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SOLUBILITY OF ALKALI AND ALKALINE EARTH ALUMINOSILICATE COMPONENTS IN AQUEOUS FLUIDS IN THE LOWER CRUST AND UPPER MANTLE PRESSURE AND TEMPERATURE RANGE

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The solubility of Na- and Ca-aluminosilicate components in aqueous fluids in the 1000°-1400°C and 0.8-2.0 GPa temperature- and pressure-range, respectively, has been determined along each of the joins CaSi_4O_9 - $\text{Ca}(\text{Ca}_{0.5}\text{Al})_4\text{O}_9$ and $\text{Na}_2\text{Si}_4\text{O}_9$ - $\text{Na}_2(\text{NaAl})_4\text{O}_9$ with 0, 3, and 6 mol% Al_2O_3 . The solubility, $X_{\text{H}_2\text{O}}^{\text{fluid}}$, ranges from 0.5 to 20 mol% depending on temperature, pressure, and bulk composition. Its temperature dependence is linear and ranges between 0.7 and $4.2 \cdot 10^{-3}$ mol%/°C depending on pressure. The pressure-dependence of silicate solubility is also positive but non-linear. The solubility decreases with increasing Al_2O_3 content.

The aluminosilicate solubility along the join CaSi_4O_9 - $\text{Ca}(\text{Ca}_{0.5}\text{Al})_4\text{O}_9$ was fitted to the expression: $X_{\text{silicate}}(\text{mol}\%) = -2.6 - 0.20 \cdot X_{\text{Al}_2\text{O}_3}(\text{mol}\%) + 0.002 \cdot T(^{\circ}\text{C}) + 0.86 \cdot P^2(\text{GPa})$. Along the $\text{Na}_2\text{Si}_4\text{O}_9$ - $\text{Na}_2(\text{NaAl})_4\text{O}_9$ join, the solubility is 2-3 times greater and is more sensitive to temperature, pressure, and $\text{Al}/(\text{Al}+\text{Si})$; $X_{\text{silicate}}(\text{mol}\%) = 1.9 - 1.3 \cdot X_{\text{Al}_2\text{O}_3}(\text{mol}\%) + 0.008 \cdot T(^{\circ}\text{C}) - 13 \cdot P(\text{GPa}) + 7.3 \cdot P^2$

The partial molar volume of H_2O in both Na- Ca-silicate-saturated aqueous fluids, $V_{\text{H}_2\text{O}}^{\text{fluid}}$, ranges between ~17 and ~27 cm^3/mol depending on pressure, temperature, and compositions. The molar volume of silicate-saturated aqueous fluid is nearly identical to $V_{\text{H}_2\text{O}}^{\text{fluid}}$ because H_2O is the dominant component.

The isochors of both Na- and Ca-aluminosilicate-saturated aqueous fluids differ from those of pure H_2O and also differ from each other. For Ca-aluminosilicate fluids, pressure-difference at given temperature ranges between 5 and 10% in the 0.8-2.0 GPa and 1000°-1400°C pressure- and temperature-range. For comparison, in the Na-aluminosilicate-saturated fluids, this difference is between 5 and 30% depending primarily on fluid density and pressure. This difference between the Na- and Ca- system reflects the different solubility of Ca- and Na-silicate in aqueous fluids.

¹H MAS NMR STUDY OF WATER SOLUBILITY IN ENSTATITE

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An exact determination of the solubility of water in nominally anhydrous minerals is a prerequisite for understanding water storage in the earth's mantle. Large discrepancies were reported between the study of Kohn (1996) using ¹H MAS NMR and other studies using infrared spectroscopy. Keppler and Rauch (2000) suggested that this was because of differences in starting materials for experiments, and because of adsorption of water onto the powders used in NMR measurements. In order to resolve this discrepancy, a series of enstatite

synthesis experiments were carried out at 900-1100°C and 1.5-2.5 GPa in the presence of 0.5-31 wt% excess water. The ¹H MAS NMR spectra shows up to 5 peaks, 4 peaks are very sharp (peak center 1.1, 4.7, 5.6, 7.4 ppm) and 1 peak is very broad and asymmetric (3.3 ppm). This is in contrast to the observation of a single broad component in a recent study (Keppler and Rauch 2000). The broad peak increases with increasing water in the bulk composition as well as with P and T. No systematic differences were observed between different types of starting materials, and no evidence was found to suggest that adsorption of water is a serious problem. The sharp peaks were assigned to OH point defects (5.6 and 7.4 ppm), water in fluid inclusions (4.7 ppm), and OH from amphibole lamella in the enstatite structure (1.1 ppm). The broad peak at 3.3 ppm is very typical for water (OH and H₂O) in glasses and gels, which occurred as quench phase in our runs. Using heat treatments up to 700°C, all peaks disappeared except the OH point defect peaks. It revealed that the main reason for discrepancies of water determination using the NMR method was caused by additional contributions of the overlapping quench-phase water peak with peaks from OH point defects. This can be controlled by an appropriate choice of temperature and bulk water concentration in the sample. About 200 ppm water at 1100°C and 1.5 GPa and 300 ppm water at 900°C and 2.5 GPa was determined for enstatite if only the point defect peaks were considered. This is in good agreement with results using the IR method.

Kohn SC, *American Mineralogist*, **81**, 1573-1576, (1996).

Keppler H & Rauch M, *Physics and Chemistry of Minerals*, **27**, 371-376, (2000).

MELTING PHASE RELATIONS IN THE SYSTEM Fe-FeO AT 15-25 GPa

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High-pressure phase relations in the system Fe-FeO has primary importance in understanding the constitution of the planetary core. Ringwood and his coworkers determined the melting phase relation of the Fe-FeO system to 15 GPa and concluded that the liquid immiscibility (which is predominant at 1 atm experiments) disappears at 15 GPa and above 2100°C (Ohtani & Ringwood, 1984) Kato & Ringwood, 1989; Ringwood & Hibberson, 1990). We revisited the system with similar experimental technique (multi-anvil press, 10 and 7 mm MgO octahedral pressure medium (for 15 and 25 GPa, respectively), LaCrO₃ heater, mixed Fe-FeO powdered specimen, and Al₂O₃ capsule). Although our run products showed textures similar to those previously reported, we reached very different conclusion. Using alumina content as an indicator, coexisting Fe and FeO melts before quenching and FeO dissolved from molten Fe-rich melt during quenching are clearly distinguished. Using the new textural criteria, the solubility of FeO in molten Fe liquid is less than 10 mol% in the temperature 2000 to 2300°C at 15 GPa. The critical point of Fe-FeO liquid immiscibility at 15 GPa must reside at much higher temperature than Ringwood proposed (ca. 2100°C, Ringwood & Hibberson, 1990). The experiments at 25 GPa are in progress and it has been demonstrated that the solubility of FeO in molten Fe is much expanded at this pressure.

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Ohtani E, & Ringwood AE, *Earth Planet Sci. Lett.*, **71**, 85-103, (1984).

Kato T, & Ringwood AE, *Phys Chem Min.*, **16**, 524-538, (1989).

Ringwood AE & Hibberson W, *Phys Chem Min*, **17**, 313-319, (1990).

FLUID HETEROGENIZATION PROCESS IN EPITHERMAL Au-Hg DEPOSITS

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Thermodynamic modeling (using CHILLER program) of Au and Hg behaviour at 250-50°C in heterogenous fluid of the same composition as real ore-forming fluids, shows that boiling of fluids with separation of gas phase ($H_2O > CO_2$) brings to transition of sufficient part of mercury in gas phase as HgO gas and removal it from the solution (70% at 250°C, up to 90% at 300-350°C). It's in conformance with really observed Hg distribution between gas phase and solution in recent geothermal systems. During isothermal heterogenization of the solution, deposition of the first portion of gold occurs due to transition of some part H_2S in the gas phase, pH increasing (owing to CO_2 degassing) and as a result deposition of adular. It's also in a agreement with often observed forming of gold + quartz + carbonate paragenesis at deep horizons of volcanogenous-hydrothermal Au-Hg deposits - at the level of boiling of ore-forming solution. After heterogenization and precipitation of some part of gold, enough quantity of Au remains in the solution ($n \cdot 10^{-6}$ mol) that deposits under subsequent temperature decrease up to 150°C. Thus, heterogenization of ore-forming solutions has very important consequences for ore deposition: 1) Hg transition in vapor-gas phase which is able to migrate independently, may explain isolated position of cinnabar mineralization relatively of Au-Hg deposits; 2) boiling of fluids explains the position of quartz-adular-carbonate veins with Au in deepest horizons of Au-Hg deposits; 3) an increase of pH (owing to CO_2 degassing) and concentration of solutions (loss of H_2O solvent) that provides stability of hydrosulfide Au-complexes and creates conditions for Au transport using such solutions to the lower temperature areas (down to 150°C). This study is supported by Russian Foundation (grant 01-05-65096).

THE HIGH-PRESSURE $P_{2/c} - C_{2/c}$ PHASE TRANSITION FOR THE CMS ($CaO-MgO-SiO_2$) CLINOPYROXENE

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A high pressure $P_{2/c} - C_{2/c}$ phase transition for a synthetic iron-free clinopyroxene with composition $Ca_{0.15}Mg_{1.85}Si_2O_6$ was observed at 5.2 GPa and at room temperature by single-crystal X-ray diffraction. The unit-cell parameters were

measured from atmospheric pressure up to 5.5 GPa. Data collections of five b -reflections ($h + k = \text{odd}$) and five a -reflections were done at each pressure step to follow the evolution of the intensity ratio (I), in order to characterise the transition. This phase transformation is first order in character with no hysteresis. At the transition pressure, the b -reflection intensities disappear and a strong decrease of unit-cell parameters (a decreases by 3.4%, c by 4.4%, β by about 6° and V by 6.4%) has been observed.

Ca-free clinoenstatite (Angel and Hugh-Jones, 1994) shows the same first order character, very similar V/V_0 step associated with the transition and a similar transition pressure during decompression, i.e. $P = 5.3$ GPa. For clinoenstatite, however, a significant hysteresis is present (between 7 and 5.3 GPa). Substitution of a small amount of Ca into the clinoenstatite structure, hence, eliminates the hysteresis of the phase transformation, suggesting that it might facilitate the nucleation of one structure from the other during the first-order transition process. At higher Ca content ($Ca_{0.50}Mg_{1.50}Si_2O_6$ (Tribaudino et al., 2001) smearing of the unit-cell parameters was observed during the phase transition, which might be explained by a possible interaction with the strain associated with compositional modulation.

Angel RJ & Hugh-Jones DA, *J. Geophys. Res.*, **99**, 19777-19783, (1994).

Tribaudino M, Prencipe M, Nestola F & Hanfland M, *Am. Mineral*, **86**, 807-813, (2001).

XANES AND RAMAN SPECTROMETRY ON GLASSES AND CRYSTALS IN THE CAS SYSTEM

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Calcium aluminate and aluminosilicate glasses are attractive materials for a wide range of technical applications due to their highly refractory nature, their excellent optical and mechanical properties. The $CaO-Al_2O_3-SiO_2$ system (CAS) is remarkable since glasses with very few SiO_2 content can be synthesized, contrary to alkali or Mg aluminosilicate glasses. We have synthesized more than 40 different glasses in the CAS system using quenching method and 6 glasses in the CA system using laser heating. These glasses were studied using a Raman spectrometer T64000 from Jobin-Yvon-Dilor company and using X-ray absorption spectroscopy at Si, Al, Ca K edges the SA32 and D44 ligne in LURE. Cormier et al (2000) have shown from X-ray and neutron diffraction that aluminium is in 4-fold coordination in this ternary system. We present Raman and XANES data obtained at room temperature for these glasses. On the join $SiO_2-CaAl_2O_4$ glass, we observe a decrease in Raman intensity with increasing $CaAl_2O_4$ content for all the bands. In particular, we observe a sizeable decrease in intensity for the T4 band near 1150 cm^{-1} assigned to T-OO in T4 units. This decrease suggests that aluminium substitutes preferen-

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tially to Si⁴⁺ in the fully polymerized structural units TO4 according with Neuville and Mysen (1996). On the join SiO₂-Ca₃Al₂O₇ (R=CaO/Al₂O₃=3), the band intensities decrease with decreasing SiO₂, which can be interpreted as a substitution of Si by Al in T4 units with other substitution of Si by Al in T3 units. From the Xanes spectra, we can conclude that: - Al is in tetrahedral site in different Q species in all the CAS system. - Ca is in octahedral site in all the CAS system, with a decrease of the site distortion as SiO₂ content increases. Finally, the anomalous behavior for the viscosity and glass transition properties in the low silica glasses can be explained by the presence of Al in Q3 species at high CaO content.

L. Cormier, D.R. Neuville, G. Calas, *J. Non-Cryst. Solids*, **274**, 110-114, (2000).

D.R. Neuville and B. Mysen, *Geochim. Cosmochim. Acta*, **60**, 1727-1737, (1996).

LIQUIDUS ASSEMBLAGES AND PARENTAL MELTS OF SAO MIGUEL AND PICO, AZORES ISLANDS: MAGMATIC INCLUSIONS STUDY

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The Azores volcanic chain is frequently attributed to melting of an underlying hotspot, but others have suggested the Azores result from the melting of a 'wet-spot'. We have made a melt inclusion study of two islands in the Azores, Sao Miguel and Pico to investigate the melting process and ultimately address the role of water in the formation of the lavas. There are significant major element differences between lavas of Sao Miguel and Pico. At the same MgO, Sao Miguel lavas are richer in TiO₂, FeO*, MnO, K₂O, Ca/Al and poorer in SiO₂, Al₂O₃, Na₂O relative to Pico. These differences are possibly compatible with smaller degrees of melting beneath Sao Miguel or the involvement of different sources or melting conditions beneath the two islands. In order to address these questions we present preliminary compositional data of liquidus assemblages and parental melt petrology for Sao Miguel and Pico islands lavas. Crystallization temperatures and compositions of melts determined from homogenization/quenching experiments of melt inclusion in olivine phenocrysts Fo 89.5-77 for Sao Miguel and Fo 86-74 for Pico range from 1330° to 1125°C (MgO = 15 - 5 wt.%) and from 1230° to 1100°C (MgO = 8.5 - 3.5 wt.%), respectively. Parental melt compositions of Sao Miguel and Pico demonstrate the same difference observable from lava compositions. Modeling the results show that more cooler and differentiated parental melt of Pico could not result from olivine or clinopyroxene crystallization from Sao Miguel parental melts. This suggests that differences in source compositions beneath the islands, not greatly evident in isotopic compositions strongly influence the composition of melts produced. The role of water may thus be possibly implicated.

INFLUENCE OF MELT COMPOSITION ON THE MOBILITY OF CARBON DIOXIDE AND IMPLICATIONS FOR THE DIFFUSION MECHANISMS

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Carbon dioxide is the second most abundant volatile in terrestrial magmatic systems after water. The knowledge of the influence of melt composition on CO₂ diffusion is crucial for understanding the CO₂ diffusion mechanisms, degassing processes of magmas, and volatile fractionation. Recently, Sierralta et al. (manuscript submitted to Am. Mineral.) have demonstrated a significant increase of CO₂ diffusivity with increasing Na₂O content and thus progressive depolymerisation in the system NaAlSi₃O₈ (Ab) + nNa₂O (n = 0-7 wt%) at 1523 K and 0.5 GPa. We performed additional CO₂ diffusion couple experiments in this system at 1373-1623 K and 0.5 GPa to obtain the activation energies. Furthermore, we performed CO₂ diffusion couple experiments in the system Ab70SiO₂30 (in wt%) at 1423-1613 K at 0.5 GPa. The one dimensional CO₂ concentration-distance profiles were monitored using micro IR spectroscopy. An error function was fitted to the symmetrical profiles to obtain diffusion coefficients of bulk CO₂. In the case of Ab + nNa₂O melts the activation energies decrease from 194 kJ mol⁻¹ in Ab melt to 123 kJ mol⁻¹ in Ab + 2.58 wt% Na₂O, and to 110 kJ mol⁻¹ in Ab + 6.87 wt% Na₂O. In contrast to this behaviour the CO₂ diffusion coefficients in Ab70SiO₂30 melt and thus the activation energy are virtually identical within error to fully polymerised Ab composition in the investigated temperature range. During diffusional processes in the melt, the equilibrium between the CO₂ species (molecular CO₂ and CO₃²⁻) is locally maintained. The equilibrium concentrations are not quenchable to room temperature (Porbatzki and Nowak, 2001; Nowak et al., manuscript submitted to Am. Mineral.). However, we can extract some qualitative information on the CO₂ diffusion mechanism. The dependence of bulk CO₂ diffusion coefficients over the range of composition studied may reflect two effects: (1) changing CO₂ speciation in the melt and (2) changes in the individual diffusion coefficients of molecular CO₂ and CO₃²⁻ with composition.

Nowak M, Porbatzki D & Diedrich O, *Am. Mineral*, **submitted**, (2001).

Porbatzki D & Nowak M, *Beih. Z. Eur. J. Mineral*, **13**, 143, (2001).

Sierralta M, Nowak M & Keppler H, *Am. Mineral*, **submitted**, (2001).

NEW INSIGHTS INTO CARBON DIOXIDE SPECIATION IN SILICATE GLASSES AND MELTS

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Next to H₂O, CO₂ is the second most abundant volatile in terrestrial magmas. CO₂ plays an important role in the petrogenesis of silica-undersaturated peralkaline magmas at mantle depth, in the evolution of oceanic basalts, and in the degassing

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processes of magmas. The knowledge of the CO₂ speciation in silicate liquids is crucial for understanding the CO₂ dissolution mechanisms, the diffusion mechanisms, and the degassing processes. Using IR spectroscopy, we investigated the speciation of CO₂ in albitic and synthetic iron free dacitic glasses by heating the glasses below the glass transition temperature (T_g) in the temperature range 673-973 K at 0.5 GPa for 48 h and rapidly quenching. Our study demonstrates that in contrast to recent suggestions, the equilibrium of the CO₂ species reaction $\text{CO}_2 + \text{O}^{2-} = \text{CO}_3^{2-}$ in silicate glasses/melts shifts towards molecular CO₂ with increasing temperature. The CO₂ species concentrations and an ideal solution model were used to determine equilibrium constants for the homogeneous species reaction. We derived the thermodynamic quantities ΔH° and ΔS° for this reaction, assuming that the species concentrations reflect those at experimental temperatures ($\Delta H^\circ = -12 \pm 2 \text{ kJ mol}^{-1}$ and $\Delta S^\circ = -23 \pm 3 \text{ J mol}^{-1}\text{K}^{-1}$ for albitic composition; $\Delta H^\circ = -29 \pm 2 \text{ kJ mol}^{-1}$ and $\Delta S^\circ = -32 \pm 3 \text{ J mol}^{-1}\text{K}^{-1}$ for dacitic composition). An estimate of the relaxation time of the albitic network structure based on viscosity data gives 126 yr at 773 K and 7.7 m.y. at 673 K. This is far above the heating duration of 48 h. Nevertheless, we observe a significant change in CO₂ speciation even at 673 K in the albitic glass. We conclude that in contrast to the H₂O species reaction the relaxation of the CO₂ speciation is decoupled from the network structure relaxation of the melt/glass. The CO₂ molecule attached to a bridging oxygen to form carbonate (Kohn et al., 1991) can explain the observed change of CO₂ speciation below T_g . The CO₂ species reaction involving attachment and deattachment of CO₂ molecules from bridging oxygens does not affect the highly polymerised rigid glass network structure.

Kohn SC, Brooker RA & Dopree R, *Geochim. Cosmochim. Acta*, **55**, 3879-3884, (1991).

THE EFFECT OF FeO ON THE SULFUR CONTENT AT SULFIDE SATURATION (SCSS) OF SILICATE MELTS

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At low oxygen fugacities sulfur dissolves in silicate melts as S²⁻ by replacing O²⁻ on the anion sublattice, as described by the reaction: $\text{S}^{2-} + 1/2 \text{O}_2 = \text{O}^{2-} + 1/2 \text{S}_2$ suggesting the relationship: $\log C_s = \log [\text{S}] + 1/2 \log f_{\text{O}_2}/f_{\text{S}_2}$ (1) where [S] is the sulfide content and C_s is the "sulfide capacity" of the melt, analogous to an equilibrium constant. C_s is a very strong function of the FeO content of the melt. For most geological applications, the main question of interest is at what point a magma becomes saturated in immiscible sulfide. The equilibrium between silicate and FeS-rich immiscible sulfide melts can be described by the reaction: $\text{FeO}_{\text{silicate}} + 1/2 \text{S}_2 = \text{FeS}_{\text{sulfide}} + 1/2 \text{O}_2$ For which: $-\Delta G/2.3RT = \log a(\text{FeS}) - \log a(\text{FeO}) + 1/2 \log f_{\text{O}_2}/f_{\text{S}_2}$ (2) Subtracting (1) from (2) to eliminate f_{O_2} and f_{S_2} gives: $\log [\text{S}]_{\text{SCSS}} = \Delta G/2.3RT + \log C_s + \log a(\text{FeS}) - \log a(\text{FeO})$ (3) where $[\text{S}]_{\text{SCSS}}$ is the "Sulfur Content at Sulfide Saturation". The interesting feature of eqn. (3) is that it shows that the SCSS of a silicate melt depends on its FeO content from two different terms, namely $\log C_s$ and $\log a(\text{FeO})$. The former term has a positive slope versus FeO and dominates at high FeO, whereas the $\{-\log a(\text{FeO})\}$ term has a negative slope versus FeO, and should dominate at low FeO. The net result is that $[\text{S}]_{\text{SCSS}}$ should show an asymmetric U-shaped dependence on FeO. To

test this experimentally, we have equilibrated a series of haplobasaltic silicate melts with FeO varying from 0.7 to 30 wt% with immiscible FeS liquid, at 1400°C and 15 kb in the piston-cylinder apparatus, using Re and Pt/graphite capsules. The results confirm the asymmetric U-shaped dependence, with the minimum in SCSS occurring at 4 wt% FeO.

COMPOSITION OF THE EARTH'S MANTLE

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The composition of the Bulk Silicate Earth (BSE) can be constrained from cosmochemical arguments. The material forming the terrestrial planets derived from a reasonably homogenous solar nebula (whose composition is that of the Sun), but modified by i) various volatility-related chemical fractionation processes, ii) possible fractionation of the major elements Mg and Si, and iii) a cosmochemical metal/silicate fractionation. Superimposed on this was the second, more important, metal/silicate fractionation that resulted in core formation. Further loss of volatile elements may have accompanied accretion and/or formation of the Moon. This complexity means that while it is reasonable to assume that Refractory Lithophile Elements (Ca, Al, Ti, REE, U, etc.) occur in the BSE in solar relative abundances, the abundances of siderophile and volatile elements, and of Mg and Si, must be established empirically. This cannot be done in isolation from an understanding of the structure and evolution of the mantle, which understanding in turn depends on knowing the BSE composition. Hence the problem is decidedly non-linear.

Geophysical observations (densities, seismic velocities, etc.) establish the main features of the Earth's structure, but cannot be converted to composition unambiguously. The abundances of incompatible siderophile and volatile trace elements can be obtained from geochemical arguments, e.g., by identifying constant element ratios in basalts. But the concentration of a major element in a partial melt depends on its chemical potential rather than its concentration in the source, hence inferring mantle abundances of the major elements requires direct study of mantle peridotite. However, all mantle peridotites are victims of a complex history that includes the development of modal inhomogeneity on the cm to 10 m scale, as well as prior episodes of melt extraction, refertilization and metasomatism. The modal inhomogeneity in mantle samples is sometimes overlooked, but may be important in understanding upper mantle processes as well as in reconstructing the BSE composition.