Physical properties of rock-fluid systems and the structure of the subduction zone

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Equilibrium distributions of H2O fluid in mantle rocks have been determined at high pressure and temperature, and are used to estimate P- and S-wave velocities (Vp and Vs, respectively) in the olivine-pyroxene-H2O system. Importantly, velocities calculated for the peridotite-H2O system successively reproduce the absolute Vp and Vs values measured in the laboratory for dehydrated serpentinite. Therefore, known equilibrium distributions of H2O-CO2 fluid in peridotite-liquid systems allow one to estimate elastic properties of fluid-bearing mantle rocks from mineral and liquid elasticity data.

We estimate effects of H2O fluid on seismic velocities in crustal and mantle rocks from the elasticity data of rocks, minerals and H2O, by taking equilibrium fluid distributions into account. We compute Vp and Vs as a function of pressure, temperature and H2O content. These numerical results are compared with seismic velocity structures of the subduction zone, and temperature and fluid distribution in the mantle wedge are investigated. Extremely-low velocities with low Vp/Vs observed in the upper crust indicate the presence of H2O fluid. On the other hand, low velocities with high Vp/Vs observed in the upper mantle suggest high temperature and partial melting.