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A Petrographic and Geochemical Analysis of the Kalahari Manganese Deposit, Northern Cape, South Africa

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The largest and most significant deposit of the ± 2220 Ma Kalahari Manganese Field (KMF) is the 320 km^2 Kalahari Manganese Deposit (KMD). The manganese (Mn) is exploited from three beds that are interbedded with hematite lutite and banded iron formation [1]. The northern KMD ores were affected by hydrothermal alteration, involving carbonate dissolution and the removal of CO_2, and the introduction of alkali elements, base metals and iron into the system [2]. Normal and thrust faults were important in localising the alteration system, as they acted as conduits for hydrothermal fluids [3], they, however, were not the only factor that contributed to the alteration of the ores. Another possibility for this enrichment, involved the flow of isotopically light fluid throughout large parts of the KMF, which was related to the Hotazel/Olifantshoek unconformity [4]. The Mn is divided into the low-grade Mamatwan and the high-grade Wessels-type ores, with the latter being constrained to the northern part of the KMD [5]. The lowermost Mn bed is the thickest and most Mn-rich and, thus, most favourable for mining [1]. A thorough understanding of the ore (the genesis and alteration of the ore, which includes both the upper and lower ore bodies, the spatial distribution of the mineral assemblage, as well as the fluid-rock interactions) is essential, in order to optimize exploitation and maintain the high quality and quantity output of the ore.

Oxides, carbonates, hydroxides and silicates dominate the mineralogy of the Mn beds. The protolith and low-grade ores are comprised of a braunite-kutnohorite-hematite assemblage, with coarse-grained carbonate ovoids, lenticles and laminae. The high-grade ores, however, are composed of a braunite-II-bixbyite-hausmannite assemblage with minor hausmannite and calcite textural features. Mn_3O_4, Fe_2O_3, CaO, MgO and SiO_2 dominate, with an overall increase in Mn_3O_4 and Fe_2O_3, and a decrease in SiO_2, MgO and CaO with increasing ore grade. The depletion of these elements indicates carbonate leaching, as well as the replacement of braunite by braunite-II, bixbyite and hausmannite during the Wessels alteration event [1]. The upper body contains higher Fe_2O_3 and SiO_2 abundances, suggesting a possible BIF-dominated environment, whereas higher CaO abundances in the lower body indicate a possible carbonate depositional environment. The trace elements vary significantly with ore grade and depth. Only Ba, Sr and B show an evident increase in concentration from the protolith to the high-grade ore, suggesting an addition of these elements by fluid. Boron (B) in particular is an important component of this study, as concentrations >400 ppm are highly detrimental to the steel quality. B abundances fluctuate between the Mn beds, but overall shows a higher average abundance within the upper bed. B maybe mineralogically controlled as the highest concentrations show large abundances of braunite/braunite-II, gaudefroyite and bixbyite. Rare Earth Element (REE) analysis indicates enrichment in heavy over light REE, and an overall increase in REE with an increase in alteration. The REE signature is similar to that of the present day deep ocean level seawater.

References:

[1] Beukes N.J (1983) Development in Precambrian Geology, 6, 131-209.
[2] Evans D.A.D et al (2001) Economic Geology, 96, 621-631.
[3] Kleyenstüber A.S.E (1993) Resource Geology, 17, 2-11.
[4] Tsikos, H (2003) Economic Geology, 98, 1449-1462.
[5] Kleyenstüber A.S.E (1984) Transvaal Geological Society of Southern Africa, 87, 257-27