Type Variations in the Merensky Reef in the Western Bushveld Complex: Critical Comparisons of the Geochemistry, Textures and Metal Distributions

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Extensive diamond drilling in the Western Bushveld Complex since 1998 has allowed vertical and lateral variations of the Merensky Cyclic Unit to be studied in detail in a variety of reef types over a wide area and using identical sampling techniques and analytical procedures. Changes in thickness, structure and textures are related to the style and distributions of PGE. Three main 'reef' types are identified. These are termed 'thick reef' type (also called Swartklip type), the spatially 'intermediate reef' type and 'thin reef' (also called Rustenburg type) over a transect extending north to south over a distance of about 10 km. Each type is quite distinct in its structure and metal distributions and poses its own challenges to mining operations. The changes are assessed in a series of projections and cross sections and show the intermediate type to be highly variable in physical form and distribution in relation to the thick reef and thin reef varieties. Two drill cores of the thick reef type, separated by some 4 km, reveal almost identical structures and metal profiles indicating that strong primary controls were responsible for the various features observed.

As in most other areas of the Bushveld Complex, the Merensky Reef can be described as a medium to coarse grained pyroxenite of variable thickness generally containing two (or more) narrow chromitite bands, with underlying norite and overlying medium grained pyroxenite (called the Merensky Pyroxenite). The PGE are concentrated within the Merensky Reef. In contrast to the Merensky Reef the Merensky Pyroxenite is remarkably consistent in thickness and textural form, and contains only low grade mineralization. The Merensky Reef of the thick reef type is 6 – 8 metres wide, that of the intermediate type is 2 – 3 m wide and thin reef is less than 35 cm wide.

In all three reef types PGE are closely correlated with each other, and concentrations of the metals exhibit very similar ranges. All have similar elemental ratios (within analytical error), but the distribution of the metals in the different reef types is different in detail. The thick reef type exhibits a series of smoothly varying small-scale oscillations (Fig. 1), with the mineralization essentially contained between the upper and lower chromitite bands. Intermediate reef has similar variations but these are more compressed, with the mineralization also largely contained between the chromitite layers. In the thin reef type the zone of mineralization is highly compressed and about 30% of the total PGE metal content is outside the upper and lower bounds of the thin chromitite layers.

The pattern of the distribution of sulphide in thick reef is one of gradually increasing content upwards in the section by way of a series of microcyclic units (Fig. 1). These microcyclic units are precisely reflected by the distribution and variation of many other major and trace elements, including the highly incompatible elements (U, W, Ta, Zr) and the rare earth elements. Even more importantly they can be correlated to the variation of sulphide content and PGE variation. The form of the microcyclic units characterizes the reef into two distinct forms – and upper section where sulphide is in greater abundance and where there is strong antipathetic variation between sulphide content and concentrations of incompatible trace elements, and the lower section where sulphide increases in sympathy with the incompatible trace elements. This suggests a multistage process for the formation of the Merensky Reef and its associated mineralization. Almost identical features are observed in both sections of thick reef studied, and also to some extent in the intermediate reef type. The thin reef type, in contrast, does not exhibit small-scale variation because of the compressed nature of the variations and the resolution imposed by the scale of the investigation.

The bulk compositions and silicate mineralogy of the three reef types are also different. The Merensky Reef in the thin reef type is modally a norite containing on average 21.2% MgO (Std. Dev. 2.0%), that for thick reef type is a feldspathic pyroxenite containing on average 23.2% MgO (Std. Dev. 0.9%), and the intermediate reef type is an olivine bearing feldspathic pyroxenite containing on average 25.5% MgO (Std. Dev. 2.3%). This suggests that the liquids which formed the different reef types were not identical, a concept supported by the REE and trace elements in primary minerals.

In addition, the intermediate reef type has a characteristic Harrisitic texture of coarse-grained skeletal olivine (Fig. 2) which indicates a state of supersaturation for that environment compared with the other reef types. The reef types may have been derived from distinctly different liquids and without implying that one reef gradually migrated to the next type. This study indicates that the change from one reef type to the next occurs over a very narrow lateral interval. Therefore the term 'facies', commonly used in describing Merensky reef is not considered appropriate for this area. The evidence also tentatively supports suggestions that the Merensky Reef formed from a unique magma of variable composition and abnormally enriched in PGE.

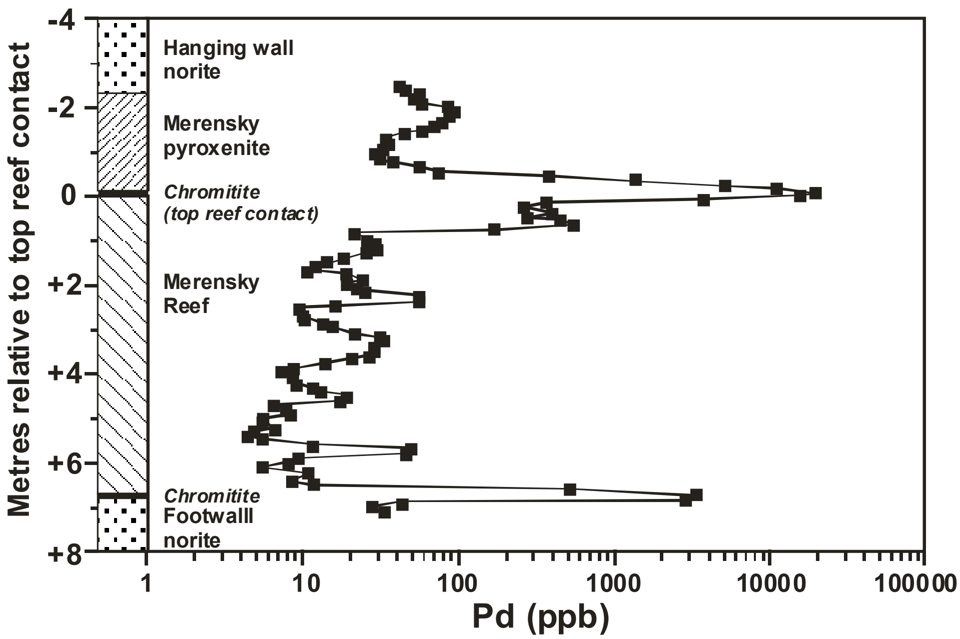

Figure 1. *Variation of Pd concentrations through the thick reef type. Positions (metres) shown relative to the top-reef chromitite layer.*

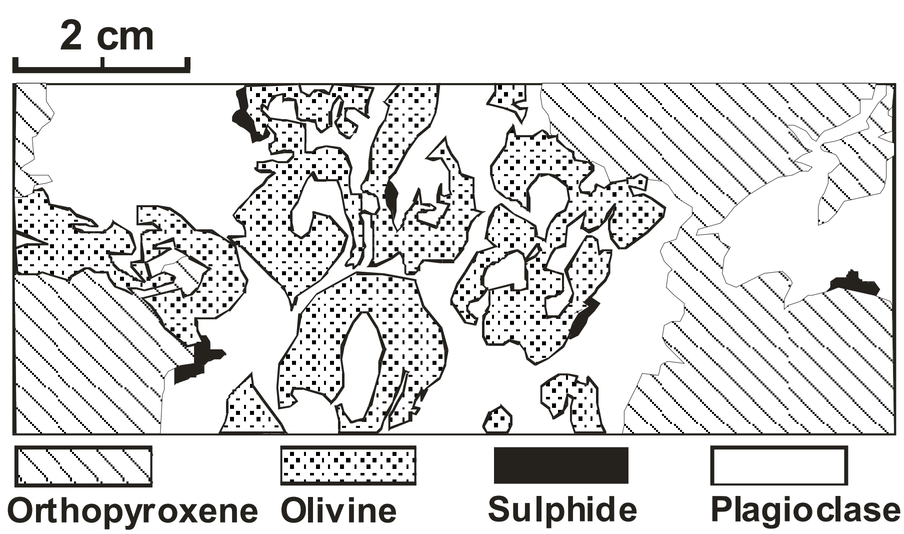

Figure 2. *Textural relations in intermediate type Merensky Reef showing Harrisitic or skeletal olivine crystals traced from polished core*