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Compressibility of two Na-rich clinopyroxenes: A synchrotron single-crystal X-ray diffraction study

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Abstract

Synchrotron-based high-pressure single-crystal X-ray diffraction experiments were conducted on synthetic clinopyroxenes at room temperature to a maximum pressure of 40 GPa. We studied two crystals with different compositions. A Na-Ti-pyroxene with formula $(Na_{0.86}Mg_{0.14})(Mg_{0.57}Ti_{0.43})Si_2O_6$ synthesized at $P = 7$ GPa and $T = 1700$ °C, and a Na-pyroxene with composition $(Na_{0.886}Mg_{0.085}Fe_{0.029})(Si_{0.442}Mg_{0.390}Fe_{0.168})Si_2O_6$ synthesized at $P = 15$ GPa and $T = 1500$ °C. These phases were found to be monoclinic with the space group $C2/c$ and exhibit K_{T0} of 106.8(2), 121.8(4) GPa, respectively. Na-Ti-pyroxene is more compressible than Fe-bearing Na-Mg-Si-pyroxene, likely due to the fact that the FeO_6 octahedron is significantly more rigid than MgO_6 at high pressure. The formation of Na-rich pyroxenes in the deep mantle is related to crystallization of low-degree alkaline carbonate-silicate melts formed when the crust and mantle interact during the slab descent and its stagnation in the transition zone.

Keywords: Pyroxene, single-crystal X-ray diffraction, high-pressure, high-temperature, phase transitions, equation of state, Earth's mantle