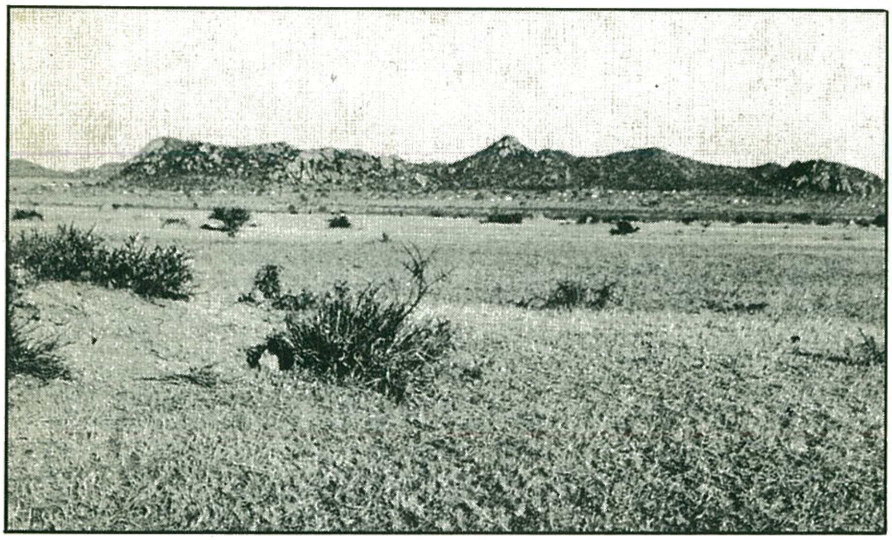
EXPLANATION: SHEET 2328 (1:250 000)
TOELIGTING: BLAD 2328 (1:250 000)



PIETERSBURG

GEOLOGIESE OPNAME
GEOLOGICAL SURVEY

REPUBLIEK VAN
SUID-AFRIKA

REPUBLIC OF
SOUTH AFRICA

Cover — Moletsi Granite surrounded by the flat, low-lying Hout River Gneiss terrain, about 25 km north-west of Pietersburg.

Voorblad — Moletsigraniet omring deur die plat, laagliggende Houtriviergneisterrein, ongeveer 25 km noordwes van Pietersburg.

Republic of South Africa
Republiek van Suid-Afrika

Department of Mineral and Energy Affairs
Departement van Mineraal- en Energiesake

GEOLOGICAL SURVEY
GEOLOGIESE OPNAME

THE GEOLOGY OF THE PIETERSBURG AREA

by/deur

G. BRANDL, Dr. rer. nat.

Explanation of Sheet 2328
Toeligting van Blad 2328
Scale/Skaal 1:250 000

Local/Plaaslik R2,00
(Plus GST/AVB)
Other Countries/Buitelands.......R2,50
Post Free/Posvry

Printed by and obtainable from the Government Printer, Bosman Street/Private Bag X85, Pretoria, 0002/0001
Gedruk deur en verkrygbaar by die Staatsdrukker, Bosmanstraat/Privaatsak X85, Pretoria, 0002/0001

ISBN........................

CONTENTS

Page

THE GEOLOGY OF THE PIETERSBURG AREA

Abstract

The oldest rock type in the area mapped is probably the Goudplaats Gneiss which is thought to have been the basement of the Bandelierkop Complex which consists mainly of ultramafic, mafic and pelitic gneisses. The complex is part of the southern marginal zone of the Limpopo Mobile Belt and the rocks have been subjected to granulite-facies metamorphism.

The Beit Bridge Complex, of the central zone of the Limpopo Mobile Belt, has been divided into the Mount Dowe, Malala Drift and Gumbu Groups. The intrusive Messina Suite is represented by ultramafic rocks. Metamorphism is mainly of granulite grade.

The boundary between the central and marginal zones of the Limpopo Mobile Belt is marked by the 10-km-wide Palala shear zone characterized by mylonitic rocks.

The Pietersburg Group has been divided into four formations composed mainly of ultramafic and mafic metavolcanic rocks. A minimum age of about 3 200 Ma is envisaged for the deposition of the Pietersburg Group, and the Beit Bridge and Bandelierkop Complexes.

The Hout River Gneiss which is intrusive into the Pietersburg Group comprises migmatite, pink gneiss and pegmatite. A number of massive granites, ranging in age between 2 400 and 2 600 Ma, form batholiths and stocks which are characterized by their resistance to weathering.

The Wolkberg Group and the overlying Black Reef Formation consist of shale, quartzite and lava. Rocks of both the Chuniespoort and Pretoria Groups occur as remnants in the Bushveld Complex. The Rooiberg Group is composed entirely or rhyolite.

The Bushveld Complex is divided into a basal mafic unit termed the Rustenburg Layered Suite and a felsic unit containing the Rashoop Granophyre Suite and the Lebowa Granite Suite. The mafic unit consists of gabbro, anorthosite, norite and pyroxenite, and the felsic unit of granophyre and red granite.

The Koedoesrand Formation is entirely sedimentary but is of unknown stratigraphic position although it is intruded by the Palala Granite which is about 1 800 Ma old.

The Waterberg Group in which six formations have been recognized is entirely composed of arenaceous and argillaceous sediments apart from the Blouberg Formation which, in addition, has lava.

The rocks of the Soutpansberg Group are divided into three formations with a total maximum thickness of about 2 800 m. At the base, basaltic lava with intercalated quartzite is developed and followed by a thick pile of quartzite. Deposition is inferred to have taken place in a fault-bounded aulacogen.

Dykes and sills of diabase have intruded into almost all pre-Karoo rocks.

The Karoo Sequence consists of a basal shaly and sandy unit overlain by basaltic lava. Seven formations have been recognized.

Most of the Swazian lithologies have been subjected to several phases of deformation resulting in complex interference fold patterns. The sediments of the Waterberg Group lie subhorizontally whereas the rocks of the Soutpansberg Group dip more steeply to the north.

Important economic minerals are chromite, magnetite and the platinum-group metals; and vein quartz from which silicon is produced.

Uittreksel

Die oudste gesteente in die kaartgebied is waarskynlik die Goudplaatsgneis wat die fondament van die Kompleks Bandelierkop wat hoofsaaklik uit ultramafiese, mafiese en pelitiese gneise bestaan, vorm. Die Kompleks vorm deel van die suidelike grenssone van die Limpopo Mobiele Gordel en die gesteentes was onderworpe aan granulietfasies-metamorfose.

Die Kompleks Beitbrug, wat die sentrale sone van die Limpopo Mobiele Gordel verteenwoordig, is in drie eenhede verdeel, naamlik die Groepe Mount Dowe, Malala Drift en Gumbu. Die intrusiewe Suite Messina word verteenwoordig deur ultramafiese gesteentes. Metamorfose is hoofsaaklik van granulietgraad.

Die skeiding tussen die sentrale en die suidelike grenssone van die Limpopo Mobiele Gordel word deur die Palala skuifskeursone wat 10 km wyd is, bepaal en word deur milonitiese gesteentes gekenmerk.

Die Groep Pietersburg is in vier formasies verdeel wat hoofsaaklik uit ultramafiese en mafiese metavulkaniese gesteentes bestaan. 'n Minimum ouderdom van omtrent 3 200 Ma word vir die afsetting van die Groep Pietersburg en die Komplekse Bandelierkop en Beitbrug voorsien.

Die Houtriviergneis het 'n intrusiewe verwantskap met die Groep Pietersburg en bestaan uit migmatiet, rooskleurige gneis en pegmatiet. Verskeie massiewe graniete met ouderdomme wat wissel tussen 2 400 en 2 600 Ma vorm koepels en batoliete wat gekenmerk word deur weerstand teen verwering.

Die Groep Wolkberg en die oorliggende Formasie Swartrif bestaan uit skalie, kwartsiet en lawa. Gesteentes van beide die Groepe Chuniespoort en Pretoria is as oorblyfsels in die Kompleks Bosveld aanwesig. Die Groep Rooiberg bestaan in geheel uit rioliet.

Die Kompleks Bosveld word verdeel in 'n basale mafiese eenheid, die Gelaagde Suite Rustenburg, en in 'n felsiese eenheid wat uit die Granofiersuite Rashoop en die Granietsuite Lebowa bestaan. Die mafiese eenheid bestaan hoofsaaklik uit gabbro, anortosiet, noriet en piroksseniet, terwyl die felsiese eenheid uit granofier en rooi graniet bestaan.

Die Formasie Koedoesrand bestaan in geheel uit sedimentêre gesteentes waarvan die presiese stratigrafiese posisie nog onbekend is. Intrusief in hierdie formasie is die Palalagraniet van omtrent 1 800 Ma.

Die Groep Waterberg, waarin ses formasies onderskei is, is hoofsaaklik saamgestel uit sandige en kleiige sedimente met die uitsondering van die Formasie Blouberg waarin ook lawa voorkom.

Die gesteentes van die Groep Soutpansberg is in drie formasies, met 'n maksimum dikte van ongeveer 2 800 m verdeel. Die basis bestaan uit basaltiese lawa met tussengelaagde kwartsiet, gevolg deur 'n dik laag van kwartsiet. Soos afgelei het afsetting in 'n verskuiwingbegrensde aulakogeen plaasgevind.

Gange en plate van diabaas het feitlik al die voor-Karoogesteentes binnegedring.

Die Opeenvolging Karoo bestaan uit 'n basale skalieagtige en sandige eenheid wat deur basaltiese lawa oorlê word. Sewe formasies is uitgeken.

Die meeste van die Swaziese litologieë was onderworpe aan verskeie fases van deformasie met gevolglike komplekse plooipatrone. Die sedimente van die Groep Waterberg lê subhorisontaal terwyl die gesteentes van die Groep Soutpansberg effens noordwaarts hel.

Belangrike ekonomiese minerale in die kaartgebied is chromiet, magnetiet en die platinumgroepmetale; en aarkwarts wat vir silikon gemyn word.

1. INTRODUCTION

The area under consideration was surveyed mainly between 1971 and 1977 by personnel of the Geological Survey, various university students and mining company geologists. The present account is based on their findings which have appeared either as unpublished reports or theses. Previous work includes two published maps, namely Sheets No. 35 and 36 Koedoesrand (1952) with accompanying explanation (1953) and Sheet 2328 Pietersburg (1959).

Most of the area forms undulating country with the altitude varying between 900 m and 1 300 m. The monotony of the plains is occasionally broken by ridges and inselbergs. Along the northern edge, resistant sediments give rise to a mountainous landscape with the highest point being 2 051 m above sea-level. A large part of the western half of the area comprises a plateau, with an altitude between 1 100 and 1 400 m, which is bounded on the west by a conspicuous escarpment.

2. GENERAL OUTLINE

The northern portion of the area forms part of the Limpopo Mobile Belt – which has been subdivided into a central and two marginal zones – separating the Kaapvaal Craton from the Rhodesian Craton (Cox et al. 1965). In the area described, only the southern marginal zone and part of the central zone are present; the latter being characterized mainly by north–south-trending cross folds whereas east–west-trending folds predominate in the southern zone. The boundary between the two has been taken, on the map sheet, to be the Melinda Fault which marks the northern limit of the Palala shear zone. The boundary between the southern zone and the Kaapvaal Craton was originally thought by Mason (1973) to be a shear zone, but has recently been redefined by Du Toit and Van Reenen (1977) and Van Reenen and Du Toit (1977) in terms of metamorphism. It is now been taken as the ortho-amphibole isograd, which being poorly established is not shown on the map sheet. This isograd roughly parallels the orthopyroxene isograd, which is shown, between 5 and 25 km farther south. The zone between the two isograds is referred to as the ortho-amphibole zone.

3. GOUDPLAATS GNEISS

The Goudplaats Gneiss*, mainly confined to the north-eastern part of the map area, includes gneiss, banded gneiss and migmatite associated with leucocratic granite in varying proportions. There are excellent outcrops on Baviaanskloof 384 LS, Rietgat 836 LS and in a river bed about 2 km south-west of Veekraal.

The prevalent migmatitic layering is defined by alternating bands of melanocratic and leucocratic material several centimetres in width. According to Du Toit (1979), the leucocratic bands are usually concordant but, to a lesser extent, cross cutting with respect to the melanocratic bands and earlier formed leucocratic bands. Locally they even form large unfoliated masses. These anatectic melts were therefore generated during several phases of mobilization over a long period.

The colour of the gneiss ranges from dark to light grey. The melanocratic bands generally consist of biotite, hornblende, oligoclase (An_{20}), quartz and hypersthene. The leucocratic material, which ranges in grain size from fine to very coarse, is composed of perthite, oligoclase (An_{16-30}) and quartz with biotite, garnet, sillimanite and magnetite as accessories.

In the south-eastern sector the Goudplaats Gneiss is less contorted and planar bands are regularly and well developed (Plate 3.1). Locally, where both the dark and light bands of the gneiss are cut by later anatectites, it is seen that the

* Termed Baviaanskloof gneiss in the Bandelierkop area by Du Toit and Van Reenen (1977) and Van Reenen and Du Toit (1977).

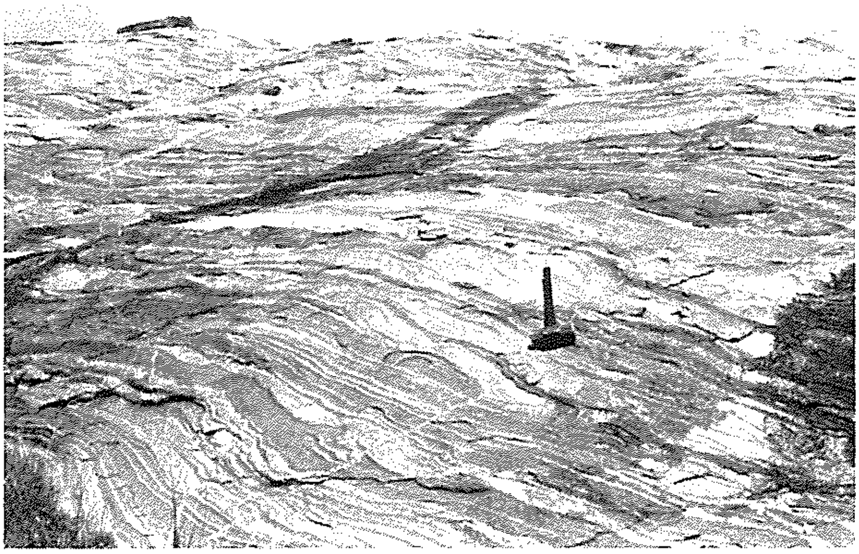


Plate 3.1 — Banded gneiss in an exposure of the Goudplaats Gneiss on Rietgat 836 LS.
Plaat 3.1 — Gestreepte gneis in 'n blootlegging van die Goudplaatsgneis op Rietgat 836 LS.

foliation planes acted as small-scale right-lateral shears.

Chemical analyses indicate that the grey migmatitic gneiss has a tonalitic and, in places, quartz-dioritic composition, whereas the leucocratic material ranges in composition between adamellite and tonalite.

The Goudplaats Gneiss is thought to have formed the basement to the Bandelierkop Complex and the Pietersburg Group on the grounds that it locally exhibits much more complex deformation. It might be a correlate of the Sand River Gneiss, in the central zone, which has yielded a radiometric age of 3 780 Ma* (Barton et al. 1977).

Ages so far obtained from the Goudplaats Gneiss vary between 2 652 and 3 054 Ma (Burger and Walraven 1979b, Walraven et al. 1981). These probably reflect metamorphic overprints.

*Age recalculated since publication.

4. BANDELIERKOP COMPLEX

This complex constitutes a typical greenstone belt succession of metasedimentary and metavolcanic rocks. It has been subdivided into ultramafic, mafic and pelitic rock units, plus metaquartzite and marble. The order of succession as given in the legend is speculative. The complex is part of the southern marginal zone of the Limpopo Mobile Belt and has been subjected to granulite-facies metamorphism; these rocks now occurring as highly deformed keels surrounded by the Goudplaats and Hout River Gneisses.

Some of the units present within the Palala shear zone have been tentatively grouped with the Bandelierkop Complex but are possibly part of a transition zone between the central and the southern zone of the Limpopo Mobile Belt.

The following account of the lithological units is based largely on the detailed work carried out by Van Reenen (1978) and Du Toit (1979).

4.1 ULTRAMAFIC ROCKS

The ultramafic rocks are present as strings of rounded bodies which once probably belonged to a continuous basal layer. These are massive, weakly foliated rocks and include peridotite, dunite, metapyroxenite and hornblendite. The peridotite has komatiitic affinities and consists of forsterite and orthopyroxene with minor clinopyroxene and hercynite. Dunite is made up dominantly of olivine and accessory pyroxene. In both, the olivine is invariably altered to antigorite. The metapyroxenite is composed of large crystals of orthopyroxene with minor spinel, amphibole and clinopyroxene. The hornblendites contain greenish hornblende and accessory hypersthene, quartz, feldspar and sphene.

The chemical composition, the close association with magnetite quartzite, gradation into mafic rocks and the occasional presence of pillow structures support the view that most of the ultramafic rocks extruded as lavas. Probably of intrusive character, however, are the fairly fresh metapyroxenites and a body of ultramafic rocks on Lemoenfontein 443 LS which contains chromite segregations. These could be equivalents of the intrusive Messina Suite of the central zone which gave a radiometric age of 3 150 Ma (Barton et al. 1979).

4.2 MAFIC ROCKS

The mafic rocks include mafic granulite, occurring north of the orthopyroxene isograd, and amphibolite outcropping in the ortho-amphibole zone.

The mafic granulite which is a medium-grained, black and white mottled rock is composed of plagioclase (An_{40-66}), augite, orthopyroxene and green to brown hornblende. Ore minerals and quartz are only minor constituents. The granulite within the Palala shear zone is a medium-grained, bluish grey rock made up of orthopyroxene with subordinate clinopyroxene and plagioclase (McCourt in press). The amphibolites are dark coloured, have a well-developed banding and are composed of light- to dark-green hornblende, plagioclase (An_{25-48}) and quartz, with some minor augite, sphene and epidote.

All of these rocks are considered to have been derived from basaltic lavas of tholeiitic and partly komatiitic type.

4.3 MAGNETITE QUARTZITE AND METAQUARTZITE

Both varieties occur only sporadically. Where the magnetite quartzite is in contact with pelitic rocks it contains, in addition to quartz and magnetite, some garnet together with orthopyroxene or ortho-amphibole.

The metaquartzite may contain fuchsitic mica or biotite.

4.4 METAPELITE

The metapelites are purplish brown in colour very resistant, and weather to form dark-brown, flat barren pavements or large boulders. The rocks are characterized by concordant bands or streaks of leucocratic anatectic material imparting a distinctly migmatitic appearance.

They are composed largely of plagioclase (An_{22-34}), quartz, biotite, garnet, cordierite, K-feldspar, spinel and kyanite. Hypersthene is an additional main constituent in those rocks occurring north of the orthopyroxene isograd, whereas south of the isograd it is replaced by anthophyllite and gedrite.

The metapelites in the Palala shear zone are mineralogically similar to those occurring north of the orthopyroxene isograd (Visser 1953).

The leucocratic bands in the metapelite are composed of quartz, plagioclase and orthoclase together with very minor garnet and sillimanite. The latter mineral may also be a constituent in the metapelite occurring south of the orthopyroxene isograd.

The precursor of the metapelite is thought to have been largely greywacke.

4.5 MARBLE AND CALC-SILICATE ROCKS

Calc-silicate rocks form only a few very small outcrops and are not shown on the map sheet in the Bandelierkop area. These pale- to dark-green, banded rocks are composed of diopside, seriticized plagioclase, sphene and epidote.

Marbles crop out west of Blouberg and within the Palala shear zone. The main constituents of these grey and pink, coarse-grained rocks are calcite and/or dolomite and pyroxene which is invariably serpentinized.

4.6 METAMORPHISM AND AGE

A three-phase metamorphic history of the Bandelierkop Complex has been deduced from the sequence of minerals contained in the metapelites.

In a first event, termed M_1, the complex was subjected to granulite-facies metamorphism with a temperature of about 800 °C and pressure in excess of 8 kb. Evidence for this episode is the stable coexistence of garnet + hypersthene + biotite without cordierite. In a second, retrograde event (M_2), at a similar temperature but slightly lower pressure, cordierite and second-generation hypersthene symplectites were formed by partly replacing garnet. This event can probably be related to a period of uplift. In a third, also retrograde episode (M_3) which established the present position of the orthopyroxene isograd, ortho-amphibole was formed as a result of the hydration of hypersthene and cordierite. Because M_3 is a retrograde event the orthopyroxene isograd is defined by the disappearance, and not appearance, of orthopyroxene. Controlling factors of this last event were probably an increase in water pressure and a slight decrease in temperature from 800 to about 750 °C. The three events are believed to represent a continuous metamorphic process and not several independant episodes.

Radiometric dating has yielded an age of 2 636 ± 98 Ma (Barton and Ryan 1977) which probably reflects a metamorphic overprint. The Bandelierkop Complex could be a correlate of the supracrustal rocks of the Beit Bridge Complex which have a minimum age of about 3 150 Ma (Barton et al. 1979).

5. BEIT BRIDGE COMPLEX

The Beit Bridge Complex, located in the central zone of the Limpopo Mobile Belt, is a succession of metasedimentary and metavolcanic rocks. On the basis of lithology it has been subdivided into the Mount Dowe, Malala Drift and Gumbu Groups (SACS 1980). Intrusive into the complex are ultramafic rocks of the Messina Suite.

This succession is thought to have been laid down in a fault-bounded basin under shallow-water conditions. These rocks were then subjected to high-grade – for the greater part granulite-facies – metamorphism. The stratigraphic order as shown in the legend is uncertain.

The following account is mainly based on the findings of Visser (1953), McCourt (1977, 1981) and Tickell (1975b).

5.1 MOUNT DOWE GROUP

This group, probably at the base of the Beit Bridge Complex, consists of metaquartzite and magnetite quartzite with minor intercalations of garnetiferous leuco-gneiss, amphibolite and mafic granulite.

The topographically prominent metaquartzite is a coarse-grained, whitish to grey rock consisting chiefly of large interlocking grains of strained quartz. Minor local constituents include green fuchsitic mica, sillimanite, dark-green tourmaline, rutile, pyrite, biotite, pyroxene and hornblende. Although almost completely recrystallized, the rock locally retains traces of bedding accentuated by green mica.

Magnetite quartzite is a medium- to fine-grained, dark-grey to black rock having a distinctly glistening appearance. It consists of alternating layers of quartz-rich and magnetite/hematite-rich material which probably reflect original bedding. Grunerite, tremolite and anthophyllite occur in places in the iron-rich layers.

It is believed that the metaquartzites are the metamorphic equivalents of orthoquartzites which locally contained argillaceous and calcareous admixtures. The magnetite quartzites have probably been formed from chemically precipitated ferruginous sediments.

5.2 MALALA DRIFT GROUP

The Malala Drift Group comprises mainly garnetiferous, leucocratic gneiss, amphibolite with mafic granulite and metapelite.

The leucocratic gneiss is a well-foliated, medium-grained, light-grey to pinkish rock which usually forms numerous small, scattered outcrops, often too small to be shown on the map, and it is thought that it underlies most of the sand-covered area.

The gneiss is made up of quartz, K-feldspar and sodic plagioclase with minor garnet, biotite and sphene. The garnet, of reddish brown colour, may be locally absent.

The amphibolite which is medium- to fine-grained and very dark grey in colour, consists of hornblende and calcic plagioclase with a little apatite and magnetite. In places the rock is garnetiferous. Most amphibolite outcrops are capped by surface limestone.

Mafic granulite which is shown on the map together with amphibolite is a dark-coloured, medium- to coarse-grained rock having poorly developed foliation. The granulite is characterized by the presence of plagioclase, hypersthene, clinopyroxene and hornblende.

The main constituents of the metapelite which is a brownish coloured, coarse-grained massive rock, are plagioclase, quartz, cordierite, hypersthene, garnet and biotite. Sillimanite may be an additional constituent.

The precursors of the mafic granulite and of most of the amphibolites are thought to have been mafic lavas. Leucocratic gneiss and metapelite were probably derived from impure arkose and calcareous shale respectively.

5.3 GUMBU GROUP

Marble together with associated calc-silicate rocks constitutes the bulk of the group, apparently at the top of the Beit Bridge Complex. Minor intercalations include amphibolite, metaquartzite and garnetiferous leucocratic gneiss. The rocks of the Gumbu Group usually form positive topographic features, often covered by surface limestone.

The marbles are medium- to coarse-grained rocks which range in colour from white through grey to an attractive pink. Almost pure marble is composed mainly of equant granular calcite/dolomite with minor phlogopite and serpentinized olivine and pyroxene. The more impure varieties additionally carry amphibole, sphene, microcline, scapolite and quartz.

Minor occurrences of calc-silicate rocks are typically medium grained, greenish grey and well banded. The last feature probably reflects original compositional layering. The main constituents are variable amounts of diopside, amphibole, calcite/dolomite, microcline, plagioclase, scapolite, olivine, sphene and quartz.

At some localities, closely associated with calc-silicate rocks and marble, a coarse-grained greenish rock consisting almost entirely of scapolite is developed in the form of thin bands and lenses.

It is believed that the calc-silicate rocks were calcareous shales, and the marbles were dolomitic limestones and calcitic dolomites. The scapolite rocks may have developed from shales containing minor amounts of evaporites (Brandl in press).

5.4 MESSINA SUITE

The Messina Suite comprises principally metapyroxenite and serpentinite which are considered to be intrusive into the Beit Bridge Complex.

The metapyroxenite is a coarsely crystalline, greenish black rock composed of large equigranular grains of pyroxene, mainly hypersthene and minor amphibole, plagioclase, spinel and magnetite.

The serpentinites which probably represent altered peridotites are dark-green and greenish black rocks in which antigorite, anthophyllite and tremolite can be recognized. The occasional presence of chromite indicates igneous origin. Coarsely crystalline hornblendite is locally associated with serpentinite.

5.5 CORRELATION AND AGE

An anorthositic rock of the Messina Suite near Messina yielded a radiometric age of about 3 150 Ma (Barton et al. 1979). As it is thought that the ultramafic rocks present in the map area are genetically related to the anorthosites, they might be of the same age.

This age for the Messina Suite also represents a minimum age for the deposition of the supracrustal rocks of the Beit Bridge Complex into which the ultramafics are believed to have been emplaced.

No equivalents of the Sand River Gneiss have as yet been positively identified in the map area but a possible correlate could be a grey migmatitic biotite gneiss of tonalitic composition which crops out on Wagendrift 244 LR where it is shown as part of the Malala Drift Group. However, McCourt (in press) proposes that the contacts indicate an intrusive relationship.

6. PIETERSBURG GROUP

The rocks of the Pietersburg Group occur as two narrow, linear arcuate belts and as numerous scattered xenoliths enveloped by granitoid rocks.

The lithologies present are typical of an Archaean greenstone belt which developed in a rifting environment probably on an unstable sialic crust.

The group has been divided into six units of which the Mothiba, Eersteling, Zandrivierspoort and Vrischgewaagd Formations have been recognized in the area.

6.1 MOTHIBA FORMATION

This formation, considered to form the base of the Pietersburg Group, is the most widespread lithostratigraphic unit and usually forms moderately high ridges. In the vicinity of Pietersburg the formation comprises mainly ultramafic metavolcanics which have strong affinities to peridotitic komatiites. Talc-chlorite and amphibole-chlorite schists, talc schist and serpentinite are the main rock types. They thin gradually towards the east, and from about Doornfontein 912 LS to the eastern boundary of the map area the formation consists of fine-grained, bluish grey amphibolite. Chemical analyses indicate that the amphibolites were derived from tholeiitic basalts. They are very similar to the amphibolites in the Eersteling Formation but are tentatively still retained in the Mothiba Formation. Thinly banded ironstone and ferruginous quartzite are locally interbedded with the ultramafics and the amphibolite.

6.2 EERSTELING FORMATION

Small scattered xenoliths of amphibolite in the extreme south-eastern part of the map area are believed to be part of the Eersteling Formation. Beyond the map area it has been established that the amphibolites are derived from tholeiitic basalts.

6.3 ZANDRIVIERSPOORT FORMATION

This formation which is not spatially connected with the main outcrop of the Pietersburg Group is considered, "on lithological grounds, to represent a lateral equivalent of the Eersteling Formation" (SACS 1980). It forms several conspicuous ridges known as the Rhenosterkoppies.

The main rock type is a mafic metavolcanic rock represented by fine-grained amphibolite which consists mainly of hornblende and plagioclase. Intercalated are magnetite quartzite and minor metaquartzite, quartz-sericite schist and calc-silicate rocks. The magnetite quartzite, which is composed mainly of quartz, magnetite/hematite and minor grunerite, forms four separate horizons in the formation (Jantsky 1978). Often closely associated with the magnetite quartzite are garnetiferous schists. At the base of the succession a thin layer of ultramafics may be present.

6.4 VRISCHGEWAAGD FORMATION

The Vrischgewaagd Formation is represented by sporadic xenoliths in the vicinity of Haenertsburg. It consists of greenish grey, fine-grained quartz-chlorite schist in which kyanite is locally present. The precursor of the rock was probably a shale.

6.5 METAMORPHISM AND AGE

Preliminary results suggest that the metamorphism of the Mothiba, Eersteling and Vrischgewaagd Formations was in the upper temperature range of low to medium grade. The Zandrivierspoort Formation was probably subjected largely to metamorphic conditions of medium grade.

No radiometric ages on the Pietersburg Group are so far available, there being only a minimum age of about 2 600 Ma which has been obtained from several intrusive granites. However, there can be little doubt that the Pietersburg Group is coeval with the Barberton Sequence which ranges in age between 3 300 and 3 800 Ma (SACS 1980).

7. INTRUSIVE ULTRAMAFIC ROCKS

The ultramafic rocks in the vicinity of Haenertsburg and around the Rhenosterkoppies include metapyroxenite and serpentinite. They are often altered to a talcose rock which is either slightly schistose or massive. The metapyroxenite, where not altered, consists typically of diopside and hornblende with minor plagioclase and magnetite (Jantsky 1978).

The intrusions are thought to have been emplaced after deposition of the Pietersburg Group, though no direct evidence is available.

8. HOUT RIVER GNEISS

Under this term a wide variety of granitoid rocks have been grouped. They include leucocratic migmatite and gneiss, grey and pink hornblende-biotite gneiss, grey biotite gneiss and pegmatitic rocks. They largely underlie flat country and are poorly exposed.

The contact between the Hout River Gneiss and the Goudplaats Gneiss, as shown on the map, is only arbitrary.

Leucocratic migmatite and gneiss consist typically of dominant quartzofeldspathic layers and thin parallel streaks, mainly of biotite. Good exposures can be seen on Waschbank 637 LS, Groothoek 129 LS and in the bed of the Hout River on Bethesda 208 LS. At the last locality trains of inclusions belonging to the Pietersburg Group occur in leucocratic migmatite (Plate 8.1). Additionally there is a small remnant exposure of a fine-grained, dark-grey biotite gneiss similar to the Goudplaats Gneiss. On Groothoek 129 LS the leucocratic gneiss carries garnets, arranged in streaks and clusters, as well.

In the Dendron and Blouberg areas the common variety is a medium- to coarse-grained, pinkish grey and pink leucocratic gneiss composed of orthoclase and quartz with minor plagioclase, biotite and hornblende. The dark minerals usually impart a strong lineation.

Grey and dark-grey biotite gneiss of granodioritic composition is developed in the Pietersburg area in a marginal zone several kilometres wide flanking the Mothiba Formation on the northern side. The gneiss is typified by the absence of anatectic material. The foliation which shows up well only on weathered surfaces parallels the fabric in the adjacent schistose rocks of the Pietersburg Group.

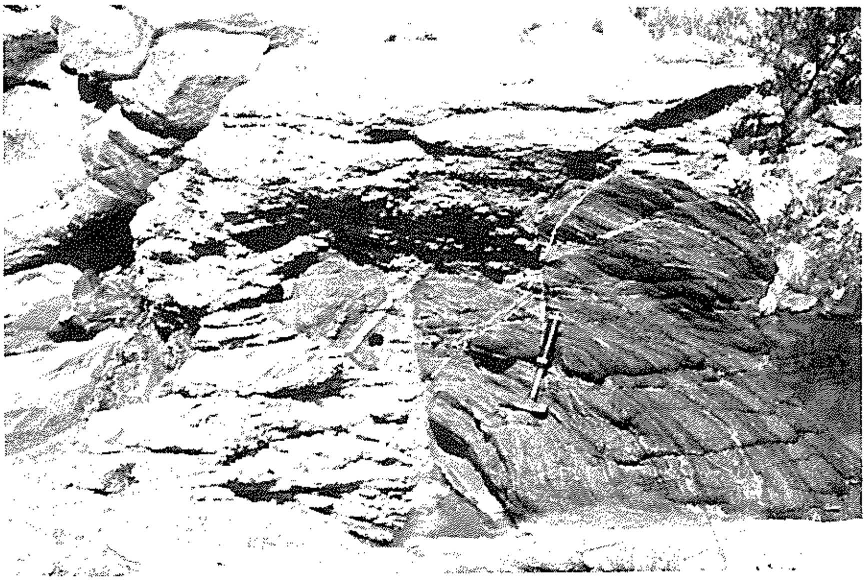


Plate 8.1 – Inclusion of amphibolite of the Zandrivierspoort Formation in leucocratic migmatite of the Hout River Gneiss on Bethesda 208 LS.
Plaat 8.1 – Insluitsel van amfiboliet van die Formasie Zandrivierspoort in leukokratiese migmatiet van die Houtriviergneis op Bethesda 208 LS.

Muscovite-bearing granite and pegmatite occur throughout the Hout River Gneiss but seem to be more prominently developed near the contact with the Pietersburg Group. They are largely massive unfoliated rocks which may have in places a directional fabric. Garnet and biotite may additionally be present in the rock. A number of samples of grey gneiss taken east of Setlaole gave radiometric ages which cluster around 2 750 Ma (Walraven et al. 1981). These ages probably reflect the last metamorphic event.

9. RANDIAN AND VAALIAN INTRUSIVES

The intrusions are largely granites which form scattered bodies in both the southern marginal zone and the adjacent Kaapvaal Craton. The bodies vary in size from large batholiths to small circular or oval stocks and are distinguished by their topographic expression. They are largely devoid of directional fabric and the majority of them can therefore be regarded as being post-kinematic.

9.1 RANDIAN INTRUSIVES

The intrusives of Randian age are represented by the Hugomond, Matok and Moletsi Granites and an unnamed granite situated at Vaalkop 819 LR and adjacent areas.

9.1.1 Granite at Vaalkop

This granite is a medium-grained, occasionally fine-grained, grey to pink rock of granodioritic composition which forms a few low hills near the southern boundary of the map area.

9.1.2 Hugomond Granite

The Hugomond Granite is a coarse-grained, sometimes porphyritic, grey biotitic rock which occurs as a number of low barren ridges on Hugomond 118 LS (Wilsenach 1980). It is cut by tourmaline-bearing pegmatitic veins having indistinct contacts. A radiometric age of 2 658 ± 65 Ma has been obtained (Burger and Walraven 1979b).

9.1.3 Matok Porphyroblastic Granite

The Matok Porphyroblastic Granite which forms a major batholithic intrusion and several stocks north of the Rhenosterkoppies is characterized by the presence of a mafic and a younger granitic phase (Du Toit 1979). The mafic phase itself can be divided into an older enderbitic and a younger charnno-enderbitic phase. Both are confined mainly to the northern edge of the batholith. The enderbite is typically fine grained and dark coloured whereas the charno-enderbite is paler and coarser grained. Mineralogically both types are similar and are composed of plagioclase (An_{38-50}) and biotite with subordinate augite, hypersthene, orthoclase and quartz. They differ only in pyroxene content, which is less in the charno-enderbite.

The younger phase is represented by various granitic rocks which range in composition from adamellitic to granodioritic. The main variety is a grey and pink, coarse-grained porphyritic granite made up of microcline phenocrysts, plagioclase (An_{18}), quartz and biotite. It is characterized by the presence of rapakivi texture. Minor varieties include a medium-grained hornblende granite and a pink, medium-grained biotite granite.

In the mixed zone, the enderbitic and charno-enderbitic rocks are partially assimilated by the younger granitic phase. The Matok Granite generally exhibits a weak foliation. Only in the north-eastern part of the batholith is the fabric fairly well developed. Enclaves of Goudplaats Gneiss and metapelite of the Bandelierkop Complex are commonly observed in the Matok Granite. Radiometric ages obtained from the granitic phase cluster around 2 650 Ma (Barton and Ryan 1977).

9.1.4 Moletsi Granite

This biotite granite which weathers typically into huge oval boulders (Plate 9.1) consists of two varieties: a pink to grey coarse-grained granite which is rimmed by a grey to pink, medium-grained porphyritic rock. The latter is more widespread. Locally the granite which has a granodioritic composition contains aligned clusters of biotite, now largely altered to chlorite. It also contains inclusions of banded gneiss and leucocratic granite. Garnets may occasionally be present (Van Wyk 1977).

9.2 VAALIAN INTRUSIVES

The Vaalian intrusives include the Mashashane Suite, the Utrecht, Turfloop, Palmietfontein, Smitskraal, Nooitgedacht and Matlala Granites, and an unnamed leucocratic granite and syenite.

9.2.1 Mashashane Suite

In the Mashashane Suite, which gives rise to a characteristic inselberg-type topography, two phases have been recognized. They are termed the Uitloop and Lunsklip Granites. The latter is medium to coarse grained, pink and

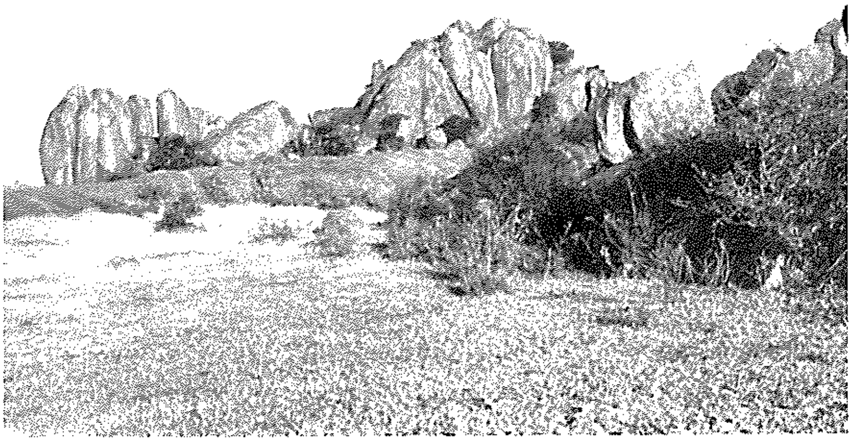


Plate 9.1 – Typical mode of weathering of the Moletsi Granite on Moletsilokasie 606 LS.
Plaat 9.1 – Tipiese aard van verwering van die Moletsigraniet op Moletsilokasie 606 LS.

pinkish grey in colour and its main constituents are quartz, orthoclase, microcline–perthite, sodic plagioclase, hornblende and biotite. The composition of the granite varies between adamellitic and granodioritic. In places there is a knife-sharp contact with the country rock.

The Uitloop Granite which forms only two minor occurrences close to the southern edge of the map area is mineralogically similar to the Lunsklip Granite but does not contain hornblende. The rock which has an adamellitic composition, is medium to coarse grained and mainly reddish in colour.

A characteristic feature in both granites is the presence of milky blue quartz which is indicative of post-crystallization stress (De Villiers and Brandl 1977, Van Wyk 1977).

Radiometric analyses indicate an age of about 2 610 Ma for the Lunsklip Granite and about 2 550 Ma for the Uitloop Granite (Burger and Coertze 1977, Burger and Walraven 1979b).

9.2.2 Utrecht Granite

The Utrecht Granite which forms a circular stock-like body north of the Platreef Mine is a fine-grained, pink biotitic rock of granodioritic composition.

Locally, garnets are present and enhance a weak foliation. They are probably derived from almost completely digested inclusions.

9.2.3 Turfloop Granite

This granite, a major batholithic intrusion, flanks the southern edge of the Pietersburg Group forming numerous isolated hills. It is a medium- to coarse-grained, grey to pinkish biotitic rock of adamellitic to granodioritic composition and contains orthoclase, microcline, quartz, sodic plagioclase and biotite with sphene and zircon as accessories (Jantsky 1978). Enclaves of migmatite are ubiquitously present and radiometric ages are in the range of 2 566 to 2 660 Ma (Burger and Walraven 1977, 1979a).

9.2.4 Syenite

Syenite forms a few intrusive stocks in the Goudplaats Gneiss and the Bandelierkop Complex. It is a greyish, medium- to fine-grained rock, in places pegmatitic, which consists largely of orthoclase, microcline–perthite, diopside, augite and quartz (Du Toit 1979). A sample of syenite from the Schiel Alkaline Complex which is situated just east of the map area has yielded a radiometric age of 2 572 ± 26 Ma (Barton et al. 1977).

9.2.5 Leucocratic granite

The leucocratic granite which crops out in the vicinity of Haenertsburg is a whitish, medium- to coarse-grained rock carrying only very minor amounts of biotite. Outside of the map area a similar granite intrudes a rock which has been dated at 2 690 ± 65 Ma (Burger and Walraven 1979b).

9.2.6 Palmietfontein Granite

This granite crops out in the north-eastern part of the map area where it forms scattered stock-like intrusions as well as locally occurring dykes and sheets. It is a light-grey, medium-grained rock of adamellitic to granitic (*sensu stricto*) composition which consists of quartz, K-feldspar, plagioclase, muscovite and very minor biotite. A radiometric age of 2 505 ± 30 Ma has been reported (Barton, quoted in Du Toit 1979).

Because the Palmietfontein Granite is devoid of an internal fabric it is believed to have been emplaced into a tectonically stable crust thus indicating the end of all tectono-metamorphic events in the southern marginal zone prior to about 2 500 Ma (Du Toit 1979).

9.2.7 Smitskraal Granite

This pink, coarse-grained biotitic rock of granitic (*sensu stricto*) composition forms some minor intrusive stocks in the Munnik area. Fine-grained or porphyritic varieties do occur locally (Jantsky 1978). The granite has radiometric ages in the range of 2 410 to 2 516 Ma (Burger and Walraven 1979a).

9.2.8 Nooitgedacht Granite

This granite forms a sheet-like intrusion between the Moletsi and Matlala Granites and is a fine-grained, in places porphyritic, pink biotitic rock.

9.2.9 Matlala Granite

The Matlala Granite occurs in outcrop as a roughly circular batholith with some offshoots at its north-eastern margin. The outcrops coincide with rugged mountainous terrain which rises to some 600 m above the surrounding plains.

In the Matlala Granite, Van Wyk (1977) recognized eight varieties which have been grouped into two on the map. The granite ranges in grain size from fine to coarse porphyritic and in colour from light grey through pink to red. The most widespread type, however, is a fine-grained grey and pink biotitic rock of granodioritic composition. Locally, the presence of rapakivi texture, milky blue quartz, and hornblende has been observed. Near the contact with the country rock angular and also partly assimilated inclusions of gneiss are often present (Potgieter 1976).

Radiometric ages obtained vary between 2 236 and 2 491 Ma (Burger and Walraven 1979a, b).

10. WOLKBERG GROUP AND BLACK REEF QUARTZITE FORMATION

Rocks of the Wolkberg Group and the Black Reef Quartzite Formation are developed in the extreme south-eastern part of the mapped area where they give rise to a prominent escarpment.

The Wolkberg Group rests unconformably on Swazian and Randian rocks and is composed of dark-coloured shale with intercalations of whitish and grey quartzite and conglomerate. The shale has a tuffaceous aspect in places. At the base, lava may be developed. This rock is, in general, deeply weathered. The thickness of the group is about 300 m.

The overlying Black Reef Formation has a minimum thickness of about 50 m and comprises greyish white, medium-grained quartzite with occasional conglomeratic beds.

11. CHUNIESPOORT AND PRETORIA GROUPS

Both groups are present only as small metamorphosed xenoliths in the Bushveld Complex. The Chuniespoort Group is represented by serpentinized dolomite which occurs near the floor contact of the Bushveld Complex.

The Pretoria Group comprises quartzite, hornfels and marble. The quartzites are fine to coarse grained and vary in colour from white through brown to bluish. Occasionally they contain clinopyroxene (hedenbergite), hornblende, biotite, chlorite and magnetite as accessory constituents (Van der Walt 1978). Hornfels which is dark grey on fresh surfaces and sometimes has a banded appearance consists mainly of plagioclase, pyroxene, quartz, biotite, cordierite and magnetite in variable amounts. Light-grey marble is composed largely of calcite/dolomite and serpentinized olivine. Wollastonite and grossularite may be locally present. These altered sediments probably belong to the Houtenbek Formation of the Pretoria Group.

12. ROOIBERG GROUP

This group which forms a major outcrop south-east of Villa Nora is represented in the mapped area only by rhyolite with interbedded agglomerate and tuff (Van der Walt 1978). The rhyolite is red and dark blue on fresh surfaces weathering into a reddish brown colour; occasionally exhibiting flow structures. The rock consists of phenocrysts of quartz, orthoclase and albite set in a groundmass of quartz, feldspar, chlorite and some magnetite. Spherulitic textures have been locally observed.

The agglomerate appears at about four stratigraphic levels and consists of fragments of rhyolite embedded in a groundmass of similar composition.

The tuff which is a fine- to medium-grained, grey to blackish rock occurs only at one horizon. Cross bedding and the presence of shaly clasts indicate that it is, at least partly, a waterlain sediment.

The age of the Rooiberg Group is of the order of 2 150 Ma (SACS 1980, p. 195).

13. BUSHVELD COMPLEX

The Bushveld Complex forms two large occurrences, one situated in the Villa Nora area and another, east of the main Waterberg outcrop zone, which trends north–south and is known as the Potgietersrus limb.

The complex has been divided into a mafic portion termed the Rustenburg Layered Suite and a felsic portion represented by the Rashoop Granophyre and the Lebowa Granite Suites. The Rashoop Granophyre Suite is genetically related to the volcanic rocks of the Rooiberg Group of which it is the shallow intrusive equivalent and thus pre-dates the other units of the Bushveld Complex (Walraven 1982).

13.1 RUSTENBURG LAYERED SUITE

In the Potgietersrus limb the following four units have been recognized: Zoetveld Subsuite; Rooipoort Norite–Anorthosite; Mapela Gabbro–Norite; and the Molendraai Magnetite Gabbro.

Following Van der Merwe (1976, 1978), his basal zone (Zoetveld Subsuite) occurs as a satellitic body up to 900 m thick which consists of bronzitite with minor intercalated harzburgite. Both lithologies exhibit a marked layering and are often serpentinized, especially near the base of the zone. Two closely spaced chromitite seams are developed near the middle of the succession. His critical zone (Rooipoort Norite–Anorthosite) which has a maximum thickness of about 400 m in the mapped area is represented by norite, pyroxenite and anorthosite consisting mainly of plagioclase, bronzite and augite in variable amounts. Olivine is conspicuously absent in this zone. Several chromitite seams occur throughout the succession.

At the base of his main zone (Mapela Gabbro–Norite) a 200-m-thick unit is developed and consists of harzburgite at the bottom followed by feldspathic and pegmatitic pyroxenite. This unit is known as the platinum reef as it contains economically viable amounts of platinum-group metals besides minor sulphide and chromitite, and it is now regarded as part of the Rooipoort Norite–Anorthosite. The platinum reef is overlain by norite, followed by gabbro which in turn is overlain by anorthosite. The anorthite content of the plagioclase in these rocks decreases from An_{77} near the base to An_{59} at the upper contact of the zone. At the top of the succession pyroxenite is developed which also forms several bands at the contact between norite and gabbro. Troctolite is present as a 100-m-thick unit in the middle of the succession.

The lower contact of the unit which attains a thickness of 2 200 m is taken at the bottom of the platinum reef, and the upper contact is defined as the first appearance of cumulus magnetite.

The Molendraai Magnetite Gabbro or upper zone, which reaches a maximum thickness of 1 100 m, is made up of alternating units of gabbro, anorthosite and ferrogabbro, the last occurring mainly in the lower third of the zone. Anorthite content of the plagioclase decreases from the bottom to the top, from An_{58} to An_{45}. The top of the succession is marked by the presence of olivine diorite which is composed of andesine, hornblende, olivine (Fa_{92}), pyroxene and minor magnetite.

So far, 20 magnetite layers are known to occur in the upper zone. The most important layer, about 2 m thick, occurs 120 m above the base of the succession.

The Villa Nora occurrence which is probably connected with the Potgietersrus limb consists of gabbro, anorthosite, ferrogabbro, norite and minor olivine diorite (Van der Walt 1978). These lithologies are believed to be part of the upper zone though Van der Walt thinks that they belong partly to the main zone as well. The olivine diorite which seems to occur here at the base of the succession is mineralogically similar to that present in the Potgietersrus limb. The anorthite content of the plagioclase of the various rock types ranges between An_{45} and An_{80}.

The Villa Nora occurrence is characterized by the presence of narrow, elongated bodies of apatite-bearing magnetite which are largely concordant with the igneous layering of the host rocks (Grobler and Whitfield 1970).

Radiometric dating of a sample of ferrogabbro from outside the mapped area yielded an age of 2 096 ± 12 Ma (Burger and Walraven 1977).

13.2 RASHOOP GRANOPHYRE AND LEBOWA GRANITE SUITE

The Rashoop Granophyre Suite forms only a few small outcrops in the Villa Nora area.

The Lebowa Granite Suite is represented in the area only by the Nebo Granite which overlies the Rustenburg Layered Suite. It is mainly a coarse-grained, reddish rock which is composed of orthoclase (perthitic), quartz, albite, hornblende and minor biotite. Locally porphyritic and fine aplitic varieties have been described. The radiometric age of the Nebo Granite is 1 920 ± 40 Ma (Coertze et al. 1978).

14. KOEDOESRAND FORMATION

This formation is confined to a narrow fault-bounded zone and forms pronounced topographic features. According to Visser (1953), it consists in general of a 90-m-thick basal unit of light-coloured quartzitic sandstone, shaly rocks and quartz-sericite schist, overlain by 130 m of mainly conglomerate. At the top, 300 m of sandstone and grit with occasional pebble beds are developed. The clasts in the conglomerates consist largely of quartzite, magnetite quartzite, vein quartz and mylonitic rocks. Cross bedding is common in the sandstones. A characteristic feature of the formation is the sheared nature of most of the rocks. Locally, shaly rocks are altered to quartz-sericite schist or phyllite, and pebbles in the conglomerates are sometimes drawn out.

The stratigraphic position of the formation is as yet uncertain. However, the complete lack of shearing in the nearby Waterberg sediments and the fact that the Abbottspoort Fault which bounds the Koedoesrand Formation on the south does not continue farther east, suggest either an early Waterberg or even a pre-Bushveld age for the Koedoesrand Formation.

15. PALALA GRANITE

Outcrops of this rock are restricted to the Palala shear zone. Here, the granite occurs as narrow strips south of the Melinda Fault and north of the Abbottspoort Fault.

The Palala Granite is a medium- to coarse-grained, pinkish grey rock which is composed mainly of quartz, orthoclase, microcline, albite, hornblende and biotite. Throughout, it exhibits weak foliation which becomes more pronounced in zones of shearing. In zones of high stress, the granite has been transformed into a pale-red blastomylonite characterized by large ovoid porphyroclasts of feldspar set in a fine siliceous matrix (McCourt in press). Good exposures of the blastomylonite can be seen on Alexanderfontein 160 LR.

Recent unpublished radiometric datings indicate that the age of the Palala Granite is in the range 1 730 to 1 893 Ma, which gives a minimum age for the deposition of the Koedoesrand Formation into which the granite has been emplaced.

16. WATERBERG GROUP

The rocks of the Waterberg Group, a mainly sedimentary succession, underlie the western half of the map area where they form a conspicuous plateau intersected by narrow steep valleys. The rocks were deposited in the northern portion of the so-called late-Waterberg basin (Jansen 1975a) a large shallow intracratonic depression whose northern boundary was structurally controlled. Six formations have been recognized in the group.

16.1 SETLAOLE FORMATION

The Setlaole Formation, at the base of the Waterberg Group in the mapped area, rests with a disconformable contact on the Hout River Gneiss, the Rooiberg Group and the Nebo Granite. It has a maximum thickness of about 1 000 m south of Villa Nora but thins gradually towards the Blouberg area.

The formation consists of medium- to coarse-grained, dark-coloured sandstone with intercalations of conglomerate, feldspathic grit, arkose and blackish mudstone (Tickell 1973). Locally, around Setlaole Hill, a 6-m-thick volcaniclastic bed represented by fine-grained, blackish tuffaceous shale and ignimbrite is developed at the base. The ignimbrite occasionally exhibits flow banding (Meinster and Jansen 1974).

16.2 MAKGABENG SANDSTONE FORMATION

This formation conformably overlies the Setlaole Formation and varies in thickness between about 500 and 1 200 m. It represents a monotonous development of a medium-grained, thinly laminated, yellowish sandstone which displays large-scale cross bedding and, sparingly, asymmetrical ripple marks. Locally, a poorly sorted conglomerate containing angular clasts is developed at the base (De Bruiyn 1971).

The sandstone is thought to be largely of aeolian origin and direction of transport was mainly from north-east (Meinster and Tickell 1975).

16.3 MOGALAKWENA CONGLOMERATE FORMATION

This formation rests with a mainly conformable contact on the Makgabeng Sandstone Formation, but in the Blouberg area it unconformably overlies the Blouberg Formation and rocks of Swazian and Randian age. It reaches a thickness of about 1 500 m and consists of purplish brown, coarse-grained sandstone with interbedded conglomerate and boulder conglomerate. The conglomerates occur mainly at three stratigraphic levels and form units up to 100 m thick (Plate 16.1). The well-rounded clasts may attain a diameter of 80 cm, but in general they measure between 3 and 10 cm. They consist largely of those rocks present in the Limpopo Mobile Belt.

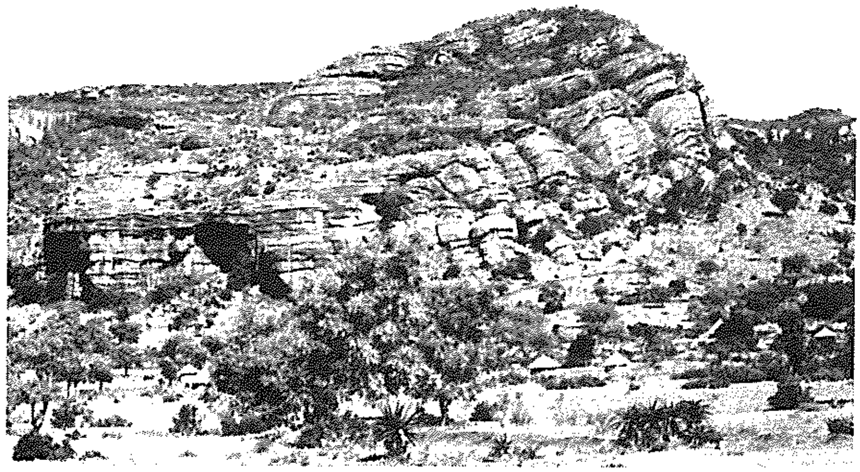


Plate 16.1 — Well-bedded conglomerate of the Mogalakwena Formation in the Blouberg area.
Plate 16.1 — Goedgelaagde konglomeraat van die Formasie Mogalakwena in die Blouberg-gebied.

According to Tickell (1975a) the coarse arenaceous succession resembles deposition in braided streams. Palaeocurrent directions inferred from cross-bed attitudes in the sandstones indicate that most of the sediments were carried from a source lying north-east and east of the Waterberg basin.

16.4 CLEREMONT SANDSTONE FORMATION

The Cleremont Sandstone Formation which rests conformably on the Mogalakwena Formation is, together with the overlying Vaalwater Formation, restricted to the extreme south-western part of the map area. The formation is about 100 m thick and consists of coarse, (in places), gritty white sandstone which is typified by large-scale, planar-type cross bedding. Near the bottom a thinly bedded, fine-grained purplish sandstone may be developed (De Vries 1971).

16.5 VAALWATER FORMATION

This formation which represents the top of the Waterberg Group consists of fine-grained, light-coloured sandstone with subordinate intercalations of siltstone, shale and mudstone. Cross bedding and ripple marks are abundantly developed. The thickness is inferred to be 100 m.

16.6 BLOUBERG FORMATION

The Blouberg Formation occurs only around Lebu Mountain and in the Blouberg area, unconformably overlying rocks of Swazian and Randian age. It represents a sedimentary–volcanic assemblage and has been divided into seven sedimentary members (grouped together on the map sheet) and a volcanic member at the top (Meinster and Jansen 1974, Jansen 1976). Owing to intense faulting in the Blouberg area, a complete succession is nowhere developed.

The sediments include conglomerate, feldspathic grit, arkose and sandstone which vary in colour from greenish grey through pink to purple. Variegated shale and mudstone occur as lenticular intercalations. The sandstones often exhibit large-scale, trough-type cross bedding. Although based on scanty data, cross-bed attitudes suggest a transport direction from the north-east.

The volcanic rocks are largely amygdaloidal and are well exposed around Lebu Mountain and, occasionally, on the southern slopes of the Blouberg Mountain. The rocks are often epidotized, but where fresh the mineralogical composition suggests they are trachytes, trachyandesites and andesites. In the andesite, hornblende and minor pyroxene are developed, whereas in the trachytic types K-feldspar and plagioclase occur in variable amounts and trachytic textures are present. The thickness of the formation has been estimated to be about 4 000 m, but could be considerably less.

16.7 AGE AND CORRELATION

Deposition of the Waterberg Group in the area is believed to have taken place around 1 700 Ma ago. This is based on the evidence that the intense shearing and faulting which has affected the Palala Granite, dated at between 1 730 and 1 890 Ma, is completely absent in the adjacent Waterberg sediments. The stratigraphic correlation of the Blouberg Formation with the main Waterberg occurrences causes many problems. The feldspathic sediments have tentatively been correlated with the arkoses present in the Setlaole Formation, whereas the clean sandstones and conglomerates are thought to be coeval with the late-Waterberg sediments.

Although the lavas are at present grouped with the Blouberg Formation there is a strong possibility that they are part of the largely volcanic Sibasa Formation of the Soutpansberg Group.

17. SOUTPANSBERG GROUP

Rocks of the Soutpansberg Group occur mainly along the northern edge of the map area where they underlie rugged, mountainous country characterized by steep-sided, cliffed southern slopes and gently dipping northern slopes (Plate 17.1). The group comprises a sedimentary–volcanic assemblage which has a maximum thickness of about 2 800 m north of Louis Trichardt. The rocks were deposited in a narrow, fault-bounded rift valley or aulacogen (Jansen 1975b) which probably represents the failed spreading arm of a plume-generated triple junction.

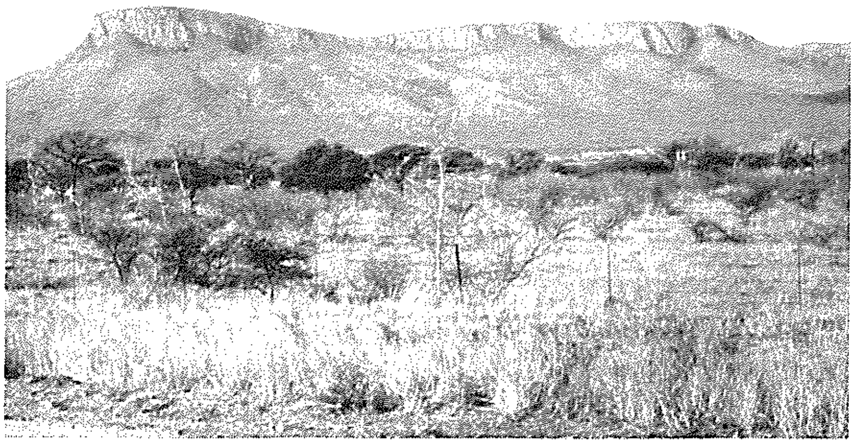


Plate 17.1 – View of the western extremity of the Soutpansberg near Vivo. Sibasa lava underlies the slopes which are capped by quartzite of the Wyllies Poort Formation.
Plaat 17.1 – Aansig van die westelike uiteinde van die Soutpansberg naby Vivo. Sibasalawa onderlê die hange wat bedek word deur kwartsiet van die Formasie Wylliespoort.

Three formations have been recognized in this area.

17.1 TSHIFHEFHE FORMATION

This basal formation which rests unconformably on Swazian rocks is only sporadically exposed in the Louis Trichardt area. It consists of epidotized, coarse feldspathic quartzite with subordinate conglomerate and shale. The angular nature of the clasts in the arenaceous sediments suggests local derivation. A thickness of between 1 and 9 m has been reported (Tickell 1974).

17.2 SIBASA BASALT FORMATION

This formation has a conformable contact with the Tshifhefhe Formation or, where it is absent, rests unconformably on Swazian and Randian rocks or the Blouberg Formation. The Sibasa Formation attains a maximum thickness of 2 100 m near Louis Trichardt and consists predominantly of lava with minor quartzite appearing at up to four stratigraphic horizons.

The lava is a greenish grey, largely epidotized, fine- to coarse-grained, often amygdaloidal rock. The bulk consists of tholeiitic basalt (Barker 1979, Barton 1979) although locally the presence of acid and trachytic varieties has been reported. Where the basalt is coarse grained and fairly fresh it is seen to be composed of phenocrysts of plagioclase (An_{40-68}), augite and ilmeno-magnetite in an altered groundmass mainly of epidote, chlorite, amphibole and quartz (Barker 1979). Stoljan (1975) reports the presence of pumpellyite in the Sibasa lava and at one locality ignimbrite has been observed near the base of the formation.

The interbedded quartzites are typically medium-grained, pinkish, often cross-bedded rocks which contain pebbly horizons. Individual quartzite layers can reach a thickness of 60 m. At the base and top of these layers very thin shaly beds may be developed.

Radiometric dating of a sample from the basal flow of basalt near Louis Trichardt yielded an age of 1 769 ± 34 Ma (Barton et al. 1979).

17.3 WYLLIES POORT QUARTZITE FORMATION

This formation which reaches a maximum thickness of about 1 000 m in the Sand River area conformably overlies the Sibasa Formation. Only at Rooirant and south of Marnitz does it rest unconformably on the Beit Bridge Complex. The lower boundary is taken as the top of the uppermost lava flow of the Sibasa Formation.

The Wyllies Poort Formation is an almost entirely arenaceous succession composed largely of medium- to coarse-grained pink, in places whitish, and red quartzite (Plate 17.2). Compositional maturity of the quartzite is reflected by the fact that both feldspar and rock fragments always amount to less than 10 per cent of the total volume of the rock (Barker 1979). Thin conglomeratic horizons occur throughout the succession, the clasts of which average about 3

Plate 17.2 — Blouberg seen from the north. The high ground is occupied by quartzite of the Wyllies Poort Formation.
Plaat 17.2 — Blouberg gesien vanuit die noorde. Die hoogliggende deel word deur kwartsiet van die Formasie Wylliespoort gevorm.

cm in diameter and are often composed of agate and jasper indicating uplift and erosion of the underlying Sibasa Basalt. Sedimentary structures in the quartzite are very abundant and include ripple marks, chaotic slumping and trough- and tabular-type cross beds (Meinster 1974). Measurements of cross-bedding inclinations broadly indicate a transport direction from the north-west.

Reddish shale and shaly sandstone only locally form lenticular lenses in the quartzite.

The quartzites are thought to have been deposited largely as point bars in a meandering river environment and the conglomerates probably represent channel-lag deposits.

18. DIABASE INTRUSIONS

Diabase intrusions occur as sills and dykes in almost all the pre-Karoo formations in the area. In the Swazian rocks and in the Hout River Gneiss they often give rise to ridges but in the sedimentary rocks they usually form negative topographic features.

Most of the dykes strike north-easterly or north-westerly but some trend east—west. Cross-cutting relationships and other field evidence suggest that they were emplaced during at least three periods of igneous activity (Van Wyk 1977).

Diabase sills are limited mainly to the Nebo Granite, and to the Waterberg and Soutpansberg Groups. In the latter group they have often intruded at the interface between shale and quartzite. They are thought to be related in composition to the volcanic episode represented by the Nzhelele Formation (not present in the map area).

The sills developed in the Nebo Granite and the Waterberg sediments seem to have been emplaced partly along pre-existing fault zones. Locally, in major sills, the diabase grades, due to differentiation, into granophyric, syenitic and tonalitic varieties.

The diabase which varies from aphanitic to coarse grained, is a greenish black rock of gabbroic composition and has ophitic texture. A specimen from north of Villa Nora consists typically of augite, calcic plagioclase and hornblende with accessory hypersthene, quartz, biotite and iron ore (Visser 1953).

A sample from a diabase dyke intrusive into the Bandelierkop Complex gave a radiometric age of 1 905 ± 245 Ma. From beyond the mapped area a radiometric age of 2 216 ± 150 Ma has been reported from a dyke cutting the Beit Bridge Complex (Barton et al. 1979).

19. KAROO SEQUENCE

The Karoo Sequence comprises a basal argillaceous and arenaceous unit with a maximum thickness of about 500 m overlain by volcanic rocks. The argillaceous beds which form the bulk of the unit are, as a rule, covered by a thick blanket of fine soil.

The sequence has been divided into seven formations, the delineations of which, as shown on the map, are largely based on borehole information.

19.1 MADZARINGWE FORMATION

This formation rests unconformably on rocks of the Beit Bridge Complex and the Soutpansberg Group. Thickness varies between 60 and 110 m in the

Tolwe area and between 20 and 50 m in the Marnitz area. The formation comprises carbonaceous shale and mudstone with minor light-grey, feldspathic sandstone which is present in the lower third. Coal seams are developed throughout.

19.2 UNNAMED UNIT

In the vicinity of Villa Nora, rocks believed to be the equivalent of the Madzaringwe Formation form several outliers on the Nebo Granite and the Palala shear zone. These outliers are part of the "Waterberg Coalfield" for which a new stratigraphic subdivision has as yet not been attempted. The unit is made up mainly of coarse-grained to gritty, greyish white feldspathic sandstone and minor mudstone. The resistant sandstone invariably gives rise to conspicuous hills such as Bobididi and Thabaneng.

19.3 FRIPP SANDSTONE FORMATION

This formation is only locally developed and consists of coarse- to medium-grained, grey and whitish feldspathic sandstone. A maximum thickness of 8 m is reported.

19.4 SOLITUDE FORMATION

This formation which attains a thickness of about 50 m in the Tolwe area and about 20 m in the Marnitz area comprises massive dark-grey, red and purple mudstone with scattered silty and sandy beds.

19.5 KLOPPERFONTEIN SANDSTONE FORMATION

This formation is composed largely of coarse-grained, feldspathic, micaceous sandstone with conglomerate occasionally developed near the base. The sandstone is commonly grey and whitish though reddish colours may prevail at the top of the unit. Cross bedding occurs locally in the sandstone. In places intercalations of a brown and purple shale are present. Thickness of the sandstone unit varies between 2 and 12 m, but reaches 30 m where the shaly intercalations are present.

19.6 BOSBOKPOORT FORMATION

A red massive mudstone comprises this formation, which has a thickness of at least 45 m.

19.7 CLARENS SANDSTONE FORMATION

The Clarens Sandstone Formation consists of fine-grained equigranular cream-coloured sandstone in which calcareous concretions are abundantly developed near the base. In general the sandstone forms good exposures, especially near faults where it has been silicified. The formation has a minimum thickness of 80 m.

19.8 LETABA FORMATION

The Letaba Formation, occurring only north of Blouberg, consists mainly of basaltic lava which is typically a fine-grained, greenish black amygdaloidal rock. In places, intercalations of what is thought to be rhyolite are present. Exposures of the lava are generally poor; black-turf soil often covering the rocks.

20. DOLERITE

Fine-grained blackish dolerite crops out only at one locality, near Tolwe, where it forms a major sill. On account of thick soil which covers much of the Karoo Sequence no dykes of dolerite have been observed.

21. QUATERNARY DEPOSITS

Deposits of Quaternary age include soil, alluvium, calcrete and scree.

Coarse, light-coloured soil covers a large portion of the mapped area; occurring mainly on granitic and gneissose rocks. Fine sand is abundant on the sediments of the Waterberg Group; even forming dunes locally. Alluvium is restricted to the water courses of the main streams.

Greyish and brownish surface limestone occurs as small deposits throughout the area, but covers large portions in the north-west where it is developed mainly on marble and mafic gneiss.

Extensive scree is found along the slopes of Soutpansberg and Blouberg, and along the fault scarp formed by the Melinda Fault.

22. STRUCTURAL GEOLOGY

In the north-western portion of the map area, which belongs to the central zone of the Limpopo Mobile Belt, three deformational episodes have been recognized. During the first two events, mainly isoclinal upright folds were produced. In a third event these were refolded into typical dome-and-basin interference structures (McCourt 1977).

The southern boundary of the central zone is marked by the 10-km-wide Palala shear zone which has been divided into three subzones (McCourt in press). The northernmost, about 2 km wide, is characterized by the presence of Palala Granite, mylonite and ultramylonite. The mylonitic bands have been isoclinally folded and, locally, even refolded (Plate 22.1). The lineation developed on the foliation surface of the mylonitic bands plunges down dip. In the central subzone various mylonitized gneisses and occasionally blastomylonite are present. The southern subzone, about 1 km wide, comprises mainly sheared and mylonitized Palala Granite, but also includes a band of felsic and mafic schists. The lineation in the felsic schists plunges with the strike.

The presence of a quartz-sericite-chlorite mineral assemblage in the southern subzone, and the occurrence of primary hornblende together with unaltered hypersthene and garnet in the rest of the shear zone indicate that two different levels of metamorphic grade are exposed within the shear zone. It is thought

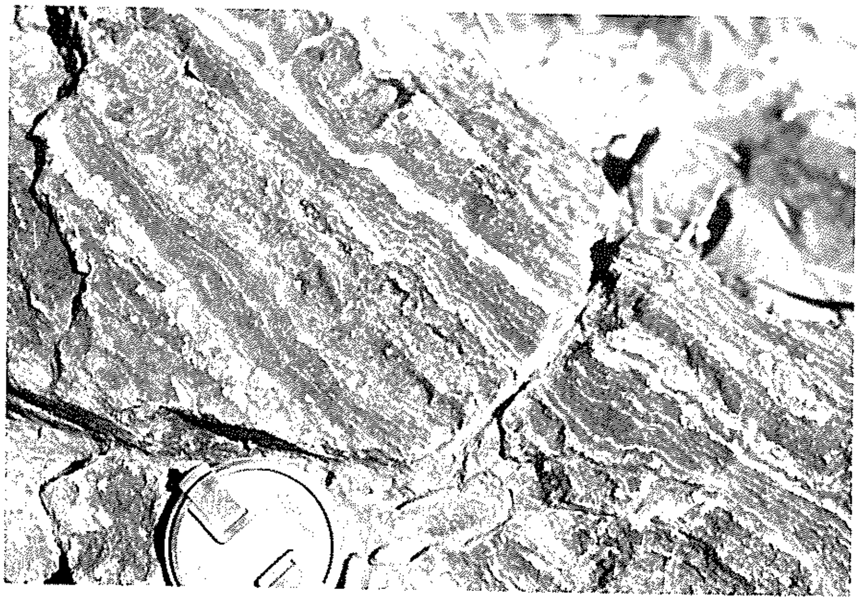


Plate 22.1 – Mylonitic banding in the northern subzone of the Palala shear zone.
Plaat 22.1 – Milonitiese gestreeptheid in die noordelike subsone van die Palalaskuifskeursone.

that the southern subzone was reactivated, probably independently of the rest of the shear zone, after the emplacement of the Palala Granite.

The possible continuation of the Palala shear zone under the Waterberg outcrop into the Blouberg area has not yet been investigated.

In the southern marginal zone of the Limpopo Mobile Belt, four periods of deformation have been recognized (Du Toit 1979). In the earliest event, termed D_1, isoclinal folds were produced about east—west-trending axial planes. This event is only inferred and may have occurred during early greenstone times. In the second event (D_2) tightening of the existing isoclinal folds about coaxial planes took place. Hook folds were produced and a strong foliation was imposed on the Goudplaats Gneiss and the rocks of the Bandelierkop Complex. The third fold event (D_3) is expressed as open cross folds which were produced about upright, north-west-trending axial planes. This event is well established only in the Matok area. The last event (D_4) is represented by north-east-trending shear zones. The Boyne lineament situated about 30 km east of Pietersburg may also be related to this episode.

Regarding the relationship between metamorphism and structure, it has been deduced that the M_2-metamorphic event (Chapter 4.6) post-dates D_2, but pre-dates the D_3 event. This is based on evidence that symplectites, developed during M_2, are devoid of a foliation but do exhibit a planar fabric in D_3-fold closures (Van Reenen and Du Toit 1977).

The rocks of the Pietersburg Group, with the exception of the Zandriviers-poort Formation, are thought to have been isoclinally folded mainly about north-east-trending axes.

In the Zandrivierspoort Formation four deformational events have been provisionally recognized. Its deformational history is probably similar to that of the southern marginal zone.

The beds of the Wolkberg Group and the overlying Black Reef Formation dip towards the south at an angle of about 30 degrees. The Rooiberg Group strikes in a north-easterly direction and dips steeply to the south-east. In the Potgietersrus limb of the Bushveld Complex the various units dip gently to the west at angles between 15 and 30 degrees. In the Villa Nora occurrence the rocks of the Bushveld Complex strike mainly east—west with dips up to 60 degrees towards the south. In the eastern part of this occurrence, however, the strike is north—south with the dip being towards the east. To what extent gentle folding might be responsible for the structural setting of the Villa Nora occurrence is as yet speculative.

The sediments of the Koedoesrand Formation form a narrow, east–west-trending zone which is bounded on the northern and southern side by faults. As the beds dip steeply away from both faults they could represent the limbs of a synclinal structure. The fault along the southern edge is known as the Abbottspoort Fault. It has a minimum vertical displacement of about 500 m. Because the stratigraphic position of the Koedoesrand Formation is not known it is, therefore, uncertain whether the two faults are normal or high-angle reverse faults.

The Waterberg beds which generally have shallow dips (Plate 22.2), between 5 and 10 degrees, have been tectonically disturbed in only a few limited zones. South of Villa Nora the lower Waterberg formations dip moderately to the south indicating an uplift of the Bushveld Complex after the deposition of these formations. South of Blouberg, beds of the Blouberg Formation were steeply tilted or even overturned in a major fault zone which trends roughly east–west and separates the main Waterberg outcrop from the Soutpansberg Group. As some of these tilted beds are unconformably overlain by higher

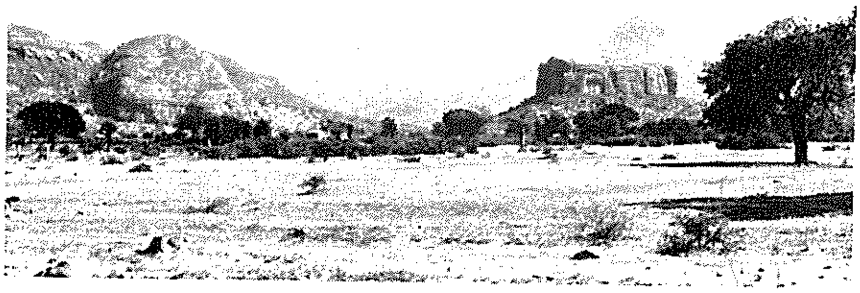


Plate 22.2 – Scenic view in the Blouberg area with conglomerate of the Mogalakwena Formation in the foreground, and lava of the Sibasa Formation overlain by quartzite of the Wyllies Poort Formation in the background.

Plaat 22.2 – Skilderagtige uitsig in die Blouberggebied met konglomeraat van die Formasie Mogalakwena in die voorgrond, en lawa van die Formasie Sibasa oorlê deur kwartsiet van die Formasie Wylliespoort in die agtergrond.

Waterberg formations (Plate 22.3) it is obvious that faulting had already commenced in this zone during deposition. It can be speculated that this fault zone represents the original southern boundary of the Soutpansberg trough.

Along the Melinda Fault the Waterberg rocks were downthrown to the south in pre-Karoo times. Vertical displacement was about 1 000 m. In post-Karoo times the fault was reactivated with a downthrow to the north. The throw was at least several hundred metres.

The beds of the Soutpansberg Group generally dip at a shallow angle towards the north. Only near Vivo and around the highest point of Blouberg Mountain are the beds flat lying. Two fault systems which trend roughly east-north-east and north-west, respectively, can be recognized in the group. These faults generally delineate elongated blocks. Most of the faults are thought to have been active in pre-Karoo times and were then rejuvenated after deposition of the Karoo Sequence. The Vivo Fault which displays a downthrow on the north, trends broadly north-easterly and has a displacement of at least 300 m.

The beds of the Karoo Sequence lie for the most part subhorizontally.

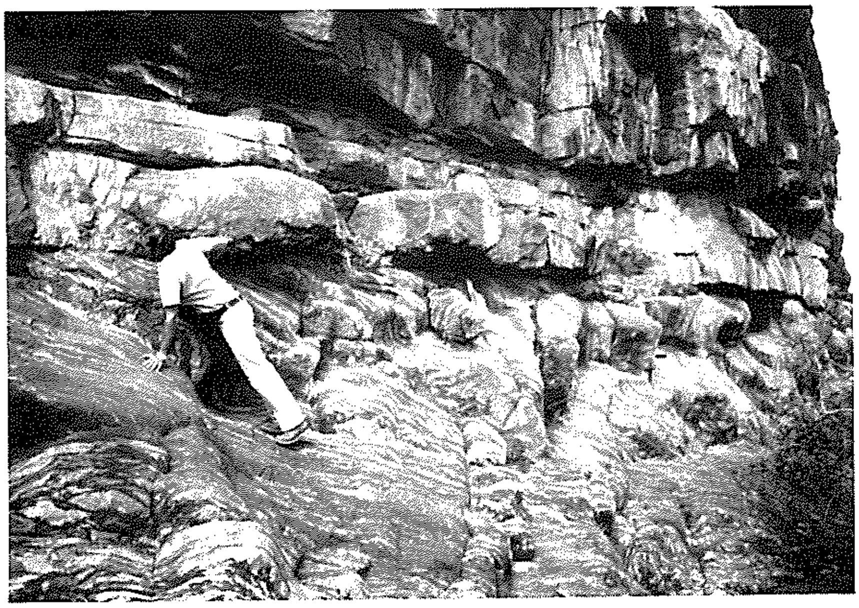


Plate 22.3 – Mottled sandstone of the Blouberg Formation unconformably overlain by arenaceous beds of the Mogalakwena Formation in the Blouberg area.
Plaat 22.3 – Gevlekte sandsteen van die Formasie Blouberg diskordant oorlê deur sandige lae van die Formasie Mogalakwena in die Blouberggebied.

23. ECONOMIC GEOLOGY

A wide variety of mineral occurrences are found in the area covered by the Pietersburg sheet. Only the more important ones are briefly described.

23.1 BARYTES

In the Bochum—Dendron area barytes occurs at three localities as veins up to 20 cm thick in the Bandelierkop Complex and the Hout River Gneiss. In places the barytes is intimately intergrown with apatite and monazite (Horn 1979).

West of Blouberg, on Langlaagte 279 LR, barytes was mined from veins which are up to 2 m thick and occur close to a major fault separating the main outcrops of the Waterberg and Soutpansberg Groups. The barytes which is mainly of a whitish, coarsely crystalline variety is here closely associated with galena, quartz and calcite. The barytes content in the ore varies between 35 and 50 per cent (Willemse et al. 1944).

23.2 CHROME

Chrome deposits occur mainly in the mafic portion of the Rustenburg Layered Suite. In the lower zone two chromitite seams are developed roughly in the middle of the succession, having thicknesses of 38 and 60 cm respectively. The seams are separated by 45 m of bronzitite. The lower seam contains on average 52,4 per cent Cr_2O_3 and has a Cr:Fe ratio of 2,22.

In the critical zone three chromitite seams, varying in thickness between 40 and 95 cm, are present. The Cr:Fe ratios of the middle and upper seams are 1,28 and 1,13 respectively. In the main zone, chromitite occurs only as irregular blobs and veinlets (Van der Merwe 1978).

On Lemoenfontein 443 LS two prominent chromite-rich zones are present in a serpentinite.

23.3 COAL

In the Madzaringwe Formation a number of coal seams are interbedded with carbonaceous shale. In the Tolwe area the coal is, according to borehole results, prominently developed in up to eleven horizons. South of Marnitz, however, coal development is restricted to only about three horizons.

23.4 CORUNDUM

Numerous corundum deposits are found in an area south of Soutpansberg which roughly conforms to the outcrop distribution of the Bandelierkop

Complex. Minor deposits are also present north of Haenertsburg. The corundum is always associated with ultramafic rocks and occurs where these are surrounded by granitic material. The mineral is mainly developed in the contact zone which is several metres wide. The origin of the corundum can be attributed to the reaction of anatectic melts with rocks of ultramafic composition (Hall 1920).

23.5 GOLD

South of Haenertsburg a number of small, now abandoned gold workings, are situated at the foot of the Strydpoort Range. The gold occurs largely in quartz veins and also in a conglomerate which is developed near the base of the Wolkberg Group (Engelbrecht 1959). The quartz veins are probably associated with a major north-east-trending fault which is situated just south of the limits of the map.

North-east of Pietersburg, on Bothashoek 879 LS, gold was intermittently exploited on a small scale. The metal occurs in two narrow shear zones in amphibolite of the Mothiba Formation.

In the Dendron and Bochum areas, notably on Goedgenoeg 185 LS and Borkum 143 LS, gold was mined from quartz veins in the Hout River Gneiss.

23.6 IRON

A potential source of iron lies in the magnetite quartzites and the magnetitite layers. The latter are present in the Rustenburg Layered Suite where 20 individual layers are known. They have a total thickness of about 5,6 m; the main layer being about 2 m thick.

Magnetite quartzites are abundantly developed in the Mount Dowe Group and in the Zandrivierspoort Formation. In the latter, four prominent layers are interbedded with amphibolite. As a result of the intricate folding the true total thickness is unkown.

23.7 LEAD

Galena together with barytes, quartz and calcite occur in a 2-m-wide brecciated zone on Langlaagte 279 LR, west of Blouberg. Although this occurrence is essentially a barytes deposit, lead was also mined at one stage. The galena together with quartz and calcite is believed to belong to a first generation of mineralization whereas barytes was introduced at a later stage partly replacing galena and quartz. The lead content of the ore is about 8 to 12 per cent (Willemse et al. 1944).

23.8 MANGANESE

At Rooirant manganese ore is concentrated along two horizons in sandstone and shaly sandstone of the Wyllies Poort Formation. Each is about 1 m thick and the Mn content varies between 28 and 37 per cent. The manganese occurs in the form of braunite, psilomelane and pyrolusite. The deposit was mined until about 1966.

23.9 NICKEL

Sulphide minerals such as pyrrhotite and pentlandite which occur in ultramafics and in the various lithologies of the Rustenburg Layered Suite are a potential source of nickel. A serpentinite of the Bandelierkop Complex on Schiermonikoog 16 LS gave a maximum value of 0,79 per cent Ni (Schmidt-Eisenlohr 1969). The nickel content of the platinum reef of the main zone is on average 0,2 per cent but may locally reach 1 per cent, e.g. on Drenthe 778 LR (Gain and Mostert in press).

23.10 PHOSPHATE ROCK

Apatite-bearing magnetitite occurs as narrow lensoid bodies in the upper part of the Rustenburg Layered Suite in the Villa Nora area. The average P_2O_5 content of these bodies which are about 20 m thick and have a strike length of up to 1 300 m is between 5 and 7 per cent (Grobler and Whitfield 1970).

A small guano-type deposit of aluminium–iron phosphate occurring on Waterberg sediments was mined on Zoetendales Vley 341 LR, south-west of the Glen Alpine Dam.

23.11 PLATINUM-GROUP METALS

These metals are present in the form of disseminated sulphides, mainly cooperite and braggite, in the 200-m-thick platinum reef of the Potgietersrus limb. The grade of platinum and palladium, combined, is on average about 1 g/t, though locally it may reach 20 g/t. The ratio Pt:Pd is about 0,8 (Gain and Mostert in press).

23.12 SILICON AND SILICA

South of Pietersburg, on Weltevreden 746 LS, silicon is produced from vein quartz having a SiO content between 99,6 and 99,8 per cent. The ore is obtained from several quartz veins up to 30 m wide which trend roughly north-east. Similar high-grade, monomineralic ore bodies having mainly the same trend also occur further north-east in the Mothiba Formation.

They have been worked intermittently at various localities for the production of silica. At present silica is only produced on Weltevreden 746 LS.

23.13 TITANIUM AND VANADIUM

A potential source of titanium and vanadium are the magnetitite layers in the upper zone of the Rustenburg Layered Suite. Van der Merwe (1976) reports that the 2-m-thick main magnetite seam contains 12,7 per cent of TiO_2 and 1,6 per cent of V_2O_5.

REFERENCES

BARKER, O.B., 1979. A contribution to the geology of the Soutpansberg Group, Waterberg Supergroup, Northern Transvaal: M.Sc. thesis, Witwatersrand Univ., (unpubl.).

BARTON, J.M., Jr, 1979. The chemical compositions, Rb/Sr isotopic systematics and tectonic setting of certain post-kinematic mafic igneous rocks, Limpopo Mobile Belt, Southern Africa: Precambr. Res., 9, p. 57–80.

BARTON, J.M., Jr, FRIPP, R.E.P. and RYAN, B., 1977. Rb/Sr ages and geological setting of ancient dykes in the Sand River area, Limpopo Mobile Belt, Southern Africa: Nature, 267, p. 487–490.

BARTON, J.M., Jr and RYAN, B., 1977. A review of the geochronologic framework of the Limpopo Mobile Belt: Bull. geol. Surv. Botswana, 12, p. 183–200.

BARTON, J.M., Jr, FRIPP, R.E.P., HORROCKS, P. and McLEAN, N., 1979. The geology, age and tectonic setting of the Messina Layered Intrusion, Limpopo Mobile Belt, Southern Africa: Am. J. Sci., 279, p. 1 108–1 134.

BRANDL, G., (in press). The geology and geochemistry of various supracrustal rocks of the Beit Bridge Complex, east of Messina: Spec. Publ. geol. Soc. S. Afr.

BURGER, A.J. and COERTZE, F.J., 1977. Summary of age determinations carried out during the period April 1974 to March 1975: Ann. geol. durv. S. Afr., 11, p. 317–321.

BURGER, A.J. and WALRAVEN, F., 1977. Summary of age determinations carried out during the period April 1975 to March 1976: Ann. geol. Surv. S. Afr., 11, p. 323–329.

BURGER, A.J. and WALRAVEN, F., 1979a. Summary of age determinations carried out during the period April 1976 to March 1977: Ann. geol. Surv. S. Afr., 12, p. 199–207.

BURGER, A.J. and WALRAVEN, F., 1979b. Summary of age determinations carried out during the period April 1977 to March 1978: Ann. geol. Surv. S. Afr., 12, p. 209–218.

COERTZE, F.J., BURGER, A.J., WALRAVEN, F., MARLOW, A.G. and MacCASKIE, D.R., 1978. Field relations and age determinations in the Bushveld Complex: Trans. geol. Soc. S. Afr., 81(1), p. 1–11.

COX, K.G., JOHNSON, R.L., MONKMAN, L.J., STILLMAN, C.J., VAIL, J.R. and WOOD, D.N., 1965. The geology of the Nuanetsi igneous province: Phil. Trans. R. Soc. Lond., A 257, p. 71–218.

DE BRUIYN, H., 1971. The geology of the eastern portion of the Waterberg basin, between Mokamole and the Blouberge (Sheet 2328): Unpubl. Rep. geol. Surv. S. Afr.

DE VILLIERS, S.B. and BRANDL, G., 1977. Die Mashashane-Granietplutoon noordoos van Potgietersrus: Ann. geol. Surv. S. Afr., 11, p. 7–13.

DE VRIES, W.C.P., 1971. Stratigraphy of the Waterberg System in the southern Waterberg area, north-western Transvaal: Ann. geol. Surv. S. Afr., 7, p. 43–56.

DU TOIT, M.C., 1979. Die geologie en struktuur van die gebiede Levubu en Bandelierkop in Noord-Transvaal: Ph.D. thesis, Rand Afrikaans University, (unpubl.).

DU TOIT, M.C. and VAN REENEN, D.D., 1977. The southern margin of the Limpopo Mobile Belt, Northern Transvaal, with special reference to metamorphism and structure: Bull. geol. Surv. Botswana, 12, p. 83–97.

ENGELBRECHT, L.N.J., 1959. Die geologie van Wolkberg en omstreke. Blad 13 (Olifantsrivier): Unpubl. Rep. geol. Surv. S. Afr.

GAIN, S.B. and MOSTERT, A.B., (in press). The geological setting of the platinoid and base metal sulphide mineralization in the Platreef on Drenthe 778 LS: Econ. Geol.

GROBLER, N.J. and WHITFIELD, G.G., 1970. The olivine-apatite magnetitites and related rocks in the Villa Nora occurrence of the Bushveld Igneous Complex: Spec. Publ. geol. Soc. S. Afr., 1.

HALL, A.L., 1920. Corundum in the northern and eastern Transvaal: Mem. geol. Surv. S. Afr., 15.

HORN, G.F.J., 1979. An investigation of barite deposits on Neu Stadt 113 LS, Horst 89 LS and Drensteinpest 85 LS in the Dendron–Bochum area in Northern Transvaal: Unpubl. Rep. geol. Surv. S. Afr.

JANSEN, H., 1975a. Precambrian basins on the Transvaal craton and their sedimentological and structural features: Trans. geol. Soc. S. Afr., 78, p. 25–33.

JANSEN, H., 1975b. The Soutpansberg trough (Northern Transvaal) – an aulacogen: Trans. geol. Soc. S. Afr., 78, p. 129–136.

____________, 1976. The Waterberg and Soutpansberg Groups in the Blouberg area, Northern Transvaal: Trans. geol. Soc. S. Afr., 79, p. 281–291.

JANTSKY, G.J., 1978. The geology of the Bosbult and Munnik areas (Sheets 2329 DA and DB): Unpubl. Rep. geol. Surv. S. Afr.

MASON, R., 1973. The Limpopo Mobile Belt – Southern Africa: Phil. Trans. R. Soc. Lond., A 273, p. 463–485.

McCOURT, S., 1977. An account of the geology in the northern portion of the Koedoesrand area, Northern Transvaal: Unpubl. Rep. geol. Surv. S. Afr.

____________, 1981. Archaean lithologies of the Koedoesrand area – a report on Sheets 2328 AA, AB and AC: Unpubl. Rep. geol. Surv. S. Afr.

____________, (in press). Archaean lithologies of the Koedoesrand area, north-west Transvaal, South Africa: Spec. Publ. geol. Soc. S. Afr.

McCOURT, S. and BRANDL, G., 1980. A lithostratigraphic subdivision of the Karoo Sequence in north-eastern Transvaal: Ann. geol. Surv. S. Afr., 14(1), p. 51–56.

MEINSTER, B., 1974. The geology of the western part of the Soutpansberg, northern Transvaal (Sheets 2229 C and D, 2329 A and B): Unpubl. Rep. geol. Surv. S. Afr.

MEINSTER, B. and JANSEN, H., 1974. The geology of the Blouberg area, Northern Transvaal (portions of Sheets 2229 C, 2328 B and 2329 A): Unpubl. Rep. geol. Surv. S. Afr.

MEINSTER, B. and TICKELL, S.J., 1975. Precambrian aeolian deposits in the Waterberg Supergroup: Trans. geol. Soc. S.Afr., 78(2), p. 191–199.

POTGIETER, G.J.A., 1976. Geologiese verslag oor kartering van 1:50 000 velle Pietersburg 2329 CD, Ga-Mashashane 2329 CC en Limburg 2328 DD: Unpubl. Rep. geol. Surv. S. Afr.

SCHMIDT-EISENLOHR, W.F., 1969. Geological reconnaissance and nickel investigation in the northern Transvaal: Unpubl. Rep. geol. Surv. S. Afr.

SOUTH AFRICAN COMMITTEE FOR STRATIGRAPHY (SACS), 1980. Stratigraphy of South Africa. Part 1 (Comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Bophuthatswana, Transkei and Venda: Handbk geol. Surv. S. Afr., 8.

STOLJAN, H., 1975. Preliminary study of some lavas in the Waterberg System, with special reference to the Soutpansberg area, northern Transvaal: Ann. geol. Surv. S. Afr., 10, p. 33–35.

TICKELL, S.J., 1973. The geology of the northern Waterberg area (Sheets 2327 and 2328): Unpubl. Rep. geol. Surv. S. Afr.

____________, 1974. The geology of the western and southern Soutpansberg (Sheets 2329 A, 2329 B and 2330 A): Unpubl. Rep. geol. Surv. S. Afr.

____________, 1975a. Braided river deposits in the Waterberg Supergroup: Trans. geol. Soc. S. Afr., 78, p. 83–88.

____________, 1975b. The geology of a portion of the Limpopo Belt around the Magalakwin River and Blouberg (Sheets 2328 BA and 2328 BB): Unpubl. Rep. geol. Surv. S. Afr.

VAN DER MERWE, M.J., 1976. The layered sequence of the Potgietersrus limb of the Bushveld Complex: Economic Geology, 71, p. 1 337–1 351.

__________________, 1978. The geology of the basic and ultramafic rocks of the Potgietersrus limb of the Bushveld Complex: Ph. D. thesis, Witwatersrand Univ., (unpubl.).

VAN DER WALT, W.A., 1978. Die geologie van 'n gebied in die omgewing van Villa Nora, Noord-Transvaal: M.Sc. thesis, Rand Afrikaans Univ., (unpubl.).

VAN REENEN, D.D., 1978. Metamorfe studies van granoliete en verwante hoë-graadse gesteentes in die suidelike grenssone van die Limpopo-Metamorfekompleks in Suid-Afrika: Ph.D. thesis, Rand Afrikaans Univ., (unpubl.).

VAN REENEN, D.D. and DU TOIT, M.C., 1977. Mineral reactions and the timing of metamorphic events in the Limpopo Metamorphic Complex south of the Soutpansberg: Bull. geol. Surv. Botswana, 12, p. 107–128.

VAN WYK, J.P., 1977. Geologiese verslag van die gebied 2329 C Pietersburg: Unpubl. Rep. geol. Surv. S. Afr.

VISSER, H.N., 1953. The geology of the Koedoesrand area, Northern Transvaal: Expln Sheets 35 and 36 (Koedoesrand), geol. Surv. S. Afr.

WALRAVEN, F., 1982. Textural, geochemical and genetical aspects of the granophyric rocks of the Bushveld Complex: Ph.D. thesis, Witwatersrand Univ., (unpubl.).

WALRAVEN, F., BURGER, A.J. and ALLSOPP, H.L., 1981. Summary of age determinations carried out during the period April 1979 to March 1980: Ann. geol. Surv. S. Afr., 15(1), p. 89–94.

WILLEMSE, J., SCHWELLNUS, C.M., BRANDT, J.W., RUSSEL, H.D. and VAN ROOYEN, D.P., 1944. Lead deposits in the Union of South Africa and South-West Africa: Mem. geol. Surv. S. Afr., 39.

WILSENACH, L., 1980. Geologie van die gebied 2329 A Vivo: Unpubl. Rep. geol. Surv. S. Afr.