Does fluid-induced eclogitization of slab crust generate arc signatures?

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A suite of co-genetic gabbros and eclogites from central Zambia has been used to investigate fluid-induced transformation processes and associated trace element mobilization. These rocks are relics of subducted lower oceanic crust and gradual stages of the prograde gabbro-to-eclogite transformation are preserved by disequilibrium textures of incomplete reactions. No evidence for prograde blueschist- or amphibolite-facies mineral assemblages was found in the eclogites. Instead, fine-grained intergrowths of eclogite-facies minerals replacing plagioclase indicate the direct eclogitization of gabbroic precursors. Eclogitization occurred at 630-690°C and 2.6-2.8GPa and was accompanied by a channelized fluid flow which lead to vein formation. The aqueous fluids had variable salinities, ranging up to brine compositions. Based on textural and geochemical evidence, we hypothesize that these mafic rocks were subducted as a coherent slab, but gabbros were only eclogitized if they were infiltrated by fluid under eclogite-facies conditions. Hence, the eclogites and their veins represent relict fluid pathways through subducted oceanic crust, providing direct evidence of channelized fluid flow within a slab. The gabbros and eclogites have MORB-like trace element patterns and initial Nd and Hf isotope compositions. In some eclogites, however, the LREE have been strongly fractionated from the HFSE and HREE, an effect that cannot be of magmatic origin but must have occurred during metamorphism. Eclogitization was limited by fluid availability, and the fluid flow through the rock is the most likely mechanism for LREE fractionation. Model fluid-rock ratios suggest that the rocks depleted most in LREE reacted with an amount of fluid equal to 20-80% of their mass. The lower gabbroic part of the oceanic crust is an unlikely source for such a large volume of fluid and thus we hypothesize that the fluid originated in the underlying serpentinised lithospheric mantle. If, after triggering eclogitization, the resulting LREE-rich, HFSE+HREE-poor slab fluid reaches the zone of partial melting in the mantle wedge, it may contribute significantly to the arc signature. We will evaluate whether the trace element mobilization during fluid-induced eclogitization could be generally responsible for producing the slab component in arc magmas.

Sr-Nd-Pb isotopic systematics of basaltic oceanic crust subducted into the subarc mantle

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Numerous geochemical models have been proposed to estimate the integrated trace element and isotopic compositions of a hypothetical slab-derived 'component' in arc and OIB lavas. However, contributions from individual sources are difficult to assess from lava compositions alone, because element fractionations during slab dehydration and mass fluxes from the various subducted 'lithologies' are poorly constrained. Therefore, an understanding of trace element and isotopic compositions of individual rock types subducted into the subarc mantle is indispensable for constraining the geochemical models for subduction-zone material recycling.

In this paper, we focus on eclogite xenoliths from the Colorado Plateau, interpreted as representing fragments of the subducted Farallon plate, in order to infer Sr, Nd and Pb isotopic compositions of oceanic crust subducted into the subarc mantle. Based on the mass balance calculations and mineralogical observations, the whole-rock chemistry of the xenoliths was contaminated by near-surface processes after eruption and limited interaction with the serpentinized ultramafic microbreccia host magma. Thus, Sr, Nd and Pb isotopic compositions of separated minerals from the xenoliths were measured to avoid these secondary effects; these separates yield distinctively enriched isotopic compositions in the range of 0.70502 to 0.70590 for $^{87}Sr/^{86}Sr$, -1.5 to -3.1 for εNd and 18.928 to 19.052 for $^{206}Pb/^{204}Pb$. This suggests that the xenoliths were metasomatized by a fluid equilibrated with the sedimentary layer probably covering the Farallon plate in the forearc region. This metasomatism resulted in the xenoliths acquiring distinctively enriched isotopic compositions compared with those of altered MORB.

Some of the distinct isotopic signatures observed in OIBs and arc lavas compared to those from MORBs have been interpreted as a result of oceanic sediment subducted deep into the mantle. Our results, on the contrary, suggest an alternative possibility that these anomalous isotopic reservoirs in the mantle are formed by the subduction of oceanic crust modified by the metamorphic fluid from the covering sedimentary rocks.