

Sulfide Distribution and Oxygen Isotopic Variation within the J-M Reef, Stillwater Complex, Montana

MP Lilley¹, EM Ripley¹, CS Li¹

¹Department of Geologic Sciences, Indiana University, Bloomington, Indiana

The J-M Reef of the Stillwater Complex, Montana is one of the world's premier platinum-group element (PGE) deposits. The Reef is stratigraphically located in what is known as the Olivine-bearing Zone I (OB I) of the Lower Banded Series of the Complex. The Reef extends over 40 km in strike length and averages 1 to 3 m in thickness. Rock types present within the Reef include dunite, troctolite, norite, and anorthosite. The origin of the J-M Reef remains controversial, and theories are broadly divided between those which favor downward collection of PGE-bearing immiscible sulfide liquids and those that favor an upward accumulation of PGEs controlled by magmatic hydrothermal fluids. In addition to the very high concentration of Pd in the Reef, the distribution of PGE-rich sulfides remains enigmatic. We have examined interfaces between sulfide-bearing units of the J-M Reef and sulfide-poor units above, below, and within the Reef itself. PGE-rich and sulfide-rich lenses show vertical separation as well as horizontal discontinuities. The downward extent of the mineralization is defined by the presence of sulfide minerals and is not controlled by variations in host lithologies. Neither downward drainage of immiscible sulfide liquid through a fractionation/differentiation sequence nor upward fluid infiltration can readily explain these features. Some of the distribution of sulfide minerals in the Reef and associated ballrooms may be a function of low-T hydrothermal fluid mobilization. Oxygen and hydrogen isotopic studies show that the J-M Reef behaved as a horizon of relatively high permeability compared to other stratigraphic units in the Complex. The presence of plagioclase feldspar with $\delta^{18}\text{O}$ values as low as 4.0 ‰ and olivine with normal mantle values of 5.4 ‰ suppressed to 4.8 ‰ when partially serpentinized are indicative of kinetically controlled oxygen isotopic exchange between silicate minerals and a low-temperature and low- ^{18}O fluid. The elevated concentrations of Pd in pentlandite (5.6 to 9.8 wt. %) associated with the desulfurization of braggite and cooperite to isoferroplatinum-sulfide intergrowths indicates that Pd was transported within late-stage fluids.