

compensating elements such as Ca. Network formers, such as Al and Si, retain their tetrahedral coordination in the alteration layer and subsequent gel. As for Zr, this will help retain charge compensating cations, such as Ca or Sr in the alteration gel. Our data indicate that distinct mechanisms participate to the formation of the gel layer, but that they do not participate to the same extent to the long term stability of the glass/gel interface.

V61D MCC: 106 Saturday 0830h

Contemporary Chemical Geodynamics I (joint with T)

Presiding: J N Kellogg, University of South Carolina; **R L Rudnick**, University of Maryland

V61D-01 0830h

The Chemical Composition of the Earth and its Envelopes

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Radiogenic isotopes systematics have led to a model for the structure of the Earth with a continental crust, a mantle, divided into a depleted mantle (40%) and a primitive mantle (60%), and a core. These two mantles have been mixed up through geological time and form now, separated by the 670 km discontinuity, an upper depleted mantle and a lower mantle, partially depleted. This model gave also the distribution of the different parent/daughter chemical ratios in the different envelopes (Rb/Sr, Sm/Nd, U/Pb, etc).

Another approach, using systematic comparisons of characteristic chemical ratios like (Mg/Al, K/U, Rb/Sr, Ti/Sr), has shown that the Bulk Earth belong to the carbonaceous meteorites trend and has thus permit to determine composition of the Earth (Allège et al, 2002).

Combining these two types of data with elemental ratios measured in surface rocks as well as in pristine ultramafics, we have developed a global model using a general inversion procedure to compute the chemical composition of the different reservoirs of the Earth (i.e. Continental crust, Mantles and Core).

The results have important geologic consequences on the formation of the core, the origin of OIB and the energetics of the Earth. The composition of the different reservoirs also establish an important chemical relationship between the position of an element in Mendeleeff table and its geologic distribution, leading to a new geochemical classification of the elements.

V61D-02 0845h

High precision Pb isotopes in Indian Ocean MORB

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Several studies have shown that MORB from the Indian Ocean have different isotopic characteristics compared to those from the Pacific or Atlantic Oceans. A particular Pb isotope feature of Indian Ocean MORB is their high ²⁰⁸Pb/²⁰⁴Pb ratio compared to those from the Pacific or North Atlantic. These isotope differences have been interpreted as reflecting the presence of an old recycled component or lithospheric delamination in the Indian MORB reservoir.

We present Pb triple spike data on MORB from three Indian spreading centers - South West Indian Ridge (SWIR), Central Indian Ridge (CIR) and South East Indian Ridge (SEIR) - and from the Rodriguez

Triple Junction (RTJ). All samples have been previously analysed for major and trace elements and Sr, Nd and Pb isotopes. Our purpose is to use high precision Pb data 1) to investigate the Pb isotope relations between the three spreading centers and 2) to find whether differences in ²⁰⁷Pb/²⁰⁴Pb can also be resolved between Indian, Pacific and Atlantic MORB.

So far, Pb isotope measurements have been obtained on CIR and SWIR, and those on SEIR and RTJ are on going. Samples from Atlantis FZ II (SWIR) have lower Pb isotope ratios (²⁰⁶Pb/²⁰⁴Pb= 17.47-17.94, ²⁰⁷Pb/²⁰⁴Pb= 15.41-15.47, ²⁰⁸Pb/²⁰⁴Pb= 37.17-37.65) than CIR-MORB (²⁰⁶Pb/²⁰⁴Pb= 18.30-18.70, ²⁰⁷Pb/²⁰⁴Pb= 15.50-15.57, ²⁰⁸Pb/²⁰⁴Pb= 38.18-38.73). In both Pb isotope spaces, CIR and Atlantis FZ II MORB define two different linear arrays with distinct slopes. The ²⁰⁷Pb/²⁰⁴Pb-²⁰⁶Pb/²⁰⁴Pb slopes correspond to model ages of 1.97 (CIR) and 2.15 Ga (Atlantis FZ II), and values of $\kappa=5.14$ and 3.62, respectively.

Our new Pb isotope data allow us to distinguish two Pb isotope domains, CIR and SWIR, while previous data show large scatter and overlap. Furthermore, the influence of the Réunion plume is reflected in the gradual increase of Pb isotope ratios along the CIR with proximity to the hotspot. Comparison of Indian MORB with those from East Pacific Rise (EPR) and South Atlantic [1] show that Pb isotope ratios increase in the order: EPR < South Atlantic ~ CIR < SWIR for ²⁰⁷Pb/²⁰⁴Pb and EPR < South Atlantic < SWIR < CIR for ²⁰⁸Pb/²⁰⁴Pb.

1. Galer, S.J.G., et al., Eos Trans. AGU, Fall Meet. Suppl., Abstract., 2001. 82: p. F1403.

V61D-03 0900h

Regional Heterogeneity Within the Icelandic Mantle Revealed Through High-Precision Pb Isotope Data

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We report high-precision Pb-isotope data for > 120 neovolcanic lavas from Iceland that were analysed on an Axiom double focusing MC-ICP-MS, using a ²⁰⁷Pb-²⁰⁴Pb double spike to correct for instrumental mass bias. The external reproducibility of Pb isotope ratios determined for the standard SRM981 was ± 100 ppm (DS corrected) and replicate analyses of samples have a similar reproducibility. The study encompasses all the neovolcanic rift and off-rift zones, including alkalic and tholeiitic picrites, basalts and rhyolites. We observe a similar range in ²⁰⁶Pb/²⁰⁴Pb to published conventional TIMS results, but with a significant reduction in the ²⁰⁷Pb/²⁰⁴Pb and ²⁰⁸Pb/²⁰⁴Pb variation at a given ²⁰⁶Pb/²⁰⁴Pb value. Some scatter in ²⁰⁷Pb/²⁰⁴Pb still remains, which probably reflects real small-scale heterogeneities. The anomalously high ²⁰⁷Pb/²⁰⁴Pb values previously reported for Oraefajokull are confirmed here. For geographically restricted areas such as Reykjanes, Theistareykir and each of the Icelandic alkaline centres, we observe tight coherent linear data arrays in ²⁰⁷Pb/²⁰⁴Pb and ²⁰⁸Pb/²⁰⁴Pb vs ²⁰⁶Pb/²⁰⁴Pb that are interpreted as binary mixing lines, although each array is offset from the others such that more than four end-members are required.

One of the most striking features of these new data is the offset in $\Delta 8/4$ Pb between lavas from localities NE and SW of the assumed plume axis. This offset is very similar to that observed between lavas from the two volcanic trends in Hawaii. In Iceland, lavas from each region fall on broad distinct arrays with their most radiogenic compositions represented by alkaline lavas from Snaefell-Oraefajokull (NE) and Eyjafjöll-Torfajokull, respectively. Furthermore, both regions seem to link up compositionally (including Sr, Nd & He isotopes) as well as physically with the adjacent Kolbeinsey and Reykjanes ridges. There is a crude negative correlation between ³He/⁴He and both $\Delta 7/4$ Pb and $\Delta 8/4$ Pb, opposite to that observed for Hawaiian lavas. However, at this stage the extreme He-Pb isotopic composition of alkaline lavas may bias our observations. In conclusion, our extensive high precision Pb isotopic data set resolves local mixing relationships, regional chemical provinces and correlations with ³He/⁴He, and demonstrates that the Pb isotope variations cannot simply be explained in terms of just two or three end-member components.

V61D-04 0915h

High-Precision Pb Isotope Systematics of Basalts from the Kerguelen Archipelago: New Insights on the Kerguelen Plume Components

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The number and origin of components involved in mantle plumes continues to be a subject of intense debate amongst geochemists. New analytical techniques are now allowing for a more refined analysis of individual oceanic islands. About 60 samples of Kerguelen Archipelago basalts (MgO > 2.3 wt.%) were re-analyzed for their Pb isotopic compositions by MC-ICP-MS (Nu Plasma 015). We carefully selected the samples on the basis of their Sr-Nd-Hf and Pb (TIMS) characteristics in order to cover the range of age, geographic and compositional variations observed on the archipelago.

These new high-precision Pb isotopic compositions (2σ ima: 100-150 ppm for ²⁰⁶Pb/²⁰⁴Pb and ²⁰⁷Pb/²⁰⁴Pb and 150 ppm for ²⁰⁸Pb/²⁰⁴Pb) reduce the total range of ²⁰⁷Pb/²⁰⁴Pb variations among Kerguelen basalts by a factor of 2. This provides an important new perspective on Kerguelen plume systematics and allows for the clear distinction of three groups: the 29-25 Ma tholeiitic-transitional basalts, the 25-24 Ma mildly alkalic basalts, and the <10 Ma more evolved, alkalic lavas and intrusions. This age and compositional evolution also corresponds to a geographic trend, where the older basalts are closest to the Southeast Indian Ridge (~300-400 km) while the mildly alkalic basalts are further away. The younger, more evolved alkalic rocks occur mainly in the same areas as the mildly alkalic basalts. These alkalic rocks result from lower degrees of melting and their distinctly lower ²⁰⁶Pb/²⁰⁴Pb (and ¹⁷⁶Hf/¹⁷⁷Hf) together with their significantly younger age indicate some interaction with the older Kerguelen Plateau. These important differences clearly reflect a Miocene change of regime of the Kerguelen plume (Mattioli et al., JP, 2002).

Among the flood basalts that cover >80% of the Kerguelen Archipelago, the mildly alkalic basalts of the 24 Ma Crozier volcanic section stand out with distinctly higher ²⁰⁶Pb/²⁰⁴Pb. The isotopic compositions of the Crozier basalts are interpreted as representative of those of the Kerguelen plume. These basaltic magmas had little, if any, interaction with either the surrounding depleted mantle or the Kerguelen Plateau during ascent, either because their magma conduits became isolated or/and because by 24 Ma, the Southeast Indian Ridge was too far away. Our study confirms that the high-precision Pb isotope systematics of basaltic lavas represent an excellent tool to decipher components in major mantle plumes, as has also recently been shown in Hawaii (Eisele et al., G3, submitted; Blichert-Toft et al., G3, submitted).

V61D-05 0930h

A New Type of Model for Understanding Lead Isotopic Heterogeneity in the Earth's Mantle

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Using an extended version of the conventional geochemical reservoir model, we investigate the meaning of the Pb isotope data in oceanic basalts. Our method, previously used to study the Nd and Sr isotopic systems, allows us to model not only the mean isotopic ratios, but also the distribution of those ratios within the reservoirs.

Owing to low chemical diffusion rates, subreservoirs that are created by mass transport into and out of the mantle effectively exist as distinct geochemical entities for all time. By tracking these subreservoirs, we obtain a model of the full range of isotopic values represented in the mantle. Using results from numerical calculations of mixing, we also track the length scales associated with each subreservoir. Applying simple statistics, we obtain the distribution of expected measurements as a function of the stirring time, effective melt fraction, sampling volume, and mass transport history.

Previous work on the Pb isotopic arrays has focused on intra-mantle differentiation (i.e. mid-ocean ridge generation and subduction) as the primary source of heterogeneity, neglecting the effects of continental extraction and recycling. Owing to the large concentration of U, Th, and Pb in the upper continental crust, we find that the effects of continental crustal recycling are very significant. Other processes we investigate include a layered continental crust, increased recycling of U in an oxidizing environment, uptake of U through hydrothermal exchange at mid-ocean ridges, and lower-crustal delamination.

V61D-06 0945h

Osmium Inference of Recycled Continental Material in the OIB and MORB Sources

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Systematic analyses of isotopic compositions in mid-oceanic ridge basalts (MORB) have revealed long wavelength anomalies affecting the different oceanic ridges. These large-scale heterogeneities are explained by the presence of a component overlapping the depleted mantle signature. The origin of these components is still debated: dispersion of old plumes, passive anomaly affecting a large part of the upper mantle, marble-cake

The presence of recycled sub-continental material has been proposed to explain the so-called DUPAL anomaly, centred in the Indian Ocean, as also in the Cape Verde source. Because of its particular properties during melting processes, Re behaves as a moderately incompatible element and Os as a compatible, the Re-Os system is a preferential tracer for the recycled crustal material. Indeed, due to their high Re/Os ratio, the latter is expected to have particularly high $^{187}\text{Os}/^{188}\text{Os}$.

The goal of this study is to investigate the Os isotopic composition of basalts from Cape Verde and MORB sampling the DUPAL anomaly. Coupling the Os isotopic ratios with the other isotopic systems as well as the trace element compositions, shows for MORBs radiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios (up to 0.166) together with high $^{87}\text{Sr}/^{86}\text{Sr}$ (up to 0.7053), low $^{206}\text{Pb}/^{204}\text{Pb}$ (down to 17.7) and high Ba/Nb, Ba/La and La/Sm. Comparison with Cape Verde archipelago suggest the involvement of a mafic component, responsible for the radiogenic Os signature, that could be recycled lower crust or metasomatised sub-continental lithospheric mantle.

V61D-07 1000h

Re-Os Isotopic Evidence for Long-Lived Heterogeneity and Equilibration Processes in Earth's Upper Mantle

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Compared to other incompatible lithophile isotope systems the Re-Os isotopic system is very well suited for tracing extraction and subduction of Mid-Ocean Ridge Basalt (MORB). During partial melting Re is mildly incompatible whereas Os is strongly compatible resulting in high Re/Os elemental ratios in MORB and correspondingly low Re/Os ratios in the depleted solid residue left behind. As ^{187}Re decays to ^{187}Os the $^{187}\text{Os}/^{188}\text{Os}$ ratios of MORB and depleted mantle residue will diverge. MORB develops high, radiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios while the depleted mantle residues develop relatively low, un-radiogenic $^{187}\text{Os}/^{188}\text{Os}$ ratios. When MORB is subducted back into the upper mantle re-equilibration with the depleted mantle residue is expected to take place, but the time scales

and length scales on which this re-equilibration occurs are poorly constrained.

We report osmium isotope compositions of more than 700 mantle-derived Os-rich platinum-group element alloys thought to represent the upper mantle. Our data form a wide, essentially Gaussian distribution demonstrating that, with respect to Re-Os isotope systematics, the upper mantle is extremely heterogeneous. Depleted and enriched domains can remain un-equilibrated on a time scale of billions of years. Effective equilibration between these domains probably requires high degrees of partial melting, such as occur under mid-ocean ridges or in back-arc settings, where percolating melts enhance the mobility of both Os and Re. The Gaussian shape of the Os isotope distribution is a signature of a random mixing process between depleted and enriched domains in a plum-pudding configuration in the upper mantle, rather than the result of individual melt depletion events. Our data lend strong support to the view that secondary metasomatic melt-rock processes define not only the major and trace element chemistry of mantle derived rocks but also their Re-Os isotope systematics. These processes can mask primary melt depletion features related to previous times that the material passed through an upper mantle region with high degrees of partial melting.

V61D-08 1035h

Hafnium-neodymium isotope systematics of ocean island basalts

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We have measured Hf and Nd isotopes in basalts from Koolau, Hawaii, as well as from the Samoa hot spot chain. The Hawaiian samples, the Koolau drill-hole, show limited variation in Hf or Nd isotope composition (epsilon Nd varies from 4.2 to 7.3 and epsilon Hf varies from 8 to 12.2). The correlated variation, based on 38 samples, has an R-squared of 0.86. The data results in a slope of 1.23 on a Hf-Nd isotope correlation diagram (epsilon notation). This slope is shallower than the mantle array defined by ocean island basalts which is 1.4.

Contrary to previous work the Hf-Nd-isotope correlation for Samoa shows an even shallower slope than the Hawaiian samples. The Samoan samples are surface samples as well as recently dredged samples of the youngest extension of the Samoan hot spot (Hart et al., 2000). The samples show a large range in Sr-Nd and Hf compositions with epsilon-Nd ranging from -2.2 to 3.5 and epsilon-Hf ranging from 2.2 to 7.5 and large range in Sr-isotopic composition with extreme values up to 0.7088. Hf-isotopic composition is well correlated with both Sr and Nd isotopic composition (R-squared is 0.93 and 0.95 respectively). Based on 10 samples the slope of the correlated isotope variation on an epsilon Hf-Nd isotope diagram is 0.97, which is shallower than any Hf-Nd-isotope correlation measured before.

The shallow slope of the Hawaiian basalts on a Hf-Nd isotope correlation diagram has been interpreted as being distinctive of a contribution of recycled pelagic sediments (Blichert-Toft et al., 1999). However, for Samoa the influence of pelagic sediments was thought to be limited as EMII basalts were thought to find its source in either a mixture of recycled oceanic crust with terrigenous sediments, or carbonatite metasomatism as an EMII-like component has been recognized in xenoliths affected by carbonatite metasomatism with Sr-isotopic compositions up to 0.7128 (Hauri et al., 1993). Our new Hf-isotope data seem to rule out a recycled terrigenous sediment component for the Samoan basalts, while the high Sr-isotopes seem to rule out a pelagic sediment component.

We propose that the shallow slope on a Hf-Nd isotope correlation diagram can also be explained by recycled oceanic lithosphere. Because melt extraction beneath mid-ocean ridges starts in the garnet stability field the Lu/Hf ratio of the residue is more fractionated than the Sm/Nd ratio. This, in time, will result in more radiogenic Hf-isotopic compositions and a deviation of from the terrestrial array. Mixing which such a component will result in elevated Hf compared to Nd isotopic composition. However, concentrations of most elements in the oceanic lithosphere are low suggesting that mixing of solids is unlikely as even for 2 Ga old lithosphere more than 80% of residual lithosphere is required to "move" the Hf-isotope composition significantly above the mantle array. Therefore, it is more likely that melts derived from ancient oceanic lithosphere, or melts that interacted with ancient lithosphere were a component of the Samoan basalts.

Blichert-Toft, J., F.A. Frey, and F. Albarede, Science, 285, 879-882, 1999.

Hart, S.R., H. Staudigel, A.A.P. Koppers, J. Blusztjan, E.T. Baker, R. Workman, M. Jackson, E.H. Hauri, M.D. Kurz, K. Sims, D. Fornari, A. Saal, and S. Lyons, Geochim. Geophys. Geosys., 2000G000108, 2000.

Hauri, E., N. Shimizu, J. Dieu, and S.R. Hart, Nature, 365, 221-227, 1993.

V61D-09 1050h

The Hf-Nd isotopic fingerprint of subducting sediments – A tale of two trenches

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We report Lu-Hf and Sm-Nd isotopic data for sediments from two DSDP cores from the Pacific (Aleutian site 183 and Tonga sites 595/6) in order to determine the isotopic fingerprint of subducting sediments and whether Hf-Nd can serve as a tracer as sediments make their way through the subduction zone. These sections appear to represent near end-member types in terms of Lu-Hf-Sm-Nd isotopic systematics. The Aleutian section is 516 meters thick, is composed dominantly of clastic turbidites and diatomaceous oozes and has an overall Hf-Nd isotopic composition similar to continental sediments. The Aleutian section has crustal Lu/Hf ratios (wt. avg. $^{176}\text{Lu}/^{177}\text{Hf} = 0.017$) and Hf-Nd isotopic compositions that lie within the Hf-Nd array (wt. avg. $\epsilon_{\text{Nd}} = -0.6$; $\epsilon_{\text{Hf}} = +5.5$). The 90 meter Tonga section, in contrast, is composed almost entirely of slowly accumulating metalliferous clays and is unique in two regards. First, it has highly radiogenic Hf ($\epsilon_{\text{Hf}} = +7.5$) relative to Nd ($\epsilon_{\text{Nd}} = -5.6$) such that it plots well above the terrestrial array. More significantly, perhaps, the Tonga sediments are also characterized by extremely high $^{176}\text{Lu}/^{177}\text{Hf}$ (0.107) and Nd/Hf (42) ratios which have two important effects. First, high Lu/Hf ratios cause the Tonga compositions to evolve quickly toward highly radiogenic Hf. Second, a simple batch mixing model between Tonga sediment and depleted mantle compositions form a highly curved hyperbolic trend. This curve diverges from mantle compositions toward $-\epsilon_{\text{Nd}}$ values, leveraged by the high Nd/Hf ratios in these sediments, and should be recognizable with as little as a 1% sediment contribution [1]. This mixing line falls along a trend recognized in Tonga arc lavas by Pearce et al. [2] clearly indicating the contribution of the Tonga pelagic sediments in the source of these arc magmas. The anomalous Lu-Hf-Nd signatures in the Tonga sediments appear to result from decoupling of Hf and Nd sources in these sediments: Nd is derived from REE scavenging from seawater and is ultimately of continental origin whereas Hf is dominated by hydrothermal inputs with a mantle isotopic signature. [1] Vervoort et al., 2002, GCA: 66:A806. [2] Pearce et al., 2002, GCA, 66:A584.

V61D-10 1105h

Neodymium and Hafnium Isotope Systematics of ~2.7 Ga Adakites and Magnesian Andesites, Superior Province, Canada: Implications for Archaean Subduction Zone Petrogenetic Processes

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An association of adakites and magnesian andesites (MA) that erupted within typical intra-oceanic arc tholeiitic to calc-alkaline basalts has recently been documented in ~2.7 Ga Wawa greenstone belts. The adakites and MA yield $2670 \pm 66 \text{Ma}(2\sigma)$ and $2623 \pm 160 \text{Ma}(2\sigma)$ Sm-Nd and Lu-Hf isochron ages, respectively. Within error these ages agree with U-Pb zircon ages (2750-2695 Ma), suggesting that the Sm-Nd and Lu-Hf systems were not significantly disturbed by post-emplacment alteration processes. At 2.7 Ga the adakites have larger positive initial ϵ_{Nd} values (+2.2 to +2.8) than the MA (+0.4 to +2.0). Calculated initial ϵ_{Hf} values, using the ^{176}Lu decay constant of Scherer et al. [1] of the MA (+2.6 to +4.9) overlap with those of the adakites (+3.5 to +4.9) but extend to slightly lower values. Clearly positive initial ϵ_{Nd} and ϵ_{Hf} values of the adakites show that their basaltic precursors, subducted late Archean oceanic crust with a short crustal residence, were derived from a long-term depleted mantle source. The lower initial ϵ_{Nd} values of the MA with

respect to that of the associated adakites can be explained by melting of a sub-arc mantle that had been variably enriched by recycling of continental material into the sub-arc mantle. Collectively, the Nd and Hf isotopic characteristics of the MA can be attributed to the decoupling of these elements during recycling of continental material into the sub-arc mantle prior to 2.7 Ga arc. During this recycling process, Hf was more conservative than Nd, suggesting sub-arc mantle enrichment by fluids [2-3]. Since the late Archean Wawa adakites and magnesian andesites were generated by subduction zone processes similar to those operating in Cenozoic arcs, it is likely that late Archean oceanic crust, and island arc crust, was also created and destroyed by geodynamic processes similar to modern plate tectonics. In the Late Archean, crustal recycling and slab melting therefore played an important role for the generation of heterogeneity in the Archean upper mantle.

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- [2] Pearce, J.A., Kempton, P.D., Nowell, G.M., and Noble, S.R., 1999. Hf-Nd element and isotope perspective on the nature and provenance of mantle and subduction components in western Pacific arc-basin systems. *J. Petrol.*, 40: 1579-1611.
- [3] Woodhead, J.D., Hergt, J.M., Davidson, J.P., and Eggins, S.M., 2001. Hafnium isotope evidence for 'conservative' element mobility during subduction zone processes. *Earth Planet. Sci. Lett.*, 192: 331-346.

V61D-11 1120h

Lithium and Boron Isotopes in the Aleutian Islands: Contribution of Marine Sediments to Island Arc Magmas

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The Aleutian Arc is characterized by the presence of thick terrigenous sediments in the trench and fracture zones on the down-going plate, and therefore provides a unique setting for assessing the role of sediments with respect to other components in arc magma genesis.

We have measured Li and B isotope compositions of the sediments from DSDP site 183 near the northern edge of the Aleutian abyssal plain and basalts from several Aleutian islands. The upper 200 m of the sediment core consist of ash-rich diatomaceous ooze and have $\delta^7\text{Li} = 4.8$ to 5.6‰ and $\delta^{11}\text{B} = 2.9$ to 5.3‰ . The underlying clay and silty turbidites are Li rich, and have $\delta^7\text{Li} = 1.3$ to 2.4‰ and $\delta^{11}\text{B} = -3$ to 1.2‰ . Thus the sediments subducted beneath the Aleutian Arc have Li isotope compositions that are MORB-like or lighter, whereas oceanic crust altered by seawater at low temperature may be isotopically heavier than fresh MORB.

Basalts from Segum Island are especially enriched in Li and B with elevated Li/Y (to 0.84) and B/Nb (to 33). $\delta^7\text{Li}$ values of Segum basalts vary between 2.0 and 4.3‰ and $\delta^{11}\text{B}$ values are between 1.9 and 3.5‰. These isotopic data suggest that sediments may comprise a significant source of enrichment of fluid mobile elements at Segum due to the focusing effect of Amlia Fracture Zone. Recheshnoi is also highly enriched in Li (Li/Y to 1.1), with $\delta^7\text{Li} = 1.0$ to 3.5‰ . In contrast, Kanaga samples show low Li/Y and B/Nb values and slightly higher $\delta^7\text{Li}$ (3.8 to 5.8‰) and lower $\delta^{11}\text{B}$ (-0.25 to 1.6‰). Other islands (Yunaska, Okmok, and Shishaldin) show a similar range of $\delta^7\text{Li}$ values (2 to 4‰).

The restricted range and relatively light $\delta^7\text{Li}$ observed in this study are consistent with previous results from other Aleutian islands and other arcs (Tomascak et al., 2002). This has been attributed to retention of the slab-derived Li in the subarc mantle. Our data from the Aleutians suggest that another explanation for the MORB-like $\delta^7\text{Li}$ values of arc lavas may be the dominance of input from the sediments.

V61D-12 1135h

Lithium Content and Isotopic Composition of the Upper Continental Crust

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The lithium isotopic composition of the upper continental crust is characterized through measurements of Li abundance and isotopic composition in a suite of sedimentary rocks [13 loess from USA, Europe, New Zealand and China (Taylor et al., 1982), 9 Post-Achaean Australian shales (Taylor & McLennan, 1985)] and a variety of granites [2 S-type granites and 8 I-type granites from Australia (Chappell, 1984); and 5 granite composites from China (Gao et al., 1998)]. These lithologies give similar and light lithium isotopic values relative to the mantle ($\delta^7\text{Li} = -3$ to $+5\text{‰}$ for loess (average: $+0.3$); -3 to $+3\text{‰}$ for shales (average: -0.8) and -3 to $+3\text{‰}$ for all granites (average: -0.2). We estimate the lithium isotopic composition of the upper continental crust is light, around $0 \pm 2\text{‰}$. From the Li content of loess (30 ± 10 ppm) and a correlation between Li content and Al_2O_3 in shales, we estimate the upper crustal Li abundance at 40 ± 10 ppm.

The shale data also yield insights into the mechanism of lithium isotope fractionation during water-sediment interaction. There is a positive correlation between $\delta^7\text{Li}$, Li content and the chemical index of alteration (CIA), suggesting that as shales or their source regions become more weathered, more ^7Li is taken up from water (analogous to the uptake of seawater Li by hydrothermally altered MORB, as detailed by Chan et al., 1992).

V61D-13 1150h

Lithium isotopic composition of xenolithic eclogites: implications for subduction zone processes

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Lithium isotopes are strongly fractionated at the Earth's surface. Seawater Li is very heavy ($\delta^7\text{Li} = +32\text{‰}$) compared to that in mantle-derived magmas (MORB = $+2$ to $+6\text{‰}$). Because heavy seawater Li is incorporated into altered oceanic crust (Chan et al., 1992, EPSL), Li isotopes may provide a new tool for tracing recycled oceanic crust in the Earth's mantle. However, Li systematics of island arc basalts are not straightforward. In most arc lavas no correlations exist between $\delta^7\text{Li}$ and other indicators of subduction (e.g., $\delta^{11}\text{B}$) and most arc lavas $\delta^7\text{Li}$ values overlap with those of MORB (Tomascak et al., 2002, EPSL). What happens to the heavy Li that is subducted? Recent investigation of Alpine eclogites, which are analogs of subducted, hydrothermally altered oceanic crust (Zack et al., EPSL, submitted), show them to have light $\delta^7\text{Li}$, ranging from 11 to $+3\text{‰}$. This is significantly lighter than fresh or altered MORB, suggesting that Li is fractionated during dehydration of the slab, with heavy seawater Li being lost early in the subduction process, perhaps to the forearc mantle. We have measured the $\delta^7\text{Li}$ of clean omphacites separated from xenolithic eclogites from the Mesozoic Koidu kimberlites, Sierra Leone. Previous studies have shown that the low MgO suite of eclogites from Koidu has geochemical properties of hydrothermally altered Archean oceanic crust (Barth et al., 2001, GCA; 2003, Prec. Res., in press). Omphacites from these eclogites have $\delta^7\text{Li}$ ranging from 2 to $+5\text{‰}$. Eclogites with $\delta^{18}\text{O}$ heavier than normal mantle range are the only samples to show $\delta^7\text{Li}$ that deviates from the MORB range (to lighter values), whereas eclogites with $\delta^{18}\text{O}$ lighter than normal mantle have $\delta^7\text{Li}$ that falls within the MORB range. We interpret the eclogites with heavy $\delta^{18}\text{O}$ and light Li to represent former oceanic crust that was hydrothermally altered at low temperatures, which increased both $\delta^{18}\text{O}$ and $\delta^7\text{Li}$. Like the Alpine eclogites, this crust lost much of its heavy Li in the earliest dehydration reactions accompanying subduction, leaving light Li behind. In contrast, eclogites with

$\delta^{18}\text{O}$ lighter than the normal mantle range have Li isotopes that are indistinguishable from MORB. This is consistent with high temperature sea floor alteration having limited impact on $\delta^7\text{Li}$, as recently shown by Chan et al. (2002, EPSL).

V62A MCC: Hall C Saturday 1330h

Evolution of the Igneous Rocks 2002 Edition IV Posters (joint with OS, P)

Presiding: Y Zhang, University of Michigan; J R Allwardt, Stanford University

V62A-1375 1330h POSTER

An Empirical Model for the Calorimetrically-Defined Glass Transition Temperature with Applications to Natural Systems

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Glassy rocks have long held a special fascination for petrologists and geochemists because they record the composition of the melt phase attending magmatic processes. Naturally-occurring silicate glasses form under a variety of geological conditions and they commonly form the main constituent in silicic volcanic rocks and in rapidly cooled mafic rocks. Glass also occurs in rocks with cooling histories that are substantially slower, such as the interiors of lava flows or mantle xenoliths. The glass transition temperature (T_g) marks the transition from the liquid to the glassy state. From a petrological perspective, the calorimetrically-defined glass transition temperature is an important limiting value for the temperature conditions at which many magmatic processes take place. Glass formation is a boundary between changing environmental states. Above T_g , rates of nucleation, crystallization and vesiculation are sufficiently fast to drive magmatic processes. Conversely, where the liquid line of descent (e.g., T-X $Melt$ path) intersects the T_g of the melt, glass forms and many magmatic processes effectively cease.

The purpose of this paper is to provide a means of exploring the T-X $Melt$ conditions for glass formation in natural magmatic systems. Specifically, we present an empirical model of predicting the thermodynamic glass transition temperature (T_g) as a function of melt composition. Operationally, the model produces temperature-dependent expressions for the heat contents of a silicate melt and glass of known composition. The point of intersection of the heat content curves for glass and melt defines the calorimetric value of T_g . Our model is constructed from experimental calorimetric heat content and differential scanning calorimetric (DSC) heat capacity measurements on silicate melts and glasses produced over the past 20 years. Calorimetric data in the model include over 500 experiments on 60 melt compositions and 250 observations on 30 glass compositions. Additional constraints on the model derive from independent estimates of the thermodynamic T_g . The model reproduces most of the measured calorimetric-values of T_g to within 30°C . The model also provides volcanologists with a tool for tracking ($T_{Magma} - T_g$) through magmatic processes such as fractional crystallization, vesiculation, partial melting. It can be used to forecast the termination of liquid lines of descent by glass formation and provides geothermometric constraints on magmatic systems by converting glass compositions into minimum pre-eruption temperatures.

V62A-1376 1330h POSTER

Viscosity of Hydrous Rhyolitic Melts

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It is critical to understand and to be able to predict viscosity of hydrous silicate melts for understanding