CHAPTER ONE

INTRODUCTION AND OBJECTIVES

1.1. INTRODUCTION

The Marble Hall Fragment represents one of the larger inliers of floor rocks in the Bushveld Complex. The Fragment is situated approximately 160 kilometres due north-east of Pretoria, in the direct vicinity of the town of Marble Hall, Mpumalanga Province.

Geological studies (De Waal, 1963; Snyman, 1958; Hartzer, 1994) showed that the Fragment forms a dome-like structure of folded supracrustal rocks of the Transvaal Supergroup. It is entirely surrounded by granite of the Lebowa Granite Suite, and, in the south-western part, overlain by flat-lying sedimentary rocks of the Karoo Supergroup. Several outcrops of basic intrusive occur in the Fragment. De Waal (1963) and Hartzer (1994) attempted to interpret the shape of these intrusions from outcrop information. However, the generally poor outcrops in this area, widely acknowledged as outstanding irrigation land, makes such interpretation speculative at best. The need for deep sensing techniques to help the situation is clearly required.

The geophysical investigation of the Marble Hall Fragment reported in this dissertation forms part of multidisciplinary Marble Hall Project conducted by the Department for Earth Sciences at the University of Pretoria. The National Research Foundation and ISCOR Mining jointly funded the project.

1.2 OBJECTIVES OF THE RESEARCH

The objectives of the Marble Hall Project are (De Waal, S.A. 1999 pers. comm.**):**

- To determine the structure and geology of the Marble Hall Fragment;
- To determine the possible link between the Marble Hall basic intrusives and other Bushveld-related intrusives, stratigraphically below the Rustenburg Layered Suite;
- To review the economic potential of the Fragment; and
- To contribute to the understanding of the intrusive mechanism and history of the Bushveld Complex.

The objectives of the geophysical investigation are:

- To add additional constraints to the existing geological interpretations of the structure of the Fragment, especially in areas covered by superficial deposits;
- To map the subsurface extent and structure of the basic intrusives; and
- To develop new possible geological models for the deep structure of the Fragment, based on the observed gravity and magnetic data.

These added constraints on the deep structure of the Marble Hall Fragment are useful to distinguish between a number of opposing hypotheses on the structural nature of the Marble Hall Fragment. The following are of importance:

The structural deformation observed relates to

- the intrusion of the Rustenburg Layered Suite,

- the intrusion of the Nebo granite, or
- predates these events.

The Marble Hall Fragment represents

- a diapir,
- upfolded floor, or
- detached folded floor.

1.3 LOCATION OF STUDY AREA:

The boundaries of the geophysical research area are formed by latitudes 24^{0} $50^{/}$ $00^{//}$S and $25^{0}06^{/}$ $30^{//}$S, and longitudes 29^{0} $10^{/}$ $00^{//}$E and $29^{0}25^{/}$ $00^{//}$E (Figure 1.1). The study area covers approximately 750 km^2 and embraces a number of farm settlements, game reserves, nature reserves, privately owned game farms and a small town.

The major river in the area is the Olifants River which flows along the eastern boundary of the research area with some meandering towards the west in places. Other smaller rivers, such as Elands and Moos Rivers, drain the central portion of the project area providing good irrigation sources for the various farmlands. Canals of the Loskop Dam Irrigation Scheme, delivering water to the large stretches of arable land, are common in the area. In addition, there are a large number of water wells and boreholes drilled for domestic purposes.

The area is endowed with a range of hills with elevations in the survey area ranging between 960 and 1144.7 metres above mean sea level. The most prominent of these hills are found in the northern part of the survey area and along the eastern boundary of the Marble Hall Fragment. The hills in the northwest are underlain by the Makeckaan Formation of the Stavoren Fragment. The Marble Hall Fragment, has a relatively flat topography.

Major roads found in this area provide access to towns such as Roedtan and Pietersburg in the north, Dennilton in the south, Groblersdal in the south-east and Siyabuswa in the west. There are other minor roads, paths and trails which provide access to smaller settlements, farms and rivers.

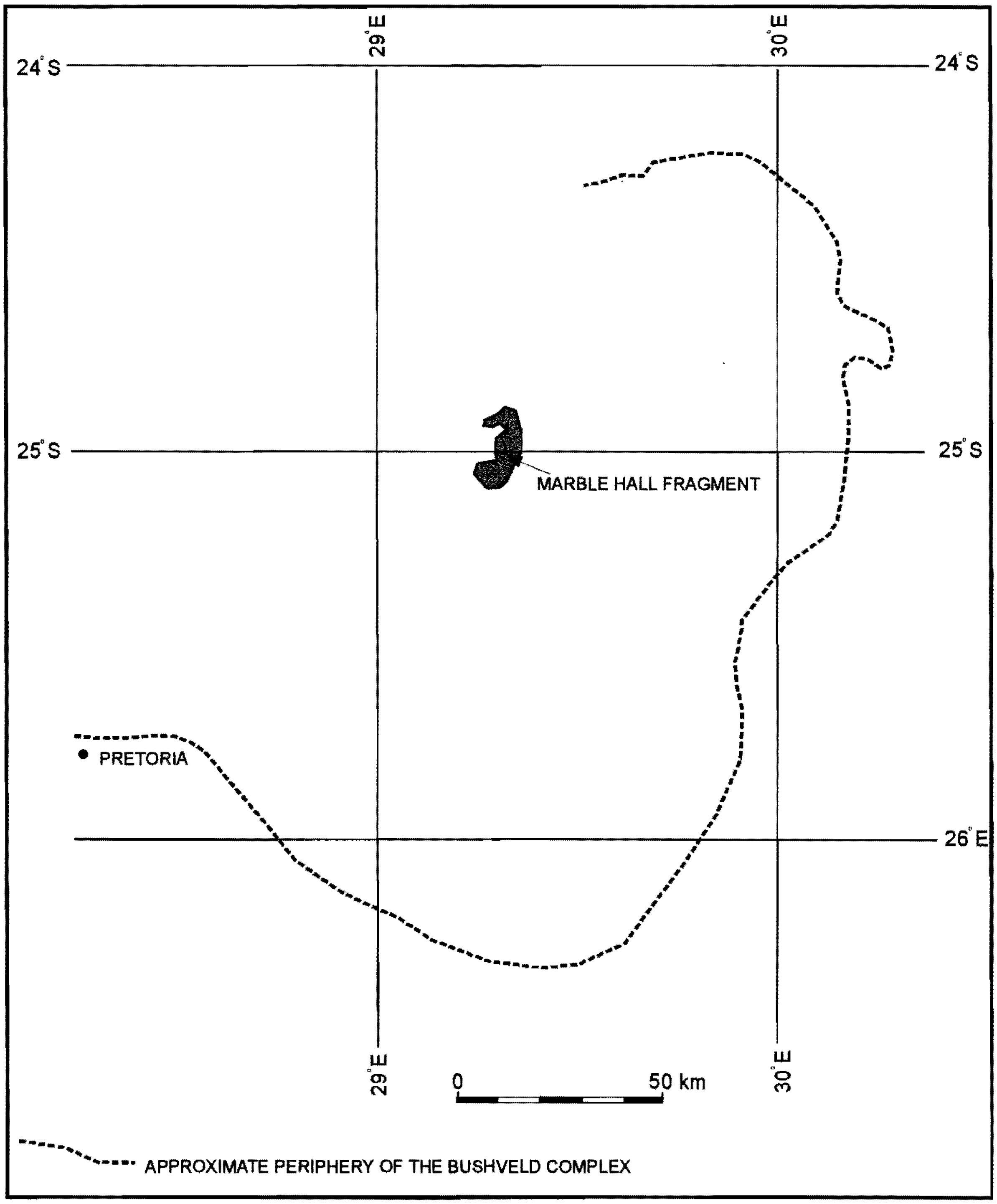

Figure 1.1 Locality map of the Marble Hall Fragment (After Hunter, 1975)

THE GEOLOGY OF THE MARBLE HALL FRAGMENT AND ITS ENVIRONMENT

2.1. GEOLOGY OF THE BUSHVELD COMPLEX

The Bushveld Complex is early Proterozoic in age and consists of three large suites of intrusive rocks, occupying a total surface area of approximately 65,000km^2. The Complex is known for its enormous concentrations of magmatic ores, a variety of pegmatitic and hydrothermal deposits, as well as industrial mineral deposits formed by the metamorphism of the floor rocks of the Complex (Cairncross and Dixon, 1995).

The three main lithological units of the Bushveld Complex are :

- Rustenburg Layered Suite
- Rashoop Granophyre Suite, and
- Lebowa Granite Suite.

A fourth suite, the Rooiberg Group of acid and basic volcanic rocks, was previously allocated to the Transvaal Supergroup (SACS,1980), but is now accepted to be an intergral part of the Bushveld Complex (Schweitzer *et al.*, 1995a, b).

2.1.1. Rustenburg Layered Suite

The Rustenburg Layered Suite is exposed in three, roughly crescent-shaped, outcrop areas, referred to as the Western, Eastern and Northern Lobes of the Bushveld Complex (Figure 2.1).

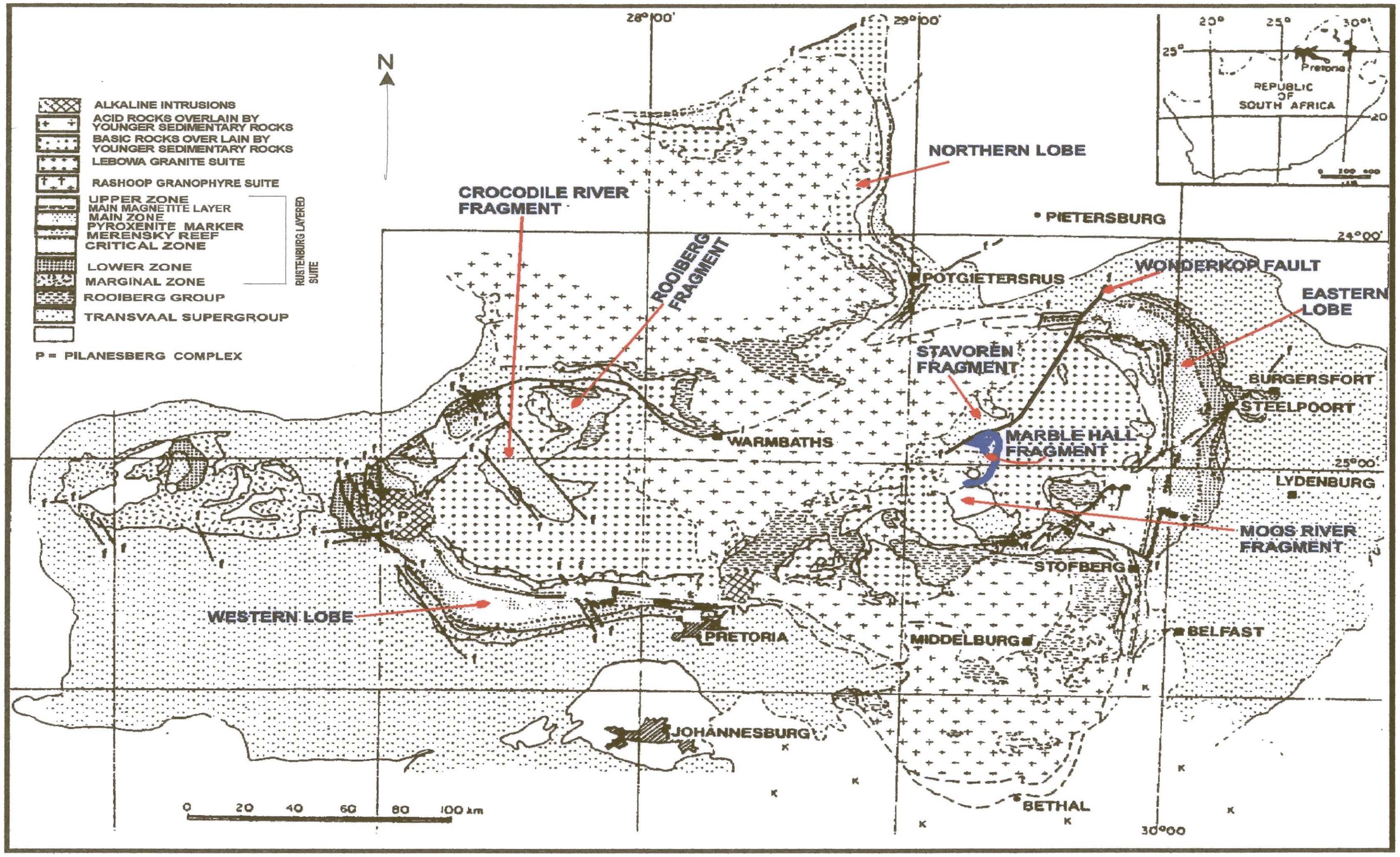

Figure 2.1. Geological map of the Bushveld Complex and environs showing the location of the study area and the distribution of the main components of the Complex (Adapted from Eales *et al.*, 1993).

The total exposed part of the Rustenburg Layered Suite covers an area of 12,200km^2. Measured thicknesses of close to 9000m are recorded in the eastern Bushveld, 7750m in the Western Bushveld and 7000m in the Potgietersrus area (Van der Merwe, 1976). The central area between the lobes is underlain by acid plutonic rocks of the Lebowa Granite and Rashoop Granophyre Suites, acid volcanics of the Rooiberg Group, and covered by supracrustal rocks of the Karoo Supergroup. Several inliers of floor rocks, as domes and diapirs (Cairncross and Dixon,1995), are present in the Complex. The largest of these are the Crocodile River, Moos River and Marble Hall Fragments (Cairncross and Dixon, 1995).

The most significant outcrops of the basic and ultrabasic rocks of the Rustenburg Layered Suite are found in the Eastern Lobe of the Complex, where the complete succession of rock types from the base to the top is exposed (Vermaak and Gruenewaldt, 1986; Molyneux, 1974; Von Gruenewaldt, 1973; Cameron and Emerson, 1959; and Cameron, 1978). In the western part of the Complex, mapping by Vermaak (1970), Coertze (1970, 1974) and Young (1978), as well as deep drilling by mining companies (Vermaak, 1976) and the Geological Survey of South Africa (now the Council for Geoscience), show a comparable lithological succession to that in the east (Vermaak and Gruenewaldt, 1986).

The Rustenburg Layered Suite is subdivided into five zones viz :

2.1.1.1. Marginal Zone

This consists of plagioclase-orthopyroxene cumulates (norites), generally finer- grained than the interior of the complex and containing abundant country-rock xenoliths which defines the base of the sequence (Eales *et al.*, 1993). It has a varying thickness (Vermaak and Gruenewaldt, 1986; Teigler, 1990), reaching 250metres in the Western limb (Vermaak, 1976). Studies by Sharpe (1981) and Harmer & Sharpe (1985) on the marginal rocks of the

Rustenburg Layered Suite, led to the conclusion that for consi[illegible]e, the mafic rocks are conformable with the sedimentary units of the floor, but that there are abrupt discordances where the magma transgressed to higher stratigraphic levels.

2.1.1.2. Lower Zone

The Lower Zone overlies the Marginal Zone and it is dominated by olivine-rich cumulates (dunite, harzburgite) and orthopyroxenite (Eales *et al.,* 1993). This zone, previously called the Basal Zone, is composed mainly of four rock units namely Clapham Bronzitite (basal subzone), Rostock Bronzitite (lower bronzitite subzone), Jagdlust Harzburgite (harzburgite subzone), Serokolo Bronzitite (upper bronzitite subzone) (SACS, 1980). Table 1 gives the relative thicknesses of the units

2.1.1.3. Critical Zone

This is characterised by the regular and often fine-scale layering it displays. Dunites, harzburgites, pyroxenites, chromitites, norites and anorthosites are disposed in layers ranging in thickness from a few millimetres to many tens of metres (Eales *et al.*, 1993). The largest deposits of chromite in the world occur in the lower and upper Critical Zones of the main eastern and western lobes of the Bushveld Complex (Vermaak and Gruenewaldt, 1986). The lower (LG) group of chromitite layers occur within the essentially pyroxenitic or bronzitic lower Critical Zone, the upper (UG) group of chromitite layers occur exclusively within the essentailly anorthositic to noritic Upper Critical Zone, while the middle (MG) group of chromitite layers occur at the pyroxenitic/anorthositic junction of the lower and upper Critical Zones (Vermaak and Gruenewaldt, 1986).

Table 1. Lithostratigraphic subdivision and thicknesses of the Rustenberg Layered Suite in the eastern Bushveld Complex (After Vermaak and Gruenewaldt, 1986)

Formal Subdivision by SACS		Lithology	Informal subdivision		Approximate thickness (m)
Rustenberg Layered Suite	Luipershoek Olivine Diorite Ironstone Magnetite Gabbro Magnet Heights Gabbronorite	Diorite and olivine diorite. Magnetite gabbro with layers of magnetite, anorthosite and olovine gabbro.	Upper Zone	SubzoneC Subzone B Subzone A	2000
Rustenberg Layered Suite	Mapoch Gabbronorite Leolo Mountain Gabbronorite Winnaarshoek Norite-Anorthosite	Mostly homogenous gabbro and norite.	Main Zone	Subzone C SubzoneB Subzone A	3500
Rustenberg Layered Suite	Winterveld Norite Anorthosite Mooihoek Pyroxenite	Alternating layers of chromite, pyroxenite norite and anorthosite. Pyroxenite interlayered with chromite and dunite.	Critical Zone	Subzone B Subzone A	1000 500
Rustenberg Layered Suite	Serokolo Bronzitite Jagdlust Harzburgite Rostock Bronzitite Clapham Bronzitite	Pyroxenite Harzburgite interlayered with pyroxenite and dunite. Pyroxenite Norite, feldspathic pyro-xenite, Harzburgite layer near the base.	Lower Zone	Subzone D Subzone C Subzone B Subzone A	1600
Rustenberg Layered Suite	Shelter Norite	Norite, feldspathic pyro-xenite, quartz norite, anorthosite norite.	Marginal Zone		Up to 100

2.1.1.4. Main Zone

This overlying zone with a thickness of about 4000m for the larger part consists of a succession of relatively homogenous rocks which builds a very prominent montain range known as Leolo Mountains stretching from Draaikraal in the south to the Olifants River in the north (Vermaak and Gruenewaldt, 1986). On the basis of layering and composition of the cumulus minerals, the Main Zone is coarser, less well defined than the often delicate, mm-scale layering of the Critical Zone and subdivided into three subzones (Molyneux, 1974 ; Von Gruenewaldt, 1973). Klemm *et al.,* 1985a; Cawthorn and McCarthy, 1985) proposed that the Main Zone appears to be devoid of any mineralisation though the pyroxenite marker has been thoroughly researched of late (Vermaak and Gruenewaldt, 1986). Table 1 gives the subdivision of the subzones.

2.1.1.5. Upper Zone

The base of the Upper Zone is defined by the first appearance of cumulus magnetite above the pyroxenite marker (Vermaak and Gruenewaldt, 1986; Eales *et al.*, 1993). This mineral makes its appearance as an intercumulus constituent in a prominent mottled anorthosite and is present as a cumulus mineral in nearly all the overlying rock types, right to the top of the Rustenburg Layered Suite. Pronounced layering is developed throughout this zone and is caused by varying proportions of cumulus minerals such as magnetite, olivine, plagioclase and pyroxene in the rocks (Vermaak and Gruenewaldt, 1986). Subdivision into three subzones is on the basis of the appearance of new cumulus minerals in the succession. The subdivisions are reflected in Table 1.

2.1.2. Rashoop Granophyre Suite

The Rashoop Granophyre Suite of the Bushveld Complex is subdivided by Walraven (1987a) into three different types.

2.1.2.1. Stavoren Granophyre

This granophyre is present throughout the Bushveld Complex and predates the basic rocks and granites of the Complex (Walraven, 1985). It is magmatic in origin and cogenetic with Rooiberg Group volcanics. It consists of medium to fine-grained rocks composed of K-feldspar, plagioclase and quartz together with hornblende, minor biotite and accessory iron oxide and zircon. It is characterised by micrographic intergrowths of quartz and feldspar . It includes sedimentary xenoliths where roof rocks are sedimentary, and spherulitic zones where they consist of Rooiberg Group volcanics (Hall, 1932, Walraven, 1985). The Stavoren Granophyre is well developed on the northern end of the Stavoren Fragment just off the northern boundary of the present study area.

2.1.2.2. Diepkloof Granophyre

This is texturally similar to the Stavoren Granophyre and restricted to the eastern part of the Bushveld Complex underlying volcanic rocks of Rooiberg Group (Walraven, 1985). It is cogenetic with granodioritic rocks present in similar geologic settings elsewhere in the Bushveld Complex and is presumed to have formed by the melting of volcanic roof rocks as a result of intrusion of basic rocks of the complex. It has the same age as the basic rocks (Walraven, 1985).

2.1.2.3. Zwartbank Pseudogranophyre

It is restricted to parts of the Bushveld Complex underlying the sedimentary rocks of Pretoria Group. It differs texturally from Stavoren and Diepkloof Granophyre and consists of intergrown quartz and feldspar indicative of replacement (Walraven, 1985). It is believed to have been formed by severe recrystallisation of sedimentary roof rocks as a result of intrusion of basic rocks of the Bushveld (De Waal, 1972, Walraven, 1985).

2.1.3. Lebowa Granite Suite

Field relationships, radiometric age determinations and geochemical studies have demonstrated the existence of several textural varieties of granites within the Bushveld Complex. Of importance to this study is the Nebo Granite that engulfs the Marble Hall Fragment.

The Nebo Granite forms a regional sill like intrusive of A-type granite (Kleeman and Twist, 1989; MacCaskie, 1983; McCarthy and Hasty, 1976; Hill *et al.*, 1996). It has an estimated thickness of some 2.5km (McCaskie, 1983). De Waal (1963), Snyman (1958) and Marlow (1976) described the main phase of this granite as red to grey in colour, coarse grained. Granular K-feldspar perthite, quartz and plagioclase are the major constituents, whereas hornblende, biotite and muscovite are minor constituents. Accessory minerals include opaque minerals, zircon, rutile and fluorite. Local granophyric and aplitic varieties are developed.

Walraven and Hattingh (1993) provide information on a dyke of Nebo Granite cutting the basic rocks of the Bushveld Complex, some 1500 m below the granite in the area north-west of Potgietersrus, in the northern lobe of the Complex. This dyke is believed to be a feeder to the main body of Nebo Granite (Walraven and Hattingh, 1993).

2.1.4. Rooiberg Group

These intercratonic volcanic rocks largely confined to the roof of the Bushveld Complex consist of nine magma types varying in composition from basalt to rhyolite (Hatton and Schweitzer, 1995). Basalts and andesites intercalated with dacites and rhyolites are found towards the base; rhyolite is the chief magma composition in the upper succession. According to Hatton and Schweitzer (1995), crustally contaminated plume magma synchronously intruded beneath the Rooiberg Group to produce the mafic rocks of the Rustenberg Layered Suite.

2.1.5. Makeckaan Formation

The Makeckaan Formation preserved in the Stavoren Fragment comprises lower and upper feldspathic sandstone members with large scale cross beds and ripple marks separated by mature, recrystallised quartzitic sandstones and micaceous wackes (Rhodes, 1972) or fluviodeltaic deposits (Schreiber, 1991). Hartzer (1994) described the Stavoren Fragment occupying a high-lying tract of land to the north and north-west of the Marble Hall dome as consisting of siliciclastic sedimentary and volcanic rocks of the upper part of the Pretoria Group and the lower part of the Rooiberg Group. It is covered by Karoo rocks towards the north and east (Hartzer, 1994).

The Stavoren Fragment has been subdivided physiologically by Hartzer (1994) into a plateau area containing the entire succession of the Upper Pretoria Group, culminating in Rooiberg lavas in the centre of the Rinkhalskop syncline and a range of hills that mark the Wonderkop fault zone. Several prominent pegmatitic quartz veins considered as late-stage differentiation products of Bushveld granitic magma (Wagner, 1927) form a series of high ridges in the eastern part of the fragment and some of these are clearly associated with the pre-existing fault planes linking up with the Wonderkop fault zone (Hartzer, 1994). These faults have important structural implications since the Transvaal succession in the fault zone consists of lower part of the Makeckaan subgroup.

The Makeckaan Formation has been brought into perspective in this study because it is part of the area embraced by this investigation and for its importance in the geophysical interpretation.

2.2. THE AGE OF THE BUSHVELD COMPLEX

Although grouped by SACS (1980) with the Bushveld Complex, the Stavoren Granophyre is considered to pre-date the basic layered rocks and granites of the complex (Walraven *et al.*, 1988). Based on the its field relationships with the Bushveld layered rocks and granite as well as from genetic relationships with the lavas of the Rooiberg Group (Walraven, 1987a), it may be concluded that the Stavoren Granophyre must be as old as 2065Ma.

By combining all the concordant whole-rock data from the Upper Zone presented by Hamilton, 1977), Sharpe (1985) and Kruger *et al.* (1987) and assigned blanket errors, the result obtained gave an isochron of 2061±27 Ma which is the preferred age for the mafic rocks of the Bushveld Complex (Walraven *et al.*, 1988).

Walraven and Hattingh (1993) indicated a crystallisation age of 2054.4±1.8Ma for the Nebo Granite from the new age determinations of zircon from the Nebo Granite using the Pb-evaporation technique.

The inter cratonic Rooiberg Group is one of the largest accumulations of silicious volcanic rocks (Schweitzer *et al.*, 1995a, b) and is largely confined to the roof of the Bushveld Complex. The age has been put at 2.06 Ga (Hatton and Schweitzer, 1995).

Despite the large range of ages obtained for the granites and basic layered rocks of the Bushveld Complex, much of the recent work strongly supports an emplacement age in the range of 2060 – 2050Ma and such ages are also evident from the earlier U/Pb zircon age determinations (Walraven *et al.*, 1988)

2.3 MODE OF EMPLACEMENT AND SHAPE OF THE BUSHVELD COMPLEX: GEOPHYSICAL DATA

The structure of the Rustenburg Layered Suite was initially considered to be either that of a huge laccolith (Molengraaff, 1901; Jorssen, 1904; Mellor, 1906), or a number of smaller laccolithic intrusions (Molengraaff, 1902), or a lopolith (Daly and Molengraaff, 1924; Hall, 1932).

The geophysical technique first used to constrain geological models of the Basement Complex was gravity modelling (Cousins, 1959). Since then regional gravity surveys, ground and aeromagnetic surveys, time domain electromagnetic surveys, DC resistivity soundings and regional seismic reflection studies have been used (Meyer, 1987).

The latest models on the shape of the Rustenburg Layered Suite see the lobes as dipping tapering sheet terminating towards the centre (Kleywegt and Du Plessis, 1986) and tapering sills (Molyneux and Klinkert, 1978) with the ferrogabbros of the Upper Zone thinning towards the geographic centre of the Complex.

Earlier workers interpreted the Bushveld Complex as a number of discrete compartments (Smit, 1961; Smit *et al.*, 1962); a series of separate overlapping intrusions (Truter, 1955; Hattingh, 1983) or curved trough-like bodies, arranged around a central dome (Cousins, 1959) or Lebowa Granite Suite underlain by Transvaal Supergroup rocks (Meyer and De Beer, 1987). They concluded from the structural and geophysical models that the central portion is not underlain by the basic rocks of the Bushveld Complex.

Based on the interpretation of a regional gravity survey of eastern Transvaal, Hattingh (1980) also proposed that the mafic rocks of the Complex have a synformal morphology. He suggested the interpretation of gravity highs as intrusion centres for the mafic magma with the feeder zones being extremely narrow. Further interpretation indicated that the mafic rocks extend underneath felsite and sediments towards 29^0 15' E; extending beneath the Bushveld Granite up to the Elandslaagte Dome (Hattingh, 1980).

2.4. THE MARBLE HALL FRAGMENT

2.4.1. LOCALITY

The Marble Hall Fragment is situated approximately 160 kilometres due north-east of Pretoria. It forms a pear-shaped outcrop measuring approximately 30km in a northeast-southwesterly direction and approximately 20km in a northwest-southeasterly direction. The town of Marble Hall is situated in about the centre of the Fragment and owes its name to marble occurrences in vicinity.

2.4.2. THE GEOLOGY OF THE MARBLE HALL FRAGMENT

The Marble Hall Fragment consists of severely deformed and metamorphosed rocks of the Transvaal Supergroup (Figure 2.2). It is entirely surrounded by Nebo Granite of the Lebowa Granite Suite and intruded by diorite. Towards the south it is partly covered by sedimentary rocks of the Karoo Supergroup.

The geological structure of the Marble Hall Fragment can be described as a north-west striking anticline, the Swartkop-Marble Hall Anticline (De Waal, 1970), that was refolded along a north-east striking anticlinal fold. The core of the north-east striking anticline forms a domal feature in the south-west of the area, known as the Elandslaagte Dome (Snyman, 1956). Mapping by Gau (1906), Wagner (1927), Wessels (1943), Lombaard (1931), Snyman (1956, 1958), De Waal (1963, 1970) and Hartzer (1994) led to the current lithological subdivision as given in Table 2.

For the sake of completeness the lithology below the Black Reef Quartzite for the Dennilton Dome is also included in Table 2. The reason for this is that the Bloempoort Formation is very poorly developed in the Marble Hall Fragment. However, these lower formations might also be present in the deeper parts of the Marble Hall Fragment and are therefore important in the geophysical interpretations.

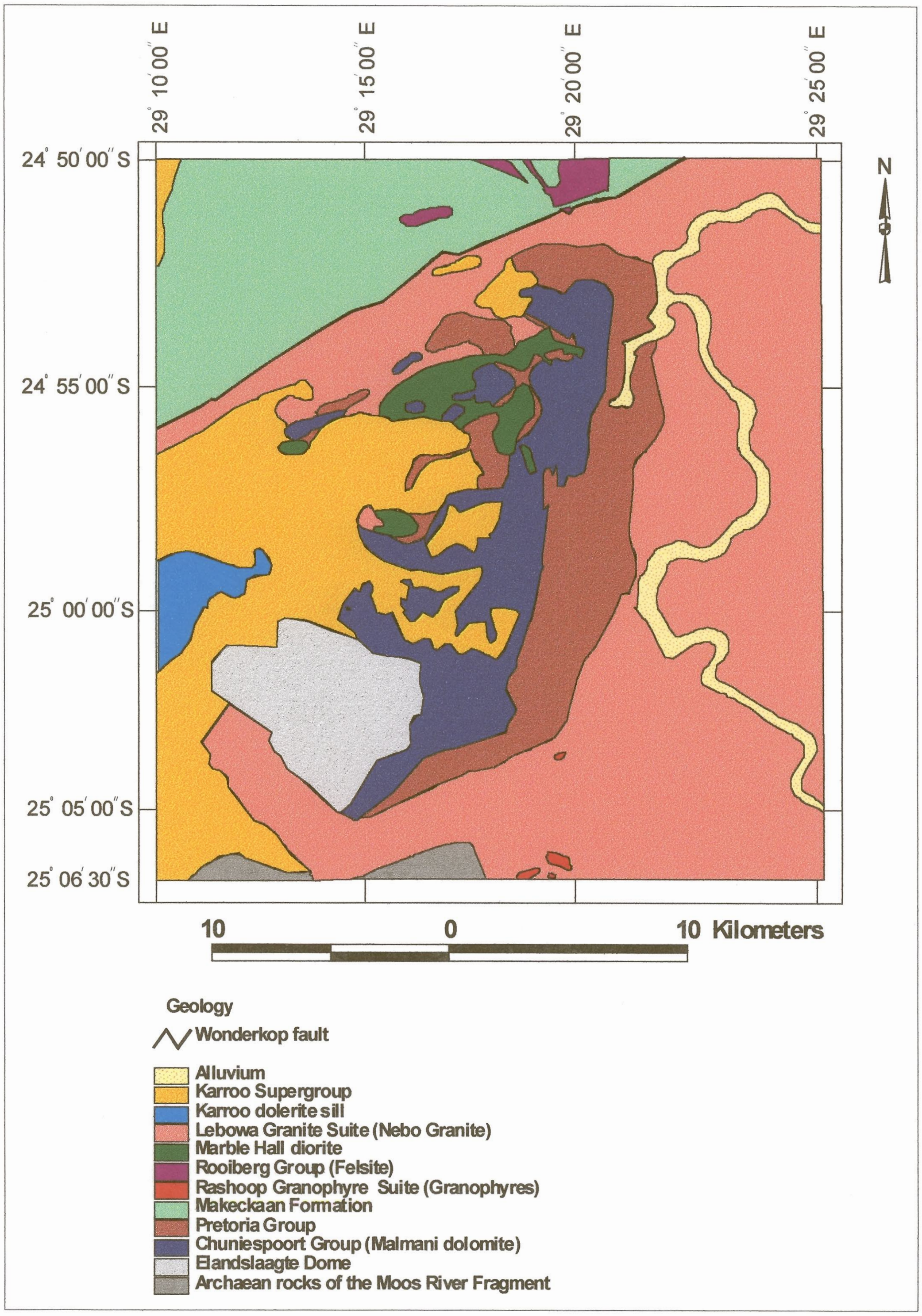

Figure 2.2. Simplified geology of the Marble Hall Fragment. The relatively thin Black Reef Formation between the Chuniespoort Group and Bloempoort Formation is shown as part of the Chuniespoort Group.

Table 2. LITHOSTRATIGRAPHIC SUBDIVISION OF THE SUCCESSI

FRAGMENT AND DENNILTON DOME (After Hartzer, 1994)

LITHOLOGY	LITHOLOGIC SUBDIVISION				THICKNESS	
					Denilton Dome	Marble Hall Dome
Lava, agglomerate, arenite, shale	Dulstroom Fm.		Pretoria Group	Transvaal Supergroup	± 183 m	
Shale, quartzite	Houtenbek Fm.		Pretoria Group	Transvaal Supergroup	160 m	
Quartzite	Steenkampsberg Fm.		Pretoria Group	Transvaal Supergroup	± 710 m	
Feldspathic arenite, shale	Nederhors Fm.		Pretoria Group	Transvaal Supergroup	± 320 m	
Arenite	Lakenvalei Fm.		Pretoria Group	Transvaal Supergroup	200 m	
Claystone	Vermont Fm.		Pretoria Group	Transvaal Supergroup	184 m	
Quartz arenite, limestone	Magaliesburg Fm.		Pretoria Group	Transvaal Supergroup	800 m	
Claystone, siltstone	Lydenburg Mb	Silverton Fm	Pretoria Group	Transvaal Supergroup	867 m +	320 m +
Tuff	Machadodorp Mb.	Silverton Fm	Pretoria Group	Transvaal Supergroup		128 m
Agglomerate		Silverton Fm	Pretoria Group	Transvaal Supergroup		64 m
Claystone, siltstone	Boven Mb	Silverton Fm	Pretoria Group	Transvaal Supergroup		167 m
Quartz arenite	Daspoort Fm.		Pretoria Group	Transvaal Supergroup	60 m	30 m
Claystone, siltstone	Strubenkop Fm.		Pretoria Group	Transvaal Supergroup	± 130 m	± 80 m
Arenite	Dwaalheuwel Fm.		Pretoria Group	Transvaal Supergroup	± 48 m	45 m
Lava	Hekpoort Fm.		Pretoria Group	Transvaal Supergroup	± 230 m	± 255 m
Claystone, siltstone		Timeball Hill fm	Pretoria Group	Transvaal Supergroup	± 230 m	± 225 m
Quartz arenite	Klapperkop Mb	Timeball Hill fm	Pretoria Group	Transvaal Supergroup	69 m	128 m
Claystone, siltstone		Timeball Hill fm	Pretoria Group	Transvaal Supergroup	± 300 m	± 490 m
Carbonate rocks	Scherp Arabie Mb	Rooihoogte Fm.	Pretoria Group	Transvaal Supergroup	± 70 m	15 m
Claystone		Rooihoogte Fm.	Pretoria Group	Transvaal Supergroup		5 – 10 m
Conglomerate	Bevets Mb.	Rooihoogte Fm.	Pretoria Group	Transvaal Supergroup	± 20 m	20 – 25 m
Claystone		Rooihoogte Fm.	Pretoria Group	Transvaal Supergroup	± 50 m	0 – 60 m
Iron Formation	Penge Fm.		Chinuespoort Group	Transvaal Supergroup	± 35 m	± 25 m
Dolomite, limestone	Frisco Fm.		Chinuespoort Group	Transvaal Supergroup	± 135 m	± 118 m
Chert-rich dolomite	Eccles Fm.		Chinuespoort Group	Transvaal Supergroup	± 245 m	220 m
Dolomite, limestone	Lyttelton Fm.		Chinuespoort Group	Transvaal Supergroup	± 233 m	
Chert-rich dolomite	MonteChristo Fm.		Chinuespoort Group	Transvaal Supergroup	± 1160 m	
Limestone, dolomite	Oak Tree Fm.		Chinuespoort Group	Transvaal Supergroup	± 330 m	
Arenite, claystone	Black Reef Fm.			Transvaal Supergroup		
Arenite, grit, siltstone	Stukje Mb.	Bloempoort Fm		Transvaal Supergroup	39 m	
Siltstone, arenite	Boshalala Mb.	Bloempoort Fm		Transvaal Supergroup	10 m	
Quart, arenite, grit	Klipfontein Mb.	Bloempoort Fm		Transvaal Supergroup	15 m	
Siltstone, arenite	Kalkput Mb.	Bloempoort Fm		Transvaal Supergroup	43 m	
Arenite, siltstone	Rooiboskloof Mb.	Bloempoort Fm		Transvaal Supergroup	17 m	
Siltstone, claystone	La Casita Mb.	Bloempoort Fm		Transvaal Supergroup	20 m	
Quart arenite	Ruzawi Mb.	Bloempoort Fm		Transvaal Supergroup	5 m	
Claystone, Siltstone	Aquaville Mb.	Bloempoort Fm		Transvaal Supergroup	114 m	
Calcareous arenite, carbonate rocks	Celandine Mb.	Bloempoort Fm.		Transvaal Supergroup	95 m	
Feldspathic and Calcareous arenite	Broekskeur Mb	Bloempoort Fm.		Transvaal Supergroup	135 m	
Conglomerate	Uitzoek Mb.	Bloempoort Fm.		Transvaal Supergroup	43 m	
Calcareous arenite	Oude Stad Mb.	Bloempoort Fm.		Transvaal Supergroup	77 m	
Lava	Uitspanning Mb.	Bloempoort Fm.		Transvaal Supergroup	45 m	
Claystone, siltstone, quartz arenite	Mpheleng Mb.	Bloempoort Fm.		Transvaal Supergroup	175 m	
Lava	Moses River Mb.	Bloempoort Fm.		Transvaal Supergroup	100 m	
Claystone, siltstone	Witpenskloof Mb.	Bloempoort Fm.		Transvaal Supergroup	925 m	
Lava, tuff, granulite schist	Dennilton Fm.				± 1500 m	
Gneiss	Vaalfontein Suite					
Amphibolite, lava, schists	Terra Nostra Fm.					

De Waal (1970) described irregular bodies of diorite and albite diorite, classified with the upper portion of the Main Plutonic Phase (Upper Zone) of the Bushveld Igneous Complex and a sheet of pyroxene granulite of the Maruleng type that intruded the Transvaal System. The diorites are now interpreted to be related to the Bushveld sill complex below the Rustenburg Layered Suite (De Waal, 1999, pers.comm.) The precise shape of these sills can not be determined from surface outcrop (De Waal, 1970; Hartzer, 1994) and as stated earlier the main motivation for this geophysical investigation.