considered either elastic or allowed to relax. The intrusion is treated as a point source and can be located in any of the layers or in the half-space. The model allows to compute geometric and orthometric vertical displacements as well as surface, free-air and Bouguer free-air corrected gravity changes. We can compute the corresponding gravity gradients. We present several examples of theoretical computations and study different types of geometric and orthometric gravity gradients. The results show that these gradients can be an useful tool to obtain information on the dynamics of the injection and post-injection processes, in particular detecting new magma intrusion or changes in the depth of the source. We also present the results of the application of the methodology to Mayon volcano, Philippines, and to Campi Flegrei, Italy.

V52E-05 1440h

Inference of Magma Chamber Geometry at Sierra Negra Volcano, Galapagos Islands, Using a 3D Boundary Element Method With Pressure Boundary Conditions and InSAR Observations

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We present a new way of implementing a 3D boundary element method with uniform pressure boundary conditions. Uniform opening dislocations have often been used to infer surface deformation due to subsurface processes such as slip on fault planes or magmatic processes under volcanoes. These models require displacement discontinuities as input parameters and quantify the displacement and stress fields at observation points in the continuum. We use the linear relationship between displacement discontinuity and stress to derive a boundary element method subject to uniform pressure boundary conditions. Application of this method to synthetic aperture radar interferometry (InSAR) data over Sierra Negra shows agreement with previous results in terms of maximum sill opening. Amelung and Jonsson et al. [2000, Nature] successfully used a sill model with spatially varying opening boundary conditions. We have improved the model by applying the physical constraint of uniform pressure on the wall of the sill. Given the model geometry, in particular, the periphery of the sill, the pressure boundary condition determines the opening at each model element. Thus the number of degrees of freedom in the problem is reduced by the number of model elements. Determining which elements open, and are thus subject to the pressure boundary condition, is a non-linear problem. We adopt a Bayesian Monte Carlo approach to estimate the sill geometry. The probability that an element either opens or remains closed is assumed to be a Gaussian random variable centered on the peak of the radar range change measured in our interferogram. Elements beneath the largest range change are most likely to be open, those far away least likely. The Monte Carlo estimation is run for an arbitrary time, and the best fitting model is chosen.

V52E-06 1455h

Distributed Source Model for Deformation Caused by Magma Reservoirs

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Volume and pressure changes in magma reservoirs cause inflation or subsidence at the surface. The changes can be caused by accumulation, withdrawal or crystallization of magma. Deformation models are used to determine parameters like location, depth, extent and shape of the reservoir. In most models today, overly simple predefined source geometries are used. These may not only give an unrealistic image of the source shape, but also mislead when interpreting the underlying deformation processes. We present a model of distributed deformation sources that inverts for the volume strain in discrete subsurface units. The deformation sources consist of centers of dilatation and double forces. Solutions are sought that minimize a residual norm weighted by the data covariance and a regularizing functional that requires the source volume to be spatially compact. Compactness is realized by penalizing locations in the model space proportional to their distance from a target location. This compactness criterion distinguishes the modeling from the commonly used approach of spatial smoothing which would smear the source out over an unrealistically large volume, implying a magma body too dispersed to be viable over long time periods. To interpret the estimated distribution of point sources in terms of a physical model, we seek closed surfaces surrounding the sources on which the normal stress is constant, and the shear stress vanishes. These surfaces then represent an equivalent magma pressure increase or decrease in a magma chamber of uniform pressure. To define the absolute size of a magma body, additional constraints are needed. The modeling algorithm is applied to deformation data from Long Valley caldera between 1985 and 1999, which experienced nearly 1 meter of uplift during that time period. We find an inflation source with a center depth of about 8 km, and with a vertical extent of about 4 km. The total volume increase over the 14 year time period is 0.06 km3. We compare our results with those obtained from simple spherical and ellipsoidal models.

V52E-07 1510h

Stress changes during the rapid deformation of Miyakejima volcano on 26-27 June 2000

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Deformation often signals the occurrence of magmatic processes within volcanoes, such as the intrusion of new magma bodies and inflation or deflation, of existing bodies. Stress change induced by magmatic activity can drive propagation of dike and earthquake activity. Conversely, by relieving stresses from previous intrusive processes, can establish stress states favorable to new or continued intrusion. In this research we have modeled stress transfer effects during the dikes intrusion sequence in Miyakejima volcano on 26-27 June 2000. On 26-27 June 2003, a kinematic GPS analysis of data from the the Miyakejima volcano captured a fast developing event in unprecedented spatial and temporal detail. Initial ground deformation toward east and upward was observed in the southeastern part of the volcano at 18:00 on 26 June 2000, almost simultaneous with earthquake swarms. Some time after 21:30 on 26 June the displacements at these sites turned from eastward to westward. Three hours later the displacement rates increased gradually at GPS sites in the western part of Miyakejima as the seismicity migrated and approached the west coast, and reached a climax with the submarine eruption at 09:00 on 27 June 2000. The non linear inversion of GPS data leads to an interpretation that the 18:00, 26 June earthquake swarm was caused by a dike intrusion near the Oyama crater. Starting from 21:30 this dike deflated and a new dike intruded near the west coast. Following the propagation of this dike to the offshore, a spherical source began deflating in the southwest of Oyama crater. This research attempts to identify and delineate stress interactions and to develop a consistent model of magmatic processes in Miyakejima volcano.

URL: http://www.seis.nagoya-u.ac.jp/~irwan/myk062000.html

V52E-08 1525h

Towards a 4D Viscoelastic Model for Deformation of the Long Valley Caldera 1997 Inflation Episode

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We investigate the effects of viscoelastic rheologies and non-spheroidal sources on time-dependent deformation for a large silicic volcanic body. We focus on surface deformation at Long Valley caldera for the 1997 inflationary episode, but the methods developed here should apply to similar systems elsewhere. We begin with the model in Newman et al. (J. Volc. Geoth. Res., 2001), a spherical magma chamber encased by a 1-km thick viscoelastic shell (μ = 5 GPa, ν = 0.25, $\eta = 10^{16}$ Pa-s – similar to a 600 degree rhyolite at 5% wt. water) in an elastic half-space (μ = 5 GPa, ν = 0.25) and extend it to include ellipsoidal geometries that better represent magmatic sources. The data include 2-color EDM baselines, 3-D continuous GPS, and temporally limited but spatially dense synthetic aperture radar interferograms. All models fit a source at similar location and depth to the inflation source identified by Langbein et al. (JGR, 1995) for the 1989 inflation episode, indicating the source has not migrated significantly in that 8 year period. Though this technique is unable to uniquely identify the source volume, allowing for significant uncertainty in magma pressure changes, all models that include a modest (500 m thick) viscoelastic shell require only a fraction of the pressure required by purely elastic models (~20-70 MPa rather than 400+ MPa). This is significant because the lithostatic load at 6 km depth is only ~160 MPa and magma pressures that far exceed it would predict eruption.

V52F MCC: 3008 Friday 1600h

Melt Formation and Migration

Presiding: **M Jellinek,** University of Toronto**; A Stracke,** Max-Planck-Institut für Chemie, Abteilung Geochemie

V52F-01 1600h

Experimental Investigation of the Partially-Hydrated Solidus of KLB-1

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It is important to study the effects of the presence of trace amounts of water, found in nominally anhydrous minerals, on mantle melting by more accurately determining the position of the peridotite solidus as a function of trace water content at upper mantle pressure and temperature conditions. The specific effects of trace water on melt productivity and the composition of liquids in equilibrium with mantle minerals can be examined using experimental methods. However, there is a lack of experimental data with regard to the trace water contents associated with the mid-ocean ridge basalt source mantle (50 to 500 parts per million H_2O) as opposed to fully saturated or nominally anhydrous conditions. The complex speciation of H_2O dissolution in silicate liquids makes it difficult to extrapolate from either dry or saturated runs into this slightly hydrous regime. The challenges to accurate experimental measurement of the "partially hydrous" peridotite solidus include control of initial and final water contents and characterization of extremely small melt fractions. An experimental protocol has been developed to minimize external water contamination. This includes a rigorous drying sequence to eliminate adsorbed water from the system. Our double capsule assembly utilizes a hematite "hydrogen-getter" in order to discourage hydrogen diffusion into the sample during the run. Time-series experiments using an anhydrous glass of albite-orthoclase eutectic composition constrain the amount of water entering the system from the environment. We found that no more than 280 ppm can contaminate the system during run durations of up to 72 hours using this assembly at P = 1.9 GPa and T = 1350°C. Peridotite melting experiments were performed using the piston-cylinder device at 2.0 GPa. The sample material is a mix compositionally equivalent to the fertile spinel peridotite KLB-1 comprised of a synthetic component commensurate to the pyroxene plus spinel portion in addition to natural KLB-1 olivine material. The olivine component was doped with H_2O in water-saturation experiments, allowing the accurate representation of peridotite composition as well as allowing for a trace amount of H_2O. The incorporation of water as measurable structurally bound hydroxyl within the olivine enables the aggressive drying protocol to remove additional adsorbed water while still permitting a pre-determined amount of water to remain in the system. In order to determine precisely the position of the solidus and to evaluate near-solidus melt productivity, a method is required by which the presence of a very small degree of melt (<1%) can be recognized. Simple observation of the presence or absence of glass or quench material may not be sufficient at such low melt fractions. To this end, analyses of the incompatible elements Na and Ti in clinopyroxene grains have been performed using a trace element protocol on the EPMA. The onset of melting is demonstrated by the sudden drop in concentration of the element in the clinopyroxene, allowing a more accurate estimation of the position of the solidus than had been previously measured. A preliminary estimate for the position of the anhydrous solidus of KLB-1 at 2.0 GPa is between 1325-1350°C. Applying a similar method with a more incompatible tracer (e.g. H or K) is expected to reveal the slightly hydrated solidus.

V52F-02 1615h

High-Pressure Experiments on Harzburgite Melting With and Without H_2O

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The effect of H_2O on the composition of harzburgite-saturated melts has been quantified with a series of hydrous and anhydrous melting experiments using a piston-cylinder device. Experimental conditions were 1.2-2.2 GPa and $1175-1500^\circ$C. Melt H_2O contents range from 0-10 wt.%. The observed effect of temperature on SiO_2 activity coefficient (γ) in the experimentally produced melts closely matches that predicted from thermodynamic properties. Pressure produces a small but discernable decrease in γ SiO_2. The primary effect of H_2O on γ SiO_2 is dilution. In addition, H_2O lowers equilibrium temperatures, and so the hydrous experiments tend to produce lower (less ideal) γ SiO_2, but the trend between anhydrous and hydrous activity coefficients is continuous. Thus, there is no discernable effect of H_2O on non-ideal mixing terms, and so hydrous melts are not intrinsically more SiO_2 rich than anhydrous melts. If this is so, then why are hydrous arc magmas typically SiO_2-rich? It is proposed that the high SiO_2 contents (and high SiO_2/[MgO+FeO] ratios) are the result of the low temperatures at which hydrous melting occurs, relative to anhydrous melting. Partition coefficients for MgO and FeO increase at lower temperatures, while the partition coefficient for SiO_2 is buffered by olivine-orthopyroxene equilibria. Therefore, the SiO_2/(MgO+FeO) ratios of harzburgite saturated melts increase as temperature falls in both hydrous and anhydrous systems. In this model, the SiO_2-rich character of arc-lavas is primarily a thermal effect, albeit one induced by the temperature lowering effects of H_2O. The experimentally measured mineral/melt partition coefficients (this study and literature data) have been parameterized in terms of pressure, temperature and melt H_2O content. These expressions have been used to construct a Gibbs-Duhem based numerical model that predicts the compositions of hydrous and anhydrous ol-opx saturated melts. Comparisons with experimental data not included in the model indicate that it is the most accurate model available for predicting the compositions of high degree mantle melts, with or without H_2O.

V52F-03 1630h

On the Thermo-Kinetic Consequences of Slab Melting

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Melting of subducted oceanic crust occurs when its *P-T* trajectory intercepts the wet basalt solidus ($700-800^\circ$C at 2-4 GPa). Thermomechanic calculations have shown that the temperature near the top of a subducted plate is around $500-800^\circ$C at 100 km depth, depending on the age of the slab and the rate of subduction. Given the relatively cold environment one might expect that kinetics play an important role in slab dehydration melting, as diffusion rates of many incompatible trace elements in eclogitic minerals are very slow under these conditions. The purpose of this study is to explore the thermo-kinetics of slab melting. A key parameter that measures the role of kinetics during slab melting is the rate of mass transfer (R) for a given element between a residual mineral and the melt relative to the rate of melting (M), designated as Dm. Disequilibrium melting is important when $Dm < 1$. A lower bound for M during slab melting can be estimated from a mass balance calculation (10^{-15} s^{-1}). R depends on (1) the rate of cation diffusion in the solid, (2) the extent of deformation in the slab, and (3) the degree of dissolution-reprecipitation during melting. Given that (2) and (3) are poorly constrained for eclogitic minerals, we estimate R using the solid diffusive time scale but with a small effective grain radius, to account for those complicated processes (10 μm for cpx and 100 μm for garnet). Using diffusivities extrapolated from Van Orman et al. (2002), we found that Dm is around $10^{-3} \sim 10^{-1}$ for LREE in the cpx and ~ 1 for REE in the garnet at 800°C and 3 GPa, whereas $Dm > 1$ for REE in the cpx when $T > 1000^\circ$C. Hence during slow melting of an effectively fine-grained eclogite, the the LREE in the cpx and the melt are likely controlled by the disequilibrium melting processes at near solidus temperatures. Diffusivities of the alkali elements Li and Na in the cpx are expected to be much larger than those of REE in the same mineral. Hence some extends of decoupling between the alkali elements and LREE are also expected during slab melting. To better understand the thermo-kinetic consequences of slab melting we calculate the incompatible trace element abundance in melts produced by dynamic disequilibrium partial melting of a hornblende-bearing eclogite, following a *P-T* path similar to that of a young subducting slab. Model calculations show that the LREE abundance in melts produced at small degrees of melting is more likely affected by the sluggish kinetics and hence is lower (not higher) than the LREE abundance in melts generated at larger degrees of melting. The LREE abundance in the larger degree melts is broadly similar to that in adakites and in melts produced at smaller degrees of equilibrium melting. If adakites are generated by partial melting of residual eclogites that underwent small degrees of disequilibrium partial melting at low temperatures, the actual degree of melting needed to generate these magmas is likely larger than previous equilibrium melting models suggested. The small-degree melts produced in the colder parts of the slab are more strongly affected by the sluggish kinetics and thus have lower La/Yb ratios, and higher Li_2O and Na_2O than melts produced by large degrees of melting at higher temperatures. Such Na_2O-rich, hydrous melts may be easily segregated from the slab. If these small-degree melts are sampled, their slab-origin may remain unrecognized because their trace element compositions are different than typical adakites. More likely, the small-degree melts may be dispersed in the mantle wedge, leaving a unique trace element and isotopic fingerprint in the peridotite that itself may undergo partial melting at a later time during island arc magmatism.

V52F-04 1645h

Did Melting Glaciers Cause Volcanic Eruptions in Eastern California? A Natural Probe of the Mechanics of Dike Formation.

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Magmatic and volcanic systems involve processes that operate over a wide range of time and length scales. In this study, a comparison of time series of basaltic and silicic eruptions in eastern California over the last 400 kyr with the contemporaneous global record of glaciation suggests that this volcanism is influenced by the growth and retreat of glaciers occurring over periods of about 40 kyr. In addition, statistically significant cross correlations between eruption data and the first derivative of the glacial time series implies that the temporal pattern of volcanism is influenced by the rate of change in ice volume. Moreover, calculated time lags for the effects of glacial unloading on rhyolitic and basaltic volcanism are distinctive and are 2.95 kyr and 11.30 kyr, respectively. A theoretical model is developed to investigate whether the increases in eruption frequency following periods of glacial unloading are a response ultimately controlled by the dynamics of dike formation. Applying results from the time series analysis leads, in turn, to estimates for the critical magma chamber overpressure required for eruption, as well as constraints on the average mechanical properties of the wall rocks governing dike propagation. Thus, an analysis of the response of a magmatic system to glacial forcing at the kiloyear time scale provides insight into crustal dynamics and magma transport.

V52F-05 1700h

U-Th-Pa Constraints on Melting Beneath Theistareykir, Northern Iceland

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New U-Pa disequilibrium data on a suite of 12 high-MgO basalts (MgO > 8 wt.%) from Theistareykir, northern Iceland, provide further constraints on the timescales and dynamics of melting than has heretofore been possible based on U-Th disequilibrium data alone. 10 out of 12 basalts from Theistareykir have ($^{231}Pa/^{235}U$) between 1.83 and 2.19 at a range of ($^{230}Th/^{238}U$) from 1.19 to 1.38. Two basalts originating from the same lava flow (Langaviti) have ($^{231}Pa/^{235}U$) of 2.41 and 2.71 with ($^{230}Th/^{238}U$) of 1.29 and 1.31, respectively. While changes in ($^{230}Th/^{238}U$) alone could be explained by changes in melt extraction velocity only, combined ($^{230}Th/^{238}U$) - ($^{231}Pa/^{235}U$) systematics require changes in both upwelling and melt velocity. The varying ($^{230}Th/^{238}U$) at relatively constant ($^{231}Pa/^{235}U$) for 10 out of 12 samples require a coupling between melt and upwelling velocity (lower upwelling velocities are associated with lower melt velocities) in order to keep the relatively large range in ($^{230}Th/^{238}U$) and create the small range in ($^{231}Pa/^{235}U$). There is a general correlation between ($^{231}Pa/^{235}U$) and major element concentrations and heavy rare earth concentrations but not light rare earth concentrations and other elemental or isotopic parameters. The samples with the highest ($^{231}Pa/^{235}U$) tend to have, for example, the highest MgO, lowest Na_2O, and Lu concentrations. Thus, the least differentiated samples have the highest ($^{231}Pa/^{235}U$). This effect is most obvious considering the two samples with the highest ($^{231}Pa/^{235}U$) from the Langaviti flow. This suggests that decay during magma evolution potentially has a second order effect on the ($^{231}Pa/^{235}U$) ratios; at least for some of the Theistareykir samples. For the two samples with the highest ($^{231}Pa/^{235}U$) from Langaviti (2.41 and 2.71), ^{231}Pa excess similar to the rest of the samples (($^{231}Pa/^{235}U$) of about 2) will result from decay during magma evolution within 20-30,000 years, which is within recent estimates for magma differentiation times. Even for these samples, however, ($^{230}Th/^{238}U$) ratios are relatively little influenced because of the approximately two times longer half life of 230Th compared to ^{231}Pa (within 30,000years, ($^{230}Th/^{238}U$) decrease from about 1.32 to 1.24, for example). The potential influence of decay during magma evolution imposes significant uncertainty on absolute estimates of melting parameters such as upwelling velocity, residual porosity and melt extraction velocity. Furthermore, the selected mineral-melt partition coefficients have a strong influence on the inferred melting parameters, independent of the choice of the melting model. Some first-order estimates using a near-fractional (dynamic) melting model, however, suggest that upwelling velocities < 2cm/yr (in good agreement with the total spreading rate of 18mm/yr), melt extraction velocities > 1m/yr and residual porosity < 0.1% are most likely.

V52F-06 1715h

^{238}U and ^{230}Th Excesses in Kolbeinsey Ridge Basalts: Implications for Melt Generation and Transport Beneath a Slow Spreading Ridge

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Here we report measurements of U-Th disequilibria, Nd, and Sr isotopes and major- and trace-element compositions for 8 samples, from two suites of basalts from the slow-spreading Kolbeinsey Ridge (approx. 1 cm/yr. half-spreading rate; $67^\circ 05' - 70^\circ 26'$N), north of Iceland. These basalts show both significant ^{238}U excesses [(^{230}Th /^{238}U)<1] and ^{230}Th excesses [(^{230}Th /^{238}U) > 1], with (^{230}Th /^{238}U) ranging from 0.95 to 1.24. While the samples ($^{230}Th/^{232}Th$) activities are essentially constant (1.25 to 1.29), there is a large range in (^{238}U /^{232}Th) activities (1.00 to 1.32); therefore these data lie on a horizontal array on a ($^{230}Th/^{232}Th$)- (^{238}U /^{232}Th) isochron plot. ^{226}Ra has not been measured for these samples; however, 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 ^{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

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