Sulfide saturation and chalcophile metal enrichment in the Late Cretaceous Giant Mascot Ni-Cu-PGE deposit, Canadian Cordillera, British Columbia*

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The Giant Mascot Ni-Cu-PGE deposit remains British Columbia’s only past-producing nickel mine (1958-1974), with ~4.2 Mt of ore grading 0.77% Ni, 0.34% Cu, minor Co, Ag, and Au, and unreported platinum group elements (PGE). Orogenic Ni-Cu-PGE sulfide deposits (e.g., Portneuf-Mauricie Domain, Québec; Huangshandong, China; Aguablanca, Spain; Americano do Brasil, Brazil) are becoming increasingly more important economic resources despite relatively unknown PGE prospectivity. The ca. 93 Ma Giant Mascot intrusion is a crudely elliptical, 3×2 km plug composed of ultramafic-mafic arc cumulates (olivine-orthopyroxene, hornblende-clinopyroxene). Twenty-eight north-plunging, sub-vertical pipes host Ni-Cu sulfide mineralization as disseminated, net-textured, semi-massive, and massive ores containing pyrrhotite, pentlandite, chalcopyrite, minor pyrite, and platinum group minerals (Pt-Pd-Ni bismuthotellurides). Olivine compositions from barren and mineralized dunite, peridotite, and pyroxenite range from Fo 89-79 and have highly variable Ni concentrations (335-3860 ppm). Mineralized samples show significant Fe-Ni exchange between olivine and sulfide during equilibration. High tenor sulfide compositions (3-14 wt% Ni, 0.1-17.1 wt% Cu, and 84 ppb-5 g/t or ppm total PGE) are calculated from chalcophile and PGE whole rock geochemistry (NiS-FA; n=78). Modeling results indicate that sulfides include a variable mixture of 20-60% fractionated monosulfide solid solution (mss) and sulfide liquid. Sulfide segregation occurred at depth prior to formation of the deposit. Net-textured sulfides have high Cu and low PGE concentrations with Cu/Pd=1.2×10^5 and Ni/Cu=3.3, and they originated from a more fractionated mss (R-factor ~50-750). Disseminated sulfides, characterized by Cu/Pd=4.0×10^4 and Ni/Cu=5.0, represent sulfide melt with upgraded metal contents due to greater silicate melt interaction (R-factor ~500-3000). Sulfur isotopes (n=34) for ultramafic rocks reveal a restricted range of slightly light  δ ^{34}S values (-3.4 to -1.3‰; mean -2.3‰) relative to typical mantle values and overlap with whole-rock analyses from locally pyritiferous Settler schist (-5.4 to -1.2‰; n=4). The presence of inherited zircon from the adjacent ca. 95 Ma Spuzzum quartz diorites indicates that significant assimilation and silica addition to the ultramafic magma occurred. Sulfide saturation within the Giant Mascot ultramafic magmas may have occurred in response to 1) assimilation of the Spuzzum pluton and addition of SiO_2, 2) significant pre- and syn-emplacement mixing of Ni-poor and Ni-rich magmas, and 3) addition of small amounts of external sulfur by assimilation of Settler schist. The presence of high-tenor sulfides indicates that orogenic Ni-Cu-PGE deposits may be of greater significance to modern exploration in the Canadian Cordillera than previously assumed.