Basin-hosted mineral systems - linking Zn-Pb, Cu-Co and U metallogeny to basin evolution

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The Paleo- to Mesoproterozoic Carpentarian Zinc Belt of Australia is the world's premier Zn-Pb province, containing three of the world's five largest Zn-Pb deposits. The host North Australian basin system also contains U and Cu-Co deposits. Similar deposits occur in the partly overlying, and much larger, Neoproterozoic Centralian Superbasin. Not all basins of these ages are mineralised however, and parts of mineralised basins do not host significant deposits. Given this unevenness, Geoscience Australia has embarked on a regional study to determine geological characteristics favourable for basin-hosted mineral systems, and which geoscience data sets can be used to assess favourability.

We used a mineral system approach, considering separately metal and fluid sources, fluid flow triggers and drivers, fluid flow pathways, and depositional mechanisms. The make-up of individual basins and geodynamic events that formed and modified basin systems influence these components.

Basin-hosted ore fluids are low-moderate temperature (80-250°C), evaporative and oxidised brines that interacted with volcanic rocks and red beds at depth, leaching metals. Limited data suggest magnetite-destructive K-feldspar-hematite alteration assemblages formed during leaching of volcanic rocks. Data sets used to map source favourability include paleomagnetic data (paleolatitude), geophysical data for volcanic sources and metal leaching, and stratigraphic thickness (with paleothermal gradients) to identify zones thermally conducive to metal leaching.

Age data suggest basin-hosted mineralising events were pulsed, with events corresponding to geological events identified from structural histories, reflection seismic data and/or changes in plate motion identified from bends in apparent polar wander paths. These triggers induced events that drove connate brines from deeper parts of basins.

Potential fluid flow pathways include stratigraphic aquifers and faults that can be identified from geological maps, regional diagenetic and structural histories, and seismic imaging. Fluid flow along these pathways may be indicated using fluid inclusion, clumped isotope and RockEval Tmax pyrolysis data, or by regional alteration zones. Basin-hosted Zn-Pb and Cu-Co deposits commonly occur in organic-rich siltstone and shale with significant carbonate. The distribution of these units in space and time, relative to known trigger events, indicates potential trap locations. A necessary step will be establishing the 3D distribution of basin units (from outcrop coupled with drill hole data and geophysical data, such as EM, IP, and seismic) Once established, the temporal and spatial distribution of these rocks can be combined with potential fluid pathways and evidence for fluid and metal sources to highlight regions within basins for follow-up study and exploration.