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Formation of Chrysocolla and Secondary Copper Phosphates in the Highly Weathered Supergene Zones of Some Australian Deposits

MARTIN J. CRANE, JAMES L. SHARPE AND PETER A. WILLIAMS

School of Science, University of Western Sydney,
Locked Bag 1797, Penrith South DC NSW 1797, Australia
p.williams@uws.edu.au (corresponding author)

ABSTRACT. Intense weathering of copper orebodies in New South Wales and Queensland, Australia has produced an unusual suite of secondary copper minerals comprising chrysocolla, azurite, malachite and the phosphates libethenite and pseudomalachite. The phosphates persist in outcrop and show a marked zoning with libethenite confined to near-surface areas. Abundant chrysocolla is also found in these environments, but never replaces the two secondary phosphates or azurite. This leads to unusual assemblages of secondary copper minerals, that can, however, be explained by equilibrium models. Data from the literature are used to develop a comprehensive geochemical model that describes for the first time the origin and geochemical setting of this style of economically important mineralization.

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Recent exploitation of oxide copper resources in Australia has enabled us to examine supergene mineral distributions in several orebodies that have been subjected to intense weathering. These include deposits at Girilambone (Gilligan & Byrnes, 1994) and Goonumbla or Northparkes in NSW (Heithersay *et al*., 1990; Crane *et al*., 1998) and several smaller deposits in the Mt. Isa Block in northwest Queensland (Ball, 1908; Day & Beyer, 1995; Carter *et al*., 1961). Consequences of the intense weathering of these deposits include the mobilization of silica and subsequent formation of considerable quantities of chrysocolla and secondary silica in the oxidized zones. Furthermore, all of these deposits are characterized by an abundance of the secondary copper phosphates libethenite and pseudomalachite associated with smaller amounts of cornetite and turquoise.

Although the secondary mineral distributions in these deposits vary, a number of recurring paragenetic relationships are evident. The copper carbonates malachite and azurite are seldom replaced by chrysocolla, nor are the secondary copper phosphates. Chrysocolla and/or secondary silica frequently envelop copper carbonates and phosphates, the more stable phases in such environments. Characteristic zoning of the phosphate minerals has also been noted, with