1. Introduction.

The present study was undertaken to describe and investigate the geology and geochemistry of the Bushveld Complex in the area immediately east of Groblersdal. Here the major acid components of the complex, the Rashoop Granophyre Suite and the Lebowa Granite Suite, as well as the acid volcanic roofrocks, the felsites of the Rooiberg Group, are exposed (Fig.1.1). Part of the area was mapped for an Honours project during July 1980. Further mapping, covering some 400 square kilometres and extending west of longitude 29°55' and south of latitude 25°00', was conducted with the aid of aerial photographs (scale 1:30000) during the summer months of 1981. The information gathered was transferred to 1:50000 topographic maps (2529AB Groblersdal and 2529BA Maleoskop) from which a final geological map was compiled (Folder 1, back folder).

A total of 270 samples were collected, of which 230 were selected (for location see Folder 2, back folder) and analysed for major and trace elements on the Siemens SRS-1 X-ray fluorescence spectrometer in the Departement of Geology, University of Pretoria. The scanning electron microscope and the electron microprobe of the Geological Survey of South Africa were used for the mineralogical investigation of some of these samples.

The aims of the present study are to provide a detailed description of the petrography of the rock types; to investigate the geochemical evolution of the Bushveld granite magmas in the region and the possible mineralization in the younger intrusives; to elucidate the geochemical specialization of the Klipkloof Granite; and to correlate the granites of the study area with those of the Zaaiplaats area.

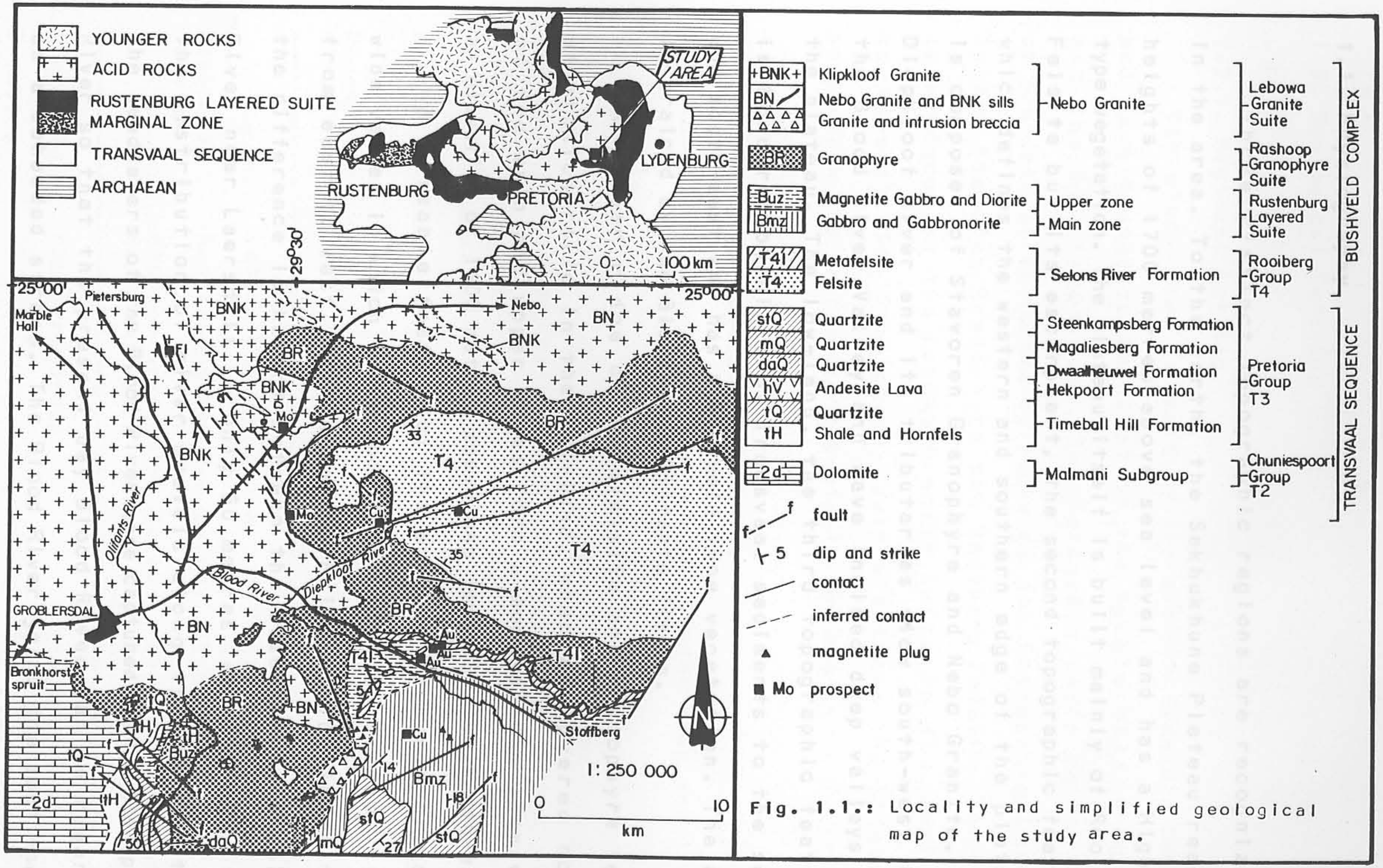

Fig. 1.1.: Locality and simplified geological map of the study area.

1.1. Physiography.

Three distinct topographic regions are recognizable in the area. To the north, the Sekhukhune Plateau reaches heights of 1700 metres above sea level and has a Highveld type vegetation. The plateau itself is built mainly of Rooiberg Felsite but its escarpment, the second topographic feature, which defines the western and southern edge of the plateau, is composed of Stavoren Granophyre and Nebo Granite. The Diepkloof River and its tributaries flow south-west into the Blood River Valley and have incised deep valleys into the plateau. The low-land, the third topographic feature, is bordered by hills of Transvaal sediments to the south and south-east and has a Bushveld type vegetation. The area is drained by the Blood- and Olifants Rivers.

A linear ridge of metafelsite and granophyre forms an erosion relic in the low-land, whereas layered rocks of the main and upper zones form a mountainous area with an elevation of 1400 metres above sea level in the south-east.

A noteable feature of the area is the exceptionally wide valley in which the Blood River, a minor stream, flows from east to west. Willemse and Frick (1970) found that the difference in height between the Steelpoort and Blood River near Laersdrif is only 50 metres, and concluded from the distribution of river gravels along the divide that the headwaters of the Blood River were captured by the Steelpoort River so that the present day Blood River can be regarded as a beheaded stream. The Blood River joins the south-north flowing Olifants River near Groblersdal.

1.2. Geological Setting.

1.2.1. Regional Setting.

The study area is part of the eastern Bushveld Complex and is situated to the east of the Marble Hall fragment and the Dennilton dome. The Maleoskop basin to the east of Groblersdal is formed by rocks of the Rustenburg Layered Suite, Stavoren Granophyre and Rooiberg Felsite. The basin is bordered by the Lebowa Granite Suite to the west and south-west. The Steelpoort fault displaces the Maleoskop basin from the Tauteshoogte basin in the east.

1.2.2. Major geological components.

The geological formations present in the area are listed in Table 1.1.

Table 1.1. Geological formations developed in the study area.

Sequence or Era	Group or Suite	Formation or Unit
Recent		Alluvium and soil
Karoo		Karoo dolerite
Bushveld Complex	Lebowa Granite Suite	Klipkloof Granite
		Nebo Granite
	Rustenburg Layered Suite	upper zone
		main zone
	Rashoop Granophyre Suite	Stavoren Granophyre
	Marico Diabase Suite	Pre-Bushveld Sills
Transvaal Sequence	Rooiberg Group	Selons River
	Pretoria Group	Timeball Hill
		Hekpoort
		Dwaalheuwel
		Magaliesberg
		Steenkampsberg

Only those formations not discussed in detail in the following chapters are described briefly below.

1.2.3. The Pretoria Group.

Quartzites and shales of the Pretoria Group, the oldest rocks in this area, are restricted to the south-western and southern parts of the area. Pre-Bushveld sills are intrusive into this sequence.

The Timeball Hill Formation dips at 50° to the east and consists of a lower shale member, a 120 metres thick quartzite member and an upper shale member. Low- to medium grade metamorphism of the lower and upper shale members by diabase sills and the Rustenburg Layered Suite resulted in the formation of muscovite hornfels.

Overlying the Timeball Hill Formation are lavas of the Hekpoort Formation, which attain a thickness of about 20 metres. Button (1973) has shown the Hekpoort lavas of the eastern Transvaal to be transitional between continental basalt and andesite compositions. Sharpe et al. (1983) found that the Hekpoort lavas of the western and eastern Transvaal are of andesite composition on some classification systems, whereas on others they belong to the basaltic andesites or even tholeiitic basalts.

The Hekpoort Formation is overlain by quartzite, which has a thickness of about 100 metres and dips at 45° to the east. According to Button (1973) this quartzite member, the Dwaalheuwel Formation, is always present overlying the Hekpoort Formation in the Transvaal basin north of Pretoria.

The Magaliesberg and Steenkampsberg Formations occur in the south-east of the study area and were described in some detail by Von Gruenewaldt (1966).

1.2.4. The Rustenburg Layered Suite.

The main and upper zones of the Rustenburg Layered Suite are represented in the area. The outcrops of the upper zone are generally weathered and magnetite plugs are sometimes the only indication of the presence of the mafic rocks, as for instance on Weltevreden 165JS.

Gabbros and gabbronorites are the predominant rock types of the main zone in the area. Dips measured on the stratification in anorthosite layers show the rocks to dip at 12 to 14° to the south-east, whereas a dip measurement on the Tennisball-marker was found to be 18° to the east. A fault could be responsible for the difference in dip.

The upper zone is represented by olivine diorite and magnetite plugs. Magnetite layer 21 crops out along the foot of the escarpement on Weltevreden 165JS and Haakdoringdraai 169JS, where it underlies the metafelsites and granophyres. A magnetite plug on Weltevreden 165JS was found to pierce the roof of metafelsite.

The Rustenburg Layered Suite is developed on both sides of the prominent ridge of fine-grained acid roofrocks on Weltevreden 165JS. However, the only indication of the presence of these rocks on the western side of the ridge are magnetite plugs and chips of gabbro recovered from old percussion drill holes.

The intrusion breccia on Rietkloof 166JS contains all the different rock types of the main and upper zones found in the area. A fine-grained mafic rock, possibly a sill of critical zone composition (M.R. Sharpe, pers. comm.), constitutes the largest part of the breccia.

Rocks of the Rustenburg Layered Suite are also developed on Kalkfontein 49JS, where a magnetite plug seems to be intrusive into the rocks of the Transvaal Sequence.

Granodiorites, representing highly contaminated upper zone liquids, occur as a sheet underlying the Stavoren Granophyre and as irregular veins and pockets in the metafelsite. They are composed of quartz, perthite, oligoclase, hornblende, biotite and fayalite. Accessory phases are clinopyroxene, apatite, zircon, magnetite, ilmenite, sphene, allanite and fluorite.

The first minerals to crystallize in the granodiorites were feldspars and quartz with hornblende interstitial between these grains. Hornblende is dark green, pleochroic and probably a hastingsite.

Olivine, another early crystallizing phase, is present in the granodiorite as a minor constituent compared to diorites of the upper zone, where it is abundant. It is altered to iddingsite or iron oxides and only the original outline of the olivine grain is usually recognizable.

Coarse granophyric intergrowth is present in the granodiorites and the content thereof increases as the granophyre is approached. The transitional rock was called a melanogranophyre by Von Gruenewaldt (1971).

Zircons in the granodiorite are zoned and two phases of growth can usually be distinguished in most grains. Most zircon grains are cracked and contain inclusions.

Allanite is a major accessory phase in the granodiorites and forms irregular patches or well developed zoned crystals.

1.2.5. Structural features.

The structure of the area is dominated by the Maleoskop basin (Clubley-Armstrong and Sharpe, 1979). Rooiberg Felsite, Stavoren Granophyre and the underlying basic rocks of the Rustenburg Layered Suite form this basin.

The structure of the Transvaal Sequence in this area is dominated by broad, open folding and by a number of major faults.

A magnetite plug crops out on Kalkfontein 49JS underlying the quartzite member of the Timeball Hill Formation. The relation of upper zone rocks in the area with critical zone further south is not understood. The occurrence of basic rocks, especially a magnetite plug, explains the gravity-high over this farm (Hattingh, 1977).

The intrusion breccia on Rietkloof 166JS is located at the intersection of faults and the extension of the ridge of fine-grained acid roofrocks (Folder 1, back folder). The intersection of faults produced a weakness in the crust, which resulted in the forceful intrusion of the granitic magma. The ridge of fine-grained acid roofrocks together with the upper zone next to it, represents a downfaulted block.

A postulated WNW-ESE striking fault, to the north of and parallel to the Blood River (Von Gruenewaldt, 1966) is considered responsible for the difference in dip and strike between the ridge of fine-grained acid roof rocks to the south and the rocks of the Maleoskop basin to the north.

1.3. Previous Work.

Previous work in this area has been carried out by Hall (1913), who gives an explanation of the regional geology; by Wagner (1929), who noted the occurrence of platinoids in the rocks of the Layered Suite on Blaauwbank 168JS; by B.V. Lombaard (1934) who concluded from his work in the Blood River valley that the granite, granophyre and rhyolite represent textural modifications of the same magma; by A.F. Lombaard (1949), who investigated the relationships between various rocks in the Blood River area; by Von Gruenewaldt (1966,1971), who did extensive work to the south and east respectively, drawing regional correlations and proposing a model for the origin of the roof rocks; and by MacCaskie (1983), who mapped the area and did extensive geochemical research on the Lebowa Granite Suite.

The felsites of the Rooiberg Group were mainly investigated by Lombaard (1932), who proposed a classification for these rocks; by Wolhuter (1954); by Von Gruenewaldt (1968), who investigated the felsites north of Middelburg; by Clubley-Armstrong (1977), who recognized the Damwal and Selons River Formation in the Loskop Dam area and by Twist (1984), who did research on the geochemistry of these rocks and recognized three magma types.

The granophyres have been the subject of detailed investigations by Von Gruenewaldt (1971) and Walraven (1982), who reached markedly different conclusions on the origin of these rocks. Von Gruenewaldt (op. cit.) argued that the granophyres crystallized from a magma which formed during the melting of felsite due to the intrusion of the Layered Suite magma. Walraven (op. cit.), however, claimed that the Rooiberg Felsite and Stavoren Granophyre respectively represent the volcanic and hypabyssal counterparts of one co-magmatic igneous suite.

Most detailed geochemical work on the Lebowa Granite Suite has been done in the Zaaiplaats area by Fourie (1969), Lenthall (1975), Lenthall and Hunter (1977), Groves and McCarthy (1978), Strydom (1983) and Coetzee (1984). Strauss and Truter (1944) and Strauss (1954) recognized four different granite types in the Zaaiplaats area: the Main Granite (Nebo Granite), the Foothills Granite, the Bobbejaankop Granite and the Lease Granite. The primary tin mineralization in the Zaaiplaats area is associated with the Bobbejaankop and Lease Granite.

1.4. Analytical Techniques.

Glass disks of the rock powders were prepared according to the method of Norrish and Hutton (1969) and analysed by XRF for all the major elements except sodium. Compressed 34 millimetre powder pellets were used to analyse for sodium and the trace elements Nb,Zr,Y,Sr,Rb,Ba,Sc,Zn,Cu,Ni,U,Th,Pb,-Nd,Ce,La,Ga,Hf,Sn,W and Mo. The experimental parameters for major and trace element analyses are listed in Tables 1.2. and 1.3. respectively.

The analytical accuracy for major elements is better than one per cent for concentrations greater than one per cent and better than two per cent where the concentration is less than one per cent. Accuracy for trace elements is about five per cent for concentrations less than 20 ppm and about two per cent for concentrations above 50 ppm.

The precision of major and trace element analyses is similar to the accuracy at low concentration of a particular element, but is better than about 0,5 per cent at concentrations of more than five per cent for major elements and more than 50 ppm for trace elements.

Table 1.2. Experimental parameters for major element analyses.

Oxide	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	MgO	CaO	K_2O	Na_2O	Cr_2O_3	NiO	P_2O_5
Tube	Cr	Cr	Cr	W	W	Cr	Cr	Cr	Cr	W	Cr	Cr
Crystal	PET	PET	LIF 220	LIF 220	LIF 220	TLAP	LIF 220	LIF 220	TLAP	LIF 220	LIF 220	Ge
Detector	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC
Aperture	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au
Collimator (Deg)	0,4	0,4	0,15	0,15	0,15	0,4	0,15	0,4	0,4	0,15	0,15	0,4
2θ-Angle	109,155	145,195	86,125	85,775	95,222	45,137	113,135	136,758	55,110	107,200	71,290	140,760
Count-time (sec)	100	100	20	20	40	100	20	20	100	100	100	100
Detection-lim (%)	0,048	0,029	0,007	0,032	0,012	0,143	0,009	0,003	0,080	0,011	0,011	0,025

Table 1.3. Experimental parameters for trace element analyses.

Element	Tube	Aperture	Detector	Crystal	Collimator	Count-time (sec)	2θ-Angle	Detection-lim (ppm)
Ba	Cr	Cr	FC	LIF 200	0,15	200	87,146	3
Rb	W	Cr	SC	LIF 220	0,15	100	37,942	2
Sr	W	Cr	SC	LIF 220	0,15	100	35,830	2
Y	W	Cr	SC	LIF 220	0,15	100	33,868	2
Zr	W	Cr	SC	LIF 220	0,15	100	32,090	2
Nb	W	Cr	SC	LIF 220	0,15	200	30,430	2
La	W	Au	FC	LIF 220	0,15	100	139,042	2
Ce	W	Au	FC	LIF 220	0,15	400	111,770	4
Nd	W	Au	FC	LIF 220	0,15	200	112,832	3
Th	W	Cr	SC	LIF 220	0,15	200	39,300	4
U	W	Cr	SC	LIF 220	0,15	200	37,400	4
Hf	Mo	Cr	SC	LIF 200	0,15	200	39,942	4
Ga	Mo	Cr	SC	LIF 200	0,15	200	38,948	1
Sc	Cr	Cr	FC	LIF 200	0,15	200	97,700	1
Zn	Au	Au	SC	LIF 220	0,15	100	60,511	2
Cu	Au	Au	SC	LIF 220	0,15	100	65,622	2
Ni	Au	Au	SC	LIF 220	0,15	100	71,348	2
Pb	W	Cr	SC	LIF 220	0,15	200	40,400	4
Mo	Au	Au	SC	LIF 220	0,15	200	28,935	3
W	Mo	Cr	SC	LIF 220	0,15	200	62,525	6
Sn	Mo	Cr	SC	LIF 220	0,15	200	19,920	6