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Chromite Geochemistry and PGE Fractionation in the Campo Formoso Complex and Ipueira-Medrado Sill, Bahia State, Brazil

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Abstract

Two districts of stratiform chromite deposits are situated near the northern margin of the São Francisco craton. The ultramafic host rocks are remnants of early Precambrian layered complexes that intruded Archean gneissic blocks prior to Transamazonian collisional events. The intrusions contain abundant chromite, exhibit orthopyroxene-rich sequences, and are similar geochemically, with highly magnesian bulk compositions (Mg/Mg + Fe = 0.91–0.67) and fractionation trends consistent with komatiitic parent magmas. The intrusion form, alteration history, and current metamorphic grade of each are distinct. At the Ipueira-Medrado mines, representative of the Jacurici Valley district, a folded segment of a 200- to 250-m-thick ultramafic-mafic sill contains a 5- to 8-m-thick highly massive chromitite layer. Green spinel in the orthopyroxene-rich peridotite and ubiquitous granoblastic textures indicate recrystallization during upper amphibolite or granulite facies metamorphism, now with incomplete retrograde alteration and serpentinization. In Campo Formoso a deeply eroded stratiform complex contains at least seven different economic chromite seams, comprising varying proportions of disseminated, net-textured, layered, and massive ores. Here greenschist alteration of the ultramafic host rocks is complete, apart from orthopyroxene relicts in an upper unit at the Cascabulhos mine.

Microprobe studies of chromite-rich specimens from representative stratigraphic sections of each intrusion suggest that unusually low TiO_2 levels (<0.9 wt %) combined with high Cr_2O_3 contents (45–55 wt %) reflect the primitive parental magma composition in both intrusions. Core compositions of chromite from Cascabulhos retain high X_{Cr} (0.57–0.72) but show a wide range of X_{Mg} (0.21–0.47), consistent with Fe-Mg exchange at grades at or below amphibolite facies. Some relict igneous fractionation is preserved, since TiO_2 increases (0.2–0.4 wt %) while Cr/Al or X_{Cr} decreases (0.70–0.55) from the massive chromitites hosted by serpentinite, through the disseminated seams above, to the two high-level seams in pyroxenite. Chromite from Ipueira-Medrado is more magnesian (X_{Mg} = 0.57–0.64) but also more aluminous (X_{Cr} = 0.60–0.64) when massive types are compared. Here the submassive minor seams stratigraphically above and below the main seam both have relatively lower X_{Mg} and X_{Cr} (0.36–0.45 and 0.45–0.57). This suggests that combined Cr-Al and Mg-Fe exchange occurred between chromite and silicates during postemplacement progressive metamorphism of the seams.

Close-spaced sampling of representative drill core sections at <2- or <4-m intervals has allowed the precious metal potential of each intrusion to be assessed. In both cases the highest total platinum group element (PGE) concentrations occur exclusively in chromitite, illustrating the well-known phenomenon of "chromite control." The Ipueira-Medrado chromitite contains lower concentrations (<350 ppb) and has unfractionated PGE patterns. Chalcophile element analyses provide little evidence of precious metal scavenging by immiscible sulfide segregation and so indicate little potential for mineralization elsewhere in the sill. At Campo Formoso the alternation of PGE-enriched chromitite and barren silicates is suggestive of repeated influxes of primitive magma during open-system fractionation. An increase in the Pt, Pd, and Rh tenor of the chromitite (to ca. 1 ppm) occurs from the lower massive group, through the upper disseminated group, to the high-level seams hosted by pyroxenite. Thus upward evolution of the host chromite mineral compositions is matched by increasing (Pt + Pd + Ru)/(Os + Ir + Ru) ratio. The covariation of PGE ratios with chromite mineral chemistry is analogous to that occurring over the sequence of chromitite seams in the Lower Critical zone of the Bushveld Complex. This provides evidence for a fundamental link in the fractionation processes controlling chromite and PGE mineralization in stratiform intrusions, which has clear implications for exploration models.

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