The Henderson Reef in the Dennilton Dome and Mineral Range Areas - A Homologue of the Platreef

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Introduction

The mafic layered suite of the Bushveld Complex comprises three major sequences of rock. These are the combined Lower and Critical Zones dominated by a sequence of dunites, harzburgites, orthopyroxenites, norites and anorthosites with major chromitite layers. These rocks occur in the eastern and western "lobes" of the complex, and are insignificant in the northern lobe. The Main Zone which was initiated with the formation of the Merensky reef is gabbronoritic in nature occurs in the eastern and western lobes and also in the northern lobe. The "Platreef" represents the interaction of the Main Zone magma with the floor rocks in this area as the chamber expanded northward, and is correlated with the Merensky reef.

In this work, the geology and geochemistry is described in view of the available literature (the thesis of SP Crous (1995); unpublished report on the "Loskop Mineral Field" by Borchers and others (1960), as well as the new field, petrographic, geochemical and isotopic data.

The Mineral Range area is unusual in a number of respects when compared with other apparently similar parts of the Bushveld Complex. The rocks in this area have diagnostic Lower Main Zone geochemical, isotopic and silicate mineralogical characteristics, but there is a significant quantity of (Fe-rich) chromitite, which in such copious quantities is usually considered diagnostic of the Critical Zone. This unusual conflux of properties implies exceptional conditions during the influx and interaction of the new Main Zone liquid and the residual Critical Zone liquid in the chamber. Furthermore, the mafic rocks (and country rocks) contain an unusually high abundance of accessory disseminated sulphide and concentration of these may result in PGE enriched Cu-Ni-Co-BMS mineralization.

The Steelpoort fault and some subsidiary faults transect the area and as this has had a profound effect on the development of the Bushveld Complex and may have acted as a conduit for magmas. Given the high sulphur and the unusually high chromite content of the rocks, a possible feeder related to the Steelpoort fault is a possibility, and location of a feeder zone may hold important economic potential.

The Main Zone rocks dip steeply to the southeast and are intimately associated and interdigitated with the floor rocks of the area. In contrast the Upper Zone rocks appear to be nearly flat-lying and appear to form a "moat"-like feature wrapping around the Main Zone. The Upper Zone – Main Zone boundary is clearly discordant with respect to the Main Zone and this implies that the Mineral Range fragment acquired its present form prior to intrusion of the Upper Zone. The Steelpoort fault zone appears to have been active throughout the development of the Main Zone, but was quiescent during the intrusion and evolution of the Upper Zone.

In this work, this little studied and structurally complex area is shown to comprise Main Zone rocks with an unusual mixed "Platreef" like unit at the base here named the "Henderson Member" or reef. The Henderson Member is situated in the same relative stratigraphic position as the "Platreef" in the Potgietersrust area and is considered a homologue.

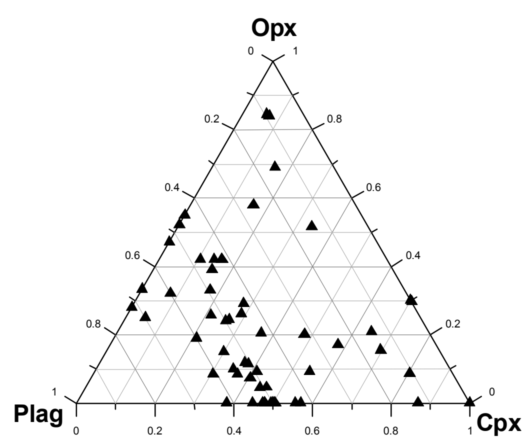

Figure 1. *Plag-Opx-Cpx triangular diagram showing the extreme petrographic variability in the Henderson member (reef), indicative of disequilibrium conditions during the Main Zone magma intrusion and interaction.*

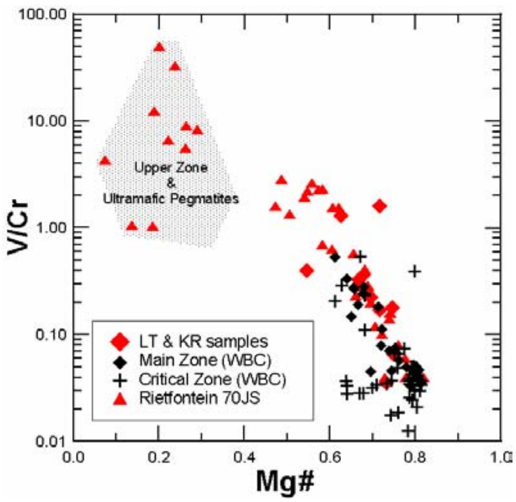

Figure 2. *The Mg #. vs. V/Cr Rocks of the different zones are clearly differentiated in this plot which tracks the mafic phases, and is insensitive to the precipitation and abundance of plagioclase.*

The Henderson "reef"

The Henderson Reef is named for Mr. C. McC. Henderson who led prospecting activity in this area after 1905. In 1908, a sample taken from the discovery chromiferous site on Laagersdrift, assayed *c.* 3.6g/tonne PGE over 1.5 m. This was the first reported discovery of substantial amounts of platinum group metals in the Bushveld Complex some sixteen years before the discovery of the Merensky Reef, and thus of great historical significance.

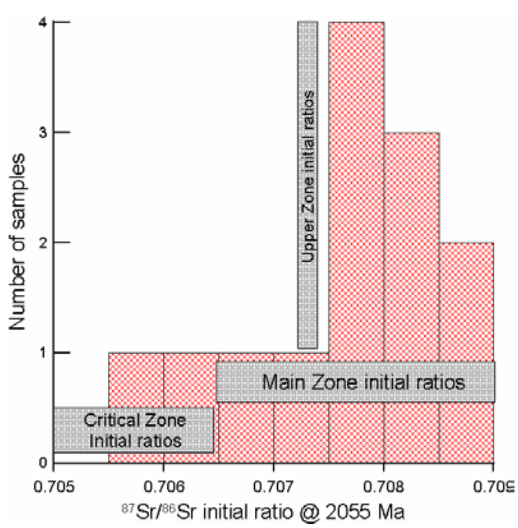

Figure 3. *Histogram of the Initial ratio at 2.05 Ga. The Mineral Range samples clearly dominantly fall in the Main Zone field defined elsewhere in the Bushveld Complex, and are not Critical Zone.*

The Henderson reef comprises a mixed, highly diverse set of rocks which are dominantly gabbronoritic but range between clinopyroxenite, ortho-pyroxenite and anorthosite (Fig. 1), and also contain shlieren of country rocks. Chromite and sulphide occur in a similar way to the chromite in the Platreef area. These rocks are capped by a chromitite layer associated with which are rounded tennisball-sized concentrations of pyroxene in an anorthositic matrix usually referred to as the "tennisball marker" or TBM. Higher in the stratigraphy, these mixed rocks give way to more normal gabbronoritic Main Zone lithologies.

Given the unusual juxtaposition of chromitite and gabbronorite with abundant clinopyroxene and the presence of mottled anorthosite in the succession, the chromitite must be compared with the UG1, UG2 and the Merensky and Bastard cyclic unit chromitites. From the available data the chromitite layers in the Mineral Range area have affinities to the chromite in the Main Zone at the base of the Bastard cyclic unit. This coupled with the geochemical data discussed below indicates a Main Zone character for these rocks and implies very unusual conditions.

Ratios of V, Cr, Sc, Co and Ni are quite sensitive indicators of fractionation involving mafic minerals. In this work the V/Cr ratio is used and is plotted against the Mg# in Fig. 2. The V/Cr ratio spans 4 orders of magnitude and clearly differentiates the different zones in the Bushveld Complex.

Initial ^{87}Sr/^{86}Sr isotope ratios have proven to be diagnostic of different zones in the Bushveld Complex. A histogram of the available Sr-isotope data (Fig. 3) clearly shows the Main Zone character of the bulk of the samples.

A Schematic Geological Model

Given the structural and other complexity, a geological model can only be sketched in broad terms. It is clear that the Steelpoort fault had a significant influence on these rocks and may be the feeder zone. The sequence of events is sketched in Fig. 4.

In perusing the available maps of the area it is clear that the "Mineral Range Fragment" duplicates much of the stratigraphy of the Dennilton dome to the NW. and that the layered and incalcated sedimentary rocks dip steeply to the east and to the south. The igneous rocks in contact with the floor sediments and interdigitating with them appear to be dominated by Main Zone lithologies. The other lithologies are those of the Upper Zone and where dip measurements are available these rocks appear to be almost flat lying to the north and east. This is emphasized by the attitude of the Rooiberg Felsites and granophyres which are also flat lying in the northern part of the area.

Therefore, at the intrusive magmatic stage the felsites formed a flat roof that floated on top of the mafic magmas, and the flat dips measured now are those of the Upper Zone at the time of solidification.

These first order observations imply that the rise of the Dennilton Dome and the Mineral Range fragment occurred during and after the intrusion of the magmas. In turn, this implies that the Main Zone magmas intruded and interacted with the country rocks to form the Henderson reef prior to the rise of the domes. These rocks crystallized in a flat position, but then started to deform and dome upward when the Upper Zone intruded. The Upper Zone magmas formed a moat-like body around the rising Dennilton Dome and the Mineral Range Fragment. Therefore the dips of the Upper Zone rocks are not the same as those of the Main Zone. Clearly this would have resulted in transgressive or onlap relationships between the Main and Upper Zones. Furthermore, sills and dykes of Upper Zone magma may transgress and intrude the pre-existing Main Zone cumulates in an interdigitating fashion.

The Mineral Range area is structurally complex, and only a few first order observations can be made without the benefit of more extensive mapping and sampling. It is clear that much of the structural complexity can be attributed to syn-intrusion updoming and movement along the Steelpoort Fault lineament, which is downthrown to the west. This loading apparently left the Upper Zone rocks to the north and east of Mineral Range flat-lying and relatively undisturbed, suggesting that these rocks are in their original flat position and oblique to the Main Zone rocks.

Conclusions

New data and interpretation of the rocks in the Mineral Range area show that this is an unusual but very important exposure of the Bushveld Complex that gives insight into the intrusion and evolution of the Main and Upper Zones not available elsewhere. The main conclusions are as follows:

a) There are no significant Critical Zone rocks in the area, despite the presence of chromitite.

b) The presence of thick chromite layers implies close proximity to a feeder to the Main Zone interpreted to be focussed on the Steelpoort Fault.

c) The rocks of the Henderson Reef are homologous with the Platreef in the Potgietersrust area.

d) The Upper Zone is a later discordant intrusion with little deformation evident in this area.

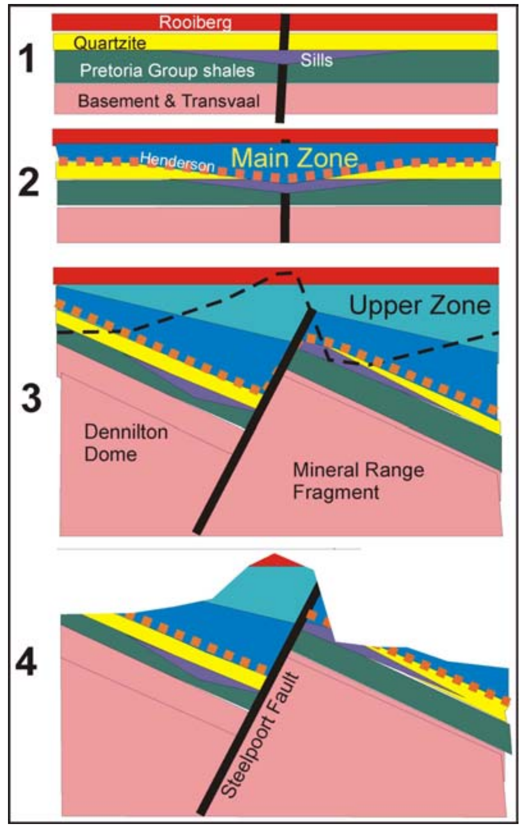

Figure 4. *Stages in the development of the Mineral range area (an approximately NW-SE section). 1. Intrusion of a sill phase of Lower and Critical Zone affinity. 2. Expansion of the Main Zone into this area with the development of the "Henderson reef" homologue of the Platreef along the base. Deformation starts and the domes and fragment rise and tilt. 3. The Upper Zone magmas intrude and surround the domes. There is little further deformation, and the overlying Rooiberg rocks remain flat lying. 4. Erosion to give the current outcrop pattern.*

References

Crous, S.P. (1995) The geology, geochemistry and stratigraphic correlations of the farm Rietfontein 70JS on the south-eastern flank of the Dennilton Dome, Transvaal, South Africa. MSc dissertation, Rhodes Univ. Grahamstown.