Utilising Indicator Minerals to Narrow the Search Space for Greenfields Exploration

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Greenfields exploration beneath passive margin basins is challenging due to the thick cover, which requires deep drilling to sample the basement. The 'Seahorse' tenement package in Western Australia is one such region where the Proterozoic basement rocks are overlain by up to 500 m of basin cover. The Mesozoic Bight Basin is filled with early to late Cretaceous carbonaceous siliciclastics in a series of grabens and half grabens, which are unconformably overlain by Cenozoic carbonates of the Eucla Basin. The collaboration between CSIRO and BHP targeted the basement-Cretaceous and Cretaceous-Cenozoic paleosurfaces for analysis of indicator-heavy minerals to detect mechanical dispersion haloes at the Seahorse project, which included a strike length of 350 km along the Rodona Shear Zone tectonic boundary covering an area of approximately 13,000 km2. Although BHP initially targeted massive Ni-sulphides associated with magnetic-gravity anomalies in the basement, our research opens new avenues for additional styles of mineralisation. Four assemblages of indicator sulphide minerals were identified based on their texture and mineral chemistry. These include: 1) detrital, composite Cu-As-Co-Fe-Zn sulphides and Bi tellurides indicating epithermal or skarn sources; 2) detrital Ni-Co-Cu sulphides indicating a volcanogenic Ni sulphide source; 3) detrital Cu sulphides associated with titano-magnetite, ilmenite and apatite indicating IOCG-style deposits; and 4) diagenetic (sediment-hosted) Pb-Zn sulphides in the Madura Formation carbonaceous siltstones. The first two types are restricted mainly to the Cretaceous-Cenozoic unconformity, implying proximal prospective basement paleohighs as the main source of sulphides, which is supported by the subangular shape and the composite structures of the sulphides. The third type is restricted to the basement-Cretaceous cover, whereas the fourth type is likely formed by microbial and hydrothermal processes close to faults. Targeting indicator minerals close to paleosurfaces and linking them to paleotopographic processes can reduce the search space and deep drilling costs for greenfields exploration.