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Is the X-discontinuity really related to the presence of eclogite bodies in the mantle?

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A local seismic feature observed at $\sim$300 km depth is referred to as the X-discontinuity (X-disc, e.g. Revenaugh & Jordan 1991). Several petrological explanations have been proposed for this discontinuity, but Pushcharovsky & Pushcharovsky (2012) attribute it to the formation of stishovite in eclogitic bodies, based upon the suggestion of Williams & Revenaugh (2005). If this link between the X-disc and the presence of eclogite is valid, it could have important geodynamic implications. In their model, stishovite appears in the eclogitic assemblage either through the transformation of previously existing free coesite or by exsolution of "excess" SiO_2 from Ca-Eskola-bearing clinopyroxene ($Ca_{0.50.5}Si_2O_6$). Essential to this model is if the amount of free SiO_2 is enough to produce the observed seismic impedance contrast or not. To test whether exsolution of stishovite from Ca-Eskola-bearing clinopyroxene is a feasible mechanism, we have undertaken high-pressure experiments to determine the maximum Ca-Eskola component that can be incorporated in clinopyroxene over a range of P-T conditions, both shallower and deeper than that corresponding to the position of the X-disc.

One series of experiments were performed in the simplified CaO-MgO-Al_2O_3-$SiO_2$$\pm$$Na_2O$ system and one with 3 "natural" analog eclogite compositions (K_2O-Na_2O-CaO-MgO-FeO-Al_2O_3-SiO_2). For the CMAS-experiments, all samples have the typical eclogitic assemblage of clinopyroxene + garnet $\pm$ SiO_2 $\pm$ kyanite. With increasing pressure, the amount of garnet increases at the expense of clinopyroxene. Maximizing the Ca-Eskola content of clinopyroxene requires coexistence with a free SiO_2 phase and an elevated Al_2O_3 content, but not necessarily the presence of kyanite. Ca-Eskola contents of $\sim$20 mol % are obtained at 4 GPa, but decrease steadily with increasing pressure so that $\leq$ 4 mol % is present at pressures corresponding to the depth of the X-disc. Experiments in natural analog eclogite compositions produced even less Ca-Eskola component in clinopyroxene. Thus no sharp change in Ca-Eskola content occurs as a function of pressure and at depths corresponding to the X-discontinuity exsolution of all Ca-Eskola component will yield only $<$ 1 wt% free SiO_2. This amount is insufficient to produce a large enough impedance contrast to explain the X-disc.

If the X-disc is related to the appearance of stishovite in eclogite as proposed by Williams & Revenaugh (2005), then free SiO_2 must be already present in the mineral assemblage. However, our preliminary results suggest that in an unmodified MORB-type eclogite only minor amounts of free SiO_2 will be present. Greater amounts of free SiO_2 can only be reached in eclogite residues after melt extraction at high pressures of $\sim$5 GPa, where as residues from melting at lower pressures (i.e. 2.5 GPa) do not produce any free SiO_2. Therefore, if at all, only subducted oceanic crust that first experienced melting at high pressures can contain enough free SiO_2 to produce the observed impedance contrast of the X-disc as it transforms to stishovite.

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