

Trace element partitioning between hydrous minerals (phengite, zoisite, amphibole) and omphacite in eclogites: Clues for modelling dehydration reactions in subduction zones

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The fluid composition emanating from dehydrating slabs below subduction zones can be strongly influenced by the presence of accessory and minor phases. A prominent example of this effect is the retention of HFSE by rutile. It is therefore important to evaluate if and how the so called fluid mobile elements (Cs, Rb, Ba, Th, U, Pb, Sr, *LREE*) can be retained in the downgoing slab due to the presence of certain phases.

A plethora of phases can be present in dehydrating altered oceanic crust and pelagic sediments at the crucial PT conditions (*c.* 650°C and 3.0 GPa to 800°C and 5.0 GPa) including high pressure phases such as phengite, zoisite, lawsonite, chloritoid and possibly also talc, apatite, zircon. In order to evaluate the trace element budget in subducting altered oceanic crust we have focussed our study on eclogites from Trescolmen, Switzerland. High pressure hydrous phases are widespread and peak PT conditions approach those of subducting slabs beneath arcs (650°C and 2.2 GPa; Meyre *et al.*,

1997). The mineral assemblage consists of clinopyroxene, garnet, barroisitic amphibole, quartz and rutile +/- phengite, paragonite, epidote group minerals, talc, apatite, zircon.

To understand dehydration processes quantitatively it would be valuable to know the partition coefficients of trace elements between hydrous minerals and fluid for the relevant PT conditions. Since clinopyroxene is the best studied mineral for fluid partitioning behaviour (Brenan *et al.*, 1995; Stalder *et al.*, 1998), we have measured the concentrations of trace elements in clinopyroxenes of the Trescolmen eclogites along with coexisting phengite, zoisite and barroisitic amphibole. With a combination of both data sets it is possible to estimate hydrous mineral/fluid partitioning data.

Results

Phases were analysed with the Laser Ablation-ICP-MS at Memorial University. In the investigated samples, it was found that zoisite has the highest affinity for Th (1.0 to 2.5 ppm), U (0.5 to 1.0 ppm), Pb (150 to 350 ppm), Sr (2900 to 5400 ppm) and the *LREE* (e.g. Ce 60 to 130 ppm). In contrast, phengite shows only moderate (Pb, Sr) to insignificant (Th, U, *REE*) concentrations for these elements but has the highest affinity for Ba (1300 to 3200 ppm), Rb (300 to 520 ppm) and Cs (6 to 12 ppm). Barroisitic amphibole (in contrast to the well investigated calcic amphiboles) is not the dominant mineral phase for any of the trace elements investigated, but instead shows moderate (Ba, Rb, Pb, Sr, *MREE*) to low (Th, U, *LREE*, *HREE*) concentrations.

Successful measurements of extremely low concentrations of Th (2 to 10 ppb), U (10 to 30 ppb), Ba (35 to 160 ppb), Ce (30 to 400 ppb) and moderate concentrations of Pb (1.7 to 5.8 ppm) and Sr (45 to 200 ppm) in the omphacites allow us to

TABLE 1. Average $D^{\text{Min/Cpx}}$ partitioning in Trescolmen eclogites

	D Phe/Cpx	D Zoi/Cpx	D Amp/Cpx
Ba	26700	25	24
Th	0.18	230	1.6
U	0.23	1770	1.2
Pb	11	87	1.7
Sr	4.4	50	0.7
Ce	0.5	2140	0.3
Nd	0.1	730	0.7
Sm	0.1	140	1.2
Y	0.13	63	4.5

calculate $D^{\text{Phe/Cpx}}$, $D^{\text{Amp/Cpx}}$ and $D^{\text{Zoi/Cpx}}$ for the elements of interest (Table 1).

Prograde metamorphism in subducting slabs

From the data presented here it becomes clear that phengite and zoisite can make a strong imprint in the slab component of island arc magmas. Fluid-mobile elements can be partially retained and/or fractionated from each other in the downgoing slab according to the presence or absence of these important accessory phases. As an illustration, the experimentally determined upper pressure limit of phengite (Schmidt, 1996) implies that significant amounts of Ba, Rb and Cs may be subducted to depths of 300 km. Zoisite breaks down at intermediate pressures (3.0 to 4.0 GPa) depending on bulk rock composition (Poli and Schmidt, 1998), so the slab signature for Th, U, Pb and Sr can be expected to change with depth.

A combination of $D^{\text{Phe/Cpx}}$, $D^{\text{Amp/Cpx}}$ and $D^{\text{Zoi/Cpx}}$ from this study and $D^{\text{Cpx/F}}$ data from Brenan *et al.* (1995) and Stalder *et al.* (1998) are used to model fluid compositions resulting from dehydration reactions in a downgoing oceanic crust. It has to be stressed that caution is needed to extrapolate from a more diopsidic composition in Brenan *et al.*'s

experiments to omphacites which are more likely to be stable in subducting oceanic crust. Correction factors can be calculated if regular trends in $D^{\text{Cpx/Grt}}$ from eclogites with varying jadeite content and constant garnet composition (e.g. Harte and Kirkley, 1997 and own data) are compared with magmatic partitioning data which have diopsidic clinopyroxene but the same garnet composition. Results of the modelling of dehydration reactions in subducting slabs are compared with systematic variations observed in across-arc studies.

References

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