

## Synthetic $P2_1/m$ amphiboles in the system $\text{Li}_2\text{O-Na}_2\text{O-MgO-SiO}_2\text{-H}_2\text{O}$ (LNMSH)

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### ABSTRACT

We describe here the synthesis of amphiboles along the nominal  $\text{Na}(\text{NaMg})\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2\text{-Na}(\text{LiMg})\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$  join, at 800 °C, 0.4 GPa. High amphibole yields (>90%) plus minor quartz and enstatite have been obtained at all compositions; amphibole crystals are acicular and their size rarely exceeds  $20\text{--}30 \times 0.5\text{--}3 \mu\text{m}$ . TEM analysis shows the presence of  $h+k$  odd reflections in all samples, indicative of a  $P$ -lattice. By similarity with closely related amphiboles from the literature (e.g., Oberti et al. 2000; Cámara et al. 2003) a  $P2_1/m$  space group was assigned to the amphiboles synthesized here. Refined cell-parameters from X-ray powder-patterns show a linear decrease as a function of increasing Li at M4,  $a$  and  $\beta$  being the most affected parameters. The four infrared OH-stretching spectra all show two main bands at  $3741\text{--}3748$  and  $3712\text{--}3716 \text{ cm}^{-1}$ , respectively. They are assigned to two independent O-H groups in the  $P2_1/m$  structure, interacting with a strongly delocalized  $^A\text{Na}$ . The spectra show in addition two minor absorptions at about  $3688$  and  $3667 \text{ cm}^{-1}$ , respectively; these bands are assigned to vacant A-sites in the structure and indicate slight departure of the nominal composition toward cumingtonite. The present work shows that one apfu of  $^B\text{Na}$  can also be completely replaced by one apfu of  $^B\text{Li}$  ( $M^+$ ), in synthetic  $\text{Na}(M^+\text{Mg})\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ , and that all compositions have  $P2_1/m$  symmetry at ambient conditions.

**Keywords:** amphibole synthesis, FTIR spectroscopy, TEM, XRPD, amphibole symmetry