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Origin of PGE-depleted Ni-Cu sulfide mineralization in the Triassic Hongqiling No.7 orthopyroxenite intrusion, Central Asian Orogenic Belt, NE China

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The $\sim$216 Ma Hongqiling No.7 intrusion is located in the southern margin of the Central Asian Orogenic Belt, NE China. It hosts the second largest magmatic Ni-Cu sulfide deposit in China. The intrusion crops out in an area of $\sim$0.013 km^2 on the surface. It intruded gneisses and marbles of the Paleozoic Hulan Formation. The intrusion is mainly composed of orthopyroxenite ($\sim$95 vol.%), with minor harzburgite and norite. Over 90 vol.% of the intrusion contains disseminated, net-textured or massive sulfides. The bulk sulfide ores (recalculated to 100% sulfide) have low average PGE concentrations (5.6 ppb Os, 3.1 ppb Ir, 4.7 ppb Ru, 2.2 ppb Rh, 31 ppb Pt and 11 ppb Pd) and high Cu/Pd ratios (3×10^5 to 3×10^7), consistent with the compositions of sulfide liquids segregated from PGE-depleted magma. Olivine composition (Fo $<$86) indicates a fractionated parental magma. Back calculation shows that the parental magma was possibly derived by olivine fractionation from a primary magma containing $\sim$16 wt.% MgO. Numerical modeling indicates that PGE depletion in the parental magma of the Hongqiling No.7 intrusion was due to previous sulfide segregation in the staging chamber. Whole rock data show light REE enrichments, negative Nb-Ta anomalies and positive εNd(t = 216Ma) values from +3 to +5, which can be explained by mixing of a mantle-derived magma with a granitic melt formed by magma underplating in the crust. The γOs(t = 216Ma) values of sulfide ores vary from +50 to +187. The highly variable γOs(t) values coupled with similar εNd(t) values indicate preferential assimilation of crustal sulfides during magma-rock interaction. Based on the observations, we propose that the parental magma of the Hongqiling No.7 intrusion formed by contamination of mantle-derived, S-undersaturated magma by crustally-derived granitic melt, together with olivine crystallization, in a staging chamber. The contaminated magma became PGE-depleted due to sulfide segregation in response to crustal contamination. The PGE-depleted magma became S-undersaturated again during ascent due to the negative effect of pressure on the maximum solubility of sulfur in magma. Upon arrival near at the present level of the Hongqiling No.7 intrusion a second event of sulfide segregation took place due to addition of crustal sulfides from immediate country rocks. The immiscible sulfide liquids and orthopyroxene crystallizing from the magma were retained in a dynamic conduit to form the ore-bearing intrusion while much of the magma left the conduit to form some of the nearby sulfide-poor intrusions. We suggest future exploration in the region to focus on olivine-bearing and orthopyroxene-dominant intrusions with ages similar to that of the Hongqiling No.7 intrusion.