

Trace element records of hydration and dehydration reactions in ultramafic rocks

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Water locked up in ocean floor serpentinites may be dragged down to depths of over 100 km in subduction zones providing the mantle wedge with an important fluid source. Serpentinites are therefore essential to our understanding of ocean-to-subduction zone transport of H₂O and trace elements. Present-day ocean floor serpentinites (DSDP/ODP) and their partially dehydrated high pressure equivalents (Erro Tobbio Unit, NW Italy) record the most important reactions and associated chemical changes in serpentinites from T < 300°C at P < 0.1 GPa to T ~500°C at ~2-2.5 GPa. Serpentine (srp) is the major host of elevated bulk rock B, Cl, Sr and Rb. Although mineralogically the same (mostly lizardite, lz), srp formed after orthopyroxene (opx) contains 2-3 times more B, Sr and Rb than srp formed after olivine (ol), due to different T of reaction and fluid chemistry. This chemical difference vanishes with progressive hydration on the ocean floor. Breakdown of ocean floor lz and chrysotile (ctl) upon subduction to form antigorite (atg) causes only minor dehydration, yet it leads to the loss of almost all Cl (735-9800 µg/g of ocean floor lz/ctl to below 869 µg/g in new atg). More than half of the B (12-87 µg/g), Sr (0.5-4 µg/g) and Rb (0.02-0.34 µg/g) hosted in reactant lz/ctl is also lost. Rapid ol + atg growth in wall rocks and veins, associated with further dehydration, fractionates B from Sr (B/Sr > 20 in rock) and liberates a fluid with B/Sr < 3. Interestingly, this fluid might be saline, as suggested by fluid inclusions in peak metamorphic veins.

We suggest that progressive hydration and subsequent dehydration of ocean-floor serpentinites is primarily influenced by disequilibrium processes (e.g., kinetically delayed reactions and/or veining). Although significant amounts of Cl are released through dehydration at shallow levels in subduction zones, the chemistry of fluids associated with higher grade atg + ol assemblages can be saline due to HP fluid rock reactions.

Experimental constraints on the phase relations in axial magma chambers under ocean ridges

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Most of the ocean crust covering 2/3 of the surface of our planet is issued from axial magma chambers (AMC) under the ocean ridges. At fast-spreading ridges, AMC's reside at the transition between gabbros and sheeted dikes which is commonly at a depth of 1 - 2 km below seafloor. Seismic, structural, and petrological studies revealed that this horizon is not static, but moves up and down within a range of several hundred meters during time scales which are only poorly constrained ranging from 50 years to 20,000 years. During upward moving, the AMC must burn through previously hydrothermalized dikes causing stoping and contamination. Due to the dehydration of altered dikes, liberated water may enter the MORB magmas. Since the water solubility for silicate melts at 50 MPa (corresponding to a thickness of ~ 1 km dike/lava rocks plus 2-3 km water column) is low (1-2 wt%), high water activities, even water saturation, can easily be achieved in the AMC, at least at a local scale. This situation is completely different compared to deeper seated magma chambers in other geotectonic settings where water-saturation is reached only seldom, due to the much higher water solubility at higher pressure.

To understand the magmatic processes ongoing in the top of AMCs, we present here new phase diagrams for hydrous MORB systems at a pressure of 50 MPa, by extrapolating results of phase equilibria experiments in hydrous systems performed at shallow pressures in primitive to evolved tholeiitic, MORB-type systems. We applied our new phase diagrams to natural rocks from the sheeted dike/gabbro transition from the EPR crust (IODP site 1256D) and from the Oman ophiolite, opening interesting perspectives to explain specific aspects of petrogenesis of these rocks: (1) effects of hydrous partial melting, (2) stability of orthopyroxene, (3) relative crystallization order of plagioclase and clinopyroxene which is relevant for the formation of wehrlites in the ocean crust.