Elusive Fourth Polymorph of Olivine

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Olivine [$(Mg,Fe)_2SiO_4$] has a stoichiometry of three cations to four oxygens. The three well-known polymorphs, olivine, wadsleyite, and ringwoodite, are the dominant mineral phases in the upper mantle and transition zone. Olivine is dominant in the upper mantle, 0 – 410km, wadsleyite in the upper transition zone 410 – 525 km, and ringwoodite in the lower transition zone at 525 – 660 km. There are sharp velocity discontinuities at 410 (olivine – wadsleyite) and 660 km (ringwoodite – bridgmanite), but no prominent discontinuity at 525 corresponding to wadsleyite – ringwoodite. There is, however a fourth polymorph, known as wadsleyite II, that has been seen in a few experiments at pressures near the wadsleyite – ringwoodite transition that might account for the lack of a sharp discontinuity at 525 km.

Wadsleyite II is a spinelloid and like wadsleyite and ringwoodite is based on a cubic-close-packed array of oxygen atoms. Its *a* and *c* crystallographic axes are similar to wadsleyite but has a very long *b*-axis (~29Å) and has only been identified in experiments that have been equilibrated for more than 20 h. Like wadsleyite and ringwoodite, it can incorporate more than two weight percent water. The structure contains both Si_2O_7 groups as well as isolated SiO_4 tetrahedra, and its density and physical properties are intermediate between wadsleyite and ringwoodite. When it occurs, in long-duration runs, it is very well-ordered with few if any stacking faults so it is likely to be a stable phase. Although anhydrous samples have been synthesized as spinelloid IV in the nickel aluminate system, the Fo_{90} silicate composition has only been seen in long-duration experiments in the hydrous peridotite system.