

Serpentinite phase relations as a monitor of hydrogen production

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The distribution of iron among secondary minerals plays a key role in controlling hydrogen production during serpentinization. We examined the compositions and phase relations of oxides, sulfides, metals, alloys, silicates, and hydroxides in altered harzburgites and dunites from ODP Leg 209 to gain new insights into Fe partitioning. Thermodynamic modeling was used to investigate the influence of phase relations and Fe distribution on hydrogen production.

The samples reveal systematic trends in alteration patterns. Incipient alteration of olivine (Mg# 91) forms mesh-rims with a distinct zoning from pure brucite (Mg# 81) at the interface with olivine followed by a zone of serpentine +brucite±magnetite and finally serpentine and magnetite in the outermost mesh rims. The composition of the serpentine (Mg# 95) and brucite remain constant throughout, while the brucite abundance decreases and magnetite abundance increases from center to rim. In paragrular veins terminating the mesh texture, serpentine is even more magnesian (Mg# 97) while magnetite abundance is increased. Ni is also extremely depleted in serpentine veins (<0.03 wt.% as opposed to 0.5 wt.% Ni in the brucite halos around olivine). These relations indicate that Fe and Ni in the outer mesh rims and paragrular veins are accumulated in oxides and sulfides. Examining these relations by thermodynamic modeling suggests isothermal serpentinization (T=150-200°C) at low water-to-rock ratios as indicated by apparently steep small-scale gradients in aqueous silica activities.

Phase relations of the Fe-Ni-O-S phases along the mesh rims provide a record of the larger-scale fluid evolution. Pentlandite+awaruite+magnetite and pentlandite+heazlewoodite+magnetite assemblages indicate uniform highly reducing conditions during serpentinization. Pyrite, millerite, polydymite and violarite are found only where talc alteration is superimposed. Reaction path modeling reveals that phase assemblages in fully serpentinized and talceous rocks cannot be explained by a simple internally buffered peridotite-seawater reaction sequence. This indicates increased f_{O_2} and f_{S_2} , possibly developing in interactions with gabbroic lithologies that are common at the sites of talc alteration. Likewise, fluids and rocks from active high-temperature vent sites also reflect interactions of seawater-derived fluids with heterogeneous basement, including gabbroic rocks.

Origins of diamond forming fluids – Constraints from a coupled Sr-Nd-Pb isotope and trace element approach

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Micro-inclusions in diamonds provide pristine information on the composition of the mantle fluids that form fibrous diamonds. While variations in the elemental composition of diamond fluids reflect mineral precipitation and fluid immiscibility their isotopic composition reflects the fluid source. We present the first ever Nd and Pb isotopic data for diamond fluids together with Sr and trace element data for a suite of diamonds from Botswana. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (TIMS) range between 0.70565 and 0.71817. ϵ_{Nd} varies between -20.8 and -27.3. $^{207}\text{Pb}/^{204}\text{Pb}$ varies between 15.61 and 15.67 and $^{206}\text{Pb}/^{204}\text{Pb}$ varies between 17.87 and 18.26. $\delta^{13}\text{C}$ is typical of fibrous diamonds (-5.5 to -7.1‰). REE patterns are steep and exhibit negative Ti_{pm} , Zr_{pm} - Hf_{pm} and Sr_{pm} and positive Th_{pm} and Pb_{pm} anomalies. Both Sr and Nd isotope ratios correlate positively with trace element contents. Clear hyperbolic trends between Sr isotope composition and element concentrations imply source mixing between 2 isotopically distinct components 1) an oxidizing fluid with highly radiogenic Sr that experienced long-term evolution within an incompatible element enriched environment; 2) a more reducing component with less radiogenic Sr, similar to the convecting mantle MORB/OIB source. This signature is different than that of carbon isotopes, which are similar to convecting mantle. We suggest that fibrous diamond precipitation was triggered by mixing of 2 fluids close to the CCO buffer enabling coexistence of carbonate and diamond. The diamonds Sr and Nd isotopic characteristics are similar to those of subcalcic garnets and glimmerites. Glimmerites could provide a source region for diamond-fluids, while the diamond forming fluids dominate the geochemical signature of subcalcic garnets.