Deep, Paragenetically Early Mineralization at the Olympic Dam Cu-U-Au-Ag Deposit

Olga Apukhtina,[1*] Vadim Kamenetsky,[1] Kathy Ehrig,[2] Jocelyn McPhie,[1] Maya Kamenetsky,[1] Roland Maas,[3] Sebastien Meffre,[1] Qiuyue Huang,[1] Cristiana L. Ciobanu,[4] and Nigel J. Cook[4]

[1]School of Physical Sciences, University of Tasmania, Hobart, TAS 7001, Australia
[2]BHP Billiton Olympic Dam, Adelaide, SA 5001, Australia
[3]University of Melbourne, Melbourne, VIC 3010, Australia
[4]School of Chemical Engineering, University of Adelaide, Adelaide, SA 5005, Australia

*E-mail, olga.apukhtina@utas.edu.au

The supergiant Fe oxide Cu-U-Au-Ag Olympic Dam (OD) deposit occurs within the Olympic Dam Breccia Complex (ODBC) which is hosted by the ~1.6 Ga Roxby Downs Granite (RDG). The ODBC is characterized by multiple stages of brecciation and texturally destructive, weak to intense Fe-oxide, and sericite alteration. The earliest alteration and mineralization consists of a Fe^{+2}-rich assemblage of magnetite-siderite-chlorite-apatite-pyrite (± chalcopyrite)-quartz-uraninite, which is overprinted and replaced by hematite-sericite-fluorite-quartz-chalcopyrite-bornite-chalcocite. Deep diamond drilling through the hematite-rich parts and on the edges of the ODBC has expanded the known spatial extent of hydrothermal magnetite. This study documents well-preserved, weakly brecciated, paragenetically early alteration and mineralization exposed by the deepest drill hole in the OD deposit.

Diamond drill hole RD2773 (~1 km east of ODBC) ended at a depth of ~2,325 m (EOH) below the surface. The upper 370 m consists of flat lying, unaltered, and unmineralized late Neoproterozoic formations. Sericite (± hematite ± chlorite)-altered RDG occurs from ~370 to 2,325 m. Doleritic to basaltic Gairdner-type dikes (~820 Ma) intrude altered RDG from ~1,250 to 1,360 m. A volcanic (i.e., melt inclusion-bearing) quartz-phyric felsic unit was intruded by the RDG from ~2,010 to 2,265 m. The RDG is weakly brecciated below 2,265 m. A mixed zone of massive anhydrite and altered RDG occurs from ~2,035 to 2,040 m.

Chlorite-magnetite alteration in RDG and a zone of weak albitic alteration of orthoclase in RDG (~1,360 to 1,650 m) may be related to intrusion of mafic dikes at ~820 Ma. These observations support findings of others and suggest that intrusion of the ~820 Ma mafic dikes remobilized some metals within the deposit to a greater extent than previously believed.

Copper occurs sporadically as 0.1to 0.3% Cu concentration spikes (over 1 m assay intervals) from ~1500 to 2150 m, and continuously (0.1–0.7% Cu) from 2150 m to EOH. Mineralization (i.e., pyrite, magnetite, calcite and with lesser amounts of uraninite, fluorapatite, REE-fluorocarbonates, monazite, sphalerite, quartz, fluorite, barite, and pyrrhotite (inclusions in pyrite)) is coarse-grained and present as veins, infill in weakly brecciated RDG and the quartz-phyric felsic unit, and along the lower contact of the felsic unit and RDG. Early pyrite is replaced by chalcopyrite and hematite, uraninite by brannerite and coffinite, and magnetite by hematite. Veins carrying galena-sphalerite-chalcopyrite-hematite-monazite-REE fluorocarbonate assem-blages are common in pyrite.

U-Pb dating of uraninite (1590.5 ± 3.4 Ma) and fluorapatite (1583 ± 14 Ma) prove, firstly, that these minerals are cogenetic and, secondly, that paragenetically early mineralization was formed soon after emplacement of the RDG. Sm-Nd isotope data for calcite associated with the felsic unit are also consistent with a ~1.6 Ga origin. A 1554 ± 18 Ma U-Pb age of hematite replacing magnetite in this zone shows that oxidative alteration also occurred in the early stage of the deposit. These dates are in agreement with the Sm-Nd isochron age of hematite-REE-rich breccias (1572 ± 99 Ma) and ^{207}Pb-^{208}Pb ages on hematite (1590 ± 8, 1577 ± 5 Ma).