Geochemical transfer from the subducting crust to the mantle

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The geochemical signature of subducted crust has been identified not only in oceanic arc basalts and continental arc andesites but also in oceanic island basalts (OIB). However, the nature of crustal components in the mantle sources of mafic volcanics still remains to be resolved. The lithochemical composition of oceanic basalts requires that subducted crustal rocks themselves are not directly incorporated into the mantle sources. Instead, they underwent metamorphic dehydration and partial melting at different depths, producing metasomatic agents that dominate the budget of fluid/melt-mobile incompatible elements and their pertinent radiogenic isotopes in the mantle sources. In contrast, the depleted MORB mantle dominates the budget of major elements in the mantle sources. As such, the composition of metasomatic agents is a key to the nature of mantle sources. This is primarily dictated by the stability of such accessory minerals such rutile and garnet in subduction-zone fluids. During subduction of an oceanic slab beneath another oceanic plate, aqueous solutions are produced at subarc depths in the stability field of rutile and garnet, acquiring the trace element signatures that are enriched in LILE and LREE but depleted in HFSE and HREE. The aqueous solutions metasomatize the overlying mantle wedge peridotite, generating the ultramafic mantle source regions for oceanic arc basalts. If the oceanic slab is subducted beneath a continental margin, more terrigenous sediments undergo partial melting at subarc depths, producing hydrous felsic melts that not only contain the arc-like trace element signatures but also are relatively enriched in radiogenic isotope signatures. The hydrous melts metasomatize the overlying mantle wedge peridotite to generate the less ultramafic mantle source regions for continental arc andesites. As soon as the oceanic slab is subducted to postarc depths, partial melting of the subducting oceanic crust becomes prominent with the dissolution of rutile, producing less hydrous felsic melts with the trace element signatures that are enriched not only in LILE and LREE but also in HFSE. Such melts metasomatize the mantle peridotite to generate the ultramafic mantle source regions for oceanic island basalts. Therefore, the nature of metasomatic agents at the slab-mantle interface is substantial to the mass transfer in oceanic subduction channels. This unified mechanism can account for the occurrence of both arc- and OIB-like basalts above oceanic subduction zones.