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Two separate Mesozoic molybdenum and gold mineralization events in the Xiaoqinling district, southern margin of North China craton

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The Xiaoqinling district along the southern margin of North China Craton (NCC) is the second largest gold producer in China, and contains several minor molybdenum deposits. Large areas of the southern NCC have been affected by Triassic orogenic deformation due to the continental collision between NCC and Yangtze craton and Early Cretaceous tectonic reactivation of the NCC. Whether the gold deposits formed in Triassic as a result of the orogeny or in Early Cretaceous associated with the cratonic reactivation remains debated. An integrated mineralogical, geochemical, and geochronological study of the Hongtuling Mo-Au deposit, northern Xiaoqinling district, provide new constraints on the timing and genesis of gold mineralization in the Xiaoqinling district.

The Hongtuling deposit contains gold mineralization predominantly in the upper level and molybdenum mineralization mainly in the deep level. Both the gold and molybdenum veins are structurally controlled by NWW- and NE-trending faults. The gold veins, ranging in width from centimeters to several meters, consist mainly of pyrite and minor amount of chalcopyrite, galena, and sphalerite. Molybdenum veins are 10.6 to 37.0 m thick and consist of molybdenite associated with minor pyrite and galena. Both Mo and Au mineralization are accompanied with well developed hydrothermal alteration, forming K-feldspar and calcite on both sides of Mo veins and sericite, sulfides, quartz surrounding gold veins.

Hydrothermal monazites are well developed in both molybdenum and gold veins, and are texturally intergrown with molybdenite and gold-bearing pyrite, respectively. Using LA-ICP-MS dating method, monazite from molybdenum and gold veins yielded concordant U-Pb ages of 203.5 ± 8.1 Ma (MSWD = 0.23, 1σ) and 130.4 ± 5.3 Ma (MSWD = 0.99, 1σ), respectively. Geochemically, monazites from gold veins have Y, Th, U contents and Th/U ratios significantly higher than those from molybdenum veins. The two types of monazite also have distinct REE patterns, suggesting that they formed from different hydrothermal fluids. This view is consistent with contrasting fluid inclusions between the Mo and Au veins. Quartz from molybdenum veins contains abundant solid-bearing fluid inclusions, which, however, are lacking in gold veins. Isotopically, pyrite from molybdenum veins has $\delta^{34}S$ values ranging from -13.40 to -9.30 ‰, with a peak at -11.0 to -10.0 ‰, whereas pyrite from gold veins has $\delta^{34}S$ of -8.98 to 0.16‰ with a peak at -2.0 to -1.0‰. Five sulfide separates from gold veins have uniform lead isotopic compositions, which are 17.003-17.393 for $^{206}Pb/^{204}Pb$, 15.373-15.442 for $^{207}Pb/^{204}Pb$, and 37.409-37.900 for $^{208}Pb/^{204}Pb$, which are distinct from those of K-feldspar from molybdenum veins (17.344-18.779, 15.436-15.554 and 37.517-38.786, respectively). The distinct S and Pb isotopic results further confirm that molybdenum and gold mineralization have different sources.

Combined with geological, geochemical, and geochronological results from independent Au and Mo deposits throughout the Xiaoqinling district, we propose that the Hongtuling Mo-Au deposit, and by inference other deposits in the district, was generated in two separate mineralization events. Molybdenum mineralization was formed in Late Triassic during the Qinling orogeny, whereas gold mineralization was the product of an Early Cretaceous tectonothermal event genetically associated with the tectonic reactivation of NCC.