

The high-pressure behavior of micas: Vibrational spectra of muscovite, biotite, and phlogopite to 30 GPa

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ABSTRACT

The infrared spectra of natural samples of muscovite, biotite, and phlogopite are characterized to pressures of ~30 GPa, as is the Raman spectrum of muscovite to ~8 GPa. Both far-infrared and mid-infrared data are collected for muscovite, and mid-infrared data for biotite and phlogopite. The response of the hydroxyl vibrations to compression differs markedly between the dioctahedral and trioctahedral micas: the hydrogen bonding in dioctahedral environments increases with pressure, as manifested by shifts to lower frequency of the hydroxyl-stretching vibrations, whereas cation-hydrogen repulsion likely produces shifts to higher frequency of the hydroxyl vibrations within trioctahedral environments. An abrupt decrease in frequency and increase in band width of the hydroxyl-stretching vibration in muscovite is observed at pressures above ~18–20 GPa, implying that the previously documented pressure-induced disordering is associated with the local environment and shifts in location of the hydroxyl unit in this material. The far-infrared vibrations of muscovite indicate that its compressional mechanism changes above 5–8 GPa, as the K-O stretching vibration with a zero-pressure frequency near 112 cm⁻¹ shifts in its pressure dependence from 6.9 cm⁻¹/GPa below this pressure range to 0.78 cm⁻¹/GPa above it. Thus, it appears that the magnitude of interlayer compression is decreased above this pressure, and hence that the compression of muscovite may become less strongly anisotropic. The mid-infrared bands that are primarily produced by vibrations of the tetrahedral layer broaden under pressure in both muscovite and biotite: within biotite, a spectral region that may be associated with higher coordination of tetrahedral cations increases in amplitude above about 25 GPa. The corresponding bands in phlogopite undergo less broadening, and their behavior is fully reversible on decompression.

Keywords: Muscovite, biotite, phlogopite, micas, pressure, amorphization, hydrogen bonding