THE UNVERSITY OF ZAMBIA
SCHOOL OF MINES
GEOLOGY DEPARTMENT

THE GEOLOGY OF NYANGWENA RIVER SOUTH,ACONFLUENCY OF THE CHONGWE RIVER,CHONGWE DISTRICT,LUSAKA PROVINCE,LUSAKA.

INDEPENDENT MAPPING PROJECT-REPORT GG 592

BY

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DEDICATION

This thesis is a dedication to my parents; Mr. Donald Kashimu and Idah Sakala for their level of sacrifice, incomparable Love, tireless effort and encouragements that have collectively seen me this far. May the almighty God bless Mom and Dad.

My brothers and sisters Nebby, Brian, Maureen and Samson are all remembered for the continued love, support and encouragements that you have all rendered to me. May the almighty God bless you brothers and sisters.

Lastly to my late brother Knieven and late sisters Anita and Jacqueline for help you had given to me at time we were together. May your soul rest in peace.

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May God bless you all.

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ABSTRACT

The Nyangwena River and its adjacent areas lies in Chongwe district in the Lusaka Province of Zambia. It is part of the Southern extension of the Irumide Belt. The study area is underlain by Mesoproterozoic Basement Complex which includes gneiss, amphibolites, quartzites and schist. The Neoproterozoic Katanga Supergroup uncomfortably overlies the Basement is mainly composed of schist. The tectonic history falls into three broad episode. The first deformation (D_1) resulted in recumbent folding and development of planar foliation (S_1) which is defined in the gneisses and amphibolites.The first deformation was accompanied by a regional prograde metamorphism(M_1) defined by the mineral assemblage being hornblende-plagioclase-biotite-quartz-garnet-sphene. The second deformation phase (D_2) resulted in steep, upright folds and thrusting in a North-West direction. In addition, the second deformatiom was accompanied by a prograde metamorphism followed by a retrograde metamorphism (M_2) due to cooling and fluid circulation. The mineral assemblage associated with (M_2) is typical of greenschist facies defined by chlorite-quartz-biotite-epidote-sphene-actinolite-iron oxide (opaque) as observed in the chlorite schist unit. The third deformation (D_3) resulted in the development of open folds and thrusting in the North-East direction.

CHAPTER ONE
INTRODUCTION

1.1 GENERAL.

This report presents an account of the findings resulting from the field work that was carried out in the Nyangwena River south, a confluent of Chongwe River, Chongwe District, and Lusaka Province of Zambia. The geological work covered a time frame of five weeks .The main objective of the investigations were to be introduced to geological mapping techniques, report writing and solving geological problems which include determining the deformational and metamorphic history of the area. This forms part of the requirements for the Bachelor s Degree in Mineral Science (Geology) of The University of Zambia.

1.2 LOCATION AND ACCESS

The Nyangwena River and its adjacent areas lies about 51 km east of the capital of Zambia Lusaka. The study area is located between Easting 690,000E to 697,000E while Northings 8303, 000N to 8310, 000N.This study area can be accessed through the great east road which links Lusaka to Chipata of the eastern province of Zambia.

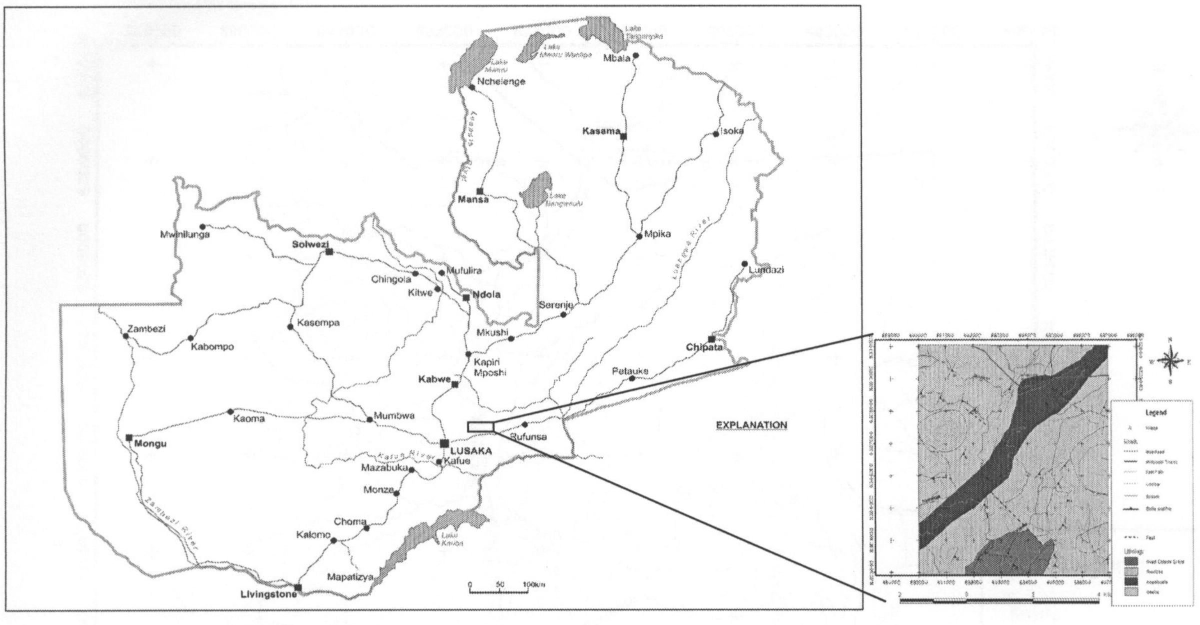


Fig 1.Map of location and access

1.3 PHYSIOGRAPHY

The study area is relatively hilly with the lowest elevation of 999m above the sea level and highest elevation being 1020m above the sea level. Most of the highest points where underlain by quartzites and augen gneiss while the lower points where underlain by schist and amphibolites. The study area is well drained with two main rivers and many tributaries in different directions. Both the Nyangwena river and Nyabisese river traverses the area from north to south and flow into the Chongwe river being the largest in the area.

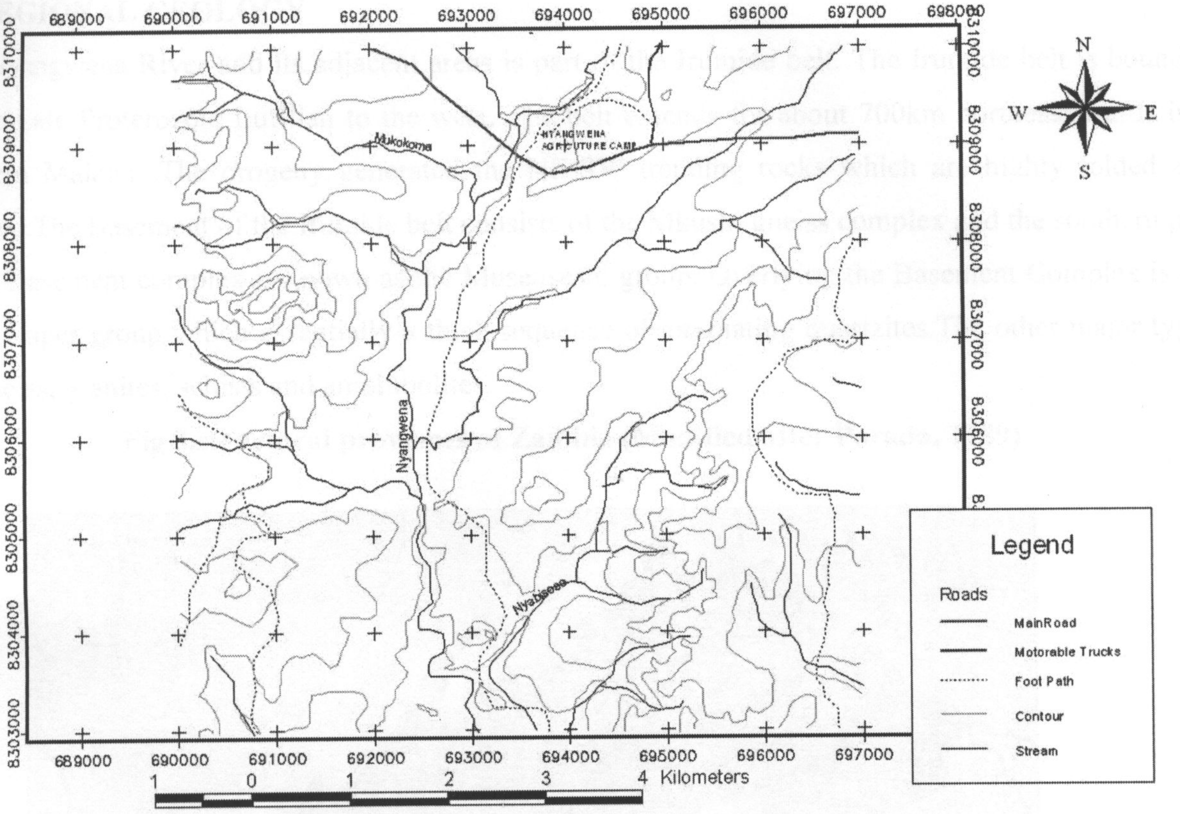


Fig 2: PHYSIOGRAPHY AND DRAINAGE MAP

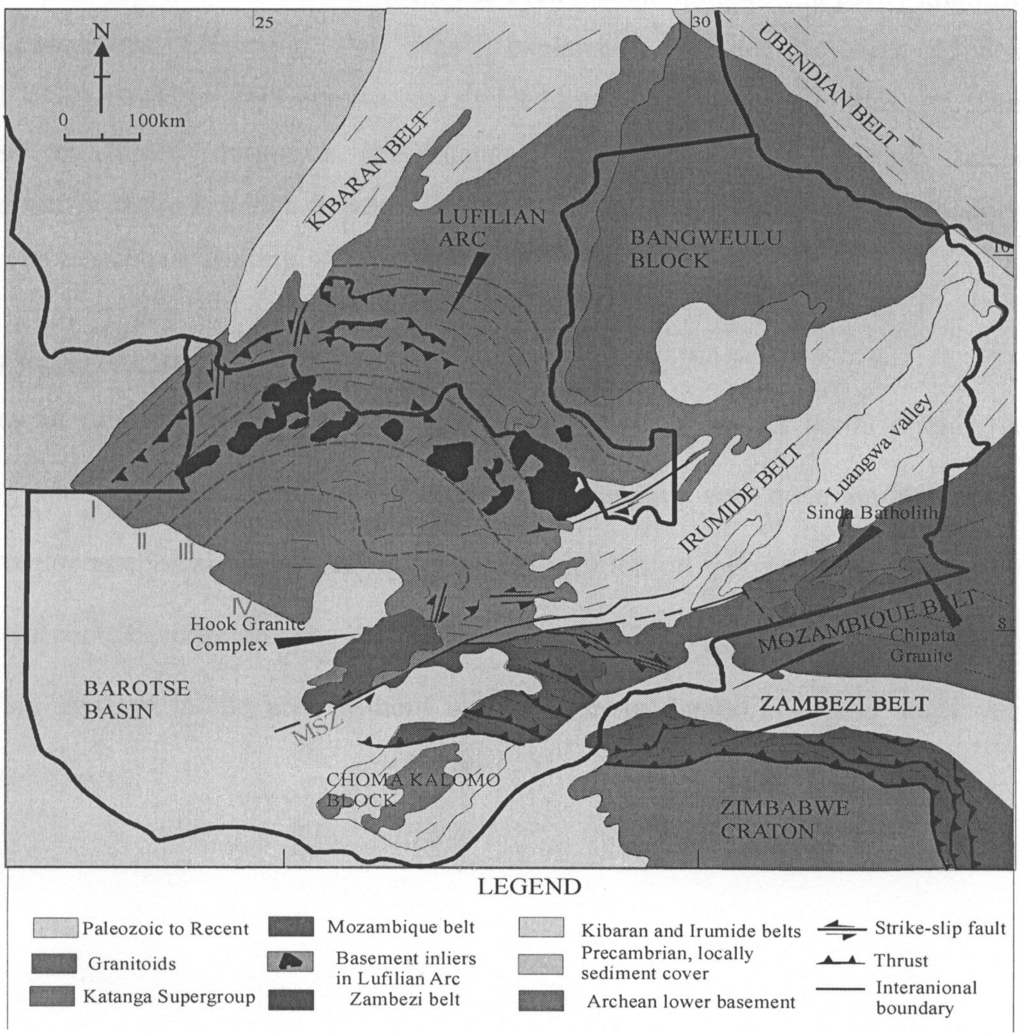
1.4 CLIMATE AND VEGETATION

The climate and vegetation of the study area is typical of the main plateau of Zambia. The mean annual rainfall is about 914mm with usually the highest record in the month of February. Annual temperature ranges from 17°C to 32°C.The vegetation is typically savannah consisting of tall grass and thorny bushes. Areas underlain by quartzites, especially the ridges show a very sparse vegetation as opposed to areas underlain by amphibolites, gneisses and schists.The area also has dambo vegetation. This is evident in the northeastern part of the study area.

1.5 REGIONAL GEOLOGY

The Nyangwena River and its adjacent areas is part of the Irumide belt. The Irumide belt is bounded by the Late Proterozoic Lufilian to the west. The belt extends for about 700km northeast wards into northern Malawi. The orogeny generated the NE-SW trending rocks which are highly folded and thrusted.The Basement of the Irumide belt consists of the Mkushi gneiss complex and the southern part of the Basement complex is known as the Musenseshi group. Overlying the Basement Complex is the Muva Super group which essentially a thick sequence of alternating quartzites.The other major types are gneiss, granites, schists and amphibolites.

Fig 3.structural provinces of Zambia (Modified after Porada, 1989)



1.6 PREVIOUS WORK

The earliest known study in the area was by Studt (1914) who classified the rocks of area into the older group of quartzites and granites, which was assigned to the Swazi system of South Africa. The younger group of rocks consisting of schists was correlated with the Transvaal system of South Africa as well. A comprehensive study of the area was done by Murray Hughes and Fitch (1929).They placed the granites and granite-gneisses together with ridge-forming quartzites in the Swazi system and carried out petrographic description of chlorite schist and amphibolites."The Geology of the Chinyunyu area", explanation of degree sheet 1529NW quarter by Simpson(1965) gives the summary of the rocks around Chinyunyu area as belonging to two broad sequences: the Basement and Katanga Supergroup.He reported that the Basement has been metamorphosed and partly granitised.In the report "The Geology of Chainama Hill area", explanation of degree sheet 1528NE quarter by Garrard(1967),the Basement Complex was divided into gneisses, amphibolites and quartzites which he described as folded during a Pre-Katanga Orogeny.These are overlain unconformably by metasediments of the Katanga Supergroup.He further summarized the tectonic history as recumbent folding and large scale faulting.

1.7 PRESENT WORK

The method of investigations involved literature review, study of aerial photos, geological field mapping and petrographic work. The geological mapping was done on the scale of 1:250,000 contoured topographical maps. During traversing location on topographic map was a vital operation and macroscopic description. The soil survey especially color proved to be important in establishing underlying geology in the area without outcrops i.e. in dambo.The field study was followed by petrographic work.

CHAPTER TWO
GEOLOGY OF THE AREA

2.1.0 INTRODUCTION

The Nyangwena River south, a confluency of the Chongwe River, consists of the Basement Complex rocks comprising of gneiss, amphibolites and quartzites and the Katanga Supergroup which overlies the Basement with rock type quartz chlorite schist.

Table 1 below shows a generalised stratigraphic succession

Table 1: Generalised stratigraphic succession.

EON	ERA	SUPER GROUP	GROUP	FORMATION	ROCK UNIT
PROTEROZOIC	NEOPROTEROZOIC	KATANGA	CHONGWE SCHIST	NYANGWENA SCHIST	QUARTZ CHLORITE SCHIST
	MESOPROTEROZOIC	MUVA (UPPER BASEMENT)	MUSENSENSHI	NYANGWENA QUARTZITES	QUARTZITE
		MKUSHI (LOWER BASEMENT)		NYANGWENA METAVOLCANICS	AMPHIBOLITE
				NYANGWENA GNEISS	AUGEN GNEISS

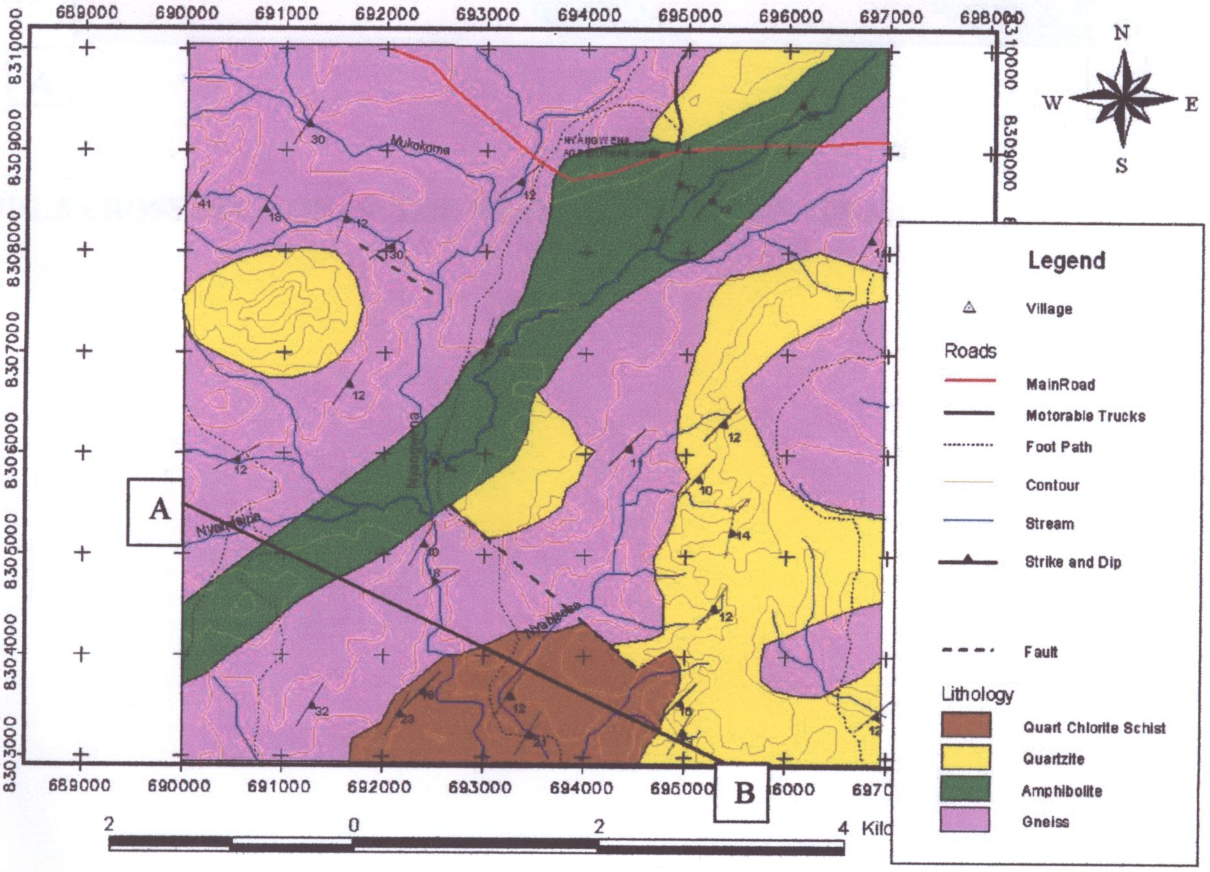


FIG. 4 THE GEOLOGY OF NYANGWENA RIVER SOUTH, A CONFLUENT TO CHONGWE RIVER.

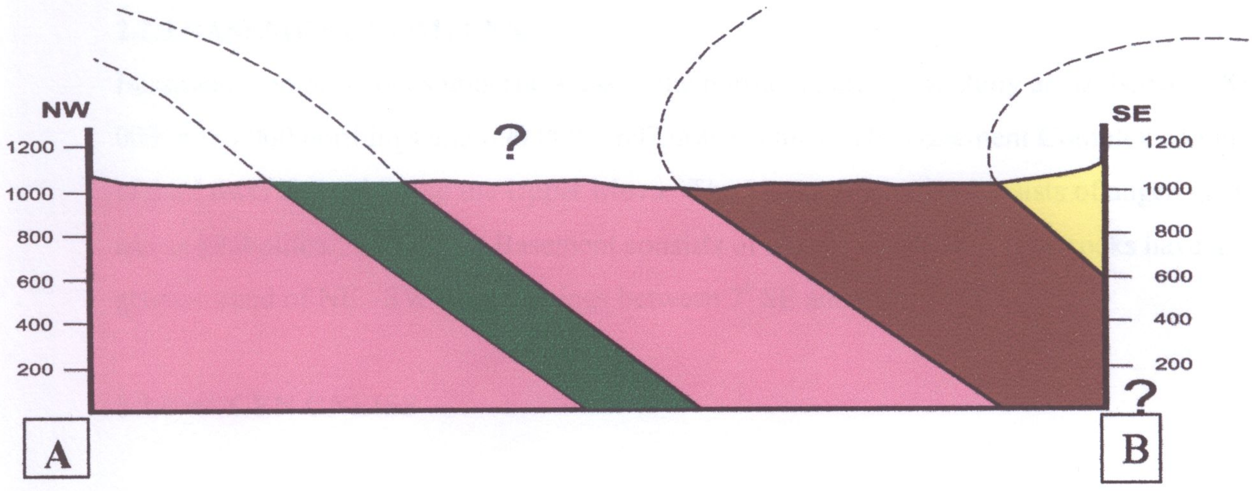


FIG .5 CROSS-SECTION OF THE NYANGWENA RIVER AREA.

2.2.0 BASEMENT COMPLEX

Basement Complex rocks underlie areas in the northern part of the study areas, between 8304 000 -8310 000 northings and 690 000 – 697,000 eastings. The Basement Complex comprises of the Lower (Mkushi) and the Upper Muva. The Lower Basement consists of augen gneiss and amphibolites. The Upper Basement consists of sugary quartizites. The rocks have a general trend of NE –SW with dippings between 7^0 SE and 40^0.

2.2.1 AUGEN GNEISS

The augen gneiss unit covers mostly the north-western part of the study area and parts of the eastern side stretching to the south west and north east. Most of the boundaries between augen gneiss and other rock types were inferred.The augen gneiss generally strikes NE-SW with dips varying between 10° -30° SE. In hand specimen, this rock type is pink greyish in colour. It is a course grained rock composed of k–feldspar augens and quartz ribbons separated by muscovite. In the north–western part, the augen gneiss contains more quartz than k-feldspar and less deformed compared to the south–eastern part. The K-feldspar augens measured up to 0.8 cm along the major axis and 0.4 cm along the minor axis. In thin section, the rock is also course grained and the overall texture is porphyroblastic. The essential minerals are K-feldspar, quartz, plagioclase, sericite, iron oxide, muscovite and biotite. Feldspars are the most abundant minerals forming large subhedral augens which are intergrown with deformed quartz. The quartz grains are parallel to the foliation direction. Muscovite and biotite flakes wrap around the K-feldspar, plagioclase and quartz augens defining foliation. The source rock could be porphyritic granite.

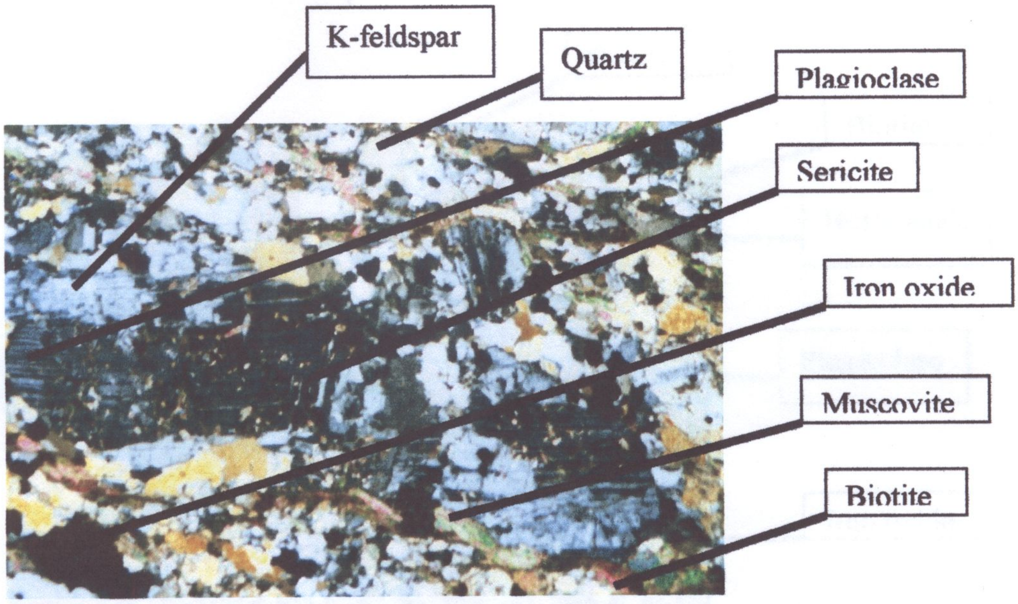


Plate 1: Photomicrograph showing augen gneiss.Augens of K-feldspar plagioclase, and stretched quartz. Magnification: X2.5, XPL.

2.2.2 AMPHIBOLITE (METAVOLCANICS)

The amphibolite units covers the central stretch of study area cutting the area in to two halves and has the general trends of NE –SW with only a few NW –SE strike. The amphibolite was likely to have been formed from metamorphism of mafic extrusions and it is well represented on stream beds. Most contacts were inferred. In hand specimen, the rock is greenish fine to medium grained, hard dark coloured and dense. The rock possesses a strong planar foliation (S_1) that dips in the ranges of 10^0 to 40^0 SE.

In thin section, the rock is medium grained. The mineral composition of the rock is plagioclase, hornblende, quartz, biotite and iron oxide. Hornblende is interlocked and folded with biotite of define (S_3) foliation. The quartz grains are elongated and form bands which are folded. The biotite and hornblende also appear crenulated defining foliation.

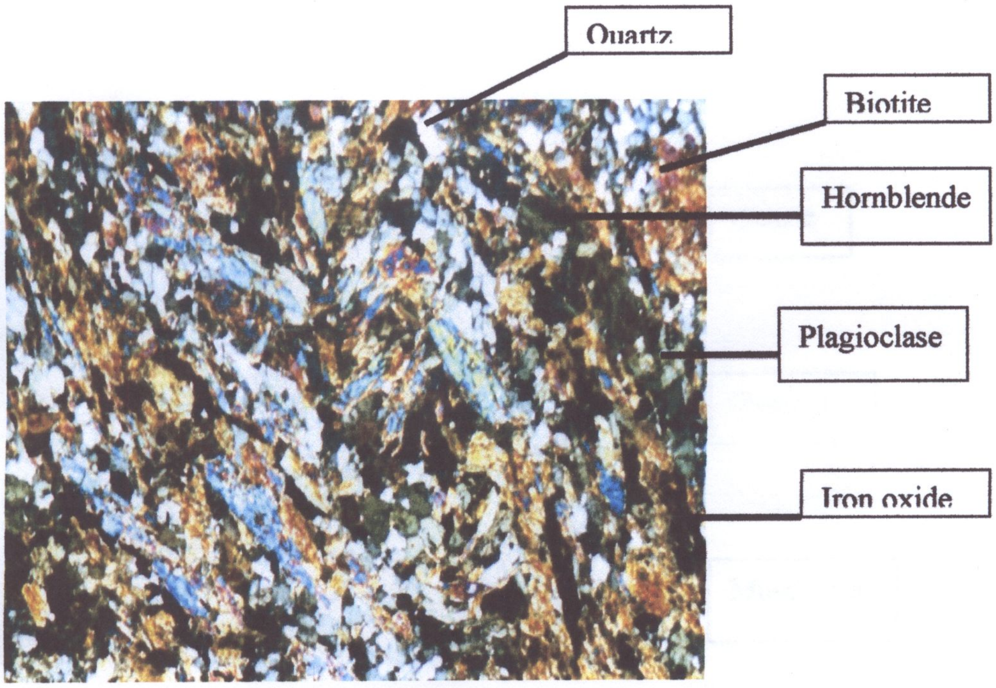


Plate 2: Photomicrograph showing amphibolites. Note the hornblende is interlocked and folded with biotite.Biotite and hornblendes also appear crenulated defining foliation.Magnification:X2.5, XPL.

3.2.3 QUARTZITE

The quartzite units out crops in most ridges of the study area with a general trend of NE-SW and cover the south eastern and north eastern parts of the study area. It is weakly foliated and composed of mainly quartz. Muscovite is a minor mineral which defines a weak foliation. In thin section, the quartzite has a granular texture and consists of mainly quartz.The fractured and elongated quartz crystals with muscovite define a weak foliation. The rock developed from the metamorphism of arenaceous sedments.

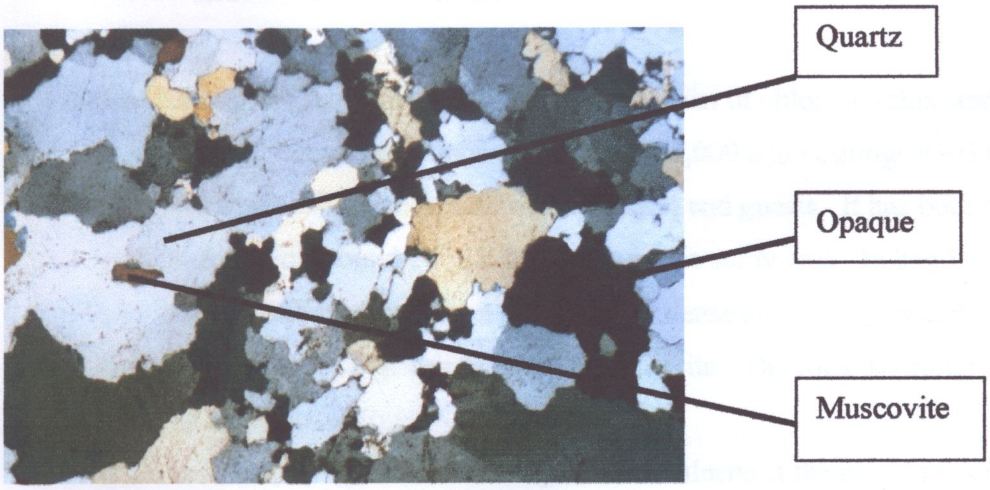


Plate 3: Photomicrograph showing a quartzite.Elongate quartz and muscovite flakes define a weak foliation.Magnification:X2.5, XPL.

2.3.0 KATANGA SUPERGROUP

The Katanga Supergroup in the study area consist of chloritic schist and is confined to the southern part, between eastings 693,000 to 695,000 and nothings 8303 000 to 8304 000. The rock unit share inferred contacts with quartzite and gneiss. It has both NE – SW and NW-SE trend and dips of around 14° SE for trends in the study area. In hand specimen, the rock is greyish- brown, fine to medium grained, less dense and relatively soft. Mineralogically, it is composed of muscovite, quartz, and minor biotite. The rock is strongly foliated with chlorite defining foliation.

In thin section, the rock is medium grained. Chlorite is the major mineral component and occurs in association with muscovite and biotite defining schistosity. The rock developed from the retrogressive metamorphism of metavoclcanics.

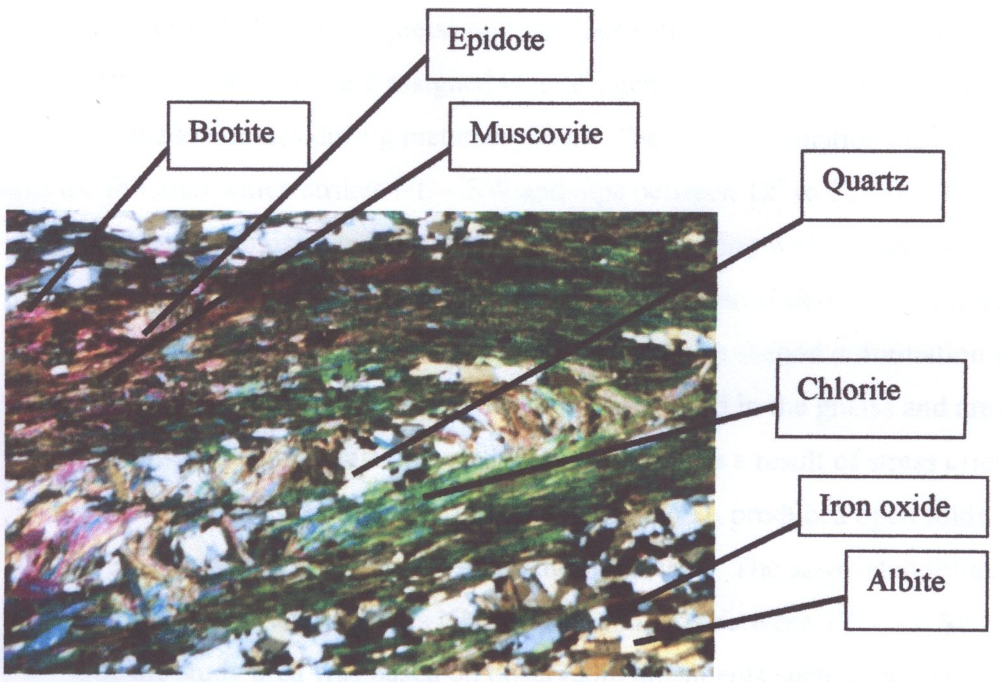


Plate 4: Photomicrograph showing quartz chlorite schist.Note the chlorite flakes defining strong foliation.Magnification X10, XPL.

CHAPTER THREE
STRUCTURAL GEOLOGY

3.1 INTRODUCTION

The Nyangwena River south, a confluency of the Chongwe River suffered both major and minor secondary structures associated with separate deformation episodes designated D_1, D_2 and D_3.

3.2 MAJOR STRUCTURES

The structures include: folds, foliation and lineations. The structures show that the study area has experienced three deformation phases represented by recumbent, upright and open folds and associated foliations. The first deformation D_1 produced recumbent folds which plunge at an angle of 25^0 SE. These recumbent folds are found in the amphibolite unit at the location point of 690,024E and 8306, 488N.The other D_1 recumbent folds plunged at an angle of 8^0 SE.These were found in the gneiss unit between 691, 100 and 691 500 east and 8306 000 and 8306 100 north and they are assigned to an F_1, generation. These are believed to have been formed due to stresses during metamorphism. The first deformation also produced gneissosity as the foliation which strikes NE – SW and dips between 12^0 to 25 ^{0}SE. The gneissosity is defined by thin bands of biotites and muscovite alternating with the bands of quartz and feldspar. In the augen gneiss, mineral stretching lineation is defined by stretched augens of feldspar wrapped by muscovite and quartz ribbons. The second deformation designated D_2 produced steep and upright folds. These folds are found in the gneiss and are assigned to F_2 generation. The second deformation D_2 was possibly as a result of stress orientation in the direction NE-SW. The third deformation designated D_3 produced open folds and theses are best seen along the Nyangwena River in the schist unit. The associated foliation S_3 is schistosity. The foliation strikes NNE –SSW and dips between 12^0 - 23^0 SE. The inference of faults in the study area was based on observable lineaments such as quartz veins. The other evidence of faulting was seen as a repeatition of amphibolites and gneiss lithilogies.

Fig. 6a Recumbent folds in the amphibolites unit.

Fig.6b.

Open folds in the gneiss unit.

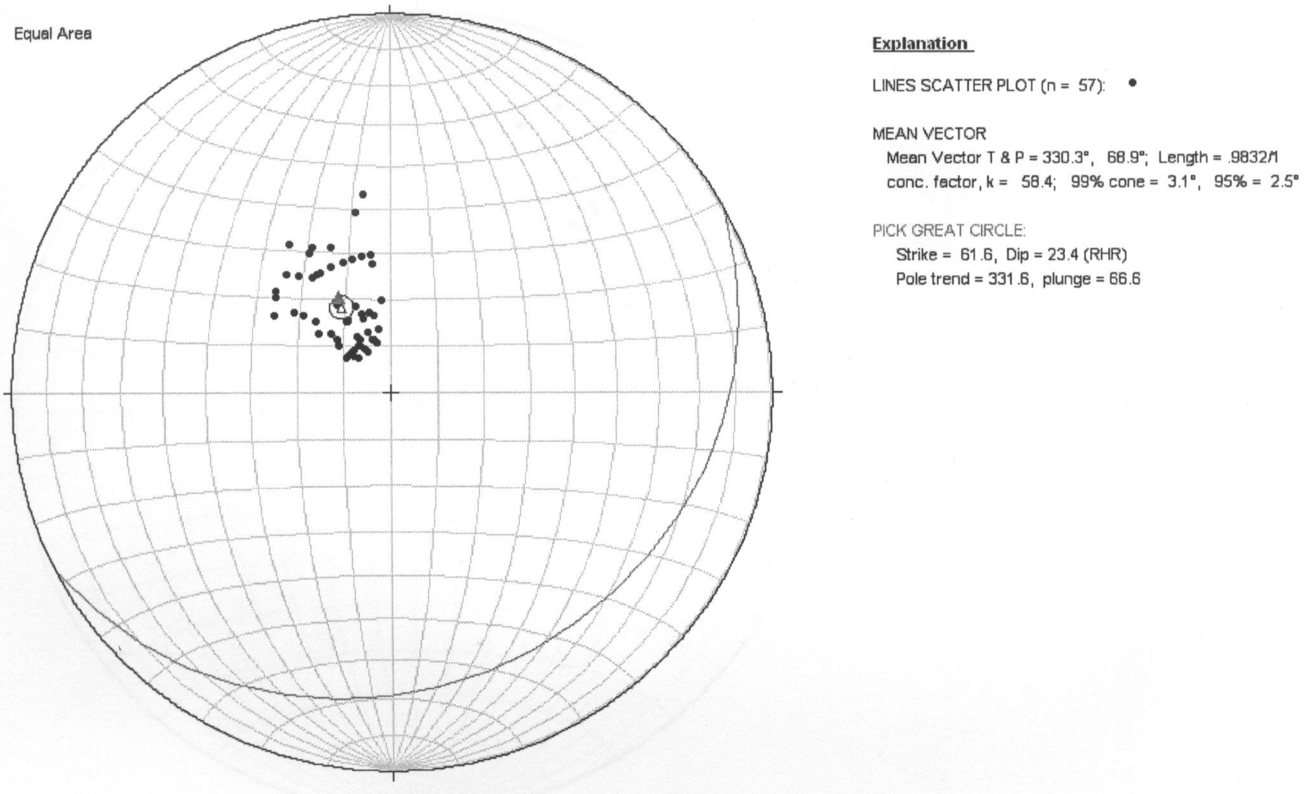


Fig. 7: Stero plot showing the structural trends of all the rock types in the study area. Note that the general trend indicates the typical trends of the Irumide Belt.

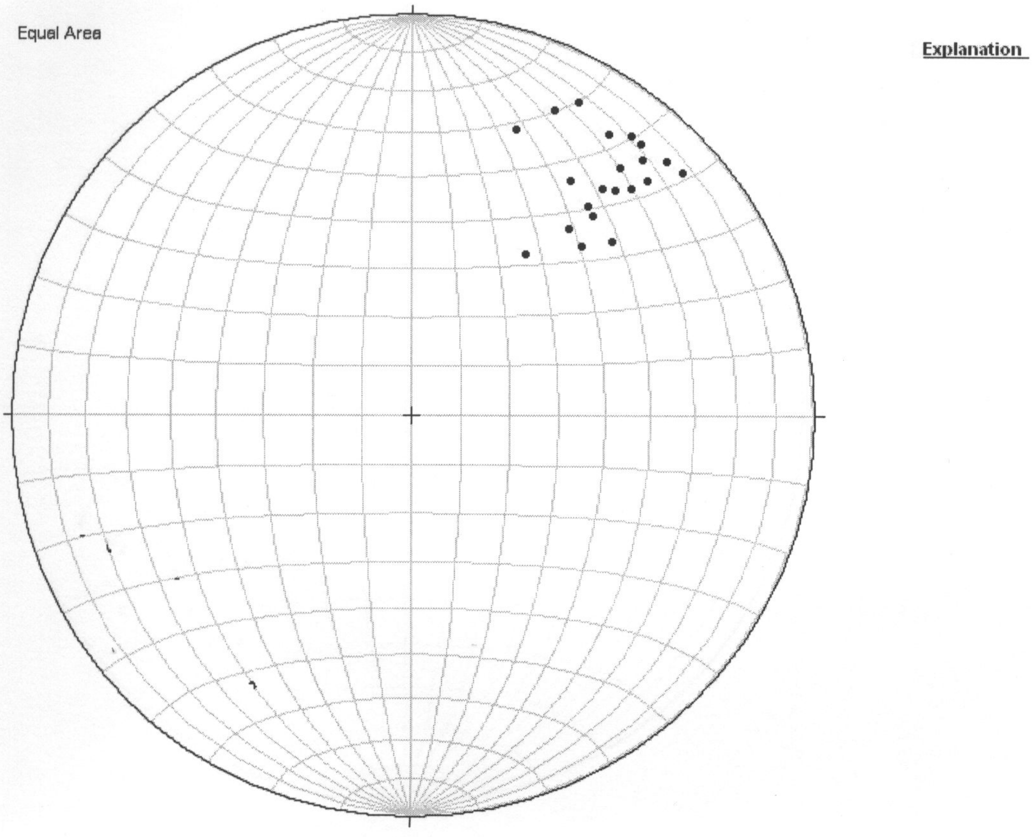


Fig. 8: Poles of foliation in the rocks of the study area.

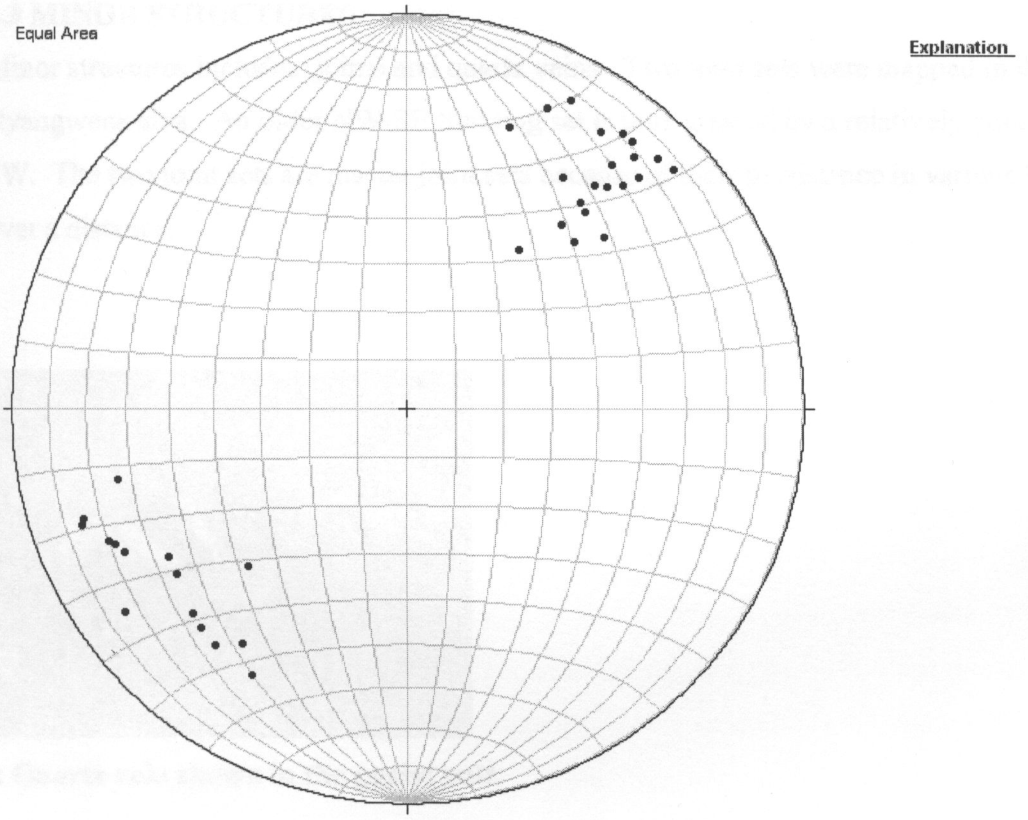


Fig. 9: Mineral stretching lineations plotted as points in the rocks of the study area.

3.3 MINOR STRUCTURES

Minor structures includes: joints and quartz veins. Two joint sets were mapped in the Nyangwena area. An older NW-SE trending set is transgressed by a relatively younger NE-SW. The two joint sets are master joint sets because of their persistence in various lithologies over a distance.

Fig. 10a: Quartz vein shown in the gneiss unit.

Fig.10b: A jointed gneiss unit.

3.4 DEFORMATION HISTORY

The Nyangwenya River south, a confluency of the Chongwe River shows three deformation episodes (D_1, D_2 and D_3) as observed in the field and presented as structural plots shown in the figures above. The first deformation episode (D_1) involved major recumbent folding (F_1) which ultimately produced S_1 foliation trending NE-SW. This deformation could be associated with basin closure in which the stresses could have been oriented in the foliation direction. The second deformation episode (D_2) involves the refolding of F1 generation folds into steep upright folds and the ultimate production of the associated foliation which trends NNE - SSW. The stresses which produced D_2 and D_1 deformation were possibly in the same direction in which S_1 and S_2 are almost parallel. Accompanying D_2 refolding (F_1) event, was thrusting in the NW direction, which is preserved as stretched quartz in the gneiss unit and tight folds in the chlorite schist. This is also evidenced in the lineaments such as quartz veins trending in the transporting direction. The third deformation phase (D_3) was the refloding and crenulation S_2 to S_3 foliation during which the open folds (F_3) formed. This foliation trends SE, implying different stress orientation from the two earlier deformations. The D_3 deformation episode was accompanied by thrusting in north-east direction. The thrusting is preserved as stretching lineation in the gneiss unit. This could possibly represent two thrust events with NE and NW transport directions. Table 2 below shows the summary of the deformation history of Nyangwenya River area.

TABLE.2: SUMMARY OF THE DEFORMATION HISTORY OF NYANGWENA RIVER AREA

DEFORMATION PHASES	DEFORMATION EFFECTS
First deformation(D1)	➢ Recumbent folding associated with basic closure producing a foliation striking NE-SW. ➢ Recumbent folds assigned to F_1 generation. ➢ Associated foliation produced as S_1.
Second deformation(D2)	➢ Refolding of F_1 generation folds to produce F_2 generation fold. ➢ Thrusting in the NW direction producing stretching lineation in chlorite schist and gneiss. ➢ S_2 crenulation cleavage preserved as a NNE-SSW foliation.
Third deformation(D3)	➢ Refolding of S_2 to form S_3 preserved as a foliation. ➢ Production of F_3 generation (open folds). ➢ Thrusting in the NE direction producing lineations as observed in the gneiss unit.

CHAPTER FOUR
METAMORPHISM

4.1 INTRODUCTION

The rocks in the Nyangwena River south, a confluency of the Chongwe River have been subjected to three types of metamorphism. These are: regional, cataclastic and hydrothermal metamorphism. The rocks suffered both prograde and retrograde metamorphism. The main regional metamorphic event produced two penetrative mineral fabrics defining preffered orientation of platy and elongate minerals. The foliations are well preserved in the gneisses, amphibolites and schists. Cataclastic and hydrothermal metamorphism resulted in mineral stretching and chemical alteration of the rocks due to fluid circulation in cataclastic metamorphism.

4.2 METAMORPHIC MINERAL ASSEMBLAGE

The rocks in the study area reflect different types of protoliths. The chemical; categories distinguished are semipelitic, psammitic basic, quartzo-feldspathic (granitic). The rock units used in the metamorphic mineral assemblage and the characteristic are listed in the table 3 below.

Table.3: Characteristics and mineral assemblage and grade of metamorphism in the Nyangwena River area.

PROTOLITH ROCK	MINERAL ASSEMBLAGE	METAMORPHIC GRADE	ROCK TYPE
Meta-volcanics	Chlorite + Quartz +Biotite + Epidote + Sphene + Actinolite + Iron oxide.	Green schist facies	Chlorite schist
Psammitic and Semi-pelitic	Quartz + Muscovite + Opaque	Amphibolite facies	Quartzite
Basic	Hornblende + Plagioclase + Biotite +Augite + Quartz + Opaque + Garnet + Sphene	Amphibolite facies	(Meta-volcanics) Amphibolite
Quartzo-feldpathic (Granitic)	Quartz + Biotite + K-feldspar + Plagioclase + Epidote + Sericite	Amphibolite facies	Augen gneiss

4.3 METAMORPHIC CONDITIONS FOR NYANGWENA RIVER AREA

During temperature and pressure changes, garnet breaks down to iron-rich chlorite and magnetite (opaque) as observed in the mineral assemblage for a chlorite schist.
During the breakdown of the garnet, the following reaction may take place.
Garnet + water ⟶ magnetite + Quartz + Iron-chlorite (Raymond: 1995).
The chemical equation is

$$Fe_3Al_2O_{12} + H_2O \longrightarrow Fe_2O_4 + SiO_2 + (Fe^{2+}, Mg, Al)_{12}(Si,Al)_8O_{20}(OH)_{16}$$

The mineral assemblage in the chlorite schist indicates that the rocks underwent retrograde metamorphism. This marked the beginning of green schist facies from the earlier amphibolite facies during M2 episode.

METAMORPHIC FACIES	ROCK UNIT	PRESSURE (K.bar)	TEMP (C)	CALIBRATION REFERENCE
Amphibolite (M1)	Meta-volcanics	3.5 - 6.0	500 - 600	Holdaway (1971)
Green schist (M2)	Chlorite schist	2.0 – 5.0	200 - 400	Goldsmith and Newton (1969)

Table.4: Metamorphic conditions for Nyangwena River area.

CHAPTER FIVE
GEOLOGICAL HISTORY

5.1.0 INTRODUCTION

The present structural and metamorphic setting of the Nyangwena River south, a confluency of the Chongwe River was as a result of a series of events dating as early as the Mesoproterozoic to Neoproterozoic era (1.86Ga -545Ma).

5.2.0 HISTORY

The first event was plutonism which led to the intrusion of granular granites into pre-existing old rock series. Then followed was rifting leading to the formation of the basin. After which deposition of arenaceous sediments took place (sedimentation). The two events took place between 1.80 Ga to 1.75 Ga. At about 1.40 Ga, there was basin closure which was synchronous with the first deformation episode (D_1) and led to the development of fabric (S_1) in the rocks during regional prograde metamorphism (M_1) during which the granites were transformed into gneisses. The basic volcanics were metamorphosed into amphibolites and arenaceous rocks formed the quartzites. The first deformation (D_1) also produced recumbent folds (F_1) which are preserved in amphibolites. There was tectonism at about 1.20 Ga to 1.00 Ga leading to the second deformation phase (D_2). The second deformation (D_2) resulted into S_2 crenulation cleavage through a prograde metamorphism. The second deformation (D_2) also resulted in the refolding of F_1 recumbent folds into F_2 upright folds. The prograde metamorphism was accompanied by a retrograde metamorphism during cooling in the presence of circulating fluids leading to the formation of quartz chlorite schist. During the second deformation episode, there was thrusting in the NW transport direction that produced quartz ribbons which are preserved in the chlorite schist. The last event took place at about 850Ma (during the Pan-African Orogeny) Involving rifting, erosion, and deposition of argillaceous semiments resulting in the creation of an uniformity between the basement complex and Katanga sediment series. At about 850 Ma, there was a third deformation phase (D_3) synchronous with regional prograde metamorphism (M_3) of the Pan-Africa arogeny.

The Table 5 below shows a summary of the geological history of the Nyangwena River area.

Table.5: Summary of the geological history

AGE	ERA	EVENT	EFFECT OF THE EVENT
1.80 TO 1.75 Ga	Paleo-Proterozoic	Plutonism leading to intrusion in the pre-existing older rock series.	Granular granites.
		Rifting to form a basin accompanied by volcanism and sedimentation	Extrusion of mafic (basic) volcanics and deposition of arenaceous sediments.
1.40 TO 1.00 Ga	Meso-proterozoic	Tectonism(D1) and regional prograde metamorphism(M1)	Development of (S1) foliation during the formation of metamorphic rocks i.e granites formed gneiss, basic volcanics formed metavolcanics (Amphibolite) and arenaceous rocks formed quartzites.
		Tectonism(D2) and prograde metamorphism followed by retrograde metamorphism(M2) thrusting in the NW direction	Development of crenulation cleavage (S2) during the metamorphic episode (M2) formation of quartz-chlorite schist rock unit and lineations.
850 Ma TO 545 Ma	Neo-Proterozoic	Rifting, Sedimentation (D3) accompanied by a prograde metamorphism (M3). Then thrusting in the NE direction.	Development of foliation(S3) and formation of lineations in the units

CHAPTER SIX
REGIONAL CORRELATION

6.1.0 INTRODUCTION

The Nyangwenya River south, a confluency of the Chongwe River forms part of the southern extension of the Irumide Belt while some parts show characteristics of the Pan-African Zambezi Belt. The Basement is part of the structural Orogenic Belt trending NE-SW, which stretches from around lake Kariba area to Mafingi hills area of Zambia. It is parallel to and of the same age as the Kibaran Belt in the Democratic Republic of Congo. (de swardt et al, 1964).

6.2.0 LITHOLOGICAL CORRELATION

The Basement rocks in the area can be traced westwards along strike through the Chainama hills (Garrad, 1968) and Lusaka (Simpson, 1968) into the Mwembeshi area. In the Chainama Hills area, the metavolcanic forms part of the Basement sequence and extend into the Chingungu area. This can be correlated basing on lithological evidence with the mapped Nyangwena metavolocanics. In addition, recent work in Eastern province of Zambia reveals a continuous occurrence of Nyangwena gneisses and basic metovlolcanics forming part of the Basement Complex. On the other hand, observed Basement rocks (Nyangwena formation) in the area correlates with the two Pre-Cambrian Basement groups described by Newton (1964, quoted by Hanson et al, 1988). The Nyangwena quartzite extends westwards to coincide with Chainama quartzites which have a sugarly texture. The unit correlates with the Muva Supergroup on the Copperbelt (Zambia) and the Lower Muva Musofu formation, Mkushi (Zambia) as described by Legg (1976).

6.3.0 STRUCTURAL CORRELATION

The Basement rocks in the area posses a general NE-SW strike and SE dip of the foliation surface (S_2) which is typical of the Irumide belt. The gneissic banding parallel to the axial plane is attributed to the typical metamorphic segregation (Swardt et all, 1969) and this is observed in the Nyangwena gneisses. The presence of stretching lineations in the Nyangwena gneiss conforms to the northwest thrust transport direction of Luongo fold and thrust zone, Irumide belt of Northern Province of Zambia. The (S_3) fabric which was produced during the third deformation phase (D_3) has been correlated with the WNW –ESE regional foliation of the Pan-African Zambezi belt.

Table: 6 Correlation of rocks of Nyangwena area
(After P.GARRARD 1968)

<table>
<tr><th>ROCK TYPE</th><th>LOCAL FORMATION</th><th>LOCAL CORRELATION Garrard (1968)</th><th>REGIONAL CORRELATION Simpson (1974) Barr (1974)</th><th>SUPER GROUP</th></tr>
<tr><td>Chlorite Schist</td><td>Nyangwena Schist</td><td>Chunga Formation</td><td>?</td><td>Katanga</td></tr>
<tr><td>Sugary Quartzites</td><td>Nyangwena River Quartzites</td><td>Chainama Quartzites</td><td rowspan="3">Basement Complex</td><td rowspan="2">Muva</td></tr>
<tr><td>Metavolcanics</td><td>Nyangwena River Metavolcanics</td><td rowspan="2">Rufunsa Volcanics</td></tr>
<tr><td>Augen Gneiss</td><td></td><td>Mkushi</td></tr>
</table>

CHAPTER SEVEN
ECONOMIC GEOLOGY

7.1.0 INTRODUCTION

The Nyangwena River has no reported mining activity. The occurrences of base metals in the area is known to be in form of copper, but Garrad (1968) reports that such are very marginal economic value that they only suffice for academic interests.

7.2.0 QUARTZ VEINS

These occur along the Great East Road inform of quartz gravel fragments. These may be useful in the production of road aggregate materials or resurfacing of motorable tracks in the area. No detailed works has been carried out to evaluate them for exploitation of concrete aggregate and road construction.

7.3.0 BUILDING SAND

A number of sites were observed for possible exploration and exploitation of river sand for building purposes. The sand in the study area appeared impure making it uneconomic. Further more, previous works reveal no deposits of sand in the area for building purpose.

7.4.0 GLASS SANDS

Attempts have been made to exploit the many quartzite ridges in the area as source of glass sand, Simpson (1960). The glass sand deposits are however small and believed to form from the breaking down of quartzites. Simpson (1960) concluded that the sands are too fine grained and most of them are too rich in iron to be considered for glass making. As such the quartzites presently cannot be exploited as a source if glass sand.

CHAPTER EIGHT

8.0.0 DISCUSSION AND CONCLUSION

The rocks underlying Nyangwena River South, a confluency of the Chongwe River are divided into two broad sequences; the Basement Complex and Katanga Supergroup.The Basement consists of gneisses, metavolcanics and quartzites.The Katanga rocks conformably overlie the Basement rocks and consist of quartz chlorite schists.

The Basement rocks suffered three deformation phases. The first deformation phase (D_1) resulted in the development of the ENE-WSW striking foliation (S_1) in the gneisses and amphibolites. Additionally, recumbent folds (F_1) were produced with a northwest vergence.The second deformation phase (D_2) resulted in the development of crenulation cleavage (S_2) and steep upright folds with a northwest vergence as well. The third deformation (D_3) affected both the Basement Complex and Katanga Supergroup rocks and resulted in the development of open folds (F_3).Mineral stretching lineations and other kinematic indicators such as sigma structures show that the transport direction during thrusting was in the northwest and northeast.

The Basement rocks first attained amphibolite facies during prograde metamorphic event as preserved in the amphibolites unit. This was followed by another prograde metamorphism which later retrograded resulting in greenschist facies as preserved in the quartz chlorite schist. The third metamorphic episode attained the greenschist facies through a prograde metamorphism.

The study area is part of the Irumide Belt by virtue of structural orientation i.e. ENE-WSW striking foliation (S_1).This is supported by the presence of folds with a northwest vergence and northwest thrust transport direction.

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APPENDIX

STRIKE	DIP
78.0	30.0
78.0	30.0
78.0	30.0
68.0	34.0
60.0	11.0
82.0	30.0
40.0	20.0
56.0	39.0
71.0	12.0
59.0	18.0
40.0	12.0
115.0	19.0
176.0	22.0
79.0	14.0
70.0	20.0
50.0	12.0
45.0	12.0
48.0	10.0
56.0	12.0
60.0	13.0
45.0	16.0
78.0	17.0
70.0	17.0
45.0	11.0
84.0	20.0
70.0	29.0
82.0	28.0
222.0	15.0
75.0	11.0
67.0	12.0
78.0	17.0
40.0	32.0
140.0	13.0
49.0	34.0
150.0	18.0
58.0	12.0
68.0	20.0
42.0	33.0
82.0	44.0
140.0	31.0
150.0	12.0

58.0	18.0
42.0	25.0
38.0	12.0
52.0	32.0
45.0	18.0
60.0	30.0
70.0	18.0
144.0	33.0
34.0	30.0
72.0	12.0
60.0	18.0
164.0	18.0
56.0	30.0
10.0	7.0
70.0	24.0
75.0	18.0
70.0	14.0
60.0	10.0
135.0	18.0
45.0	18.0
28.0	12.0
62.0	14.0
40.0	27.0
60.0	18.0
56.0	12.0
74.0	30.0
20.0	25.0
224.0	22.0
25.0	17.0
35.0	15.0
70.0	30.0
60.0	35.0
62.0	36.0
79.0	40.0
58.0	30.0
65.0	30.0
60.0	40.0
59.0	22.0
65.0	25.0
70.0	21.0
60.0	23.0