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#### DECLARATION OF ORIGINALITY

I certify that all material in this thesis represents the original work of the author, except where specific acknowledgement is made to the work of others.

Date 28<sup>th</sup> December, 1976 Signature J.J. Broderick

RHODESIA GEOLOGICAL SURVEY

SHORT REPORT No. 43

Explanation of the  
Geological Map of the  
Country East of Kariba

*by*

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ISSUED BY AUTHORITY



SALISBURY—1976

## CONTENTS

	<i>Page</i>
Introduction . . . . .	1
Physical features . . . . .	2
Previous geological work . . . . .	4
Table of geological formations and events . . . . .	5
Outline of the geology . . . . .	7
The Urungwe Paragneiss . . . . .	9
The Chiroti Paragneiss . . . . .	10
The Chipisa Paragneiss . . . . .	11
The Kariba Paragneiss . . . . .	13
The Kariba Sillimanite Quartzite . . . . .	14
The Piriwiri Group . . . . .	15
The enderbites . . . . .	20
The Nyaodza Centre and metamorphic event . . . . .	21
The Makuti Group . . . . .	23
The Makuti Outlier . . . . .	24
The Rukwesa Formation . . . . .	25
The Tsororo Formation . . . . .	26
The Vuti Formation . . . . .	27
The structure of the Makuti Group . . . . .	33
The metamorphism of the Makuti Group . . . . .	36
Geochronology . . . . .	38
Minor mafic intrusions . . . . .	38
The Karoo System . . . . .	41
Superficial deposits . . . . .	43
Economic geology . . . . .	45
Mica . . . . .	47
Beryl . . . . .	71
Muscovite quartzite . . . . .	73
Copper . . . . .	74
Graphite . . . . .	74
Sillimanite . . . . .	75
Tourmaline . . . . .	75
Wolfram . . . . .	75

APPENDIX

	<i>Page</i>
The Geology of the Country West of Magunge, Urungwe and Kanyati Tribal Trust Lands . . . . .	79
Introduction . . . . .	79
Urungwe Paragneiss . . . . .	81
Chiroti Paragneisses . . . . .	83
Chipisa Paragneisses . . . . .	84
Piriwiri Group . . . . .	84
Enderbite . . . . .	92
Granite . . . . .	92
Pegmatite . . . . .	93
Quartz-epidote rocks . . . . .	93
Minor mafic intrusions . . . . .	94
Karoo System . . . . .	95
References . . . . .	97

TEXT FIGURES

	<i>Page</i>
1. Structure of the Makuti Group . . . . .	34
2. Regional metamorphism around Makuti, Karoi and Kariba . . . . .	37
3. Distribution of economic minerals in relation to sillimanite-bearing Piriwiri Group rocks . . . . .	46
4. Surface plan of the Gatapie pegmatite . . . . .	52
5. Surface plan of the Gil Gil and Ingwe pegmatites . . . . .	54
6. Section along Jack's Luck 1 pegmatite . . . . .	57
7. Diagrammatic cross-section of the Nzoe 6 pegmatite . . . . .	64
8. Plan of the St. Mark's No. 4 and 5 Claims . . . . .	68
9. Plan of the Wanyonzi pegmatite . . . . .	71
10. Geological map of the country west of Magunge (A. K. Kuhne, 1973)	82

TABLES

	<i>Page</i>
I Analyses of paragneisses, adamellite and Piriwiri Group rocks . . . . .	16
II Analysis of grandidierite . . . . .	20
III Analysis of water from the Chipisa Spring, Kariba . . . . .	36

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Ministry of Lands are responsible for road access in the Tribal Trust Lands and the African Purchase Lands, respectively, and the Central African Power Corporation provides maintenance tracks along the power-lines that sweep across the country from Kariba to the first main switching station near Norton. The country above the Escarpment to the east of Kariba is extremely rugged and tracks should not be attempted except in a four-wheel-drive vehicle. The condition of these tracks should be ascertained beforehand, especially during and after the rains when dangerous washouts are likely to occur.

Climatically Kariba is hot and humid. Mean summer temperatures average 30°C (86°F), with temperatures in October that often exceed 40°C (100°F). Away from the Lake the humidity decreases and the increased altitudes above the Escarpment have a cooling effect. The township's mean annual rainfall is 665 millimetres (26,2 inches), most of which falls in the months between November and February.

Basically, the area is well timbered but population pressures in the tribal areas, and depredation by elephants elsewhere, have made serious inroads upon the natural vegetation. The gneissic terrain above the Escarpment is characterized by mufuti trees (*Brachystegia boehmii*). The baobab (*Adonsonia digitata*) is common in the larger river valleys and in the low-lying area surrounding the lake shore where it occurs together with mopane (*Colophospermum mopane*) and thick jessie bush. In the river valleys, trees typical of the Zambezi Valley are common and include the tamarind (*Tamarindus indica*), mumvey (*Kigelia africana*) and *Steculia* species. Buffalo beans (*Mucuna coriacea*) are not uncommon in grassy river-beds.

## PHYSICAL FEATURES

### *Relief*

Physiographically, the area can be subdivided into three distinct regions, all of which have a marked geological control. They are—

- (1) The fault-lined Gwembe trough which has subsequently been inundated by the waters of Lake Kariba to an average altitude of 487 metres (1 600 feet) above sea level since the completion of the dam across the upstream entrance to the Kariba Gorge in 1960. The flat land that now forms part of the lake shore is underlain by sediments of Karoo age and these, in the mapped area, occupy the Charara and Gachegache Basins, that lie to the north and south respectively of the Msango Range. These flat-lying areas give way sharply to the

gneissic terrain of the Zambezi Metamorphic Belt along the fault-lined Zambezi Escarpment.

(2) The northern boundary of the area and the Msango Range are underlain by metasediments of the Makuti Group. The relief is strongly influenced by the regional geological structure of these complexly folded rocks with resistant meta-arkose and quartzite forming the sharp ridges and metapelites occupying the valleys. The ridges and valleys trend eastwards in the Msango Range, but along the northern boundary they trend north-westwards.

(3) The linear topographic features of the Makuti Group terrain give way southwards to the older gneisses along an abrupt scarp edge, the base of which is marked by the Tsororo River. This terrain of gneisses is very rugged and highly dissected above the Zambezi Escarpment until it flattens out, at about 900 metres (2 950 feet) above sea level, into the Urungwe Tribal Trust Lands. In the rugged country above the Escarpment, granulites of the Piriwiri Group stand out above the gneisses as steep-sided conical hills. The country rises in a series of fault-lined steps to its highest point, at Nyamangwe trigonometrical beacon, which stands at 1 336 metres (4 382 feet) above sea level.

#### *Drainage*

The main rivers in the area are the Nyanyana, the Rhuwe, the Charara, the Tsororo, the Kasiga, the Nyaodza and the Sunde, and these all flow south and westwards into Lake Kariba. In contrast, the Zambezi River flows northwards until it has passed through the Kariba Gorge, a short distance upstream from the Otto Beit Bridge at Chirundu.

The drainage is controlled to a great extent by the north-east-trending major fractures. Major down-faulting along the Escarpment has caused a rejuvenation of the erosion cycle, and the rivers to be incised deeply into the landscape to form such features as the Nyaodza River Gorge.

Within the Makuti Group the rivers are controlled by the structure and a trellis-type of drainage has developed, parallel to the strike of the rocks. This pattern, however, is frequently disrupted by cross-faulting and folding of the rocks.

Debouching onto the Karoo surface, rivers such as the Charara, develop meanders with broad, sandy beds and terraced alluvial banks.

## PREVIOUS GEOLOGICAL WORK

Molyneux (1922) visited the Kariba Gorge in 1912 whilst he was engaged in a geological reconnaissance of the Sanyati Valley.

H. S. Keigwin, whilst serving his tenure as Native Commissioner for the Lomagundi District during the 1914-18 War, was the first person to realize the potential of the Kariba Gorge for dam construction. Since then P. H. Haviland (1929) and J. L. S. Jeffares (1941) completed initial surveys connected with the proposed dam.

In 1928, Tyndale-Biscoe completed a geological reconnaissance through the area in connection with the proposed Sinoia-Kafue rail link. In his report he noted the rocks now allocated to the Makuti Group and he discussed the Karoo sediments of the Charara Basin.

A report on the Chipisa Hot Springs by Lightfoot, was published by Maufe (1933).

With the initiation of the Kariba Dam project, members of the Geological Survey produced a number of technical reports on the geology of the proposed dam sites. A number of unpublished reports on mines in the West Urungwe Mica Fields have also been prepared by members of the Geological Survey.

In 1958 Hitchon described the geology on the Northern Rhodesian or Zambian side of the Zambezi around Kariba. This included work on the dam site and the Kariba Township area.

Seismic activity resulting from the filling of Lake Kariba has been the subject of papers on load-induced earthquakes and on stress and deflection experienced in the earth's crust around the Lake (Gough and Gough, 1970). Observations of the deflection along the road from Makuti to Kariba are being continued by the Surveyor-General's Department (Sleigh 1976).

In 1969, Loney (1966, 1968, 1969) presented a Ph.D. thesis on the Kariba area in which he paid particular attention to the amphibolites as well as introducing some new radiometric dates for the area.

Interest in the Zambezi Metamorphic Belt resulted in the compilation of an air-photo interpretation by Vail (1965). This was followed by a more detailed interpretation by the Rhodesia Geological Survey and a subsequent reconnaissance geological report of the road from Makuti to Kariba was prepared by Kirkpatrick and Robertson (1968).



## TABLE OF GEOLOGICAL FORMATIONS AND EVENTS

## RECENT

Soils, alluvium and talus.

*Unconformity. Prolonged erosion. Minor movements on faults to present.*

## KAROO SYSTEM (Mesozoic)

Cross-bedded sandstones, siltstones and local conglomerates.

Arkosic grit and sandstone. Immature sediments of local origin.

Mudstones (green to grey) and some sandstones. Fossil wood and indeterminate plant remains.

Basal Beds: conglomerate, grit, sandstone and purple mudstone.

*Unconformity. Prolonged erosion. Trough-faulting to form Middle Zambezi Karoo basin.*

*Intrusive contact.*

Metadolerites.

*Major north-easterly faults initiated.*

*Miami Metamorphism: Minor folding. Upper amphibolite grade regional metamorphism and granitization with the injection of tourmaline-bearing pegmatites.*

*Katangan Metamorphism: Tight folding on N.N.W. axes and repeated regional open folding on north-westerly axes. Regional metamorphism increasing southwards and eastwards from greenschist facies to upper amphibolite facies.*

## MAKUTI GROUP (Late Precambrian)

Vuti Formation: Pink paragneiss with beds of quartzite, biotite schist, muscovite schist, calc-silicate rocks, hornblende amphibolite and chloritic schist. Largely psammitic.

Tsororo Formation: Biotite-rich gneisses with thin beds of meta-arkose quartzite, calc-silicate rocks and hornblende amphibolite. Largely pelitic. Granitized in places.

*Relationship uncertain.*

Rukwesa Formation: Muscovite-biotite schists and gneisses with beds of meta-arkose and calc-silicate rocks. Some contain sillimanite and garnet.

*Major unconformity. Erosion.*

*Local retrograde metamorphism.*

*Intrusive contact.*

Mica pegmatites and wolfram-quartz veins.

*Nyaodza Metamorphism. Metasomatic feldspathization of paragneisses, Piriwiri rocks and enderbites.*

*Anatexis. Formation of Nyaodza adamellite centre by direct granitization.*

*Intrusive contact.*

Enderbite.

*Magondi Metamorphism: Folding on north-easterly axes and regional metamorphism. Deep burial and granulitic grade metamorphism.*

**PIRIWIRI GROUP (Middle Precambrian)**

Gneisses of pelitic origin containing sillimanite, garnet and cordierite, sometimes with microcline porphyroblasts. Grade locally into granulites.

*Unconformity. Folding and metamorphism*

**KARIBA PARAGNEISS (Precambrian)**

Folded, banded biotite gneiss with many pegmatites and infolded sillimanite quartzite in upper part. Porphyroblastic in parts.

*Relationship not known.*

**CHIPISA PARAGNEISS (Precambrian)**

Strongly foliated biotite-rich gneiss with many pegmatites and inclusions.

*Relationship not known.*

**CHIROTI PARAGNEISS (Precambrian)**

Porphyroblastic biotite, gneiss.

*Unconformity.*

**URUNGWE PARAGNEISS (Precambrian)**

Migmatized sedimentary rocks. Contains inclusions of hornblende amphibolite and tremolitic rocks.

## OUTLINE OF THE GEOLOGY

The area covers part of the western end of the Zambezi Metamorphic Belt as it is known in Rhodesia. Most of the rocks are paragneisses of various ages that have suffered a long and complex history which has taken them into the highest facies of metamorphism and into the realm of granitization. Only the Karoo sediments of the Zambezi Valley are unaffected by these metamorphic events.

From the scanty geochronological results obtainable from the north of Rhodesia, the history of this area started more than 2 500 million years ago. In the east and south-east of the mapped area are a group of highly migmatized granitic gneisses which represent a continuation westwards of similar rocks found in the area described in Bulletin 51 by Wiles (1961). These Urungwe Paragneisses are regarded as forming the basement on which all other rocks in the area lie, although their relationship with the Basement Complex is unknown.

The south-central portion of the area is covered by a monotonous series of foliated biotite-rich paragneisses comprising the Chipisa Paragneiss. Similar biotite gneisses are noted at the western extremity of the Msango Range and around Kariba Township itself, where sillimanite quartzites form an upper psammitic facies. To the south, the Chiroti Paragneiss is found and it has become apparent that extensive sedimentation took place prior to the deposition of the Piriwiri rocks.

The Piriwiri Group rocks, which were deposited some 2 000 million years ago, are largely peltitic and they overlie the Chipisa Paragneiss unconformably. It is possible to trace south-westwards and northwards an increase of metamorphic grade within these rocks, from upper amphibolite facies in the south and east to the granulite facies rocks that occur in the vicinity of the Gil Gil and Nzoe mines. Deep burial of the crust soon after the deposition of the Piriwiri sediments resulted in granulite and enderbite formation along a regional north-east-trending zone. The dehydration process in this deep environment probably initiated anatexis of the gneisses which resulted in the widespread potassium metasomatism so evident in the Urungwe District.

The Nyaodza Centre and its environs represent the most prominent expression of granitization that was brought about by the Nyaodza Metamorphism. Local "hot spots", related to this event, have been noted at various localities within the older rocks, including those at Kariba itself, where granitic rocks are intimately associated with porphyroblastic

gneisses. The Nyaodza Metamorphism has probably resulted in the genesis of the economic mica-bearing pegmatites and the wolfram-bearing quartz veins. In addition the "wet" environment has caused extensive retrogressive metamorphism of the granulites, enderbites and gneisses.

An extended period of erosion apparently followed this period of metamorphism and deformation so exposing the deep seated rocks and providing the source material for the Rukwesa Formation, the basal formation of the Makuti Group. The Rukwesa Formation is now represented as a series of micaceous sillimanite schists, meta-arkoses and calc-silicate rocks which may be related to the onset of deposition of the Makuti Group.

The Makuti Group is a thick sequence of interbedded metasediments that can be directly correlated across the Zambezi River to the Katangan Group of south-eastern Zambia. The Group consists of a basal Rukwesa Formation overlain by a largely pelitic sequence that has been termed the Tsororo Formation, and an upper Vuti psammitic Formation in which meta-arkosic rocks become prominent. At the onset of the Katangan and Miami Metamorphisms, there was a widespread injection of mafic magma which apparently took the form of concordant sills, mostly near the base of the Makuti Group. Repeated folding of the rocks in the whole area followed, resulting in complex structures with dominant north-westerly trends. At the same time the Makuti Group rocks were raised in metamorphic grade to a maximum of the upper amphibolite facies in the south. A younger set of tourmaline-bearing pegmatites was injected into the Tsororo Formation rocks, which are extensively migmatized in places.

The final deformation at the close of the Miami Metamorphism was the initiation of major north-east-trending fractures which remained active during the formation of the fault-lined Zambezi Valley. Karoo sediments were deposited across the floor of the low-lying valley from material locally derived from the surrounding gneisses. Some of the faults along the mid-Zambezi Valley have been reactivated with the filling of Lake Kariba and this has resulted in considerable, but very weak, earthquake activity.

Mining in the area is largely concentrated on the West Urungwe Mica Fields from which large quantities of mica have been won in the past. The Gil Gil Mine was the largest producer and in the Nzoe Group a number of pegmatites were exploited. An attempt to revive the mica

mining industry in 1969 resulted in the exploitation of a number of pegmatites near the Nyaodza River and at the St. Mark's Claims above the Zambezi Escarpment. More recently gem-quality beryl has been won from such localities as the Pfuma Ishingu prospect and wolframite is the basis of a new mining venture centred on the Ma's Luck Mine just west of the Gil Gil Mine. Copper was the only economic mineral found in the Makuti Group but it appears to be of low concentration with a marked stratigraphic control. Cleaved muscovite quartzite, or "glitterstone", is obtained from the Rhostone Quarries near Kariba Airport.

#### THE URUNGWE PARAGNEISS

Wiles (1961) described the granitic gneisses that occur over a large area west of Karoi, regarding them as Piriwiri rocks of pelitic origin which were approaching the end product of granitization, but later Wiles and Tatham (1962) saw these gneisses as a basement of the more micaceous Piriwiri metasediments. The Urungwe Paragneisses are regarded as the basement in the mapped area. They extend westwards from the vicinity of the Catkin Mine and appear to pass beneath rocks of the Chipisa Paragneiss, the Piriwiri Group and the Rukwesa Formation. In the north-east these gneisses are faulted against rocks of the Makuti Group. Unfortunately, in the vicinity of the Nyaodza Centre, the rocks show a high degree of granitization and have been thoroughly permeated by potassium-rich solutions, as is shown by the coarse and conspicuous porphyroblastic texture of the gneisses. It therefore becomes difficult to decide on geological boundaries, as other adjacent formations have also been permeated in a similar way.

The Urungwe Paragneisses are extremely variable in texture and composition. They are usually exposed as a gneiss rich in biotite and were therefore, in all probability, originally derived from pelitic rocks. The gneisses can normally be described as migmatites, although banding is seldom conspicuous and the rock appears granitic. The degree of permeation of the original rock has been uneven, resulting in the variation of rock types. The most intense alteration occurs in the vicinity of the Nyaodza Centre, where the rocks have an adamellitic composition. The Centre represents a focus from which granitizing potassic fluids have emanated. These fluids were probably derived from a partial deep-seated melt and have resulted in the extensive "wet" metamorphism or metasomatism described by Wiles (1961, p. 46). The large amounts of pegmatitic material within these gneisses is further evidence of permeation and granitization.

South of the Makuti Group contact, the rocks are normally grey, foliated granitic gneisses. They can often be described as leucogneisses as shown by slide 21827\* which is a medium-grained quartz-microcline rock with virtually no other mineral constituents. It possibly represents a psammitic band.

In the south along the Murereshi and Rukuwe rivers, the gneisses are distinctly migmatitic with well-defined leucosomes in a biotite gneiss. This is shown by slides 21828 and 21829 in which the bands are made up of quartz and microcline. The normal feldspar of the palaeosome is oligoclase. Garnets are common in the gneisses along the Murereshi River and in those surrounding the Nyaodza Centre. They are often associated with pegmatite bands. In more granitic varieties, microcline is a common constituent. The oligoclase is normally turbid and sericitized.

Slide 21830 from the Kavende River near the Nyaodza Centre, shows the development of microcline porphyroblasts. The rock is granitic in texture, and it contains slightly more microcline than oligoclase. Myrmekite is common. It shows the replacement of microcline by oligoclase leaving vermicular quartz within an enclosing mass of secondary plagioclase (Wiles 1961, pp. 49-51).

A large number of calcareous bands occurred within the original sediments and they are now represented as calc-silicate resisters within the gneisses. Slide 21831 from one can be described as a diopside-hornblende calc-silicate gneiss. However, the mineral composition of these rocks is extremely variable. Hornblendic amphibolites and occasionally ultramafic tremolite-chlorite rocks are also encountered, and probably represent remnants of igneous intrusions. Metadolerites of post-metamorphic age are more common in these gneisses than they are farther west.

#### THE CHIROTI PARAGNEISS

Although rocks belonging to this formation are unimportant in the mapped area, they occur in a small area in the extreme south-east. These porphyroblastic biotite gneisses are interpreted as being an outlier of Chiroti Paragneiss. Wiles (1961, p. 52) originally regarded these rocks as having been derived by potassium metasomatism of

\*Numbers refer to slides in the Geological Survey slide collection, Salisbury.

original amphibolites. In the southern Urungwe area these gneisses contain up to 30 per cent. biotite and were regarded as metasediments by Stagman (1962, p. 27). Khume (1973) showed that these gneisses extend from the vicinity of Magunge in the Urungwe Tribal Trust Land, south-westwards to the type area around the Chiroti Fly Gate.

The Chiroti gneisses are more massive than those of the Chipisa Paragneiss and they are characteristically porphyroblastic. Chemically, however, they are very similar (Table I). The exact relationship of these rocks to those of the Chipisa Paragneiss is not clear, but they may be of much the same age and origin. It is possible that the Chipisa Paragneiss was refoliated during the Miami and Katangan metamorphisms whereas the Chiroti Paragneiss has only been affected by the earlier Magondi Metamorphism.

#### THE CHIPISA PARAGNEISS

Gneisses regarded as belonging to this formation cover the greater part of the area lying to the south of the overlying Makuti Group. The gneiss has been named after the Chipisa Hot Springs which are on the fault-lined scarp edge south-west of the Nzoe Group of mines. The hot springs emanate from a foliated biotite gneiss typical of the formation. Reconnaissance has shown that these gneisses continue with a south-westerly trend to form the Whamira Hills and the conspicuous Matusadona Range in which the Gachegache and Sanyati rivers are deeply incised. Mapping has also shown that similar gneisses occur along the western extremity of the Msango Range, which juts out into Lake Kariba, and around Kariba Township itself. These are discussed separately as the Kariba Paragneiss.

The Chipisa rocks are biotite and biotite-muscovite gneisses with occasional garnets. Although the gneisses are granitic in places, their relatively homogeneous and monotonous character serves to distinguish them from Urungwe Paragneisses to the east. The gneisses are generally well foliated and have suffered permeation and migmatization. They have suffered from intense pegmatite injection and the surface is characteristically strewn with quartz and pegmatite rubble.

The Chipisa Paragneiss can be regarded as being metasedimentary and is probably of pelitic origin because of the high biotite content which makes up about 25 per cent. of the rock. This view is supported by the numerous calc-silicate resisters within the gneisses. Hornblende amphibolites, which probably represent original mafic intrusions, and

occasional ultramafic resisters are also present. Although white feldspathic leucogneiss occurs, few rocks of a probable arenaceous origin are found.

A typical sample of Chipisa Paragneiss is represented by slide 21832. The sample, which comes from above the Escarpment near the track which runs just south of the St. Marks' Claims, is a coarse-grained, roughly foliated biotite gneiss. The quartzo-feldspathic leucosomes are separated by preferentially orientated biotite and muscovite flakes which show up a microfolding with axes parallel to the foliation plane. The biotite is associated with zircons and apatite. The groundmass is made up of quartz and calcic oligoclase. A minor amount of potash feldspar is untwinned, and myrmekite characteristically occurs at the oligoclase grain boundaries. Slides 21834-5 are also typical of the Chipisa Paragneiss and a sample (slide 2190) from the Sapi River, is a foliated biotite-muscovite gneiss.

In the south, in a zone running north-east and south-west from the Nyaodza Centre, the gneisses have been intensely permeated by potassic fluids related to the Nyaodza Metamorphism. The metasomatic introduction of potash-bearing fluids is shown in slide 21833 by the presence of large microcline and microcline-perthite augen up to 30 mm across. The augen have formed between the biotite-rich layers and have forced these bands apart. Biotite and muscovite flakes are elongated and there are fine-grained crush-textures within the quartz and sericitized oligoclase groundmass, which is also rich in microcline. Whereas virtually no microcline is found within the normal biotite gneisses, up to 35 per cent. microcline is found in the permeated rocks.

Mehnert (1968, p. 35) has described similar gneisses from Norway and Sweden in which the augen have developed within an earlier fabric by a process of blastesis or metasomatic feldspathization caused by the addition of potash feldspar.

Chemical analyses of the Kariba, Chiroti and Chipisa paragneisses are markedly comparable (Lab. No. 62/61, 62/62, 67/32, Table I). When compared with an analysis of a rock from the Nyaodza Centre (Lab. No. 73/42, Table I), however, there is a definite increase in the potash content of this rock, showing that potassic fluids have been introduced.

Calc-silicate rocks occur as localized inclusions within the Chipisa Paragneiss. They are distributed throughout although they become



conspicuous north of the Nyaodza and Kasiga rivers, and to the south of the Makuti Group contact along the Tsororo River. These calc-silicate resisters are extremely variable in their character and mineral composition. Quite often micaceous paragneiss grades into local horizons of calc-silicate gneiss, but most of the inclusions consist of hard fresh rocks with a variety of calcareous minerals, dependent on the original composition of the rock.

A specimen of calcareous, feldspathic gneiss from the Tsetse Control track 3.5 km north of the Jack's Luck 1 Mine above the Kasiga River, is shown by slide 21914 to be a leucocratic gneiss rich in microcline with a foliation defined by a dissemination of green hornblende, minor amounts of diopside and accessory grains of magnetite, sphene and apatite. Slide 21913 is cut from a sample taken from a local resister in the paragneiss above the Tsororo River to the north of the previous sample, is hard, fine-grained and hornblendic. The diopside is almost completely altered to a granular mass of weakly pleochroic, green-brown hornblende with associated tremolite-actinolite laths. Fresh, well-twinned labradorite with a little quartz comprises about 35 per cent. of the rock. Titaniferous magnetite grains show reaction rims of sphene, and spongy granules derived from this alteration form an important accessory.

#### THE KARIBA PARAGNEISS

The Kariba Paragneiss includes those gneisses which are exposed at the western end of the Msango Range and those centred on Kariba Township itself, where they extend across the Zambezi River into Zambia. Lithologically the Kariba Paragneiss is very similar to the Chipisa Paragneiss, but the two are treated separately as they are not directly linked. Stagman (1962) noted that the biotite paragneisses from Kariba are similar to those of the Chiroti Paragneiss and this is shown by chemical analyses from both areas (Lab. No. 62/61, Table I).

The Kariba Paragneiss has been described by both Hitchon (1958) and Loney (1969), and is generally a well foliated, banded rock which is often folded on a mesoscopic scale (slides 21837 and 21838). In the flatter area north of Kariba Airport and in the Kariba hills, the gneisses show intense pegmatite injection. Calc-silicate resisters are common north of the airport and occasionally thin leucogneisses and muscovite quartzites occur within the gneisses.

There are zones of massive porphyroblastic biotite gneiss in the Kariba Township area, particularly in the Mahombe Kombe African Township, in road cuttings leading up to the Police Station and just to the east of Nyamsowa Peak. These rocks weather spheroidally in contrast to the deeply weathered and friable biotite gneiss. The porphyroblastic gneisses are found to be intimately associated with small plug-like granitic bodies of adamellitic composition to the east of Nyamsowa Peak. Similar porphyroblastic biotite gneisses occur along the Msango Range and a granitic plug has been established near Charara Point. Hitchon (1958) has described a rock of granodioritic composition from the Shamba Quarry on the north bank at Kariba, which is related to porphyroblastic biotite gneisses.

Metamorphism has probably resulted in anatexis in depth and the subsequent granitic melt has domed up into the overlying gneisses. Potash, alumina and silica-bearing fluids diffused into the surrounding biotite gneisses where crystallization took place and formed microcline and microcline-perthite porphyroblasts.

Petrographically the porphyroblastic biotite gneisses (slides 21831 and 21911) are massive rocks with hybrid appearance which show large euhedral microcline and micropertite porphyroblasts interspersed in a mosaic of strained quartz and andesine with bent twin lamellae. Mafic minerals include biotite flakes which commonly show a reaction rim of granular garnet. A little hornblende occurs and both it and the biotite can be seen to be altering to chlorite, which is a retrograde mineral. Magnetite and apatite are accessories. Myrmekite is well developed at the interface between porphyroblasts and plagioclase grains, and fine-grained quartz-feldspar crush zones surround the porphyroblasts, suggesting that they were introduced and grew *in situ*.

Slide 21912 is of a calc-silicate rock from the Central Mechanical Engineering Department Workshops at Andora Harbour, Kariba. It is essentially an epidote-quartz calc-silicate rock folded into the Kariba paragneiss. Sericitized andesine is associated with the quartz, and tiny sphene grains occur with the epidote and zoisite granules.

#### THE KARIBA SILLIMANITE QUARTZITE

The Kariba Quartzites are peculiar to the Kariba Township area where they cap the surrounding hills. Their outcrop pattern suggests that the quartzites overlie the biotite gneisses with an unconformity and

they appear as if they were related to the quartzites of the Makuti Group. Normally the contact between the gneisses and quartzites is obscured by scree, but field evidence shows that interbedding of the quartzites and gneisses takes place over a broad contact zone. This has been noted at a quarry site on Boulder Ridge, along the shore line near Mica Point and in the pendulum shaft near the dam wall. This evidence suggests that the Kariba Quartzites are older than the Makuti Group and that they represent either an arenaceous facies of the Kariba Paragneiss, or else are an overlying, but complexly infolded, quartzite.

The Kariba Quartzites characteristically contain sillimanite whereas the quartzite associated with the Makuti Group are of a lower metamorphic grade. That the Quartzites were involved in the Makuti Group folding is shown by the presence of open folds with north-west- or south-east-plunging axes. However, north-easterly trending synclines, probably related to the earlier folding of the Kariba Paragneiss, have subsequently been folded on north-west-trending axes. This evidence detracts from a possible correlation of the Quartzite with the Makuti Group. It should be noted that thin muscovite quartzites have also been found interbedded lower down in the biotite gneiss sequence east of Kariba.

Petrographically the Kariba Quartzite is distinctive as is shown by slide 21839 which is a coarse-grained recrystallized sillimanite-bearing quartzite from Nyamsowa Peak. The rock is yellow in colour with pink iron-staining. About 85 per cent. of the rock consists of an interlocking mosaic of quartz grains up to 5 mm across. Fine sillimanite needles radiate from nucleating centres, which often contain anhedral masses of muscovite. This muscovite is regarded as being a product of retrogressive metamorphism. Other muscovite flakes occur independently, and small euhedral magnetite grains are an essential accessory.

#### THE PIRIWIRI GROUP

Wiles (1961), whilst mapping the Miami Mica Fields, noted a northward increase of metamorphism from phyllites of the greenschist facies to sillimanite of the upper amphibolite facies. In the vicinity of Catkin Mine and extending westwards into the mapped area, Wiles mapped a muscovite-rich sillimanite gneiss of the Piriwiri Group. A similar increase in metamorphism of Piriwiri rocks can be traced northwards from the southern Urungwe District. These rocks, which are of pelitic origin, are distinctive, and are regarded as outliers of the Piriwiri Group which rest directly upon the older Urungwe and Chipisa Paragneisses.

TABLE I

## ANALYSES OF PARAGNEISSES, ADAMELLITE AND PIRIWIRI GROUP ROCKS

Slide No.	—	16765	UCR 7436	21852	21843	21844	16951
Lab. No.	62/61	62/62	67/32	73/42	73/23	73/24	62/63
	%	%	%	%	%	%	%
SiO <sub>2</sub>	66,31	65,95	64,60	72,34	63,12	64,48	56,21
Al <sub>2</sub> O <sub>3</sub>	15,07	15,48	14,07	14,21	20,13	18,98	23,20
Fe <sub>2</sub> O <sub>3</sub>	1,07	0,78	1,93	0,24	1,43	1,51	6,97
FeO	5,82	5,41	6,10	2,24	5,08	5,11	1,62
MgO	0,65	1,18	2,07	0,74	2,06	1,78	1,29
CaO	3,48	3,31	3,23	1,50	0,92	0,55	0,18
Na <sub>2</sub> O	2,73	3,16	2,28	2,13	1,77	1,46	0,68
K <sub>2</sub> O	3,24	2,57	2,92	5,52	3,78	4,15	4,85
H <sub>2</sub> O+	0,46	0,47	1,35	0,52	0,69	0,62	4,08
H <sub>2</sub> O-	0,09	0,13	0,20	0,10	0,20	0,17	0,01
CO <sub>2</sub>	—	—	0,04	0,03	0,03	0,07	—
TiO <sub>2</sub>	1,09	0,89	1,22	0,45	0,92	0,93	0,40
P <sub>2</sub> O <sub>5</sub>	0,35	0,38	0,23	0,08	0,09	0,09	0,09
MnO	0,10	0,09	0,11	0,02	0,14	0,11	0,06
TOTALS	100,42	99,80	100,35	100,12	100,36	100,01	99,64
S.G.	—	—	—	2,64	2,93	3,04	—

Analyst: B. J. Radclyffe.

## C.I.P.W. NORMS

	%	%	%	%	%	%	%
Q	26,74	26,20	27,28	33,13	30,51	33,59	31,58
C	1,51	2,31	1,87	2,25	11,72	11,44	16,69
or	19,15	15,20	17,26	32,62	22,33	24,55	28,67
ab	23,08	26,75	19,30	18,04	14,95	12,32	5,77
an	15,19	14,16	14,44	6,76	3,87	1,78	0,39
hy	8,26	7,98	7,78	3,22	6,87	6,79	—
en	1,62	2,94	5,15	1,85	5,13	4,43	3,21
mt	1,55	1,13	2,80	0,35	2,08	2,20	4,24
hm	—	—	—	—	—	—	4,04
il	2,06	1,68	2,32	0,85	1,74	1,76	0,76
ap	0,78	0,84	0,50	0,19	0,19	0,19	0,19
cc	—	—	0,09	0,07	0,07	0,16	—
H <sub>2</sub> O	0,55	0,60	1,55	0,62	0,89	0,79	4,09

## Localities:

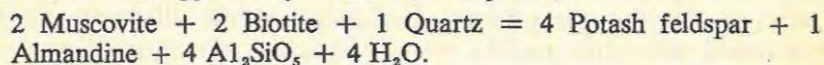
- 62/61 Kariba Paragneiss, Dam site, Kariba (Stagman, 1962; Phaup, 1973, p. 193).
- 62/62 Chiroti Paragneiss. About 2,1 km south of Dekete Camp, Rungwe Tribal Trust Land, Urungwe District (Stagman, 1962).
- 67/32 Chipisa Paragneiss. End of Sanyati Gorge, 3,1 km W.S.W. of Dandawa, Gatshe Gatshe Tribal Trust Land, Kariba District (Phaup, 1973, p. 197).

TABLE I (continued)

- 73/42 Porphyroblastic adamellite. Nyaodza Centre, 4 km south of Nyamangwe trigonometrical beacon. (Grid Ref. QM 362541), Nyaodza Tribal Trust Land, Urungwe District.
- 73/23 Garnet-sillimanite granulite, Piriwiri Group. Mouth of Nyaodza River Gorge (Grid Ref. QM 290606), Zambezi Parks and Wild Life Land, Urungwe District.
- 73/24 Garnet-sillimanite granulite, Piriwiri Group. Power-line pylon 109, base of Musiga Hill (Grid Ref. QM 255549), Zambezi Parks and Wild Life Land, Kariba District.
- 62/63 Phyllite, Piriwiri Group. About 3,2 km north of Garowa Hill, Plot No. 8, Tengwe Block, Urungwe District (Stagman, 1962).

The distribution of Piriwiri rocks within the area underlain by the older gneiss is widespread, and they characteristically form rugged country with conical, steep-sided hills. The restriction of Piriwiri rocks to high ground and the exposure of Chipisa paragneiss in the valleys suggests that they overlie the older rocks. The Nyaodza River Gorge provides a good exposure of Piriwiri rocks where, in places, the river cuts directly into the underlying migmatized biotite gneiss. Occasionally, as along the steep power-line road near Tokapi Mine, a gradation through sillimanite schists can be seen at the base.

In the east of the area there are highly micaceous sillimanite gneisses in which a core-zone of garnet-sillimanite gneiss is found. The hitherto essential micas have obviously undergone a major chemical change similar to that suggested by Winkler (1970, p. 216).



Westwards the garnet-sillimanite gneisses become commoner, but they retain their foliation (slide 21917) and, on Nyahunzwi Mountain, regional trends can be detected. In the vicinity of the Gil Gil and Nzoe mines however, the rocks become massive and granoblastic and are granulites after Spry's (1969) definition. The granulites are high-grade, regionally metamorphosed rocks which are composed dominantly of anhydrous minerals including quartz, feldspar, garnet, sillimanite, and cordierite. The rocks have a granoblastic-polygonal texture which is restricted to rocks that have reached the granulite facies of metamorphism, or show partial retrogression from this facies. Hyperthene-bearing enderbites are included under this definition.

Slide 21840, from a point 1,5 kilometres south of Hoko Hill, is a schistose and highly micaceous sillimanite gneiss. Biotite occurs with a

little muscovite and is associated with knots of contorted sillimanite needles. A few grains of magnetite occur within the biotite. Anhedral quartz and a little plagioclase make up the rest of the rock. Farther west, near the Kamongwa River, slide 21841 is of a similar, but fine-grained, quartz-biotite-sillimanite-muscovite gneiss. This gneiss gives way directly to a garnet-sillimanite gneiss (slide 21842) which forms a core-zone. In this rock the biotite percentage is greatly reduced and there is no muscovite, but garnet, sillimanite and microcline perthite are plentiful. This assemblage is suggestive of the reaction mentioned in the discussion above and is borne out by the textures within the rock. Garnets, which occur as xenoblastic masses within the foliation, contain inclusions of sillimanite and other minerals. Magnetite is closely associated with the garnet and occurs as granules, as a fine dust within the garnets, or as a vermicular exsolution texture. The biotite may be a product of retrogressive metamorphism as it appears as aggregates, apparently after sillimanite, and not as fresh flakes. Microcline perthites are untwinned and occur as fresh grains with fine exsolution lamellae. Perthite now makes up some 30 per cent. of the rock whereas it was not present before chemical change.

Further west, to the Nyaodza River Gorge, these rocks become more granoblastic in appearance as is shown by slide 21843. A chemical analysis of it (Lab. No. 73/23) is listed in Table I. Xenoblastic garnet becomes an important mineral and is associated with exsolved magnetite and green spinel. Sillimanite laths and needles show a preferred orientation and biotite aggregates are associated with the sillimanite. Fresh, untwinned microcline perthite forms a granoblastic-polygonal ground-mass together with quartz and a little cloudy oligoclase.

On the power-line near Ma's Luck Mine the relict gneissic foliation seen to the east is lost (slides 21844 and 21918) and the rocks become true granulites. A chemical analysis of the former sample (Lab. No. 73/24) is shown in Table I. The rock is massive, dark grey with coarse, greasy aggregates of microcline-perthite, and minor amounts of quartz and plagioclase. Xenomorphic garnets contain exsolved magnetite and sillimanite inclusions and fine sillimanite needles also occur with biotite produced by retrograde metamorphism.

Slide 21818 from near the Tokapi Mine contains coarse patches of xenomorphic garnet with large radiating needles of sillimanite up to 4 mm long. The rock is rusty brown in colour and contains much fine-grained iron ore produced by exsolution during the formation of the

garnet. There is a little quartz in the antiperthitic groundmass which contains significant amounts of cordierite.

A pale coloured quartz and antiperthite-rich granulite (slide 21845) from a point just to the north-west of Nzou Fly Gate contains conspicuous red-brown garnet porphyroblasts as well as biotite, sillimanite and accessory magnetite and green spinel. Cordierite has dust-like inclusions and shows lamellar and radial-sector twinning. It is mostly pseudomorphed by a yellow isotropic mineral.

From the above discussion it would appear that the granulites have been derived isochemically from an original pelitic rock. Chemical analyses of the granulites show a marked similarity to an analysis of a Piriwiri phyllite (Lab. No. 62/63, Table I) from the southern Urungwe (Stagman, 1962). However, in the vicinity of Ma's Luck Wolfram Mine, quartz veining is associated with a massive, coarse-grained porphyroblastic rock containing large greasy euhedral porphyroblasts of microcline perthite which often show carlsbad twinning. Exfoliation surfaces in outcrop show a preferred orientation to these porphyroblasts, suggestive of flow, and therefore an introduction of the feldspar. Slide 21846 contains knots of biotite and garnet with accessory apatite, magnetite and secondary muscovite together with grains of quartz and plagioclase which form an interstitial mass between porphyroblasts. Crush-textures, which are shown up as bent twin lamellae in the plagioclase, are suggestive of later blastesis, as is the well-developed myrmekite formed at the boundaries of plagioclase grains and introduced porphyroblasts. This potash feldspathization appears to be related to the Nyaodza Metamorphism which affected the older rocks in this area. It is probable that the mica and beryl pegmatites also owe their origin to this event.

It is important to note that, as in the Miami and East Urungwe Mica Fields, the mica pegmatites in the West Urungwe Mica Field are intimately related to the sillimanite-rich rocks of the Piriwiri Group (Fig. 3).

Wolfram mining is also related to the Piriwiri Group and the quartz veins at the Tembo Mine, about a kilometre west of Hoko Hill, occur in a tourmaline griessen (slide 21847). This tourmaline is regarded as a product of boron metasomatism as is the presence of the complex aluminium borosilicates, grandierite and kornerupine, within Piriwiri granulites (slide 22316) south of the Gil Gil Mine (Anderson, 1975) and

near Pfuma Isingu beryl mine to the north of Ma's Luck Mine. Grandidierite from Urungwe was first identified by C. B. Anderson in 1967 from a concentrate submitted for identification at the Geological Survey Department. A full chemical analysis (Lab. No. 71/32, Table II) and later X-ray work by S. M. Anderson confirmed this identification. Grandidierite and kornerupine had not previously been recorded from Rhodesia.

TABLE II  
ANALYSIS OF GRANDIDIERITE

	%
SiO <sub>2</sub>	20,50
Al <sub>2</sub> O <sub>3</sub>	50,02
Fe <sub>2</sub> O <sub>3</sub>	1,87
FeO	7,45
MgO	8,90
CaO	Trace
Na <sub>2</sub> O	Trace
K <sub>2</sub> O	Trace
H <sub>2</sub> O	0,65
TiO <sub>2</sub>	Trace
P <sub>2</sub> O <sub>5</sub>	Trace
B <sub>2</sub> O <sub>3</sub>	11,00
Cr <sub>2</sub> O <sub>3</sub>	0,08
MnO	0,13
<u>TOTAL</u>	<u>100,60</u>

*Analyst:* B. J. Radclyffe.

*Locality:*

Lab. No. 71/32. Low hill on left of road 5 km north-west of the Nzou Fly Gate and 5 km south of the Gil Gil Mine (Grid Ref. QM 279485), Zambezi Parks and Wild Life Land, Urungwe District (Anderson, 1975).

#### THE ENDERBITES

Enderbites are not true charnockites as described from the type area in Madras, in that compositionally, andesine becomes dominant over microcline. They are regarded as charnockitic granodiorites. Enderbites are found within the area of granulite facies metamorphism where they were formed under dry, high temperature and pressure conditions in a deeply buried environment. They are distributed both north-east and south-west of a focal point represented by the Nyaodza Centre and are known to extend beyond the area. Local occurrences have been established between the Nyaodza and Tsororo rivers as well as at a point on the power-line west of Kariba Airport (slide 21951).



Slide 21848 is from an enderbite body forming a small bornhardt which stands out above the surrounding country north-east of the Nyaodza Centre and north of the cattle fence. The rock is massive and medium-grained with a dark, waxy lustre. It consists of a granoblastic-polygonal groundmass of quartz and andesine showing both polysynthetic and pericline twinning. A little poorly twinned microcline perthite is present. The most important mafic mineral is hypersthene, but retrogressive reactions are shown by the coronas of spongy garnet and biotite with associated magnetite and apatite. Larger red-brown flakes of biotite also occur. Later deformation of the rock has strained and fractured the quartz and bent the twin lamellae in plagioclase.

Slide 21849, from a point on the power-line near the cattle fence crossing, is a coarse-grained enderbite which has suffered feldspathization during the Nyaodza Metasomatism. The rock has a dark, waxy lustre and contains large (10 mm) euhedral microcline perthite porphyroblasts with carlsbad twinning. The porphyroblasts are surrounded by a crushed vestige of fine-grained quartz and feldspar which is impregnated with myrmekite. Interstitial to the introduced feldspar is a granular mass of strained quartz and andesine with bent twin lamellae. This is associated with pleochroic hypersthene which is altered along fractures to green hornblende and biotite. Retrogressive reactions are shown by spongy masses and coronas of red-brown biotite, garnet, hornblende and magnetite. Apatite and zircon are accessories.

Slide 21850 is a very coarse-grained augen rock from the main Nzoe road, west of the power-line. Westwards it grades into enderbite. Low castle koppies in either side of the Nyaodza Centre are made up of this coarse, friable rock in which waxy microcline perthite augen reach 40 mm in length. The augen make up 50 per cent. of the rock and show carlsbad twinning, fine exsolution lamellae, fractures and inclusions of the original minerals. They are surrounded by a fine-grained quartzo-feldspathic crush with associated myrmekite. Flakes of brown biotite are stretched within the original, but now interstitial, groundmass of quartz, plagioclase and microcline. Garnet, magnetite and apatite occur, but there is no original hypersthene.

#### THE NYAODZA CENTRE AND METAMORPHIC EVENT

The Nyaodza Centre is a circular, plug-like body, nearly four kilometres in diameter and situated some four kilometres south of Nyamangwe trigonometrical beacon near the Nyaodza River. The Centre

is cut diagonally from north-east to south-west by the cattle fence. Surrounding the Centre are three satellites of similar rock type, the most prominent of which is Vagwiri Hill across the Nyaodza River to the south-west of the Centre (slide 21916).

The rocks making up the Nyaodza Centre and its satellites are granitic in character. They form castle koppies with smooth exfoliated surfaces. There is an intense development of euhedral potash feldspar porphyroblasts, giving the rock its granitic appearance and adamellitic composition as is shown by the chemical analysis (Lab. No. 73/42, Table I). In the valleys between the koppies the rocks contain more biotite, fewer porphyroblasts and retain their original gneissic foliation. A distinctly arcuate trend to the koppies can be detected on air photographs and it is possible that the mobile potash- and alumina-bearing fluids came up through the country rock in a series of cone-shaped pulses to form the plug. That the original rocks of the Nyaodza Centre were pelitic paragneisses is further evidenced by the numerous garnets within the rock and the presence of calc-silicate resisters.

Slide 21852, which has been chemically analysed (Lab. No. 73/42, Table I), is an adamellite by composition. The rock shows the development of euhedral microcline-perthite porphyroblasts, 10-20 mm long, with fine exsolution lamellae and carlsbad twinning. The porphyroblasts contain rounded inclusions of quartz and andesine and show a gregarious development of myrmekite, especially around the edges. The interstitial matrix represents the original rock and is made up of a fine-grained, often crushed, mass of strained quartz, fresh andesine, brown biotite flecks, fragmented garnet and a few specks of ore. Oligoclase is the normal plagioclase found in these rocks and porphyroblasts often show irregular twinning typical of high-temperature formation, as in slide 21853.

The Nyaodza Centre represents a focus of intense potash metasomatism and the country rocks have been affected in a zone both north-east and south-west of the Centre. The related metasomatic effect on the enderbites, granulites and surrounding gneisses has already been discussed. The affected zone was one of deep burial as is shown by the initial formation of granulites and enderbites. With the dehydration of the rocks in depth and the increasing temperatures and pressures, the availability of water was able to initiate anatexis within the gneisses to form a eutectic melt of granitic composition. The elements of this melt were mobile and able to migrate upwards into the country rocks where

crystallization took place in the form of perthitic augen and porphyroblasts.

Similar feldspathized granitic rocks and associated enderbites (Kuhme, 1973) are found to the south-west where they form Mount Kalukumbula and also in the vicinity of Manyangau Hill and Urungwe Hill in the Mukwishe Tribal Trust Land. Wiles (1961, p. 79), relates the formation of the economic mica pegmatites and the Miami biotite granites to an earlier soda metasomatism, the last stages of which was the production of a migma-magma capable of forceful injection. Both Stagman (1962) and Harper (1973) produce evidence for potash metasomatism in the rocks of southern Urungwe. The regional potash metasomatism within the Urungwe District is widespread, but the potash has not necessarily been added as it is possible to derive all that is required from the original rocks. It may have been part of the extensive granitization process so apparent in the area whereby the potash and other granophile elements have been mobilized within the rock mass. These elements migrated and a later aggregation and concentration resulted in the formation of porphyroblasts, pegmatites and ultimately granites.

A number of "hot spots" have been found in which granitic rocks are intimately associated with blastesis in the country rocks. These occur near St. Marks' mica claims on the edge of the Escarpment where small plugs of granite occur, and along the Msango Range where massive porphyroblastic biotite gneiss has been developed similar to that at Kariba. Slide 21854, from a small plug near Kariba, just north of the main road and below Nyamsowa Peak, is a fine-grained, grey granitic rock with concentrations of mafic material scattered throughout as specks. The rock is largely equigranular with strained quartz, cloudy sericitized oligoclase and cross-hatched microcline. The microcline is sometimes perthitic and shows porphyroblastic tendencies with related myrmekite. Brown, unoriented biotite is the major mafic mineral and is often altered to chlorite and allanite. Apatite is accessory as are ore specks which have reaction rims of sphene. Retrogressive metamorphism is apparent as it is in most of the Kariba rocks.

#### THE MAKUTI GROUP

The Makuti Group was first mapped on either side of the Great North Road between Vuti Township and Makuti, a small settlement at the junction of the main Kariba road from which the Group takes its name. On air photographs the Makuti Group rocks can be traced northwards

to the Zambezi Escarpment where they are terminated by faults, and thence westwards across the Zambezi River into Zambia. The northern boundary of the mapped area from the Kariba Gorge eastwards to the Tsororo River forms the southern extent of the Makuti Group. The nature of the contact of the Makuti Group with the older paragneiss north of Kariba and along the abrupt southern boundary, the base of which is followed by the Tsororo River, is that of a marked unconformity. In the east, the Group is terminated by the prominent north-east-trending Tsororo-Kasiga Fault. A small outlier of the Makuti Group rocks occurs a few kilometres south of the junction of the Nyaodza and Tsororo rivers at the point where the power-line ascends the Escarpment. Karoo sediments cover Makuti Group metasediments in the Charara Basin so dividing the east-trending Msango Range from the northern main body of the Group which has strong north-west structural trends.

The Makuti Group rocks are traced across the Kariba Gorge into Zambia where they were mapped by Hitchon (1958) as belonging to the Deweras and Lomagundi Groups. The rocks on the north bank of Kariba are now considered to be equivalent to the Katangan Group in the Gwembe, Monze and Mazabuka Districts of southern Zambia. Here the dominant north-westerly trend is continued in contrast to the north-easterly trend of structures in the older rocks. The older north-east trend is reflected in structures of the Piriwiri and Lomagundi rocks of the Urungwe District so detracting from a possible correlation with these rocks.

The Makuti Group has been subdivided into three formations which in ascending order are (a) the Rukwesa, (b) the Tsororo, and (c) the Vuti Formations. The small gneissic Makuti Outlier, 3 to 4 kilometres south of Baobab Camp on the Nyaodza River, which is probably a basal part of the Group, has not been subdivided.

#### THE MAKUTI OUTLIER

The Makuti Outlier is about 1,0 to 1,5 kilometres wide and extends for 6,5 kilometres east of the Karoo boundary fault in the Chipisa Paragneiss. The Outlier is crossed by the Kariba to Norton power-line which ascends the Zambezi Escarpment at this point.

In contrast to the surrounding Chipisa Paragneiss the Makuti rocks have a very strong easterly trend and include an interbedded sequence

of pink meta-arkose rocks (slide 21860), calc-silicate rocks, biotite-sillimanite schists and amphibolites. The dominant rock type, however, is an exceptionally well-foliated biotite gneiss (slide 21858) which petrographically is no different from the adjacent Chipisa Paragneiss. The rocks of the Outlier have suffered extensive migmatization and pegmatite injection, similar to the Makuti rocks in the Tsororo Valley just to the north. As along the southern edge of the main Makuti Group outcrop, the Outlier rocks have attained the sillimanite-almandine-muscovite sub-facies of metamorphism.

#### THE RUKWESA FORMATION

A group of meta-arkose, micaceous schist and calc-silicate resistors can be distinguished in the east where they appear to overlie the older rocks which have been affected by the Nyaodza Metamorphism and the formation of enderbites. The Formation takes its name from the Rukwesa Fly Gate, which is at the point where the cattle fences bounding the Vuti Purchase Area and Nyaodza Tribal Trust Land meet.

Two separate areas of outcrop have been mapped. The first occurs on both sides of the cattle fence which extends south-westwards from the Rukwesa Fly Gate, and the second area is north of Hoko Hill. Rocks of the northern occurrence are regionally folded in sympathy with the Makuti Group. They appear to cut across rocks of the Piriwiri Group and are dextrally displaced more than two kilometres by the Tsororo-Kasiga Fault. It is thought that the rocks of the Rukwesa Formation are basal beds related to the initial sedimentation of the Makuti Group, and represent outliers to the south of the main outcrop.

Outcrop on either side of the cattle fence is poor and often quartz and pegmatite rubble together with outcrops of calc-silicate rocks and meta-arkose are the only indication of rocks which must be a largely pelitic sequence of micaceous schists. Slide 21855 is from a buff-coloured meta-arkose band which forms along an east-trending spur above the Kavende River. The rock is foliated and made up largely of an equigranular mass of quartz, cross-hatched microcline and a little sericitized oligoclase. Brown biotite occurs as small oriented flakes evenly distributed through the rock. A little secondary muscovite, a few specks of magnetite, apatite and zircon are accessory. Many of the meta-arkoses show a distinct rodding (slide 21919) which plunges to the north-west and is related to the deformation of the Makuti Group.

Micaceous schists and gneisses with occasional sillimanite are probably the dominant rock type. Just north of a prominent east-trending meta-arkose band which lies to the south of the Kasiga River, these micaceous rocks become sillimanite-rich. Coarse-grained quartz-sillimanite boulders are characteristically scattered on the surface along with quartz and pegmatite rubble. Slide 21856 is a biotite-muscovite-sillimanite schist. Flakes of biotite and muscovite up to 3 mm long show a well-defined foliation in which is found sillimanite occurring as knots of fibrolite, apparently after muscovite and quartz. A few small garnets occur with flecks of magnetite in a groundmass of equigranular quartz which makes up about half the rock. Feldspars are a rare constituent of the Rukwesa schists.

A few small mica workings occur on pegmatites within the sillimanite-rich schists, and the Catkin graphite claims are near the cattle fence, west of Rukwesa Fly Gate.

#### THE TSORORO FORMATION

The Tsororo Formation outcrops near Vuti in the core of a complex antiformal structure on the north side of the Tsororo-Kasiga Fault. The entire length of the lower Tsororo River flows across rocks of the Formation where they represent the southern edge of the Makuti Group. Further mapping might show that the mixed semi-pelitic, psammitic and amphibolite rocks of the Rhuwe and Nyanyana valleys belong to the Tsororo Formation, as they too have been injected by pegmatite.

The rocks in the Tsororo Valley consist largely of a thick, biotite-rich semi-pelitic gneiss with numerous thin interbeds of meta-arkose as well as occasional beds of quartzites, calc-silicate rocks and concordant amphibolite bands. In contrast to the overlying arenaceous rocks, the Tsororo Formation has suffered greatly during the period of deformation largely because of its basal position and general incompetence. The rocks have been injected by pegmatites and in places they have suffered intense migmatization. The layers of variable rock types have been complexly interfolded in sympathy with the structure of the Makuti Group as a whole. The foldings was probably assisted by the induced plasticity and permeation of the rocks during the migmatization process resulting in the highly mixed character of the Tsororo Formation outcrops. For this reason the micaceous metasediments tend to be gneissic rather than schistose.

At the Nyaodza River crossing at Baobab Camp, the rocks show the effects of intense migmatization with various folded, layered schlieren and even nebulitic structures. Original biotite-rich pelites and associated amphibolites appear to have been injected by concordant aplitic veins. They have been thoroughly permeated and folded during migmatization and now form extremely heterogeneous and variable rock types. Slide 21857 is a migmatized biotite gneiss showing concordant development of quartzo-feldspathic leucosomes between mafic biotite and hornblende-bearing bands which represent the paleosome. Biotite defines a foliation and the elongation of hornblende crystals shows a lineation within the foliation. Zircons have formed pleochroic haloes in biotite flakes. Apatite and magnetite are accessory. A few altered garnets in the groundmass of quartz and slightly sericitized calcic oligoclase show radiating expansion cracks. In contrast, the strained quartz and oligoclase of the leucosome form bands of coarse-grained mosaic.

To the east of Matambudziko Spring, which lies on a major fault in the Tsororo Valley, the river flows across a variable group of biotite gneisses (slide 21859) that include interbeds of meta-arkose, hornblende gneiss and calc-silicate rock. These rocks have been injected by pegmatite and in places resemble the Chipisa Paragneiss. Farther east they overlie micaceous sillimanite schists of the Rukwesa Formation.

#### THE VUTI FORMATION

The Vuti Formation takes its name from Vuti Township on the main road from Salisbury to Chirundu and that portion of the road between Vuti and Makuti is regarded as the type section for the Formation because of its accessibility and exposure. The Vuti Formation makes up the greater portion of the Makuti Group, the topography and outcrop being dominated by leucocratic pink paragneiss, regarded as a meta-arkose, and occasional quartzite bands, which give the Formation its psammitic character. These rocks alternate rapidly with aluminous, muscovite-bearing meta-pelites, calc-silicate gneisses, amphibolites and occasionally ultramafic schists. There is evidence to suggest that the amphibolites are of mafic igneous origin, but the remainder of the Makuti Group can be regarded as an interbedded sequence of meta-sediments, probably of Katangan age, that overlie the older paragneisses with distinct unconformity. The environment of deposition was probably one of low energy and deep water and the original sediments, which were poorly sorted, included arkoses, graywackes and dirty calcareous sediments. Separate horizons are often thin, but can be traced for many

kilometres along strike. The linear and complexly folded structure of the Vuti Formation, together with the constant repetition of the different rock types has made it impractical to determine any stratigraphic succession in it.

Unlike the Tsororo Formation, the Vuti Formation has suffered little pegmatite injection and consequently its outcrop area is relatively free of surface quartz rubble.

*Pink Paragneiss* is the most distinctive rock unit of the Vuti Formation and both north of Kariba and above the Tsororo River Escarpment, it appears to form a thick basal sequence to the Formation. Along the Msango Range, pink paragneisses make up most of the major east-trending ridges, but north-east of Kariba, the paragneiss horizons are widely separated by broad pelitic bands which dominate the outcrop here.

The pink paragneiss, or meta-arkose, is largely a leucocratic quartz-microcline rock whereas the dominant feldspar in the adjacent pelitic rocks is plagioclase. The microcline therefore shows a strong stratigraphic control that is probably related to the composition of the original sedimentation, and the foliation which one measures may be parallel to the original bedding. The pink paragneiss characteristically cleaves along mica-rich planes on this foliation and the rock break into blocky flags. Where mica is sparse, however, the gneiss becomes compact and granitic.

A specimen (slide 21861) from the steep, scarp edge north of Kariba, which marks the contact of the Makuti Group with the Kariba Paragneiss, is a compact, flesh-coloured quartzo-feldspathic rock with a few iron-stained fractures. It is almost devoid of micas and a faint foliation is shown by the concentration of magnetite. The rock is largely an equigranular mosaic of quartz and cloudy microcline with a little oligoclase. Sphene and allanite occur as accessory minerals along with magnetite, biotite and a few tiny zircons.

A specimen (slide 21862) from a point where the Nowa River cuts across ridges of the Msango Range north of Baobab Camp, is a leucocratic pink paragneiss made up largely of a hypidiomorphic assemblage of quartz and microcline that is perthitic in places. The microcline crystals are larger than the quartz, and plagioclase is not apparent in the slide. Small muscovite and rare biotite flakes define a foliation along which a vein of coarse-grained, sutured quartz has been introduced.



Magnetite, which appears to be an essential accessory of the paragneiss, is present with a little sphene.

South-east of Rugare Spring the meta-arkose gneiss develops microcline porphyroblasts and quartz veins lie in a foliation defined by a higher biotite content that is normal in the paragneiss. This apparent granitization may be related to that in the porphyroblastic gneisses to the south of Makuti. Slide 21863 from just to the north of the track that follows the watershed between the Kasiga and Tsororo rivers, shows the development on a preferred orientation of the biotite which is slightly altered to chlorite. The groundmass of quartz, microcline and a little sericitized plagioclase is xenomorphic-granular. Clusters of perthitic microcline show the start of blastesis and a little myrmekite is developed adjacent to these clusters. Magnetite is partly oxidized to hematite. Zircon, apatite and muscovite are accessory minerals.

*Quartzites* are usually found close association with muscovite schists in the Makuti Group, and they form very sharp crested ridges that can often be traced for many kilometres. Although the copious amounts of scree tend to suggest a far wider extent, the quartzite beds are normally narrow and true outcrop is hard to find.

Quartzite bands are common north-east of Kariba Airport where Chiremgwe is a prominent feature, and they again occur to the south-east and south-west of Chidoma Mountain, a point on the boundary between Kariba and Urungwe Districts just north of the mapped area, where they highlight the complex folding. Only a few thin bands of quartz-muscovite schist occur along the Msango Range.

Slide 21864 is from a coarse-grained recrystallized muscovite quartzite from Chiremgwe, a prominent ridge north of Charara Fly Gate on the main road to Kariba. Large quartz grains, up to 5 mm across, form a sutured mosaic making up some 85 per cent. of the rock. Small muscovite and biotite flakes are strongly oriented parallel to the foliation. The muscovite flakes occur as inclusions in the quartz grains and occasionally they occur in altered knots from which tiny brown needles of rutile radiate and penetrate the quartz. A little magnetite and zircon are accessory.

At the Rhostone Quarries near the Nyanyana Bridge on the Kariba road, a band of well-cleaved muscovite quartzite, dipping at 70 degrees to the north-east, is being extracted as a building stone. The band continues north-westwards and is dextrally displaced by about 300

metres on the Nyanyana Fault. A quarry has been established on the far side of the fault. The rock (slide 21865) from these quarries, shows strong development of muscovite along the cleavage surface, with a concentration along low ridges on the surface defining a lineation. The rock consists of a mosaic of interlocking quartz grains with interstitial microcline. A few tiny specks of magnetite and rare green tourmaline also occur.

The *Calc-silicate rocks* in the Vuti Formation, can be traced as bands for many kilometres along strike and occasionally they appear to be genetically related to low-grade copper horizons. The calc-silicate bands represent original calcareous sediments but the only true marbles occur as small pods in the upper Charara Valley. The calc-silicate rocks are a heterogeneous group of mineralogically differing rock types that are usually hard, fresh and granoblastic. The commonest group of calc-silicate rocks, however, is gneissic and of similar texture to the pink paragneiss or meta-arkose. The normal mineral assemblage is that of hornblende, diopside, epidote, quartz andesine and microcline. Although microcline can be derived by chemical reaction, the lack of actinolite and the average of 30 per cent. of microcline in these rocks suggests that they were originally calcareous sediments related to the arkoses.

Calc-silicate rocks occur as bands in the Nyanyana Valley, north-east of the Rhostone Quarry and as thin horizons along the Msango Range, such as in the Nyadara Valley and just north of Msango Harbour (slide 21867). In the north-east corner of the mapped area, above the Tsororo River, calc-silicate bands have been isoclinally folded on a regional scale and have been subsequently refolded. Slide 21866 from above the Tsororo River, is a coarse-grained hornblende-diopside-epidote calc-silicate gneiss. Coarse grains of microcline make up about 30 per cent. of the rock and are associated with quartz and calcic oligoclase. Magnetite granules are common with a little apatite and sphene.

*Micaceous schists* of a pelitic or semi-pelitic origin are common in the Vuti Formation but they are not always apparent as they occupy the valleys and are poorly exposed being overlain by brown, micaceous soils. Biotite and biotite-muscovite-bearing semi-pelites are commonest and contain quartz and plagioclase, but rarely microcline. The true pelites contain less than 35 per cent. of quartz and feldspar, are highly micaceous, and often contain almandine garnet and alumino-silicates.

In the low-lying Nyanyana and Rhuwe valleys, biotite schists are common and they contain thin interbedded psammitic bands, muscovite

schist and amphibolite. Similar rocks occur in the Msheka Valley where they are associated with amphibolite.

Biotite and biotite-muscovite schists occur in narrow bands along the Msango Range. Slide 21868 from one of these bands, is a well-foliated and crenulated biotite-muscovite schist in which the coarse mica flakes are strongly aligned and make up some 50 per cent of the rock. Between the micaceous layers interlocking quartz and rare plagioclase grains are elongated parallel to the foliation. A few tiny grains of green tourmaline are present with accessory apatite and zircon.

On the game fence, south of Msango Fly Gate, the semi-pelites are folded and appear gneissic in places. Slide 21869 is from a fine-grained, biotite-rich gneiss containing hardly any muscovite. It has a granular groundmass of sericitized, poorly twinned oligoclase, and subordinate quartz makes up about 70 per cent. of the rock.

Near the Rhostone Quarry (slide 21870) is a very fine-grained, puckered biotite-rich pelite in which are set a number of snowball garnets. The garnets have been rotated and the quartz inclusions and surrounding biotite have been drawn into a spiral arrangement. Associated with the biotite are small grains of kyanite and tiny euhedral crystals of green tourmaline which may have been introduced after deformation. A fine-grained, hypidiomorphic-granular groundmass of quartz and a little plagioclase forms about 40 per cent. of the rock.

*Chlorite-rich schists*, possibly of ultramafic igneous origin are rare in the Vuti Formation where they occur as conformable lenses and bands of limited lateral extent. Actinolite-chlorite-bearing schists have been noted in the mapped area just north of Kariba Airport, in the east along the game fence, and just north of the Tsororo River. It is thought that these rocks are related to the amphibolites of the Makuti Group, and may represent an ultramafic differentiate of the original magma that produced the amphibolites, but in view of the chemical homogeneity of the amphibolites, this may not be true. C. B. Anderson (personal communication) found similar chlorite-tremolite schist directly related to amphibolite in the area east of Mount Darwin. Although it is possible for chlorite to remain stable in the amphibolite facies of metamorphism, where it occurs in the absence of quartz, it is also possible that the chloritic schists represent a retrograded amphibolite. It is unlikely that these schists are an original sediment.

On the game fence south of Chidoma Mountain is a folded, well-foliated chlorite-tremolite schist (slide 21872). Large green flakes of strained clinocllore occur in the folded foliation of the rock which contains numerous small euhedral crystals of actinolite elongated on a lineation parallel to the fold axis. Many specks of magnetite are scattered through the rock and there is no quartz or feldspar.

*Amphibolites* are numerous in the Makuti Group, especially near the base of the sequence. They are everywhere conformable with the meta-sediments and form persistent bands, usually associated with the well-foliated semi-pelitic rocks.

Loney (1966) paid a lot of attention to the chemistry and genesis of the Makuti Group amphibolites. Field relationships are not conclusive in deciding the origin of the amphibolites but comparative chemistry suggests that they are of mafic igneous, rather than of sedimentary origin. Whether the amphibolites were originally basaltic lavas or dolerite sills is a matter for conjecture.

Separate horizons vary in thickness from several centimetres to broad bands, and their contact with the country rock is always sharp. A few cross-cutting relationships have been observed in river exposures south of Makuti. If the amphibolites were lava flows it is unlikely that they would have shown the persistence along strike which they do, and at the same time have the effect of separating thin and continuous sedimentary horizons which suggest an uninterrupted sedimentation process. It is suggested, therefore, that the amphibolites represent a series of dolerite sills which were preferentially injected into the Makuti Group along well-developed bedding planes at the onset of the Katangan Metamorphism. Few amphibolites of great lateral extent were noted in the older rocks, other than in the Piriwiri Group rocks in the Rukomeshe Valley east of Vuti. A similar origin for the amphibolites in the Lomagundi rocks around Shamrocke Mine is invoked by Thole (1974) but this mafic suite is considered to be older than that of the Makuti Group.

A specimen (slide 21873) of dark, fresh amphibolite from the Rhuwe River near the main Kariba road comes from a narrow amphibolite band in biotite schist. It has a well-developed metamorphic fabric with hornblende crystals aligned on a lineation that plunges gently to the north-west in the foliation. The slide is cut across the lineation and numerous euhedral basal sections of hornblende make up over 50 per

cent. of the rock. A few flakes of biotite and specks of magnetite are present. Euhedral sphene is common but without orientation. Hexagonal basal sections of apatite are also aligned along the lineation. The hypidiomorphic-granular groundmass of quartz and partially sericitized andesine is largely interstitial amongst the darker mineral grains.

A dark, well-foliated amphibolite (slide 21874) from the headwaters of the Nowa River in the Msango Range is diopside-bearing and has a flaggy appearance. The horizon, which can be traced westwards into undoubted diopside-bearing calc-silicate rocks, was the only amphibolite found that could have originated from a calcareous sediment. The slide shows a strong orientation of green, pleochroic hornblende crystals parallel to the foliation. Hornblende forms about 45 per cent. of the rock, but subordinate bands of pale green xenomorphic diopside are interspersed in the hornblendic layers. Minute crystals of sphene, magnetite and apatite are accessory minerals. Poorly twinned andesine and a little carbonate material form a largely interstitial matrix. Quartz is absent.

#### THE STRUCTURE OF THE MAKUTI GROUP

The Makuti Group is situated at the western end of the east-trending Zambezi Metamorphic Belt in Rhodesia. The Group suffered severe and repeated deformation during the Katangan and Miami metamorphisms resulting in strong north-westerly structural trends, similar to those in the Katangan rocks of southern Zambia. The late north-westerly trends are detectable in the older gneisses surrounding the Makuti Group, especially in the competent Kariba Quartzites. However, the older rocks have been involved in previous deformations in which the dominant structural trend was north-easterly; the later folding cuts across these trends.

Along the Kariba Gorge and stretching into Zambia, the regional structure is that of both simple and overturned anticlines and synclines with their axes plunging at low angles to the north-west. This gives rise to the marked north-west-trending grain of the country. As one goes eastwards the plunge of the structure steepens to the north-west, and large, open structures that have been cross-folded have developed. Complex interference structures occur and near Makuti some of these folds even plunge to the north-east.

The first phase of regional folding trended north-westwards and resulted in tight and even isoclinal folds on this trend. South and south-

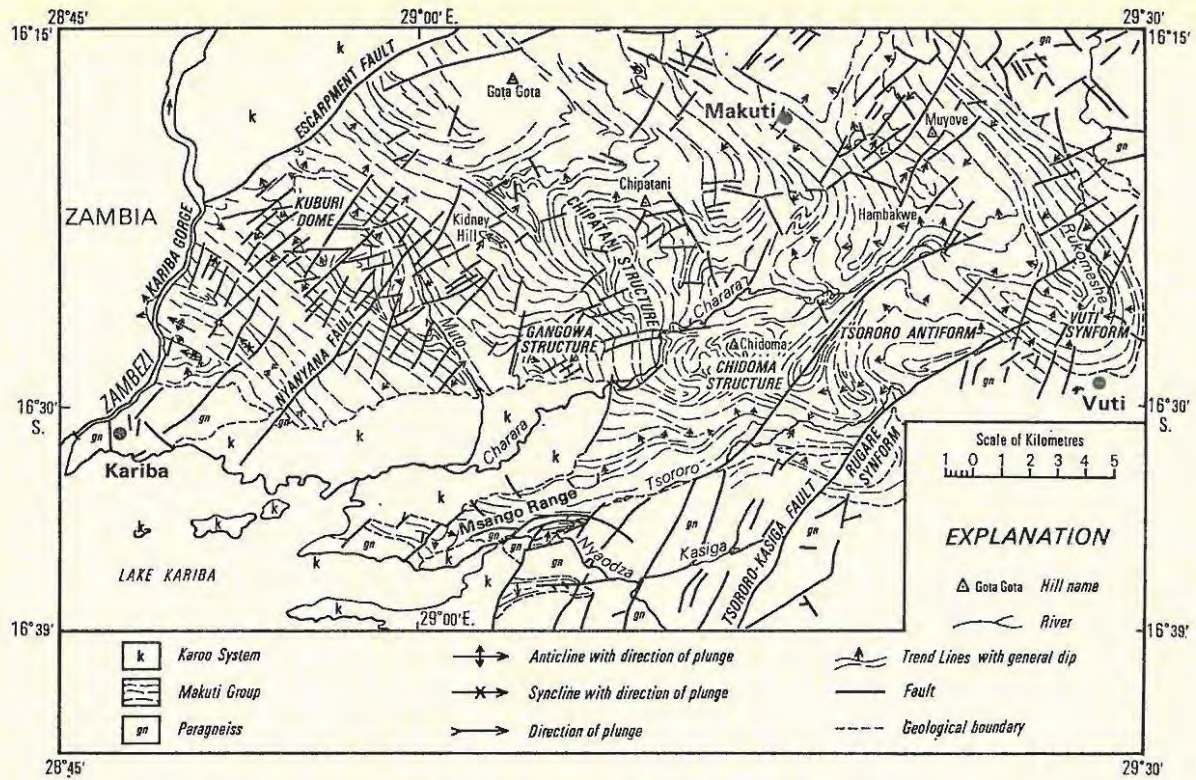


FIG. 1. Structure of the Makuti Group.

east of Makuti the initial folds have been strongly refolded on a similar north-westerly trend producing broad, open structures such as the Vuti Synform, the Tsororo Antiform, and the Rugare Synform, which affects rocks of the Rukwesa Formation, as well as the Chidoma, Chipatani and Gangowa structures (Fig. 1). Strong refolding of the beds in the Vuti Synform has had the effect of exposing older rocks of the Tsororo Formation as windows in the core of the structure. Along the Msango Range the rocks have an easterly trend, but gentle, open synforms and antiforms, with their axes plunging north-north-west, represent the second fold phase. Complex interference patterns in the folding indicates that further deformation took place, probably contemporaneous with the second fold phase.

Loney (1969), has shown that the schistosity, which is sub-parallel to the bedding, and a mineral lineation were probably formed during the first fold phase. The schistosity was itself folded during the second fold phase, and most small-scale open folding and boudinage is related to the last deformation. A prominent rodding was developed parallel to the fold axes of second phase minor structures. It plunges north-westwards at relatively low angles and can be related to the plunge of the axes of the major second phase structures. A statistical analysis of structural readings taken on the Vuti Synform indicates that this structure plunges at 22 degrees on a bearing of 309°.

The final deformation appears to be the initiation of the prominent north-east-trending fracture pattern which has resulted in major faulting in the Kariba area and along the whole Middle Zambezi Valley. The fractures were probably caused by a release of pressure at the close of the Miami Metamorphism and they have remained active from pre-Karoo times to the present. Water from the Chipisa Hot Spring, for which a chemical analysis is shown in Table III, has an eye temperature of 82°C, which indicates a depth of origin of some 3 000 metres for this water. This shows the magnitude of some of these faults.

The breccias in these faults are invariably silicified and contain remnants of the country rock. From the Escarpment edge, south of the Nyadza River, a hard siliceous rock (slide 21876) with fractured angular remnants of the original gneiss caught up in a fine-grained, cryptocrystalline mylonite matrix of crushed quartz and feldspar grains and bent biotite flakes, partly altered to chlorite, occur in the fractured gneiss. Crystallization of secondary calcite and quartz has since taken place in the open fractures.

TABLE III

ANALYSIS OF WATER FROM THE CHIPISA SPRING, KARIBA  
(Parts per million)

Carbonate . . . . .	Nil	Hypothetical Composition of Salines	
Bicarbonate . . . . .	189,1	Magnesium bicarbonate . . . . .	9,1
Chloride . . . . .	66,6	Calcium bicarbonate . . . . .	145,8
Sulphate . . . . .	608,0	Sodium bicarbonate . . . . .	98,7
Sodium . . . . .	355,0	Sodium sulphate . . . . .	899,0
Potassium . . . . .	25,0	Sodium chloride . . . . .	72,6
Calcium . . . . .	36,0	Potassium chloride . . . . .	47,8
Magnesium . . . . .	1,5		
TOTAL . . . . .	<u>1 281,2</u>		

*Analyst:* B. J. Radclyffe.

*Locality:*

Lab. No. 72/13, September, 1972. Chipisa Hot Spring, Sunde River Valley, at base of the Zambezi Escarpment, 6 km south-west of the Midway Mine, Kariba District.

## METAMORPHISM OF THE MAKUTI GROUP

The metamorphism of the Makuti Group was achieved during the Katangan and Miami metamorphisms, whereas the older rocks had experienced repeated earlier metamorphisms. The granulite facies of the West Urungwe Mica Field was probably attained prior to the Miami Metamorphism which here reached the upper amphibolite facies. The Makuti Group everywhere overlies rocks that have at least attained the sillimanite-almandine-muscovite subsfacies of metamorphism.

Figure 2 shows the regional trends of progressive metamorphism in the Kariba and Urungwe districts.

From observations of mineral assemblages in pelitic rocks of the Makuti Group, approximate isograds can be drawn (Fig. 2) showing zones of progressive regional metamorphism within the Group. Loney (1969) mentioned the presence of albite in phyllites around Gota Gota and Kirkpatrick and Robertson (1968) found quartz-chlorite-sericite schists between Chitonobero and Camp Hill on the road from Makuti to Kariba. These assemblages fall into the Greenschist Facies of Turner and Verhoogen (1960).

The metamorphism increased progressively southwards from Gota Gota in an arcuate form. South and north-east of Makuti, the assemblage quartz-kyanite-staurolite-muscovite-paragonite-almandine shows the progression into staurolite-almandine subsfacies of the amphibolite facies.



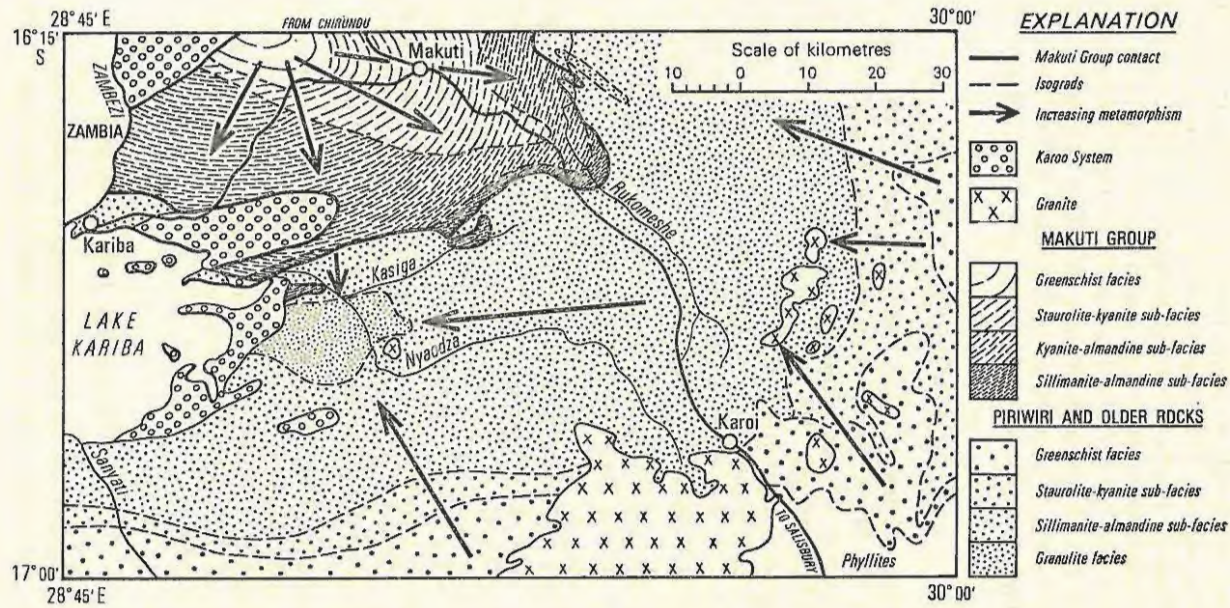


FIG. 2. Regional metamorphism around Makuti, Karoi and Kariba.

South-east and south of Makuti and at localities in the Umzimwizi and Charara valleys, near Kidney Hill and north of Kariba Airport, the assemblage of quartz-kyanite-almandine-muscovite  $\pm$  biotite defines the kyanite-almandine-muscovite subfacies. On the cattle fence at the centre of the Vuti Synform and just north of the Tsororo River, kyanite is found to co-exist with sillimanite in pelites containing quartz, mica and garnet. Along the southern margin of the Makuti Group and in the Vuti Synform, the sillimanite-almandine-muscovite subfacies is attained.

### GEOCHRONOLOGY

Numerous radiometric age determinations from pegmatites and granites in the Miami and Catkin areas as well as from Zambia give ages of between 300 and 600 Ma and effectively set an age for the Miami Metamorphism. Loney (1969) quotes a Rb-Sr whole rock isochron determination for the Makuti Group pink paragneiss, between the Muto and Umzimwizi valleys, of  $800 \pm 30$  Ma and  $850 \pm 30$  Ma, using alternative decay constants for  $^{87}\text{Rb}$ . The Lusaka Granite which intrudes rocks of Katangan age is dated at 725 Ma (Snelling *et al.* 1964).

Clifford *et al.* (1967) quote a whole rock Rb-Sr age of  $1\,170 \pm 40$  Ma or  $1\,250 \pm 40$  Ma for the granite that intrudes the Piriwiri Group near Badze Fly Gate in the southern Urungwe. K-Ar ages for the biotite was  $833 \pm 40$  Ma and for the muscovite  $937 \pm 40$  Ma. This gives an idea of the time span during which the Katangan rocks were deposited (Vail and Dodson, 1969).

Loney (1969) introduces whole rock Rb-Sr isochron ages for the Shamba Quarry granodiorite on the north bank of Kariba as  $1\,980 \pm 30$  Ma or  $2\,090 \pm 40$  Ma, using different decay constants for  $^{87}\text{Rb}$ . This age may be related to the Nyaodza Metamorphism.

Using the same decay constants, Rb-Sr rock isochron determinations for the Kariba Paragneisses give ages of  $2\,290 \pm 90$  Ma and  $2\,420 \pm 100$  Ma. Similar determinations for the Chipisa Paragneiss on the power-line south of the Nyaodza River are given as  $2\,360 \pm 90$  Ma and  $2\,500 \pm 100$  Ma.

### MINOR MAFIC INTRUSIONS

As in the Karoi area, two distinct groups of mafic intrusive rocks are recognized. These are firstly the metadolerites which were injected

during the dying stages of the Miami Metamorphism and secondly an old group which are of pre-Miami metamorphic age.

The older group was described by Wiles (1961, p. 98), and he classified the majority of these rocks as epidiorites. However, in the mapped area, where the metamorphism has reached the upper amphibolite and granulite facies, these early intrusions are represented by hornblendic amphibolites which occur as small inclusions in all the rocks of Piriwiri age and older. Also occurring in these rocks are occasional small plugs and inclusions of ultramafic tremolite-chlorite, chlorite-actinolite and rarely talcose rocks.

The amphibolites are most common in the east where they intrude the Urungwe Paragneiss, but they continue westwards into the Chipisa Paragneiss where they are common on the Escarpment edge above the Chipisa Mine and north of the Nyaodza and Kasiga rivers. Amphibolites were noted in road cuttings in Kariba Township and to the north of Kariba Airport. The latter have been discussed by Loney (1969). The ultramafic rocks are less common although their distribution is widespread in the older gneisses. Two small plugs occur in Chipisa Paragneiss about one kilometre north of the Jasp Mine.

A sample (slide 21925) from the steep power-line track as it ascends the Zambezi Escarpment, is a dark hornblendic amphibolite which occurs in the Chipisa Paragneiss. Dark green-brown hornblende laths are strongly aligned so defining a mineral lineation. There is somewhat more than 50 per cent. of hornblende interspersed with white streaks of andesine. The slide is cut across the mineral lineation and so numerous euhedral cross-sections of hornblende crystals are seen, but many small laths have no particular orientation and lie across this lineation. Fresh andesine, both twinned and untwinned, occupies the interstices between hornblende crystals. Numerous tiny euhedral hornblende and spongy sphene grains occur as poikilitic inclusions in the feldspar grains. Spongy sphene of late origin, magnetite specks and a few tiny apatite crystals are accessory minerals associated with the hornblende.

Slide 21929 is of a hornblende amphibolite from a large mafic body above the Chipisa Mine on the Escarpment edge. The texture of the rock is unusual for an amphibolite in that the plagioclase occurs as distinct knots in a groundmass of euhedral green hornblende crystals. The hornblende shows a tendency to be orientated on a mineral

lineation but the feldspar knots are rounded and consist of a large but irregular plates of well-twinned calcic andesine. The andesine plates, up to 5 mm across, are sometimes cross-hatched and invariably contain numerous tiny inclusions of hornblende, quartz, sphene and apatite. Accessory magnetite and sphene are associated with the bright green to straw-coloured hornblende crystals which surround the feldspar plates. Tiny zircons form pleochroic haloes in the hornblende.

Slide 21927 is of a compact chlorite-actinolite ultramafic rock from a small plug-like inclusion in the Chipisa Paragneiss, just over one kilometre north-west of the Jasp Mine. The specimen is a dark green, medium-grained rock devoid of feldspar. Basal sections and laths of pale green, slightly pleochroic, actinolite constitute about 50 per cent. of the slide. The grains are up to one millimetre across and cleavage traces contain a fine dusting of exsolved magnetite. In places the actinolite has altered to a highly birefringent mass of fibrous talc with which are associated irregular magnetite grains derived from the breakdown of actinolite. Numerous tiny flakes of pale green clinocllore with associated magnetite form the groundmass which makes up some 35 to 40 per cent. of the rock. As the plug-like body of rock contains essentially two mineral phases, actinolite and chlorite and has a chromium and nickel content of over 0,1 per cent. (spectrographic analysis by I. H. Green), it is reasonable to conclude that it had an ultramafic igneous origin.

Metadolerites, which are in the form of small dykes and which display their original textures, are quite widespread within the Urungwe Paragneiss and the Rukwesa Formation rocks in the east. These intrusions become more isolated to the west although they occur in the Chipisa Paragneiss and Piriwiri Group rocks. In the Kariba Paragneiss an outcrop occurs on the main road near the airport (slide 21922). Metadolerites and gabbros have been found in the Makuti Group rocks to the north and north-east of the mapped area.

A coarse-grained metadolerite (slide 21878) from above the Nyaodza and Kasiga river junction is typical of these rocks although the degree of alteration is variable. The original ophitic texture has been preserved and laths of turbid labradorite, occasionally zoned, are partially enclosed in plates of relict clinopyroxene. The pyroxenes are cloudy with exsolved iron ores and have reaction rims of green-brown hornblende which in turn is rimmed by colourless, granular garnet. Flakes and radiating aggregates of biotite occur and often surround magnetite granules,

hornblende and garnet. Apatite is accessory, and quartz is not apparent in this slide although it occurs in others. In slide 21879 from a tributary of the Murereshi River, altered olivine has been found.

The metadolerites show retrograde metamorphism and were probably emplaced at the close of the Miami Metamorphism some 500 Ma ago.

### THE KAROO SYSTEM

Sedimentary rocks of the Karoo System occupy the low-lying country below the Zambezi Escarpment in the lower Charara Valley and south of the basement high represented by the Msango Range, where they continue as the Gachegache basin around the eastern end of Lake Kariba to the mouth of the Sanyati Gorge. This area represents the eastern end of the Gwembe Trough in the fault-lined Middle Zambezi Valley (Gair, 1959).

Sedimentation appears to have taken place within two palaeo-valleys and structurally the rocks are very gently synclinal. The northern boundary of the Charara basin forms a sedimentary contact with the pre-Karoo surface but the southern contact is abrupt and often fault-lined. Large faults also line the Escarpment edge in the southern Gachegache basin. Judging from the general immaturity of the sediments, the source area for material is probably local.

The Karoo succession on the Zambian side of Lake Kariba has been established by Gair (1959) but, it must be realized that in the mapped area where no palaeontological evidence is available, only lithology can be used. Gair's stratigraphic succession is as follows—

#### UPPER KAROO

- Batoka Basalts
- Red Sandstones
- Sandstones and interbedded siltstones
- Escarpment Grit

#### *Unconformity*

#### LOWER KAROO

- Madumabisa Mudstones
- Gwembe Coal Formation
- Red mudstone
- Basal sandstone.

The *Basal Beds* are a thin horizon of distinctive red to purple mudstones with a sub-conchoidal fracture along the northern boundary of the Charara basin between Mopane Bay and the Nyanyana River bridge near Kariba Airport (slide 21880). A thin basal conglomerate is exposed

upstream of the Nyanyana bridge and in the river the interbedding of many bands of gritty sandstone was observed. Outcrop along the remainder of the northern contact of the Charara basin is masked by thick residual soils and gravel outwash from the surrounding gneisses, but siltstones, sandstones and grits are exposed.

In the Gachegache basin, a thin conglomerate is in direct contact with the gneisses on the southern shore of the Msango Range, but it is not known at which stage the poorly sorted boulder conglomerate with its dirty and highly micaceous matrix (slide 21924) found in the Sunde River near the Chipisa Hot Springs, was formed. It was probably formed from locally derived material as a direct result of faulting.

The *Coal Formation* has not been established within the area although reports of carbonaceous shales outcropping at a point where the old road from Makuti to Kariba drops off the gneisses into the Charara Valley have been received from W. H. H. Nicolle, a respected early traveller in the Kariba area. (Personal communication.)

Tyndale-Biscoe (1928) in his geological reconnaissance of the proposed Sinoia-Kafue rail link was of the opinion that the coal would be deeply buried beneath the 'Escarpment Grit', although he conceded that if it did outcrop, it would be on the northern flank of the Charara basin.

*Mudstones* outcrop within the Nyanyana, Rhuwe and upper Charara valleys as a thick southerly dipping sequence of green and grey rocks (slide 21881) containing petrified wood and unidentifiable plant remains. Mudstones also occur along the northern shores of Redcliff, Antelope and Zebra Islands and are taken to be the uppermost mudstones. Sandstones become interbedded within the mudstones near their contact with the grits.

In the southern basin, outcrop is very poor. Molyneux (1912) has mentioned the occurrence of grey "Madumabisa Mudstones" at the point where the Sanyati River debouched onto the Zambezi Valley floor, and Brassey (1949) mapped other mudstones along the lower Sanyati Valley. The soils south of the Gachegache Estuary are fine, clayey soils and appear to have been derived from mudstones. They are taken to be an eastwards extension of the mudstones found at Dandawa near the mouth of the Sanyati Gorge.

*Arkosic grits* form a prominent east-north-east-trending ridge north of the Charara River. It continues out into the Lake to form Redcliff,

Antelope and Zebra Islands. Similar grits re-appear along the southern Escarpment edge of the Charara basin. The grits appear to thicken towards the edge of the basin, which is in direct contact with the area of provenance. In the southern or Gachegache basin a similar easterly trending ridge of grit forms the Nyaodza Peninsula. The grits have a southerly dip and re-appear just north of the Gachegache Estuary and along the Escarpment edge in the south.

The arkosic grits and sandstones are very immature sediments, suggesting local derivation from fast flowing streams coming off the Escarpment. A sample from a point near the Msango Fly Gate (slide 21882), just before the Kariba power-line ascends the Escarpment, is a typical example. It is a khaki-coloured arkosic grit which is coarse-grained and poorly sorted with unorientated flakes of muscovite. Angular quartz grains together with a little microcline and sericitized plagioclase occur within a feruginous-clay matrix. The mica flakes have been bent around the quartz grains during compaction of the sediment. The matrix is often calcareous.

*Cross-bedded sandstones* with interbedded siltstones (slide 21883) are best observed in the Charara River where they grade directly upwards from the arkosic grits. Cross-bedding becomes common within the sandstones. Siltstones, mudstones and occasional coarse-grained grits and thin conglomerates are commonly interbedded.

Similar poorly exposed rocks occur in the southern basin surrounding Gachegache Bay. A sample (slide 21923) from the Sapi River is a red gritty sandstone containing angular grains of quartz with minor microcline together with bent flakes of biotite and muscovite. The matrix is calcareous and contains a lot of siderite which gives the rocks its red colouration. Dull, opaque flecks in the sediment may be mangani-ferous.

#### SUPERFICIAL DEPOSITS

Soils in the area are residual and are rarely deep except in parts of the Karoo basins. The soils derived from the gneisses are grey, sandy and of poor fertility. Red soils reflect amphibolites and brown soils, biotite-rich rocks. Alluvial soils occur at points along the Nyaodza and Charara rivers and are especially well developed around the Nyaodza Estuary which is the point where the river formerly flowed onto the Karoo surface. Many of the Karoo soils are alluvial as they are derived

from above the Escarpment. Gravels containing gneiss, quartz and breccia form an extensive outwash on the Karoo surface and are especially widespread near Kariba.

Ferricrete is sometimes formed within vlei areas underlain by Makuti Group rocks and tufa has been found as accretions at the lips of waterfalls, where feldspathic pink paragneiss is the fall maker.

At the point where the power-line ascends the Escarpment, south of the Nyaodza Estuary, a large fault with silicified breccia forms an abrupt line of hills with aprons of talus breccia on the lower slopes. Silicified breccia float or rubble is common on the Karoo surface.

Steep slopes, such as the abrupt scarp which forms the southern contact of the Makuti Group along the Tsororo Valley and on the steep quartzite-capped Kariba Hills, have extensive talus developed along their bases. In Kariba this talus occasionally occupies former erosion channels.



## ECONOMIC GEOLOGY

*All measurements have been converted to metric units and all outputs and mining information, unless published elsewhere, are up to 31st December, 1965.*

Mining activities have been centred on the West Urungwe Mica Fields which occupy the rugged country above the Zambezi Escarpment some 70 to 80 kilometres south-east of Kariba by road. The area is best approached, however, through the Urungwe Tribal Trust Land from Karoi which by road lies some 90 kilometres farther to the south-east. Mica mining was established during the late 1940's but the area has only been made accessible by the construction of the Kariba to Norton power-line and through the Tsetse Fly Control programme which has necessitated the construction of numerous tracks.

Mica mining has been the mainstay of the industry in this remote area and mines such as the Gil Gil and the Nzoe Group have been active until recently. An attempt was made by the Nyaodza Mica Mining Co. to revive the industry in 1968 but since 1970 there has been virtually no mica production from the West Urungwe Mica Field.

Beryl mining has supplemented mica production in the past but recently a few new prospects have produced gem quality material. Recently wolfram has become the basis of a new mining venture and it is the only mineral of importance being produced at present.

Up to 1965 a total of 417,9 tonnes of cut mica was produced from the area, valued at \$457 982. Of this, nearly 25 per cent. came from the Gil Gil Mine and only three other groups of mines have exceeded a production of 45 tonnes of cut mica. The Gil Gil is the only underground mine of any consequence and on few others have attempts been made to work below surface. It is clear that many pegmatites have been prematurely abandoned and the potential production from old workings is still great. Diamond drilling may indicate the structure and suitability of pegmatites for mica production.

A very significant point which has emerged from mapping is that the economic muscovite pegmatites are intimately related to the sillimanite-bearing gneisses and granulites of the Piriwiri Group (Fig. 3), a point which became apparent during the mapping of the Miami Mica Fields (Wiles, 1961).

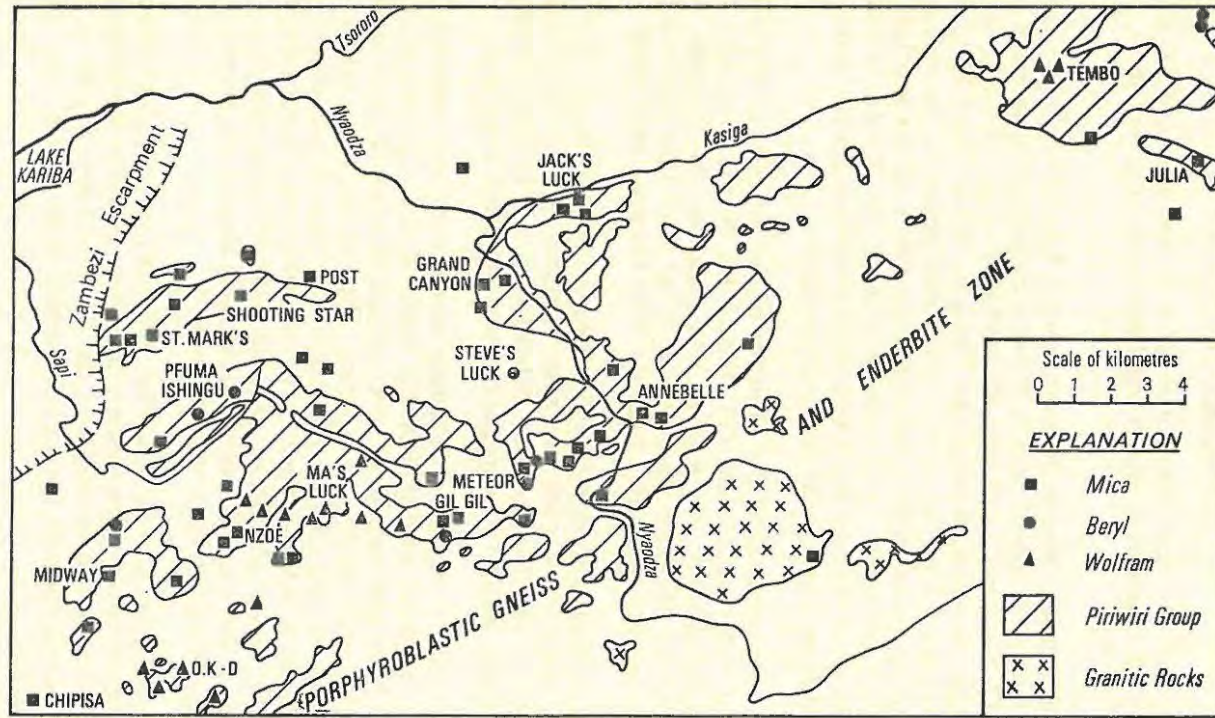


FIG. 3. Distribution of economic minerals in relation to sillimanite-bearing Piriwiri Group rocks.

Most mines and claims in the mapped area occur within the Zambezi Parks and Wild Life Land which covers the West Urungwe Mica Field and cuts across the Kariba and Urungwe district boundary. Where mines occur in the Tribal Trust Lands, African Purchase Area or in the Kariba Township area, this is mentioned in the text.

#### MICA

The *Annabelle Mine* is situated near the Nyaodza River about 2,5 km south-west of Nyamangwe trigonometrical beacon. The pegmatite was opened up by the Nyaodza Mica Mining Co. in 1968 and was described by Stidolph (1969).

The pegmatite follows a rather warped E.S.E. strike, and opencast workings, which have been developed to an average depth of four metres, follow the strike for most of its 90 m length. About 30 m south-east of the eastern end of the opencut, an inclined adit has been driven south for 30 m into the hill. From this point, a drive was advanced westwards until it intersected the pegmatite at 34 metres. The drive has been developed along the pegmatite for 30 metres.

The Annabelle is a zoned, lenticular body, with a discontinuous core of microcline and occasionally quartz. Much graphic intergrowth of quartz and microcline occur towards the centre. The mica, which averages second to third quality spotted, occurs in the hanging wall. There is a micaceous wall zone, 30 to 100 cm wide, with quartz, plagioclase and a little perthite. The wall zones appear to coalesce in the opencut.

Underground, the initial 21 m of pegmatite had poor mica development. It began as a narrow body about 100 cm across but widened fairly rapidly to about 600 cm around an isolated quartz core where mica with herring-bone structure was developed. The mica quality improved beyond the core and averaged about 270 kg of crude mica per metre blasted. Towards the western end of the opencut there was a large percentage of mica, but it was wedge-shaped and interleaved with biotite.

The pegmatite has since been abandoned but considerable potential for mica production must still exist, especially if underground development is continued.

The *Bonanza Mine* was partly developed by the Nyaodza Mica Mining Co. in 1969. It is situated on the east bank of the Nyaodza

River, just over a kilometre upstream of the cattle fence crossing. The pegmatite strikes north for some 36 m but the structure is unknown. In the first blast on 31st January, 1969, almost a tonne of crude mica was extracted. Most of it was high-grade spotted and clear brown-green mica. The pegmatite is small but it has potential as a rich mica body.

The *Chaka Claims* lie between the Doza and Gatipic claims on the west bank of the Nyaodza River and were exploited by the Nyaodza Mica Mining Co.

The *Challenger Mine* is situated one kilometre north-north-west of the Gil Gil Mine on the spur of a hill on the opposite side of the valley to the Gil Gil. The mine was originally worked by G. Paterson and Sons and later by J. F. Turner.

Wiles (1962) describes two parallel-striking pegmatites trending N.W. but dipping to the south-west at different angles. A dip of 65 degrees was measured on the main pegmatite but it would appear that the average dip is steeper than this. The pegmatite is mostly discordant to the country rock, though folding in the latter has produced some local concordance. The pegmatite is lenticular and may not extend to any depth. It is zoned, but books of good quality spotted mica are disseminated throughout both intermediate zones with a tendency to be richest towards the core margins, with the hanging wall side the richer of the two. The books of mica are set in a quartz-plagioclase matrix, the plagioclase having the platy cleavandite structure.

The smaller 'reef' has a flat dip of some 5 degrees and may well be a spur off the main body. It has produced some good quality spotted mica near the surface but the body narrows rapidly at a shallow depth.

For the full potential of this mine to be realised, a vertical shaft should be sunk at the crest of the spur on the foot-wall side of the pegmatite. From 1947 to 1949 the declared production amounted to 5 817 tonnes of cut mica valued at \$6 144.

The *Chingua Mine* is situated on the south-western slopes of Nyahunzvi Mountain, near the Annabelle Mine, and was exploited by the Nyaodza Mica Mining Co. between 1968 and 1970.

The pegmatite is classically zoned with a wide quartz core and hanging wall and foot-wall mica shoots. It strikes at approximately 050° magnetic and is almost vertical. The pegmatite has been described by both Wiles (1968) and Stidolph (1969) who regard the north-west side

of the quartz core as the hanging wall zone. Large books of muscovite are set in a quartz-albite matrix and are orientated, as is normal, with their cleavage planes at right angles to the walls. The mica is second quality spotted. Biotite flakes are abundant and beryl and apatite occur in the core and core margins of the pegmatite.

The workings consist of a large opencut, excavated some 60 m into the hill along the hanging wall zone, to a depth of about 15 metres. A second opencut has been made in the foot-wall shoot. Some 60 m north of, and perhaps 30 m lower than the hanging wall opencut, a horizontal adit has been driven into the hillside in a south-easterly direction towards the pegmatite.

The pegmatite extends for at least 150 m in a gradual curve that swings from E.N.E. to N.E. It narrows at the north-east end but is said to extend up the hill. Although the mine has been abandoned, the pegmatite may extend in depth and have a large mica potential.

The *Chipisa Mine* is situated above the Sunde River nearly 2,5 km east-north-east of the Chipisa Hot Springs, near the Zambezi Valley floor. The mine was worked by E. G. Boswell and J. F. Turner before being transferred to the Gemsbok Rhodesia Development Co. in June, 1949.

Wiles (1962) visited the prospect but found that the pegmatite was almost completely mined out in the old open workings. At one point some small 'mussel' mica from the border zone of the pegmatite was observed adhering to the well-defined foot-wall which dipped at 60 degrees to the north. The pegmatite clearly bore a discordant relationship to the gneiss. From the material on the waste dump it would appear that the pegmatite was ideally zoned with a quartz core and hanging and foot-wall mica shoots. The outputs reveal that, for the amount of work done, the pegmatite was extremely rich in spotted quality block mica.

An adit was driven below the level of the open workings and there is a short drive to the east. Here the pegmatite has flattened appreciably and is very narrow, though full of mica. East of the open working the pegmatite has been followed to the point where it strikes into the hill, is narrow, and uneconomic. There is no western extension of the pegmatite because of the configuration of the ground and it would appear that this pegmatite has been exhausted.

The declared outputs for 1948-9 amounted to little over 33 tonnes valued at \$33 446. The 1959 production has been declared with Midway Mine.

The *Choice Claims* are reported to be 3 km south of the Rukwesa Fly Gate in the Nyaodza Tribal Trust Land. No workings were located.

The *Chufe Mine* forms part of the Nzoe Group of mines and it adjoins the Undina Mine on the west. It is nearly 5 km W.S.W. of the Gil Gil Mine. The mine was worked by J. F. Turner.

Wiles (1954) reported the pegmatite is a wide one, striking 080° magnetic and dipping steeply north. In places, however, the dip appears to be nearly vertical, but at the lowest point in the mine a dip of 60 degrees was measured. The structure is relatively simple and the pegmatite is zoned in so far as having a hanging wall mica shoot. On surface, at a point near the east end of the visible strike, there is an outcrop of quartz which may constitute a core.

There is some evidence that a strong spur 'reef' branches off to the west from the hanging wall side of the main body, and could be explored by extending the existing small cross-cut.

The mica is of mixed quality, both ruby and spotted, and there is still much mica to be won. Also there is a plan of the workings, which are accessible by road. The outputs from this mine have been declared with a number of other blocks.

*Derek Claims* See *Lakhi*

The *Doro Mine* was part of Turner's Nzoe Group.

The *Doza Mine* is situated above the west bank of the Nyaodza River some 3,5 km E.N.E. of the Gil Gil Mine. The workings form part of the Nyaodza Mica Mining Co's group of mines.

Stidolph visited the mine in January, 1969, when development consisted of several trenches and a main area of excavation 18 m long by 5 m wide, reaching a depth of just over one metre.

Exposure is poor, but the pegmatite appears to have an extensive strike of over 180 m E.S.E. Discontinuous outcrops of quartz indicate an interrupted quartz or quartz-microcline core.

Development has shown a strong concentration of small- to medium-sized books of spotted mica, set in an intergrowth of muscovite-quartz-

microcline with flakes of biotite. The pegmatite should still be able to produce large quantities of small-sized spotted mica of third quality.

The *Drum Mine* lies about a kilometre north of St. Mark's No. 5 block and is on the edge of the Escarpment. The surface workings by A. M. Hulley were visited by Stidolph in January, 1969.

The pegmatite which is fairly large and unzoned, has an easterly strike of 90 m or more and dips steeply to the south. The width of the excavated portion is 10 m, but the pegmatite pinches and swells along strike. It consists of quartz and perthitic feldspar with intergrown biotite shoots along the walls.

On the waste dumps some large sizes of good quality ruby mica were found, but striations and herring-bone structure are fairly common. A potential for small sizes of good quality ruby mica must still exist.

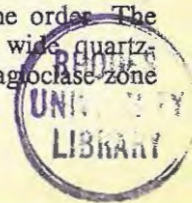
The *Gatipie Mine* is situated nearly 3 km south-west of Nyamangwe trigonometrical beacon and is on the west bank of the Nyaodza River, opposite the Annabelle Mine. This unusual pegmatite was developed by the Nyaodza Mica Mining Co. and was visited by Stidolph in 1969 (Fig. 4).

Mineralogically, the bulk of this body consists of a medium to coarse-grained intergrowth of quartz, muscovite and microcline with scattered leaves of biotite. It is only at the northern end, where the 'funnel' bends to the north-east, that an outcrop of quartz core, about 30 m in length, is seen. The mica, which is said to be distributed throughout, is spotted and attains large sizes.

A large opencut extends through the hill along the body and is about 9 m deep. An adit has been driven into the south side of the hill to check the extension in depth and to try to define the structure of this curious pegmatite.

The *Gemini Mine* which is in the Nyaodza Tribal Trust Land 3 km north of the Nyaodza River and 10 km east of the Gil Gil Mine is situated on the southern margin of the Nyadoza Centre. It was examined by Wiles in 1962.

The pegmatite is a somewhat ovoid, pipe-like body with a visible strike of only 12 m and a width of very nearly the same order. The pegmatite dips at 40 degrees to the north. There is a wide quartz microcline core bordered on the hanging wall side by a plagioclase zone



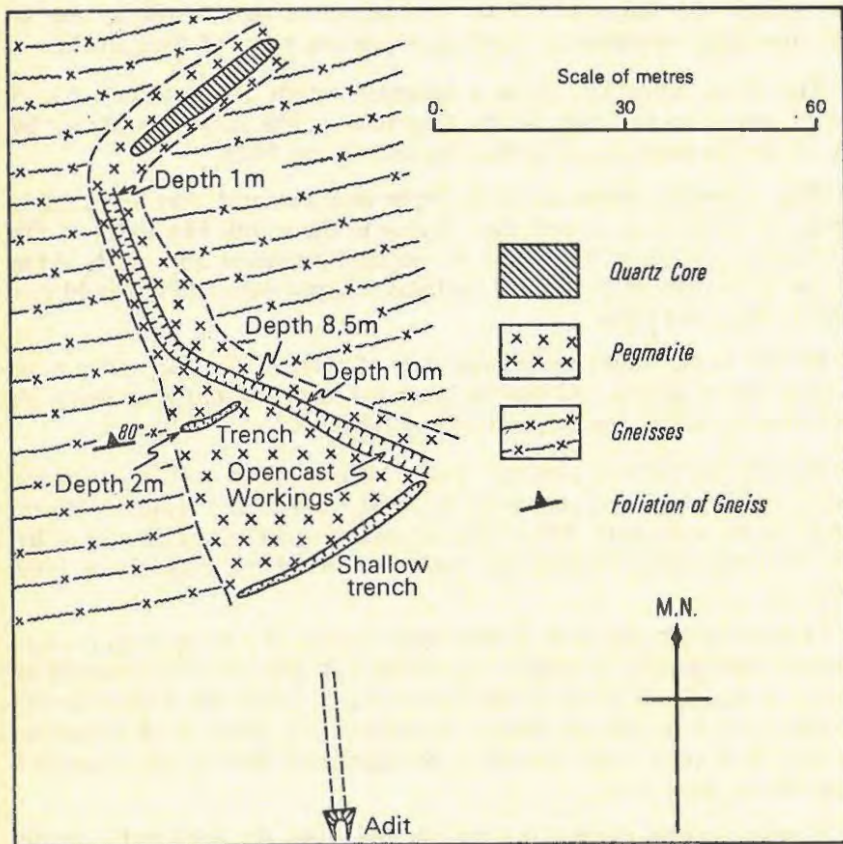


FIG. 4. Surface plan of the Gatipie pegmatite (Stidolph, 1969).

some 50 cm wide. A few small crystals of flat, but broken, mica occur here but do not constitute a mica shoot. A little biotite occurs in the border zone and in the core. The foot-wall was not exposed.

Much of the mica mined was disseminated throughout the main mass of the pegmatite as largely valueless, wedge-shaped, herring-bone books. It is reported that a few, quite large, hard, ruby mica books of good quality were extracted from a point where the core terminated and the plagioclase zones came together near the extremity of the pegmatite. A little underground work has been done but is inaccessible. The pegmatite is probably not worth further investigation.



The *Georgia Mine* is 700 m E.N.E. of the Meteor Mine and 3 km E.N.E. of the Gil Gil Mine. It was visited by Wiles (1962) who, because of water, could only examine the pegmatite at the entrance to an adit drive which is believed to be some 8 m long. The strike is northerly and the dip nearly vertical, or very steep to the west. The body is about 3 m wide and at outcrop is largely quartz bordered by narrow zones of mixed feldspars. On the west side there is a weak concentration of small books of mica constituting something of a wall zone. Some of the books appear flat with a good cleavage, but others have the herring-bone structure. Clear brown-green and good quality spotted mica were noted. Probably not much mica is to be had here.

See also under beryl.

The *Gil Gil Mine* is situated west of the Nyaodza River, in rugged country above the Zambezi Escarpment, close to where the Kariba power-line ascends the Escarpment. It is accessible by road through the Urungwe Tribal Trust Land and is some 90 km from Karoi. The main block of 30 claims was first registered by J. de Oliveira on 29th May, 1946, and was transferred to Laxman Nairn on 12th August, 1946. It remained the property of Nairn until his death in 1968 and has not been worked since.

The mine has been visited and reported on by Wiles on numerous occasions since 1955. He regards it as being the only mica mine of any consequence in Rhodesia during recent years. Consolidated Gold Fields of South Africa took out an option on the mine, which was reported on by Mehliß (1960).

The pegmatite has been emplaced along a strong fissure and bears a discordant relationship to the country rock. It strikes approximately north and dips east at various angles owing to a rolling of the "reef". Dips of 60 degrees on the third level and 30 degrees on a lower level have been noted. Some warping of the structure has taken place, presumably after the emplacement of the pegmatite, and this has resulted in some fracturing and occasionally buckling of the mica books.

The pegmatite has a variable width of between 1 and 3 m and is of the simple zoned type. This means that the pegmatite is zoned only in so far as mica is concerned. The mica occurs mainly as a strong hanging wall shoot. The main body of the pegmatite is homogeneous and is composed predominantly of sodic plagioclase with subordinate amounts of quartz. No biotite or tourmaline have been observed.

The quality and quantity of mica improved in depth, and in the main, the mica has been a good quality spotted. Below the 4th level an appreciable quantity of clear brown mica has been extracted, including a proportion of specials. Figure 5 after Mehliss (1960), is a general surface plan of Gil Gil Mine.

The Gil Gil pegmatite has been developed by means of five adits separated by vertical intervals of between 6 and 12 metres. From the 5th level a sub-inclined shaft goes down to the 6th level, about 15 m vertically below. The greatest strike exposure is over 175 m on the 5th level and the body has been explored vertically for 70 metres. It has largely been stoped out above the 5th level, but numerous large pillars remain.

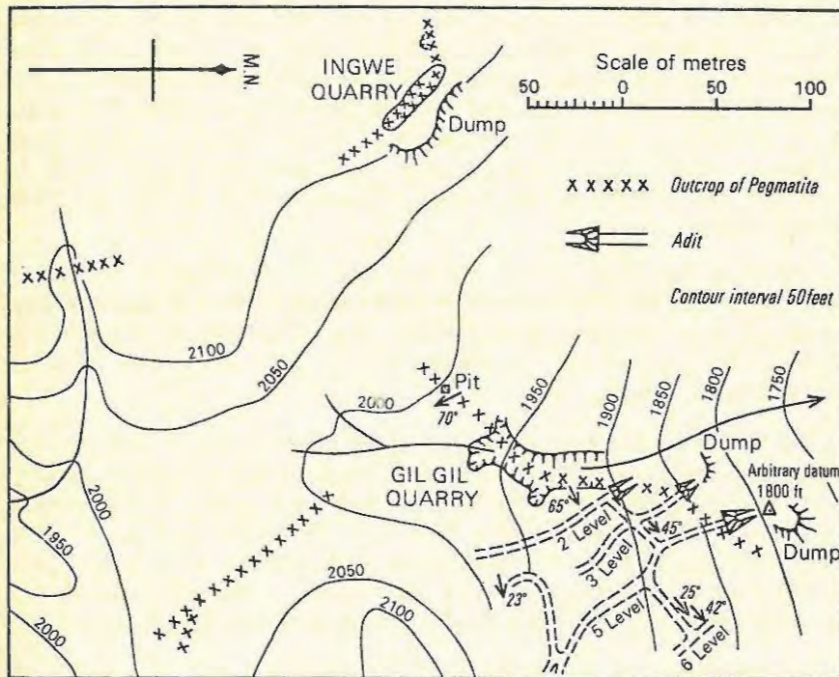


FIG. 5. Surface plan of the Gil Gil and Ingwe pegmatites (Mehlis, 1960).

The output of cut mica between 1946 and 1965 amounted to 96,34 tonnes valued at \$115 360. In addition 5,5 tonnes of crude mica was sold in 1959 valued at \$600.

The mine can probably still produce a large tonnage of cheaply mined, readily available mica. The full economic potential of the pegmatite has not been proved and further development is necessary. Mehliiss (1960) estimated an ore reserve of at least 18 100 tonnes of pegmatite, equivalent to 181 tonnes of cut, saleable mica. There is still a large quantity of waste mica on the dumps.

The *Grandeur Mine* is 6 km north-west of the Gil Gil Mine near the Kariba power-line. It produced 107 kg of cut mica valued at \$56 in 1965.

The *Grand Canyon Mine* is 6 km north of the Gil Gil Mine and is situated on the steep fault-scarp that cuts across the mouth of the Nyaodza River Gorge. It was worked by G. Paterson and Sons and was described by Wiles in 1962.

The large pegmatite strikes east down the steep eastern slope of the fault-lined valley, about 500 m from the debouchment of the Nyaodza River from the Gorge. The over-all dip would appear to be almost vertical.

There is a large quantity of ruby mica here but it is of very low cutability due to striations and buckling. At one point on the north wall there is a good concentration of badly striated mica associated with plagioclase. Generally, the mica is disseminated throughout the wide microcline-rich body forming the core of this poorly zoned pegmatite.

During investigations on beryl-bearing pegmatites in the Miami and Urungwe areas by the United Kingdom Atomic Energy Authority (Gordon and Wade, 1961), the rare mineral herderite, a fluor-phosphate of beryllium and calcium, was reported from the Grand Canyon pegmatite.

Some development and stoping has been done from an adit 21 m long on the north side of the pegmatite and there is also some opencast work on the outcrop. A small adit has been put into the middle of the pegmatite in the quarry area. Further opencast workings occur on a pegmatite about 500 m south of the Grand Canyon. The strike of this body is 030° magnetic.

In 1946 a total of 1,72 tonnes of cut mica was sold from the Grand Canyon and Grand Canyon 2 Claims. It was valued at \$2 514. There

is still a great deal of mica to be recovered here but its exploitation will be purely a question of economics.

The *Ham Mine* is one of Turner's Nzoe Group and between 1944 and 1947 a total of 9,43 tonnes of cut mica was sold for \$14 344.

The *Heyes 1* and *Heyes 2 Claims* are just to the east of Bonanza Mine on the east bank of the Nyaodza River, where they straddle a steep-sided hill 4 km south-west of the Nymangwe trigonometrical beacon. The claims were exploited in 1969-70 and a small production has been declared with other mines of the Nyaodza Mica Mining Company's group.

The *Ingwe Mine* is situated on a steep hill slope about 300 m south-west of the Gil Gil Mine. The pegmatite has been thought by some to continue down-dip as the Gil Gil body (Fig. 5) but this would seem doubtful as the quality of mica and the character of the pegmatites are different. Unlike the Gil Gil pegmatite, the Ingwe pegmatite has produced a fair tonnage of beryl.

Between 1946 and 1948 G. Paterson and Sons declared 40,44 tonnes of cut mica from the open workings, valued at \$32 538. See also under beryl.

The *Invasion Mine* is about 1 km north-west of the Rukwesa Fly Gate and 1,5 km S.S.W. of the Julia Mine in the east of the mapped area. A number of small pegmatites in the vicinity have been exploited by opencast methods. During the 1944-5 period E. H. C. Bolt declared 479 kg of cut mica valued at \$722.

*Jack's Luck 1 Mine* is located 5,5 km north-west of the Nyamangwe trigonometrical beacon on the steep southern slope of the Kasiga Valley. The mine which was visited by Stidolph (1969) was first registered by the Katsiga Syndicate in 1966 before being developed by the Nyaodza Mica Mining Co.

This is a large zoned body, which extends some 120 to 150 m in a northerly direction down the slope, and dips steeply to the east over most of its exposed length. It is ideally situated for cheap mining by adit methods.

Wiles (1969) noted a hanging wall concentration of mica, with smallish mica disseminated throughout the pegmatite. An extensively recrystallized horse of gneiss was seen in the pegmatite and movements in the peg-

matite were revealed by some buckling of the mica. Quartz inclusions were present in the mica books.

An opencast operation at the top of the slope was the first stage of mining and a fair tonnage of fourth quality, black-spotted mica was extracted. The quarry development revealed that the pegmatite thins upwards to the crest of the hill, with a width of under two metres. The top portion of the pegmatite, which was barren of economic muscovite, consists of quartz, feldspar and biotite with a thin micaceous border zone. At this point the pegmatite dips steeply at 80 degrees south-west.

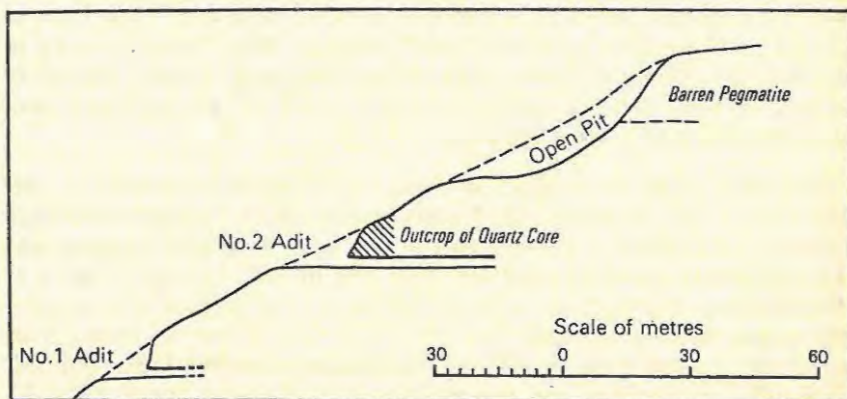


FIG. 6. Section along Jack's Luck 1 pegmatite (Stidolph, 1969).

The first adit was put in towards the pegmatite, some 90 m down the slope and a second adit has been developed about 30 m below the lower end of the quarry (Fig. 6). This adit follows the pegmatite at  $160^\circ$  magnetic, and has been developed along the hanging wall of a quartz core adjacent to which mica development is poor. However, several large mica books occur in the wall zone at this point. The quartz core can be followed in the adit for 12 m after which the adit seems to be in an intermediate zone of quartz, mica and plagioclase. A horse of gneiss is present at 38 m into the adit.

At present production has ceased but potential for mica production must still exist, especially beyond the quartz core.

The *Jack's Luck 2 Mine* is situated up the slope, a few hundred metres from the Jack's Luck 1 workings. It was described by Stidolph (1969).

The pegmatite seems to be zoned with a discontinuous core of quartz and quartz-microcline. It follows an easterly strike for some 150 m and dips steeply north. The dip shows signs of variation in depth.

The main development is an opencut along the southern (foot-wall) side of the core, along about 30 m of strike. Good quality spotted mica with some brown-green clear mica was produced from here in sizes which averaged Grade 5.

There has also been some shallow excavation on the hanging wall side revealing narrow shoots of clear brown-green mica. The hanging wall core margin has a good concentration of large-sized "fish" mica. In the southern face of the foot-wall opencut, there appears to be a number of pegmatite shoots with various attitudes. Several mica-rich pegmatite veins outcrop along the track south of the open pit and may be connected to the main body.

The *Jasp Mine* is situated just over a kilometre north-west of the junction of the Nyaodza and Kasiga rivers. Small opencast workings have been developed at the eastern end of a large east-striking pegmatite. The pegmatite can be traced for over 500 m and appears to have a discontinuous quartz core. The remainder of the pegmatite is largely feldspathic and disseminated in it are small-sized muscovite books. The pegmatite is away from the sillimanite-rich granulites that are associated with other mica mines, and has probably not produced any worthwhile quantities of mica. The pegmatite may have potential as a producer of beryl.

The *Jeriti Pegmatite* is one of the Nzoe Group and strikes at 250° magnetic, dipping northwards at 27 degrees. There is a quartz core bordered by plagioclase-rich zones 60 cm wide. There is a weak hanging wall shoot of small much broken mica books associated with quartz. The pegmatite narrows along strike.

The *Julia Mine* is two kilometres north of Rukwesa Fly Gate in the Vuti African Purchase Area. It has had numerous owners and has produced mica and a little beryl intermittently between 1946 and 1958. More recent developments have largely been concerned with large amounts of scrap mica.

The mine has been developed in a large, conformable pegmatite that occurs in an outlier of sillimanite gneiss. A deep opencut has largely removed the pegmatite near the surface along a strike of 103° for a

distance of about 90 metres. A vertical shaft has been sunk in the centre of the opencut.

Between 1949 and 1958 14,20 tonnes of cut mica were sold at a price of \$15 380. See also under beryl.

The *Kariba Mine* is situated on Camp Hill at Kariba where it overlooks the Kariba Gorge, a few hundred feet above the present lake shore. The mine was owned by G. Paterson and Sons and was managed by N. A. Tatham. A few small prospects occur in the vicinity of Mahombe Kombe African Township.

Between 1944 and 1948 a total of 13,05 tonnes of mica valued at \$7 726 was declared from the Kariba Claims. Beryl was produced from here. See also under beryl.

The *Lakhi Mine* is two kilometres east of the Gil Gil Mine. There is little to be seen of the pegmatite at surface and the small amount of underground work is inaccessible.

The pegmatite would appear to strike at  $105^\circ$  and to have a very steep northerly dip. The mica, which is apparently distributed throughout the pegmatite in a metre-wide zone, is of ruby quality.

There is a shallow trench on strike, a vertical shaft to a depth of 5 m, and a drive to the east reported to be 15 m in length. There is also a collapsed adit on the southern slope of the hill.

The mica was flat but of small average size, and the production was declared with that of the Gil Gil Mine.

The *Lynne Mine* is situated just south of Jack's Luck 1 Mine and a small output was declared with other mines of the Nyaodza Mica Mining Co. in 1968.

The *Mahundi Mine* is situated on the south-west side, near the crest of the steep hill of the same name. The mine is 7 km W.S.W. of the Gil Gil Mine and 2 km east of the Midway Mine. The pegmatite was exploited by J. F. Turner during the early 1960's and has been described by Wiles (1962).

Along the outcrop the pegmatite is almost horizontal, but deeper into the hill the underground workings have revealed dips of 8 to 25 degrees to the east. Between the two adits the pegmatite is zoned with a discontinuous quartz core. Near the western adit the pegmatite is some 4 m

wide and the quartz about 1 m wide. A cast of a beryl crystal, measuring 70 by 18 cm, was seen in the quartz. The beryl is associated with apatite and a few garnets. There is the usual wedge-shaped, radiating, herring-bone, core-margin mica which is best developed on the hanging wall side. Intermediate perthite zones occur and that on the hanging wall side is the wider. Plagioclase forms wall zones, but wall mica shoots have not developed.

The quartz core disappears in all directions and the intermediate perthite zones coalesce. The muscovite books, together with very large biotite books, are disseminated throughout the perthite zone. The muscovite produced has ranged in quality from clear and slightly stained ruby to second quality spotted. The better quality mica occurs in the western portion of the mine, but the area between the two adits has produced the bulk of the mica.

Farther into the mine the pegmatite thins and the uneconomic plagioclase-rich wall zones come together to form a pegmatite less than a metre wide. A little sillimanite, associated with biotite, has been found in the pegmatite. A nearby dolerite dyke can be expected to cut the pegmatite.

A plan of the mine exists. Much of the pegmatite has been stoped out and it would seem that the pegmatite has been stoped beyond its economic limits. The mine produced 2,87 tonnes of cut mica between 1962 and 1963, valued at \$7 876.

The *Meteor Mine* is 700 m south-west of the Georgia Mine and 2 km E.N.E. of the Gil Gil Mine. The mine was first registered by G. Paterson and Sons and was later transferred to Grand Parade Associate Mines. Since 1951, this rich pegmatite has been worked intermittently by J. F. Turner, but it was closed in 1961 because of the low quality of the densely spotted mica.

The mine was visited by Wiles (1962), but the pegmatite could not be closely examined. The pegmatite is a concordant body striking north-west and dipping to the south-west. It would appear that at one time it was part of the flat-lying pegmatite farther up the hill which has been prospected by means of an adit and an opencast on and near the summit. The main pegmatite has been stoped from surface and there are numerous small workings in the near vicinity.



This pegmatite may still yield an appreciable tonnage of easily mined and manageable low-grade mica.

Between 1946 and 1951, 55,47 tonnes of mica valued at \$44 506 was produced. Since then Turner has included the production of this mine with Midway and other mines in his group. In 1963, Turner declared 7,78 tonnes of crude mica valued at \$406 from the Meteor. See also under beryl.

The *Midway Mine* is 9 km west of the Gil Gil Mine and it is accessible by road from the lake shore, which is 9 km west of the Midway Mine, and below the Escarpment. The mine was first worked by Boswell and later by Turner. The mine was visited and described by Wiles in 1957 and 1962.

Two concordant pegmatites striking east and dipping north have been mined both opencast and underground. The richer of these was the smaller which is almost in line with, but to the west of the larger one. If it outcropped it must have been very inconspicuous as it is in low ground, but the larger body makes a prominent low ridge because of its quartz core. The main surface work is on the hanging wall side at the western end of the strike where a small mica-shoot has been stoped. Ruby mica of fair size and quality was extracted.

Though ideally zoned, this pegmatite has so far proved disappointing in depth. Attempts to locate further shoots by cross-cutting from the two vertical shafts failed, but this work was inconclusive.

A small, valuable, pencil-like shoot was located at a shallow depth on the small pegmatite.

Between 1948 and 1961, 20,74 tonnes of cut mica, valued at \$41 908 was declared, but this includes the production from a number of prospects. In 1959, 18,62 tonnes of crude mica was declared from Midway valued at \$496.

The *Mpata Mine* is on the cliff-like southern face of the Nyadza River Gorge, 6,5 km north of the Gil Gil Mine.

Very little work has been done and this all but virgin body is likely to contain a large tonnage of mica of good quality spotted and clear brown-green (Wiles, 1962). However, its location will make its exploitation an engineering feat.

The crest and keel are both on the steep slope and, but for the river gorge, would not be exposed. This suggests that there must be some

valuable sub-outcropping pegmatites which could only be found by chance.

Over most of the outcrop the pegmatite averages about 3 m in width and strikes at  $160^\circ$  across the foliation of the enclosing sillimanite gneiss. It has an easterly dip of 65 degrees.

The body is, for the most part, classically zoned with a quartz core and both hanging and foot-wall mica shoots. The mica books are set in plagioclase and orientated with their cleavage at right angles to the walls. The foot-wall shoot is strongest near the mid-point of the pegmatite. Where the quartz core disappears down the dip, the core is composed of microcline and quartz with disseminated biotite and small muscovite books.

Production for 1958 was declared under Midway.

*Nancy Mine.* See *Wanyonzi*.

The *Nema Pegmatite* is near the Nzoe Group of mines and occurs in rather inaccessible terrain. No output has been declared though it seems to have yielded some good books of mica. There is nothing at surface which recommends further investigation.

*Nyaodza Mine.* See *Mpata*.

The *Nyowan Claims* are reported to be 2 km north-west of the Gil Gil Mine near the steep power-line road.

The *Nyza Mine* is 3 km west of Nyamangwe trigonometrical beacon on the Tsetse Control track which follows the east bank of the Nyaodza River. The mine was first registered as the Surprize Mine and later as the Nyaza Mine. It was worked by the Nyaodza Mica Mining Co. and was described by Stidolph (1969).

An open-cut has been developed into the hill on the west side of the road and meets the pegmatite at about 30 metres. The pegmatite which strikes south-west, is a well-zoned body with a good outcrop of quartz core over 150 m in length. The quartz core extends beyond the open-cut for about 120 m to where two small trenches reveal wedge-shaped mica of ruby quality alongside the north-west wall of the quartz core. It appears that the north-west wall is the hanging wall.

The hanging wall intermediate zone can be seen over about 24 m in the open-cut and is composed of quartz, muscovite and feldspar,

mostly plagioclase. There is also a well-developed border zone of fine-grained micaceous material. Some large ruby mica sheets were obtained from the hanging wall and this may have potential if mica shoots can be found.

The *Nzoe Group* includes numerous pegmatites that have been worked for mica by J. F. Turner, and from 1949 to 1950 by the Gemsbok Rhodesia Development Co. Ltd. Turner was active in the area until the 1960's. The Group is accessible by road through the Urungwe Tribal Trust Land and is in rugged country some 5 km west of the Gil Gil Mine. The Group includes claims up to Nzoe 13. Most were mined by opencast methods during the late 1940's. Not all the mines could be located but Wiles (1957 and 1962) has described many of the pegmatites.

The *Nzoe 2 Mine* is the westernmost of all the Nzoe mines and is one kilometre north of Midway Mine, overlooking the Sapi Valley. There are several closely spaced pegmatites, all having the same general characteristics.

The largest of the pegmatites has a N.N.W. strike of about 180 m and a practically vertical dip. The largest workings are on this body and it is presumed that a fair tonnage of mica must have been extracted. There is little or no further potential for this pegmatite.

The *Nzoe 4 Mine* is on the southern slope of the same hill as Nzoe 2. It has been locally known as Kazangarare Special.

The pegmatite has been truncated by the hillslope and appears to dip flatly into the hill on two levels and to have something of a Z-like cross-section. The upper and westernmost section has, from near the surface, yielded a large tonnage of ruby mica from which some very valuable large sizes were cut.

Large flakes of biotite, a metre and more in length, occur in a base composed largely of pink microcline. There is much albite on the waste dump indicating some form of zoning.

An appreciable amount of work has been done from an adit on the lower, eastern section, where a feebly developed, unpayable mica shoot was found.

Around the hill to the south-east and down the slope are further small workings on separate pegmatites of little value.

The *Nzoe 5 Mine* is situated on a spur, 6 km west of the Gil Gil Mine. A good payable mica shoot was seen by Wiles on the adit level which is now blocked by a fall of rock.

The pegmatite is concordant, striking east and dipping north at 70 degrees. A hanging wall mica shoot extends along the whole length of the 27-metre-long adit drive. There is also a little mica on the foot-wall of the pegmatite which is zoned only in so far as there are wall zone mica occurrences. The rest of the pegmatite is homogeneous. The strike will probably not exceed 50 metres. A large north-east-trending fault occurs just north of the mine. The pegmatite branches to the east in the open workings and a shaft has been sunk on the hanging wall spur.

The *Nzoe 6 Mine* and *Nzoe 7 Claims* are on the hill above the old Nzoe camp, 5,5 km west of the Gil Gil Mine. The Nzoe 6 pegmatite, which occupies a true fissure, has been mined opencast and been prospected in depth by means of adits (Fig. 7). The adit just below the open workings reveals a very narrow hanging wall mica shoot of small, quite unpayable mica.

From 1946 to 1949 the Nzoe and Chufe pegmatites yielded 51,19 tonnes of mica valued at \$75 170. The 1950 production included 15 tonnes of crude mica. Between 1959 and 1961, 9,76 tonnes of mica valued at \$10 700 was declared. It included some production from the Meteor Mine in 1961.

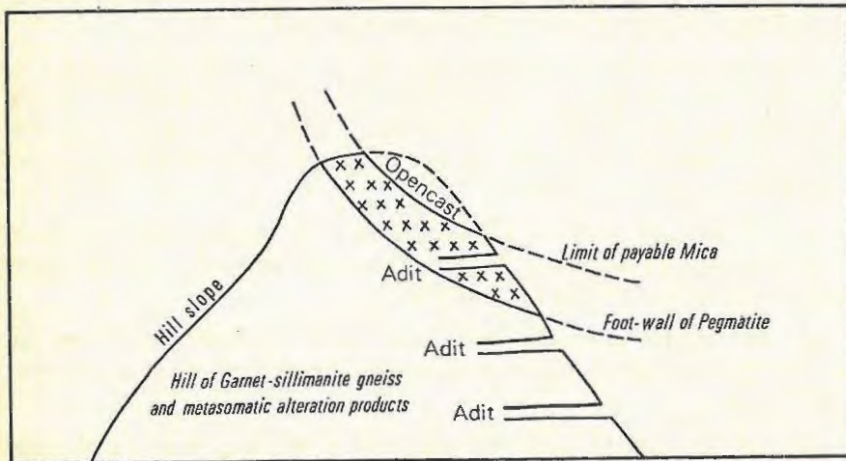


FIG. 7. Diagrammatic cross-section of the Nzoe 6 pegmatite (Wiles, 1957).

The *Oaklands Claims* occur at the base of the Escarpment, just west of the St. Mark's Mine. In 1959 10 kg of mica valued at \$22 were declared.

*Ponderosa Claims.* See *Bonanza*.

The *Post (Patty) Mine* is 4,5 km north of Musiga Hill and 2 km east of the Shooting Star Mine. The mine was worked by G. Paterson and Sons and has been described by Wiles.

The pegmatite is apparently a discordant body striking north-west with the foliation, but dipping more steeply across it at 86 degrees to the south-west. It is about 4 m wide midway along the 180 m strike. Ruby mica and biotite are disseminated in a largely microcline-perthite and quartz body but there are weak plagioclase-rich wall zones. Because of the composition of the pegmatite a great deal of waste mica can be expected.

The workings consist of a shallow opencast at the north-west end and a short adit, which has now collapsed, has been put in up the slope some 15 metres above the river. More than half the pegmatite is untouched.

In 1946 2,40 tonnes of ruby mica was cut and sold for \$3 424 and in 1954 96 kg of mica was sold for \$172.

The *St. Mark's Claims* consist of six blocks of claims, registered as St. Mark's 1 to 6, which are located on the edge of the Escarpment, 5 km east of the Lake Kariba shoreline, where it narrows to the mouth of the Nyaodza River. The claims were first worked on surface by A. M. Hulley in 1963-64 and later the St. Mark's 2, 4, 5 and 6 Claims were exploited by the Nyaodza Mica Mining Co. Stidolph (1969) visited the claims and described many of the pegmatites.

The *St. Mark's 1 Claims* are situated 2 km just north of west from the Shooting Star Mine.

The *St. Mark's 2 Claims* are situated 2 km west of the Shooting Star Mine. A north-west-striking pegmatite has been prospected by opencast methods south-west of a small conical hill, near its base.

The *St. Mark's 3 Claims* are just to the south-west of St. Mark's 2 Claims.

The *St. Mark's 4 and 5 Claims* occur on the Escarpment edge about 500 m north across a deep valley from the point where a Tsetse Control track ascends the Escarpment. Stidolph (1969) described ten pegmatites on these claims and their distribution is shown in figure 8. Six of these pegmatites have been trenched on surface, and underground development was started on two. They all can produce good quality ruby mica.

*St. Mark's 4 No. 1 pegmatite* is a zoned pegmatite with a very strong quartz core extending east-to-west for 76 m along the crest of a hill and dipping steeply north. Surface excavation has taken place on both walls, but is more extensive on the foot-wall side. About 73 m down the southern slope, a horizontal adit has been driven in a north-westerly direction towards the pegmatite. At 64 m a thin satellite pegmatite was intersected and followed east for 10 metres. The satellite is unzoned and dips steeply south. It has produced several hundred pounds of small-sized, good quality ruby mica.

The quartz core is flanked by intermediate zones of quartz, microcline and muscovite with a highly micaceous core margin and a thin wall zone on the hanging wall side. On surface the hanging wall side does not seem very rich in cuttable mica.

At the western end are a couple of small parallel, satellite pegmatites which are of the simple unzoned type. They are composed of quartz, muscovite and microcline and dip steeply south.

*St. Mark's 4 No. 2 pegmatite* forms the core of a small hill and has an easterly strike of 50 m. It is classically zoned with a prominent outcrop of quartz core along the ridge of the hill. The body dips at 65 degrees to the north for 6 m and it then rolls to horizontal. Outside the quartz core is a quartz-microcline zone with scattered small mica books. The wall zone is very well developed and is composed almost entirely of euhedral, pseudo-hexagonal mica crystals. The ruby mica shoot is said to occur on the inner contact of this zone. The outer contact is marked by a friable 70-cm-thick border zone of small mica books, garnet and feldspar.

A mica shoot has been excavated on the foot-wall zone from surface to a depth of up to 3 m along the entire strike. This development was continued to greater depth in the central part of the pegmatite where the roll was encountered. An adit was later developed from the western end of the hill, parallel to the strike of the pegmatite. At 18,5 m a cross-cut north was begun with the intention of intersecting the foot-wall

of the pegmatite. The adit was continued to 24,5 m and a second cross-cut was driven 4,4 metres north where a raise was put up into the surface workings. The foot-wall mica shoot was intersected and yielded good quantities and sizes of high quality ruby mica.

This small pegmatite is very rich and could be developed further.

*St. Mark's 4 No. 3 pegmatite* is a small satellite shoot parallel to No. 1 and No. 2 pegmatites. It has been trenched to a depth of less than a metre over the strike-length of 12 metres. The average width is one metre, along this unzoned, mica-rich, quartz-microcline pegmatite.

*St. Mark's 4 No. 4 pegmatite* strikes at 320° magnetic for at least 60 metres. It has a strong quartz core and some micaceous feldspar outcrops along the wall zone. There is no development.

*St. Mark's 4 No. 5 pegmatite* is exposed at the top of a hill and has been excavated down the western slope for 78 metres. The pegmatite is unzoned and is composed of quartz, muscovite and mixed feldspars. Large flakes of biotite and some tourmaline are present. The pegmatite is discordant and is 3 m wide in the centre, thinning to less than a metre in the west.

There is a good percentage of mica distributed throughout, but wastage is high and the large mica books tend to be striated and warped.

*St. Mark's 4 No. 6 pegmatite* has been trenched along its strike-length of 60 metres. It is a curved body, on the crest of a hill, some 90 m east of No. 2 pegmatite. Zoning is poor, and the body consists of quartz, feldspar and muscovite with large wedge-shaped books of biotite. There is good quality ruby mica, but the larger sizes are striated and wastage is high.

*St. Mark's 5 No. 1 pegmatite* is at least 120 m in length and has been opened up on surface for 60 m to depths of up to 3 metres. This 2-m-wide pegmatite is roughly zoned with a lensoid quartz core that pinches and swells long the strike. A wall zone is barely developed or absent. Biotite is found in joints in the quartz core, on the core margin, and near the walls. The good quality ruby mica is small, but where the quartz core swells, the mica is striated, compressed and interleaved with biotite. There is a high proportion of wastage.

*St. Mark's 5 No. 1 Parallel* is simply zoned and appears to be only 20 m long on a strike of 280° with a steep north-east dip. It is 3 m

wide in the centre, tapering off on either side to about a metre. The mica is distributed throughout the quartz-microcline-muscovite zone that forms the bulk of the pegmatite. There is a small quartz core, but no wall zone. Large books of biotite occur and the muscovite is good quality ruby, but often striated.

*St. Mark's 5 No. 2 Parallel* has a ridge of quartz that can be traced for some 45 m on a strike of  $310^\circ$ . It seems to curve at the southern end.

*St. Mark's 5 No. 3 Parallel* has the same strike as No. 2 Parallel and is discordant. A quartz-microcline core extends for 90 m or more, and biotite is developed at the northern end.

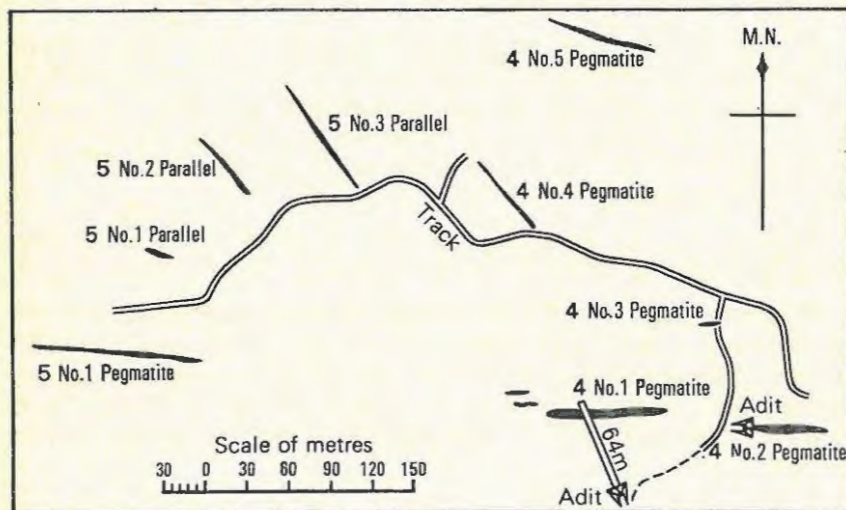


FIG. 8. Plan of pegmatites on *St. Mark's No. 4 and 5 Claims* (Stidolph, 1969).

*St. Mark's 6 Claims* are adjacent to *St. Mark's 4 and 5* and are a prospect only.

Between 1963 and 1965 1,49 tonnes of cut mica and 4,44 tonnes of crude mica valued at \$2 664 were produced from the *St. Mark's Claims*. Since 1968, the Nyaodza Mica Mining Co. has developed the claims.

The *Sapi Mine* overlooks the *Sapi Valley*, 2 km north of *Nzoe Mine*. In 1950, 100 kg of mica was sold for \$172.



The *Shooting Star Mine* is 8 km north-west of the Gil Gil Mine and was worked by G. Paterson and Sons (Wiles, 1962).

This is possibly one of the largest mica pegmatites in the western group. It strikes approximately west and has a length of about 215 metres. The dip is nearly vertical, but an old plan indicates a southerly dip.

There is a discontinuous quartz core at the eastern end where the pegmatite is about 7 m wide. In the western sector the core is microcline-rich with disseminated spotted muscovite and biotite. There are weak wall zone mica shoots of small books set in an albite matrix that is visible near the foot-wall inclined shaft. In most of the opencut, which is deepest at the eastern end, little pegmatite is visible, and most of the production must have come from the disseminated mica here. Where the pegmatite has been left intact in the eastern sector of the opencut, the books are both buckled and flat, of irregular shape, and rather broken giving a large percentage of waste mica.

From 1945 to 1949 a total of 51,54 tonnes of cut mica was sold for \$35 352.

The *Shovel Mine* is one of the Nzoe Group and in 1951 and 1952 Grand Parade Associated Mines declared a production of 1,54 tonnes valued at \$1 624.

*Surprize Mine.* See Nyza.

The *Undina Mine* is 300 m east of the Chufe Mine and 4,5 km W.S.W. of the Gil Gil Mine (Wiles, 1962).

The pegmatite is concordant and is about 180 m long, striking at 260°. The gneisses dip at 70 degrees north. From about mid-point a spur branches off at 130° and has been prospected by an opencast trench 80 m long. Both have yielded some ruby mica.

The main pegmatite has an almost vertical dip at its eastern end. In the short opencut another spur, 8 m wide and quite rich in mica, branches off to the west on the northern side of the body, but does not reach surface. There is little indication of economic mica on the northern wall of the main pegmatite and the opposite wall is not exposed in the workings. The pegmatite is poorly zoned with a sparse dissemination of striated muscovite and biotite. The mass of the pegmatite contains microcline with quartz and there is a narrow albite-quartz wall zone.

There is a little collapsed underground work at the bottom of the open-cut.

G. Paterson and Sons declared 5,61 tonnes of cut mica valued at \$5 902 from the mine between 1945 and 1946.

The *Wanyonzi Mine* is situated on the upper slopes of Nyahanzvi Mountain, a kilometre north-east of the Nyamangwe trigonometrical beacon. The mine is reached by a footpath and rough track which wind up the 35 degree slope from the valley 300 metres below. The ore was brought down by cable-way. The mine was first worked by L. A. de Rome and was described by Stidolph in 1969 (Fig. 9).

The pegmatite is classically zoned with a strong quartz core that outcrops down the slope of the hill for 27 m and is 3 m across at its widest point. The pegmatite may be followed along its south-easterly trend for 75 m and it dips north-east at about 60 degrees. Surrounding the core is an intermediate zone of quartz, microcline and muscovite, a metre thick on the foot-wall side of the core and about 3 metres on the hanging wall side. There is a wall zone of quartz, microcline and book mica, and a well-developed micaceous border zone which is best at the lower end of the pegmatite where the two walls coalesce. Biotite flakes are common at the upper end of the pegmatite.

At either end, a number of stringers and small horses of micaceous rock, similar to the wall zone, are found where the foot-wall and hanging wall intermediate zones meet. A number of small veins of pegmatite radiate out from both ends of the main pegmatite.

The mica seems to be best developed at either end of the quartz core. Wedge-shaped mica with herring-bone structure is developed on the hanging wall core margin. There does not appear to be a foot-wall mica shoot of any significance.

The initial openpit was at the lower, south-eastern end of the quartz outcrop and this was followed by an adit into the hillside. A large micaceous horse was intersected and it reduced the width of the pegmatite to about a metre. Development has shown this to be the bottom of the pegmatite where the hanging and foot-wall zones meet. An E.N.E. cross-cut was developed for 6 m followed by a vertical raise of 4 m, but no pegmatite was found. A second vertical raise was developed from the adit. At the north-west end of the pegmatite there is an openpit. The

readily extractible mica has been won from this mine, and the underground potential will have to be proved by further development.

In 1965, 252 kg of cut mica was declared at a value of \$162. Development was continued in 1968 by the Nyaodza Mica Mining Co.

The *Willis Mine* is reported to be 6,5 km south-west of the junction of the Kasiga and Nyaodza rivers. The Minister of Mines declared 435 kg of mica valued at \$784 in 1949.

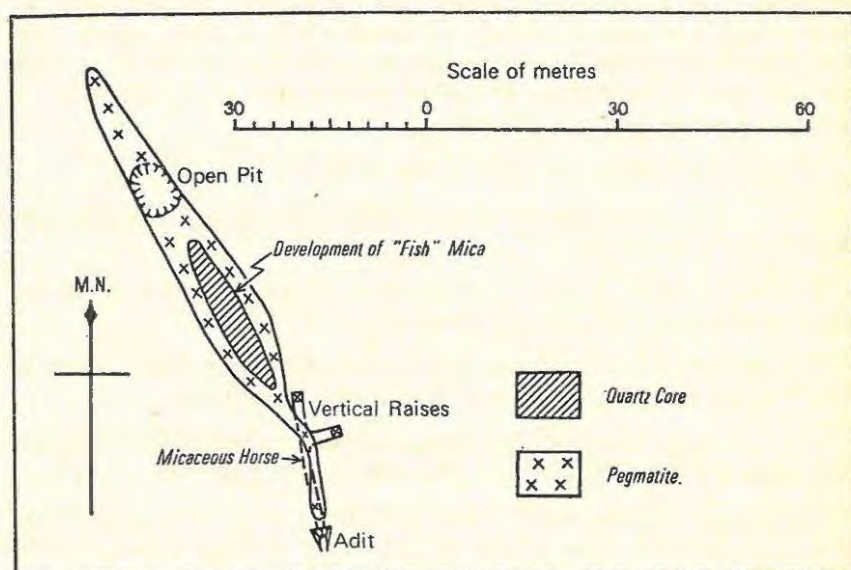


FIG. 9. Plan of the Wanyonzi pegmatite (Stidolph, 1969).

#### BERYL

Beryl mining in the west Urungwe District has not been of much significance in the past, but in recent years a few pegmatites have been worked and some good quality gem beryl has been won (Fig. 3).

The *Annie Mine* is situated above the Sapi Valley on the steep Escarpment edge near the Nzoe 2 mica workings. The claims were owned by Richart and Bennet in 1970, and were later prospected by J. Manyowa in 1973. The pegmatite is large and has a well-developed quartz core at its eastern end. The body strikes down the steep slope at  $290^\circ$ . The beryl has been won from the microcline-rich intermediate

zones and there does not appear to be any extensive development of mica.

The *First Rung Claims* are just over a kilometre west of the Gil Gil Mine, near the Kariba power-line. Although pegged for wolfram, a small beryl production was declared in 1970.

The *Georgia Mine*, a beryl-bearing pegmatite, has been worked about 90 m west of the Georgia Mica Mine and some very large crystals, weighing up to a tonne, were found near the surface. The workings are only a couple of metres deep on a pegmatite with a strong quartz core and large wedge-shaped, core margin mica. Coarse microcline crystals are the main constituent of the outer intermediate zone. The strike is north-west over a length of 18 metres.

In 1953, 7,87 tonnes of beryl valued at \$2 820 was declared.

The *Gil Gil Mine* produced 0,036 tonnes of beryl in 1963, valued at \$6. See also under Mica.

The *Ingwe Mine* produced 7,73 tonnes of beryl valued at \$2 704 between 1953 and 1957. See also under Mica.

The *Ju Jube Mine* produced 0,65 tonnes of beryl in 1963 valued at \$102 but the mine has since been developed for wolfram.

The *Julia Mine* produced 3,17 tonnes of beryl valued at \$630 between 1951 and 1953, but it has been primarily a mica producer.

The *Kariba 2 Claims* were worked by Grand Parade Associated Mines (Pvt.) Ltd. in 1954, when a total of 1,28 tonnes of beryl valued at \$374 was produced.

*Ma's Luck Mine* produced a little beryl in 1970, but it is worked primarily for wolfram.

The *Meteor Mine* was developed as a mica mine but in 1962 J. F. Turner declared 9 kg of beryl valued at \$18. Murumahoko has since extracted a little beryl, largely from the waste dumps.

The *Nyaodza Claims* are reported to be 3 km downstream from the junction of the Nyaodza and Kasiga rivers and in 1964 the Tagara Syndicate declared 0,57 tonnes of beryl valued at \$90.

The *Nzoe Claims* produced 4,90 tonnes of beryl between 1953 and 1956, valued at \$1 496. See under Mica.

The *Pfuma Ishingu Mine* is situated 7 km north-west of the Gil Gil Mine on the northern side of the Sapi Valley. A prominent quartz core strikes at  $162^\circ$  and dips steeply to the west. Small, uneconomic mica books are disseminated through the microcline-rich zones. A significant tonnage of beryl, which has included a high proportion of gem quality stones, has been produced from the opencast workings, largely adjacent to the core margin. The mine is worked by A. M. Hulley.

Some old workings occur a kilometre to the south-west.

The *School Mine* is in the Vuti Purchase Area about 500 m north of Chatigera Hill, and two prospects are being worked for beryl, which includes gem quality material. A thin pegmatite vein, about a metre wide, is being worked from surface. Tourmaline and some large garnets occur in the pegmatite which strikes on  $050^\circ$  and dips to the south-east.

Just to the north, a second pegmatite has a quartz core that strikes at  $080^\circ$ , but it has not been developed.

Significant amounts of green and honey-coloured beryl have been recovered from surface gravel in the claims area.

The *Shorai Mine* is the old Post Mica Mine which has recently been reworked for beryl by J. Manyowa.

The *Steve's Luck Mine* has recently been worked by E. J. Rees for gem beryl. It is situated 2,5 km north of the Meteor Mine in an area of highly pegmatized biotite gneiss. The claims are remote and have been haphazardly mined on surface. Apart from a strong quartz core striking at  $030^\circ$ , little structure is apparent. The pegmatite is microcline-rich, and muscovite is insignificant. Numerous pegmatites occur in the vicinity and may have potential for beryl production.

#### MUSCOVITE QUARTZITE

Some of the quartzites within the Makuti Group have the property of cleaving into large sheets, parallel to the orientation of the muscovite flakes. This has proved to be a popular ornamental building stones and is commonly known as glitterstone.

The *Rhostone Quarries* are situated nearly three kilometres north-east of Kariba Airport, just to the north of the Karoo contact with the Makuti Group. The main road from Kariba to Makuti traverses a band of well-cleaved muscovite quartzite, which strikes at  $135^\circ$  and dips constantly at 70 degrees to the north-east.

From the point where the quartzite emerges from beneath the Karoo cover, the band can be traced north-westwards for two kilometres. The horizon is 250 m wide and has been quarried at a low hill north of the main road. The quartzite is cut by the Nyanyana Fault and has been displaced dextrally for some 300 metres. The well-cleaved quartzite continues north-west from the fault for a further three kilometres and can be traced beyond the limits of the map. Further quarrying has been started north of the Nyanyana River.

#### COPPER

No copper is mined in the mapped area although to the north, above the Escarpment, Exclusive Prospecting Orders No. 91, 183 and 192 were granted for the metal and covered rocks which belong to the Makuti Group. The Chimwa Claims north of Kariba Airport were worked for some time but there was no declared production. Copper mineralization in the Nyadara and Umzumbwizi valleys indicates strong stratigraphic control as it can be traced along separate horizons for great distances. The copper concentration is low and appears to be largely associated with calc-silicate horizons.

In the older rocks a little copper mineralization occurs in wolfram veins of the Ma's Luck Mine and F. A. Taute (personal communication) reports copper minerals in the Sunde Valley.

To be profitable a copper deposit in the Kariba District would have to be large in order to overcome the problems of remoteness as well as the high costs of transport, labour and water supply.

#### GRAPHITE

The *Catkin Graphite Claims* are situated about 15 km west of the Lynx Graphite Mine and 5 km beyond the Rukwesa Fly Gate along the cattle fence (Harrison, 1972). At this point, the claims are about 500 m S.S.W. of the fence. Other claims lie just to the east of the Julia Mica Mine in the Vuti Purchase Area.

The graphite occurs in rocks of the Rukwesa Formation and is closely associated with meta-arkose beds and sillimanite-muscovite schist. The graphitic rocks outcrop in the schists as isolated lenses of short strike and narrow width. There is a variation in the quality of the graphite, although flaky graphite occurs in pure bands a few centimetres wide or as intense concentrations in the massive rock. Bands of non-graphitic

rock occur within the lenses. The largest lens is a highly carbonaceous meta-arkose in which the graphite is largely earthy and amorphous.

Harrison estimated a variable grade of between 20 and 35 per cent. carbon and an ore reserve of about 5 000 tonnes of graphite. Further prospecting in the area is warranted to see if larger lenses exist.

#### SILLIMANITE

Prospecting for this mineral may be warranted especially in the east in the sillimanite-bearing schists and gneisses of the Piriwiri Group and Rukwesa Formation. Here much coarse-grained sillimanite and quartz surface rubble has been formed from pods in the gneiss. Little coarse sillimanite was seen in the west, where the grade of metamorphism is higher.

#### TOURMALINE

Tourmaline is comparatively abundant in the younger pegmatites which intrude the rocks of the Tsororo Formation and less abundant in the older pegmatites of the West Urungwe, some of which have yielded gem quality tourmaline however. Some gem quality tourmaline has been recovered from the Meteor pegmatite which is described under Mica (Gordon and Wade, 1961).

#### WOLFRAM

The wolfram-bearing veins, like the mica pegmatites, occur in the garnet-sillimanite gneisses and granulites of the Piriwiri Group (Fig. 3) especially where these rocks have been affected by the potash-metasomatism and granitization of the Nyaodza Metamorphism, and contain microcline perthite porphyroblasts. The wolfram occurs in narrow and usually steeply dipping quartz veins related to the granitization.

The largest group of wolfram mines is centred on the Ma's Luck Mine and a smaller group occurs four kilometres to the south-west and is centred on the O.K-D Mine. The Tembo Mine is isolated and occurs in a tourmaline greisen 2 km west of Hoko Hill.

The wolfram is being extracted from shallow surface workings only, and is the only mining activity of consequence within the mapped area at present. The mining is largely under the direction of African managers.

The *All Hopeful Mine* was registered on 1970 by A. W. Parsons and a small production was declared. The claims straddle a large hill of garnet-sillimanite granulite just over 1 km west of Ma's Luck Mine.

The *Amazone Mine* is reported to be adjacent to the Kariba power-line about 1 km south-west of the Gil Gil Mine. A small tonnage of wolfram was declared by Laxman Nairn in 1966.

The *Bangle Mine* is situated nearly 2 km west of Ma's Luck Mine and is on the Escarpment edge above the Sapi River, overlooking Lake Kariba. The mine is owned by the Northern Gem and Mineral Co.

The mine is on a steep hill-side, the top of which is garnet-sillimanite granulite which becomes foliated down the slope. A deep open-cut has exposed four thin conformable quartz veins containing fine-grained wolfram. These veins strike with the country rock at  $070^\circ$  and have a dip of 70 degrees to the south. A little copper mineralization is associated with the quartz veining. The veins have been mined over a strike-length of some 30 m and are known to extend beyond the workings.

The *First Rung Mine* is situated just over 1 km west of the Gil Gil Mine near the Kariba power-line. There was a small wolfram production in 1970.

The *Ju Jube Mine* is situated about 800 m east of Ma's Luck Mine near the Kariba power-line. Wolfram production was declared by E. Marumahoko in 1970 and later by P. J. Venter.

Two large trenches have been excavated, each some 75 m in length and extending downwards for some considerable depth in wolfram-rich zones. Flooding prevented close examination.

The country rock is a coarse-grained schistose biotite-muscovite gneiss containing sillimanite. Parallel quartz veins containing wolfram and a little copper mineralization strike with the foliation of the country rock and are usually steeply dipping. Other veins show slightly cross-cutting relationships. The strike of the gneisses is  $085^\circ$ . A few sub-parallel veins have been excavated between the two major trenches here and farther east near the power-line.

The *Ma's Luck Mine* which was first registered in 1967, is the largest wolfram mine in the mapped area. The mine is approximately 13 km by road north of Nzou Fly Gate and is just over 3 km west of the Gil Gil Mine. The mine is owned by F. A. Taute and is locally known as Mukandabutse.



The mine is on a low hill where the country rocks are gradational between gneisses and granulites. Feldspathic, porphyroblastic granulite occurs in the rocks adjacent to the mine. Many wolfram-bearing quartz veins occur and most are narrow (a few to 40 centimetres in width), steeply dipping, and concordant. Some veins show slight cross-cutting relationships with the gneiss; others are flat-lying. Copper mineralization is sometimes associated with the veining. The general trend of veins is about  $090^\circ$ , but the discordant veins vary in their trend and attitude.

A system of contract mining has been introduced whereby each African miner exploits a certain quartz vein or part of a vein and is paid according to the weight of wolfram he recovers. This has led to a most haphazard mining practice, the whole hill being a maze of opencast workings and waste dumps. It is a very wasteful method and African women are able to recover much ore by washing the waste and alluvial gravels.

The *Ma's Pride Mine* is in the valley near the All Hopeful Mine and it is owned by the Northern Gem and Mineral Co. One quartz vein is being worked and a little alluvial wolfram recovered. Quartz veins have been exposed up the hill-side on a trend of  $080^\circ$ , where porphyroblastic granulite occurs.

The *Mumonda Mine* was registered by S. Chimbanda in 1970 and is situated a few hundred metres west of the All Hopeful Mine.

The *O.K-D Mine* is situated some 5.5 km to the south-west of Ma's Luck Mine and is in biotite-muscovite gneiss on the northern slopes of a hill of garnet-sillimanite granulite. The quartz veins are concordant, striking on  $095^\circ$  and dipping at 55 to 60 degrees to the north. The claims have been repegged and are now being worked by J. Knott.

The *Olga Mary Claims* were not located but are two blocks registered by Duguid, one on a steep hill one kilometre south-east of the O.K-D Mine and the other a kilometre west of the O.K-D Mine.

The *Partnership Mine* is in the southern group of claims and is situated about 1 km south-west of the O.K-D Mine and just west of the Sunde River. It was first worked by Arro and Duguid and now by Denis. Extensive excavations have been made along a strike of  $140^\circ$  in garnetiferous Piriwiri Group rocks. There is one major trench over 100 m long and several workings occur on sub-parallel veins.

The *Partnership 2 Mine* is just north of the Partnership Mine on the east bank of the Sunde River. There are extensive opencast workings along a strike of 355°.

The *Pasi Panapa Mine* is just over 2 km south-west of the Ma's Luck Mine and 2 km north-east of the O.K-D Mine. It is owned by the Northern Gem and Mineral Co. It occurs in foliated muscovite gneiss which strikes at 238°. Three vertical, concordant quartz veins are being mined by opencut methods.

The *Tembo Mine* is in the east of the mapped area in rugged country some 2 km west of Hoko Hill and is owned by Arro. The quartz veins occur in a red-coloured tourmaline greisen. The main workings are on the western slope of a steep hill where two closely spaced, concordant quartz veins are being worked. The veins strike at 090° and dip to the north at 73 degrees. There is an opencut about 10 m deep and there are other workings in the vicinity. The top of the hill has been scraped to try and locate other veins.

The *Tokapi Mine* is situated on the steep power-line road as it drops over the Escarpment edge nearly 2 km north-east of Ma's Luck Mine. The mine is owned by the Northern Gem and Mineral Co. Wolfram and minor copper mineralizations occur in three concordant quartz veins, the widest having a width of 300 cm. A deep opencut follows the strike for over 30 m and is being developed down the slope. The country rock is garnetiferous, and is foliated on a strike of 097° dipping steeply northwards at 84 degrees.

## APPENDIX

# The Geology of the Country West of Magunge, Urungwe and Kanyati Tribal Trust Lands

by

T. J. BRODERICK

## INTRODUCTION

The geological map (Fig. 10) covers an area of 976 km<sup>2</sup> in the Urungwe and Kariba administrative districts and lies between latitudes 16° 45'–17° 00' south and longitudes 29° 00'–29° 20' east. The area was geologically mapped on a reconnaissance basis by Mr. A. K. Kuhme during the 1971 and 1972 field seasons with the aid of air photographs and 1:50 000 topographical maps produced by the Surveyor-General's Department. The following short geological account is based on notes left with the author by Mr. A. K. Kuhme.

The mapped area falls almost entirely within the Urungwe, Rengwe and Kanyati Tribal Trust Lands which are administered from Karoi. The north-west corner of the area, above the Zambezi Escarpment, falls into the Zambezi Parks and Wild Life Land of the Kariba District. The African population is concentrated in the Urungwe Tribal Trust Land, mainly in ribbon fashion along the main roads. A small and remote population is found in the Gachegache Valley, but to the west of the cattle fence joining the Chiroti and Nyongwicha fly gates, the Kanyati Tribal Trust Land is unpopulated.

The area is reached by road through Magunge Township in the Urungwe Tribal Trust Land, some 32 km from Karoi. The Hostes Nicolle Trail, which connects Karoi with Binga, traverses the southern edge of the mapped area. A good network of Tribal Trust Land and Tsetse Control tracks occur and the Kariba to Norton power-line crosses the north-east of the area.

Apart from the north-west corner, the whole area lies above the Zambezi Escarpment where it has a characteristic undulating topo-

graphy brought about by the very close dendritic drainage pattern and the westward flowing Kanyati, Nyadara and Gachegache rivers. Only in the north-east do the Murereshi, Rukuwe and Chivura rivers flow northwards into the Nyaodza River. All drainage is towards the Sanyati River or into Lake Kariba. In the extreme north-west, below the Escarpment, the elevation is 533 m (1 750 ft.) but most of the area lies above 915 m (3 000 ft.) and levels out at a maximum elevation of 1 158 m (3 800 ft.) in the east. The only features are the Whamira Hills in the west and Kalukumbula Hill which reaches 1 113 m (3 650 ft.).

This reconnaissance mapping connects the current work east of Kariba with the southern Urungwe area (Stagman, 1962) and with the Miami Mica Field (Wiles, 1961). It clarifies a number of problems encountered in these areas and shows the areal extent of various rock units as well as the regional effects of the earlier metamorphic events.

No previous geological work has been undertaken although the country was traversed by Molyneux (1922), who noted the Karoo basalt outlier. Lightfoot also traversed the area in 1929 when he visited the Chipisa Hot Springs (Maufe, 1933). Mining activities are restricted to small mica, beryl and wolframite prospects, none of which have any importance and none of which have progressed in development beyond small opencuts and pits.

The westward limit of the Urungwe Paragneiss is established and this is regarded as being the basement on which all other rocks in the area lie. An important result is that the Chiroti Paragneiss can be traced north-eastwards from its type-area at Chiroti Fly Gate, to join with the porphyroblastic biotite gneiss found in the vicinity of Magunge. The south-westward extension of the Chipisa Paragneiss forms the Whamira Hills and continues as the Matusadona Range.

The apparent anomaly of having low-grade mica schists of the Piriwiri Group south of Magunge is clarified as similar schists can be traced north-eastwards from the southern Urungwe. The mica schists overlie the Chiroti Paragneiss unconformably, and the gneiss emerges as windows through this cover. The grade of regional metamorphism in the Piriwiri Group rises rapidly northwards from phyllites in the greenschist facies, through staurolite-bearing mica schists to garnet-sillimanite schists and gneisses of the upper amphibolite facies. However, rocks interpreted as belonging to the Piriwiri Group become highly feldspathic and are variable in character. This is accentuated along a strong north-east-trending zone of grey and red porphyroblastic gneisses.

These Kalukumbula Gneisses are intimately associated with enderbites and represent a direct south-westerly extension from the Nyaodza Centre of a once deeply buried zone that experienced granulite grade metamorphism followed by the potash metasomatism of the Nyaodza Metamorphism.

A massive leucocratic granite, an extension of the granites found to the south and east, occurs in the south-east near Chivakanenyama School. During the extended period of erosion which followed, the development of north-east-trending faults and minor dolerite intrusion seem to have been the only significant events. Apparently the north-westerly trend of the Katangan and Miami tectono-thermal events have not affected the area south of a major fault with a downthrow to the south. It has preserved an outlier of Karoo-age basalts and basal sandstones. Immature conglomerates and sandstones of the Karoo System occur below the Escarpment in the north-west near Chipisa Hot Springs.

#### URUNGWE PARAGNEISS

The Urungwe Paragneisses are exposed in the north-east of the mapped area where they occupy about 45 km<sup>2</sup> in the Mureshe and Rukuwe valleys and represent the western limit of the Urungwe gneisses. The Urungwe Paragneisses cover some 1 500 km<sup>2</sup> of country both west and north of Karoi.

The paragneisses are an extremely variable unit as they have suffered a long and complex history of repeated metamorphism and migmatization. The rocks are widely migmatized and permeated, and have suffered intense pegmatite injection, the degree of alteration accounting for the variety of rock types. They retain calc-silicate residues and are in places highly micaceous.

Within the mapped area the dominant gneisses are grey, well-foliated and micaceous. They are biotite-quartz-oligoclase gneisses with accessory microcline, muscovite and garnet. Myrmekite commonly replaces microcline, but where microcline porphyroblasts have been introduced during the Nyaodza Metamorphism (slide 22317 from north of Karambazungu School) the introduced microcline replaces the plagioclase with quartz exsolution. One sample (slide 22318) is a biotite-rich gneiss, but another (slide 22319) from nearby is micaceous and has been thoroughly permeated by quartz-plagioclase veins.

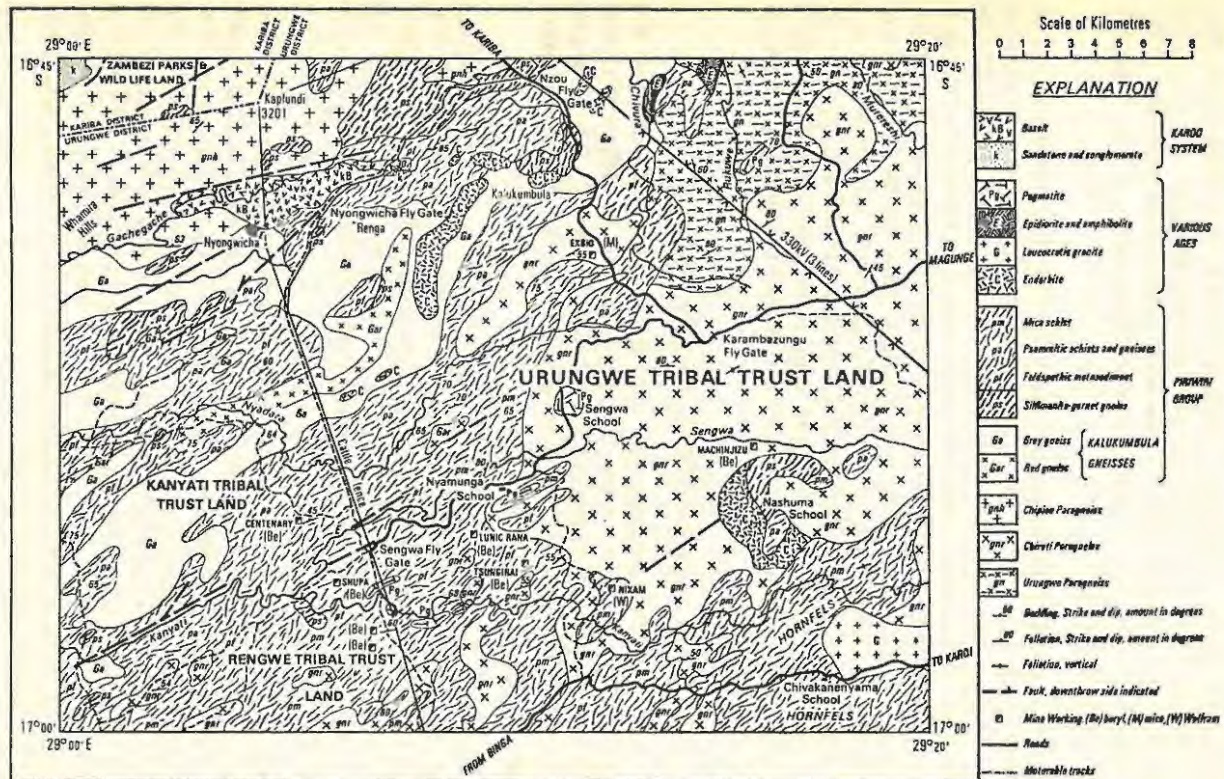


FIG. 10. Geological map of the country west of Magunge, Urungwe District, by A. K. Kuhme, 1973.

A second group of pink, feldspathic gneisses are far more granitic in hand specimen as they contain a greater percentage of microcline and much less mica than the grey gneisses. A sample (slide 22320) from the loop road running north to the Nyaodza T.T.L., is a coarse-grained, granular quartz-microcline-perthite rock with a subordinate development of plagioclase and microcline. Tiny unorientated flakes of biotite are distributed throughout and there are a few small anhedral garnets. A coarse-grained quartz-microcline pegmatite vein cuts the rock.

#### CHIROTI PARAGNEISSES

The Chiroti Paragneisses cover a wide area in the south, east and central portions of the mapped area where they show a general north-easterly trend from their southern Urungwe type-area (Stagman, 1962), to the vicinity of Magunge Township (Wiles, 1961). The Chiroti Paragneisses overlie the Urungwe Paragneisses in the east and are overlain by an extensive cover of schists and phyllites of the Piriwiri Group in the south. The Piriwiri schists are at a lower grade of metamorphism than the gneisses and are strongly infolded so that the biotite paragneisses protrude through the cover as a series of north-east-striking windows. Where the gneisses form the dominant exposure in the east, infolded outliers of Piriwiri schist are noted, so explaining the presence of those apparently thrust outliers which occur south of Magunge. In places the paragneisses show evidence of mobilization and exhibit intrusive characteristics into the overlying schists.

In the south the paragneisses are often well-foliated, containing as much as 30 per cent. of biotite. However, potash metasomatism is strongly evident throughout the Chiroti gneisses and they are normally coarse-grained, massive, dark and homogenous rocks, with large, often euhedral, microcline porphyroblasts. For this reason the outcrop of these rocks is distinctive. They occur as large, black-weathering pavements, as large, massive spheroidal boulders, or as castle koppies. A fine-grained red granitic gneiss is intimately associated with the Chiroti Paragneisses in the south, but its distribution is limited.

A sample (slide 22321) from the cattle fence, just north of Chiroti Fly Gate, is a biotite-rich gneiss showing microcline porphyroblasts within the foliation. The original feldspar is a sericitized calcic oligoclase whilst the microcline porphyroblasts are fresh and slightly perthitic. Slide 22342 was cut from a sample taken just west of Chitembe School. It is a massive biotite-rich gneiss. Quartz and plagioclase are coarsely

recrystallized and there is little microcline. Garnet and muscovite are rare accessories.

### CHIPISA PARAGNEISSES

The Chipisa Paragneisses occupy about 80 km<sup>2</sup> of rugged country above the Zambezi Escarpment in the north-west of the mapped area, where they form Kapfundi Hill and the Whamira Hills. These micaceous gneisses are a south-westward continuation of similar rocks which form a monotonous sequence centred on the West Urungwe Mica Field. They continue towards the Sanyati River Gorge which is deeply incised into the Matusadona Range. Outliers of garnet-sillimanite gneiss of the Piriwiri Group rest above the paragneisses. The Chipisa Paragneisses are of similar age and lithology to the Chiroti and Kariba Paragneisses, but the relationships between the three units are unknown.

The rocks here are relatively fine-grained, well-foliated, biotite gneisses, with the occasional development of muscovite and garnet. In most, calcic oligoclase is the dominant feldspar but in much of the area, especially near the southern margin, microcline becomes important. Some of this microcline may be primary but on the other hand much has been introduced during the Nyaodza Metamorphism which has affected the Chipisa Paragneisses.

Slide 22343 is a typical, well-foliated, biotite-rich gneiss in which quartz and sericitized oligoclase are the dominant minerals. Microcline porphyroblasts were initiated in the foliation planes where they form blows associated with coarse, sutured quartz grains. Slide 22344, from the Escarpment edge above the Chipisa Hot Springs, is a foliated biotite gneiss of similar composition in which slightly more microcline has developed and the coarse-grained quartz gives the rock a rodded appearance. Myrmekite is common in the microcline-bearing gneisses where it replaces plagioclase.

### PIRIWIRI GROUP

The Piriwiri Group rocks found within the mapped area represent a direct continuation north and north-eastwards of the mica schists found in the north-western corner of the southern Urungwe area (Stagman, 1962, p. 39). These schists with their fine-grained psammitic horizons are very similar to the thermally metamorphosed inclusions found in the adjacent fine-grained biotite granite south-east of Chiroti



Fly Gate. However as one passes northwards away from the granite, the schists probably owe their origin to regional metamorphism of the north-east-trending Magondi tectono-thermal event. The rocks pass rapidly from phyllites, through micaceous chlorite schists into the quartz-albite-epidote-almandine subfacies of the greenschist facies of regional metamorphism (Turner and Verhoogen, 1960) the grade of regional metamorphism continues to increase rapidly northwards so that in the centre of the mapped area schists within the staurolite-almandine subfacies are found. Kyanite has not been recorded but in the north, near Nzou Fly Gate, schists and gneisses in the sillimanite-almandine-muscovite and sillimanite-almandine-orthoclase sub-facies occur. Rocks that have reached granulite facies metamorphism are recorded not far north of Nzou Fly Gate, near the Gil Gil Mine.

However, the lithology of the Piriwiri Group is complicated by the fact that north of the southern margin of the mapped area an extremely heterogenous group of feldspathic metasediments occur. Farther north microcline develops in these rocks and in places, especially along the Kanyati Valley and adjacent to the Kalukumbula Gneiss, microcline porphyroblasts are developed. Although some of these rocks may be of psammitic origin, mainly have been altered by potash metasomatism during the Nyaodza Metamorphism and have therefore been partly granitized.

A broad band of resistant porphyroblastic gneisses, the *Kalukumbula Gneisses* named after the hill, cross the mapped area south-westwards from a point on the power-line south of Nzou Fly Gate, to a point just north of where the Kanyati River leaves the mapped area. They form fairly rugged hilly country and broaden out in the south-west. They are infolded with the overlying feldspathic metasediments of the Piriwiri Group, from whence they were probably derived during the Nyaodza Metamorphism. A zone of red, migmatized, microcline-rich granitic gneiss occupies the core of the Kalukumbula Gneiss and is well-exposed in the Nyadara Valley. The Kalukumbula Gneisses are intimately associated with enderbite pods and represent a once deeply buried north-east-trending trough within the earth's crust.

~~The Mica Schists are an heterogenous group of rocks that are best developed in the Rengwe Tribal Trust Land and along the Kanyati Valley which crosses the whole southern portion of the mapped area. The schists form a continuation of those mapped by Stagman (1962) to the north of the Urungwe Allochthon. They occur as soft, fine-grained,~~

reddish-grey oxidized schists and form low north-east-trending ridges. Red-brown flaggy boulders often overlie the red residual soils, except where the schists occupy valleys. Here they are harder, and light to dark grey in colour. There are numerous north-east-trending windows of the underlying Chiroti Paragneisses exposed and in places along the Kanyati Valley outcrops of pegmatitic granite occur. Farther east the schists form infolded outliers above the older rocks.

The rocks in the south are fine-grained, foliated quartz-sericite schists, but they are rather coarser grained than the typical Piriwiri phyllite. As one progresses northwards the schists become coarser grained and develop garnets. Muscovite and biotite occur as large flakes and micro-folding is much in evidence, the garnets being commonly rotated in snowball fashion. From farther north still, in the Nyadara Valley east of the cattle fence, slide 22322 reveals staurolite in a coarse-grained quartz-poikiloblastic garnet-biotite-muscovite schist. In all these schists, chlorite is a common retrograde mineral derived from both the micas and garnet.

Slide 22323 is cut from a grey-green, fine-grained sample taken near Kanyati School in the south-east of the mapped area. The rock shows a faint foliation with rounded quartz grains separated in a matrix of fine-grained sericite and clinocllore. Slide 22324 is from a sample taken farther west in the Rengwe T.T.L. This schist is fine-grained but a cleavage has been developed due to shear on microscopic kink folds. Quartz grains form some 35 per cent. of the rock. The sericite was beginning to recrystallize as muscovite flakes. Biotite is common and magnetite granules are accessory. A sample (slide 22325) from the cattle fence in the same area, is similar in composition and texture but large poikiloblastic snowball garnets lie in the cleavage. Late, but warped, quartz veins cut across the foliation.

Just to the south of Kalukumbula Hill the rocks develop a very coarse, schistose aspect and samples (slides 22326-7) from near the Exbio Mine are garnetiferous mica schists. Slide 22326 is from a strongly foliated, coarse-grained biotite-muscovite schist with large poikiloblastic garnets. A concordant quartz-sericite vein may have a psammitic origin. Slide 22327 is an even coarser grained biotite-muscovite-quartz schist with subordinate garnet.

The *Psammitic Schists and Gneisses* are widespread in the Piriwiri Group rocks and usually dominate the outcrop so giving a possible erroneous idea of their importance. These rocks occupy a broad north-

east-trending zone south of the outcrop of the Kalukumbula Gneiss. They overlie the Kalukumbula Gneiss in the western Nyadara Valley and to the south of Nzou Fly Gate. In the south, where they are less widespread, these feldspathic rocks are fine-grained, well-foliated schists. In the northern areas, however, they become gneissic and adjacent to the Kalukumbula Gneiss large microcline porphyroblasts and augen are often present. The rocks are white to flesh-pink in colour. They usually have a fine sheen of sericite or muscovite flakes, and large red garnet porphyroblasts are common. Pegmatite injection is frequent in these rocks, especially in the northern areas, and this may account in part for their feldspathization.

Slide 22328 is a fine-grained, well-foliated sericite-oligoclase-microcline schist. It has a pale pink colour and contains some 30 per cent. of microcline. Tiny garnets are an accessory. A sample (slide 22329) from north of the Exbio Mine is a coarse-grained, white, leucocratic granular gneiss with muscovite and large red euhedral garnets. Coarse grains of quartz and microcline suggest pegmatization. A sample (slide 22330) from the north, near Nzou Fly Gate, is a white, foliated, microcline-perthite gneiss with quartz rodding and muscovite flakes aligned in a lineation. Samples taken from the point adjacent to the Kalukumbula Gneiss (slides 22346-7), are coarse-grained, pink microcline-rich gneisses with minor amounts of muscovite and garnet. Large microcline augen have been introduced deforming the foliation, and myrmekite replacement is common.

The *Garnet-sillimanite Gneisses* occur in two important areas, one in the south-west centred on Chivakanenyama and Mashuma schools and the other in a zone south-west of Nzou Fly Gate. Small outliers occur in the south-west and above the Chipisa Paragneiss north of the Karoo basalt.

In the extreme south-east, near Chivakanenyama School, hard, dark, massive, garnet-sillimanite-bearing rocks are found closely associated with the north-western extent of the granites lying to the south and east. These rocks occur too far south to be a product of high-grade regional metamorphism, and more likely are hornfelsic rocks formed by contact metamorphism of the schists in an aureole about the granite. Kuhme suggests that they might be calc-silicate hornfels rocks as these are found just to the south as small lenticular horizons in the schists (Stagman, 1962, p. 36). However, the samples collected by him are not calcareous and appear to be of pelitic origin. Slide 22348 is of a dark,

massive garnet-sillimanite-biotite hornfels that is partly granitized into a coarse-grained quartz and microcline-perthite mass.

However, a few kilometres to the north, near Mashuma School, garnet-sillimanite gneisses and granulites are intimately associated with enderbite. This is an apparent anomaly in the regional metamorphic picture, but the outcrop pattern suggests some form of dome structure. It possibly represents a localized "hot spot" that has been forced up into the surrounding low-grade country rocks by some structural or intrusive mechanism. A sample (slide 22349) from near Mashuma School, is typical of the garnet-sillimanite granulites of the West Urungwe Mica Field to the north. The rock is slightly foliated, tough, and dark grey in colour. Sillimanite, garnet and subordinate biotite form over 50 per cent. of the rock in a granular groundmass of quartz, microcline-perthite and andesine with accessory magnetite and green spinel.

The northern area represents a south-westward continuation of the high-grade garnet-sillimanite gneisses and granulites that form the West Urungwe Mica Field. These rocks are mostly associated with, or occur north of the Kalukumbula Gneiss and they probably represent the high-grade equivalents of the mica schists already described.

A sample (slide 22331) from an isolated outlier in the western Nyadara Valley, is a coarse-grained feldspathic gneiss. The feldspar is greasy in appearance and is highly perthitic. Large garnet porphyroblasts up to 1 cm in diameter are associated with coarse laths of prismatic sillimanite and fine-grained biotite-rich patches. The garnet-sillimanite rocks from near Nzou Fly Gate and to the south along the Karambazungu road are weathered feldspathic gneisses (slides 22332-3). However, at points west of Nyongwicha Fly Gate true granulites occur (slide 22334) along with enderbites. Many of the rocks in the northern area have been affected by the deep-seated Nyadza Metamorphism and are partially granitized.

The *Feldspathic Metasediments* compose the bulk of the rocks allocated to the Piriwiri Group by Kuhme. This is an exceptionally heterogeneous group of rocks that occurs mainly to the north of the low-grade mica schists and tends to parallel or overlie the Kalukumbula Gneisses. Kuhme has described four major groups of feldspathic metasediment and he mentions several other textural and compositional varieties of localized extent. Some of these rocks are of probable psammitic origin, but most can be recognized as feldspathized schists that grade north-

wards into the gneisses that overlie the Kalukumbula Gneiss. It appears that the feldspathic metasediments were not as deeply buried as the Kalukumbula Gneiss but were partially metasomatized and therefore granitized during the Nyadza Metamorphism. This has to a great extent obliterated the regional metamorphic effects of the earlier Magondi Event.

The original rocks from which the first group of metasediments have been derived can generally be easily recognized. They are a group of compact, dark, fine-grained, micaceous rocks that normally occur in localized areas within, or just to the north of, the mica schists. Rarely do they occur adjacent to or north of the Kalukumbula Gneiss. They contain only accessory amounts of microcline. Fine-grained biotite is the dominant mica with accessory garnet, sphene, apatite and magnetite occurring in a groundmass of quartz and calcic oligoclase.

A sample (slide 22335), which is recognizable as a fine-grained sericite-biotite schist contains up to 30 per cent. of granular quartz, but feldspathization has formed oligoclase crystals in the foliation. A sample (slide 22336) from near the Sengwa Fly Gate has also been derived from a schist, and is now a compact, fine-grained, grey-green biotite-sericite rock with a granular groundmass of quartz, andesine and microcline. Slide 22337 was cut from an epidote-rich sample from farther east, near the Nixam Claims. The sample is again a compact, fine-grained, dark muscovite-biotite rock but was derived from a calcareous sediment. Where the Kanyati River crosses the cattle fence there is a dark, fine-grained rock (slide 22335) containing some 60 per cent. of quartz, with oligoclase, biotite and garnet. The rock was probably of psammitic origin.

The second group of feldspathic metasediments, and perhaps the most widespread, are recognized by their greater degree of feldspathization and greater microcline content. Most are found either adjacent to or overlying the Kalukumbula Gneiss although many occur farther south in the Nyadara and Sengwa valleys. A sample (slide 22339) from the Rengwe T.T.L. and same location as slide 22335, is still recognizable as having been derived from a sericite-biotite schist, but there is a greater degree of feldspathization. Microcline has been introduced and gives portions of the rock a granitic texture. Farther north in the Sengwa River just west of the cattle fence, the rocks (slide 22340) have a far more granitic appearance. Fine flakes of biotite and sericite occur in a groundmass of quartz and microcline and, as in many of these rocks, the ilmenite

has altered to form coronas of sphene and leucoxene. Microcline porphyroblasts rarely develop in these metasediments but where they overlie, or occur north of the Kalukumbula Gneiss they become coarse-grained biotite-muscovite gneisses (slides 22341-2) that are not easily distinguishable from the older Chipisa Paragneiss, especially when both are microcline-bearing.

The third group of metasediments occurs along the western Kanyati and Sengwa valleys which follow a major north-east-trending fault. In this group microcline porphyroblasts have developed and extensive shearing gives them a gneissic appearance. The rocks are normally rich in fine-grained biotite with subordinate sericite and muscovite. Quartz and calcic oligoclase form the groundmass and the rocks usually contain large microcline porphyroblasts (slides 22350-1). A sample (slide 22352) from the cattle fence north of the Sengwa River crossing, is so intensely sheared that the quartz grains are stretched into rods with a preferred orientation. Another sample (slide 22353) from the Kanyati River is a sheared, pink, porphyroblastic gneiss of granitic appearance with the sericite concentrated along the shear planes.

A fourth group of feldspathic Piriwiri rocks occurs south of the Nyadara River, near the western edge of the mapped area, where they overlie the Kalukumbula Gneisses. These rocks continue north-eastwards along the Chiwarongwe River to the cattle fence. They are distinctive in that they have a very granular texture, are grey in colour and weather into brick-like blocks with a brown outer surface. These rectangular blocks are scattered over the surface in random fashion. Slide 22354 is from one to the south of the Nyadara River. It is an even-grained massive rock with granular texture, and is rich in quartz with subsidiary oligoclase and no microcline. Tiny garnets and biotite flakes are evenly disseminated and magnetite is accessory. A rock (slide 22355) from the Nyadara River a couple of kilometres to the north has a very similar composition and a compact granular texture.

The *Kalukumbula Gneiss* is a granitic gneiss that crosses the area in a broad north-east-trending swath. In the west these gneisses extend from south of the Whamira Hills to the Kanyati River, but they narrow in the north to a point east of Nzou Fly Gate and just south of the Nyaodza Centre. They are resistant and create fairly rugged, hilly country forming such prominent points as Nyongwicha, Renga and the Kalukumbula Hills. The surrounding feldspathic metasediments grade

into the granitic gneisses which were derived from them by granitization during the Nyaodza Metamorphism. They are well-foliated on the edges and granitic towards the centre of the outcrop area. Most are dark grey in colour and are characterized by large, elongated, euhedral microcline and microcline-perthite porphyroblasts, that often exhibit carlsbad twinning. In the core zone of the grey gneiss, Kuhme has differentiated a red, highly migmatized, microcline-rich granitic gneiss. In the vicinity of Kalukumbula Hill and along the power-line to the south of the Nyaodza Centre, enderbites are exposed in the core zone and they too have been affected by the potash metasomatism. Probably deep burial took place during the Magondi Metamorphism and the Piriwiri rocks were raised to the granulite facies of metamorphism with enderbites forming locally. The intense potash metasomatism and granitization of the Nyaodza Metamorphism, so evident in the Urungwe District, followed and the Kalukumbula Gneisses and the Nyaodza Centre were probably the deepest rocks affected by this metasomatic event. The outcrop pattern suggests that they are exposed in a large, south-west-plunging anticlinal core.

Two granitic gneisses (slides 22356-7) are well-foliated grey rocks, with quartz, sericitized oligoclase and microcline forming between 65 and 80 per cent. of the rock. Tiny flakes of biotite with accessory muscovite, magnetite, sphene and apatite form the remainder. A similar sample (slide 22358) from the Nyadara River in the west is not well-foliated and contains euhedral microcline porphyroblasts up to 2 cm long. Granitic rocks (slides 22359 and 22360) from the west and north-east are of similar composition to the gneissic varieties although slide 22359 contains microcline porphyroblasts with carlsbad twinning. Myrmekite is well-developed in all these rocks.

The red granitic gneisses are of similar composition to the grey gneisses but they have been intensely migmatized and injected by microcline-rich pegmatite veins. They are especially well-exposed in the Nyadara River where they appear to form the core of the Kalukumbula Gneiss. A sample (slide 22361) from this river exposure is well-foliated. Large pink microcline augen are developed in the foliation planes which are defined by tiny biotite flakes. Garnet and sphene are accessories. A sample (slide 22362) from the western edge of the mapped area shows a similar development in the foliation of microcline-perthite augen with carlsbad twinning.

## ENDERBITE

There are two main localities for enderbite, the most important being intimately related to the Kalukumbula Gneiss in the vicinity of Kalukumbula Hill and continuing north-eastwards across the power-line. These enderbites represent a direct south-westward extension of those found to the north in the vicinity of the Nyaodza Centre. The second locality is centred on Mashuma School in the south-east. The enderbites here are associated with garnet-sillimanite granulites of the Piriwiri Group and have been structurally domed up or else intruded into the overlying low-grade Piriwiri rocks. No intrusive relationships with the country rocks are recorded by Kuhme.

It is significant that all the northern enderbites are granitic and rich in biotite. The biotite represents a retrograde effect of the Nyaodza Metamorphism when varying amounts of potassium-bearing fluid were introduced into the enderbites and surrounding rocks producing the microcline porphyroblasts. The enderbites were formed prior to the Nyaodza Metamorphism, probably during the north-east-trending Magondi Tectono-thermal Event. The Mashuma School enderbite (slide 22363), however, retains its greasy lustre with hypersthene as the dominant mafic mineral, and andesine as the dominant feldspar. Large red-brown biotite flakes are common and the large, fresh, well-twinned andesine grains are crushed and bent as in the other enderbites found in the Kariba and Makuti areas. These crush-textures possibly indicate intrusion of the enderbite in a partially crystalline or plastic state.

Slide 22364 was cut from a sample taken south-west of Kalukumbula Hill, in the main enderbite body. This granitic rock is weathered and has lost its greasy lustre. Red-brown biotite dominates over hypersthene and defines a foliation. The rock contains about 15 per cent. of microcline, largely in a coarse, concordant pegmatite vein. Slide 22365 is from a similar biotite-rich enderbite with microcline-perthite porphyroblasts composing some 20 per cent. of the rock. The andesine grains are fresh but the patchy hypersthene is considerably altered. Apatite is an important accessory and myrmekite an important replacement product.

## GRANITE

A small, 10 km<sup>2</sup> area of leucocratic granite is exposed in the south-east corner of the mapped area just to the east of Chivakanenyama School. It probably represents the north-western extent of the granites described by Stagman (1962) and Wiles (1961) to the south and east



respectively. These granites bear an intrusive relationship to the Piriwiri Group rocks and have had considerable contact metamorphic effects on them. It is hard to imagine that these granites have been derived by metasomatism and granitization of the Piriwiri rocks.

The two samples collected by Kuhme (slides 22366-7) are both massive, leucocratic microcline-rich granites with minor amounts of sericitized oligoclase partly replaced by the microcline. The granites contain up to 8 per cent. of fine-grained muscovite and are probably equivalent to similar granites found to the east (Wiles, 1961, p. 66). Biotite, hematite, sphene and zircon are accessories.

#### PEGMATITE

Pegmatitic rocks are ubiquitous within the area, but they are poorly exposed and are of limited extent. In the south especially, many of them appear to represent coarse-grained pegmatitic granites that tend to occupy the low-lying country in the Piriwiri schists. Such pegmatitic granites are well-developed where the Kanyati River crosses the cattle fence and slide 22368 is from a coarse-grained leucocratic pegmatitic granite with graphic quartz texture. Perthitic microcline and oligoclase occur in equal quantities and small euhedral garnets with a dusting of tourmaline contaminate the rock. These pegmatitic granites possibly represent a remobilization of Piriwiri rocks that have been intruded into themselves. Pegmatite injection is commonly associated with the leucocratic psammitic rocks of the Piriwiri Group. Similar pegmatitic granites are found in the Urungwe and Chiroti Paragneisses and a large zone of pegmatization is centred on Sengwa School (slide 22382).

Most of the economic mica pegmatites are restricted to rocks that have attained the upper amphibolite facies of metamorphism in the north. These mines include the Rukoi, Exbio and the Chitete 1 and 2, and are situated in the Whamira Hills. The beryl-bearing pegmatites are more widespread as they have not had such a strong metamorphic control. There are numerous small workings, which include the Shupa, Centenary, Luwic Rana and Tsungirai mines, centred on the Sengwa Fly Gate and associated with the pegmatitic granite already described.

#### QUARTZ-EPIDOTE ROCKS

Numerous quartz-epidote inclusions and veins of limited extent are found within the Urungwe Paragneiss, Chiroti Paragneiss and Piriwiri

Group rocks. Many of them bear an intrusive relationship to these rocks, as do the numerous quartz veins, but many represent calc-silicate inclusions that have been derived from calcareous sediments. A great variety of calc-silicate rocks are found as resisters in all the metasediments and paragneisses to the north and north-east. A sample (slide 22364) from near Nyongwicha Fly Gate, for instance, is a foliated epidote, hornblende, labradorite calc-silicate rock. Another (slide 22380) from the Nyadara Valley, however, is a massive, pale coloured quartz-epidote rock containing accessory plagioclase.

#### MINOR MAFIC INTRUSIONS

Wiles (1961, p. 98) recognized two distinct groups of mafic intrusion in the Karoi area. They also occur within the mapped area and are the post-kinematic metadolerites and an older group of pre-metamorphic intrusives which range from epidiorites in the low-grade rocks of the south, to true hornblendic amphibolites in the high-grade northern rocks.

In the south epidiorites occur in dyke form and a concentration of these occur near the junction of the Sengwa and Kanyati rivers. A sample (slide 22370) from here is a coarse-grained hornblendic rock in which coronas of bright green, pleochroic, hornblende needles have completely replaced the original pyroxene. The large plagioclase laths are clouded, but the original ophitic texture is still apparent. Biotite and specks of magnetite are common with quartz and sphene as the accessory minerals. A sample (slide 22371) from farther upstream in the Sengwe River, is a massive, grey-green rock in which the pyroxene is altered to a dull, weakly pleochroic hornblende and the plagioclase is highly saussuritized. Quartz has been introduced in small veinlets. Biotite and chlorite are alteration products of the hornblende, and magnetite is accessory. With progressive metamorphism these rocks develop into true amphibolites and a sample (slide 22372) from the Gachegache River where it crosses the Chipisa Paragneiss is a well-foliated amphibolite containing some 60 per cent. of hornblende in a granular groundmass of andesine. Magnetite is an important accessory. In the north-east, near the power-line, a fairly large area is underlain by hornblendic amphibolite, which (slide 22373) contains some 50 per cent. of hornblende with accessory magnetite and sphene in a granular groundmass of andesine.

Rare ultramafic inclusions are also found in the rocks of the western Urungwe and from the Karambazungu Fly Gate is a coarse-grained,

red-brown anthophyllite rock (slide 22374) in which large euhedral crystals of anthophyllite have a random orientation. In places the laths are asbestiform and are slightly altered to chlorite. A spectographic analysis of the rock by I. H. Green reveals an abundance of silica, magnesium and iron with about 5 per cent. aluminium, traces of sodium and chromium and no calcium. A second sample (slide 22375) from near the confluence of the Sengwa and Kanyati rivers is typical of the chlorite-tremolite schists found in the Kariba area.

The metadolerites are in the form of small dykes which intruded all rocks older than the Karoo System during the dying stages of the Miami Metamorphism. They are widely scattered throughout the area with the only concentration being in the Rhuwe and Chivura valleys in the north-east. A sample (slide 22376) from where the Chivura River crosses the power-line, is a dark, massive metadolerite with its original ophitic texture intact. Clouded laths of labradorite penetrate pyroxene crystals that have well-defined coronas of hornblende, biotite and magnetite. Apatite is accessory.

#### KAROO SYSTEM

The Karoo System in the mapped area is limited to a small outlier of basalt with a thin underlying bed of red sandstone and a fault-lined northern margin. This fault-block is downthrown to the south and occurs just north of Nyongwicha Hill. In the extreme north-west corner of the area, below the fault-lined Zambezi Escarpment, a small patch of poorly sorted boulder-conglomerate and sandstone occurs. This is an extension of similar sediments found in the Sunde Valley, near Chipisa Hot Springs. These sediments were locally derived from above the Escarpment after the trough-faulting formed the Middle Zambezi Valley.

A thin, fine-grained, basal red sandstone was found in the Gachegache River at the eastern end of the basalt. The sandstone dips northwards at 30 degrees beneath the basalts and towards the fault plane. Although cross-bedding was observed, the sandstone is generally massive and well-sorted, being composed of some 90 per cent. of quartz with accessory iron oxide, microcline, andesine and zircon grains (slide 22381).

The basalt sheet covers an area of some 15 km<sup>2</sup>, is 10 km long and 2 km across at its widest point. Its length, which is crossed by the westerly flowing Gachegache River, is aligned along a major fault which trends at 077° and downthrows to the south. Kuhme was able to

distinguish a minimum of four basalt flows in the Gachegache River, ranging in thickness from 5 to 16 metres.

There are both massive and amygdaloidal basalts in these flows. A sample (slide 22377) from the centre of a lava flow is a dark, relatively coarse-grained, labradorite-augite basalt. The augite granules, slightly altered to chlorite, are enclosed in interlocking laths of labradorite and there is a little magnetite and interstitial glass. A sample of amygdaloidal basalt (slide 22378) from the southern margin of the basalt sheet is highly weathered and the interstices between the labradorite laths are filled with dark glassy material. A few phenocrysts of augite survive, but up to 20 per cent. of the rock is formed by amygdales filled with flesh-pink zeolites which Kuhme has identified as stilbite and heulandite. Some large vugs and fractures in the amygdaloidal basalts are filled with dark green celadonite-stained chalcedony (slide 22379).

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