(e.g., Peterson and Tilling, 1980). In the latter, the boundary separating pāhoehoe and ‘a‘ā is represented qualitatively by an inverse relationship between apparent viscosity and shear rate. Recent investigations of the rheology dependence of the transition have revealed a critical crystallinity range at which pāhoehoe transforms to ‘a‘ā of $\phi = 0.18$ to 0.35 that can vary between flows. Here, we extend this approach to investigate the shear rate dependence of the pāhoehoe-to-‘a‘ā transition. We use a suspension of corn syrup and rice to represent lava with crystals. Suspensions of varying particle concentration ($\phi = 0.15$ to 0.40) are sheared in a Couette rheometer over a range of constant shear rates (0.1 to 2.0 s^{-1}). We describe three deformation regimes, clumping, shear zone formation, and fluid failure that produce changes in the suspension microstructure and lead to shear localization. The deformation mechanisms are imaged with digital video and quantified by tracking individual particle paths. In the presence of cooling, these shear localization may be the mechanism by which ‘a‘ā flow surfaces form. We find that the onset of each regime follows the expected inverse relationship between shear rate and suspension viscosity. We expect that the results of these experiments apply to the thermal boundary layer of a flow and thus bridge the distinct approaches taken to investigate this phenomenon. The results of these experiments can contribute to more detailed lava flow modeling and better assessment of flow dynamics from solidified lava flows.

V51L-05 1120h

Solubility of H_2O in Rhyolitic Melts at Low Pressures

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Reversal experiments of H_2O solubility in synthetic haplogranitic and natural rhyolitic melts were conducted at 700 − 1200°C and 0.098-25 MPa. H_2O contents were determined using Fourier transform infrared spectroscopy. When temperature decreases from 1000 to 700°C, the solubility of H_2O increases from 0.100 to 0.124 wt% at 0.098 MPa, from 0.99 to 1.36 wt% at 11 MPa, and from 1.46 to 2.17 wt% at 25 MPa. At 6 MPa, the solubility of H_2O increases from 0.63 to 0.77 wt% from 1200 to 850°C. Using these data and those from the literature for a total of 203 measurements, an empirical solubility model for pure H_2O fluid has been constructed for rhyolitic melt and takes the following expression: $w=(354.97P_w^{0.5}+9.585P_w-1.5095P_w^{1.5})/T+0.0012365P_w^{1.5}$, where w is water contents in wt%, $P_w=X_w^f P$ (in MPa) where X_w^f is the mole fraction of H_2O in the fluid, and T is in K. This empirical model has a 2σ relative uncertainty of 10% and is applicable to 700 − 1200°C and 0-500 MPa. It also applies to H_2O solubility in mixed H_2O-H_2 fluid at total pressure ≤300 MPa (that is, the presence of H_2 in the fluid does not affect H_2O solubility). An empirical model for mixed H_2O-CO_2 solubility is developed and consists two equations: $w=(354.97P_w^{0.5}+9.585P_w-1.5095P_w^{1.5})/T+0.0012365P_w{}^{1.5}+P_{CO2}(-0.0001102P_w^{0.5}-1.341\times10^{-5}P_w)$, $CO_2=(7507P_{CO2}-1.86P_{CO2}^2)/T+0.905P_w^{0.5}P_{CO2}+P_{CO2}(-785.3P_w^{0.5}-40.85P_w+2.291P_w^{1.5})/T$, where w is water content in wt%, CO_2 content is in ppm by mass, $P_w=X_w^f P$ and $P_{CO2}=X_{CO2}^f P$ (in MPa), where X_w^f and X_{CO2}^f are the mole fraction of H_2O and CO_2 in the fluid, and T is in K. The above equations are applicable to 700 − 1200°C and total pressure of ≤500 MPa. The 2σ relative uncertainty is 13% for the H_2O equation, and 25% for the CO_2 equation. Both empirical models are recommended for the modeling of volcanic eruptions and magma chamber dynamics.

V51L-06 1135h

Influence of halogens (F, Cl, Br, I) on lava rheology.

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Degassing of halogens from magma is an important constraint on the nature and efficiency of volatile degassing in subvolcanic systems. Fundamental information on the transport properties of halogens in melts and the melts containing halogens are required for the quantification of models dealing with disequilibrium degassing based on halogens abundances in quenched volcanic glasses. The shear viscosities of melts in the system Na-Fe-Si-O-Br-I have been determined over a wide range of temperatures (1200-400 °C) at 1 atm pressure in air. The compositions are based on the addition of Fe2O3, FeBr3 and FeI2 to a base melt composition corresponding to sodium disilicate (Na2Si2O5). Viscosities were determined using concentric cylinder and micropenetration methods and measurements span the range of 100.5 to 1011 Pa s. The chemical compositions of these melts have been analysed after viscometry determinations. The iron is fully oxidized under the conditions of the viscometry. Although Bromine and iodine are highly volatile elements in silicate melts, levels of bromine and iodine over 1 wt.% have been stabilized in these melts, presumably assisted by the presence of ferric iron. Although some volatilisation occurs during the original synthesis of these samples none occurs during viscometry. The anionic substitutions Br2O-1 and I2O-1 have very small influences on the viscosity of these melts. These effects are similar to the influence of Cl2O-1 substitution. As a consequence, minor to major element abundances of Br and I in strongly peralkaline undersaturated volcanic rocks are not likely to have a significant influence on melt viscosity. These results lead us to infer low values of diffusivity for Br and I in volcanic melts. Thus disequilibrium degassing involving Br and I is highly likely.Implications of these these putative diffusivities of Br and I in explosive volcanism will be discussed.

V51L-07 1150h

Experimental Temperature-X(H_2O)-Viscosity Relationship for Peraluminous Leucogranites, and Comparison With Synthetic Silicic Liquids

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Viscosities of liquid albite ($NaAlSi_3O_8$) and a peraluminous Himalayan leucogranite have been measured between $10^{9.0}$ and $10^{13.8}$ Pa.s for water contents between 0 and 3.4 wt.%. This leucogranite is the first naturally occurring liquid composition to be investigated over the full range of T-X(H_2O) conditions that may be encountered in both plutonic and volcanic settings (rhyolites of near-identical composition are known from Peru).
At typical magmatic temperatures of 750 °C, the viscosity of the leucogranite is $10^{11.0}$ Pa.s for the anhydrous liquid, dropping to $10^{6.5}$ Pa.s for a water content of 3 wt.% H_2O. For the same temperature, the viscosity of liquid $NaAlSi_3O_8$ is reduced from $10^{12.2}$ to $10^{6.3}$ Pa.s by the addition of 1.9 wt.% H_2O. Combined with published high-temperature viscosity data, these results indicate that water reduces the viscosity of $NaAlSi_3O_8$ liquids to a much greater degree than that of natural granitic liquids. Furthermore, the viscosity of $NaAlSi_3O_8$ liquid becomes substantially non-Arrhenian at water contents as low as 1 wt.% H_2O, while that of the leucogranite appears to be near-Arrhenian to at least 3 wt.% H_2O. Therefore the viscosity of hydrous $NaAlSi_3O_8$ liquid does not provide a good model for natural granitic or rhyolitic liquids, especially at lower temperatures and water contents.
Qualitatively, the differences can be explained in terms of configurational entropy theory because addition of water should lead to higher entropies of mixing in simple model compositions than in complex natural compositions. This hypothesis also explains why the water reduces magma viscosity to a larger degree at low temperatures, and is consistent with published viscosity data for hydrous liquid compositions ranging from $NaAlSi_3O_8$ and synthetic haplogranites to natural samples. Therefore predictive models of magma viscosity need to account for compositional variations in more detail than via simple approximations of the degree of polymerization of the melt structure.

V51L-08 1205h

Non-Arrhenian Multicomponent Melts Viscosity: Extension of the Model.

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Viscosity exerts a strong control on many magmatic and petrological processes on micro- and macroscopic scales. Furthermore, knowledge of such a property gives important constraints for structural theories of silicate melts. Giordano and Dingwell (GD)[1] recently described the viscosity of a large number of silicate melts coping a wide compositional range, on the basis of an empirical parameter (SM), sum on a molar basis of the network modifying cations. That model does not consider the contribution of the iron oxidation state to influencing the viscosity. Here, this is rectified. In this experimental study we have doubled (over 700 data) the number of viscosity determinations input into the model provided by [1] extending the compositional basis to further rhyolitic, trachytic, moldavitic, andesitic, latitic, pantelleritic, basaltic and basanitic melt compositions. The effect of Fe^{2+}/Fe^{3+} on viscosity has been expressly examined. The temperature-dependence of the new liquid compositions have been investigated at high temperature (1050-1600°C) and low temperature (616-860°C) by using a concentric cylinder apparatus and the micropenetration technique, respectively. Fe^{2+}/Fe^{3+} ratio has been determined by combining a wet chemistry technique (potassium dichromate titration) with microprobe analysis for each sample, before and after the high and low-T viscometry. Viscosity parameterization along the lines of the GD model, and incorporating the constraint that the high-T viscosities converge to a common value [2], reveal very good agreement with those calculated by [1]. Explicit redox influences appear to be small. [1] D.Giordano, D.B. Dingwell, 2003. Earth Planet. Sci. Lett. 208, 337-349; [2] J.K. Russell, D. Giordano, D.B. Dingwell, 2003, Am. Mineral. 88, 1390-1394.

V52A MCC: Level 1 Friday 1330h

Light Element Geochemistry: Insights Into High-Temperature Processes III Posters

Presiding: **A J Kent,** Oregon State University**; F von Blanckenburg,** Institute for Mineralogy, University of Hannover

V52A-0415 1330h POSTER

Hydrogen Isotope Fractionation in the System Brucite-Water at 3GPa

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Upper mantle rocks are depleted in D by $80^o/_{oo}$ relative to the oceans. As water is recycled through the upper mantle-hydrosphere system over geologic time, the offset between mantle and ocean is likely created by fractionation of isotopes during hydration of the oceanic crust and subsequent partial dehydration of subducted material. To understand how δD of the slab is modified during subduction, we need to know fractionation factors for hydrous mantle minerals at pressures and temperatures relevant to subduction. The

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aim of this study is to develop experimental and analytical techniques that will allow us to extend measurements to temperatures and pressures attainable in solid media high pressure apparatus. We have made our first measurements in the chemically simple brucite-water system, which has been the subject of previous high pressure experimental (up to 0.8GPa, 600°C) and theoretical work.
Piston cylinder experiments were performed at 3GPa and 500-700°C with starting materials consisting of fine grained (< 5μm) brucite (δD = -100$^o/_{oo}$) and water (δD between -190 and +117$^o/_{oo}$). Brucite and water were mixed such that free water constituted 70% of the total H_2O, and were sealed in thick-walled Au capsules. Partial exchange experiments, consisting of three separate piston cylinder runs containing different starting waters, but otherwise identical conditions, were conducted to determine equilibrium fractionation factors. Experimental duration was between 12 and 144 hours. After equilibration, the water was extracted completely from the capsule and divided between several charges, and aliquots of brucite were heated on a vacuum line to liberate water, which was analysed using conventional Zn-reduction methods. Experiments contained enough material for up to 5 water and 2 brucite analyses. In experiments where replicate analyses were made, the average uncertainty (1σ) was 1.8$^o/_{oo}$. Bulk D/H ratios in experiments that used deionised water (δD = -54$^o/_{oo}$) remained constant within analytical uncertainty, while experiments with waters that were enriched or depleted in D became systematically lighter or heavier by up to 9$^o/_{oo}$. This might be due to diffusive exchange with the pressure medium. Results of 48h partial exchange experiments at 500 and 700°C and 12h experiments at 700°C, together with a single 144h experiment at 700°C, indicate that brucite/water fractionation factors are smaller than -10$^o/_{oo}$ under these conditions. These fractionation factors are significantly smaller than those measured at lower pressure, and so confirm that pressure continues to be an important variable in controlling D/H fractionation at up to 3GPa, even at elevated temperatures. More experiments are required to constrain the fractionation processes that control hydrogen isotopic ratios in the mantle and hydrosphere.

V52A-0416 1330h POSTER

Tracing recycled Li in the mantle: insights into mantle heterogeneities

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Li isotope measurements (the ratio of the stable isotopes 7 and 6, expressed as d7Li) have a fundamental importance in the study of crust-mantle material cycling processes, due to the strong Li isotopic contrast between materials of mantle provenance (low d7Li 3 - 5$^o/_{oo}$, and [Li] 4 ppm) and those with near surface histories, such as altered oceanic crust (mean d7Li 8$^o/_{oo}$, and [Li] 10 ppm) (Brenan, and Shaw, 1998, Seyfried and Chan, 1998, Chan and Teagle, 2001). Mantle containing recycled material should therefore have a heavy Li isotope composition. However, recent work has suggested that effect of recycling Li could be more complex than simply increasing the d7Li of the mantle. It has been proposed that dehydration during subduction fractionates the Li isotopic composition of the slab. Fluids carry heavy Li into the mantle wedge, leaving the deep recycled residue isotopically light (Tomascak, 2002, Zack et al, 2003). Thus isotopically heavy material is returned to the shallow mantle and light material deep recycled. It might be anticipated that a shallow MORB reservoir should hence evolve to higher d7Li than a deep OIB reservoir. A key to using Li isotopes as a tracer for recycled material is being able to measure Li isotopes more precisely than before, in order to distinguish the small-scale natural variations. This has been made possible with recent developments in plasma ionisation multi-collector mass spectrometry (PIMMS). The Thermo Finnigan Neptune, PIMMS shows excellent stability and sensitivity for Li. Using rapid sample-standard bracketing, Li isotopes can be measured with a 0.2$^o/_{oo}$ or better reproducibility, a factor of four better than most reported techniques. d7Li results from Iceland, Azores, La Palma (Canaries), show a limited range in Li isotopes d7Li 3-4.5, with similar values to a suite of MORB we have analysed (Elliot et al, 2002). However results from Pacific islands Mangaia, Rurutu, and Tubuai, which have a HIMU mantle signature, tend to show heavier d7Li up to 5.7$^o/_{oo}$. These analyses were made on fresh, hand picked olivines to avoid potential alteration in these 10My samples. HIMU OIB have frequently been proposed to be derived from sources with a large component of deep recycled, mafic oceanic crust, which recent work suggests should have a light Li isotope signature. We therefore propose that the heavy d7Li results from enriched mantle wedge, which contains the heavy d7Li residue from the slab dehydration event (Zack et al, 2003), and not the slab itself as previously thought.

V52A-0417 1330h POSTER

Lithium Isotopic Fractionation in Subduction Zones: Clues From Clays

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Lithium isotope ratios show such large variations in nature (>30 per mil), that many areas of geosciences are exploring the usefulness of this system in explaining the evolution of particular rocks. Here we show how the lithium isotope ratios change during the transformation of smectite clay minerals to illite during burial metamorphism. Such a transition may be a common feature in the shallow regions of subduction zones and may ultimately affect the Li isotope compositions of fluids contributing to arc magmatism. Lithium is a ubiquitous trace element in natural formation waters that, like B, shows large isotopic fractionation especially during interactions with clay minerals. Lithium is adsorbed in the interlayer region of expandable clay minerals but is easily exchanged. Lithium is also incorporated into the octahedral sites. The substitutions of Li in two crystallographic sites of clay minerals may complicate interpretations of bulk Li-isotope ratios. We suggest that the magnitude of the isotopic fractionation of Li between fluid and clay is different in the interlayer sites of clay minerals than in the octahedral sites of clay minerals. Examination of Li contents and isotope variations in experimental reactions of smectite to illite (300C, 100MPa) shows changes with structural rearrangement of the clay layers. The Li-isotope trend declines (from +6 to -13 per mil, expressed as ratios of 7/6) throughout R1-ordering of the mixed-layered illite smectite (I/S). However, the equilibrium end products of the reaction have R3-ordering and show a heavier isotope ratio (0 per mil). This observation is very similar to the trends we observed for B-isotopes, where the interlayer B initially overprinted the tetrahedral-layer B isotope composition, but as the interlayer sites were collapsed during illitization, the equilibrium isotope composition was approached. The significant Li and B isotopic changes that occur during ordering of I/S coincides with the temperatures experienced during the early stages of subduction and undoubtedly influences the isotopic makeup of those higher pressure phases that contribute Li and B to the region of arc magma generation.

V52A-0418 1330h POSTER

Boron Isotope Systematics of New Zealand Hydrothermal Systems

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Recent analytical developments in multiple collector ICP-MS have allowed for the rapid and precise determination of B isotope ratios (Aggarwal et al 2003). This technique has been applied to the New Zealand environment to better understand the recycling of B in such a geologically diverse environment. Geothermal fluid samples have been collected from hot springs along the Alpine fault in the South Island, and extensively across the Taupo Volcanic Zone (TVZ), and the east coast of the North Island. These samples have been purified and analysed by an Axiom multiple collector ICP-MS with a direct injection nebuliser. Sample sizes were typically 200ng B, and analysed in duplicate giving an external precision of <0.2$^o/_{oo}$. The data group into three. Samples from the Taupo Volcanic Zone from both geothermal wells and hot springs show δ^{11}B values between -9$^o/_{oo}$ and 0$^o/_{oo}$ and similar Cl/B. These δ^{11}B values are independent of temperature and reflect subtle differences in the isotopic composition of the hydrothermal systems and their host rock. This is consistent with other data from the Ngawha geothermal system in the north of the North Island that have δ^{11}B values of -3.5$^o/_{oo}$. This is in contrast to most other arc magmas that have higher δ^{11}B values. The TVZ δ^{11}B values are similar to those from Iceland (Aggarwal et al 2000) where B is sourced from the mantle suggesting that B could also be derived from mantle. It is however more likely that since the TVZ δ^{11}B values are similar to those from Ngawha in the far north of the North Island, the sources would also be similar indicating that B is crustally derived. In contrast hydrothermal fluids from the east coast of the North Island show δ^{11}B values from 18 $^o/_{oo}$ to 37$^o/_{oo}$. Cl/B ratios in these fluids are different to that of seawater indicating a minimal seawater involvement. Instead, it is likely that the high δ^{11}B values are a result of the addition of fluids with a high δ^{11}B value possibly from the dewatering of the adjacent accretionary prism during subduction. Samples from the third group come from a wide range of localities show a substantial spread of δ^{11}B values (20$^o/_{oo}$ to -2$^o/_{oo}$). This range is perhaps a result of adsorption of ^{10}B in the cooler fluids and the consequent fractionation of B isotopes from the crustal δ^{11}B values seen in the TVZ and in Ngawha. It conclusion, B isotope measurements from New Zealand indicate that the Taupo Volcanic Zone is dominated by crustally derived B whereas on the east coast, B is influenced by B being dewatered from the subducted accretionary prism. Elsewhere B is strongly fractionated from the crustal signatures seen at Ngawha and in the Taupo Volcanic Zone.

V52A-0419 1330h POSTER

Light element systematics of Woodlark Basin volcanic rocks - evidence for old and new slab inputs?

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In the Woodlark Basin/New Georgia subduction system, late Miocene collision of the Ontong Java Plateau changed the polarity of subduction, from SW subduction of the Pacific plate beneath the Solomon Is., to very steep, NE subduction of the Woodlark Basin microplate. This recent subduction has generated Plio-Pleistocene volcanism in the New Georgia Group unusually close to the trench. Questions have been raised as to whether this melting is triggered by recent slab additions beneath the New Georgia Group, or represents mantle modified by past subduction reheated by a new, hot slab. To address these questions, we have examined Li, Be and B systematics in a suite of lavas from the New Georgia Group (NG) and the Woodlark Spreading Center (WSC), which is being subducted beneath the NG. Boron enrichments can indicate relatively recent (<5Ma) slab inputs at arcs, while Li abundance and isotopic variations may reflect longer-term slab enrichments, as Li can be retained in olivine and other magnesian mantle minerals. Li-B decoupling has been used to suggest the presence of older slab-modified mantle in the Panamanian arc segment (Tomascak et al. 2000). The Li, B, and Be concentrations of our samples vary from 3-38 ppm, 2-34 ppm, and 0.08-2 ppm, respectively. Li and Be vary regularly with MgO content and indices of differentiation in NG lavas, while B show greater scatter. B/Be ratios range widely in NG lavas, but the minimum values encountered at each center show a pattern of decline toward the WSC-trench intersection. Li/Y and Li/Yb ratios show no change with position, and are less variable overall. The Li and B concentrations in WSC MORB samples are slightly elevated relative to MORBs (5.5-7.0 ppm Li; 2.1-3.3 ppm B) compared to normal MORBs (3-4ppm), as are Li/Yb and B/Be ratios (2.1-2.8 and 3.1-9.7, respectively). Differences in B enrichment relative to the WSC intersection point to recent subduction inputs, while elevated Li in NG and WSC samples may indicate pre-existing mantle wedge enrichments. Li isotopic results may shed further light on this question.

V52A-0420 1330h POSTER

Insights into off-axis volcanism in the Trans Mexican Volcanic Belt: B-Li-Be systematics of lavas from the Colima Graben and the Michouacan-Guanojuato Volcanic Field

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In the Trans-Mexican Volcanic Belt (TMVB) major calc-alkaline stratovolcanoes are associated with alkaline and calc-alkaline monogenetic centers in extensional basins. A past B-Be survey of TMVB lavas (Hochstaedter et al. 1996) suggested a distinction between lavas from stratocones and associated monogenetic centers, possibly related to differences in the mantle sources of these rocks. We are examining this distinction further, utilizing Li-Be-B systematics and other trace element variations to constrain the roles of melting, assimilation/ crystallization, and

source differences in the genesis of TMVB lava types. Samples analyzed thus far include relatively primitive and evolved alkaline lavas from the Colima graben (minettes and lamprophyres); calc-alkaline andesites from Volcan de Colima; gabbroic xenoliths entrained in Colima lamprophyres; and alkaline and calc-alkaline lavas from small centers in the Michoacan-Guanojuato volcanic field (MGV), including suites (and associated crustal xenoliths) from Jorullo and Paricutin. TMVB alkaline lavas vary from 3-13 ppm Li, 1-5 ppm Be, and 1-12 ppm B. Calc-alkaline Colima andesites range from 5-18 ppm Li, 0.2-1 ppm Be, and 2-8 ppm B. B/Be ratios of Colima alkaline rocks are <5 and distinct from calc-alkaline lavas (7-12), due primarily to lower Be. Li/Yb ratios are high and similar in both lava types (4-16). Lavas from Jorullo widely in Li and B (8-20 ppm Li and 1-47 ppm B) suggesting incorporation of Li and B-enriched crustal materials (Jorullo xenolith: 25 ppm Li, 95 ppm B). Gabbroic xenoliths from the Colima graben are much lower in Li and Be (<3 ppm and 0.01 ppm). B systematics in TMVB monogenetic centers suggest limited H_2O-rich inputs from the slab, and point to a significant role for crustal assimilation during magma evolution. Li systematics record the anomalous crystallizing assemblages of TMVB alkaline lavas, and may, along with elevated Ba and Be contents, indicate mantle sources modified by a higher temperature slab component.

V52A-0421 1330h POSTER

The Role of Shock in the Redistribution of Volatile Elements in Basalts. Implications for the Interpretation of Martian Magmatism.

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The mineralogy and geochemistry of martian basalts have been used to estimate the amount of water in martian magmas and to model the martian hydrologic cycle. The mineralogy of martian basalts and the composition of associated melt inclusions have been interpreted as indicating that martian basaltic magmas had very little water (less than 0.1% H2O). On the other hand, the behavior of geochemical tracers (Li and B) has been interpreted as indicating that this low water content was the product of extensive magmatic outgassing and that martian basalts initially contained significant water. This interpretation is based on the observation that Li and B decrease in the rims of pyroxenes in basaltic shergottites resulting from the partitioning of these incompatible elements into a fluid phase during degassing. In that many martian basalts experienced substantial shock (20-40 GPa), it is possible that the magmatic volatile record preserved in martian basalts has been disturbed. To better understand the possible effects of shock on this volatile record, we are studying the redistribution of volatile elements in naturally and experimentally shocked basalts. The initial study of tholeiitic basalts associated with the Lonar impact structure in India illustrates one of the possible effects of shock on the redistribution of volatile elements such as Li and B. High-Ca pyroxene in the unshocked Lonar basalt ranges in composition from approximately Fs23 in the core to Fs41 at the rim. As expected in a basaltic system, incompatible trace elements Ce, Be, Li and B increase from pyroxene core to rim. Relationships among incompatible elements are characteristic of basaltic systems (i.e. Li/Be decreases with increasing Li). The shocked basalt examined in this study is characterized by the conversion of plagioclase laths to maskelynite. This corresponds to shock pressures between 20-40 GPa. The high-Ca pyroxene in this basalt has similar major element characteristics as the unshocked basalt and both Ce and Be increase from core to rim. In contrast to the unshocked basalt, the pyroxene exhibits a decrease in Li, Li/Be and Li/Ce in the high-Fe rim. These initial observations suggest that shock may produce the decrease of volatile trace elements in pyroxenes that had been attributed to degassing.

V52A-0422 1330h POSTER

Large Iron Isotope Variations in Mantle Minerals: The Influence of Oxidation State and the Implications for the Iron Isotope Heterogeneity of the Upper Mantle

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Controversy exists over whether or not there are significant variations in the iron isotope compositions of terrestrial mantle rocks, and whether stable isotopic fractionation can take place at high temperatures. Recent studies imply that significant iron isotopic fractionations exist between high temperature mantle minerals (Zhu et al., 2002, EPSL 200, 1-2). This suggests that isotope fractionation at the mineral scale has the potential to influence the terrestrial mass balance for iron isotopes. We present MC-ICP-MS iron isotope data for minerals from mantle peridotite to determine if there is isotopic fractionation between minerals, and what the physical and chemical parameters that could cause fractionation are. In order to evaluate the level of mantle iron isotope heterogeneity at the mineral scale, spinel and spinel-garnet facies peridotites, representative of sub-arc mantle, sub-continental cratonic lithospheric mantle and MORB-source mantle, were selected. Systematic isotopic fractionations exist between silicate minerals. The $\delta\ ^{57}Fe/^{54}Fe$ compositions of the olivines are $\sim 0.20\ ^{o}/_{oo}$ lighter than those of clinopyroxene and orthopyroxene, consistent with the results of Zhu et al. Although the differences are small, they are greater than our long-term reproducibility ($0.13\ ^{o}/_{oo}$ 2 S.D.). The ranges in the $\delta\ ^{57}Fe/^{54}Fe$ compositions of olivine, clinopyroxene and orthopyroxene are 0.6, 0.7 and 0.9 $^{o}/_{oo}$, respectively. Spinels show a range of over 1.70 $^{o}/_{oo}$. The lightest isotopic compositions are for minerals from island-arc peridotites, the heaviest are for minerals from xenoliths that sample sub-continental cratonic mantle. The spinel $\delta\ ^{57}Fe/^{54}Fe$ compositions correlate negatively with spinel ferric/total iron contents, determined by Mössbauer spectroscopy, suggesting that this parameter has a strong influence on isotope fractionation. The $\delta\ ^{57}Fe/^{54}Fe$ compositions of the silicate minerals show some correlation with those of co-existing spinels. One explanation for the variations is that significant differences exist between the iron isotope compositions of sub-arc and sub-continental cratonic lithospheric mantles. These differences could arise as a consequence of melt extraction or melt-rock interaction processes as ferric iron partitions preferentially to ferrous iron into silicate melts. The iron isotope compositions of spinels may be especially sensitive to such processes because spinels are the main carriers of oxidized Fe in the shallow mantle (Wood and Virgo, 1989, GCA, 50, 6).

V52A-0423 1330h POSTER

Iron Isotope Fractionation in Metamorphic Rocks

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Polyakov and Mineev [1] predict high-T equilibrium fractionation favouring incorporation of heavy Fe isotopes into Fe(III)-containing minerals. We have confirmed this prediction for metamorphic rocks. A prerequisite was the development of highly accurate and precise protocols for Fe isotope analysis (Delta 56Fe/54Fe to 50ppm at 2 sigma of repeatedly separated natural samples; Delta 57Fe/54Fe to 70ppm; and Delta 58Fe/54Fe to 280ppm, n=40) using a Finnigan Neptune MC-ICP-MS at the University of Hannover. In greenschist facies rocks, Delta 56Fe of magnetite and pyrite is 0.3 to 0.6permil heavier than Fe in Fe(II) silicate minerals. In migmatites formed at 800C Delta 56Fe of magnetite is 0.1 to 0.3 permil above Fe(II) silicate minerals (Chlorite, Biotite). These observations confirm that (a) high-T equilibrium fractionations of Fe do indeed exist; (b) strongly-bound Fe(III) oxides and sulfides do indeed favour heavier isotopes; and that (c) a temperature-dependency exists, favouring higher fractionation at lower temperature as predicted [1]. It will now be important to explore the potential of this new isotope system for of high-T thermometry and in terms of redox conditions in metamorphic rocks and melts. 1 V.B. Polyakov and S.D. Mineev, The use of Mössbauer spectroscopy in stable isotope geochemistry, Geochimica Cosmochimica Acta 64, 849-865, 2000.

V52B MCC: Level 1 Friday 1330h

Messages from the Underworld: Linking Geophysical Signals to Eruptive and Hydrothermal Processes II Posters *(joint with S)*

Presiding: **T L Wright,** U.S. Geological Survey

V52B-0424 1330h POSTER

A statistical model for the timing of earthquakes and volcanic eruptions influenced by periodic processes

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Evidence of non-uniformity in the rate of seismicity and volcanicity has been sought on a variety of timescales ranging from 12 hours (tidal) to $10^3 - 10^4$ years (climatic), but the results are mixed. Here, we propose a simple conceptual model for the influence of periodic processes on the frequency of geophysical 'failure events' such as earthquakes and volcanic eruptions. In our model a failure event occurs at a 'failure time' $t_F = t_I + t_R$ which is controlled by an 'initiation event' at the 'initiation time' t_I and by the 'response time' of the system t_R. We treat each of the initiation time, the response time and the failure time as random variables. In physical terms, we define the initiation time to be the time at which a 'load function' exceeds a 'strength function' and we imagine that the 'response time' t_R corresponds to a physical process such as crack propagation or the movement of magma. Assuming that the magnitude and frequency of the periodic process are known, we calculate the statistical distribution of the initiation times on the assumption that the load and strength functions are otherwise linear in time. This allows the distribution of the failure times to be calculated, if the distribution of the response times is known also. The predictions of this simple theory are compared with some examples of observed periodicity in seismic and volcanic activity at tidal and annual timescales.

V52B-0425 1330h POSTER

3-d Visualization of Earthquakes and Erupting Vents in Time-series Animations: Application to Kilauea and Miyakejima volcanoes

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Computer programs have been developed to view erupting vents and earthquake sequences on and beneath transparent topography shown by a DEM, vertical image, or map. In a single frame an earthquake dataset can be rotated with the mouse to create perspective views. Multiple-frame time animations are created in which the perspective (e.g., map, cross-section) and time increments (e.g., hour, day, month) are chosen by the user. Viewed as movies, the animations allow recognition of seismicity patterns occurring over large areas and long time periods. Departures from characteristic activity are easily spotted and can be further investigated in a single frame or in animation with shorter time increments. Time animations have been made of earthquake sequences accompanying several eruptions of Kilauea volcano and the Miyakejima eruption and associated dike emplacement in 2000. An earthquake swarm shallower than 6 km beneath Miyakejima island began on the evening of 6/26/2000. The seismicity moved to the southwest, then to the north and offshore, and a submarine eruption occurred on the morning of 6/27. Shortly thereafter, earthquakes of M 4 and above migrated westward, also becoming deeper (to 20 km), marking the emplacement of a large dike northwest of Miyakejima island. Eruptions at Miyakejima from 7/8 to 9/1 were associated with formation of a new caldera. The timing and location of the submarine eruption can be seen

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