Pyrite Nodules in Black Shales: Recorders of Craton-Scale Mineralization and Indicators of Basin Fertility for Orogenic Gold and VHMS Cu-Zn Deposits in the Eastern Goldfields Superterrane, Western Australia

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Pyrite nodules commonly form during sedimentation and diagenesis and occur throughout the rock record in carbonaceous black shales of nearly all geologic ages. Because of their protracted formation history, which can span millions of years, they are uniquely suited to record the chemistry of various fluids that pass through them (i.e., seawater, pore fluids, hydrothermal/metamorphic fluids, etc.). In the Eastern Goldfields Superterrane of Western Australia, pyrite nodules are present in sulfidic and carbonaceous black shales at the Golden Mile Au deposit; the Nimbus Ag-Zn-Pb VHMS deposit (15 km E of the Golden Mile), the Lucky Bay polymetallic prospect (70 km SE of Kalgoorlie), and the Erayinia (King) Cu-Zn VHMS deposit (150 km SE of Kalgoorlie). The morphology and geochemistry of the nodules from each locality varies significantly but systematically: for example, at the Golden Mile, three black shale units—the Kapai Slate, Oroya Shale, and Black Flag Group—contain pyrite nodules with morphologies and, more importantly, geochemical signatures that are unique to one particular unit.

In general, all pyrite nodules analyzed via LA-ICP-MS in this study are enriched in many trace elements (compared with average sedimentary pyrite), with up to 5 ppm Au in Oroya Shale nodules from the Golden Mile. Nodules from the Golden Mile are highest in gold, while the nodules from Nimbus and Erayinia are higher in Zn and lower in gold than the Golden Mile examples. Nodules from Lucky Bay compositionally fall in between the Golden Mile and Nimbus/Erayinia nodules.

In addition, at least one nodule from all four localities has pronounced pressure shadows that are predominantly filled with quartz but also contain chalcopyrite, sphalerite, and cubic pyrite in many instances. Trace element imaging of these features shows that the chemical signature of the cubic pressure shadow pyrite is not the same as that of the nodules. What is more, the pressure shadow pyrites from the Golden Mile, Lucky Bay, Nimbus, and Erayinia have nearly identical trace element profiles, suggesting that a similar process formed these sulfides at all four localities, perhaps even at or around the same time.

From this study, it is evident that diagenetic pyrite nodules faithfully record the chemistry of the fluid(s) that formed them, which, in the case of the Golden Mile (Au) and Nimbus (Zn), is dominated by the economic metal in those districts. They may, therefore, be used as a first-pass indicator of metallogenic fertility in a given basin.