

## CHAPTER ONE: INTRODUCTION

### 1.1 Introduction and Aims

The Platreef is a platinum group element (PGE) and base metal enriched mafic ultramafic layer situated along the base of the northern (Potgietersrus) limb of the Bushveld Complex (Fig. 1.1). It represents an important resource of PGE, estimated by Vermaak (1995) to contain 6581 tonnes of PGE to a depth of 1200 m, which is only in its early stages of exploitation.

In addition to the northern limb, basal PGE mineralisation of a similar type to that found in the Platreef has recently been described from the Mineral Range (Sharpe et al. 2002). In the remainder of the Complex, basal PGE mineralisation appears to be absent. Past workers have proposed that this is due to the fact that the floor rocks to most of the eastern and western limbs of the Bushveld Complex are constituted by relatively refractory quartzites. In contrast, in the northern limb, the floor rocks show more lithological variation, including shale, ironstone, dolomite, and granite gneiss. These lithologies are believed to be more reactive when in contact with magma (e.g. de Waal, 1977). The assimilation of country rock material by the magma is generally thought to be important in the formation of magmatic sulphides (e.g. Gain and Mostert, 1982; Buchanan and Rouse, 1984; Barton et al. 1986; Buchanan, 1988). However, the precise mechanism that may have triggered the sulphide segregation remains unclear. For example, de Waal (1977) proposed that devolatilization of the dolomite may increase the O fugacity of the magma, thereby decreasing the activity of  $Fe^{2+}$  and decreasing S solubility. Alternatively, sulphide segregation could have been triggered by assimilation of S from the floor rocks.

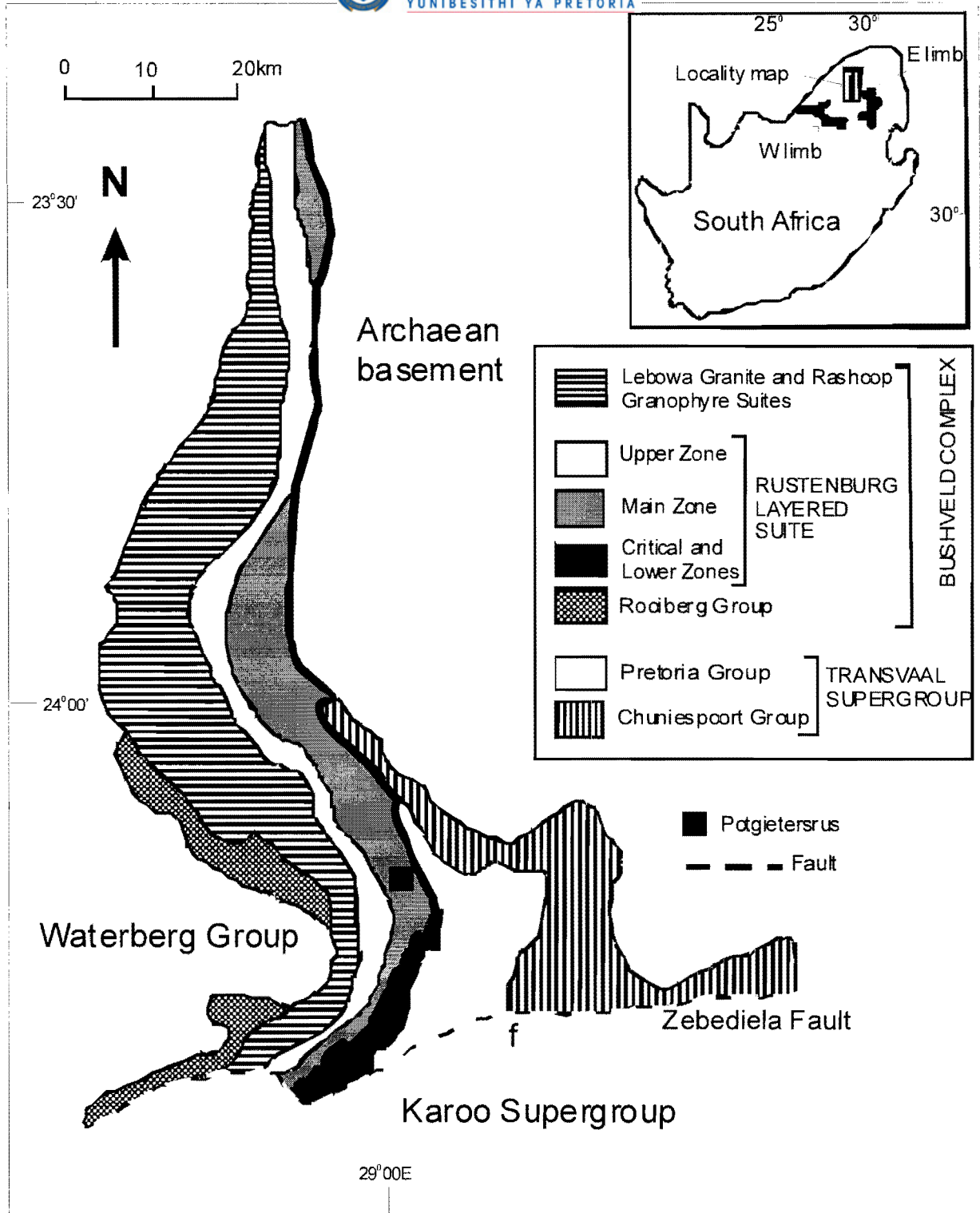


Figure 1.1: Geological map of the Potgietersrus limb of the Bushveld Complex. Thick black line, running north from Potgietersrus, represents the trace of the Platreef. Insert shows the outcrop of the Rustenburg Layered Suite in Southern Africa (modified after Harris and Chaumba, 2001).

Some authors (Lee, 1996) proposed that the Platreef sulphides segregated in a staging chamber at depth and were entrained by the ascending Critical Zone silicate magma.

One of the main problems in constraining the mechanism of mineralization is that there have been few quantitative studies of noble metal concentrations in the Platreef rocks. The most comprehensive description of the mineralization so far has been published by Viljoen and Schurmann (1998). Maier (2003; submitted) presented Pt, Pd, Cu and Ni contents of the Platreef on the farm Townlands (Fig. 1.2). Armitage et al. (2002) published more complete noble metal data from 13 Platreef samples at Sandsloot, some 30km to the north of Potgietersrus. The scarcity of data make it difficult to judge whether there is any regional variation in metal tenors and whether such variation, if present, can be correlated to lithological and chemical variation of the floor rocks. The present study was initiated to address this scarcity of data, and to thereby constrain the genesis of the mineralization. In particular, I provide

- i) a detailed lithological and petrographical description of the Platreef as exposed in a 200 m borehole core intersection on the farm Townlands (Fig. 1.2),
- ii) new major and trace element data, including concentrations of the noble metals.

## **1.2 General geology**

The Platreef consists of an up to 250 m thick package of texturally heterogeneous pyroxenite, norite and gabbro, containing numerous xenoliths of metadolomite, calcsilicate and shale derived from the floor rocks. The xenoliths range from several

cm to 100 m in diameter. The reef is overlain by a thick (up to 2000 m) package of gabbro, magnetite gabbro and diorite belonging to the Rustenburg Layered Suite. Buchanan et al. (1981) correlated the Platreef with the Critical Zone, the overlying gabbro with the Main Zone, and the magnetite gabbro and diorite that may contain up to ca. 20 layers of massive magnetite with the Upper Zone (Fig. 1.3). The intrusion transgresses the floor rocks of the Transvaal Supergroup, to the south of Potgietersrus, the reef overlies the Magaliesberg Quartzite Formation, but towards the north, it rests on progressively lower portions of the Pretoria Group and finally on the Achaean granite-gneiss basement.

Detailed descriptions of the lateral extension of the Platreef are lacking. Viljoen and Schurmann (1998) and White (1994) report that the well mineralised sectors of the Platreef extend about 35 km northwards from the farm Townlands to the farm Drenthe, but unconfirmed reports from various exploration companies suggest that the Platreef is developed along most of the base of the northern limb of the Complex, albeit in variable thickness. The average dip of the Platreef is  $\sim 40^\circ$  to the southwest.

The Platreef has been interpreted as the local equivalent of the Merensky reef (Wagner 1929, White 1994). Significant differences, however, exist between the Platreef and the Merensky reef as exposed in the western and eastern lobes of the Complex (e.g. Van der Merwe, 1976; Buchanan et al., 1981; Cawthorn et al., 1985; Eales & Cawthorn, 1996). Firstly, the Merensky reef tends to occur within the layered sequence, in many instances some 2 km above the floor of the Bushveld Complex, whereas the Platreef overlies the floor of the complex (Fig. 1.3). Secondly, the mineralized interval is much thicker in the Platreef than in the Merensky reef (up to

200m versus ca 1m). Thirdly, there are signs of compositional differences between the two layers, e.g. a relatively higher crustal signature and lower metal tenors (e.g. Buchanan et al. 1981, Barnes and Maier, 2002) in the Platreef relative to the Merensky reef.

### **1.3 Methodology**

Fourty samples of quarter borehole core, 10-30 cm in length, from borehole TL01-3 (Fig. 1.2) were selected for detailed study. Polished thin sections were prepared for all 40 samples. The modal proportions of mineral phases were estimated by point counting, where samples were relatively unaltered. Thirty two samples were pulverised using a C-steel jaw-crusher and a C-steel milling vessel. The samples were analysed for major and trace elements by X-ray fluorescence spectroscopy (XRF) at the University of Pretoria. The PGE concentrations were determined at the University of Quebec at Chicoutimi, Canada by Ni-sulphide fire assay followed by INAA. The compositions of selected minerals were determined by electron microprobe at Rhodes University, South Africa. Sulphur isotope analyses on selected samples were done at the University of Indiana, U.S.A. All analytical details are given in Appendix 1.

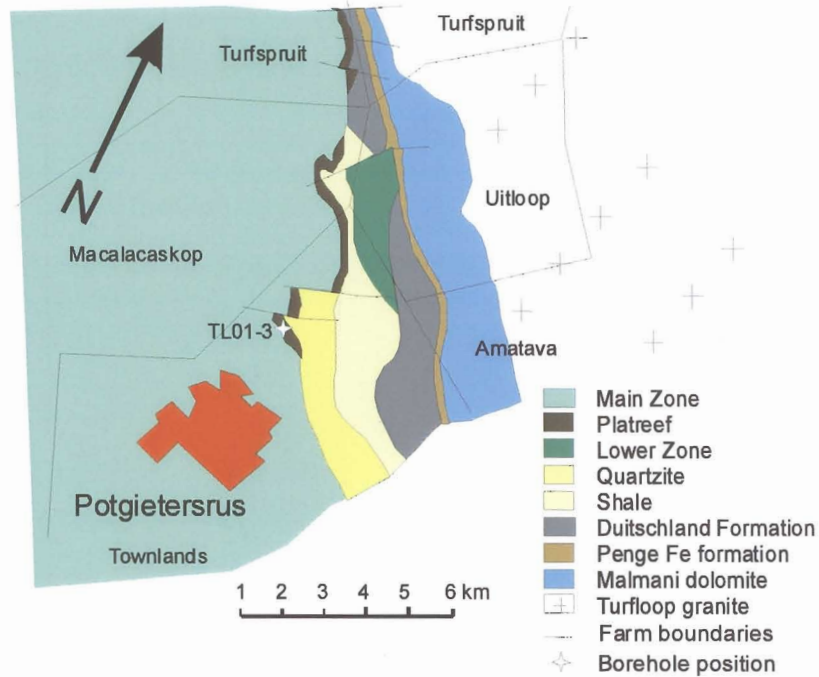


Fig. 1.2: Geological map of the Platreef on the farm Townlands and the position of the borehole TL01-3.

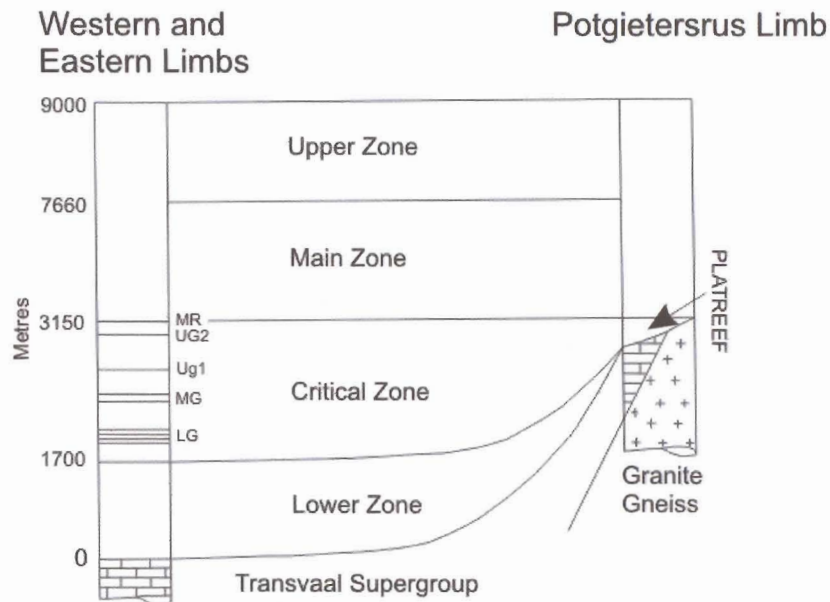


Fig. 1.3: Schematic section through the Rustenburg Layered Suite in different limbs of the Bushveld Complex (from Cawthorn et al. 2002). Lateral correlation after Buchanan et al. (1981).

#### 1.4 Previous work

The first report on the occurrence of platinum in the northern limb was made in 1923 by a prospector named A. Erasmus, referring to a farm 31 km southwest of Potgietersrus (White, 1994). Wagner (1929) provided the first descriptions of the Platreef during platinum-mining operations in the 1920s. He correlated the variably sulphide mineralised, composite rocks forming the floor rocks of the Bushveld Complex in the northern limb with the Merensky reef. Wagner described three distinct layers, which Buchanan (1979) later referred to as the A, B and C units (or reefs), from the base to the top, based on texture and mineral mode. The 'A' reef may contain finely disseminated sulphides and, commonly, larger blebs (up to 3 cm) of composite base metal sulphides (BMS) (Buchanan and Rouse, 1984; Buchanan, 1988; White, 1994). The 'B' reef generally has the largest amount of disseminated base metal sulphides (White, 1994), whilst the 'C' reef is usually barren of PGE mineralisation.

Other studies of the Platreef have emphasized the abundance of xenoliths of metasediments and dolomite in the rocks. Buchanan et al. (1981) proposed that the Platreef sequence on Tweefontein reflects the assimilation of anhydrite-bearing Malmani dolomite, banded ironstone, argillaceous sediments, and micronoritic sills by Bushveld magma. They conducted S isotopic studies on sulphides from the Platreef and suggested that the anhydrite-bearing dolomite reacted with the Platreef magma releasing sulphur which resulted in the precipitation of an immiscible sulphide liquid. In contrast, de Waal (1977) and Gain and Mostert (1982), the latter authors working on the farm Drenthe, north of Potgietersrus, prefer a mechanism whereby the

Bushveld magma was oxidized in response to devolatilization of the dolomite. The devolatilisation released  $H_2O$ ,  $CO_2$  and S into the magma thereby changing the physicochemical parameters of the magma leading to a decrease in sulphur solubility and triggering sulphide supersaturation.

Regional trends in the platinum-group mineralogy of the Critical Zone of the Bushveld Complex (hosting the Platreef) were investigated by Kinloch (1982). The author reported that unlike the Merensky reef and UG-2 chromitite, the Platreef on the farm Zwartfontein is depleted in laurite ( $RuS_2$ ). This was attributed to the metamorphism of dolomite floor rocks and xenoliths by the Platreef magma releasing  $CO_2$  which volatilises Ru.

Cawthorn et al. (1985) presented major element, trace element and Sr isotope data of the Platreef on the farm Overysel. Here, the immediate floor rocks consist of a suite of highly metamorphosed, banded tonalitic gneisses with leucotonalitic veins. Through isotope and trace element modeling, the workers suggested that the immediate floor rocks cannot be the source of contamination. Instead, the contaminant was the partial melt derived from granites that intruded the metamorphosed floor rocks of the Transvaal Sequence to the south.

White (1994) provided a description of the Platreef at several localities. He reported that the pyroxenite of the B reef has virtually no olivine and that the PGE grades in the Platreef are dependent on the floor rocks. PGE grades are relatively higher where the floor rocks consist of dolomite, but relatively lower where they consist of granite,



iron-formation or shale. A chromitite layer was intersected by drilling on the northern portion of Tweefontein, where floor rocks are banded iron formation and hornfels. The sulphides were thought to have segregated due to a decrease in S solubility in response to a decrease in FeO content of the silicate magma as a result of chromite formation.

*In situ* formation of the Platreef sulphides was rejected by Lee (1996) who instead proposed that the sulphides segregated in a staging chamber at depth and were entrained by the ascending Platreef magma.

Viljoen and Schurmann (1998) produced a detailed summary of the available data on the Platreef, including information on geology, mineralogy and theories of ore genesis.

Harris and Chaumba (2001) conducted a detailed major and trace element investigation as well as S and O isotopic study of the Platreef at Sandsloot. They found evidence for local contamination of Bushveld magma by dolomite, but in addition they suggest a component of contamination that occurred in a staging chamber.

Armitage et al. (2002) studied the PGE mineralisation in the Platreef at Sandsloot platinum mine and provided an account of the PGE and Au concentrations, and the nature of the PGM. Notably, at this locality, disseminated and vein-type PGE mineralisation is found up to several meters within the sedimentary floor rocks, below

the basal contact of the intrusion. From SEM studies of four polished samples, the authors report the complete absence of PGE sulphides and the existence of low-temperature semi-metallides and alloys and their high-temperature equivalents. The authors also report that PGE signatures in the intrusion and its footwall are broadly similar pointing to similar processes controlling or influencing the final PGE distribution in the two packages. Based on the above and the widespread evidence for fluid activity, the authors favour hydrothermal activity as the major process that influenced the final distribution of the PGE in the rocks.