

a prominent southeastward increase that has been interpreted to reflect landward tilting of the Paleogene portion of the wedge after peak heating. In contrast, the latter indicate consistent temperatures during late-stage faulting across all three locations investigated. Although this result suggests minimal modification of the thermal structure that is recorded by the trapped fluids, the fluids reveal a southeastward decrease in molar proportion of methane relative to carbon dioxide that may reflect tilting adequate to differentially expose this metamorphic gradient. In total we document thermally-driven oxidation of methane relatively late (i.e., post-cleavage) in the deformation history of the Shimanto accretionary wedge.

V11B-09 1105h

Helium-Carbon Relationships in Geothermal Fluids of Guatemala: Mapping the Subducted Sedimentary Component

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As part of the Central America MARGINS initiative, we report a comprehensive study of helium isotope ($^3\text{He}/^4\text{He}$), carbon isotope ($\delta^{13}\text{C}(\text{CO}_2)$) and He-C abundance relationships of geothermal fluids from 7 volcanic centres of Guatemala. Guatemala was selected to provide a contrast to on-going studies in Costa Rica (see next abstract) as the arc crust in this region is thicker and older, and (unlike Costa Rica) the entire sedimentary sequence on the down-going plate (both hemipelagic muds and underlying pelagic carbonates) likely contributes to the slab flux.

The Guatemalan volcanic centres of Amatitlan-Pacaya, Tecuamburro, Moyuta, Zunil and V. Fuego have $^3\text{He}/^4\text{He}$ values which fall within the range normally associated with subduction zones ($5 - 8 R_A$ where $R_A = ^3\text{He}/^4\text{He}$ of air). Slightly lower $^3\text{He}/^4\text{He}$ values ($< 3 R_A$) are found at San Marcos and L. Atitlan but sampling in these regions was less extensive. $\text{CO}_2/^3\text{He}$ ratios vary between 5 and 81 ($\times 10^9$) with $\delta^{13}\text{C}$ values scattering between -1.4 and -5.5 ‰. Although the helium in Guatemala is overwhelmingly of mantle wedge derivation, He-C results are consistent with the bulk of the CO_2 having a slab origin.

Using the approach of Sano and Marty (Chem. Geol., 1995) i.e. volcanic gases can be approximated by a 3-component mixture of MORB (M: $\delta^{13}\text{C} = -6.5$ ‰), slab-derived marine carbonate/limestone (L: $\delta^{13}\text{C} = 0$ ‰) and (organic) sedimentary (S) endmember components, the calculated L/S ratio for Guatemala is 8 and 5 for sedimentary endmember values of -30 and -20 ‰ respectively. These values are higher than worldwide arc averages and imply preferential incorporation of carbonate into the slab flux compared to the hemipelagic muds. However, both values are lower than those found for Costa Rica which indicates that possible loss of subducting sediments (e.g. by underplating) is less pronounced in Guatemala compared with contiguous arc segments to the south.

V11B-10 1120h

Carbon and noble gas composition of the Central American Volcanic Arc: Implications on global recycling of subducted carbonates.

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Four geothermal fields in Central America were sampled for gas composition in order to determine the degree to which mantle and subducted components contribute to the present CO_2 flux. Subducted marine carbonates contribute 86% to 98% of the carbon dioxide emitted by volcanoes of the Central American arc system, based upon $\delta^{13}\text{C}$ values and $\text{CO}_2/^3\text{He}$ ratios. Previous investigations from active arc systems around

the world report similar proportions of recycled carbon dioxide. The highest proportion of carbonate recycling in Central America occurs in the Costa Rican segment of arc, presumably due to higher temperatures of the subducting slab. Although the subducted sediment column along the Middle America Trench system is rich in carbonate lithologies, carbon-helium relationships require that only 0.3% to 3.3% of the subducted carbon is released through devolatilization beneath the arc, roughly an order of magnitude less than other arc systems which generally contain a higher water content and lower carbon content. The lack of extensive decarbonation along the subducting Central American slab is due to insufficient mineral-bound water in the subducted sediments, as well as insufficient temperatures beneath the volcanic axis. When differences between Central America and other arc systems are accounted for, the total global flux of carbon from island arcs is only 0.18×10^{12} mol/a. This is much less than previous estimates, yet balances the flux of carbon dioxide gas at mid-ocean ridges and the return of subducted carbon to the mantle. Given the low flux of subducted carbon from active arc volcanoes, global models which consider arc volcanism as a substantial source of exospheric carbon should be reconsidered.

V11B-11 1135h INVITED

Isotopic and Elemental Signatures of the Forearc, and Impacts on Subduction Recycling: Evidence from the Marianas

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Trace element and B and Li isotope systematics of serpentinites from the Conical Seamount in the Mariana forearc indicate significant geochemical changes occur in the slab and mantle wedge in the earliest stages of subduction. Elevated K, Rb, Cs, B, Li and possibly Pb and As contents in fluids, clasts, and/or muds from Conical indicate transport of H_2O -soluble species off the slab at < 30 km depths. Boron contents in Conical clasts correlate broadly with LOI, suggesting continuous inputs of B with progressive hydration. Abundances of Li, Rb and Cs covary mutually, but do not correlate with LOI or other elemental concentrations in Conical clasts. The alkalis may thus reflect a different (later?) stage of slab inputs in which a broader menu of species are mobilized.

Boron isotopic systematics of Conical serpentinites point to additions of fluid with uniform $\delta^{11}\text{B}$, irrespective of fluid-rock ratio. This fluid, at $\delta^{11}\text{B}$ of $+13$ ‰, is > 10 ‰ heavier than any subducted component, indicating fractionation of B isotopes during slab fluid releases beneath forearcs. The temperatures of shallow slabs must be cool enough for B isotope fractionations to occur, which is consistent with the observed, low T serpentine mineralogy in Conical samples. The fraction of slab B recycled in the forearc depends on the model for developing high $\delta^{11}\text{B}$ arc lavas: either slab fluids with elevated $\delta^{11}\text{B}$ are released beneath arcs, or a hotter (and presumably lower $\delta^{11}\text{B}$) fluids from the slab mix with some portion of hydrated, high $\delta^{11}\text{B}$ mantle convected in from shallower depths.

Li isotopes in Conical serpentinites indicate more modest, if variable, slab inputs. $\delta^7\text{Li}$ variations in these samples (from -0.5 to $+11$ ‰) are greater than those observed in probable slab materials, or in most arc lavas, and may indicate the development of Li isotopic heterogeneities in the Mariana forearc mantle, like those suggested by Li isotope variations in "hot" arcs (Tomaschak et al., 2000). $\delta^7\text{Li}$ in Mariana arc lavas (at $+1$ to $+8.5$ ‰), are more diverse than observed in other arcs, but show less variation than Mariana forearc rocks, supporting contentions that Li from the mantle wedge dilutes the slab input during arc melting.

V12A MC: Hall D Monday 1330h

Ridge Processes and Products

Presiding: R Keaten, MBARI

V12A-0942 1330h POSTER

Hf Isotope Compositions in MORB from the Arctic MAR

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We report on $^{176}\text{Hf}/^{177}\text{Hf}$ for 52 MAR basalt glasses from $66 - 78^\circ\text{N}$. Spreading rate, ridge axis elevation, and degree of melting progressively decrease northwards to very low values. On southern Kolbeinsey Ridge ($66 - 69^\circ\text{N}$), ϵ_{Hf} increases from $+14.5$ north of Iceland to $+19.5$ at the Spar FZ, where typical N-MORB erupt ($\epsilon_{\text{Nd}}=+11$, $(\text{La}/\text{Sm})_n=0.5$, $(\text{Lu}/\text{Hf})_n=2.8$). This gradient reflects mixing of the Iceland plume with depleted upper mantle. On northern Kolbeinsey Ridge ($69 - 71^\circ\text{N}$), ϵ_{Hf} decreases steeply from $+19.5$ at the Spar FZ to $+15$ at the Jan Mayen FZ, reflecting mixing between depleted upper mantle and the Jan Mayen plume, located 160 km to the east. On Mohs Ridge ($71 - 73.5^\circ\text{N}$), ϵ_{Hf} increases abruptly from $+10$ at Jan Mayen platform ($\epsilon_{\text{Nd}}=4.5$) to $+24.3$ at the intersection with Knipovich Ridge, where N-MORB erupt with $\epsilon_{\text{Nd}}=+10$, $(\text{La}/\text{Sm})_n=0.6$, and $(\text{Lu}/\text{Hf})_n=1.3$. The ϵ_{Hf} gradient over Mohs Ridge reflects the northward dispersion of the Jan Mayen plume and its mixing with depleted upper mantle. Along Knipovich Ridge ($73.5 - 78^\circ\text{N}$), which runs NW parallel to and on the fringe of the Barents Sea-Svalbard continental shelf break, ϵ_{Hf} scatters between $+20$ and $+23$, a relatively small and highly radiogenic range compared to that of $+7.2$ to $+10$ for ϵ_{Nd} . Overall, the Hf isotope latitudinal profile is similar to that of Nd and opposite those of Pb and Sr. A major distinction between the Hf and Nd isotope profiles is the magnitude of the maxima observed where N-MORB are present. The $^{176}\text{Hf}/^{177}\text{Hf}$ maximum at 73.5°N ($\epsilon_{\text{Hf}}=24$) is significantly higher than that at 69°N ($\epsilon_{\text{Hf}}=19$), whereas the opposite is observed for $^{143}\text{Nd}/^{144}\text{Nd}$. In Nd-Hf isotope space, three distinct mixing trends are observed, stacked significantly above the global mantle array. The farthest displaced Jan Mayen-Mohs trend converges at a sharp angle with the mantle array at $\epsilon_{\text{Nd}}=5$. The southern and northern Kolbeinsey trends are superimposed, run subparallel to the mantle array, and intersect the Jan Mayen-Mohs trend at $\epsilon_{\text{Nd}}=6.5$. The Knipovich trend falls in between the Jan Mayen-Mohs and Kolbeinsey trends, intersecting the former at $\epsilon_{\text{Nd}}=7.5$. Small differences in the Hf/Nd ratios of the end-members of these binary mixing arrays are suggested by their slight downward concavities. The $^{176}\text{Lu}/^{177}\text{Hf}$ latitudinal profile resembles that of $^{143}\text{Nd}/^{144}\text{Nd}$ rather than $^{176}\text{Hf}/^{177}\text{Hf}$, indicating relatively recent decoupling in parent/daughter- $^{176}\text{Hf}/^{177}\text{Hf}$ isotope systematics over the Knipovich and northern Mohs Ridges. The proximity of Knipovich Ridge to the Svalbard-Barents Sea continental break, its youth, shear-dominated spreading, and punctiform nature of volcanism, with graben-like sections invaded by turbidites, are likely the cause of this decoupling. Melting of randomly distributed sub-continental mantle lithosphere schlieren embedded in the depleted upper mantle beneath Knipovich Ridge was proposed based on Pb-Nd-Sr-He isotope systematics. The unusually radiogenic Hf isotopic signature further suggests these heterogeneities may be deep restites from ancient melt extraction at great depth where garnet/clinopyroxene ratios would have been high, producing residue aging with higher-than-usual $(\text{Lu}/\text{Hf})/(\text{Sm}/\text{Nd})$. The slow spreading and small degree of melting characterizing Knipovich Ridge can readily account for the relatively high $(\text{La}/\text{Sm})_n=1-1.5$ and low $(\text{Lu}/\text{Hf})_n=0.7-1$ also observed in these MORB.

V12A-0943 1330h POSTER

Contrasting Geochemistry of on- and off-axis Magmatism, 26°S Mid-Atlantic Ridge

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We present trace element (ICP-MS) and high-precision (triple-spike) Pb isotope data for a suite of 28 fresh glasses from a single segment of the MAR at 26°S, and from near-ridge seamounts in the same area. The samples have previously been analysed for major elements and Sr-Nd-He isotopes (Castillo and Batiza, 1989; Niu and Batiza, 1994; Graham et al., 1996). The MAR at 26°S is an ideal place in which to examine the origins of mantle heterogeneity far from mantle plumes, and how such heterogeneities are sampled by on- and off-axis magmatism.

All samples are depleted N-MORB. Basalts from the ridge axis display systematic latitudinal chemical variations; samples from the center and ends of the segment tend to be less evolved, and have more enriched incompatible trace element and isotope compositions. In triple-spike Pb-Pb space, lavas from the ridge axis display remarkable linear arrays, which may result from two component mixing, possibly involving the Trinidad plume. Seamount lavas are more depleted in highly incompatible elements than axial lavas (Ba concentrations are 0.4-0.5 times those of the axial lavas), but have high Sr, Pb and Eu, relative to REE of similar incompatibility (Ce/Pb for seamount lavas is 18.6-19.4). Sr/Sr* and Pb/Pb* correlate positively with Eu/Eu* for all samples, and the seamount lavas have values of these ratios that are >1 (e.g., Eu/Eu* 1.05-1.10). Seamount lavas with the highest Sr/Sr* have the highest ⁸⁷Sr/⁸⁶Sr (up to 0.7036) and ³He/⁴He (up to 11.0 R/R_A), and the lowest incompatible trace element concentrations. The low Ba concentrations of the seamount samples indicate that neither assimilation of plagioclase-rich crustal gabbro, nor melting of recycled oceanic crust, can explain the high Sr/Sr*, Pb/Pb*, Eu/Eu* of seamount lavas. Instead, these trace element features may result from remelting a source that underwent an earlier melt extraction event. The combination of low Rb/Sr and high ⁸⁷Sr/⁸⁶Sr indicates that this depletion occurred relatively recently. Sr-Nd-Pb isotope systematics are consistent with derivation from residues of melting above the Tristan plume at about 130 Ma, although ³He/⁴He ratios of seamount lavas are higher than those of young Tristan lavas. Our results suggest that South Atlantic MORB may be derived largely from melting of mantle plume 'residues', (Hanan et al., 1986; Phipps Morgan et al., 1995; Fontignie and Schilling, 1996).

V12A-0944 1330h POSTER

Generation of Mid-ocean Ridge Basalts at Pressures From 1 to 7 GPa

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We propose a model for the generation of MORBs based on phase relations in the CaO-MgO-Al₂O₃-SiO₂-Na₂O-FeO (CMASNF) system (Walter and Presnall, 1994; Gudfinnsson and Presnall, 2000) at pressures from 1-1.6 GPa and vapor-absent melting relations in the CaO-MgO-Al₂O₃-SiO₂-CO₂ (CMAS-CO₂) system at pressures from 3-7 GPa (Dalton and Presnall, 1998). As the CMASNF system contains about 99% of the composition of the mantle source and about 98% of the composition of MORBs, it combines the rigor and generality of model-system phase relations with a close approach to natural compositions. Use of the CMAS-CO₂ system allows modeling of melting relations at very low melt fractions in the presence of the most abundant volatile component.

The MELT seismic tomographic cross section across the East Pacific Rise (Forsyth et al., 2000) shows the most intense melting in a restricted region centered at about 30 km depth and lesser amounts of melting at greater depths. The major-element similarity of MORB compositions at all ridges suggests that the MELT seismic results apply globally. We use a low-temperature

mantle adiabat (~1300°C at zero pressure) that is consistent with this result. The model involves mixing of carbonatitic to kimberlitic melts produced at very small melt fractions (<0.2%) in the low-velocity zone at depths of ~80-220 km (~2.4-7 GPa) (Dalton and Presnall, 1998) with basaltic melts produced by much larger amounts of polybaric fractional melting (<15%) at the pl/sp lherzolite transition at ~1-1.6 GPa. Melting in the pressure range of the pl/sp lherzolite transition strongly controls the major-element characteristics of MORBs. Although isentropic decompression melting in the CMAS system is suppressed at the pl/sp lherzolite transition (Asimow et al., 1995), our data indicate that this does not occur in the topologically different and geologically more relevant CMASNF system. Also, in the CMASNF system, we do not find the negative dP/dT slope of the peridotite solidus at the pl/sp lherzolite transition calculated by Asimow et al. (2001) from MELTS.

Parental melts generated in the source region in the pressure range of the pl/sp lherzolite transition are compositionally distinct from all MORB glasses and require the crystallization of both plagioclase and olivine in order to reach the composition field of the most primitive MORBs. This requirement is consistent with the occurrence of olivine and/or plagioclase phenocrysts in the most primitive MORBs, the location of these MORBs close to the 1-atm olivine/plagioclase-divariant liquidus surface in the CMAS system, and the close proximity of parental melts to this liquidus surface.

In this model, global inverse correlations of FeO and CaO/Al₂O₃ with Na₂O at MgO = 8 are the result of phase equilibrium constraints at relatively constant P and T in the pl/sp lherzolite transition rather than melting columns of varying lengths and potential temperatures (Klein and Langmuir, 1987, 1989; Langmuir et al., 1992). However, realization of these systematics requires source heterogeneity. Thus, for the model we propose based on a relatively uniform adiabat worldwide with most of the melting occurring over a relatively narrow pressure and temperature interval, existence of the global correlations implies mantle heterogeneity on a regional scale.

V12A-0945 1330h POSTER

Down Hole Variation in the Chemistry of Gabbroic Rocks From Atlantis Bank, ODP Hole 1105A, Southwest Indian Ridge: Magma Chamber Processes

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Geochemical studies on cored sections have been conducted on gabbroic rocks recovered from ODP Leg 179 Hole 1105A. Hole 1105A was drilled on the Atlantis Bank through the same gabbroic massif cored at Hole 735B (Leg 118 and 176). Both holes are located along the Atlantis II Transform, Southwest Indian Ridge. Hole 1105A is offset 1.2 Km from Hole 735B, the deepest hole ever drilled in to the plutonic foundation of the oceanic crust. Preliminary shipboard magnetic, resistivity, lithologic and geochemical data suggest a possible correlation of lithostratigraphic units identified in both holes.

Four major rock types have been identified in the cored section of Hole 1105A. They are the gabbros, olivine gabbros, oxide olivine gabbros and the oxide gabbros. The cored section is divided into 4 major units based on the presence and absence of oxide minerals in the gabbroic rocks. The major rock types are distinguished on the basis of the presence of cumulus phases olivine, clinopyroxene, plagioclase. Whole rock Mg numbers range from 83.5 to 19.6 indicating extensive fractionation of magma. The oxide free gabbroic rocks have a very low abundance of incompatible elements like P₂O₅, TiO₂, Zr and LREE indicating that they crystallized as accumulates or mesocumulates with little to no trapped melt retained. The oxide gabbro layers have a higher abundance of Fe₂O₃ and TiO₂. Textural variation is observed with changes in Mg number down hole.

Clinopyroxenes show a wide range of composition, Mg number ranging from 50.86-83.78. The mineral chemistry matches closely with the whole rock data and shows down hole cryptic chemical variation. Variations in Mg numbers of CPX occur on thin section scale as well as in meter scales. Down hole cryptic chemical variations suggest periodic replenishment of the magma chamber, fractionation and magma mixing. The bulk rock major, trace, REE and the mineral chemistry suggest that gabbroic rocks formed as cumulates with low to negligible trap melt and none can be shown to resemble congealed melt likely to form as a chamber chilled margin. Sharp contrasts in equilibrium melt compositions over short distances, may indicate infiltration of fractionated melts into a relatively primitive cumulate assemblage. It appears that these fractionated melts result in localized accumulus crystal growth.

V12A-0946 1330h POSTER

Melt Movement Beneath the East Pacific Rise Constrained by Uranium-Series Disequilibrium Studies of Off-Axis Basalts

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We measured the uranium-series disequilibrium of basalts from 5 to 40 km off axis near 9°30'N of the East Pacific Rise, in order to develop a better understanding of melt movement processes beneath the East Pacific Rise. Some basaltic samples from 10 to 20 km off axis show significant (more than 10 percent) U-Th disequilibrium. These data also indicate near-symmetrical eruptions of normal mid-ocean ridge basalts and enriched mid-ocean ridge basalts up to 20 km off axis. Combining U-Th disequilibrium data with our trace element data, we suggest the existence of subsurface lateral melt transport over 10-15 km from the ridge axis. We can further estimate the lateral velocity of this melt movement. This study has broad consequences for our understanding of melt generation and movement processes beneath mid-ocean ridges.

V12A-0947 1330h POSTER

An Along-Axis Study of Basaltic Glass from the Northern Gorda Ridge

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Basaltic samples from the Northern Gorda Ridge (NGR) were collected in August 2000 during a joint cruise by the Monterey Bay Aquarium Research Institute and NOAA's National Underwater Research Program. Using the ROV Tiburon, samples were collected from three dive sites; the Seaciff hydrothermal site on the east wall, the western edge of the axial graben at Narrowgate, and a cone complex, including a large flat-topped cone, a linear chain of cones, and a flat flow between the two, located south of Narrowgate and the 1996 eruption site. High-resolution video shows vent and flow morphology at sample sites. Eighteen additional samples from small axial graben cones and flows were collected using a wax-tipped glass sampler. Together these samples cover 22 km along the NGR axis. Sampling density is roughly every 2 km, compared to 25 km for previous regional surveys.

Major element compositions of glasses were determined by electron microprobe. All samples have N-MORB compositions and Mg# 54-66 but the more primitive rocks in previously published NGR ranges were not found. There are two K₂O trends at comparable Mg#; low and lower. The low K₂O trend (0.09-0.2%) includes material from the southern cone complex, TiO₂ (1.1-1.4%), and axial cones and flat flows. The lower K₂O trend (0.07-0.10%) includes samples with two TiO₂ trends; those from Narrowgate and small axial graben cones with TiO₂ 1.3-1.9%, and flows found in the floor of the axial graben, TiO₂ 1.1-1.3%. A subset of these low TiO₂ flows is found between the two cones in the southern cone complex and has lower TiO₂ (1.1-1.2%) at comparable Mg# than other NGR samples. Both K₂O trends at comparable Mg# are exhibited in glass from the small axial graben cones and flows, and samples from the Seaciff site (0-51 ka) which have low TiO₂ (1.2-1.4%). CaO and Al₂O₃ are inversely related to Mg#, ranging 11.0-12.5% and 14.5-16.5% respectively.

Trace- and rare-earth-elements (REE) of glass samples by ICP-MS analysis are also typical of N-MORB. The samples have consistent flat heavy-REE, [Sm/Yb]_N range 1.03 to 1.22, and significant Eu depletion (Eu* ranges 0.86 to 1.00), indicating variable plagioclase fractionation. Light-REE depletion varies significant, [La/Sm]_N range 0.56 to 1.02, and may indicate source variation. Light-REE depletion correlates with low K₂O, K₂O/TiO₂ trends and lower Ce/Yb ratios. The different chemical types do not have a morphologic, location, or time correlation. High Ce/Yb ratios in samples from the Seaciff site, southern cone complex, and from small axial flows and cones correlate with high Mg#_N, CaO, and K₂O/TiO₂; and may indicate clinopyroxene in the magma source with smaller

degrees of partial melting that preferentially melts clinopyroxene from the source.

Lavas of the NGR are heterogeneous N-MORB's, they are produced by several similar processes which alternate through the smallest spatial and time scale we can examine within this dataset.

V12A-0948 1330h POSTER

A New Geologic Map of the NESCA Site at Escanaba Trough, Southern Gorda Ridge

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We have completed a new geologic map of the NESCA site at Escanaba Trough that shows a large continuous area of volcanic flows, ridge-parallel faults as well as ring faults around uplifted sediment hills, and a 4-km wide neotectonic zone. The Escanaba Trough, at the southern end of the Gorda Ridge, is one of the few known sediment-covered seafloor spreading centers. It is a slow-spreading center with axial depths locally exceeding 3300 m. Escanaba Trough contains at least six large sediment-hosted massive sulfide deposits. The NESCA site, near 41° north latitude, is one of several discrete volcanic edifices along the slow spreading ridge. It is the only one where active hydrothermal venting (with temperatures up to 217°C) has been documented.

Our interpretations of major faults and contacts are based primarily on 60-kHz sidescan and 4.5-kHz seismic-reflection data collected simultaneously in 1996, with groundtruth by submersible observations. The system was towed 100 to 200 m above the seafloor, providing high-resolution data. The NESCA site is covered by two complete sidescan mosaics, with one and two-meter pixel resolutions, which were collected along nearly orthogonal track lines. The seismic reflection profiles image the upper 30 to 50 m of the turbiditic sediment fill. One pair of track lines extends approximately 20 km south of the NESCA site, providing partial coverage of the SESCO volcanic edifice. Several massive sulfide deposits occur in the SESCO area, but none are known to be hydrothermally active.

The NESCA map shows the zone of neotectonic activity, with well-defined areas of disturbed sediment and volcanics, bordered by uplifted fault benches covered with undisturbed sediment. Recent volcanic activity within the neotectonic zone has created three distinct tectonic features: uplifted sedimentary hills (related to sill injection), a fissured and apparently inflated volcanic hill, and an adjacent pillow mound with an extensive sheet flow apron.

Central Hill, the site of active hydrothermal deposits and ODP leg 169 drilling, is bound by both ridge-parallel basement faults and a concentric set of faults around its rim, associated with sill intrusion. A generally continuous area of volcanic flows occurs east of Central Hill. Submersible observations indicate that lava flows around the sediment hills and is ponded against the eastern up-faulted sediment bench. Previously collected deep-penetration seismic data indicate that the lavas overlie about 450 m of sediment which fills the trough. The pillow mound east of Central Hill may be the eruptive source of these flows. Late stage intrusion of basalt has uplifted and rifted part of the pillow mound.

Fine-scale faulting delineates the active portion of the neotectonic zone, which passes between Central Hill and Southwest Hill. Southwest Hill has been dissected by faulting and the sides have failed by mass wasting, forming slump deposits. Crosscutting lineations southeast of Southwest Hill have offsets that indicate oblique basement faulting occurred after ridge-parallel faulting. Similar to Central Hill in the NESCA area, ring faults also surround the uplifted sediment hill named North Hill at the SESCO volcanic center. Volcanic flows originate from the ring faults at the base of North Hill; this suggests that the intrusions, which uplift the sediment hills, occasionally erupt to form lava flows that overlie the sediment fill.

V12A-0949 1330h POSTER

Compositional Diversity of Basaltic Glasses Collected with MBARI's ROV Tiburon from Escanaba Trough, Southern Gorda Ridge

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Basaltic glass was recovered from Escanaba Trough (ET) on a joint research cruise by the Monterey Bay Aquarium Research Institute (MBARI) and NURP in August 2000, using MBARI's ROV Tiburon and R/V Western Flyer. Glass-rimmed lava and glass fragments in sediment scoops and cores were recovered from the NESCA and SESCO sites, from a cluster of conical volcanic vents in northern Escanaba Trough, and from an up-lifted fault block on the west wall of the axial graben. Microprobe analyses of glasses from the NESCA site span a slightly larger compositional range (6.8-7.7% MgO) than previously reported from this area, but all have higher K₂O than samples from the sediment-free northern part of ET or from the northern Gorda Ridge. Glass compositions from SESCO also span a larger range (7.8-8.5% MgO) than previously reported but are typically more primitive (MgO > 8% MgO) than NESCA basalt. Glass compositions from the volcanic cones in the northern part of the trough are relatively primitive (7.3-8.5% MgO), low-K₂O N-MORB, within the range of northern Gorda Ridge lava. Glasses collected from the up-lifted west wall show the greatest diversity, including low-K₂O N-MORB, some more enriched in K₂O, similar to glass from the NESCA site, and some (from the uppermost part of the wall) have higher K₂O (to 0.55%) than any previously reported from the Gorda Ridge.

The similar compositions of glass from the NESCA hydrothermal site, from a long flow at the north side of the sill complex, and from the distal ends of the lava field, suggest a single eruptive event, although some parts of the flow predate and others post-date deformation and uplift of the sediment hills. Likewise, samples from the SESCO site appear to represent a single eruptive event, although from a less evolved magma. A dive south of the SESCO site, at 40°41.5'N latitude, found no exposed lava flows or glass fragments in the sediment, suggesting that lava did not erupt on the seafloor when this shallow sill complex was intruded. Unlike the active NESCA site, no hydrothermal venting was observed at the SESCO or the southernmost site. Progressively thicker and more tectonized sediment cover, and greater degradation of sulfide mounds from NESCA to the southernmost site suggest that volcanic and hydrothermal activity are progressively older toward the south. The sill complexes in the three areas apparently each resulted from a single magmatic pulse that supported short-lived hydrothermal circulation and mineral deposition.

V12A-0950 1330h POSTER

A Plume Head and Tail in the Bengal Basin and Bay of Bengal: Rajmahal and Sylhet Traps with Surrounding Alkaline Volcanism and the Ninetyeast Ridge

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Although the 116-113 Ma-old Rajmahal-Sylhet Traps of the Bengal basin, potentially covering an area > 2x10⁵ km², can be directly linked via Ninetyeast Ridge to the Kerguelen Plume, more than 5,000 kms away, it is generally believed that this flood basalt volcanism originated from a normal MORB-type mantle at the boundary of a mantle plume. This model, primarily based on geochemical analysis of a limited number of Rajmahal basalts, requires initiation of rifting of the eastern Indian margin by a smaller thermal flux than necessary for creating a large igneous province.

Here we show that the extent of volcanism associated with the Rajmahal-Sylhet Traps is far greater than usually assumed, thus requiring a direct involvement of the Kerguelen Plume. In addition to the surface exposures of the flood basalts in Rajmahal-Sylhet, the basaltic rocks have been encountered in many parts of the Bengal Basin in bore holes reaching a maximum thickness of 600 m in the western margin of the Basin (Sengupta, Bull. AAPG, 1966) Most importantly, several suites of ultrapotassic and alkalic intrusive complexes, similar to those associated with the Deccan and Siberia Traps, occur over wide areas within and outside the Basin: i) southwest of the surface exposures of Rajmahal basalts, distance 200km, intrusive in Lower Gondwana coals, Ar-Ar age 114 Ma (P.R. Renne, personal communication), ii) 400 km north of Rajmahal, exposed in Sikkim, intrusive into metamorphic crystalline nappes of the Himalayas; distance here is not real and must be a minimum as the nappes have been transported from the north, iii) northeast of Rajmahal in Meghalaya State, distance 550 km, intrusive into metamorphic Precambrian basement rocks.

Nd-Sr isotopic ratios and trace element characteristics of these above ultrapotassic and alkaline rocks are consistent with their origin associated with the Kerguelen Plume. The wide range in Nd-Sr array for these rocks, including the Sylhet and Rajmahal basalts, shows initial $\epsilon_{Nd}(T)$ values of +4 to -8 and ⁸⁷Sr/⁸⁶Sr of 0.7045 to 0.7100, which are similar to Kerguelen transitional and alkaline basalts, Bunburry Gosselin lavas and Naturaliste plateau basalts. Therefore, the zone of influence of the plume head with Rajmahal at the center would be at least 700 km in diameter, and such a large area would require direct involvement of the Kerguelen Plume head for magma genesis in the Bengal basin. Recognition of associated volcanism in the northeast of Sylhet Traps allows Ninetyeast Ridge to be the appropriate hotspot track in the Bay of Bengal.

V12A-0951 1330h POSTER

Volatile, Halogen and Light-Element Systematics of On- and Off-Axis Basalts From the EPR (~9° 30' N)

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Compositional affects of sub-axial magmas mixing with sea water-derived end-members and/or assimilation of sea water-altered crustal components along mid-ocean ridges are still generally ill-defined. We report new volatile (CO₂, H₂O, S), halogen (F, Cl) and light-element (Li, Be, B) data for basaltic samples previously collected from the ~9°30'N axial region of the northern East Pacific Rise (EPR), as well as from surrounding sites of probable off-axis eruptions. This section of the EPR is one of the most heavily studied areas of the global ridge system, and the general geochemical and petrologic aspects of this region are well-constrained. In addition, extensive geophysical surveys conducted in this region suggest the presence of an axial magma chamber at 1600-2500m below the ridge axis.

Volatile (CO₂, H₂O, S), halogen (F, Cl) and light-element (Li, Be, B) concentrations were determined instrumentally on the Cameca IMS 6F ion probe at DTM. Three fresh, aphyric glass shards of each sample were analyzed using the standard procedure employed at this facility (Hauri, 2001). The basaltic samples were selected to include compositions spanning the range observed in this region from incompatible element depleted to enriched, with MgO contents > 6wt%. Importantly, samples were also taken from small off-axis pillow-mounds, inferred to be sited of young off-axis eruptions, and off-axis samples previously dated and being significantly younger than expected from their geological spreading-rate age. A large proportion of the samples selected were collected during *Alvin* dives, giving a good geographical control on their location.

We utilize the unique and contrasting compositional characteristics of the selected volatiles, halogens, and light elements in basaltic mid-ocean ridge magmas and possible contaminants, i.e. sea water, brines and sea water-altered oceanic crustal components, to assess on- and off-axis shallow-level magmatic assimilation of these components.

V12A-0952 1330h POSTER

²³⁸U and ²³⁰Th Excesses in Kolbeinsey Ridge Basalts

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We report measurements of U-Th disequilibria, Nd, Sr and Pb isotopes and major- and trace-element compositions for 8 samples, from two suites of basalts from the slow-spreading (~1 cm/yr. half-spreading rate) Kolbeinsey Ridge (67°05' – 70°26'N), north of Iceland. These basalts show both significant ²³⁸U excesses [(²³⁰Th/²³⁸U) < 1] and ²³⁰Th excesses [(²³⁰Th/²³⁸U) > 1], with (²³⁰Th/²³⁸U) ranging from 0.95 to 1.24. The samples (²³⁰Th/²³²Th) activities are essentially constant (1.25 to 1.29), but there is a large range in (²³⁸U/²³²Th) activities (1.00 to 1.32); therefore these data lie on a horizontal array on a (²³⁰Th/²³²Th) - (²³⁸U/²³²Th) isochron plot. While ²²⁶Ra has not been measured for these samples, the fact that they form a horizontal array, which can be interpreted as a zero-age slope, provides strong evidence in support of the young age of these samples. Another independent geological constraint on these samples' young ages comes from the observation that the cruise dredges recovered basaltic glass, rather than glacial wash-out, suggesting their ages are <10ka. Normalized trace element abundances indicate that all samples are highly depleted [e.g. (La/Yb)_n < 0.4]. The samples with ²³⁸U excesses have the lowest Th concentrations, which is compatible with either shallow mantle melting or shallow mantle melt-rock reaction. Another important constraint is these samples near constant ⁸⁷Sr/⁸⁶Sr, ¹⁴³Nd/¹⁴⁴Nd and ²⁰⁸Pb/²⁰⁶Pb isotopic compositions: ⁸⁷Sr/⁸⁶Sr ranges from 0.70274 to 0.70290; ¹⁴³Nd/¹⁴⁴Nd ranges from 0.51310 to 0.51316; ²⁰⁸Pb/²⁰⁶Pb ranges from 2.89 to 2.91. This uniformity in isotopic composition indicates that all the melts were derived from a common source, suggesting that the measured variability in U/Th and (²³⁰Th/²³⁸U) is best explained by melting processes and not the mixing of melts from compositionally and lithologically distinct sources (e.g. pyroxenite veins and ambient peridotitic mantle).

V12A-0953 1330h POSTER

A Variety of Magmatic Processes at a Mid-ocean Ridge, Evidence Exposed by the Mendocino Transform Fault, Offshore Northern California

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The Mendocino Transform Fault (MTF) extends 3000km westward from the Mendocino Triple Junction in the northeastern Pacific. It is an active zone of dextral strike-slip motion between the Gorda Plate, <25Ma, and the Pacific Plate, ~30Ma. The MTF changes morphology at 126°W. To the east, the steep north-facing Gorda Escarpment (GE) is elevated up to 1.5km above the Gorda Plate. The south-facing Mendocino Ridge (MR), west of 126°W, is up to 1km below the Gorda Plate. At 127°30'W the MTF intersects the Gorda spreading ridge (GR). Samples were collected along the MTF at frequent intervals (30-100m) vertically up the exposed fault scarps during 14 dives with the remotely operated vehicle (ROV) Tiburon in 2000 and 2001. Rocks from the MTF are unusual in having a very broad compositional range. A detailed geochemical (XRF, ICPMS) study of relatively fresh basalts and diabases indicates that the rocks were formed by a variety of magmatic processes and probably from different mantle sources. Trace-element data, particularly Nb/Y (0.02-0.72) vs. Zr/Y (2.2-6.4), and REE patterns show depleted-, transitional- and enriched-type trends. The rocks from the structurally distinct regions, MR and GE, have similar ranges of compositions suggesting similar petrogenetic origins. Higher TiO₂ (2.0-3.2wt%) values and LREE/HREE ratios (La/Sm 1.1-2.8), in some of the T-type MORB from the MR and GE rocks suggest a transform fault effect on mantle melting, where decreasing amounts of melting occurs at the GR as it approaches the MTF. These compositions occur in addition to lavas with relatively fractionated seamount-like, E-type compositions. The wide range of Mg# (38-70) and CaO/Al₂O₃ (0.28-0.84) suggest extensive fractionation in shallow level magma chambers. This resulted in varying phenocryst assemblages (ol±plg±cpx) and crystallization orders. The chemistry of the MTF rocks in general match those of axial lava flows, and off-axis seamounts associated with the GR. In addition, the eastern part of the GE has lavas

with more enriched compositions than the off-axis GR seamounts, but not as enriched as typical Pacific Plate seamount lavas. ⁴⁰Ar-³⁹Ar dates from 8.5 to 13.4Ma further support an origin from the GR. The rocks of the GE have been transferred from the Gorda Plate to the Pacific Plate in a transpressional setting. Consistency in geochemistry, and exposed sections of intact oceanic crust as seen during the ROV dives, indicate transfer as coherent slabs. In contrast, the MR is likely to represent a tectonic melange.

V12A-0954 1330h POSTER

Vapor in the Deep Ocean? Insights From Collapse Features on the Northern East Pacific Rise

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Seafloor lava flows often display a wide dimensional range of void spaces exposed through collapse of the surface crust. Submarine volcanic collapse provides a fundamental control on shallow hydrothermal circulation, the porosity of the upper ocean crust, extent of subsurface habitats, and lava distribution and channelization. Visual and photographic observations collected using the submersible Alvin and a towed camera system on the East Pacific Rise at 9°37'N and 9°50'N were analyzed to describe variations in volcanic collapse as a function of spatial location. At both locations ~13% of the surface area of lava flows is collapsed.

Diameters and depths of penetration for volcanic collapse features in the study area fall along a spectrum with end member size categories inferred to have genetic implications for the processes that formed collapse. Although the amount of collapsed area at 9°37'N and 9°50'N is identical, the style and distribution of collapse differs markedly between the two locations. The 9°50'N area is located at a magmatically robust segment center, and collapse is dominated by features at the small end of the collapse spectrum, <2m in diameter. The 9°37'N site is located at a segment end. This area is inferred to be magmatically starved relative to 9°50'N site, and collapse is dominated by features at the large end of the collapse spectrum, >2m in diameter.

The mechanisms responsible for the formation of small and large collapse can be inferred from the presence of delicate drip structures and reaction patinas on the interior of lava crusts sampled from collapsed flows. Due to the speed at which molten lava solidifies in contact with seawater, we infer that drip structures must have formed within a hotter medium than seawater. As lava is extruded across a porous substrate, the new submarine lava crust traps superheated water that is channeled upward. The superheated fluid creates a pressurized void space separating the crust from the molten interior of the flow, and maintains temperatures in the cavity high enough for drip structures to propagate. The envelope of void space separating the molten interior of the flow from the surrounding seawater thermally buffers the lava crust and prevents the formation of cooling cracks in the flow surface. Large collapse features are associated with rapid withdrawal of magma beneath an inflating lava flow, either into the down-slope terminus of a lava tongue, local fissures, or the primary eruptive vent fissures. The size of large collapse features is determined by the strength and spacing of the walls and pillars that support the roofs over void spaces, and often yields depths of penetration up to 20m.

V12A-0955 1330h POSTER

Temporal Variations in the Mantle Source of MORB near the Vema Fracture Zone (Central Atlantic): Nd and Sr Isotopes in Peridotites and Basaltic Glasses

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Sr-Nd-Pb isotopic ratios of zero age basalts sampled along Mid-Ocean Ridges (MOR) have demonstrated that the mantle is heterogeneous at a regional scale. However, how the mantle evolves through time below a single segment of MOR it is still matter of debate. Peridotites and basaltic glasses were collected along a lithospheric section uplifted and exposed on the southern side of the Vema transform (10° North, Atlantic Ocean) along a seafloor spreading flow line for a stretch of almost 200 km (corresponding to roughly 10 my). This set of samples offers a unique opportunity to detect changes through time of the mantle signature in a segment of Mid Atlantic Ridge, by analyzing radiogenic isotopes in the clinopyroxenes (cpx) from peridotites and glasses from the overlying basalts.

Work is in progress; initial Sr and Nd measurements from cpxs within peridotites indicate several things. First, the cpxs display "depleted" mantle signatures. Second, there is a considerable variation of the isotopic ratios along the exposed section (¹⁴³Nd/¹⁴⁴Nd varies from 0.51293 to 0.51345, ⁸⁷Sr/⁸⁶Sr varies from 0.70228 to 0.70422) and these variations occur over a short time scale (some occur within an interval of one million year). Next, the Sr and Nd ratios are inversely correlated and fall along the mantle array. Finally, cpx Nd ratios are inversely correlated with the Cr/Al ratio of the spinel and orthopyroxene (opx) from the peridotites while Sr ratios are positively correlated. Thus, the chemically most depleted peridotite with high Cr/Al ratios show the most enriched isotopic signatures, a pattern that has also been observed in alpine-type peridotites and peridotite nodules and that is generally interpreted as metasomatism by enriched fluids affecting depleted peridotite more extensively than less depleted peridotite. This may indicate that the temporal variations in the extent of melting detected by Cr/Al ratio in spinel and opx (Bonatti et al., Variations with age of mantle ultramafic composition near the Vema Fracture Zone, Central Atlantic. EOS, Vol.79, No.45, F919) are related to rapid changes in the degree of depletion of the upwelling mantle sources and that the degree of depletion of these mantle sources is an inherited feature from earlier processes rather than the result of melting at the MOR.

V12A-0956 1330h POSTER

Evaluation of the Split-Ridge Hypothesis and Generation of Oceanic Crust along the Cleft Segment of the Southern Juan de Fuca Ridge (JdFR)

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Morphologic, structural and petrologic studies of the southern JdFR, suggest that it has evolved through cycles of accretion related to magmatic output. During the first cycle, which is dominated by magmatism and volcanic construction, the ridge axis has morphologic characteristics similar to a fast spreading ridge but as magmatism wanes tectonic extension dominates resulting in a more rugged, faulted morphology similar to a slow-spreading ridge ("split-ridge" hypothesis of

Kappel and Ryan, 1986). Off-axis sampling and observations made with the ROV Tiburon provide a unique perspective on the crustal evolution along this typical moderate spreading-rate ridge. The rift valley walls are comprised of a series of major bounding faults, separated by blocks of oceanic crust that exhibit little or no deformation. Unlike the present axis that is dominated by sheetflows, these blocks are almost entirely comprised of unfaulted, constructional pillow ridges, mounds and hornitos. These blocks conform to the mound-like areas identified by Kappel and Ryan (1984) based on Sea MARC I images and our EM300 data. There is observational evidence of small volumes of off-axis volcanism along eruptive fissures and from point-sources that appear related to the formation of rift-bounding faults. Other volcanic constructs seem to be related to the formation of the first series of abyssal hills, consistent with "volcanic growth faults" draped with syntectonic lava flows.

Off-axis samples are moderately to highly evolved N-MORB but also include ferro-andesites and a dacite with somewhat "transitional" chemical characteristics. The range of compositions is greater than that previously reported for the entire southern JdFR. In contrast, samples recovered from the south Cleft axis are moderately evolved N-MORB and exhibit little chemical variability. Lavas sampled in cross-axis traverses encompass the entire range of compositions with no readily discernible pattern of variation with distance from the axis nor are the chemical trends symmetric across the ridge crest; features which are inconsistent with the split-ridge hypothesis. Initial geological correlations suggest the less evolved flows form the outward-facing constructional mounds and hills, whereas the most evolved types (FeTi basalts) form the small hornitos and areas of extensive sheetflows and lava drainback that are perched on "benches" between faulted, pillowed walls. We suggest that the less evolved samples are related to axial volcanism while the more evolved samples were formed by post-axial or off-axis volcanism. The highly fractionated off-axis MORB could have been derived from the cooler, distal edges of a magma chamber. Most of the major and trace element chemical variability can be explained in terms of low-pressure fractional crystallization (up to 50%) of parental magmas with compositions similar to recently erupted axial MORB. Ferro-andesites recovered from an outcrop along the inner valley wall appear to be spatially related to the major axial bounding fault and to some extinct sulfide chimneys. These highly fractionated andesites (and the dacite from the RTI), require extreme amounts of fractional crystallization as well as additional processes (assimilation/mixing) to explain their unusual compositions.

V12A-0957 1330h POSTER

Eruption Recurrence Rates and Compositional Variability of Discrete Lava Flows on the S-EPR from ^{238}U , ^{230}Th , ^{226}Ra , ^{210}Pb , ^{232}Th

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Quantification of the absolute ages and geochemistry of individual seafloor lava flows provides important constraints on the magmatic processes responsible for building the oceanic crust. Here we present new ^{238}U , ^{230}Th , ^{226}Ra , ^{210}Pb radioactive disequilibrium age constraints (decadal to millennial time scale) for 3 mid-ocean ridge lava flows at 17°26'S on the East Pacific Rise (EPR): Aldo-Kihi, Rehu-Marka, and a neighboring unnamed flow. Our continuing study using high-resolution surveys and manned-submersible sampling (NAUDUR, 1993, and STOWA, 1991, expeditions) has previously shown that Aldo-Kihi is compositionally variable, is probably one of the youngest axial lavas in the 17°-19°S region, and was most likely erupted from a series of fissures extending >18 km along the ridge axis (Sinton et al., JGR, in revision). Rehu Marka has a more trace element enriched and evolved composition. The strongest age constraints in our U-series data set are from the ^{210}Pb , ^{226}Ra (half-life = 22.3 yrs) and ^{226}Ra , ^{230}Th (half life = 1600 yrs) systems. ^{210}Pb , ^{226}Ra disequilibrium (as 5-7% Pb deficits) is common in lavas from our S-EPR study area and slightly lower than disequilibria we have measured in lavas erupted in 1991 and 1992 at 9°50'N EPR. Although we are still developing our understanding of how this disequilibrium arises in MORB (e.g., how the radioactive "clock" is set for this isotope pair) a number of features of our preliminary data support the idea that these lavas are very young and that geologically observed contact relationships in the field separate the products of chronologically distinguishable eruptions. Also, the extent of ^{226}Ra , ^{210}Pb disequilibrium in 3 Aldo-Kihi samples compared to that observed at 9°50'N indicates that the Aldo-Kihi lava probably erupted within the last 10-20 yrs, and the higher but still <1 (^{210}Pb / ^{226}Ra) activity ratio in a lava sampled near to but outside the boundaries of Aldo-Kihi indicates it is slightly older, but probably only by a decade or so. Although the older lava's major element composition is very similar to Aldo-Kihi, it has distinct U-Th-Ra chemistry, indicating it is from a different parental magma. Finally, the compositionally very distinct Rehu Marka flow just to the north has no ^{226}Ra , ^{210}Pb disequilibrium, indicating it is likely older than the maximum resolvable age with this method (100-120 years). An age estimate (about 750 yrs) of the latter can be made from its ^{226}Ra excess. Together, these preliminary age constraints provide insight into eruption recurrence rates and the processes that allow for preservation of compositional variability within proximally located (in space and time) lava flows along this magmatically robust segment of the EPR.

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V12A-0958 1330h POSTER

Subduction of the Woodlark Spreading Center: Geochemical and Tectonic Effects

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The triple junction formed by the subduction of the Woodlark spreading ridge beneath the New Georgia Group (NGG) of the Solomon Islands is associated with unusual arc-related volcanic centers on the subducting Australia-India plate and a foreshortened arc-trench gap (30 - 90 km). Large calc-alkaline seamounts have grown along the north-trending Simbo ridge and the ESE-trending Ghizo ridge. These two features intersect the trench system at points separated by nearly 100 km, and the absence of a deep trench in this area and the lack of a strong Benioff zone beneath the NGG suggests that subduction is being stifled by the presence of the high-standing Woodlark ridge topography. The presence of numerous arcuate faults in the triangular region bounded by the ridges and the trench suggests the area is under extreme rotational stress due to this impingement. Rotation and faulting here may have allowed magmas to rise along the zones of weakness at the Simbo and Ghizo ridges, which are a Woodlark transform and a possible former spreading segment, respectively.

Arc-like volcanism to the south of the triple junction has been attributed to migration of calc-alkaline magmas from a source region under the Pacific plate. However, the mantle in this area was geochemically enriched by a previous episode of southerly subduction of the Pacific Plate. The impingement of the Ontong Java Plateau in the Miocene caused a subduction polarity reversal and initiated the current northerly subduction direction, placing mantle that was once in a back arc region under the NGG and Australia-India plate. This enrichment is observed in MORB and andesites acquired from the Woodlark spreading center up to 50 km from the triple junction, and increases with decreasing distance from the arc. We are testing the hypothesis that the anomalous lavas of the NGG and on the Australia-India plate are both generated in-situ and tap similar mantle sources that were enriched by the earlier phase of subduction.

Samples from seamounts on both sides of the trench in the triple junction area were collected during the 2000 CSIRO Franklin cruise (FR04/00) by dredge and rock grab. Major and trace elements, and Sr, Nd, and Pb isotopic compositions of the rocks are being compared in this study to constrain the geochemical characteristics of the mantle sources being sampled by these volcanic centers, to identify geochemical gradients in the region, and to evaluate any contributions by the subducted Australia-India slab to the NGG lavas.

V12A-0959 1330h POSTER

Mafic Clasts with Unusual REE Patterns in Felsic Volcanic Rocks: Evidence of Subsolidus Alteration of Mafic Rocks from Ascension Island, South Atlantic Ocean

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Incompatible trace element abundances and patterns, particularly those of the rare earth elements (REE), have traditionally been used in igneous petrogenesis as indicators of processes relating to crystal fractionation, partial melting, and characteristics of mantle source regions of ocean island basalt (OIB) suites. However, unusual features of REE patterns, e.g. negative Ce anomalies, have been reported from basalt (island arc and OIB) and even from mantle peridotite. Mafic clasts hosted in trachyte from Ascension Island show unusual distribution of REE.

Ascension Island lava flows and pyroclastic deposits are transitional to mildly alkaline and are a continuous fractionation series of basalt-hawaiite-mugearite-benmoreite-trachyte-ryholite. The major element variations from basalt to trachyte conform to those expected from crystal fractionation of the observed phenocryst phases from basalt parent magma. The mafic clasts in trachyte have the same compositional range (47 to 55 wt.% SiO₂) from basalt to hawaiite, mugearite, and benmoreite with the majority of the clasts collected having a mugearitic composition. The mafic lava flows and pyroclastic deposits have been divided into four distinct genetically identifiable groups based on trace element and isotopic characteristics: 1) high Zr/Nb (5.6 to 6.1) basalt; 2) Dark Slope Crater type (Zr/Nb of 4.9 to 5.4) hawaiite; 3) low Zr/Nb (4.1) hawaiite; 4) intermediate Zr/Nb (4.7 to 5.4) basalt-hawaiite-mugearite-benmoreite. The mafic clasts are geochemically heterogeneous with compositions varying from the high Zr/Nb basalt to the intermediate Zr/Nb hawaiite-mugearite-benmoreite.

Oblong shapes and uniformly smooth nature of the mafic clasts point to mechanical abrasion. The felsic magmatism that brought the clasts to the surface could not have mechanically abraded them into such shapes. Hence the rocks the clasts were derived from must have been abraded by mechanical weathering.

Some of the mafic clasts also have extremely high abundance and anomalous distributions of rare-earth elements (REE) and yttrium (Y), whereas other incompatible trace element concentrations and O, Sr, Nd, and Pb isotopic ratios do not differ from those of mafic (basalt to benmoreite) flows. The possibility of inheriting the REE from the host trachyte is not likely as the REE enrichment is different in different clasts. Also, the REE enrichment in the mafic clasts is commonly much greater than in the host trachyte. REE and Y enrichment in the clasts with respect to the mafic flows is a post-magmatic alteration feature. This is supported by negative Ce anomalies in these mafic clasts, since decoupling of Ce from the other REE is restricted to oxidizing, low-temperature, aqueous environments. Similar Nd isotopic ratios between the clasts and the mafic flows preclude the possibility that additional REE and Y are derived from marine sediment or guano, but rather suggest an origin under subsolidus conditions perhaps from interaction of mafic rocks with meteoric water circulating through the volcanic edifice.

V12B MC: Hall D Monday 1330h

Hawaii Hotspot

Presiding: J Morgan, Rice University

V12B-0960 1330h POSTER

Geochemical Structure of the Plume Beneath Maui Nui, Hawaii

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Lavas from West Maui volcano show a significant contribution from the Kea component, a mantle source for Hawaiian volcanoes characterized by depleted isotopic signatures. We analyzed shield-building stage W. Maui samples from a valley-exposed 300 m section, and