
Preservation of Clay Minerals in the Precambrian (1.1 Ga) Nonesuch Formation in the Vicinity of the White Pine Copper Mine, Michigan¹

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Abstract: The Middle Proterozoic (1.1 Ga) Nonesuch Formation, host of the stratiform copper deposit at White Pine, Michigan, consists of 200 m of principally dark grey clastic sediments which contain detritus obtained dominantly from underlying mafic to intermediate volcanic rocks. Clay minerals from samples collected from the mine area and drill holes up to 100 km away have been studied using SEM, EMPA, TEM and AEM. Two morphologies of phyllosilicates, both including white mica and chlorite, occur in the 'lower' Nonesuch Formation: (1) detrital-shaped and (2) matrix. Detrital-shaped phyllosilicate grains are up to 450 microns long with long axes parallel to bedding. Matrix phyllosilicates occur as packets typically <200 Å thick and as pore-filling cement.

TEM images of detrital-shaped chlorite generally display 14-Å periodicity, although 24-Å corrensite-like units occur locally. Most detrital-shaped chlorite from the mine area samples have a relatively restricted range of Fe/(Mg+Fe) ratios from 0.52 to 0.58, but the Fe/(Fe+Mg) ratios of detrital-shaped chlorite outside the mine area range from 0.27 to 0.64. TiO₂ crystals occur within and surrounding the detrital-shaped chlorite. Matrix chlorite has Fe/(Fe+Mg) ratios of 0.47 to 0.63, indicating that it is relatively homogeneous and enriched in Fe compared to detrital-shaped chlorite.

Detrital-shaped white mica occurs as a 2M₁ polytype and generally has a phengitic composition. Matrix illite-rich I/S occurs as a 1M_d polytype, is K and Al deficient relative to end-member muscovite and contains significant Fe and Mg.

The data are consistent with homogenization of detrital-shaped chlorite in the White Pine mine area by hydrothermal fluids during copper mineralization. The TiO₂ crystals and corrensite-like units in detrital-shaped chlorite imply that it is at least in part derived from alteration of biotite. The presence of immature 1M_d illite-rich I/S and a one layer chlorite polytype with stacking disorder suggests that the matrix clays are in their original, post-smectite state of formation as consistent with an authigenic origin during early burial diagenesis; i.e., they have not undergone subsequent transformation even though sedimentation and ore deposition occurred prior to 1 Ga.

Key Words: Chlorite • Diagenesis • Illite • Mixed-layer illite/smectite • Nonesuch Formation • White mica

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