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Can subducted eclogite be the petrologic explanation for the X-discontinuity?

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The X-discontinuity (X-disc) is a seismic feature observed at some locations around 300-350 km depth (e.g. Revenaugh & Jordan 1991; Deuss 2009). A number of petrologic explanations have been proposed for this discontinuity, but most recently Pushcharovsky & Pushcharovsky (2012) consider it to be due to the formation of stishovite in eclogitic bodies, based upon the suggestion of Williams & Revenaugh (2005). This explanation considers that stishovite will appear in an eclogitic assemblage either through the transformation of previously existing free coesite or by exsolution of "excess" SiO_2 from Ca-Eskola-bearing clinopyroxene ($Ca_{0.5}AlSi_2O_6$). An essential aspect to this model is whether enough free SiO_2 would be present to produce the observed seismic impedance contrast or not. Our previous experimental study (Knapp et al. 2013) indicated that the exsolution of stishovite from Ca-Eskola-bearing clinopyroxene is probably not a feasible mechanism. Here we report the results of further experiments to investigate if the amount of free SiO_2 in eclogite could be adequate to explain the X-disc.

A series of experiments was performed with 3 "natural" analog eclogite compositions in the K_2O-Na_2O-CaO-MgO-FeO-Al_2O_3-SiO_2 system over a range of pressures from 4 to 10 GPa at 1000-1200°C. The compositions were chosen to simulate i) altered MORB with no melting (cold subduction), ii) eclogite after shallow melting at 2.5 GPa (slow, flat subduction) and iii) eclogite after deep melting at 5 GPa (fast, deep subduction). All experiments produced the typical eclogitic assemblage of clinopyroxene + garnet ± SiO_2. Compositions of clinopyroxene confirm that changes in the Ca-eskola content cannot play a role in producing the X-disc. In fact the Ca-eskola contents are very small ($<$ 4 mol %). As expected, the amount of free SiO_2 depends on initial bulk composition. The shallow melting residue (comp. ii) produced no free SiO_2 at 4 or 6 GPa. The deep melting residue (comp. iii) produced $<$ 4 wt % coesite at 6 and 8 GPa with no jump in amount at 10 GPa where stishovite is stable. These amounts are too small to produce the impedance contrast observed for the X-disc ($\geq$ 5 wt % SiO_2, Williams & Revenaugh 2005). The unmelted altered MORB (comp. i) yielded 6-7 wt % free SiO_2 in the mineral assemblage, even at 10 GPa. Thus, only subducted oceanic crust that never underwent any partial melting (cold subduction) would contain enough free SiO_2 to explain the X-disc as it transforms to stishovite at depths of about 300 km.

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