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THE GEOLOGY OF THE AREA SOUTH OF KAPOPO SCHOOL, CHIBOMBO DISTRICT, CENTRAL PROVINCE, ZAMBIA.

A Dissertation submitted to the Geology Department, School of Mines as a partial fulfillment for the award of Bachelor of Mineral Science degree at the University of Zambia.

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BY

CHABALA CHANDA

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DEDICATION

This thesis is dedicated to my dad and mum (Mr. and Mrs. Chabala) for all the sacrifices they have made in reaching me this far.

To my brothers: Bright, Harrison, Mwila, Morgan, Mumba, Chikwa and my sisters: Precious and Malama. Guys, you are the best.

ABSTRACT

The area south of Kapopo School located NW of Lusaka is underlain by a granitic boss and metasediments of the Chunga and Cheta formations that form part of the Zambezi mobile belt's tectono-stratigraphy.

Metasediments of the Chunga Formation include quartz-muscovite-biotite-garnet schist and quartzite whilst those belonging to the Cheta Formation include banded (quartz-muscovite) marble, phyllite and quartz-muscovite-biotite-chlorite schist.

The area has suffered two deformation phases D_1 and D_2 and associated metamorphic episodes M_1 and M_2 which are represented in quartz-muscovite-biotite-garnet schist by the formation of two foliations S_1 and S_2. The most predominant S_1 foliation is represented in all rock units including granite whilst the weak S_2 foliation is only observed in quartz-muscovite-biotite-garnet schist more distinctly in hand specimen by the crenulation of S_1 foliation.

Quartz-muscovite-biotite-garnet schist has a mineralogical makeup typical of regional metamorphism of amphibolite facies conditions and evidence of retrograde regional metamorphism to greenschist facies condition is shown in the mineralogical makeup of quartz-muscovite-biotite-chlorite schist.

The area is distinctly marked by two quartz veins (vein quartz) whose strikes are parallel to the foliation of the local metasediments.

ACKNOWLEGEMENT

This report would be incomplete if I didn't acknowledge people that have tirelessly contributed and assisted me during independent mapping period and in the final preparation of this report.

My special thanks go to Dr Ahmed (my supervisor), Mr. Musonda, Mr. Simasiku and Dr Nkhuwa for their helpful criticism and advice during independent field mapping.

Words alone can never depict how indebted I am to my dad and mum (Mr. and Mrs. Chabala) for the moral, spiritual and financial support they have rendered me. May God richly bless you all for being perfect and supportive parents.

My other thanks go to my classmates, Banda Kawawa, Chimusambo Joshua, Sekelani Stence and Zimba Munshya, for the support they gave me over these years we have been together. To my colleague Zimba Munshya, I am saying "Protea hotel" and thanks for the time well spent together during independent mapping at Kapopo School.

To Mr. Zimba Paul (CGAU), am saying thank you very much for taking your precious time in showing me how to work with ArcView software and for all the support you gave me in the CGAU during the preparation of this report.

Lastly I extend my hand to Mr. Muleya and all other teachers (especially the head mistress) at Kapopo School for accommodating and making us feel at home during our stay at Kapopo School.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

This project took six weeks and was undertaken between August and September 2006. The aim of the project was to train in geological mapping methods and report writing as is the requirement for the degree of bachelor in mineral science in geology at the University of Zambia.

Mapping was done on a scale of 1 to 25 000 with traverses running perpendicular to the local strike of the lithologies. The traverses were spaced at 250m taking into account the nature and density of exposures. In areas with poor lithological exposures, soil mapping served to be helpful in inferring geological boundaries coupled with satellite images acquired from Google earth. Images from Google earth were used to increase the confidence with which lithological boundaries have been inferred. Though used after field work, the images proved useful and were of high resolution.

1.2 LOCATION AND ACCESS

The mapped area lies 20 Km northwest of Lusaka and covers an area of 25 Km^2 (Fig 1). It is bound by longitudes 0625 000 mE and 0630 000 mE and by latitudes 8306 000 mS and 8311 000 mS.

The area is accessible by a gravel road branching off Great North road (Lusaka-Kabwe road) at a point called "ten miles". The gravel road runs westwards for about 10 Km before a T-junction at which a road going southwards leads directly to the study area (Kapopo School). The gravel road is regularly maintained by resurfacing but a 4 wheel drive vehicle is recommended during the rain season.

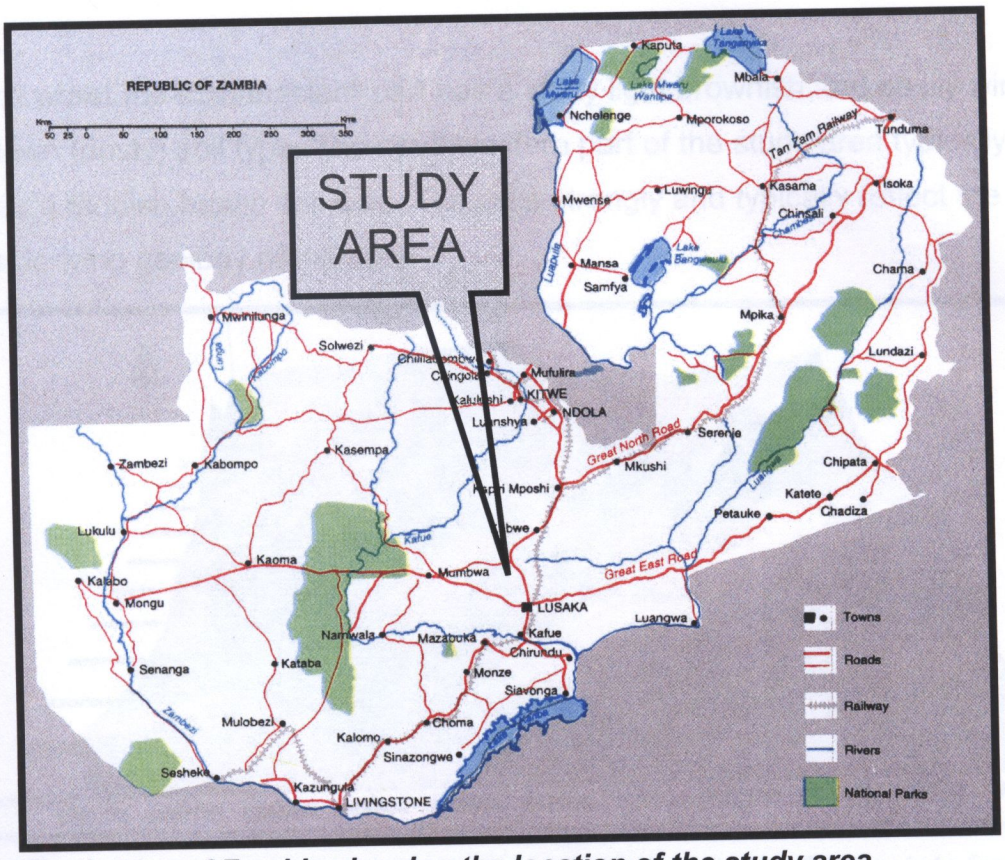


Fig 1: ***Map of Zambia showing the location of the study area.***

1.3 TOPOGRAPHY, SOIL AND DRAINAGE

The area is relatively rugged with the lowest elevation of 1110m above sea level recorded in the southwestern end whilst the highest elevation of 1210m above sea level, was recorded in the central, northwestern and partly in the northern end of the mapped area (Fig 2). Prominent hills occupy the northwestern –northern and partly the central part of the study area with elevations of between 1200m and 1210m above mean sea level. These hills are granitic and quartzitic respectively. The granite hill is steep sloped whilst the quartzite hill is flat topped and gently sloping.

The area displays four types of soil; brownish soil with quartz fragments which is present in the northwestern to northern part of the area, the central part displays a characteristically dark greyish sink-holed and compact soil type with carbonate (calcite) granules visibly present in the

soil whilst the southeastern part has a shiny light brownish and easily wind blown (dusty) soil type. The southwestern part of the study area typically has a reddish brown soil type. The soils strongly and typically reflect the underlying geology of the area.

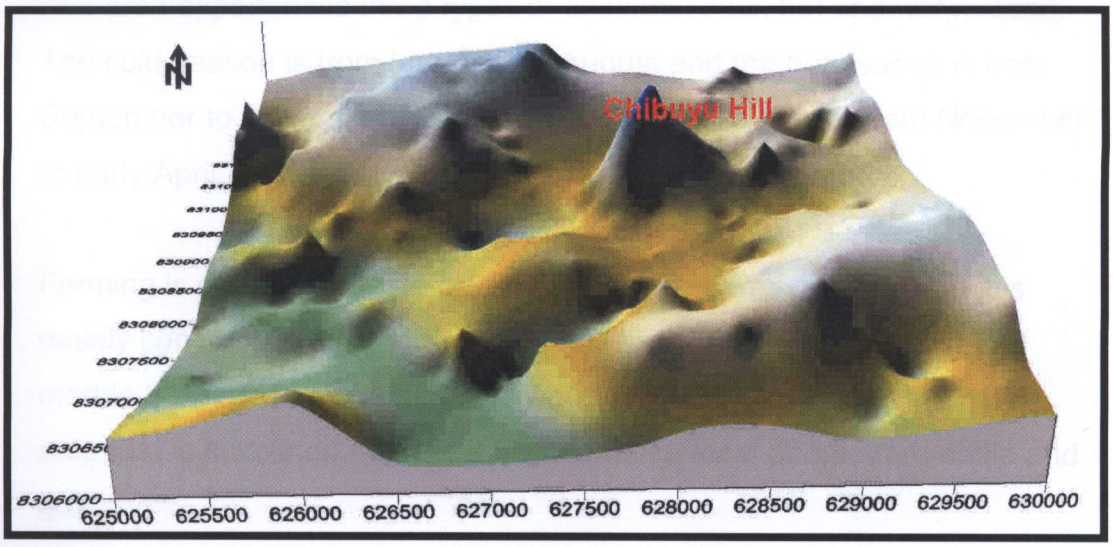


Fig: 2. ***Surfer generated 3D model of the study area using GPS points from the field.***

The study area displays three vegetation types, acacia (thorny) trees in the central, pine trees in the southwestern whilst the northwestern and southeastern part displays a similar vegetation type. The acacia trees are sparse when compared to the other two grass types.

A trellis drainage pattern is displayed within the area with distributaries joining the main streams at an angle close to 90^0 (Fig 4). The streams are generally straight and geologically controlled. All streams, save Chunga and Maukuuku streams, are intermittent.

The main streams (Kabuyu, Masasabi and Naliyanda) flow from NE to SW with the exception of Chunga and Maukuuku streams that flow NW from SE.

A spring occurs in the Kabuyu stream near the western margin of the study area.

1.4 CLIMATE AND AGRICULTURE

The area experiences three types of seasons: cold, hot and wet season. The cold season is from late April to August and the hot season is from September to November whilst the wet or rainy season is from November to early April.

Farming is on a small scale covering only small areas of land and it is mainly concentrated along Kabuyu and Chunga streams in schist and marble terrains due to fertility and water availability. Maize is the main crop that is cultivated and apart from farming, local people rare cattle and goats.

The main economic activity in the area, at the time of mapping, was sand quarrying.

1.5 REGIONAL TECTONIC SETTING

The study area falls within the Zambezi Belt of Neo-Proterozoic age which was formed during the Pan African orogenic cycle that spanned from 950Ma to 540Ma (Kroener: 1984). The Zambezi Belt occupies the Northern part of Zimbabwe, Southern Zambia and western Mozambiquian pedicle with a general strike of NW-SE.

In Zambia, the Zambezi belt is separated from the Lufilian Arc by the Mwembeshi Shear Zone. The Mwembeshi Shear Zone marks a sinistral trans-current boundary which sharply separates the low grade metamorphic rocks of the Lufilian arc from the deep crustal medium to high grade metamorphic rocks of the Zambezi Belt (De Swardt and Drysdall: 1965).

The meta-sedimentary sequence of the Zambezi Belt (Porada: 1988) has at its base the Chunga Formation comprising feldspathic quartzite,

calcareous schists and dolomitic limestone including garnet-bearing amphibolites and Rhyolite (probably Kafue rhyolite). Schists, probably representing altered basement gneisses, exist at the base of the Chunga sequence. The overlying Cheta Formation consists of a thick basal limestone which is overlain by quartz-muscovite (chlorite) schist and quartzite. The next unit, the Lusaka dolomite comprises a variety of carbonate rocks ranging from dolomite to limestone.

The Kawena Formation at the top of the sequence is argillaceous at the base and psammatic in its upper part and is unconformably overlain by a coarse conglomerate (in few localities) which includes clasts from the underlying Katanga Supergroup (Porada: 1969).

The metamorphic grade in these rocks range from medium to high grade with relict two pyroxene facies assemblage in sheared basement rocks in Southern Zambia and sillimanite-bearing assemblage in Zimbabwe (Vail and Snelling: 1971)

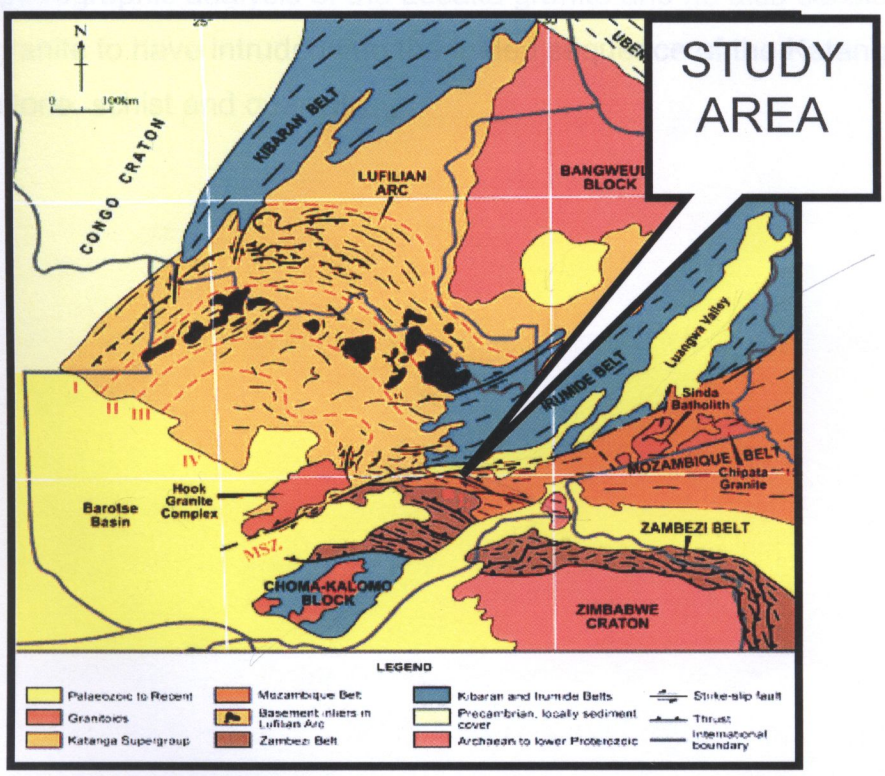


Fig 3: ***Structural map of Zambia showing the location of the study area.***

1.6 PREVIOUS WORK

The granite is mentioned by Murray-Hughes and Fitch (1929, p135) who includes it in the post Katanga hook granite complex. In 1930, the area was mapped on a scale of 1 cm: 300 m by geologists of the Loangwa Concession (N.R) Ltd, who considered the mass to be a typical "younger granite" intrusive into the surrounding sedimentary series. The granite was examined during the regional mapping of the Lusaka area by Simpson, Drysdall and Lambert (1963, p24) who considered it to have intruded the Chunga and Cheta formations of the Katanga System during the waning phases of the Lufilian orogeny. In 1964, Snelling, Hamilton, Drysdall and stillman determined the age of the Lusaka granite and the significance of its age as compared with that of the Nchanga granite is discussed by Drysdall and Garrard (1964). In 1968, J. G. Thieme carried out a structural and petrographic analysis of the Lusaka granite and he also considered the granite to have intruded into the folded sequence of the Katanga limestone, schist and quartzite.

CHAPTER 2

GEOLOGY OF THE AREA

2.1 SUMMARY

The mapped area is underlain by five mappable metamorphic rocks and an intrusive granitic pluton (Fig 4). The northern half of the mapped area is underlain by granite, quartz-muscovite-biotite-garnet schist, quartzite and banded (quartz-muscovite) marble. Marble continues into the southern half of the mapped area which is also underlain by phyllite and quartz-muscovite-biotite-chlorite schist.

Quartz-muscovite-biotite-garnet schist is crenulated and of medium grain size whilst quartz-muscovite-biotite-chlorite schist does not show any form of crenulation and it is fine grained.

The granitic pluton generally runs from east to west and is weakly foliated. Two types of granite can be distinguished: white and pink granite. White granite occurs as patches within pink granite.

Banded marble hosts other varieties of marble in form of veins and probably lenses.

The rock units are generally poorly exposed and faulted making unraveling of the true stratigraphy very difficult.

The metasediments of this area have a general NW-SE trend which ties with the general trend of the Zambezi Mobile Belt within which the study area lies though a local NE-SW trend is uncommon in marble exposed east of Kapopo School.

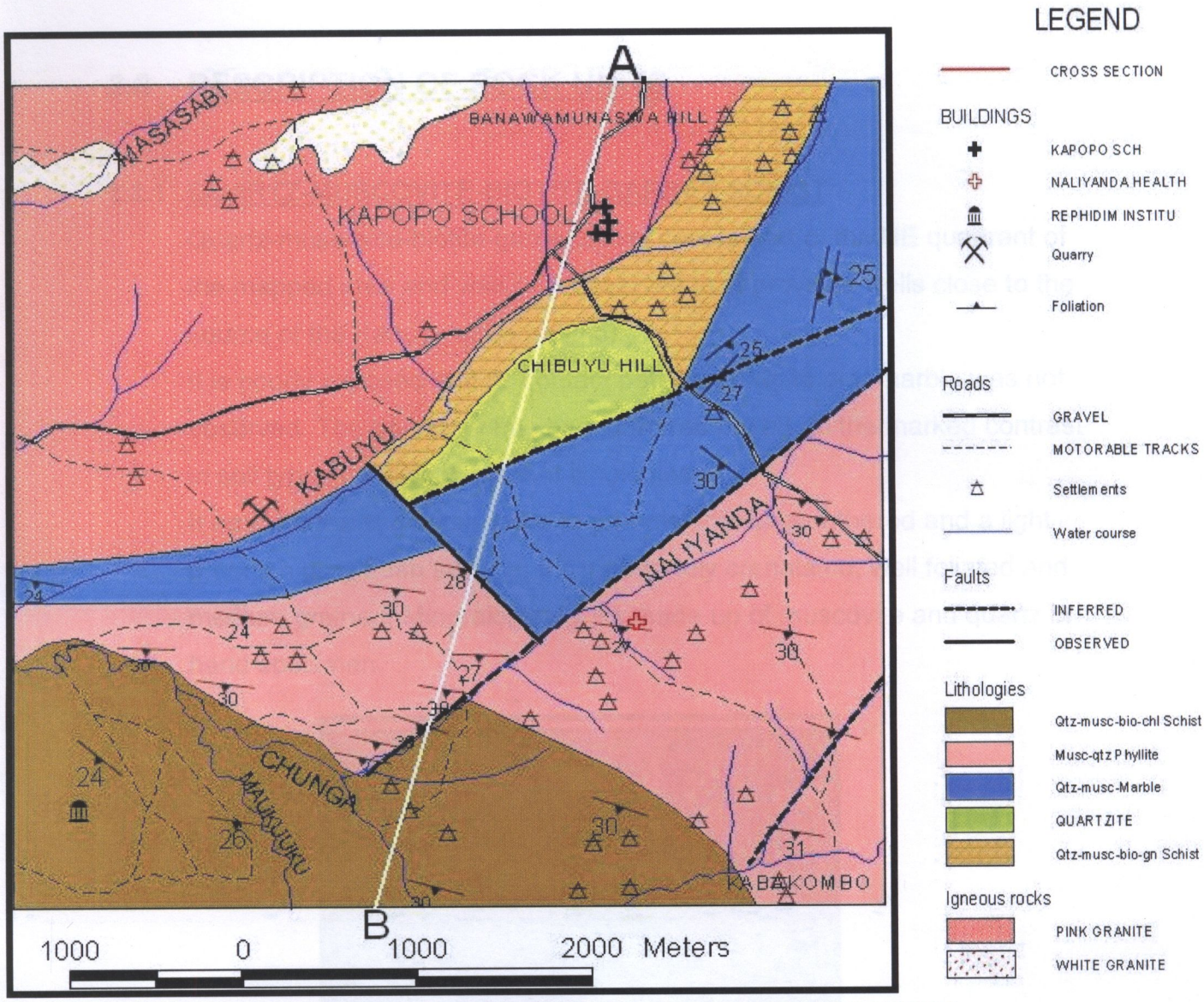
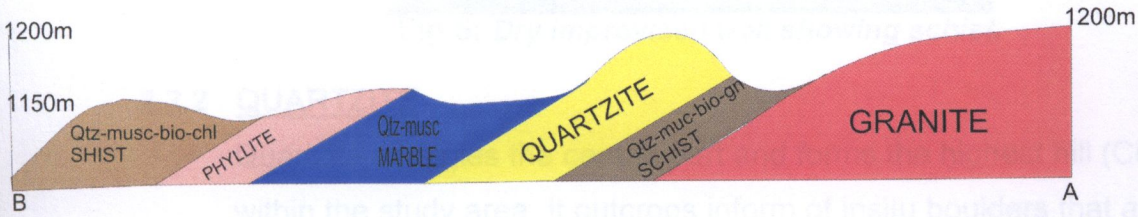


Fig 4: GEOLOGICAL MAP OF THE AREA SOUTH OF KAPOPO SCHOOL



2.2 DESCRIPTION OF ROCK UNITS

2.2.1 QUARTZ-MUSCOVITE-BIOTITE-GARNET SCHIST

Quartz-muscovite-biotite-garnet schist covers part of the NE quadrant of the mapped area and was only observed in improvised wells close to the source of the Kabuyu stream (fig 5).

It is poorly exposed and its contact between granite and marble was not observed. The boundary has been inferred based on the marked contrast in soil types overlying adjacent lithologies.

It has shades of greyish white to greenish brown weathered and a light greenish grey fresh surface. It's moderately crenulated, well foliated and medium grained. Mineralogically it's made up of muscovite and quartz in hand specimen.

Fig 5: ***Dry improvised well showing schist.***

2.2.2 QUARTZITE

Quartzite occupies the central part and forms the highest hill (Chibuyu Hill) within the study area. It outcrops inform of insitu boulders that abruptly terminates into the poorly exposed marble on the southern end. No contact was observed between this rock unit and any other adjacent rock units.

It has a whitish weathered and fresh surface, massive and mineralogically it's composed of quartz (Fig 6). It is very resistant to hammer blows and is moderately fractured. A few outcrops are jointed though without any conformable attitude.

Fig 6: ***Hand specimen of Quartzite from Chibuyu Hill.***

2.2.3 MARBLE

Marble covers part of the NE and SE quadrant and pinches out westwards within the mapped area. It outcrops in form of slabs covering large areas with little to no soil on top. In other areas it outcrops from dark greyish to black compact, sink-holed ground/soil and it generally occupies relatively low areas. The bands present in marble exposed east of Kapopo School, strike NE-SW and those exposed east and south of Chibuyu Hill have bands that strike NW-SE.

Four types of marbles were observed in the field: 1) banded, 2) rhodocrositic, 3) white and 4) grey massive coarse grained marble. Generally banded marble is the most prevalent and by far the most exposed.

Rhodocrositic marble occurs as veins in banded marble (Fig 8a) and the other two types were observed to occur within the banded marble though

the nature of occurrence is uncertain, due to the poor exposure of the host lithology, it is however highly probable that they occur as lens within the banded marble.

2.2.3a Quartz-muscovite-dolomitic marble (banded marble)

Banded marble is fairly exposed south and east of Chibuyu hill but it is poorly exposed near the western margin and central part of the mapped area.

It has a dark greyish weathered and fresh surface with light greyish bands (Fig 7a). The bands measure from less than 1mm to 9cm. This lithology is moderately weathered and weakly to slightly karstified in certain localities. It has a medium grain size and exhibits elephant skin exfoliation.

No contact was observed in the field between the marble and any other rock units.

Fig 7: ***(a) Hand specimen of banded marble and (b) white marble.***

2.2.3b Quartz-phlogopite marble (white marble)

White marble is exposed in the Kabuyu stream, about 500m north of Chunga Stream, near the western end of the mapped area. Because of its poor exposure coupled with the poor exposure of the lithology within which it occurs, it was difficult to establish its mode of occurrence in banded marble.

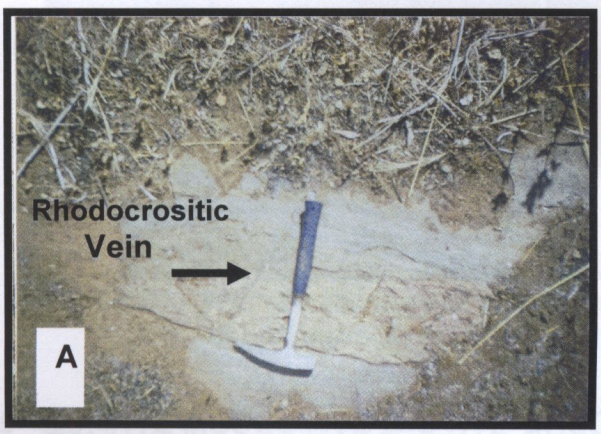
It has a white weathered and fresh surface. It is moderately weathered, hard and medium to fine grained. It has bands that measure less than a

millimeter but generally it is relatively massive on its weathered surface (Fig: 7b).

2.2.3c Tremolite-phlogopite-rhodocrositic marble

Rhodocrositic marble is well exposed some 2.5 Km south of the source of Kabuyu stream, in the NE quadrant of the study area.

It occurs as a vein within the banded marble (Fig: 8a) and it is fine to slightly medium grained, relatively hard and compact. The veins measured from 3cm to 20m in few localities.



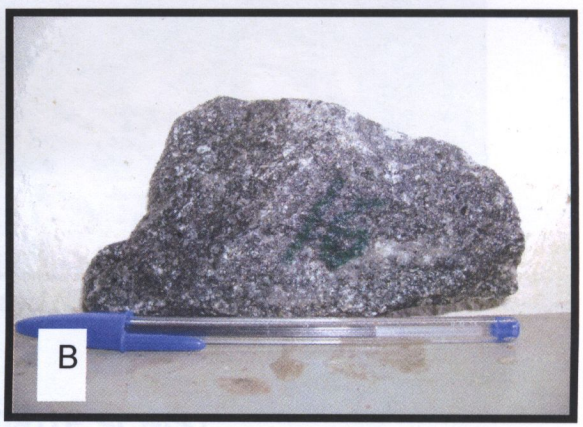


Fig 8: (a) ***Rhodocrositic vein in banded marble. (b) Hand specimen of grey massive marble***

2.2.3d Quartz (Grey massive) marble

Massive grey marble is exposed some 1.5 km east of Kapopo School. It is poorly exposed and seemly occurs in association with the banded marble. It is weakly to moderately weathered and slightly soft. This type of marble is generally massive, coarse grained and it has a sugary texture (Fig 8b). A sample collected east of Kapopo School contained some grains of Chalcopyrite.

2.2.4 PHYLLITE

Phyllite occurs in the SE quadrant and part of the SW quadrant of the studied area. It is exposed in stream beds and banks with best exposures in the Kabakombo stream, Naliyanda stream and the banks of Chunga

stream (some 500m west of the point at which Naliyanda stream joins Chunga stream). It is equally exposed by minor creeks.

It is highly weathered with a shiny light greyish greasy weathered and fresh surface. It is moderately soft to slightly hard and breaks into slabs due to its good phyllitic texture.

Phyllite exposed on the banks of the Chunga stream was observed to contain grains of Iron wrapped by micas.

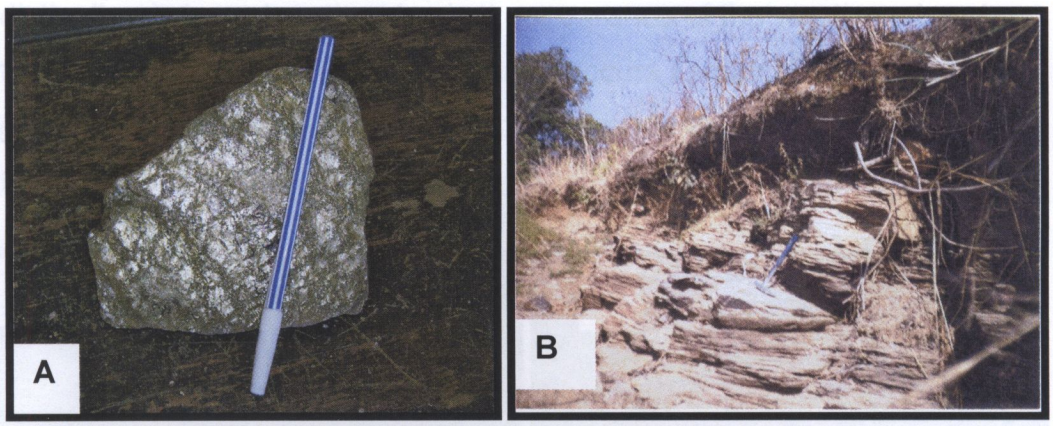


Fig 9: ***A) Hand specimen of Phyllite and (B) Phyllite as exposed in Kabakombo stream***

2.2.5 QUARTZ-MUSCOVITE-BIOTITE-CHLORITE SCHIST

Quartz-muscovite-biotite-chlorite schist is exposed in the SW quadrant of the study area along the Chunga stream banks; equally it is exposed in Naliyanda stream some 2.5 Km southwest of Chibuyu Hill (Fig: 10b).

It has a dark greyish to black weathered and a light greyish fresh surface. It is very hard and consists of yellowish and greyish band like structures that both measure about 1.7cm. It is fine grained with a silt feel to the touch. In one locality, it is striated (Fig 12).

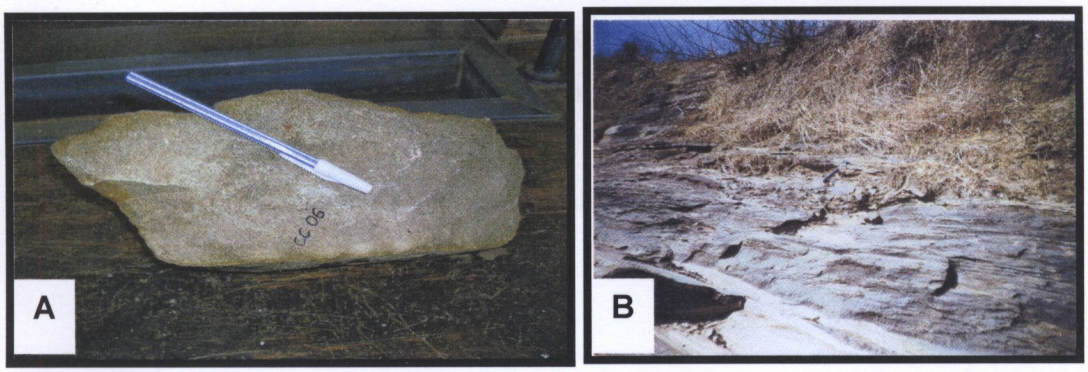


Fig 10: ***(A) Hand specimen and (B) nature of exposure of quartz-muscovite-biotite-chlorite schist.***

2.2.6 IGNEOUS ROCKS

Granite is well exposed in the NW quadrant of the mapped area. It outcrops in form of large moderately rounded boulders at an elevation of 1200m rising from 1110m (appendix 2).

The contact between the granite and adjacent country rocks is nowhere exposed within the study area.

Two types of granites can be distinguished: pink and white granite. The distinction is based on the physical appearance of the weathered and fresh surface (fig: 11a,b). White granite occurs as patches within pink granite near the northern margin of the mapped area and equally west of Kapopo School.

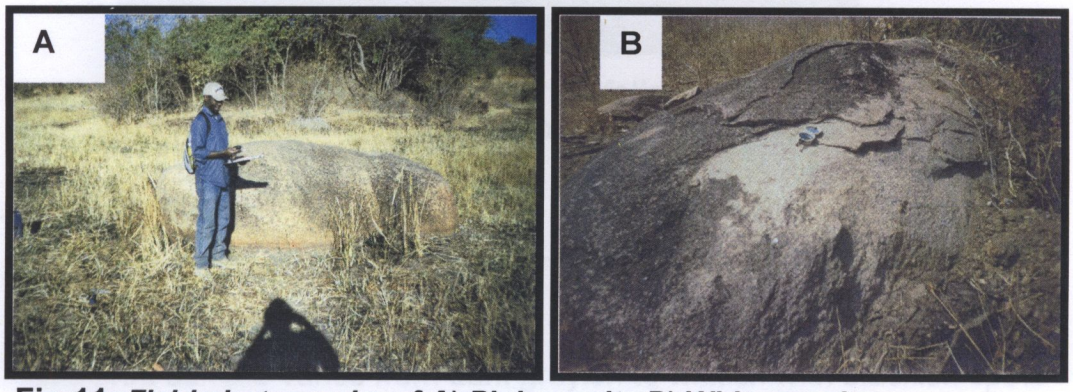


Fig 11: ***Field photographs of A) Pink granite B) White granite***

2.2.6a PINK GRANITE

Pink granite is the most predominant and hosts the white granite. The southern part of the NW quadrant exposes a weakly foliated form of pink granite. This weak foliation is defined by biotite in east-west direction (fig: 12). Biotite roughly wraps around the quartz grains and feldspar rendering an augen gneiss appearance to the pink granite.

The weathered and fresh surfaces are both pinkish and the rock unit is generally coarse to medium grained with grains measuring between 0.5mm and 8mm. In few localities, the pink granite is cut by both quartz veins and aplites of random orientation.

Mineralogically it is made up of biotite, K-feldspar and elongated quartz which are very visible in hand specimen.

Fig 12: ***Foliated pink granite, the foliation is perpendicular to the north arrow on the sample.***

2.2.6b WHITE GRANITE

White granite occurs as patches within the pink granite. It is well exposed west of the Banawamunaswa Hill and at the seismological centre. The weathered surface varies from dark greyish to whitish with blackish spots (Fig: 11b). Its fresh surface is black spotted but generally whitish. It exhibits an onion skin type of exfoliation.

White granite is medium to coarse grained, generally massive, hard and compact. Mineralogically, it is composed of quartz, biotite and whitish feldspar.

CHAPTER 3

PETROGRAPHY

3.1 QUARTZ-MUSCOVITE-BIOTITE GARNET SCHIST

In thin section the rock contains quartz (50%), muscovite (30%) biotite (10%) garnet (5%), and plagioclase (5%).

Biotite and muscovite define both a weak S_2 and dominant S_1 foliation. S_2 foliation is not well defined but it is displayed in some portions of the thin section "CC 20" were both muscovite and biotite are oriented almost orthogonal to the main foliation. Crenulation is more pronounced in hand specimen.

Quartz grains are predominantly subhedral to anhedral, fractured indicating brittle deformation and show undulatory extinction. They display a sutured grain boundary though a granoblastic polygonal texture is not uncommon.

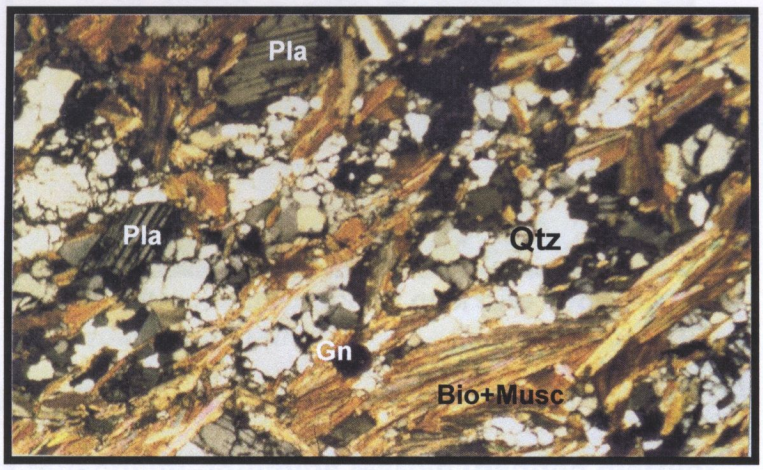


Fig 13: ***Photomicrograph of quartz-muscovite-biotite-garnet.***

Garnet (spessartine) displays well formed six faces and some of the grains are fractured. It appears brownish in plane polarized light and black in crossed polarized light with no evident inclusions. It is of fine grain size

(2mm) typical of mangananiferrous garnets in metachert (Yardley et al, 1990, page 47 and 71).

Plagioclase is randomly distributed throughout the thin section "CC 20" with a grain size of between 1mm and 4mm. It is fractured and relatively poikilitic and subhedral in shape. Its polysynthetic twinning is closely spaced typical of albite.

3.2 QUARTZITE

Quartzite is a mono-mineralic rock and contains quartz grains which have been elongated in one common direction (Fig 14). Quartz grains present in the thin section "CC 05" typically show undulatory extinction and are relatively fractured. The grains are subhedral to anhedral in shape and display to some extent an elongated granoblastic texture.

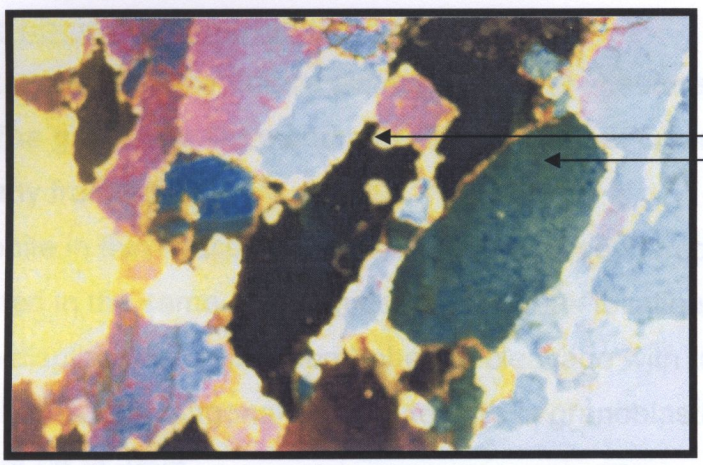


Fig 14: ***Photomicrograph of quartzite showing quartz elongation.***

3.3 MARBLE

Quartz-muscovite-dolomitic Marble (banded marble)

Quartz grains present in this rock unit display a typical granoblastic texture. They exhibit undulose extinction and are subhedral to euhedral.

A weak foliation is defined by muscovite. Muscovite has a grain size of not more than 1.5 mm in thin section "CCLT 05." (Fig 15a)

Calcite displays perfect rhombohedra cleavage with the twin lamellae parallel to the long diagonal of the rhombohedral cleavage. The grains measure up to 3mm and display a granoblastic texture.

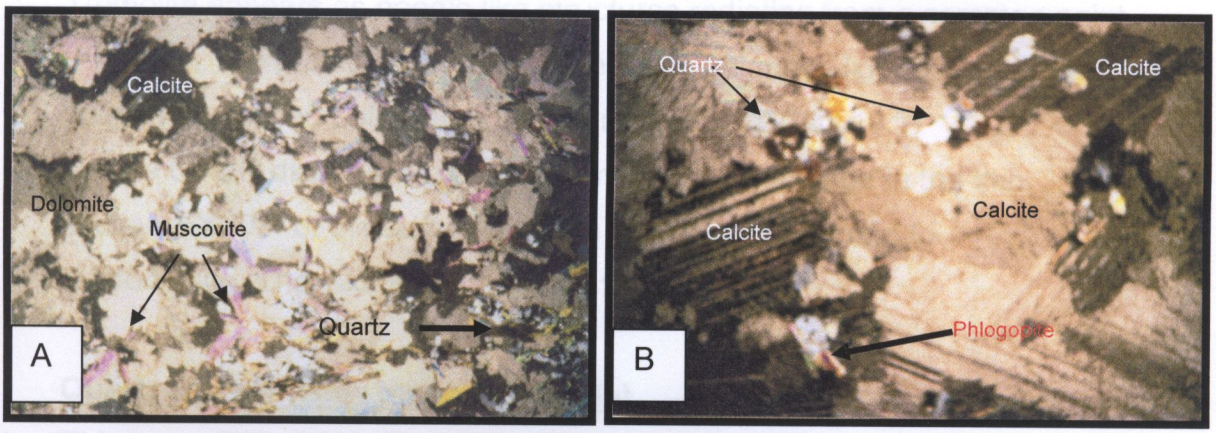


Fig 15: ***Photomicrograph of (A) quartz-muscovite-dolomitic marble and (B) quartz-phlogopite marble.***

<u>Quartz-phlogopite-marble (white marble)</u>

Quartz grains show undulose extinction and have sutured boundaries (Fig 15b). The grains are 1mm and subhedral in shape. Quartz crystals don't show any fractures.

Phlogopite in thin section "CCLT 09" occurs as scattered grains and are all elongated in the same direction defining a weak foliation (Fig 16a).

Calcite displays its typical rhombohedral cleavage with the twin lamellae parallel to its long diagonal and the texture is granoblastic. Calcite grains measure up to 3mm.

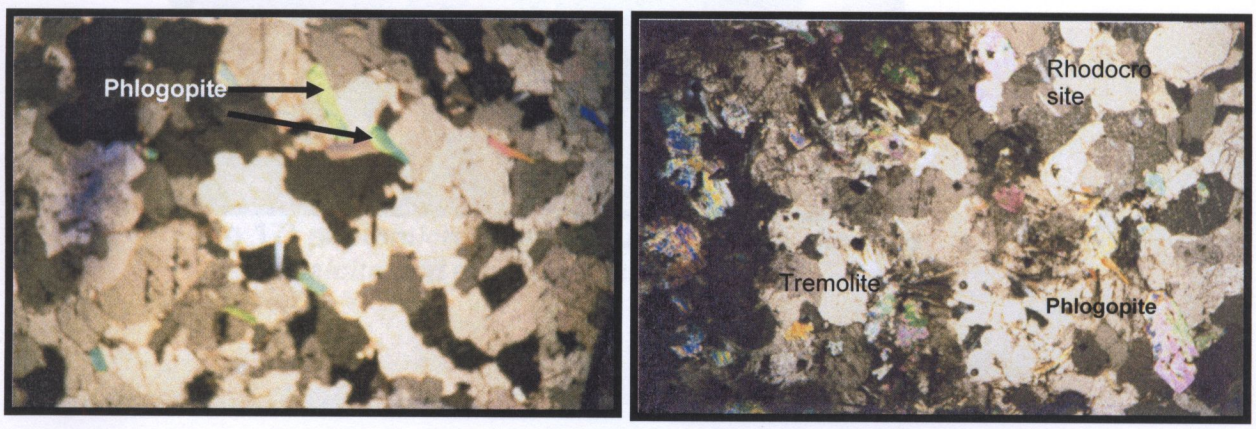


Fig 16: ***Photomicrograph of (A) quartz-phlogopite-dolomitic marble and (B) phlogopite-tremolite-rhodocrositic marble.***

Phlogopite-tremolite-rhodocrositic marble

Phlogopite has subhedral to euhedral shape with a prismatic habit. On rotation, phlogopite is pleochroic from light greenish with shades of purple to dark green and the grains are 2mm.

Tremolite appears as needle like structures radiating from a common point (Fig 16b). The grains are colourless in plane polarized light and are greyish in crossed polarized light in thin section "CCLT 19."

Calcite clearly displays its typical rhombohedral cleavage in the thin section "CC 03" of the same rock type and is insubordinate to rhodocrosite. The texture is granoblastic polygonal.

Quartz-marble (Grey massive marble)

This type of marble contains calcite with perfect twin lamellae and rhombohedral cleavage (Fig 17). The grains measure more than 4mm. Quartz grains occur as patches or blebs in thin section "CCLT 14a" and they show a granoblastic texture with a grain size of less than a millimeter. The extinction displayed is undulose.

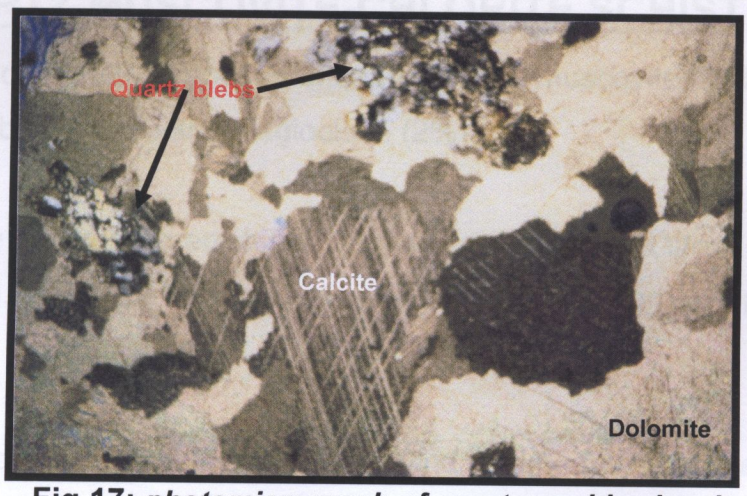


Fig 17: ***photomicrograph of quartz marble showing calcite and quartz bulbs.***

3.4 PHYLLITE

Phyllite is predominantly composed of muscovite, biotite, quartz, sericite and traces of opaque minerals (Iron). Both muscovite and biotite are kinked in the thin section "CF" and quartz grains seemingly appear to be below muscovite and biotite that define a phyllitic texture typical of phyllite. The quartz grains are fractured and display a granoblastic texture.
The muscovite has been sericitized as can be seen in the left top corner of the photomicrograph above (Fig 18).

Fig 18: ***Photomicrograph of phyllite***

3.5 QUARTZ-MUSCOVITE-CHLORITE SCHIST

Mineralogically it composed of quartz (70%), muscovite (15%), chlorite (10%), biotite (3%) and plagioclase (2%).

Chlorite appears greenish both in plane polarized and cross polarized light (Fig 19). It is in the transformation phase to reddish brown appearing biotite.

Quartz displays undulose extinction and is euhedral to subhedral displaying a granoblastic texture.

Plagioclase is randomly distributed and it is distinguished by its typical polysynthetic twinning. The grains are not more than 1mm.

Foliation is defined by muscovite, biotite, and chlorite. To some degree the foliation is defined by elongated quartz grains.

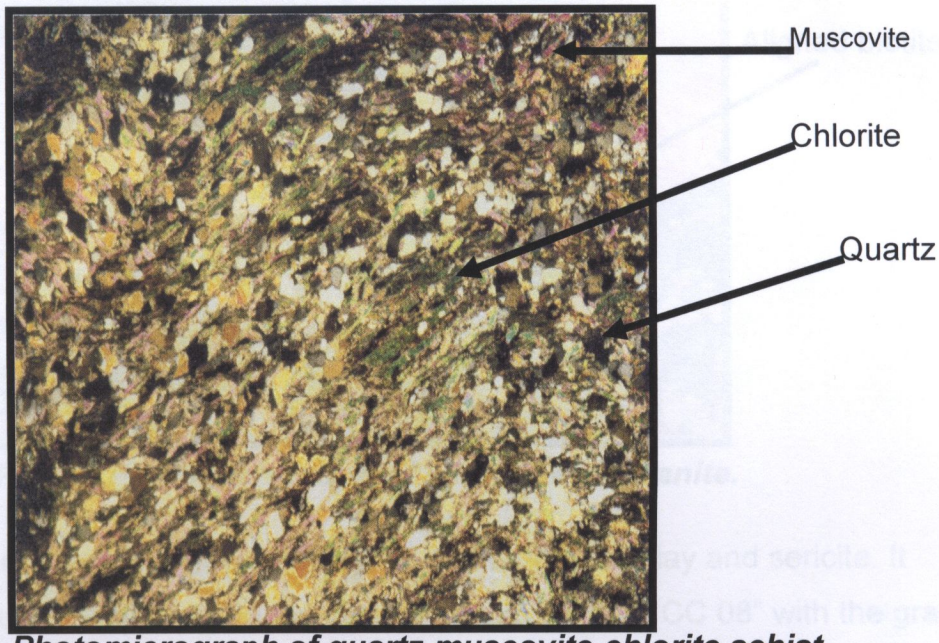


Fig 19: ***Photomicrograph of quartz-muscovite-chlorite schist.***

3.6 PINK GRANITE

Pink granite is composed of quartz (45%), microcline (35%), plagioclase (15%) and biotite (5%).

Quartz is predominantly fractured indicating deformation under brittle conditions and shows granoblastic texture. The grains measure more than 4mm. The grains show undulose extinction in which the extinction is seen to sweep over the crystal.

In the thin section "CC 08", plagioclase crystals are typically poikilitic (with tiny quartz inclusions) and are equally fractured. The grains of plagioclase measure more than 5mm and tend to occur as phenocrysts. Some plagioclase grains show alteration of polysynthetic twins.

Biotite flakes measure about 2mm and are un-eveningly distributed but they display some degree of parallelism defining a weak foliation (Fig 20) as observable in thin sections "CCLT 11" and "CC 08."

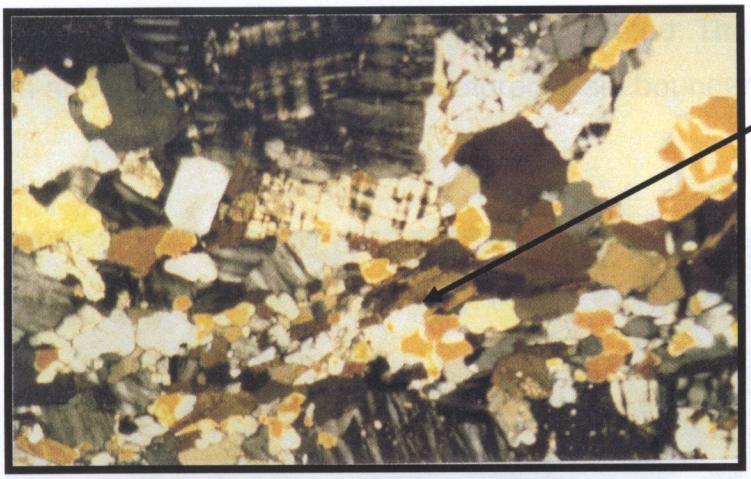


Fig 20: ***Photomicrograph of pink foliated granite.***

Microcline displays some degree of alteration to clay and sericite. It equally occurs as phenocrysts in the thin section "CC 08" with the grain size exceeding 5mm. Microcline grains are uniformly distributed and have subhedral to anhedral shape.

3.7 WHITE GRANITE

The thin section is composed of quartz (50%), microcline (35%), plagioclase (10%) and biotite (5%).
Biotite has a grain size of between 2 and 3 mm; it appears brownish with a greenish tint and the shape is subhedral to anhedral.

Plagioclase has inclusions of quartz grains in some portions of the thin section "MZ 62" and tends to be myrmekitic. It can be observed as megacrysts (5mm) in some portions of the thin section. The polysynthetic twinning is typical of albite and shows some alteration. The grains measure 3mm, typically subhedral to anhedral and they are not as uniformly distributed as microcline.

Microcline occurs as megacrysts with grain size exceeding 8mm (Fig 21). It contains quartz inclusions as well.

Quartz shows undulose extinction and is fractured. The grains measure 3mm and show a granoblastic to sutured grain boundary.

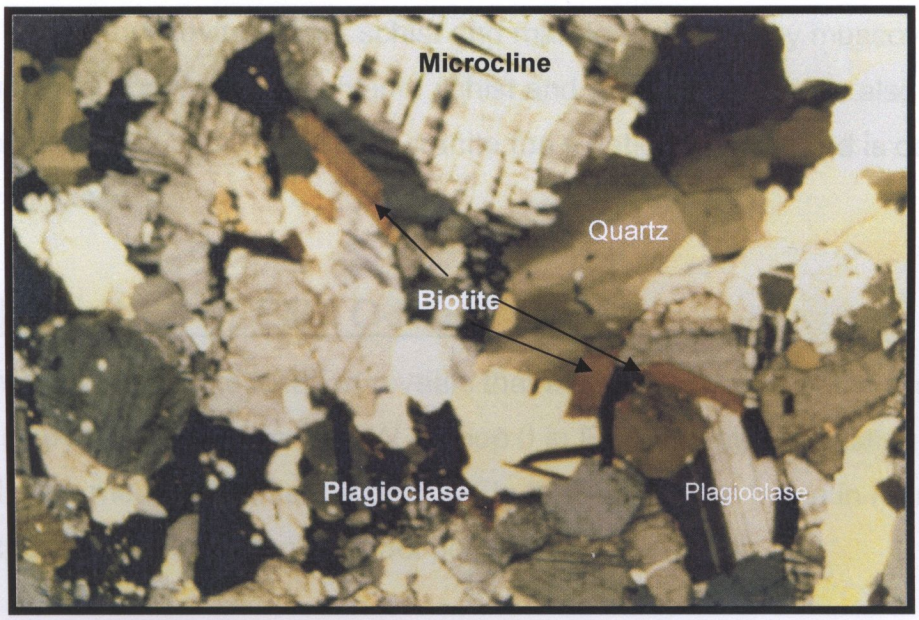


Fig 21: Photomicrograph of white granite

CHAPTER 4

STRUCTURAL GEOLOGY

4.1 FOLIATION

All the rock units except quartzite show some degree of foliation. Foliation in quartz-muscovite-garnet schist and marble is defined by muscovite. In quartz-muscovite-biotite-chlorite schist and phyllite, foliation is also defined by muscovite whilst in granite the foliation is weak and is defined by biotite.

4.2 PLOT OF POLES TO FOLIATION

The plot of poles to foliation reveals that the general trend of the rock units is NW-SE with a dip in the SW (Group 0 in Fig 23). The contrasting foliation measurements (group 1 in Fig 23) which were taken in marble exposed east of Kapopo School possibly denote folding.

The dips of the lithologies, as can be deduced from the plot, vary considerably because of the effect the intrusion has had on adjacent lithologies compared to those at a distance from the intrusion.

4.3 FAULTING

There is no evidence of faulting in the field apart from striations which were observed only on quartz-muscovite schist at one location (0627 097mE, 8306 928mS) in the Naliyanda stream (Fig 22). The faults have been delineated using satellite images sourced from Google earth (appendix 1). The 3 major inferred faults are nearly parallel to each other and trend generally in the NE-SW direction whilst the fourth inferred fault trends SE-NW.

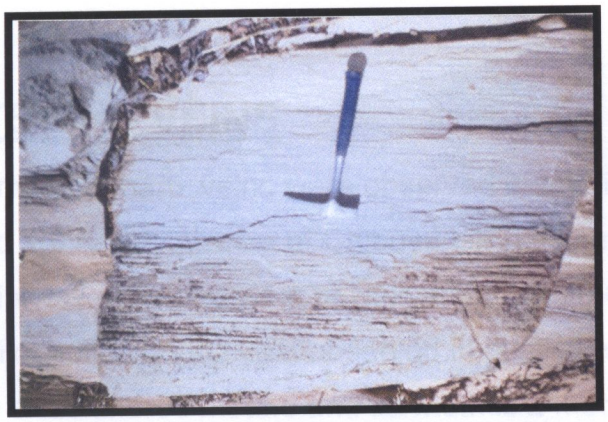


Fig 22: ***Striations on quartz-muscovite-biotite-chlorite schist***

4.4 FOLDING

There is no pronounced evidence of folding in the field apart from the contrasting strike observed in marble exposed east of Kapopo School. The area also displays ptygmatic folding in bouldinaged marble. The M and Z folds observed in marble are poorly and limitedly exposed for a reasonable structural analysis (appendix 3).

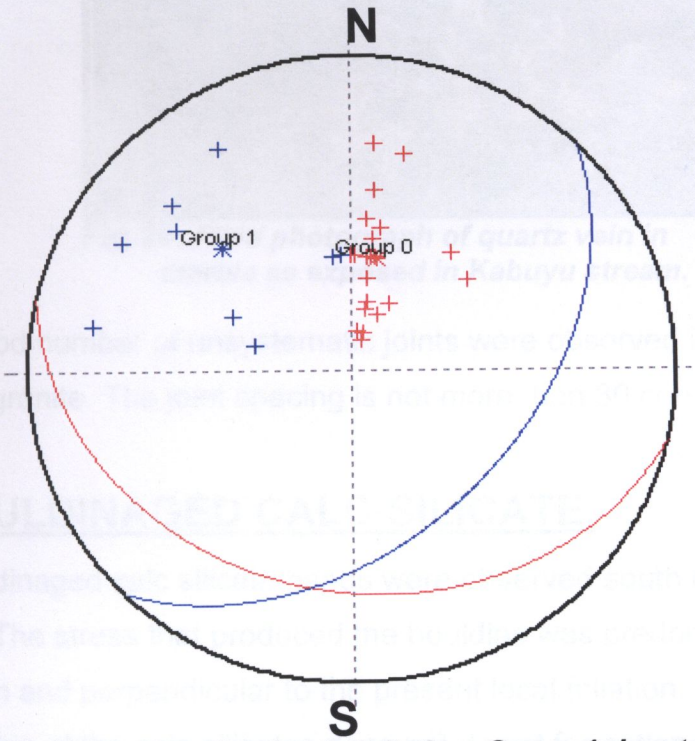


Fig 23: ***A plot of poles to foliation. Group 1 denotes measurements from marble exposed east of Kapopo School.***

4.5 JOINTS AND VEINS

Two prominent quartz veins were observed in the field. The first vein was observed 1.8 Km southwest of Chibuyu hill in Kabuyu stream (fig 24). The other vein was observed west of Naliyanda Health Centre some 1.2 Km (appendix 4). The quartz vein observed in phyllite was traceable over a distance of a hundred meters and its width is 2 meters. The strike for both veins is NW-SE.

The two quartz veins have a very close resemblance to quartzite and it is highly probable that these two veins were emplaced prior to metamorphism.

Fig 24: ***Field photograph of quartz vein in marble as exposed in Kabuyu stream.***

A good number of unsystematic joints were observed in marble, phyllite and granite. The joint spacing is not more than 30 centimeters.

4.6 BOULDINAGED CALC-SILICATE.

Bouldinaged calc silicate bands were observed south of Chibuyu Hill (Fig 25). The stress that produced the bouldins was predominantly North-South and perpendicular to the present local foliation. The present location of the calc-silicates does not depict formation from the thermal effect of granite hence pointing to the fact that the calc-silicates have been tectonically moved from there original position.

Fig 25: ***Field photograph of bouldinaged Calc-silicate bands.***

4.7 APLITE DIKES

A good number of granite boulders are cut by aplite dikelets of various and random orientation. The dikelets measure not more than 30cm (appendix 4). Mineralogically, the dikelets contain quartz, microcline and traces of biotite.

CHAPTER 5

METAMORPHIC GEOLOGY

5.1 METAMORPHIC MINERAL ASSEMBLAGE AND GRADE

The mineral assemblage in quartz-muscovite-biotite-garnet schist is typical of regional metamorphism of the Amphibolite facies conditions (Table 1). However the mineral assemblage, in quartz-muscovite-biotite-chlorite schist and marble, suggests regional metamorphism typical of the greenschist facies conditions. This gives evidence that the area was metamorphosed to the amphibolite facies conditions during the first metamorphic episode M_1 and that the second metamorphic episode M_2 was retrogressive to greenschist facies conditions.

Table 1: mineral assemblages for the mapped rock units

ROCK TYPE	MINERAL ASSEMBLAGE	THIN SECTION	PROSSIBLE PROTOLITH
Quartz-muscovite-biotite-garnet schist	Quartz + muscovite + biotite + garnet + plagioclase(albite)	CC 20	shale
Quartzite	Quartz	CC 05	Pure sandstone
Marble	Quartz + calcite + dolomite + muscovite + phlogopite + tremolite		Calcareous limestone
Phyllite	Muscovite + quartz + biotite	CF	shale
Quartz-muscovite-biotite-chlorite schist	Quartz + muscovite + biotite + plagioclase (albite) + chlorite	CCLT 06	pelites

The mineral assemblage "quartz-muscovite-biotite-garnet" is typical of pelites metamorphosed to amphibolite facies and equally the assemblage

"quartz-muscovite-albite-chlorite" is typical of pelites metamorphosed to the greenschist facies Ehlers et al (1982: p 547). This suggests that the protoliths for the two mapped schist were pelites. The mineral assemblage "quartz-calcite" with or without tremolite is an indicator of metamorphism of calcareous protolith to the greenschist facies Ehlers et al (1982: p 547).

5.2 METAMORPHISM AND DEFORMATION

The poly structural features (S_1 and S_2 foliations) displayed in the schist show that metasediments of the area south of Kapopo School have been subjected to two metamorphic episodes: M_1 and M_2 with associated deformational phases D_1 and D_2 respectively.

The first metamorphic episode M_1 caused the re-crystallization of quartz in quartzite and schist whilst the first deformational phase D_1 caused the elongation of quartz grains in quartzite and schist. D_1 also caused the re-orientation of biotite and muscovite in granite, marble and schist.
The granitic pluton is reported by Drysdall et al (1963: p24) to be syntectonic and emplaced during the waning phases of the post Katanga which affected it and caused the development of a foliation which is parallel to the regional trend.

The second metamorphic episode M_2 was less intense but strong enough to cause the formation of tremolite in marble. Tremolite and phlogopite are indicator minerals of metamorphic grade to the greenschist facies conditions, coupled with quartz and calcite, in meta-calcareous protoliths Ehlers et al (1982: p 547). It is therefore evident that the second metamorphic episode was retrogressive and this can be corroborated by the mineral assemblage quartz-muscovite-biotite-chlorite-albite observed in schist of the chunga stream (Table 1). The associated deformational phase D_2 occurred under brittle to semi ductile condition and caused the

observed fracturing of quartz grains in granite, schist and quartzite. Crenulation observed in quartz-muscovite-biotite-garnet schist and sericitization of muscovite in phyllite are also ascribed to the second deformational phase D_2.

CHAPTER 6

GEOLOGICAL HISTORY

The presence of calcareous sediments intermixed with pelitic sediments clearly depicts a deposition environment typical of marginal marine where regression and transgression played a major role.

Pelite possibly siltstone or shale was deposited first then pure orthoquartzite was later deposited. This sequence of sediment deposition reflects a change in flow regime of transporting media.
It is highly likely that subsidence followed thereafter and the flow regime became more calm leading to the deposition of calcareous or impure limestone. The impurities were necessary in limestone in forming tremolite during metamorphism. The presence of muscovite in marble also corroborates the idea that there was interplay between continental and marine sediments. Uplift of sedimentary basin or change of flow regime could have caused the deposition of the pelitic sediments after the deposition of impure limestone.
The sediments were then regionally metamorphosed and deformed. It is during this first deformation phase D_1 that granite probably intruded the metasediments.
The pelites gave rise to the two schists and phyllite whilst impure limestone gave rise to marble. Orthoquartzite was transformed to quartzite.

Second metamorphism set in with its associated deformation phase. The second deformation phase caused crenulation of the first foliation F_1 and fractured quartz grains. The sutured grain boundary displayed by quartz grains reflect insufficient time of re-crystallization during the second weak metamorphic episode M_2.

CHAPTER 7

REGIONAL CORRELATION

Based on the mineralogical assemblage, the quartz-muscovite-biotite-garnet schist has been ascribed to the Chunga Formation together with the quartzite. Marble, phyllite and quartz-muscovite-biotite-chlorite schist have been put in the Cheta Formation based on the grade of metamorphism and lithological description (Appendix 5). The Chunga Formation contains rock units that have been metamorphosed to the amphibolite facies whilst the Cheta formation is typically of low grade or greenschist facies (Drysdall et al 1963: p 21, 29).

Cheta Formation consists of two calcareous and two schist members. The lower of the two limestones is the thicker and can be followed along strike into the Kafue area where it has been named the Mampompo limestone. The second calcareous horizon may correspond to the limestone-dolomite horizons within the Chilanga psammite which overlies the Mampompo limestones (Drysdall et al 1963) whilst the rock units of the Chunga Formation are similar to those exposed in the Chalimbana area (Table 2).

It is possible that Chunga Formation is equivalent to the Lower Roan and Cheta Formation with its prominent calcareous horizons is equivalent to the Upper Roan (Drysdall et al 1963: p16). This correlation is summarized in table 2.

Drysdall et al (1963: p 21) compare the scapolite discovered in the Mungule area to that described by Mendelsohn (1961: p109) to be the typical regional metamorphic mineral in argillites of the Upper and Lower Roan in the Roan-Muliashi Basin on the Copperbelt in an effort to correlate the Cheta and Chunga Formation to the Upper and Lower Roan respectively.

The age of the Lusaka granite has been given as 820Ma by Katongo et al (2004) and the Nchanga granite has been dated at 880 by Armstrong (1999). This rules out the correlation of the Lusaka granite to the Nchanga granite. Moreover the field relations are also in contrast, the Nchanga granite is not intrusive into the metasediments whilst the Lusaka granite is intrusive into the metasediments making the metasediments of the Lusaka area older than those on the Copperbelt.

Table 2: Summary of the regional correlation (after Drysdall et al 1963).

CENTRAL PROVINCE SEQUENCES AND CORRELATIONS

Luiri Hill (Phillips 1958) (see Smith et al. 1960)	Mwembeshi Area (Simpson 1962)	Lusaka Area	Kafue Area NE. of Munali Hills (Smith in press)	Probable Age Equivalents
Rudaceous and Calcareous-Arenaceous Groups	Kawena Sandstone } Kawena Formation			
Unconformity				? Kundelungu
Transition Beds	Kawena Argillite } Kawena Formation			
	Unconformity			
Carbonate-Argillite Group	Lusaka Dolomite	Lusaka Dolomite	Lusaka Dolomite	
	Structural break and possible unconformity			
	Cheta Formation	Cheta Formation	Cheta Formation { Chilanga Psammite, Mampompo Limestone }	Upper Roan
Quartzite-Schist Group	Chunga Formation	Chunga Formation	{ Chipongwe Psammite, Funswe Pelite, Mulola Formation }	Lower Roan ?
			Nazingwe Formation (?)	?
Unconformity				
Paragneiss Group	Mwembeshi Quartzite, Kembe Gneiss and Schist	Basement quartzites and gneisses	Kafue Volcanics(?), Mpande Gneiss	Basement Complex

CHAPTER 8

ECONOMIC GEOLOGY

8.1 SCHIST AND QUARTZITE

Schist and quartzite can be used as building stones and can equally serve as an attractive finish to walls and verandahs.

8.2 BUILDING SAND

The area is richly endowed with building sand and it is readily available. Most sand quarrying activities were concentrated near dambos and dry river beds adjacent to the granite. The sand is the subsequent result of the intense weathering of granite.

8.3 GRANITE

Granite outcropping in the mapped area is suited for both road construction and ornamental stone. At the time of mapping granite was being quarried west of Chibuyu Hill near Kabuyu stream by a road construction company from Lusaka.

8.4 COPPER

The area east of Kapopo School exposes marble that contains grains of chalcopyrite. This area was referred to as "peacock claims" by Drysdall et al (p: 34). Drysdall et al states in their report that malachite, chalcopyrite, chalcocite and cuprite are restricted to quartz veins, ***limestones (marble)*** and schists of the Cheta Formation. However, a detailed study of the truth of this is highly encouraged.

CHAPTER 9

CONCLUSION

The mapped rock units underlying the area south of Kapopo School have been ascribed to the Chunga and Cheta Formations based on metamorphic mineral assemblages and lithological descriptions.

The rock units falling in the Cheta Formation show mineral assemblage typical of greenschist facies conditions and those put in the Chunga Formation show mineral assemblage typical of the amphibolite facies conditions. Quartzite has arbitrary been assigned to the Chunga Formation because it does not have a representative mineral assemblage typical of any of the two facies but the lithological description is similar to quartzite described under the Chunga Formation by Drysdall et al (1963). The area has thus been subjected to two metamorphic episodes: M_1 and M_2. The first metamorphic episode M_1 reached the amphibolite facies conditions whilst the second metamorphic episode was retrogressive and reached the greenschist grade of metamorphism.

All the rock units show the effect of the first deformation D_1 phase by elongation of individual grains and the formation of the more pronounced S_1 foliation defined by muscovite and biotite. The second deformation phase D_2 was weak but strong enough to cause fracturing of quartz, plagioclase etc in the mapped rock units and formed the crenulation cleavage which is well displayed in the schist ascribed to the Chunga Formation.

The granitic pluton was emplaced during the closing phases of the post-Katanga orogeny and was affected by it, developing a foliation parallel to the regional trend (Drysdall et al 1963 p 24).

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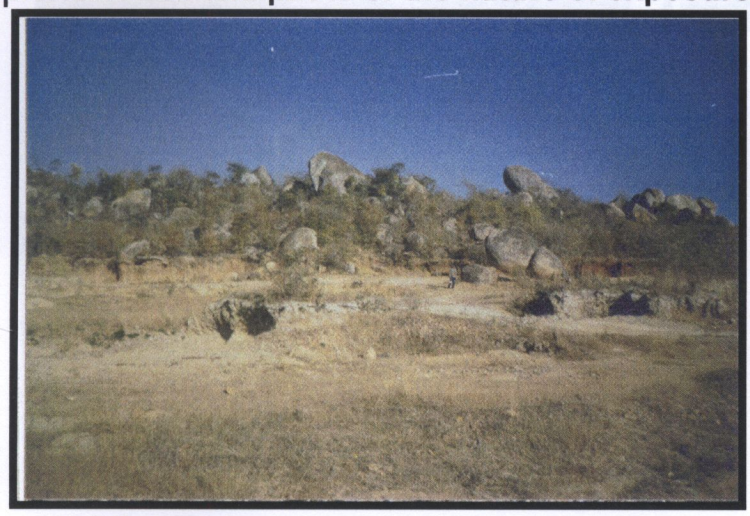
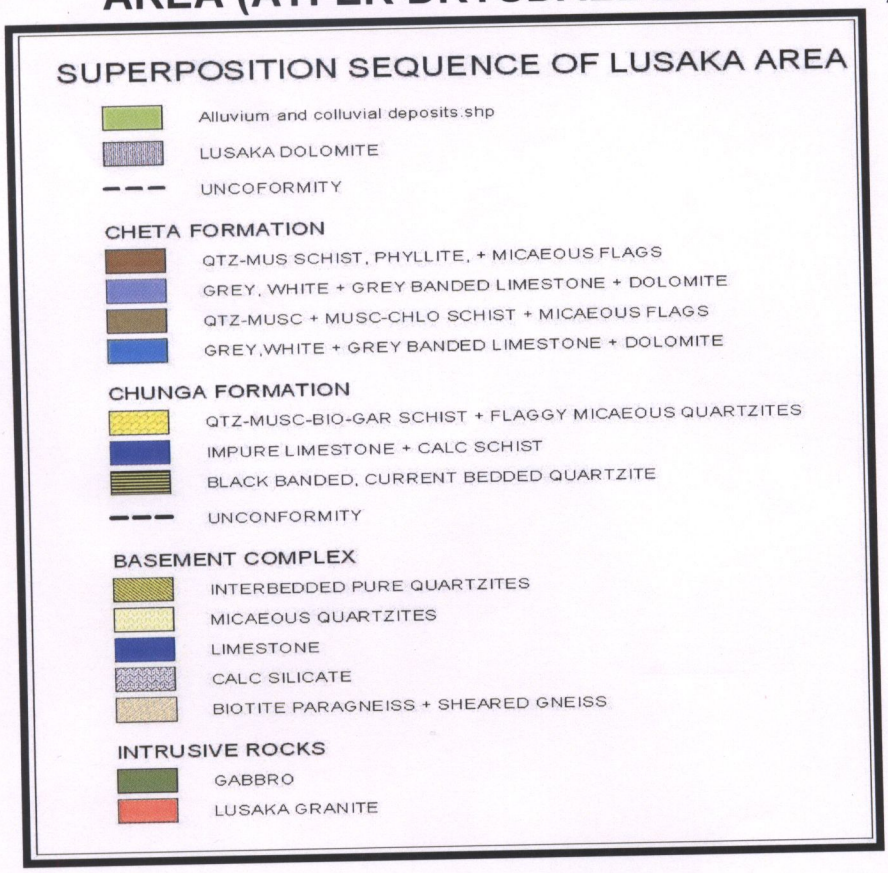
APPENDIX 1: SATELLITE IMAGE OF THE STUDY AREA.

Source: Google Earth

Appendix 2: Field photo of the nature of exposure of granite.



Appendix 3: **Nature of folding in Calc silicates. Left: Field photo of possible flow folding in marble. Right: poorly exposed S-folds in calc silicates.**

Appendix 4: Left: **Quartz vein exposed in phyllite west of Naliyanda Health Center. Right: Field photo of aplite dikelet in pink ~~marble~~.** Granite

APPENDIX 5: SUPERPOSITION SEQUENCE OF LUSAKA AREA (ATFER DRYSDALL ET AL 1963)