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Effect of Al on stability of DHMS up to the uppermost lower mantle

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Abstract

A series of dense hydrous magnesium silicate phases (DHMS) such as phase A (PhA), phase E (PhE), superhydrous phase B (SUB) and phase D (PhD) have been suggested as potential water carriers to transition zone and even to the lower mantle under the conditions present in the cold subducting slabs [e.g. Kawamoto, 2004; Komabayashi and Omori, 2006]. Recently, the newly reported Al-bearing PhD is stable at temperatures up to 2,000^{o}C at 26 GPa, which indicates aluminum increases stability regions of DHMS [e.g. Pamato et al., 2015]. To systematically study the effect of Al on the stability of hydrous phases, we conducted experiments using nature clinochlore, which contains about 15 wt% H_2O and about 14 wt% Al_2O_3. The Al-bearing hydrous PhE, SUB and PhD were observed with P-T increasing according to our results. Following the P-T path of cold subduction, the phase assemblage PhE + PhD is stable at 14-23 GPa, and even a trace of PhE is detected at 1150^{o}C and 25 GPa coexisting with PhD. The phase SUB is stable between 16-22 GPa coexisting with PhE + PhD. Following the P-T path of hot subduction, the phase assemblage PhE + Gt is observed at 14-18 GPa coexisting with fluid or melt. The phase assemblage SUB + PhD is stable at 18-25 GPa, which may extend to higher pressures and temperatures. In addition, it is found that PhE contains 8.5-15 wt% Al_2O_3, SUB contains 3-8.5 wt% Al_2O_3 and PhD contains 8-18 wt% Al_2O_3 in present studies. It is obvious that Al enhances the stabilities of these three hydrous minerals, which are stable even in the hot subducting conditions, and the water content drastically increases estimated from deficit of total weight percent. On the other hand, the Al substitution mechanism in PhE, SUB and PhD were clarified according to chemical compositional relationship between Mg, Si, Al. This shows that they can hold a significant amount of H (water) in their structure. Our results may indicate that the wide stabilities of Al-bearing DHMS increase the chance of obtaining water after antigorite (serpentine) decomposes at the shallow region of the subduction zone and transporting water to the deep lower mantle. The stability of chemical mixture Fe-free clinochlore and Al-bearing PhD are also reported.

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