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Geochronology of the Sequence Hosting the Broken Hill Pb-Zn-Ag Orebody, Australia

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Abstract

Robust, stratigraphic control and constraints on the timing of events have been established for the Paleoproterozoic metasedimentary and metavolcanic succession that hosts the Broken Hill Pb-Zn-Ag orebody in western New South Wales. Geologically consistent depositional, intrusive, and metamorphic ages are elucidated by means of SHRIMP U-Pb analyses of zircon and integrated field studies. Comparisons of the new SHRIMP results with those of previous studies clarify some previously untenable age interpretations.

A range of zircon provenance ages is found in albitic metasedimentary rocks from one of the oldest recognized parts of the Willyama Supergroup (Thackaringa Group). The zircons indicate maximum depositional ages of 1720 to 1730 Ma, and a minimum stratigraphic age for the lower Thackaringa Group is constrained by the 1704 ± 3 Ma intrusive Alma Gneiss. The latter is the same age as gneissic granitoid rocks in the Redan zone (southern Broken Hill Domain: 1703 ± 3, 1705 ± 3 Ma). Felsic magmatism of this age has long been known in the contiguous Olary Domain (South Australia), but has not been recognized previously at Broken Hill.

Depositional ages in the Broken Hill Group, the upper part of which hosts the Pb-Zn-Ag orebody, indicate that the entire package was deposited within a period of ca. 10 m.y. An age of 1685 ± 3 Ma for felsic metavolcaniclastic rocks in the Hores Gneiss (spatially and stratigraphically associated with the ore horizon) corroborates previous work. This age is within error of that determined for the hanging-wall and footwall unit (Rasp Ridge Gneiss) of the orebody (1683 ± 3 Ma). It suggests that felsic magmatism in the Rasp Ridge Gneiss was coeval with that of the Hores Gneiss. Previous interpretations, which suggested that the Hores Gneiss is not a single stratigraphic entity but comprises younger intrusions having ages from 1690 to1640 Ma, are not supported by our data and conclusions. The stratigraphic integrity of the Broken Hill Group (excluding some mafic intrusions) is further supported by results from an older formation near its base, where tuffaceous metasedimentary rocks from the Ettlewood Calc-Silicate Member (Allendale Metasediments) define an age of 1693 ± 4 Ma. This is in good agreement with the age of 1693 ± 5 Ma for the immediately overlying Parnell Formation.

Provenance ages obtained from detrital zircons in Broken Hill Group psammites indicate a remarkable uniformity of Paleoproterozoic and late-Archean source(s). Generally matching provenance ages are found in the overlying Sundown Group psammopelites, suggesting a stable flux of sediment fill as the basin deepened and matured. Similar provenance is indicated for upper Paragon Group sedimentary rocks, and inherited zircons in most of the younger granitoids have age spectra similar to those of the detrital zircons. The perpetuation of these age patterns, in both clastic detritus and magmatic xenocrysts, thus broadly fingerprints exposed and buried older crustal elements that provided material to produce the Willyama Supergroup basin fill.

Tuffaceous metasiltstones in the middle Paragon Group (Bijerkerno Metasediments) are interpreted to have been derived partly from air-fall volcaniclastic material and give consistent depositional ages of 1655 ± 4 and 1657 ± 4 Ma in the northern Broken Hill and Euriowie blocks, respectively. Younger tuffaceous metasiltstones in the upper Paragon Group (Dalnit Bore Metasediments) provide a stratigraphically consistent, maximum depositional age of 1642 ± 5 Ma.

Zircon ages from granitoid intrusions that bracket the deformation events suggest that the D_2 and D_3 deformations are inseparable within the interval 1597 ± 3 to 1591 ± 5 Ma. Low Th/U zircon overgrowths are ubiquitous and, irrespective of stratigraphic position, record metamorphic ages of ~1600 Ma. Metamorphic rutile has the same age, confirming that high-grade metamorphic event(s) and D_2 and D_3 structural events were approximately synchronous. We find no isotopic support for any pre-1600 Ma, high-grade metamorphic events.

Using newly acquired local age control for the galena Pb isotope growth curve, the new data support a stratigraphic (syngenetic or diagenetic) model of primary ore formation for the Broken Hill orebody at ca. 1690 Ma, although the present distribution of the lodes likely reflects displacement as a result of later structural remobilization.

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