Implication of post-perovskite production on oceanic crust recycling in Earth's D" layer

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The aim of this experiment was to measure the effect of Al and Fe on post-perovskite phase thermoelastic properties and perovskite / post-perovskite phase transition boundary. We have previously obtained precise measurements on the pure end-member $MgSiO_3$ (see HS-2863 report), which can be used as a good approximation in a Earth's mantle type composition. But the oceanic crust materials are far richer in Fe and Al than the environning mantle. This leads to the production of extremely Fe and Al-rich (Al,Fe)-$MgSiO_3$ perovskite and post-perovskite phases. It is now clear that Al has a significant effect on the perovskite phase EoS. It is very likely to observe such an effect in the case of the post-perovskite phase. Besides, Fe^{3+} should be easily stabilised in the post-perovskite structure since Fe_2O_3 has also the post-perovskite structure at high pressure and high temperature.

We used a glass with (Al,Fe)-$MgSiO_3$ composition as starting material. Au was mixed with it to be used as an internal pressure gauge. The sample was then loaded in a 30 microns hole drilled in a Re gasket. NaCl was used as a pressure transmitting medium and thermal insulator. We used ID27 double sided YAG laser heating facilities to heat the sample up to 2500 K from 0.8 to 1.2 megabar.

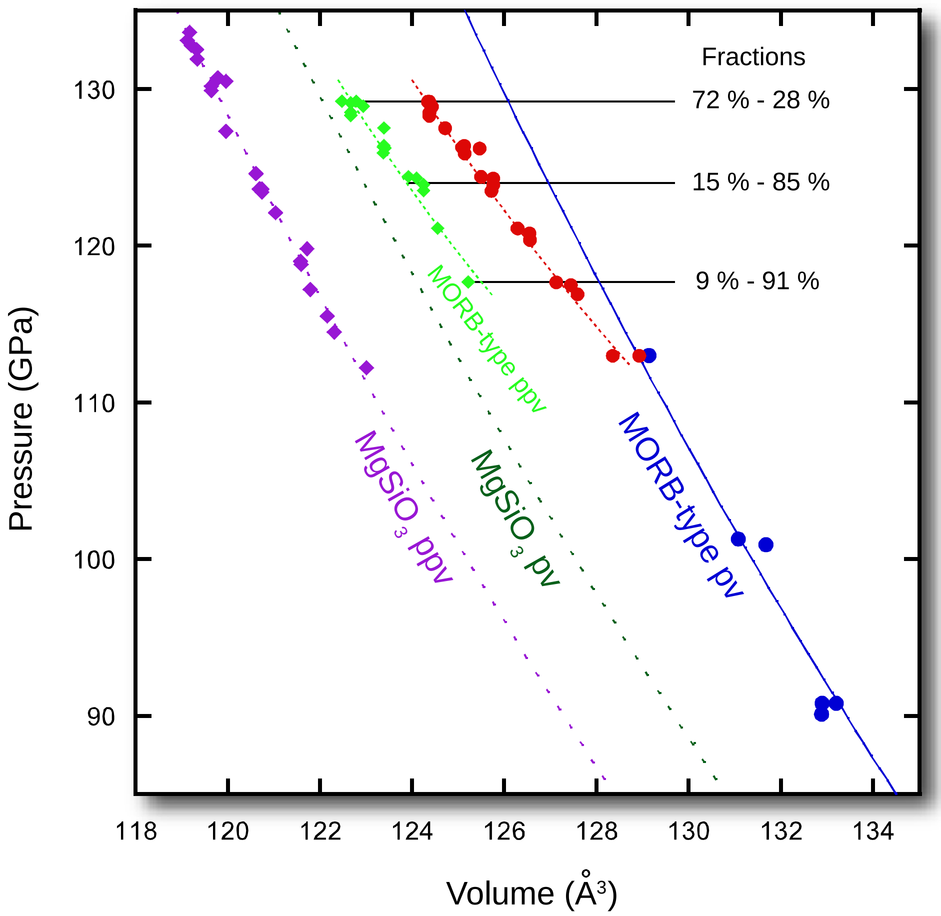

Figure 1. Compression of MORB-type and pure $MgSiO_3$ perovskite and post-perovskite phases at 300 K. The sudden change in volume observed in the MORB-type compounds can be explained by a continuous change of their chemistries while their respective fractions evolve.

Figure 1 displays the obtained dataset, with pressure as function of the unit-cell volume of perovskite and post-perovskite phases. $MgSiO_3$ compounds are traced as references. The Al-

Fe rich perovskite (MORB-type pv) is logically bigger in volume that its $MgSiO_3$ counterpart. However, when Al,Fe rich post-perovskite (MORB-type ppv) starts to be produced, an important decrease of unit cell volumes of both phases is observed. This decrease is much to important to be explained only by the compression factor and indicates a change of chemistry of each phase. At the same time, a very slow production of the post-perovskite phase with only 9 % produced at 118 GPa and 72 % at 128 GPa is observed, suggesting a broad phase transition in contrast with the very sharp transition in the case of pure $MgSiO_3$.

These observations are to be related to ab initio calculations showing that incorporation of Al in the post-perovskite structure tends to produce a phase loop instead of a sharp phase transition (Figure 2). The consequence for the oceanic crust is a slow transformation compared to the environning mantle that could slow down its advance down to core-mantle boundary. The upcoming paper based on this experiment will provide details on that subject, as well as thermoelastic properties of these compounds based on high tempertature data.

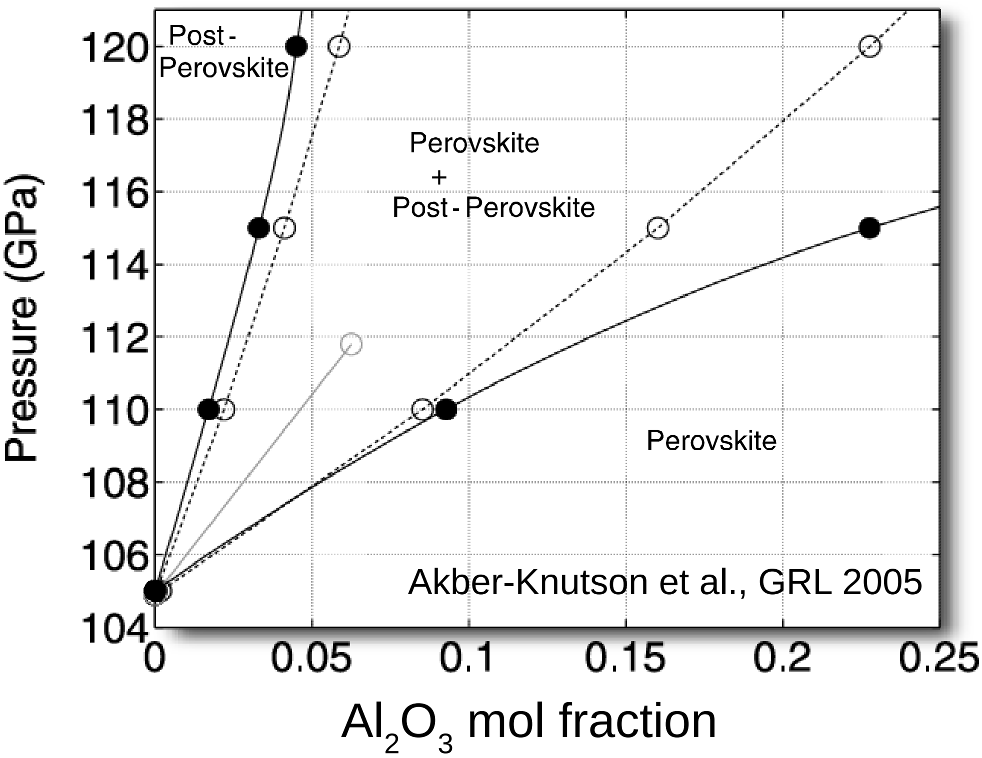

Figure 2. Phase loop due to Al_2O_3 incorporation in perovskite and post-perovskite phases deduced from ab-initio calculations (Akber-Knutson et al., 2005).