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 ^{238}U excesses have the lowest Th concentrations, which is compatible with either shallow mantle melting or shallow mantle melt-rock reaction. Nd and Sr isotopic compositions of these samples are not correlated with (^{230}Th /^{238}U) and fall into two groups relative to their proximity to Iceland: samples south of the Spar fracture Zone generally are isotopically enriched, while samples north of the Spar fracture zone are isotopically depleted, reflecting a change in mantle source composition north and south of the fracture zone . The lack of a correlation between the Nd and Sr isotopic compositions and (^{230}Th /^{238}U) suggests that the variability in U/Th and (^{230}Th /^{238}U) in the Kolbeinsey samples is best explained by melting processes and not the mixing of melts from enriched (pyroxenitic) and depleted (peridotitic) sources. Comparing this data with our recently published data suite from the fast spreading East Pacific Rise (as well as other samples from the global MORB data base) enables us to further define the relationships between U-series disequilibria, axial depth and axial spreading rate.

V52F-07 1730h

^{226}Ra-^{230}Th-^{238}U and ^{231}Pa-^{235}U Isotopic Disequilibria at the Galapagos Spreading Centre: Inferences About Mechanisms of Plume-Ridge Mass Transfer

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Mass transfer between a plume and an adjacent spreading ridge may occur either as movement of solid mantle or movement of melt. Recent modeling quantifies the limiting conditions at which long-distance melt transport can occur. Braun and Sohn [2003; EPSL 113: 417-430] estimate that Darcian transport to a ridge through sub-lithospheric channels could occur for several hundreds of kilometers, *provided* that channel porosity is appreciably high ($\geq$ 3%). Using the Galapagos Spreading Center (GSC) as an example, these authors argued that transport by melt migration could best account for the distribution of the enriched plume-like signature on the GSC directly north of the hotspot, as a solid flow model should produce a skewed (eastward) enrichment pattern, due to the general flow direction of the upper mantle.

Our new U-series data from 86°W to 92.3°W on the GSC provide an independent test of this melt migration model. Assuming U-series disequilibria are unsupported during lateral transport, the disequilibria will decrease with transport time (and distance). If plume-melts mix with more depleted (zero-aged) ridge-centered MORB melts to generate the GSC basalts, aged' plume-derived melts delivered to the GSC would have significantly lower U-series disequilibria than the same melts erupted directly above the hotspot. In order to minimize radioactive decay during transport, we assume fast lateral melt transport within 70 kyr from plume to the ridge, corresponding to 100 km distance at 10% channel porosity (Braun and Sohn, 2003). To explain the observed GSC mixing relations at these conditions, the initial (^{230}Th)/(^{232}Th) in the enriched melt component must be $\sim$1.15 and (^{230}Th)/(^{238}U) and (^{231}Pa)/(^{235}U) must be $\sim$50% and $\sim$300%, respectively. The short half-life of ^{226}Ra requires that all (^{226}Ra)/(^{230}Th) disequilibria observed at the GSC must exclusively originate from the MORB melt component. The inferred initial ^{231}Pa and ^{230}Th excesses in the plume-melt component appear to be unrealistically high compared to global OIB database and need to be tested with data from the Galapagos islands directly above the inferred plume stem. If the inferred values prove to be too high, this would imply that the model may only work for shorter transport times, and to get shorter transport times appears to require high channel porosities in excess of 10% that are probably unrealistic.

V52F-08 1745h

Decoupling of δLu/Hf and ^{230}Th/^{238}U in the Galapagos Lavas: The Who is Who in the Garnet Signature

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High δLu/Hf and (^{230}Th/^{238}U) disequilibrium have been used as indicator of mantle melting in the garnet stability field. In contrast to our expectations, the Galapagos samples with high ^{230}Th excess have low δLu/Hf. 30 samples previously analyzed for Th isotopes (ranging from 0.98 to 1.484) have been analyzed for Hf isotopes (ϵHf ranging from 8.49 to 13.16; δLu/Hf 0.75 to 0.2). ϵHf and ^{230}Th excess increase, while δLu/Hf and $(Sm/Yb)_{PM}$ ratios decrease with increasing distance from the center of the plume (considered to be Fernandina based on ^{3}He/^{4}He isotopes). The increase in ϵHf and decrease in δLu/Hf and $(Sm/Yb)_{PM}$ ratios has previously been explained by a decrease in the depth of mantle melting, from the garnet to the spinel stability field, associated with an increase in the asthenospheric component in the source of melts erupted at increasing distance from the center of the plume. However, this hypothesis cannot explain the increase in ^{230}Th excess. Evaluation of trace element composition and Sr, Nd, Pb, Hf, He and Th isotopes of Galapagos lavas indicates that magma mixing between plume and asthenosphere melts has been the main process responsible for the geochemical variation observed in the archipelago. The correlation between isotopes and trace element ratios (such as Nb/La, Nb/Zr, Ba/La, K/Rb and Ba/Ce) indicates that magma mixing controls most of the trace element variations in the basalts. The correlations between (^{230}Th /^{232}Th) and Sr, Nd, Hf and Pb isotopes confirm that the Th isotopic ratios are mainly source-controlled and are the result of magma mixing between the plume and asthenosphere melts. The high (^{230}Th/^{238}U) disequilibrium found in Galapagos lavas indicates that they originated total or partially in the garnet stability field. The decoupling between the (^{230}Th/^{238}U) excess and δLu/Hf can be accounted for by mixing of low extent of melting from a plume source in the garnet stability field with magmas produced by relatively large extents of melting from the asthenosphere in the spinel stability field. This mixing model illustrates that the mixture carries a garnet signature in the most incompatible elements (such as U, Th) even though the variation of the MREE (and Hf) to HREE does not reveal any indication of melting in the garnet stability field.

V52G MCC: 3006 Friday 1600h

Geologic History of Volcanic Regions II

Presiding: **F Goff,** Los Alamos National Laboratory**; D Elliot,** Ohio State University and Byrd Polar Research Center

V52G-01 1600h

Rise and Fall of the Great Basin Region

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Cenozoic stable isotope records for terrestrial carbonate and authigenic smectite from the Great Basin region are presented. In the northern Great Basin, a $10^{o}/_{oo}$ decrease in δ^{18}O values is observed in lacustrine carbonates during the Eocene, followed by a $5^{o}/_{oo}$ increase in δ^{18}O values in authigenic carbonate and smectite between the late Miocene and Pliocene. Thin-section analysis indicates all samples were not exposed to significant burial diagenesis, and evaporative and temperature effects alone are not sufficient to explain the observed isotopic shifts. We suggest the observed isotopic shifts are caused by regional surface uplift and subsidence events during the Eocene and Miocene, respectively. A similar Neogene oxygen isotope record is observed in Mojave Desert and southern Basin and Range province stratigraphic sections.

V52G-02 1615h

Mawson Formation at Allan Hills, Antarctica: Evidence for a Large-scale Phreatomagmatic Caldera

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At Allan Hills, Transantarctic Mountains, Jurassic Mawson Formation pyroclastic rocks are more than 300 m thick. Previously described as unconformable on older Permian and Triassic Beacon strata, the Mawson is now known to be, at least in part, intrusive. Triassic Feather Formation country rocks at the contact display a zone of in situ brecciation. This is followed inward by a zone of megaclasts (10s of m long) derived from younger Triassic Lashly Formation strata, and then by a structureless, grey, sand-rich breccia which has increasing proportions of pyroclasts laterally and vertically. The grey breccia is overlain by units, up to 10s of m thick, of stratified tuff breccia and lapilli tuff, both of which consist of high proportions of Beacon and dolerite clasts set in a matrix of pyroclasts and sand-sized debris also derived from Beacon rocks. All but the brecciated country rocks are cut by basaltic diatremes, and by tuff-breccia and lapilli-tuff intrusive bodies. Megaclasts are mainly Lashly C strata which were a minimum of 120 m stratigraphically and topographically above any extant country rock, and demonstrate that the Mawson rocks are filling a collapse structure. The sequence of events is interpreted to be: 1) initial phreatic activity, on emplacement of a Ferrar Dolerite sill at depth, causing in situ brecciation; 2) withdrawal of magma and collapse of overlying strata to form a caldera containing megaclasts of Lashly strata; 3) renewed magma emplacement which initially caused phreatic activity but increasingly became phreatomagmatic, and formed the grey breccia by disaggregation of the collapsed Beacon strata; 4) full scale phreatomagmatism that erupted the stratified tuff breccia and lapilli tuff; 5) intrusion of basalt diatremes, bodies of tuff breccia and lapilli tuff, and dolerite plugs and dikes. Away from the mapped area, on the southern arm of Allan Hills, tuff breccia and lapilli tuff are crudely stratified and could be either outflow facies or part of the caldera fill; if the latter, the areal extent of this caldera exceeds 50 km2. Locally, base surge deposits cap the coarse pyroclastic rocks. Jurassic pyroclastic rocks at two other localities in the Transantarctic Mountains appear to fill comparable large-scale calderas.

V52G-03 1630h

Megabreccias, Early Lakes, and Duration of Resurgence Recorded in Valles Caldera, New Mexico

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New 1:24,000 scale geologic mapping combined with previous and ongoing geoscientific studies are revealing significant new findings on intracaldera stratigraphy and structure, initial development of intracaldera lakes, and the duration of resurgence within the ca. 1.25 Myr Valles caldera. The caldera is about 22 km in diameter and contains a resurgent dome that is a northeast-trending oval roughly11 x 9 km in dimension. Maximum resurgence (uplift) was more than 1000 m, during which the dome split into three principal segments herein named the Redondo Peak, Redondo Border, and Valle San Luis segments. These segments are separated from each other by long, narrow grabens herein called the Redondo Creek, Jaramillo Creek, and San Luis Creek grabens. Differential uplift accompanied by intense faulting has exposed large, rootless megabreccia (Mbx) blocks composed of precaldera rocks submerged in densely welded, intracaldera upper Bandelier Tuff. The largest Mbx blocks are roughly 0.2 to 2.0 km long and consist primarily of Abo Fm (Permian), Gallisteo Fm (?) (Eocene), Santa Fe Group (Miocene), Paliza Canyon Fm (late Miocene) and lower Bandelier Tuff

(ca. 1.62 Ma). Deep geothermal wells drilled within the Redondo Creek graben from 1970 to 1983 penetrate as much as 2032 m of intracaldera Bandelier Tuff and post-Bandelier rocks before intersecting caldera floor rocks (average = 1646 m, n = 23 wells). Evidence that a lake developed within the caldera depression is preserved in finely laminated lacustrine beds and rhyolitic, hydromagmatic tuffs that overlie intracaldera Bandelier Tuff on the resurgent dome. The lacustrine rocks contain organic remains and the hydromagmatic tuffs contain accretionary lapilli. In some locations, lacustrine and hydromagmatic rocks are interbedded. Earliest post-caldera rhyolite lavas (Deer Canyon Member) display occasional pepperite and pillow textures. Many lavas contain significant amounts of fine, opalized flow breccia indicating interaction with water. Associated Deer Canyon tuffs are altered to variable mixtures of silica, smectite, clinoptilolite, mordenite and other phases. Slightly younger rhyolite lava flows (Redondo Creek Member) occasionally display upper flow surfaces in which cracks are filled with zeolitized mud. The combined geologic evidence indicates that the initial Valles lake was widespread and relatively shallow, containing waters with neutral to alkaline pH and relatively high K/Na ratios. 40Ar/39Ar dating of sanidine separates from Deer Canyon and Redondo Creek rhyolites yields ages that are statistically indistinguishable from the age of underlying upper Bandelier Tuff. These results indicate that the intracaldera lake developed immediately after the caldera formed and that the resurgent dome rose out of a lake. Most resurgence occurred after Redondo Creek rhyolite was erupted because the unit is intensely faulted and associated lacustrine beds are now as much as 500 m above the undeformed caldera moat. In contrast, rhyolite lavas of the first post-caldera moat complex, Cerro del Medio (about 1.22 Ma) show no apparent deformation or uplift due to resurgence. Within the errors of the various 40Ar/39Ar dates, the apparent duration of resurgence was no longer than about 50,000 years yielding a minimum resurgence rate of about 2 cm/y.

V52G-04 1645h

^{40}Ar/^{39}Ar Age Constraints on the Timing and Duration of Resurgence of the Valles Caldera, New Mexico

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New ^{40}Ar/^{39}Ar ages for rocks from the Valles caldera of New Mexico imply that resurgent uplift of the caldera floor occurred within at most, 51,000 years of caldera collapse. Redondo Peak, part of the resurgent dome of the Valles caldera, was uplifted approximately 1000 m above the surrounding caldera floor during resurgence. The lower time constraint on resurgence is the eruption of the upper Bandelier Tuff, which occurred concurrently with collapse of the Valles caldera. The upper time constraint is the emplacement of the oldest post-collapse ring fracture dome complex, Cerro Del Medio, which displays no apparent faulting or deformation due to resurgence. ^{40}Ar/^{39}Ar dating places these time constraints at 1.256 $\pm$ 0.009 Ma (2σ; ages relative to Fish Canyon Tuff sanidine at 28.02 Ma) for the upper Bandelier Tuff and 1.231 $\pm$ 0.017 Ma for Cerro Del Medio. Therefore, resurgent uplift of the Valles caldera resurgent dome occurred at a minimum rate of approximately 2 cm/yr. The Deer Canyon and Redondo Creek members of the Valles Rhyolite formation erupted prior to and during resurgence; both units stratigraphically overlie the upper Bandelier Tuff. The Deer Canyon member erupted immediately prior to resurgence, and is mainly overlain by caldera fill sediments. The Redondo Creek member erupted before and during resurgence, and is intensely faulted and tilted by resurgent uplift. It is mainly interbedded with caldera fill sediments. The Deer Canyon member is characterized by a phenocryst assemblage that includes abundant sanidine and quartz, minor oxides, and rare plagioclase and zircon. The Redondo Creek member differs from other intracaldera units, with phenocrysts of abundant biotite and plagioclase (often rimmed by sanidine), minor oxides and homogeneous sanidine, and rare pyroxene and zircon. Magnetite/ilmenite pairs from the Redondo Creek member yield eruption temperatures of 810 $\pm$ 6°C. Preliminary whole rock analyses of the Deer Canyon and Redondo Creek members show that they are rhyolitic in composition and may be related to the upper Bandelier Tuff magma. Sanidine phenocrysts from the Deer Canyon member yield ^{40}Ar/^{39}Ar single crystal laser fusion ages ranging from 1.257 $\pm$ 0.022 Ma to 1.281 $\pm$ 0.017 Ma (n=5). With one exception at 1.208 $\pm$ 0.017 Ma, the Redondo Creek member gives ages between 1.237 $\pm$ 0.018 Ma and 1.292 $\pm$ 0.043 Ma (n=3). Field work demonstrates that the Deer Canyon and Redondo Creek members are younger than the upper Bandelier Tuff. However, most ages from the Deer Canyon and Redondo Creek members are within 2σ error of the upper Bandelier Tuff age (1.256 $\pm$ 0.009 Ma), suggesting that resurgence commenced soon after collapse of the Valles caldera and eruption of the upper Bandelier Tuff. The possibility of excess argon in melt inclusions in post-collapse units was investigated. Although ^{40}Ar/^{39}Ar analysis of melt inclusion bearing quartz phenocrysts from the Deer Canyon member demonstrates that some amount of excess argon resides in melt inclusions, there is no measurable effect on sanidine phenocrysts in either the Deer Canyon or Redondo Creek members.

V52G-05 1700h

Evolution of a Large-Volume Explosive Vent-Complex at the Base of the Karoo LIP: Sterkspruit Complex, South Africa

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The Sterkspruit Complex, is a well-exposed example of a recently recognized type of volcanic landform common at the base of continental flood basalt sequences. The complex is a suite of volcaniclastic rocks and lavas filling a broad crater (>40 km2) cut into country rock and surrounded by a blanket of distal bedded volcaniclastic rocks. The complex is a series of nested vents spaced a few hundred meters apart whose deposits may overlap. Volcaniclastic facies are rich in degassed basalt clasts and/or composite mingled basalt-sediment particles, and are intruded by rare irregular basalt dikes. Craters housing these vents grew mainly via collapse of their margins rather than by downward quarrying. Widespread pillow lavas and associated reworked sediments indicate an abrupt end to fragmental volcanism in the Sterkspruit Complex and flooding of the lowest part of the crater. A rapid transition to subaerial flood basalt flows points to rapid inundation of the landscape by lava immediately following explosive volcanism. The 50-100 m thick distal blanket of mainly bedded, fine-grained deposits records a variety of fall, flow and reworking processes. The Sterkspruit Complex seems typical of the volcaniclastic centers that form in the very earliest stages of many LIPs worldwide, and records overlapping processes of (1) explosive phreatomagmatic and strombolian eruptions seated at shallow levels in small debris-filled vents, (2) disruption of extrusive and shallowly intrusive basalt, (3) lateral growth of large craters via coalescence of many small vents by crater-margin collapse, and (3) transport of parts of this debris beyond the complex to blanket preeruption topography.

V52G-06 1715h

Structural Control of the Ubinas-Huaynaputina-Ticsani System: A Large, Young Silicic Magmatic System in Southern Peru

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The location of magma reservoirs and volcanic centers are commonly controlled by tectonic structures (e.g., Hutton, 1989; Gibbons and Moreno, 2002). In the Central Volcanic Zone, southern Peru, volcanism is mainly associated with the major NNW-SSE sinistral strike slip fault systems underlying the main volcanic arc. However, a group of related silicic volcanoes was recently discovered which crop out beyond the arc; the Ubinas-Huaynaputina-Ticsani system (UHTS). Characterizing its dimension and tectonic influences are crucial in order to evaluate corresponding volcanic hazards. Potentially active fault systems as well as major tectonic features in and around the UHTS were mapped and the structural framework was elucidated. The UHTS is located within a north to south extensional domain housing three fault systems: (1) the arc related NNW-SSE fault system, intersected by (2) a unique N-S en echelon strike slip fault system, and (3) a minor W-E fault system. Identification of confined Cretaceous volcanics known as the Matalaque formation indicated the presence of a narrow graben that developed on the western side of the N-S fault system. Interestingly all volcanic centers are positioned at the intersection of the NNW-SSE faults with the N-S faults. Seismic records revealed the concentration of seismicity around depths ranging between 20 and 33 km. The position of the UHTS is dictated by the intersection of the NNW-SSE and N-S major en echelon strike slip fault systems. We propose the role of the NNW-SSE fault as a deep pathway for magma ascent whereas the N-S strike-slip motion allowed the release of stress and deviation of magma, which scattered and ponded between adjacent NNW-SSE faults at 30 km depths. Based on the vent distribution, we estimated the size of the silicic magma reservoir as approximately 40 x 60 km; this is a reasonable estimate since the withdrawal of a volume larger than 10 km^3 was not significant enough to produce an equivalent caldera collapse. We finally propose that the occurrence of five 33-km deep earthquakes about 45 km to the SSE of Ubinas, in the last 40 years, may indicate the progression of the next regional eruption. References: Gibbons, W., Moreno, T., 2002, Tectonomagmatism in continental arcs; evidence from the Sark arc complex. Tectonophysics 352, 185-201. Hutton, D.H.W., 1989, The role of regional tectonics in the emplacement mechanism of granites (Abstr.). 28th International Geological Congress, 2, 2.88-2.89.

V52G-07 1730h

Tephra deposits in the Deccan Trap, Peninsular India

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In this paper, the tephra samples collected from the Bori, the Son valley and the Wardha river in the Deccan Trap, western and central of the Peninsula India were analyzed in the chemical and isotopic compositions. When the tephrostratigrphy and tephrochronlogy of tephra layers in the ODP 758 core in the India Ocean were revised (Chen et al., 2003), it raised more contradictions in terms of the source argument of tuff in the Peninsula India. Based on the new correlation in the chemical and isotopic compositions of volcanic tephra between the Indian Ocean and the inland materials of the Toba eruptions, the tephra sources in the Deccan Trap can be clearly identified from the OTT eruption with the special finger prints of the chemical compositions of mineral crystal and isotopic values of glasses. Therefore, the tephra deposits in above places can be considered as the synchronous event with the OTT eruption about 0.8 Ma, instead of the former of the YTT eruption around 75 Ka (Westgate et al., 1998).

V52G-08 1745h

Large Volume ^{18}O-depleted Rhyolitic Volcanism: the Bruneau-Jarbidge Volcanic Field, Idaho

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The Bruneau-Jarbidge (BJ) volcanic field is located in southern Idaho at the intersection of the western and eastern arms of the Snake River Plain. The BJ region is an oval structural basin of about 6000 km^2, and is likely a system of nested caldera and collapse structures similar to, though larger than, the Yellowstone Volcanic Plateau. BJ rocks are high-temperature rhyolite tuffs, high-temperature rhyolite lavas, and volumetrically minor basalts. Exposed volumes of individual rhyolite units range up to greater than 500 km^3. We have analyzed feldspar and, where present, quartz from 30 rhyolite units emplaced throughout the history of the BJ center. All, including the Cougar Point Tuff, are ^{18}O depleted ($\delta^{18}O_{FSP}$ = -1.3 to 3.7$^o/_{oo}$), while petrographically, temporally, and chemically similar lavas erupted along the nearby Owyhee Front have "normal" rhyolite magmatic $\delta^{18}O$ values of 7 - 9$^o/_{oo}$. There is no evidence for significant modification of $\delta^{18}O$ values by post-eruptive alteration. No correlation exists between $\delta^{18}O$ and age, magmatic temperature, major element composition or trace element abundances among depleted BJ rhyolites. The BJ and WSRP rhyolites possess the geochemical characteristics (depressed Al, Ca, Eu, and Sr contents, high Ga/Al and K/Na) expected of liquids derived from shallow melting of calc-alkaline granitoids with residual plagioclase and orthopyroxene (Patino-Douce, Geology v.25 p.743-746, 1997). The classic Yellowstone low $\delta^{18}O$ rhyolites are post-caldera collapse lavas, but at BJ, both lavas and caldera-forming ignimbrites are strongly ^{18}O-depleted. The total volume of low $\delta^{18}O$ rhyolite may be as high as 10,000 km^3, requiring massive involvement of meteoric-hydrothermally altered crust in rhyolite petrogenesis. Regional hydrothermal modification of the crust under the thermal influence of the Yellowstone hotspot apparently preceded voluminous rhyolite generation at Bruneau-Jarbidge.

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> Pfister, R. G., and M. S. Nestler, Sharing community data, services and tools using the EOS clearinghouse (ECHO), *Eos Trans. AGU, 84*(46), Fall Meet. Suppl., Abstract U41B-0006, 2003.

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