



The 410-km discontinuity: water fractionation in wadsleyite and consequences on the olivine-wadsleyite phase boundary in the Earth upper mantle

F. Deon (1), M. Koch-Müller (1), D. Rhede (1), and S.M. Thomas (2)

(1) GFZ, Deutsches GeoForschungsZentrum, Section 3.3 Chemistry and Physics of Earth Materials, Potsdam, Germany, fdeon@gfz-potsdam.de, Tel: +49-331-2881887 Fax: +49-331-2881402, (2) Department of Earth and Planetary Science, Northwestern University, Evanston, Illinois, U.S.A.

Wadsleyite (wad), the high P polymorph of olivine (ol), belongs to the category of the Nominally Anhydrous Minerals (NAMs), which may incorporate water as hydroxyl via point defects. It is widely discussed that the presence of water in the Transition Zone (TZ) of the Earth upper mantle could imply changes in the depth of the 410-km discontinuity, e.g. of the ol-wad phase boundary (Chen et al. 2002; Frost and Dolejs 2007). Aim of this study is to see how the ol-wad phase boundary is shifted by the presence of water and what causes the shift. We have performed dry and water-saturated experiments using a rotating-rocking multi-anvil press both in the pure MgO-SiO₂-H₂O system, at 13-14 GPa and 1200 °C and, to better simulate the Earth interior conditions, also in the (MgO,FeO)-SiO₂-H₂O system at 12-13 GPa and 1200 °C. Raman spectroscopy combined with the method developed by Thomas S.M et al. (2008) was used to quantify the water content in pure Mg-wad synthesized at 13.3 GPa and 1200 °C as 0.90 (±0.1) wt.% (value confirmed by SIMS); for pure Mg-ol synthesized at 13.2 GPa and 1200 °C SIMS measurements gave a result of 0.2 (±0.1) wt.%. We observed a shift of 0.7 GPa toward lower pressures of the ol-wad transformation, which is most likely induced by the stronger fractionation of water in wad rather in ol. This value is in good agreement with the shift previously determined by Frost and Dolejs (2007) indicating that the 410-km discontinuity would be shallower in a wet mantle. By adding Fe to the starting materials of the experiments performed in the dry system at 12.4 GPa-1200 °C, we could obtain coexisting ol and wad in good agreement with the dry phase boundaries proposed by Agee (1998). On the other hand experiments performed with water at the same conditions resulted in coexisting ol-wad-ringwoodite (ring), thus the triple point occurs at higher P. The shift of the ol-wad-ring phase boundary is consistent with the results of Kawamoto (2004) in the system Mg₂SiO₄. Beside the shift we observe a broadening of the ol-wad and wad-ring coexisting regions in the presence of water. Using SIMS we were able to quantify water in coexisting Fe-bearing ol, wad and ring: the highest water content was measured for wad as 1.0 ±(0.1) wt.%, than for ring as 0.4 ± (0.05) wt.% and finally for ol as 0.27 ± (0.01) wt.%.

References: Agee CB (1998) Reviews in Mineralogy, Vol 37 Chen J, Inoue T, Yurimoto H, Weidner DJ (2002) Geophys Res Lett 29: 1875, DOI: 10.1029/2001GL014429 Frost DJ and Dolejs D (2007) Earth and Planet Sci Lett 256: 182-195 Kawamoto T (2004) Physics of the Earth and Planetary Interiors 143-144, 387-395 Thomas SM, Thomas R, Davidson P, Reichart P, Koch-Müller M, Dollinger G (2008) Am Min 93: 1550-1557