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Atomic-scale observations of franckeite surface morphology

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ABSTRACT

Franckeite, approximately $Pb_{4.6}Ag_{0.2}Sn_{2.5}Fe_{0.8}Sb_2S_{12.6}$, consists of alternating pseudohexagonal (H) and pseudotetragonal (Q) layers. Scanning tunneling microscopy (STM) and atomic force microscopy (AFM) of freshly cleaved franckeite, from San José, Bolivia, revealed the atomic structure of the pseudohexagonal component. On AFM images, the expected pattern with b = 3.2 Å was observed. STM revealed a $\sqrt{3} \times \sqrt{3}$ superstructure, with b' = 6.3 Å, interpreted to be caused by tunneling effects. The pseudotetragonal layer was not identified in any images.

Layer modulation, which results from the non-commensurate fit of the alternating H and Q layers, was observed with both AFM and STM. Modulation waves are sinusoidal and regular and they are always parallel. The calibrated modulation wavelengths averaged to 3.77, 4.10, 4.45, and 4.74 nm (with uncertainty ≤0.10 nm) corresponding to pseudotetragonal/pseudohexagonal (Q/H) matches of 13/12, 14/13, 15/14, and 16/15, respectively. These correspond with observations made using bulk analytical methods on individual members from the franckeite-cylindrite family but scanning probe microscopy (SPM) was able to show that Q/H match varies on a local scale, with sharp domain boundaries. Domains can be on the order of 150 nm in width.