The Supergiant Olympic Dam Cu-U-Au-Ag Ore Deposit: Toward a New Genetic Model

Vadim S. Kamenetsky,[1,*] Kathy Ehrig,[2] Roland Maas,[3] Sebastien Meffre,[1] Maya Kamenetsky,[1] Jocelyn McPhie,[1] Olga Apukhtina,[1] Qiuyue Huang,[1] Jay Thompson,[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 5000, Australia
[3]School of Earth Sciences, University of Melbourne, Parkville, VIC 3010, Australia
[4]School of Chemical Engineering, University of Adelaide, Adelaide, SA 5000, Australia

*E-mail, Dima.Kamenetsky@utas.edu.au

All supergiant ore deposits pose major questions relating to the processes responsible for metal concentration and their duration. The supergiant Olympic Dam Cu-U-Au-Ag ore deposit is even more enigmatic because it is polymetallic, and the economic elements and iron are concentrated within a breccia complex hosted by undeformed, weakly altered granite. Although the age of the granite is well established at ca. 1590 Ma, the timing of metal addition and accumulation is uncertain, largely because the context and textures of the ore are variable and indicative of several genetic processes. In addition to high-precision U-Pb ages of uraninite spreading over 1 b.y.; here we show that different rocks and mineral assemblages record post-1590 Ma tectonic, magmatic, sedimentary, and hydrothermal events.

Zircon in clasts of quartz-rich sandstone in the hematite-rich breccia (RD2751, 855-914 m) belongs to three age populations (1612.9 ± 9.1, 1732.7 ± 5.5, 2485 ± 30 Ma) that correspond to those of detrital zircon in the ca. 1425 Ma Pandurra Formation (Cariewerloo Basin overlapping the Gawler LIP). The presence of Pandurra Formation in the breccia complex suggests brecciation and incorporation of sediments at <1425 Ma.

The Sm-Nd dates of step-leached ore samples are similar to published whole-rock data and define a ~1300 Ma apparent age, which is broadly supported by Rb-Sr isochrons for the same fractions. Sericite in ca. 1590 Ma basaltic dikes and picrite lavas at Olympic Dam has an age of 1128 ± 19 Ma (Rb-Sr). A similar age is suggested by Pb isotope systematics of authigenic pyrite in a mafic sandstone belonging to bedded sedimentary facies, and galena in the mineralized sample (RU27-7551, 303.5 m).

The Gairdner Dykes intruded the breccia complex at ca. 820 Ma, and are associated with coeval brecciation and circulation of syn- and postmagmatic fluids. The related hydrothermal alteration is characterized by redistribution of Fe, Cu, Pb, P, REE, etc., and precipitation of magnetite, apatite, titanite, pyrite, chalcopyrite, and galena.

The youngest ages (Ordovician, ca. 440–480 Ma) are recorded by (1) authigenic apatite (U-Pb dating) in the bedded sedimentary facies, including ironstones, (2) hydrothermal apatite and monazite (U-Pb dating) in the sulfide-bearing mineralization associated with basaltic dikes, and (3) fluorite (Sm-Nd dating) from extensive fluorite-barite-siderite veins crosscutting the breccia complex. Importantly, roughly Delamerian ages are reported for "massive" uraninite.

The described post-1590 Ma brecciation, alteration, and mineralization events coincided with tectonic and magmatic events that affected the Gawler craton margin in response to amalgamation and/or breakup of three supercontinents—Columbia (breakup 1.6–1.3 Ga), Rodinia (amalgamation 1.3–1.1, breakup 0.85–0.6 Ga), and Gondwana (amalgamation 0.6–0.3 Ga). We attribute the extraordinary metal accumulation at Olympic Dam to a favorable position at the craton's margin, where multiple events of metal addition and redistribution can be linked to supercontinent cycles. A possibility of post-1590 Ma uranium addition will be advocated based on $^{207}Pb/^{206}Pb$ of bulk rocks and sulfides.