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The oxidation state of the Earth's mantle and the X-discontinuity

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A low-magnitude seismic discontinuity, named X-discontinuity, is located at a depth of 260-330 km. A typical amplitude of $\sim 2\%$ in shear- and compressional-wave velocities ascertain its existence. It is widespread but restricted in extension locally. It seems that the discontinuity does not correlate with any tectonic feature, as it appears below continents, ocean basins and in subduction zones [1] . The variability in depth and geological conditions indicate that the X-discontinuity may be caused through several processes [2], or that the effects of other processes or structures (e.g. the Lehman discontinuity) suffice to blur the discontinuity so that its seismic signal is no longer as clearly defined [3]. Possible causes may be the formation of a hydrous and compact magnesium silicate (phase A) the phase transition of the orthorhombic crystal structure of orthopyroxene to monoclinic, or the transformation of coesite to stishovite in eclogite. None of these theories is able to explain the X-discontinuity quantitatively, whereas the interaction of different causes with each other would suffice as an explanation of the change in the wave velocity.

In the present approach the question was addressed experimentally whether a disproportion of Fe^{2+} to Fe^{3+} or another mechanism of oxidation can, together with an increase of the modal garnet assemblage, cause the X-discontinuity, or if this theory can be excluded as an explanation.

For this purpose, several high-pressure experiments have been carried out with the Multi-Anvil-Press in the range of 6 – 14 GPa and a constant temperature of 1300 °C in the simplified CMAS + Fe system (with a model eclogitic composition). The run products were analysed by EPMA and the Fe^{3+} content was determined by the flank method [4].

The results so far allow an interpretation that from 10 GPa onwards, trivalent iron is increasingly incorporated in excess of what is expected from lower pressure trends. The generation of increasing andradite also causes a modal increase of garnet leading to an overall increased density. However, this effect is probably also too small to cause the X-discontinuity.

[1] Williams & Revenaugh (2005) Geology, **33**, 1-4

[2] Bagley und Revenaugh (2008) JGR, **113**, B12301

[3] Woodland (1998) GRL, **25**, 1241-1244

[4] Höfer & Brey, 2007 Am. Min. **92**, 873-885