

Stability relations of an aluminous phase in the uppermost lower mantle.

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Inclusions within diamonds from Sao Luiz, Brazil (Harte & Harris, 1994), indicate a mineral assemblage: fPer+MgSiPvk+CaSiPvk, where fPer refers to ferropericlase, MgSiPvk is magnesium-silicate perovskite, and CaSiPvk is calcium-silicate perovskite. This assemblage is believed to form the dominant mineralogy of peridotite or pyrolite rock compositions in the lower mantle (below the 660 km deep discontinuity). In the same diamonds as the above there are also occasional inclusions with compositions $(\text{Mg,Fe})_3\text{Al}_2\text{Si}_3\text{O}_{12}$ corresponding to pyrope-almandine garnet, but which have been shown to have a tetragonal structure markedly distinct to garnet (Harris et al., submitted, Nature) and this new phase is here referred to as TAPP (tetragonal almandine-pyrope phase). A phase corresponding structurally to TAPP has not been reported in high-pressure experimental studies, despite careful consideration of the relative importance of majoritic garnet (mGrt), alumina-bearing MgSiPvk, or new experimental phases as the location of Al in the uppermost part of the lower mantle (e.g. Irifune et al., 1996 and references therein). This abstract considers the possible location of a stability field for TAPP, which involves relatively little readjustment of lower mantle phase relations elicited by experimental work.

Much experimental work indicates that at relatively low pressures within the lower mantle, significant amounts of Al_2O_3 become soluble in MgSiPvk and the assemblage MgSiPvk+corundum(Crn) also becomes stable, thus restricting the stability of phases having garnet, majoritic garnet, or TAPP compositions to the shallowest depths in the lower mantle. A possible version of the stability relationships for the join MgSiPvk- Al_2O_3 in the system MgO-SiO₂- Al_2O_3 is shown in Fig. 1. The solid lines are based largely on the experimental work for 1500 °C presented by Irifune et al. (1996); with the exception that fields of stability of TAPP and MgSiPvk+TAPP have been inserted between the fields of stability of mGrt and MgSiPvk+Crn. TAPP has the composition of pyrope garnet ($\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$) and shows no majoritic solid solution. Some displacement, probably to higher pressure, of the field boundaries of Fig. 1 will occur with some partial substitution of Fe for Mg.

The solid lines of Fig.1 fit the general assemblage information from the Sao Luiz inclusions, but there is one case where MgSiPvk and TAPP inclusions are in actual contact and the MgSiPvk contains 2.7 wt % Al_2O_3 and a calculated 1.8 mol % of trivalent cations. This is substantially less than the amount of Al_2O_3 solid solution in MgSiPvk shown by the solid lines in Fig. 1, which are based on experimental data. If the compositions of the natural inclusions reflect true high pressure equilibrium, then the dashed field boundaries of Fig. 1 become more appropriate. Even with the dashed boundaries, all the Al_2O_3 of a pyrolite-peridotite composition may be accommodated in MgSiPvk at depths greater than about 26GPa.. TAPP would be a more widespread phase in basic than ultrabasic compositions, and may help to make basic compositions relatively bouyant compared with ultrabasic ones.

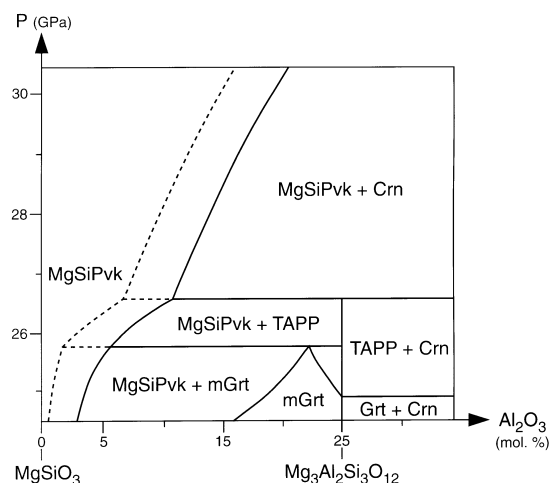


Fig.1. Possible phase relations of TAPP in MgO-SiO₂- Al_2O_3 system, partly based on Irifune et al. (1996).

References:

- Harte, B. & Harris, J.W. 1994. Mineral. Mag., 58A, 384-385.
 Irifune, T., Koizumi, T., & Ando, J. 1996. Phys. Earth Planet Int., 96, 147-157.