

**THE SURFACE GEOLOGY  
OF THE LAVINO CHROME MINE  
on the farm GROOTBOOM 336KT,  
Eastern Transvaal**

**THESIS**

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by

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## ABSTRACT

A mapping project of the surface geology of the Lavino chrome mine and its surroundings was initiated in order to establish the surface geological relationships in the area. In so doing the chromitite layer presently being mined has been identified and potential exploration targets in the area have been outlined.

The Lavino Chrome mine field area is situated within the eastern lobe of the Bushveld Igneous Complex. The area is bounded by in the north by the Steelpoort Lineament, in the west by the Dwars River fault and in the east by the contact with the Transvaal Sequence floor rocks. Layered igneous rocks (pyroxenites, norites and anorthosites) of the Rustenburg Layered Suite dominate the geological landscape at the Lavino mine. The fact that outcropping igneous rocks of the Critical Zone abut directly against the quartzite floor rocks on the mine property makes this area unique in the Bushveld Complex. The hills in the field area are capped by mafic/ultramafic iron-rich sheet-like bodies. Extensive strike-slip faulting is seen in outcrop in the area to the north/northwest of present mining operations.

On the basis of field relationships, the main chromitite layer presently being mined at Lavino is identified as the Middle Group chromitite layer MG 1. Three other prominent chromitite layers stratigraphically associated with MG 1 are identified as the Middle Group chromitites MG 2, MG 3 and MG 4. Several other less prominent outcropping chromitite layers are tentatively identified as those belonging to the Lower and Upper group of chromitites.

The disconformable nature of the contact between the layered igneous rocks and the Transvaal Sequence floor rocks has resulted in the development of a wedge of undifferentiated pyroxenites in the north of the field area. The economically important LG 6 chromitite layer may be developed in subcrop within this wedge.

# TABLE OF CONTENTS

1. INTRODUCTION
2. BACKGROUND TO THE LAVINO MINE
3. OBJECTIVES OF THE LAVINO MINE RESEARCH PROJECT
4. GEOLOGICAL MAPPING STRATEGY
5. GEOLOGY OF THE GROOTBOOM FARM
  - 5.1. A REGIONAL GEOLOGICAL PERSPECTIVE
  - 5.2. THE MAIN GEOLOGICAL FEATURES OF THE GROOTBOOM FARM
  - 5.3. CHROMITITE LAYER STRATIGRAPHY ON THE GROOTBOOM FARM
6. PRECIOUS AND FERROUS METAL MINERALISATION ON THE GROOTBOOM FARM:  
IMPLICATIONS TO THE MINING INDUSTRY
  - 6.1. CHROMITE ORE BODIES
    - 6.1.1. MINING OPERATIONS ON THE MIDDLE GROUP 1 CHROMITITE  
LAYER
    - 6.1.2. EXPLORATION FOR THE LOWER GROUP 6 CHROMITITE LAYER

## 6.2. PLATINUM GROUP METALS MINERALISATION

### 6.2.1. THE MERENSKY REEF

### 6.2.2. THE MIDDLE GROUP CHROMITITE LAYERS

### 6.2.3. THE UPPER GROUP 2 CHROMITITE LAYER

## 6.3. THE MAFIC / ULTRAMAFIC IRON-RICH BODIES

## 7. CONCLUSIONS

## 8. BIBLIOGRAPHY

## LIST OF ILLUSTRATIONS

- FIGURE 1. A : PROVISIONAL GEOLOGICAL MAP - LAVINO CHROME  
MINE : GROOTBOOM 336 KT
- B : SCHEMATIC CROSS-SECTIONS THROUGH POINTS  
A - B AND C - D OF FIGURE 1A
- C : LOCALITY MAP OF THE GROOTBOOM FARM
- FIGURE 2 : STRUCTURAL MAP OF THE GROOTBOOM FARM SHOWING  
THE DIP AND STRIKE OF THE IGNEOUS LAYERING  
RELATIVE TO THE CONTACT WITH THE FLOOR
- FIGURE 4. : REFERENCE AND GENERALISED LITHOSTRATIGRAPHIC  
SECTIONS OF THE LAVINO MINE
- FIGURE 5.1. : MAP SHOWING THE OUTLINE OF THE RUSTENBURG LAYERED  
SUITE
- FIGURE 5.2. : MAP SHOWING THE REGIONAL GEOLOGICAL FEATURES OF  
THE EASTERN LOBE OF THE RUSTENBURG LAYERED SUITE
- FIGURE 5.3. : SCHEMATIC CROSS-SECTIONS SHOWING THE VARIATION IN  
THICKNESS ALONG STRIKE OF THE MG1 CHROMITITE LAYER.

## PREFACE

The author would like to thank Anglovaal Ltd for allowing him access to the Lavino mine property and for assisting him with the logistical side of the mapping project. The author would also like to acknowledge the enthusiastic support of his wife Sharlene and the assistance and invaluable advice of Dr A.R. Butcher during the course of the project.

## 1. INTRODUCTION

This report accompanies the provisional geological map of the surface geology of the Lavino Chrome Mine on the Grootboom Farm (Fig 1.). The report provides a general background to the mapping project, summarises the main surface geological features of the Lavino Mine and briefly discusses some of the implications that these features may have on future mining operations and exploration strategies in the area.

## 2. BACKGROUND TO THE LAVINO MINE

A chrome mine was first established on Grootboom 336KT in 1956 by Lavino S.A. Ltd. The mine was subsequently passed through several owners including International Minerals and Chemicals (IMC) of New York, and Applied Industrial Minerals Corporation (AIMCOR) of Illinois. In 1989, AIMCOR sold the Grootboom Chrome Mine (now Lavino Mine) to Anglovaal Ltd.

Updip mining methods have been employed in order to exploit the main (# 1) chromitite layer on the Grootboom Farm. In this manner, nine levels have been worked above surface and three below the surface. The mine produces about 400 000 ton/year, about half of which is lumpy chrome ore. The remainder is in the form of fines and a small quantity of foundry sand. The chrome ore has a chrome-iron ratio of 1.5 : 1 and comprises 41% chromic oxide and 8% silica.

### 3. OBJECTIVES OF THE LAVINO MINE RESEARCH PROJECT

At the time when Anglovaal Ltd acquired the Lavino Chrome Mine, the little local geological information that was available could have been summarised in one sentence - "chrome seams outcropping over two hills separated by a dyke" (Chromium Review, 1990). This was despite some thirty years of previous mining operations and was probably due to the fact that mining was largely constrained to an area where the chrome layers were generally of consistent thickness and showed little, if any, structural complexity.

With the planned expansion of Anglovaal's mining operations on the Grootboom Farm, it became clear that the company would benefit from a thorough understanding of the geology of the mine. An aeromagnetic geophysical survey recently flown by Anglovaal on the Grootboom property gave inconclusive results due to the large number of geological unknowns present.

The primary objectives of the mapping project were three-fold;

1. to investigate the local field relationships of the Rustenburg Layered Suite and in so doing to :
  - a. determine the three-dimensional nature of the igneous layering;
  - b. positively identify the dominant chromitite layers.

2. to determine the nature of the contact between the floor rocks and the Rustenburg Layered Suite.
3. identify potential exploration targets in the field area.

#### 4. GEOLOGICAL MAPPING STRATEGY

In accordance with the limits set out by Rhodes University, the mapping project and accompanying report were time-constrained to a period of ten weeks.

The first task was to establish a reference lithostratigraphic section to be used for the positive identification of the chromitite layers exposed at surface. The chromitite and silicate layers in the 10 level adit (at right angles to the strike of the igneous layering) were used for this purpose (Fig 4.1.).

An area of approximately  $10^2$  kilometres, with a range in altitude of more than 600 metres, was mapped using 1:5000 scale black and white orthophotographs. All outcropping chromitite layers were noted in detail and this information was then used for the construction of detailed lithostratigraphic logs (Fig 4.2.). Upon comparison of these field logs with the reference lithostratigraphic section, the individual chromitite layers were identified.

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 FIGURE 4.2: GENERALISED LITHOSTRATIGRAPHIC SECTION OF THE GROOTBOOM FARM

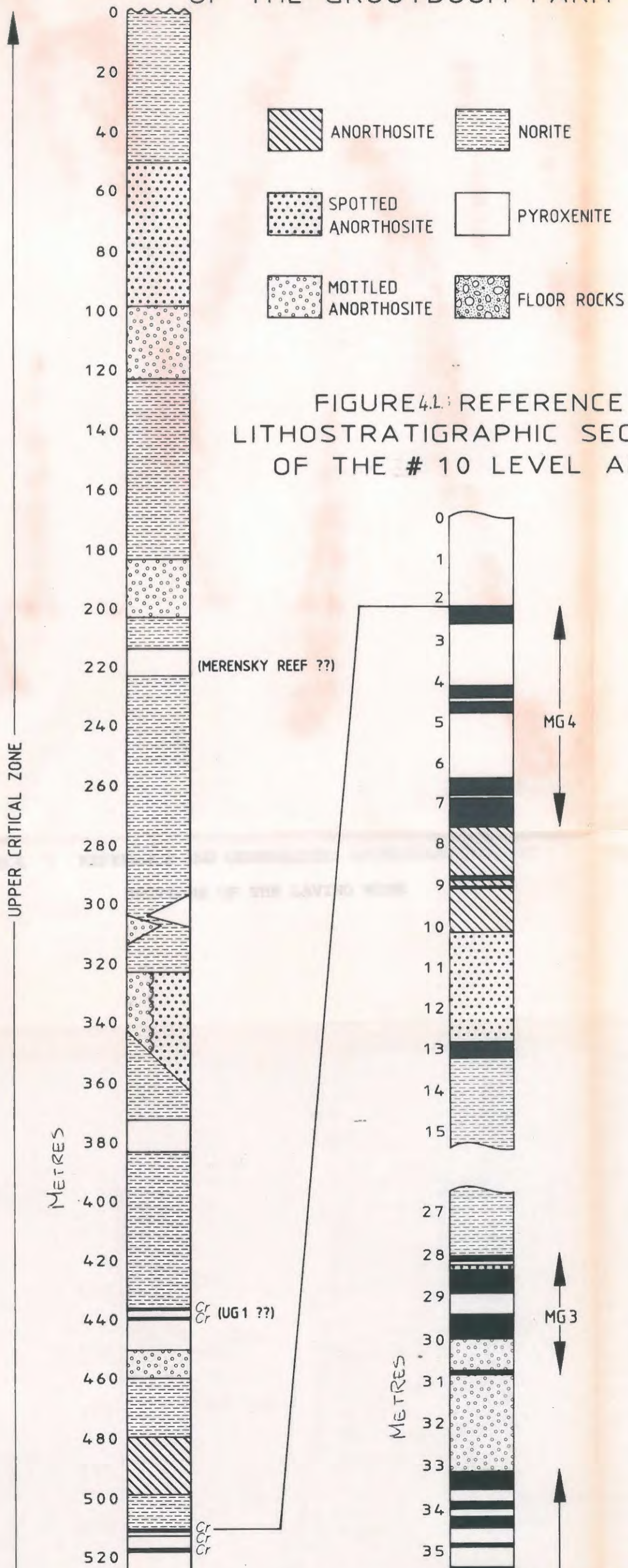
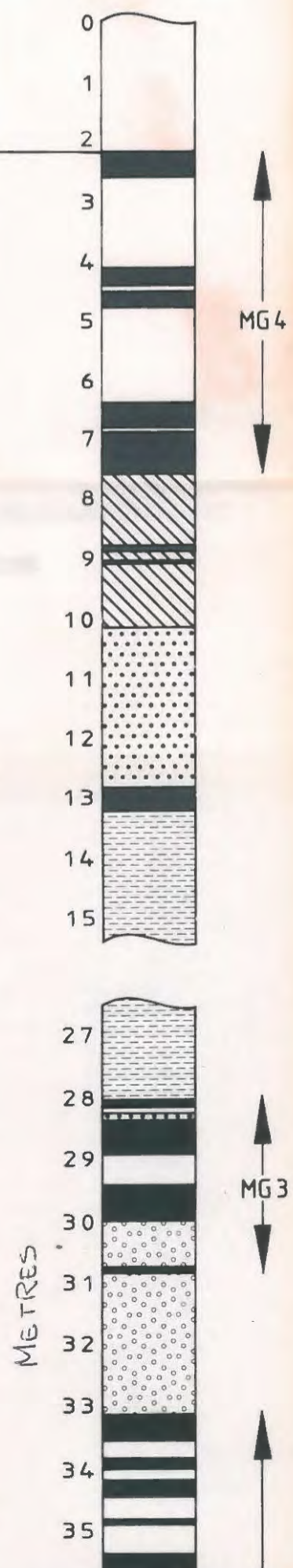
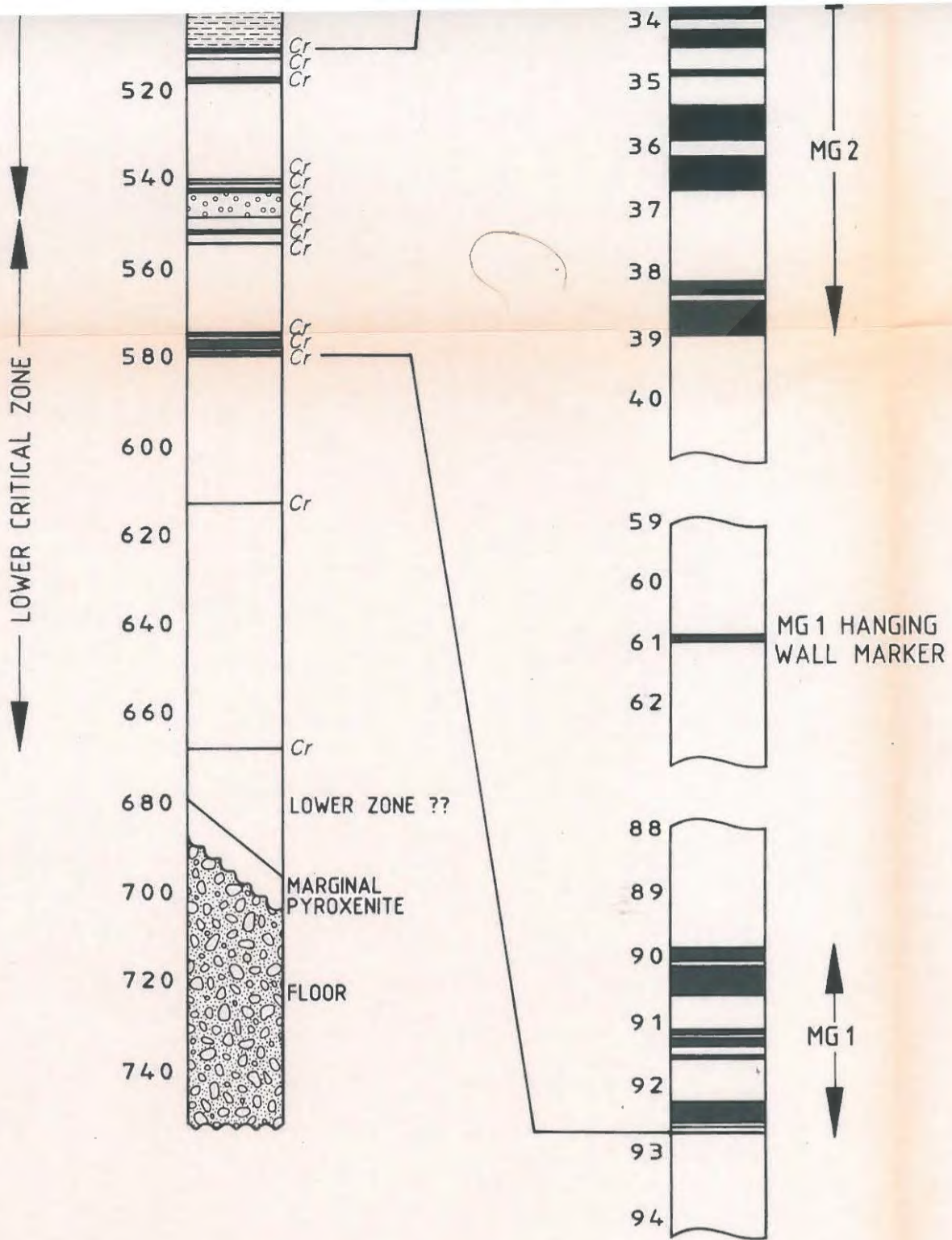


FIGURE 4.1: REFERENCE LITHOSTRATIGRAPHIC SECTION OF THE # 10 LEVEL ADIT





This information was then fed back into the daily compilation of the geological map.

The use of a stereograph with 1:20000 scale colour aerial photographs was employed in order to locate positive and negative topographical features in the area as an aid to the mapping exercise.

## 5. GEOLOGY OF THE GROOTBOOM FARM

### 5.1. A REGIONAL GEOLOGICAL PERSPECTIVE

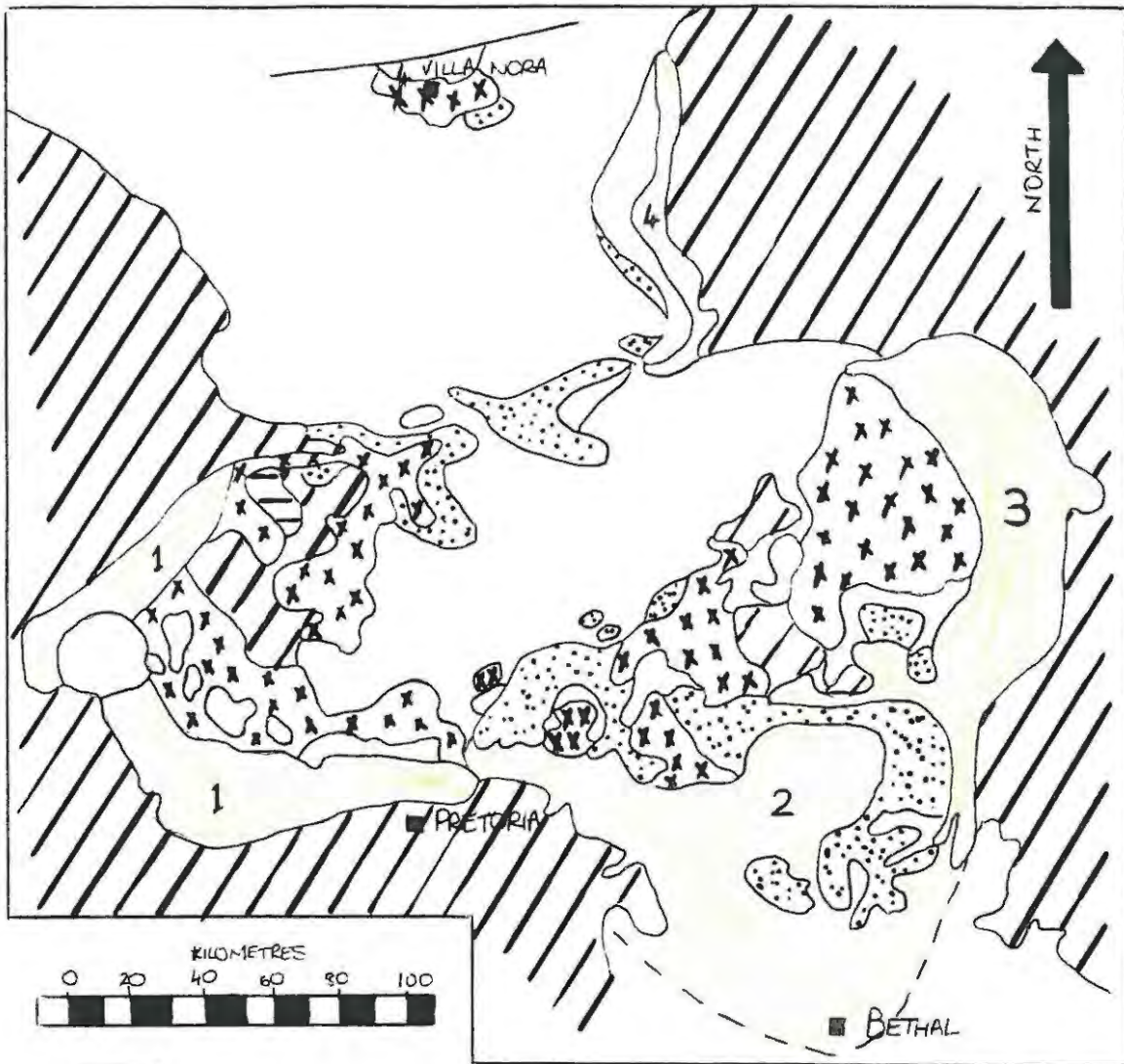
The local geology of the Grootboom farm is set within the regionally extensive Bushveld Igneous Complex and associated sedimentary host rocks. This igneous complex is unique in the world in terms of its size, mineralisation, igneous layering, and igneous cyclicity. The layered mafic / ultramafic rocks of the Bushveld Complex (the Rustenburg Layered Suite) are outlined or subdivided in outcrop into four major lobes or compartments (Fig 5.1.). These lobes are characterised by both gross similarities as well as by some significant differences.








The eastern lobe of the Rustenburg Layered Suite, of which the rocks on the Grootboom Farm are part, is typically well exposed in outcrop. This lobe extends from Zebediela in the north to Bethal in the south (Fig 5.2.). A prominent linear feature, the Steelpoort Lineament, cuts across the igneous

rocks with a north-east trend, effectively dividing the lobe into two sectors.

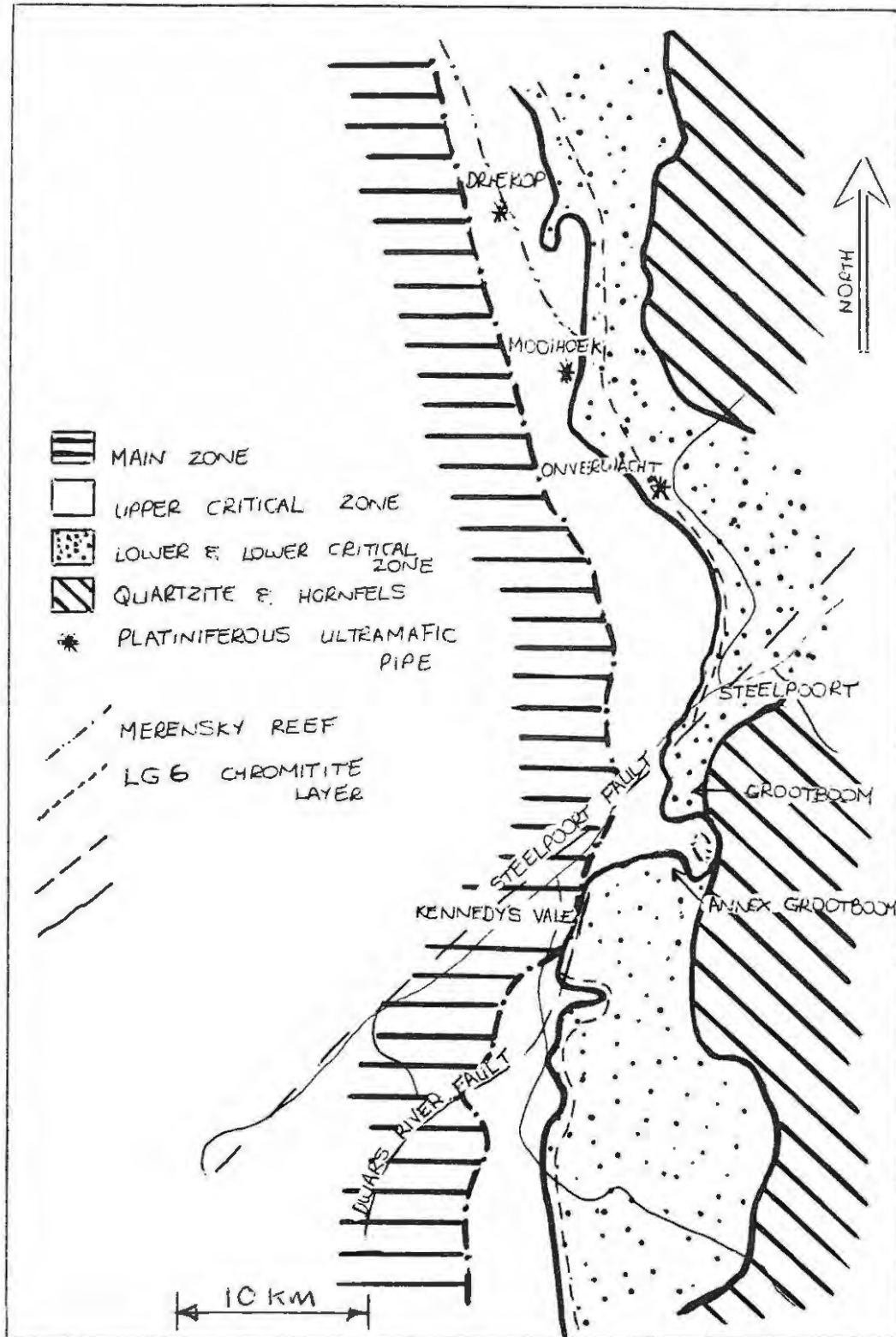
In the northern sector of the eastern lobe, a complete sequence of Lower, Lower Critical, Upper Critical, Main and Upper Zone rocks are developed. Several authors (Cameron, 1978; Sharpe and Chadwicke, 1982; and others) have identified the Lower Zone situated in trough-like regions within the floor of the Complex.

Prior to the completion of the mapping project, the Lower Zone had not been positively identified in the southern sector of the Eastern Lobe. However, it was recognised that the Lower Critical Zone abutted directly onto the Transvaal sequence floor rocks. The identification of the main chromitite layers on the Grootboom Farm remained inconclusive. The prominent LG6 chromitite layer, as is typical to the Winterveld Chrome Mine situated just to the north of the Steelpoort Lineament, does not occur to the south of this feature. This lack of continuity across the Steelpoort Lineament is difficult to quantify due to the thick surficial cover in the Steelpoort Valley.



-  YOUNGER ROCKS
  -  LEBOWA GRANITE SUITE
  -  RASHOOP GRANOPHYRE SUITE
  -  RUSTENBURG SUITE
  -  ROOIBERG FELSITE
  -  ROCKS OF TRANSVAAL SEQUENCE & OLDER
  -  - - - - INFERRED EXTENT OF MAFIC ROCKS (SHARPE, 1986)
- 1 - WESTERN LOBE
  - 2 - SOUTH-EASTERN LOBE
  - 3 - EASTERN LOBE
  - 4 - NORTHERN LOBE

**FIGURE 5.1.** : MAP SHOWING THE OUTLINE OF THE RUSTENBURG LAYERED SUITE



**FIGURE 5.2.** : MAP SHOWING THE REGIONAL GEOLOGICAL FEATURES OF THE EASTERN LOBE OF THE RUSTENBURG LAYERED SUITE (After Viljoen and Scoon, 1985)

## 5.2. THE MAIN GEOLOGICAL FEATURES OF THE GROOTBOOM FARM

The important geological features on the Grootboom Farm, as illustrated by figures 1 and 2, may be summarised as follows:

1. Layered pyroxenites, norites and anorthosites of the Rustenburg Layered Suite dominate the geological landscape of the farm. The extreme topography has resulted in a well exposed stratigraphic succession from the upper Lower Zone through to the Critical Zone.

2. The contact between the Rustenburg Layered Suite and the Transvaal Sequence floor rocks is well exposed in outcrop and is clearly visible on both the 1:5000 scale orthophotographs and the 1:10000 scale radiometric map of the Grootboom Farm. This contact is disconformable in that the layered igneous rocks generally have a shallower dip than the sedimentary floor rocks. Furthermore, the strike of the layered igneous rocks does not parallel the contact with the floor rocks. This disconformable relationship has resulted in the development of a wedge of undifferentiated (Lower Zone ?) pyroxenite in the north of the field area whilst the Critical Zone rocks abut against the floor rocks in the south.

3. The layered igneous rocks generally show a dip of between  $16^{\circ}$  and  $34^{\circ}$  towards the northeast, an attitude consistent with the regional geometry of the Rustenburg Layered Suite. This local dip is particularly so in the north of the field area (that area associated with the main mining operations), and in the south (around hill, trigonometric beacon #17). However, in the centre of the field area, specifically in the region towards the floor contact, the layered rocks exhibit highly irregular changes in attitude.

4. A marginal pyroxenite is developed at the contact between the floor rocks and the layered igneous rocks.

5. Mafic / ultramafic iron-rich bodies cap all the major hills on the farm. Field relationships suggest that these bodies are late-stage sheet-like intrusions; together the individual bodies may represent the eroded remnants of one, originally much larger, sheet. These iron-rich bodies are often pegmatitic and show a zonation pattern comprising an outer gabbroic sheath surrounding a core of magnetite-rich mafic material. In several outcrops a close relationship exists between chromitite layers and these late stage ? iron-rich bodies. This relationship may have important genetic implications and needs to be investigated further.

6. The Grootboom Farm is cut by several major semi-vertical dolerite dykes that trend northeast - southwest or north northeast - south southwest. These fine grained magnetite-rich dykes have a characteristically high magnetic signature.

7. In the Steelpoort Valley area of the Grootboom Farm, the layered rocks have been subjected to tectonic displacement resulting in a series of strike-slip faults in the region.

To the northwest of the present mining operations, the strike-slip faults strike north-east and north north-east, a trend that approximates the strike of the local dykes. Whilst the faulting in this area is extensive, the amount of displacement is difficult to measure due to the homogeneous nature of the rock (predominantly norites / anorthosites) and lack of any marker horizons

Strike-slip faults exposed in outcrop directly to the north of the mine strike in a northeast - southwest and north - south direction. Faulted chromitite layers within the pyroxenites of the Lower Critical Zone exposed in this area allow the amount of displacement to be measured. This displacement can be as much as 16 metres horizontally and more than 2 metres vertically.

Additional geological and geophysical research would be required before the relationship between these local

strike-slip faults and the regionally extensive Steelpoort Lineament and the Dwars River Fault could be assessed.

### 5.3. CHROMITITE LAYER STRATIGRAPHY ON THE GROOTBOOM FARM

It is well established (Hatton and Von Gruenewaldt, 1986; and others) that the first appearance of cumulus plagioclase is taken to mark the boundary between the Upper and Lower Critical Zones of the Rustenburg Layered Suite. This significant geological event is clearly marked in the reference adit (# 10) section of the Lavino Mine where the first appearance of cumulus plagioclase occurs as a 3.5 metre thick mottled anorthosite unit (Fig 4.1.). The chromitite layers directly below and above the mottled anorthosite may be identified as the Middle Group 2 (MG 2) and 3 (MG 3) chromitites respectively. Following on with this line of argument, the main chromitite layer presently being mined at the Lavino Mine is positively identified as the Middle Group 1 (MG 1) chromitite layer (Fig 4.1.).

The Middle Group chromitite layers are well exposed in outcrop on the Grootboom Farm where, as a package, they tend to show variation in thickness away from the contact with the Transvaal floor rocks. This is due mainly to changes in the thickness of the intervening silicate layers.

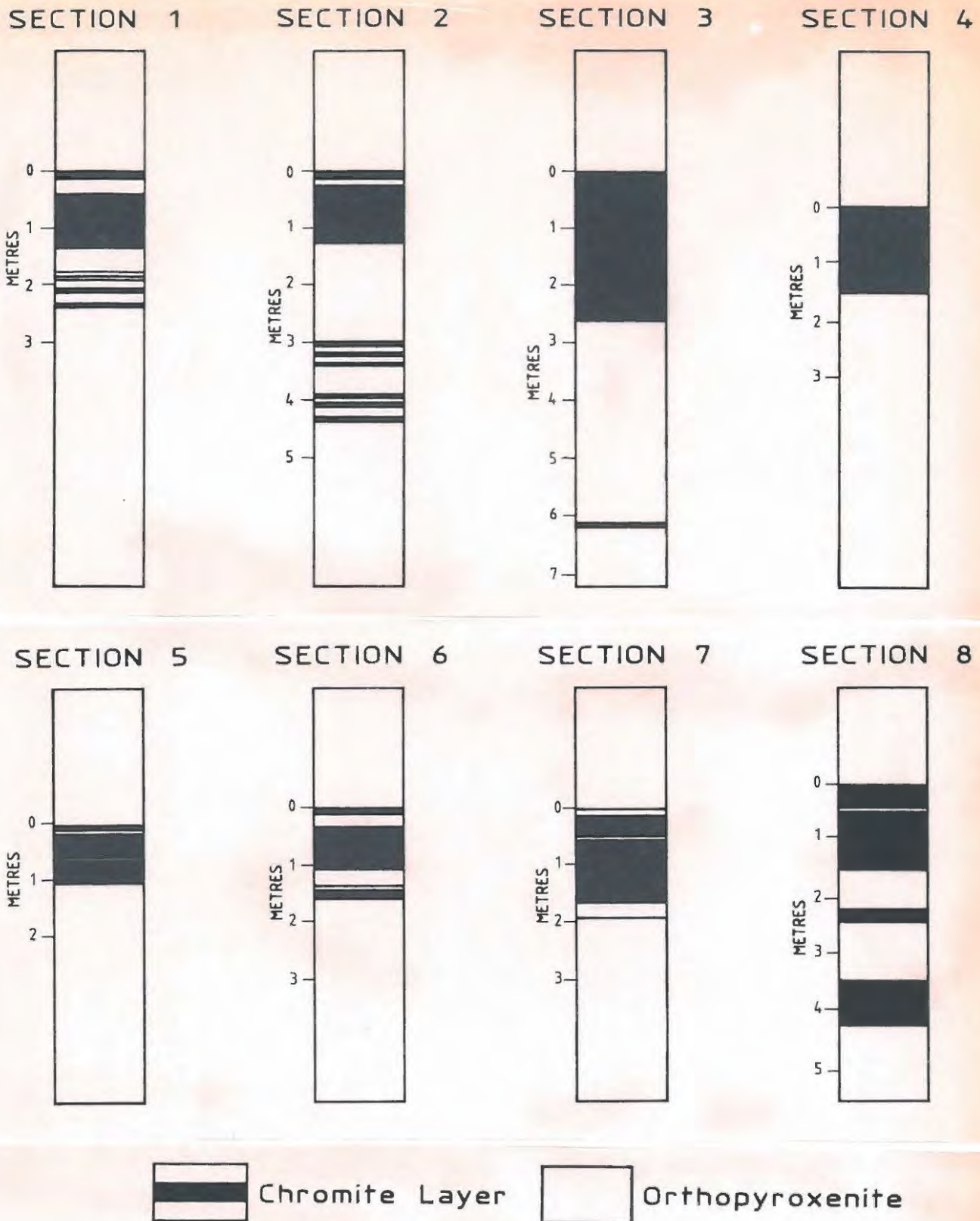
Variation in the chromitite layer thickness is less pronounced, the MG 1 chromitite layer varies in thickness

from 0.80 metres to 2.00 metres, (Fig 5.3.).

With the Middle Group chromitite layers on the Grootboom Farm so identified, it now becomes possible to determine whether or not the Upper Group (UG 1 - UG 2) and Lower Group chromitites are also present.

Several chromitite layers outcrop some 30 to 100 metres stratigraphically below the main (MG 1 ) chromitite layer. These chromitite layers, which average 20 centimetres in thickness, are hosted in pyroxenites and may represent the uppermost of the Lower Group chromitite layers, namely LG 6 ?, LG 7 ?, and LG 8 ?.

A prominent chromitite layer (C5 of Fig 1.) is seen in outcrop approximately some 70 metres stratigraphically above the MG 4 chromitite and may represent the Upper Group 1 (UG 1) chromitite layer. The local structure at this outcrop is complex and it is difficult to determine the thickness of the layer and the nature of either the footwall or of the hanging wall rocks. A poorly exposed chromitite layer outcropping stratigraphically above the UG 1 ? chromitite layer may be the UG 2 chromitite layer.



**FIGURE 5.3.** : SCHEMATIC CROSS-SECTIONS SHOWING THE VARIATION IN THICKNESS ALONG STRIKE OF THE MG1 CHROMITITE LAYER.

6. PRECIOUS AND FERROUS METAL MINERALISATION ON THE  
GROOTBOOM FARM : IMPLICATIONS TO THE MINING INDUSTRY

6.1. CHROMITE ORE BODIES

6.1.1. MINING OPERATIONS ON THE MIDDLE GROUP 1 CHROMITITE  
LAYER

To date, mining operations on the Grootboom Farm have been confined to those areas where the MG 1 chromitite layer was relatively consistent in terms of thickness and dip.

An expansion of mining operations in a south-east direction towards the floor will be adversely affected by the structural complexity of the igneous layering in this region. Here the chromitite layers show local tight folding and sharp changes in dip.

Recent drilling results in the area downdip from the present mining operations have confirmed the presence of the large vertical and horizontal displacements due to strike-slip faulting as seen in surface outcrop. This extensive faulting will necessitate tight geological control in future mining operations in the area towards the Steelpoort River.



## 6.1.2. EXPLORATION FOR THE LOWER GROUP 6 CHROMITITE LAYER

The economically important LG 6 chromitite layer (as is typical to the Winterveld Chrome Mine) is not exposed in outcrop on the Grootboom Farm. The well established stratigraphic relationship that exists between the LG 6 layer and the Middle Group chromitite layers means that the positive identification of the latter at the Lavino Chrome mine has important implications in terms of exploration for the LG 6 chromitite layer. Field evidence suggests that the Lower Zone is developed within a wedge - shaped area in the north-eastern region of the field area on the Grootboom Farm. It is reasonable then to expect the LG 6 chromitite layer to be developed in suboutcrop within this wedge. Exploration for this layer would entail a drilling program in order to establish the depth to the chromitite layer, a situation made favourable by the localised topographic differences.

## 6.2. PLATINUM GROUP METALS MINERALISATION

### 6.2.1. THE MERENSKY REEF

Hiemstra and van Biljoen (1958) reported the presence of "Merensky Reef as a continuous outcrop", some 5 to 20 feet thick, "around the hill on which the trigonometrical beacon 17 is situated" (pg 249). This pyroxenitic layer is typically feldspathic and coarse-grained but not quite pegmatitic.

The layer is marked out on the hillside by several adits that apparently pre-date the 1950's (Hiemstra and van Biljoen, 1958). A thin chromitite layer ( 1 cm thick) and some minor sulphides were observed in the pyroxenitic waste on the adit dumps. Hiemstra and van Biljoen (1958) state that the pyroxenitic layer has been "well prospected" (pg 254 op cit) and that tests for platinum have proved to be negative. However, due to the proximity of the layer to the floor and to the ultramafic iron-rich sheet, it is possible that the potential for platinum enrichment does exist, and these adits should be investigated in more detail.

### 6.2.2. THE MIDDLE GROUP CHROMITITE LAYERS

Chromitites in mafic layered intrusions are often enriched in platinum group elements when compared to their silicate-rich host rocks. Recent studies (Lee and Parry, 1988) of the platinum-group element geochemistry in chromitites of the Eastern Bushveld have found that platinum enrichment is not restricted to the UG 2 and Merensky chromitites but is also a phenomena of the Lower and Middle Group chromitites.

The Middle Group chromitites are enriched over the Lower Group chromitites in total platinum group elements, particularly in the elements Pt + Pd + Rh. With improved metallurgical technology, Lavino mine, with its well developed Middle Group chromitite layers, may prove to be a valuable source of PGE's in the future.

### 6.2.3. THE UPPER GROUP 2 CHROMITITE LAYER

If the UG 2 chromitite layer is developed within the field area on the Grootboom Farm, it will have a limited extent due to its topographical position and proximity to the floor. Consequently, ore deposits due to platinum mineralisation in this chromitite layer will be negligible.

### 6.3. THE MAFIC / ULTRAMAFIC IRON-RICH BODIES

The mafic / ultramafic iron-rich bodies have been trenched (and probably sampled for PGE's) prior to Anglovaal's acquisition of the mine. These bodies show similar zonation patterns to that of Kennedy's Vale magnetite pipe and may contain economically viable grades of vanadium pentoxide. However their sheet-like nature implies a limited potential ore reserve.

## 7. CONCLUSIONS

1. The main chromitite layer that is presently being mined at the Lavino Chrome mine is identified (on the basis of field evidence) as the Mg 1 chromitite layer. The MG 2 - 4 chromitite layers are also positively identified. In addition, several other chromitite layers have also been tentatively identified.

2. The contact between the floor rocks and those of the Rustenberg Layered Suite is disconformable, and, as a result, rocks of the Lower Zone have been developed in a wedge-shaped area in the north-east of the field area.

3. The layered igneous rocks are generally consistent with regard to their dip and strike. However, some structural complexity is present in the centre of the field area, whilst the igneous layered rocks to the north/northwest of the present mining operations have been extensively faulted.

4. Mafic / ultramafic iron-rich ore-bodies cap all of the major hills in the field area.

5. Future mining operations on the main chromitite layer (MG1) at Lavino will require tight geological control. The economically important LG 6 chromitite layer may well be developed in suboutcrop within the northeastern section of the field area. The potential for economically viable deposits of platinum group metals and vanadium within the Lavino Mine property is limited.

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