Olympic Dam Fe Oxide Cu-U-Au-Ag Deposit: Discovery to Recovery

Kathy Ehrig,[1,]* Vadim S. Kamenetsky,[2] Maya Kamenetsky,[2] Nigel J. Cook,[3] Cristiana L. Ciobanu,[3] and Douglas Haynes[4]

[1]BHP Billiton Olympic Dam, Adelaide, SA 5001, Australia
[2]School of Physical Sciences, University of Tasmania, Hobart, TAS 7001, Australia
[3]School of Chemical Engineering, University of Adelaide, Adelaide, SA 5005, Australia
[4]Douglas Haynes Discovery Pty Ltd, Maleny, QLD 4552, Australia

*E-mail, kehrig@bigpond.net.au

Mineral deposits are localized, anomalous accumulations of potentially economic minerals in the Earth's crust. Minerals are spatially zoned across a deposit in response to evolving physicochemical conditions that caused their precipitation/accumulation. Deposit-scale mineral zonation is used as a targeting tool to discover new deposits and to discover extensions to existing resources in known mineral deposits. This zonation also results in variable quality ore, e.g., changing mineral abundances in metallurgical plant feed, as the deposit is progressively mined and processed. Understanding mineral dissolution, precipitation, and enrichment mechanisms, in addition to quantifying the distribution of minerals across the deposit, is fundamental to the effective exploitation of ore deposits from discovery through to recovery.

Completion of diamond drill hole RD1 marked the discovery of Olympic Dam by Western Mining Corporation geoscientists in July 1975. The exploration program was underpinned by the research of Haynes (1972), which demonstrated that alteration of continental tholeiitic basalts to an assemblage of albite-hematite-phyllosilicates-epidote-carbonates released copper, hosted mainly in magnetite, into oxidized fluids. Copper-bearing fluids then migrated up steeply dipping faults until encountering reduced sediments, leading to copper precipitation. Even though the conceptual exploration model was for a sediment-hosted Cu deposit, which differs significantly from the current genetic model for IOCG deposits, the "Basalt-Alteration Model" was an early example of the successful use of a mineralogy-based, holistic system (source-transport-trap) approach for generating exploration models.

Progressive Fe oxide addition to and sericite replacement of the primary host rocks (e.g., Roxby Downs Granite, bedded clastic facies, and mafic-ultramafic dikes) produced distinctive, albeit complex, hydrothermally altered and mineralized zones in the deposit. More than 90 ore and gangue minerals are present. These minerals can be grouped according to their spatial location in the deposit and/or impacts on the metal extraction process. From the periphery toward the deposit center and upward from depth, the most significant zones are as follows: (1) reduced Fe oxide (magnetite-apatite-siderite-chlorite-quartz) → oxidized Fe oxide (hematite-sericite-fluorite) → hematite-quartz-barite alteration, (2) pyrite → chalcopyrite → bornite → chalcocite → nonsulfide Cu and Au, and (3) base metal-poor (Mo-W-Sn-As-Sb) → base metal-rich (Cu-Pb-Zn) minerals → sulfide-barren breccias. Isolated remnants of advanced argillic alteration (sericite + quartz ± Al-OH minerals) affect metallurgical performance.

The qualitative to semiquantitative geologic and petrographic observations used to define the alteration/mineralization zones are transformed into quantitative mineral abundances via the resource model. Each of the ~20 million blocks in the resource model contain geostatistically estimated values of bulk dry density, magnetic susceptibility, litho/alteration type, 26 element concentrations, and 15 mineral abundances. Geometallurgical testing is used to develop quantitative relationships which express processing performance as a function of mineralogy, chemical composition, and/or density. Hence, processing performance can be evaluated on each resource block. The geometallurgically enabled resource model is used for in- and near-mine exploration to generate short-, medium-, and long-term mining/processing production plans and as inputs into expansion studies. Quantification of mineralogy across the deposit has significantly enhanced our understanding of the metallurgical properties, alteration characteristics, controls on mineralization, and architecture of the Olympic Dam deposit.