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# Variations in oxygen fugacity and sulfide compositions of the Permian magmatic Ni–Cu deposits in the southern Central Asian orogenic belt

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The Permian magmatic Ni–Cu deposits in the Central Asian Orogenic Belt, NW China, belong to a relatively new class of Ni–Cu deposits occurring in convergent settings. These deposits contain ~300 Mt reserves at average grades of 0.5 wt.% Ni and 0.3 wt. % Cu, representing one of the most important Ni provinces in China. The new data obtained from microbeam XRF images on sulfide compositions, together with published data, were used to estimate the variations in oxygen fugacity and sulfide melt composition of these deposits. Oxygen fugacity was estimated by a recalibrated semi–empirical oxygen barometer ($\Delta QFM = (9.837 + 0.414 \cdot C_{Ni} - K_D) / 4.357$, where $K_D$ is the distribution coefficient for Fe-Ni exchange between olivine and sulfide and ΔQFM denotes divergence from the fayalite–magnetite–quartz buffer). Generally, these deposits exhibit a range of oxygen fugacity (QFM–1.2 to ~QFM +1) and Ni tenor (metal concentration in pure sulfide, ~3 wt.% to 16 wt.%), and overall low but variable platinum group elements (PGEs) tenors. The Poyi and Huangshannan deposits in east Tianshan contain high Ni tenor sulfides, varying from 12 to 16 wt.%, and relatively high PGE tenors (average Ir and Pd tenors of 23–45ppb and 500–700 ppb, respectively). The relatively high Fo values (>85 mol.%) and Ni contents (>2000 ppm) in olivine of these deposits indicate that the high Ni–PGE tenor sulfides were segregated from less differentiated high-Ni magmas that also had relatively high oxygen fugacity (~QFM +1). The remaining Ni–Cu deposits in east Tianshan - the Huangshandong, Huangshanxi, Hulu, Tulaergen, Tudun, and Xiangshanzhong deposits - have intermediate Ni tenors (5–8 wt.%), and relatively low PGE tenors (average Ir and Pd tenors of 3–9 ppb and 50–300 ppb, respectively). These sulfides correspond to the intermediate Fo values (80–84 mol.%) and Ni contents (700–1400 ppm) in the coexisting olivine, illustrating that they were segregated from magmas with reduced Ni contents thought to be the result of a large amount (15-20%) of olivine fractionation at depth. These magmas are more reduced ($-1.2 < \Delta QFM < +0.3$) than the less evolved magmas (~QFM +1). The ΔQFM value for the deposits in east Tianshan decreases with the decreasing Fo value, indicating that the host magmas became gradually reduced during evolution, which can be explained by primarily oxidizing magma progressively assimilating crustal material containing reducing agents, such as graphite. The Kalatongke deposit in the East Junggar belt, containing the lowest Ni tenors in sulfides (3–5 wt.%), relatively low Ir tenor (~10 ppb) but high Pd tenor (~400 ppb) in sulfide, and low Fo values in olivine (<78 mol.%), was derived from relatively oxidizing magmas (~QFM + 1). The overall low PGE tenor of all the deposits is attributed to sulfide retention in the mantle source. We propose that the variation in oxygen fugacity and Ni tenor in the Permian Ni–Cu deposits in the CAOB is the result of gradual contamination and a variable degree of fractional crystallization.