

Contrasting bonding behavior of two hydroxyl-bearing metamorphic minerals under pressure: Clinozoisite and topaz

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ABSTRACT

Clinozoisite and topaz are examined to pressures of 36 and 24 GPa, respectively, at 300 K using infrared spectroscopy. Both minerals metastably persist throughout this pressure range at ambient temperature. Both stretching and bending vibrations of the silicate tetrahedra are tracked upon compression and decompression of each phase, as are their hydroxyl-stretching vibrations. The hydroxyl-stretching vibrations lie at 3650 cm^{-1} in topaz and 3351 cm^{-1} in clinozoisite and shift by $0.6 (\pm 0.3)\text{ cm}^{-1}/\text{GPa}$ and $-5.1 (\pm 0.9)\text{ cm}^{-1}/\text{GPa}$, respectively. Therefore, the hydrogen bonding in clinozoisite and topaz responds completely differently to pressure: hydrogen bonding increases in clinozoisite, but decreases in topaz. The clinozoisite hydroxyl-stretching vibration also broadens by almost a factor of six under compression. Both the clinozoisite peak shift and its pressure-induced broadening are simulated using a model of the hydrogen bond potential. The markedly different structural responses of these two minerals to pressure are interpreted on crystal-chemical grounds, and demonstrate that the bonding of hydrogen in possible subduction-related hydrous phases varies dramatically, depending on crystal chemistry.