Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34394

Origin of the Late Devonian Binggounan magmatic Ni-Cu sulfide deposit, North Qimantage, East Kunlun Orogenic Belt

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The East Kunlun Orogen bears a protracted Paleozoic–Triassic accretionary record and is a prospective domain for magmatic Ni-Cu sulfide deposits. To constrain magma source properties, redox state, and the tectonic setting governing mafic–ultramafic magmatism and Ni-Cu sulfide mineralization, we carried out systematic petrography, geochemical and geochronological analyses on the Binggounan Ni–Cu sulfide deposit in the North Qimantage Belt. LA–ICP–MS zircon U–Pb dating of troctolite and gabbro yields weighted-mean $^{206}Pb/^{238}U$ ages of 374.9 ± 1.9 Ma and 374.6 ± 1.4 Ma, respectively, defining a Late Devonian (~375 Ma) magmatic event. The host mafic–ultramafic rocks are sub-alkaline with arc-like trace-element affinities (LILE enrichment: Rb, Ba, Pb, Sr; HFSE depletion: Nb, Ta, Ti) and weakly fractionated E-MORB-like REE pattern. Radiogenic isotopes (initial $^{87}Sr/^{86}Sr$: 0.70537–0.70896; $\varepsilon_{Nd}(t)$: +1.83 to +4.61; zircon $_{\varepsilon Hf}(t)$: +6.5 to +16.0) indicate a mantle-dominated magma origin with limited evolved crustal input, while whole-rock Pb isotopes ($^{206}Pb/^{204}Pb$ = 18.05–18.42; $^{207}Pb/^{204}Pb$ = 15.57–15.66; $^{208}Pb/^{204}Pb$ = 37.96–38.42) confirm an EM–II-type signature. Together with variable Ba/Th ratios, these features show parental melts formed from slab-fluid-metasomatized subcontinental lithospheric mantle (spinel–garnet lherzolite), with asthenospheric input and ~15–20% upper-crustal contamination. Mineral chemistry (Ca-rich olivine, clinopyroxene–spinel compositions) indicates hydrous mantle melting/asthenospheric melt–rock interaction. Elevated fO_2 and rift-related cumulation are inferred; hornblende thermobarometry shows shallow emplacement (1.5–2.7 kbar) under oxidized conditions (NNO+0.9 to +2.2). Combined with coeval A2-type granitoids in the belt, the deposit formed in a Late Devonian (~375 Ma) post-collisional extensional regime after Proto-Tethys Ocean closure. We propose intracontinental extension triggered asthenospheric upwelling and partial melting of the asthenosphere and metasomatized lithospheric mantle, generating the mafic–ultramafic intrusions and forming favorable magmatic-chemical conditions for economic Ni-Cu sulfide mineralization.