Microstructures, Mixed Layering, and Polymorphism of Chlorite and Retrograde Berthierine in the Kidd Creek Massive Sulfide Deposit, Ontario[1]

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Abstract: Transmission electron microscopy (TEM) was utilized to determine the origins of berthierine and chlorite in the core of the footwall alteration zone of the Kidd Creek massive sulfide deposit, Ontario. TEM images show lamellar intergrowths of packets of berthierine, mixed-layer chlorite/berthierine, Fe-Mg chlorite, and relatively Fe-rich chlorite that contain dislocations, stacking faults, kink bands, and gliding along (001). Interstratification of packets of berthierine and chlorite with one to several tens of layers commonly is associated with terminations of a layer of chlorite by two layers of berthierine. Layers in adjacent domains of berthierine and chlorite are continuous across interfaces that transect their common {001} planes. High-strain zones that cut across cleavage planes, consisting of distorted layers and lens-shaped pores, are associated with stacking faults and gliding along cleavage planes in chlorite crystals. Similar features separate interstratified chlorite/berthierine of different structures and textures, implying development of such composite grains after deformation of chlorite. Electron diffraction patterns show that the chlorite is an ordered one- or two-layer polytype or a one-layer polytype with semi-random stacking, and that the berthierine is a one-layer polytype with semi-random stacking epitaxially intergrown with chlorite.

Coexisting chlorite and berthierine have nearly identical ranges of compositions, containing Si $\cong$ 5, Al $\cong$ 6, and Fe $\cong$ 6.5 $-$ 8.5 pfu, and minor, variable Mg and Mn contents, in formulae normalized on the basis of 20 total cations. This implies polymorphism among Fe,Al-rich members of the serpentine and chlorite groups. In one of the samples, berthierine and mixed-layer chlorite/berthierine coexist with chlorite having two compositional ranges, including Fe-rich chlorite with a relatively wide range of Fe-Mg contents, and a dominant Fe-Mg chlorite. In another sample, compositionally homogeneous Fe-rich chlorite is associated with berthierine and mixed-layer chlorite/berthierine; Fe-Mg chlorite was not detected.

The microstructural relations and the presence of coexisting polymorphs, complex mixed layering, heterogeneous polytypism, and wide ranges of mineral compositions are consistent with replacement of chlorite by berthierine under non-equilibrium retrograde conditions, in contrast to the generally assumed prograde origin for other berthierine occurrences.

Key Words: Berthierine • Chlorite • Massive sulfide deposit • Microstructures • Mixed layering • Polymorphism • Polytypism • Transmission electron microscopy

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