B11F-06 1150h

Distribution of Aeolian Dust Determined From Magnetic and Chemical Properties in Surficial Substrates of Grassland and Shrubland, Central Colorado Plateau (Utah)

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Rock-derived nutrients in soils originate from both local bedrock and atmospheric dust. Distinction between sediment derived from local bedrock and from dust provides better understanding of nutrients and the processes responsible for their distributions across landscapes. Sandy surficial deposits overlying dominantly sandstone substrates cover vast upland areas of the central Colorado Plateau. These deposits typically contain 5-40% fines (silt and clay measured using laser-diffraction methods), depending on geomorphic setting and slope (excluding drainages and depressions). Far-traveled aeolian dust in the deposits is indicated by the presence of titanium-bearing magnetite grains that are absent in the sedimentary rocks of the region. Thus, the quantity of dust can be estimated from magnetic properties that primarily reflect magnetite content, such as isothermal remanent magnetization acquired at 0.3 Tesla (IRM3). IRM3 was measured on bulk (<2 mm) sediment samples (IRMsoil; 0-10 cm depth) from a transect in surficial sediment (10 samples, each separated by 20-30 m) down a 2-3 degrees slope away from an exposure of Cedar Mesa Sandstone. The mass proportion (f) of aeolian fines in each sample was calculated using values of IRMsoil, IRMrock (average of 19 samples of regionally distributed Cedar Mesa Sandstone), and IRMdust (on sediment deposited over four months in nearby dust collectors at 2-m height determined on sand-free and organic matter-free bases): f=(IRMsoil-IRMrock)/(IRMdust-IRMrock). Very small magnetic contributions from hematite are responsible for the IRMrock value, which is 6 to 60x less than IRMsoil values. IRM-based calculations show a systematic down-slope increase in aeolian dust (2-18%), similar to the down-slope increase in total fines (18-40%). Aeolian dust calculated by the same method using titanium and vanadium contents closely matches the IRM-based results (6-20% and 5-19%, respectively). IRM-based dust estimates of soils correlate much more strongly with P, Na, K, Mn, Fe, Zn, and Mg (r^2>0.8) than do amounts of total fines. The combination of substantial aeolian dust contributions to soil fines and high concentrations of rock-derived nutrients in dust relative to local parent materials suggests that dust is a major source of potential plant nutrients in this setting.

B11F-07 1205h

Detection of the geographic distribution of source soil mineralogy in long range transported aerosol from Ca measurements and simulations in the Dust Entrainment And Deposition (DEAD) model

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Calcium carbonate plays important indirect forcing roles in the chemical and biogeochemical system. Dust-borne $CaCO_3$ determines whether dust forms $Ca(NO_3)_2$ and deliquesces at ambient relative humidity, helps determine aerosol pH, and limits uptake of reactive species such as HNO_3 and SO_2. We compare simulations with the Dust Entrainment and Deposition Model (DEAD) to observed climatologies of $CaCO_3$ at stations worldwide. Simulations employing realistic spatially heterogeneous $CaCO_3$ content in source soils perform better than simulations which assume the same global-mean $CaCO_3$ content is homogeneously distributed in Earth's soils. The signature of soil $CaCO_3$ heterogeneity is detected in mineral dust deposition at remote downwind stations in the Atlantic and Pacific. Examining the $CaCO_3$ deposition flux normalized by the annual dust deposition flux, we find that North Atlantic deposition is relatively poor in $CaCO_3$ due to lower-than-average content in African source regions. In contrast, Asian deposition is relatively high in $CaCO_3$ due to alkaline Central Asian soils. This regional $CaCO_3$ abundance amplifies the role of dust in heterogeneous chemistry in Asian regions. Summertime Asian dust reduces tropospheric O_3 more strongly than African dust to Asian dust encountering more ozone precursors (e.g., NO_x) and having greater $CaCO_3$ abundance. Our simulations show that assuming soil composition is globally uniform leads to detectable biases. This has important implications not only for $CaCO_3$, but for other biogeochemically significant mineral carried in dust such as Iron and Phosphate.

B12A MCC: Level 2 Monday 1330h

From Mantle to Microbe: Ridge2000 Research and Progress Posters *(joint with OS, T, V)*

Presiding: **C Fisher,** Pennsylvania State University**; D K Smith,** Woods Hole Oceanographic Institution

B12A-0725 1330h POSTER

Development of a Rapid, Standardized Data Inventory for R2K Field Programs

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Effective data management for Ridge2000 requires the production of a complete data inventory for every field program in a timely and standardized way. We are developing a set of forms to document 1.) basic field program information (dates and locations, platform, science party, etc); 2.) an inventory of sensor systems, data types (marine geophysical, physical and chemical oceanographic, rock and sediment samples, and biological), and file formats; 3.) supplemental attachments (written reports, instrument diagrams, etc); and 4.) a basic navigation track. We regard this as the minimal set of metadata which should be produced immediately at the end of a field program, in order to publicize it in an online database and satisfy agency requirements. We have developed a prototype set of Portable Document Format (PDF) forms which can be completed during a cruise through a combination of manual and automated input. PDF is a stable and widely-used format, with software available as both a commercial product (Adobe Acrobat) and an open-source library (http://www.pdflib.org). Completing a PDF form requires only the Acrobat Reader software, which is freely available for every major computing platform. Acrobat offers extensive functionality to aid in data inventory, including the ability to verify content on-the-fly, import data from other files and forms, show controlled vocabularies as pop-up menus, export to XML format, and print a high-quality readable report. Prototype forms have been tested on a recent transit of the CGC Healy, and we plan to continue testing on other ships and soliciting community feedback over the next several months. We envision a long-term plan in which a master set of forms is deployed with every R2K field program, along with a copy of Acrobat Reader, on lightweight storage media such as USB keys. The completed forms will then be transmitted to the data management center, where they are ingested automatically and the information made available in the online R2K database.

B12A-0726 1330h INVITED POSTER

Time-Critical Studies: Rapid response to Transient Dynamic Mid-Ocean Ridge Events

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The Time-Critical Studies (TCS) Theme of Ridge 2000 focuses on observations of the immediate geochemical and geobiological consequences of magmatic and tectonic events along the global mid-ocean ridge system. To date funding has centered on the Juan de Fuca and Gorda Ridges which are within the range of the U.S. Navy's Northeast Pacific Sound Surveillance System (SOSUS). NOAA's T-Phase Monitoring Program has accessed SOSUS in real-time since 1993, providing the TCS community with detection of seismicity associated with eruptive or tectonic activity along these two ridges. This remote detection of earthquake swarms along the N.E. Pacific mid-ocean ridge coupled to NSF funding for pre-event staging equipment and supplies has allowed directed and increasingly well-organized field responses to the event site. Major rapid and follow-up response cruises have been successfully mounted to 1993 CoAxial, 1996 and 2001 Gorda Ridge, the 1998 Axial Volcano, and 2001 Middle Valley magmatic episodes. The logistical approach required to study these events has been greatly facilitated by the RIDGE/Ridge 2000 programs and collaboration between university, NOAA and Canadian investigators. Not only have our studies of these events significantly impacted our ideas on the nature of crustal accretion, but they also have led to the discovery and preliminary documentation of a previously unrecognized biomass reservoir that lives below the seafloor and is swept out during these cataclysmic events, and to increased appreciation of the formation and thermal, chemical and biogeochemical implications of the 'Event Plumes' commonly associated with sea floor magmatic events. Rapid shore-to-event site response is an important aspect of TCS. Proposals to enhance the event detection and response effort are welcome at any Ridge 2000 target date. The Ridge 2000 program recognizes that even the most rapid ship response will miss the earliest subsurface and water column expressions of magmatic events. Consequently, Ridge 2000 also seeks proposals to develop alternate ultra-rapid response methods including air-droppable monitoring devices and in situ sensors. Coordination with Integrated Study Sites and proposed cabled and moored Ocean Observatories at Ridge 2000 Integrated Study Sites is also encouraged.

B12A-0727 1330h INVITED POSTER

The Eastern Lau Basin Integrated Studies Site (ISS)

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A new venue for Ridge 2000 (R2K) Integrated Studies, the Eastern Lau Spreading Center (ELSC) adds the element of a spreading center in a back-arc basin to the R2K program. The ELSC, located in the western Pacific near Tonga, is a 390 km-long first-order ridge segment that displays a broad range of effects of the back-arc environment. At its southern end it is only 40 km from the Tonga arc volcanic front and is propagating southward into a back-arc rift. At its northern end it is 100 km from the volcanic front and terminates at a large, non-transform offset. The ELSC displays substantial and systematic changes in multiple parameters: spreading rate, magma source and lava chemistry, axial depth and morphology, melt lens characteristics, and crustal thickness and structure. A main focus of the work at the ELSC is to determine how changes in these forcing functions affect key parameters such as magma source composition, crustal structure, and characteristics of hydrothermal venting such as temperature, chemistry, and faunal composition and abundance. Prior reconnaissance investigation shows that these hydrothermal field characteristics also vary within the southernmost segments, and show distinct differences compared with well-studied mid-ocean ridge sites. Four R2K cruises are planned for the ELSC in 2004. The first cruise (PI: Martinez) will investigate interrelationships among crustal structure, volcanism, and hydrothermal activity using deep tow, CTD's, and Tow-Yo. A second cruise (PI: Langmuir) will focus on petrological and water column properties using dredging, CTD's and ABE. The next cruise (PI: Tivey) will provide an initial characterization of vent fields, fluid chemistry, mineralogy, and biodiversity using Jason II and net tows, and a final cruise (PI: Childress) will investigate community ecology using Jason II. An additional study (PI: Thurnherr) will deploy autonomous floats to investigate hydrothermal plume circulation and dispersal . An overview of the site is presented here.

B

B12A-0728 1330h POSTER

Along-Axis Crustal Structure of the Lau Back-Arc Basin From Multichannel Seismic Observations

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The Lau basin is a back-arc, intermediate-rate spreading environment comprised of two complementary southward propagating ridge systems, the Central Lau Spreading Center (CLSC) and the Eastern Lau Spreading Center/Valu Fa Ridge (ELSC/VFR). Multichannel seismic images reveal systematic variations in axial crustal structure related to spreading rate, proximity to the volcanic arc, morphology, and petrology. Upper crustal refraction data selected from all seven along-axis seismic lines shot during this study were modeled in the t-x and tau-p domains to create velocity-depth models, providing validation and detail to the seismic reflection observations. As the spreading rate decreases southward from about 90 mm/yr to 40 mm/yr, several overall trends are apparent: 1) The average crustal depth of the axial magma chamber (AMC) increases from $\sim$1.3 km along the CLSC to $\sim$2.9 km along the VFR, excluding the northern section of the ELSC which lacks an axial high and shows no AMC reflector, 2) Seismic layer 2a thickens by $\sim$700 m, from $\sim$300 m in the northern extent of the basin to just over 1 km at the southern extent, and 3) The upper-crustal basement velocities decrease from $\sim$2.8 km/s to $\sim$1.9 km/s to $\sim$1.6 km/s along the CLSC, ELSC, and VFR, respectively. A closer look at the along-axis layer 2a thicknesses and AMC depths reveal discrete jumps within the overall trends that coincide with changes in the axial morphology; the ELSC, for example, transitions from axial high morphology and consistent layer 2a and AMC values of 900 m and 2.7 km, respectively, to the more blade-like morphology of the VFR whereupon the corresponding values become fairly fixed at 1.1 km and 2.9 km, respectively. Another key to understanding the Lau basin is noting the significant differences between the CLSC and the ELSC. The thinner layer 2a, shallower AMC, faster crustal velocities and axial morphology of the CLSC are usually indicative of fast-spreading environments, suggesting variations in spreading character within the basin. The ELSC and VFR were modeled with a thin ($\sim$250 m), lower-velocity layer that comprises the upper portion of layer 2a, thereby inferring a more porous, densely-fractured near-surface crust than at the CLSC. Along the VFR, the average velocity and depth values defining this low-velocity layer, in addition to the average AMC depth and crustal velocities, correlate well with values presented by *Turner et al.* in their 1999 analysis of a wide-angle seismic survey of the southern basin.

B12A-0729 1330h POSTER

Geomorphology of the East Lau Spreading Center

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The East Lau Spreading Center (ELSC) is a 390 km-long first-order ridge segment accommodating opening behind the Tonga subduction zone. The axial morphology of the ELSC changes in a way similar to the variation seen at fast- to intermediate-rate mid-ocean ridges (MORs) but with an opposite sense of spreading rate variation. The axis is comprised of en-echelon segments with non-transform overlapping offsets. From south to north the ELSC separates from the Tofua Arc volcanic front by 40 to 100 km as spreading rates increase from 40 to 85 mm/yr. At its southern end (22 45'S-21 25'S) the ELSC forms a narrow axial high with depths of about 1700-2000 m. Between 21 25'N and 20 43'N the ELSC axis deepens from 2000-2300 m and forms shallow and narrow valleys within a broader flanking high. North of 20 30'N the axis abruptly deepens again by 200-300 m. The axial depression continues to deepen and broaden to the north approaching 3000 m water depths. The deepening is not dynamically maintained as at slow spreading MORs, but rather reflects thinner crust near the axis than on the shallower flanks as indicated by local seismic measurements, by northward increasing mantle Bouguer anomalies, and by less volcanic and more tectonic morphology. The axial variations are mirrored on the flanks. They indicate systematically changing melting conditions in the mantle wedge as the spreading center propagated southward with its tip near the arc volcanic front and diverged northward from the arc. The axial variations imply that: The local proximity of the spreading axis to the volcanic front not only controls the degree of melting and crustal thickness and composition, but also in controls the occurrence and depth of magma chambers, crustal vesicularity, brecciation and faulting styles. In turn these effects should influence the style, intensity, and composition of hydrothermal circulation and the crustal mineralizations produced. Changes in morphology from a peaked shallow axial high to a broad deep axial valley may also influence near-bottom water circulation patterns, the dispersal of hydrothermal plumes and of vent biota. A planned survey of the ELSC Integrated Study Site will investigate the variations and interrelationships between crustal structure, volcanism and hydrothermal circulation along the length of the ELSC.

B12A-0730 1330h INVITED POSTER

The East Pacific Rise 8°to 11°N Integrated Studies Site (ISS); Update and Opportunities

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The 8°to 11°N segment of the East Pacific Rise (EPR) represents a dynamic, fast-spreading type of mid-ocean ridge selected for focused interdisciplinary study within the Ridge 2000 program. Diverse fast spreading environments are encompassed by the site including a hierarchy of axial segments and discontinuities. The site "bull's- eye" is at 9°49' to 9°51' N where numerous high temperature vents and diffuse flow communities have been mapped and monitored over the past 14 years. Concentric circles around the bull's eye encompass ridge segments at a range of scales, from the first-order segment bounded by the Siquieros and Clipperton transform faults to the fourth-order segment which includes the extent of the 1991 and 1992 volcanic eruptions. Five-year goals for the site include a working model of mantle flow and melt supply; detailed imaging of subseafloor structures and relationships to vent communities and chemistry; quantitative data about microbes and macrofauna and linkages with fluid flow, tectonics, and magmatism; quantification of the heat/chemical flux into the water column; and linkages and temporal variation in geological, chemical, and biological parameters. Field programs in 2002 collected data for calculations of primary and secondary productivity at different vent communities, with a focus on tube worms and bivalves; searched for hydrothermal signals from an earlier earthquake swarm; and continued time-series fluid sampling at all 9°10 to 9°51N high-temperature vents. 2003 cruises will continue geophysical/volcanological studies and deploy an array of in situ chemical sensors for use in monitoring vent fluids. Programs scheduled to begin in 2004 include three-dimensional multi-channel seismic and magnetotelluric studies of subsurface structure at the site "Bull's eye", initiation of monitoring studies of seismicity, fluid temperature and chemistry, and vent fauna. An overview of on-going and upcoming studies at the site will be presented.

B12A-0731 1330h POSTER

Sulfide Bioavailability and Potential Toxicity in the Environment of Vent Organisms: a Comparison of Characteristic Habitats of the EPR 13°N and 9°N Vent Fields

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Sulfide is a key player of biogeochemical interactions in deep-sea vent ecosystems, owing to its essential role in bacterial primary production and its potential toxicity to aerobic organisms. Still, the relative importance of these constraints in the different vent habitats remains poorly known. Contrasted chemical controls in the habitat of two invertebrate species were hypothesized, resulting of different sulfide speciation. The variability of sulfide geochemical patterns between different habitats at one site or between similar types of habitat at different sites or vent fields also has to be considered. From in situ analysis of sulfide and ferrous iron combined to pH and temperature sensing and chemical modeling we addressed sulfide to temperature dependence and sulfide speciation in the close vicinity of Riftia pachyptila bushes and Alvinella pompejana colonies at different 13°N and 9°N EPR sites. Very different sulfide to temperature ratios appear to characterize the environment of the two dominant organisms, even at the scale of one single site. The A. pompejana surroundings display an unexpectedly high sulfide to temperature ratio while this ratio is much lower in the tubeworm environment. In this last case, up to one order of magnitude difference is observed between sites, resulting in very different sulfide levels for similar temperature ranges. The iron to sulfide ratio was suggested to drive the biological impact of sulfide. As previously shown, partial sulfide detoxification can be expected in the environment of A. pompejana. Still, due to iron depletion in the fluid, the contribution of the most toxic sulfide form can be much more important at some particular sites with respect to the more general case. To the opposite, iron does not appear to influence sulfide bioavailability in the R. pachyptila environment, even for colonies displaying very contrasted patterns. A more complex combination of environmental and biological factors should be considered.

B12A-0732 1330h POSTER

Geomicrobiology of Archaeal Communities Isolated from an Off-axis Abyssal Hill Fault Scarp on the East Pacific Rise Flank at 9° 27'N

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Although heat flow studies suggest that 70% of the hydrothermal heat loss in the oceans occurs in the abyssal hill terrain on the flanks of mid-ocean ridges, very few off-axis hydrothermal sites have been discovered. In May 2002, sedimentary blowout structures of probable hydrothermal origin were discovered along East Pacific Rise at 9° 27'N on an off-axis abyssal hill bounded by a fault scarp covered with orange-brown microbial flocculations. Recovered samples of these flocculations have presented an opportunity to study the unknown nature and role of thermophilic and hyperthermophilic microbial communities on the ridge flanks. Furthermore, the archaeal communities that we have identified in the samples are useful "microbial tracers" which can be used to locate off-axis areas of moderate-to-high temperature fluid flow (>50°C). In this study, we used molecular techniques to isolate, amplify, and sequence community archaeal RNA sequences from fault scarp flocculations collected with a slurp pump system mounted in the Alvin basket. Molecular phylogenies based on 16S rRNA were constructed. Phylogenetic relationships of isolated clones were used to infer temperature preferences of archaeal communities. We identified 12 clones that clustered within thermophilic or hyperthermophilic clades within Archaea suggesting that moderately high temperature fluid (>50°C) exited the seafloor along this abyssal hill fault scarp. Our studies also suggest that these communities mediate the formation of Fe-sulfide mineral phases. Analysis of the samples with an Environmental Scanning Electron Microscope (ESEM) and X-ray energy dispersive analysis (EDS) revealed unique iron sulfide mineral phases with anomalously low Fe/S ratios in direct association with microbial communities.

B12A-0733 1330h POSTER

The distribution of species and biomass in *Riftia pachyptila* communities from environmentally different hydrothermal vent habitats at 9°N (East Pacific Rise)

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Hydrothermal vents have been characterized by high biomass, high productivity, high endemicity, and low species diversity. However these ecological characteristics are rarely quantified at an ecosystem level. At 9°N (East Pacific Rise), the giant tubeworm *Riftia pachyptila* can form dense aggregations in the dynamic mixing zone of hydrothermal vent effluent and deep-ocean bottom water. *R. pachyptila* must obtain carbon dioxide, hydrogen sulfide, and oxygen in order to support an obligate nutritional symbiosis with chemolithoautotrophic bacteria. In this patchy and ephemeral habitat, the tubes of *R. pachyptila* provide biogenic substrate that can support high relative abundances of heterotrophic species. As one part of a multidisciplinary collaboration to model the productivity in these habitats, the purpose of this study is to quantify the species composition and the biomass distribution in the *R. pachyptila* community. Within the scope of this work, a sampling design was employed to concurrently test for spatial and temporal variability in the community structure. Quantitative samples of the *R. pachyptila* community were collected in consecutive years (2001, 2002) at two environmentally different sites. At one site (Riftia Fields), the mixing zone has relatively low concentrations of hydrogen sulfide, low pH, and high concentrations of iron, whereas the mixing zone at the other site (Tica) has a wider range of hydrogen sulfide concentrations, closer to neutral pH, and undetectable iron concentrations. Analyses of the species composition in eight quantitative samples indicate that there is not a significant difference in species richness and Shannon-Weiner (H') diversity values between sites or years, and that Bray-Curtis community similarity values are very high. When all of the species in a sample are added together, the total abundance and total biomass are much higher in the *R. pachyptila* community at Tica than at Riftia Fields. The results and of this project will be integrated with species-specific respiration rates and in situ environmental measurements to generate an ecosystem-level model of the net primary productivity.

B12A-0734 1330h POSTER

Shallow (Layer 2A) Crustal Shear Velocity Structure Near the 9-50'N Vent Fields, East Pacific Rise

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In 1994, we exploded 16 explosive shots on the seafloor to generate seismic arrivals that were detected by 8 ocean bottom seismometers in the vicinity of the 9-50 N vent fields on the East Pacific Rise. The shots generated high frequency (0.5-15 Hz) surfacewaves (also called Stoneley waves) which traveled primarily in the low velocity waveguide formed by the top of the extrusives layer. Waveform modeling of the surface wave trains recorded provides strong constraints on the shear wave velocity in the uppermost 200m in very young oceanic crust. The results demonstrate shear velocity increases rapidly from values below 200m/s in the uppermost 20m, to values near 500 m/s near the bottom of the extrusives layer. This rapid increase in velocity must primarily be associated with lower porosity and higher confining pressures at depth within the layer. Variations in shear velocity around the vent fields may represent the effects of hydrothermal cementation and changes in porosity due to mineralization. The body waves arrivals generated by these shots were analyzed using tomography to generate models of P and S wave velocity in layers 2A and 2B. This work is described elsewhere in this volume (Sohn et al. , 2003).

B12A-0735 1330h POSTER

High-Frequency Seismic Tomography of the EPR 9-50N Hydrothermal System

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The sub-surface nature of fluid flow that fuels deep-sea hydrothermal systems is of fundamental importance to our understanding of how heat transfer from the Earth's interior at mid-ocean ridges supports unique biological communities, but it is difficult to constrain owing both to the complexity of the crustal accretion system and the difficulties associated with making relevant observations in the deep ocean. Here we present the results from a unique seismic tomography study of the shallow crust on the East Pacific Rise 9°50'N. We have imaged a high-velocity anomaly at the base of the extrusive layer on the rise axis, which may represent a mineral deposit formed as high-temperature fluids encounter cold pore fluids for the first time on their ascent to the seafloor. We use elastic models to relate the size of the seismic velocity anomaly to the size of the mineral deposit, and use first-order mass balance methods to constrain the feasibility of the mineral deposit interpretation with respect to accepted values for heat and mass flux at the 9°50'N vent fields. We consider our tomographic models in the context of high-resolution magnetic, gravity, and crack distribution surveys conducted at the site, and synthesize these results with convection/heat-transfer models to provide new constraints on the nature of sub-surface circulation at the EPR IS site.

B12A-0736 1330h POSTER

A proposal for drilling to the base of a Lamont Seamount at 9°50 N EPR

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The Lamont Seamount chain intersects the East Pacific Rise at 9°50N and is a significant feature within the RIDGE2000 program integrated study site at 8-10°N. However, the origin of this, as well as all near-ridge seamount chains, remains unresolved. Geochemically, Lamont Seamount lavas form an excellent depleted end-member magma which mix with more enriched magmas to form typical 9°N EPR NMORB. Here I present the case for an IODP project to obtain a drill core to the base of a Lamont Seamount in order to gain fundamental insight into mantle melting processes. Drilling into the oldest Lamont Seamount will test the hypothesis that seamount chains reflect the presence of dunite melt conduits in the upper mantle feeding magma to near-ridge locations. If these conduits are created by the passage of reactive melts derived from melting of enriched mantle heterogeneities, the base of the oldest seamount should contain geochemically enriched melts. Seamount chains like Lamont aligned along absolute plate motion would reflect a melt conduit in the upwelling asthenosphere while relative motion hotspot chains would reflect dunite in the lithosphere. A stratigraphic sequence of seamount lavas in a core will also allow an assessment of whether melt compositions are chromatographically modified during ascent. This would also allow quantification of melt porosities in the melting column, complimentary to geophysical tomography efforts. A final hypothesis is that once established, dunite conduit systems lead to a melting process whereby diffusion of alkali elements into the surrounding mantle flux melts the mantle at shallow depths. This process might explain the production of anorthitic plagioclase in MORB, the creation of anomalous Cl rich melt inclusions in MORB, and the production of the volumetric majority of magmas beneath a mid-ocean ridges. Finally, a >1km long drill core would also allow other interdisciplinary RIDGE research such as unmatched look at microbial alteration of basalt through time.

B12A-0737 1330h POSTER

An Investigation of Small Scale Ridge Axis Offsets Using Near Bottom Magnetic Data from the East Pacific Rise, 9°25'N to 9°58'N

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The axial high of the fast-spreading East Pacific Rise (EPR) mid-ocean ridge (MOR) is known to be offset over multiple length scales. Devals (deviations from axial linearity) are the smallest defined offsets (<0.5km) separating the ridge into 5-15km length segments which, it has been suggested, form as a consequence of distinct magmatic systems distributed along the spreading axis. High-resolution magnetic field data provides information on how stable and long-lived these "devals" are through time and whether or not they migrate like the larger scale offsets. Previous magnetic surveys along the segment of the EPR between 9°-10°N have identified the Central Anomaly Magnetic High (CAMH) along the ridge axis, which is believed to reflect both the width of the neovolcanic zone and the spatial distribution of lava emplacement. However, interpretation of the CAMH has remained ambiguous because of the low resolution of these sea surface level data. We present the analysis of near bottom magnetic data (∼100m above the seafloor) collected between 9°25'N and 9°58'N. Our main goal is to identify any offsets or variations in magnitude of the magnetic anomaly and magnetization results that may correlate with observed "deval" offsets in the topography from detailed side scan images. Crustal magnetization represents a time-integrated signal so that any observed magnetic offsets would indicate that these offsets have been stable on timescales of a few thousands to tens of thousands of years. First, we find undulations in magnetization amplitude along ridge axis with "lows" located at "deval" offsets. However, there are no significant lateral offsets in the magnetization suggesting that "devals" are ephemeral features. Second, from the south to the north in the study area we see a first order increase in magnetisation around 9°37'N. Possible reasons for this increase include thickening of the axial crust, a systematic change in geochemistry or recent extrusion of lavas. Finally, it is known that Layer 2a thickness doubles over 1-2km distance away from the ridge axis. This has been attributed to off axis deposition of lavas and the character of the CAMH is influenced by these features. Several finger like anomalies which run from the axis out onto the flanks appear to correlate with these lava flows.

B

B12A-0738 1330h POSTER

Sub-Moho Melt Accumulations Beneath the East Pacific Rise Between the Siqueiros Fracture Zone and the 9°03'N Overlapping Spreading Center

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We present the results of a tomographic investigation of the uppermost mantle structure along an 80-km-long section of the East Pacific Rise bounded by the Siqueiros fracture zone and the 9°03'N overlapping spreading center (OSC). Mantle images were obtained by the undershooting technique, using delay times generated by 979 sources and recorded by 15 ocean bottom receivers. Both sources and receivers were located along rise-parallel lines. Off-axis crustal structure is well constrained by first and secondary arrivals (Pg, PmP and Pn waves). Mantle structure beneath the axial region is reconstructed from the delay times of Pn waves. We find that the data require an anisotropic upper mantle and significant isotropic heterogeneity. We do not directly invert for the intensity and orientation of seismic anisotropy. Instead, images are obtained for a range of anisotropic starting models. For a constant field of anisotropy, the minimum data misfit is obtained for 7% anisotropy with the fast axis oriented approximately parallel to the spreading direction. Examination of the delay time residuals after inversion suggests that seismic anisotropy may be heterogeneous at a scale of 5 to 10 km. The tomographic images of isotropic heterogeneity reveal that the axial high is underlain by a continuous low-velocity anomaly that decreases in magnitude from north to south. Parallel to the EPR

the location of the upper-mantle, low-velocity anomaly is closely aligned with the sinuous morphology of rise. The magnitude of the sub-Moho anomaly is greatest between 8°50'N and 9°N, a region immediately south of the OSC where the cross-sectional area of the axial high is greatest and hydrothermal plume activity has been documented. Both the amplitude and the cross-axis width of the low-velocity anomaly are less to the south of 8°45'N and toward the Siqueiros fracture zone, a result consistent with a relative decrease in the amount of melt present at sub-Moho depths. This region of EPR includes a section that has recently experienced anomalous seismic activity and where bathymetric data and dredge samples show the presence of volcanic ridges comprised of high-silica basalts.

B12A-0739 1330h POSTER

Three-dimensional Reflectivity Images of Moho and Melt Sills beneath the 9 03' N Overlapping Spreading Centre at the East Pacific Rise

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In 1997, a 3D seismic reflection and tomography experiment (ARAD) was carried out over the 9ON overlapping spreading centre (OSC) at the East Pacific Rise. The 3D seismic reflection image shows wide spread presence of axial magma chambers (AMC) beneath two limbs of the OSC, which indicates the existence of a robust local magma supply. The data also show the Moho reflection beneath the AMC on the eastern limb of the OSC where the AMC is very wide (4.5 km). The presence of Moho beneath the AMC suggests that either the Moho is formed at zero-age or the crust beneath eastern limb of the OSC is old. Over a distance of 10 km along the ridge crest a rapid increase in two-way travel-time (30%) between the AMC and the Moho reflections is observed, which can be interpreted to be due to the presence of a large amount of melt in the lower crust or due to a very thick lower crust. Tomography studies from the area show the existence of low velocity anomalies in the lower crust and upper mantle, which reinforces the interpretation of a large melt anomaly in the lower crust. The absence of any other reflections between the AMC and the Moho reflection suggests that the melt in the lower crust should either be in pores or in small pockets. The localised nature of this large lower crustal melt anomaly beneath the eastern limb of the OSC suggests that this anomaly may be responsible for the southward propagation of the eastern limb and the tectonic evolution of the OSC.

B12A-0740 1330h POSTER

Constraining the Magmatic Budget of the EPR at 9°N Using Broadband Marine MT

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In February 2004 we will be conducting a 60 site broadband magnetotelluric (MT) survey at the Ridge2000 integrated study site (ISS) on the East Pacific Rise (EPR) near 9°N. Broadband marine MT instrumentation developed at Scripps Institution of Oceanography and used extensively by the petroleum industry will allow resolution of electrical conductivity structure at much shallower depths than traditional MT instrument systems. A small aperture (30km) transect of densely spaced MT sites across the ridge at the ISS "bull's eye" focus area at 9°50'N will image the electrical conductivity structure of the crust and shallow mantle in the vicinity of the ridge axis. A large aperture (200km) MT transect across the ridge at 9°30'N will target both crustal and upper mantle conductivity structures. We will also be deep-towing the new Scripps Underwater Electromagnetic Source Instrument (SUESI) to allow for controlled-source EM data which will provide constraints on the shallowest/resistive structures. Key issues we are addressing with our experiment are: 1. What is the distribution, vertical extent and volume fraction of melt present in the mid to lower crust? A dense transect of MT sites near the ridge axis at the ISS "bull's eye" focus area at 9°50'N will delineate the region of crust containing partial melt and constrain the total amount of connected melt present. 2. To what extent does hydrothermal circulation play a role in heat removal from the crust? What link(s) exists between the hydrothermal activity and crustal magma at the ridge axis? How does hydrothermal circulation affect the lateral extent of the crustal melt? A wide array of MT sites will provide estimates of lateral electrical conductivity variations in the crust near the mid-ocean ridge, from which constraints on temperature, porosity and permeability variations in the region surrounding the mid to lower crustal melt accumulations at 9°50'N can be made. 3. To what extent is melt accumulating at the base of the crust? Does a relatively thin layer of concentrated melt pond at the base of the crust, or does melt accumulate from a broader region of the mantle? A wide aperture line of MT sites up to 100 km from the ridge axis at 9°30'N will help to distinguish between these hypotheses. 4. What, if any, connection exists between the crustal melt accumulations and the region of decompression melting deeper in the mantle? Again, the wide aperture line of MT sites will allow us to place constraints on the delivery of melt to the ridge by the crust-mantle system. Electrical conductivity images of the crust and upper mantle from this experiment will complement existing results from other geophysical methods used at this segment of the EPR (seismic refraction/reflection, compliance and gravity). Estimates of the amount and distribution of partial melt in both the crust and upper mantle, and of the temperature, porosity and permeability structure of the crust will provide useful constraints on the nature of the complex magmatic system, and will support the interpretation of a wide variety of other Ridge2000 EPR ISS experiments.

B12A-0741 1330h POSTER

Crustal Seismic Structure along the East Pacific Rise 8°20'N to 10°10'N: Crustal melt accumulation and its relation to Mantle Melt Delivery, Tectonic Segmentation, Seafloor Geology and Hydrothermal Activity

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The UNDERSHOOT seismic experiment was designed to test competing magma supply models for the East Pacific Rise (EPR). P-wave energy that traverses the ridge within the crust allows us to map the variability of magma storage within the crust along the entire length of the transform-bounded segment of the EPR between the Siqueiros and Clipperton fracture zones. This 200-km-long section of ridge exhibits several small discontinuities of the bathymetric structure and one large overlapping spreading center (OSC) at 9°03'N. Earlier work has shown that the ridge is underlain by a shallow melt lens at approximately 1.5 km depth and by a prominent low velocity zone (4-8 km wide) that extends from the melt lens downwards into the mantle. This low velocity zone is indicative of high temperatures and a partially molten region of up to 10-40 percent magma storage. During the undershoot experiment P-wave crustal refractions and Moho reflections uniformly sampled this low-velocity zone along the entire length of this transform-bounded ridge segment. We use this data to tomographically image variations of the low-velocity zone along the ridge, including crustal thickness variations, and by inference variations in magma storage and supply. We jointly solve for the three-dimensional velocity structure of the crust and crustal thickness using a newly developed tomographic technique. While vertical resolution is poor beneath the rise, the high density of crossing ray paths, over a wide range of angles, provides excellent constraints on lateral variations in velocity structure. Initial results of this study do not reveal a discontinuity in the crustal low-velocity region beneath the OSC as expected by some models of OSC formation. This result correlates with a mantle tomographic image [Dunn et al., 2001] which likewise does not reveal a discontinuity in the mantle level low-velocity region just beneath the OSC. Our results, in combination with tomographic images of the uppermost mantle, document relations between the distribution of crustal melt storage, mantle melt supply, and the characteristics of tectonic segmentation, the axial summit and active hydrothermal venting.

B12A-0742 1330h POSTER

Seismic Monitoring of the East Pacific Rise Ridge 2000 Integrated Studies Site

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In September 2003 a closely spaced array of twelve ocean bottom seismometers will be deployed within the 'bull's-eye' region of the R2K ISS at 9deg49'N - 9deg51'N on the East Pacific Rise as part of the Ridge 2000 Integrated Studies Site. The array is to be deployed for approximately three years, with annual turnaround cruises. We plan to address a number of fundamental scientific questions, both seismic and interdisciplinary. We expect to study the character of near-axis faulting, to map the seismically active hydrothermal system, to look for tidal triggering of seismicity, and to determine the seismic character of magmatic activity should any be observed. We will make use of the latest advances in earthquake location methodology by computing highly accurate relative locations using the double-difference technique to remove model errors and waveform cross correlation to reduce pick uncertainties. This program is tightly coordinated with the fieldwork of other multidisciplinary monitoring in the area, which will provide an unprecedented opportunity to understand mid-ocean ridge system linkages. We hope to help document links between the seismicity, the hydrothermal system and the associated biology and provide a rigorous understanding of the significance of seismic activity to the mid-ocean ridge system. We will present a detailed outline of the experiment plans, as well as our plans to integrate and share the data collected. Details will also be presented of the deployment cruise including imaging of the 9deg50'N area.

B12A-0743 1330h POSTER

Mantle Structure Beneath the East Pacific Rise and its Relation to Tectonic Segmentation, Axial Morphology and Hydrothermal Activity

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The UNDERSHOOT experiment was designed to test competing magma supply models for the East Pacific Rise (EPR) by mapping the pattern of magma delivery from the mantle to the crust along the entire length of a transform-bounded segment between the Siqueiros and Clipperton fracture zones. Here we present tomographic images of shallow mantle, seismic heterogeneity for the region of 9°-10°15'N. These results, in combination with those obtained for the 9°03'N overlapping spreading center (OSC) [Dunn et al., 2001] and the rise axis south of the OSC [Jousselin et al., 2003], document relations between the distribution of mantle melt and the characteristics of tectonic segmentation, the morphology of the axial high and the distribution of hydrothermal activity. At the segment scale, the mantle low-velocity zone (MLVZ) is comprised of two contiguous trends that lie sub-parallel to the axial high. These trends are shifted with respect to one another in a right-lateral sense at 9°18'N, 30 km north of the OSC. South (north) of this shift the MLVZ is located more than 5 km west (east) of the axial high. North of 9°18'N the trend of the MLVZ is rotated counterclockwise with respect to the axial high, such that the MLVZ lies east of the rise south of 9°30'N and either beneath or slightly to the west of the rise north of 9°30'N. It is an open question as to whether the segmentation of the MLVZ into two linear trends is a response to or cause of OSC propagation. Parallel to the

rise the amplitude of the MLVZ is modulated at intervals of approximately 20 km. Sections of the rise associated with significant hydrothermal plume activity (e.g., 8°48'-8°58'N and 9°29'N-10°01'N), as defined by light attenuation measurements, are associated with larger amplitude, rise-centered MLVZs. Conversely, sections of the rise lacking continuous hydrothermal plume activity (e.g., 8°58'N-9°29'N) are underlain by either relatively low-amplitude, rise-centered MLVZs or MLVZs located off axis. These relations may indicate that vigorously venting hydrothermal fields require abundant accumulations of melt at mantle depths which can frequently replenish the crustal magmatic system. Between the Clipperton and the Siqueiros transforms the largest amplitude MLVZ is located off axis near 9°10'N, in a region where crust is anomalously thick, axial depth is relatively deep and the cross-sectional area of the axial summit is decreased. We thus infer that along-axis variations in axial depth and cross-sectional area of the axial high bear more relation to the cross-axis location of the MLVZ, than they do to magma supply. This is consistent with models that attribute axial high depth and morphology to a flexural response.

B12A-0744 1330h POSTER

Modeling Crustal Thickness Variations Beneath the East Pacific Rise: Mantle Diapirs or Plate Kinematics?

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Geophysical studies along the East Pacific Rise between the Siqueiros and Clipperton fracture zones reveal along- and cross-axis variations in crustal thickness whose origins are poorly understood. By one view, variations in crustal thickness are the result of three-dimensional upwelling of the mantle associated with a melt-rich diapir centered at 9°50'N. Alternatively, it has been proposed that the migration of the 9°03'N overlapping spreading center (OSC) alters the thickness of crust by increasing the amount of time that a crustal unit resides near the spreading axis. In this case, crustal thickness variations arise from plate kinematics, and not from three-dimensional variations in mantle upwelling. We report on a modeling study designed to explore how the evolution of OSCs may alter the thickness of newly-formed crust. OSC propagation is modeled using the kinematic algorithm developed by Wilson [1990], modified to track parcels of crust through time. Given an OSC's kinematic history and two-dimensional descriptions of the melt flux out of the mantle (i.e. invariant along the rise), we predict relative variations in crustal thickness. Our modeling assumes that underplating increases the thickness of the crust and/or Moho transition zone as long as a crustal unit resides over the source of mantle-derived melt. Results suggest two general kinematic mechanisms whereby variations in crustal thickness can occur: those due to an offset between the mantle-level magmatic system and the spreading axis, and those due to any relative reduction in the velocity of a crustal unit as it moves off axis. Offset-induced crustal thickness variations are manifest as long-wavelength (∼50 km), low-amplitude cross-axis asymmetries. Local slowing of crustal units as they move off axis – in direct association with the OSC and its overlap basins – results in relatively short-wavelength (∼10 km), high-amplitude variations in crustal thickness. Using a kinematic history appropriate for the 9°03'N OSC, we predict both long- and short-wavelength variations in crustal thickness that are comparable to those observed in seismic refraction data [Canales et al., 2003]. We conclude that a combination of plate kinematics and underplating of crustal material is a viable mechanism for generating observed variations in crustal thickness.

B12A-0745 1330h POSTER

Spatial and Temporal Variability in Seismicity of the East Pacific Rise: Constraints from Hydroacoustic Monitoring and Evidence for Triggering of Transform Earthquakes

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We utilize hydroacoustic data collected since May 1996 by NOAA's Equatorial Pacific autonomous hydrophone array to investigate the first order spatial and temporal variability of seismicity at the East Pacific Rise (EPR) within the array. We also investigate earthquake stress interaction and triggering at three sites: the Clipperton and Siqueirous transform faults, which are part of the Ridge2000 EPR Integrated Study Site (ISS), as well as a section of the ridge at 5.4°S near the Gofar transform fault. Our analyses reveal strong evidence of seismic clustering along the EPR. The majority of earthquakes (> 90%) clustered in seismic swarms, in which individual events occurred within a few km and within minutes or hours of each other. Through correlating hydrophone data to teleseismically recorded events, we have located several moderate size earthquakes on the Siqueiros and Clipperton transforms. Some of these moderate size events occurred closely in space and time, suggesting the possibility of earthquake triggering. At 5.4°S we found evidence for possible interaction between two moderate size events, one of which occurred on the EPR axis and the other about 100 km northward on the Gofar transform fault. Stress calculations were carried out for several pairs of the moderate size events. The close correlation of the calculated Coulomb stress changes with the observed spatial and temporal variations in seismicity patterns provide strong evidence for possible earthquake triggering along the transform faults. This might have important implications for processes acting in the EPR ISS, including the relationship between seismicity and changes in hydrothermal circulation patterns.

B12A-0746 1330h POSTER

MORB Petrogenesis and Crustal Development of the East Pacific Rise (EPR) at the R2K ISS (9°-10° N)

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During the past decade (1991-2002) we collected over 1200 basalt samples from the 9° 17' N to 10° N section of the EPR; the focus area for the 8°-11° N EPR R2K Integrated Study Site (ISS). Many of the samples were recovered from 1 km-wide area around the AST with ALVIN, but more than a dozen off-axis traverses documented the geology up to 5 km away from the axis. All of the basalts have been analyzed for major elements and many have complete sets of trace elements. A representative set has been analyzed for Sr, Nd, Pb, Hf and U-series isotopes and volatiles. The data set now available from this area represents the most concentrated and extensive for any portion of the MOR and provides us with the ability to investigate the spatial and temporal variability of magmatism at this ISS and how magmatism is related to crustal structure and melt distribution. Our spatial analyses show that the distribution of basalt types is not symmetric across the crestal plateau and there are distinct chemical discontinuities that correspond to 3d-order ridge segmentation. Chemical variation observed over scales as small as a few 100 meters suggests major changes in magmatic systems on time scales of less than 5 kA. Relatively evolved ferrobasalts and T- and E-type MORB only exist in small areas (< 1 km2) on the crestal plateau and commonly are spatially related to prominent scarps or fissures. Evolved and/or high-K/Ti basalts have not been recovered proximal to the axis (excepting near the 9° 37' OSC). Off-axis lavas are statistically different from the more homogenous and mafic axial basalts. All of the samples collected above the axial magma chamber (AMC) contain more than 7.2 wt% MgO while approximately one third of the basalts away from the AMC contain less than 7.2 wt% MgO. Similarly, none of the samples lying above the AMC have K/Ti values of over 12, while about 25% of the samples away from the AMC have more elevated values. Although most of the chemical variability in the N-type MORB can be explained by shallow-level fractional crystallization of similar parental melts, Ra and Th isotopic systematics suggest some of the variation is due to differences in the depths and extents of mantle melting. The combined information obtained from our field studies, chemical analyses and U-series dating confirm that a significant terrain up to 2.5 km away from the ASC on the crestal plateau has been affected by more recent volcanism than predicted by spreading rate-distance estimates predict. Some of this volcanism is a consequence of relatively voluminous lobate and sheet flows that extend away from their axial eruptive source and some is related to small-volume eruptions related to the in-situ development of off-axis faults and fissures. We suggest a petrogenetic model whereby the differences between the compositions of lavas /magmas erupted on-axis and those erupted off-axis are related to their location relative to crustal magma chambers. Axial eruptions are derived from the region of high melt fractions, and highest temperatures where it is expected that convection will be more vigorous and the AMC appears to be relatively efficient at homogenizing the melt whereas more evolved and enriched lavas are derived from the flanks of the magma chambers/lens. The off-axis eruptions may be due to sills that propagate toward the surface along off-axis faults.

B12A-0747 1330h INVITED POSTER

Endeavour Segment, Juan de Fuca Ridge, Integrated Studies Site (ISS) Update and Opportunities

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The Ridge 2000 (R2K) Integrated Studies bull's eye on the Juan de Fuca Ridge is focused on the Main Endeavour hydrothermal field, located on the central portion of the Endeavour Segment. This vent field is one of the most vigorously venting systems along the global mid-ocean ridge spreading network, hosting at least 18 large sulfide structures that contains more than100 smokers. Prior to a magmatic event in 2000 some of the edifices had been venting 380C, volatile-rich fluids with extremely low chlorinities for a decade. In addition to the Main Endeavour Field there are four other known high temperature vent fields spaced approximately 2 kilometers apart along the segment (with hints of more) and abundant areas of diffuse flow, both nearby and distal to the high temperature venting. Diffuse flow from the structures and from a variety of basaltic-hosted sites provides rich habitats abundant with microbial and macrofaunal communities. There are well-developed gradients in volatile concentrations along axis that may reflect influence from a sedimentary source to the north, and high chlorinity fluids vent from the most southern (Mothra) and northern fields (Sasquatch). Twenty years of research have laid a firm base for the 5-year plans of R2K at this site, which include examining the response of this segment to perturbations induced by tectonic and magmatic events, identification of the reservoirs, fluxes, and feedbacks of mass and energy at this site, and predictive modeling coupled with field observations. Since designation as an IS site, high-resolution bathymetric mapping (EM300) and an extensive multi-channel seismic survey have been conducted along the entire segment. Smaller focused areas have also been mapped at meter resolution by SM2000 sonar. Intense field programs in 2003 established the first in-situ seismic array along a mid-ocean ridge, which includes installation of a buried broadband seismometer and 7 short-period seismometers emplaced within basaltic bedrock along the flanks of the segment and within the axial valley. It is anticipated that this network will be in place for many years. In addition to monitoring seismic activity, in-situ fluid samplers have been deployed in two of the vent fields for a year, temperature monitoring devices are installed in three of the 5 fields, and two high-temperature prototype incubators were emplaced in the walls of active sulfide chimneys for long-term monitoring and sampling of microbial communities. Discrete fluid sampling in four of the five fields, and sampling of microbial and macrofaunal communities were also conducted. To examine the transfer of fluid and heat along the axial valley, a fence of current meters and up-looking acoustic current profilers were installed that bound the Main Endeavour Field. Data collected with these instruments will be coupled to intense water column surveys by ABE in 2004. An overview of the site is presented here.

URL: http://Ridge2000.bio.psu.edu

B12A-0748 1330h POSTER

A Long-Term Seismic Array on the Endeavour Segment of the Juan de Fuca Ridge

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The Keck Foundation with additional support from the Monterey Bay Aquarium Research Institute and the University of Washington has funded a five-year, five-million dollar program for archetypic experiments on the northern Juan de Fuca Plate. The goal of this program is to constrain the linkages between deformation (earthquakes), fluid flow and chemistry, and microbial response across the northern Juan de Fuca Plate in the northeastern Pacific Ocean. A key component of these studies is an array of ocean-bottom seismometers to record the temporal and spatial distribution of seismic activity in the region. The current network, deployed in August of 2003, is comprised of eight autonomous instruments: one broadband seismometer and seven short-period seismometers. The instruments are distributed within and around the axial valley at the center of the Endeavour segment and spaced about 4 km apart, composing an array about 7 km wide and 9 km long. The short-period instruments, sensitive over a frequency range of 1 to 32 Hz, utilize an MBARI/GEOSense BH1 three-axis corehole geophone connected to an MBARI/GEOSense LP1 data logger. For five of these instruments the corehole sensor is inserted into a 7 cm diameter hole drilled into the basaltic basement rock, thus providing excellent coupling. For the other two instruments where suitable drilling sites were not available, the sensors are inserted into 55 kg concrete blocks placed on the sediment. The broadband instrument is a Guralp CMG-1T three-axis seismometer, sensitive over a frequency range of 2.8 mHz (360 sec) to 50 Hz. The sensor is completely buried in sediment inside a 60 cm deep by 60 cm diameter caisson, thus reducing the effects of water currents on the recorded data. A 20 m cable connects the sensor to an LP1 data logger and a 30 kW-hr battery sitting on the sediment. A complete data set will be recovered from the array when the instruments are revisited during the summer of 2004. However, data from two events, an M=7.5 teleseism in the Scotia Sea and an M=3.0 earthquake at the northern Endeavour segment, were recovered from the broadband instrument during a site revisit two weeks after its deployment. These high-quality recordings of both teleseismic and local events show low background noise levels and excellent instrument response. The small, but focused network should facilitate the recording of both tectonic and volcanic events along the spreading axis with a high degree of resolution.

B12A-0749 1330h POSTER

Integrating Acoustic Imaging of Flow Regimes With Bathymetry: A Case Study, Main Endeavor Field

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A unified view of the seafloor and the hydrothermal flow regimes (plumes and diffuse flow) is constructed for three major vent clusters in the Main Endeavour Field (e.g., Grotto, S&M, and Salut) of the Endeavour Segment, Juan de Fuca Ridge. The Main Endeavour Field is one of RIDGE 2000's Integrated Study Sites. A variety of visualization techniques are used to reconstruct the plumes (3D) and the diffuse flow field (2D) based on our acoustic imaging data set (July 2000 cruise). Plumes are identified as volumes of high backscatter intensity (indicating high particulate content or sharp density contrasts due to temperature variations) that remained high intensity when successive acoustic pings were subtracted (indicating that the acoustic targets producing the backscatter were in motion). Areas of diffuse flow are detected using our acoustic scintillation technique (AST). For the Grotto vent region (where a new Doppler technique was used to estimate vertical velocities in the plume), we estimate the areal partitioning between black smoker and diffuse flow in terms of volume fluxes. The volumetric and areal regions, where plume and diffuse flow were imaged, are registered over the bathymetry and compared to geologic maps of each region. The resulting images provide a unified view of the seafloor by integrating hydrothermal flow with geology.

B12A-0750 1330h POSTER

Measuring pH(in-situ) of hydrothermal fluids at Mid-ocean ridges: Main Endeavour Field(JDF); EPR 21°N, 9-10°N; Galapagos Rift

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The in situ pH measurements of seafloor vent fluids were conducted using a newly developed solid-state sensor. Measurements were made during a series of dives with DSV Alvin at the Main Endeavour Field (MEF, Juan de Fuca Ridge), East Pacific Rise (EPR) at 21°N, EPR at 9-10°N, and at the Galapagos Rift. Vent fluid temperatures and pressures ranged from 22 to 380°C and 220 to 250 bars (2200 to 2500 meters depth), respectively. The pH of the highest temperature fluid is only slightly acidic (5.1-5.4), instead of being at least a full unit lower as often measured at the room condition from fluid sample. However, our in-situ pH results are at the same magnitude with theoretically predicted in-situ values from the room condition measurement. Dramatic pH lowering is observed during vent fluid mixing with seawater, which is likely due to the effect of cooling on metal sulfide precipitation and homogeneous equilibria. In contrast, pH of low temperature diffuse flow vent fluids at Galapagos decreases with increasing temperature achieving values approximately 0.5 units lower than ambient seawater at the discharge point, where the fluids are 22°C and directly associated with colonies of Riftia pachyptila. The ability to measure and monitor in-situ pH in real time offers great promise for future study as efforts continue to better understand the complex interplay between inorganic and organic processes associated with hydrothermal activity at mid-ocean ridges.

B12A-0751 1330h POSTER

Results of New High-Resolution Geological Mapping and Geochemistry of the Endeavour Segment, Juan de Fuca Ridge

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Major and trace element concentrations, petrography, and volcanic stratigraphy of 40 mid-ocean ridge basalts (MORB) collected by ROV along the Endeavour Axial Ridge Volcano (EARV) have been analyzed to determine geochemical variations as a function of proximity to the spreading axis and potential sites of off-axis volcanism. The EARV ISS site is an 18 km long, 6 km wide pair of axial highs separated by a 1 km wide, 200 m deep valley. At a half-spreading rate of 30 mm/yr, it is <50,000 years old. Lavas are encompassed by numerous fissures on the valley floor, including en echelon grabens between Mothra and Main Field. Geochemical and structural characteristics of this southern segment (between Mothra and Main Field) can best be explained by a series of axis-parallel dike injections with little crustal hydridization of magmas. This may be a result of the intensity of crustal fracturing and robust hydrothermal circulation. Large-offset faults uplift relatively intact terraces and define the valley walls. About 80% of the lavas have <2% plagioclase (An70-90) and olivine (Fo85) phenocrysts. More porphyritic lavas are restricted to one near-axis hornito that sits astride the western boundary fault. Most lavas are moderately differentiated (MgO=7-8 wt.%) with geochemical variations consistent with modest ol+pl+sp fractionation. Incompatible element ratios vary by a factor >1.6 within scores of meters in the rift valley (e.g., Nb/Zr (0.09-0.14), La/Yb (2.9-4.2), and K2O/TiO2 (0.20-0.32)) and usually are higher (more E-MORB) than off the EARV. This indicates that the AMC may be episodic, and that off-axis magmas bypass it altogether. Variations in enrichment seem more related to source heterogeneity than degree of melting.

B12A-0752 1330h POSTER

Seismic Structure of the Endeavour Segment, Juan de Fuca Ridge: Correlations of Crustal Magma Chamber Properties With Seismicity, Faulting, and Hydrothermal Activity

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Multichannel seismic reflection data collected in July 2002 at the RIDGE2000 Integrated Studies Site at the Endeavour segment, Juan de Fuca Ridge show a high-amplitude, mid-crustal reflector underlying all of the known hydrothermal vent fields at this segment. This reflector, which has been identified with a crustal magma body [Detrick et al., 2002], is found at a two-way travel time of 0.85-1.5 s (1.9-4.0 km) below the seafloor and extends approximately 25 km along axis although it is only 1-2 km wide on the cross-axis lines. The reflector is shallowest (2.5 km depth on the along-axis line) beneath the central, elevated part of the Endeavour segment and deepens toward the segment ends, with a maximum depth of 4 km. The cross axis lines show the mid-crustal reflector dipping from 9 to 50? to the east with the shallowest depths under the ridge axis and greater depths under the eastern flank of the ridge. The amplitude-offset behavior of this mid-crustal axial reflector is consistent with a negative impedance contrast, indicating the presence of melt or a crystallizing mush. We have constructed partial offset stacks at 2-3 km offset to examine the variation of melt-mush content of the axial magma chamber along axis. We see a decrease in P-wave amplitudes with increasing offset for the mid-crustal reflector beneath the Mothra and Main Endeavour vent fields and between the Salty Dawg and Sasquatch vent fields, indicating the presence of a melt-rich body. Beneath the High Rise, Salty Dawg, and Sasquatch vent fields P-wave amplitudes vary little with offset suggesting the presence of a more mush-rich magma chamber. Hypocenters of well-located microseismicity in this region [Wilcock et al., 2002] have been projected onto the along-axis and cross-axis seismic lines, revealing that most axial earthquakes are concentrated in a depth range of 1.5 - 2.7 km, just above the axial magma chamber. In general, seismicity is distributed diffusely within this zone indicating thermal-related cracking above the magma chamber, although the cross-axis line at the Salty Dawg vent field shows seismicity localized along a steeply dipping fault-like plane that terminates just above the magma chamber. A faint reflector at 1.5 km below the seafloor (700 m below the layer 2a reflector) is present near the top of this axial zone of seismicity and may represent a cracking-related boundary in the porosity structure of the shallow crust.

B12A-0753 1330h POSTER

Crustal Structure and Evolution Along the Juan de Fuca Ridge Flanks

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An extensive seismic investigation of the Juan de Fuca Ridge was carried out in 2002. Here we focus on flank profiles crossing the Endeavour, Northern Symmetric, and Cleft ridge segments. These profiles are

a few hundred km-long, extend out to crust about 5 my old, and provide structural information giving insight into crustal evolution. We observe spatial variation in sedimentary cover, tectonic activity, layer 2A thickness, depth to the axial magma chamber and Moho structure. Whereas the western ridge-flank appears to be tectonically stable, normal faults are imaged within the thick sediment section of the eastern flank indicating recent activity well beyond the axial region. Fault offsets diminish upsection suggesting growth faulting caused by long-term slip within the basement structure. In places, imaged fault planes extend through the sediments and crust to the Moho. Reflections from crustal gabbros are not likely unless the rocks are serpentinized at fault planes, which is indicative of fluid flow deep into the crust. Bright Moho where the deep faults plunge into the upper mantle suggests that fluid exchange may extend below the crust. The reflection images show that the western and eastern ridge flanks are evolving in a markedly different way. We believe that the main causes for differential flank evolution are distinct sedimentation and tectonic histories. Massive sediment accumulation on the eastern flank strongly affects the hydrothermal fluid flow regime and the evolution of layer 2A. Faulting profoundly affects the crust by providing new pathways for fluids trapped in the upper crust. Bending of the oceanic slab due to nearby subduction is a likely driving force for the faulting. The density and magnitude of faulting do not monotonously decrease away from the trench, as would be expected from pure slab bending, indicating that other factors contribute to the faulting. Magnetic and bathymetry data tie the faulted areas to propagator wakes. The crust formed at ridge propagators may be weaker than that formed under normal spreading conditions, and thus may be the first to be faulted as the crust approaches a subduction zone.

B12A-0754 1330h POSTER

Crustal Structure of the Cleft Segment (Southern Juan de Fuca Ridge) From Multichannel Seismic Profiling

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We use multichannel seismic data collected in 2002 to constrain processes of magmatic accretion, and the structure of young oceanic crust formed along the intermediate-spreading Cleft segment, in the southern Juan de Fuca Ridge. The Cleft segment is characterized by a 10-15-km-wide area elevated ∼450 m above the surrounding seafloor. Within this relatively inflated morphology, the axial region is characterized by 1-3-km-wide smooth terrain bounded to the east and west by linear ridges 100-m-high. The study area was densely surveyed with 5 axis-parallel profiles running along zero-age crust and up to 430-kyr-old crust along both flanks of the ridge axis, and with 13 cross-axis profiles extending up to 600-kyr-old crust. Migrated seismic images show that at least 65% of the Cleft axial region is underlain by a bright reflector continuous along distances of 10-15 km, interpreted as the top of an axial magma chamber (AMC). The depth of the AMC appears to decrease from 950 ms two-way travel time (∼2.4 km, assuming an average velocity of 5 km/s above the AMC) below the seafloor beneath the Monolith hydrothermal vent near the northern end of the segment, to 810 ms (∼2.0 km) beneath the hydrothermal vents in the RIDGE Seafloor Observatory near the southern end of the Cleft segment. The AMC is narrower (∼600 m) near the northern end of the segment, and wider (∼1100-1650 m) in the other areas. The extrusive volcanic layer (2A) shows contrasting patterns within and outside the axial region. Layer 2A thickness within the axial region is 200-300 ms (∼300-450 m, assuming an average velocity of 3 km/s). This layer thickens off-axis symmetrically by ∼55%, to 335-435 ms (∼500-650 m) immediately outside of the axial region. This thickening is rapid, with no clear correlation with topographic slopes, suggesting that the linear ridges that flank the axial region play an important role on the emplacement process of the extrusive layer.

B12A-0755 1330h POSTER

A New View of 3-D Magma Chamber Structure Beneath Axial Seamount and Coaxial Segment: Preliminary Results from the 2002 Multichannel Seismic Survey of the Juan de Fuca Ridge

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In the summer of 2002, a multichannel seismic (MCS) experiment was conducted across all segments of the Juan de Fuca Ridge, including Axial seamount and Coaxial segment. These two segments were surveyed over a twelve-day period, with a lengthy excursion southward to the Vance/Cleft segments due to sea-state. In total, some 20 MCS profiles were collected in these two areas, including a dense survey over Axial seamount. Not to disappoint, magma bodies were imaged beneath both the Axial and Coaxial segments, although absent along portions of Coaxial where previous work suggested sub-surface melt accumulations; in contrast, a large magma body was imaged along the southeast flank of Axial seamount in a region thought to be devoid of significant amounts of melt. MCS profiling across Axial seamount revealed a very complex set of reflections, with significant depth variations. The two-way travel-time between seafloor and melt sill reflectors varied between 600 ms to 1200 ms, with a minimum depth of about 1400 m bsf based on travel-time modeling of individual gathers. Melt appears to underlie most of the caldera, with depth variations of at least 600-800 m. Outside of the caldera, most of the melt is observed extending outward, along the southeast flank of Axial seamount to a distance of 12 km and appears to be quite extensive. No significant melt bodies were observed along either of the ridge-related rift zones. A magma chamber reflector was also seen along extended parts of Coaxial segment, in particular a continuously bright event was observed in between the conjugate set of ridges between 46°25'N and 46°15'N. This region was the site of a recent extrusive event, although the source for this eruption was thought to lie to the south, around 46°09'N. Interestingly, the southern section of Coaxial appears to be devoid of such a melt-lens. Further south, toward Helium basin, a small stranded melt-lens was imaged at approximately 46°05'N. Three-dimensional, interactive "fly-throughs" of magma chamber structure will be presented.

B12A-0756 1330h POSTER

Microbial diversity in subseafloor fluids from Explorer Ridge, Northeast Pacific

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The Gorda, Juan de Fuca and Explorer Ridges are first order spreading centers located in the northeast Pacific. While the Gorda and Juan de Fuca Ridges have been extensively sampled for chemical and microbiological analyses, what little is known about the Explorer Ridge is from preliminary observations made in the mid-1980's. A cruise in 2002 revisited the area and discovered vigorous hydrothermal activity at Magic Mountain, a site located outside the primary rift valley. Explorer Ridge is an important site to compare with other well-described vent sites on the Juan de Fuca Ridge. Our research has focused on describing the phylogenetic and physiological diversity of bacteria and archaea in low temperature hydrothermal fluids in an effort to identify subseafloor indicator organisms and to use the physiological characteristics of these organisms to help constrain subseafloor habitat characteristics. We have previously established that there are microbial taxa that are unique to subseafloor habitats associated with diffuse flow fluids at Axial Seamount and at Endeavour both located on the Juan de Fuca Ridge. These included cultured anaerobic, thermophilic and hyperthermophilic heterotrophs, methanogens and sulfur metabolizers. Moreover, results from molecular phylogeny analyses using the 16S rRNA sequences identified a phylogenetically diverse group of bacteria belonging to the epsilon-proteobacteria. While anaerobic hyperthermophiles were cultured from some diffuse-flow vent sites at Explorer, they were less abundant than at Axial Volcano and Endeavour, and curiously, no methanogens were cultured or detected in 16S rRNA clonal libraries. Like Axial, a diverse group of epsilon-proteobacterial clones were found with many similar to those identified from Axial Seamount and other hydrothermal vent sites, although there appears to be some unique species. The overall bacterial diversity at Explorer appears different than at Axial, possibly linked to temperature or chemical characteristics. This study extends the distribution of the epsilon-proteobacteria to the Explorer Ridge and further indicates that while similar phylotypes of microorganisms are present in all subseafloor habitats at vents, the species composition differs reflecting different habitat characteristics.

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B12A-0757 1330h POSTER

Identification of a Possible Second, Large Propagator North of the Hess Deep Rift

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The ridge-ridge-ridge triple junction at the northern edge of the Galapagos microplate is located at 2 40'N, where the Incipient Rift (IR) intersects the East Pacific Rise (EPR). The IR is north and west of Hess Deep and is a slowly diverging (15 mm/yr full-rate) spreading center separating the Cocos and Galapagos plates (the IR was first identified by P. Lonsdale and co-workers). In August, 2002, we mapped and sampled a broad area centered on the IR, including its intersection with the EPR and its apparent termination about 75 km to the east. Seabeam 2000 bathymetric and side-scan (amplitude) data, surface-towed magnetic data, imagery from 14 camera tows, and rock samples (53 dredges, 5 wax cores) and MAPR and CTD data were collected (results to be described by Klein et al. 2003 and Hanna et al. 2003). Seabeam bathymetry data collected to the northeast of the IR on our transit to port revealed a surprising result: a series of prominent NW/SE striking lineations, interpreted as faults, were mapped on about 1.5 My old crust. These faults are not evident in the satellite altimetry data. The faults dip to the NE and have throws of up to 500 m. We conducted a brief (aprox. 6 hr) Seabeam survey of the region to obtain a clearer idea of what the faults represent. Based on our limited survey, the faults appear to be the southern boundary of a west-pointing, v-shaped gore (similar orientation as the Hess Deep and IR gores). Our survey did not reveal matching faults on the northern boundary of the gore, but instead an abrupt transition from east-west lineations likely associated with Cocos-Nazca spreading to north-south abyssal hill lineations inherited from the EPR. A swath of multibeam data was collected for us by G. Christeson in August 2003, just to the east of our survey, and shows NE/SW lineated topography intersecting the northern boundary of the Galapagos gore. We infer that this newly mapped feature was a relatively large propagating rift that became inactive about 1 My ago. At that time the propagator associated with Hess Deep became the single dominant propagator in the region and the IR was formed. The existence of this second, perhaps larger propagator to the northeast of the IR emphasizes the complicated nature of the microplate boundaries in this region.

B12A-0758 1330h POSTER

Microbial Diversity at the Low-Temperature Hydrothermal Vents of the Galapagos Rift

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Deep-sea hydrothermal vents were discovered more than 20 years ago at the Galapagos Rift. However, no systematic assessment of the microbial diversity has been done at this historic site. In May 2002, we revisited the Galapagos Rift, noted many changes at the former active sites and discovered new vent fields. The microbial diversity associated with water and rock samples was determined using a molecular phylogenetic approach based on the small subunit rRNA. Both typical vent and non-vent microbes were detected, such as epsilon- and gamma-Proteobacteria respectively. The archaeal diversity included members of the marine crenarchaeal group I, and euryarchaeal group II and III. Similar microbial diversity has been observed at other low-temperature deep-sea vent sites of the Juan de Fuca Ridge, Mid-Atlantic Ridge, and Loihi Seamount. Such communities are probably restricted to areas where low temperature fluids are discharged at low velocities. In these conditions, opportunistic seawater microbes may share the same ecological niches as vent microorganisms. The presence of epsilon-Proteobacteria at the Galapagos Rift further confirm the global distribution of this group at deep-sea vents.

B12A-0759 1330h POSTER

Lipid Biomarkers and Molecular Carbon Isotopes for Elucidating Carbon Cycling Pathways in Hydrothermal Vents

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Increasing molecular evidence suggests that hydrothermal vents in mid-ocean ridges harbor large populations of free-living bacteria, particularly the epsilon Proteobacteria. However, pathways for carbon metabolism by these bacteria are poorly known. We are addressing this question by analyzing the lipid biomarkers and their isotope signatures in environments where the epsilon Proteobacteria are likely predominant. Solid materials were collected from hydrothermal vents in the East Pacific Rise and at the Guaymas Basin in the Gulf of California. Fatty acids extracted from these samples are dominated by 16:0 (27-41%), 18:0 (16-48%), 18:1 (11-42%), 16:1 (7-12%), and 14:0 (5-28%). In addition, 15:0 and anteiso-15:0 are significantly present (2-3%) in samples from the Guaymas Basin. The isotopic compositions of these fatty acids range from -15.0$^{o}/_{oo}$ to -33.1$^{o}/_{oo}$ with the most positive values occurring only in monounsaturated fatty acids (16:1 and 18:1). We are currently unable to assign these biomarkers to any of the epsilon Proteobacteria because biomarkers are poorly known for these organisms isolated from the vents. However, no polyunsaturated fatty acids were detected in these samples, which are consistent with the absence of vent animals at the sampling sites. Signature biomarkers of 20:1 and cy21:0, which are characteristic of the thermophilic chemolithoautotrophs such as *Aquificales*, are also absent in these samples. These results imply that the deeply branched *Aquificales* species do not constitute the major microbial community in these vent environments. The large range of molecular isotopic compositions suggests that these lipids are synthesized from various carbon sources with different isotopic compositions or through different biosynthetic pathways, or both. We are currently measuring the isotopic compositions of the total organic carbon in the bulk samples and will determine the fractionations between lipid biomarkers and the total organic carbon. Molecular DNA data from these vent environments indicate that the reversed TCA cycle may be used for CO_2 fixation by the epsilon Proteobacteria for chemolithoautotrophic growth. Isotopic fractionation patterns between lipid biomarkers and the bulk organic carbon can provide independent information on this unique biosynthetic pathway.

B12A-0760 1330h POSTER

The Majority of Free-Living Autotrophic Bacteria use the Reductive TCA Cycle for Carbon Fixation at Deep-Sea Hydrothermal Vents

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Deep-sea hydrothermal vents support large micro and macroscopic communities, without the input of photosynthesis. Autotrophic production at these vents is based on hydrothermal vent fluid chemistry. Primary production has been thought to occur mainly via hydrogen sulfide oxidation through the Calvin-Benson pathway, as measured by the presence of Rubisco in endosymbionts of several invertebrate hosts. Recently, we characterized two fosmids from a large insert library of the epsilon Proteobacterial episymbionts of Alvinella pompejana. Both contained sequences encoding ATP citrate lyase, a key enzyme in the reverse TCA cycle, an alternate carbon dioxide fixation pathway. Previous investigators have demonstrated the dominance of the epsilon subdivision in the free-living bacterial communities at hydrothermal vents. Based on these results, our working hypothesis is: The rTCA cycle is the dominant pathway for carbon fixation in the free-living bacterial communities at hydrothermal vents. A selection of free-living bacterial communities from various geographic locations (9N, East Pacific Rise and Guaymas Basin) were screened for the presence, diversity and expression (via RT-PCR) of Rubisco (forms I and II) and ATP citrate lyase. Our results indicate that the ATP citrate lyase gene is diverse and is consistently expressed in several types of vent communities. The two forms of Rubisco are not consistently present or expressed in the same environments. These results indicate that chemoautotrophic production in the free-living bacterial communities at deep-sea hydrothermal vents is dominated by bacteria that utilize the rTCA cycle, and parallels the phylogenetic dominance of members of the epsilon subdivision of Proteobacteria.

B12A-0761 1330h POSTER

Dissolved Organic Metals in the Hydrothermal Plume

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In the hydrothermal plume, there are the unique microbiological communities and the microorganism utilizes various chemical substances. The interactions between heavy metals and microorganisms in the hydrothermal plume are important to comprehend the oceanic geochemical cycles of heavy metals. It is considered that the heavy metals in hydrothermal plume are organically bound with dissolved organic matter derived from the hydrothermal microorganism. This study funded by the O'Archaean Park project of MEXT is a first attempt to observe the bioavailability of heavy metals in hydrothermal plume. The hydrothermal plume samples were taken from two different kinds of hydrothermal sites, the Suiyo Seamount caldera and the Central Indian Ridge. The mini CTDT-RMS mounted twelve 1.2L Niskin bottles was installed on the manned submersible, and the hydrothermal plume samples were collected by taking the distance from the hydrothermal vents gradually. The solid phase extraction technique in C18 Sep-Pak cartridge (Millipore Waters) was used to extract the dissolved organic matter from the hydrothermal plume samples. Dissolved heavy metals (Al, Mn, Fe, Cu, Zn, Co, Ni, As, Mo, Cd and Pb) bound with C18 Sep-Pak extractable organic matter, dissolved organic metals, were analyzed by GFAAS. In all measured heavy metals, the dissolved organic metals existed in the hydrothermal plume samples collected from two sites. The concentration of the dissolved organic metals ranged from 0.5nM to 30nM and was about 1/1000 1/100 of the total dissolved heavy metals concentration. It suggests that these heavy metals were bound with organic matter originated in the hydrothermal microorganism. Though the abundance of the organism in the Central Indian Ridge is larger than that in the Suiyo Seamount caldera, the concentration of the dissolved organic metals in the plume samples at the Suiyo Seamount caldera was higher than that at the Central Indian Ridge. These results indicate that the bioavailability of heavy metals is different in two sites.

B12A-0762 1330h POSTER

Mass Transfer in Diffuse Low-Temperature Hydrothermal Systems

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Diffuse low-temperature venting (<100°C) carries 50-90% of heat transferred at mid-ocean ridges from the lithosphere to the hydrosphere, implying that mass transfer associated with this type of fluid flow may be significant. Alteration of ocean crust by circulating seawater is manifested by the breakdown of primary minerals and deposition of secondary minerals in voids. Diffuse fluids vent through basalt or sulfide when spatially associated with high-temperature vents and only through basalt when located distally from these vents. Diffuse fluids react with the basaltic crust through which they pass, however, chemical and mineralogical effects of these reactions has not been explicitly examined. The goal of this project is to examine chemical fluxes associated with these reactions in two hydrothermal systems on the Juan de Fuca Ridge, each in different stages of evolution. Chemical fluxes between basalt, secondary minerals and hydrothermal fluids will be quantified in the context of the systems environmental parameters, age and geological setting. This is the first study to directly link hydrothermal fluid chemistry with secondary minerals deposited by low-temperature alteration. Samples collected were in direct contact with diffuse hydrothermal fluids and where possible, fluid temperatures were taken simultaneously with sample collection. The East Field at Axial Volcano represents a young end-member of a hydrothermal system where an eruption took place in January, 1998. Basalt samples collected are very fresh with alteration manifested as surface coatings. Preliminary chemical results indicate depletion of Si by 1 wt. %, compared to samples of the 1998 lava flow collected away from vents. Secondary mineralogy indicates subsurface hydrothermal fluids in this region are warmer than those vented at the seafloor. Barite and anhydrite indicate subsurface mixing of hotter fluids with fresh, oxygenated seawater for these vents. The Endeavour hydrothermal system (~5000-8000 years old) represents a mature end-member for this study. Samples are more altered than those from Axial, with alteration penetrating into sample interiors and more extensive surface coatings. Geochemical modeling of basalt, secondary mineral and fluid chemistries will be used to predict subsurface conditions for reactions that occurred.

B12A-0763 1330h POSTER

Plate Tectonic Modulation of Microbial Productivity in the Deep Ocean-A Keck-supported Proto-NEPTUNE Experiment

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Deformation and volcanic activity in a plate tectonic framework must result in fluid, and therefore nutrient, fluxes within the upper oceanic crust, and between the oceanic crust and the deep ocean. These fluxes support microbial activity of many types, but the linkages are difficult to define and the magnitude of the overall process is extremely difficult to characterize and quantify because of the episodic behavior of the processes involved. Solving this problem requires long-term commitment of instrumental arrays designed to simultaneously identify and measure interactions between the seafloor and the overlying ocean. Although largely operating in a plate tectonically dominated regime on earth, similar geo-biochemical processes may be active on any number of planets at some time following accretion. Understanding the interactions here on earth may inform exploration for life on other bodies in our solar system and beyond. As an initial step toward exploring these linked phenomena, three adjacent plate boundaries along the northern edge of the Juan de Fuca Plate, were instrumented in the summer of 2003 with support from the Keck Foundation and the NSF. The intent is to initiate a proto-NEPTUNE suite of experiments designed to define the basic relationships involved microbial productivity resulting from plate boundary deformation. Although deployed in an autonomous mode now, the instruments and the approaches involved will transition to the Regional Cabled Observatory planned for the NE Pacific within five years. The principal focus of this initial

deployment was on a vigorously active ridge crest hydrothermal system overlying a known magma chamber. In the summer of 2003, a permanent installation of 8 seismometers, 7 seven-short period instruments and one broad band sensor, was completed at the northern end of the Juan de Fuca Ridge on the Endeavour Segment. The seismic array is complemented by a suite of temperature, fluid flow, and pressure measuring devices, as well as time-series fluid sampling systems, located in three of the five known hydrothermal vent fields. A well-defined mud volcano located along surface trace of the adjacent Nootka Transform fault, and seepage along a major carbonate-cemented active fault zone located near the toe of the nearby subduction complex were also instrumented with flow monitors and fluid sampling devices. Preliminary seismic data, baseline fluid chemistry, and selected microbial activity were characterized as an initial stage of the experiment.

URL: http://www.neptune.washington.edu/keck

B12A-0764 1330h POSTER

Reconciling Geophysical and Hydrothermal Data Concerning the Transfer of Heat from the Lithosphere to the Oceans at Fast and Slow Spreading-Centres

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Understanding the complex interplay between the geophysical and geological processes active at Mid-Ocean Ridges and their interplay with the overlying ocean through submarine hydrothermal circulation remains a fundamental goal of international mid-ocean ridge research. Here we reflect on some aspects of the current state of the art (and limits thereto) in our understanding of the transfer of heat from the interior of the Earth to the Ocean. Specifically, we focus upon the cooling of the upper ocean crust and its possible relationship to heat-transfer via high-temperature hydrothermal circulation close to the ridge-axis. For fast-(and intermediate-)spreading ridges we propose a simple conceptual model in which ridge extension in the upper crust is achieved via episodic ca.30-50-km-long diking events with a repeat period at any given location of ca.50 years and a "quantum" extensional dimension of ca.5m (ca.3m on intermediate ridges). We argue that the heat available from cooling of such a system to the roof of an axial magma chamber could be removed by (i) ca.5% instantaneous heat loss through "Event" plumes and (ii) ca.20% rapid discharge (order 5 yrs.) through rapid cooling of the upper ca.500 m of the crust via diminishing but vigorous (order 10 GW to 1GW) high-temperature hydrothermal flow. The residual heat available from cooling of the lower section of the dike, as far as the roof of the AMC (iii) would then be sufficient to sustain further high temperature flow in the form of discrete, long-lived (decadal), but less-vigorous (order 100 MW) high-temperature fields sited every ca.10 km along-axis. On the slow spreading Mid-Atlantic Ridge (MAR) our understanding of the mechanisms for the formation of long-lived tectonically-hosted fields such as TAG and especially Rainbow are more problematic. The apparent heat-flux required at these sites appears to be at least one order of magnitude greater than can readily be explained. The slow-spreading ridges exhibit much greater irregularity and episodic focussing of heat sources in space and time. This much is evident, for example, from variable off-axis seafloor morphology/residual gravity anomaly and from the activity over 1-2 Ma of individual mega-mullion detachment fault surfaces. The latter are associated with much thinner apparent crustal thickness, hence, an apparent deficit in magmatic heat release during their formation. This degree of apparent focussing of heat sources spatially and temporally along the MAR could readily facilitate the sustained 2.3 GW flow calculated for Rainbow, over 8-12 ky.

B12A-0765 1330h POSTER

Permeability-Porosity Relationships in Deep Sea Hydrothermal Vent Deposits

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To map out the thermal and chemical regimes within vent deposits where micro-and macro-organisms reside requires accurate modeling of mixing and reaction between hydrothermal fluid and seawater within the vent structures. However, a critical piece of information, quantitative knowledge of the permeability of vent deposits, and how it relates to porosity and pore geometry, is still missing. To address this, systematic laboratory measurements of permeability and porosity were conducted on 3 large vent structures from the Mothra Hydrothermal vent field on the Endeavor Segment of the Juan de Fuca Ridge. Twenty-five cylindrical cores with diameters of 2.54 cm and various lengths were taken from Phang (a tall sulfide-dominated spire that was not actively venting when sampled), Roane (a lower temperature spire with dense macrofaunal communities growing on its sides that was venting diffuse fluid of $< 300^\circ$C) and Finn (an active black smoker with a well-defined inner conduit that was venting 302°C fluids prior to recovery (Delaney et al., 2000; Kelley et al, 2000)). Measurements were made to obtain porosity and permeability of these drill cores using a helium porosimeter (UltraPoreTM300) and a nitrogen permeameter (UltrapermTM400) from Core Laboratories Instruments. The porosimeter uses Boyle's law to determine pore volume from the expansion of a know mass of helium into a calibrated sample holder, whereas the permeameter uses Darcy's law to determine permeability by measuring the steady-state flow rate through the sample under a given pressure gradient. A moderate confining pressure of 1.38 MPa was applied during the measurements to prevent leakage between the sample surface and the sample holder. The permeability and porosity relationship is best described by two different power law relationships with exponents of ~ 9 (group I) and ~ 3 (group II), respectively. Microstructural observations suggest that the difference in the two permeability-porosity relationships reflects different evolution processes as pores are sealed within different parts of the vent structures. Our data suggest that correctly identifying the processes of pore space evolution in seafloor vent deposits is the key to successfully relating permeability to porosity.

B12A-0766 1330h POSTER

NaCl-H2O Phase Diagrams and Equations of State for Modeling Geo-hydrothermal Systems

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Fluids in seafloor hydrothermal systems and many underground geothermal systems contain certain amount of salts, which have a significant effect on the dynamics of fluid flow and transport processes. Equations of state and phase diagrams of the NaCl-H2O system are needed to determine phase equilibrium and thermodynamic properties of fluids in modeling high-temperature geo-hydrothermal systems, particularly those near mid-ocean ridges. Extant equations of state and phase diagrams in the literature are either applicable to pressure/temperature ranges that are not sufficient to cover those of seafloor hydrothermal systems, or have significant flaws that render successful modeling impractical. To carry out our research projects on modeling seafloor hydrothermal systems, we have developed phase diagrams as described below. Pressure-temperature-salinity and pressure-temperature-density phase boundaries containing the liquid-vapor region of NaCl-H2O system for temperatures from 300°C to 801°C (the melting point of halite) and pressures from 0.1MPa to above 200MPa were first constructed based on Anderko and Pitzer's [1993] method. These boundaries were then extrapolated to include temperature ranges of 100°C-300°C to the low end and 801°C-1200°C to the high end according to data along the critical line and of the saturated phases on the liquid-vapor-halite three-phase boundary in the low- and high-temperature ranges, respectively. Based on the assumption of NaCl-H2O solution as a water-slat assembly with linear contributions from water and salt, the pressure-temperature-enthalpy phase boundary was formed on the basis of pressure, density and salinity data along the boundary.

B12A-0767 1330h POSTER

On Possible Relationships Between Diking, Magma Lenses, and Location of Hydrothermal Sites at Mid-Ocean Ridges

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Magma chambers beneath fast spreading mid-oceanic ridges appear in the form of thin lenses in the cross- axis sections. Furthermore, the recent data indicate that such a magma lens also lies beneath the intermediate spreading rate Endeavor segment on the Juan de Fuca Ridge. This shape indicates that the pressurization of the magma chamber should result in the stress concentration near the tips of the lens while the rest of the host rock would be in the state of compression. It is likely, therefore, that if an episode of magma replenishment in the magma lens results in diking, the dikes will initiate near the lens tips. The further propagation of dikes can be described by the principles of fracture mechanics. Our calculations suggest that the dikes propagate almost vertically towards the seafloor from the lens tips. Because diking is likely to generate a region of high permeability near its margin in addition to heat, hydrothermal activity may be localized by diking events. This suggests that hydrothermal vent fields may be located above the tips of the magma lenses away from the ridge axis (i.e., in the cross-axis profile of the lens). Alternatively, the diking may result from solidification of the magma lens. Because the density of magma is lower then that for the fresh rock, crystallization leads to the pressure decrease in the lens. Consequently, the stress distribution in the host rock changes and becomes tensile in the middle part of the magma lens and compressive in the tip regions. In this scenario, the dikes are likely to initiate from the central areas and the hydrothermal sites would be more expected to occur above the central part of the magma lens. Comparing observations of the location of the hydrothermal sites with respect to the magma lens location may be useful for constraining the mechanisms of magma lens evolution. For example, the Salty Dawg hydrothermal site on the Endeavor segment appears to be located near the western tip of the seismically imaged magma lens. Our model suggests that the venting activity at this site may be localized by diking triggered by the lens pressurization.

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B12A-0768 1330h POSTER

Disequilibrium Two-Phase Flow? The Case at A Vent EPR 9°N, April 1991 and at Endeavor, JDF, June, 1999

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During the two week period immediately following the magmatic eruption on the East Pacific Rise near 9°N, fluid discharging at A vent exhibited temperatures near 400°C, placing the fluid in the two-phase regime at a seafloor pressure of 25 MPa. The vent salinity was less than 0.1 that of seawater, indicating a vapor phase. Similarly, in June 1999, following a magma/tectonic event, salinity at Puffer and Sully vents on Endeavor, Juan de Fuca Ridge, suddenly dropped to less than 0.1 that of seawater, while temperature remained in the two-phase regime corresponding to a seafloor pressure of 22 MPa. Despite these low salinities, however, the observed vent salinity is greater than that corresponding to the temperature and pressure at the respective vents, and thus the apparent vapor phase does not correspond to thermodynamic equilibrium. Because the equilibrium brine phase is generally denser than seawater and tends to sink, and because the salinity of the equilibrium vapor phase tend to increase with pressure, we argue that the vapor phases at A vent in April 1991 and at Puffer and Sully vents in June 1999 represent vapor phases that were in equilibrium at greater depths in the system. Because of their rapid ascent, these low density vapor phases remain in disequilibrium with their seafloor environment. Assuming disequilibrium, the time series at A vent allows us to estimate the rate of ascent and indicates that the subsurface permeability there is $\sim 10^{-13}$ m^2.

B12A-0769 1330h POSTER

Discovering New Mantle-Hosted Submarine Ecosytems: The Lost City Hydrothermal Field

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In April-May 2003, the Lost City Hydrothermal Field was investigated during 19 Alvin dives and 17 missions with the autonomous vehicle ABE to examine the linkages among geological, chemical and biological processes associated with a submarine hydrothermal system hosted on mantle material. In concert, these two programs resulted in 1) delineation of the geologic features that control hydrothermal flow in this area; 2) an extremely high-resolution bathymetric map (meter scale) of the field and adjacent areas of the Atlantis Massif; 3) interdisciplinary sampling of 10 individual venting sites within the field; and 4) documentation of a nearly continuous zone of deformation at the top of the massif that is very likely the surface expression of a long-lived detachment fault that caps the massif. This hydrothermal system, which is driven by exothermic serpentinization reactions beneath the Atlantis Massif, is unlike any known field examined to date. It is hosted on 1-2 my old variably altered mantle material, it contains more than 30 carbonate chimneys that reach up to 60 m in height, and generation of diffusely venting 40-90C fluids with pH 9-11 that are enriched in methane, hydrogen and other hydrocarbons support dense microbial communities. ABE bathymetry shows that a linear array of the largest structures within the field is controlled by an E-W trending, 200 m long lineament intersected by a N-S trending fault. Mapping of the near vertical cliffs adjacent to the field indicates that much of the subsurface flow within this area is controlled by very gently west-dipping faults that result in a nearly horizontal, sheet-like style of flow. Venting of diffuse fluids directly from the near vertical walls forms perpendicular growths of carbonate flanges, and results in the formation of vertical spires, and massive, shingled deposits that cascade down the cliff faces. The plumbing system within this area is very different from the vertical conduits that typify black smoker environments. The large surface areas exposed to hydrothermal fluids along the gently dipping faults may provide important environments for microbiological communities within the subsurface. Stockwork systems and variably cemented breccias preserved along the steep walls immediately adjacent to the field are reminiscent of ancient ophicalcite deposits preserved in ophiolitic rocks since the Archean. The Lost City Field is an astounding, intensely beautiful area that hosts numerous composite chimneys that extend over an area >350 m in length. Many structures contain an array of delicate flanges, multiple pinnacles, and beehive deposits. The complex structure Poseidon dominates the field: it is over 60 m in height, >40 m in length and it hosts multiple active and inactive towers, smaller pinnacles, and flanges. It is unlikely that hydrothermal systems like Lost City are unique along the global mid-ocean ridge spreading network; where massifs similar to those at the Atlantis Fracture Zone are common. In these environments, intense long-lived faulting and seismic activity, coupled with serpentinization reactions act depth serve to promote hydrothermal flow.

URL: http://www.lostcity.washington.edu

B12A-0770 1330h POSTER

Preliminary Geochemistry of Volatile Species From Active Vents at the Lost City Hydrothermal Field

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The Lost City Hydrothermal Field is a unique site of hydrothermal venting, as the energy driving circulation is provided solely from exothermic reactions between seawater and the underlying ultramafic rocks. These serpentinization reactions produce large amounts of hydrogen, and the resulting reducing conditions favor methane as the dominant carbon volatile species. Samples taken during the return visit to Lost City in the Spring of 2003 provide the opportunity to characterize the volatiles of an ultramafic hosted hydrothermal system without a magmatic contribution. Preliminary results from fluids sampled using non-gas-tight major samplers indicate high levels of hydrogen (mmol/kg) and methane (hundreds of umol/kg), and abundant low molecular weight hydrocarbons (hundreds of nmol/kg). While the ratio of methane to higher organics (on the order of 100:1) is similar to results from sedimented mid-ocean ridge hydrothermal fluids, the lack of organic rich sediments at Lost City requires an alternate source of light hydrocarbon gases. Abiotic synthesis of low molecular weight hydrocarbons through Fischer-Tropsch type reactions is a potential pathway, and has been invoked in the high-temperature ultramafic system at Rainbow. However, the relatively cool temperature of venting at Lost City (<100°C) may provide a kinetic barrier to this type of reaction. Biological production may be an active mechanism of methane production, but it is unlikely that higher organics are formed this way. It is our hope that a careful analysis of the concentrations and isotope ratios of the collected gasses from major-pairs and gas-tight samplers at Lost City will lead to a better understanding of the flow of carbon at Lost City, and provide a model for other, yet undiscovered systems driven by the reaction of cold seawater with cold mantle rocks.

B12A-0771 1330h POSTER

Vent Plume Characteristics at the Lost City Hydrothermal Field

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Lost City is a peridotite-hosted hydrothermal field driven by exothermic serpentinization reactions at depth. Venting of high pH (9-11), 40 − 90° C fluids and seawater promotes growth of carbonate structures that reach up to 60 m in height. To characterize the plume around this novel actively venting field and to investigate other potential venting sites, 14 CTD casts were completed in the vicinity of the field. In addition to potential temperature, conductivity, and oxygen, hydrocasts were also equipped with an Eh sensor to measure redox potential through the water column. Fluids from 11 of these casts were also sampled for hydrogen and methane, as these gases are byproducts of serpentinization reactions. To quantify the strongest hydrothermal signals, four casts were taken directly above and adjacent to Poseidon, the largest structure in the field (60 m tall, reaching to an elevation of 730 m). To place constraints on the extent of plume movement at Lost City, one cast was taken 125 m to the west, another 75 m to the east, and 2 were taken in a shallow depression that bounds the field 50-60 m to the north. Of the 9 casts proximal to the field, almost all showed a moderate to steep increase in Eh values 10-20 m off the bottom. Dramatic gradients in Eh occurred near bottom at all boundary stations as well. Hydrogen concentrations 100 times those of background ocean waters were measured near bottom at stations just north of the field and strong signals up to 20x background were measured near and to the east of Poseidon. Highly elevated methane concentrations were measured at the eastern boundary cast (180 nM), while other stations to the north and east of the main Lost City field had moderately elevated values (40-55 nM, up to 30x background). Higher concentrations of both hydrogen and methane were consistently found in the 750-800 m depth range. These data show that plumes derived solely from serpentinization reactions are characterized by steep gradients in Eh and elevated volatile concentrations very near bottom. In contrast to plumes associated with black smoker systems, the limited buoyancy of Lost City-like plumes and lack of particulate or strong thermal anomalies will make prospecting for other peridotite-hosted systems challenging.

B12A-0772 1330h POSTER

High Resolution Multibeam Sonar Mapping of the Lost City Hydrothermal Site with the Autonomous Benthic Explorer

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The Autonomous Benthic Explorer (ABE) of the Woods Hole Oceanographic Institution (WHOI) collected high-resolution multibeam sonar bathymetry of the Atlantis Massif and the Lost City vent site in May 2003. A Simrad Mesotech SM 2000 multibeam sonar has been fully integrated into the vehicle for this purpose. The challenging topography of the Lost City site demanded careful AUV survey planning, but also afforded the opportunity to try new survey techniques, particularly side-looking surveys along steep slopes. The quality of post-processed navigation has been improved with the addition of a model-based smoother. To aid in processing the large volume of sonar data generated during surveys, we have developed a high-level user interface in the form of a MATLAB GUI that allows users to inspect sonar images and the corresponding bathymetry concurrently. Using these techniques, bathymetric maps gridded on 2 m regular grids are visually free of trackline artifacts.

B12A-0773 1330h POSTER

Geolipids produced by methanogens and sulfate-reducing bacteria at the Lost City Hydrothermal Field

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Molecular biomarkers document the presence in a geologic system of particular microbial lineages, or of microbes that use specific metabolic processes. Lipid extracts from carbonate rocks of the Lost City Hydrothermal Field yield a predominance of biomarkers diagnostic for methanogenic archaea including the ether lipids archaeol, *sn*-2 and *sn*-3 hydroxyarchaeol, and dihydroxyarchaeol and the hydrocarbon 2,6,10,15,19-pentamethylicosane (PMI). Sterols and hopanoids, diagnostic for eukaryotes and bacteria respectively, were subordinate. At ten sites surveyed thus far, biomarker types were not correlated with vent temperature or activity. Hydroxyarchaeols were detected in three active (T ≥ 70°C) and two inactive vents. Glycerol monoethers with saturated and unsaturated C15-C20 n-alkyl chains, diagnostic for sulfate-reducing bacteria, were detected in five active and three inactive vents. Carbohydrates were detected in four active vents, but not in the inactive vents. High concentrations of *sn*-2 and *sn*-3 hydroxyarchaeol and a dihydroxyarchaeol at a 70°C site (sample 3869-1404) suggest that methane cycling is the dominant metabolic processes at this location. The presence of methanogens at this site is confirmed by the presence of pentamethylicosane. Stable isotopic compositions of these biomarkers will be used to determine whether these methanogens are consuming or producing methane. This sample also contains C16 and C18 saturated glycerol monoethers. In conjunction with genomic studies, the biomarker analyses will document the metabolic roles of microbes in this system.

B12A-0774 1330h POSTER

Cross-Section of the Atlantis Massif — Geologic Framework for the Lost City Hydrothermal Vent Field

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The Atlantis Massif is an oceanic core complex situated on 1.5-Ma-old crust at 30°N on the Mid-Atlantic Ridge. Its domed, corrugated upper surface is interpreted as a major detachment fault. The steep, mass-wasted south wall of the massif provides a window into the architecture of the footwall of this detachment fault and underlying rocks. *Alvin* and *Argo II* were used to collect outcrop-scale geological data in the context of fine-scale bathymetry from ABE surveys. Variably serpentinized peridotite and lesser gabbroic rock form the bulk of the massif. Outcrops below ~1800 m.b.s.l. are generally massive, grading upward into a region cut by an array of shear zones, faults, and joints. The uppermost ~50 m of basement rock show a pervasive anastomosing foliation dipping gently west and cropping out for about 3 km. Samples from this interval include mylonitic material wrapping around less deformed phacoids of basement rock. The mylonites are unconformably overlain by a thin (1-3 m) cap of breccia, grading upward into pelagic limestone. The breccia is massive to crudely bedded with both clast- and matrix-supported textures. It includes subangular clasts of basalt and serpentinite in a limestone matrix. Small normal faults offset all of these units and the unconformity. The Lost City Hydrothermal Vent Field sits on top of the breccia unit. We interpret the mylonites as a detachment fault responsible for exhumation of the upper mantle material that forms the core of the massif. The overlying sedimentary rocks represent debris shed onto the detachment fault surface when it defined the median valley wall. As the detachment fault surface moved off axis and flattened into its present orientation, the sedimentary material changed progressively from clastic to pelagic and became consolidated. This assemblage may cover the rest of the Atlantis Massif and occur on other oceanic core complexes.

B12A-0775 1330h POSTER

Long-Lived Serpentinization and Carbonate Precipitation at the Lost City Hydrothermal Vent Field

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The discovery of spectacular, actively venting carbonate chimneys at the Lost City hydrothermal vent field (LCHF) on the Atlantis Massif (MAR 30°N) has stimulated great interest in the role of serpentinization in driving hydrothermal circulation in peridotite-hosted systems and in the biological communities that may be supported in these environments. The top of this fault-bounded, dome-like massif consists of variably deformed, talc-bearing serpentinites and gabbroic rocks (~1.5 Ma), unconformably overlain by polymictic sedimentary breccias and bedded pelagic limestones or chalks that form a flat-lying carbonate cap. The limestones and matrix of the breccias consist of highly indurated foraminiferal sand with a well-preserved sub-tropical fauna, which were at least locally deposited before the last glacial maximum. Calcite and/or aragonite veins are abundant; fractures in the basement are filled by carbonate sediments and lithic fragments. Veining generally pre-dates sedimentary fracture-infilling. The youngest hydrothermal phases include the LCHF chimneys and carbonate precipitates on outcrop surfaces, in cavities, and as growths protruding from fissures that are locally venting fluids. Sr-, C- and O-isotope analyses and radiocarbon age-dating indicate that this system is the integrated effect of tectonic activity, serpentinization, and hydrothermal flow that has lasted at least 30,000 years. C- and O-isotope compositions indicate a range of precipitation temperatures from ambient conditions up to $\sim 250^{\circ}C$ at depth and reflect mixing of seawater and serpentinization-derived hydrothermal fluids. Analyses of separated fractions of sedimentary and hydrothermal components define a sedimentary end-member composition of $\delta^{13}C = 1.3 \pm 0.3$ and $\delta^{18}O = 1.5 \pm 0.5^{o}/_{oo}$ (VPDB) and a hydrothermal end-member composition of $\delta^{13}C = 3.3$ and $\delta^{18}O = 5^{o}/_{oo}$. Based on the present-day degree of serpentinization, the geophysical structure and age of the lithosphere at the Atlantis Massif, and the radiocarbon ages, we estimate a minimum rate of serpentinization of $1.2 \cdot 10^{-4} km^3/y$. Our field observations together with available gravity and seismic data indicate that a considerable proportion of the massif is relatively unaltered peridotite. The access of seawater to relatively cool, fresh peridotite, coupled with faulting, volumetric expansion and mass wasting processes are crucial to sustain such systems. In addition, diffusely percolating, high pH fluids emanating from the underlying serpentinites promote rapid sediment lithification, which offers an efficient mechanism for slowing heat loss and maintaining higher temperatures in the basement. Collectively these processes have the potential to prolong hydrothermal activity for tens of thousands of years.

B12A-0776 1330h POSTER

Chemistry of a serpentinization-controlled hydrothermal system at the Lost City hydrothermal vent field

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The Lost City Hydrothermal Field (LCHF), at 30°N near the Mid-Atlantic Ridge, is an off-axis, low temperature, high-pH, ultramafic-hosted vent system. Within the field, carbonate chimneys tower up to 60 m above the seafloor, making them the tallest vent structures known. The chemistry of the vent structures and fluids at the LCHF is controlled by reactions between seawater and ultramafic rocks beneath the Atlantis massif. Mixing of warm alkaline vent fluids with seawater causes precipitation of calcium carbonate and growth of the edifaces, which range from tall, graceful pinnacles to fragile flanges and colloform deposits. Geochemical and petrological analyses of the carbonate rocks reveal distinct differences between the active and extinct structures. Actively venting chimneys and flanges are extremely porous, friable formations composed predominantly of aragonite and brucite. These structures provide important niches for well-developed microbial communities that thrive on and within the chimney walls. Some of the active chimneys may also contain the mineral ikaite, an unstable, hydrated form of calcium carbonate. TIMS and ICP-MS analyses of the carbonate chimneys show that the most active chimneys have low Sr isotope values and that they are low in trace metals (e.g., Mn, Ti, Pb). Active structures emit high-pH, low-Mg fluids at 40-90° C. The fluids also have low Sr values, indicating circulation of hydrothermal solutions through the serpentinite bedrock beneath the field. In contrast to the active structures, extinct chimneys are less porous, are well lithified, and they are composed predominantly of calcite that yields Sr isotopes near seawater values. Prolonged lower temperature seawater-hydrothermal fluid interaction within the chimneys results in the conversion of aragonite to calcite and in the enrichment of some trace metals (e.g., Mn, Ti, Co, Zn). It also promotes the incorporation of foraminifera within the outer, cemented walls of the carbonate structures. The Lost City system represents a novel natural laboratory for observing hydrothermal and biological activity in a system controlled by moderate temperature serpentinization reactions. The LCHF is the only vent field of its kind known to date; however, it is likely not unique along the global mid-ocean ridge spreading network.

URL: http://www.lostcity.washington.edu

B12A-0777 1330h POSTER

Serpentinization and Heat Generation at Slow Spreading Ridges

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The discovery of ultramafic hosted hydrothermal systems at Rainbow on the Mid Atlantic Ridge and Lost City, a vent site approximately 15km west of the MAR, provides unique perspectives on chemical and heat generating processes associated with serpentinization at a range of chemical and physical conditions. Vent fluid chemistry associated with alteration of ultramafic rocks at an axial and an off axis site on the MAR provides important constraints on heat and mass transport in subseafloor reaction zones. Low pH, high temperature fluids issuing from vents at the Rainbow site indicate slow rates of olivine hydrolysis and the near proximity of an intermittent magmatic heat source, which is needed to account for the high temperatures and flow rates observed at this site. Based on geochemical constraints, the Lost City vent fluids suggest higher temperatures than actually measured at vents. Therefore, the relatively low measured temperature of the Lost City vent fluid, likely reflects the effects of conductive cooling during transit from the site of alteration to the seafloor. Heat balance models suggest that heat production during serpentinization is ineffective, especially at relatively low and high temperatures due to kinetic constraints. Even at intermediate temperatures, however, where the olivine to serpentine conversion rate is more rapid, relatively low fluid to rock mass ratios are needed for exothermic heat generation to have even a minor influence on alteration temperature. Vent fluid chemistry reported for Lost City, however, suggests relatively high fluid to rock mass ratios as indicated by near seawater concentrations of dissolved Cl, K and Na. Although it can be argued that Cl is taken up during alteration in amounts that exactly balance hydration effects, the same would have to be true of K and Na, which is an unlikely scenario. The combination of vent fluid chemistry and heat balance models indicate that Lost City vent fluids may be associated with tectonically driven circulation where long lived faults allow fluid to access deep crustal sections at relatively high temperatures. Alternatively, vent fluids at Lost City may be produced by off axis gabbroic intrusions or near axis locations where magmatic heat sources are available and then transported to the current off axis location.

B12B MCC: Level 2 Monday 1330h

Impacts of Biomineralization on Earth Environments I Posters *(joint with A, OS, PP, V, GC, MR)*

Presiding: **L Wasylenki,** Virginia Polytechnic Institute and State University**; P Dove,** Virginia Polytechnic Institute and State University

B12B-0778 1330h POSTER

Microbial Biosignatures in High Iron Thermal Springs

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The emerging anoxic source waters at Chocolate Pots hot springs in Yellowstone National Park contain 2.6 to 11.2 mg/L Fe(II) and are 51-54°C and pH 5.5-6.0. These waters flow down the accumulating iron deposits and over three major phototrophic mat communities: *Synechococcus/Chloroflexus* at 51-54°C, *Pseudanabaena* at 51-54°C, and a narrow *Oscillatoria* at 36-45°C. We are assessing the contribution of the phototrophs to biosignature formation in this high iron system. These biosignatures can be used to assess the biological contribution to ancient iron deposits on Earth (e.g. Precambrian Banded Iron Formations) and, potentially, to those found on Mars. Most studies to date have focused on chemotrophic iron-oxidizing communities; however, recent research has demonstrated that phototrophs have a significant physiological impact on these iron thermal springs (Pierson et al. 1999, Pierson and Parenteau 2000, and Trouwborst et al., 2003).