

Trace Elements in Sedimentary Pyrite and Gold Content from Selected Black Shale Formations in Malaysia: Evidence of Diagenetic Gold Enrichment in the Ocean

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Sedimentary pyrites in organic-bearing black shales of various ages in Malaysia were analyzed by LA-ICP-MS to determine the relationships among gold and other trace elements and the gold source rock potential of each black shale formation. In Late Silurian time, Al₂O₃ content in the Singa black shales varies positively with Ni, Cu, Zn, As, and Sb whereas organic carbon has no relationship with trace elements. Gold content in the black shale ranges from 40 to 65 ppb (mean 51 ppb). The gold content in sedimentary pyrite measured from 0.05 to 1.61 ppm (mean 0.31 ppm), varies positively with Mo, As, Co, Ag, Sb, Te, Tl, Bi, and V. This suggests gold may have been concentrated by organic processes.

In Late Devonian time, organic carbon content in the BRSZ Unit 1 black shales varies positively with V, Cr, Ni, Mo, Sn, Sb, and U. Gold content in black shale ranges from 3.5 to 38.6 ppb (mean 23 ppb) and has a weak negative correlation with organic carbon but a positive correlation with Al₂O₃. The gold content in sedimentary pyrite ranges from 0.06 to 5 ppm (mean 0.95 ppm) and varies positively with Co, Zn, Se, Ag, Sb, and Pb. This suggests gold was introduced to the basin attached to clays.

Framboidal pyrites from Carboniferous black shales in proximity to the Selinsing gold deposit contain elevated Co, Ni, Zn, As, Se, Cd, Sb, Au, Tl, Pb, and Bi that correlate positively with V suggesting that these elements were introduced into pyrite by organic processes. Gold content in pyrite varies from 0.02 to 0.8 ppm (mean 0.3 ppm) and shows a positive relationship with V, Zn, Ag, Sb, Te, and Bi.

In the Triassic, gold content in the Gua Musang black shales ranges between 3 and 51 ppb (mean 28 ppb), exhibiting a weak correlation with Al₂O₃. Organic carbon content shows a weak positive correlation with S, V, Ni, and Sb. In diagenetic pyrites, gold content ranges between 0.25 and 1.83 ppm (mean 0.78 ppm) and varies positively with V, Se, Ni, Zn, Ag, Sb, Te, and Pb. Gold may have been introduced into sediments attached to clay minerals or contained in aluminosilicates for the Gua Musang, and BRSZ Unit 1 black shales.

Trace element contents normalised to worldwide diagenetic pyrites depict enrichment and depletion trends in the paleo-ocean from Silurian to Triassic. The three trace element trends are as follows: (1) Au is consistently enriched in diagenetic pyrite; (2) Mo is depleted and Tl is strongly depleted in all formations; and (3) elements such as Co, Ni, Cu, Zn, As, Se, Ag, Cd, Sb, Te, Pb and Bi oscillate through time. This study has revealed that diagenetic pyrite in black shale is a possible source for gold in sedimentary basins within both the Sibumasu and East Malaya terranes in Malaysia.