

THE GEOLOGY OF THE LILY SYNCLINE
AND PORTION OF THE EUREKA SYNCLINE BETWEEN
SHEBA SIDING AND LOUW'S CREEK STATION,
BARBERTON MOUNTAIN LAND

by

C. R. ANHAEUSSER

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Telephone : 835-8181
Telegrams : EGRU UNIVERSITY

UNIVERSITY OF THE WITWATERSRAND,
MILNER PARK,
JOHANNESBURG.

In reply please quote :

DECLARATION

I, Carl Robert Anhaeusser do hereby declare that
this Dissertation is my own work and has not been
presented to any other University for the purpose
of obtaining a Degree.

C. R. Anhaeusser

C.R. ANHAEUSSER,
December, 1963.

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ABSTRACT

The following account is a description of the stratigraphy, metamorphism, structures and mineralogy found in the Lily Gold Mine and layered rocks south of the Nelspruit Granite Contact Belt between Sheba Siding and Louw's Creek Station - a strongly folded region of the ancient Archaean rocks of the Barberton Mountain Land.

A general account of the geography of the area is presented and previous work is reviewed. The detailed stratigraphic investigations resulted in an appreciation of the problems presented in the area and enabled the formation of a better understanding of the difficulties regarding the origin of the various rock types.

Evidence suggests that the Jamestown Igneous Complex group of rocks are not as widespread in their development as was previously contended. Most of the basic hornblends, tremolite-actinolite or calc schists are grouped into the Onverwacht Series of the Swaziland System and are thought to be the metamorphosed expression of a layered sequence of rocks formerly comprised of impure dolomitic limestones together with possible acid lava and porphyry horizons.

The Nelspruit Granite is shown to be responsible for the production of a metamorphic aureole portrayed by the metamorphic facies changes of rocks away from the contact belt. It is suggested that the variations of the rock types on either side of the Lily Syncline are an expression of the degree and intensity of metamorphism experienced by the formations, coupled possibly, with an initial facies variation within the depositional basin itself.

Basic intrusive rocks are shown to exist but they are characteristically different in structure, petrology and mode of occurrence to the basic schists.

The Nelspruit Granite is described and its relationship to the layered rocks of the Barberton Mountain Land is discussed. A possible pre-deformation or palaeohistory of the area is considered. The history appears to involve a series of subsidences and transgressions with the depositional exclusion of the Fig-tree Series from the Lily Syncline, except on a limited scale in the west towards the New Consort Mine.

Structural mapping was undertaken and an explanation of the tectonic history of the area is given together with an attempt at regional

structural correlation of features common to both the report and adjacent areas.

Four phases of deformation can be recognized in the Mountain Land. The Lily Syncline is considered to have formed early on together with the other major synclines of the District. The Lily Fault is thought to have originated during the first phase events. The second phase deformation is manifest in the area by the occurrence of numerous rock fabrics including lineation, foliation and schistosity, flattening, elongation and orientation of conglomerate pebbles. The Nelspruit Granite intrusion was emplaced late during this period. Folding associated with the late phase is also described. The third phase involved the great inflection of the Eureka and Ulundi Synclines but there is little evidence of structures associated with this deformation in the area. A fourth phase is recognized and indicates a vertical stress field. It is expressed in minor structures such as conjugate folds or crenulation folds.

The economic geology of the region is discussed with special emphasis on gold. The other minerals examined were magnesite, talc and nickel. The gold mineralization is shown to occupy a zone at the base of the Fig-tree Series and presumably along the Lily Fault. The mineralized auriferous horizon could be traced from Joe's Luck Siding to a point east of Louw's Creek - a distance of over 12 miles. The easterly extent of the Consort Contact gold horizon is traced to a point immediately northwest of Sheba Siding.

The Lily Gold Mine is discussed fully and a summary of the locality of gold mineralization in the Barberton region is presented together with the mineralogy and types of ore deposit encountered in the District. The mine is placed into the regional setting and is considered to be situated on a longitudinal strike fault - the Lily Fault.

Detailed underground structural mapping was undertaken and the orientation of various small scale structures were recorded. Two sets of fracture systems were noted. The first, a vertical set is related to the second phase of regional deformation while the second set, a cross-cutting flat fracture system is regarded as being consequent on the stronger vertical set. The relationships of the fracture systems to zones of economic payability is discussed and the structure of the pipe-like brecciated shoot is explained. The approximate amount of shortening and flattening of the Fig-tree succession in the mine is calculated.

The ore mineralogy of the deposit is described and can be confirmed as belonging to the arsenopyrite-pyrrhotite type of ore-body with subordinate amounts of chalcopyrite and pyrite present. The unusual mineral melnikovite-pyrite is also described.

Gold was seen to occur essentially in association with quartz or the sulphide arsenopyrite. The "bonanza" pockets of gold and their mode of occurrence is described and evidence is presented that indicates that supergene or secondary concentrating influences were probably responsible for the abnormally rich zones. A table of output from July, 1958 to March, 1963, is given indicating the recovery during that time of 18,843 fine ounces of gold - approximately 7,510 ounces or 40% of which were recovered from about 6 rich pockets. The gold mineralization is believed to have been structurally controlled and introduced into suitable channelways and a breccia sheet that was formed during the second phase deformation.

X-Ray diffractometer study of natural pyrrhotites from the mine indicated that the pyrrhotite was deposited at temperatures of approximately 330°C. A maximum temperature of 350 - 400°C. is postulated for the deposit.

The wall rock alteration by hydrothermal mineralizing solutions is shown to be slight and the probable paragenetic sequence of mineral precipitation is suggested. The availability of a suitable chemical environment necessary for gold solution is considered and factors favouring supergene enrichment, mechanisms of enrichment and causes of localization of the gold are discussed.

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CHAPTER I

INTRODUCTION

A. GENERAL STATEMENT

The following report on the Geology of the Lily Gold Mine and surrounding countryside is part of a systematic program undertaken by the Economic Geology Research Unit, of the University of the Witwatersrand, to investigate geological aspects of the Barberton Mountain Land with a view to gaining further information on the numerous problems associated with the structural, stratigraphical and mineralogical controls of the ore deposits in the area.

In this connection several investigators have, during the past few years, been engaged on detailed study of areas considered to be the most pertinent to the attainment of the above-mentioned aims.

Working along similar lines and in conjunction with the Economic Geology Research Unit, the Eastern Transvaal Consolidated Mines geologists are investigating the areas to the south and southwest of Barberton, in addition to their program of detailed investigation in and around their major producing mines Sheba, New Consort and Agnes.

The Unit commenced its activities in the Barberton district in 1961, when it engaged E.J. Poole to study in detail the possible factors controlling the mineralization of the Agnes Gold Mine. Later the same year J. Ramsay from the Imperial College, London, visited South Africa and undertook a brief study of the Barberton Mountain Land. He was the first to investigate the area from the structural viewpoint, applying modern techniques and ideas. His work laid the foundation for the examination in greater detail of zones regarded as critical for the interpretation of the complex geological history of the area.

C. Roering began work, again involving detailed structural analysis, on the Saddleback Syncline in the central portion of the Mountain Land while further to the southwest G. Herget tackled the structural and stratigraphical aspects of the Montrose area. Between this area and Barberton itself, R. Cooke working for U.I.C. Mines Ltd., has actively been engaged in similar studies centred about the Agnes Mine.

The investigations thus far had proved to be fruitful and informative and it was decided to extend the program for a further period. In 1962 work was begun by C. van Vuuren in an attempt to unravel the structure of the Ulundi syncline and to add to the knowledge of the localization of the Fairview and Sheba Mines along the Sheba Fault.

N. Gay undertook a trace element study of the gold ores from several of the producing mines with a view to finding some factor that might be of use in geochemical prospecting or, failing this, to find some property that might be of aid to the development programmes of the producing mines.

Finally a detailed structural and petrological examination was undertaken by M. Viljoen between the New Consort Mine and the area east of Joe's Luck Siding. This area is the most critical from the point of view of elucidation of the style and numbers of tectonic events to have affected the rocks of the Archaean Complex. The present writer's contribution to the scheme of analysis was to investigate fully an ore deposit of lesser magnitude than any of the other presently producing mines in the district and in addition, to extend the structural and petrological work done by Viljoen further along the contact to Louw's Creek Station. The combined efforts produced a composite analysis of the relationships between the Nelspruit Granite and the sedimentary and volcanic sequences to the south over a distance of approximately 15 miles. The study so far undertaken by the Economic Geology Research Unit has incorporated work over a wide area involving almost every type of environment presented in the Mountain Land and the scale of investigations has ranged from detailed study of smaller individual units such as the mines, to the broader regional geological aspects.

B. LOCATION OF AREA

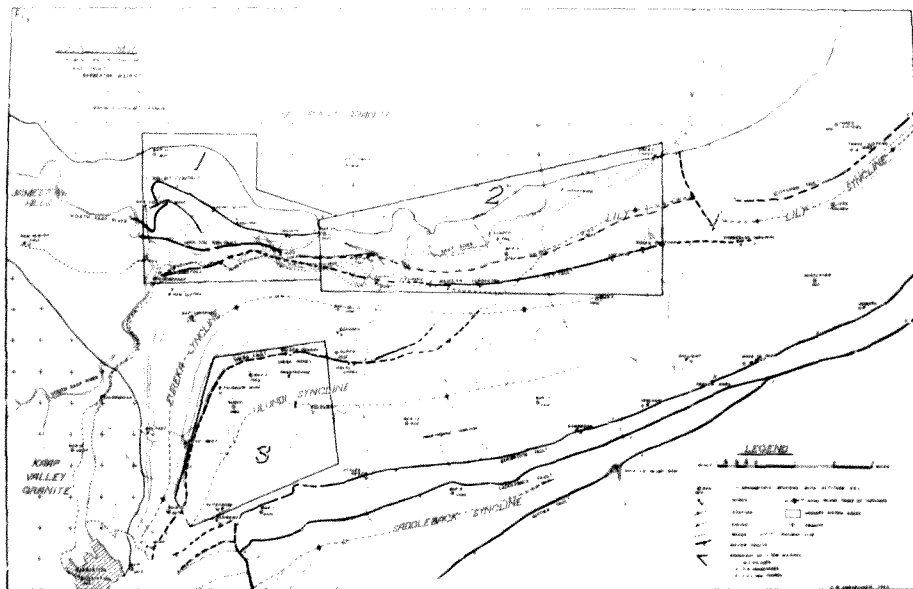
The area investigated occurs roughly 24 miles from Barberton on the northeastern fringe of the Mountain Land. The co-ordinates determine the area as lying between $31^{\circ}9'$ and $31^{\circ}17'$ East and between $25^{\circ}38'$ and $25^{\circ}41'$ South. (See Locality Map, Figure 1).

The boundaries confining the area are,

1. the Nelspruit Granite massif to the north.
2. the stream known as Louw's Creek in the east.
3. the trigonometrical beacon Bar 5 in the west, and
4. the final boundary, was taken to be the Basal Conglomerate

horizon of the Eureka Syncline south of the tarred road and where this was absent towards the east, the boundary was drawn through the lands on the farm Lilydale.

The Lily Mine, 4 miles south of Louw's Creek Station occurs within these confines. The regional mapping covered approximately 25 square miles of countryside.



(Fig. 1) Locality map showing the major synclines and faults together with some of the more important gold mines in the Barberton District.

At this stage a point of clarification is necessary regarding the use of the term Louw's Creek in the text. Henceforth the farming settlement along the railway line will be referred to as Louw's Creek Station while the stream draining the eastern portion of the area will be referred to as Louw's Creek.

C. HUMAN ACTIVITIES AND COMMUNICATION

The Louw's Creek area is rapidly becoming one of the leading vegetable producing regions in the country. Timber plantations have been introduced to the mountainous regions to the southeast in the Khamlabane area.

There are several gold mines in the near vicinity most of which have been closed down for many years. These include the Three Sisters Mine, the Scotsman, Kimberley Imperial, Daylight, Barbrook, French Bobs, Maid of the Mist, Aurora and Vesuvius Mines. The Lily and Rose's Fortune Mines are the only presently producing mines. (See Locality Map, Figure 1, for the location of these deposits).

Renewed interest has recently been shown by mining groups, in the Barbrook Fault area just south of Louw's Creek Station.

Communications have been improved with the tarring of the road from Barberton to Kaapmuiden while in the mountains numerous forestry roads have been built.

The volume of produce and materials transported by rail to and from Louw's Creek itself has warranted the raising of the status of Louw's Creek Siding to that of a station. The railway line follows the valley from Kaapmuiden to Noordkaap and then to Barberton. The Kaap River Valley provides the only favourable means of rail communication between the Barberton or De Kaap Valley and the outside world.

An airstrip for light aircraft exists at Tonetti, about 4 miles northeast of Louw's Creek Station.

D. HISTORICAL

During the course of mapping, several interesting historical sites were encountered that date back to the early days of the Barberton gold mining camps. The information pertaining to the past history of the area was obtained from Mr. E.I.E. Andrews, one of the most notable pioneers of the Lowveld (written communication). Information regarding old mines in the Eureka area was also acquired from Mr. Andrews (1961).

Much of the activity in the past was centred around Avoca which later changed to Eureka when Eureka City in the Sheba Hills became deserted. Mining was carried out in the Sheba Valley at several localities, among them being the Sheba, Edwin Bray and Oriental Mines. A narrow gauge railway line was constructed down the Fig Tree Creek past Sheba Siding to the Oriental Mill near the junction of the Creek with the Kaap River. Power to run the mill was derived from the Oriental Hydro Plant that was built in about 1886 on the south bank of the Kaap River.

The hydro plant with its machinery still fairly intact is in good repair but all that remains of the old mill site are ruins. The large residue dumps near the mill were retreated in 1939. Another mill site and dumps were encountered on the farm Camelot just north of Ezzy's Pass.

According to the De Kaap Annual for 1896 this belonged to the Sheba Gold Mining Company. They had 60 stamps working at this site that were shut down owing to damage caused to the water race and dam by floods. The stamp mill was reassembled near the Sheba Mine in 1895.

Two other mines, the Mexican and the Cleopatra, were situated in the vicinity of Eureka. The Mexican Mine was worked over 70 years ago by about 24 Cornish miners. In an old publication entitled "Mines of the Transvaal", the Mexican is mentioned as having produced ore to the value of an ounce to the ton. Free gold was noted in the ore from the mine.

The Cleopatra Mine east of the Mexican consisted of several shafts and shallow quarries. A 5 stamp battery milled the ore which was compared with the ores of the Lily Mine about 4 miles to the east. They were considered identical. It was reported that a small rich patch of 50 ounces was obtained from one of the shafts but like the Lily Mine these rich patches were erratic.

Further east the Lily and Rose's Fortune Mines were first worked in the late 1880's and mining was confined essentially to the quarries. The ore was transported along a narrow gauge track that led from the mines to the battery at the mill site in the Louw's Creek Poort. The residue dumps are all that remain there today. The ore was later taken to Vesuvius Mine for treatment. The Kimberley Imperial Mine, 2 miles to the east of Louw's Creek, was worked in 1935. A company erected a 10 stamp mill and cyanide plant. The ore from the mine also contained free gold.

Communications into the area were confined to an old road that ran down the Kaap River Valley. This road was the only route used by transport riders from the Witwatersrand to Delegoa Bay. The original road can still be seen today south of the Cleopatra Mine and in Sheepskin's Neck south of the Lily Mine. After crossing Louw's Creek the road kept to the hills and continued to the Maid of the Mist Mine where one branch went

along the northern bank of the Hlambenyati Stream to reach the flats about 10 miles from Hectorspruit. The main reason for the road keeping to the higher ground was to avoid malarial fever and tsetse fly. A second branch turned south from the Maid of the Mist Mine past the Makonjwa Peak to the Lomati flats. This road led to Natal via Bremersdorp and was only passable in winter when the Lomati and Komati Rivers were low.

In 1927 the Barberton Motorists Association considered it necessary to avoid the 4 crossings of the Kaap River near Sheba Siding that were often impossible during the summer. Mr. E.T.E. Andrews was responsible for showing the road inspector, Mr. Ezzy a favourable site and a road was later constructed along the edge of the cliff near Sheba Siding. This was named Ezzy's Pass.

The area was made further accessible when in 1896 the railway line between Kaapmuiden and Barberton was completed.

E. PHYSIOGRAPHY

(a) Climate

The area has on the whole a temperate climate. The low lying areas and the river valleys have a mild dry winter season and a hot humid summer season. The Kaap River Valley has an elevation of approximately 2,000 feet near Eureka and this valley can become extremely hot during the drier summer periods between October and February. The average rainfall is approximately 30" throughout the area - most of it falling in the summer periods, especially January and February. The area is prone to violent electric and hail storms. Temperatures sometimes approach 100°F. in the summer months, while in winter months, only rarely does frost occur.

(b) Drainage

The area is drained by the Kaap River and its tributaries in the west and by Louw's Creek in the east. The Kaap River rises in the Barberton or De Kaap Valley and makes its way eastward along the northern fringes of the Barberton Mountain Land to Eureka where it suddenly cuts north through the quartzite-conglomerate horizon of the Lily Syncline and parallels this formation to Honeybird Siding where it changes course abruptly and flows due north into the granite massif for about 3 miles before joining the Crocodile River near Kaapmuiden. It is supplemented near Sheba Siding by the Fig Tree Creek (now Sheba River) that drains portion of the Eureka Syncline and near Honeybird Siding, by the stream



NEES.

HOOD
KODU RIVER

CHERRY
HONEYCREEK

THE FOLLOWING IS A LIST OF THE
PLACES VISITED DURING THE
TRIP TO THE MOUNTAINS
IN THE MONTH OF
JULY 1964.



flowing through Honeybird Creek. The eastern area is drained by Louw's Creek which is joined by Revolver Creek north of Louw's Creek Station and both enter the Kaap River near Kaapmuiden. The drainage pattern both in the Burberton Mountain Land as well as in the Nelspruit Granite region is typically dendritic. Most of the rivers that drain from the mountainous area are perennial but the valley tracts have only intermittent flowage. This is also partly due to the drawing off of water in furrows by farmers.

(c) Vegetation

The granite country to the north has a vegetation cover of tall grass and scattered bush while the river valleys again have characteristically tall, dense grass and reeds as well as evergreen trees. The mountainous areas to the south also have thick dense covers of thornbush and tall grass. Certain sections, for example, on the farms Surprise and Crystal Stream have almost impenetrable bush cover, especially in creeks and gullies on the southern slopes of the mountains where greater shade and dampness occurs.

The vegetation and dense bush often made mapping and identification of position on aerial photographs very difficult.

(d) Relief

Considerable contrasts of relief are manifest in the area. To the north the granites form gently rolling hillsides that reach an elevation of over 3,000 feet on the farm Lovedale.

The Kaap River Valley separates the granites on the north from the sedimentary formations on the south. The valley is made up of broad flat lying tracts of land separated from one another by the sinuous meandering of the Kaap River itself. In the west the river enters the area at an elevation of 1,730 feet and at Honeybird Siding, some six miles away leaves the area at approximately 1,620 feet. The average gradient of the river is therefore, a little more than 1 : 300.

The most prominent feature of the area is provided by the range of mountains known as the Lily Syncline (see Plates 1, 2, 3 and 37). This range can be traced across the entire area mapped from the beacon at Bar 5 to Louw's Creek and beyond. One of the greatest elevations is reached at the Lily beacon which is 3,029 feet above sea level. Also along the crest of the same formation is beacon Bar 4 which has a height of 2,792 feet. Bar 5, the highest point in the area is 3,040 feet in altitude.

In the eastern portion of the area there is a further prominent range situated south of the main quartzite-conglomerate horizon and is



Plate 2. View looking east across Three Sisters (at left), the Mt. Sycamore (in the center and right), and in the center the low-lying ridge is seen to split into two separate ridges.

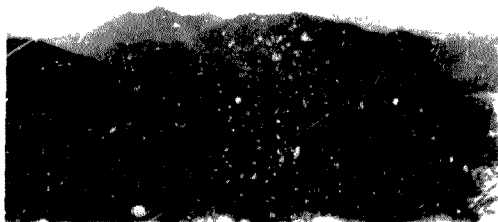


Plate 3. Another view of the Three Sisters (at left) and the Mt. Sycamore (in the center and right), and the low-lying ridge is seen to split into two separate ridges.

separated from it by a deep, thickly wooded valley on the farm Surprise. This latter range splits into two limbs that continue east of Louw's Creek towards the beacon Holnek.

Numerous chert bars provide resistant ridges that can be traced for several miles from Joe's Luck Siding, west of Sheba Siding, right through the area to Louw's Creek.

The Lily Mine occurs on the slope of one of these better developed ridges at an altitude of approximately 2,500 feet. Further to the east the Rose's Fortune Mine has an elevation of 2,000 feet - less than 100 feet above Louw's Creek.

F. WATER

Very few boreholes exist in the region examined due to the fact that the rivers in the area are mostly perennial. The Kaap River has been used for the production of hydro-electric power at several points, where a favourable hydraulic head of water could be utilized. The largest of these plants was situated near Eureka Siding. Numerous weirs have been constructed across the Kaap River and the water diverted into furrows for use several miles lower down-stream on large tracts of arable land.

The smaller tributaries contribute water to additional furrows but the intermittent nature of these streams only ensures a steady supply of water if the rainfall has been consistent. The Shia-lo-Ngubu River is thought to have beheaded Louw's Creek. In 1939 the Shia-lo-Ngubu Dam was built and the water was diverted through a tunnel back into Louw's Creek for use by farmers in the Louw's Creek Valley. Numerous irrigation furrows have been cut to the lands around the Louw's Creek Settlement. Water for domestic purposes is obtained from rainwater, a few boreholes and by filtering river and stream water. There is a danger of bilharzia from untreated water.

The Lily Mine itself, has little or no underground water apart from the normal water table, which on the hillslope, is approximately 200 feet below surface. Water for mine use was pumped several hundred yards from an irrigation furrow in the valley.

G. GENERAL GEOLOGY OF THE BARBERTON MOUNTAIN LAND

The Barberton Mountain Land comprises part of an ancient folded belt of diversified Archaean rock types classified with the early Pro-cambrian systems of Southern Africa. These ancient layered rocks have been subjected to several periods of igneous intrusion and deformation, resulting in a complex history of events.

The great succession of strata in the area has been subdivided by the Geological Survey, (Visser, 1956) into an older group, the Swaziland System and a younger group, the Moodies System.

In Swaziland the Geological Survey differ from their South African confederates in that they still use the term Moodies Series (Hunter, 1961). They make recognition of the fact that an unconformity does exist between the Moodies and earlier sedimentary formations. They believe, however, that the Moodies Series is genetically related to the remaining formations of the Swaziland System, partly because some of the successions are derived from erosion of the earlier sediments but principally because they consider that the entire Swaziland System was deposited in a single trough or geosyncline. This geosyncline was subsequently involved in the evolution of a single tectonic cycle. They explain the unconformities that exist as being the result of local disturbances within the basin.

The South African Geological Survey (Visser, 1956) has again sub-divided the Swaziland System into a lower series known as the Onverwacht Series, consisting predominantly of acid and basic volcanic rocks with a few subordinate intercalated chert bands, and an upper series known as the Fig-tree Series characterised by an argillaceous assemblage of rocks consisting for the most part of great thicknesses of cleaved fine and coarse grained graywacke and slates (Ramsay, 1963). In addition laminated shales and banded ironstones with local development of numerous chert bands as well as schistose talc and carbonate rocks are to be found. van Eeden (1941) also mentions the development of a trachytic lava near the top of the sequence. Ramsay (1963) calls the same rock a felspathic graywacke.

Unconformably overlying the Swaziland System is a further succession mainly comprised of arenaceous and rudaceous rocks belonging to the Moodies System. The System has a wide distribution and is separated from the older rocks below by a basal conglomerate. The remaining strata include extensive development of quartzites and subordinate impure sandy and shaly horizons.

The sedimentary sequence was then invaded by the suite of basic and ultrabasic rocks of the Jamestown Igneous Complex. included in this

intrusive array are various basic schists, serpentinites, amphibolites, diabases and the acidic granodiorite pluton known locally as the Kaap Valley Granite.

Following this, further igneous activity resulted in the emplacement of the Archaean Nelspruit Granite. Intrusive relationships are portrayed along the contact by innumerable migmatized amphibolite xenoliths and by the intense metamorphism, locally, of the invaded sediments.

Hypabyssal rocks in the form of dykes and sills are prolific in the District making up a systematically orientated pattern conforming largely with the structural controls responsible for the overall deformation of the Mountain Land.

A remarkable feature of the region is the comparative absence or rarity of metamorphic phenomena. Only local development of metamorphic effects are seen in close proximity to the Nelspruit Granites. The James-town intrusives produced metamorphism of a decidedly restricted nature and were themselves affected by the granites along the contact-zone. The Geological Survey (Visser, 1956) has divided the metamorphic rocks of the area into two main categories, the one being dynamic metamorphism and the other, contact metamorphism, with a third and less well displayed sericitization effect.

Despite the intense folding and shearing experienced by the sediments, dynamic metamorphism on a regional scale is absent but is developed along some of the major thrust faults. Mylonitization and silicification exemplify, in many cases, the fault and crush zones.

Certain metamorphic rocks have escaped classification into one or other series mentioned earlier owing to their obscure origin.

The Barberton Area is noted also for its diversification of structural parameters. Complex folding and faulting is everywhere evident. Notable too are the enormous synclinal structures that manifest themselves throughout the region. Anticlinal structures are rare or entirely lacking. The rocks, with a few exceptions viz. the Eureka and Ulundi Synclines, are generally folded about E.N.E. - W.S.W. trending fold axes and strike faults extending over many miles follow approximately the same trends.

It has for a long time been realized how important was the part played by structure in determining the whereabouts of ore-deposits but it was only recently that Ramsay (1963) brought to the fore the true significance of detailed structural investigation and interpretation. Preliminary work led him to conclude that at least three periods of deformation had

affected the area and that the mineralization had been controlled by the second phase structures - pre-dating the development of the third phase.

H. PREVIOUS WORK

Some of the earliest work done in the Barberton District was attempted late last century by Molengraaff (1897); by Hatch (1904) and Draper (1913). The first work of any real note however, was published by Hall (1918) when he proposed that the sediments in the Barberton Area should be placed in the "Swaziland System", a term coined by him.

Hall's threefold classification of the System was:-

1. Moodies Series - an arenaceous and argillaceous facies.
2. Jamestown Series - basic suite with sediments.
3. Onverwacht Volcanic Series - acid and basic volcanics.

He recognized two varieties of granite - the one a mica rich variety, the other rich in hornblende but gave no evidence as to how these two were related. This remained the standard work for some time and early in 1938 the Geological Survey began investigating the area and in 1956 published a 1 : 50,000 scale geological map of the Barberton District together with an accompanying explanation.

It was found necessary to revise many of Hall's earlier conclusions especially with regard to the re-definition of his Moodies Series, and in its place two systems were recognized, viz. the Moodies System and the Swaziland System.

The first was seen to embrace a suite of predominantly arenaceous rocks while the second consisted essentially of argillaceous and volcanic successions. The Systems are separated from one another by an apparent conformable relationship, but sufficient evidence was staged to show that the relationship was unconformable. This included such features as a sharp change in the depositional style and the development of a thick basal conglomerate horizon between the two, containing pebbles derived from rocks belonging to the older sequences below.

van Eeden (1941) working for the Geological Survey was responsible for the mapping of the Sheba Hills area together with part of the Krokodilpoort Mountains to the north, (Geological Survey, Visser, 1956), and a very concise account of the stratigraphy was given by him in an unpublished Stellenbosch University D.Sc. thesis entitled "Die Geologie van die Sheba-Rante en Oostreke, Barberton Distrik".

Suffice it is to mention here only certain aspects of his work considered pertinent to the discussion following later in this report.

van Eeden recognized along the Kaap River Valley a group of basic and acid rocks practically devoid of volcanic structures. He expressed doubt as to their position in the stratigraphic column but indicated that they could represent rocks belonging to the Onverwacht Series. Microscopic evidence led him to believe that the series contained intensely sheared acid lavas and quartz porphyries. These rocks have been excluded from the recent Geological Survey map and there appears in their place basic and acid schists of the Jamestown Complex.

Higher in the succession, at the top of the Fig-tree Series, van Eeden mapped as trachytic lava a zone of dark coloured rocks studded with minute crystals of felspar. Included in this zone and immediately below the Basal Conglomerate of the Moodies System he noted the presence of nodular masses resembling the pebbles in a conglomerate. He mentioned the possibility of them being autoliths but expressed doubt as to their origin.

The great variety of basic and ultrabasic rocks that occur interspersed between sediments of the Swaziland and Moodies Systems as well as the vast array of rock types between the sediments and the granites were considered to belong to the Jamestown Complex. The contact amphibolites were considered to be the result of thermal metamorphism of the pre-existing basic varieties while those further from the granites were produced largely under the influence of dynamic metamorphism. The change from one basic type to another is gradual and no mention is made as to whether the varieties, not classed as serpentinites or diabases, are conformable or transgressive with the sediments.

van Eeden (1941) also regarded the Jamestown Complex as being intrusive into the Swaziland and the Moodies Systems. The Nelspruit Granite, he concluded, was intruded subsequent to the Jamestown igneous invasion. The great amount of silicification displayed in the vicinity of the Kaap River, and especially that seen in the Lily Line, he attributed to the effects of the Jamestown Complex.

In places along the granite contact belt there are inclusions and xenoliths, that have been so metamorphosed that they cannot definitely be placed in any series. van Eeden considered the possibility of them belonging for the most part to the Fig-tree Series and the Jamestown Complex.

From a structural viewpoint it was van Eeden's contention that the Barberton Mountain Land as a whole had been affected by one deformative

period. The style of the folding was considered to be largely influenced by the Kaap Valley Granite, a granite he considered intrusive into both the Jamestown Complex and the Swaziland System. Pressures emanating from the NW and SE tended to warp the surrounding rocks around the granite pluton.

Extensive shortening occurred at right angles to the trend of the major fold axes in the area and lengthy strike faults running more or less parallel to these axes were developed in weak zones resultant from the folding. Deformation produced overfolding of the strata to the NNW. The greatest inflection took place SE of New Consort Mine in the Eureka and Ulundi Synclines while the strike of fold axes in the less affected areas paralleled the regional strike of the Mountain Land.

The folding, was thought by van Eeden, to have taken place prior to or at the same time as the introduction of the Welspruit Granite. Structures in the granites suggested to him that elongation had occurred in a direction parallel to the Barberton Mountain Land.

Vertical elongation was seen in the parallelism of conglomerate pebbles at Sheba Siding. However, he did not think the conglomerates were unduly deformed, citing the fact that both rounded granitic pebbles and flattened chert pebbles occurred side by side. The orientation was explained by pebble imbrication at the time of deposition. The orientation coincided with the 'a' direction of folds causing him to suggest differential movement between the beds during folding. Finally the dyke swarms were considered to have taken advantage of joints and tension fractures in the Mountain Land and in the elongated solid, massive Kaap Valley Granite.

The Geological Survey, (Visser, 1956) discussed the view that the Fig-tree Series had in part suffered folding prior to the deposition of the Moodies System. The added intensity of folding in the Fig-tree Series led them to suggest that the argillaceous sediments represented an incompetent succession of strata between over and underlying massive rocks composed of quartzites and lavas.

The Lily Syncline was found to be best developed south of Three Sisters while towards the west the southern limb was considered to be overfolded to the north. East of Eureka Siding the closed fold of the Lily Syncline split into bands that rejoin west of Scotia Talc Mine. The Basal Conglomerate apparently pinched out or was not developed further to the west. The quartzites however, bent south and were traceable to Joe's Luck Siding where they disappeared beneath scree and soil reappearing again southeast of New Consort Mine.

Koen (1947) examined the country around the Sheba Mine paying special attention to the graywacke-greenschist occurrences and concluded, after examination and measurement of zircon grains in both these rock types, that the greenschist was derived or altered from the sediments (graywackes and cherts). Thus the first doubt was cast as to the validity of an igneous origin for the concordant zones of basic rock in the Fig-tree sediments.

Still later Gribnitz (1961) cast further doubt on the Geological Survey ideas and considered that many of the rocks formerly placed in the Onverwacht, Fig-tree and Jamestown groups should not be thus classified. In fact, Gribnitz has seriously disputed the existence at all, of the Jamestown Igneous Complex and proposes the introduction of a further series, the Gorschot Series. The Series is named from the farm where O. Kuschke first noted that rocks mapped as Jamestown Complex rocks consisted of dolomitic and arenaceous varieties with interbedded banded cherts, ironstones, carbonate-bearing shales and a conglomerate horizon.

Kinemetamorphic processes are thought to have converted carbonate-bearing rocks into talc carbonates and quartz-sericite schists.

More recently Herget (1962) working in the Montrose area to the southwest of Barberton came to the conclusion that the rocks in the area, classified by the Geological Survey as belonging to the Jamestown Igneous Complex, did not display intrusive relationships and in fact were always concordant with the sediments. Metamorphism of the sediments in close proximity to the serpentinites is entirely absent. The serpentinites were found to occupy only the cores of anticlinal structures and lay beneath the Fig-tree Series graywackes, shales and cherts. This would indicate therefore, that the serpentinite horizon was emplaced prior to the Fig-tree deposition and also prior to the folding deformation.

On the other side of the Barberton Mountain Land in the Swaziland Area Urie (1957 and 1961), and Pretorius (1948) also studied the contact relationships between the granites and the Fundamental Complex.

Pretorius found basic and ultrabasic rocks metamorphosed extensively into a variety of schists and he was able to group these rocks into zones even though they bore a gradational relationship to one another. He found that metamorphic zoning in the Jamestown Complex was directly related to the distance from the granite contact.

Mention was also made of shale and quartzite bands in the schists in addition to patches of conglomerates. These he ascribed to being xenoliths of Moodies sediments caught up in the intrusion of the original basic lava of the Jamestown Complex. The absence of metamorphic minerals of the

type usually found in altered sediments and the prevalence of amphibole, chlorite, talc, biotite and magnetite were mentioned as supporting evidence for the igneous origin of the Jamestown suite.

Urie (1957) found that the Jamestown Igneous Complex in north-western Swaziland was essentially concordant but did locally transgress the sediments. He stated that the transgression was selective and penetrated argillaceous formations leaving siliceous horizons and xenoliths extending for some distance into the body of the intrusion. He also noted a gradual diminution of metamorphic grade of the assemblages away from the granite contact.

The degree of alteration within the Complex is believed to be related to a process of steatization produced by the metamorphic and retrograde metamorphic effects of the hot aqueous solutions emanating from the intrusive granite.

Urie considered that the lower portion of the Fig-tree Series was assimilated by the ultrabasic magma. The fact that the contacts of basic material with sediments is usually sharp led him to exclude metasomatic alteration and preference was attributed to local digestion and small scale stoping. The occurrences were viewed in the light of Bowen's Reaction Series and were found to be chemically possible but additional problems were immediately posed. If assimilation had taken place it must have done so at low temperature because metamorphic evidence excludes a high temperature. Orientation of the xenoliths along the contact were explained as being due to high confining pressures existing at depth in a geosynclinal pile. His conjecture theorizing however, did emphasize the numerous difficulties and problems involved.

With regard to occurrences of the Moodies conglomerates in the Swaziland Area Urie noted a parallel alignment of the major axes of the pebbles and attributed the fact to the structural deformation of the strata rather than to sedimentary depositional alignment.

In 1942, van Zyl, et al; described the magnesite occurrences of the Barberton Area and mentioned briefly the deposit near Sugden Siding. A brief description of the ores as well as a theory of origin were included. Little prospect was given to their being reworked at a later date due to decreasing density of seams and progressive deterioration in grade with depth.

The nickel prospect near Sheba Siding was mentioned by Du Toit (1926) and was more fully investigated by Partridge (1943). He gave a detailed mineralogical report on the trevorite ore and described a new nickel-magnesian-hydrated silicate (Nipouite) from the same deposit.

The mineralogy of the ore deposits in the Barberton District have been discussed by de Villiers (1957) and Hearn (1943) investigated the ores of the New Consort and Sheba Gold Mines. These reports are dealt with later in the discussion of the generalized scheme of mineralization of the Barberton Mountain Land.

Age determinations were done by Nicolaysen (1962), on rocks in the area and youngest measurements were obtained from post Moodies migmatite granites. These gave an age of close to 2,600 million years.

In Swaziland the G4 granite, also intrusive into the Moodies and Swaziland Systems gave a "Total Rock" Rb - Sr age of $2,950 \pm 100$ m.y. Immediately north of Johannesburg the granites are found intrusive into basic rocks correlated with the Jamestown Complex. Ages there determined gave an approximate $3,200 \pm 120$ m.y. This would imply that the Swaziland System has an age greater than 3,200 m.y.

More recently an age of $3,100 \pm 100$ m.y. was obtained from the Kaap Valley Granite on the farm Somerset. (Nicolaysen verbal communication).

At this point it would be appropriate to mention some of the previously held views on both the origin and time of emplacement of the Kaap Valley Granite and the Nelspruit Granite.

In 1918, Hall suggested that the Kaap Valley Granite should be regarded as a phase of the Nelspruit Granite. He explained the difference between it and the Nelspruit Granite as being due to the assimilation of Jamestown basic rocks that occurred in the area. Willemsse (1937) also maintained that the "quartz diorite" as he called it, might be a product of differentiation of the original magma.

Later van Eeden (1941) came to the conclusion that the Kaap Valley Granite was emplaced prior to the deformation that affected the area. The granite pluton he suggested, acted as a resistant mass against which the stratified formations were compressed and folded. The Nelspruit Granite according to him was intruded more or less synchronously with the folding in the area and, therefore, was much later than the Kaap Valley Granite.

Hearn (1943) was opposed to this idea suggesting that the Kaap Valley Granite was a later phase of the Nelspruit Granite and he attributed or coupled the mineralization of the Barberton Mountain Land with this intrusion.

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Read (1951) ascribed the low grade of metamorphism in the Swaziland System as being due to the resistant barrier provided by the basic

rocks of the Jamestown Complex that encircle the sedimentary sequences. The Nelspruit Granite in his opinion was "produced by the migmatization of semi-pelitic and more siliceous rocks". Local products of high grade metamorphism e.g. sillimanite gneisses indicated that the Nelspruit migmatite was mobilized and intruded into the neighbouring country rocks.

The Geological Survey (Visser, 1956) suggests that the Nelspruit Granite represents the product or series of products of granitization. Assimilation and anatexis of enormous volumes of Swaziland System and Jamestown rocks are considered to have been involved in the process. Most of the granites may have originated by metasomatic replacement yet the nature of the contact implied an intrusive relationship.

Ramsay (1963) questioned the whereabouts of the foundation upon which the sediments are deposited, and suggests that much of the granite material formed a fundamental basement complex on which the volcanic and sedimentary rocks were deposited. The entire mass was subsequently deformed and intruded by other granite and they together suffered later regional metamorphic effects.

Ramsay (1963) changed considerably the previously held views on the structure of the Barberton Mountain Land when he proposed evidence for the existence of at least three separate deformations. Working largely in the New Consort, Fairview and Sheba areas he proceeded to unveil the structural history by the examination in great detail, of minor structural parameters.

Briefly his deformation history was,

1. the development of a series of major and minor folds, the traces of which trended N.E. - S.W. or N.N.E. - S.S.W. The major faults were probably initiated during this period of deformation.

2. further compression with the regional strain oriented N.N.W. This led to a slaty cleavage cross-cutting the first formed folds. Only locally were new folds developed and low grade regional metamorphism accompanied the deformation. Also during this second phase the Nelspruit Granite was intruded and thermally metamorphosed the adjacent strata. Ramsay postulated that the main period of gold mineralization was probably late during this deformation.

3. the third deformation is displayed by the folding of the slaty cleavage and schistosity by large and small scale folds. The great arcuate structure of the Eureka and Ulundi Synclines took place and at the same time conjugate folds and faults occurred. Ramsay does not exclude the possibility of these last mentioned structures belonging to a fourth age of deformation.

The maximum compressive stress affecting the third deformation was found to be at right angles to those of the earlier deformations and he suggests a possible considerable time lag between these periods.

The faulting was subsequently reactivated during later periods of folding, producing brecciated zones in the cleaved slates of the Fig-tree Series.

Ramsay described conjugate folding from the region in the Economic Geology Research Unit Information Circular, No. 6 (1962a) where he explains that they are produced by failure of the rock on two inclined shear surfaces. Brittle rocks when deformed, develop conjugate folds and the principal axes of stress may be calculated using the methods described by Ramsay (1962b).

Ramsay also applied the structural data he acquired to the mineralization of the District. In a summary of his findings he suggests that the mineralization predated the development of some slightly sheared sheets of granite pegmatite which were deformed during the second regional deformation. He found that the ore sheets were linear and ran parallel to the minor structures believed to be parallel to the axes of the second folds. The third phase of folding deformed the ore shoots.

The ore fluids, he suggested, were introduced during the second period of deformation and perhaps at a late stage synchronously with the intrusion of the Nelspruit Granite. Arsenopyrite needles associated with the gold mineralization sometimes show a preferred orientation parallel to the second phase lineations.

7 REASONS FOR AND AIMS OF THE PRESENT INVESTIGATION

(a) Introduction

Encouragement for the present study was fostered by the discovery several years ago of very rich lenses or pockets of visible gold in the Lilly Mine. It was considered by those concerned with the mine that a geological study of the deposit might give some indication as to whether additional pockets may be encountered or, failing this, to give some reason for the control of the gold previously mined. It was considered that structural phenomena were responsible and that investigation along these, as well as other lines might prove fruitful.

(b) Aims and Scope

Using new techniques of structural geology work was commenced early in 1962 and it soon became apparent that the mine and surrounding countryside were beset with various problems.

Within the mine itself the following projects were undertaken:

1. the mapping of the mine both on surface and underground in detail, paying close attention to the structure and petrology of the formations.
2. to describe fully the mineralogy of the deposit.
3. to investigate and offer some explanation for the phenomenal "bonanza" gold occurrences mined in the past and to suggest if possible the whereabouts of further similar bodies.
4. to attempt some explanation as to the source of the mineralizing solutions responsible for the formation of the deposit.
5. to place the mine into the regional pattern and to examine other mines and prospects in the immediate vicinity.
6. to compile a regional geological and structural map and to study the intrusive contact relationships of the granites with sedimentary and volcanic formations of the Barberton Mountain Land.
7. to investigate, in the area, the basic suite of the Jamestown Igneous Complex and to view the rocks in the light of recent information suggesting that they be, at least in part, the altered and metamorphosed products of pre-existing sedimentary rocks or a layered sequence.

At an early stage it was recognized that the detailed work involving structural measurements would be valueless if they were not accurately plotted onto a suitable base map. The only existing maps of the area were confined to mine properties and to the map prepared by the Geological Survey on a scale of 1 : 50,000 - far too small a scale to be of practical use.

An accurate base map was required for the plotting of lithologic and structural data and in this respect the Economic Geology Research Unit obtained financial assistance from Eastern Transvaal Consolidated Mines Limited and Federale Myntbou Beperk.

The Aircraft Operating Company was commissioned to compile a contoured base map on a scale of 1 : 10,000, from aerial photographs. Finances limited the ultimate extent of the area covered by the map and it was unfortunate that only about one quarter of the area discussed in this report was included in the undertaking.

The area between the trigonometrical beacons Bar 5 and Bar 4 may, therefore, solely be regarded as having correct angular planimetry. It was left to the writer's discretion to choose a particular method (taking into consideration the factors of time, materials and existing maps available), for the construction of the remaining portion of the base map. The final maps were compiled by a series of stages involving:-

1. the enlarging of the 1 : 50,000 Geological Survey plan to 1 : 10,000 on an electrically operated mirror pantograph.
2. the tracing off of detailed topocadastral information from aerial photographs enlarged to an approximate scale of 1 : 6,000.
3. the reduction of this tracing to a scale of 1 : 10,000.
4. the compensation of error derived from the comparison of the sound portion of the map between Bar 5 and Bar 4 with that of the tracings of the same area.
5. the final compilation of the maps on 1 : 10,000 scale and the subsequent reduction to 1 : 15,000 by photographic means (Figs. 2 and 3).

J. WORK ACCOMPLISHED

As was mentioned previously work on the underground mapping of the mine began early in 1962. In January of that year, underground plans to be used for mapping were prepared from survey plans. The existing 1 : 1,000 mine plans were enlarged to 1 : 250 in order that detailed structural observations could be recorded accurately (Fig. 4).

A surface plan of the mines and prospect trenches in the claim area compiled by surveyors of Eastern Transvaal Consolidated Mines Ltd., on a scale of 1 : 2,000 was reduced to a scale of 1 : 5,000 (Fig. 5).

Detailed structural investigations both on surface and underground involved the recording of such minor structural features as fold axial traces, plunging directions of folds and lineations, attitudes of fold axial

planes, conjugate fold axes and axial planes. Lineations were also found expressed in deformed and elongated conglomerate pebbles. Other features such as planar fabrics viz. cleavage and schistosity were noted in addition to the conventional parameters, dip and strike and bedding, fault and fracture orientations, brecciation, slickensiding, joint directions, boudinage, shearing and the directional younging of sediments.

Underground mapping began in February and continued to the end of May. During this time both the Lily Mine and the Rose's Fortune Mine were mapped. Investigations then were focused on the regional geology of the area between Sheba Siding and Louw's Creek for a further four months. Final field work involving the linking of the area mapped by M. Viljoen with the area mapped by the writer was accomplished during February, 1963. The intervening period was employed in laboratory work involving thin section and polished section study of the petrology and mineralogy of over 150 specimens collected during the field seasons.

In addition X ray diffractometer work was done on samples of pyrrhotite especially chosen for the purpose of attaining a temperature of formation of the sulphide deposition in the Lily Mine.

Gold samples were prepared and sent off for analysis of the gold to silver ratios. These samples depict a vertical range of concentrates gathered from the mine for the purpose of investigating purity changes in the gold at different depths.

Sulphide specimens were assayed to determine the grade of the ore in various localities throughout the mine.

All the above aspects are dealt with more fully later in the report.

Over 1,500 structural parameters were recorded and stereographic plots were prepared using an equal angle Wulff Stereonet. The plots display more clearly the various structural aspects noted in the course of mapping. Size axes of deformed pebbles from Sheba Siding were measured and compared with undeformed pebbles obtained from a relatively undisturbed portion of the Mountain Land.

Numerous diagrams dealing with various aspects of the work such as the $\frac{A}{R}$ and $\frac{A}{C}$ (conventional signs after Cloos, 1947) ratios of deformed conglomerate pebbles and the ratios of the percentage of gold and silver to changes in depth were prepared and photographed. In addition photographs taken in the thesis area as well as microphotographs in colour and black and white were printed by the writer.

The central section of the Lily Mine has been developed more than other sections due to the occurrence of an ore shoot that contained exceptionally high gold values. The underground data was used to construct a glass model showing the mode and occurrence of fractures and quartz veins. Breccia zones and the easterly plunging shoot with the bonanza gold pockets are also indicated on the model.

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Much useful assistance was afforded the writer by Eastern Transvaal Consolidated Mines Ltd., Barberton, who placed at his disposal innumerable maps, materials and information pertaining to the geology of the Barberton District and the Lily Mine in particular and thanks must be given to the geological staff who were always ready to be of the fullest assistance.

To Mr. M. van R. Steyn, geologist at Fairview Mine, who gave useful advice on underground mapping techniques and to Mr. E. Burrow, manager of the Scotia Talc Mine, thanks are extended.

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CHAPTER 2

RESULTS OF PRESENT INVESTIGATION

A. GENERALISED GEOLOGICAL PICTURE OF THE AREA

(a) Classification and Distribution of Rock Types

Broadly, the area is bounded in the north by the Nelspruit Granite which displays intrusive relationships along the contact. Immediately to the south of the granite and often occurring as xenoliths within the granite are a group of basic amphibole schists which according to the Geological Survey, (Visser, 1956) belong to the Jamestown Complex. These contact amphibolites form a broad zone that occupies portion of the Kaap River Valley from Eureka Siding to Honeybird, and in addition, they make up much of the flat country near Louw's Creek Station. Within this contact amphibolite belt are several quartritic schist horizons that are especially well developed to the north and northwest of Eureka Siding. This is followed by a further group of basic rocks consisting essentially of green amphibolites. The contact amphibolites and these predominantly tremolite-actinolite schists are separated by a fairly sharp boundary where exposures are good but generally the contact is obscured by flat scree and soil covered ground.

Extending across the entire area to the south of the green amphibole schist horizon is the massive Moodies conglomerate - quartzite horizon forming part of the Lily Syncline. This formation builds a prominent ridge that occurs as a tightly folded syncline in the east and a closed fold in the central portion of area. Towards the west the ridge splits into three distinct bands separated by intrusive green serpentinites and talc schist bodies.

South of the main quartzite-conglomerate ridge more basic schists occur. These consist essentially of talc-chlorite-carbonate schists but may grade laterally and very often imperceptibly into tremolite schists, or quartz-chlorite-carbonate schists.

Green serpentinites are intruded into different rock types but attain their maximum development to the northwest and north of the Scotia Talc Mine near Sheba Siding. Another serpentinite intrusive occurs in the central portion of the area near Sugden Siding.

Following on the basic suite is a sheared horizon consisting mainly of acid lava, quartz porphyries and quartz-sericite schists with a few intercalated shaly and siliceous horizons. These rocks are considered to belong to the Onverwacht Series and are best developed between Honeybird

Creek and Louw's Creek, where they build a prominent ridge. To the west, however, only scattered outcrops occur between broad zones of farmland and scree cover. They are often invaded by basic horizons that occur conformably between the siliceous and cherty zones. There are additional talcose schist horizons and serpentinites south of the Onverwacht horizon. Fig-tree Series shales and graywackes with chert bars and banded ironstone horizons follow conformably above the basic zones. In the east near the Lily Mine these shales and banded ironstones are best developed at the base of the Series and are followed successively by siliceous cherty zones, graywackes and shales and zones of chloritic carbonate-rich rock and talc carbonate schists. The latter are concordant with the sediments.

The upper portion of the Fig-tree succession is marked in the west by the occurrence of what the Geological Survey (Visser, 1956) call lavas. These are overlain by the Basal Conglomerate horizon of the Moodies System.

A wide variety of dykes are found throughout the area. Many of the rocks formerly grouped as belonging to the Jamestown Complex have been reclassified into the Onverwacht Series and the Fig-tree Series lava horizon has been viewed in a new light.

Table I gives a revised stratigraphic column of the area with the approximate thickness of the units, (see page 24).

(11) Structure

The Lily Syncline is a narrow structural entity occurring along the northern fringe of the Barberton Mountain Land between the Nelspruit Granite massif and the Eureka Syncline. As mentioned earlier the Syncline is tightly folded with its southern limb overfolded to the north. The entire structure dips steeply to the south and in the central portion it occurs as a tightly closed fold. In the west the sequence has been separated by basic intrusives. In the area northwest of the Scotia Talc Mine the Lily Syncline is considerably disrupted and the quartzite-conglomerate members are dissociated from one another by large intrusive serpentinite bodies.

The Lily Syncline appears to be separated from the Eureka Syncline by two faults: viz. the Main Southern Fault and the Lily Fault. These faults are similar to other faults in the District in that they also occur in the anticlinal divides separating major synclines.

The Main Southern Fault especially and possibly to a lesser extent the Lily Fault, act as high angle longitudinal thrust faults in much

TABLE I
STRAIGRAPHIC COLUMN

Recent Alluvium, Oukilo Banks and Terraces					
LILLY SYNCLINE			EUREKA SYNCLINE		
Northern Limb		Faulted Anticlinal Divide	Northern Limb		
Rock Types	Thick- ness	Rock Types	Thick- ness	Rock Types	Thick- ness
MOODIES SYSTEM					
Quartzite	20'-	Quartzite	20'-	Present but not	
Varieties	400'	Varieties	400'	mapped	
Basal Conglomerate	30'-	Basal Conglomerate	0'-	Basal Conglomerate	30'-
	250'		300'		50'
SWAZILAND SYSTEM					
Fig-tree Series					
Developed only in N.W. altered lavas	0'- 1000'	Not Developed		Lava ? or tuffa- ceous graywacke	0'- 300'
Developed only in N.W. shales and altered graywackes	0'- 200'	Not Developed		Graywacke, shale chert, banded ironstone, basic schists	750'- 5000'+
OVERWICHT SERIES					
Green amphibole schists	200'- 2700'	Talc-chlorite- carbonate schists	50'- 250'	Not Exposed	
Black Contact Amphibolite, intercalated acid schists.	50'- 3500'	Talc-carbonate- chlorite quartz-sericite schists, altered acid lavas	1000'- 2000'	Not Exposed	
Magnetic shale and garnetiferous quartzites					
INTRUSIVE ROCKS					
Green serpentinites with magnesite	)	Jamestown Complex ?		50'- 1500'	
Magnetic nickeliferous serpentinite					
Mispur Granite, gneiss, pegmatites and apatites					
Dykes, dolerite, diabase, porphyritic diabase, amygdalite					

the same manner as the Barbrook, Sheba and other faults in the Mountain Land. These faults almost without exception occur in the divides between the major synclines.

The granite along the contact belt exhibits intense shearing and the development of a pronounced lineation. Although outcrops are restricted, numerous folds are also seen in exposures along the contact. There is a strongly developed foliation and schistosity manifest throughout the area. This is seen both in the field and in the examination of thin sections. Conglomerate horizons are flattened and elongated into stringers and boudinaged structures; sediments are altered almost beyond recognition at times. Under the microscope small scale folds can be seen and practically all the rocks have a foliation. There is in the Kaap River Valley a strong alignment of basic minerals of the contact amphibolite succession and in the central area a shear zone trending approximately NW - ENE is made clear by a filling of white vein quartz that forms a prominent ridge for several miles. The formations have a consistent regional trend and the predominant dip is steeply to the south with most variations occurring to the west of Eureka Siding and approaching the area in the vicinity of Bar 5. Variations in the attitude of the bedding in the Fig-tree rock is mainly due to the intensely folded nature of the sediments.

Minor structures, similar to those found in the area between New Consort Mine and Joe's Luck Siding are also found in the mapped area but to a considerably lesser degree. These structures indicate that the deformative processes were operative over a wide area but were only recorded locally in horizons of a brittle nature e.g. in quartz-sericite schists.

(iii) Metamorphism

Metamorphism of varying grade is manifest almost entirely throughout the area with the exception of the Fig-tree succession occurring in the southeast portions of the area. The metamorphism is considered to be largely due to the thermal effects produced by the intrusion of the granites in the north coupled with dynamic metamorphism resulting from the deformation of the area. A gradual lowering of the grade of metamorphism can be detected away from the granites and the metamorphic mineral assemblages are considered in the light of the facies concept of metamorphism as discussed by Ramberg (1952), Tilley (1948) and Turner and Verhoogen (1960).

It has been possible to group the successions into three grades. Those rocks nearest the granites fall into the hornblende-hornfels facies. These give way to rocks classified into the albite-epidote-hornfels facies

and still further south the rocks can be grouped in the greenschist facies.

Locally, for example in the Lily Mine, the hydrothermal mineralizing solutions have superimposed higher grades of metamorphism (albite-epidote-hornfels to hornblende-hornfels facies) over the regional metamorphism.

(iv) Mineralization

By far the most important economic mineral in the area is gold. It is produced on a small scale from two mines viz. the Lily and the Rose's Fortune Mines, both south of Louw's Creek Station. Mineralization has largely been confined to a narrow zone at the base of the Fig-tree Series. It has been possible during the course of regional mapping to delimit the mineralized zone to a thin strip of country extending entirely across the area mapped, and later, in conjunction with M. Viljoen who mapped the New Consort - Joe's Luck area, it was found possible to extend the same mineralized zone still further to the west.

Evidence suggesting the existence of the Lily Fault is presented and its influence as a channel for hydrothermal ore solutions is discussed.

Other economic minerals found in the area include the nickel-bearing serpentinites to the northwest of the Scotia Talc Mine, as well as the non-metallic minerals talc and magnesite that occur near Sheba Siding and Sugden Siding respectively.

(b) Scheme of Approach to Detailed Geology of the Area

(1) Introduction

A detailed account of the stratigraphy found in the area is discussed below under the following headings:-

(ii) Field Occurrence and Description

Under this section the localities and mode of occurrence of the rock types are described and a detailed macroscopic and microscopic description of hand specimens and thin sections is given.

(iii) Structure

A brief account of the principal structures seen in the field and in thin section is given. A more complete structural analysis is presented in a later section.

(iv) Metamorphism

Descriptions of the metamorphic minerals found in this area are discussed and related to the facies concepts of metamorphism.

(v) Origin

The probable origin of the various rock types is discussed and the theoretical aspects relating to their former nature are briefly considered.

C. ONVERWACHT SERIES - SWAZILAND SYSTEM.

(a) Introduction

As has been mentioned earlier Gribnitz (1961) considered the introduction of another series, the Oorschot Series, for many of the rocks regarded by the Geological Survey as belonging to the Jamestown Igneous Complex. The writer, after studying the rocks in the report area, felt that there was considerable justification to warrant a reconsideration of the existing ideas but considered it unnecessary at this stage to introduce a further series to the Swaziland System.

The questionable successions appear to all be pre-Fig-tree in age and are, therefore, by definition placed in the Onverwacht Series.

Three easily distinguishable varieties of basic rock are included in the series. These are:-

1. Dark Contact Amphibolites or quartz-hornblende schists
2. Green amphibole schists consisting essentially of tremolite and actinolite schists
3. Talc-carbonate-quartz-chlorite schists

In addition there are intercalated zones of acidic rock probably comprising altered sheared acid lavas, quartz porphyries, quartz-sericite schists, garnetiferous quartzites, and a magnetic shale-quartzite horizon.

(b) Contact Amphibolites

(i) Field Occurrence and Description

The contact amphibolite horizon occurs immediately to the south of the Nelspruit Granite and extends across the entire area. In the west the succession is narrowest and in places the amphibolites appear as scattered xenoliths in the granite, while in the east the zone widens out considerably and attains a maximum thickness of about 3,500 feet in the Louw's Creek - Honeybird region. The contact with the granite is mostly hidden by scree and soil, or large tracts of arable farmland. Exposures are particularly good along several sections of the Kaap River and in the area north and northwest of Eureka Siding. Amphibolitic xenoliths are commonly encountered along the immediate contact zone but in a few instances may also occur as such as a quarter of a mile to the north of it. The granite displays intrusive relationships with the amphibolites. The scattered xenoliths have sharp boundaries with the igneous material and are pierced by tongues and veins of perthitic, aplitic and granitic rock.

The amphibolite zone generally occupies the divide between the granite hills to the north and the Lily range to the south. The Kaap River meanders through this low lying area before it continues northwards into the granites at Honeybird. Towards Louw's Creek Station the formation lies on a few isolated hills.

In the exposures provided by the Kaap River north of the farm Annex Riverbank, possible remnants of the original layered sequence can be seen and are only partially affected by the metamorphism that enveloped the area.

Typically, the rocks closest to the granites contain abundant dark green pleochroic hornblende with accompanying plagioclase feldspar (albite) and fine-grained quartz. Minor variations in the composition occur on the farms Perl and Naude's Rust where the rocks contain abundant epidote. Minute hairlike fractures in the amphibolites are invariably filled by the yellowish-green mineral epidote, while occasionally larger veins of epidote, a rock composed primarily of quartz and epidote, occur in the larger fracture and joint planes. An intensely deformed migmatite zone on Perl also contains a scattered development of epidote. Away from the contact the rock still maintains the black schistose appearance but seems to consist more of quartz and hornblende with plagioclase feldspar and biotite mica in lesser amounts.

Well developed euhedral almandine garnet porphyroblasts were found north of Annex Riverbank. The garnets are free of inclusions indicating a fairly effective metamorphism from the original material. Green pleochroic biotite mica frequently accompanies the amphibole.

(11) Structure

The entire contact amphibolite belt is well foliated and the rocks dip steeply to the south. The schists are aligned parallel to the granite contact and it is this strong alignment that imparts a well developed foliation to the rock. Only rarely are folds seen - a good exposure being visible in the Kaap River cutting near Honeyblind Siding. Here the axial plane of the folds dip south at approximately 30 degrees while the axial trace is roughly east-west (see later under Structural Geology).

Frequently xenoliths occur in the granites. The xenoliths display similar features to those seen in the broader amphibolite schist zone in the south. Invariably there is developed a strong and systematic joint pattern. All joints are roughly at right angles to the granite contact and are probably due to tensional stress. A plot of joint directions indicated a fairly consistent trend on 160 degree bearing. Along the joint planes (see Plate 4). Although a characteristic of joint planes is that they reveal no movement, de Sitter (1956) has shown that there is a gradual transition between joints with no movement through joints with a small motion, to small faults and then on to large faults. Under the microscope several interesting structural features confirm field observations. The amphibole and biotite minerals are, without exception, aligned with their long axes parallel to the planar fabric. Slight modification is produced when garnets for example, have forcibly thrust aside the constituents producing "augen structures". A slight rotation of the garnet porphyroblasts has caused the biotite and amphibole flakes to coil around the crystals and is probably due to garnet growth coupled with movement in the plane of schistosity. Boudinaged bands can be seen in the field (see Plates 6 and 7) and in many thin sections.

The fine-grained quartz, like the quartz in almost all the other deformed rocks in the area, reveals strain extinction and is often chert-like in appearance.

The structure of the whole Onverwacht Series will be dealt with later after examining each horizon in turn.

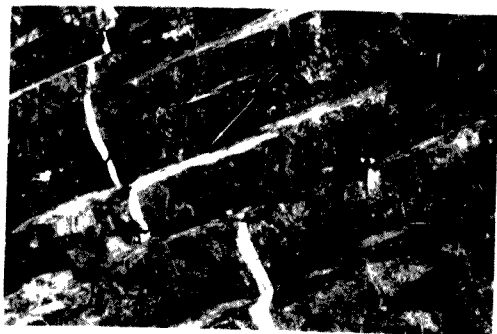


Fig. 4. Contact of limestone with
the crystalline schist.
Kamchatka, north of the
Pavlovskaya station.
Fracture planes.

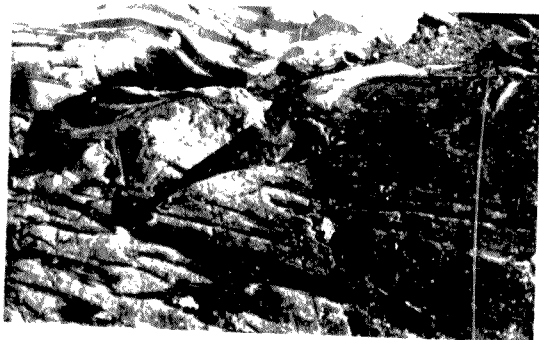


Fig. 5. Contact of limestone with the
crystalline schist.
Kamchatka, north of the
Pavlovskaya station.



6. A small, dark, cylindrical object (possibly a probe or a small container) placed on a textured surface for scale.



7. A small, dark, cylindrical object (possibly a probe or a small container) placed on a textured surface for scale.

(iii) Metamorphism

The contact amphibolites are undoubtedly the result of extensive contact metamorphism. The hornblende-plagioclase-quartz assemblage indicates a zone of high grade metamorphism similar to that described by Eskola (1914) in the contact aureoles of granite batholiths in the Orijärvi region of southwest Finland.

In addition to the dark green hornblende, biotite and plagioclase feldspar minerals several localities were noted where almandine garnet porphyroblasts are developed. The intense or high grade metamorphism produced in contact aureoles can lead ultimately to the formation of a hornblende-plagioclase-quartz-biotite assemblage similar to that present in the area under discussion. Turner and Verhoogen (1960) have classified this mineral assemblage into their hornblende-hornfels facies of contact metamorphism. Formation of the hornblende-hornfels facies has tentatively been correlated with temperatures of about 500° to 700°C in the pressure range $P_{H_2O} = 1000 - 3000$ bars, or should the water pressure be around 500 bars, temperatures could probably be lowered by about 50 degrees. (Turner and Verhoogen, 1960). Figure 27 shows the distribution of the contact metamorphic facies in the area.

(iv) Origin

Several reasons are given for assuming that the contact amphibolites represent the alteration products of a pre-existing layered sequence and not basic intrusives.

1. Within the amphibolite zone are several persistent and well developed quartzite and quartz-sericite schist horizons (see later). These can be traced for several miles into the adjacent areas where they can be followed well to the north of the New Consort Mine. M. Viljoen (verbal communication) found shaly horizons together with these quartzites. Sedimentary layers or acid igneous lavas are indicated. On Bon Accord farm north of Sheba Siding large garnets occur in the siliceous horizons.
2. Zones of partially altered rock resembling stratified sedimentary layers are frequently encountered. The possibility exists that they could have been finely bedded tuffs or lava flows. The xenoliths have their constituents aligned parallel to the regional trend of the successions.
3. Composition banding is widespread and there is a preference for certain minerals like hornblende and biotite to occur in distinct bands. Metamorphic differentiation, it must be admitted, may also produce banding.

The abundance of quartz throughout these contact amphibolites probably suggests the presence formerly of abundant siliceous material.

As mentioned earlier the Geological Survey (Visser, 1956) has included these rocks in the basic suite of the Jamestown Complex. Theoretically there are only two possible rock assemblages that on metamorphism, could alter to the hornblende-plagioclase-quartz schists or hornfelses that occur along the granite contact.

The two possibilities are

1. basic or ultrabasic igneous rocks.
2. siliceous dolomites and limestones of various compositions (Turner and Verhoogen, 1960).

The introduction of increasing temperatures would cause the physical and chemical nature of the sequence to undergo changes with the formation of a new mineral assemblage. If siliceous dolomites and limestones of varying composition are subjected to metamorphism, then reactions involving the progressive elimination of carbon dioxide take place. The amount and intensity of the process is dependent on the temperatures and pressures existent at the time.

(c) Green Amphibole Schists

(1) Field Occurrence and Description

It was found with these rocks as well as the other basic rocks in the area that they grade rapidly and often imperceptibly from one variety to another within short distances. This was also found to be the case in areas to the south of the Barberton Mountain Land by Pretorius (1948). An attempt was made to differentiate between the types where possible but locally occurrences of any one of the basic schists may be found within the broad group.

The green amphibolites, consisting primarily of massive light green actinolite or tremolite, occur mainly south of the contact amphibolites and forms a considerable thickness that is well exposed in the road cutting through Honeybird Creek. The contact zone between these green amphibolites and the dark contact amphibolites is sharp where exposures permit observations. There are however, large flat areas on the farm Naude's Rust where the formations are hidden beneath soil and scree cover, and it is only towards the east approaching Louw's Creek that contact relationships can be determined. Also near Sudden Siding sharp conformable contacts are displayed. To the south of the Lily range the

tremolite schists make an appearance at scattered intervals between Crystal Stream and Camelot Farm.

In hand specimen the typical light green needles of tremolite and actinolite are seen to constitute the greater portion of the rock. In thin section the rocks generally contain varying amounts of carbonate material, talc and magnetite. A little chlorite is invariably present as well. Locally, euhedral rhombic crystals of sphene and prismatic chloritoid needles were noted. There is a notable absence of dark green hornblende and plagioclase feldspar. Accessory minerals that accompany the light green amphibole schists also include ilmenite and its alteration product, leucoxene with biotite and apatite fairly prominent especially from the Naude's Rust area.

(11) Structure

The green amphibole schist sequence lies conformably above the contact amphibolite schist zone. The rock possesses a foliation that once again parallels the regional trend of the formations and is practically everywhere vertical or steeply dipping to the south.

Indications were found in the strongly schistose amphibolites, of two superimposed lineations. These rocks are however, not conducive to the recording of structural phenomena, and it was only in rare instances that minor structures could be recognized in outcrop. The rocks have recorded the deformations as is evidenced by microscopic folds seen in thin section but it appears that in the field, the rock that will probably display the structural phenomena must be partly weathered.

Microscopic structures vary little from those seen in the contact amphibolites. There is a tendency at times for the mineral orientation to become less regular and radiating tremolite needles are occasionally seen probably indicating that the confining pressures were less intense.

(111) Metamorphism

The metamorphic effects produced by the granite intrusion in the north are also undoubtedly reflected in this zone. The grade of metamorphism is slight in comparison with the hornblende schists.

From north to south there is a progressive decrease in hornblende and a corresponding increase in the amount of tremolite-actinolite present. Once again compositional banding is evident. This is particularly clearly shown in the road cutting through Honeybird Creek.

The sharp contact between the dark amphibolites in the north and the light green amphibole schists may be ascribed to a possible combination of factors. These are (a) a decrease in heat and, therefore, a lowering of the metamorphic grade and (b) a compositional variation or change of the pre-existing formation.

The metamorphic mineral assemblage in order of abundance was found to be: tremolite and actinolite, chlorite, biotite, talc and locally some sphene and chloritoid. The northern portions of the sequence may contain some green hornblende and plagioclase feldspar (albite). Quartz is ubiquitous though sometimes it occurs only as a fine matrix.

The tremolite-actinolite schist zone would conform to an outer margin of a contact aureole. The mineral assemblage constituting this zone allows it to be placed in the albite-epidote-hornfels facies of Turner and Verhoogen (1960). The pressure-temperature conditions that were probably operative is shown to be approximately $P_{H_2O} = 1,000$ bars and $400^\circ C$, although temperatures as low as $200 - 250^\circ C$ are sufficient for tremolite to form (Bowen in Barth, 1952).

(iv) Origin

These rocks have much in common with those discussed earlier belonging to the contact amphibolite zone. Mineralogical banding is again evident but there is a lack of quartzitic or silica rich horizons. The overall deficiency of quartz may be attributed to a lack of this constituent in the earlier formations prior to metamorphism.

Tremolite has been regarded as one of the first formed metamorphic products in an equilibrium series of reactions involving progressive elimination of carbon dioxide from siliceous dolomites at any given pressure in an advancing temperature environment (Foley, 1948). From an impure dolomite the first formed new mineral would be talc and with advancing metamorphism tremolite would appear.

The occurrence of chloritoid, an iron-alumina silicate into which little or no magnesia can enter probably indicates special conditions for its development from a possible sedimentary succession. Barth (1952)

states that chloritoid is unable to form in magnesia-rich rocks but does not know the exact conditions of temperature and pressure necessary for its formation.

(d) Talc-Carbonate-Quartz-Chlorite Schists.

(1) Field Occurrence and Description

Under this heading have been included the several varieties of basic schist found almost exclusively on the southern limb of the Lily Syncline. Again, the varieties are gradational from one type to another.

The rock types generally include the following:-

1. talc schists.
2. talc-carbonate-schists.
3. talc-chlorite-carbonate-quartz schists, and
4. tremolite in addition to the minerals mentioned above.

The talc schists apparently are restricted to zones where deformation has been strong. The most common occurrence is along the Lily Fault, especially clearly seen in the neighbourhood of the Lily and Rose's Fortune Mines. Minor showings of talc schist can, however, be encountered practically anywhere south of the Lily ridge. Further development of talc schist occurs in the Scotia Talc Mine where it sometime attains great purity.

Talc-carbonate schists occur in and around the talc mine predominantly, with minor localized patches elsewhere in the zone. Both these rock types are very soft and seldom produce outcrops but are often preserved where they abut against siliceous or cherty bars. The rocks near Eureka Siding and the Scotia Talc Mine are darker green than elsewhere and in thin section consist primarily of a felted mass of talc with carbonates in the matrix and larger aggregates of calcite randomly disseminated throughout the rock. In some instances magnetite is particularly abundant and forms euhedral crystals sometimes occurring in bands or stringers.

The talc-chlorite-carbonate schists make up the remainder of the succession but as indicated previously may also contain zones in which tremolite and actinolite are abundant.

In the field, carbonate rich zones may be marked by the presence of numerous calcite veins that occur in the plane of foliation. Differential weathering produces alternate carbonate zones and quartz-

chlorite schist zones. Tourmalinization of the schists is common especially in the neighbourhood of quartz-tourmaline veins. The tourmaline is invariably the iron-rich variety schorlite and occurs as euhedral prismatic crystals. Some thin sections of rocks near the talc schist belt in the Lily Mine indicate the presence of antigorite. Some of the talc-chlorite zones contain abundant fine cherty quartz present in layers between the chloritic material.

(ii) Structure

The rocks generally display a strong schistosity. The talc schists near the mine have the appearance of being sheared. On the whole, outcrops are poor and only in artificial exposures, e.g. the Main Quarry of the Lily Mine, can any structure be seen. The schistosity is again developed parallel to the regional trend of the formation. Minor flexures and contortions with horizontal or nearly horizontal axial planes were noted.

The other schistose rocks are more brittle and in the field are seen to display only a well developed foliation that is vertical or steeply dipping. In thin sections a marked banding of chloritic material is seen together with alternate siliceous and cherty bands. Boudinaged structures indicate considerable compression perpendicular to the foliation trends.

Where weathered the talc schist often has a sponge-like appearance with numerous holes and cavities throughout the rock. In some cases a section cut across a less weathered specimen shows numerous euhedral cubic specks of a mineral altered to limonite.

(iii) Metamorphism

The metamorphic mineral assemblages of this basic suite of rocks are indicative of a low grade metamorphic zone.

Talc and chlorite are the main minerals produced by the metamorphic alteration with tremolite occurring locally. Whereas the chlorite is invariably aligned in alternating bands or layers the tremolite is often seen to be growing at right angles to the foliation planes. Frequently circular radiating needles of tremolite were noted within a finely crystalline quartz matrix.

The talc occurs in felted masses that do not bear much relationship to the foliation planes. Carbonate is frequently

intimately connected with the talc and tremolite. Rhombic crystals of calcite showing twinning often appear as a centre around or from which the tremolite laths radiate.

The entire basic suite conforms to the greenschist facies introduced by Eskola (1921). Some doubt exists as to the upper limit of the greenschist facies, i.e. what is the borderline in the pressure-temperature field separating the greenschist facies from the albite-epidote-amphibolite facies. Vogt (1927) and Eskola (1921) differ from Turner (1948) in that they disallow actinolite entirely from the greenschist facies while Turner admits it into the upper part of this facies. Ramberg (1932) shows how the Mg/Fe ratio as well as the Al content effects the equilibrium temperatures and it would appear that he too is in favour of allowing actinolite into the facies.

Turner and Verhoogen (1960) give an approximate temperature and pressure range for the greenschist facies in deeply filled geosynclines as being between 300° and 500°C and P H₂O = 3,000 to 8,000 bars. The low grade metamorphic assemblages displayed in the report area have probably not been affected by such a high temperature-pressure range but were most likely formed at temperatures of 100° to 250°C or less (Barth, 1932).

It was mentioned earlier that talc schists were largely restricted to fault zones or where deformation was strong. This phenomena may be due to a retrogressive metamorphic readjustment of a higher temperature assemblage to a lower temperature assemblage. The hydrothermal activity along the Lily Fault coupled with strong deformational shearing may have been responsible for the talcose assemblages. Hydrothermal activity in the Scotia Talc Mine was probably largely responsible for the production of the high grade talc deposits.

(iv) Origin

Low temperatures have produced a correspondingly low grade of metamorphism. Tilley (1948) regarded the talc assemblages as being the first formed new minerals derived from the metamorphism of siliceous dolomites. He ascribed the production of talc and tremolite in the outer aureole to a series of reactions involving increased decarbonation.

Although a large proportion of the talc-carbonate-quartz-chlorite schist zone is considered by the writer to have been derived from earlier sedimentary horizons the possibility is not excluded that some of the talc schists might have formerly constituted basic igneous

rocks. Talc schists occur throughout the Barberton Mountain Land but frequently occupy the areas immediately adjacent to large scale faults. Shearing movements along the fault zones are likely to produce a schist of this sort if the composition of the original rock was conducive to talc formation. Equally probable, however, the fault plane could have supplied the channelway for the introduction of basic or ultrabasic magma. Intrusive relationships are lacking and the conformable contacts are inclined to cast doubts on an intrusive origin. The talc schist bodies north of the Lily Mine and the Rose's Fortune Mine are examples of this problem. Metamorphism in the mine itself indicated that high temperatures were involved. These temperatures, however, could have been due to hydrothermal mineralizing solutions and not necessarily the result of heat from a basic intrusive.

It must be mentioned that zones of schist ranging from talc-carbonate schists to quartz-chlorite schists are found in the lower horizons of the Fig-tree succession near the Lily Mine. The Geological Survey (Visser, 1956) mentions similar occurrences in the Sheba Valley. These rocks belong to the Zwartkoppe Zone of the Fig-tree Series. The schists near the Lily Mine occur between chert bars in much the same way as those between the Zwartkoppe Bar and the Southern Cross Bar.

(e) Acid Rocks of the Onverwacht Series

(i) Introduction

van Eeden (1941) included certain horizons south of the Lily Syncline in the Onverwacht Series but these were subsequently omitted from the Series by the Geological Survey (Visser, 1956).

During the course of mapping several persistent acidic horizons were encountered within the dark contact amphibolite zone bordering on the granites. Some of these zones escaped attention prior to this investigation while others were regarded as being "metamorphic rocks of unknown origin" (Geological Survey, Visser 1956).

These rocks that all appear conformably intercalated within the broader schist zones appear to form a part of a "layered sequence" of a stratigraphically developed succession.

A detailed account of each of these horizons is given for the rocks occurring on the northern limb of the Lily Syncline and for the rocks occurring in the anticlinal zone between the Lily Syncline and the Eureka Syncline.

1. The horizons on the northern limb of the Lily Syncline include sheared lineated quartz-sericite schists, quartz-mica-sericite schists, magnetic shales and quartzites and garnetiferous quartzites.

2. In the anticlinal zone there occur talc-chlorite-quartz-sericite schists, probably sheared and altered acid lavas and quartz porphyries.

(ii) Northern Limb of Lily Syncline

1. Field Occurrence and Description

Within the contact amphibolite schist zone there are isolated siliceous horizons the main development of which occurs in the central and westerly portions of the area. Good exposures of a lineated quartz-sericite schist are to be found in the railway cutting northeast of Eureka Siding. The Kaap River in that area also reveals some clear exposures.

Towards the west the quartzites or siliceous horizons may be followed with minor interruptions past the Bar 5 beacon into the adjacent area and well to the north of the New Consort Mine (M. Viljoen verbal communication).

The horizons are seldom very wide and vary from a few feet to a maximum of about 150 feet. The narrowest development is in the west where all the successions diverge, some being pinched out altogether.

In thin section these siliceous horizons consist essentially of quartz and sericite with local development of biotite and muscovite flakes, small quantities of twinned and untwinned feldspar (generally albite or microcline) tourmaline, almandine garnet, pyroxene (diopside-sillarsite) clinozoisite, magnetite, ilmenite and leucosene. On Bon Accord farm garnet porphyroblasts are developed, some of which are nearly an inch in diameter.

Towards the east the outcrops are poor and are confined to exposures in river and stream channels. In many instances these siliceous units occur adjacent to the granites and it is often impossible to differentiate between the two rock types in the field.

A magnetic shale and quartzite horizon is confined to the central portion of the area on the farm Annex Riverbank near Sugden Siding. The horizon, composed essentially of massive quartzites with

The quartzites are essentially impure and consist of quartz and ferruginous material - limonite, goethite, magnetite and ilmenite. The shales are also ferruginous and are not unlike a banded ironstone in appearance. Only rarely is this horizon magnetic. Granulite amphibole was also noted. The thickness of the unit was never more than about 50 feet wide.

The deformed quartz-sericite schists are mylonitized and, due possibly to their brittle nature, the rocks have recorded strongly developed lineations. These are well displayed in the railway cutting mentioned previously, where they plunge to the southwest (see more detailed discussion on the lineations under Structural Geology).

The sillaceous zones possess a strong foliation with micaceous developed in the foliation planes. Generally, the dip of the foliation is vertical or to the south at steep angles, again in accordance with the regional trend. Minor variations occur especially in the disturbed and folded regions north of Bar 5.

In thin section, there is a marked parallel alignment of the constituent minerals. The phyllosilicate component is, in particular, well orientated and are disturbed only by garnet porphyroblasts, around which they have a tendency to curl or "flow". The quartz is fine-grained, microcrystalline at times with occasional "nests" of larger fragments or aggregates.

Structures are generally absent in the magnetic shale-sandstone horizon. The rocks are poorly bedded except for the shales which dip steeply to the south.

Metamorphism of the siliceous and quartzitic horizons has locally been of an exceptionally high grade for, in addition to the already mentioned mineral assemblages found in these rocks, there is development of sillimanite. This high temperature metamorphic mineral is best developed in the western regions but occurs principally where the quartzites are in direct contact with the granite and where the quartzites are also restricted to these zones. Pegmatite intrusives. Pyroxenes are also restricted to these zones.

- 40 -

Extensive development of garnets take place in the zones closest to the granites and provide a useful marker horizon. The grade of metamorphism decreases in the southernmost of these siliceous bands and the metamorphic assemblage consists primarily of micas, a few garnets with poeciloclastic texture and minerals such as clinzoisite, sericite, microcline, and magnetite-ilmenite.

Turner and Verhoogen (1960) have stated that the high grade minerals sillimanite, almandine and diopside may occur in the hornblende-hornfels facies in the immediate vicinity of granite contacts. The development of these minerals is greater, however, in the pyroxene-hornfels facies and in the almandine-amphibolite facies. As the sillimanite bearing rocks are isolated and do not form a broad continuous zone it is considered unjustifiable to introduce either one of these last mentioned facies merely to accommodate the scattered appearance of this mineral.

The temperatures necessary for the formation of the contact amphibolite have already been shown as being between about 550°C and 700°C. The upper temperature range coupled with pressures of approximately 2,000 bars water pressure was probably operative for the sillimanite formation.

Elsewhere and with increasing distance from the granite contact the temperatures would be lower and classification into the hornblende-hornfels facies would not be unreasonable. (See Fig. 27)

Apart from grunerite no new metamorphic minerals are developed in the shale-quartzite horizon near Sugden Siding. The principal readjustment was the fusing of the sequence into a massive quartzite in which the bedding relationships have been obliterated.

4. Origin

Some of the horizons give the impression of having once constituted a pure quartz sandstone or orthoquartzite sedimentary layer while others, containing abundant quartz and sericite, may have represented acid igneous lavas or porphyries. Their persistent development over long distances and their conformable relationship with the surrounding amphibolitic horizons points strongly to the validity of the layered sequence argument.

It must be mentioned that magnetic shale horizons are reported from elsewhere in the Barberton Mountain Land. One occurrence is known

belonging to the Lower shale horizon of the Moodies System while the Middle and Upper Shales of the Eureka Syncline possess magnetic shales composed almost entirely of magnetite (Geological Survey, Visser, 1956). The possibility, therefore, cannot entirely be discounted that the occurrence near Sugden Siding is a remnant of the Moodies System.

Due to its position in the area however, the writer considers it more likely that it forms part of the Pre-Moodies formation.

(iii) Southern Limb or Anticlinal Divide between the Lily Syncline and the Eureka Syncline.

1. Field Occurrence and Description

On the southern limb of the Lily Syncline and stretching from east to west is a narrow zone of siliceous rocks in places intercalated with basic tremolite or talc-chlorite-quartz schists. Exposures are generally poor but in the east the formation is strongly developed and builds a prominent ridge that reaches its maximum development north of the Lily and Rose's Fortune Gold Mines. This zone was formerly mapped as the doubtful metamorphic zone of unknown origin by the Geological Survey (Visser, 1956).

Additional exposures occur in the Kaap River near Eureka Siding and on the main road near Honeybird Creek. The sequence consists essentially of acidic rocks with intercalated zones of basic material. In a few instances, north of the Lily Mine and where the sequence diverges north of the Rose's Fortune Mine, finely bedded "varved" slates were noted together with poorly developed banded ferruginous cherts. The slates are dark in colour with individual layers less than a millimeter thick. The colour of the individual layers varies from light gray to black. Metamorphism of a low grade has affected these rocks and no new minerals were formed but in places the fine bedding has become obliterated.

The writer, and earlier van Eeden (1941), could find no significant difference between the intercalated basic rocks and the talc schists, talc-carbonate-chlorite-quartz and tremolite schists mentioned earlier in this report. Microscopically there is also no apparent difference.

The siliceous zones form resistant low mounds and in places lofty ridges. In places the rocks resemble cherts. Outcrops display a sheared sericitic lustrous rock with numerous small cherty-quartz nodules that may represent altered amygdalae or phenocrysts (see Plate 8). In this section the rocks are composed almost entirely of quartz and



(Plate 8) Small chert or
quartz nodules in acid
schists immediately north
and northwest of the Lily
Mine. The nodules are
probably representative of
altered amygdaloids.
(Onverwacht Series)



(Plate 9) Microfold in quartz-
sericite schist. Note the
parting or cleavage along
planes composed essentially
of sericite and chlorite.
(Onverwacht Series,
north of Lily Mine.)

(Ordinary light x45)

sericite mica. Felspar, both plagioclase and orthoclase, in various stages of alteration to sericite, is common. Minor amounts of magnetite occur in parallel layers while quartz "nests" within the microcrystalline matrix occur regularly. The rocks are similar in many ways to the horizons of siliceous rock found on the northern limb of the Lily Syncline.

A dark waxy sheared variety was found near the road on Crystal Stream. Microscopically the mineral assemblage of this rock was the same as that mentioned above, with only the dark matrix being different. This matrix was too fine or cryptocrystalline to identify under the microscope. The colour of the matrix was probably due to impurities in the sericite or chloritic material. In general the rocks were found to be quartz-sericite schists.

In order to gain some comparison, samples of deformed Onverwacht rocks were obtained from exposures in the neighbourhood of Three Sisters, some 5 miles to the northeast of the area dealt with in this report.

Thin section study gave essentially the same features and mineral constituents, only the degree of deformation or apparent shearing was far less intense.

2. Structure

Due to the fact that these rocks are largely of a brittle nature they have recorded numerous small scale or minor structural features such as crenulation folds, and conjugate folds (see Plates 10 and 11). The sequence once again is parallel to the regional trend. The formation appears to be intensely sheared with the result that a strong foliation has developed parallel to the strike of the horizons. The foliation is almost vertical or it dips steeply to the south.

In the eastern portion of the area near Louw's Creek, the formation is separated by basic talc schists and serpentinitic rocks. It would appear just from aerial photographs that this unit could be a westerly plunging anticlinal structure but no field evidence of any sort could be obtained to substantiate such a proposal.

Minute accordion folds, crenulation folds and at times conjugate folds, can be seen at intervals between Shebs Siding and Louw's Creek. Sharp jagged outcrops occur on the crests of the ridges. A more complete account of the structure is given at a later stage under Structural Geology.



Plate 10: Small scale crenulation folds with associated conjugate folds. Quartz schists - schists of the Enverwacht Series north of the Dwyer line.



Plate 11: One set of conjugate folds intersecting crenulation folds. Quartz schists - schists of the Enverwacht Series north of the Dwyer line.

Microscopic structures were largely obliterated by the strong foliation and parallel alignment of the mineral constituents. Boudinaged quartz "nests" are prominent (see Plate 60). These may be deformed amygdaloids or quartz phenocrysts of an original acid lava. Minor accordion folds seen under the microscope tend to part or cleave along planes composed essentially of sericite or chlorite (see Plate 9).

3. Metamorphism

Metamorphism has produced chlorite and chloritoid. The chloritoid invariably occurs as euhedral hexagonal crystals displaying at times hour glass structure and polysynthetic twinning. Occasionally the chloritoid crystals occur in radiating groups while in some instances euhedral crystals were seen orientated at right angles to the foliation and schistosity indicating that they formed subsequent to the deformation (see Plates 12 and 13).

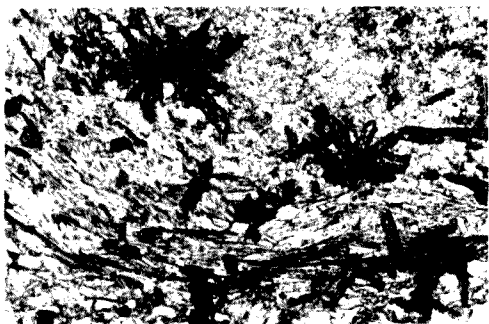
The rocks generally contain abundant silica which prompted van Seden (1941) to state that he thought the intrusion of the basic James-town Complex had silicified many of the formations including the Lilly Syncline quartzite-conglomerate zones.

The metamorphism is unusual in that it is more of a destructive type rather than a constructive type. This is evident from the absence of large well formed crystals and a corresponding prevalence of fine, almost mylonitic material. It would appear that the destructive deformation might have been produced at an early stage, probably with the 1st. and 2nd. phase of events as laid out later under the section on Structural Geology. Superimposed on this regional metamorphism the heat effects of the intrusive granite in the north could have been responsible for the subsequent alteration.

The rocks, due to their low grade metamorphic mineral assemblages, can only be placed in the low grade greenschist facies. Turner and Verhoogen (1960) have given a possible range of temperature and pressure conditions for stability of typical greenschist minerals. Their estimates range from 300° - 500°C temperature at lower pressures ranging from 3,000 to 8,000 bars.

4. Summary

Again these rocks will be considered in a later section but briefly it is thought possible that some of the acid phases represented might well have formerly been acid volcanic lavas or quartz porphyries.



(Plate 12) Radiating clusters of individual prismatic crystals of chloritoid in quartz-sericite schist. Manner of crystal growth indicates post deformational origin of the chloritoid. North of Lily Mine. (ordinary light x75)



(Plate 13) Tabular chloritoid crystal growing almost at right angles to the schistosity. Quartz-sericite schist (Inveracht, England) (x75)

In this regard then, the writer favours van Eeden's (1941) idea and includes the sequence in the Onverwacht Series. The isolated shale or slate horizons and banded ferruginous chert occurrences might represent a further manifestation of the "layered sequence" proposal.

D. FIG-TREE SERIES - SWAZILAND SYSTEM.

(a) Introduction

This Series is composed predominantly of an argillaceous sedimentary succession. The rocks include a very varied group of shales, graywackes, banded ironstones, cherts, talc-carbonate-chlorite schists and an upper lava or tuffaceous horizon. Within this sequence is the mineralized zone along which are situated numerous old workings and the Lily and Rose's Fortune Gold Mines.

(b) Field Occurrence and Description

The Fig-tree succession is mostly confined to southern portions of the area. It occupies portion of the Kaap River Valley to the west of Sheba Siding where it occurs as a narrow strip largely obscured by scree and soil cover. It reaches its maximum development in the southeast on the farm Lilydale and gradually tapers in a wedge shape towards Eunaka Siding.

At the base of the succession the rocks abut against basic schists, and consist essentially of narrow well bedded shaly horizons and a few graywacke units.

Laterally the sequence may grade from shales to banded ironstones and banded ferruginous cherts.

The banded chert horizons are usually fairly persistent and can be traced almost without interruption across the entire area. The cherts are fine-grained, hard, compact rocks and invariably form low ridges. Often the banded cherts are light coloured with dark gray to whitish bands, locally ferruginized to a banded ferruginous chert. Metamorphism has produced numerous variations and mineral assemblages are particularly well displayed in the Lily Mine. The mineralization while not entirely confined to the base of the succession is mostly of economic significance along the Lily Fault. The term "base of the succession" is applied to the Fig-tree rocks found in the Lily and Rose's Fortune Mines refers to the base as it exists today - there being no evidence of Fig-tree rocks to the north. Because the mines occur on what might

possibly be a fault zone (or an) the true base could conceivably have been eroded away. A few of mineralization occur in the banded chert horizons to the southwest of the Lily Mine. The shales give way in the south to a predominantly graywacke sequence. These are variable in colour and grain size. Usually a wide variety of brown and khaki coloured sediments predominate. Rhythmic alternation of coarse and fine material is frequently observed. Within the sequence, and exposed to the southwest of the Lily Mine, are a group of carbonate-rich horizons intercalated with altered sericite and chloritic schists. The zones are often several hundred feet wide and on outcrop the carbonate is present as crystalline or partly crystalline rhombic calcite. The rocks probably represent former impure limestones as fairly large areas are involved.

As was mentioned earlier, horizons of concordant basic schists were noted in the lower Fig-tree sequence near the Lily Mine. The schists may correspond with those in the Zwartkoppie Zone at or near the base of the Fig-tree Series as recognized in the type locality in Sheba Valley.

In thin section the typical graywacke consists of fine, medium and coarse grained, ill-sorted angular to subrounded particles of quartz, chert, feldspars, chlorite and a usually obscure matrix of quartz, clay minerals and ferruginous material.

Towards the top of the Fig-tree succession there is a gradual, almost imperceptible gradation from graywacke to a rock mapped by van Eeden (1941) as a trachytic lava. These form a well defined stratigraphical unit underlying much of the Basal Conglomerate of the Moodies System. The rock is fine to medium textured and resembles a graywacke, especially where weathered. This close visual similarity has caused some doubt to be cast on previous observations and conclusions. Ramsay (1963) found little evidence to warrant the term 'lava' being used and suggests that the rock be called a felspathic graywacke.

Higher up in the "lava" succession the rock becomes coarser and has large inclusions imparting to the unit a conglomeratic appearance. The nodular masses are drawn out and aligned in much the same way as the adjacent Basal Conglomerate (see Plate 15). van Eeden (1941) and the Geological Survey (Visser, 1956) regarded the nodular mass as autoliths formed when the lava was partly crystallized, yet still in a fluid state. The fact that the nodules are drawn out and orientated parallel to the bedding or foliation plane would seem to indicate that they behaved in much the same way as the conglomerate pebbles; being flattened by compression and then undergoing cleavage deformation normal to the compression direction.

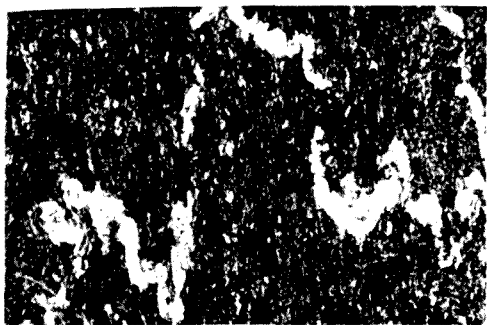


Plate 14) Photomicrograph showing microfolding of a quartz vein as a result of differential shear movement in the metamorphosed Fish-tree shales. (ordinary light x45, rhy line.)



Plate 15) elongated and flattened laumontite or conglomerate pebbles in lava or felspathic tuffaceous graywacke, Upper Clinton Series.

Road cutting west of Sheba siding.

The Survey also regarded the fact that the nodules are restricted to the upper sections of the unit as further evidence in favour of a primary origin for the nodules themselves. The writer on examination of the Sheba Siding exposure felt there was little field evidence to support the view that these rocks were lavas. There is a profound absence of typical lava textures such as flow structure, pillow structure and amygdalae. The new road cutting west of Sheba Siding (Bazy's Pass) displays an almost entire cross-section of the conjectural "lava" horizon. A series of samples were taken for thin section study at intervals along the exposure. A similar traverse was undertaken near Clutha Mine in the vicinity of Noordkaap Station, where further good exposures occur. The autolith or nodular horizon was found to contain elongated chert pebbles at Sheba Siding while at Clutha both chert pebbles and large fragments of jasper are contained in the upper portions of the horizon.

Thin section study of the rocks of both localities indicated the following main features:

1. There is no microscopic evidence of flow structure or foliation although certain zones do display alignment of chlorite and matrix. This alignment was most prevalent immediately in contact with the Basal Conglomerate at Sheba Siding and near a gabbro dyke at Clutha. The slight foliation at Clutha might also be ascribed to the strong cleavage that is developed in that area.

2. There is a decided lack of quartz in the rocks and an abundance of feldspathic material. The feldspars (untwinned oligoclase-albite, perthites and microcline) generally exhibit incipient alteration to sericite.

3. Many of the larger feldspar crystals display perfect euhedral crystal form and zoning is not infrequent.

4. The typical mineral assemblages are:- plagioclase feldspar (twinned and untwinned), green chloritic crystals and matrix, biotite, quartz, magnetite, ilmenite and a few pyrite cubes. The quartz is largely confined to the matrix although some sections show isolated quartz "nests". The accessory minerals usually include epidote, apatite and carbonates.

5. The texture of the rocks are variable but essentially the larger feldspar crystals are euhedral in shape while the smaller particles are decidedly angular. The grain size variation and mineral angularity is similar in many respects to a graywacke.

(c) Structure

The Fig-tree succession as a whole consists of thinly bedded units. This lithological arrangement is largely responsible for the Series behaving as an incompetent mass between the Mondies System above and the Onverwacht Series below. The result has been that the shales and banded ironstones, in particular, have been intensely folded and contorted. The upper graywacke succession does not display the intensity of disturbance.

Typically developed in the shale horizons, are tight isoclinal folds, while the chert zones being more brittle, break angularly especially in the hinges of tight folds.

There has been a large amount of cleavage and schistosity development in the shale horizons especially near the Lily mine. Pe- adjustment of mineral components, especially amphibole needles, in the bedding plane has produced a strongly developed planar fabric. In the mine, shearing is evident due to the slickensided faces seen in the bedding plane. Brecciation frequently accompanies the shearing. A more complete structural account of the mine is given at a later stage. Additional structural information is confined to clear surface outcrops where graded bedding can be used to determine the direction of younging of the sequence. Cleavage is absent, or if present, occurs in the bedding plane and is thus obscured. Finally it must be mentioned that the bedding attitude in this zone of Fig-tree sediments is very irregular. The sediments are normally very steeply dipping or vertical but may dip north or south within a matter of feet from one observation to the next. This variation is due to the numerous tight isoclinal folds occurring in the sequence.

(d) Metamorphism.

Metamorphism in this succession is not universally displayed and is largely dependent on certain factors. The intensity of deformation and the occurrence of hydrothermal mineralized zones causes local variations in the metamorphic assemblages. In the Lily Mine for example, metamorphism has resulted in the formation of tremolite-actinolite, garnets, biotite, chlorite and sericite. The quartz has also undergone a change and is partly crystalline and chert-like. Tourmalinization of the sediments, as well as the ultrabasic and basic schists was noted. This aspect is dealt with under Quartz Veins later in this chapter. The Fig-tree Series generally is poorly metamorphosed and only rarely does it display features sufficient to classify it into

anything but the lowest grades of the greenschist facies. The metamorphism seen in the Lily Mine was, therefore, largely dependent on the heat effects of the hydrothermal mineralizing solutions or the intrusion of basic rocks of the Jamestown Complex (discussed later in the chapter on the Lily Mine).

(e) Possible Origin of the "Lava" or Tuff Horizon

A further suggestion as to the probable origin for the uppermost horizon of the Fig-tree succession would be to consider the rocks as representing a volcanic tuff or tuffaceous graywacke with a porphyritic texture. Pettibohn (1957), describes pyroclastic deposits, formed by volcanic eruption, as also being in part porphyritic. He mentions the close microscopic similarity between these rocks and graywackes.

As was mentioned earlier the feldspar crystals exhibit zoning. It is suggested that this zoning might be attributed to the formation of the crystals in the partially solidifying mass, prior to explosive eruption. The absence of glass fragments, shards and spicules as well as the fact that no welded tuffs are found would seem to indicate that the volcanic mass was fairly cool and partially crystalline prior to expulsion.

The nodular occurrences together with the chert and jasper fragments would possibly represent explosive bomb-like concentrations of congealed magma and shattered sedimentary formations respectively.

Later deformation has flattened the fragments and has probably caused the vertical elongation of the components. This flattening and elongation is, however, not universal and is not well developed at Clutha.

(f) Other Occurrences of the Fig-tree Series

A narrow zone of Fig-tree rocks occurs to the north and northwest of the trigonometrical beacon Bar 5. The succession has largely been modified by the adjacent granite intrusives. Also in this area the metamorphic equivalent of the upper lava or tuffaceous succession is developed. The horizon is narrow north of the beacon, pinching out in the east as a result of serpentinite invasion. In the west it widens out considerably. Lying conformably beneath this horizon are shales and hornfelses known in the New Consort Mine area as the Consort hornfelses. The shales have abundant garnet porphyroblasts that act as a good marker horizon. Numerous old trenches occur along the zone known as the Consort Contact. This stratigraphic horizon can be traced several miles to the west to the New Consort Mine where it is the main

old ore horizon.

The entire Fig-tree succession northwest of Sheba Siding becomes narrower towards the east and is finally engulfed by intrusive granites and serpentinites. Granitic and pegmatitic intrusions are responsible for the absence of the succession in the area northeast of Joe's Luck Siding.

E. MOODIES SYSTEM

(a) Introduction

In contrast to the pelitic or shaly succession of the Fig-tree Series, the rocks of the Moodies System are predominantly psammitic and psamphitic sediments dominated primarily by quartzites and conglomerates. No angular unconformity between the Fig-tree Series and the Moodies System has ever been found in the area. The Geological Survey (Visser, 1956) have based the unconformity on deduction from several factors viz. the sharply contrasted sedimentary nature of the two formations; the occurrence of Fig-tree and Onverwacht pebbles in the Moodies conglomerates; a basal conglomerate and evidence indicating a considerable time lapse between the Fig-tree Series deposition and that of the Moodies System.

The Moodies rocks in the report area differ from most other Moodies occurrences in the Barberton Mountain Land in that they have been subjected to more severe deformation and metamorphism.

(b) Field Occurrence and Description

Moodies rocks in the area are primarily confined to the Lily ridge, a conspicuous mountain range that occurs along the northern rim of the Mountain Land from Noordkaap Station in the west to Three Sisters and beyond in the east; a total distance of about 25 miles. The Syncline reaches its maximum development in the east near the beacon Holnek. In the mapped area between Sheba Siding and Louw's Creek the Lily Syncline is best developed in the east where it reaches an elevation of 3,000 feet and more in places. The range is broadly concave towards the granites in the north and has generally an east-west trend. The Lily Syncline's Moodies succession has as its base several hundred feet of Basal Conglomerate consisting of pebbles of chert, banded ironstone and quartzite. The conglomerates grade laterally along strike into quartzites and the latter are frequently altered or recrystallized to massive light coloured rocks with a cherty texture.

Deformation, largely the result of compression and flattening, has produced considerable alteration resulting in the rocks being almost unrecognizable at times. The conglomerates are best developed in the Lower's Creek region where they make up most of the succession. Scattered zones of conglomerates occur along the entire length of the Syncline but are frequently obscured by the intense mylonitization, particularly in the central portions of the area. Good conglomerate development occurs again to the north of the Scotia Talc Mine where it attains a considerable width.

Formerly, it was considered by van Eeden and the Geological Survey (Visser, 1956) that the Lily Syncline turned southwest of the talc mine and continued along the northern rim of the Kaap River Valley to Joe's Luck Siding. It was possible, however, through detailed mapping, to trace the conglomerates to the northwest where they pinch out rapidly. They were located again immediately north and northwest of the Bar 5 beacon, from whence they again turned southwest to link up with the conglomerate horizon north of Joe's Luck Siding.

It is now considered that the large masses of quartzite in the Bar 5 area, formerly mapped by the Geological Survey as "contact metamorphic rocks of uncertain origin", are in fact Moodies rocks that are altered by metamorphism from the intrusive Jamestown serpentinites and the Nelspruit Granites.

Thin sections of typical Moodies quartzites from the area reveal the following minerals. Quartz is by far the most abundant and occurs in a variety of sizes and textures depending on the amount of deformation and reconstitution that took place. In addition there is often a little feldspar that invariably displays incipient alteration to sericite. Muscovite mica is more common than biotite but both are only locally developed. The Geological Survey, (Visser, 1956) mentions that the Lower Moodies quartzites of the Mountain Land in general are carbonate-rich rocks. No carbonates were seen in the Moodies rocks of the Lily Syncline although the occurrence of zoisite and clinozoisite would seem to indicate an originally calcareous sediment which was also partly aluminous. Accessory minerals include magnetite and ilmenite together with a few rutile grains. Poorly developed garnets with poikilitic textures occur in the impure quartzites while in certain localities, for example north of the farm Crystal Stream, abundant sericite and fuchsite mica imparts to the rocks a pale greenish colour. These rocks are not unlike the quartzites found in the Hospital Hill Series of the Witwatersrand System. Pretorius (1948) also described similar rocks on the Swaziland side of the Barberton Mountain Land.

Fuchsite mica, identified by its dark green colour and strong green pleochroism in thin section, was also frequently found in cracks and bedding planes. Here it occurred as small radiating crystal masses or clusters (see Plate 61). An occurrence of pinkish-red tourmaline (elbaite) was noted northeast of Eureka Siding. The tourmaline imparted a purple colouration to the quartzite outcrops.

Shales are generally poorly developed within the Lily Syncline, but occur sporadically between Bar 4 beacon and the Lily beacon in the central part of the range. They form flattish areas on the crests of the ridges and are composed essentially of arenaceous varieties, reddish in colour, grading into impure ferruginous quartzites.

Bordering on the southern portion of the area mapped is an additional horizon of basal conglomerate belonging to the Eureka Syncline. This horizon could be traced with certainty for a considerable distance from Noordkamp in the west, well into the area discussed in this report, it was found convenient to terminate the mapping on this horizon. The basal conglomerate lies conformably above the "lava or tuff" horizon of the upper Fig-tree Series. Only in the east on sections of the farm Crystal Stream does it lie directly on shales and graywackes.

The conglomerate, in contrast to that occurring in the Lily Syncline, is in a less well consolidated form and contains an assortment of flattened chert, banded chert, quartzite, jasper and granite pebbles. The granite pebbles are, however, less deformed than the chert pebbles (see later under Deformed Conglomerate Pebbles).

(c) Structure

The Lily Syncline is a large isoclinal fold with both limbs of the structure dipping to the south at approximately 75 degrees. The southern limb is overfolded to the north. The central portion of the Syncline is a tightly closed fold, again dipping south. Towards the west the formation narrows and then splits into 3 separate bands that continue almost without interruption from Eureka Siding into the adjacent area near Joe's Luck Siding.

The split is caused by large masses of intrusive serpentinite that have been forcibly injected into the quartzites causing them also to disrupt or alter the regularity of strike and dip. Near Bar 5, the quartzites occupy a considerable outcrop area attributable to the flatter dips of the beds.

Author Anhaeusser C R (Carl Robert)

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