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Subduction-triggered mineralization in the giant Haiyu gold deposit, North China Craton, revealed by in-situ xenotime-monazite U-Pb dating

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North China Craton is the world's third-largest gold province, with over 5800 t gold endowed in the Jiaodong Peninsula. Among these world-class gold deposits, the Haiyu gold deposit (discovered in 2015) represents China's first subsea gold system, hosted within the Sanshandao-Cangshang fault zones. It contains proven reserves of 562 t Au (avg. 4.2 g/t), with mineralization extending >1.5 km below the seafloor. Despite its economic significance, the Haiyu gold deposit remains understudied compared to terrestrial ones in the Jiaodong district. Here, we integrated filed investigation, petrography, in-situ trace element and U-Pb isotopic analyses (zircon, xenotime, monazite) to resolve the timing of gold mineralization at Haiyu and its relationships to regional tectonothermal events.

Gold mineralization at Haiyu is characterized by disseminated gold ores and auriferous quartz-sulfide vines, which primarily occur within the Linglong biotite granites (zircon U-Pb: 154±1 Ma, 2σ; magmatic monazite: 153±2 Ma, 2σ). This intrusion was intruded by Early Cretaceous Guojialing porphyritic granodiorites (zircon U-Pb: 125±1 Ma, 2σ). Based on well-established paragenetic stage, texture, and compositions, hydrothermal xenotime and monazite are recognized in pre-ore K-feldspar-quartz-pyrite assemblages, and syn-ore disseminated ores and quartz-sulfide veins. Xenotime of pre-ore stage has been dated at 125±1 Ma (2σ), which is coeval with the emplacement of Guojialing intrusion. Systematic U-Pb dating of thirty-one monazite grains from six syn-ore samples shows an isotopic cluster of 120±3 Ma to 118±2 Ma (2σ), overlapping with pre-ore activity within uncertainty. This temporal consistency demonstrates an early Cretaceous (~120 Ma) gold mineralization event at Haiyu.

Our results, when combined with published data, suggest that broadly contemporaneous gold mineralization in the Jiaodong is likely related to post-subduction opening of a slab gap at ~120 Ma during Izanagi plate rollback. This tectonic process is accompanied with volumes of mafic and felsic magmas that provide sufficient Au-rich fluids migrating along NNE-trending faults and depositing ores within Precambrian basement and/or Mesozoic granitoids. In summary, this study highlight that the Haiyu deposit as a subsea system preserve critical records of upper-crustal fluid flux during late Mesozoic lithospheric thinning and further address the Jiaodong Peninsula as a typical cratonic destruction-related metallogeny worldwide.