

Origin of sulfide mineralization in the Podong mafic-ultramafic intrusion in the western Beishan orogenic belt, NW China: With exploration implications

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The sulfide-mineralized Podong mafic-ultramafic intrusion is part of the Pobei mafic-ultramafic complex in the western Beishan Orogenic Belt, NW China. The Podong intrusion consists of an ultramafic unit (lherzolite and troctolite) and a mafic unit (olivine gabbronorite, gabbronorite and gabbro) with gradational contacts. SIMS zircon U-Pb dating of gabbronorite yields a crystallization age of 270 ± 2.7 Ma, identical to the age of the Poyi magmatic Ni-Cu sulfide deposit that occurs ~12 km to the southwest within the Pobei complex. Sulfide mineralization in the Podong intrusion occurs as steeply dipping disseminated sulfide lenses mostly associated with olivine gabbronorite and gabbronorite. The forsterite (Fo) contents of olivine in the ultramafic and mafic units are from 77 to 87 mol% and from 76 to 79 mol%, respectively. The parental magma for the most primitive rocks (lherzolites) in the Podong intrusion is estimated to contain 8.20 wt.% MgO and 8.22 wt.% FeO. Rounded sulfide inclusions are observed in olivine crystals containing Fo as high as 82 mol%, indicating sulfide segregation during olivine crystallization. The $\delta^{18}\text{O}$ values of cognate zircon crystals from gabbronorite vary from 6.43 to 8.52‰. These values are much higher than the mantle value (5.3 ± 0.3 ‰), indicating significant crustal contamination. The $\delta^{34}\text{S}$ values of sulfide separates are 0.82 to 2.02‰, which are similar to the mantle values (0 ± 2 ‰). The O-S isotope data support the premise that siliceous crustal contamination played a major role in triggering sulfide saturation in the Podong mafic magma. The involvement of multiple pulses of sulfide-bearing magma in the formation of the Podong deposit is evident from abrupt change in olivine Fo content with depth and large variation of Ni contents in olivine with similar Fo contents from the different parts of the deposit. Like other broadly coeval magmatic sulfide deposits in the region, the PGE tenors of the Podong deposit are very low. The estimated initial concentrations of PGE in the parental magma of the Podong deposit are more than one order of magnitude lower than undepleted picritic basalts worldwide. The PGE depletion in the Podong magma is likely due to sulfide retention in the source mantle during partial melting or sulfide segregation during magma ascent. Like other Permian sulfide-mineralized mafic-ultramafic intrusions in the region, the Podong intrusion is characterized by are-like geochemical features such as negative Nb-Ta anomalies and Ca depletion (<1000 ppm) in olivine. This, together with a constrained post-subduction environment for these intrusions from holistic geological records, reveals that the source mantle for these intrusions was metasomatized by slab-derived fluids previously. The widespread sulfide mineralization in these intrusions suggests that more important magmatic sulfide deposits are yet to be found in the region.