Mantle source of fluids and metals in the Jiaodong gold province, China: evidence from noble gaseous components in ore-related pyrite

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The Jiaodong Peninsula, eastern North China Craton (NCC) is the largest gold district in China and has proven reserves exceeding 3000 t Au. To a first order the deposits were formed in a short time interval (120 ± 10 Ma) and are largely hosted by strike-slip faults in Jurassic-Cretaceous granitoids and Precambrian basement rocks (1.9–2.9 Ga). Up to present, the classification of the Jiaodong gold deposits remains problematic. Some studies classified them as orogenic gold deposits for a unified model in which metals are derived from late-orogenic metamorphic devolatilization. However, others argued that the oreforming fluids and gold were largely exsolved from coeval deep-sourced magmas with evidence for mantle–crust mixing.

The origin and the interaction history of the ore-forming fluids is a key factor for understanding the formation of the Jiaodong gold deposits. He and Ar isotopes provide powerful tools to constrain the origin of ore-forming fluids. He-Ar isotopes are reported for ore-forming fluids from 20 pyrite samples in the eastern Jiaodong deposits. $^{3}He/^{4}He$ range between 0.42 and 2.39 R_a, $^{40}Ar/^{36}Ar$ are 367 to 2,112, $Ar^*/^{4}He$ values are 0.26–2.50. The data is a mixture of gas from three sources; a dominant mantle-derived component plus subordinate crustal radiogenic and meteoric components. The mantle end-member has $^{3}He/^{4}He$ (3.3–4.0 R_a) that is lower than most estimates for sub-continental lithospheric mantle (6–7 R_a), implying that it was probably refertilized by subduction-related fluid metasomatism. This is consistent with He-Ar isotopes reported for SCLM and xenoliths from basalts in the Shandong Province. Within the mineralization province, mine Au reserves are positively correlated with the proportion of mantle-derived He in the ore-forming fluids. This implies that the fluids, and by inference the gold, was largely derived from mantle degassing during lithospheric extension. Previous work also documented a common magma mixing source and thus a direct genetic link between the coeval mafic magmas that formed the dykes and ore formation in the Jiaodong gold province. This is indicated by several lines of evidence: (1) they both share the same structural features and some dykes themselves were mineralized; (2) they formed at the same time and under a similar extensional tectonic regime; (3) Pb isotopic signatures of the ore sulphides overlap those of the mafic dykes; and (4) metal ratios in magmatic sulphides trapped in minerals from mafic dykes are similar to those of the bulk ore.

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