these surfaces. By contrast, this basalt quenched to glass, if re-heated in air at temperature between 775 and 900°C, shows a Ca-enrichment at the surface. The underlying Ca-diffusion is a result of the oxygen gradient between glass and air, and was assigned to the very negative ΔG for the CaO-formation [1]. According to microprobe analyses of pyroxene and plagioclase that form during re-heating above 930°C, both phases increase in Ca with increasing T. It is therefore possible that Ca becomes largely fixed in these crystals and is hence not available for diffusion at higher T.

[1] Burkhard D.J.M. (2001) J. Petrol. 42, 507-527.

V71A-1265 0830h POSTER

Piggyback Tectonics: Long-Term Growth of Kilauea on the South Flank of Mauna Loa

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New compositional and age data from offshore pillow lavas and volcaniclastic sediments, along with onland geologic, seismic, and deformation data, provide broad perspectives on the ancestral growth of Kilauea volcano and the long-term geometric evolution of its rift zones. Sulfur-rich glass rinds on pillow lavas and volcaniclastic sediments derived from them document early underwater growth of a large compositionally diverse alkalic edifice. The alkalic rocks yield 40Ar/39Ar ages as old as about 275 ka; transitional-composition lavas, which mark beginning of the shield stage while the edifice remained below sea level, were probably first erupted at about 200 ka. Breccias from Papau Seamount, long interpreted as a landslide mass from the south flank of Kilauea, instead are fragments derived from subaerial Mauna Loa, requiring that the flank of a large Mauna Loa edifice underlies western parts of Kilauea at shallow depth. Seismic and gravity data show that the deep plumbing system for Kilaueas magma supply extends through the oceanic crust to depths of at least 30-35 km, directly below its present-day caldera. Proximity of Kilaueas caldera to the surface boundary with Mauna Loa and the presence of Mauna Loa rocks at shallow depth are difficult to reconcile with a submarine origin for early Kilauea alkalic lavas, unless geometric relations between the two volcanoes changed substantially during growth of the Kilauea shield since its inception at about 200 ka. Seismic and ground deformation data suggest seaward spreading of the entire south flank of Hawaii Island, independently of the boundary between Kilauea and Mauna Loa, along a landward-dipping detachment fault system largely following the basal contact of the composite volcanic edifices with underlying sea-floor sediments. Current steady-state horizontal displacements increase progressively seaward, at rates of 1.5 cm/yr on the lower flank of Mauna Loa and reaching 5-8 cm/yr at the Kilauea coastline. Infrequent (100 yr) large earthquakes generate similar displacement geometries, but 102 larger displacements per event. Prior to inception of Kilauea and during its early growth, Mauna Loa is inferred to undergone more active volcano spreading, involving the Kaoiki-Honuapo fault system (considered a geometric analog of the Hilina system on Kilauea). Cumulative deformation of Mauna Loas south flank during growth of Kilauea since 200-300 ka is estimated to have involved 10-15 km of seaward spreading, displacing the rift zones of Kilauea while its deep plumbing system and summit magma reservoir remained nearly fixed in space. Kilaueas rift zones, rather than migrating southward with time solely due to dike emplacement preferentially on the mobile seaward side, alternatively are interpreted to have largely been transported passively southward, "piggyback" style, during shield-stage growth of Kilauea on a still-mobile south flank of Mauna Loa. Such an evolution of Kilauea can account for the arcuate geometry of the present-day rift zones, proximity of the summit magma supply to the exposed flank of Mauna Loa, initial submarine growth of the ancestral edifice, and present-day location of Mauna Loa rocks at shallow depth beneath the south flank of Kilauea.

V71A-1266 0830h POSTER

Shallow Eruption Depths for Ancestral Kilauea: Implications for its Growth

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The midslope bench on the submarine south flank of Kilauea volcano consists of volcaniclastic breccias and sandstones shed from Mauna Loa and Kilauea. Highly alkalic clasts (alkali basalt to nephelinite and phonotephrite), previously dated between 275 and 130 ka, record early Kilauea volcanism. High S concentrations (>750 ppm) in clasts and many sandstone glasses have suggested that early Kilauea alkalic magmas were erupted in deep water. To better evaluate eruption depths, we have measured (FTIR) H_2O and CO_2 dissolved in glasses from early alkalic breccias and sandstones and overlying alkalic to tholeiitic pillow lavas. Saturation pressures were calculated from mixed-volatile solubility models, then converted to eruption depths assuming gas saturation pressure is equal to or greater than eruption pressure.

Despite high dissolved S concentrations in most samples, 22 of 31 alkalic glasses were erupted at or near sea level (H_2O ~0.1 wt %, CO_2 below detection). Of the remaining nine, none were erupted below ~3000 m water depth (CO_2 < 130 ppm). High S in otherwise degassed alkalic glasses indicates incomplete S degassing due to rapid ascent rate, compositional dependence, or both; S content is not a reliable indicator of eruption depth. The subaerial to relatively shallow submarine eruption depths for the alkalic magmas indicate that early Kilauea grew high on the submarine shoulder of the Mauna Loa edifice, well above the surrounding sea floor at ~5500 m depth. These results require that Mauna Loa is larger, and Kilauea smaller, than commonly postulated. Glass rinds of in-place transitional pillow basalts (pre-shield-phase Kilauea), from three sites above and east of the midslope bench, have H_2O (0.2-1.0 wt %) and CO_2 (170-270 ppm) concentrations that indicate eruption depths of 3500 to 5500 m. As the alkalic phase waned (post-130 ka) and transitional lavas erupted, activity propagated eastward into deeper water, marking the inception of Kilauea's east rift zone (Puna Ridge). During the volcano's mature shield stage, tholeiitic magmas have erupted subaerially and as pillow lavas along the east rift zone, reflecting continued growth both upward and laterally to the east.

V71A-1267 0830h POSTER

Ultra-high Chlorine in Submarine Kilauea Glasses: Evidence for Assimilation of Brine by Magma

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Basaltic glass grains in sandstone from the submarine south flank of Kilauea, Hawaii, have Cl concentrations of 0.01-1.68 wt%, and are products of brine assimilation by tholeiite magma. To our knowledge, these include the highest dissolved Cl concentrations reported for mid-ocean ridge or ocean island basaltic glasses. The ultra-high Cl glasses are grains in a sandstone clast in bedded breccias draping the southwestern end of Kilaueas submarine mid-slope bench, collected by the JAMSTEC ROV Kaiko in 2001. The clast contains two distinct suites of comagmatic glass grains. Most abundant are degassed (low S, Cl, H_2O; CO_2 < detection) Loa-type tholeiite grains (n=22 analyzed) likely from subaerial lavas of Mauna Loa that shattered upon ocean entry. A second suite of Kea-type tholeiite grains (n=17 analyzed), has higher S (780-1050 ppm) and a wide range in Cl (110-16800 ppm). Ten grains in this group have Cl >1000 ppm, six >5000 ppm, and two grains have >10,000 ppm dissolved Cl. The grains contain traces of olivine, clinopyroxene, and spinel, but no plagioclase. FTIR analyses show that the glasses have elevated water (0.42-1.27 wt%) and CO_2 (<50-130 ppm) concentrations, consistent with eruption at 2000-3000 m water depth. Water and Cl concentrations increase together to ~1.2 wt% H_2O and ~3000 ppm Cl; H_2O remains at ~1.2 wt% in grains with >3000 ppm Cl. The correlation of H_2O with Cl indicates assimilation of fluid, not salt or rock. Coupled major-element variations characterize the assimilant as ~70 % H_2O (wt), 17 % Cl, 5.5 % Na, and 3.8 % each Ca and K (a brine, not seawater) and that ~10 wt% assimilation was necessary to produce the highest Cl glasses. Assimilation of this composition as a single-phase brine at magmatic temperature would require pressure >175 MPa. Subsequent ascent to a submarine vent degassed H_2O from the more strongly contaminated magmas, reducing H_2O to ~1.2 wt% without lowering Cl, Na, or K measurably. Small amounts of crystallization accompanied fluid assimilation, but plagioclase crystallization was suppressed due to elevated H_2O. Cl-rich glasses are strongly enriched in Ba (to 1.6x), Rb (to 2x), and Pb (to 3x) (LA-ICPMS) relative to grains with normal tholeiite Cl contents (110-200 ppm); other trace elements correlate weakly (Sr), or not at all (F, Zr, Nb, REE), with Cl. The high-H_2O, -Cl Kilauea glasses show that droplets of hydrothermal fluid can enter and be absorbed by active magma bodies. Under rare circumstances, the quantities of assimilated fluid can be substantial (to 10 wt%), can modify the course of crystallization-differentiation, and can dominate the budgets of some petrogenetically important trace elements. Fluid assimilation would be difficult to recognize in degassed subaerial magmas or for assimilation of Cl-poor fluids.

V71B MCC: Hall C Sunday 0830h

Flood Basalts and LIPs Posters *(joint with T)*

Presiding: **C R Neal,** University of Notre Dame

V71B-1268 0830h POSTER

How do Your Flood Basalts Grow? Facies Architecture of Large Igneous Provinces

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In terms of their detailed volcanology and facies architecture, Continental Flood Basalts (CFBs) and associated volcanic rifted margins reveal important information to help our understanding of their evolution. Mafic volcanism, which makes up the majority of preserved material, is characterized by flows 2-3 m to several 10s of meters thick, with ponded flows and occasional massive flow events of the order of 100 m thick. Although most of the flows are emplaced by the same mechanism as passive inflated sheets, a variety of different facies associations exist dependent on flow volumes and to some extent flow composition. The largest silicic volcanic events are comparable in size to the largest recorded mafic events, however, they are potentially more catastrophic if erupted as ignimbrite flows. Facies, and facies associations identified in CFBs include: Tabular-Classic flows, Compound Flows, Ponded flows, truncation-onlap volcanic disconformities, burial-onlap volcanic disconformities, prograding hyaloclastite facies, preserved shield volcanic features, and sill facies. Many of these features occur on an intermediate to large basin wide scale and may only be revealed by detailed fieldwork, photogrammetry and 3-D geological models

URL: http://www.dur.ac.uk/d.a.jerram/

V71B-1269 0830h POSTER

Basaltic Lava Floods on Continents: A Case of Exothermic Magma Mixing in the Columbia River Basalt Group, American Northwest

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The Columbia River Basalt Group (CRBG) in the northwestern United States is one of the smallest (approx. 174,000 km^2) and youngest example of a continental tholeiitic flood basalt province that was once generated by the Yellowstone plume. Individual lava flows of the CRBG have flooded over hundreds of km^2 area. The CRBG has been divided into several formations based on their first order geochemical differences. Among them, the Grande Ronde Formation (GR) is volumetrically most significant, constituting about 87% of the CRBG. GR lavas are chemically quite evolved (SiO_2: 52-57 wt%, MgO: 3-6%) and erupted essentially as melts carrying no more than about 5% phenocrysts (large crystals of plagioclase, pigeonite, and augite). Basalts from elsewhere in the world that are chemically as evolved as the GR generally contain 15-20% phenocrysts, and therefore the scarcity of phenocrysts in the GR basalts on such a large spatial scale is a fundamental problem. One view is that these lavas represent primary or near primary melts generated by large-scale melting (30-50% melting) of eclogite in Yellowstone plume. A second view is that the magmas had high dissolved H_2O, which kept the magmas close to their liquidi and prevented crystals from forming. On a normative cpx-ol-pl-qz projection, GR lavas plot very close to the 1 atmosphere pseudo-cotectic; clearly indicating that the erupted melts underwent fractionation and mixing processes at a very shallow level, possibly in an upper crustal network of sills and dikes, and thus these lavas cannot be primary melts. Analysis of whole

V

rocks and glass inclusions in phenocrysts indicates that the dissolved H_2O content could not have been more than about 0.4 wt%. Large plagioclase phenocrysts have been marginally re-melted and grown, trapping melt inclusions in an outer zone. Even though augite and pigeonite do not have a reaction relationship, pigeonite phenocrysts were found to be rimmed by augite. These and other trace element evidence indicate that shallow level magma mixing played an important role in the composition and eruption of the GR lavas. Moreover, the mixing process clearly led to heating and partial (total?) dissolution of some of the phenocrysts. It is likely that such magma mixing was coupled with an efficient fractional crystallization process in controlling the chemical and physical behavior of GR lavas. The small amount of superheat carried by these mixed lavas may have been responsible for lowering their viscosity, which in turn allowed the individual lava flows to travel lateral distances as far as 350 km from their loci of eruption, flooding vast terrains. It is possible that similar exothermic mixing caused large-scale basalt lava flooding in other continental flood basalt provinces as well.

V71B-1270 0830h POSTER

Compositional Variability in Lavas from the Ontong Java Plateau: Results from the Volcaniclastic Sequence of Ocean Drilling Program (ODP) Leg 192 Site 1184.

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The Ontong Java Plateau (OJP) is remarkable in the lack of variation of lava compositions so far reported for this edifice. The most ubiquitous lava type comprises the Kwaimbaita Formation (Tejada et al., 2002, J.Pet. 43:449) and is found on the southern margin of the OJP (outcropping in the Solomon Islands) and on the northern margin (ODP Leg 130, Site 807, Units C-G). In both of these localities, the Kwaimbaita Formation is generally capped by the isotopically distinct and more incompatible element rich Singgalo Formation. ODP Leg 192 recovered predominantly lavas from the Kwaimbaita Formation, although more primitive lavas were also recovered from 2 sites. Site 1184 stands out as an anomaly because of the thick volcaniclastic sequence that was drilled through that contained the first real evidence of emergence (or near emergence) of the OJP. Contained within this sequence were clasts of basaltic material that exhibit the widest compositional range of basalts thus far seen from the plateau. Here, we report the compositions of 14 clasts, which are moderately to highly altered, but immobile elements exhibit a wide range of compositions (e.g., [La/Yb]N = 0.4-1.2; Zr/Nb = 5.8-17.6]. Five clasts are similar to the average Kwaimbaita-type (or Units C-G-type) basalt composition (Neal et al., 1997, Geophys. Mono. 100:183), both in incompatible trace element (e.g., Nb/La 1) and isotopic compositions. Three clasts are enriched relative to the Kwaimbaita lavas and contain a deep negative Eu and Sr anomalies on primitive mantle (PM) normalized diagrams. These samples also show a large fractionation of Nb from La and have Nb/La ratios of 2. One clast has similar elemental abundances to the Kwaimbaita lavas, except for a marked enrichment in the LREE, Zr and Hf; markedly negative Sr and Eu anomalies are present and Nb/La is 0.5. The remaining clasts exhibit evidence of crystal accumulation (overall depletion in incompatible elements, large positive Sr anomalies), or have only portions of their profiles being similar to the Kwaimbaita lavas. For example, one clast exhibits incompatible element abundances very similar to the average Kwaimbaita composition, except for the REE, which are depleted. Subtle REE depletions are present in several clasts and are interpreted to be the result of weathering and complete alteration of a major phase; this may be plagioclase as such clasts also contain negative Sr anomalies. We tentatively interpret these clasts to represent the products of a magma chamber or chambers feeding the volcaniclastic eruptions at Site 1184. Preliminary isotope data, however, suggest several distinct source regions may be represented. One of these is the Kwaimbaita (OJP) source and another maybe akin to MORB. The high degree of alteration in these mantle-derived samples has mobilized the REE and may be responsible for generating Nb/La ratios other than 1, but it is also evident that the compositions of several clasts are the result of extensive fractional crystallization.

V71B-1271 0830h POSTER

Age and duration of magmatism on the Ontong Java Plateau: ^{40}Ar-^{39}Ar results from ODP Leg 192

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Large igneous provinces represent some of the most voluminous outpourings of magma in the last 200 million years. With a size roughly equivalent to Alaska, the Ontong Java Plateau (OJP) is the largest of these provinces. Prior to ODP Leg 192, basaltic basement was recovered from 3 ODP sites (803, 807 and 289) as well as obducted sections on the Solomon Islands. Published ^{40}Ar-^{39}Ar results suggest that the OJP formed in at least two discrete episodes at 122 and 90 Ma, while samples from the Soloman Islands also indicate igneous activity at 60 and 36 Ma. From this limited data set it has been suggested that the Ontong Java Plateau was periodically active every 30 m.y. beginning at 122 Ma.

During Leg 192 another 5 drill sites (1183, 1185, 1186 and 1187) successfully reached basaltic basement, which comprised a thick sequence of basaltic pillow lavas. In contrast, a sequence of volcaniclastics was recovered from Site 1184. Initial shipboard biostratigraphy suggested that the basaltic basement forms part of the older proposed pulse of activity at 118 Ma, and the volcaniclastics from Site 1184 are from NP16 or 41-43 Ma. New whole rock ^{40}Ar-^{39}Ar analyses on the basaltic basement recovered during Leg 192 show that the OJP is no younger than 117 Ma (*L. cabri* zone). Significantly, the volcaniclastic rocks recovered at Site 1184 yielded minimum ^{40}Ar-^{39}Ar ages of 70-80 Ma, and are therefore not Eocene in age.

Reanalysis of OJP samples from other ODP sites (e.g. Site 807) has shown that analysis of rocks with low K/Ca ratios, containing 5 total incremental-heating steps, does not always resolve problems of argon recoil and can yield artificial age plateaus. These apparent age plateaus can break down into the typical stepwise decreasing age pattern of argon recoil, and can therefore significantly alter the age of the rock. Apart from having implications for the proposed pulsed nature of magmatism on the OJP, it also shows that the normal acceptance criteria for ^{40}Ar-^{39}Ar ages in low K rocks may need to be re-evaluated.

V71B-1272 0830h POSTER

What Factors Control Platinum-Group Element (PGE) Abundances in Basalts From the Ontong Java Plateau?

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Eleven samples encompassing four sites drilled by Ocean Drilling Program Leg 192 to the Ontong Java Plateau (OJP) were analyzed for major, trace and platinum-group (PGEs: Ir, Ru, Rh, Pt, and Pd) elements. Based on major and trace element chemistry, these are divided into two groups: a primitive group, which was newly discovered on Leg 192, and Kwaimbaita-type basalts, which are ubiquitous on the OJP (cf. Tejada et al., 2002, J. Pet. 43:449). The primitive group is relatively enriched in MgO, Ni, and Cr and relatively depleted in incompatible elements compared to the Kwaimbaita-type basalts. Petrography indicates that the fractionating phases during emplacement of both types of basalts were olivine and Cr-spinel +/- plagioclase +/- cpx. Normalized PGE profiles are fractionated, but exhibit a flattening between Ru and Ir and occasionally an enrichment in Ir. It has been shown that chromite can preferentially incorporate Os and Ru (Kd ?150) over Ir (Kd ?100), which may account for the Ir and Ru systematics. We do not consider sulfide to be a factor in fractionating the PGEs because it is either absent or present as a trace phase in these basalts and the OJP basalts are sulfur undersaturated (Michael & Cornell, 1996, EOS 77:714). Additionally, the primitive samples from the OJP also have Cu/Pd ratios (4500-8000) that are roughly similar to primitive mantle (7300), and have a generally flat transition from Pd to Y on a primitive mantle-normalized plot. It is unlikely that these samples reached sulfur saturation. The Kwaimbaita-type basalts have slightly elevated Cu/Pd ratios (9000-14000). While there are subtle differences between the PGE profiles of basalts from the Leg 192 drill cores compared to OJP basalts from subaerial outcrops in the Solomon Islands (e.g., the former have general lower Pt/Rh and higher Rh/Ru ratios), it is apparent that silicate and oxide phases are controlling the PGE profiles and abundances. For example, the six samples analyzed from Site 1185 demonstrate a positive correlation of Ru and Ir with Cr and Ni, suggesting a close association of these elements with the observed olivine and Cr-spinel phenocrysts. For all OJP basalts for which we have PGE data, there is a general positive correlation using MgO (or Cr or Ni) as a fractionation index and PGE abundance as well as ratios such as Pt/Y. Therefore, fractional crystallization controls the PGE contents of the OJP basalts. However, as noted by Ely and Neal (2002, Chem. Geol., in press) the abundances require a source enriched in the PGEs over upper mantle and, in some cases, primitive mantle. Such sources require a PGE enriched component that could be from the outer core, although as noted by Parkinson et al. (2001, EOS 82:F1398) this component is not always required. Further work is underway to substantiate this.

V71B-1273 0830h POSTER

Volatiles in Submarine Basaltic Glasses from the Ontong Java Plateau (ODP Leg 192): Implications for Magmatic Processes and Source Region Compositions

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The Ontong Java Plateau (OJP) in the western Pacific is the largest volcanic oceanic plateau and may represent the largest magmatic event on Earth in the last 200 m.y. During ODP Leg 192, unaltered basaltic glass was recovered from igneous basement at five widely separated sites in previously unsampled areas of the plateau. At four of the Sites (1183, 1185, 1186, 1187) the glass is derived from pillow basalt rims, whereas at Site 1184 the glass occurs as non-vesicular glass shards in volcaniclastic rocks. We have analyzed the glasses for major and volatile elements (H_2O, CO_2, S, Cl) using FTIR spectroscopy and electron probe. Our results complement previously published data for glasses recovered from Sites 803 and 807 on the OJP (Michael, 1999). An exciting discovery of Leg 192 was that basement at Site 1187 and the upper group of flows at Site 1185 are composed of high-MgO, incompatible-element-poor basalt that is unlike basalts found elsewhere on the OJP. Glassy pillow rims from these basalts have 8.3 to 9.3 wt% MgO compared with values of 7.2 to 8.0 wt% MgO for glasses from Sites 1183, 1184, 1186, and the lower group of flows at 1185. Relatively low K_2O, Na_2O, and P_2O_5 in all glasses suggest that OJP basaltic magmas formed by large extents of melting. H_2O concentrations are similar in the two basalt types (high-MgO average 0.19 $\pm$ 0.01 wt% H_2O; low-MgO average 0.22 $\pm$ 0.02 wt%) despite the lower K_2O and TiO_2 of the high-MgO glasses. Average S concentrations are 910 $\pm$ 60 ppm for the high-MgO glasses vs. 1030 $\pm$ 60 ppm for the low-MgO glasses. When compared with MORB, the OJP glasses have lower S at comparable FeO, indicating that OJP basaltic magmas were not saturated with immiscible sulfide during crystallization. Cl contents of the glasses are very high compared with MORB, as was found previously for glasses from Sites 803 and 807. Cl/K ratios for all glasses are relatively high ($>$ 0.7). This ratio is sensitive to assimilation of hydrothermally altered material (Michael and Cornell, 1998), so the high values indicate extensive assimilation during shallow level crystallization of OJP magmas. Ratios of H_2O to Ce, which have similar incompatibility, are 355-370 for high-MgO glasses and $\sim$270 for low-MgO glasses. These values are slightly higher than most depleted and enriched MORB (Michael, 1995). However, the high H_2O/Ce values of the high-MgO glasses may be caused in part by assimilation. As with the previous results for Sites 803 and 807, there is no evidence for high H_2O contents in OJP basalts that might have significantly increased extents of mantle melting beneath the OJP. Instead, large extents of melting must have been caused by a relatively high mantle potential temperature.

V71B-1274 0830h POSTER

Trace Element Analysis of Basalt Provinces in the Early History of the Yellowstone Hot Spot

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Previous studies have linked the Miocene-aged Columbia River Basalt Group (CRBG) with the paleolocation of the Yellowstone Hot Spot. In this study, new geochemical analyses from the Grande Ronde (GR) Basalts of the CRBG support that relationship, given an understanding of small-scale magmatic processes associated with the eruption. Proportions of the high field strength elements (HFSE) of the early-erupted members of the CRBG, including the GR Basalts, are consistent with magmas derived from a mantle plume. The paleolocation of the Yellowstone Hot Spot also correlates to the divergent margins of the Kula, Farallon and Pacific plates, suggesting a potential plume component to the 60-50 Ma Crescent formation of the Olympic Peninsula and the 70 Ma Carmacks group of the Yukon. New major and trace element data are presented for the Grande Ronde Basalts of the CRBG and for the Crescent formation. Trace element analysis is presented for the three provinces as evidence for their relationship to the Yellowstone plume.

V71B-1275 0830h POSTER

The Volcan de l'Androy Massif, Madagascar

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The thickest accumulation of lavas in the Cretaceous province of Madagascar is in the southeast at Volcan de l'Androy, where >1500 m of basalt and phenocryst-poor rhyolite flows are interbedded. Although the area was located near the predicted center of the Marion hotspot at 84 Ma, rhyolite formation, rather than purely basaltic flood volcanism, may have been promoted by thick lithosphere and limited extension. Both the basalts and rhyolites probably were erupted locally, as compositionally identical intrusions are exposed near the massif. Two distinct groups of basalt are present. Group I basalts are similar to basalts in southwestern Madagascar, with Nb-Ta troughs and Pb peaks in mantle-normalized patterns, low initial ϵ_{Nd} (-2.5 to -13.2), high initial $^{87}Sr/^{86}Sr$ (0.70915-0.71500), $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$, relatively high SiO_2, and other features indicative of significant crustal assimilation. Group II basalts are stratigraphically lower, lack Nb-Ta troughs, have small or no Pb peaks, lower SiO_2, higher ϵ_{Nd} (+0.6 to -2.5), and lower $^{87}Sr/^{86}Sr$ (0.70579-0.70734), $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$. They are distinct from Marion hotspot compositions, however, and may be relatively small-degree melts of lithospheric mantle or hotspot-derived magmas that interacted significantly with such mantle. The rhyolites also define two groups. Group I rhyolites have initial ϵ_{Nd} = -7.6 to -17.3, $^{87}Sr/^{86}Sr$ = 0.71088-0.73622, and high $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$; some have Nb-Ta troughs. Those with the lowest ϵ_{Nd} represent large proportions of crustal melt, whereas the others can be derived from Group I basalts by fractional crystallization or a combination of melting and fractionation. Group II rhyolites have higher Th, Nb, Ta, Zr, and Hf and ϵ_{Nd} = -2.7 to -1.8; they define a Rb-Sr isochron with initial $^{87}Sr/^{86}Sr$ = 0.7135 and an age of 82.5 ± 1.2 Ma, close to Storey et al.s [Science, 267, 1995] 84.4 ± 0.4 Ma ^{40}Ar-^{39}Ar age. These rhyolites may be derived from Group II basalts by coupled assimilation and fractional crystallization, followed by variable closed-system fractionation.

V71B-1276 0830h POSTER

Significance of mafic hornblende pegmatites intruding ultramafic rocks of the accreted oceanic plateau in Colombia: Ar-Ar and radiogenic isotope constraints

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The accreted remnants of the Cretaceous basaltic oceanic plateau in Colombia are tectonically interleaved with flysch metasediment. At Bolivar, in the Western Cordillera, ultramafic/gabbro parts of the plateau are exposed are intruded by spectacular coarse hornblende pegmatites. Some pegmatites are deformed along with the enclosing mafic/ultramafic rocks but others are cross-cutting with magnesio-hornblendes growing out from the margins of the veins. The leucocratic veins vary from hypersthene leucogabbro, through dominant hornblende anorthosite to (rarer) tonalites with biotite and quartz. Clearly, the hydrous pegmatites were generated while the host rocks were still undergoing deformation, but continued to be emplaced when deformation of the hot mantle rock ceased. There are two potential explanations: that water from the intercalated metasediments migrated into the imbricated hot mantle sequence during tectonic accretion to the South American margin; or that these hydrous late-stage processes are part of the initial plume and plateau formation.

New step-heating Ar-Ar plateau-ages indicate that the pegmatites are 90.5±0.9 Ma, and so are indistinguishable in age from the basalts and high-MgO rocks of the Colombian-Caribbean oceanic plateau. Geochemically, the pegmatites are low in incompatible trace elements and have generally chondritic trace element ratios. They possess initial epsilon Hf and epsilon Nd values, which range from +12 to +15 and from +6.5 to +7.5 respectively. These values overlap the range of basaltic and picritic plateau rocks of the Caribbean-Colombian plateau. Critically, the pegmatites possess little trace element evidence of a subduction-related signature, and so it is difficult to argue for an arc-related setting, or for sedimentary involvement in their petrogenesis. Alternatively, it would seem that these hydrous pegmatites are part of the oceanic plateau itself, and are unrelated to later obduction. This bears upon whether mantle plumes are wet or dry.

V71B-1277 0830h POSTER

The Volcaniclastic Opening Phase of Karoo Flood Basalt Volcanism: Drakensberg Formation, South Africa

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New field mapping of a 10 km by 10 km, 150+ m thick volcaniclastic succession in the Sterkspruit Valley, Eastern Cape, South Africa reveals products of a variety of fragmentation, transportation and depositional processes. The succession is the product of (1) quench fragmentation of lava, (2) injection of fluid basalt into unconsolidated volcaniclastic and country rock, (3) phreatomagmatic explosive eruptions, (4) passive effusion of large volumes of lava and (5) reworking and mass transport of the products of (1)-(4). Deposits are divided into (a) structureless to extremely thick-bedded tuff breccia and lapilli tuff, often fining upward into thin bedded tuff and capped by pillow lava, and (b) thinner-bedded lapilli tuff and tuff with minor breccia, capped by subaerial lava. The lapilli-tuff succession rests on a peneplain developed in contemporaneous quartzo-felspathic aeolian-fluvial sediments whereas the structureless to extremely thick-bedded units fill a broad crater-like depression.

Minor units in the succession, which provide precise paleo-environmental information, include pillow lava, laminated aeolian and fluvial sandstone, and accretionary-lapilli-fall beds.

The Sterkspruit complex contributes to a growing body of evidence that the onset of flood volcanism is often a complex process, with local hydrology and topography playing a significant role in the style of eruption and geometry of resulting deposits. Diversity in these deposits reflects overprinting of these localized controls by the effect of large volumes of magma in the shallow subsurface feeding surface eruptions over a broad area. Under some conditions these early stages of LIP volcanism can generate large, and hitherto under-recognized, volumes of pyroclastic, hyaloclastic, peperitic and reworked deposits, which are typically characterized by mingling and mixing of juvenile basalt with pre-existing and syneruptive sediment.

V71B-1278 0830h POSTER

Structure and Formation of Jurassic Sediment Volcanoes in the Karoo Basin, South Africa

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Mud volcanoes are formed by extrusion of fluids and sediments at the surface in a number of onshore and offshore sedimentary basins. Mud volcanism is caused by buildup of overpressure in the subsurface. The overpressure buildup can be related to burial of thick clay sequences, tectonic deformation in accretionary wedges or by formation of biogenic and thermogenic gas. In addition, mud volcanism is sometimes associated with pressure buildup in hydrothermal systems at divergent and transform plate boundaries. In this abstract, we present a new type of setting for sediment volcanism: volcanic sedimentary basins, and presents the characteristics of fossil occurrences of subaerial sediment volcanoes. Injection of magmatic melts in sedimentary basins is often associated with rifting and continental breakup, and voluminous intrusive complexes (sills and dykes) are found in e.g., the Karoo basin (South Africa), the Parana basin (Brazil), the Vring and Mre basins (offshore Norway) and on the NW Australian shelf. An important effect of the intrusive activity is that the magma caused rapid heating of the intruded sediments and their pore fluids, locally leading to boiling of the pore fluid, and to metamorphic reactions. These processes may lead to buildup of high overpressures and sediment volcanism if the local permeability is low.

The Paleozoic Karoo basin was intruded by voluminous basaltic melts at ca. 183 Ma. The upper sequences (Stormberg Group) are characterized by few magmatic intrusions and hundreds of hydrothermal vent complexes formed in a subaerial setting. Recent fieldwork has focused on mapping the structure and morphology of one hydrothermal vent complex (Witkop III) in the Dordrecht-Rossow area. This hydrothermal vent complex represents a positive erosional remnant 2-300 meters in diameter with inward dipping surrounding sedimentary strata. Field observations suggest that the vent complex was a sediment volcano. The dominant rock type is a clast-rich rock with a sand matrix, where the clasts are mainly claystone, siltstone and sandstone. This rock is believed to have formed during brecciation and fluidization of sediments from the strata below, mixing with sand at the paleosurface. Numerous sediment pipes and dikes in the inner zone of this complexes shows that sediments were mobilized towards the paleosurface. The biggest pipes are up to 25 meters in diameter, and shows sharp cutting relations with the host rock and deformed breccia zones.

We propose a two-stage model for sediment volcanism in volcanic basins based on the field studies in the Karoo basin. The model is corroborated by numerical modeling of pressure buildup processes and seismic and borehole analyses of hydrothermal vent complexes in volcanic basins offshore Norway. Stage 1: Intrusion of magma leads to heating, and locally boiling, of pore fluids in the intruded sediment. Fluid decompression may lead to an explosive gas-driven eruption at the paleosurface, forming a hydrothermal vent complex. The explosive rise of fluids towards the surface cause brecciation and fluidization of the sediments. The fluidized and brecciated sediments rising from below mix with sand in the near-surface part of the basin. Stage 2: Following this initial explosive stage, fluidization occurs in discrete channels as the sediments compact enough to allow the necessary pressure buildup. Both sand, coarse sand and gravel migrate through pipes and erupt at the surface. Note that both stages are short-lived, i.e., they last for tens to hundreds of years.