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What Governs the Origin of the Slab Component in Subducting Oceanic Crust? Insights from Trace Element Distribution in Deformed and Massive Eclogites

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A prominent characteristic of volcanic rocks in subduction zones is an enrichment in fluid-mobile trace elements (e.g., Li, B, As, Rb, Sr, Sb, Cs, Ba, Pb, U) in relation to volcanic rocks that originated in divergent-margin settings. It is generally agreed that this enrichment is produced by trace element-rich fluids that originated from subducting slabs during dehydration reactions. One challenging task regarding this so-called subduction component is to model fluid compositions resulting from different dehydration reactions and compare them with estimates based on the investigation of subduction-related volcanic rocks.

In addition to improved knowledge of phase relations in metamorphic rocks under extreme high P, low T conditions (lawsonite eclogites, garnet mica schists), partition coefficients are required between minerals and fluid ($D^{Min/Fluid}$) for a range of trace elements and high pressure phases. Crucial data have been collected by means of laboratory experiments for some minerals such as garnet, clinopyroxene, amphibole and rutile (e.g., Brenan et al., 1998; Stalder et al., 1998). However, for many important hydrous phases that are thought to be stable in subducting slabs at depths of 100 km and greater (e.g., lawsonite, zoisite, phengite, apatite; Schmidt & Poli 1998) there are almost no experimental data sets available. The main reason for the lack of experimental data is the sluggish reaction rate at low temperatures where these phases are stable.

As an alternative approach to determine partitioning data, we have analyzed coexisting hydrous phases (Min= amphibole, phengite, zoisite, paragonite, apatite) and clinopyroxene (Cpx) by laser ablation microprobe-ICP-MS (LAM) for a large suite of subduction-relevant trace elements (Li, Be, B, Sr, Y, Zr, Nb, Ba, Ce, Nd, Sm, Pb, Th, U) in a sub-suite of well-equilibrated eclogites from Trescolmen, Central Alps (Zack et al., submitted). The large data set of $D^{Min/Cpx}$ values from this study is intended to be combined with existing experimental data for $D^{Cpx/Fluid}$ to derive key partitioning data for most relevant phases in the subducting oceanic crust.

This approach has been applied previously with sparse trace element mineral data from the literature (e.g., Brenan et al., 1998; Becker et al., 1999). However, this is the first study in subduction-related metamorphic rocks with the aim of developing criteria to find the most appropriate assemblages for attainment of trace element equilibria. The methodology involved a combination of textural observations and major and trace element mineral characteristics.

It has been found that four metabasaltic samples with homogeneous clinopyroxene compositions and a preferred orientation of all high pressure phases give consistent $D^{Min/Cpx}$ values and we can therefore recommend the use of partition coefficients from these samples for subduction zone modelling. In contrast, partition coefficients for eight metagabbroic and/or massive eclogite samples give widely varying results. For example, $D^{Amphibole/Cpx}$ values for Sr of the preferred samples range from 1.0 to 1.9, whereas results from the other samples scatter from 0.15 to 22. We have distinguished between equilibrated deformed eclogites and non-equilibrated massive eclogites in our study, and we can support the conclusion of Messiga et al. (1995) that synmetamorphic plastic deformation significantly enhances the trace element equilibration processes.

The results from this study imply that the deformation history in subducting ocean crust has to be considered as an important parameter before dehydration models that assume perfect equilibrium, such as Rayleigh fractionation, can be applied. In fact, disequilibrium assemblages in eclogite-facies rocks have been described more often than equilibrium assemblages, but the possibility of sampling bias preclude any quantitative statement. We would like to raise the question of whether metasediments and the uppermost metabasaltic crust, close to the high-stress slab-mantle interface, might experience a close attainment to equilibrium conditions, whereas in the massive metagabbroic lower oceanic crust disequilibrium might be a common feature.

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