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Metastable postspinel and post-garnet transitions in pyrolite: an implication for multiple seismic discontinuities

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Postspinel and post-garnet transformation experiments were carried out at pressures between 22 and 27 GPa at a temperature of 1873 K using synthesized polycrystalline sample with pyrolite comoposition which consists of ringwoodite and majorite garnet. We observed that three discontinuous transitions occur in the ringwoodite + majorite garnet polycrystalline sample: (1) disproportionation of MgSiO3-rich perovskite (MPv) with small amount of alumina and CaSiO3-rich perovskite from majorite garnet at about 22 GPa; (2) postspoinel transition producing alumina-free MPv and magnesiowustite at about 23 GPa; (3) transition of alumina-rich majorite into alumia-rich MPv that should be accompanied by formation of an aluminous phase at 27 GPa. The presence of the observed transitions in three steps in metastable pyrolite is very different from the equilibrium transitions studied in previous studies: postspinel transition is sharp and postgarnet transition proceeds gradually in a binary loop in MgSiO3-Mg3Al2Si3O12 system. The equilibrium transition can explain features of 1D earth models such as PREM: the sudden increase of velocities at 660 km depth corresponds to the postspinel tranisition and the increase of the velocities with steeper gradient between 660 and 720 km to gradual transition of majorite garnet. The results of the present study suggest that the metastable transformations in pyrolite explain the regionally observed splitting of 660 km discontinuity, especially beneath subduction zones: the postspinel transition causes the discontinuity near 660 km depth (which can be deeper than 660 km depth because of low temperature of subducting slab); the shallower and deeper discontinuities might be caused by the metastable transformations of majorite garent.

Keywords: metastable transformation, pyolite, multiple seismic discontinuities, 660 km detph