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A STRUCTURAL INTERPRETATION OF THE GEOLOGY

OF THE SHABANI AREA, RHODESIA.

J.W. Oldham, Ph.D. Thesis.

PRESENTED AT THE UNIVERSITY OF LONDON IN

APRIL 1969.

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ABSTRACT:

The major structure of the Shabani area is a north-south trending syncline, involving "Greenstones" which rest unconformably on various schists and gneisses of pre-Bulawayan age. These basement gneisses have been divided into: migmatites, banded gneisses, granitic gneisses and gneissic granite, a sub-division that has proved extremely useful in evaluating the mutual relationships within the gneisses and between the gneisses and the later formations.

The Basement Rocks: The oldest rocks found within the area are the migmatites and banded gneisses and, where more granitized, the granitic gneisses. Although no lithological distinction may be seen, it is believed that the strongly banded gneisses and the migmatites, <sup>together</sup> consist of at least two structurally distinct generations of rocks; an earlier group having an east-south-east, west-north-west trend and a later group having a predominantly north-south trend. It is suggested that a second period of deformation caused the refolding of the already deformed first series of gneisses. This situation is most clearly demonstrated in the area to the north-west of the "Great Dyke". A gradation into only partially migmatized rocks is found within both of these groups, the original rocks were evidently iron rich sandstones, greenstones and a more

calcareous sediment.

A west-north-west, east-south-east trending batholith, into which the earlier migmatites grade both laterally and marginally, is responsible for the formation of the earlier migmatites. This granite batholith must have been at least partially fluid during its emplacement, since during the growth of microcline phenocrysts within the rock, small euhedral crystals of plagioclase, sphene and muscovite, attached themselves onto the growing crystal faces of the phenocryst.

The Lower Sedimentary and Volcanic Greenstones: Overlying the basement gneisses (structurally higher), mainly in the south of the area, is a series of sedimentary and volcanic greenstones that have been thermally metamorphosed by the intrusion of later granitic rocks. Near the top of this sedimentary sequence, opposite the Ngesi Antimony Claims, at the Ngesi River bridge on the Shabani-Belingwe road, a silt of subaqueously deposited tuff occurs. Within this deposit, graded bedding, flame structures, ripple marks and accretionary volcanic lapilli may be observed, demonstrating the sedimentary nature of this horizon, and in this locality its slightly overturned attitude.

22 K

After the deposition of this series, the intrusion of concordant ultrabasic sills occurred, the presence of such

sills seems characteristic of these deposits.

The greenstones have been mapped southwards by Dr. B. G. Worst, where they are deformed into a major synform, plunging steeply to the north-east.

It is suggested that these rocks may be correlated with the rocks mapped as "Bulawayan" in the Mashaba area by Dr. J. F. Wilson, and as "Sebakwian" in the Selukwe area by Mr. C. W. Stowe.

The Middle Sedimentary and Volcanic Greenstone Group:

Resting unconformably upon the Lower Sedimentary and Volcanic Greenstones, which had already been folded about north-east, south-west trending axial planes, are the Middle Sedimentary and Volcanic Greenstone rocks, composed of volcanic lavas, tuffs and sub-aqueous sediments. This sequence begins as a predominantly sedimentary series of ironstones and conglomerates, volcanic materials increasing in amount at higher stratigraphic levels. The Middle Sedimentary and Volcanic rocks overstep the <sup>folded</sup> Lower Sedimentary and Volcanic Group onto the gneisses of the basement.

The Middle Sedimentary and Volcanic Greenstone Group compose the most widespread lithological unit of the greenstone rocks and are preserved in a tight synform, trending north-south and slightly overturned towards the east.



Throughout this large structure, graded bedding, ripple marks, flame structures and pillow lavas, all demonstrate that the rocks are the "right way up", and that the structure is an upward "facing" syncline.

The Upper Sedimentary Group: In the south of the area, the synclinal core of the Middle Sedimentary and Volcanic Greenstone Group is occupied by rocks of a distinctly different lithology; conglomerates, grits, siltstones and mudstones. The strike of this younger series is on the whole parallel to that of the Middle Sedimentary and Volcanic Greenstone Group, the dip vertical, but there are many local variations in strike and many minor, internal unconformities.

The outcrop pattern of this Upper Sedimentary Group is suggestive of one that has been modified by the slumping of still unconsolidated sediments during the latter stages of synclinal infilling.

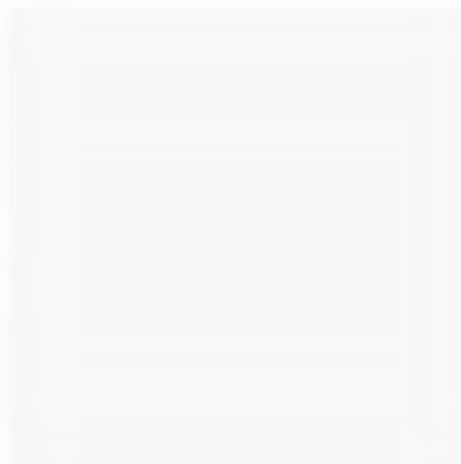
Later Tectonic Events: Following the deposition of the Upper Sedimentary Group, the major synclinal structure suffered an updoming about a west-north-west, east-south-east axis, which was accompanied in its later stages of development by the intrusion of the Younger Granite.

The latest major tectonic event was the emplacement of the Great Dyke, parallel to the north-south axis of the Middle Sedimentary and Volcanic Greenstone syncline. Later, normal

both sinistral  
faulting, and dextral wrench faulting, trending west-north-  
west, east-south-east, has affected the whole area.

PART 1

INTRODUCTION



## INTRODUCTION

The area that has been mapped and is presented here is a "quarter degree sheet" area of Rhodesia (fig. 1) and is contained by the latitudes: 20.00 S, 20.30 S, and the lines of longitude: 29.45 E, 30.15 E. The area is covered by the four 1:50,000 topographical sheets published by the Federal Survey, Nos: 2029Bb, 2030A<sub>1</sub>, 2029Bd and 2030A<sub>3</sub>.

The areas immediately adjacent to the present area have all been mapped by members of the Southern Rhodesian Geological Survey, that to the north around Selukwe by Mr. C. W. Stowe, to the east around Mashaba by Mr. J. Wilson, to the south by Dr. B. G. Worst and Mr. Ferguson and to the west by Mr. N. M. Harrison. The only work that has as yet been published is that of Worst and Ferguson in Memoir No. 43 "The Geology of the Country between Belingwe and West Nicholson" (1956).

Of the three years that this research has occupied, approximately nineteen months have been spent in Southern Rhodesia. The nineteen months was divided into two visits, covering the field seasons of 1965 and 1966. During the first and longer of the two visits, a reconnaissance map of the greater part of the area was able to be produced, this being completed together with the more detailed mapping of several selected areas, during the 1966.

Mapping was carried out upon overlays of 1:20,000

aerial photographs, reduction taking place during the transference of the information onto the 1:50,000 field sheets. The mapping of the more detailed areas was similarly upon overlays of aerial photographs of the scale of 1:10,000, plotting onto maps that have been prepared from these photographs.

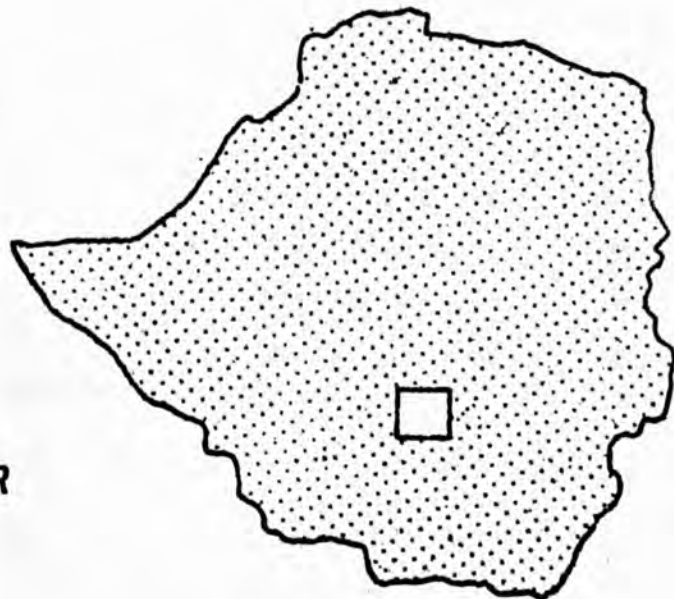
*Fig. 1*



SKETCH MAP OF  
AFRICA SHOWING  
LOCATION OF  
RHODESIA

A

SKETCH MAP OF  
RHODESIA SHOWING  
LOCATION OF AREA  
PRESENTED ON  
SHEETS ONE TO FOUR



B

Previous Geological Work:

Previous to the work carried out by the Geological Survey of Southern Rhodesia, on adjacent areas, very little information concerning the actual area is available.

Several rock specimens that were collected near Belingwe, were described and identified by Mr. F. P. Mennell in 1904, whilst he was attached to the Museum in Bulawayo.

In 1927 the "Greenstone" rocks to the north of the Ngesi River and to the south of the latitude 20.15 S, was mapped and described by Mr. F. E. Keep in the Geological Survey Bulletin No. 12, "The Geology of the Shabani Mineral Belt, Belingwe District".

The "Greenstone" rocks to the north of latitude 20.15 S remains unsurveyed from the ground by the Geological Survey of Rhodesia, although the contact between the "Greenstone" rocks and the basement gneisses and granites has been sketched in from evidence found on aerial photographs by Mr. R. Tyndale-Biscoe, for the sake of complete coverage in the publication of the "Geological Map of Southern Rhodesia" on the scale of 1:1,000,000, (1961).

A small area to the north-north-west of Shabani has been mapped by Mr. D. Catherall and described as part of an M.Sc. thesis, submitted to the University of Witwatersrand, 1965. This work covers a portion of the "Younger Granite" in the area.

A small portion of the south-western "Greenstone" rocks

has been reconnaissance mapped for the Geological Survey by Mr. R. Tyndale-Biscoe in 1958, on the scale of 1:50,000.

This work remains as yet unpublished.

The only other work that has been undertaken in this area is by the geological staff of the Shabanie Mine, as part of their surface survey of the Shabani asbestos body.

#### Drainage:

The drainage network of this region is a portion of the catchment areas of the Lundi, Ngesi and Mchingwe rivers, only the latter two rivers flowing throughout the year. All major drainage has a south-easterly flow, the Mchingwe being a major tributary through the Portuguese East African Territory of Mozambique to the Indian Ocean.

Rivers that flow over the basement rocks tend to have developed a dendritic drainage pattern whilst those flowing over the "Greenstone" rocks have developed a more trellised pattern, governed by the stronger lithological differences in the latter group. The only other structural control imposed upon the drainage, which on the whole shows a mature development, is that of rivers occasionally having linear stretches as they follow the zones of weakness surrounding faults.

#### Geomorphology:

The general elevation of the area is approximately 1,050 metres (3,500 ft.), rising from between 900-1050 metres (3,000-3,500 ft.) in the south-east to 1,200 metres (4,000 ft.)



and slightly over in the north-west and west. The area of greatest elevation lies to the west of the Great Dyke, and is caused by the occurrence in that locality of Mr. N. M. Harrison's "Porphyritic Granite".

Regions of greatest relief tend to occupy areas within the "Greenstone" rocks and within the adjacent gneisses where quartz "reefs" are found along fault planes.

The "Younger Granite" also gives rise to areas of higher relief but these tend to be either in the form of "kopjes" (residual inselbergs), or in zones where the granite is adjacent to rocks that are much less resistant to erosion, i.e. the Great Dyke.

The Great Dyke forms both regions of higher relief, as in the south, and regions of lower relief as in the north where bands of the Pyroxenite or Harzburgite rock are less prominent. Within the schist belt the horizons that form the zones of highest relief are "banded ironstone", which form very distinct horizons and barriers to both drainage and communications.

Two very interesting features of weathering are to be found in the area. The first is on the gneissic rocks and are shallow depressions, approximately circular, 1 metre in diameter and 0.2 metres in depth (Plate I). These depressions often have within them spherically shaped pebbles and water after periods of rain. These depressions are usually found on flat outcrops of granite/gneiss, and

hydration has caused the upturning of their edges.

The only feasible explanation for the origin of these structures is that they are the result of weathering on the under sides of boulders, particularly after rainfall when the boulder and the adjacent gneiss are wet. The small pebbles characteristic of these features may be the residual portions of the original boulder.

Once a slight depression has originated, then it is suspected that the retention of water after rainfall plays a large part in the further widening and deepening of these features.

The second feature of interest on the area is in the form of hexagonal fractures, found upon pebbles of an  
25 M intrusive acidic sill, in the south of the area. The axes of the hexagons are normal to the pebble surface, and approximately 0.015 metres apart. The hexagons are not present around the edges of the pebble, which are usually discoidal in shape. The hexagons are not due to any internal structure of the rock since it is homogeneous and the depth of penetration is of the order of 0.03 - 0.05 metres only.

It can only be assumed that this feature is caused by the low thermal conductivity of the rock which causes a hexagonal fracture pattern to develop when subjected to the diurnal temperature range over long periods.

Plate 1.

Saucer structure on gneissic pavement - note water and residual pebbles retained within the depression.



PART 11

THE BASEMENT GNEISS COMPLEX

## INTRODUCTION

Nearly half the area that has been presented on the four sheets of 1:50,000 scale of mapping, is composed of rocks that have been classified as belonging to the basement gneiss complex.

The rock types that are included within this basement gneiss complex classification are all the rocks that have been subjected to the effects of granitization. These basement rocks vary in composition from amphibolite schist, through a series of migmatized rocks and banded gneisses to a gneiss of granitic composition some fractions of which, had at the time of formation, a true liquid character. (see section on feldspar phenocrysts). pp 42-46.

Throughout the whole range of these rock types a common foliation is present caused by the orientation of the mafic minerals and a parallel fabric shape orientation of the leucocratic mineral grains, this latter feature being most noticeable in the strongly banded gneisses.

The general strike of this foliation is west-north-west, east-south-east, swinging around into a north-south trend, to the north-west of the Great Dyke, (sheet 1, and the eastern margins of sheets 2 and 4).

1-8, A-G

Within the gneissic basement rocks there is an obvious increase in the melanocratic proportions of the gneisses northwards and eastwards, (sheets 1 and 2), whereas southwards

the rocks gradually become more granitic in character, these granitic rocks occurring in the form of a large, west-north-west, east-south-east trending batholith.

The Basement Schists Bh<sub>1</sub>, Bh<sub>2</sub>.

At two areas within the Basement Gneiss complex there are found occurrences of coarse grained amphibolite schists and calc-silicate schists, occupying structures that appear as rafts, floating in the granitic Basement Gneisses. These raft-like structures are often bounded by peripheral banded ironstone beds that are typically discontinuous. The best examples of these rafts are found 1,200 metres to the north of the Lundi Bridge, along the Mashaba Road (sheet 2), and in the northern half of the triangular area of Basement Gneisses exposed to the north-west of the Great Dyke, (sheet 1). This difference in character of the schistose raft from the underlying Basement Gneisses is not only confined to the sharp distinction in lithology, but includes the foliation in the surrounding gneiss being markedly divergent to that of the rafts.

The general sequence of rock types in the Basement Schists is:

top	amphibolite schist	30-300 metres
.	calc-silicate schists	6 metres
.	amphibolite schist	30-300 metres
.		
base	banded ironstone	6 metres

A description of rock types:

The Banded Ironstone Rocks: In the field these rocks form very low, yet in the areas of gneissic rocks, very distinctive



topographic features. Unlike later ironstones of the Lower Sedimentary and Volcanic Greenstones, the basement ironstones are extremely impersistent, terminating abruptly, and giving way to outcrops of the gneisses.

The feature that is perhaps most indicative of the presence of the ironstones is a very wide and dense ironstone float, actual solid outcrops of this rock type being rare.

In the hand specimen these rocks are seen to be composed of alternating bands of iron ore and quartz crystals, the iron ore bands being slightly thicker and giving the rock an overall composition of 30 per cent quartz, and 70 per cent iron ore.

In thin section, the ironstones of the basement are in no way compositionally different to the ironstones of later series. In slide 235 the ironstones may be seen to be composed of 30 per cent iron ore, 10 per cent of limonite and 60 per cent of quartz grains. The discrepancy between the evaluation of the iron/quartz content in the field, (hand specimen), and in thin section, appears to be due to the presence of many quartz crystals within the iron ore bands, only being visible in thin section.

The quartz crystals have undergone complete recrystallization and can in many instances be seen to enclose grains of iron ore.

In slide 7, a rather peculiar arrangement of quartz

rods may be seen, orientated at right angles to some parts of the boundaries of certain limonite grains. No explanation of this texture is offered, other than drawing attention to the similarity of this to the crystal form of quartz that has originated during the infilling of cavities, Grigor'ev, 1961, pp. 226.

The Amphibolite Schists: In the field the only indication of the presence of these rocks in unexposed ground is a deep red soil that they give rise to, Where exposed the rocks are very dark green, almost black, and evenly coarse grained having an apparently monomineralic amphibole composition. These rocks characteristically have a well developed foliation, due to the parallel orientation of the amphibole minerals.

No exposures of the contacts of this rock group with the adjacent gneisses have been found, but since the change in soil colour over these contact zones is so rapid it seems unlikely that these contacts are gradational.

A typical amphibolite (slide 229) in thin section is a coarse grained rock, composed of 70 per cent hornblende, the majority of this having an anhedral shape due to the interference of adjacent crystals; the remainder of the slide is occupied by anhedral plagioclase that is in the process of replacing the hornblende. In slide 228, there are what appears to be intimate intergrowths of hornblende and plagioclase wherever these two minerals are in contact.

The hornblende towards these zones of intergrowth becomes bleached of colour, and alters to clino-enstatite within the rod-like intergrowths with the plagioclases.

The occurrences of symplectic intergrowth of plagioclase and hornblende are by no means confined to the basement schists of the Shabani region, nor are they a recent discovery, the earliest accounts of this type of feature being by Bailey, 1892, Smyth, 1894, and Lacroix, 1900.

The Calc-Silicate Schists: Occurring within the bands of amphibolite schist are small elliptical areas of a calc-silicate rocks, measuring some 6 by 15 metres and elongated parallel to the foliation of the amphibolite schists. In the field, these rocks are very badly exposed having a very soft and friable nature.

In the hand specimen it is rather difficult to determine the mineralogical composition of these rocks other than that they are in part composed of micas, iron ore and a soft silicate mineral,

In thin section, slide 226, the calc-silicate rocks are seen to be fine grained rocks, having a very well developed cleavage and composed of 25 per cent muscovite, 20 per cent enstatite, 20 per cent calcite, 15 per cent iron ore and 10 per cent of quartz and feldspar.

The iron ore is in the form of small opaque anhedral grains that are widely distributed throughout the rock.

The muscovite is evidently responsible for the well developed foliation, and is in sub-parallel bands, parallel to the foliation. The enstatite crystals have the form of irregular, sub-hedral grains, quite clearly being replaced by the micaceous minerals and the accessory feldspars.

The junction of the Basement Schists with the underlying Basement Gneiss varies from gradational to sharp, and the composition of the gneiss adjacent to the sharp junctions with the schists, varies from strongly banded gneiss to granitic gneiss.

At one locality, 12,000 metres to the north of the Lundi River Bridge along the Mashaba Road, sheet 2, a small  
 8Y elliptically shaped mass of amphibolite schist, 900 by 500 metres in diameter, rests within the core of a synformal structure within the strongly banded gneiss. This locality is one of the rare examples of a gradation from schistose raft into strongly banded gneiss, clearly visible over a distance of 90 to 100 metres.

As this north-south trending belt of strongly banded gneiss is followed northwards, it is seen to swing around to the east as it approaches the Jenya wrench fault, and before the gneiss abuts against the fault, a thin bed of banded ironstone replaces the amphibolite schist of the south, along  
 6AA the same horizon.

The only other example of a gradational change is exposed 3,000 metres to the south-west of Kashambi Halt

4G railway station, sheet 1, where a north-west south-east trending belt of gneiss is exposed which passes laterally, along the strike, into basic amphibolite schists before swinging back northwards upon itself in the form of a tight isoclinal fold. The termination of this northern limb of the folded schist is sharp and abrupt, showing no sign whatsoever of any gradation into the adjacent Basement Gneiss, ( $\beta_3$ ). Approximately 1,000 metres along the strike to the north-west, a further outcrop of Basement Schist is again visible, which persists for a distance of 1,000 metres in a north-westerly direction before being faulted out by a north-south trending vertical fault.

2F

If the north-west, south-east trending belt of strongly banded gneiss, (3,000 metres south-west of Kashambi Halt, sheet 1), is followed northwards, it is inferred to terminate by passing underneath a north-east, south-west trending banded ironstone member of the Basement Schists.

2F

THE BASEMENT GNEISS

Introduction

Nearly one half of the area of sheets 1 to 4 is composed of rocks that are collectively referred to as the "Basement Rocks" and by far the greater proportion of this group is composed of rocks belonging to the Basement Gneiss Division.

The rock types included within this classification are a gradational series of gneisses from a strongly banded gneiss through a granitized sequence to a foliated rock of granite composition. Many of these rocks have been subjected to the effects of migmatization.

Although the Basement Gneiss Complex occupies over one half the area mapped, exposure is never very good, since it outcrops on the relatively flat erosion surface of 1,050 metres.

The lithological divisions that have been made in the Basement Gneisses are:

- |   |                        |
|---|------------------------|
| (a) Strongly Banded Gneiss .....          | $\gamma_1$             |
| (b) Migmatite .....                       | $(\gamma_1 - \beta_3)$ |
| (c) Banded Gneiss .....                   | $\beta_3$              |
| (d) Skialithic and Schlieren Gneiss ..... | $\beta_1 - \beta_2$    |
| (e) Granitic Gneiss .....                 | $\beta_0$              |
| (f) Porphyritic Granitic Gneiss .....     | $\beta_0$              |
| (g) The Mushandike Granite .....          | $\alpha_1$             |

The Mushandike granite is believed to be a further unit within the gneissic sequence, (banded gneiss to porphyritic granitic gneiss), and because of its intrusive mode of emplacement it is discussed last.

## A. Description of the Lithological Units

### γ<sub>1</sub> (a) Strongly Banded Gneiss.

Because of the initial uncertainty in distinguishing between strongly banded gneiss and migmatite as defined by Sederholm (1907, pp. 110; 1926, pp. 136), the lithological unit that has been mapped as "Migmatite, γ", includes large areas of strongly banded gneiss. This initial uncertainty arose because of the strongly banded gneiss originating by the reworking<sup>of</sup> an earlier series of migmatized rocks.

The strongly banded gneisses are a group of striped, coarse grained, metamorphic rocks, composed of alternating parallel bands of melanocratic and leucocratic rock.

Over the zone of transition from strongly banded gneiss to basic schist, the leucocratic mineral content of this schist decreases as the leucocratic mineral bands appear. This evidence suggests that the origin of this gneissic banding is due to a mechanism of lateral secretion similar to the mechanism proposed by Hol<sup>m</sup>quist, (1907, 1910, 1920 and 1921), to explain his venite banding.

The width of the leucocratic portions of the gneissic banding varies from 0.01 metres to 0.1 metres and<sup>they</sup> have sharp straight contacts with the melanocratic schist portions of the gneiss.

The areas of strongly banded gneisses are confined to the north and east of sheets 1 and 2: west of the Great Dyke, the central area and the area of the Lundi/Msebaise confluence.

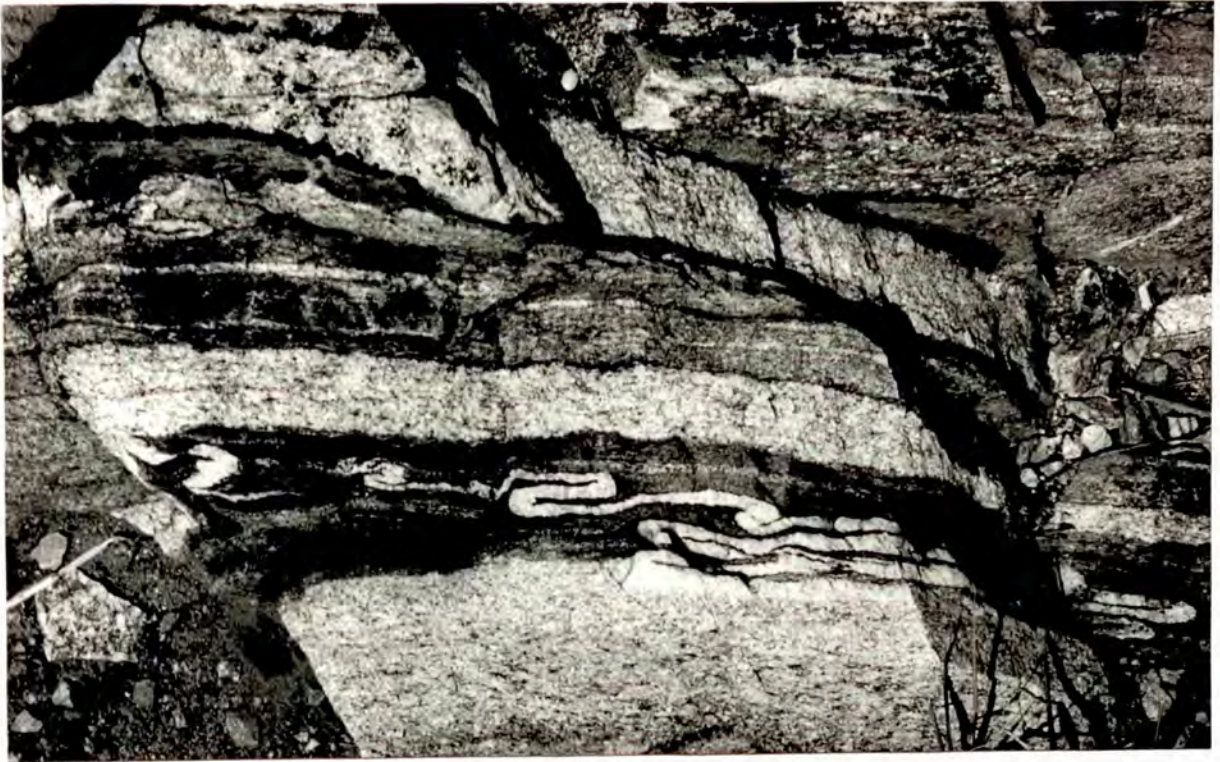
Plate 11.

Folded pegmatite vein in Strongly Banded Gneiss,  
note slight decrease in the thickness of the limbs.

Plate 111.

Folded pegmatite vein in Weakly Banded Gneiss, note  
the great reduction in the thickness of the limbs.





In thin section, the strongly banded gneisses are composed of bands of leucocratic and melanocratic mineral assemblages. Typical mineral assemblages of these two portions of the rock are illustrated in slide 222, and the melanocratic portion is seen to be composed of 50 per cent hornblende, 40 per cent feldspar, and 10 per cent of epidote, iron ore and sphene.

The hornblende is in the form of subhedral grains, and in slide 222, which is cut at right angles to the foliation, the plane containing the b-c crystallographic axes of the hornblende crystals is parallel to the foliation and causes the fabric shape in this slide. In slide 222 there has also been a second generation of hornblende growth, the crystals enlarging themselves in the direction of the foliation, i.e. in the plane of the b-c axes.

The feldspar is in the form of large anhedral crystals that have no characteristic shape or orientation and clearly may be seen to replace the hornblende crystals. The epidote, iron ore and sphene have the form of small anhedral grains in association with the hornblende, representing minor constituents only.

The more acidic assemblage of the leucocratic bands is composed of 40 per cent microcline, 40 per cent quartz, 10 per cent orthoclase feldspar and 10 per cent of mica, hornblende and chlorite.

The microcline is in the form of large clear anhedral

crystals which are sometimes seen to <sup>be</sup> replaced ~~the~~ <sup>by</sup> orthoclase feldspar crystals.

There is also slight evidence to suggest that the microclines are being replaced by quartz crystals.

In one of the crystals of microcline feldspar, deformation and fracturing has occurred causing the nucleation and growth of numerous small feldspars along the line of fracture.

The quartz is in the form of small grains which [when in contact with adjacent quartz grains] usually show good textural equilibrium, Voll, 1960, when in contact with grains other than quartz, uneven crystallographic boundaries are common.

The anhedral crystals of orthoclase have been very heavily kaolinitized and sericitized, and are in the process of being replaced by the microcline feldspar.

The hornblende, biotite mica and epidote have the form of small anhedral grains.

The contact between the melanocratic and the leucocratic bands is extremely sharp, and is marked, as one passes from the basic to the acidic rock, by the disappearance of the hornblende crystals and the appearance of a high percentage of quartz, especially in the acidic rock adjacent to the contact.

Y<sub>1</sub> - P<sub>3</sub>(b) Migmatites

Superimposed upon the series of basement gneisses that have been discussed in the previous section is a sequence of migmatites, i.e. "mixed rocks" of Sederholm (1907, pp. 110, and 1926, pp. 136).

The migmatites are composed of a melanocratic schistose rock that has been penetrated by leucocratic veins; variations in the physical relationship of these two lithological elements cause several types of migmatite to be recognised:

## (1) Agmatite.

This first type of migmatite although not common is the most distinctive variety and is composed of angular fragments of a melanocratic material that are contained within a coarse network of leucocratic veins. The edges of adjacent fragments of the melanocratic material have shapes that would very easily fit together if the intervening leucocratic material were removed. The rock has the appearance of a brecciated melanocratic schist that has been intruded by an acid magma, causing the separation of the original breccia fragments.

This first variety of migmatite is the "agmatite" of Sederholm (1923).

The occurrence of agmatite is confined to small rounded, pipe-like masses, approximately 2 metres in diameter and apparently having vertical contacts. The best exposure of such a feature is in the Msebaise river section, 12,000 metres upstream from the Lundi/Msebaise confluence, (sheet 2).

(2) Concordant Arterite.

The second variety of migmatite is composed of a basic gneiss that has been intruded by a parallel series of leucocratic veins, the acid veins are also sub-parallel to the metamorphic banding.

The width of the acid veins vary from 0.02 metres to 0.2 metres, increasing in width and frequency of occurrence towards the more granitic gneiss.

Because of the very slight transgression of the metamorphic banding by these veins and their increasing size and frequency towards the granitic gneisses, this rock type is considered to be a (concordant) "arterite" of Sederholm (1923).

(3) Transgressive Arterite.

As the leucocratic veins of the concordant arterite are followed towards the granitic gneiss, their physical relationship with the host gneiss begins to change.

Overprinted on this first series of parallel veins is a group of fine transgressive veins that form a network of leucocratic material, permeating the more basic banded gneiss.

This series of transgressive veins again increase in size and frequency of occurrence towards the granitic gneiss.

This rock-type is considered to be a (transgressive) "arterite" of Sederholm (1923).

(4) Nebulites.

With the increasing development of the leucocratic veins of the transgressive arterite (3), as the granitic gneisses are

approached, the rock becomes overwhelmed with diffuse leucocratic material. This overprinting of the gneisses with leucocratic veins causes any earlier compositional banding to be preserved merely as ghost-like remnants of the earlier structure.

This rock-type is considered to be the "nebulite" of Sederholm (1923).

Description of the Migmatite Exposure, Mapped on the  
Scale of 1:12 (SHEET 6)

14 X

An extensive outcrop of migmatite was mapped in detail. It is situated approximately 750 metres north of the Shabani-Mashaba road bridge over the Lundi River, and exposed along its western bank.

The map has been compiled from photographs taken vertically from a height of 1 metre above the rock pavement. A sketch map of the exposure, marking the different rock units was made at the same time. All the photographs had a one third overlap and were mounted as a mosaic before the present map was traced from them.

The migmatites and banded gneisses at this locality are considered to have originated in part from the Sebakwian schists, as mapped by Dr. J. Wilson on the adjacent Mashaba sheet (unpublished Geological Survey Bulletin). The gneisses and migmatites are also considered to be the **equivalent of** the Younger Basement Schists, mapped in this thesis to the north-west of the Great Dyke.

Near to this exposure are occurrences of the Mushandike (older) Granite, this granite is later than the granitization and many of the pegmatite and concordant arterite veins are thought to be genetically associated with the emplacement of this acid magma.

To the north-east of this exposure granitization decreases whilst to the south-west it increases.

A description of the Rock Units.

(a) The Gneisses: The individual minerals in these rocks are usually fine-grained, the width of the metamorphic banding varying throughout the exposure from 0.002 metres to 0.05 metres. From the mineral assemblages these rocks are ascribed to the amphibolite metamorphic facies.

From evidence of sedimentary structures that are found to the north, along the strike, it is suggested that these rocks are paragneisses.

(b) Porphyroblastic Zones: The porphyroblasts consist of growths of quartz and feldspar, measuring from 0.002 metres to 0.05 metres, and elongated within the foliation. These structures are usually surrounded by a zone of more basic schist, the quartz and feldspar from which has apparently migrated towards the growing porphyroblast. The mafic constituents of this porphyroblastic zone have conversely migrated outwards.

The occurrence of this type of growth is usually confined to either discrete parallel zones or to the cores of the later folds.

(c) Aplites: These are fine-grained acidic rocks having sharp and irregular contacts. The aplitic rocks occur as dykes, varying in thickness from 0.05 to 0.4 metres, and also as irregular replacive bodies within the cores of folds. The aplite veins must have been unstable since alteration of these intrusions to pegmatites is a common



feature.

(d) Vein Pegmatites: These are of two distinct types,  
(1) Pegmatites composed wholly of quartz and feldspar,  
usually microcline, and often containing "stringers" of  
amphibolite along their centres. This variety of pegmatite  
has developed from the alteration of aplite veins.

(2) Pegmatites which contain far more internal, irregular  
clots and schlieren of amphibolite schist, and along their  
highly convoluted margins often enclose portions of the  
basified marginal rocks.

This type of pegmatite is thought to have developed as  
an extension of the process by which the porphyroblastic  
feldspars were formed.

(e) Granite: This rock is a medium-grained grey granite,  
having sharp, irregular contacts that cross-cut the  
foliation of the gneisses. This rock is thought to be the  
equivalent of the Mushandike Granite (mapped by Dr. J. Wilson  
on the adjacent Mashaba sheet).

#### Structure and Sequence of Events.

This map contains areas marked by two different  
structural patterns and separated by the central pegmatite.

To the west of the central pegmatite the gneisses have  
a relatively simple structure, the foliation is straight and  
undisturbed and the metamorphic mineral banding is far less  
pronounced than to the east of the map. Here only one  
simple fold is apparent; it is marked by the northerly

closure of the mineral banding and earliest foliation into a very tight isoclinal similar fold which causes the development of a second foliation. No complementary southern closure is visible. This fold has its axial plane parallel to the second foliation which is also sub-parallel to the earliest foliation within the area.

The simple structure of this area is traversed by porphyroblastic zones which have a simple linear form and are parallel to the general foliation and mineral banding.

To the east of the central pegmatite (in the second area), the folding is much more intense and the mineral banding much better developed. The deformation within this area consists of tight isoclinal folds of the mineral banding, similar to that described within the western area and is therefore thought to be equivalent to it, superimposed upon which is a later deformation.

The later folding is dominantly concentric in style and in places very disharmonic, the fold limbs passing into small shears which have an orientation parallel to that of their axial planes.

Within the cores of these later folds, although by no means confined to these positions, are often found aplites, porphyroblastic zones of feldspars and very strongly developed bands of amphibolite. All these features have contacts that are parallel to the folded foliation and mineral banding.

The plunge of the folds is difficult to determine

throughout the exposure, since the relief on the pavement is very small, but is suspected to be steep towards a northerly direction.

Sequence of Events:

- (a) Folding of the original gneiss during the initial migmatization, into tight isoclinal structures that have axial planes parallel to the foliation.
- (b) Development of some porphyroblastic zones.
- (c) Emplacement of some pegmatites.
- (d) Development of the later folding, accompanied by shearing within the gneisses and the emplacement of some aplites, further growth of porphyroblastic feldspars, together with an intensification of the metamorphic mineral banding.
- (e) Emplacement of aplite veins.
- (f) Emplacement of pegmatites.
- (g) Emplacement of aplites followed by the emplacement of the Mushandike Granite.
- (h) Further compression causing buckling or stretching of variously oriented pegmatite veins.
- (i) Annealing of the fractures within the gneissic rock.

$\beta_3$  (c) The Banded Gneiss

This third lithological unit that has been mapped in the basement gneisses around Shabani, is again composed of melanocratic and leucocratic elements, as in the strongly banded gneisses, but in the melanocratic portion of this rock unit there is a very finely disseminated minor amount of leucocratic material (see plate III).

The transition between the strongly banded gneisses and the banded gneisses, when transitional, is marked by the first appearance of quartz-feldspar, augen-shaped bodies, approximately from 0.01 to 0.05 metres in size, and in all sections these bodies have their longer axes oriented parallel to the foliation.

As the banded gneiss becomes more and more granitic in composition; the quartz-feldspar porphyroblastic bodies occur more frequently, the lit-par-lit parallel banding becomes less distinctive, the leucocratic bands becoming more diffuse along their borders and more irregular and cross-cutting in their orientation to the gneissic banding until the rock has a general overall dioritic composition.

Also occurring within this banded gneiss unit as it becomes more granitic in composition are areas in which the gneissic banding becomes extremely vague, the texture igneous looking and the composition dioritic. These "enclaves" within the gneiss are believed to be an equivalent rock type to the "anatexite" of Roques (1941),

Plate 1V.

Folded Strongly Banded Gneiss.

Plate V.

Folded Weakly Banded Gneiss.



in his migmatite stratigraphy of the Massif Central.

In thin section (slide 233), the banded gneiss, a coarse grained, igneous looking rock, typically composed of 50 per cent feldspar, 25 per cent quartz, 10 per cent amphibole, 5 per cent pyroxene and 10 per cent chlorite, iron ore, calcite and biotite.

The feldspar crystals are mainly anhedral in shape, composed of orthoclase that is in part being replaced by microcline, and they generally show a high degree of sericitization. The quartz grains are anhedral in shape, quite large and show a poor development of textural equilibrium along their boundaries, (Voll, 1960). The amphibole is of hornblende composition, in the form of subhedral grains that are clearly after the pyroxene crystals which have the appearance of hypersthene and are in the form of small anhedral grains. The chlorite crystals are replacing the large plates of the brown biotite micas and the iron ore and calcite are usually in association together, often adjacent to the crystals of hornblende.

The whole rock has a granulitic-looking texture, having the appearance of a rock that has been subjected to a high degree of internal deformation.

$\beta_1 - \beta_2$  (d) Skialithic and Schlieren Gneiss, (weakly banded granitic gneiss)

The schlieren gneiss is composed of a weakly foliated gneiss of grano-dioritic composition in which are found very faint and vague remnants of ghost-like swirling folds, only visible on large surfaces of freshly weathered smooth gneiss where small increases in the mafic constituents of the gneiss may be detected. See plate III.

Cooexisting with this schlieren gneiss as it becomes more granitic in composition is a granitic gneiss containing small inhomogeneities of an amphibole rich rock that have very sharp boundaries with the granitic gneiss host. These amphibole rich bodies have an elongate or drawn-out augen-shape whose longer axes have a parallel orientation to the gneissic foliation.

The sharpness of the boundaries of these basic streaks or skialiths appears in many instances to be accentuated by the adjacent gneiss having been leached of all its mafic minerals.

The origin of these basic augen-shaped bodies is thought to be that they represent the undigested portions of some rock resistant to granitization (xenoliths), similar to the drawn-out segments of basic dykes described by Watterson (1965), rather than due to "some obscure process of segregation", as suggested by Grout (1932, pp. 61).

This rock type **could only** be mapped as a



Plate VI.

Skialithic Gneiss.



1B-G

separate unit in the area to the north-west of the Great Dyke and it is only in this area that a boundary between the weakly banded granitic gneiss and the structurally higher

2G-D

banded gneiss has been mapped.

β.

### (e) Granitic Gneiss

In the field the granitic gneiss is a coarse grained rock of igneous texture, having a granite to granodioritic composition.

The areas underlain by the granitic gneiss are typically low, gently undulating landscapes characterised by a fine white sandy soil.

Throughout this rock there is a very faint but characteristic foliation, caused by the parallel orientation of micaceous minerals and although less distinct, equally important, a fabric shape orientation of the elongated quartz and feldspar minerals, parallel to the foliation of the micaceous minerals.

Occasionally within the granitic gneiss there are found vague suggestions of a diffuse, highly folded gneiss more rich in mafic minerals, and lenticular clots of amphibole crystals that are elongated within the foliation; i.e. . enclaves of schlieren gneiss and skialithic gneiss.

In thin section this rock may be seen to be a coarse grained igneous looking rock of granitic composition, composed of 65 per cent feldspar, 25 per cent quartz, 5 per

cent hornblende and mica, and 5 per cent of sphene and iron ore.

The majority of the feldspar in this slide is microcline in the form of large anhedral crystals, often overgrown by orthoclase that has since been sericitized. It is in these crystals that the orientated inclusion of plagioclase, hornblende, sphene and micas which are to be discussed later, are found.

The quartz has the form of large clear un-strain-shadowed anhedral crystals, and when in contact with crystals of feldspar often shows the development of myrmekitic structures.

The hornblende is in the form of small sub-hedral (anhedral when included within a microcline phenocryst) crystals that are after pyroxenes. The mica is the biotite variety and in the form of large euhedral plates.

The sphenes are present as small euhedral crystals that are often in association with the iron ore grains.

β. (f) The Porphyritic Granitic Gneiss.

The only outcrop of this lithological unit that has been mapped as a discrete body may be found on sheet 1 between the "Schist Belt" and the Great Dyke. As in the case of the weakly banded gneiss, this locality is by no means the only exposure of this rock type that has been encountered during the course of field mapping, but it is the only occurrence of this rock type around which a boundary could be

Plate VII.

Porphyroblastic feldspars in folded Strongly Banded Gneiss, note the elongation of the porphyroblasts parallel to the lithological banding.

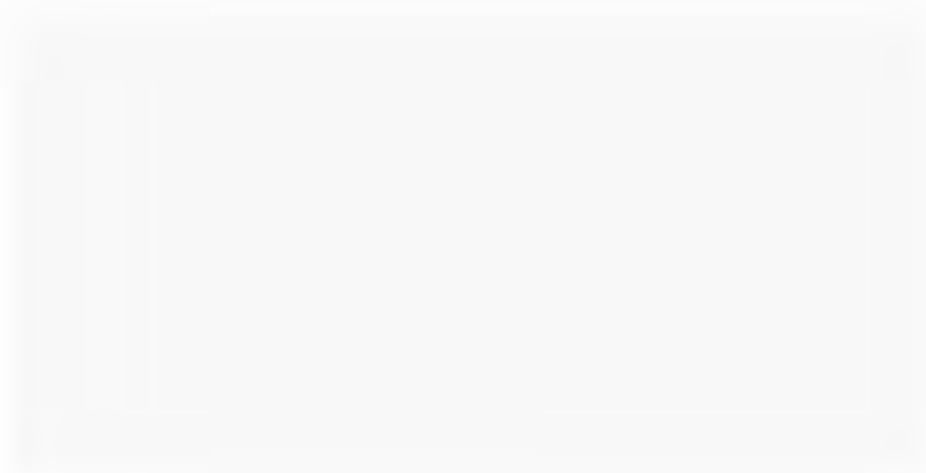


Plate VIII.

Photomicrograph of synantectic structures along hornblende-feldspar junctions, x 20.





8K-M

placed with any degree of certainty.

As the name suggests, the composition of this rock type is almost identical with that of the granitic gneiss, differing only in the increased occurrence of the microcline phenocrysts.

As might be expected with such a rock type, its contact with the adjacent granitic gneiss is gradational and extremely indistinct, and it is only in the above locality that the size of this particular mass of the porphyritic granitic gneiss warranted that a boundary should be placed around it.

#### Feldspar Phenocrysts of the Porphyritic Gneiss.

The distinguishing feature of the porphyritic gneiss is the occurrence of large subhedral to anhedral phenocrysts of microcline feldspar. These phenocrysts are approximately 0.015 metres in length, 0.006 metres in width, and have included within them smaller euhedral crystals of: plagioclase feldspar, sphene, hornblende and mica. The **plagioclase** feldspars are by far the most common inclusions and are approximately 0.001 metres in length, and have an oligoclase-andesine composition. There is often visible in the centre of the plagioclase inclusions a zone composed of fine-grained micaceous material that gives a cloudy appearance to the core of these crystals.

The inclusions of plagioclase have a very slight zoning along their margins towards an andesine composition.

The most interesting feature of these inclusions is

their very regular orientation, the b-c crystallographic plane (100) of the hornblende, the (001) plane of mica, the (010) plane of the plagioclase and either the (101) plane or the (100), (001) planes of the sphene are nearly always arranged so that they are parallel to the (100) and (010) faces of the microcline phenocryst.

The inclusions are also concentrically arranged, in rectilinear zones, all the inclusions in the zone having their longer axis parallel to the side of the rectangle, which in turn is parallel to either the (100) or (010) face of the microcline phenocryst, see plate IV.

In certain thin sections of these phenocrysts, where there are few inclusions present, the inclusions that are separated may be seen to occupy the same zone, the zone is continued in the absence of larger inclusions by the presence of a dust of micaceous material.

The situation that has been described above is very similar to those described by Schermerhorn (1956), Wallace (1956), Voll (1960), Smithson (1963), and Hibbard (1965).

Unlike the zoned feldspar phenocrysts that have been described before, the inner boundary of each zone in the microcline phenocryst of the Shabani gneiss is very sharp, very few plagioclases occupy positions within the microcline that are outside the zones. This would seem to suggest that the growth of the microcline has not been continuous, but rather in a series of stages.



Plate 1X.

Photomicrograph of a feldspar phenocryst containing inclusions of plagioclase, hornblende, sphene and mica.



The maximum number of zones found within any one phenocryst is four, although it is more usual to find only two zones in any one section.

The origin of these features seems to have only one plausible explanation and that is that the plagioclases attached themselves to the growing crystallographic faces of the microcline phenocrysts. This hypothesis is by no means original, and has been suggested firstly by Voll, and then Hibbard and others, and requires that the host microcline grew in an environment that was at least partially liquid.

Nearly all the petrofabric features that are described by Voll (1960), are to be found within this gneiss. Features such as warts of myrmekite at quartz/microcline contacts, swapped rims at microcline/microcline boundaries are identical to those described by Voll.

Voll also records that those plagioclases that are parallel to the crystallographic faces of the microcline host are only slightly corroded, whilst those plagioclases with a high degree of misfit are strongly corroded. In the gneissic rocks of Shabani, similar relationships are observed.

$\alpha_1$  (g) The Mushandike Granite, (Older Granite).

The name "Mushandike Granite", was given by Dr. J. F. Wilson to an older generation of intrusive granites which he found whilst mapping the quarter degree sheet of the "Country around Mashaba" for the Rhodesian Geological Survey.

This name has been applied to a foliated granite that occurs in the Shabani area; this is of an earlier date of emplacement than the "Younger Granites".

14V Occurrences of the older granite are confined to areas to the east of Shabani (sheets 2 and 4), and are in the form of elliptically shaped bodies, their longer axes trending parallel to the foliation of the basement gneiss; from east-north-east to north-south.

The size of the older granite bodies varies from stocks 80 metres by 15 metres to a batholith whose minimum dimensions are of the order of 3,000 metres by 10,000 metres.

The typical landform is a low flatly rolling country, having a very white, coarse sandy soil, supporting a grass-land which is usually utilized as cattle pasture.

In the hand specimen the granite is a medium grained foliated rock, weathering deeply to very white friable boulders and giving rise to patches of quartz-feldspar gravels around the exposures which are very well drained and favoured by aloes, cacti, and other xerophytic plants.

15X On the scale of 1:50,000 the foliation, caused by the orientation of the micaceous minerals in the older granite, appears to be of the same generation (similar orientation), as the foliation in the gneissic basement. Approximately 100 metres to the north of the Lundi Bridge, Mashaba-Shabani Road; and 50 metres south-east of Lahalas "ranch" house, Lundi Bridge, the foliation of the gneisses may on many

occasions be seen to be cross-cut at a high angle by the Mushandike Granite contact, and the gneissic foliation warped against this junction. The foliation of the gneiss therefore is not in complete continuity with the foliation that is found within the Mushandike Granite. In most examples examined, this situation is thought to be due to the more competent behaviour of the granite during later compression of the rocks, along similarly oriented axes as those responsible for the production of the gneissic foliation. In other exposures however, the earliest folds within the gneiss are very tight isoclinal structures whose axial planes are parallel to the foliation, these structures are cross-cut by the granite and its related pegmatites. A good example of this is the river exposure, 50 metres to the south of the Lundi Dam at the confluence of the Lundi and Msebaise Rivers.

14Y

Perhaps the best evidence that has been found for the date of the older granite emplacement being later than the deformation of the basement gneisses may be found in the exposure shown in "The Plan of a Migmatite Exposure". At this locality the pegmatite dykes are associated with the older granite, may clearly be seen to have suffered far less deformation than the migmatites and banded gneisses in which they occur.

Towards the north-eastern edge of sheet four, the Mushandike Granite trends west-north-west, east-south-east, widening south-wards. Along both the eastern and western

contacts of this body there are dykes of a gabbroic rock, which although somewhat discontinuous, are concordant with the granite/gneiss junction. The gabbroic dyke of the western granite contact continues south-wards along the granite/gneiss junction for a minimum distance of 6,000 metres, along the north eastern bank of the river flowing over the Ludi Bridge Ranch.

As the granite contact is approached:

- (a) The migmatites and gneisses become much more coarsely banded, the distinction between the leucocratic and melanocratic veins becoming very sharp.
- (b) Pegmatite porphyroblasts of quartz and feldspar composition from 0.05 to 0.3 metres in length and from 0.02 to 0.05 metres in width, elongated within the foliation and surrounded by a basic amphibolite schist, occur more frequently.
- (c) There is a noticeable increase in the number of intrusive pegmatite and aplite veins.

Exposure of the granite contact are rare, apart from the localities listed above but where the contact is seen it has a very straight and sharp form.

### Pegmatites:

Although the definition of the term pegmatite, as given by Anderson, (1931), places no restriction on the composition of the rock, only those pegmatites of an acid composition will be given consideration in this section.

The pegmatites that are to be found in the gneissic rocks around Shabani can be divided into four varieties.

The first type appears to be an earlier series of pegmatite veins that have been folded and sheared, the limbs attenuated to such an extent that they often form no more than a series of stringers. The separation between segments of the limbs is approximately half their length. The closures of the folds are now seen as sigmoidally shaped pod-like masses, (Migmatite Map) the separated limb making a very small angle with the foliation.

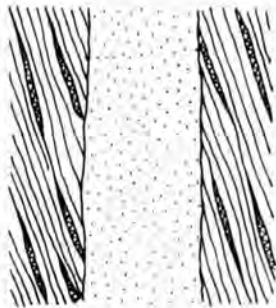
The second type of pegmatite is in the form of a series of pod-like, augen-shaped masses, varying in size from 0.01 metres, to 0.75 metres. The augens are apparently unconnected and lie within the foliation.

The third variety is a series of veins that are parallel to the foliation of the gneiss, many of the veins having been drawn out into boudins.

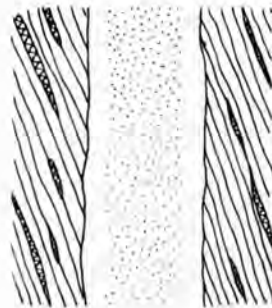
It is suggested that the pegmatite of the second type is of a secretory origin, replacing the host rock and completely cross-cutting, without displacing, any oblique

DIAGRAMMATIC REPRESENTATION OF THE STAGES  
OF PEGMATITE DEVELOPMENT

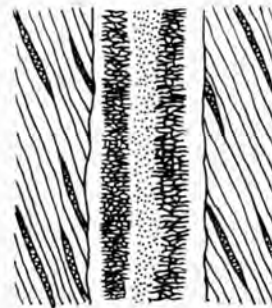
Fig. 2



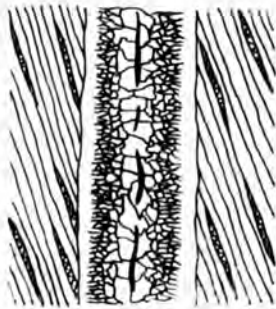
A



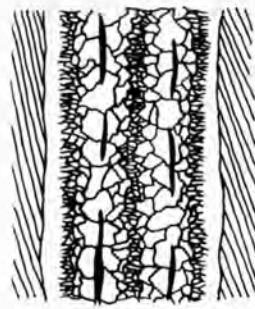
B








C



D



E

-  GNEISS
-  QUARTZ VEINS
-  APLITE
-  RECRYSTALLIZATION
-  BASIC STRINGERS



banding within the gneiss.

The fourth variety of pegmatite is usually found in close proximity to the older Mushandike Granite, first described by Mr. J. Wilson in the as yet unpublished Bulletin of the Geological Survey of Southern Rhodesia, of the Mashaba Area. This group of pegmatites is found in the form of linear veins, 0.3 to 0.5 metres in width, and approximately 10 to 20 metres in length. The largest exposure of this type of pegmatite that has been found is at the bridge of the Lundi River where the Shabani-Mashaba road crosses the river. The dip and strike of these veins is rather variable, but in the majority of cases they are sub-parallel to the local foliation of the gneiss. In this type of pegmatite there appears to be both an intrusive and a replacement mode of emplacement. Occasionally, both modes of emplacement are detectable in the same vein.

At any one exposure, a maximum of seven relative ages of dyke emplacement may be determined by the use of cross-cutting criteria, (see fig. 3). Since the mode of emplacement varies, it was hoped that the relative dating of this series of pegmatites (and consequently the identification of one age of vein), might be continued from exposure to exposure, by use of the severity of deformation suffered by that vein. Unfortunately, the severity of deformation, (folding/boudinage), is apparently a function not of the age of the vein so much as the original

*divided?*

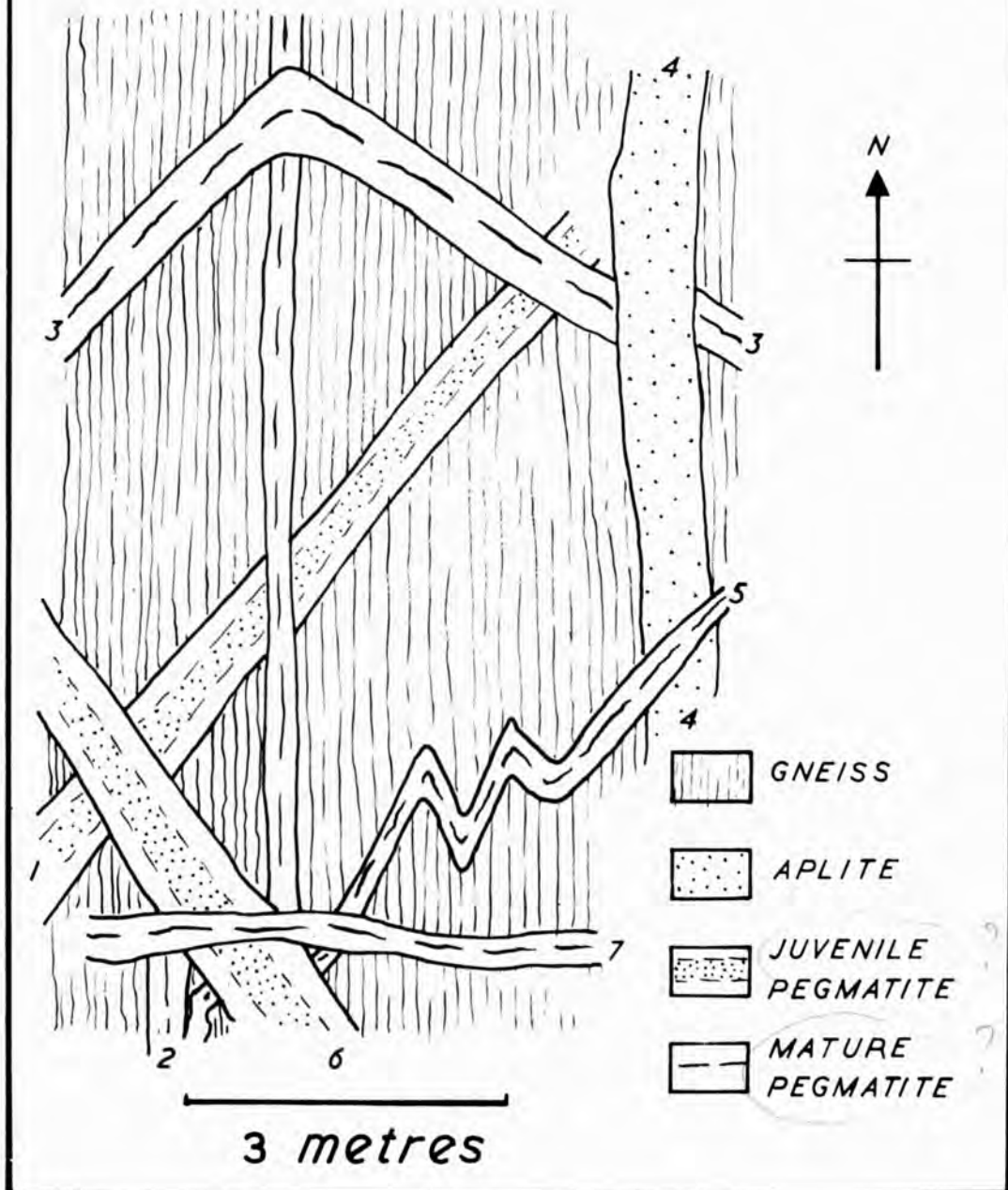
orientation of the vein to the X , (X of Flinn 1956) axis of the deformation ellipsoid.

The criterion that has been used in order to determine the mode of emplacement, is the one first suggested by Goodspeed, 1940, i.e. the occurrence of, or lack of, offsetting of obliquely intersected planar structures. The objection that was raised by Wells and Bishop, 1940, King 1948 and others, that lateral movement along the dyke in many cases invalidates the evidence of offsetting, has not been found to be a common feature, although a very small number of examples have been recorded. The criterion used to determine a replacement mode of emplacement, is that used and described by King, (*op. cit.*) which is, no displacement of transgressed oblique structures, this type having irregular outlines. Evidence of "no disturbance of the foliation", (King), has been found to be of restricted use, since later compression has caused a warping of the foliation, especially at the contacts of inhomogeneous bodies within the rock, such as pegmatite dykes, whose angle of incidence to the gneissic foliation is greater than twenty degrees.

A very common form of pegmatite that is found in this area consists of coarsely crystalline quartz and feldspar, the coarseness of which increases from the margins towards the centre, where is found a narrow and discontinuous zone of mafic minerals, (hornblende and lithium mica). The features of these pegmatites appear to be very similar to

Fig. 3.

RELATIVE AGE OF  
PEGMATITE DYKES



those of the pegmatites described by Reitman 1965.

After the field examination of several hundred pegmatites of this type, at various stages of their development, a series of stages that are believed to be continuous to the final mature form have been distinguished.

The initial stage of development of this type of pegmatite is that of the emplacement of an aplitic vein which is usually, but by no means always, of an intrusive nature, (see fig. 2A). The second stage is that of a quartz-feldspar enrichment of the margins of the dyke, the quartz and feldspar apparently migrating from the core of the dyke and during this primary stage of enrichment only, from a zone approximately 0.1 to 0.15 metres in width in the adjacent host rock. The mafic constituents of the dyke margin migrate inwards, giving the appearance of a basification of the central portion of the dyke.

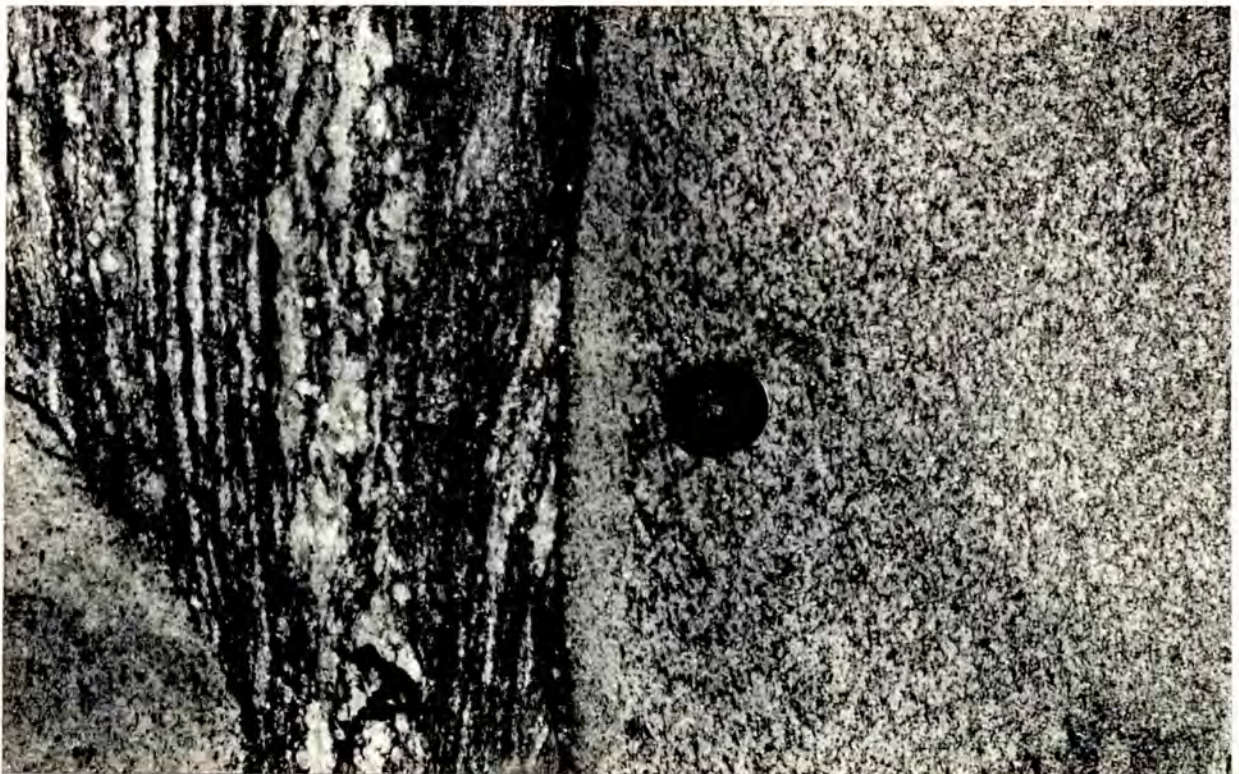
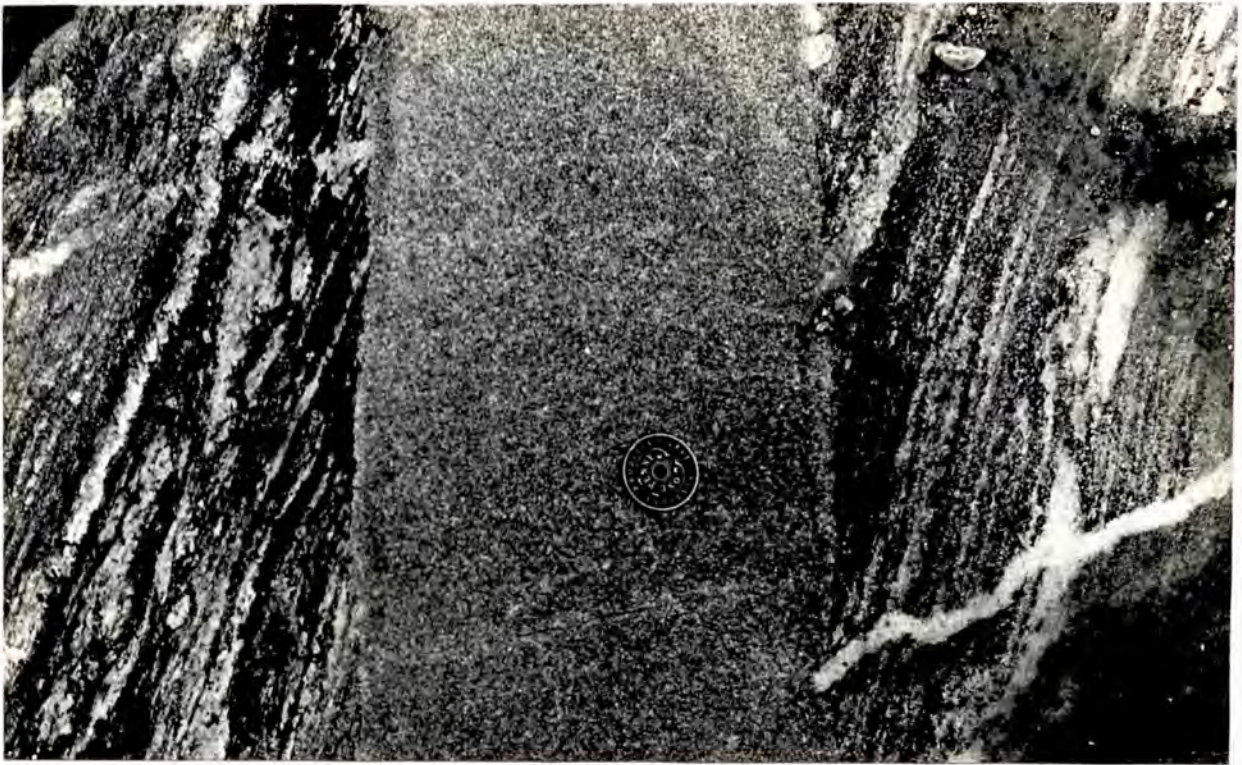
As the width of this border zone increases, the migration of quartz and feldspar from the host rock ceases and a re-crystallization of this already enriched margin begins, the quartz/feldspar re-crystallization follows the inwardly migrating front of enrichment through the following stages. Since the secondary crystallization commences at the borders of the dyke, and the most favourably orientated crystals grow to the greatest size, the secondary crystals in each successive growth zone become

Plate X.

Initial intrusion of an aplite dyke.

Plate XI.

First stage of recrystallization - the appearance of a leucocratic rich zone along the edge of the aplite, together with a narrow melanocratic rich zone within the adjacent gneiss.



larger, so giving a "drusi crystalline" appearance to the re-crystallized quartz and feldspar of the mature pegmatite.

The final stage in the generation of the mature pegmatite is the recrystallization of the mafic constituents in the core of the vein (see fig. 2D).

There are many cases of pegmatites that are very similar to those described above, and illustrated in fig. 2E. In such cases as these, where there are two such concentrations of medial mafic minerals, the coarseness of the quartz and feldspar increases as the mafic zones are approached. The mechanism that is responsible for this second type of zoned pegmatite, is considered to be not unlike that producing the first and more simple type.

In this second type of pegmatite, the enrichment and concentration of quartz and feldspar within the original aplitic vein takes place not only along the borders of the dyke, but also along a central zone. No evidence has been found that indicates multiple intrusion as a possible cause for this double central zone enrichment in the second and more complex type of zoned pegmatite.

Very similar features in pegmatite dykes are recorded by Vogt, 1931, from a small area at Skjaenhlden, within the Iddefjord of South-eastern Norway.

The driving force of this secondary recrystallization (also called exaggerated grain growth and discontinuous grain growth) of the original aplite that has been suggested

Plate XII.

Second stage of recrystallization - melanocratic minerals migrate towards the core zone of the dyke followed by the "front" of recrystallization of the leucocratic minerals.

Plate XIII.

Final mature pegmatite vein of a melanocratic rich core and a coarsely crystalline leucocratic rich margin.





by Reitman, (*op. cit.*) is that the recrystallization causes a reduction in the total free energy of the system. This is brought about by the reduction of the area of grain boundary and the replacement of high energy boundaries, (sutured), by those of a lower energy, (more planar), Voll, 1960.

Greenstones:

In this thesis the term Greenstone is used, as it is commonly used in Rhodesian Geology, to denote a lithological group composed mainly of basic lavas, volcanic agglomerates, tuffs and ashes together with their sedimentary equivalents.

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PART III

THE GREENSTONE ROCKS OF THE "SHABANI SCHIST BELT"

### INTRODUCTION

The rocks that are included within this group occupy a north-south trending belt cropping out on all four of the 1:50,000 scale maps.

Although this group of rocks is composed of three distinct generations, (geological systems?), separated by unconformities, they **share** a common similarity in lithology, (sediments and basic extrusive rocks), and have in the past been collectively referred to as "Gold Belts", a misleading term that is not used **in** this description.

A general **succession** of the "Shabani Schist Belt" is:

Shabani	·	·x) Upper Sedimentary Group	900 metres
	·	-----	unconformity
Schist	·	·y) Middle Sedimentary and Volcanic Greenstones	1,500 metres
Belt	·	-----	unconformity
	·	·z) Lower Sedimentary and Volcanic Greenstones	4,500 metres
	·	-----	intrusive/tectonic contact.

The Basement **Gneisses**, Schists and Granites.

2- (A) The Lower Sedimentary and Volcanic Group

The outcrop of the Lower Sedimentary and Volcanic Group is confined to three localities: the south-west, (sheet 3), the south-east, (sheet 4), and the north, (sheet 2).

By far the most widespread occurrence of this **group** is in the south-western area, where it occupies a triangle some 180 square kilometres (approximately 70 square miles) in area, of badly exposed, low, undulating country, bounded by the Ngesi to the north, the Great Dyke to the west and the Belingwe-Hippo Pools road to the south.

24K-25 B

The maximum thickness of this **group**, measured between the Black William Mine and the Hippo Pools Hotel (sheet 3), is of the order of 9,000 to 10,000 metres. If one regards this figure as including much tectonic thickening and repetition, as is suggested by the outcrop patterns in the vicinity of the Mchingwe Fault, Belingwe Block, a more realistic estimate of thickness is about 4,300 to 4,800 metres, which includes 600 metres of intrusive ultrabasic rocks. The average strike of bedding is approximately north-south, becoming north-north-westerly in areas adjacent to the Mchingwe fault, the dip varying from vertical to 70 degrees east, and the rocks have nearly always been found to "young" eastwards. Occasionally, exposures are found where the rocks dip steeply to the west; this is caused by a slight overturning and not local isoclinal folding.

22H

The most notable occurrence of overturning is found in a river exposure of the Ngesi, opposite "Ngesi Antimony Claims", 200 metres north of the Belingwe road bridge where graded bedding, ripple marks and sedimentary flame structures (plate xxiv) provide unequivocal evidence of the easterly direction of "younging".

The general trend of the first cleavage is northwards, sub-parallel to the bedding, dipping either steeply westwards or having a vertical attitude.

The second cleavage, a fracture cleavage, has whenever visible, a north-westerly trend and a near vertical attitude.

The contact of the Lower Sedimentary and Volcanic Group with the underlying migmatites and gneisses is rarely to be found exposed and its position has, in most cases, been located and plotted by the use of such evidence as: soil colour change, (from a coarse red-brown on the sediments and volcanics to a fine white sand on the gneisses), general topographic change, (from an undulating landscape on the sediments and volcanics to an area of very low relief on the Basement Gneisses), and surface rock float.

20H

The best exposure of this zone is to the east of the Greystones Road, 200 metres to the north of its junction with the Shabani-Bulawayo Road.

As the section is traversed from east to west, two very notable changes occur:-

- (1) The frequency of occurrence of acid microgranite

intrusions sharply increases as the contact is approached, the width of this zone in which the intrusions occur is approximately (over a distance of) 20 metres, eastwards from the contact. The intrusions are usually about 1 metre in width and where furthest from the contact, (approximately 20 metres), are often in the form of vertical dykes, but they become less transgressive towards the contact, until they are perfectly conformable sills.

(2) The colour of the sedimentary greenstones darkens and they become recrystallized towards the granite. This recrystallization from a pale green, fine grained, sedimentary-looking rock, increases westwards towards the contact, the rock changing progressively to a dark green, coarsely crystalline, igneous-metamorphic rock, looking not unlike an intrusive amphibolite.

As the contact is approached, there is no apparent feldspathization of the rock, although during the earlier recrystallization small euhedral feldspar porphyroblasts developed, and are still preserved in the rocks that have only been subjected to the initial effects of metamorphism. This feature is thought to be due more to the "sweating out" of, rather than to the addition of, a feldspar component. The earlier cleavage "flows" around the feldspar porphyroblasts, suggesting that they have either a pre- or syn-deformational origin, Becke (1904), Rast (1965).



No exposure of the contact between the Lower Sedimentary and Volcanic Greenstones and the underlying Basement Gneisses has been located in the Shabani area.

As this junction is followed southwards from the north of sheet 3, onto the adjacent southern area (Belingwe, Worst 1956), the style of this contact suffers a marked change.

In the north this contact is straight and parallel (sub-parallel) to the basal horizons of the Lower Sedimentary and Volcanic Greenstones, suggesting an almost sedimentary junction.

Southwards, (the southern portion of sheet 3), the contact is straight, angular and changes direction sharply having no relation to structures in either the Basement Gneisses or the Lower Sedimentary and Volcanic Greenstones. The style of the contact in this area suggests a faulted junction between these two groups of rocks.

In the adjacent southern area, the basal horizons of the Lower Sedimentary and Volcanic Greenstones are repeatedly cut out by large rounded embayments of the "Gneissose Granite". (Worst 1956).

This southerly change in style of this junction is suggestive of an increasing tectonic level during the deformation of the Lower Sedimentary and Volcanic Greenstone Group.

A Description of the Lithological units.

25 (a) The Sedimentary Greenstone. The sedimentary greenstone

rocks of the Lower Sedimentary and Volcanic Greenstone Groups underlie the areas of lowest relief and are composed of a group of deeply weathered, fine grained well cleaved rocks that give rise to a reddish brown sandy soil. Although this group of rocks is variable in composition there is throughout this division a poor bedding visible and occasionally sedimentary structures such as; graded bedding, ripple marks and flame structures.

In thin section (slides 33 and 36) the sedimentary greenstones of the Lower Sedimentary and Volcanic Greenstone Groups prove to be a group of extremely fine grained rocks composed of detrital particles of recrystallised quartzitic material in a matrix of either calcium carbonate or iron oxide. In slide 36 a prominent (second) strain-slip cleavage is visible along which there has been the growth of iron stained chlorite. In slide 45, a bedded silt, small particles of pumice and occasional shards are visible which provides evidence of the volcanic origin of this group of sediments.

- zi (b) The Banded Ironstone. In the field the banded ironstones form very noticeable zones of higher relief and give rise to a widespread surface float of angular unclesaved ironstone blocks and a poor red stony soil.

In thin section the banded ironstones are seen to be composed of alternating bands of iron ore rich quartz grains

and bands of almost pure quartz. Because of the strong banding within this group of rocks and their apparent competency there are numerous small (0.001 metres throw) faults preserved within this lithology, both in the field and in thin section.

- zv (c) Volcanic Greenstones. In the field the volcanic greenstones have a more massive appearance than the sedimentary greenstones and a slightly darker brown colour, giving rise to a brown sandy soil and areas of greater relief. Throughout this rock type there is only the vaguest suggestion of layering other than where intercalated beds of sedimentary horizons are present and where pillow structures have formed (the western bank of the Ngesi River, opposite Ngesi Antimony Claims).

22 K

In thin section (slides 56 and 140a-g) this rock type is a fine grained, almost glassy, igneous rock of basic composition. In thin sections of pillow lavas (slides 140e, f, and g) a secondary calcification of the pillows is visible, the "front" of calcification migrating inwards to the centre of the pillow and although very deeply sutured has a sharp junction with lava that is uncalcified. In slides 140l and k, taken from the edge of the pillows, zones brecciation of calcified lava are identified.

- zq (d) Siliceous Greenstones. In the field the siliceous greenstones have a massive pale green colour, a poor

development of any cleavage and give rise to a pale brown soil. In thin section these rocks are a homogeneous sequence of fine grained siliceous silt or mud in a siliceous matrix.

The General Succession of the Lower Sedimentary and Volcanic Greenstone Group:

Middle Sedimentary and Volcanic Greenstone Group

Unconformity	-----		
	• sedimentary greenstone	• only	
	•	• exposed	
	• conglomerate	• on Belingwe	
	• ironstones and	• sheet,	2,500 m.
	• sedimentary greenstones	• B. G. Worst	
		• (1956)	
		•	
	zs sedimentary greenstone	260 - 10,000 m..	
Lower	zi banded ironstone	15 - 20 m..	
Sedimentary	zq siliceous greenstone	15 - 250 m..	4,500 m
and	zs sedimentary greenstone	0 - 2,500 m..	
Volcanic	zq siliceous greenstone	0 - 250 m..	
Group	zv volcanic greenstone	0 - 4,000 m..	
	zs sedimentary greenstone	0 - 1,000 m..	
	intrusive --- tectonic --- contact		
	basement gneisses and migmatites		

Also to be included in this generalized sequence, are from 0 - 1,200 metres of transgressive acid tuff and from 0 - 1,000 metres of conformable ultrabasic sills.

Approximately north of the Shabani-Bulawayo Road the whole of the Lower Sedimentary and Volcanic Greenstones are composed of sedimentary horizons, which as they are followed south, become interdigitated with beds of volcanic greenstones, siliceous greenstones and intrusive ultrabasic sills.

As each unit of volcanic greenstone and siliceous greenstone is traced southwards along its strike from the Shabani-Bulawayo Road it wedges out and reappears, its place being taken along the strike by the sedimentary greenstones. A good example of this is the siliceous greenstone, outcropping on the west bank of the Ngesi, to the south of the Shabani-Belingwe Road.

The most persistent horizon of the Lower Sedimentary and Volcanic Group is undoubtedly the banded ironstone, which, although it cannot be traced continuously along the strike, it is located intermittently (along the strike) for a distance of 64,000 metres. The banded ironstone is one of the better "marker horizons" of the Lower Sedimentary and Volcanic Group.

The form of ultrabasic intrusions also change southwards; from small irregular-shaped pods in the north, to larger elliptical bodies (whose longer axes are parallel to the cleavage) in the central area, and finally to persistent conformable sills in the south.

Bedding is rarely visible in the sedimentary greenstone horizons, but when it is observed, it is seen to be sub-

parallel to the dominant first cleavage.

On occasions exposures are found where sedimentary structures such as graded bedding, flame structures and ripple marks, display evidence for the undoubted sedimentary origin of these rocks. Such exposures are:-

- 191 (a) The eastern bank of the Ngesi River, south of the Bannockburn dam wall (sheet 3).
- 22J (b) The western bank of the Ngesi River, south of Mr. Todd's ranch house dam, 5,000 metres south of Dadaya Mission (sheet 3).
- 22K (c) The western bank of the Ngesi River, opposite the "Ngesi Antimony Claims", 130 metres north of the Shabani-Belingwe Road (sheet 3).

Within the areas that have suffered less disturbance due to faulting and thermal metamorphism, small (0 - 15 metres) lenticular bodies, of such rock types as sedimentary sands and "packstone" (Dunham, 1962) conglomerates, may be found. The longer axes of the lenticles are aligned parallel to the strike. A very good example of a sedimentary conglomerate is also exposed to the west of the building in the irrigation area of Kromdraai Ranch, on the western bank of the Ngesi, west of Dadaya Mission (sheet 3).

201

Within the sedimentary group, there are many occurrences of small, irregularly distributed, lenticular masses of volcanic lavas; these are too impersistent to be represented on the 1:50,000 map.

Accretionary Volcanic Lapilli (Chalazoidites).

Within the uppermost horizons of the "Lower Sedimentary and Volcanic Greenstones Group" are found structures that are considered to be accretionary volcanic lapilli. These structures are ellipsoidal particles, the axes measuring 0. 013 metres, 0. 008 metres, 0. 006 metres, the shortest axis being orientated normal to the cleavage, whilst the longest plunges at 70-75 degrees northwards within the plane of the cleavage.

The lapilli are found within a rock that is a tuffaceous sub-aqueous deposit. The best exposure of the accretionary volcanic lapilli is 180 metres north of the Belingwe-Shabani road along the west bank of the Ngesi River, opposite and a little higher upstream than the "Ngesi Antimony" claims.

22K

The rock in the field appears as a dark green-grey massive siltstone, showing only faintly developed cleavage and bedding, the latter visible as a colour banding. Within this homogeneous siltstones may be seen elliptically-shaped paler and finer grained masses, occasionally containing a darker nucleus.

The distribution of the lapilli is not widespread, The above example being the only exposure of this feature within the Lower Sedimentary and Volcanic Greenstones, although it is suspected that similar features are found in the overlying Middle Sedimentary and Volcanic Green-

Plate XIV.

Accretionary volcanic lapilli in a shallow, sub-aqueous deposit of volcanic tuff.

Plate XV.

Photomicrograph of accretionary volcanic lapilli, x 8. Note the concentric banding within each lapillus and the minor plane of unconformity through the slide.





**Group**  
stone **A.** in the north of the "Schist Belt".

The distribution within the exposure is also rather confined, the lapilli occurring along one horizon, none below this and rapidly becoming fewer as distance above this horizon increases. The appearance that is given is that of a graded bed, yet the matrix shows no such grading.

On first examination the lapilli were thought to be similar to the oxidation-reduction spots of the eyed slates of Llanberys (North Wales), but when seen in thin section there can be no doubt as to their origin.

In thin section the lapilli are seen to consist of three distinct zones: a core or nucleus, an intermediate zone and a shell. The nucleus is composed of a very fine-grained, devitrified volcanic glass, extending for perhaps one eighth of the diameter.

Surrounding this is the intermediate zone which is composed of a coarser material, the components of which are: shard-like particles, small anhedral crystals of feldspar, and dusty devitrified volcanic glass. The shard-like elongate particles that are found in this zone are all aligned parallel to the concentric banding.

The final zone is composed of very fine grained dust, the composition of which is indeterminable, becoming finer grained as the edge of the lapilli is approached. This material constitutes the shell.

The lapilli are contained in a matrix that is identical

to that composing the intermediate zone, the elongate shards being aligned parallel to the bedding surface.

The lapilli have only a very small variation in their size.

The rock in which these accretionary volcanic lapilli have been found is a sub-aqueous deposit of a poorly consolidated volcanic tuff; only a short distance away (3 metres along the strike), bottom structures and sedimentary slumping have been recorded.

The rocks in which the lapilli are found and those rocks of adjacent exposures are all derivatives of volcanic eruptions.

The lapilli that have been found in either exposure or thin section have usually been whole and unbroken, showing no sign of corrosion.

The ellipsoidal shape of the accretionary volcanic lapilli is a result of post-depositional deformation rather than a primary feature of these structures.

The first account of accretionary volcanic lapilli appears to be contained in the description of the Volcanic District of Naples by Scrope, (1829), but a much more extensive discussion of these structures and a review of the literature on accretionary volcanic lapilli has been given by Moore and Peck (1962).

Accretionary volcanic lapilli have been recorded in

at least ten observations of historic volcanic eruptions, all authors ascribing the production of these lapilli to one of four accretionary processes:

(1) Absorption of fresh ash by the water of a fallen raindrop during a light rain (Scrope, 1829, p. 346; Lacroix, 1904, p. 420).

(2) Accretion on the ground of fresh ash around a nucleus blown by the wind or rolling down a slope (Stearns, 1925, p. 202).

(3) Accretion of moist ash in an eruptive cloud to form "mud pellet rains" Perret, 1924, p. 48; Stearns, 1925, p. 202).

Another possible mode of formation that has not been observed in "the field", is suggested by Moore and Peck, and is:

(4) The lapilli formed in water by the gentle agitation of a nucleus in contact with unconsolidated volcanic ash.

When the observations of the lapilli are considered it is obvious that the majority of the suggestions are untenable in this particular case.

If the lapilli were formed by wind or gravity causing ash to adhere to the surface of a rolling nucleus, then a phase of transport at some time in their history is necessary, in order to deposit them in the sub-aqueous environment in which they are now found. If this were so, then it would be expected that broken, or at least corroded, lapilli would be found. This is not the case.

Moore and Peck consider the lack of a spiral banding precludes formation by a rolling mechanism; the lack of this feature is not thought to be significant.

The absorption of fresh ash by the water of a fallen raindrop again fails to explain the banding within the lapilli, also some of the lapilli would be expected to show signs of fragmentation caused by their transportation.

The mechanism of rolling of a nucleus in water, as is stated by Moore and Peck has never been observed happening. In the Shabani area it is not thought to be a plausible mechanism, since it still leaves the problem of grading unexplained.

In the case being considered, the third suggestion, of the agglutination of moist ash in an eruptive volcanic cloud, would satisfactorily explain the observations.

Moore and Peck consider that the conditions of formation of accretionary volcanic lapilli are:

"Clouds of ash rich in water vapour form during volcanism, mostly during phreatic eruptions of basaltic ash (such as that at Vesuvius in 1906, Taal in 1911, and Kilauea in 1790 and 1924) or during Pelean eruptions of rhyolitic and andesitic ash (such as Pelee and Santa Maria in 1902). As the eruptive cloud rises to great heights, cooling causes condensation of moisture derived from the vent and perhaps also from air flowing in from the surrounding regions. The condensed moisture causes rapid agglutination of ash

in the cloud, forming cores of accretionary lapilli. The rapidity of the phase of the formation is indicated by the coarse and relatively unsorted nature of ash in the cores and the lack of concentric structure and tangential mineral orientation.

As each embryonic lapillus falls through the eruptive cloud, an outer shell is built up by ash sticking to the moistened surface of the lapillus. Platy and linear shards and microlites adhere along their largest surface to the outer surfaces of growing lapilli, resulting in a tangential arrangement of their long axes. Typically the ash in the shell decreases outward in grain size, and the shell is composed of thin layers, most of which also grade outwards from coarse to fine grained. The outward decrease in grain size of the shell possibly is caused by progressive increase of temperature in lower parts of the cloud. Higher temperatures reduce relative humidity and bring about a progressive decrease in the amount of moisture that condenses on the surface of the falling lapilli; as a result, progressively slower and more selective accretion of finer and finer ash takes place as the lapilli fall into lower portions of the cloud, even though the average grain size of ash in the lower part of the cloud may well become progressively coarser."

The only reservation in the acceptance of this hypothesis completely, is that the lapilli have apparently withstood,

both impact with the surface of the water, and a period of immersion in that water without disintegration. It is not inconceivable that the rate of sedimentation under such conditions of a phreatic eruption must have been great and burial rapid. Further evidence is gained from the descriptions of falling lapilli as "... brown, dry, compact pisolites ..." Stearns<sup>n</sup>, (1925, P. 202) such particles could perhaps survive impact with, and immersion in, water.

The point of greatest interest is perhaps the age of these features. Previous to this encounter of lapilli in Pre-Cambrian rocks, the oldest deposit that has been described is of Ordovician age.

v - (B) The Middle Sedimentary and Volcanic Greenstone Group

Resting unconformably on the folded Lower Sedimentary and Volcanic Greenstones is a group of volcanic lavas, tuffs and sediments that have been designated the "Middle Sedimentary and Volcanic Greenstone Group".

Keop, 1929, an earlier worker in this area, called this group of rocks the "Basement Schists, (Archean)", which is perhaps the most reliable age-name that may be applied to this group, but is not used in this thesis to denote this group of rocks. Later workers in this area, (Laubscher 1960, Catheral 1962), would seem to have followed the lead that had been offered by Worst, 1956, who, whilst mapping the continuation of these rocks along the strike, applied the name "Bulawayan" to them.

This Bulawayan age that has been given by Worst is based apparently on the similar position of these rocks in the general sequence, and on the similarity of their lithology, to those rocks defined by Macgregor 1947, as true Bulawayan.

The lower contact of the Middle Sedimentary and Volcanic Greenstone Group with the underlying basement gneisses and migmatites was first found to be exposed and described by Laubscher 1959 as unconformable. The locality of this exposure that has been described is 6,000 to 8,000 metres to the south of Shabani, in a river section along the eastern contact of the Middle Sedimentary and Volcanic



23T Greenstone Group and the Basement Gneisses.

At this locality Dr. Laubscher describes a basal conglomerate, containing well rounded pebbles of the basement gneiss, and passing upwards into the lower horizons of the Bulawayan (Middle Sedimentary and Volcanic Greenstone Group).

A description of the lithological units.

vi (a) The Banded Ironstones.

The banded ironstones are probably the most obvious and persistent rocks that are to be found within the Middle Sedimentary and Volcanic Greenstone Group, and are perhaps, the most reliable marker horizons.

The ironstones form very noticeable zones of high relief, surpassed in this only by the quartz reefs that are contained within fault planes.

The thickest banded ironstone that has been mapped, (30 metres in width), is the lowest horizon of the Middle Sedimentary and Volcanic Greenstone Group on the eastern limb of the synclinal "Schist Belt", near Shabani, which causes the eastern boundary of the "Schist Belt" to be marked by a ridge that rises 180 - 200 metres above the peneplane of gneisses, and causes both the Shabani-Bannockburn railway line and the Shabani-Bulawayo Road to make sharp bends as they pass over this band of ironstone.

210

Some of the most accessible exposures of this horizon

are to be found 90 metres to the southwest of what was  
210 Moorcrofts Butchery, near the Sabi River along the Bulawayo  
road, and 1,500 metres westwards along the railway line to  
210 Bannockburn from Shabani station. In these localities the  
banded ironstone may be seen to be composed of alternating  
bands of iron ore and quartzite, approximately 0.01 metres  
in width, the banded ironstone dipping steeply to the west  
at approximately 80 degrees.

The steep north-south trending schistosity that is  
typical of the "Schist Belt" rocks is not at all well  
developed in the ironstones, represented only as a widely  
spaced fracturing.

In thin section, the ironstone is seen to be composed  
of alternating bands of amorphous iron ore grains, magnetite  
and haematite, and almost iron-free bands of quartz grains  
of a sand-silt grade.

The contacts between the bands is sharp, no grading  
being visible. The quartz crystals show very good textural  
equilibrium as described by Voll, (1960). The bands of iron-  
ore show no internal structures, apart from a coarse banding,  
and there is no evidence to suggest that it is of organic  
origin. It is assumed that the iron-ore bands are the  
result of chemical deposition.

yi (b) Banded Ironstone Breccia.

This rock is composed of 70 per cent of poorly sorted and rounded ironstone fragments that have an approximate average dimension of 0.015 metres. The rock is a "wackstone" of the North American carbonate sedimentologists.

In thin section the ironstone fragments are identical in composition to the massive ironstones below, the matrix of this rock being composed of pure quartz crystal grains. This rock is thought to have originated by the slumping of the poorly consolidated underlying ironstones just after their deposition.

There is an apparent increase in the amount of limonite in this rock, especially around the borders of the ironstone fragments, which may indicate a slight chemical weathering of the fragments prior to their reconsolidation.

yp (c) The Sedimentary Silts and Grits.

Occasionally, within the sedimentary greenstones there are exposures of silt and grit horizons that contain very good examples of sedimentary structures which provide the best "younging" evidence to be found within the "Schist Belt" rocks.

The exposures of these rocks are usually concealed by surface "float" of the adjacent ironstones, but a good example of the grit may be seen in the exposure that has already been cited in connection with the banded ironstone, south-west of what was Moorcroft's Butchery, Shabani, and the

silts are well exposed 8,000 metres due east of Dadaya  
20P+ Siding, next to an unmarked and disused mine working. This  
last exposure is best approached by motor vehicle along a  
track that begins opposite Moorerofts Butchery, and the  
journey should only be attempted during the dry season.

The *grits* are a conformable deposit of coarse angular  
quartzitic material which is very persistent in the south-  
central area, grading into silts only as they pass north-  
wards.

In thin section, the grits may be seen to be composed  
of well rounded grains of single crystals or multiple crystals  
of strain shadowed quartz, these grains composing 65-70 per  
cent of the total rock. The size of these grains is from  
0.002 to 0.005 metres, the matrix being composed of very  
fine quartz crystals that show very good textural equilibrium  
(Voll, 1960, pp. 536). The size of these crystals is of the  
order of 0.0003 metres, completely equidimensional and  
displaying no preferred shape fabric orientation.

The quartz crystals of the matrix adjacent to some of  
the large crystal grains become much smaller in size as the  
crystal grain is approached. No explanation of this feature  
is offered.

Occasionally the large grains may be seen to be  
replacing the groundmass crystals.

#### ys (d) The Sedimentary Greenstones

The sedimentary greenstones in the field appear as pale

Plate XVI.

Volcanic agglomerate from the Middle Sedimentary and  
Volcanic Greenstone Group.



Plate XVII.

Sedimentary conglomerate from the Middle Sedimentary and  
Volcanic Greenstone Group.



green, well cleaved rocks in which bedding surfaces are occasionally visible; they tend to show little resistance to erosion and form areas of low relief and poor exposure. The soil derived from this rock-type is characteristically of a dull red-brown colour and sandy texture, containing a large percentage of well rounded, dusty green, sedimentary greenstone "float". The vegetation supported on these areas tends towards a sparsely wooded grassland, becoming heavily wooded only where left permanently ungrazed.

Although this whole unit has been classified as a sedimentary rock, small amounts of rocks of an undoubted non-sedimentary nature are often present, i.e. lavas, nor are sedimentary rocks confined to this unit. This grouping is essentially a field classification based on the predominantly sedimentary nature of this formation as opposed to the predominantly volcanic nature of the overlying volcanic greenstones.

Rocks that occur within this unit are:

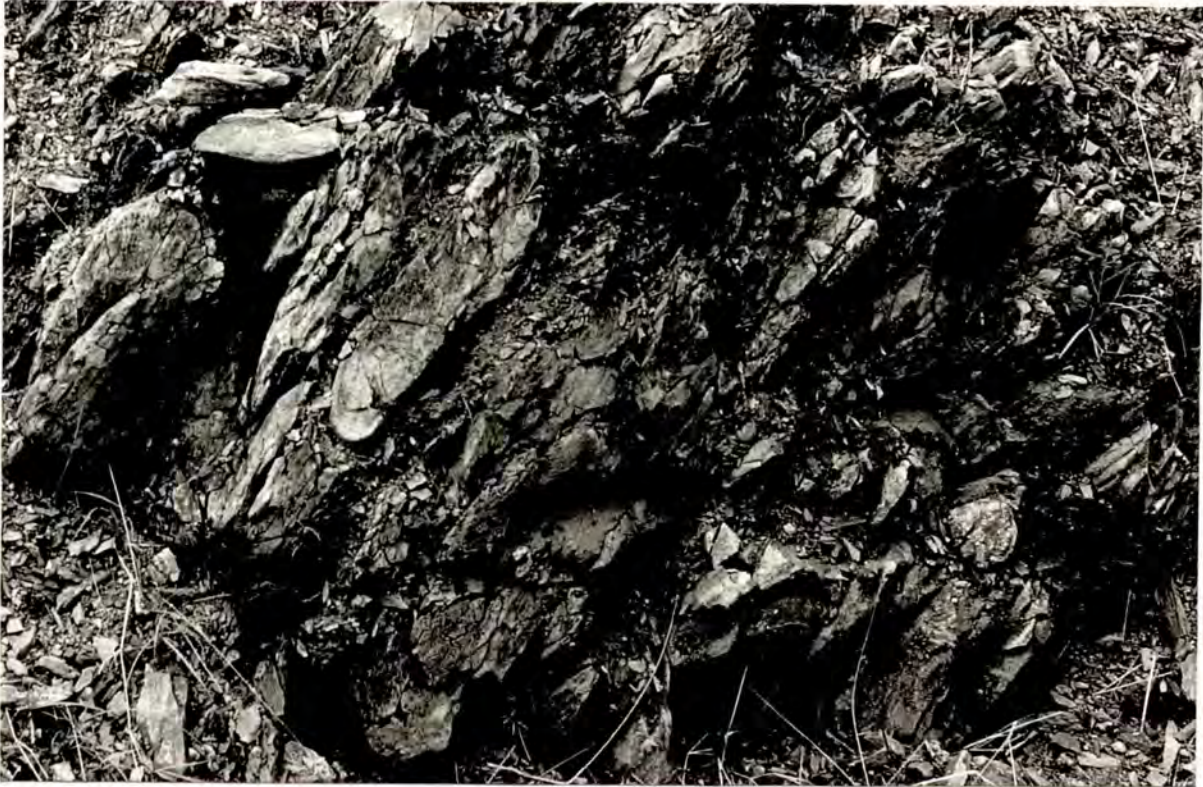
(1). Slates. These are highly cleaved argillaceous rocks, containing a fine, persistent colour banding, and on occasion displaying well developed graded bedding. The best exposure of this type of rock is to be found 180 metres to the east of Nangakwe Dip (sheet 2).

(2). Tuffs and Ashes. These are fine grained hard rocks having a well developed cleavage and fracture pattern, the latter feature is often suspected of having originated as

Plate XVIII.

Volcanic ash of the Middle Sedimentary and Volcanic  
Greenstone Group.





fragments of pumice, devitrified quartz-feldspar glass and large, corroded feldspar crystals around which shards have been deformed. Most of the features that have been described by Rast, 1962, have been seen in thin sections of these rocks.

4P In the north of the area, 400 metres south-east of Nangakwe Dip (sheet 2), a river section shows a rock containing ellipsoidal fragments. This rock may be traced intermittently around the whole of the northern "Schist Belt" closure. The ellipsoids are apparent as a colour variation in the rock rather than as a variation in lithology and all have an identical orientation of their longest axes. In thin section, this rock is obviously of a fragmental character, and no difference is visible in the composition of the groundmass and the composition of the ellipsoidal fragments other than a slight decrease in the content of hornblende within the fragments. It is suggested that these fragments are accretionary volcanic lapilli (Moore and Peck, 1962), that have been deformed during the main synclinal compression.

#### v v (c). The Volcanic Greenstones.

In the field the rocks of the volcanic series are a dark olive-green colour, are resistant to erosion, and lack any trace of bedding; they are poorly cleaved, highly fractured and on the whole are a monotonous sequence of rocks.

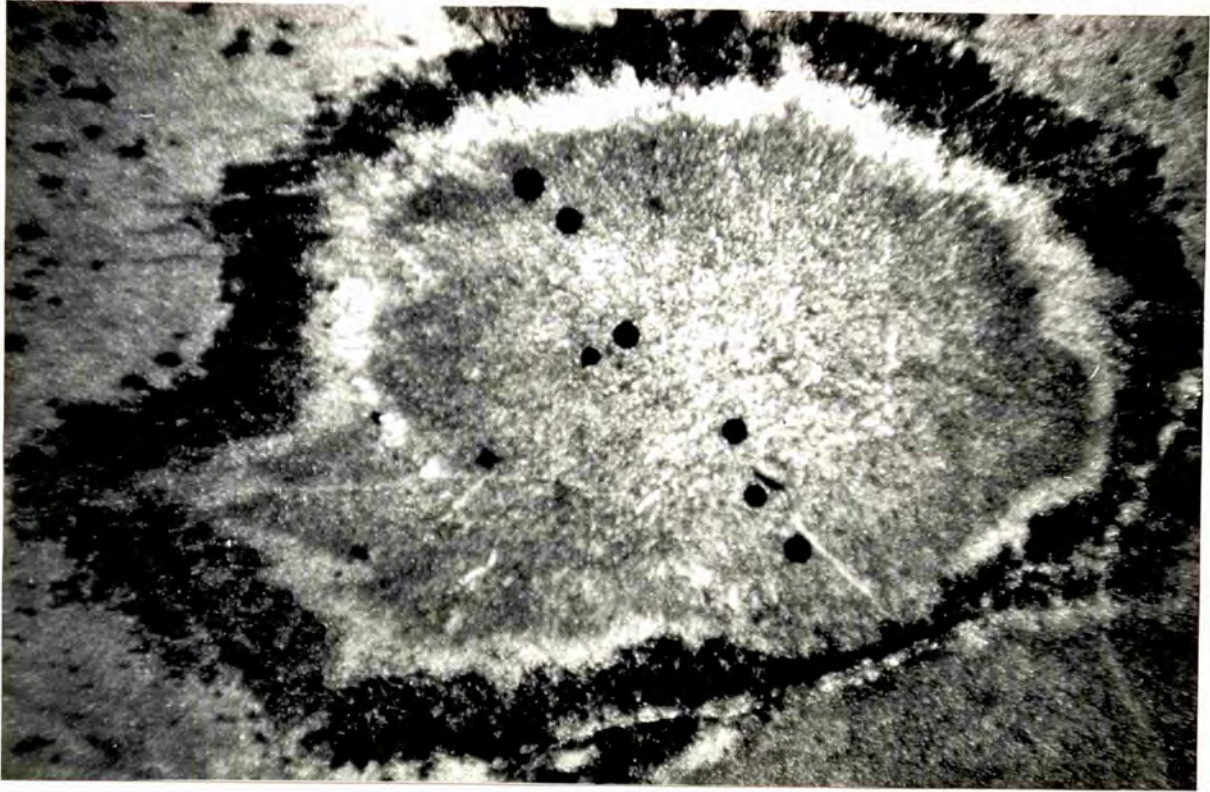
Excellent exposures of such features as: pillow lavas,

Plate XIX.

Photomicrograph of an amygdale in lava of the Middle Sedimentary and Volcanic Greenstone Group, x 20.

Plate XX.

Photomicrograph of shards in a volcanic tuff of the Middle Sedimentary and Volcanic Greenstone Group, x 20.



11,000 metres west of Kings Rest (sheet 4); vesicular pillow lavas in which the vesicles increase in size and frequency towards the edge of the pillow, a railway cutting 25R 8,500 metres north of Zoederbergs Siding (sheet 4); and exposures of lavas containing pipe-amygdales of zeolites, 12,000 metres west-south-west of Kings Rest (sheet 4), have provided "way up" evidence in this series.

In one exposure, opposite Ngesi Antimony Claims (sheet 22K 3), a partial calcification of pillow lavas is visible, the calcification decreasing in intensity towards the centre of the pillow.

The areas of the volcanic greenstones are usually ones of high relief, 120 - 150 metres, especially when contrasted with the underlying sedimentary greenstones, and which tend to weather into angular blocky float, giving rise to a dark brown rocky soil supporting a dense thorny scrub vegetation.

In thin section the volcanic greenstones are characterized by a high degree of alteration. A typical lava in thin section is composed of 20 per cent of lath-like feldspar network that includes 20 per cent of euhedral pyroxenes, augites and small epidotes, 30 per cent chlorite and 10 per cent of calcite. 20 per cent of the mineral assemblage is too small to be resolved under the microscope.

The large laths of feldspar have recrystallized into smaller, clearer feldspars less rich in lime, and have undergone a partial alteration to the clay minerals, still

Plate XXI.

Pillow structures in lava of the Middle Sedimentary  
and Volcanic Greenstone Group.

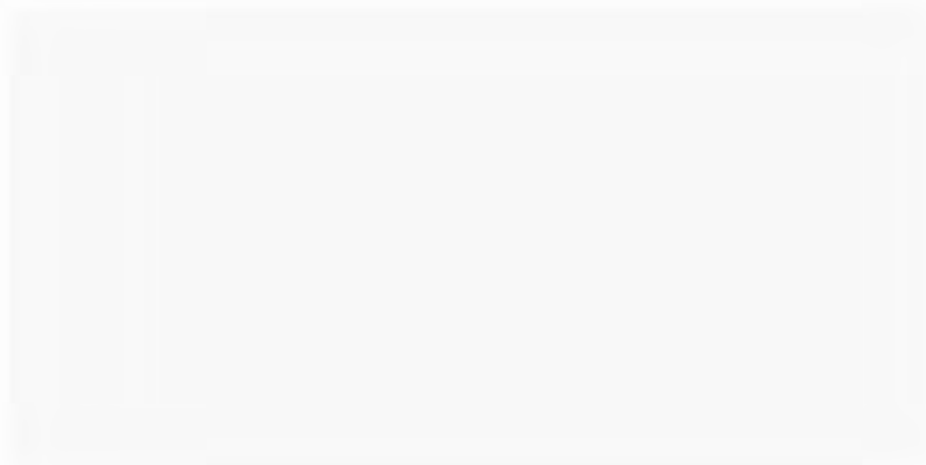


Plate XXI.

Detail of the margins of the pillows from Plate XXI.  
Note the vesicular borders to the pillows.



maintaining their original outlines, and some of the original feldspar has been replaced by calcite.

The pyroxene has altered to amphibole and chlorite, much more of the chlorite is suspected of replacing original micaceous minerals.

The calcite has obviously been a late stage replacement mineral, forming discrete irregular masses, overprinting feldspars and adjacent pyroxenes.

A more ultrabasic lava (slide 207), is composed of serpentized olivine phenocrysts, separated by iron ore (magnetite), late calcite and chlorite. There appears to have been an original pyroxene, iron ore grains having been <sup>S</sup>olved onto the cleavage traces within pyroxene pseudomorphs, the pyroxene having been serpentized.

#### 79 (f). The Siliceous Greenstones.

Rocks of the siliceous greenstone group are a very pale green, fine-grained, homogeneous **deposit** having no trace of bedding and only a very poor development of a widely spaced, coarse cleavage. These rocks give rise to areas of very high relief (180 to 200 metres), and weather to a thin pale brown soil which supports a dense **thorn-scrub** vegetation.

Although no bedding or sedimentary structures **can** be seen within this rock type, the fine grain size<sup>f</sup> (silt) homogeneity, siliceous character and conformable orientation and intercalation with adjacent deposits suggest that the



siliceous greenstone is of a sedimentary origin.

In thin section the siliceous greenstone is found to be composed of 30 per cent quartz, 20 per cent calcite, 20 per cent chlorite, 10 per cent feldspar, 10 per cent epidote and 10 per cent iron ore and other minerals.

The siliceous greenstone is a fine grained metamorphosed rock of sedimentary origin, composed of 20 per cent of quartz-feldspar angular fragments, 0.002 to 0.004 metres in size, contained in a matrix of quartz, calcite, epidote, chlorite and magnetite. The crystals of quartz are found as small anhedral crystals within the groundmass, as replacement of, and intergrown with the large feldspar crystals, and as large clear anhedral crystals in association with the large feldspars.

The calcite is usually in the form of small crystals that are grouped together around the borders of the feldspars which are undergoing breakdown, and often in association with epidotes.

In slide 26a there is one occurrence of a subhedral, 0.0005 metres, tourmaline, probably schlorite.

It is suggested that this rock at the time of deposition was a fine grained quartz-feldspar silt, rich in carbonate, probably of a tuffaceous origin.

Banded ironstone occurs towards the bottom of the lowest member of the three siliceous greenstones that are found along the western limb of the southern "Schist Belt", also suggesting a sedimentary character for the sequence.

A Generalised Succession of the Middle Sedimentary  
and Volcanic Greenstones in the south of the area

	<b>yp</b>	phyllite	0- 30 metres :	
	<b>yc-g</b>	conglomerate-grit	0- 30 metres :	
Middle Sed.	<b>yCc</b>	calc-silicate rocks	0- 30 metres :	
	<b>yq</b>	siliceous greenstone	0-3,000 metres :	6,000 metres
Volc.	<b>yv</b>	volcanic greenstone	0-3,000 metres :	
Group	<b>ys</b>	sedimentary greenstone	1,600-3,000 metres :	
	<b>yc</b>	conglomerates	0- 30 metres :	
	<b>yi</b>	banded ironstone	0- 45 metres :	
-----			Unconformity	

Lower Sedimentary and  
Volcanic **Group** and Basement  
Gneisses and Migmatites

A generalized Succession of the Middle Sedimentary  
and Volcanic Greenstones in the north of the area

	<b>ys</b>	sedimentary greenstone	0- 600 metres :	
	<b>yCc</b>	talc schist	300 metres :	
	<b>yv</b>	volcanic greenstone	300- 600 metres :	1,500
	<b>yBh</b>	amphibolite	15 metres :	metres
	<b>ys</b>	sedimentary greenstone	1,500 metres :	
-----			Unconformity	

Lower Sedimentary and  
Volcanic **Group** and Basement  
Gneisses and Migmatites

The **Succession** of the Middle Sedimentary and Volcanic Greenstone **Group**.

The rocks of the Middle Sedimentary and Volcanic Greenstone **Group** occupy a north-south trending belt exposed on all four of the 1:50,000 sheets, the width of this belt increasing from 3,500 metres in the north, (sheets 1 and 2), to 15,000 metres in the south, (sheets 3 and 4).

As the lower junction of the Middle Sedimentary and Volcanic Greenstone **Group** is examined, the basal beds are seen to overstep from the Lower Sedimentary and Volcanic Greenstones onto members of the Basement Gneisses. The unconformable nature of this contact was first demonstrated by Dr. D. Laubscher (*op. cit.*), and during the present mapping a further exposure of this unconformity has been found in the eastern face of a railway cutting, 150 metres to the north of the New Dadaya Mission railway crossing, along the Shabani-Bulawayo road, (sheet 3).

20 J

At this locality the unconformity is one showing "buried topography", and is marked by a zone of calcification of the Lower Sedimentary and Volcanic Greenstones, approximately 1 metre in width below the plane of unconformity. The appearance of this exposure is similar to that of "Huttons Unconformity", north of Loch Ranza, Arran.

The origin of this calcified zone is thought to be similar to that of the Cornstones of the Old Red Sandstone deposits of Britain, (McCullough 1869, Allen 1960,

Burgess 1961).

In this locality the underlying Lower Sedimentary and Volcanic Greenstones can be **seen** to have suffered folding about north-east, south-west trending axes, and denudation before the deposition of the Middle Sedimentary and Volcanic Greenstone Group.

As this western unconformable contact is traced southwards, its exact position becomes uncertain due to the appearance of an ultrabasic sill of Lower Sedimentary and Volcanic Greenstone age (Sebakwian?), in the vicinity of this junction. The mode of weathering and slight transgressive nature of this sill, within the upper horizons of the Lower Sedimentary and Volcanic Greenstone Group, allows no further exposure of this unconformity.

In only one other locality does the Middle Sedimentary and Volcanic Greenstone Group rest unconformably on the Lower Sedimentary and Volcanic Greenstones, and this is in the far north of the synclinal schist-belt, in the vicinity of Chamini School, (sheet 2).

In this locality the unconformity never crops out, but the junction between these two groups of rocks is marked by the appearance of a zone of talc schists, some 6 to 10 metres in width, which occasionally has a nodular character. This talc-schist zone is again suspected of having an origin similar to that of the fossil calcareous soils that have already been described.

The rocks of the Middle Sedimentary and Volcanic Greenstone Groups occupy a north-south trending belt, exposed on all four of the 1:50,000 sheets, whose structure may easily be demonstrated to be that of a simple synformal trough. The width of this north-south trending belt increases from 3,500 metres in the north (sheets 1 and 2) to approximately 15,000 metres in the south (sheets 3 and 4). Since the strike of the rocks within this belt is parallel to the trend of the belt, and their dip remains constant, the widening of the belt is a reflection of an increase in the thickness of the deposits. The thickness of the Middle Sedimentary and Volcanic Greenstone Group increases from 1,500 metres in the north to some 6,000 metres in the south.

The increase in the thickness of these deposits is due both to an increase in the number of formations within the sequence and an increase in the thickness of each individual formation southwards.

Although the rocks of the Middle Sedimentary and Volcanic Greenstone Group have been subdivided into several distinct formations, there exist great variations of lithological composition along the strike within any one formation, together with a considerable variation of lithological composition between similar formations occurring at different stratigraphic levels.

The earliest formation that is found within the "Schist Belt" of the Middle Sedimentary and Volcanic Greenstones is

20P

a thick (45 metres), homogeneous and persistent horizon of banded ironstone, occurring several thousand metres to the west and south of Shabani, (sheet 4).

The ironstones, because of their strong banding, show numerous small folds very clearly and frequently. These folds have steep axial planes whose axes are either horizontal or have a gentle southerly plunge, although a compass orientation of these structures is difficult to determine due to the strongly magnetic character of these rocks.

The style of folding within the ironstones is dominantly **parallel** (more so in the quartzitic bands than in the iron ore rich bands), and fractures are often developed along one of the fold limbs, similar to De Sitter's conception of the origin of thrust faulting, (De Sitter 1959, p. 241).

Since stream sections through this basal banded ironstone rarely show any exposure of banded ironstone it seems likely that the stream courses are determined by gaps in the ironstones due to fault displacements.

Occurring immediately above this basal banded ironstone is a group of basal banded ironstone breccia, having the form of irregularly spaced lens-shaped masses, some 20 to 30 metres in length, their longer axes lying parallel to the strike of the bedding of the adjacent banded ironstone. The angular fragments of this deposit are often distributed in such a way as to suggest the presence of disharmonic folds whose sense of movement is most commonly towards the

west, i.e. down dip. The presence of these folds, the stratigraphic position of this deposit, together with the occurrence of a chemical weathering around the edges of the fragments, suggest that the banded ironstone breccia have originated by the slumping of the still unconsolidated upper surface of the basal banded ironstone.

Resting directly upon the lowest banded ironstone group in this locality is a deposit of poorly sorted grit, composed of subangular siliceous particles contained within a sandy matrix. As these three lowest sedimentary horizons are followed north-wards they suffer a slight reduction in thickness before terminating against an intrusion of "Younger Granite", 7,500 metres to the north-west of Shabani, sheet 3, their place being occupied along the strike by sedimentary greenstones.

18 N

24 K

Along the southern portion of the western limb of the "Schist Belt" syncline, 5,000 metres south of New Dadaya Mission (sheet 4) the basal horizons of the Middle Sedimentary and Volcanic Greenstone Group consist of a thick (300 metres), grit containing a thin (20 metres) bed of banded ironstone that is not continuous along the strike.

23 T

The next member of the sequence, only found exposed along this south-eastern limb of the Middle Sedimentary and Volcanic Greenstone syncline, 8,000 metres to the south-south-east of Shabani in the vicinity of the "Sheffield Claims", (sheet 4), is a conformable horizon of basic igneous

rock.

This basic igneous rock has in the past been mapped as having the form of a sill, (Laubscher, 1960), apparently upon the basis of its general lithological similarity to the basic intrusion of Shabanie Mine. After the present and more extensive mapping, this igneous rock is found to have a conformable sheet-like form that gradually "wedges out" northwards where the upper surface of this sheet has a much more weathered appearance. This evidence, together with the occurrence of pillow lavas suggest that this igneous rock has the form of a basic lava flow.

Overlying the basic lava of the "Sheffield Claims" and over-stepping it northwards onto the grit, is the first occurrence of the variable sedimentary greenstones whose average thickness is of the order of 2,000 metres.

After overstepping the lower sequence of the Middle Sedimentary and Volcanic Greenstone Group already described, the sedimentary greenstones rest directly upon the rocks of the "Basement Gneisses". No exposure of this contact has been found in the north-western area, but since the junction between the Middle Sedimentary and Volcanic Greenstone Group and the "Basement Gneisses" has already been demonstrated to be an unconformity in the south-east, it seems reasonable to assume a similar relationship between these two groups in the northern area.

Any exposures of the junction where the sedimentary



greenstones first come into contact with the "Basement Gneisses" are obscured by the intrusion of the "Younger Granite". This is unique in the Shabani area as it is only at this locality that the "Younger Granite" actually cuts across the lower junction of the Middle Sedimentary and Volcanic Greenstone **Group**. A more detailed map of this feature, (1:20,000), is presented in the M.Sc. thesis of Mr. D. Catharal, 1961.

Along the western limb of the Middle Sedimentary and Volcanic Greenstone **Group** syncline the stratigraphical equivalent sedimentary greenstones overstep from the Lower Sedimentary and Volcanic Greenstones onto the Basement Gneisses, approximately 5,000 metres to the north-east of Bannockburn (sheet 1). At this locality there is a slight increase in the metamorphic grade within the sedimentary greenstones, (from chlorite to amphibole), over a distance of 25-30 metres, this increase in metamorphism is attributed to the thermal effect of the "Younger Granite" which has been interpolated to be in close vertical proximity.

Along the south-western limb of the Middle Sedimentary and Volcanic Greenstone **Group** syncline the lowest formation of sedimentary greenstone is much thinner, (800 metres), and contains within its uppermost horizons a narrow, (20 metres), discontinuous bed of banded ironstone, 1,000 metres to the south-west of the Lundi Bridge along the Shabani-Bellingwe Road, (sheet 4).

Also in the above locality there is a very persistent horizon of ultrabasic lava, 30 metres in thickness, containing good examples of pillow structures. The stratigraphic position of this lava suggests some correlation with the less basic extrusion of the "Sheffield Claims".

The lowest formation of sedimentary greenstones are one of the most persistent lithological units encountered in the Shabani area, forming the basal formation of the Middle Sedimentary and Volcanic Greenstone **Group** around the whole of the northern closure of the "Schist Belt".

Overlying this very persistent group of sedimentary greenstones is the lower volcanic greenstone formation. The thickness of this formation varies from 0 to 300 metres, and its composition includes beds of pillow lavas, massive lava flows and amygdaloidal and vesicular lavas, together with agglomerates and the ill-defined coarse debris of volcanic deposition. The shape and attitude of the pillow lavas and vesicles have provided excellent "way up" evidence throughout this group of rocks.

The lower volcanic greenstone is the most persistent volcanic greenstone formation in the Middle Sedimentary and Volcanic Greenstone **Group**, and may be traced along either limb of the syncline northwards from the Solukwo-Shabani Road, (sheets 1 and 2), as far as the northern closure. The thickness of the lower volcanic greenstones around the northern closure of the "Schist Belt" is of the order of

300 to 600 metres, an apparently thicker sequence is found in the southern portion of this northern area, (1,000 metres, 3,000 metres to the north-east of Mberashaba trigometrical station, sheet 1), but this is due to the structural repetition of the volcanic greenstones in the core of the major syncline.

As the "Schist Belt" syncline is traced northwards, (sheet 1 and 2), higher structural levels are encountered; the volcanic greenstones occupying the core (3,000 metres to the north-east of Mberashaba trigometrical station) give way to the overlying middle sedimentary greenstones, the volcanic greenstones continuing along both the eastern and western limbs of the syncline towards the northern closure. Around this northern closure the same stratigraphic level along the strike as the lower volcanic series is occupied by a group of calc-silicate rocks, the junction along the strike between these two groups of rocks although badly exposed, is apparently gradational.

To the south of the Selukwe-Shabani Road, the lower volcanic greenstones are far less persistent, especially along the south-western limb of the syncline where the same stratigraphical level as the lower volcanic greenstones is occupied by lenticular shaped masses of siliceous and sedimentary greenstone, i.e. in the vicinity of the Shabani-Belingwe Road Bridge over the Ngesi River, (sheet 3). The lower volcanic greenstones reappear 6,500 metres to the east

25 M of the Black William Mine, (sheet 3).

Conformably overlying the lower volcanic greenstones is the middle sedimentary greenstone formation, almost identical in lithology and appearance to the rocks of the lower sedimentary formation. During the initial period of mapping the middle and lower sedimentary greenstones were thought to be the same horizon, their repetition being structurally controlled. After the location of many examples of "younging" and "facing" evidence during the second period of more regional mapping, the hypothesis of structural repetition became clearly untenable, and the rocks of the middle sedimentary greenstones must be considered as a separate horizon from those of the lower sedimentary greenstones.

The middle sedimentary greenstones crop out throughout the whole of the "Schist Belt", from the south to the northern closure; the thickness of this formation varies from 1,000 metres in the south to 300 metres in the north.

To the north of the Shabani-Selukwe Road, (sheets 1 and 2), the middle sedimentary greenstones occupy the core of the "Schist Belt" syncline and represent the youngest formation that is present, and structural repetition causes the apparent thickness of this series to be of the order of 600 metres.

South of the Shabani-Selukwe Road the middle sedimentary greenstones, in part, pass laterally into rocks of the siliceous greenstone group i.e. 3,000 metres north-west of

the Shabani-Bulawayo, Shabani-Belingwe Road junction, (sheet  
20 M 3).

The siliceous greenstone formation occupies the same stratigraphic level as the middle sedimentary greenstones along either limb of the southern half of the major "Schist Belt" syncline, (sheets 3 and 4). Along the eastern limb of the syncline, in the vicinity of Zoederbergs Siding, sheet  
27 S 4, the siliceous greenstone is from 2,500 to 3,000 metres in thickness and contains occasional lenses of sedimentary greenstone that have dimensions along the strike of up to 1,000 metres and thicknesses of up to 800 metres.

Along the western limb of the syncline, 3,500 metres  
23 K-M south-east of the Lundi Bridge along the Shabani-Belingwe Road (sheet 3), the siliceous greenstone occupies three distinct levels within the middle sedimentary greenstone formation, each having an approximate thickness of 300 metres and passing laterally both northwards and southwards into the middle sedimentary greenstone.

If the band of siliceous greenstone occurring on the eastern limb of the syncline is followed northwards, it is  
24 R seen to bifurcate 5,500 metres to the south-west of the Nil Desperandum Mine, Shabani, each of the two bands dividing  
23 P once more as they pass under the 33 Kv. cables from Shabani.  
22 Q These four bands of siliceous greenstone finally pass laterally into the middle sedimentary greenstones in the vicinity of  
21 O the Shabani-Bulawayo Road.

This cutting out of the siliceous greenstone is a real and not apparent feature, the siliceous greenstones passes laterally into the middle sedimentary greenstone before reaching what must be a large closure of the major "Schist Belt" syncline, and so this cutting out of strata is independent of folding.

Overlying the middle sedimentary greenstone series and apparently having a conformable junction with these sediments are the upper volcanic greenstones, differing only very slightly in lithology from the sequence of lower volcanic greenstones already described. This upper series of extrusive rocks have, if anything, a more massive character than the lower volcanic greenstones, the frequency of occurrence of pillow lavas and flow banding is much less in this younger sequence.

25 R Approximately 8,500 metres to the north-west of Zeederbergs Siding, sheet 4, between the Lorenzo Marques railway line and the railway line construction road, an amygdaloidal lava is very well exposed having well developed pipe anygdales containing zeolites of a radiating fibrous structure. Du Toit, 1907 and Bailey, 1911 consider that the origin of pipe anygdales is due to the rising up of steam, through the lava flow, from the moist surface over which the lava has flowed. Such amygdaloidal structures commonly occur at the base of lava flows where the lava has been extruded over wet mud. No contradictory

evidence to this theory is present in the amygdaloidal lavas of the Shabani area since the flows in which such structures are found are always small and rest upon deposits that have an aqueous sedimentary origin.

In the southern portion of the "Schist Belt", the upper volcanic greenstones are the only formation in which there is a large scale closure around the major syncline. The calculated axial plunge of this closure is approximately 70 degrees towards the south.

The style of this large closure is dominantly similar, contrasting with the dominantly parallel style of the closure within the lower volcanic greenstones around the northern termination of the "Schist Belt".

The youngest formation of rocks that are included within the Middle Sedimentary and Volcanic Greenstones are the upper sedimentary greenstones, and this group have undoubtedly the most sedimentary character of the three sedimentary greenstone formations.

At the base of the upper sedimentary greenstones, along the western limb of the synclinal "Schist Belt", 4,500 metres east of the Shabani-Belingwe Road Bridge over the Lundi River, sheet 3, there is present a very coarse sandy sedimentary greenstone. This deposit contains a thin banded ironstone that crops out intermittently along the strike for a distance of some 4,000 metres. Above this bed of banded ironstone, the upper sedimentary greenstones continue as

normal tuffs, ashes and sub-aqueously deposited tuffaceous sands.

23N The upper surface of this group of sediments is best exposed in the vicinity of Oreti Siding Asbestos Processing Plant, (sheet 3), where a deeply weathered transgressive zone has been exposed after excavation; this marks the upper surface of the Middle Sedimentary and Volcanic Greenstones, (Bulawayan?), of the Shabani area.

On the scale of 1:50,000, the various lithological units within the syncline of the Middle Sedimentary and Volcanic Greenstones have the appearance of bands, contained within a sedimentary greenstone matrix, that gradually "wedge out" northwards. The conclusion drawn from this feature is that the trough into which the Middle Sedimentary and Volcanic Greenstone **Group** were deposited had a greater rate of subsidence and infilling in the south than in the north.



x - (C) The Upper Sedimentary Group (Shamvaian?)

Within the core of the syncline of the southern "Schist Belt" is a group of younger rocks showing a marked change in lithology from the Middle Sedimentary and Volcanic Greenstone Group that underlie them. This younger group of rocks (the Upper Sedimentary Group), is completely devoid of any volcanic deposits and is composed of conglomerates, silts, sands, slates, ironstones and limestones.

Over the central core of the southern "Schist Belt" syncline, the Upper Sedimentary Group form an area of much lower relief which has been utilized in the construction of the Lorenzo Marques-Gwelo railway line. Moreover, the synclinal form of the Upper Sedimentary Group provides an excellent reservoir for the retention of ground water, the number of railway boreholes per mile of track is far greater over the Upper Sedimentary Group than it is over the adjacent volcanic greenstone horizons or gneissic basement rocks.

River vleis deposits are not an uncommon feature, and are with irrigation extremely productive arable areas, e.g. 2,000  
230 metres south of Oreti Sidings (sheet 3).

Along the eastern limb of the synclinal core the junction between the Upper Sedimentary Group and the underlying Middle Sedimentary and Volcanic Greenstone Group is marked by the occurrence of a coarse conglomerate containing well rounded pebbles of the underlying greenstone rocks.

In the south of the sedimentary core, the strike of the

underlying sedimentary and volcanic greenstones adjacent to  
 27S **is parallel to that of the Upper Sedimentary Group**  
 the Zoederbergs Siding, (sheet 4). Around the northern  
 closure however, adjacent to Oreti Siding and the Yellow Vlei  
 22N Mine (sheet 3), the strike of the younger group: is markedly  
 oblique to the strike of the underlying Middle Sedimentary and  
 Volcanic Greenstone Group.

The great change in lithology and depositional environment;  
 the difference in the directions of strike of the beds  
 between the rocks of the Middle Sedimentary and Volcanic  
 Greenstone Group: and the Upper Sedimentary Group:; and the  
 occurrence of a basal conglomerate to the Upper Sedimentary  
 Group., beneath which the upper surface of the greenstones  
 has a deeply weathered appearance; all suggest that the  
 contact between these two groups of rocks is an unconformity.

#### A Description of the Lithological Unit.

##### xc (a). Conglomerate.

The conglomerates are composed of a coarse pebble fraction  
 contained in a matrix of siliceous silt, the rock would be  
 classified as a "packstone" by carbonate sedimentologists  
 (Dunham, 1962). Pebbles from these conglomerates consist  
 of poorly rounded fragments of the rock types that occur in  
 the underlying greenstones; quartzite, sedimentary green-  
 stone and basaltic lava. The sizes all fall within the  
 range of 0.02 - 03 metres. A further exposure of a  
 conglomerate occurs in the very centre of this upper series

of rocks, 6,000 metres to the north-west of Zeederbergs  
 23P Siding. The conglomerate at this locality is composed of  
 quartzitic and iron-rich quartzite pebbles that have been  
 strongly deformed. This rock is also a "packstone" (Dunham  
 1962), and the pebbles are contained in an iron rich silt;  
 the dimensions of the pebbles (ellipsoids), are approximately  
 0.03 metres by 0.02 metres by 0.015 metres. Their longest  
 axes plunge steeply (70°) southwards.

xi (b). Limestone.

The rock type that has been classified as a limestone  
 would perhaps be better called a calcium carbonate rich silt.  
 This rock has a very restricted outcrop, occurring only in  
 the lower horizons of the south-western sedimentary core on  
 28P Cheshire Ranch, north of the Ngesi River.

xi (c). Banded Ironstones.

The lithology of the banded ironstone is identical to  
 that of the banded ironstones that are found in the Lower  
 Sedimentary and Volcanic Greenstones and the Middle  
 Sedimentary and Volcanic Greenstone Group.

xg (d). Grit.

The rocks that have been mapped as "grit" are rocks that  
 vary from sandstones to very coarse grit and on occasion to  
 almost agglomerates. The only common characteristic is a  
 relatively iron free siliceous composition that distinguishes  
 them from the silts and sands of the Upper Sedimentary Group.

The grits are composed of angular grains consisting of quartz and feldspar crystals, approximately 0.002 to 0.003 metres in size, in a matrix of siliceous cement. Occasionally small crystals of mica are present, and even more rarely small grains of iron ore.

x p (c), Silt.

The rocks that have been classified as silts are by far the most widespread lithological group within the Upper Sedimentary Group, outcropping throughout the whole of this sedimentary synclinal core.

These rocks vary from siltstones to mudstones, and are composed of very fine grained quartz, calcium carbonate and iron ore; they occupy areas of low relief and have a characteristic red-brown colour.

23P Approximately 6,000 metres to the northwest of Zeederbergs Siding, adjacent to a borehole owned by Mr. Moorcroft, the "silts" are in fact mudstones that have developed the main "Schist Belt" cleavage to such an extent that they have been quarried as a poor roofing slate.

Plate XXIII.

Deformed conglomerate of the Upper Sedimentary Group.



A General "Stratigraphic" Section Across the Upper  
Sedimentary Group in the vicinity of Zeederbergs  
Siding

		?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
Upper		xc	conglomerate	15 metres	the whole	.													
Sedimentary		xg	grit	15 metres	of this	.													
Group		xi	ironstone	15 metres	sequence is	.												900	
		xl	limestone	6 metres	contained in	.												metres	
		xc	conglomerate	15-30 metres	a silt (xp)	.													

----- Unconformity

Middle Sedimentary and Volcanic Greenstone Group.

The Succession of the Upper Sedimentary Group.

The succession of this youngest (Shamvaian age?) group of sedimentary rocks of the "Greenstone Schist Belt" is extremely variable along their strike, especially in the northern closure of this core (sheet 4).

24-25  
P-Q

24 P

In this area, e.g. 8,000 metres to the north-west of Zeederbergs Siding (sheet 4), apparently normally bedded sequences of rocks completely cross-cut the regional strike. The best example of this in the above locality is where a bed of banded ironstone together with a thick adjacent quartzite trend at a high angle from the lower surface of the Upper Sedimentary Group on the north-western limb over the axial trace of the syncline towards the south-eastern limb without an accompanying change in strike. Abutting sharply against the upper surface of this banded ironstone

is a quartzite that is conformable with the regional strike.

Southwards of this northern closure the bedding surfaces of the varying lithologies within the Upper Sedimentary Group become much more conformable with the limbs of this syncline although before the horizons pass into persistent beds, south of the Mchingwe fault, they have a markedly lenticular character and contain great lithological variation along their strike.

Along the eastern margin of the synclinal Upper Sedimentary Group a basal conglomerate is present forming a noticeable topographic feature which in this area clearly defines the margin of the synclinal core.

Along the south-eastern margin of the syncline the basal horizon of the Upper Sedimentary Group is occupied by a persistent bed of banded ironstone.

Resting on top of these basal horizons and overstepping them to the north is a thick sequence of silts within which are contained beds of banded ironstone and grits. The form of these silts and grits changes southwards from lenticular bodies in the north to more continuous horizons in the south. If these horizons are followed southwards onto the adjacent Belingwe sheet, (Worst, 1951), they are seen to close completely around the southern termination of the syncline.



Methods of Determining the "Way Up" in the "Greenstone Schist Belt" Rocks.

Outlined below are the criteria that have been found useful in the determination of the original attitude of the "Schist Belt".

Methods

- (a) Lithological nature.
- (b) Ripple marks and bottom structures.
- (c) Flame structures.
- (d) Current bedding
- (e) The shape of pillow lava surfaces.
- (f) The flow direction of vesicles in lavas.
- (g) Graded bedding

The most useful criterion was found to be that of the shape of pillow lava surfaces, owing to the widespread occurrence and excellent exposure of this rock type through out the "Schist Belt".

When freshly broken surfaces of vesicular pillow lava are available for inspection, and the vesicles are unoccupied by eggs, larvae or adult insects, the direction of extension of the vesicles may be determined and so the "way-up" during cooling ascertained.

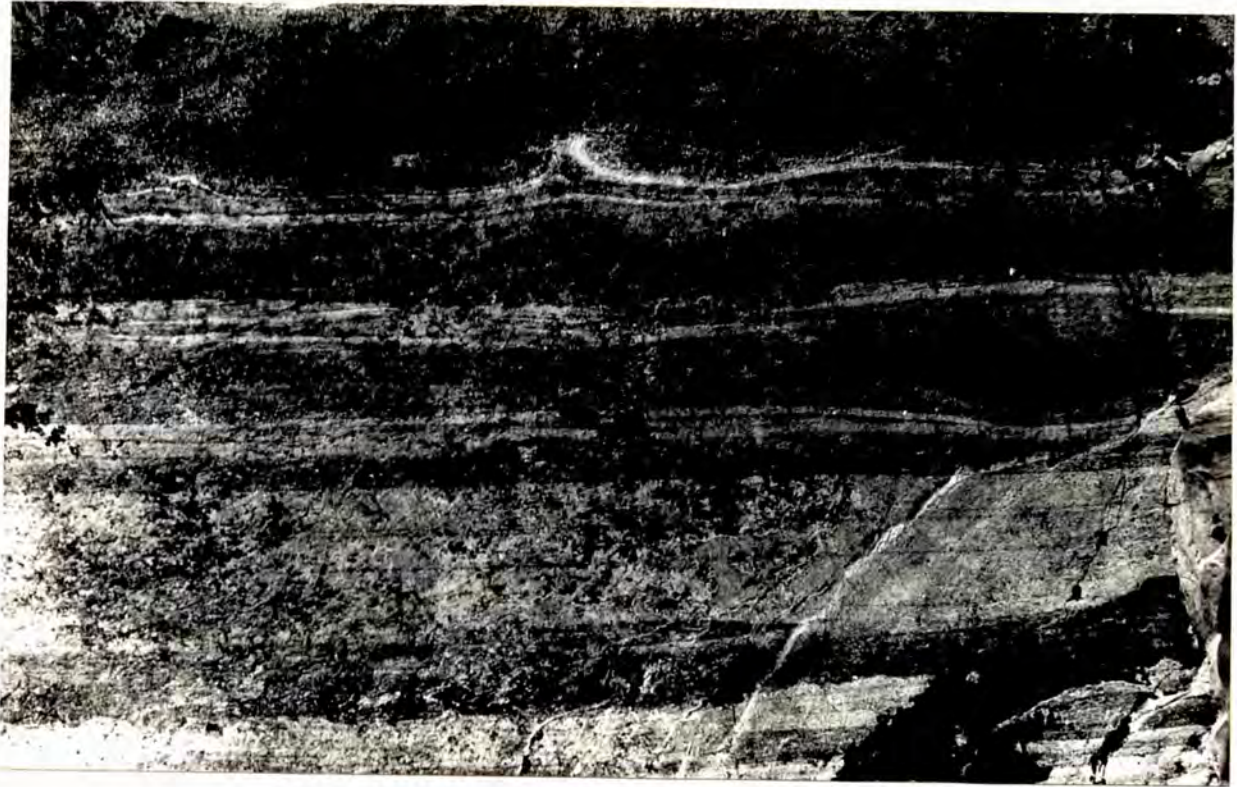
The use of lithological content is confined to the grits and conglomerates immediately above the two unconformities found within the "Schist Belt", and the presence of fragments of rocks from one group, in the rocks of another,

Plate XXIV.

Flame structure in silts of the Middle Sedimentary  
and Volcanic Greenstone Group.

Plate XXV.

Slump structures in the silts of the Middle Sedimentary  
and Volcanic Greenstone Group.



confirms that the latter group of rocks are younger in age.

Ripple marks and bottom structures, flame structures, graded-bedding and current-bedding are best exposed in one **group** of localities along the western bank of the Ngesi River between the Belingwe road and Mr. Garfield Todd's lower irrigation dam, in the uppermost sediments of the Lower Sedimentary and Volcanic Greenstone **Group**.

Throughout the whole of the "Schist Belt" the "way-up" evidence suggests that the structure is "younging" towards its centre and is an upward facing syncline, (Shackleton 1958). In the series of exposures that have already been described above, along the western bank of the Ngesi, the rocks are seen to have been slightly overturned to the east, in all other localities the rocks are found to be the "right way up".

PART IV

INTRUSIVE ROCKS

a - 9 (a) THE SHABANIE MINE ULTRABASIC

The map accompanying this description (map 7), has been compiled from the mapping of Dr. D. Laubscher and Mr. D. Catheral, as presented in their respective Ph.D. and M.Sc. theses.

The Shabanie Mine Ultrabasic mass is in the form of a layered sill, striking north-west to south-east, and dipping south-westwards underneath the Middle Sedimentary Volcanic Greenstone syncline. The amount of dip is variable from almost horizontal in the north-east, where the sill has also been folded about north-west, south-east axes into a series of simple buckles by the post-Bulawayan deformation, to an approximate south-westwards dip of seventy degrees. Within this sill has occurred the formation of chrysotile asbestos and the deposit is owned and worked by the R.S.T. Corporation.

The lithology and structure have been mapped by the geological staff of Shabanie Mine, mainly from the use of underground survey information, and adequately described by Dr. Laubscher in his Ph.D. thesis on the formation of chrysotile asbestos fibre, Witwatersrand, 1958.

The sequence of compositional layering is simple, the layers being parallel to the hanging wall and foot wall of the sill and from the base to the top have been designated as: dunite, peridotite, harzburgite, pyroxenite, actinolite rock and actinolite feldspar rock. The contention of Dr. Laubscher is that the layering is due to the simple crystal

settling within the still liquid magma of the sill after its intrusion, and so the layering must have had, at the time of formation, a horizontal attitude. Since the adjacent sedimentary deposits have a dip some 20 degrees or so steeper than the igneous layering, the intrusion and the crystal settling must have taken place when the eastern limb of the adjacent Middle Sedimentary and Volcanic Greenstone Group syncline had a westerly dip of approximately 20 degrees. The development of asbestos fibre is a much later feature in the history of the sill, as is the formation of the talc carbonate rock, found along numerous north-east, south-westerly trending near-vertical shears within the intrusion. In order to satisfy the requirements of fibre formation and serpentization, it is essential that a reasonable quantity of water be introduced into the system. The origin of this water has been suggested to be one of the following:-

- (a) Connate water from the Middle Sedimentary and Volcanic Greenstone Group, ("Bulawayan") syncline, permeating through the intermediate gneisses during the post-"Bulawayan" deformation, (Dr. Laubscher, Ph.D. thesis).
- (b) Hydrothermal water vapour, originating from the intrusion of the "Younger Granite" at depth, travelling upwards along the talc-carbonate shear zones, (Mr. Catheral, M.Sc. thesis).

Of the two suggestions the second would appear to be more plausible when one considers the lateral proximity of

the Younger Granite and Mr. Catheral's postulated north-east, south-west trend of the Younger Granite. (From the results of a more regional mapping, presented in this thesis, the trend of the outcrops of the Younger Granite, if anything, appears to be north-west, south-east.) (See "Description of the Lithological Map of the Shabani Region".) Unfortunately, a bore-hole sunk on the Nil Desperandum section of the mine, passed through the foot-wall of the sill and 30 metres or so of the gneiss, without encountering any Younger Granite rock.



6, G (b) Intrusive Basic Rocks.

Within the rocks of the Shabani area there is found a suite of intrusive basic rocks, varying in composition from dunites to dolerites, and in form from dykes to stocks. They exclude the "Great Dyke" of Rhodesia and all have a date of intrusion older than the emplacement of the "Younger Granite".

(1) The Olivine-rich Intrusive Rocks.

Intruded only into the rocks that are older than the lower horizons of the Middle Sedimentary and Volcanic Greenstone Group (Bulawayan?), is a group of coarse-grained olivine-rich intrusive bodies.

Within this group of rocks two distinct ages of emplacement have been distinguished:

(a) A series of north-south trending sills, 600 metres in width and up to 16,000 metres in length along their strike. These sills are all unconformable with the bedding surfaces of the Lower Sedimentary and Volcanic Greenstone Group. Because this group of ultrabasic sills has acquired the foliation of the Lower Sedimentary and Volcanic Greenstone Group, their date of emplacement must have been after the deposition and before the deformation of the Lower Sedimentary and Volcanic Greenstone Group.

Further evidence of this age may be seen towards the south of sheet 3 where concordant sills of the Lower Sedimentary and Volcanic Greenstone Group terminate against

23 K the unconformity between the Lower and Middle Sedimentary and Volcanic Greenstone Group.

As these sills are followed southwards onto the adjacent "Belingwe Sheet" (Worst, 1959), they are seen to have been deformed around the first folds of the Lower Sedimentary and Volcanic Greenstone Group, south-west of High Peak, Belingwe.

(b) A second group of intrusive basic bodies in the form of  
23 I conformable sills, 300 metres in thickness, and stocks up to 1,000 metres in diameter are unaffected by the earliest deformation of the Lower Sedimentary and Volcanic Greenstone Group.-

These intrusive bodies occur along the southern half of both the eastern and western limbs of the main "Schist Belt" syncline. As the sills of the western limb of the syncline (sheet 3) are followed northwards, they change **in their form**, from sills to stocks, both of these forms containing the north-south trending vertical cleavage of the major "Schist Belt" syncline.

The youngest rocks that have been intruded by this second group of intrusive bodies are the lowest horizons of the Middle Sedimentary and Volcanic Greenstone Group.. One transgressive sill of this second group has had its upper surface "planed off" before the deposition of the earliest volcanic greenstone horizon of the Middle Sedimentary and Volcanic Greenstone Group, 3,000 metres north-west of

28W Vukwe Peak (sheet 4).

The most elegant method of dating this group of ultra-basic rocks is that used by Dr. D. Laubscher in dating the ultra-basic sill of Shabanie Mine. The method employed is based upon fact that the layers of gravity-settled crystals that are contained within the sill, must at their time of formation have had a horizontal attitude.

Since the gravity-settled layers have at the present time a dip that is 23 degrees less steep than the dip of the adjacent "Schist Belt" rocks, the date of formation of the gravity-settled layers must have been when the rocks of the adjacent "Schist Belt" had a westerly dip of 23 degrees, i.e. very early in the depositional history of the Middle Sedimentary and Volcanic Greenstone **Group**.

The distribution of the parallel ultrabasic sills along the southern portion of both limbs of the Middle Sedimentary and Volcanic Greenstone **Group** syncline is similar to the ultrabasic belts that are found on a much larger scale, bounding orogenic zones (Hess 1955).

The form of the ultrabasic intrusives of the Shabani area may be seen to alter with structural depth, so that sills become isolated stocks as they approach the surface (southern half of sheet 3).

In thin section the ultrabasic rocks are seen to be a varied compositional group, ranging from peridotites and serpentinites to pyroxenites, typical slides of these rock

types are 118a, 118b and 43b.

**Serpentinite:** This rock is composed of 90 per cent serpentine and 10 per cent of iron ore. The serpentine has resulted from the alteration of olivine, and the iron ore is disseminated throughout the rock and concentrated in the form of sub-parallel, undulating bands of small anhedral grains.

As in most thin sections of serpentinites, this rock has a large number of fractures traversing the serpentine along which the smaller grains of iron ore have collected.

This rock was apparently at one time monomineralic peridotite that at some time after its emplacement suffered serpentinization the appearance of the small bands of iron ore suggesting that this rock had an original layered character.

**Pyroxenite:** A typical pyroxenite (slide 43b) is composed of 80 per cent augite, 15 per cent enstatite (bronzite), and 5 per cent of accessory crystals, the individual augites interfering with the free growth of the adjacent crystals.

Throughout the slide there are large subhedral crystals of enstatite (bronzite), that have an apparent parallel orientation to each other, their faces having been interfered with during crystallization by the growth of the augite crystals.

The feldspar in the slide replaces some of the augite crystals.

## (2) The Gabbroic Rocks.

The outcrop of the intrusive rocks of gabbroic composition are in all but one instance characterised by having the form of concordant sills, very similar to the form of the olivine rich intrusive rocks.

Exposures of gabbroic rocks appear as low, well rounded, hummocky features that are traversed by fractures, have a dark brown colour <sup>are</sup> and often overgrown with a yellow lichen.

The gabbroic sills are characteristically intruded along the central parts of the siliceous greenstones; this habit was at first thought to indicate a genetic relationship between the two rock types. A good illustration of this feature is seen 3,000 metres to the east of the Shabani-Belingwe road bridge over the Ngesi River (sheet 3). Here the gabbro forms small elliptically shaped masses 3,000 metres by 50 metres, their longer axes being parallel with the trend of the siliceous greenstone; since no thickening of the siliceous greenstone occurs, they appear to have arrived at their present position by a mechanism of replacement.

Surrounding the gabbroic masses in the above localities is a sheath of hornblende-rich siliceous greenstone 10 metres in width across the strike from the gabbro contact and up to 100 metres along the strike from the gabbro.

As mapping progressed eastwards the notion that the gabbroic rocks and the siliceous greenstone had a genetic

Plate XXVI.

Photomicrograph of serpentinite, x 20.



relationship was found to be untrue after intrusive masses of gabbro and beds of siliceous greenstone were also found to occur independently of each other and intrusions of gabbro which appeared to be concordant in fact proved to be slightly transgressive.

The gabbroic rocks in thin section are a series of coarse grained homogeneous rocks, having a similar composition throughout the area. A typical thin section of this rock is represented by slide 39, collected from 4,000 metres to the north-west of New Dadaya Mission (sheet 3).

This gabbro is composed of 40 per cent plagioclase, 30 per cent augite, 10 per cent iron ore, 10 per cent olivine and 10 per cent of orthoclase feldspar and chlorite.

The plagioclase is in the form of long euhedral laths which have been heavily sericitized, so making any optical determination of composition impossible. In the interstitial spaces to these laths there are small euhedral pyroxenes (augite), that have been partially corroded around their borders and replaced by orthoclase feldspar and chlorite. In association with the pyroxenes are small grains of iron ore.

This slide shows small, subhedral grains of what appear to have been olivine crystals. It is inferred that original olivines have been altered to pyroxene and then partly altered to chlorite, still maintaining the fractures characteristic of olivine crystals.

The intrusion of the ultrabasic and gabbroic rocks has



been confined to the southern half of the "Schist Belt", and their most northerly occurrence is approximately the line of the Shabani-Bulawao road.

This limit coincides approximately with the maximum lateral thinning of the "Schist Belt" rocks and also with the position of the most rapid change in structural depth.

A minimum structural depth appears to have been necessary before the intrusion of the ultrabasic and gabbroic rocks could take place.

The relative age of the gabbroic intrusions may be ascertained with a reasonable degree of certainty since the Younger Sedimentary Group has been laid down upon the already eroded surface of a gabbroic mass that had been intruded into the Middle Sedimentary and Volcanic Greenstone Group. This evidence is best seen 3,000 metres to the south-east of the Shabani-Bulawayo, Shabani-Belingwe road junction (sheet 3).

(3) "Dolerites".

The "dolerites", because of their similarity in colour, resistance to erosion, and colour of the resultant soil, are difficult to distinguish from the rocks of the "Schist Belt" on either aerial photographs or from the ground. The "dolerite" intrusions that have been mapped throughout the "Schist Belt" always have the form of narrow vertical dykes, apparently quite randomly oriented. Occasionally chilled margins are seen and rarely a weak banding parallel to the

dyke walls is visible.

A typical "dolerite" is represented by slide 119a, composed of 50 per cent hornblende, 40 per cent of feldspar and 10 per cent of quartz and iron ore. The dolerites are all fine grained; the hornblende is completely anhedral and in places contains small pleochroic haloes.

The feldspars have cores of oligoclase which gradually change to albite towards their margins.

The iron ore is in small groups of anhedral grains in association with the hornblende.

α (c) The Younger Granite.

The Younger Granite consists of a white, homogeneous, coarse grained, igneous rock of granitic composition, having been emplaced in the form of stocks and batholiths.

The outcrop of this granite is confined to two main localities; in the vicinity of, and to the west of, the Great Dyke, and to the east of the northern portion of the "Schist Belt" syncline (sheets 1 and 2). Both areas are characterized by relatively high relief and are well exposed. Weathering of this rock takes place by exfoliation, exploiting a planar jointing within the rock and so divides the weathered granite into well rounded cuboidal blocks.

The contact of the granite with adjacent rocks is only rarely seen, this zone usually being covered with a talus deposit of weathered granite.

180 A granite contact with migmatitic rocks, 5,000 metres north-west of Shabani on the northern bank of the Shabi River, has been described by Mr. D. Catheral (1961). Here the granite intrudes the migmatite gneiss, the contact is straight and sharp, and the granite shows only a slight decrease in grain size towards the gneisses and migmatites. Similarly the xenoliths of gneiss show only a slight magmatic basification, and the development of a quartz rich zone, 0.01 metres in width around them.

The granite cross-cuts the foliation of the gneiss abruptly causing very little disturbance.

Another exposure of the contact of the Younger Granite  
7 R can be seen in a river section, 5,000 metres to the north of Ramorfa School along the only road running northwards along the adjacent gneisses to the east of the "Schist Belt". The section begins at the road bridge over a tributary of the Lundi, and continues along the river for a distance of 50 metres. Here the Younger Granite has a sharp contact with the sediments and volcanics of the lower horizons of the Lower Sedimentary and Volcanic Greenstone Group, and shows only a slight decrease in grain size towards the contact. The Lower Sedimentary and Volcanic Greenstone Group which are normally in the "greenschist" facies, show hornfelsing towards the contact, and an increase in the grade of metamorphism to the amphibolite facies.

In the above locality the structural disturbance is very slight, the first foliation of the greenstones has been deformed into open second folds caused apparently by the emplacement of the granite. The axial planes of these folds dip steeply towards the granite (eastwards), and have almost horizontal axial plunges.

The Younger Granite also intrudes rocks of the Middle Sedimentary and Volcanic Greenstone Group, but no exposure of this contact are found. Exposures of the granite in the Middle Sedimentary and Volcanic Greenstone Group are confined to three areas:

- 5P (a) 1,500 metres west of Chimini School (sheet 2).  
 4N (b) 6,000 metres south-west of Lundi School (sheet 1).  
 18N (c) 6,000 metres north-east of Old Dadaya Mission (sheet 3).

The granites in the first two of these localities are elliptically shaped masses, the ratio of the major to the minor axes being 4 to 1 in area (a), and 2 to 1 in area (b). The major axis in both cases has an approximately north-south orientation. In localities (a) and (b) the orientation of the stocks is parallel or sub-parallel to the first foliation in the "Schist Belt".

In the third area, (c), the granite stocks are again elliptically shaped, the ratio of the principal axes being 2 to 1, the major axis being some 5,000 metres in length and trending north-east, south-west. This granite stock cross-cuts the "Schist Belt" foliation at right angles.

Within the Middle Sedimentary and Volcanic Greenstone Group synclinal "Schist Belt", 5,600 metres and 5,000 metres to the north-west of the Younger Granite mapped by Mr. D. Catheral, there are found two elliptically shaped areas of amphibolitized greenstone (sheet 3). The major and minor axes of these two ellipses measure 2,500 metres by 800 metres and 4,000 metres by 1,500 metres, the trend of both the major axes being parallel to the trend of the "Schist Belt" foliation in this locality.

Because of the similarity in lithology between the rocks of these two elliptical masses and the rocks of the

contact aureoles of the Younger Granite stock to the east, their orientation along the local trend of Younger Granite intrusion, and their close proximity to occurrences of the Younger Granite; it is suggested that these two amphibolitized zones are the surface expression (contact aureoles), of two Younger Granite intrusions that remain unexposed at depth.

The contacts of the various younger stocks are, on the whole, very smooth and confine the granite into discrete masses, having no sharp or angular projections unless offsetting of the contact has taken place due to later wrench faulting.

18 B,C

In only one locality, 13,000 metres west of Mapirimiri trigometrical station, on De Beers Block (sheet 1), has the granite magma "pierced" this smooth boundary and formed a mushroom-shaped "pod", connected to the main granite mass by a neck 150 metres in width. Around the margins of this "pod" there is a notable increase in the grain size, and a far greater development of large, silvery lithium micas, suggestive of the latest pegmatitic phase of granitic intrusion.

10P

Although inclusions of country rock within the granite are not common, areas of the granite, which have a much more basic composition (stippled  $\alpha$ ), are occasionally found. The largest of these are 6,000 metres south-west of Ramorfa School (sheet 2).

The contacts of these more basic portions are gradational

(over a distance of 50 metres), their shape is irregular, and they show the same homogeneous nature as the main granite mass. These basic patches occupy a position very close to the margins of the granite, which at this locality is a faulted junction with the Middle Sedimentary and Volcanic Greenstone Group of the "Schist Belt".

It is suggested that the more basic granite owes its origin to the digestion of inclusions of a more basic rock.

The schists and gneisses adjacent to the granite stocks and batholiths have, on the scale of an exposure, suffered very little disturbance, although the Lower Sedimentary and Volcanic Greenstone Group, (area b), have been deformed into small scale folds during the emplacement of this granite.

On a larger scale however, the gneisses and schists have been gently warped by the emplacement of this granite. Examples of this warping are, 5,000 metres north of Ramorfa School (sheet 2), and 6,000 metres north-west of Ruwanda School (sheet 1).

6 S

5 K

On the scale of mapping (1:50,000), the whole of the greenstone "Schist Belt" has been warped into an open anticline. The axis of this structure trends west-north-west, east-south-east, plunging steeply to the west-north-west. The anticline has a wave-length of 50,000 - 60,000 metres and the convex side of this structure faces west-north-west.

It is suggested that the emplacement of the Younger Granite was due to the forceful injection of a liquid magma,

causing a structural readjustment of the surrounding country rocks. During this injection a small amount of stoping occurred.



(d) The Great Dyke of Southern Rhodesia

The Great Dyke was first mapped and described completely by Dr. B. G. Worst, 1961 and published in Bulletin No. 47 of the Southern Rhodesian Geological Survey.

The age of the Great Dyke (Fauro et al., 1963) has been radiometrically determined as: 2,110 plus or minus 350 , 1,000,000 years, i.e. a similar age as that determined for the Bushveld Complex of the Transvaal, South Africa.

The Great Dyke is approximately from 4,000 to 5,000 metres in width and approximately 482,000 metres in length, trending north-north-east, south-south-west, this trend varying only in the extreme north along the Zambesi escarpment where the Dyke has been deformed into an "S" shaped structure, much of which appears due to a later wrench faulting.

This unusual igneous intrusion is composed of a series of layered basic rocks having an almost horizontal attitude, but dipping gently inwards towards one of four postulated centres of intrusion.

The structure of the Dyke is of four connected basins or lopoliths the centres of which are demarcated by the outcrops of the youngest intrusions of gabbroic rocks and are situated at: Musongesi, Hartley, Selukwe and Wedza. The lengths of each of these individual lopoliths are respectively 48,000; 313,000; 96,000 and 80,000 metres.

Dr. B. G. Worst suggests that these connected lopoliths

are marginally bounded by two faults, the central basic rocks having been down-faulted into a graben structure. Evidence for this rift structure is:

- (a) The straight, continuous nature of the marginal contacts, which although rarely exposed, are occasionally seen to dip inwards at varying angles.
- (b) The "cutting out", along the marginal contacts, of otherwise very persistent layers of pyroxenite and serpentinite.
- (c) The Great Dyke is in direct line with, and has a similar orientation to, the East African rift system, which is also of pre-Cambrian age.

In order to determine the nature of this structurally controlled contact, (obvious from evidence (b) above), there are three lines of approach:

- (1) The nature of the margins at the northern and southern terminations of the "Dyke".

Unfortunately, the northern termination has suffered a considerable deformation and is affected by many north-east, south-west trending shear faults, obscuring any evidence of lateral faulting that there may have been. At the southern end of the "Dyke" there is no evidence at all of faults continuing from the margins into the basement gneisses.

- (2) The tracing of some linear elements in the basement rocks over the "Dyke" margin into ~~included blocks~~ of the same basement rocks, ~~ascertaining any~~ difference in elevation of this lineation. The most obvious ~~example of~~

such a linear element in these basement rocks would be a fold axis along a particular horizon.

There are to be found within the "Dyke" inclusions of the basement schists and gneisses, mainly in the vicinity of Hartley, but unfortunately no linear elements are present within the inclusions that may be traced over the "Dyke" margin.

(3) The third line of evidence is that offered by a geophysical survey (gravimetric), and contributing evidence more towards the shape of the intrusion margins than to their structural nature.

The major geophysical work that has been undertaken and published is the gravimetric and magnetic survey that has been carried out by Weiss, 1940. A gravimetric survey undertaken near Hartley showed that the gravity anomalies are the largest ever published over similar **narrow** widths on any continent; the interpretation of these results indicates the existence of a slowly tapering and very deep linear core with a specific gravity of 3.3. At this locality, (Hartley), the cross section of the Dyke is symmetrical and funnel-shaped, the walls becoming increasingly steep with depth, (Swift 1961).

At the present time, a complete gravimetric survey of the Great Dyke is being carried out by Mr. F. Podmore, U.C.R. towards the degree of Ph.D.

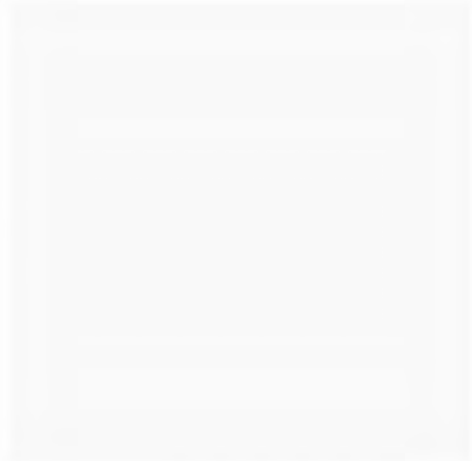
Dr. Worst originally envisaged the shape of the Great

Dyke as a flat-bottomed trough, as is indeed suggested by the orientation of the high level pyroxenite layers, interrupted only in the localities of the four centres of intrusion. A borehole sunk into the Dyke at Wedza penetrated 1,600 metres of the "Dyke" without encountering the underlying basement rocks.

The core information from this borehole indicates that at depth, the Dyke consists exclusively of dunite, the serpentinization of the dunite ceasing at 300 metres below the surface, and consequently the conclusion has been drawn that the serpentinization is due to meteoric and not magmatic waters, (Swift, 1961).

PART V

STRUCTURE



### (a) Structure and Lithology of the Shabani Region

This chapter is intended as an explanation to the map presented as sheet 5 which has been compiled by the reduction of the thesis mapping together with the reduction of work carried out by members of the Geological Survey of Rhodesia on adjacent areas.

All responsibility for the classification of the various rock types into geological systems is accepted by the writer, and has been carried out, not in an attempt to reorganize the geology of the Rhodesian Basement Rocks, but rather in an endeavour to impose some semblance of order on the varying rock types of the Shabani and adjacent areas.

In the basement rock of Rhodesia, three systems of sedimentary deposits have been recognized by the Geological Survey (Macgregor, 1947), they are:

- |     |           |            |              |
|-----|-----------|------------|--------------|
| (3) | Shamvaian | (youngest) | (2,700 m.y.) |
| (2) | Bulawayan |            | (2,900 m.y.) |
| (1) | Sebakwian | (oldest)   | (3,200 m.y.) |

The recognition of similar systems throughout Rhodesia is usually based upon the recognition of similar rock types which are assumed to belong to the same system.

The recognition of ~~similar~~ lithological units on the maps of adjacent areas around Shabani is difficult, owing to the differing criteria for the classification of basement rocks used by the various authors.

However, certain general groups of similar lithology

may be recognized:

- (1) A series of basement schists, composed of banded ironstones, talc-carbonate rocks and amphibolite schists which have suffered migmatization and have been deformed into a series of tight synformal structures, trending north-east, south-west.
- (2) A second group of rocks of similar lithology may be seen which have also been deformed into tight (isoclinal) structures distinguishable from the earlier series (1), by having a different axial trend (north-south), and around which the earlier structures have been deformed. Areas in which this folded relationship is best illustrated are north-west of the Great Dyke (area F, sheet 5), and the central portion of the area around Selukwe (area C sheet 5).
- (3) On areas C (Selukwe) and D (Mashaba) there is a series of sedimentary and volcanic greenstones that gradationally changes into the rocks of (2).

Because of their similar lithology, grade of metamorphism, and structural trend to the rocks that have been mapped as "Lower Bulawayan" by Dr. B. G. Worst around Belingwe (area A), "Bulawayan" by Mr. N. M. Harrison south of Fort Rixon (area E), and as "Bulawayan" by Dr. J. F. Wilson around Mashaba (area D), they are all thought to be of an equivalent age to the rocks that have been designated as "Lower Sedimentary and Volcanic Greenstone Group" in the Shabani area (F).

- (4) Resting unconformably on these earlier groups of rocks

are a series of sedimentary and volcanic greenstones that have been deformed into a north-south trending syncline.

The occurrence of this group is believed to be confined to areas C (Selukwe) and F (Shabani).

(5) Finally, deposited unconformably onto the rocks of group 4 are a series of sedimentary rocks, composed of conglomerates, grits, ironstones and silts. These rocks are found only in the area around Shabani, (area F).

Since there is in the Shabani area evidence to suggest that the rocks of group 2 are the migmatized equivalent of group 3 there are apparently four separate systems of rocks.

On the basis of metamorphic and lithological similarity to the rocks designated as Sebakwian, Bulawayan and Shamvaian in Rhodesia (Macgregor, 1947), it appears that the above groups of rocks may be fitted into the three systems of rocks already recognized in Rhodesia.

<u>Shabani Region</u>		<u>Rhodesian Geological Survey</u>	
Group	5 .....	Shamvaian	(x-)
Group	4 .....	Bulawayan	(y-)
Group	3		
Group	2)   .....	Sebakwian	(z-)
Group	1)   .....	?	

### Conclusions

The rocks found within the Shabani region may be satisfactorily fitted into the three systems of rocks



already recognized by the Rhodesian Geological Survey with the exception of group 1, and possibly group 2.

It is suggested that there is at least one, and possibly two, pre-Sobakwian systems within the basement rocks of the Shabani region.

## Evidence for two deformations of the Basement Schists

The suggestion of an earlier deformation than that responsible for the formation of the north-east trending syncline of the Lower Sedimentary and Volcanic Group on the southern Belingwe area (Sheet 5, and p.173) has been made.

This suggestion is made from evidence found on the 1:50,000 maps, sheets 1-4, and from infrequent (due to the scarcity of solid exposure) field observations which are listed below:

1) In the localities of 7B, 5-6E, 2f (sheet 1) one group of basement schists are seen to have sharply abutting contact relationships with another structurally lower group (earlier?).

This divergence of trend of two adjacent groups of schists is not only confined to their lithological contacts but also to their schistosity.

2)a. Both to the north-west of the Great Dyke 4G (sheet 1), and to the north of the Lundi Bridge 87, 6AA (sheet 2) basement schists are found to grade laterally along their strike into rocks of the migmatized strongly banded gneiss group.

b. To the north-west of the Great Dyke (sheet 1) folded and migmatized strongly banded gneiss is found to have been refolded around later closures within the Basement Schists 8C, 4-5 D-E.

c. At some exposures within the strongly banded gneiss, an earlier foliation is discernible, folded around later folds e.g. 8C (sheet 1), 3W (sheet 2).

The simplest explanation of this situation is that an earlier group of Basement Schists ( $Bh_1$  where distinguished) were deformed and granitized into a series of north west - south east trending folds.

These schists ( $Bh_1$ ) and their granitised equivalents were later refolded around a second group of Basement Schists ( $Bh_2$  where distinguished) whose predominant fold trend is slightly east of north.

(b) Structure of the Granitised Basement Complex**Bh<sub>1-2</sub>** (1) The Basement Schists.

The group of rocks that are included within this classification have a composition that varies from banded ironstones to amphibolite, calc-silicate schists, all of which have been granitised and folded within the Basement Gneisses.

The general form of the outcrop pattern of these schistose basement rocks, other than the Lower Sedimentary and Volcanic Greenstones, is either of small raft-like structures or of isoclinally folded narrow bands. The length of these bands varies from 600 metres, 8,000 metres to the west of Kashambi Halt railway station, sheet 1, to a length of 16,000 metres, 6,500 metres to the south-west of Kashambi Halt, sheet 1.

This group of schists can be sub-divided into at least two and possibly three distinct generations, (geological systems ?), each generation having a structurally higher level than the Basement Gneisses upon which they rest.

(a) The earliest generation of Basement Schists is composed of a granitised sequence of amphibolite schistose rocks, the best exposures of which are found to the north-west of the "Great Dyke", sheet 1. This group of schists typically crop out in the form of folded linear bands whose structure, (inferred from lithological repetition), is that of isoclinal folds.

The prominent foliation of these rocks, caused by the parallel orientation of the micaceous minerals and the elongated amphibole fabric, is parallel to their boundaries with the adjacent gneisses and to the weak foliation within the adjacent gneisses.

(b) The earliest group of schists, ((a) above), and their granitised equivalents have sharply abutting junctions with a second generation of schists of a very similar composition and structure. The best examples of this relationship are  
3F exposed 5,000 metres to the west of Kashambi Halt, sheet 1,  
7B and 8,000 metres to the south-west of Kashambi Halt, suggesting that there are two distinct ages of Basement Schists.

Alternatively, the discordant junctions between two groups of schistose rocks may represent thrust junctions, similar to those described by Mr. C. W. Stowe in the northern adjacent area around Selukwe.

This second generation of schists have the form of isoclinaly folded synformal masses with an axial plane foliation that is oblique to the foliation of the adjacent Basement Gneiss. The axial planes of these structures have a north-east, south-west trend and a very steep or vertical dip. The amplitude of these folds is of the order of 7,500 metres and a wave-length of approximately 1,500 metres.

(c) The third and final group of granitised schists that are found within the Basement Gneisses and which have been

included with the description of the Greenstone Rocks of the Shabani "Schist Belt", are the Lower Sedimentary and Volcanic Greenstones. This group of rocks, composed of sedimentary volcanics, extrusive volcanics and banded ironstones, has been deformed and weakly granitised before the deposition of the younger members of the "Greenstone Schist Belt". The rocks of this group crop out on the western half of sheet 3, their structure being that of the northern limb of a tight synform, the nose of this fold occurring to the south, in the Belingwe area, mapped by Dr. B. G. Worst, 1951.

The axial plane of the Lower Sedimentary and Volcanic Greenstones trends north-east, south-west, the axis plunging steeply towards the north-east at approximately  $80^{\circ}$ .

The style of this synform is principally similar, although the banded ironstone horizons have deformed in a **parallel** style, the difference in geometry of these two styles is accommodated by the sedimentary greenstones adjacent to the banded ironstones. The amplitude of this fold is approximately 6,000 metres and the wave length of this structure of the order of 10,000 metres.

It is possible that this third group of schists, the Lower Sedimentary and Volcanic Greenstones is equivalent in age to the second generation of "Basement Schists" since there are no occurrences of the refolding of the second group by the third, nor are there any unconformable junctions between the two groups.

## (11) The Basement Gneisses.

γ<sub>1</sub> (a) The Strongly Banded Gneiss

The outcrops of the strongly banded gneisses can be conveniently divided into three areas, each area exhibiting a different outcrop pattern of the strongly banded gneiss in relation to the adjacent gneisses.

The three areas are: (1) West of the Great Dyke, (2) The central area, and (3) the Lundi/Msebaise confluence; for ease of description of the various structures, each of the three areas will be described separately.

## (1) West of the Great Dyke.

The strongly banded gneisses of this area occupy long narrow bands, up to 600 metres in width and 5,000 metres in length, the gneissic foliation being parallel to the borders of the band. The foliation of the gneisses has a very steep to vertical dip and a trend varying from north-north-west, south-south-east to a north-south direction.

Although the exposure in this area is poor, the junctions between the strongly banded gneisses and the banded gneisses appears to be gradational both marginally and laterally. Towards the centres of the bands the gneisses often grade into "inliers" of basic amphibolite schist.

The earliest folds affecting these gneisses are a series of tight isoclinal structures that deform the gneissic banding and axial planes parallel to the foliation. These folds have north-west, south-east axial traces and axes that

plunge very steeply towards the north-west.

(2) The Central Area.

The strongly banded gneisses of the central area have a more widespread and complicated pattern of outcrop than in either area (1) or area (3).

In this area the trend of the strongly banded gneiss  
 2 R varies from east-west in the vicinity of Shonikanu Peak  
 1 X (sheet 2), to north-south near Matenda dip (sheet 2). The  
 attitude of the gneissic foliation varies from vertical to  
 a steep north-easterly dip.

In this central area the shape of the strongly banded  
 gneissic bodies is again that of large lenses  
 approximately 6,000 metres by 1,000 metres, the longer axes  
 of which are parallel to the foliation.

In the strongly banded gneisses of this area, large  
 second generation structures are much more common than in  
 either of the other two areas, the most obvious fold of this  
 3 R type is exposed 3,000 metres to the south of Shonikanu Peak.  
 At this locality a large scale closure of the gneissic  
 banding has been mapped, the "half wave-length" of this fold  
 measuring some 2,500 metres whilst the amplitude of this  
 fold remains unknown since no inflection occurs in either  
 limb. This structure is a mixed **parallel**-similar styled  
 fold whose axial plane has an east-west trend and axial  
 plunge ~~that~~ has been calculated as approximately vertical.

To the north of the Jenya fault in the vicinity of



2 W Domchibi School (sheet 2) a series of complex, second generation structures have deformed the large mass of strongly banded gneisses that crops out here. The original isoclinal closures of the gneissic banding that had north-west, south-east trending axial planes that dipped steeply towards the north-east, have been refolded about west-north-west, east-south-east trending, **parallel** styled second generation folds. The axial plunges of these later folds are of the order of fifty degrees towards the south-east.

Occasionally the strongly banded gneisses of this central area have a gradational contact with the adjacent banded gneisses e.g. north-east of Matenda Daip (sheet 2), but far more commonly the junction between these two rock types is in the form of a sharp discontinuity, both in lithology and the orientations of the gneissic banding.

Examples of such a discontinuity in trend between the foliation of the strongly banded gneisses and the underlying banded gneisses of a more granitic composition are most obvious at localities: 1,500 metres north-west of Bengwe Dip (sheet 2), 3,000 metres to the south-east of Wande Dip (sheet 2) and 3,000 metres to the south-east of Siku School (sheet 2).

9 W (3) The Lundi/Msebaise Confluence.

Msebaise = *Msebaise*  
 Msebaise = *Msebaise*  
 J.D.B.

In this third area of strongly banded gneissic rocks, a large mass of gneiss in the form of a synformal, north-east, south-west trending lobe has been buckled about a north-

west, south-east axis. The length of this lobe is from 25,000 metres to 30,000 metres, and its width increases southwards from just over 1,5000 metres in the north to 11,000 metres in the south.

As this synformal mass of rock is traced southwards the intensity of granitization and the occurrences of a concordant arterite variety of migmatite increases, so that the sedimentary horizons of banded ironstone and chloritic schists that **can**

be distinguished in the north, become metamorphosed beyond recognition as they are followed southwards along their strike.

This north-west south-east trending synform shows the clearest gradational change, from original sedimentary rocks into strongly banded gneisses, that is to be seen in the Shabani area. Unfortunately the key area in this transition has been invaded by stocks of the Mushandike Granite causing the strongly banded gneisses to become migmatites by the intrusion of leucocratic veins parallel to the gneissic banding.

The strongly banded gneisses of this region have a northern termination against the Jenya Fault, and they are suspected of continuing on the eastern adjacent sheet that has been mapped by Dr. J. Wilson of the Rhodesian Geological Survey.

The southern termination of this synformal structure is in the form of a gradational contact between interdigitated

bands of concordant actinolite and strongly banded gneiss. This contact has been further complicated by a later folding about north-south trending, vertical axial planes.

$\beta_3$  (b) The Banded Gneiss.

In order to simplify the discussion of the banded gneiss it has been found convenient to divide the area into the same three divisions as those made in the discussion of the strongly banded gneiss.

(1) West of The Great Dyke.

In this first locality the banded gneiss is the most widespread rock-type that occurs, forming a blanket-like feature structurally above the granitic gneiss and upon which the strongly banded gneiss and basement schists rest in synformal structures. The general trend of the gneissic foliation is north-west, south-east, swinging around to a north-south trend towards the south of this area. The attitude of the foliation is at all times steep, approaching vertical. There is in this locality an intimate association between the strongly banded gneisses and the banded gneisses, the foliation of these adjacent rock-types being parallel, and their contact is at all times gradational.

Although the banded gneisses have been folded around closures of basement schists, there is no close parallelism of the foliation of the two lithological units and so it must be assumed that the banded gneisses underwent a deformation before the folding of the basement schists.

## (2) The Central Area.

In this area the foliation of the banded gneisses is again parallel to that of the overlying strongly banded gneisses and subparallel to the contact of the banded gneiss and the underlying granitic gneiss. The general trend of this foliation is north-west, south-east having a very steep to vertical dip, and the structures found in these rocks are very similar to those found in the adjacent banded gneiss.

## (3) The Lundi/Msobaise Confluence.

In this last area the banded gneiss has the form of a sheath around the structurally higher strongly banded gneiss, and through which 10,000 metres to the north-east of the **8A-C** Lundi/Msobaise confluence dome-like projections of the underlying granitic gneiss are visible.

The general structural form of the banded gneiss in this area is that of a large synform trending north-south, having a vertical axial plane and an approximately horizontal axial plunge. To the east of the Lundi/Msobaise confluence, and to the north-east the eastern limb of the synform turn **9-15** over steeply into a similarly orientated antiformal structure **AB** over the dome-like occurrences of the granitic gneiss, before dipping eastwards under a further exposure of the strongly banded gneiss.

$\beta_1 - \beta_2$  (c) The Skialithic and Schlieren Gneiss.

This lithological division has only been distinguished as a separate rock type to the north-west of the Great Dyke, sheet 1, and it is only in this area that a boundary between the skialithic and schlieren gneiss and the structurally higher banded gneiss is sufficiently sharp to allow distinction on the scale of the 1:50,000 map.

The form of the skialithic and schlieren gneiss bodies of this north-western area are north-west and north-east trending antiformal structures, protruding through the overlying gneiss.

In the eastern and central areas the skialithic and schlieren gneiss is present as small enclaves within the banded gneiss, into which they have a gradational transition, i.e. 15,000 metres to the south-west of Domchibi School, sheet 2.

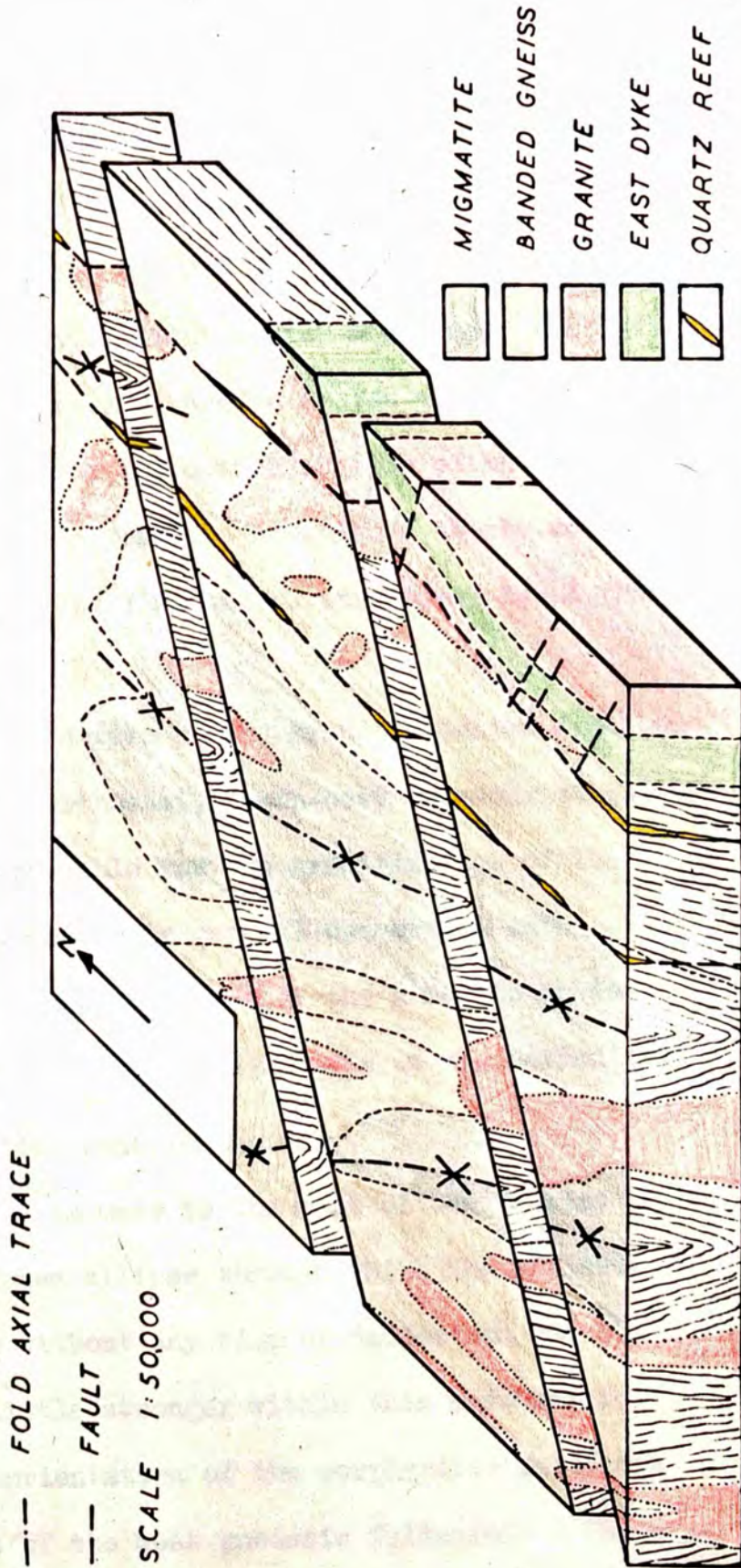
$\beta_0$  (d) The Granitic Gneiss.

The granitic gneiss is by far the most widespread lithological division of the Basement Gneisses, and exposures of this rock type are found on each of the four 1:50,000 sheets.

The form of the granitic gneiss outcrops vary in each area, in the north eastern area the granitic gneiss has an intimate replacement relationship with the structurally higher banded gneiss. The contact between these two rock types is heavily sutured as the granitic gneiss is interdigitated

**Fig. 4**  
**DIAGRAMMATIC REPRESENTATION OF THE STRUCTURAL FORM**

**OF THE MUSHANDIKE GRANITE**



into the banded gneiss, each of the fingers having a parallel orientation to the gneissic foliation, i.e. north-west, south-east.

As the granitic gneiss outcrops are examined southwards, the form of these bodies gradually increase in their extent until in the south-western area the granitic gneiss is a large blanket-like cover within which rest small, elliptically shaped, synformal masses of banded gneiss and Basement Schists.

It is thought that the differing form of the granitic gneiss outcrop pattern from the north-west to the south-east is due to a gradual lowering of the structural level that is exposed southwards.

The overall structure of the granitic gneiss division is one of a large north-west, south-east trending batholith that has been responsible for the granitization of the Basement Schists, and their partial conversion into Basement Gneisses, the foliation of the granitic gneiss is throughout, parallel to the longer axis of the batholith.

$\beta$ . (e) The Porphyritic Granitic Gneiss.

The form of this mass to the west of the "Schist Belt" is in plan an uneven ellipse through which the gneissic foliation passes without any sign of deflection and is perhaps even a little stronger within this porphyritic body due to the orientation of the porphyritic feldspars within the plane of the weak gneissic foliation. The size of this mass is approximately 6,500 metres by 3,000 metres,

the longer axis of the ellipse having a north-east, south-west orientation.

From the evidence of the feldspar phenocrysts (see pp 42-46, discussion on feldspar phenocrysts), this rock type was at some stage during its evolution at least partially fluid, and perhaps marks the beginning of a late stage mechanical movement of the granitic magma, before the final compression of the Basement Gneisses about north-east, south-west axes.

$\alpha_1$  (f) The Mushandike Granite, (Older Granite).

12-16 V-2 After an inspection of the outcrops of the Mushandike Granite, i.e. the south-east corner of sheet 2, the three dimensional exploded block diagram of the same area, and the plan of a migmatite exposure, several characteristic features of these granite masses become obvious:

(1). The granite is in a series of separate elliptically-shaped bodies, the axes measuring 1,600 metres by 400 metres, and having a smooth sharp contact with the adjacent gneisses.

(2). The longer axes of these ellipses have a tendency to be orientated in a north-west, south-east direction.

(3). The granite within these small bodies has a weak foliation due to the parallel alignment of the micaceous minerals, which is parallel to the longer axis of the elliptical shape and sub-parallel to the foliation of the adjacent gneisses.

(4). The zone within which outcrops of the Mushandike Granite has been located has a similar shape and orientation



to the individual masses of granite, i.e. a north-west, south-east trending ellipse.

(5). The small elliptically-shaped individual granite intrusions usually occupying synformal structures within the gneissic foliation (see fig. 4).

(6), In the field the granites may be seen to be cross-cutting to the gneissic foliation and responsible for the formation of late folds within this foliation, (see plan of a migmatite exposure).

From the evidence that is listed above it is concluded that the Mushandike Granite had a diapiric mode of emplacement, the intruded granite then being subjected to a compression about north-east, south-west axes.

It is concluded that the Mushandike Granite was emplaced towards the end of the migmatization of the north-south trending migmatite-gneiss trough in the vicinity of the  
 15X Lundi Bridge, Mashaba Road, and during the emplacement the area was under the influence of a north-east, south-west orientated stress system which has been responsible for the shape and orientation of the individual granite bodies and the weak foliation that is present within this older granite.

Since the orientation of the stress system in operation at the time of the Mushandike Granite emplacement is parallel to that which was active during the granitization of the basement rocks, it is thought that the Mushandike Granite

may represent the liquid fraction of the granitic basement gneiss, (and might be related to a parautochthonous-intrusive granite of H. H. Read's Granite Series).



(c) Folding and Ptygmatic Structures of the Pegmatite Veins

15X Within the Basement Gneisses of the Shabani area, and in particular in the vicinity of the Iundi Bridge along the Mashaba Road, there has been a repeated emplacement of acidic pegmatite veins which are commonly folded. The style of these folds is approximately 65 to 70 per cent **parallel** (Ramsay, 1962), the similar component of style increasing until it becomes dominant as the intrusions of the Mushandike Granite are approached.

The axial planes of these folds, where there is a sufficient development of the similar component of style to suggest such a structure, is always parallel to the gneissic foliation. The axial plunges of these structures is always steep, approaching vertical, suggesting that the pre-deformational attitude of the veins was steep, McBirney and Best, 1961. (See also: The Determination of the Minimum Deformation Ellipsoid). pp 188 - 206

The amplitudes and wave-lengths of these folds, although variable, appears to increase as the veins become thicker and closer to the occurrences of the Mushandike Granite.

The severity and type of deformation of the veins varies with their orientation to the gneissic foliation: those veins almost parallel with the gneissic foliation have been deformed into boudins, whose axes are usually either very steep or almost horizontal; those veins at right angle to the foliation have been deformed into folds of varying

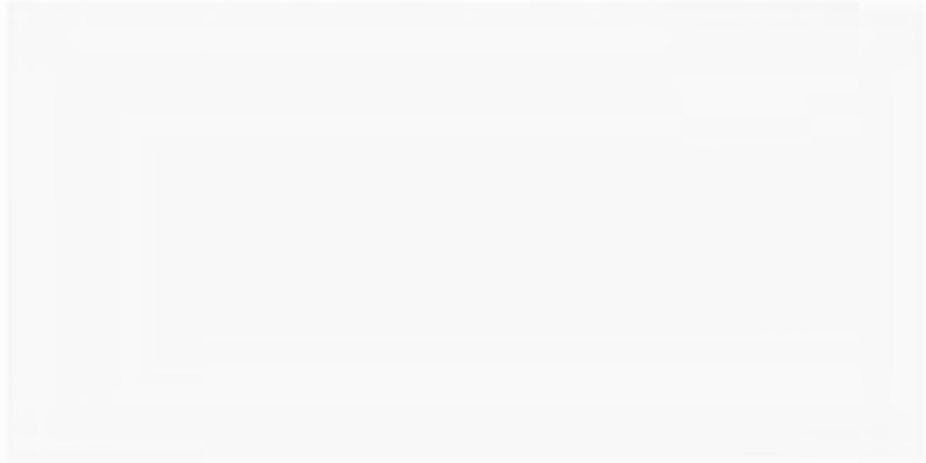
"tightness".

Since the term, *ptygmatic*, was coined by Sederholm in 1907, (p. 110), a thorough and extensive series of papers on the origins of these structures has been published. A brief selection of the more popular hypotheses are listed below:

- (a) Spreading and/or laminar flow, a possibility at the interface of immiscible liquids, (Sederholm 1926, Hills 1953).
- (b) Replacement-expansion flowage, by analogy with the hydration of anhydrite to gypsum, (Goldschmidt 1920), such conditions are not considered possible in migmatitic environments.
- (c) During metasomatism, (Turner and Verhoogen 1951).
- (d) Filling of tortuous fissures, (Read 1928), opposing faces of the veins should, but **do not**, have a similar shape.
- (e) Aberrant injection, (Suter 1924, Niggli 1925 and Wilson 1952), i.e. the injection of a material that is less mobile than the country rock.
- (f) Tectonic deformation, (Milch 1900, Sander 1914, modified by: Spurr 1923, Kuenen 1938, Goguel 1948, Godfrey 1954 and Ramberg 1952 and 1956).

From the observations of the folded pegmatitic veins at Shabani that have been given, it is clear that the ~~only~~ most probable explanation from those listed above for the

origin of these folds, is the last one, the one of tectonic deformation. The last explanation only, seems to satisfy all the observed features of the folded veins in this area.



1881  
The  
of this vein. The

(d) Structure of the Greenstone Schists

The lowest member of the greenstone group "The Lower Sedimentary and Volcanic Greenstones", suffered folding about north-west, south-east axes before the deposition of the Middle Sedimentary and Volcanic Greenstone Group. The most widespread and indisputable evidence for this event is to be found in the adjacent southern area that has been mapped and described by Dr. B. G. Worst, 1956, "The Geology of the Country Between Belingwe and West Nicholson". The only clear evidence for a deformation before the deposition of the rocks of the Middle Sedimentary and Volcanic Greenstone Group that is found within the area presented, is the angular nature of the unconformity between the Lower and Middle Sedimentary and Volcanic Greenstone rocks, and the intimate folded contact between the Basement Gneiss and the Lower Sedimentary and Volcanic Greenstones.

The rocks of the "Middle Sedimentary and Volcanic Greenstone Group" occupy a north-south trending belt that increases in width, from approximately 3,000 metres in the north (sheets 1 and 2), to 24,000 metres in the south (sheets 3 and 4).

Within this "V"-shaped belt of greenstone rocks the bedding of the stratified horizons are seen to have a very steep inward dip, the dip becoming almost vertical towards the central axis, and closing northwards around the centre of this belt. The plunge of these large closures is at

all times very steep, (approximately 70 degrees in a southerly direction).

The rocks of this "Greenstone Schist Belt" also contain a very prominent cleavage that is almost vertical, and parallel to the synclinal axial trace.

From such evidence as: inward dipping bedding planes, closure of beds around the central axis, the repetition of strata about this central axis and the bedding-cleavage relationships, the structure of the Greenstone Schist Belt is easily demonstrated to be synformal.

Clear evidence of graded bedding on cleavage planes, and other younging and facing criteria allow the further elucidation of this structure as being an "upward facing" syncline, Shackleton (1958).

South of the Belingwe-Shabani Road (sheet 3), the appearance of horizons of a higher stratigraphic level suggest a deepening of the syncline southwards.

The occurrence of small folds on the limbs of this large synclinal structure, "drag folds" of Leith (1923), Nevin (1949), Billings (1954), "parasitic folds" of De Sitter (1958), are rare, but where they are seen they have a similar style, axial planes that are parallel to the axial plane of the major syncline, i.e. parallel to the main cleavage, and a steep or vertical plunge towards the south.

The description of early folds having axes that plunge

at a high angle to the plunge of the major structure in which they occur is by no means new, see Clifford et. al. (1957), Ramsay (1958, 1963), Fleuty (1961), who describe structures in the Glen Orrin and Loch Monar Regions of the Northern Highlands of Scotland. In the above examples it is postulated that the minor folds are not syn-genetic with the development of the major structure.

In the Shabani area the axial planes of the minor folds are parallel to the axial plane of the major structure. Since the axial plane is the only geometric feature of a fold that bears any relation to the stress system producing it, (see McBirney and Best 1961), it is considered that the major structure and these minor folds which it contains, originated at the same time.

The rocks of the Upper Sedimentary Group, the youngest sedimentary rocks found in the Shabani area, are preserved in the core of the "Schist Belt" syncline, south of the Belingwe-Shabani Road. The trace of the trough surface (Ramsay 1967, pp. 355) along the ground of this central core has a very slight oblique orientation to the trough surface of the Middle Sedimentary and Volcanic Greenstone syncline, and from this evidence it is concluded that the deformation of the synclinal "Schist Belt" commenced before the deposition of the Upper Sedimentary Group.

Within the rocks of the Middle Sedimentary and Volcanic Greenstone Group and Upper Sedimentary Group, there are



two types of linear elements; a spindle-like fracturing of the rocks, and an elongation of particles of known original shape.

The tuffs and ashes of the greenstone rocks characteristically weather into spindle-like rods that are contained within the plane of the cleavage. The axes of these rods have a very steep plunge that tends towards the vertical. The division of the rock into spindles is apparently due to the intersection of the cleavage with a set of undulating, impersistent and near vertical partings that are present within these tuffaceous rocks.

The direction of elongation of particles of known original shape is another linear element within the schist belt. Such objects are accretionary volcanic lapilli of the Middle Sedimentary and Volcanic Greenstone Group and deformed pebbles of a conglomerate in the Upper Sedimentary Group (see plate XVIII).

Since these two linear features are in general parallel, it is suggested that they both represent the direction of tectonic transport, i.e. the "a" tectonic axis, and this direction has remained constant throughout the major synclinal deformation of the Middle Sedimentary and Volcanic Greenstone Group and the Upper Sedimentary Group.

At the northern termination of the Middle Sedimentary and Volcanic Greenstone Group, the synclinally folded bedding planes and the axial-plane cleavage of this syncline may be

seen to turn westwards, through 180 degrees, in the style of a concentric fold. The plunge of this fold-like structure is southwards at approximately 75 to 80 degrees.

Unfortunately, the form of this structure is complicated by the intrusion of a stock of the Younger Granite which causes amphibolitization of the adjacent greenstones and obscures any trace of original bedding surfaces, and the occurrence of north-south trending wrench faults giving rise to a local strain-slip cleavage and the development of small, chevron style, folds.

In the adjacent basement gneisses, there is no equally tight bending of the metamorphic banding around this concentrically styled swing in the overlying greenstone rocks.

Since there appears to be no plausible tectonic mechanism whereby such a structure could originate other than by the development of a nappe (for which there is no evidence), it is suggested that this westward swing in the northern greenstone "Schist Belt" has originated by the compression of a primary westward warp of the greenstone sedimentary trough.

This northern buckle of the beds and foliation of the "Schist Belt" has been further exaggerated by the development of north-south trending wrench faulting and the intrusion into the "Schist Belt" of a stock of the "Younger Granite".

Approximately 16,000 metres to the north-west of

Shabani, in the vicinity of the main outcrop of "Younger Granite", the adjacent "Schist Belt" has been warped into a large but gentle buckle, concave westwards.

The style of this buckle is **parallel**, the plane of symmetry of this buckle trends west-north-west, east-south-east and the crest plunges in a westerly direction at approximately 70 degrees.

The amplitude of this later buckle is estimated, (since only one half wavelength is present), at 11,000 metres, the half wavelength being of the order of 32,000 metres.

After examination of the "Lithological Map of Shabani Region", it is apparent that the zone over which the "Younger Granite" outcrops, is not only parallel to, but also coincident with, the axis of the later buckle of the "Schist Belt" syncline.

It is suggested that the later buckling of greenstone syncline has been brought about by the updoming of the gneisses and greenstones during the emplacement of the "Younger Granite".

The only other structures that are to be found within the greenstone "Schist Belt" are an infrequently occurring system of **parallel** style folds whose axial planes are sub-parallel to local wrench faulting, and the strain-slip cleavage planes that are associated with this faulting.

The clearest and largest example of folds which are associated with faulting is to be found at the eastern

termination of the Mchingwe fault (along the southern edge of  
27-30 sheet 4), where, as this structure dies out as a fracture  
P-T it passes laterally eastwards into a **parallel** fold.

(c) Faulting

The faults that have been mapped in the Shabani area and indicated as such on sheets 1 to 4, are fractures across which there is a displacement greater than (usually far greater than), 1 metre.

In this area the most distinctive features that are associated with faulting are: quartz reefs, parallel shear joints, splay faults, tension gashes and a second cleavage caused by the re-orientation of micaceous minerals in the rocks adjacent to the faults.

The quartz reefs usually form very distinctive features, recognizable on aerial photographs as very steep and narrow ridges, which on the ground prove to be composed of quartz and give rise to a widespread quartz float. The quartz reefs are usually narrow continuous lenticles, but may have the form of a separated series of pod-like masses, located along a common fault plane.

The quartz is either of a pure white variety, barren in ore minerals and referred to by the local miners as "buck reef", or as a blue-grey variety of quartz that may contain ore, but more usually is also barren.

To find exposures of "solid" quartz reef is rare unless recent trenching has been carried out, exposures usually being confined to surface "float".

There appears to be two main theories for the origin of this reef quartz:

(a) Deposition of the quartz from circulating solutions rich in silica, of an unknown origin, (Billings 1942).

(b) Mylonitization and recrystallization of blocks of country rock that have been included within the fault plane during the dislocation, (Read 1951), the few mafic constituents that would be present within the included blocks of the country rock, being caused to migrate outwards.

The appearance of exposures of the quartz reefs in the field are of an equi-grained, monomineralic and undisturbed quartz deposit, showing no obvious orientation of the quartz crystals, no partially or fully mylonitized fragments, nor do they show any systematic variation in grain size of the quartz crystals.

This appearance is continued in the microscopic fabric of the thin section, where medium grained crystals of quartz having only a small amount of strain shadowing are seen. At quartz/quartz boundaries there are occasionally small biotite crystals, but apart from these the rock is composed of pure quartz.

Adjacent to the fault planes in some of the better exposed localities there has been a secondary enrichment in the mafic minerals over a zone from 1.5 to 6 metres across. This mafic enrichment has been in the form of an irregular and fine network of green micaceous minerals, the principal of which is chlorite.

It is suggested that the origin of the quartz reefs of

the Shabani area are due to that mechanism postulated by Read (1951), the blocks of included country rock in the fault plane having suffered complete mylonitization and subsequent recrystallization, the mafic constituents having migrated into the adjacent country rocks.

There are occasionally found sigmoidally shaped tension gashes, infilled with quartz and described as feather joints by Cloos (1932), Wilson (1961). The best exposures of these gashes is in the bed of the Ngesi River south of the Shabani-Belingwe road bridge (sheet 3), (see **plate xxviii**).

2 2 K

A very similar feature, but on a much larger scale, is to be found to the north of the Mchingwe fault (sheet 3), where the sigmoidal gashes are infilled with dolerite, approximately 3,000 metres in length and ten to 15 metres in width.

23 F

|

26 L

On first inspection the large scale feather joints would appear to owe their formation to movement along the Mchingwe fault. If the sense of movement required to produce the tension gashes and the sense of movement along the fault are examined, it is found that the movements are inconsistent. The only explanation that satisfies the orientation and location of these feather joints is that they are located along a second order shear, (Ramsay 1962), in line with a smaller parallel fault that only becomes obvious as it is followed westwards where this structure causes a displacement of the Great Dyke.

To the west of the Great Dyke the Mchingwe Fault has been mapped by Mr. N. M. Harrison of the Southern Rhodesian Geological Survey, in his as yet unpublished Bulletin of the area "To the South of Fort Rixon". The Mchingwe Fault in this area outcrops over very poorly exposed ground, and the position of the fault has only been located by the frequent occurrence of small dolerite dykes that in this locality are found to make an angle of 65 degrees with the trend of the fault.

2 2 K Splay faults, similar to those described by Moody and Hill (1956), have been distinguished not only along wrench faults, but also along normal and reversed faults. In the bed of the Ngesi River 90 to 100 metres to the north of the Belingwe/Shabani road bridge, second, third and fourth order faults can be distinguished. The amount of throw decreases with the increasing order of the fault.

The second cleavage that is associated with faulting is most obvious in the areas of gneissic rocks where the first foliation is very weak. The development of this second cleavage in zones adjacent to the fault plane is often so strong that the overprinting of this second schistosity often results in the obliteration of the former cleavage.

It is suggested that in the Shabani area there are at least two fault systems, the first is a complementary system of wrench faults, having a small displacement and caused by a stress field whose major axis had a north-south orientation.



Plate XXVII.

Quartz reef along the Mchingwe Fault.

Plate XXVIII.

Quartz <sup>^</sup>/~~in~~filled tension gashes and kink bands in the vicinity of the Mchingwe Fault.



The second is composed of a complementary system of major wrench faults that have a dextral sense of movement and a west-north-west, east-south-east orientation. The length of outcrop of some of the members of this group is of the order of 65,000 metres the movement across the fault planes up to 8,000 metres.

The most obvious displacement across the Jenya Fault is that of a dextral sense of movement as illustrated by the displacement of the Great Dyke (sheet 1). In the Selukwe area however, Mr. C. W. Stowe records an earlier sinistral movement along this fault causing displacement of an earlier **Group** of migmatites.

The total displacement of this series of west-north-west, east-south-east wrench faults is best illustrated by the displacement of the Great Dyke, a north-north-east, south-south-west trending structure occurring across the whole of the area. The total displacement of this body in a sinistral sense is 1,600 metres and in a dextral sense, 6,800 metres, causing an overall dextral displacement of 5,200 metres.

Associated with the wrench faulting is a system of very well developed shear joints, parallel to the major shears and only developed in the granitic rocks.

Shear joints are perhaps best developed in the "Younger Granite" that outcrops to the east of the "Schist Belt", 16,000 metres to the north of Shabani along the Shabani-

13M Selukwe road where it crosses the "Schist Belt". At this locality the "Schist Belt" has suffered a dextral displacement of about 180 metres due to the effects of a complementary series of wrench faults and causing the "Schist Belt" to be completely "faulted out" for a distance of 800 metres along the strike (sheet 2).

After faulting a process of annealing, (the cold working of metallurgists) has taken place in the granitic rocks, yet no such mechanism has been found to operate in the more basic rocks.

The clearest indication of this is where a faulted dolerite dyke in the gneissic rocks has suffered displacement. When the fault plane is followed into the gneisses it is marked only by a zone of coarser grained leucocratic minerals.

limitations and assumptions of the determination of the minimum deformation ellipsoid within the Basement Gneiss.

- 1) The veins are assumed to have had an original random orientation. This seems reasonable when their post-deformational distribution on a stereographic net is examined (p.195).
- 2) The veins have behaved passively during the deformation of the gneiss. This is obviously not so since folding and boudinage of some veins has occurred but this is apparently of minor influence in the calculations involved (fig.6a-c, p.195).
- 3) Where veins are folded: (a) the attitude of the enveloping surface has been measured and used.  
(b) it is of course possible that only the long limb of a folded vein (whose attitude approaches that of the circular section of the determination ellipsoid) is measured. From the check applied (fig.6a-c, p.195) this again does not appear to be a serious limitation.
- 4) The major limitation of these measurements are that a limited depth of rock has been measured, controlled by the amount of relief of the gneissic pavement. This limitation is applicable to any geological field work, and in this particular instance seems to have little effect upon the general conclusions (fig.6a-c, p.195).

(f) Determination of the Minimum Deformation Ellipsoid in the Rocks of the Shabani Area

It is usual in discussing rocks that have undergone irrotational finite homogeneous strain (deformation), to invoke the deformation ellipsoid, a concept involving the deformation of an original and perhaps hypothetical spherical body of the rock. The principal axes of the deformation ellipsoid will be designated X Y Z.

Within the rocks of the Shabani area there appear to be at least three distinct periods of irrotational finite homogeneous deformation that are in need of elucidation, they are:

- (1) The deformation of the Basement Gneisses and Basement Schists.
- (2) The deformation of the Lower Sedimentary and Volcanic Greenstone Group within the Basement Gneisses.
- (3) The deformation of the overlying "Greenstone Schists", in particular the final deformation of the "Schist Belt" that has involved the youngest horizons of the Upper Sedimentary Group.

(1) The Basement Gneisses

The determination of the amount of deformation (the geometry of the deformation ellipsoid), in rocks deformed by irrotational finite homogeneous strain (Jaeger 1956, p. 23) is a relatively simple process if objects of a known original shape are present within the rock.

The only criteria that have been suggested that might bear any direct relationship to the amount of irrotational finite homogeneous strain that such gneissic rocks have undergone, are:

- (a) The shape and orientation of mineral grain fabrics, (Strand 1944; Flinn 1956).
- (b) The frequency of folds and the distribution of their axes on a stereographic plot (Flinn 1962, p. 407).

Unfortunately both of the above criteria have been found unsuitable in estimating the amount of strain that the Basement Gneisses have undergone, both from theoretical considerations and from observations in the field:

The suggestion that the fabric shape is representative of the amount of strain that the rocks have undergone is based upon the premise that the mineral grains have deformed either in accordance with Riecke's Principle, or by such a mechanism as Nabarro-Herring diffusion, (two almost identical processes which allow the minerals to deform in a manner similar to irrotational finite homogeneous deformation). Such deformation would cause each individual mineral grain to acquire **diameters** that **are** inversely proportional to the stress, i.e. each mineral grain would become an individual deformation ellipsoid.

Although there is a very well developed fabric shape in the quartz and hornblende minerals of the Basement Gneisses of the Shabani area, the proportional values of the

major and minor axes of the elliptical mineral sections, which have at all times a similar orientation, are far from constant.

These variations in the fabric shape appear to be caused by:

- (a) In a monomineralic band; the width of the band, the wider the band the larger the grains.
- (b) In a non-monomineralic band; the composition of the adjacent minerals, one mineral in contact with a mineral of a different composition will have a different rate of growth to that same mineral in contact with a mineral of similar composition. (Minerals of differing composition have differing properties of interfacial tension, Smith 1948, 1952).
- (c) The location of the minerals within the exposure. The proportional values of the major and minor axes of the elliptical mineral sections of minerals of a similar composition vary over distances of 1 metre or more. The cause of this variation appears to be zones of differential deformation throughout the exposure, which are either the cause or the effect of the rock being rich in mafic minerals.
- (d) A late fracturing of the minerals has been accompanied by a secondary recrystallization and grain boundary migration, so preventing an accurate determination of the axial values of the original elliptical mineral section.



Similar observations to (a) and (b) above have been made by Voll, 1960, p. 528, and (c) would seem to suggest that the deformation is far from homogeneous over distances greater than 1 metre.

If the frequency of folds and the distribution of their axes on a stereographic plot is to be regarded as an indication of the deformation path "k", (Flinn 1962, p. 407), then any folds present within the rock must owe their origin to the folding of what were originally curved surfaces, and so presumably, would be very few in number.

Since the profiles of the folds that are found within the gneisses of the Shabani area have a **parallel** component of style, it is concluded that these folds are the result of an initial deformational process other than irrotational finite homogeneous strain.

McBirney and Best, (1961, p. 495), have demonstrated experimentally that such folds are generated with their axial planes normal to the maximum compressive stress, and so the axes of these folds would be contained within the plane that contains the intermediate and minor axes of the stress ellipsoid.

Any conclusions that are drawn from the frequency and orientation of fold **axes** as to the value of the deformation path "k", are therefore highly questionable.

It is suggested that the most reliable method of determining the form of the deformation ellipsoid, is by

measurement of the severity of rotation of what were originally randomly orientated planes (poles to planes), In the gneisses of the Shabani area use has been made of a series of **acid** pegmatite veins in order to determine the **form** of the deformation ellipsoid.

Approximately 16,000 metres along the Mashaba Road from 15X Shabani, at the Lundi River bridge, a pavement of gneiss exposed in the bed of the Lundi River is cut by numerous acidic pegmatite and aplite veins, these **veins** have **at** least seven ages of emplacement.

The veins have been both folded and boudinaged; those at a high angle of incidence to the gneissic foliation being folded much more tightly than those at a low angle, which tend to form boudins.

There appears to be some correlation between the thickness of the vein and the wave-length of the fold (compare Ramberg, 1960 and 1963) and between the thickness of the vein and the size and frequency of the boudins, i.e. the thicker the vein, the larger the wave-length of the fold, the larger the boudins and the greater the boudin separation.

The style of the pegmatite folds is principally **parallel** but with a noticeable component of similar style, suggesting an axial plane to these structures, the axial planes of all folds are parallel to the gneissic foliation and the plunge, where discernible, is very steep, approaching vertical.

There is no correlation between the severity of deformation (tightness and frequency of folds), and the relative age of emplacement of the pegmatite veins, and so the deformation of the veins must have been after the final period of vein emplacement.

The majority of boudin axes are nearly vertical in attitude and are contained within the gneissic foliation, a few of these axes are almost horizontal suggesting that the rock has a deformation path ("k"), equal to or slightly less than 1, (Flinn 1962, p. 405).

By plotting a large number of what were originally randomly orientated linear (or the poles to planar) elements, it is possible to determine the values and orientations of the three principal axes of the deformational ellipsoid from the concentration of these linear elements.

Five hundred poles to pegmatite veins have been plotted and presented in fig. 5a-5b. The distribution of these poles is in the form of a single elliptically shaped maximum and not, as might be expected, in up to seven separate concentrations to correspond to the seven relative ages of vein emplacement.

This single elliptically shaped concentration of fig. 5b is easily recognised as the plot of a series of regularly spaced radii of a sphere that has been deformed into a bi-axial ellipsoid. Similar concentrations, some of which have been contoured, are represented in: Ramsay 1967, fig. 4-21, pp. 154-155, fig. 4-28, p. 163. fig. 4-29, p. 164, and

Flinn 1962, fig. 6, p. 406, figs. 8-14, pp. 410-413.

The three possible explanations of this single concentration are:

- (a) The pegmatite veins were emplaced in their present orientation in accommodation to the gneissic foliation.
- (b) The pegmatite veins were, during the deformation, rotated into their present attitude from an original (random ?) orientation.
- (c) A combination of (a) and (b) above.

A weak foliation within the pegmatites sub-parallel to the gneissic foliation, the folding of veins having a high angle of incidence to the gneissic foliation, and the boudinage of those veins having an almost parallel orientation to the gneissic foliation, suggest that it is highly unlikely that the veins were emplaced in their present attitude.

A single concentration of the poles to the pegmatite veins suggests that there was no preferred orientation of the veins at the time of their emplacement, especially since seven relative ages of emplacement have been determined.

As there is no correlation between the age of the veins and their severity of deformation, it does not seem likely that the veins have been emplaced during the deformation.

The strongest evidence supporting the rotation of the veins into their present attitude is found where a vein, having a high angle of incidence to the gneissic foliation, cuts a vein whose orientation is almost parallel to that of

the foliation of the gneisses.

As the path of the first vein is followed from the gneiss into the second vein, its angle of incidence to the gneissic foliation decreases, in one instance from 50 to 11 degrees. This decrease (an apparent refraction) is due to the vein in the incompetent gneiss suffering rotation during the deformation, whilst the vein in the more competent second pegmatite suffers only the minor rotation that is undergone by its host vein.

The above relationship is diagrammatically represented in fig. 6a, 6b and 6c, in which the original undeformed length of the square is made to equal 1 unit.

$$\frac{a}{1} = \tan 11, \quad \therefore a = 1. \tan 11$$

The area of triangle xyz =  $0.5 \cdot 1 \cdot \tan 11$

From fig. 6c;

$$\frac{b}{\Lambda} = \tan 50,$$

$$b = \Lambda \cdot \tan 50$$

Since constant volume is assumed during the deformation:

$$0.5 \cdot 1 \cdot \tan 11 = 0.5 \cdot \Lambda \cdot b \quad (\text{Since } b = \Lambda \cdot \tan 50, \text{ fig. 6c})$$

$$\tan 11 = \Lambda^2 \cdot \tan 50$$

$$\Lambda^2 = \frac{\tan 11}{\tan 50}$$

$$\underline{\Lambda} = \underline{0.4038} \quad (+ \text{ an estimated } 0.005)$$

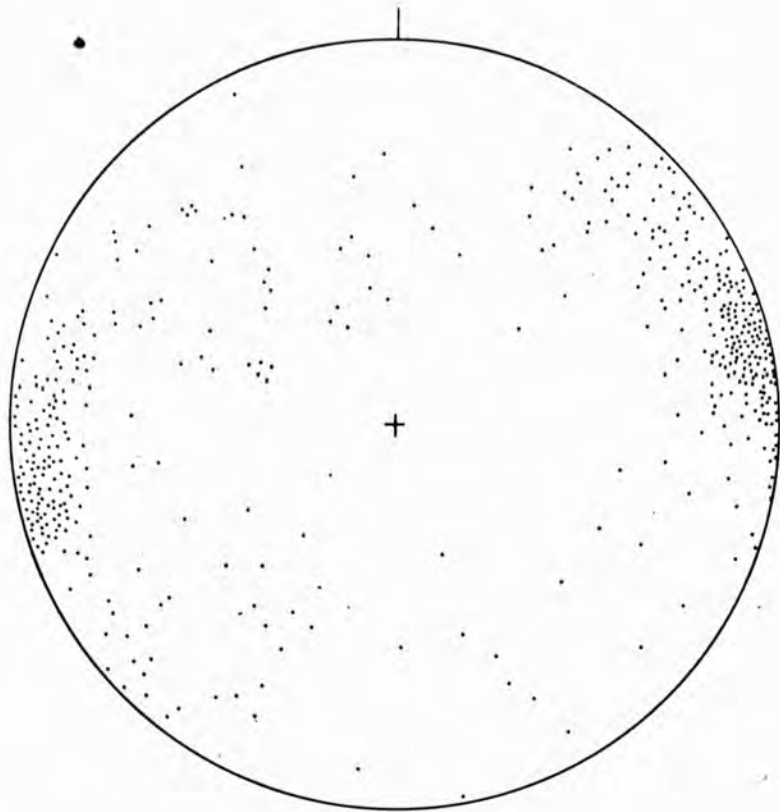


Fig.5a 500 poles to pegmatite veins.

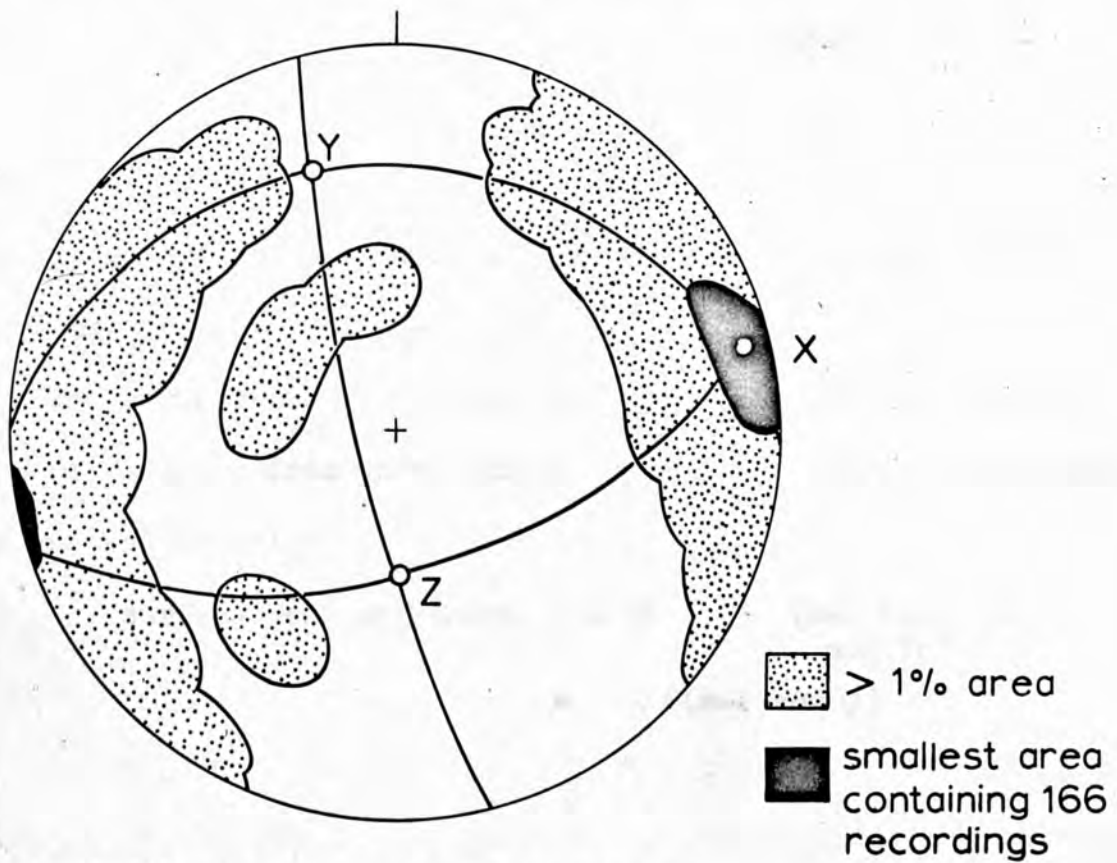


Fig.5b The above plot contoured.

This suggests that an undeformed length of 1 unit, orientated parallel to the maximum compressive stress, has suffered shortening during the deformation to a length of 0.4 units.

If we consider a sphere of rock, of unit radius, in which there are three axes at right angles, A, B and C (fig. 7a), and we allow numerous randomly orientated diameters to pass through this sphere then: the simplest surface shape about any point on the surface of the sphere that contains 1/6th of the area, (and so 1/3rd of the randomly orientated diameters), is a circle.

Now if we allow this point to coincide with the intersection of the C axis and the surface of the sphere, then the circular area described about the C axis is really the circular section of a cone whose point of origin is the centre of the sphere and whose axis of symmetry is coincident with the C axis.

The angle of the cone that includes 1/6th. of the surface area of a sphere from whose centre it originates is derived from the general formula:

$$\begin{aligned} \text{surface area of sphere} &= 2 r h && \text{(see figs. 7a,} \\ & && \text{and 7b)} \\ &= 2 r(r-r \cos \varphi) \end{aligned}$$

and so 1/6th. of the surface area =

$$\frac{2 r^2}{6} = 2 r^2 (1 - \cos \varphi)$$

$$\frac{1}{6} = 1 - \cos \varphi$$

$$\cos \varphi = \frac{5}{6}$$

$$\varphi = 33 \text{ } 33'$$

If this sphere is now subjected to irrotational finite homogeneous deformation, at constant volume, the resultant object will be an ellipsoid of fig. 7c, the principal axes of which X, Y, Z, are parallel to the axes of the sphere. The smallest surface area of the ellipsoid that now contains 1/3rd. of the originally randomly orientated diameters will be a cone of elliptical section whose axis of symmetry is coincident with the Z axis of the ellipsoid, (fig. 7c).

From the contoured stereographic plot of poles to pegmatite dykes, fig. 5b, the smallest area containing 1/3rd of the recordings has an elliptical shape (cross-section of an elliptical cone) whose major and minor angular measurements between the edges of the cone and its axis of symmetry, (the Z axis of the ellipsoid), are 10 degrees and 7 degrees 30 minutes, i.e. the angles subtending lengths b' and a' of Fig. 7c.

As constant volume deformation is being considered, and for the sake of mathematical simplicity, the change in shape



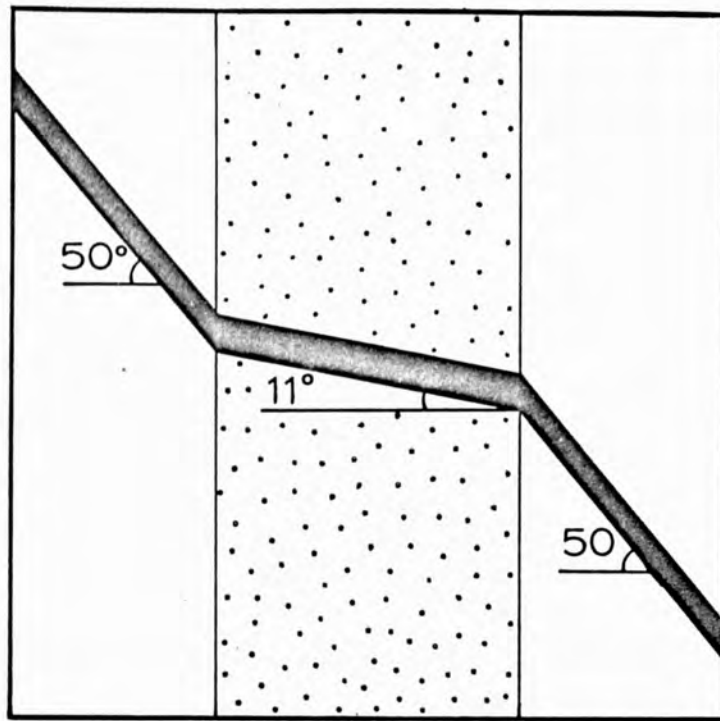


Fig. 6a Diagrammatic representation of two intersecting pegmatite veins.

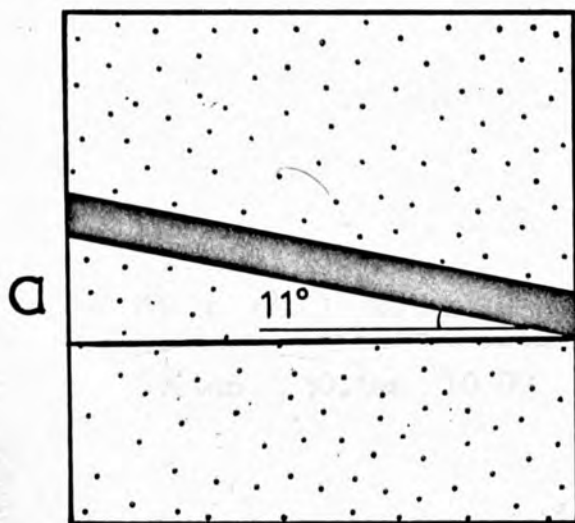


Fig. 6b.

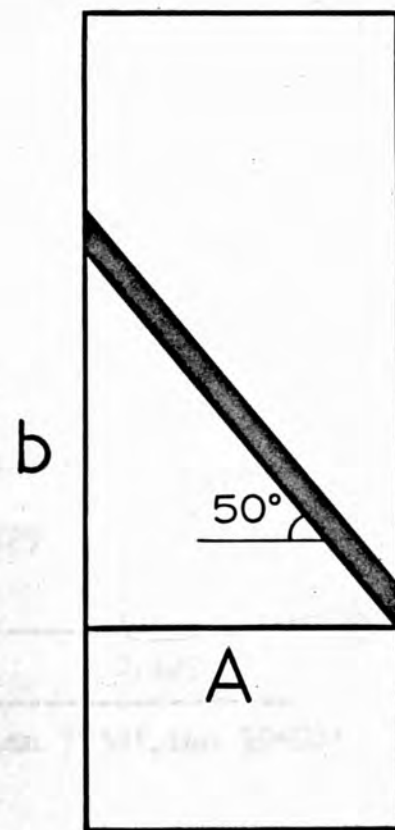


Fig. 6c.

of the rectangular solid forms:  $r, a, b$  (fig. 7a) to  $a', b', Z$  (fig. 7c) will be calculated.

From fig. 7b, since the angle  $\varphi = 33^\circ 30'$ ,

$$\frac{a}{r} = \tan 33^\circ 30'$$

$$a = r \tan 33^\circ 30'$$

$$\underline{\underline{a = 0.655}}$$

and so the volume of the solid rectangular form:  $a, b, c$  ( $a, b, r$ ) of fig. 7a, equals  $0.655 \cdot 0.0655 \cdot 1 = 0.429$  cubic units.

After a constant volume deformation this same volume is bounded by the edges  $a', b', Z$ , and so  $a', b', Z = 0.429$

$$\frac{a'}{Z'} = \tan 7^\circ 30'$$

$$a' = Z' \cdot \tan 7^\circ 30'$$

$$\frac{b'}{Z'} = \tan 10^\circ 00'$$

$$b' = Z' \cdot \tan 10^\circ 00'$$

and so  $Z' \cdot \tan 7^\circ 30' \cdot Z' \cdot \tan 10^\circ 00' \cdot Z' = 0.429$

$$Z'^3 \cdot \tan 7^\circ 30' \cdot \tan 10^\circ 00' = 0.429$$

$$Z' = \sqrt[3]{\frac{0.429}{\tan 7^\circ 30' \cdot \tan 10^\circ 00'}}$$

$$\underline{\underline{Z' = 2.6148}}$$

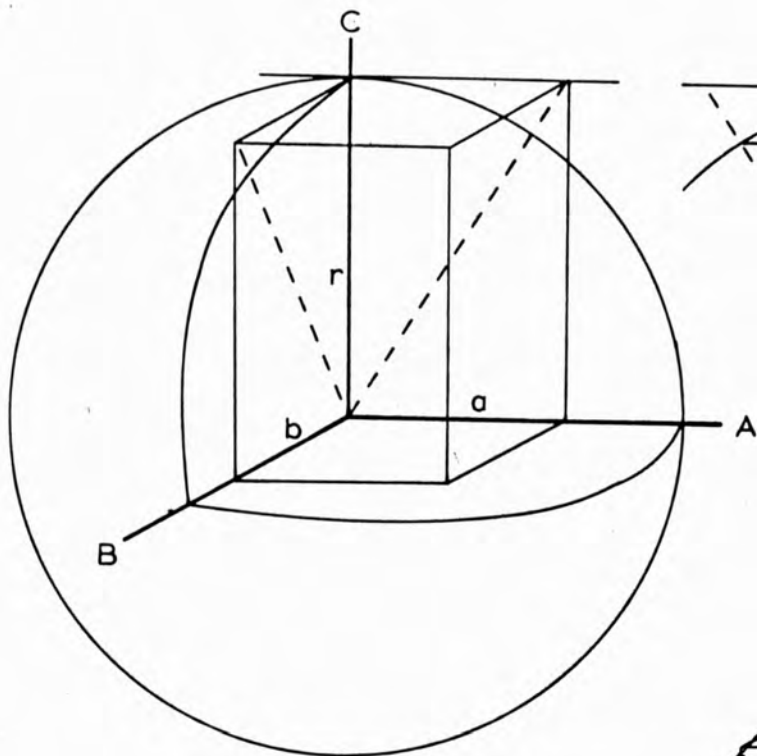


Fig. 7a.

Development of the  
deformation ellipsoid.

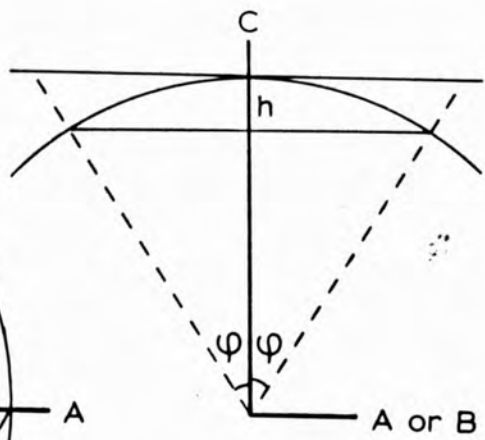


Fig. 7b

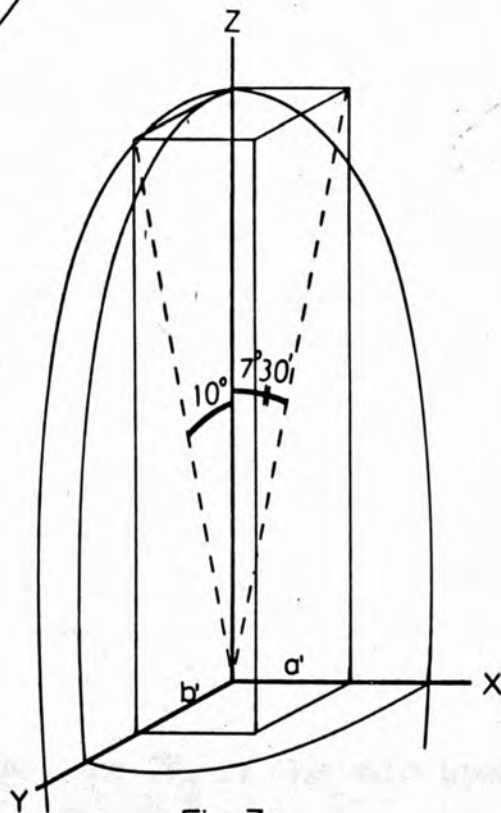


Fig. 7c.

From simple trigonometry:  $b' = 0.467$

$$a' = 0.347$$

$$(0.467 \cdot 0.347 \cdot 2.647 = 0.429)$$

Since the distance  $a$  of fig. 7a is 65% of the  $\Lambda$  axis, it follows that the lengths  $b'$  and  $a'$  of fig. 7c are 65% of the values of the X and Y axes, and so:

$$\underline{\underline{X = 0.529, Y = 0.713, \text{ and } Z = 2.615}}$$

An important property of a bi-axial ellipsoid is the angle between the poles to the two circular sections, this angle is referred to as  $2V$  by mineralogists considering the optical indicatrix, and it is common practice to measure this angle over the  $Z$  axis, i.e.  $2V_Y$  . ( $2V_Z$ )

The standard formula for the calculation of  $V_Y$  , given by Wahlstrom (1951, p. 145) is:

$$\tan^2 V_Y = \frac{1/\alpha^2 - 1/\beta^2}{1/\beta^2 - 1/\gamma^2}$$

Flinn, (1962, p. 388, equation (1) ). by substituting  $a$  and  $b$  for  $Z/Y$  and  $Y/X$ , derives the formula:

$$\tan^2 V_Z = \frac{a^2 (b^2 - 1)}{a^2 - 1}$$

From either of the above formulae, the  $2V_Z$  of the calculated minimum deformation ellipsoid of the Basement Gneisses at the Lundi Bridge locality is  $167^\circ 48'$ .

The deformation path, "k", (Flinn, 1962, p. 388), is given by the formula:

$$k = \frac{a - 1}{b - 1} = \frac{X(Z - Y)}{Y(Y - X)} = 7.8$$

A sphere of unit radius, contained within the Basement Gneisses of the Shabani area, would after deformation, have changed shape into a bi-axial ellipsoid with the properties:

Principal axes;       $X = 0.529$  units

$Y = 0.714$  units

$Z = 2.616$  units

$a = \frac{Z}{Y} = 3.664$

$b = \frac{Y}{X} = 1.350$

"Optic" angle;       $2V_Z = 88^\circ 40'$

Deformation path;       $k = 7.8$

**Sample Size = 500**

-----

## (2) The Lower Sedimentary and Volcanic Greenstone Group

In rocks that have undergone irrotational finite homogeneous strain the calculation of the minimum deformation ellipsoid is a relatively simple process **if** objects of a known original shape are present in the rock. When such objects had an originally spherical shape, then direct measurement of their post-deformational ellipsoidal shape is, in effect, a direct measurement of the minimum deformational ellipsoid.

Within the uppermost horizons of the Lower Sedimentary and Volcanic Greenstone Group there are present several specimens of accretionary volcanic lapilli, (chalazoidites), that have a bi-axial ellipsoidal shape. The principal axes of these ellipsoid have average lengths: 0.006 metres, 0.008 metres and 0.013 metres.

When the above lengths are recalculated from a sphere of unit radius the properties of the deformation ellipsoid are:

Principal axes;       $X = 0.702$  units

$Y = 0.936$  units

$Z = 1.521$  units

$a = \frac{Z}{Y} = 1.625$

$b = \frac{Y}{X} = 1.333$

Optic angle;       $2V_Z = 96^\circ 04'$

Deformation path;       $k = 1.875$

Sample Size = 27

---

### (3) The Upper Sedimentary Group.

Within the uppermost (youngest) horizons of the Upper Sedimentary Group there is exposed a strongly deformed conglomerate whose pebbles all have a similar bi-axial shape and orientation. The average principal dimensions of the pebbles are: 0.015 metres, 0.02 metres, and 0.03 metres.

When these dimensions are recalculated from a similar deformation of a sphere of unit radius, the properties of the deformation ellipsoid are found to be:

$$\begin{aligned} \text{Principal axes;} \quad X &= 0.726 \text{ units} \\ & Y = 0.966 \text{ units} \\ & Z = 1.450 \text{ units} \\ a &= \frac{Z}{Y} = 1.501 \\ b &= \frac{Y}{X} = 1.331 \end{aligned}$$

$$\text{Optic angle;} \quad 2V_Z = 98.08$$

$$\text{Deformation path;} \quad k = 1.494$$

$$\text{Sample Size} = 100$$

-----

In the gneisses at the Lundi River bridge there is an obvious discrepancy between the observed orientation of fold and boudin axes and those orientations predicted by Flinn 1962, pp. 404-407, including fig. 6, p. 406, where  $1 < k < \infty$ . However, as the pegmatite veins have deformed in part by a mechanism other than irrotational finite homogeneous flow, and the deformation path is only slightly greater in value than 1, (7.8), there appears to be a surprisingly close correlation between the observed and predicted orientations of structures, especially the orientation of fold axes.

In each of the other two examples where the deformation ellipsoid has been calculated, (The Lower Sedimentary and

Volcanic Greenstones and the Upper Sedimentary Group ), there is an unusually close relationship between the observed and predicted orientations of structures. There is however one apparent discrepancy, the folds that were formed only in the Lower Sedimentary and Volcanic Greenstones, prior to the deposition of the Upper Sedimentary Group appear to be equally tight structures (an equally severe deformation?) to those formed during the deformation of the Upper Sedimentary Group.

If this situation of two equally severe deformations is true, as it appears to be from the observed structures, it would be expected that it could be verified by the cumulative effect upon the earlier deformation ellipsoid. This is not so, both of the deformation ellipsoids have almost identical dimensions.

The only explanations for this situation are:

- (1). The deposits of the Lower Sedimentary and Volcanic Greenstone Group, after their lithification and first deformation, were unable to deform by irrotational finite homogeneous strain.
- (2) The deformation of the Upper Sedimentary Group was contained within a very localised vertical zone, the adjacent lithified deposits behaving, together with the Basement Gneisses as broad, open concentric folds, causing the constriction of the Upper Sedimentary Group within the Greenstone "Schist Belt", and its resultant defective style.



PART VI

GEOLOGICAL HISTORY OF THE AREA AND CONCLUSIONS

(a) History of Igneous, Metamorphic, Sedimentary and Structural Events.

The earliest recognizable event is the deposition of a sedimentary and volcanic ~~group~~ of banded ironstones and epidote amphibolite schists from which the metamorphic oldest Basement Schists have been derived. Since the lithology of this oldest Basement Schist group is similar to the amphibolitized rocks of the Lower and Middle Sedimentary and Volcanic Greenstone **Group**, it would seem reasonable to assume that the oldest Basement Schists had a sedimentary and volcanic origin.

The nature of the basement upon which these rocks were deposited is not determinable, but it is simpler to explain the later gneissic structures, on the assumption that the original surface was eroded across gneisses and migmatites.

After deposition and folding, the oldest Basement Schists were granitized with the development of, in part, banded gneisses, the banding having a north-west, south-east trend. The earliest structures found within these rocks are small, tight, isoclinal folds of a similar style. The axial planes of these structures are north-west, south-east parallel to the foliation, and have steep northerly to vertical plunging axes.

As granitization progressed, a later series of folds that deformed both the gneissic banding and the foliation developed. The style of these later folds is dominantly

similar, but with a large **parallel** component. The axial planes of these folds have a north-west, south-east trend and axial plunges that are either very steep, towards the north or vertical.

Because of their southward overturning, these folds have axial planes with a curved trend of outcrop and north-west, south-east trending crestal surfaces (Ramsay, 1967, pp. 356), and hinge lines that plunge steeply to the north-west.

The large folds have styles that suggest they are of a progressive deformational origin, (Flinn, 1958), i.e. a "refolding" of the axial plane about the same axis.

Areas of basement rocks become more granitic in composition towards the south-west, the folding becomes more drawn out and tighter (a more viscous mechanism of deformation, than is found in the north east), and the earliest structures that are visible are evidently the second generation structures of the gneiss to the north-east.

The next event in the complex history of this region, appears to be the deposition and granitization of a very similar lithological group, the Younger Basement Schists.

This group of rocks is composed of horizons that are identical in lithology to those of the earlier schists, but have suffered a later deformation into a series of large isoclinal folds that have north-north-east - south-south-west trending axial planes and vertically plunging axes. The difference in age between these two lithologically similar

groups of schists can be appreciated at no less than six localities, all to the north-west of the Great Dyke (sheet 1).

Basement schists of a very similar lithology and trend are to be found towards the east of sheet 2, in the core of a synformal lobe of strongly banded gneiss. The trend of the synform is slightly east of north and after allowance is made for later buckling (during the deformation of the greenstone "Schist Belt"), the original trend must have been north-north-east, south-south-west.

This belt of strongly banded gneiss can be traced into the adjacent area to the east ("Mashaba" sheet, Wilson, 1959), where the basement contains numerous north-south trending in folds of similar basement schists to those that have already been described. Here the basement schists have been designated the "Magnesian Series", one of the lithological divisions employed by the Geological Survey of Southern Rhodesia.

It is suggested that the north-north-east, south-south-west trending basement schist belts occurring in the west of sheet 1 and the east of sheet 2, belong to the same series.

After deformation these later (younger) basement schists, together with the earlier basement rocks, suffered a further granitization, involving reworking of the earlier schists and gneiss. The clearest example of this is the updoming and interruption of a north-west, south-east trending band of the earliest basement schist, 8,000 metres to the west of Kashambi Halt, (sheet 1), by a north-east, south-west trending

dome structure composed of skialithic and schlieren gneiss.

At some time before the intrusion of the Mushandike Granite, the deposition of the Lower Sedimentary and Volcanic Greenstone Group occurred and was later deformed about north-east, south-west trending axes.

This group of rocks is composed of sedimentary and volcanic greenstones, banded ironstones and a group of calcium carbonate rich tuffs, very similar in lithology to the rocks of the Younger Basement Schists.

It is possible that the rocks of the Lower Sedimentary and Volcanic Greenstone Group of the "Schist Belt" are contemporary with the rocks of the Younger Basement Schists.

Evidence that suggests this contemporaneity is:

- (1) Their lithological similarity.
- (2) The Lower Sedimentary and Volcanic Greenstone Group have, together with the Younger Basement Schists, suffered a strong deformation about north-east, south-west trending axes.
- (3) The Lower Sedimentary and Volcanic Greenstone Group and the Younger Basement Schists have both been intruded by a gneissic granite (the Mushandike Granite), and so are older than this granite.
- (4) In the basement rocks to the east of the "Schist Belt", (sheets 2 and 4), the Younger Basement Schists have a trend that if projected southwards is the same as that of the Lower Sedimentary and Volcanic Greenstone Group..

- (5) There is no evidence that the Younger Basement Schists have been deformed by a later deformation of the Lower Sedimentary and Volcanic Greenstone Group.

After the deformation and granitization of the Younger Basement Schists and the Lower Sedimentary and Volcanic Greenstone Group, the basement rocks were forcibly intruded by a series of granitic stocks, elliptical in shape, having a weak foliation, and causing the migmatization of adjacent strongly banded gneisses.

This older (Mushandike) granite was also the source of numerous intrusive and replacive aplite/pegmatite dykes. At least seven episodes of emplacement of these dykes have been determined.

The major stress axis at the time of forceful intrusion of this granite is suggested to have had a north-west, south-east orientation, (that is after a 50 degree correction, by the anticlockwise rotation of the basement rocks in the south-east of sheet 2 has been applied; which is necessary to compensate for the later deformation of the "Schist Belt").

During and just after the intrusion of the Mushandike Granite, the basement rocks suffered a further compression about a north-west, south-east axis resulting in the formation of tight folds of the gneissic banding and foliation, and also rotation and folding of the pegmatite dykes.

The deformation ellipsoid of the rocks of this area

15 X (south-east corner of sheet 2) has been calculated as having major axes of values:

$$X = 0.529, \quad Y = 0.714, \quad Z = 2.616.$$

The next event that has been determined in the geological history is the unconformable deposition, on the folded and weathered surface of the Lower Sedimentary and Volcanic Greenstone Group, of the Middle Sedimentary and Volcanic Greenstone Group.

The deposition of this second member of the "Schist Belt" was in a north-south trending trough, deposition of the sedimentary and volcanic sequence beginning in the south of the trough (sheets 3 and 4). The earliest member of the Middle Sedimentary and Volcanic Greenstone Group is a basal conglomerate followed by a thick banded ironstone and a grit horizon. Each of these three earliest members is much thicker and more persistent along the south-eastern limb of the syncline than at any other position within the syncline suggesting a much heavier and more continuous deposition in this south-eastern area.

This sedimentary sequence was interrupted by the outpouring of a basic lava in the south, the sedimentary derivatives of which spread northwards and now form the basal horizon of the northern "Schist Belt".

At the base of this sedimentary-volcanic horizon, 22 X opposite "Negesi Antimony" claims, accretionary volcanic lapilli have been discovered. Their present form is that of

triaxial ellipsoids, and since their formation the minimum deformation ellipsoid has been calculated as having axes whose ratios are:  $X = 0.702$ ,  $Y = 0.936$ ,  $Z = 1.521$ .

At approximately this period of the development of the north-south trending "Schist Belt" trough, there occurred the intrusion of the Shabanie Mine layered ultrabasic sill, and probably the other associated stocks and sills of dunite and serpentinite.

The rather exact timing of this event is based upon:

- (1) The layers of gravity-settled crystals in the sill have a westward dip 23 degrees less steep than the bedding planes of the adjacent "Schist Belt". Since the gravity settled layers must have been horizontal at their time of formation, it follows that the bedding planes of the "Schist Belt" must have had a westward dip of 23 degrees during the cooling of the sill.
- (2) An associated transgressive sill of serpentinite, approximately 4,500 metres north-west of Vukwe Peak (sheet 4), appears as though it has been planed off before the deposition of the main volcanic greenstone horizon.
- (3) No ultrabasic sills have been intruded into rocks that are younger than the lowest sedimentary greenstone horizons of the Middle Sedimentary and Volcanic Greenstone Group. The next stage in the sequence of the Middle Sedimentary and Volcanic Greenstone Group was the widespread out-pouring



of the main volcanic greenstone horizon, composed of pillow lavas, massive lava flows, volcanic breccias and tuffs. This volcanic greenstone along the eastern limb of the syncline thickens southwards and includes many elliptically-shaped masses of sedimentary greenstone, before it finally passes onto the southern adjacent area (the Belingwe Area, mapped by Dr. B. G. Worst, (1959)). This horizon along the western limb  
 228 of the syncline, wedges out 5,000 metres south of Dadaya Mission (sheet 3).

Although the next horizon of the "Schist Belt" is the last one that extends from the northern closure to the far south of the area, it is this bed that probably marks the real beginning of the southern deepening of the trough during deposition. As this northern core of sedimentary greenstone is traced southwards it splits into two members, one along each limb, as the closure of the younger volcanic greenstone appears in the core of the suncline. As the sedimentary greenstone passes southwards it also begins to thicken, from a vertical thickness of 900 metres in the north to some 3,000 metres in the south. This great thickening is also accentuated by beds of the siliceous greenstone becoming interdigitated with the sedimentary greenstone (within this horizon) as it is followed southwards.

The sequence of the Middle Sedimentary and Volcanic Greenstone Group is continued by another horizon of volcanic greenstone above which is a final horizon of sedimentary

greenstone, within which there is found a small discontinuous banded ironstone along the upper surface of the western limb.

The last two horizons that have been described are only found in the southern portion of the syncline.

At this stage in the development of the syncline there must have been a slight compression about an east-west axis before the beginning of the deposition of the Upper Sedimentary Group.

The presence of a rather unusual dome structure in the last horizon of sedimentary greenstone, west of the Upper Sedimentary Group (sheet 4) would be explained by a compression about an east-west axis before the deposition of the Upper Sedimentary Group.

Another feature that requires a similar tectonic event for its explanation is the slight obliquity of the axes of the depositional troughs of the Middle Sedimentary and Volcanic Greenstone Group and the Upper Sedimentary Group.

Before the deposition of the Upper Sedimentary Group there was the intrusion of a transgressive sill of gabbroic rock, west of the northern closure of the Upper Sedimentary Group (sheet 3); the upper surface of this sill had been "planed off" before the deposition of the Upper Sedimentary Group.

The Upper Sedimentary Group is a group of banded ironstones, silts, conglomerates and grits that occupy the core of the "Schist Belt" syncline (sheets 3 and 4). In the northern

closure of the Upper Sedimentary Group, beds of banded ironstone and grit are not conformable with the bedding of the adjacent silts and the style of the outcrops is suggestive of slumping of these beds whilst in an unconsolidated state.

24 P

After the deposition of the Upper Sedimentary Group there was the emplacement of a series of concordant and transgressive gabbroic sills which have a parting parallel to the "Schist Belt" foliation.

The main compression of the "Schist Belt" syncline must have taken place after the deposition of the Upper Sedimentary Group, since the rocks of the Middle Sedimentary and Volcanic Greenstone Group and the Upper Sedimentary Group have a common foliation.

From the evidence of deformed pebbles that are found in the Upper Sedimentary Group, the ratios of the major axes of the deformation ellipsoid, since the deposition of this Upper Group, have been calculated as:  $X = 0.726$ ,  $Y = 0.966$ ,  $Z = 1.450$ .

16 MN

The precise dating of the dolerite sill, (north-east corner of sheet 3), is rather uncertain. This sill intrudes into the rocks of the Middle Sedimentary and Volcanic Greenstone Group and has a poor parting, parallel to the "Schist Belt" foliation, suggesting an age of intrusion prior to the main "Schist Belt" deformation.

Since a series of dolerite sills was intruded into the rocks of the Upper Sedimentary Group before the main east-

west compression, it is suggested that the dolerite sill that occurs in the north-east corner of sheet 3 has a similar date of intrusion.

At some time after the deformation of the "Schist Belt" the "Younger Granite" was intruded, cutting straight across the bedding and foliation of the "Schist Belt" rocks. The greenstones adjacent to the contact of this granite have been metamorphosed up to the amphibolite facies.

The effect of this intrusion upon the basement gneisses is a slight warping of the gneissic banding, a low grade thermal metamorphism and the emplacement of late pegmatite veins in the adjacent gneiss within 90 metres from the granite/gneiss contact.

At some time between the deformation of the Younger Basement Schists and the emplacement of the Great Dyke of Rhodesia, the north-west, south-east trending Jenya Fault originated and had an initial sinistral sense of movement. The evidence for the sinistral sense of movement of the fault has been taken from the northern adjacent area around Selukwe (C. W. Stowe 1960) where a migmatized contact has suffered a sinistral displacement by this fault.

Because of the parallelism in trend of the Younger Granite intrusions and the axis of a late buckle in the synclinal

Sheet 5 "Schist Belt", (see map of the Shabani region) it is suggested that the emplacement of the granite caused the up-doming of the "Schist Belt" into an antiformal structure of parallel

style whose crestal trace trends north-west, south-east, and plunges steeply towards the north-west.

At some time after the intrusion of the Younger Granite, the Great Dyke of Southern Rhodesia was emplaced. The history of this intrusion is believed to be the same as that suggested by Dr. B. G. Worst, (1959), i.e. it originated as four, north-south aligned, connected lopoliths that have since been down-faulted into a graben structure.

After the emplacement of the Great Dyke a widespread fracturing of the basement rocks occurred in the form of numerous north-west, south-east trending dextral wrench faults.

The two faults across which there has been the greatest amount of movement are the Jenya Fault (sheets 1 and 2), 1,200 metres, and the Mchingwe Fault (sheets 3 and 4), 3,200 metres. The distance of separation of these two parallel fractures is approximately 48,000 metres. In the intervening area between these two large fractures there is a series of sub-parallel dextral wrench faults whose average displacement is 70 metres and average distance of separation 3,000 metres.

The cumulative dextral displacement of the Great Dyke (an older structure than the faulting) across the area is approximately 11,000 metres.

The Great Dyke appears to have acted as an inhomogeneity in the basement rocks during the faulting. The faults as they pass through the Great Dyke are "refracted" away from the "normal" to the "Dyke" margins.

If this phenomenon is compared to that of the passage of light through materials of differing refractive indices, it is similar to the path of a ray of light obliquely passing through a bar of lower refractive index.

At approximately this stage in the development of the area, a set of north-south trending vertical felsite dykes have been emplaced.

Associated with the dextral wrench faulting (second order shear directions, Moody and Hill, 1956), are a series of north-west, south-east and east-north-east, west-south-west trending, "en echelon" dolerite dykes.

This phase of dolerite intrusion was followed by the development of north-north-east, south-south-west trending, sinistral wrench faults, and the further development of, and movement along, already existing dextral north-west, south-east trending wrench faults.

The final events in the history of the area have been the erosion of the basement rocks into the 1,050 metre (3,500 foot) erosion platform, the development of ferricrete on this surface and the deposition of tufa from streams where their kinetic energy is greatly reduced.


(b) Conclusions

In the basement rocks of the Shabani area there has been a minimum of four tectonic events, each of which was accompanied by igneous activity in the form of intrusions of either acidic or ultrabasic magma.

The effect of these processes has been to involve the **supracrustal** deposits, in the form of tight similar styled synclines, within the basement rocks with the ultimate conversion of these deposits into granite.

Several stages in the formation of this ultimate granite can be inferred from the rocks of the Shabani area:

- (1) The deposition of basic volcanic and sedimentary rocks in troughs within the Archean basement.
- (2) An updoming of the adjacent gneisses into broad, **parallel** styled structures, the troughs being compressed into tight synclinal "Schist Belts", i.e. a dejective style of folding.
- (3) Conversion of the schists into gneisses by granitization.
- (4) Migmatization of the gneisses by the injection of lit-par-lit leucocratic veins (concordant arterities).
- (5) The gradual development of a pattern of leucocratic veins (cross-cutting arterites), which eventually becomes a diffuse network of leucocratic <sup>m</sup>aterial (nebulitic gneiss). The original mafic constituents of the rock "Disappear, as if by magic", (Sederholm 1926, pp. 138).

- (6) Development of a granitic gneiss, some of which had a true liquid character.
  - (7) Mobilisation of the granitic gneiss into intrusive granites.
- 



### Acknowledgements

The author would like to gratefully acknowledge the assistance afforded to him, and the facilities that have been made available to him by the various members of staff of: The Geology Department of the University College of Rhodesia; the Geological Survey of Rhodesia; the Research Institute of African Studies, Leeds; and the members of the geological staff of Shabanie Mine.

The author would particularly like to thank Professor B. C. King of Bedford College, London, for his constant encouragement, discussion and advice during the preparation of this thesis.

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J. W. Oldham

A SHORT NOTE ON THE RECENT GEOLOGICAL MAPPING OF THE SHABANI AREA

by

J. W. OLDHAM

ABSTRACT

The lithology and stratigraphy of the various Precambrian rock units in the area around Shabani are described together with their mutual structural relationships. A table is presented showing the lithological units in the Shabani area.

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The area around Shabani was mapped on the scale of 1 : 50,000 in 1965 and 1966, and extends from Lat. 20°00' south to 20°30', and from Long. 29°45' east to 30°15' east.

I THE BASEMENT COMPLEX

Outline of Formations and Events

GREAT DYKE      *WNW wrench faulting*  
 Emplacement  
*Doming and intrusion of Younger Granites*  
*Folding on north-trending axes. Metamorphism and granitization.*

BASEMENT SCHISTS

*Isoclinal "slump" folding*

Upper Sedimentary Formation: conglomerate, grit, banded ironstone, argillite.

Middle Greenstone Formation: sedimentary\* and volcanic greenstones.

Deposited unconformably on Lower Sedimentary and Greenstone formations in south and overstepping onto gneiss in the north.

*Unconformity. Folding on ENE-trending axes in the south*

*Granite intrusion*

Lower Sedimentary Formation: conglomerate, banded ironstone, argillite.

Deposited only in south.

Lower Greenstone Formation: sedimentary\* and volcanic greenstones.

Thinner in the north.

*Unconformity. Folding on NNE-trending axes. Granite intrusion and migmatization.*

Later Basement Schist: hornblende and talc schists, banded ironstone.

*Unconformity. Folding on WNW-trending axes. Granite intrusion and migmatization.*

Earlier Basement Schists: hornblende amphibolite.

\*Note: Owing to the excellent preservation of original structures it was possible to distinguish between volcanic greenstone with pillow structures and sedimentary greenstone with bedding and accretionary lapilli.

A The Basement Schists

Schistose rocks of two distinct generations are included within this group; (i) an earlier granitized sequence of epidote-amphibolite schists, occasionally reaching

the garnet grade of metamorphism; and (ii) a later granitized sequence that shows evidence of having had an original sedimentary origin.

Stratigraphy of the later Basement Schists:

Structural Position	Rock Type	Thickness in Feet
Highest (youngest?)	Hornblende schist	100-1,000
	Talc schist	0- 20
Lowest (oldest?)	Hornblende schist	100-1,000
	Banded ironstone	0- 20

Following the deposition and deformation of the earlier sequence of Basement Schists into isoclinal synformal structures that have a west-northwest trend, the later, more sedimentary sequence of Basement Schists was deposited and deformed into similar synformal structures, trending north-northeast. The subsequent folding of the Earlier Basement Schists around closures of the Later Basement Schists are most clearly illustrated in the area to the northwest of the Great Dyke (locality 1).

Since their deposition, both of these sequences have suffered migmatization and a later granitization from their original compositions of iron-rich sandstones (locality 2), greenstones, and a more calcareous sediment (locality 3). Due to the effect of a granitic batholith having a west-northwest trend, the Basement Schists have been altered through a gradational series of gneisses into a gneiss of a true granitic composition. For simplicity, only the end members of this series have been distinguished on the accompanying map.

The granite batholith must have been at least partly fluid during its emplacement, since small euhedral crystals of plagioclase, sphene, hornblende and muscovite attached themselves onto the growing crystal faces of its microcline phenocrysts (locality 4). These euhedral inclusions are not randomly distributed throughout the microcline but are arranged in discrete concentric zones, up to three zones in any one phenocryst. The plagioclase inclusions are orientated parallel with each of the sides of the zones, and are in lattice continuity with the microcline, a relationship only explicable if the phenocrysts grew in a liquid environment. (*cf.* Drescher-Kaden 1948; Voll, 1960; Hibbard, 1965).

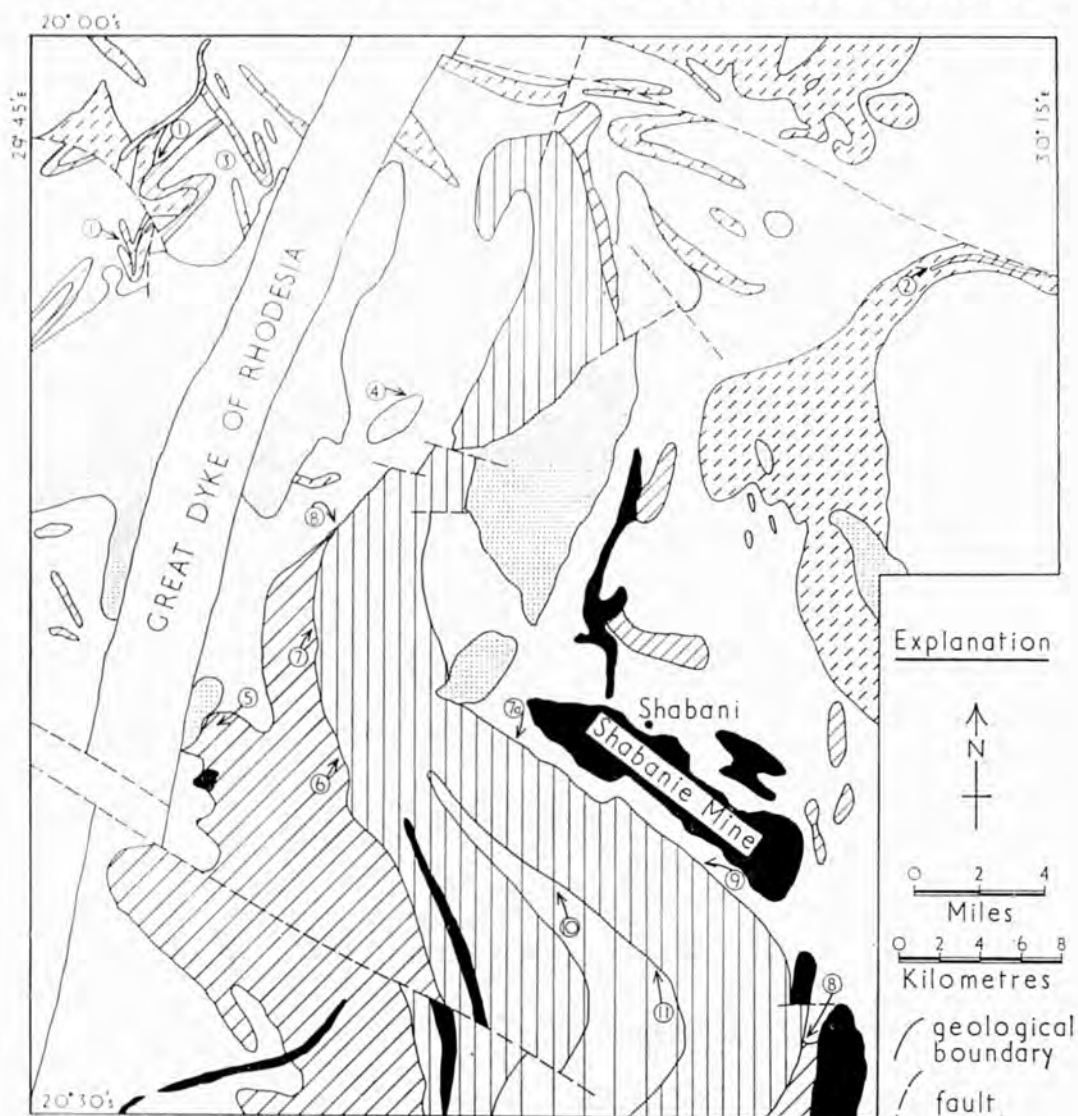
#### B The Lower Greenstone Formation

The general stratigraphy of the Lower Sedimentary and Greenstone Formations:  
Middle Greenstone Formation

		<i>Unconformity</i>	
Sedimentary greenstone	}	Only exposed on Belingwe sheet, B. G. Worst (1956)	
Conglomerate			
Ironstones and Sedimentary greenstones			
Sedimentary greenstone	850-33,000 ft.	}	15,000 ft.
Banded ironstone	50- 70 ft.		
Siliceous greenstone	50- 800 ft.		
Sedimentary greenstone	0- 8,000 ft.		
Siliceous greenstone	0- 800 ft.		
Volcanic greenstone	0-12,500 ft.		
Sedimentary greenstone	4,000 ft.		
<i>Unconformable, intrusive, tectonic contact</i>			
Basement gneisses and migmatites			



LOCALITY MAP OF THE SHABANI AREA



ORNAMENTATION					
	Granite		Migmatite and Gneiss		Upper Sedimentary Formation
	Granite		Basement Schist		Middle Sedimentary and Volcanic Greenstones
	Ultrabasic Intrusives		Granitic Gneiss		Lower Sedimentary and Volcanic Greenstones

Also to be included in this generalized sequence, are from 0-4,000 feet of transgressive acid tuff and from 0-3,000 feet of conformable ultrabasic sills. Overlying the basement gneisses, mainly in the south of the area, is a group of sedimentary and volcanic greenstones, the Lower Greenstone Formation, that have been intruded by ultrabasic sills and thermally metamorphosed by the intrusion of

later granitic rocks (locality 5). Their original contact with the underlying basement rocks must have been an unconformity. A subaqueous volcanic silt occurring towards the top of the sequence, displays graded bedding, flame structures, ripple marks, and accretionary volcanic lapilli (locality 6).

The greenstones have been mapped southwards by Worst (1956) where they are affected by a major synform that plunges steeply to the northeast. The greenstones may be correlated with the rocks mapped as "Bulawayan" in the Selukwe area (Stowe, 1964).

### C The Middle Greenstone Formation

A generalized stratigraphy of the Middle Greenstone Formation in the south of the area:

<i>Unconformity</i>		
Phyllite	0- 100 ft.	} 20,000 ft.
Conglomerate-grit	0- 100 ft.	
Calc-silicate rocks	0- 100 ft.	
Siliceous greenstone	0-10,000 ft.	
Volcanic greenstone	0-10,000 ft.	
Sedimentary greenstone	5,000-10,000 ft.	
Conglomerates	0- 20 ft.	
Banded ironstone	0- 150 ft.	

*Unconformity*

Lower Greenstone Formation

A generalized stratigraphy of the Middle Greenstone Formation in the north of the area:

<i>Unconformity</i>		
Sedimentary greenstone	0- 2,000 ft.	} 5,000 ft.
Talc schist	1,000 ft.	
Volcanic greenstone	1,000- 2,000 ft.	
Amphibolite	0- 50 ft.	
Sedimentary greenstone	5,000 ft.	

*Unconformity*

Lower Greenstone Formation and gneiss

Resting unconformably on the Lower Greenstone Formation, which had already been folded about east-northeast axes, the Middle Formation volcanic and sedimentary rocks are composed of volcanic lavas, tuffs and subaqueous sediments. They are predominantly sedimentary ironstones and conglomerates (locality 7) in the lower part with volcanic rocks increasing proportionately upwards. They overstep the Lower Sedimentary Formation onto the gneisses of the basement (locality 8), as has been reported by Laubscher (locality 9). The unconformity in a cutting 200 yards north of the Dadaya Mission railway crossing (locality 7) where the volcanics rest on the Lower Greenstone Formation, displays "buried topography" marked by a zone, some three feet in width, showing calcification of the greenstones, which in appearance is not unlike the exposure of "Hutton's Unconformity" in Arran (Hutton, 1795). The calcified zone may have originated in a manner like the Cornstones of the Carboniferous (Allen, 1960), and the fossil soils of the Upper Old Red Sandstone of south Ayrshire (Burgess, 1961; McCullough, 1869).

The volcanics are the most widespread lithological type of the Middle Greenstone Formation, and are preserved in a tight synform, trending north and slightly

overturned towards the east. Graded bedding, ripple marks, flame structures, and pillow lavas, all demonstrate that the rocks are everywhere the "right way up", the structure nowhere overturned.

#### D The Upper Sedimentary Formation

A general stratigraphic section across the Upper Sedimentary Formation (in the vicinity of Zeederbergs Siding):

Conglomerate	50 ft.	} 3,000 ft.
Grit	50 ft.	
Ironstone	50 ft.	
Limestone	20 ft.	
Conglomerate	50- 100 ft.	

*Unconformity*

Middle Greenstone Formation

In the south of the area, the core of the north-trending syncline of Middle Formation deposits is occupied by rocks of a distinctly different lithology; conglomerates, grits, siltstones, and mudstones. The strike of this younger Formation is in general parallel to the Middle Formation volcanics and the dip almost vertical, but there are many local variations in strike and many minor, internal unconformities.

The outcrop pattern of the group suggests a sequence modified by the slumping of still unconsolidated sediments during the later stages of synclinal infilling. A very good example of sedimentary slumping is found two miles southeast of Oreti Siding, Zeederbergs Block, where a quartzite bed abuts sharply against a "transgressive" banded ironstone.

The contact between the Upper Sedimentary Formation and the Middle Greenstone Formation has nowhere been seen, but 150 yards north of Zeederbergs Siding (locality 11), a coarse conglomerate containing pebbles of the underlying Middle Formation volcanics may be the basal conglomerate of the Upper Sedimentary Formation.

## II OTHER TECTONIC EVENTS

Following the deposition of the Upper Sedimentary Formation the major synclinal structure suffered an updoming about a west-northwest axis which was accompanied in its later stages of development by the intrusion of the Younger Granite.

The latest major tectonic event was the emplacement of the Great Dyke, parallel to the north-south axis of the syncline. Later, normal faulting and dextral wrench faulting, trending west-northwest, affected the whole area.

## III SUMMARY

The Basement Complex gneisses of the Shabani area suffered deformation and migmatization during the at least two periods before the deposition and deformation of the sediments and volcanics.

The "notion" that the "schist belt" rocks of Rhodesia rest in synclinal troughs within a basement granite, the synclinal structure being due to the updoming of the basement gneiss in areas adjacent to the synclines by intrusions of a "Younger Granite", as suggested by earlier workers (Macgregor, 1951, and others) would appear to be a gross oversimplification of the problem.

The writer would like to express his thanks to Dr. D. Powell, Bedford College,

London, and Professor T. N. George, Glasgow, for their very helpful, constructive criticism.

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READ 27TH OCTOBER, 1967

#### DISCUSSION

Mr. E. J. Poole

The southern part of the area closely resembles Ramsey's Type 2 interference pattern due to the subsequent refolding of recumbent folds. Can the Lower and Middle Greenstone Formations be easily distinguished in the field?

Mr. R. Mason

Tight isoclinal folds in the basement that have been refolded are frequently not recognized. Two beds of metaquartzite in a very tight isoclinal fold may be sufficiently close together as to be mapped as one bed and the true structure missed.

Mr. C. W. Stowe

Mr. Oldham and Dr. Worst (1956) both say that the two formations can be distinguished in the field and there is a distinct unconformity at the base of the Middle Formation. The older ENE folds have been refolded by the northerly folds and an interference pattern with many minor structures has resulted. Many well-preserved pillow-lavas, current-bedding, etc. show that the rocks are almost always right way up so there has not been recumbent isoclinal folding. There are, however, refolded, recumbent isoclinal folds in the migmatites and granulites to the north.

Mr. M. v. R. Steyn

Where do the fairly extensive, sill-like bodies of ultramafic rocks fit into the succession?

Mr. C. W. Stowe

The ultramafic bodies are of various ages. The older chromite-bearing serpentine bodies at Selukwe are intruded by the younger granites and can be traced as inclusions and migmatite in the gneissic granite towards Mashaba where the Mashaba Igneous Complex which is younger than the Selukwe ultramafic rocks, intrudes the older gneissic granite.

Dr. J. F. Wilson

There are at least two ages of ultramafic rocks around Mashaba, the inclusions in the gneisses and the Mashaba Igneous Complex which was intruded into the gneisses as a magma and, later, was intruded by the Younger Granite.

Mr. R. Mason

Are there any net-vein effects where the Younger Granite intrudes the ultramafic rocks?

Dr. J. F. Wilson

The actual contacts are not exposed but a dyke of serpentine half to three-quarters of a mile wide ends suddenly and 50 yards away are exposures of granite. The contact of the Younger Granite and the older gneisses is well exposed. It is sharp and shows thermal metamorphic effects. Contact effects vary and seem to be a question of the level exposed. The Chibi Granite which has sharp contacts in the northeast has gradational contacts with potassium metasomatism in the southwest.

Mr. C. W. Stowe

Contact phenomena are related to level. At Selukwe the contacts of the G.3. granite and of the roof-cupolas are very sharp whereas the G.3. granite contact is gradational over a width of one mile.

SHEET 1 NW.

29°45' East,  
20'00" South

SELUKUM  
PARISH  
DISTRICT

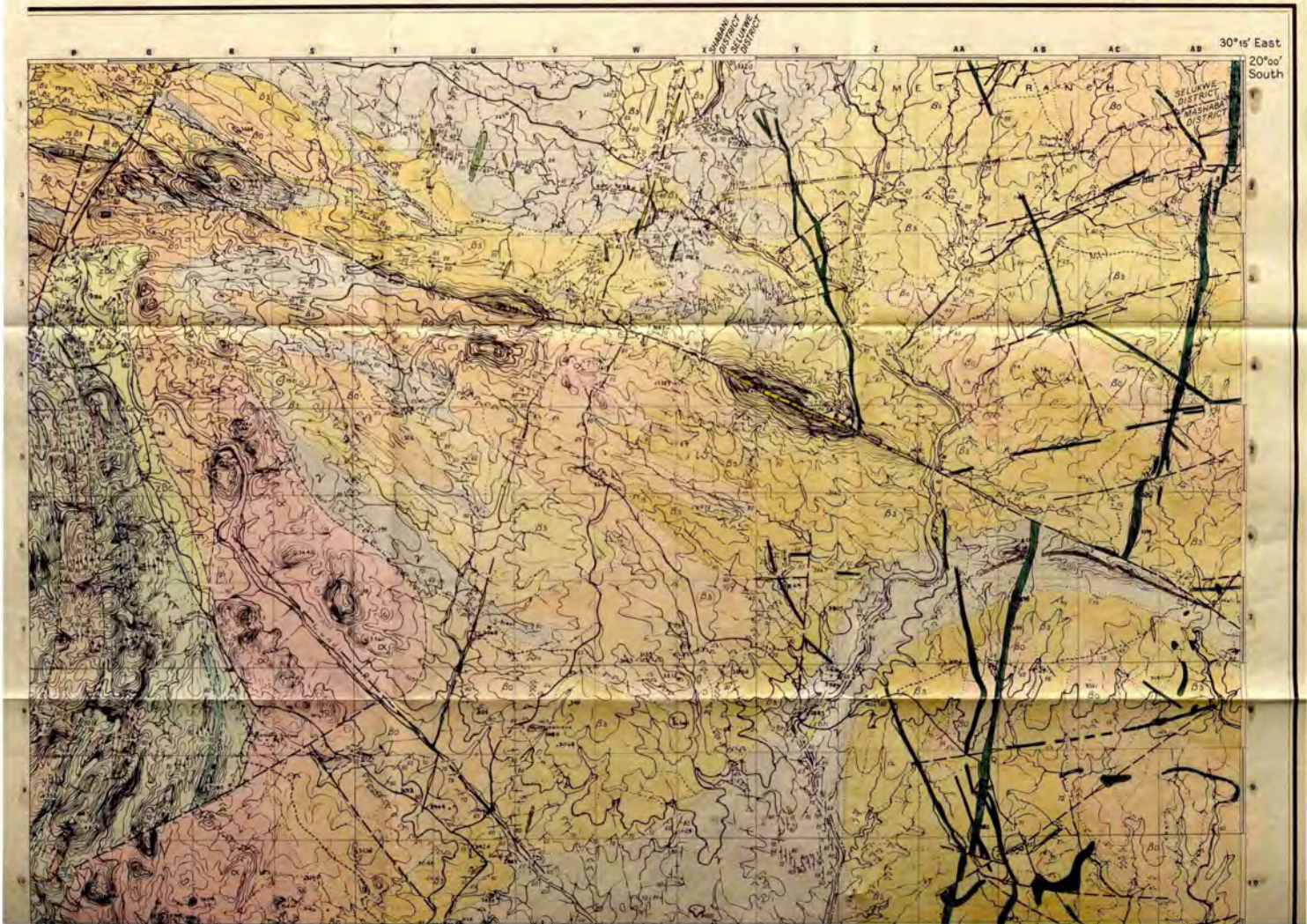
SELUKUM  
PARISH  
DISTRICT

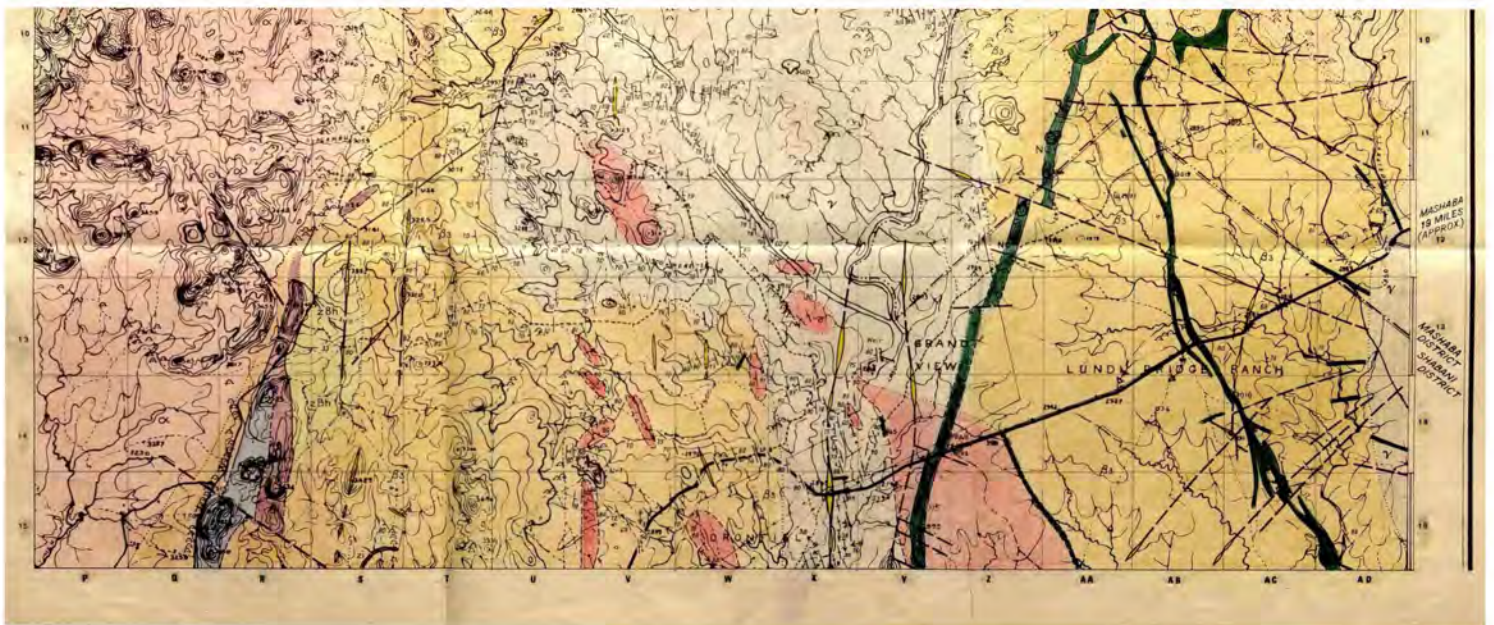
SELUKUM  
PARISH  
DISTRICT





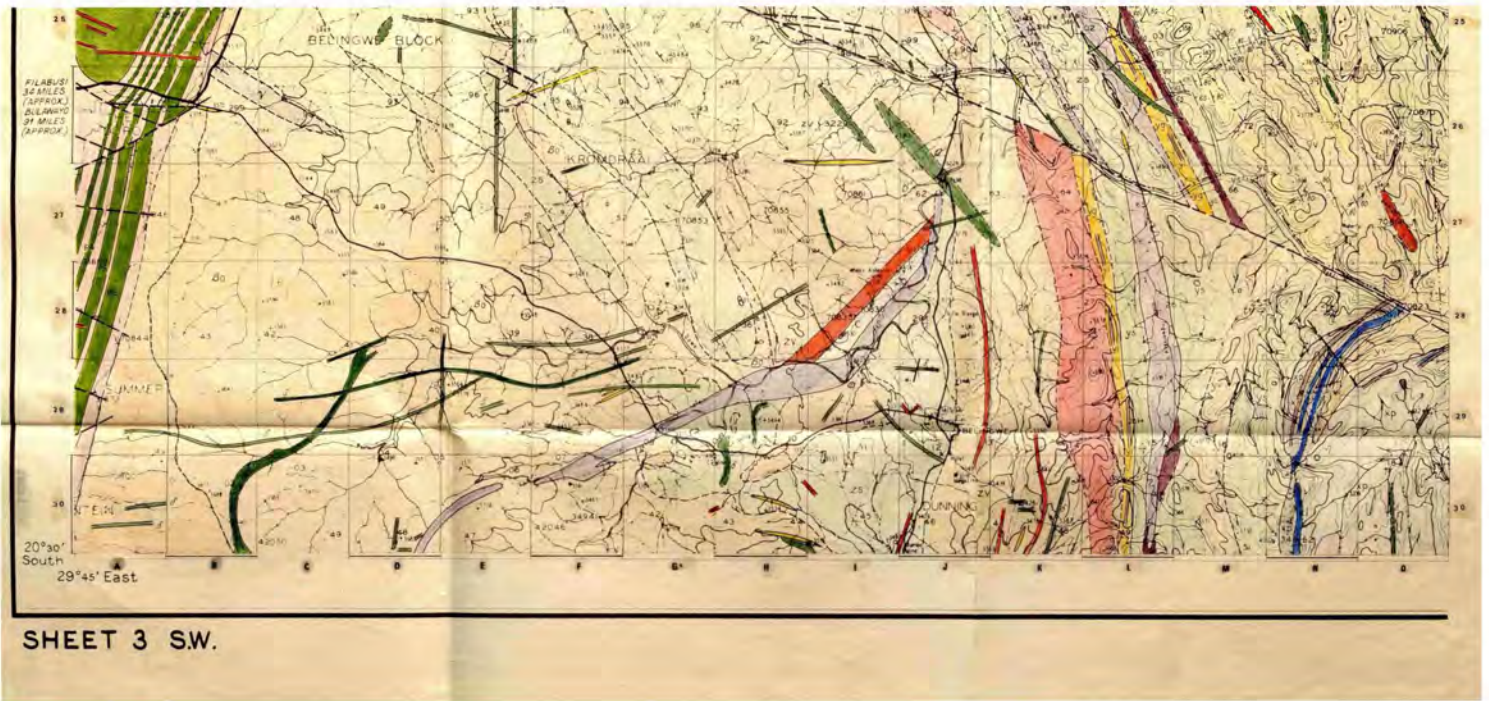
SHEET 2 NE.











SHEET 3 SW.

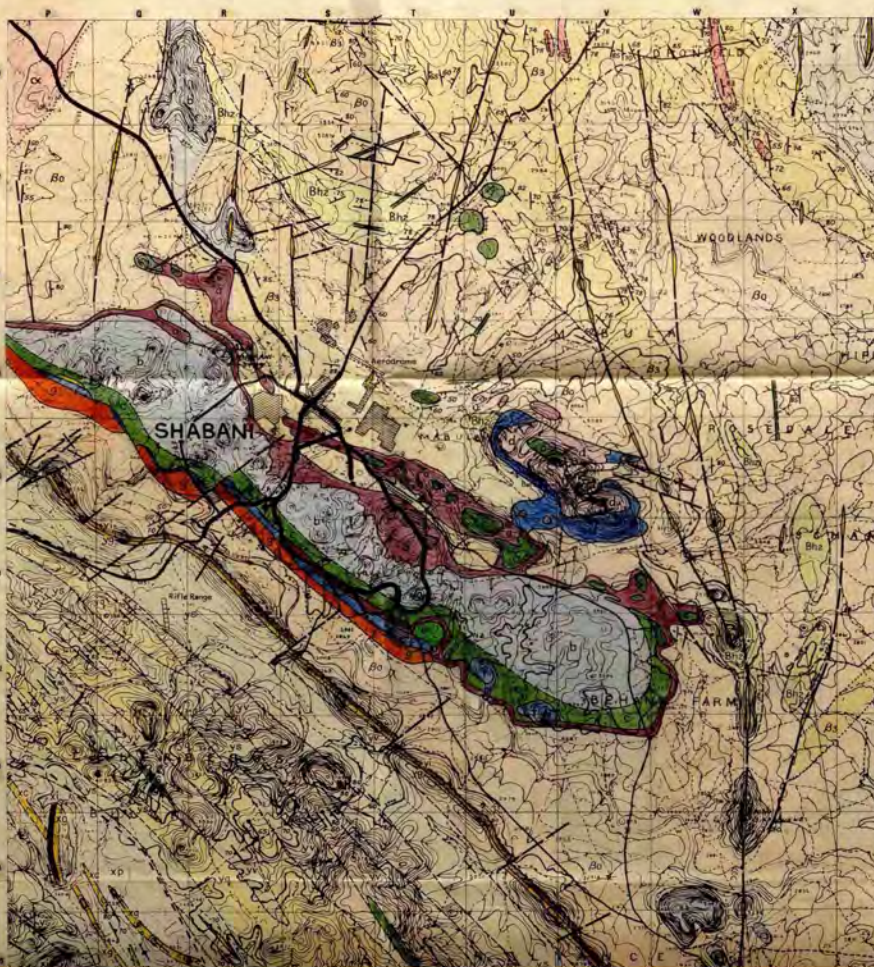
# GEOLOGICAL MAP OF THE COUNTRY AROUND SHABANI, RHODESIA.

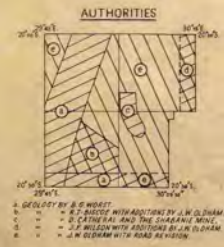
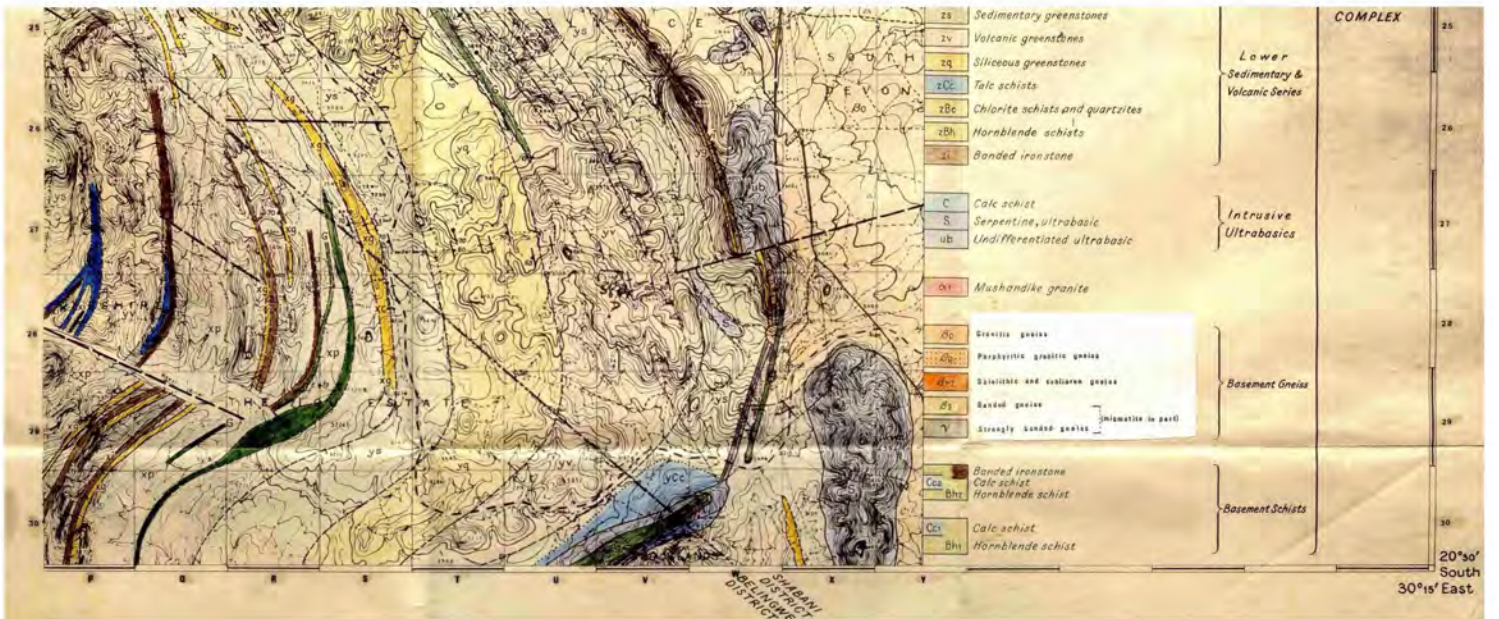
Scale 1:50,000 or 1:267 inches to 1 Mile

Geology by J. W. Oldham, 1965-66.

## EXPLANATION

	Quartz	} VARIOUS AGES
	Dolerite (δ), gabbro (G)	
	Felsite & aplite	
	Quartz gabbro	
	Gabbroic rocks	
	Pyroxenite with band number	
	Serpentine, hornblende & schiele CHROMITE HORNBLENDE WITH HORSDON NUMBER	
	Dioritic younger granite	
	Younger granite	
	Phyllite	
	Conglomerate (xc), grit (yg)	
	Banded ironstone	
	Crystalline limestone	} Middle Sedimentary & Volcanic Series
	Phyllite	
	Conglomerate (yc), grit (yg)	
	Amphibolitized greenstone	
	Calc-silicate rocks	
	Ultrabasic lavas, where differentiated	
	Siliceous greenstone, hornblende containing metamorphic aureole (a)	
	Volcanic greenstones	
	Sedimentary greenstones	
	Banded ironstone	
	Actinolite-feldspar rock	} Shabani Mine Ultrabasic Sheet
	Actinolite rock	
	Pyroxenite	
	Hornblende	
	Peridotite	
	Dunite	
	Talc-carbonate rock	} ARCHAEOAN BASEMENT COMPLEX
	Felsitic tuffs	
	Sedimentary greenstones	





- Trunk road
- Main "
- Other "
- Track
- Unclassified track or footpath
- Railway
- " , light
- Built-up area
- House or other buildings
- African kraal or compound
- Trigonometrical station with number
- Height in feet above mean sea-level

- R E F E R E N C E**
- Farm boundary
  - " , fenced with gate
  - Administrative District boundary
  - Electricity transmission line
  - Mine dump
  - Open cut or quarry
  - Dipping tank
  - Wind-pump (water)
  - River or watercourse with sandbank
  - " , bridge
  - Dam; weir
  - Contour lines
  - Dip and strike of bedding, amount in degrees
  - " , cleavage or foliation in igneous rocks
  - " , bedding, vertical
  - " , cleavage or foliation, vertical
  - " , second cleavage, amount in degrees
  - " , direction of lineation plunge, " "
  - " , plunge of fold axis, " "
  - Geological boundary
  - " , indefinite
  - " , gradational or inferred
  - Unconformity
  - Fault, mark on downthrow side

**SHEET 4 SE.**

A LITHOLOGICAL MAP OF THE SHABANI REGION



KEY TO SYMBOLS AND AUTHORITIES









A LITHOLOGICAL MAP OF THE SHABANI REGION

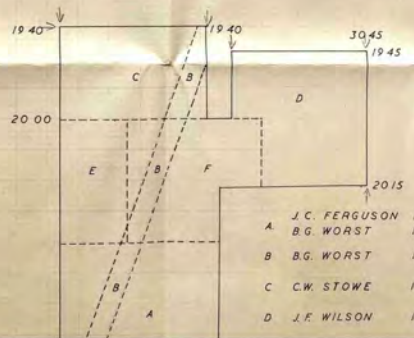


KEY TO SYMBOLS AND AUTHORITIES











KEY TO SYMBOLS AND AUTHORITIES

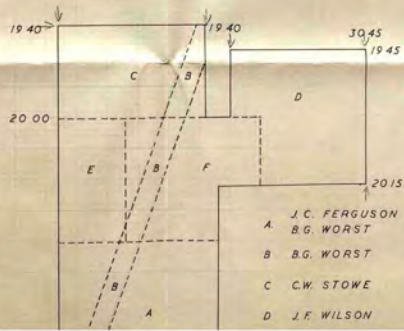
-  INTRUSIVE GRANITE
-  INTRUSIVE BASIC ROCKS
- Shewanite?*  UPPER SEDIMENTARY BULAWAYAN
-  BULAWAYAN VOLCANICS
- Subvolcanic?*  LOWER BULAWAYAN
-  MIGMATITES
- "*  BASIC SCHISTS
-  ACID GNEISS



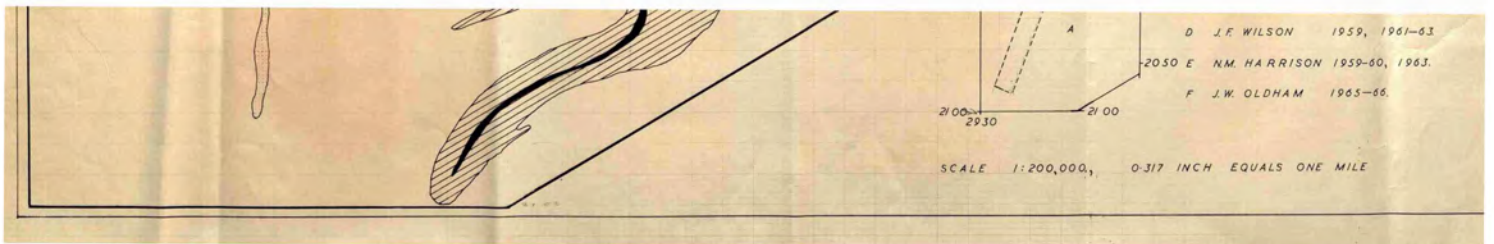


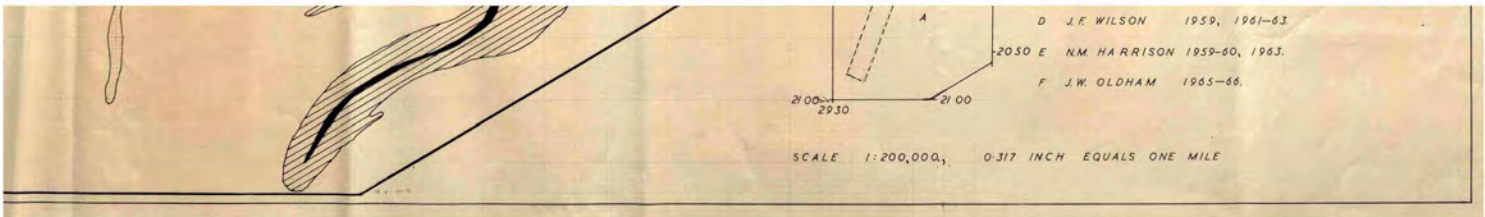
KEY TO SYMBOLS AND AUTHORITIES

-  INTRUSIVE GRANITE
-  INTRUSIVE BASIC ROCKS
- Glauconite?*  UPPER SEDIMENTARY BULAWAYAN
-  BULAWAYAN VOLCANICS
- Schistosity?*  LOWER BULAWAYAN
-  MIGMATITES
- "  BASIC SCHISTS
-  ACID GNEISS







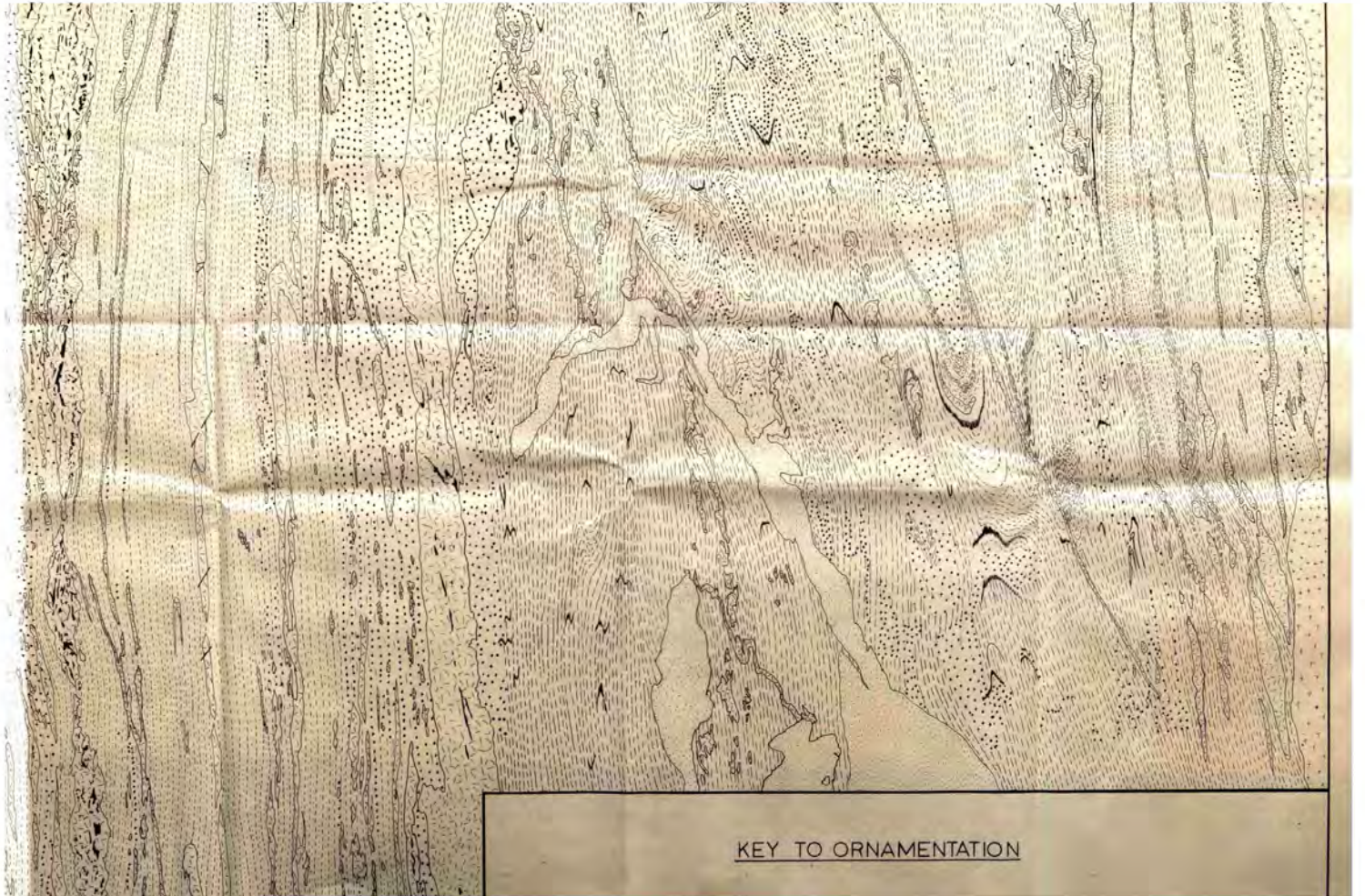


PLAN OF A MIGMATITE EXPOSURE



PLAN OF A MIGMATITE EXPOSURE










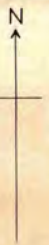
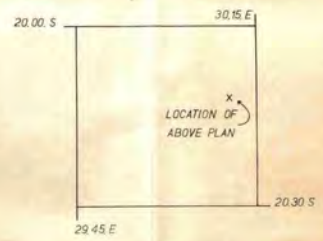


KEY TO ORNAMENTATION

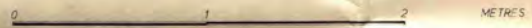
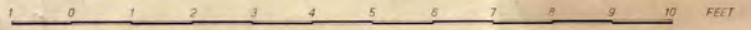


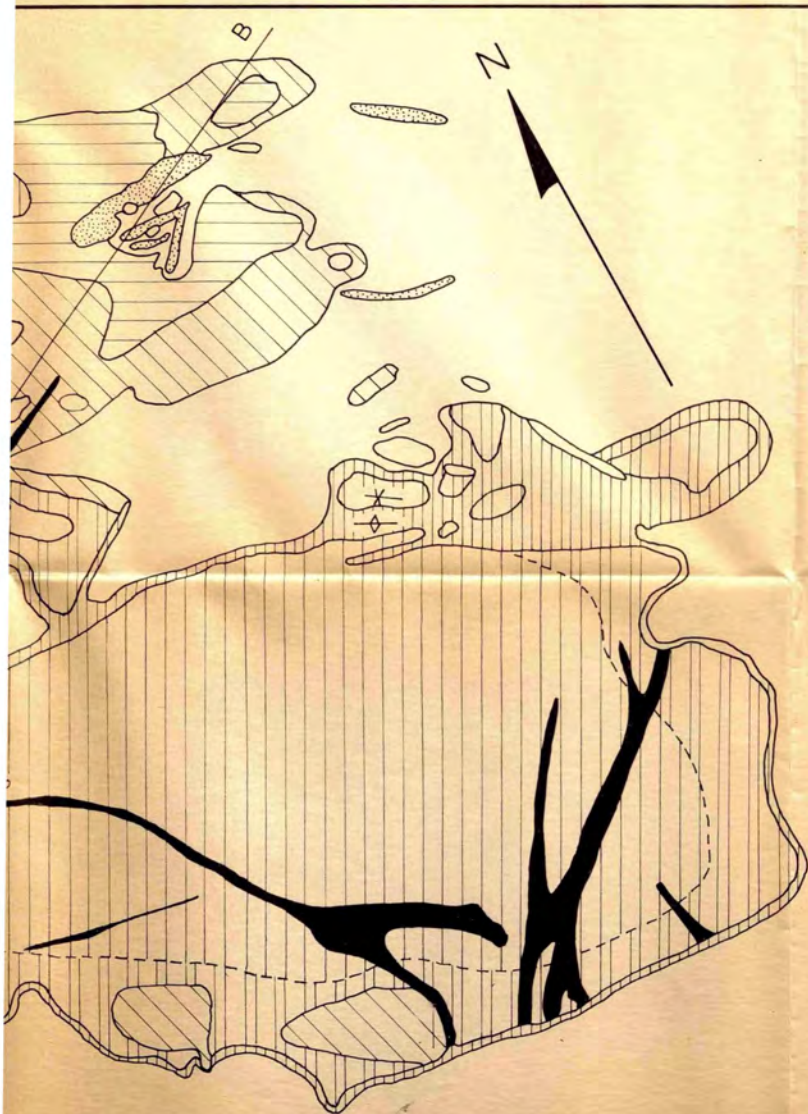
### KEY TO ORNAMENTATION

-  GRANITE
-  APLITE
-  PEGMATITE WITH AMPHIBOLITE
-  GNEISS
-  ACID GNEISS
-  AMPHIBOLITE SCHIST
-  PORPHYROBLASTIC GNEISS
-  AMPHIBOLITE



### Scale





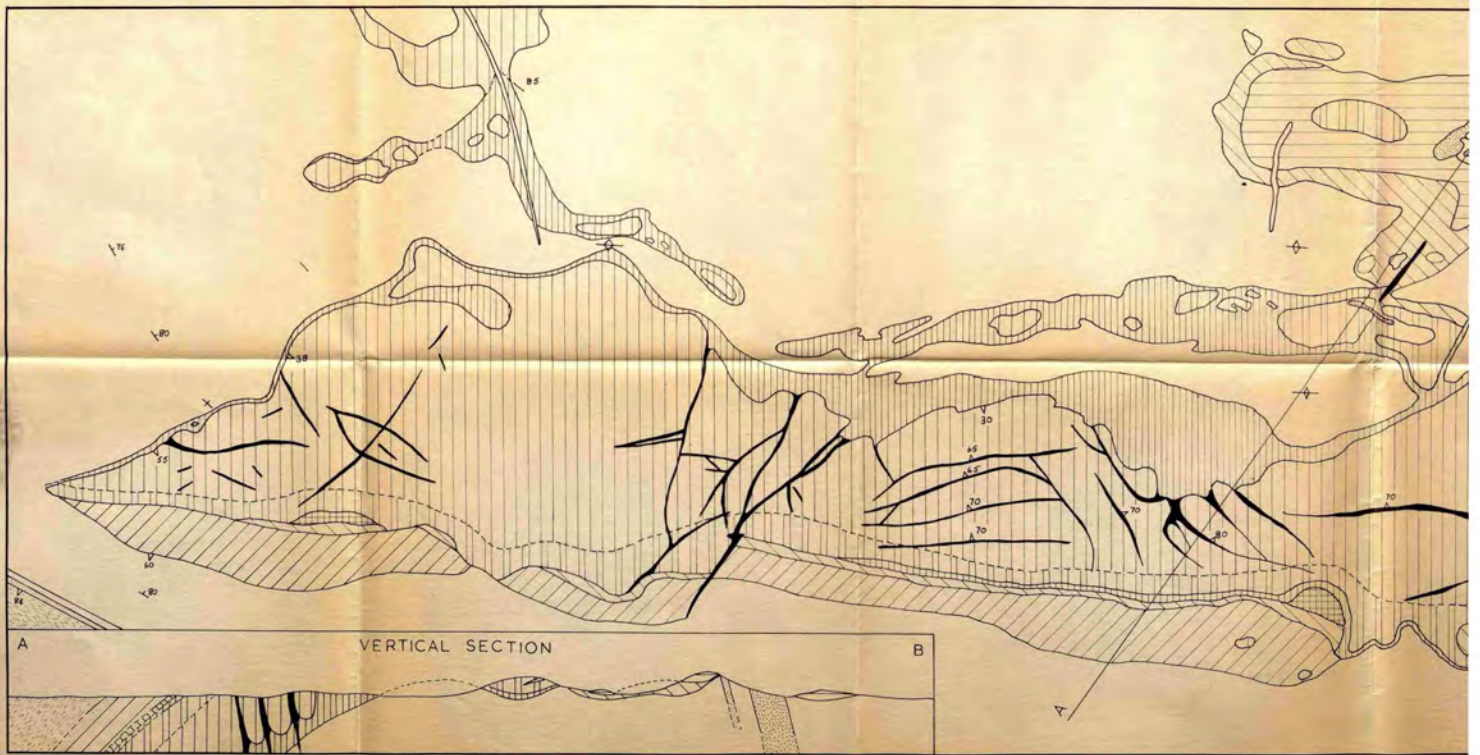
EXPLANATION

-  talc shear zone
-  actinolite feldspar rock
-  actinolite rock
-  pyroxenite
-  harzburgite
-  peridotite
-  dunite
-  talc carbonate
-  greenstone
-  grit
-  banded ironstone
-  dip and strike of foliation
-  dip and strike of bedding

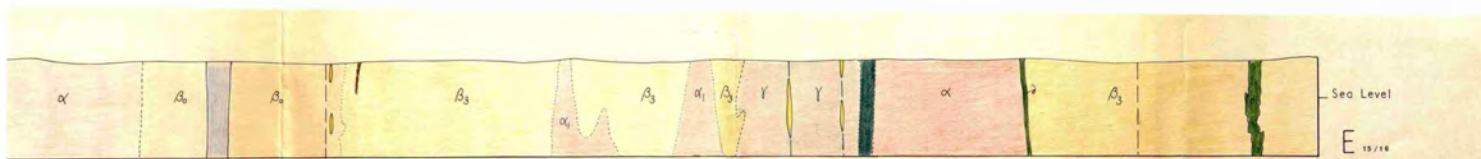
SCALE 1:20,000



GEOLOGY OF SHABANIE MINE







CROSS SECTIONS OF THE SHABANI AREA



UPPER SEDIMENTARY SERIES

- $\alpha p$  phyllite
- $\alpha g$  grit
- $\alpha l$  limestone
- $\alpha i$  ironstone

ACID INTRUSIVES

- $\alpha$  younger granite
- $\alpha_1$  dioritic granite
- $\alpha_2$  older granite

BASIC INTRUSIVES

- actinolite feldspar rock
- peridotite
- talc-carbonate rock
- dolerite

GREAT DYKE ROCKS

- N gabbroic rocks
- P pyroxenite
- S serpentine etc.
- E east dyke

VERTICAL SCALE EQUALS HORIZONTAL SCALE, EQUALS 1:50,000 OR 1-267 INCHES EQUALS 1 MILE

15/16 W



GEOLOGICAL CROSS-SECTION

15/16 N



N	
sheet 1	sheet 2
sheet 3	sheet 4
S	

- FAULT
- UNCONFORMITY
- BOUNDARY DEFINITE
- BOUNDARY INDEFINITE

BASEMENT ROCKS

- basement schist
- migmatite gneiss
- banded gneiss
- granitic gneiss

MIDDLE SEDIMENTARY & VOLCANICS

- banded ironstone
- siliceous greenstone
- sedimentary greenstone
- volcanic greenstone
- calc-schist
- grit
- amphibolite schist

UPPER

- banded ironstone
- grit
- amphibolite schist