Economic Geology, v. 101, pp. 1437–1444

GENESIS OF NATIVE COPPER LODES IN THE KEWEENAW DISTRICT, NORTHERN MICHIGAN: A HYBRID EVOLVED METEORIC AND METAMOPHOGENIC MODEL

ALEX C. BROWN[†]

Department of Civil, Geological and Mining Engineering, École Polytechnique de Montréal
P.O. Box 6079, Sta. Centre-Ville, Montreal, Quebec, Canada H3C 3A7

Abstract

The Keweenaw Peninsula of northern Michigan is well known for early diagenetic sulfide-dominant sediment-hosted stratiform copper mineralization hosted mainly by basal siltstone-shale units of the Nonesuch Formation in the White Pine district, and later native copper lodes hosted mainly by flow-top breccias and amygdaloidal portions of flood basalts and interbedded conglomerates of the stratigraphically lower Portage Lake Volcanics. The native copper mineralization is generally attributed to downdip burial metamorphism of the host strata. An alternative model is proposed here, involving a complementary influx of evolved meteoric water (elevated in salinity and progressively equilibrating with its aquifers), similar to the fluid which formed the White Pine mineralization. This model has several advantages over the metamorphogenic model alone. It would provide the salinity (by dissolution of evaporites) and moderately oxidizing conditions (as a result of hematitization, i.e., reddening, of coarse continental rift sediments) necessary for copper transport, and the evolved meteoric water would have been an important cupriferous brine owing to the leaching of trace amounts of copper from the voluminous aquifers. Further reduction of the evolved fluid would also explain the updip deposition of native copper in association with dehematitized pumpellyite- and chlorite-dominant (i.e., reduced) hydrothermal mineral assemblages. At the same time, this influx of meteoric water from highlands adjacent to the Keweenaw rift basin would have provided a mechanism to move the deep-seated hot, dense ore brine upward along the aquifers of the Portage Lake Volcanics. On its ascent from deep portions of the rift basin, the gravity-driven evolved meteoric brine would have mixed with the fluid generated by burial metamorphism to form a hybrid evolved meteoric-metamorphogenic ore-forming hydrothermal brine.

[†] E-mail: acbrown@polymtl.ca

0361-0128/06/3629/1437-8