Compressibility and high pressure structure refinement of tremolite, pargasite and glaucophane

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Abstract: Compressibility measurements and high pressure structure refinements were performed on tremolite, glaucophane and pargasite at pressures up to 41 kbar. The diffraction data were collected with a four-circle diffractometer equipped with a Merrill-Bassett diamond anvil cell.

The cell volume reduction is almost constant for the three amphiboles, with bulk moduli increasing slightly from tremolite ($K = 850$ kbar) to glaucophane ($K = 960$ kbar) and pargasite ($K = 970$ kbar). All three specimens show anisotropic compressibility, with $\beta_a = 5.9$ in tremolite, 5.3 in glaucophane, 4.6 in pargasite (kbar$^{-1} \times 10^4$); $\beta_b = 2.7, 2.4$ and 2.8, and $\beta_c = 2.6, 2.3$ and 2.4, respectively, for the three specimens.

The most evident structural effect is the reduction of bowing of the tetrahedral double-chain, which assumes a flatter configuration. This effect is greatest for glaucophane, followed by tremolite and pargasite. Opposite movements have been reported for tremolite on heating. Minor variations in the dimensions of the I-beam occur along [001], that is the extension direction of the tetrahedral chain, and along [010] across the M4 sites. The tetrahedral double-chain shows an increase in ditrigonal character with increasing pressure.

The A-polyhedron is the softest, followed by M4 and by M1-M2-M3. The M-polyhedra show the most prominent compositional effects ; the M2-octahedron is the hardest polyhedron in glaucophane, where it is occupied by trivalent cations, but it is the softest in tremolite and pargasite. The values of polyhedral bulk moduli are in the order: $K_{M2} > K_{M1} > K_{M3} > K_{M4}$ in glaucophane and $K_{M3} > K_{M1} > K_{M4} > K_{M2}$ in tremolite and pargasite.

The geometrical results, obtained through compressibility measurements and high pressure crystal structure refinements on tremolite, glaucophane and pargasite, basically show similar pressure behaviours in the different calcalkaline amphiboles, with only minor compositional effects. The compressibility and elastic anisotropy of amphibole is intermediate between that of mica and pyroxene, as expected by considering amphibole as intermediate between the close-packed pyroxene and layer-silicate structures.

Key-words: amphibole, compressibility, structure, high pressure.

Introduction

Amphiboles are important rock-forming minerals, common in metamorphic as well as igneous rocks (e.g., Robinson et al., 1982; Wones et al., 1982). Due to flexible structural behaviour, amphiboles show wide compositional variability (e.g. Hawthorne, 1981), and may form under a broad range of P, T conditions in sedimentary, metamorphic and igneous environments, both in the crust and in the upper mantle (e.g. Lambert and Wyllie, 1968; Green and Wallace, 1988). Abundant experimental work on these minerals (e.g. Graham et al., 1989) has focused on different aspects of crystal chemistry and phase relations. Specific areas of investigation are systematic crystal structure refinement (Ungaretti et al., 1987), spectro-