How well do trace element proxies predict slab fluid behavior?

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We present volatile, major and trace element data for olivine-hosted melt inclusions from a suite of cross chain seamount samples extending across the Mariana arc from Guguan volcano to the Mariana Trough. H_2O, CO_2, S, F and Cl abundances, as well as trace elements, have been determined by SIMS [1]. Our results show that there is a strong decoupling of water and slab fluid tracers such as Ba/La and B contents, beyond the main arc system. As might be anticipated, trace element enrichments generally associated with the subducting slab show a systematic decrease across the arc into the back-arc. However, water contents in cross-chain samples, 230 km above the subducting slab, show similar values to the arc-front samples, implying that water release is a continuous process across the arc. This finding is consistent with experimental results [2] and melt inclusion studies across the Central American arc [3]. In contrast to H_2O contents, we observe significantly higher CO_2 contents in the cross chain samples (up to 820 ppm) as compared to the arc samples (max CO_2= 550ppm), suggesting either enhanced decarbonation at depth, or that the cross chain samples have experienced less degassing. Our observations show that fluid release can be substantial behind the main volcanic front and that a re-evaluation of the common use of slab-fluid tracers is clearly needed.

References

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An experimental study of the origin of reaction textures in mantle xenoliths

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Sieve-textured clinopyroxene and spinel are common in mantle lherzolite and harzburgite xenoliths. Various interpretations have been put forward to expalin the origin of this texture, including partial melting, mantle metasomatism and host magma – xenolith reaction during transport. Shaw *et al* (2006) suggested that sieve texture was a result of a two stage process involving breakdown of orthopyroxene with generation of a secondary Si-Al-alkali-rich melt, followed by migration of this melt along grain boundaries where it dissolved clinopyroxene and spinel in an incongruent reaction.

In this study, we have performed a set of time series experiments to test the above hypothesis. The experiments were performed under both reducing and oxidized conditions at 1200 and 1156 ^{o}C at one atmosphere, using a synthetic leucitite melt and discs of natural lherzolite. Experiment durations ranged from 1 to 15 days.

Sieve texture was developed on clinopyroxene and spinel in all experiments, but only on grains in direct contact with melt derived from symplectic reaction zones around orthopyroxene. Reaction zone thickness does not show a simple relation to experiment duration, however reaction zones developed at 1156^{o}C are narrower than those formed at higher temperature.

Our results show that sieve texture development on clinopyroxene and spinel in orthopyroxene-bearing mantle xenoliths is the result of a multistage reaction process. In the first step, orthopyroxene undergoes incongruent dissolution to produce a silica and alkali-rich melt together with olivine and clinopyroxene. As this melt migrates along grain boundaries it causes incongruent dissolution of clinopyroxene and spinel. The incongruent dissolution reactions involve complete dissolution of the reacting mineral followed by nucleation and growth of the secondary phases once the reacting melt is saturated with them. These secondary phases have a smaller volume than the primary grain,s leaving behind a reaction zone with interstial melt, i.e. a sieve textured zone. The reaction of orthopyroxene, clinopyroxene and spinel with infiltrated host magma results in a range of melt compositions that are indistinguishable from those interpreted to be due to very small degrees of partial melting.

References

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