Velocity softening in natural orthopyroxene at high pressures and temperature: Implications for velocity anomalies in cold subducted slabs

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Abstract

Orthopyroxene ($(Mg,Fe)SiO_3$) is considered to be the second most abundant mineral in the top upper mantle of the Earth. Several polymorphs of $MgSiO_3$ (eg. OEn(Pbca), LPCEn($P2_1/c$), HPCEn($C2/c$), HPCEn2($P2_1/c$), etc.) have been found to be stable under high pressure and temperature conditions relevant to various tectonic settings of the upper mantle. Previous acoustic experiments on OEn $MgSiO_3$ indicated that both Vp and Vs of OEn undergo continuous softening above 10 GPa at room temperature, which has been attributed to the phase transition from OEn to the metastable phase HPCEn2. To date, no experimental studies of acoustic velocities of orthopyroxene at simultaneous high temperatures and pressures have been reported.

In this study, we measured the compressional and shear wave velocities of natural orthopyroxene up to 13.5 GPa and 873K by using ultrasonic interferometry in conjunction with synchrotron X-ray diffraction. The polycrystalline specimen used in the current experiment was hot-pressed at 5 GPa and 1000°C for 1 hour in a 1000-ton uniaxial split-cylinder apparatus (USCA-1000) in the High Pressure Laboratory at Stony Brook University using natural pyroxene powder as starting material. For the first time, our results suggest that pressure induced velocity softening can occur not only at room temperature as previously observed, but also at high temperature conditions relevant to the Earth's subducting zones. Implications for possible seismic anomalies in cold subducted slabs will be discussed.