Experimental investigations of initial melt migration in pelites

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Cores of 1cm length and 0.3cm diameter were drilled from fine grained, high-grade contact metamorphic rocks (andalusite-cordierited-biotite-zone). Experiments were performed in cold seal vessels at 2kbar under dry and (near) H_2O-saturated conditions at 700°, 750° and 800°C (167-508hrs run duration). After quench, melt and mineral compositions, and textures were analysed by SEM and electron microprobe.

Muscovite break down melting is induced in all samples. The initial grain shape of ms is outlined by melt pools containing biotite, and aluminium silicate (als) needles. Pervasive melt films formed on grain boundaries between dissimilar minerals, while melt filled cracks were rarely observed. Melt cracks are restricted to relict andalusite. Initial melt composition is highly variable over the cross section of a core (approx. 3x10 mm; e.g. variation > 5% in SiO_2; >3% in Al_2O_3 at 800°C, 240hrs). In contrast, no systematic gradients are apparent across individual grain boundaries or melt pools even for short run durations. Core scale heterogeneity decreased with time (e.g. < 2% in SiO_2 and Al_2O_3 for a run at 800°C, 507hrs**)**. SiO_2 content of the melt decreased towards a granite minimum melt due to melt/mineral reactions.

Initial melting on grain scale in intact rock textures results in significant chemical gradients on grain scale. First melts, formed by muscovite break down, are reactively propagate along grain boundaries, driven by chemical gradients. Continuous reaction with adjacent grains increased the melt amount, and hence porosity. Textures indicate that reactive melt transport is most efficient along grain boundaries rimmed by dissimilar grains. Even infertile mineral pairs, like quartz-andalusite, are reactively permeated along grain boundaries. No apparent overall volume change is visible.

We suggest that the grain scale heterogeneity of a melting rock results in sufficient chemical potential gradients in the melt formed, that chemical potential driven mass transport is a major force for initial melt migration and melt distribution during melting. Melt extraction is facilitated by reactive chemical potential melt migration which results in pervasive melt films

Crustal transport of flood basalt magma: the record of crystal isotopic zoning.

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We have initiated a microsample-based Sr isotope study of phenocrysts and groundmass from selected Columbia River Basalt flows using both laser ablation, and microdrilling followed by dissolution and column purification. All isotope ratios were determined on the ThermoFinnigan Neptune® MC-ICP-MS instrument recently installed in the GeoAnalytical Lab at Washington State University. As a precursor to precise and accurate determination of $^{87}Sr/^{86}Sr$ by laser ablation (using a 213nm laser), a subset of plagioclase samples were analyzed without undergoing chromatography to determine the effects of molecular and isobaric interferences on resulting Sr isotope compositions. Laser ablation results will be reported at the meeting.

We have initially analyzed 3 flows from each of the early, most primitive, and isotopically least enriched Imnaha Fm. and the late, isotopically enriched Saddle Mountain Fm. In each case, whole plagioclase grains have consistently lower $^{87}Sr/^{86}Sr_{(17Ma)}$ than groundmass ($\Delta Sr_{plag-gm}$ = -0.0001 to -0.0004). The same contrast is reflected in core-to-rim Sr isotopic zoning in single plagioclase grains sampled by microdrilling, with rims having similar $^{87}Sr/^{86}Sr$ to groundmass and cores being less radiogenic. Hence, the $^{87}Sr/^{86}Sr$ of the liquids increased during plagioclase growth. We regard this as unequivocal evidence for assimilation of radiogenic Sr into the CRBG magmas at crustal pressures. The apparent lack of evidence for a crustal component in Os isotope data from the Imnaha Fm. [1] may indicate that the contaminant was an Os-depleted felsic rock incapable of exerting significant leverage on the relatively Os-rich Imnaha lavas. Furthermore, the consistent crystal-groundmass $^{87}Sr/^{86}Sr$ relations argue for a similar history of crustal interaction, and perhaps transport, for all the CRB lavas we have studied so far. Tracer diffusion modeling of $^{87}Sr/^{86}Sr$ profiles through plagioclase phenocrysts indicate maximum crystal residence times in magma of the order of decades.

Reference

[1] Chesley & Ruiz (1998) EPSL 154, 1-11