Mineralogical, geochemical and isotopic constraints on multiple sources of metals in highly metalliferous black shales: An overview

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Black shale can contain high metal abundance up to economic level to form a variety of ore deposits in the world. One typical example is the Ni-Mo-PGE ore bed in the Lower Cambrian black shale sequence in South China. In general, typical metal enrichment in black shale includes Ni, Mo, PGE, Re, Au, U, V, Co, Se, As, Zn, Cr, Cu, Cd, Ba, P and rare earth elements (REE). The origin for the extremely metal enrichment in black shale has been controversial for a long time, and three models have been proposed: (1) extraterrestrial origin (i.e., meteorite impacts); (2) hot water origin (i.e., a submarine exhalative hydrothermal process); (3) cool water origin (i.e., chemical precipitation directly from seawater). This paper summarizes all available geological, geochemical, and isotopic evidence, in particular those from the Ni-Mo-PGE mineralization in Lower Cambrian balck shales of South China, to demonstrate that a multiple source for various metal enrichment is required and a syn-sedimentary hydrothermal fluid can make great contribution to the abnormal metal enrichments in the black shales to form a variaty of ore deposits. The typical Cu-Pb-Zn polymetallic mineralization of submarine hydrothermal origin may occur in a relatively oxidized (suboxic) seafloor environment, whereas an anoxic to sulfidic bottom water environment is required for those redox-sensitive metal enrichments, such as those Ni-Mo-PGE mineralizations, which occurred in the early Cambrian ocean on the Yangtze Platform, South China.