Mineralogy of the Middle Group chromitite cumulates at the Tweefontein Chrome Mine section, central Critical Zone, eastern Bushveld Complex

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ABSTRACT

The understanding of the silicate mineralogy in the Middle Group chromitite section of the central Critical Zone at Tweefontein in the eastern Bushveld Complex south of Steelpoort is essential for the investigation of the genesis of the cumulate rocks; in particular the crystallization history of the cumulus minerals and the development of the interstitial liquid are considered to be key parameters controlling the PGM distribution in those mafic rocks. The detailed ongoing investigation of the textural relationships and the mineral chemistry of the rock forming minerals may therefore assist in explaining the PGE distribution. Vertical geochemical and modal mineral distribution patterns are prime indicators of magmatic system conditions. The investigations will help to better understand the PGE distribution in a dynamic ultramafic to mafic system on the theoretical side, and will characterize the possibly variable PGE patterns of the different Middle Group chromitite sections within the Bushveld Complex. Practical conclusions such as PGE abundances and their occurrence in various minerals, as well as grain sizes and textures relations relevant for liberation are important for economic extraction processes.

Key words: Middle Group Chromitite, Platinum Group Elements, Tweefontein, Eastern Bushveld Complex

INTRODUCTION

The goal of this project and investigations is to achieve a better understanding of the mechanisms that cause distribution and control of Platinum Group Elements (PGEs) in the Middle Group (MG) Chromitite and intercalated mafic cumulate layers of the eastern Bushveld Complex.

The focus lies on the laterally extensive massive chromitite layers MG0 to MG4 at Tweefontein Chrome Mine in the eastern Bushveld Complex (Figure 1), and involves petrographic, geochemical, and micro-analytical (SEM-W/EDX) studies. The question is if current models of PGM formation (hiatus model, Cawthorn, 1999; plume-model / R-factor, Naldrett, 1989, 1997; cluster theory / PGEs in chromite and olivine-orthopyroxene, Tredoux et al., 1995) and PGE enrichment apply, or if other mechanisms have to be postulated for this special stratigraphic position at the interface of ultramafic-to-mafic cumulate rocks in the Bushveld Complex.

The project will employ state-of-the-art hydro-separation and micro-analytical methodology to document and interpret the abundance and distribution of Platinum Group Minerals (PGMs) in the chromitite layers of the central Critical Zone in the eastern ‘lobe’ of the Bushveld Complex south of Steelpoort.

Figure 1. Geological and locality map of Tweefontein Mine in the Critical Zone of the eastern Bushveld Complex.
METHOD AND RESULTS

Investigation started with a literature overview of the PGE in MG chromitite layers for orientation purposes and focussed on areas of the Eastern and Western Bushveld Complex. Exploration drill core from Tweefontein Chrome Mine (Figure 1) was sampled and polished thin sections and polished sections were made for petrographic studies. The remainders of the preparation were used for whole rock geochemical analysis by XRF (Panalytical Axios) to investigate vertical chemical variations. Later applied methods will include ICP-MS analyses of PGE after fire assay of both silicate and chromitite rocks, as well as EMPA and MLA analyses of PGMs, chromeite, and silicate minerals.

Figure 2. Schematised stratigraphic rock column of the central part of the Critical Zone at Tweefontein Mine.

Most MG sections of the Critical Zone of the Bushveld Complex show considerable variations in their vertical whole-rock and mineral chemical pattern, which are typical for the transition from more ultramafic to mafic cumulate rocks indicating possible magma replenishment by renewed influxes.

At Tweefontein, below the MG 2 chromitite layer, pyroxenites are the dominant cumulate rocks; the first mafic anorthosite horizon occurs above the MG2C chromitite layer, whereas above the MG3 mainly norites are found (Figure 2).

Further mineral chemical investigation will confirm whether chromeite, orthopyroxene, and clinopyroxene compositions at Tweefontein mimic the whole-rock geochemical trends. PGE concentrations are highest in the MG1 chromitite layer and the MG1 hanging wall marker, but are well below those of UG2 chromitite or Merensky Reef pyroxenite horizons.

Since the MG mineralogy is distinct, new models of PGM formation and PGE enrichment may apply. The new data will provide a solid base for evaluation and assessment of previous models of ore formation (orthomagmatic - sulphide immiscibility - high partition factors of PGEs, complex-forming, magmatic-hydrothermal).

The MG chromitite layers could potentially offer a new PGE resource and open up mining potential after exhaustion of Merensky, UG2 and UG1 resources, which will be of economic importance to South Africa and the worldwide PGE market. The investigations are also important to predict possible beneficiation strategies to economically extract PGEs from the MG chromitite layers.

CONCLUSIONS

The understanding of the silicate mineralogy appears to be an essential part of the investigation of the crystallization history and the development of interstitial liquid, which are, among others, key parameters controlling the PGE distribution in chromeite-bearing mafic rocks. Therefore this detailed investigation of the textural relationships and the mineral chemistry of the rock forming minerals may explain the PGM content of the MG chromitite layers. Vertical geochemical and modal mineral patterns are supposed to establish relationships which allow explanation of magmatic system conditions within the MG chromitite section; once there is more clarity about system conditions, key parameters which control the quality and distribution of PGMs may be identified.

It is of particular interest to discuss any exceptions to those rules, in agreements or disagreements with previously published work. The theoretical implications of the work will be the better understanding of PGE distribution in a dynamic ultramafic to mafic system and
the practical conclusions have relevance for PGE pattern characterization within various MG sections of the ‘lobes’ of the Bushveld Complex (Merkle, 1992), and the textural implications for economic extraction processes.

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REFERENCES


