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Potential link between antigorite dehydration and shallow intermediate-depth earthquakes in hot subduction zones

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ABSTRACT

The distribution of earthquakes at intermediate depths corresponding to pressures <2 GPa in several hot subduction zones (such as Cascadia and southwestern Japan) coincides with the breakdown of antigorite to forsterite and talc; thus, this reaction may have triggered these earthquakes. However, previous studies have overlooked the potential significance of this reaction. Here, we performed a series of time-dependent dehydration experiments on antigorite at a pressure of 200 MPa and a temperature range of 500–650 °C. The results show that dehydration is controlled by a heterogeneous nucleation and growth mechanism and has an activation energy of 354 ± 24 kJ/mol. The formation of fine-grained forsterite and large talc crystals is consistent with kinetic results indicating Avrami exponents n = ~1.4–1.1 and ~2.7, respectively. Fluid production rates at 600 and 650 °C are 2.54×10^{-6} and 4.69×10^{-5} $m^3_{fluid}m^{-3}_{rock}s^{-1}$, respectively, which are much faster than those of mantle deformation, causing high fluid pressure in hot subducting mantle but not necessarily embrittlement. We emphasize the role of kinetic mechanisms in controlling the grain sizes of reaction products, which likely determine the mechanical behavior of serpentinized fault zones. Superplasticity or velocity weakening of fine-grained forsterite and velocity weakening of antigorite by water and/or talc may be responsible for earthquake nucleation and propagation in a heterogeneous system, which can be either dehydration products within a serpentinized fault zone or the mixture of antigorite fault and surrounding peridotite in hot subduction zones (<2 GPa).

Keywords: Antigorite, talc, forsterite, kinetic mechanism, subduction zone, shallow intermediate-depth earthquakes