

## Subduction of hydrated lithosphere: 300 ppm H<sub>2</sub>O in subducting olivine would eliminate the metastable olivine wedge

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In subducting slabs, where temperatures may be low enough to inhibit equilibrium transformation of olivine, the persistence of metastable olivine into the earth's transition zone would reduce subduction rates and possibly result in deep focus earthquakes through transformational faulting. Several studies have used experimental transformation kinetic data to model the depth range of metastable olivine persistence under subduction zone conditions (Kirby *et al.* 1996; Mosenfelder *et al.* 2001, Marton *et al.* 1999, 2005). H<sub>2</sub>O in olivine has been shown to enhance growth rates in the olivine-wadsleyite and olivine-ringwoodite phase transformations (Kubo *et al.* 1998, 2004) Recent modeling of the depth range of metastable olivine persistence has included a power law dependence of water concentration (Hosoya, 2005). Here we present new experimental results on the transformation of hydrous San Carlos olivine (300 wt-ppm H<sub>2</sub>O) to ringwoodite at 18 GPa. Our experiments show that 300 ppm H<sub>2</sub>O greatly enhances ringwoodite growth rates, resulting in an activation enthalpy of 186 kJ/mole. Even at temperatures as low as 700 °C, we obtain measurable growth rates, implying that rapid ringwoodite growth at temperatures corresponding to the interiors of cold subducting slabs. Combining our kinetic data with thermal modeling of subduction zones shows that even for very old and fast subduction zones, 300 ppm H<sub>2</sub>O would eliminate the metastable olivine wedge. Alternatively, if deep-focus earthquakes are triggered by olivine-transformational faulting in cold subducting slabs, then the olivine in such slabs cannot be significantly hydrated.

### References

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## Chlorine isotope distribution on Earth

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With our ability to analyze <sup>37</sup>Cl/<sup>35</sup>Cl ratios ( $\delta^{37}\text{Cl}$  values) of small amounts of solid materials, it is now possible to use chlorine isotope geochemistry of low Cl-concentration solids as a tracer of fluid movement in the subduction process. Cl is a hydrophilic ion that should faithfully track aqueous fluids throughout the crust and mantle. The  $\delta^{37}\text{Cl}$  values of primitive carbonaceous chondrites, pristine MORB glasses and samples of sub-continental mantle origin are all close to 0‰, equal to average crustal values (Sharp *et al.*, Nature '07). Notable variations do exist, however. Primitive sodalite inclusions from Allende (CV chondrite) average -1.3(±0.6)‰, and MORB glass from 12°N, EPR have  $\delta^{37}\text{Cl}$  values of -1.0‰. The sodalite may represent a separate nebular Cl reservoir or have low  $\delta^{37}\text{Cl}$  due to an equilibrium isotopic fractionation. The 12°N, EPR data may represent mantle heterogeneity, as is seen in other geochemical systems. The overall homogeneous  $\delta^{37}\text{Cl}$  value of 0‰ for Earth means that even small deviations from this value require a distinct source or fractionation process to explain the non-zero values.

Chlorine isotope fractionation between phases is generally very small, and cannot change the  $\delta^{37}\text{Cl}$  of a system by more than ~0.5‰. Two mechanisms which cause appreciable fractionation have been identified. The first is vaporization of NaCl, where liquid-vapor fractionation at 800°C is ~0.7‰. While not large, fractionation in a Rayleigh distillation process in the solar nebula could easily exceed 2‰, even at high T, if 90% of a sample is vaporized. Far more remarkable is the fractionation between hydrochloric acid and vapor, where fractionations in excess of 8‰ are observed in simple boiling experiments. This fractionation process explains extremely variable  $\delta^{37}\text{Cl}$  values (covering a range of 16‰) found in high temperature, acidic volcanic fumaroles in Central America (Barnes *et al.*, this meeting). Excepting these unusual fractionation processes, chlorine isotope ratios should maintain fidelity throughout subduction and return in arcs. Non-fractionated samples from Central America and the Izu Bonin arcs have values clustering around -2‰, presumably recording the value of their source.

### References

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