recent parent magma studies from ophiolites are mainly based on mass-balance calculations [6,8]. These calculations were applied to the Blow Me Down (BMD) Massif, Bay of Islands Complex in Newfoundland, Canada. This massif forms part of a series of exposed oceanic rocks along the western coast of Newfoundland. Two complete traverses were modelled for the BMD massif which spanned the entire crustal stratigraphy and were termed the Eastern and Western traverses. An average chemical composition in terms of major and minor oxides and trace elements (Zr, Y, Rb, Sr, Ni, Cr) was determined for each of the different crustal stratigraphic units. The averages for all the units were summed together in proportions weighted according to their stratigraphic thicknesses in each traverse. Average parent magmas for the two traverses were named EPM (Eastern traverse parent magma) and WPM (Western traverse parent magma) to facilitate the discussion.

The main contrasting chemical feature between EPM and WPM is the difference in MgO weight % ranging from 11.29 in EPM to 25.74 in WPM. The more than doubled MgO weight % in WPM is a consequence of the large proportion of dunite (nearly 40%) contributing to that traverse.

The BMD Parent Magma (BAP) was calculated by averaging the compositions for the two traverses. Table 1 shows the calculated chemical composition for BAP. A number of other parent magmas, as postulated by different authors are also portrayed in the same table. In contrast to other postulated parent magmas, BAP indicates the highest pressure of formation from a study of pseudoliquidus diagrams [11]. It falls on the OL-OPX cotectic at 25 Kbars, a small distance from the 25 Kbar eutectic point. It is almost identical to the calculated parent magma for the Tortuga Ophiolite in Chile [6]. The Bay of Islands Complex and the Tortuga Ophiolite are widely separated in both space and time. The fact that parent magmas for these ophiolites are so similar suggests that processes controlling the formation and development of the oceanic crust are greatly similar both spatially and temporally.

TABLE 1 : PARENT MAGMAS FROM DIFFERENT STUDIES

(Wt %)	BAP	SAVE[8]	Saudi[9] Picrite	Spinel[10] Incl.	Tortuga[6] Ophio.
SiO2	46.64	51.10	45.90	50.26	47.25
TiO2	0.71	0.60	1.60	0.61	0.79
Al2O3	13.28	16.60	14.20	14.21	13.64
FeO	7.93	5.83	11.34	0.14	8.79
Fe2O3	0.98	0.72	-	0.76	1.09
MnO	0.15	0.12	0.17	0.10	0.14
MgO	18.51	9.20	12.10	11.89	17.61
CaO	8.42	12.80	9.00	13.46	9.58
Na2O	1.83	2.30	2.20	1.42	0.89
K2O	0.14	0.12	0.51	0.07	0.06
P2O5	0.09	0.05	2.20	0.00	0.00
FeO*/MgO	0.48	0.71	0.94	0.57	0.55
Mg *	0.80	0.73	0.65	0.77	0.77

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TRACE AND MAJOR ELEMENT GEOCHEMISTRY OF TWO XENOLITH BEARING ALKALIC BASALTS FROM XALAPASCO DE LA JOYA, SLP, MEXICO: A PRELIMINARY REPORT;

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Two relatively fresh xenolith bearing alkalic basalts from the Cenozoic maar Xalapasco de La Joya, SLP, Mexico have been analyzed for their major and trace element compositions (XRF and INAA). In spite of the very high MgO and slightly lower Al_2O_3 contents, the major element data of these two basalts are very similar to the typical olivine nephelinites and some xenolith bearing basanites around the world [1,2,3,4]. CIPW norm calculations indicate that these two basalts are very high in normative olivine and nepheline belonging to the olivine nephelinite suite. As shown in Table 1, the MgO content and Mg#s are very high for these two samples (14.96 wt% and 71.2 for X-30, 16.86 wt% and 73.5 for X-500) reflecting their very primitive nature. Assuming a partition coefficient of 0.3 for FeO/MgO between olivine and basaltic magma [5], the Mg#s of olivine in equilibrium with these two basalts are 89.2 and 90.2 respectively.

Table 1. Bulk rock major (in wt%) and trace element (in ppm) data

	SiO2	TiO2	Al_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	Cs	Sr
X-30	43.02	2.47	11.03	10.80	0.19	14.96	9.59	3.20	1.92	1.05	98.23	0.40	812
X-500	42.55	2.39	10.69	10.82	0.19	16.86	9.76	2.49	1.61	1.09	98.45	0.53	902

	Rb	Ba	Y	Th	U	Hf	Zr	Ni	Cr	Co	Sc	La	Ce	Nd	Sm	Eu	Tb	Yb	Lu
X-30	28	450	31	6.4	1.74	5.8	290	521	952	56.9	15.9	49.9	102	46.2	8.74	2.74	1.06	2.02	0.25
X-500	27	644	24	5.5	1.24	5.3	266	633	893	59.6	15.6	51.5	104	55.5	9.28	2.78	.88	1.72	0.28

Among the four compatible trace elements, Co and Sc contents are very similar to the typical abundances in olivine nephelinites [2,3,4]. Ni and Cr, on the other hand, are higher than the similar rocks reported (200-460 ppm for Ni, 100-520 ppm for Cr), except the one by Eiche and others (1987). Two posssible interpretations for these normal Co and Sc but higher Ni and Cr abundances are proposed here. Similar to Eiche and others (1987), these two samples represent the least fractionationed primary alkaline magmas produced by small degrees of partial melting (e.g. 0.6-4%) of a garnet peridotite at higher pressures (e.g. P>25 Kb). By using a equilibrium melting model [6], a mantle source with 4800-5800 ppm Ni and 3300-3900 ppm Cr were obtained. An alternative to this is the mechanical mixing model in which the above resulted from mixing with the genetically unrelated spinel lherzolites (with/without preferential dissolving of OPX+SP+/-CPX) on their way to the surface. Mass balance calculations show that mixing with 5% and 11% spinel lherzolite (an average composition) from that area are needed to account for the higher Mg#, Cr and Ni contents in X-30 and X-500 respectively, if a primary magma having a Mg# of 69, a Cr content of 700 ppm and a Ni content of 460 ppm was used in the calculation. Preferential dissolving of OPX+SP (5-10%, OPX/SP= 20-33) only were better to account for the high Cr content (e.g. to 520 ppm) but weaker for Ni (600 ppm).

Compared with the primordial mantle [7], the highly incompatible elements Rb, Ba, Th, U, K, Sr, P and LREE in the two samples are enriched by factors of 50-80, while the moderate incompatible elements Y and HREE are only enriched by factors of 5 to 10, which are typical of alkalic basalts [1,2,3,4]. A Eu anomaly is not observed in either sample, suggesting that contamination from crustal rocks are below the present detection limits. Futher isotopic data (e.g. $Sr^{87/86}$, $Nd^{143/144}$) is needed to constrain the mixing problem. In spite of the debated nature of their very high Ni, Cr and Mg#s, the incompatible element abundances in the two samples usually fall in the low abundance end for a suit of alkalic basalts. Chondrite normalized LREE/HREE ratios are fairly lower, namely 19-20, suggesting the very primitive nature of these two samples. By assuming a minimum amount of CPX (+/-Garnet) fractionation, the possible mantle sources and degrees of partial melting were examed using the equilibrium melting model [6]. Extremely small degrees of partial melting (e.g. <0.05%) of a depleted mantle source (LREE~1.3x, HREE~2.1x ch) [7] was required to account for the observed REE pattern. Only 1% of partial melting was needed for a primordial mantle source (LREE~2.9x, HREE~2.4-2.6x ch) [7]. And 6% of partial melting of an enriched mantle source (LREE~10-13x, HREE~3-4x ch) [2] was expected to produce a melt with the similar REE pattern.

To summarize, the two samples reported here represent a very primitive lava composition (though the higher Ni, Cr are debated) suffering from a minimum degree of fractionation. The very reliable incompatible element data suggest that they were resulted from small degrees of partial melting of a garnet peridotite at high pressures (e.g. P>25Kb). An enriched mantle source is slightly favored over the depleted one due to the physical possibilities involved for extracting such small amount of melt.

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THE NORTH AMERICAN TEKTITE STREWNFIELD: INTRAFIELD RELATIONS AND PARENT MATERIALS. Karen M. Love, Department of Geosciences, Univ. of Houston, Houston, TX 77004.

The North American strewnfield consists predominantly of tektites from Texas and Georgia. Although geographically separated, these two tektite occurrences have been linked to a single hypothesized impact event on the basis of geochemical data and a common age of approximately 35 million years. A regression analysis, however, of location (Texas versus Georgia) on major element composition reveals that as few as three elements suffice to predict location at the 0.05 significance level. This result suggests that the two groups, although possibly originating from the same event, represent either 1) different parent materials, probably from a range of excavation depths; 2) two distinct products of selective volatilization; or 3) two distinct ends of a theoretically continuous compositional spectrum, derived from the same parent materials, but missing the mid-range compositions. If the latter supposition is correct, both the bediasites and the Georgia tektites should show the same interelement relations; however, the chemical relations within each group are different, suggesting either different source materials or dichotomous volatilization.

Given the chemical distinctiveness of the Texas and Georgia tektites, attempts to identify source materials for the North American tektites must undertake separate evaluations of each group. For this reason, analyses using only bediasite data were conducted to determine their potential source materials. Models developed using new statistical tests for compositional data allowed statistically rigorous evaluation of a series of geologically viable parent materials, resulting in the following conclusions: the bediasite chemistries 1) cannot be explained solely as an effect of selective volatilization of a single source material; 2) require a minimum of two contributing endmember materials; and 3) suggest a binary mixture of endmembers chemically resembling a subarkose and a ferro-aluminum residual clay.

THE SIGNIFICANCE OF *Oldhamia* IN THE BLOW ME DOWN BROOK FORMATION, WESTERN NEWFOUNDLAND. Rosanne M. Lindholm, Dept. of Geosciences, University of Houston, Houston, Texas 77004.

Sedimentary structural slices occur beneath ophiolitic and volcanic units in the Humber Arm Allochthon of western Newfoundland. In the Bay of Islands area, the structurally highest sedimentary slice is a conspicuous, relatively coherent unit designated the Blow Me Down Brook Formation that consists of alternating units of turbiditic coarse- to medium-grained arkosic sandstones and subordinate shales. The age and tectonic depositional environment of this unit along with its correlation with other siliciclastic units within the allochthon has remained uncertain due to the lack of fossil control.

Trace fossil assemblages are common in the shales of the Blow Me Down Brook Formation. *Oldhamia*, a late Precambrian to Early Cambrian trace fossil, is a common member of these assemblages. The presence of this fossil confirms that the Blow Me Down Brook Formation represents late Precambrian-Early Cambrian turbiditic deposition along the recently rifted North American margin during the early history of the Iapetus Ocean and does not, as it was previously interpreted, represent a Middle Ordovician flysch facies associated with the Taconic Orogeny. *Oldhamia* has been found at 20 localities along the length of the allochthon and is present in the highest sedimentary slice beneath each of the ophiolitic massifs (i.e., Table Mountain, North Arm, Blow Me Down, Lewis Hills) and thus helps define the Blow Me Down Brook Formation as a relatively continuous and coherent thrust slice. The presence of *Oldhamia* is also useful in differentiating the Blow Me Down Brook Formation from Middle Ordovician flysch (Lower Head Formation). The flysch appears to occur primarily near the base of the allochthon and, in the Bay of Islands area, is highly broken, dismembered, and often converted to melange.

An Early Cambrian age for the Blow Me Down Brook Formation places some constraint on the age of rifting of the Iapetus Ocean. This unit represents a "deeper-water" facies (probably a facies equivalent to the shallow-water Early Cambrian Bradore Formation), and, as such, suggests its deposition occurred in a young, but established, oceanic basin subsequent to the rift-drift transition.

GEOPHYSICAL INVESTIGATION OF THE AUSTRALIAN-ANTARCTIC DISCORDANCE ZONE.

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The Australian-Antarctic Discordance zone (AAD) is an anomalous segment of the Southeast Indian Ridge (SEIR) characterized by anomalously deep depths, rough north-south trending morphology, and asymmetric spreading. The segment is bounded on the east and west by large transform faults across which major changes in depth, morphology, magnetic anomaly amplitude, seismicity, and geochemistry occur. This ridge segment is most unusual when compared to other mid-ocean ridges, and it is reasonable to postulate that some unusual process is associated with the AAD and is the source of many of the anomalous features observed.

Sufficient quantities of high quality data cover the AAD and surrounding region to permit a thorough investigation of the process to be made. The intent of my research is to perform such an investigation. In particular, the research will determine the physical properties of the process, interpret the properties in light of a possible dynamic source, and examine the influence of the process on the tectonics of the region. These tasks will be accomplished in series of steps. The first step is to determine the physical properties of the AAD by constraining mantle properties predicted from solid earth geophysics with observed geophysical data. The second step entails constructing a forward model of a dynamic process from the determined AAD properties, and comparing signals computed from the model to those observed over the AAD. Finally, the last step is to ascertain whether the past and present regional tectonics corroborate the AAD model.

Once the properties and dynamics associated with the AAD process have been determined, important correlations with other oceanic plates and ridges can be made. For example, the influence of the AAD mantle process on the SEIR can be constructively compared with the better understood influence of hotspots on other ridges. Mantle processes are also expressed in oceanic plates away from ridges, in the form of correlated depth and gravity anomalies. If the SEIR ridge effects are properly removed from the observed AAD depth and gravity anomalies, the remaining anomalies can be compared directly with anomalies viewed in other oceanic plates. An increased understanding of both the mantle process associated with the AAD and mantle processes associated with other ridges and oceanic plates will result from these comparisons.

The scientific contributions resulting from this proposed research will be fourfold. In short, the AAD properties, dynamic source, and influence on the regional tectonics will be determined. Additionally, an increased understanding of the influence of mantle processes on other oceanic ridges and plates will result.

ON THE ORIGIN OF SUBOPHIOLITIC BASALTS FROM THE HUMBER ARM ALLOCHTHON OF WESTERN NEWFOUNDLAND. David P. Meaux, University of Houston, Dept of Geosciences, Houston, TX. 77004

Several geographically distinct basalt suites occur as individual tectonic slices along the length of the Humber Arm Allochthon in western Newfoundland. The structural position of the basalts is consistent relative to overlying and underlying tectonic slices. The basalts typically occur beneath ophiolite massifs of the Bay of Islands (BOIC) and Coastal Complexes (CC) and are above a regionally and laterally persistent slice known as the Blow Me Down Brook Formation. Models of ophiolite emplacement suggest the basalts originated sometime between 600 m.y.a. and 450 m.y.a. in an area between the proto North American continental margin and an encroaching island-arc.

Geochemical investigations of the basalts are hampered by the abundance of low-grade metamorphic mineral assemblages which have replaced most primary minerals. Previous investigators have shown that these basalts underwent zeolite facies metamorphism characterized by high μH_2O and low P conditions. Under such conditions certain major and trace elements are mobilized by hydrothermal fluids. Thus, they cannot be utilized, via analytical chemistry, to characterize primary geochemical processes which were present during original emplacement. Investigations must instead center on elements which were immobile during low-grade metamorphic conditions. Examples include the high field strength elements (HFSE), REE, and certain highly compatable trace elements such as Ni and Cr.

The origin of three subophiolitic basalt suites have been studied using this approach. Each is located along the west coast of Newfoundland in and around the Bay of Islands. Each locality is separated by an approximate distance of 40km. The first of these is located in the BOI and is here referred to as the Woods Island basalts. Low Zr/Y ratios coupled with very low HFSE abundances of samples suggest an island-arc origin. This is supported by high abundances of Ni and Cr. REE concentrations are moderately LREE-enriched ((Ce/Yb)n = 2.13 ,La = 60 x chon.). The Beverly Cove basalts to the north seem quite different. They are characterized by moderate Zr/Y ratios more indicative of ocean floor basalts. Other HFSE ratios suggest a MORB affinity. This is supported by LREE-depleted patterns ((Ce/Yb)n = 0.75 ,La = 6 x chon.).

Probably the most noteworthy slice is the Skinner Cove basaltic sequence. High TiO_2 and P_2O_5 values coupled with high Zr/Y ratios indicate that these basalts are moderately alkalic. This is supported by high TiO_2 values in unaltered clinopyroxenes (3%). REE concentrations are highly LREE-enriched ((Ce/Yb)n = 15 ,La = 200-500xchon.). Although it is certain these basalts were derived from a within-plate provence, it is unclear whether this was a continental or oceanic environment. La/Nb ratios of 1.0 - 1.4 suggest that the basalts could have interacted with continental crust before emplacement. However, these values are similar to those seen in the modern-day ocean islands of Gough and Tristan da Cunha and typify La/Nb ratios from regions of enriched or undepleted mantle. Forthcoming Sm/Nd isotopic data should help to further resolve the origin of the Skinner Cove basalts.

MIOCENE RADIOLARIAN BIOSTRATIGRAPHY AND PALEOCEANOGRAPHIC RECONSTRUCTION OF BAJA CALIFORNIA AND TRES MARIAS ISLANDS, MEXICO.

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A total of eight land-based sedimentary sections and one offshore site (Experimental Mohole) were studied. Four sequences are from Baja California and two from the Tres Marias Islands. Based on the tropical radiolarian zonation proposed by Riedel and Sanfilippo (1978), the radiolarian zones recognized in this study were: *Dorcadospyris alata, Diartus petterssoni, Didymocyrtis antepenultima, D. penultima* and *Stichocorys peregrina.* However, the *Didimocyrtis antepenultima* Zone (time range between 10.1 and 7.8 Ma.) is the best represented in the sections studied. The zones recognized were also correlated with the cold water radiolarian assemblages of Weaver *et al.* (1981) in southern California (endemic fauna of the California Current). This correlation appears best with the northern Baja California sections and Experimental Mohole.

Paleo-distributional and paleo-environmental data of Holocene and Tertiary radiolarians from the Pacific Ocean were extrapolated to reconstruct relative paleotemperatures, paleocirculation and paleo-upwelling. Results include the recognition of warm and cold episodes possibly related to changes in strength of the California Current and maybe also related with the paleo-Niño event. The most significant siliceous deposition in Baja waters occurs between 10.1 and 7.8 Ma within the *Didimocyrtis antepenultima* Zone. These upwelling conditions were interrupted by much warmer conditions around 11 to 10 Ma. and around 8 Ma., which might coincide with the warm events (11, 10, 9 and 8 Ma) reported by Barron and Keller (1983) based on diatoms and planktonic foraminifera from the northeastern Pacific and the warm event (8 Ma) based on radiolarians from the Northern Pacific (Romine, 1985). This well-reported warm event at 8 Ma and the relative paleotemperatures obtained in this study (15° to 22° C in the northern sections and 26° C in the southernmost section) suggest paleo-El Niño conditions and, therefore, a weak paleo-California Current so that the paleo-Eastern Tropical Warm Water fauna reached farther to the north at that time.

The radiolarians in the San Felipe section represent an endemic fauna with affinities to that of the Gulf of California, although somewhat older in age (7.8- 5.5 Ma.).

HYDROGEN ISOTOPE RATIOS OF KAOLINITES IN THE LOWER CRETACEOUS DAKOTA GROUP AND MOWRY SHALE, NORTH-CENTRAL COLORADO: EVIDENCE FOR A TERTIARY EQUILIBRATION EVENT.
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Hydrogen isotope analyses have been made on kaolinites from the Lower Cretaceous Dakota Group and Mowry Shale east and west of Denver, Colorado. Modern meteoric waters of north-central Colorado were also collected so that their hydrogen isotope values (δD) relative to SMOW could be compared to the δD values from the kaolinites.

If the kaolinites are in isotopic equilibrium with the modern meteoric waters, their values would be approximately 30%. lower than the meteoric waters. However, the average δD value of all the kaolinites is significantly higher than the meteoric waters. This indicates that the Dakota and Mowry kaolinites do not reflect isotopic equilibrium with the modern meteoric waters of north-central Colorado.

Kaolinites formed in equilibrium with meteoric waters from cooler climates have lower δD values than kaolinites formed in warmer climates. Calculations indicate kaolinites in equilibrium with warm meteoric waters of the Early Cretaceous would have higher δD values than those of this study. During the Late Cretaceous, elevated temperatures due to burial of the strata would also have increased the δD values higher than the values of this study. As temperatures were cooler during the Pleistocene, δD values which date from this time would be lower than the values of this study. Therefore, the δD values of this study must post-date the Early Cretaceous and pre-date the Pleistocene.

Laramide activity during the Latest Cretaceous and Early Tertiary uplifted the kaolinites and exposed them to large quantities of meteoric waters. Kaolinites in New Mexico known to have formed during the Tertiary have δD values similar to the Dakota and Mowry kaolinites. Additionally, previous work involving Paleozoic kaolinites in south-central Colorado indicate recrystallization took place during or after Laramide activity. Their calculated δD values are also similar to those of this study. Therefore, equilibration between the Dakota and Mowry kaolinites and meteoric water most likely occurred during the Tertiary.

CHEMICAL STRATIFICATION IN MAFIC MAGMA CHAMBERS: EVIDENCE FROM OPHIOLITES AND BASIC LAYERED INTRUSIONS. Kent Ross University of Houston, Houston, Texas.

Investigations of cumulate mineral compositions in layered ultramafic and gabbroic rocks in ophiolitic cumulate sequences and in basic layered intrusions have shown that magma fractionation is recorded by changes of mineralogy and mineral compositions with stratigraphic height. These studies have revealed complex patterns of fractionation with repeated reversals in chemical trends rather than the steady decline in fractionation indices (such as Fo in olivine and Mg# in pyroxene) expected for closed system fractionation. Recent studies have utilized a fine-scale sampling approach, with samples collected every 10 to 100 centimeters. These studies demonstrate that magmatic trends can best be resolved with this fine-scale approach. In particular, fine-scale studies of cryptic variation have been reported by Browning (1984), Samail ophiolite; Elthon et al. (1984), Komor et al. (1985, 1987) and Ross et al. (1987), for the Bay of Islands ophiolite, by Wilson (1982) for the Great Dyke; and by Raedeke and McCallum (1984), Barnes and Naldrett (1986), and Ross and Elthon, (1988) for the Stillwater Complex (Fig. 1).

The narrow stratigraphic interval encompassed by the normal fractionation trends in these studies, such as unit B in Fig. 1, suggest that small magma batches, representing a small fraction of the magma resident in the chamber at any one time, undergo differentiation in quasi-isolation from other magmas in the chamber. Using an equation developed by Browning (1984) it is possible to calculate the height of the liquid column that crystallized a particular cryptic layer. The height of the magma layer that crystallized unit B is 150 meters, using Mg/Fe partitioning between orthopyroxene and liquid. The maximum exposed thickness of cumulates in the Stillwater complex is approximately 6 km. The roof zone of the complex is not exposed. An unknown quantity of upper level cumulates were removed by erosion. It is believed that the quantity of magma in the chamber greatly exceeded the 150 meter thickness determined for unit B. This suggests chemical stratification in the Stillwater magma chamber. A model similar to that proposed by Irvine et al. (1983), with layers of magma separated by double-diffusive interfaces depositing distinct cumulus assemblages is supported. Adjacent magmas ultimately mix when the density and/or temperature contrast between them becomes very small. Repeated magma replenishments and/or convective motions in the chamber provide more primitive magmas which partially mix with more evolved magmas to produce many hybrid magmas and lead to deposition of reverse layers such as units A and C in Fig. 1.

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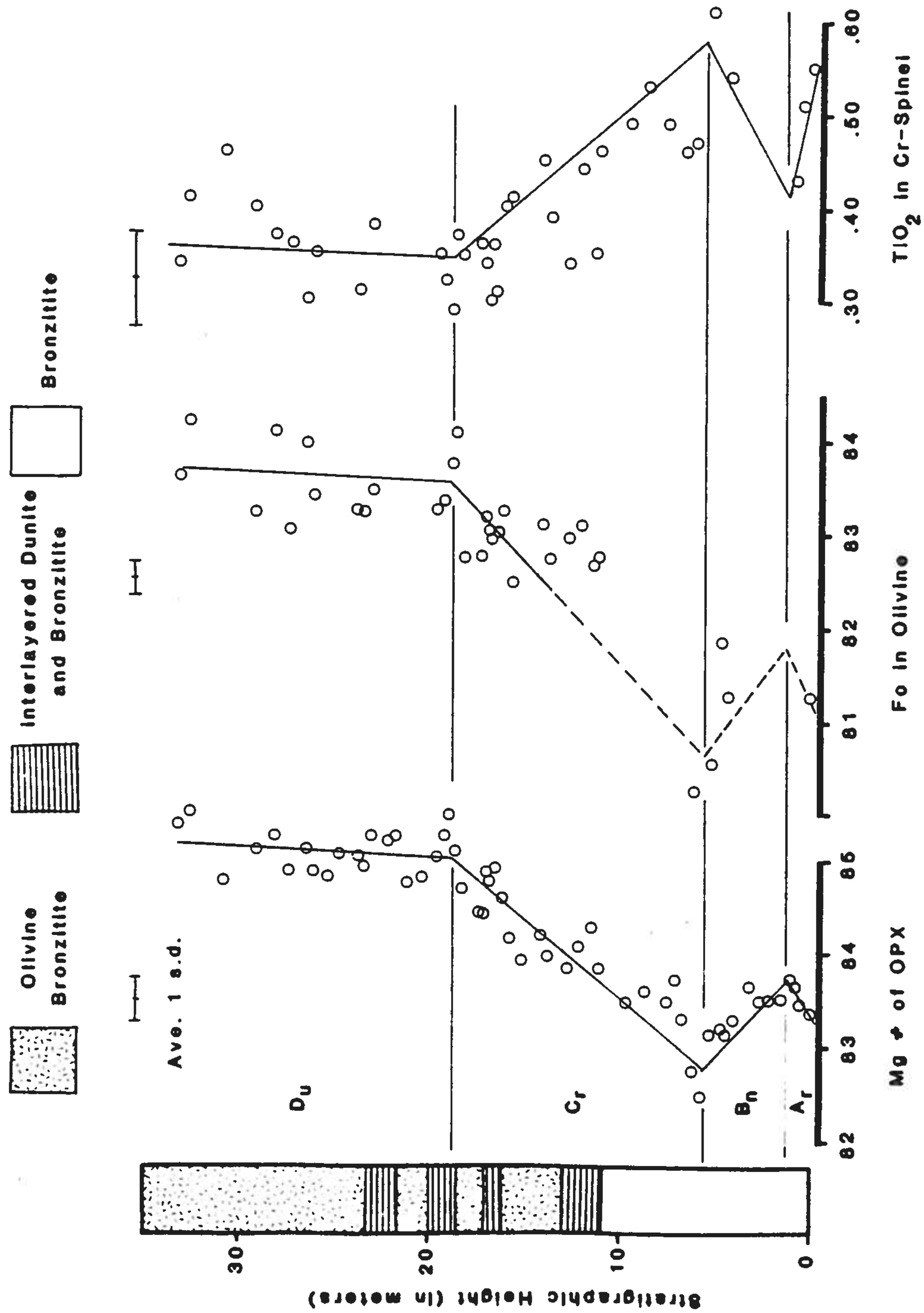

Figure 1. Cryptic layering in a fine-scale traverse within layered ultramafic rocks from the Stillwater Complex, Montana.

IDENTIFICATION, GEOMETRY, AND MOVEMENT HISTORY OF ACTIVE SURFACE FAULTS IN FORT BEND COUNTY, TEXAS. John H. Ruhl, Department of Geosciences, University of Houston, Houston, TX 77004.

Newly discovered surface faults in Fort Bend County, Texas increases the number of known surface faults in the Houston Area. An investigation was initiated in June, 1985 to identify and map previously unreported surface faults. Additionally, both the map view geometry and cross-sectional geometry were studied. Subsurface geometry of applicable faults was analyzed, in part, to prove a connection between surface traces and deep subsurface faults. Movement along individual faults, between faults, and comparison of this movement to movement of previously documented surface faults in the Houston Area are being analyzed.

Using six complete sets of aerial photographs ranging in years from 1940-41 to 1985, photolineaments were mapped onto a county base sheet (scale: 1"=1 mi.). Subsurface faults from the Frio and Yegua formations were projected to the surface. A topographic map consisting of 1-foot contour intervals was examined for closely spaced contours. All lineaments were field-checked where possible for disruption of man-made structures, or vegetative patterns related to surface faults. Surface geometry will be analyzed noting length and sinuosity of faults. Topographic surveys using a water-level yielded a cross-sectional surface geometry. Water well logs, oil well logs, and seismic reflection data allowed for construction of a 3-dimensional subsurface fault plane geometry. Movement histories for individual faults will be determined over geologic time using paleontologic information; and more recently using the topographic profiles adjusted for original street geometry and time of street emplacement.

Of approximately four hundred surface lineaments investigated, thirteen of these lineaments are surface faults. Eight of these faults are radial faults off of salt domes, the remaining five are regional in nature. All but one of the radial faults is located near the Blue Ridge salt dome. Ten of the thirteen faults trend northeast-southwest, two trend northwest-southeast, the other trends east-west. All but one of the regional faults is downdropped to the coast. Analysis of the Clodine fault demonstrates a shallowing of dip angle with depth. In two cases, where the surface trace of a fault terminates laterally, so does the fault in the subsurface. Cross-sectional scarp geometries of many of the surface faults follows patterns already described in the literature. Unlike previous works, scarp geometries in this study are imprvoved in that the bias of the original street geometry has been mathematically removed. Using this procedure in addition to learning the date of emplacement of certain streets has yielded movement rates of apprroximately 1cm/yr for several faults in the Blue Ridge Area. If specific time datums can be attached to Tertiary microfossils, movement rates over geologic time can also be calculated.

John H. Ruhl

This study has shown that surface faults are not shallow cracks, but are instead deep subsurface fractures reaching up to the surface. Removing the bias of original street geometry has made visible those scarps which would have gone unseen, thus possibly leading to incorrect conclusions regarding the existence of a particular surface fault. It is also noted that road materials also affect the geometry of a scarp. The lateral extent of subsurface faults planes extends no further that the surface trace. Of the faults recognized in this study , all appear on aerial photographs before the Houston subsidence bowl reached Fort Bend County. The greatest concentration of faults occurs near the Blue Ridge salt dome, most likely related the to the very shallow nature of the dome. It is inconclusive at to the cause of contemporary movements for surface faults in either Fort Bend County or the Houston Area in general.

DIAGENETICALLY ALTERED STABLE ISOTOPE VALUES FROM PETROGRAPHICALLY PRISTINE BRACHIOPODS: L.DEVONIAN HELDERBERG GROUP, NEW YORK STATE

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Brachiopods in the Devonian Helderberg Group carbonates and overlying Oriskany Sandstone are preserved with either an "unaltered" fabric which exhibits extremely fine preservation of original texture, or as neomorphosed coarsely crystalline bladed calcite. Petrographically pristine-looking, as well as obviously neomorphosed brachiopods, both display the same diagenetically altered carbon isotopic signatures. The carbon values of all skeletal components, including the petrographically well-preserved brachiopods, show a gradational change with stratigraphic distance beneath a Devonian unconformity. These values range from 2 to 3.5 ‰ PDB approximately 40 meters below the unconformity to -.06 to 1.5 ‰ PDB immediately subjacent to the unconformity. Superjacent to the unconformity, brachiopods retain an isotopic signature of 2.3 to 3.7 ‰ PDB, which is similar to values observed well below the unconformity. Diagenesis of the skeletal material must have occurred in contact with a meteoric system during the Siegenian (Lower Devonian) exposure. Of greater significance, petrographically pristine brachiopods have not retained their original carbon isotopic signature, instead these brachiopods have equilibrated with lighter meteoric waters without any visible change in their skeletal ultrastructure.

This analyses was performed on the Lower Devonian Helderberg Group of Central New York State. An accumulation of paralic to shallow open marine carbonates deposited on a shallow gradient (1:8000) ramp in a slowly subsiding (1.5 cm/1000 yrs) foreland basin.