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Elasticity of Orthopyroxene at High Pressure and Temperature: Insights into the Metasomatism of mantle wedge by siliceous melts

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Large amounts of silica held by slabs during subduction prefer to concentrate into the eclogite melts and further lead to the metasomatism of the overlying mantle wedge. However, the process of the metasomatism in mantle wedge by siliceous melts remains poorly constrained. Peridotite in the mantle wedge is sufficiently silica undersaturated. Therefore, SiO_2-rich melts would react with olivine in the peridotite to form orthopyroxene (opx). The local enrichment of opx has also been proposed to account for the observed low V_P/V_S ratio in the mantle wedges of a few subduction zones, revealing the metasomatism by silica saturated melts there. But the anomalously low V_P/V_S regions in a few subduction zones are inconsistent with the widespread metasomatism of the mantle wedge. In this study, we determined the elastic properties of Fe-bearing opx $(Mg_{0.875}Fe_{0.125})SiO_3$ at high pressure and temperature conditions. The V_P/V_S ratio of opx has a strong dependence on the pressure and temperature (P-T) conditions, and only exhibits low V_P/V_S at low pressure and high temperature. Although the enrichment of opx may be widespread, it can only produce a discernible low V_P/V_S ratio at subduction zones with proper thermal conditions. Together with the elasticities of other major minerals in the upper mantle, we investigated the effect of opx enrichment on the V_P/V_S ratio at mantle wedge conditions. The V_P/V_S ratio linearly decreases with the opx volume fraction (Ω), and the relationship can be described as V_P/V_S = 1.772 - 0.142Ω at 2 GPa and 1500 K, providing a simple way to access the enrichment degree of opx. Combined with seismic and geodynamic studies, we also constrained the mineral proportions of a mantle wedge in Alaska. The opx proportion maximal at the mantle wedge center suggests that the siliceous melts generated from the slab prefer to ascend and remain relatively isolated until they mix in the shallow hotter core of the mantle wedge.