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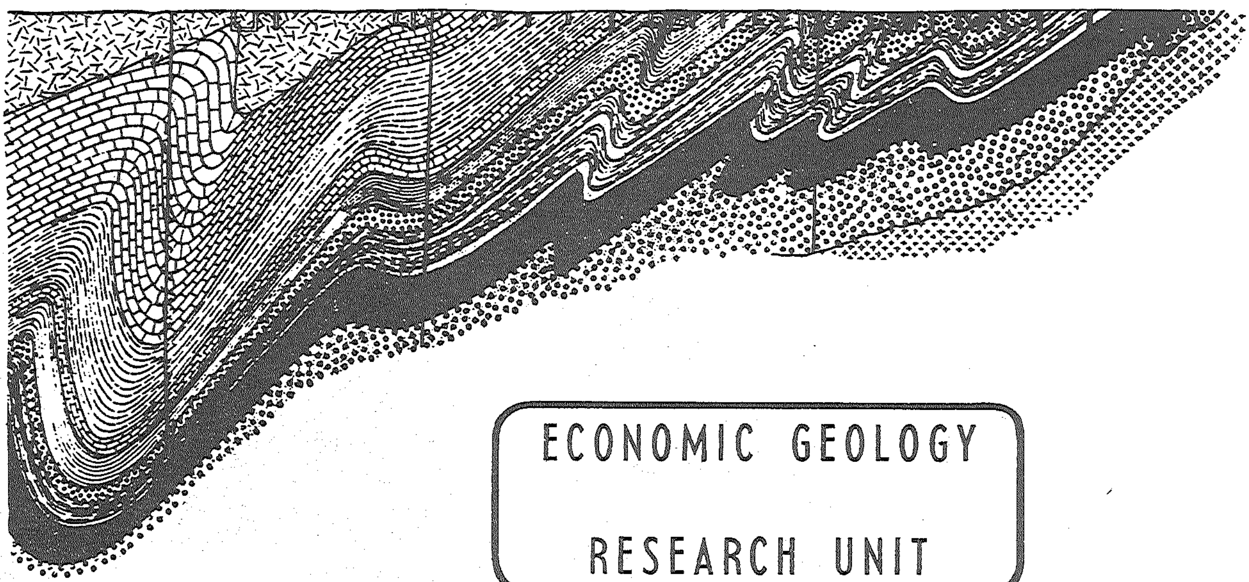

ECONOMIC GEOLOGY

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THE BASE OF THE SWAZILAND SYSTEM IN THE BARBERTON - NOORDKAAP - LOUW'S CREEK AREA, BARBERTON MOUNTAIN LAND

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by

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INFORMATION CIRCULAR No. 25

JUNE, 1965

INFORMATION CIRCULAR No. 25
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THE BASE OF THE SWAZILAND SYSTEM IN THE BARBERTON - NOORDKAAP - LOUW'S CREEK AREA, BARBERTON MOUNTAIN LAND

ABSTRACT

A description is given of the stratigraphy and metamorphism of a complexly deformed portion of the northwestern part of the Barberton Mountain Land. The major portion of the area is situated between the Consort Gold Mine at the eastern extremity of the Jamestown Hills and Louw's Creek, some 15 miles still further east, and covers a region along the contact zone between the ancient layered Archean rocks of the Swaziland System and the Nelspruit Granite. In addition,a narrow zone of basic rocks between the Kaap Valley Granite and the Eureka Syncline, north of Barberton, is included.

A comprehensive account is given of previous work relating to the Jamestown Igneous Complex and the Onverwacht Series rocks in the entire Barberton Mountain Land, especially as it applies to the areas under discussion.

A well-developed, layered suite of basic rocks below the Fig Tree Series and constituting the basal zone of the Lily Syncline is reclassified into the Onverwacht Series. It lies in direct contact with the Nelspruit Granite, and is considered to represent a metamorphosed succession of impure dolomites with arenaceous and minor shaly horizons, together, probably, with some basic and acid lavas. Evidence suggests that rocks of the Jamestown Igneous Complex are not as widespread in their development in this area as was previously contended. Most of the basic hornblende, tremolite-actinolite, or talc-chlorite schists are grouped in the Onverwacht Series, while the basic intrusives consisting essentially of massive bodies of pure serpentinite are grouped into the reconstituted Jamestown Ultrabasic Intrusive Series. There is a possibility that certain of the purer talc-carbonate schists along the Kaap River represent altered ultrabasic intrusives. A remobilized marginal phase of the Nelspruit Granite was largely responsible for the production of a contact metamorphic aureole, the grades within which decrease progressively in intensity away from the contact. Three distinct facies of contact metamorphism can be recognized in the area.

A reassessment of the stratigraphic column of the entire Barberton Mountain Land appears necessary with respect to the reclassification and recorrelation of rocks previously assigned to the Jamestown Complex. Most such rocks, instead of being the youngest members of the Swaziland System, really belong to the Onverwacht Series, the oldest group with the Mountain Land.

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THE BASE OF THE SWAZILAND SYSTEM IN THE BARBERTON - NOORDKAAP - LOUW'S CREEK AREA, BARBERTON MOUNTAIN LAND

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THE BASE OF THE SWAZILAND SYSTEM IN THE BARBERTON - NOORDKAAP - LOUW'S CREEK AREA, BARBERTON MOUNTAIN LAND

INTRODUCTION

Over most of its distance round the entire periphery of the Barberton Mountain Land, the contact zone of the Swaziland System and the various granites and gneisses is characterized by the presence of basic schists, intrusives, and extrusives with intercalated clastic and non-clastic sediments. The rocks generally separate the granites from the mass of sediments which belong to Fig Tree and Moodies assemblages. Correlation is usually effected without difficulty in the case of these latter sediments, but the basic rock-types present a far more complex and controversial problem. The Geological Survey of South Africa (Visser et al, 1956) believes that, for the most part, the schists, lavas, and intrusive rocks belong to the Jamestown Igneous Complex, and therefore represent the youngest of the Archean formations which comprise the Mountain Land. A particularly favourable area for the intrusion of the igneous rocks was the contact between the granites and the Fig Tree and Moodies sediments. In that the basal schists and other rock-types are everywhere overlain by allegedly older sediments, it follows that, according to the correlations of the Geological Survey, the base of the Swaziland System is formed by the youngest rocks in the sequence.

This conclusion has recently been challenged by Gribnitz et al (1961), Herget (1963), Anhaeusser (1964), van Vuuren (1964), Viljoen (1964), and Cooke (1965). The general concensus of opinion is that the base of the Swaziland System is composed of a stratiform sequence of altered basic and acid lavas and sediments of pre-Fig Tree age. Whether such pre-Fig Tree rocks belong to the established Onverwacht Series (the oldest group in the Swaziland System), or the lower portion of the Fig Tree Series, or to a previously unrecognized group is debatable. What is accepted among all these investigators is that the base of the Swaziland System is not represented by intrusive Jamestown rocks belonging to the end-phase of the formational cycle, but by extrusive and sedimentary pre-Fig Tree rocks formed during the initial stages of the Swaziland geosyncline. Most of the contact rocks are not, therefore, members of the Jamestown Complex which is represented only by a relatively small volume of intrusive ultrabasics.

The object of this paper is to describe the rocks occurring along the granite - Swaziland System contact between the town of Barberton and Louw's Creek Station on the Transvaal side of the Mountain Land, and to discuss their origin and their place in the sequence of events which went to form the Mountain Land. The paper also attempts to differentiate pre-Fig Tree basic rocks from post-Moodies Jamestown intrusives as they occur in the contact zone, and to show that the majority of what were previously classified as Jamestown rocks are, in fact, members of the Onverwacht Series.

Between Barberton and Noordkaap, some nine miles to the north, the zone of basic rocks between the Kaap Valley Granite on the west and the Swaziland sediments on the east seldom exceeds half-a-mile in width. Eastwards from Noordkaap to Louw's Creek, the acid and basic schists and intrusive serpentinite bodies form a zone two miles wide along the contact with the Nelspruit Granite. However, in some places, this width is considerably reduced as a result of encroachment of the granite and of intrusion pegmatites (Figure 1).

A. PREVIOUS OBSERVATIONS ON THE ONVERWACHT - JAMESTOWN PROBLEM IN THE TRANSVAAL

The stratigraphic column for the Barberton - Noordkaap - Louw's Creek area drawn up by the Geological Survey (Visser et al, 1956) is as follows :-

Intrusive Rocks	Post-Karroo	Porphyritic and olivine-bearing dolerite dykes
	Post-Transvaal	Quartz diorite and quartz gabbro dykes, diabase dykes and sills
	Pre-Transvaal	Diabase dykes and sills
	Post-Jamestown	Mpageni Granite (and related syenitic rocks)
		Nelspruit Granite (gneiss, migmatites, granite)
	Jamestown Igneous Complex	Kaap Valley Granite Gabbro, diabase, green and blue serpentinite and amphibolite, varied serpentinite, amphibole, carbonate, and talc schists
Moodies System		Conglomerate, calcareous quartzite, limestone, quartzite, shale, magnetic slate, jasper, and subordinate lava
Swaziland System	Fig Tree Series	Shale, banded ferruginous and siliceous rocks, graywackes, grit, and lava
	Onverwacht Series	Basic and acid lava with interbedded bands of chert

Hall (1918) called a group of rocks consisting predominantly of intrusive ultrabasic and basic igneous rocks,with both massive and schistose habits, the Jamestown Series of the Swaziland System. The group included siliceous rocks of sedimentary character, especially in the Jamestown Schist Belt stretching northwestwards from Noordkaap to Kaapse Hoop. Near Steynsdorp, he found short tongues of granitic rocks intrusive into the basic representatives of the Onverwacht Volcanic Series. In many localities he noted basic volcanic rocks and quartz porphyries in close association with carbonate rocks and other schists identical to those which characterized his Jamestown Series on the northern side of the Mountain Land. Hall thought that the volcanic rocks were not restricted to the Komati River Valley, but that some of them could also be found in the Jamestown Series around Noordkaap.

Hall (1918) was well aware of the problems and complexities associated with the basic assemblages which, he noted, occurred, almost invariably, around the periphery of the Mountain Land, within the contact belt of the granites. He found it difficult to decide on the genesis of the basic schists which he divided into four sub-groups : (1) soft basic schists consisting of green hornblende schists, dark green chlorite schists, gray-yellow talc schists, and schistose rocks with combinations of talc, carbonate, and chlorite, (2) massive magnesian rocks comprising serpentinites of several varieties containing chrysotile asbestos and talc, (3) hard siliceous rocks with bedded slaty rocks, narrow bands of calico rock (banded cherts), and graphitic slates, and (4) later intrusions of dykes and, exceptionally, sills. The soft basic schists presented such a wide variety of rock-types, each with its own peculiar problem, that he was completely undecided on their origins. He stated that it was frequently not possible to determine whether one was dealing with silicified talc-chlorite-calc schists or impure siliceous limestones, with altered serpentinites or dolomites. He considered some varieties, at least, to be derived from the metamorphism of serpentinites within the zone of influence of the intrusive granite contacts. Hall (1918) noted in the northern part of the Mountain Land that many horizons appeared to be of sedimentary origin. He wrote, "rocks probably of sedimentary origin form a long narrow band extending from the Consort Mine continuously to Eureka Siding". Numerous rock-types found in the Noordkaap area were stated to resemble very closely some of the basic varieties found in the Komati River area north of Steynsdorp.

Many problematical localities were mentioned by Hall (1918). Around the Worcester Mine, in the Jamestown Schist Belt, occurring together with a wide variety of basic rocks, were found hard siliceous banded calico rocks (banded cherts) and hard compact black fissile thinly-bedded slaty rocks and siliceous slates. North of Eureka Siding a garnet-sillimanite quartzite horizon was found to be surrounded by basic schistose rocks. Two possible explanations were offered as to the origin of the horizon. It was considered to be either a xenolith caught up in the intrusive rocks of the Jamestown Series, and subsequently metamorphosed by the younger granite intrusion, or it was thought of as belonging to the Lily Line or to a separate horizon altered by the granites. Within the type-area of the Jamestown Series, between the Kaapse Hoop and Noordkaap, several bands of slaty quartzite and other sedimentary rocks were found conformably alternating with basic schists. Carbonate-bearing rocks were observed to occur widely in all the localities where the basic assemblages were present. The origin of the carbonate was also problematical. Although a secondary origin could often be supported, there nevertheless were rocks that had the appearance of silicified limestones of a primary nature.

Due to the abundance of basic inclusions in the Nelspruit gneiss north of Consort Mine, it was suggested by Hall (1918) that the whole area south of the Crocodile River Valley, from Kaapmuiden in the east to below the escarpment in the west, as well as part of the Kaap Valley down to Caledonia Siding, "was originally occupied by basic rocks of which the present Jamestown Series represents merely the intensely metamorphosed schistose remnant". Original olivine and pyroxene crystals in serpentinite bodies at many places were interpreted as being indicative of true intrusive basic and ultrabasic bodies.

Hall (1918) encountered difficulty in interpreting the relationship between his Jamestown and "Moodies Series" (now known as the Fig Tree Series), and stated that very often a narrow band of problematical carbonate rocks separated the granite from the argillaceous succession. This relationship was displayed in the Clutha locality where he noted dolomitic rocks lying sharply against shaly phases of the present Fig Tree Series in an apparently conformable sequence.

According to van Eeden (1941), basic Onverwacht lavas are often represented by talc-carbonate schists, talcose schists, schists with long amphibole needles, and even serpentinite. He pointed out that such rocks cannot be distinguished, in many cases, from similar Jamestown rocks formed from the alteration of basic intrusives,and he found it very difficult to classify such rocks where they occurred in isolated patches and without associated volcanic rocks. South of the Lily quartzite horizon, in the northern part of the Mountain Land, van Eeden (1941) described certain basic rocks consisting of serpentinite, talc-carbonate schists, talc schists, and amphibole schists. This assemblage was associated with quartz-mica schists, and from their field relationships he tentatively classified them as altered basic and acid lavas of the Onverwacht Series. He also considered the serpentinites to be representative of original basic intrusives belonging to the Jamestown Complex, and suggested that the remaining rock-types might perhaps be altered sediments rather than altered lavas.

According to the Geological Survey (Visser et al, 1956) the Onverwacht Series consists almost entirely of volcanic rocks divided into a lower basic phase consisting of massive fine-grained andesitic lava, and an upper acid phase consisting of quartz and felspar porphyries. After the deposition of the Moodies System a suite of basic and ultrabasic rocks, now represented by green and blue serpentinite, amphibolite, diabase, and various basic schists, intruded into the area. This episode of basic intrusion was followed by the emplacement of a granodiorite magma which broke through the basic rocks, and at the same time invaded the adjacent older sedimentary formations. This granodiorite is locally known as the Kaap Valley Granite, and together with the suite of older basic rocks constitutes the Jamestown Igneous Complex. The Geological Survey (Visser et al, 1956) regarded the sedimentary bands within Hall's (1918) Jamestown Series as inclusions that belonged either to the Fig Tree Series or the Moodies System. The Jamestown Series was thus deprived of the sedimentary successions, and the remains, consisting of basic intrusive rocks now largely altered to serpentinites, amphibolites, and basic schists, were referred to as part of the Jamestown Igneous Complex.

Gribnitz et al (1961) considered that the Onverwacht Series consisted mainly of basic rocks, generally intrusive, but also extrusive, into an earlier series he called the Oorschot Series. On the Geological Survey map these are partly grouped as Onverwacht and partly as basic Jamestown rocks. This new series comprised the oldest known sediments within the Swaziland System, and consisted of partly arenaceous calcareous sediments intimately associated and interbedded with banded cherts and ironstones (itaberites). At least one case of an intraformational conglomerate, in the form of rounded chert pebbles, was mentioned, as well as subordinate beds of black carbonaceous shale. They contended that subsequent kinemetamorphic influences converted large portions of the carbonate-bearing rocks into talc-carbonate and quartz-sericite schists, various occurrences of which have previously been placed in the Onverwacht and/or Fig Tree Series, as well as in the Jamestown Igneous Complex. Gribnitz et al (1961) were sceptical of the existence of a Jamestown Igneous Complex. They stated that there was abundant field evidence to suggest that the dolomites and other calcareous rocks of the "Oorschot Series" represented the unmetamorphosed "parent rock" of the basic schists - a fact that was emphasized by the ubiquitous association of greenschist with the banded cherts and ironstones. They noted also that in many schist bodies remnants of original dolomites and cherts could be observed, yet they knew of no case where unaltered remnants of an intrusive rock had been found in talc-carbonate or quartz-sericite schists. They were convinced that at least the vast majority of the green and gray schists represented altered products of dolomites, limestones, arenaceous limestones, and cherts.

Herget (1963), mapping in the Montrose area southwest of Barberton, found several interesting features related to the basic rocks in the area. He considered that the basic and ultrabasic lavas of the Onverwacht Series in the area were serpentinized, and that transitions to talc-carbonate schists existed. The serpentinites were often found surrounded by talc-carbonate schists, and contained layers of banded ferruginous chert, banded chert, and shales. He concluded that the serpentinite was derived from rocks of dunitic and pyroxenitic composition. Contrary to the Geological Survey (Visser et al, 1956),Herget (1963) considered that these serpentinites were older than the Moodies and Fig Tree sediments. He argued that the serpentinites, together with talc-carbonate schists, were always exposed in the same stratigraphical position in the Montrose area, and always underlay the Fig Tree Series. He remarked that the succession appeared similar to that of the Zwartkoppie Zone, with certain basic bodies occupying the cores of anticlines. The pre-Fig Tree nature of the occurrences led him to classify the serpentinites and talc-carbonate schists as part of the Onverwacht Series. Like Gribnitz et al (1961), Herget also concluded that the serpentinites and talc-carbonate schists yielded no proof of intrusion, and he therefore could not support the existence of the Jamestown Igneous Complex in the Montrose area. On petrographical and field data he considered the serpentinites to be pre-Fig Tree in age, and, since occurrences of serpentinite and talc-carbonate schists were already known in the Onverwacht Series (Visser et al, 1956), he regarded it reasonable to classify the basic rocks of the Montrose area as part of the Onverwacht succession.

More recently, van Vuuren (1964) considered the problems associated with the origin of the talc-carbonate rocks exposed in the Zwartkoppie Fold Belt. He indicated that the rocks could either be altered carbonate-bearing sediments near the base of the Fig Tree Series, metamorphosed basic lavas of the Onverwacht Series, or metamorphosed ultrabasics intruded into the Onverwacht Series or lower part of the Fig Tree Series. The carbonate-chloritic-talc rocks were found, in the field, to occupy the lowest stratigraphic position, and apparently occurred in the cores of anticlines. Trace element analyses were employed to determine whether the basic schists represented transformed sediments (rich in magnesium carbonate), or transformed igneous rocks (rich in magnesium silicates).

A comparison was made between the nickel and chromium contents of the samples taken from the controversial talc-carbonate schists, and the average trace element content of sedimentary limestones and dolomites and igneous rocks of intermediate composition. It was found that the nickel content of these samples varied from 300 ppm. to 1800 ppm. (average 1000 ppm.), and the chromium content from 1400 ppm. to 4300 ppm. (average 2200 ppm.). Van Vuuren (1964) indicated that Goldschmidt (1954) had found the chromium content of olivine rocks and pyroxenites to range from about 1000 to 4000 ppm. The nickel content decreased in the normal sequence of magmatic rocks, starting from dunites and peridotites to gabbroic and basaltic magmas. The amount of nickel and cobalt in calcareous marine sediments was found to be exceedingly small - a few parts per million or less, and the same was true for dolomitic rocks. In general, the Ni and Cr contents of the rocks analysed were richer than the average values reported for a wide variety of sedimentary limestones and dolomites, and for igneous rocks of intermediate composition. Van Vuuren (1964) therefore concluded that it was unlikely that the andesitic and basaltic lavas of the Onverwacht Series were the origin of the trace elements, and he favoured the ultrabasic intrusives as a more likely source.

B. PREVIOUS OBSERVATIONS ON THE ONVERWACHT - JAMESTOWN PROBLEM IN SWAZILAND

Bond (1929) observed hornblende and other basic schists on the contact with the granite east of Forbes Reef in Swaziland. He referred to a narrow band of serpentinite, and considered it to be the only example of an ultrabasic rock in the area.

In the area between the Komati River and the Ushushwana River in northwestern Swaziland, Pretorius (1948) noted that talc-carbonate schists occurred inter-layered with shale horizons and banded cherts of the Fig Tree Series. He concluded that there was little likelihood of the schists representing original metamorphosed shale bands. It was found difficult to fix the base of the Fig Tree Series in the area, due to the intimate association of these alleged Jamestown schists and the Fig Tree cherts. Shale and quartzite bands were found in the schists, but because of their limited extent they were regarded as of minor importance compared to the mass of schists. Patches of conglomerate were also noted in the schists, and were considered to represent small xenoliths of Moodies sediments caught up in the intrusion of basic lavas of the Complex. The prevalence of hornblende, tremolite, chlorite, quartz, magnetite, talc, and biotite, and the absence of cordierite, sillimanite, andalusite, staurolite, and kyanite were considered to indicate that the Jamestown Complex represented an original igneous group of rocks, rather than a sedimentary sequence. The possibility that the rocks were originally calcareous in nature was not considered, however.

Way (1952) divided the Fig Tree Series into a lower and an upper group. In the lower group he placed all the strongly metamorphosed "originally sedimentary rocks", represented by meta-quartzites, cherts, amphibole schists and gneisses, granulites, and serpentines. The upper group consisted of less altered argillaceous phyllites. No reference was made to the Onverwacht Series. A basic metamorphic series of talc, carbonate, and chlorite schists, and amphibole gneisses and schists was placed in Hall's (1918) Jamestown Series. These rocks were believed to have originally been of volcanic origin.

Later, Davies (1956) stated that the Jamestown Igneous Complex ultrabasic rocks were intruded into flat-lying formations. He considered that much of the Fig Tree Series was absorbed and partially or wholly assimilated, resulting in peculiar mixed rocks, such as talc-chlorite schists, psammitic and amphibole schists, talcose rocks and many others, some of which still exhibit a pseudo-bedding. He reported that certain zones in the talc schist were extremely pelitic, indicating possibly an impure mixture of ultrabasic material, now represented by the talc group of minerals, and argillaceous horizons. Evidence was put forward that the hard siliceous cherts almost completely resisted assimilation. Except for the cherty rocks, assimilation was stated to be complete in the basal portion of the Fig Tree Series, where no shale xenoliths were found. Elsewhere, however, comparatively unaltered ferruginous and sandy shales occurred, and it was contended that continuous chert and banded ironstone horizons acted as a protective barrier to the assimilating intrusions. Only in rare instances did the ultrabasic rocks manage to pierce the chert barriers, and then only on a very limited scale where minor faults provided weak zones. The overlying Moodies succession suffered almost no assimilation or intrusion by the Jamestown Igneous Complex - the explanation again being the absorbing effect of the resistant underlying series. The form of the intrusions were sill-like, being always concordant with the rocks into which they intruded.

Urie (1957), working in the Bomvu Ridge area of Swaziland, came to the conclusion that much of what he termed the "basal zone" of the Fig Tree Series was originally largely composed of argillaceous and carbonate-bearing formations, together with narrow interbedded siliceous (banded chert) horizons. This basal zone lying conformably below typical Fig Tree rocks was later highly altered. It was contended that the argillaceous material was assimilated by a process of "re-active solution", and converted into ultrabasic rock. The basification was apparently due to the effects of the Jamestown Complex. The siliceous horizons were totally unaffected by this assimilation process which must, therefore, have been highly selective, and now occur as siliceous bands within the basic schists. As stated by Urie (1957), many difficulties attend such a process of selective assimilation. The basic rocks penetrated along the argillaceous formations, leaving the siliceous horizons as "arms" or disconnected rafts with little or no disarrangement of their position relative to the country rock. Very little thrusting aside of the invaded formations apparently took place.

Onverwacht rocks are not extensively developed. The best exposures of this series consist of amygdaloidal basaltic lava in the area southwest of Kamhlabane beacon (Hunter, 1961). Many so-called Onverwacht lavas are considered indistinguishable from the altered ultrabasics of the Jamestown Complex, and the phyllites and micaceous schists of the Fig Tree Series.

Several other writers have contributed descriptions of areas in Swaziland that display basic rock assemblages. Mehliss (1961) described Jamestown Complex rocks from the Mankaiana District. He mentioned that no sediments could be found which could be correlated with either the Fig Tree or Moodies Series, but he assigned small xenoliths of gneisses and schistose rocks (chiefly amphibolites and talc schists) to the Jamestown Complex. The xenoliths occurred widely distributed throughout the granite, and the parallel alignment of green hornblende and quartz imparted to the rock a schistose appearance. Talcose and talc carbonate varieties were also noted in the area. Jones and Hunter (1963) found no Onverwacht rocks in the Pigg's Peak area, but talc-tremolite schists, talcose schists, and amphibolites were found and grouped into the Jamestown Complex. The amphibolites occupied the contact zone of the granites. Jones (1963) also noted Jamestown rocks in the Malolotsha Valley. The basic rocks constituted three forms. The first occurred in association with the Fig Tree Series in the cores of folds, while the second form intruded the Moodies Series as narrow intercalated lenses around the noses of major folds. The third form occurred along major fractures and fault planes in the area. From the observations he proposed three alternative interpretations : (i) the intrusives pre-dated the Moodies Series; (ii) a pre-existing ultrabasic magma became remobilized as a result of tectonism, or (iii) the intrusions occurred in a number of pulsations. A wide variety of metamorphic mineral assemblages, including hornblende and other amphibole schists, was grouped into the Jamestown Complex. Jones (1963) also described an area in the Hhohho-Pigg's Peak area where, again, Jamestown rocks were stated to be represented by a suite of ultrabasic intrusives which had been subjected to metamorphism. The amphibolites occurred as a broad strip along the granite contact. The main body of schists was intimately associated with the sediments of the Fig Tree Series, suggesting that the magma appeared capable of selective assimilation along argillaceous sediments, leaving the more siliceous horizons as "rafts" within the schists.

The Swaziland Geological Survey (Hunter, 1961) has adopted Way's (1952) subdivision of the Fig Tree Series, and it recognizes an upper argillaceous group that gave way with depth to siliceous metasediments. The lower group is intruded by the Jamestown Complex, and is considered to result largely from the metamorphism of pre-existing sediments. The Jamestown Complex in Swaziland is reported to be intrusive into both the Fig Tree and Moodies Series. The Complex is stated to have a variegated petrology due to the influences of metamorphism, the probable differentiation within the magma, the assimilation of sedimentary material, and the effect of the intrusion of the younger granites. Metamorphism is held to include both serpentinization and steatization. The meta-sediments comprise mainly quartz-mica gneisses with garnets, quartz-amphibole gneisses (actinolite-epidote and hornblende gneiss), and calc-silicate, grading into hornblende, gneisses. The banded gneisses often show colour banding, presumably reflecting compositional differences in the original sediments. Hunter (1961) also states that structural evidence suggests that these rocks are the highly metamorphosed and metasomatized equivalents of a supra-structural Fig Tree Series of the Swaziland System.

Two types of serpentinites occur in the Barberton Mountain Land - a light green and a blue-green variety. At Havelock, van Biljon (1959) found that the serpentinites grade along strike into talc and chlorite schists. Invariably, however, extreme faulting obscures the relationships of the serpentinites to the country rock. The serpentinites are generally acknowledged as having been derived from the alteration of intrusive rocks of duntic or peridotitic composition. Many of the basic rocks are confined to the region separating the granites from the sedimentary successions of the Swaziland System. Van Biljon (1959) contended that this situation was suggestibe of a genetic relationship between the granites and the ultrabasic rocks themselves. Read (1951) considered that the low grade of metamorphism displayed in the Mountain Land was due to the protective barrier, or buffering effect, of the ultrabasic rocks which separate the granites from the sediments. Van Biljon (1959) rejected this argument, and proposed that during the granite emplacement water was driven out of the invaded rocks and accumulated in the remaining sediments, thereby raising the water vapour content, and at the same time making the resistance to metamorphism or granitization considerably greater than if the sediments were deficient in water. Difficulty was found in explaining the intimate relationship of serpentinites occupying positions between chert bands, and serpentinites that grade along strike into argillaceous rocks. Only if the basic magma were in a completely liquid state could a complex process of stoping assimilation have taken place. Van Biljon (1959) suggested that a metasomatic origin for the serpentinites might be more acceptable.

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THE BASAL ROCKS IN THE NOORDKAAP - LOUW'S CREEK AREA

A. GENERAL GEOLOGICAL SETTING

(a) Classification and Distribution of Rock-Types

The area is bounded on the north by the Nelspruit Granite, forming part of the Krokodilpoort Range. It displays intrusive relationships along the contact. Immediately to the south of the granite, and often occurring as xenoliths within it, is a group of very dark basic hornblende schists. These 'contact' amphibolites attain their best development in the eastern part of the area where they form a broad zone that occupies portion of the Kaap River Valley from Eureka Siding to Honeybird Siding. In addition, they make up much of the flat country near Louw's Creek Station. Similar rocks occur in the western part of the area, but their distribution is more sporadic due to extensive intrusion of granite and pegmatite. The dark amphibolites are followed to the south by a second group of basic rocks consisting essentially of green amphibolitic schists composed mainly of tremolite and actinolite. In certain areas, and especially well-developed north of the Consort Mine, are large bodies of green serpentinite occurring between the 'contact' amphibolites and the green amphibolitic schists. Within this basic rock-suite, and well-developed in the western part of the area, are a number of rather persistent quartzitic horizons. They diminish rapidly in size in the Joe's Luck area, and only two such horizons persist into the eastern part of the area.

The authors are of the opinion that the majority of these basic rocks, classified by the Geological Survey (Visser et al, 1956) as contact metamorphic rocks of uncertain derivation and age, or as members of the Jamestown Igneous Complex, are of sedimentary origin, but that undoubted basic intrusives and probably some acid and basic extrusives are also present. All of these rocks, barring most of the serpentinite bodies, are believed by the authors to belong to the Onverwacht Series at the base of the Swaziland System.

In the western part of the area, the stratified basic rock sequence discussed above is overlain by a well-developed, metamorphosed succession of Fig Tree rocks. This sequence attains its best development in the Consort Mine area, but thins rapidly eastwards until it finally wedges out in the vicinity of Beacon Bar 5. At the base of this succession occurs the so-called "Consort Contact" along which silicified, cherty rocks (the "Consort Bar") and the gold mineralization in the area are invariably developed. The "Contact" is overlain by the so-called "hanging-wall" rocks or "shales" of the Consort area. These comprise a succession of metamorphosed argillaceous sediments which grade upwards into rocks which have been regarded as lavas, but which are now thought to be more in the nature of crystalline tuffs.

Extending across almost the whole area (to the south of the green amphibole schist horizon in the eastern sector, but overlying the "lava" sequence in the western part) 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 isoclinal fold further to the west. From Eureka Siding to the west of Beacon Bar 5, the ridge splits into three distinct bands separated by intrusive green serpentinites and talc schist bodies.

The thickness of the entire succession of Onverwacht, Fig Tree, and Moodies rocks mentioned above decreases from about 9,500 feet in the Consort Mine area, where it attains its best development, to about 3,600 feet near Joe's Luck Siding where the whole succession is still present, but on a much reduced scale.

The Lily quartzites are truncated on their southern side by a major reverse, or high-angled thrust, fault (the Main Southern Fault). This has resulted in the re-appearance on the southern side of the fault of various talc-chlorite-carbonate schists which may grade laterally, and very often imperceptibly, into tremolite schists, or quartz-chlorite-carbonate schists. Within this basic suite in the eastern part of the area are sheared quartz-sericite schists with a few intercalated shaly and siliceous horizons. In the extreme western part of the area, high-angled faulting has resulted in the occurrence of quartzite and some shale and "lava" blocks within these talcose rocks. This basic suite is considered for the most part as belonging to the Onverwacht Series. These talcose rocks are followed upwards in the sequence (i.e. going south), by shales, "lavas", conglomerates, and quartzites, forming another regular succession of Fig Tree and Moodies rocks, and representing part of the northern limb of the Eureka Syncline.

Green serpentinites are intruded into different rock-types. They attain their maximum development to the northwest and north of the Scotia Talc Mine, near Sheba Siding, and north of the Consort Mine, in a strip close to the granite contact. Other serpentinite intrusives occur near Sugden Siding and to the east of Noordkaap.

(b) Metamorphism

The area can be conveniently divided into the following three distinct facies of contact metamorphism related to the Nelspruit Granite - more particularly to the mobilized border phase of the latter :-

(i) a hornblende-hornfels facies along the immediate contact zone;

(ii) an albite-epidote-hornfels facies covering most of the central part of the area, including the Consort Mine; and

(iii) a greenschist facies along the Kaap River and extending as far south as the Woodstock Mine and Noordkaap.

Locally, for example near the Lily Mine, the hydrothermal mineralizing solutions have superimposed higher grades of metamorphism over the regional metamorphism. In addition, quite severe dynamic metamorphism has occurred along the granite contact zone as a result of the updoming of the Nelspruit gneiss. Some of the major faults have produced a considerable amount of local dynamic metamorphism. Although no conclusive evidence exists, there is a possibility that the widespread dynamic action along the contact zone might have led to a certain amount of retrograde metamorphism.

(c) Stratigraphic Column

As a result of recent detailed remapping of the area, the following stratigraphic column has been devised to replace that previously compiled by the Geological Survey (Visser et al, 1956) :

Intrusive Rocks	Pre-Transvaal to Post-Karroo dykes	Dolerite, diabase, prophyritic diabase, and amphibolite dykes
	Mpageni Granite, Nelspruit Granite, Kaap Valley Granite	Granites, pegmatites, gneisses, porphyritic granites, granodiorites, hornblende-rich granodiorites, etc.
	Jamestown Ultrabasic Intrusive Series	Green and blue serpentinite bodies with magnesite, chrysotile asbestos, magnetic nickeliferous serpentinites, possibly talc schists
Swaziland System	Moodies Series	Quartzites Basal conglomerate zone
	Fig Tree Series	"Lavas" or tuffaceous graywackes, crystalline tuffs, shales, graywackes, cherts, banded ironstones, and Zwartkoppie Zone "green-schists" Consort "Contact"
	Onverwacht Series	Green tremolite-actinolite schists, intercalated quartzite horizons, carbonate-rich talc, tremolite, and chlorite schists. Dark contact amphibolites (hornblende-rich with intercalated acid schist horizons (quartz-sericite-schist), altered acid lavas?, magnetic shales and garnetiferous quartzites, dolomitic rocks, impure siliceous limestones, marble, impure carbonate-bearing schists, felspar porphyries
Basement Granite - Gneiss		

B. ONVERWACHT SERIES

(a) Contact Amphibolites

(i) Composition and Structure

The Nelspruit Granite is intrusive along the contact into rocks that have a highly distinctive appearance almost the whole way from the Consort Mine to Louw's Creek. These contact amphibolites attain their maximum development of approximately 3,500 feet in the area between Sugden Siding and Louw's Creek, and also north of the Consort Mine where they are often separated from the northernmost quartzite horizon by a green serpentinite layer. In this area, a tongue of black amphibolite with hundreds of associated xenoliths runs out into the granite. The granites display sharp contact relationships with the amphibolite, and the scattered xenoliths are pierced by innumerable tongues and veins of pegmatitic, aplitic, and granitic rock, as well as quartz veins.

In appearance these rocks are very dark, and in many places they are black in colour. In other areas they have a mottled black appearance with numerous white flecks, or are dark green. They frequently show a mineralogical banding, with bands of nearly pure amphibole and other bands with about half amphibole and half quartz and felspar. Mineralogically, the rock consists predominantly of green pleochroic hornblende and plagioclase (usually andesine). Quartz is usually present, but is variable in amount from place to place. Locally, the rock is composed primarily of hornblende, to the near exclusion of felsic constituents. Diopside occurs abundantly in some areas close to the granite contact, in addition to garnet and minor amounts of biotite.

The entire contact amphibolite belt is well foliated, and the rocks dip steeply to the south. The amphibolites have a foliation, or schistosity, that is aligned parallel to the granite contact and the granite foliation. The orientation of the xenoliths is usually elongated parallel to the contact, and the strike of the foliation within the xenoliths is also parallel to the regional foliation. Under the microscope, the rocks display a strong mineral alignment, with amphibole and biotite or phyllosilicate minerals aligned with their long axes parallel to the planar fabric. The mineral alignment was found to be very nearly coincidental with the axes of minor folds. The latter strike roughly east-west, parallel to the contact, and their axial planes are generally coincident with the foliation dip to the south. The plunge of these minor folds is nearly horizontal. The mineral elongation approximates more closely to a "b" rather than to an "a" lineation ("b" defining the fold axis) (Viljoen, 1964). In addition to the mineral alignment mentioned above, the rocks display augen structures, rotated garnet porphyroblasts, boudinaged structures, joint and fault planes, and lineations (Anhaeusser, 1964; Viljoen, 1964).

The contact amphibolites are undoubtedly the result of extensive contact metamorphism. The hornblende-plagioclase-quartz assemblage can be placed in the hornblende-hornfels facies of Turner and Verhoogen (1960), or the amphibolite facies of Eskola (1921). Such assemblages are usually extensively developed in contact aureoles and as xenoliths in granite and granodiorite. In the higher grades of metamorphism, hornblende is replaced to a greater or lesser degree by diopside that occurs in bands which were presumably richer in lime. The assemblage encountered in the hornblende-hornfels zone (Figure 2) consists of plagioclase-hornblende (quartz-biotite), and plagioclase-hornblende-diopside (quartz-biotite), and is one with excess silica (SiO_2) and of a basic nature.

(ii) Origin

The contact amphibolites described above could represent the products of high-grade metamorphism of basic or ultrabasic rocks, or of impure dolomitic limestones, together with calcareous, siliceous, and magnesian shales, or of sedimentary rocks influenced by FeO-MgO-CaO-rich effluents from ultrabasic igneous rocks. Several reasons can be presented for concluding that the contact amphibolites represent the alteration products of a pre-existing layered, or stratiform, sequence of rocks.

The very marked mineralogical banding, so often observed, is considered to be indicative of a sedimentary, rather than an igneous, origin. The close association of these rocks with quartzite horizons that can be traced, often uninterruptedly, for several miles, and which are of undoubted sedimentary origin supports this view. It should be mentioned that the amphibolites are in no way similar to the metamorphosed Fig Tree Series or Moodies Series rocks which are well exposed in the Consort Mine area. It can only be suggested that the original composition of the amphibolitic rocks must have been very different from these. Their basic nature precludes the possibility of their being altered Moodies shales, as previously suggested by van Eeden (1941). The amphibolite succession occurs at the base of a stratigraphic sequence which lies conformably below the Fig Tree shales and graywackes, so that, from a structural viewpoint, the likelihood of the amphibolites representing actual altered Moodies or Fig Tree shales is small. Dolomitic rocks of the type from which the amphibolites could easily have been derived by physical and chemical changes accompanying the granite intrusion are known to exist below the Fig Tree Series in many other parts of the Mountain Land. These have been classed by Gribnitz et al (1961) as belonging to a proposed Oorschot Series, and it is suggested that the amphibolites might well represent the strongly metamorphosed equivalents of such rocks, except that no need is seen to introduce a new series of rocks, in addition to the Onverwacht Series, below the Fig Tree sequence. The presence of quartz throughout the contact amphibolite zone suggests abundant siliceous material in the original rocks.

(b) Green Amphibolitic Schists

(i) Composition and Structure

The green amphibolitic schists, consisting primarily of light and dark green tremolite-actinolite schists, constitute the largest mass of basic rocks occurring in the area. The green amphibole schists occur between the dark contact amphibolites and the Consort "Contact" in the Consort Mine area, but further east, although in much the same stratigraphic position, they occupy part of the northern and southern limbs of the Lily Syncline. In the latter area the Fig Tree Series is not developed, and the basic schists are overlain by quartzites and conglomerates of the Moodies Series. There is commonly a fairly extensive zone of serpentinite separating these schists from the contact amphibolites. The development of serpentinite bodies within the tremolite schist zone seems to be at random, although areas of almost pure serpentinite generally tend to occur as lensoid bodies parallel to the general schist foliation. The "schist-shale" contact in the Consort Mine is sharp. The contact between the dark contact amphibolites and the light green amphibolitic schists is also sharp in places, but might also be gradational.

The dominant minerals in this zone are tremolite and actinolite, with occasionally some development of cummingtonite. These rocks frequently grade to serpentinite so that antigorite is abundant in some specimens. Tremolite and actinolite occur in radiating needles, but are mostly orientated in parallel planes. Varying amounts of carbonate, talc, magnetite, chlorite, sphene, chloritoid, ilmenite, and leucoxene can be seen in places. Notable is the absence from this zone of green hornblende and plagioclase felspar.

The banded nature of these rocks is again much in evidence. Near the Consort Mine, rocks consisting of bands of actinolite and bands of almost pure pyroxene occur together. Zoisite and green chlorite also occur in layers. Diopside is found close to silicified and mineralized zones, and may be the result of high temperatures, associated with mineralizing fluids, acting on original lime-rich bands in the vicinity, although the possibility cannot be excluded that it represents a new gangue mineral formed in the zone of wall-rock alteration associated with the mineralization.

These amphibolitic schists, like the dark contact amphibolites to the north, possess a strong foliation that once again parallels the regional trend of the formations, and is practically everywhere vertical or steeply south-dipping. In the Consort Mine area the pronounced mineral orientation, so common in the contact rocks, is generally not as apparent in some places, but in others there is a strong tendency towards parallelism of the mineral constituents. Microscopic structures vary little from those seen in the contact amphibolites. In the field the rocks are noticeably devoid of minor structures, and it is only in a few small areas and in particularly favourable rocks that minor folds are developed. There is evidence of intense shearing within these rocks, resulting in the breakdown of felspars to sericite, together with fine-grained talc. In addition, boudinaged structures lying in the planes of foliation confirm that a strong deformative stress was operative. There is also evidence of post-metamorphic deformation, for in numerous localities folded and bent tremolite-actinolite needles are present.

The metamorphic effects of the granite intrusion in the north are also undoubtedly reflected in this zone. The grade of metamorphism is considerably reduced, when compared 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 (Figure 2). The mineral assemblages in this zone appear to be typical of the albite-epidote-hornfels facies of Turner and Verhoogen (1960), or the epidote-amphibolite facies of Ramberg (1952). The assemblage in this facies has much in common with the typical greenschist assemblages of low-grade metamorphism, as listed by Turner and Verhoogen (1960), but it must be pointed out that these rocks, due to their particular bulk composition, have successfully "camouflaged" the true extent of their metamorphism. They are intimately connected with abundant higher temperature grossularite and andalusite in the metamorphosed argillaceous Fig Tree Series sediments which overlie the schists to the south, and which are even further away from the granite contact than the latter.

(ii) Origin

These rocks have much in common with those of the contact amphibolite zone. The majority of the green tremolite-actinolite schists are considered to represent the slightly less metamorphosed equivalents of the black contact type, and in a number of places a gradation between these two is evident. It must be mentioned that remnants of fairly large olivine and pyroxene crystals have been found in serpentinite bodies within this green schist zone. This is interpreted as indicating the existence of at least some ultrabasic intrusive material, now represented by the more massive serpentinite occurrences. These are different, however, from the zones and patches of partly serpentinized tremolite schists which are always strongly foliated and often banded.

The strong foliation, banding, and close association of these basic schists with quartzitic horizons seems to indicate that, as with the contact amphibolites, these green schists are also mainly of sedimentary origin. The possibility cannot be excluded, however, that at least some of these rocks represent basic lavas, and that some of the associated quartzitic horizons represent acid lavas. This seems to apply especially to certain of the less well-banded and more massive basic schists, and also to the sericite-rich quartzitic horizons. The authors are more inclined to the view that, as with the contact amphibolites, these rocks are for the most part derived from original sedimentary rocks which must have been close in composition to siliceous magnesian limestones.

(c) Carbonate-bearing Talc and Chlorite Schists

(i) Composition and Structure

Under this heading have been included several varieties of basic schist found almost exclusively on the south side of the Lily Line. The occurrence of these basic rocks, apparently lying above the Moodies quartzites and, at the same time, below the Fig Tree shales which form part of the northern limb of the Eureka Syncline, is ascribed to faulting and, possibly, very strong folding. The rock-types include talc schists, talc-carbonate schists, talc-chlorite-carbonate-quartz schists, tremolite-bearing schists containing all the above minerals, and talcose dolomitic rocks. The talc schists apparently are restricted to zones where deformation has been strong. The most common occurrence is along the Lily Fault, especially in the neighbourhood of the Lily and Rose's Fortune Mines. A further development of talc schist occurs in the Scotia Talc Mine where they often attain great purity. Rather pure talc-carbonate schists occur quite abundantly in the eastern part of the zone. On fresh outcrop they have a distinctive light greenish-gray colour, but, where weathered, a dirty pinkish-brown colour. A typical schist consists of numerous amygdale-like patches, varying in size from about 1 mm. to 1 cm. These patches consist of either a pure white carbonate, probably calcite, or sometimes a pinkish to light brown carbonate which is possibly siderite. The groundmass consists predominantly of fine-grained talc laths. Varying amounts of fine-grained chlorite often occur, together, sometimes, with a few quartz and felspar grains. On weathering of the carbonate patches, the rock develops a very distinctive "pocked" surface, consisting of numerous hollows, either clean, or partially filled with limonitic material. Talc-chlorite-carbonate schists make up most of the remainder of the succession, and may contain zones in which tremolite and actinolite are fairly abundant. In some areas, and very well seen immediately north of Noordkaap, the chlorite occurs as very long, individual crystals, arranged in a sub-parallel fashion, giving a marked lineation.

In the area immediately south of the Woodstock Bar occurs a zone of poorly exposed talcose and dolomitic rocks. In the underground workings of the Woodstock Mine distinct varieties of dolomite, with talcose rocks, have been mapped. In the Clutha Mine area to the south, and lying just beyond the area of this paper, dolomitic rocks were first noted by Hall (1918). Subsequent detailed mapping in this area by R. Cooke (unpublished map, E.T.C. Mines Ltd.) and Anhaeusser (work in progress) has shown the existence of an extensive zone of different varieties of dolomitic rocks (see section on basal rocks between Barberton and Noordkaap). 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. The tourmaline is invariably the iron-rich variety, schorlite, and occurs as euhedral prismatic crystals. Euhedral pyrite crystals, usually partly altered to limonite, often have well-developed pressure shadows of secondary quartz or calcite associated with them.

These schists are often very strongly sheared or cleaved, and in the Noordkaap area, especially, are very strongly lineated. The schistosity is generally parallel to the regional trend. The lineations in the Noordkaap area usually plunge to the north at very steep angles, and can definitely be ascribed to a mineral elongation. These lineations have been deformed in many places by a set of minute crenulation folds with near horizontal axial planes and fold axes, the latter striking generally east-west. In many places around Noordkaap the folds are very well developed, and stand out as hundreds of small corrugations. However, they are more often only developed on a micro-scale, and appear in hand specimen as a series of minute crinkles or very thin parallel lines that pervade the whole rock and which are scarcely perceptible to the naked eye.

The metamorphic mineral assemblage of this basic suite of rocks is indicative of a low-grade metamorphic zone, and fits best into the greenschist facies first introduced by Eskola (1921). Some doubt exists as to the upper limit of the greenschist facies. According to Ramberg (1952), the following reaction is critical for the establishment of the uppermost border of this facies :-

$$\text{calcite + chlorite + silica} \rightleftarrows \text{actinolite + epidote + water + carbon dioxide}$$

Turner and Verhoogen (1960), however, allow actinolite into the upper part of their greenschist facies, and the definition thus covers a somewhat higher grade than that of greenschist facies of Eskola (1921) and Ramberg (1952). The tremolite-bearing rocks, therefore, belong probably to the upper part of the greenschist facies, whereas the dolomitic and talcose rocks immediately south of the Woodstock Mine, together with some of the slightly talcose dolomitic rocks near Clutha Mine, can be classed in the very lowest part of the facies. The majority of the rocks in the Clutha Mine area have probably suffered no, or, at the most, a very slight amount of, thermal metamorphism.

(ii) Origin

Carbonate-bearing rocks of the type described above can form either from the low-grade metamorphism of dolomitic rocks, or from the alteration of basic igneous rocks. Tilley (1948) has discussed the earlier stages in the metamorphism of siliceous dolomites, and has found a definite sequence. This sequence is almost identical to that occurring in the area discussed above. The production of talc and tremolite in the outer aureole is ascribed to a series of reactions involving increased decarbonation. Talc is regarded as being the first new-formed phase, and its formation results from a reaction between dolomite and quartz. This first-formed talc zone can be subdivided into one in which the association of talc with fine granular calcite is very similar to the main assemblage along the Kaap River in the western part of the area, and into another, outer or lower-grade, zone consisting of subordinate talc associated with calcite and dolomite, which is similar to the mineral assemblage occurring immediately south of the Woodstock "Bar", and partly similar to the assemblage mapped in the Clutha Mine area. In the latter area, the main rock-types are dolomitic, with generally only a subordinate amount of talc, and are considered to be rather similar to the parent rock from which many of the more highly metamorphosed basic schists, described previously, could well have been derived.

The possibility is not excluded that some of the purer talc-carbonate schists might have formerly constituted basic igneous rocks. According to Turner and Verhoogen (1960), such rocks can be derived from original ultrabasic bodies which have been submitted to carbon dioxide metasomatism. Steatization, or the hydrothermal alteration of an ultrabasic body leading to a talcose end-product (Hess in Turner and Verhoogen, 1960), may be accomplished by the simple addition of silica and, in some cases, water to serpentinized peridotites. Further, if carbon dioxide metasomatism is involved (which is considered to be more commonly the case), then dolomite or magnesite may appear as constituent phases of the end-product. Steatization is considered to be a hydrothermal process connected with the intrusion of granite magma, and it is possible that the Nelspruit Granite might have been a source of such solutions. It would be expected, however, that such lime-bearing hydrothermal solutions would have affected all serpentinite bodies in the zone subjected to metasomatism. To the south of the Woodstock Mine occurs a fairly large serpentinite body, completely fresh, and with no signs of talcification, surrounded by, and evidently in sharp contact with, talc-carbonate and dolomitic rocks. From this it is concluded that carbon-dioxide metasomatism played little part in the development of the carbonate rocks in the area, and that the present abundance of carbonate material is, for the most part, inherited from the original dolomitic nature of the sediments. The serpentinite body referred to above is considered to represent an ultrabasic rock intrusive into the latter sediments. In the area to the northwest of Noordkaap there is an apparent gradation from a talc-carbonate schist to a partly talcified serpentinite, and the possibility cannot be ruled out that this represents a case of carbon-dioxide metasomatism. However, this is in a higher temperature zone than the fresh serpentinite body south of the Woodstock Mine, and the carbonate material is thought to have been derived largely from the surrounding carbonate-bearing rocks, rather than from a hydrothermal source.

From the above considerations, the authors are inclined to the view that these rocks originated, for the most part, from the metamorphism of dolomitic rocks, siliceous in part, and containing considerable amounts of impurities in places, as evidenced by the occurrence of fairly well-developed zones of chlorite. As shown by Tilley (1948), the latter mineral does not occur at any stage at all in the metamorphism of pure siliceous dolomite. Although some of the purer talc and talc-carbonate schists might have been derived from original serpentinized ultrabasic rocks, the relative abundance of chlorite and quartz in the majority of these rocks is taken as evidence against such an origin. They are considered to be altered derivatives of the Onverwacht Series, and not of the Jamestown Ultrabasic Intrusive Series.

(d) Acid Rocks in the Northern Limb of the Lily Syncline

(i) Composition and Structure

Within the basic suite of rocks lying below the Fig Tree Series occur certain rather persistent quartzitic horizons. They attain their best development in the area to the north of the Consort Mine, but persist for a long way to the east. In this zone they constitute part of the succession making the northern limb of the Lily Syncline. In the western part of the area, the quartzitic horizons are generally confined to the zone of serpentinites and green tremolite-actinolite schists. It appears as though five horizons are present in this area, but they pinch and swell and disappear completely in certain places, and no single band of uniform thickness can be traced right across the area. Proceeding eastwards from Joe's Luck Siding, the quartzitic horizons, as with all the rock groups in this area, thin markedly, and only two persist into the area east of

Eureka Siding. With the narrowing of the whole succession from Joe's Luck eastwards, and with the associated reduced thickness, or complete absence, of serpentinites along the contact zone, metamorphism has been more intense. This has resulted in most of the quartzitic horizons in the eastern part being located within the more highly metamorphosed black contact-type amphibolites. The various horizons occur as more-or-less intercalated bands within the basic schists, and are conformable to the schist foliation. They form an integral part of the whole basic suite lying below the Fig Tree Series.

In colour, they are generally whitish to gray, but often have a greenish tinge due to the presence of fuchsite or chrome muscovite. They are commonly extremely fine-grained, and resemble cherts. In places a very marked banding is present. Two distinct types of quartzitic horizon can be distinguished - a very pure variety consisting almost entirely of fine-grained quartz, and a sericite-bearing variety consisting of about equal amounts of quartz and sericite (or fine-grained muscovite), with occasional small grains of plagioclase. The purer variety consists mainly of fine irregular quartz occurring as bands of coarse- and finer-textured material. Some very fine grains of sericite are invariably present as well, usually occurring in zones which are much richer in this mineral. In some specimens the rock is evenly fine-grained, and sericite forms a very insignificant proportion of minute flakes, together with small magnetite grains. An occasional small crystal of plagioclase is sometimes present. In some of the northerly quartzitic horizons on Bon Accord Farm, large subhedral garnet (almandine-spessartite) porphyroblasts occur, either as a discontinuous trail along foliation planes, or as randomly-occurring specks in the quartzite. These garnets are often up to about 0.33 inches in diameter, and appear as rather friable reddish-brown patches in the white quartzite. They are generally much more prone to weathering than the quartzite, and, as a result of this selective weathering, they are often completely removed, leaving a pocked quartzite with fair-sized hollows. A number of quartzitic horizons, especially in the area approaching Joe's Luck Siding, have a distinct greenish colour which at times becomes very pronounced, and is reminiscent of the green colour of the Hospital Hill Quartzite of the Lower Division of the Witwatersrand System. The colour is imparted to the rock by green fuchsite. In the area just north of Joe's Luck Siding the mineral is often fairly coarse-grained, and aggregates of pure green fuchsite are quite plentiful. In a few horizons close to the contact, and better developed in the quartzitic rocks near Joe's Luck Siding than in those to the north of the Consort Mine, fine fibrous needles of sillimanite are often present.

Altered shaly horizons with oxidized sulphide mineralization are often present within more-or-less pure quartzites. Due to their greater rate of decomposition and weathering, as compared to the surrounding quartzites, it is only in certain favourable localities that they are revealed. A thin-section of a typical shale horizon taken from the hills about $1\frac{1}{2}$ miles north of the Consort Mine reveals a light green amphibole as the dominant mineral, together with almost solid bands of garnet (probably almandine), invariably associated with much magnetite and sulphides. The above quartzites are generally the most resistant rocks in the area, and, where well-developed, especially in the area north of the Consort Mine, stand out as distinct ridges in the surrounding basic rocks. These purer quartzites constitute the dominant variety, and are sometimes associated with less resistant, more felspathic-looking rocks. There is often quite a sharp contact between the two, but they also seem to grade into each other at times. The softer quartzitic rock is composed predominantly of sericite, with quartz usually forming less than half of the rock. Darker bands are sometimes present, and then, in addition to sericite and quartz, hornblende, clino-zoisite, magnetite, ilmenite, tourmaline, and leucoxene usually occur. In the hills north of Consort Mine a similar rock has an almost shaly appearance. It is very fine-grained, and dark gray in colour, and consists of sericite, quartz, and much magnetite, the latter occurring as numerous very small specks. In a few places garnets were observed in these sericite schists. Small crystals of plagioclase are invariably found as minor constituents of this type of quartzite.

A ferruginous shale and quartzite horizon, never more than 50 feet wide, occurs on the farm Annex Riverbank, near Sugden Siding. The horizon, composed essentially of massive quartzites with shaly intercalations, is entirely enveloped within the dark contact amphibolites. The quartzite layers are essentially impure, and consist of quartz and ferruginous material - limonite, goethite, magnetite, and ilmenite.

Grunerite amphibole is also present. The shales are also ferruginous, and are not unlike banded ironstone in appearance. Only rarely is this horizon magnetic.

Most of the above quartzitic rocks are very strongly sheared. The purer varieties are often nearly chertified, and in places they could almost be termed mylonites. The formation of sericite can possibly be ascribed to a breakdown of felspars during a period of strong shearing. Microscopically, the mica flakes are well aligned in planes which give the rock a very pronounced foliation. Muscovite, not being prismatic, does not give a mineral lineation, so that the flakes are orientated parallel to the schistosity, with their basal (001) sections normal thereto, and are disturbed only by garnet porphyroblasts around which they have a tendency to curl or flow. In addition to being strongly foliated, these rocks are often well lineated with minor structures. Two sets of lineations are present. These include a steeply south-plunging set, and another set of nearly horizontal lineations. The former type are confined to the pure quartzitic horizons, whereas the latter are very well-developed in the sericite schist horizons, although sometimes they are also developed in the purer varieties. The lineations are not evenly distributed throughout the area, and in some localities are not developed at all. The horizontal lineations in the sericite schists appear as a series of very straight and regular lines which, on microscopic investigation, are seen to represent fold axes of minute crenulation- and accordion-type folds. The well-aligned sericite and mica flakes have been bent, broken, and folded, and have been subjected to post-crystalline deformation. The steeply-plunging lineations are, in some places, parallel to the fold axes of tight isoclinal folds in the quartizte. Banding in these quartzitic rocks is often very tightly folded, especially in the vicinity of the granite contact. North of the Consort Mine, well-developed conjugate folds are present in a finely-laminated cherty rock. The largest is about 2½ feet in size. A plot of the stress field calculated from this fold indicates a nearly vertical maximum stress direction.

A fairly extensive development of sillimanite in quartzitic horizons close to the contact, in addition to garnet and corundum at one place, indicates a very high grade of metamorphism, such as the pyroxene-hornfels facies of Turner and Verhoogen (1960). However, the abundance of hydrous minerals - hornblende and muscovite (or sericite) - in associated basic and quartzitic rocks respectively, which are characteristically absent from the pyroxene-hornfels facies, indicates that the bulk mineral assemblage cannot be higher than the hornblende-hornfels facies. The presence of sillimanite probably indicates that the quartzitic rocks close to the contact belong in the upper part of the latter facies. Sillimanite was not observed in the southern quartzitic horizons in the Consort area. This, plus the association of these siliceous horizons with tremolite-actinolite schists which belong probably to the upper part of the albite-epidote-hornfels facies, indicates that these southernmost quartzitic horizons can also be classed in this facies.

(ii) Origin

Most of the horizons give the impression of having once constituted original orthoquartzitic or chert horizons within a predominantly sedimentary succession. Others, however, and especially those containing abundant quartz and sericite, might represent acid igneous lavas or porphyries. The main southern quartzite horizon in the Consort area reaches considerable dimensions near the Bullion Mine, and is very rich in sericite. It is apparently similar to a felspathic-quartzitic rock from near Three Sisters, well to the east, described by van Eeden (1941), and considered by him to possibly represent a highly altered acid lava. However, the strong mineralogical banding seen in the closely associated contact-type amphibolites and the banding often observed in the quartzites are considered to point to a sedimentary, rather than a volcanic, origin for both of these. In a number of the most northerly horizons, garnets are fairly abundant, often in distinct bands, and are taken as additional evidence for a sedimentary origin. Possibly the main argument for a sedimentary origin is the presence, in a number of these quartzites, of shaly horizons consisting now of garnet-amphibole hornfelses often charged with magnetite.

All of these rocks are classed in the Onverwacht Series which, on the northern limb of the Lily Syncline, is taken to be represented by a suite of sedimentary rocks, near the base, overlain by sediments and/ or lavas.

(e) Acid Rocks in the Northern Limb of the Eureka Syncline

(i) Composition and Structure

On the northern limb of the Eureka 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. This horizon was originally mapped by the Geological Survey (Visser et al, 1956) as a zone of metamorphic rocks of unknown origin. The sequence consists essentially of acidic rocks, with intercalated zones of basic material. In a few instances north of the Lily 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 layers varies from light gray to black. There is no significant difference between the intercalated basic rocks and the various talcose, carbonate, chlorite, and quartz-bearing schists described previously. The siliceous zones form resistant low mounds and, in places, lofty ridges. In some instances the rocks resemble cherts. Outcrops display a sheared sericitic lustrous rock, with numerous small cherty-quartz nodules that may represent altered amygdales or phenocrysts. In thin-section the rocks are composed almost entirely of quartz and sericite. 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 in the northern limb of the Lily Syncline.

Due to the fact that these rocks are largely of a brittle nature, crenulation and conjugate folds are common. The formation is intensely sheared, with the result that a strong foliation is developed parallel to the strike of the horizons. The foliation is almost vertical, or steeply south-dipping. Under the microscope, boudinage quartz nests are prominent. These may be deformed amygdales 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.

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 are orientated at right angles to the foliation and schistosity, indicating that they formed subsequent to the deformation. The rocks generally contain abundant silica, which led van Eeden (1941) to state that the intrusion of the basic Jamestown Complex had silicified many of the formations, including the Lily Syncline quartzite-conglomerate zones. These rocks, due to their low grade metamorphic mineral assemblages, can only be placed in the greenschist facies.

(ii) Origin

It is thought probable that some of the acid phases represented might well have formerly been acid volcanic lavas or quartz porphyries. It is believed that, as with the acid rocks in the northern limb of the Lily Syncline, the sequence described above belongs in the Onverwacht Series.

C. FIG TREE SERIES

(a) Composition and Structure

This Series is composed predominantly of an argillaceous sedimentary succession which includes a very varied group of shales, graywackes, banded ironstones, cherts, and some talc-carbonate-chlorite schists, with an upper lava or tuffaceous sequence. At the base of this succession in the Consort Mine area occurs a siliceous mineralized zone known as the Consort Bar or Consort Contact. A similar type of mineralized zone, the Lily Fault, also occurs at the lower contact of the sequence in the eastern part of the area. The Fig Tree rocks are confined essentially to two main areas. Typical banded shales and graywackes, together with associated chert horizons and an upper tuffaceous lava zone, occur in a long strip almost right across the southern part of the area, in the immediate vicinity of the Kaap River. They dip to the south, and constitute part of the northern limb of the Eureka Syncline. Metamorphosed argillaceous rocks and tuffaceous lavas occur in the vicinity of the Consort Mine, and in a long strip down Dicey's Creek to Bar 5 Beacon situated between Joe's Luck and Sheba Sidings. They constitute part of the northern limb of the Lily Syncline, but are only developed in the western part of the area.

The typical unmetamorphosed shale is usually a well-banded, fine-grained, dark rock, consisting of quartz and some plagioclase, with chlorite and much carbonate in places. The unaltered graywackes are dark gray to black in colour, but weather reddish-brown. They consist mainly of angular sericitized felspar, with fragments of chert and quartz, all of varying size. The finer matrix material consists mainly of quartz, with a little carbonate, together with chlorite and clay minerals. The banded chert horizons are usually fairly persistent, and can be traced for long distances. The cherts are fine-grained, hard, compact rocks, and invariably form low ridges. Often the banded cherts are light in colour, with dark gray to whitish bands, but are locally ferruginized to a banded ferruginous chert. 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 which forms a well-defined stratigraphical unit underlying much of the basal conglomerate of the Moodies Series. In hand specimens, these rocks have a distinctive dark green colour, and are characterized by numerous white felspar crystals which give the rock a distinct porphyritic appearance. Near the top of the succession the rock has a marked nodular structure, with slightly lighter coloured nodular masses giving very much the appearance of pebbles in a conglomerate. Chert and jasper pebbles are occasionally found in this zone. Van Eeden (1941) termed these nodular masses "autoliths". A typical "lava" consists mainly of fairly large, often partly sericitized soda-plagioclase and microcline crystals in a finer-grained groundmass. These felspars are often zoned with respect to the crystal boundaries. Although the vast majority of the felspar crystals are subhedral to euhedral, there also occur very angular and ragged, almost shattered grains of felspar. The groundmass consists of finer-grained quartz and a greenish amphibole (probably actinolite which is often partly or wholly changed to chlorite), together with some biotite and sericite.

Much attention has been paid to the Fig Tree rocks in the Consort Mine area, as these represent some of the few examples in the whole Barberton area of metamorphosed shaly and lava-type rocks of the Series. In general, these rocks are more correctly hornfelses, and, when partly weathered, often have a peculiar knotted or warty surface due to resistant porphyroblasts standing out in relief. A typical hornfels is usually quartz-rich, and almost all specimens contain tremolite and/or actinolite, together with biotite. Other minerals, usually confined to distinct bands, include euhedral almandine-spessartite garnets (Hearn, 1943), bladed andalusite crystals, diopside, and some zoisite, together with olive-green epidote and chloritoid. Certain banded ferruginous cherts have been converted into cummingtonite-grunerite-garnet rocks. The metamorphosed "lavas" are invariably rich in small laths of actinolitic hornblende. Other minerals include quartz and smaller amounts of plagioclase, microcline, epidote, and biotite. Within the metamorphosed "lavas" of the Consort area occur two very distinctive and persistent marker horizons. The first lies towards the top of the succession, within the "autolith" zone, and is a peculiar, persistent, laminated horizon containing abundant, highly sheared, flattened quartz lenses or blebs, and has consequently been termed the

"Quartz Bleb Marker". The average width of this horizon is about 30 feet. Microscopically, the rock consists mainly of an intergrown mass of fine-grained quartz and larger soda-plagioclase and microcline crystals, together with light green tremolite, some green hornblende, numerous small granular grains of zoisite, and lesser amounts of epidote. Almost pure, intergrown quartz mosaics represent the quartz blebs, as seen in hand specimens. The other horizon, termed the "Pyroxene Marker", occurs right at the top of the "lava" succession, immediately underlying the basal conglomerate of the Moodies Series. It is very persistent, and is found occupying the same stratigraphical position wherever outcrops occur. The thickness of this horizon is generally of the order of 35 feet. In appearance, the rock can be described as a well-banded, greenish, crystalline rock. The composition varies quite markedly, but it always retains its well-banded appearance. Very often it consists almost entirely of a coarsely crystalline mass of diopside. The crystals are generally very large, and show a very coarse type of sieve texture, with numerous small plagioclase and microcline crystals and a few quartz inclusions. Very often, in addition to bands of diopside, there occur narrow zones consisting mainly of tremolite with zoisite and some plagioclase.

The mineralized zones at the base of the Fig Tree Series are grouped in the Series for convenience, but it is clear that they are largely of secondary origin, associated with zones of movement and detachment. The Consort Bar (Hearn, 1943) is characteristically an exceedingly hard, almost chert-like, dark-brown rock, varying in thickness from 1 inch to 80 feet, but more usually from 2 to 6 feet thick. Bar development is very strong in the immediate mine area where it is also strongly folded on a large scale. From the northerly section of the mine the Consort Contact trends regularly eastwards, more or less following the northern side of Dicey's Creek, until it is obliterated by extensive granitic and pegmatitic intrusions in the Joe's Luck Siding area. To the east of Joe's Luck Siding, and extending as far as Bar 5 Beacon, isolated patches with fairly good bar development occur. Microscopically, the typical bar consists mainly of quartz, with a great number of minute, brown, pleochroic biotite flakes arranged parallel to the banding (Hearn, 1943). In the eastern part of the area, at the contact between talcose schists of the Onverwacht Series and the Fig Tree Series, and within the northern limb of the Eureka Syncline, occurs a silicified mineralized zone termed the Lily Fault. The fault zone is marked by a sheared, silicified, and partly brecciated zone approximately 30 feet wide in places. In this zone occur cherty bands and masses of vein quartz in disturbed argillaceous and ferruginous sediments.

Other than a widespread cleavage, which is often very difficult to detect because it lies in the plane of bedding, minor structures are generally poorly developed in the unmetamorphosed graywackes. However, the shales and banded ironstones are often intensely folded and contorted. In the hornfelses of the Consort Mine area there is often a very marked alignment of biotite flakes and amphibole needles. This strong arrangement, especially of biotite flakes, often gives the rock a distinct schistosity. This strong mineral orientation, which is parallel to the cleavage, has been folded by the major folds, and their associated minor folds, in the Consort area. The "autoliths", or nodular masses, in the upper part of the "lava" succession have invariably been strongly deformed, and in all cases have suffered the same type of deformation as the overlying conglomerate pebbles. They are flattened in the plane of cleavage, and their long axes plunge generally at fairly steep angles in the direction of dip of the bedding. The typical felspar porphyry "lavas", which are best developed in a strip underlying the northern limb of the Eureka Syncline, are generally more massive, although a general foliation conformable to the bedding in the surrounding sediments is often observed. Elongated elements in the groundmass of this type of "lava" invariably wrap around the large felspar crystals, and there are often indications of intense shearing, especially in a narrow zone immediately underlying the basal conglomerate of the Moodies Series. The "Quartz Bleb Marker" has suffered intense deformation, and wherever outcrops occur, the horizon consists of intensely sheared, drawn-out, flattened quartz fragments, together with a very strong alignment of amphibole needles parallel to the same plane of flattening. The strong mineral alignment foliation mentioned above has been strongly folded by the main system of folds in the Consort area.

It is clear that the grade of metamorphism of the Fig Tree Series forming the northern limb of the Lily Syncline is not very great. The sieve texture of the andalusite and some of the biotite, together with the presence of minerals such as zoisite, epidote, biotite, and even chlorite, indicates a relatively low temperature.

Almandine-spessartite garnet, actinolitic amphibole, diopside, and possibly some hornblende are perhaps indicative of a slightly higher temperature than the previously mentioned minerals. However, the majority of the minerals fit into the albite-epidote-hornfels facies of Turner and Verhoogen (1960), or the epidote-amphibolite facies of Ramberg (1952). The succession south of the Kaap River has suffered very little metamorphism, and, at the highest, could possibly be classed in the lowermost division of the greenschist facies, as defined by Ramberg (1952).

(b) Origin

It is suggested that, for the most part, the uppermost horizon of the Fig Tree succession represents a crystalline tuff (as defined by Pettijohn, 1957). Pyroclastic deposits formed by volcanic eruption have been described as porphyritic in part, and a close microscopic similarity has been noted between these rocks and graywackes. As mentioned earlier, the felspar crystals exhibit zoning. It is suggested that this zoning might be attributed to the formation of the crystal in the partially solidified mass prior to explosive extrusion. 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 angular fragments are interpreted as having formed due to disintegration during explosion. The nodular occurrences, together with the chert and jasper fragments, might possibly represent explosive, bomb-like concentrations of congealed magma and shattered sedimentary formations respectively.

The most widely held view on the origin of the Consort Bar (Hearn, 1943; Schoeman et al, 1946) is that it resulted from the silicification of an intensely sheared zone occurring between a competent rock (hanging-wall hornfelses) and an incompetent rock (footwall schists). This sheared contact horizon afforded an easy passage for ascending hydrothermal solutions. The Lily Fault occupies exactly the same stratigraphic position as the Consort Contact, but within the northern limb of the Eureka Syncline. It is considered to have formed in essentially the same way as the Consort Bar.

D. MOODIES SERIES

Moodies Series rocks belonging to the Lily Syncline can be traced for over 15 miles eastwards from the Consort Mine to Louw's Creek Station and beyond. The Moodies formations overlie the "lavas" of the Fig Tree Series in the area between the Consort Mine and Joe's Luck Siding, but further east the arenaceous rocks are underlain by basic amphibolite schists of the pre-Fig Tree succession. The Moodies rocks are best seen in the area east of Eureka Siding, and reach their maximum development near Louw's Creek Station. Formerly it was considered by the Geological Survey (Visser et al, 1956) that the "Lily Line" extended more or less due east of Joe's Luck Siding along the northern side of the Kaap River. Detailed mapping, however, enabled the conglomerate zone to be traced north of the Bar 5 Beacon where it narrows considerably and eventually disappears. Well-developed conglomerate is again encountered northwest of the Scotia Talc Mine at Sheba Siding. The large masses of quartzite in the Bar 5 area, formerly mapped as "contact metamorphic rocks of uncertain origin", can now be classified as Moodies rocks that have suffered considerable alteration by metamorphism associated with the intrusive Jamestown serpentinites and the Nelspruit Granite.

The Moodies Series is characterized by the presence of a conglomerate zone near the base. The conglomerate consists of numerous conglomeratic bands separated by quartzite horizons. In some places the conglomerate is not strongly developed, and the unit comprises mainly quartzites and, in places, poorly-developed shales. The quartzites contain felspar, muscovite, biotite, zoisite, clinozoisite, and accessory amounts of magnetite, ilmenite, and rutile. A few poorly-developed garnets were noted, in addition to localized occurrences of green fuchsite mica. The abundance of sericite and fuchsite at times imparts a greenish coloration to the quartzites. A further quartzite block, occurring near Noordkaap, immediately south of the Kaap River, consists of a more-or-less normal Lower Moodies quartzite with poorly-developed conglomeratic patches. It has been intensely sheared in places, and is unrecognisable at times as a quartzite. The shearing is often so intense that the rock consists almost entirely of very fine-grained quartz and sericite, the minute sericite flakes having a strong alignment.

The quartzites and conglomerate horizons form a persistent ridge in the centre of the Lily Syncline. The broad block of quartzites forming the extreme western limit of the Lily Line attains its appreciable outcrop thickness just east of the Consort Mine due to strong folding, both on a major and minor scale. The Lily Syncline forms a tightly-closed fold, with both limbs dipping to the south. Near Sheba Siding the formation narrows, and splits into three separate bands. The split is caused by large masses of intrusive serpentinite that have been forcibly injected into the quartzites near Bar 5 Beacon, so that numerous quartzitic horizons appear as rafts within the serpentinite bodies. In the area south of the Consort Mine, the Main Southern Fault truncates the fold trends of the strongly folded quartzite block. Upthrow on the south of the large reverse, or high-angled thrust, fault exposes rocks that are characteristic of the lower part of the stratigraphical succession in the area. Markedly deformed conglomerate pebbles in the basal conglomerate are indicative of the intense folding and flattening that occurred regionally along the contact belt as a whole. The rocks become mylonitic and chert-like at times. The most marked overall feature is the considerable reduction in grain size of the rock constituents. Pebbles of chert are drawn out into boudinaged structures and occasionally crenulation folds occur in the brittle horizons.

The alteration of the Moodies rocks has been largely due to dynamic metamorphism resulting from the intense shortening and flattening of the succession, coupled with heat effects of the intrusive Nelspruit Granite. The Lily Line quartzites have been recrystallized, and new minerals have formed. Generally, the quartzites are fairly pure, and, as noted by van Eeden (1941), they have probably been subjected to secondary silicification, especially in the area from Joe's Luck Siding eastwards. The typical metamorphosed quartzite consists of a fine-grained intergrown quartz mosaic with attendant albite plagioclase, some muscovite, and a few specks of biotite. Near Joe's Luck Siding an impure quartzite resembles an arenaceous hornfels, and amphibole is developed, usually consisting of tremolite-actinolite, together with some biotite. Impure quartzitic rocks were also found to contain an abundance of diopsidic pyroxene, zoisite, and clinozoisite. From this it is concluded that these rocks must have been fairly rich in carbonate. The mineral assemblage in general may be regarded as belonging to the albite-epidote-hornfels facies of Turner and Verhoogen (1960), and corresponds with the low temperatures and pressures of the outer margin of a zoned metamorphic aureole (see Figure 2).

E. JAMESTOWN ULTRABASIC INTRUSIVE SERIES

Certain of the more massive basic rock assemblages may be classified as belonging to the Jamestown Intrusive Series. Included in this group are massive green serpentinites, blue serpentinites, and other basic rocks.

(a) Massive Green Serpentinites

This group is by far the most widespread type of serpentinite in the area. These massive bodies, in which asbestos veinlets are often noticeable, reach their maximum development in the area north of the Consort Mine, in a strip usually a few hundred yards in width, lying between the contact amphibolites and the tremolite schists (see Figure 3). In the east, towards Sheba Siding, two further large occurrences are found. Several minor serpentinite zones also occur south of Noordkaap, and in the vicinity of the Woodstock Mine and the Kaap River.

The massive body to the north and northwest of the Scotia Talc Mine at Sheba Siding has intruded into the sedimentary sequences of the Lily Syncline, causing the central Moodies Series quartzite and conglomerate horizon to split into three distinctly separate bands, beginning just east of Eureka Siding, and reaching their maximum divergence about $1\frac{1}{2}$ miles to the west. The intrusion has disrupted the sedimentary succession in this area, and this, coupled with the altered nature of the quartzites, formerly made classification of these rocks difficult. In many cases, serpentinite bodies grade into well-foliated tremolite schists. Lensoid bodies of serpentinite occurring within the tremolite schists occur in a randomly distributed manner, and show all gradations between areas of nearly pure amphibole and areas of antigorite. Just north of the Consort Mine, nearly pure serpentinite bodies stand out as more resistant masses within the schists.

Microscopically the serpentinite, as typically developed, consist of a fibrous mass of antigorite and serpentine, usually with a few irregular magnetite grains. Rarely are palimpsest or relict olivine and pyroxene crystals seen, and no completely fresh olivine or pyroxene has been observed. Muscovite and fuchsite sometimes occur in areas usually close to pegmatite bodies, and appear to have formed by pneumatolytic processes accompanying the intrusion of these bodies. In close proximity to the granite contacts, veins of cross-fibre chrysotile asbestos are developed, in some cases of good quality, with fibres over an inch in length, and with very high tensile strength. Magnetite is generally fairly abundant, and, together with a few chromite grains, forms the principal accessory mineral in the rock. Occasionally these euhedral grains form in parallel bands, suggestive of magmatic differentiation.

The relict olivine and pyroxene crystals in the serpentinites leave no doubt that many of these bodies have formed from an original magnesian-rich parent rock of ultrabasic composition, such as olivine- and pyroxene-bearing peridotites and pyroxenites. This view is also supported by the fact that many of the serpentinite bodies have fairly high concentrations of nickel, chromium, and magnetite, minerals generally associated with ultrabasic igneous rocks. The serpentinite bodies, together with many other basic schistose rocks, have previously all been regarded as belonging to the Jamestown Igneous Complex. Whereas the majority of the basic schists underlie the Fig Tree Series as a stratiform sequence, the serpentinites, in strong contrast, can also occur at the top of the stratigraphic succession, well within the Moodies Series. These bodies might have been squeezed up in a more-or-less cold state from the basic pre-Fig Tree complex into higher rock strata during the deformation of the area. Conformable contacts are the rule, and serpentinites are not found cross-cutting the quartzite formations. In addition, there are no signs of contact metamorphism associated with the serpentinites. The metamorphism is always found to be more intense on the Nelspruit Granite side of the serpentinite bodies, suggesting that the metamorphism was primarily due to the intrusion of the granites. The grade of metamorphism on the granite side at times approaches the sillimanite-pyroxene-hornfels facies. On the other side of the serpentinite masses, i.e. away from the granites, the metamorphic grade is slight, and successions adjacent to this contact may be classified as lower-grade members of the albite-epidote-hornfels facies, or of the greenschist facies.

The serpentinites are invariably massive structure-less bodies, although in some cases a rude foliation, coinciding with the attitude of the surrounding foliation, can be detected. The bodies are usually lensoid, and elongated parallel to the regional structure. In the field they occur as, or appear to be, steeply-inclined lenses or sheets lying concordantly with the surrounding formations. The dip of the foliation, where it can be detected, generally conforms to the regional structure, and indicates that these serpentinite masses underwent deformation similar to, or synchronous with, that of the adjacent rock-types.

(b) Blue Serpentinites

The blue serpentinite occurrences are less numerous, and are restricted to a few small bodies in the area north of the Consort Mine and east of Eureka Siding. The most prominent occurrence is in the area between Noordkaap and Caledonian Siding, where they are intimately associated with green serpentinites and a variety of basic schists. The outcrops are often distinguished by the abundant growth on them of vegetation.

The rock is characterized by its dark gluish-green colour, and its greater resistance to weathering, as compared with the surrounding green variety. The Geological Survey (Visser et al, 1956) considers the blue variety to be probably closer to pyroxenite or olivine hypersthenite in original composition, rather than to peridotite.

(c) Other Basic Rocks

Included within this subdivision are a variety of basic rocks that are connected with the main serpentinite bodies. These include a string of xenoliths lying within the zone of contact amphibolites north of Consort Mine, but which are totally different from the associated black hornblende amphibolites. The xenoliths form a straight line, parallel to the granite contact and to the foliation of the surrounding amphibolites. They are regarded as representing a serpentinized ultrabasic sill, or an horizon of a much more basic nature intercalated in the surrounding amphibolites. In addition to these basic xenoliths, there are numerous irregular bodies or zones of talcose rocks. The main talc occurrences are centred around the Scotia Talc Mine, an economic deposit situated between two quartzite-conglomerate bands of the Lily Syncline, in a zone of intrusive altered green serpentinite. Black schorl tourmaline is commonly associated with the talc in the area, and it is apparent that the Scotia deposit has largely been controlled by intensive shearing, coupled with hydrothermal solutions that emanated from the nearby intrusive Nelspruit Granite. Most of the talc bodies can be directly attributed to zones of movement,or faulting,or strong structural disturbance.

Magnesite-bearing serpentinites occur in places, the largest deposit of which is situated near Sugden Siding. This deposit was mined briefly prior to 1942 (van Zyl, 1942). Abundant antigorite, magnetite, carbonate material, and altered olivine relicts were noted in the country-rock surrounding the ore-body. In addition to the magnesite near Sugden Siding, further occurrences of this mineral are developed northwest of the Scotia Talc Mine. In this area the serpentinites are also locally strongly magnetic, due to the presence in certain shear zones of the nickel-magnetite mineral trevorite and the hydrated nickel-magnesian silicate neporite. It is considered that the nickeliferous material was introduced into the area as an original constituent of the ultrabasic intrusive, and that subsequent shearing and hydrothermal activity associated with the granite emplacement was responsible for the solution and reprecipitation of the nickel-bearing constituents within the shear zones.

F. NELSPRUIT GRANITE

(a) Composition and Structure

The Nelspruit Granite occurs along the entire northern fringe of the Barberton Mountain Land, where it builds well-rounded hills that form the Krokodilpoort Range. The main granite mass lies between one and five miles north of the Consort Mine, and forms the highest ridge behind it. With the rapid thinning of the basal layered sequence of the Swaziland System towards the east, the contact swings abruptly southwards to approximately one mile north of Sheba Siding. From here it trends roughly east-northeast towards Louw's Creek Station.

The granite is by no means homogeneous in character, and two fairly distinct types with variations and gradations are apparent. These are a migmatitic variety, which is the most common, and an intrusive variety along the contact zone with the Swaziland System.

The migmatite constitutes the dominant variety in most of the area from the Consort Mine to Nelspruit (van Eeden, 1941). It is predominantly a gneissic, light gray, biotite granite or migmatite, with the gneissic banding invariably highly contorted. Microscopically, the rock consists of soda-plagioclase, microcline, quartz, and biotite, the darker bands being exceptionally rich in the latter mineral. Very little hornblende is present. At no place has a sharp contact been seen between the gneissic granite and the black contact amphibolites, although ghost-like relics of rather diffuse darker-coloured zones, and irregular patches of nearly pure femic minerals (mainly biotite with some hornblende) are fairly plentiful in the contorted gneiss. Definite intrusive granite veins and pegmatites cut the gneiss in many areas.

Along the immediate contact zone occurs a relatively narrow belt of intensely sheared intrusive granite and associated pegmatites. The average width of this zone in the Consort area appears to be about 1,000 feet, but this varies considerably. There is usually a gradational change to a more homogeneous, finer-grained, and more compact granite before the true gneiss is encountered. The phenomena seen along the contact can only be interpreted as representing an intrusive relationship between granite and the dark contact amphibolites lying to the south. The intrusion is thought, for the most part, to have caused the strong thermal metamorphism. Typically, the intrusive granite is medium- to coarse-grained, and light in colour. A marked feature, especially close to the contact, is the very strong foliation always parallel to the contact, and to xenoliths which occur frequently within the granite. Often, the granite is porphyritic in nature, and contains large felspar phenocrysts. These have usually been rounded due to intense shearing, and the crystalline groundmass surrounding them has been thoroughly ground up. In thin-section, the rock is principally composed of quartz, microcline, twinned and untwinned felspar (usually oligoclase or albite), and minor amounts of biotite, muscovite, and magnetite.

Where intrusive masses of granite cut the sediments, they are often coarse-grained and pegmatitic in character. The main minerals in such varieties are orthoclase, quartz, microcline, muscovite, and some plagioclase. Biotite and other ferromagnesian minerals generally occur very sparingly. These rocks are essentially potash- and soda-rich. There is always a very sharp boundary between intrusive granitic and pegmatitic sheets and the contact amphibolites. The coarse-grained granites frequently grade into bodies which are definitely pegmatitic in character. In addition to the above, individual and often very coarse-grained irregular pegmatite bodies of varying size occur in many localities throughout the area. There is an abundance of intrusive coarse-grained granitic and pegmatitic material in the Joe's Luck Siding area and in the valley of Dicey's Creek. In the latter area, the intruded sheets have been guided to a large extent by the bedding surfaces of the metamorphosed shales and graywackes of the Fig Tree Series, so that they form a series of regular sheets and veins which seldom transgress the bedding. In a number of places these sheets have been drawn out into boudins. Pegmatites younger than all the granitic rocks mentioned above often cut the gneissic granite and the well-foliated intrusive granite. Very coarsely crystalline pegmatites not infrequently transgress earlier-formed, and more finely-grained, pegmatite bodies. The majority consist of quartz-albite-microcline-orthoclase and quartz-albite-muscovite-microcline-orthoclase. The latter are invariably the most coarsely-grained, and generally occur as isolated, irregular, non-foliated masses of greatly varying size within the layered sequence. They seldom, if ever, occur as sheets and veins, the latter type of body invariably being composed mainly of quartz and felspar. The muscovite is often rather coarse-grained, with individual large crystals frequently well over an inch across. Zoning is generally absent, but a few of the larger bodies have well-developed milky-white to slightly translucent quartz cores. Occasionally magnetite crystals are present, but no economic minerals, such as the cassiterite, euxinite, monazite, etc. of the mineralized pegmatites of Swaziland, have been found. Narrow aplitic veins and dykelets are confined to the immediate contact zone.

The typical banded, biotite gneiss is intensely contorted and folded in a most irregular fashion, and the axial planar trace directions of these flowage folds vary greatly, even over a small area. The most striking feature occurring in all the intrusive granites is the very strong foliation, always parallel to the metamorphosed layered sequence to the south. This appears to be due partly to the strong alignment of mineral components under high pressure during cooling of the granite, and partly to a later, very intense dynamic shearing. The latter led to a mechanical grinding up of the granitic material, which occurred mainly after crystallization. The parallel orientation of both these planar features has had the effect of greatly intensifying the overall foliation, which phenomenon makes the distinction between these two types in the field very difficult. In the porphyritic granite, the uncrushed lenticular phenocrysts give the rock a characteristic augen structure. Where the augen themselves have been ground down and have disappeared, the rock consists exclusively of very fine fragments, and resembles a mylonite. The groundmass is often so fine that, in hand specimens, the rock looks like a chert. The whole process is considered to be a purely dynamic one which took place under cold conditions.

The foliated granite has itself been strongly folded, and the strong lineation in the granite is parallel to the minor fold axes. Lineations are well developed and exposed in the bed of the Kaap River, immediately north of Joe's Luck Siding. In this area, a set of fairly shallow-plunging lineations occurs in granite bodies, and in impure meta-sediments and "lavas". The lineations plunge to the east-southeast at about 30°, and parallel the "a" direction of deformed and elongated pebbles in a nearby conglomerate. This indicates that the lineation has resulted essentially from an elongation of elements within the rock. For the production of lineations of this kind, a primary foliation must have existed in the granite. This primary foliation is probably to be found in the aligned mica flakes, concentrated in thin bands within the intrusive granites. As shown before, these lineations are intimately connected with some of the folds which might be of a cataclastic type. If this is the case, then the lineations would also have formed during the period of cataclasis mentioned above.

(b) Origin

The authors are of the opinion that the typical Nelspruit migmatite represents, for the most part, the basement upon which all the layered rocks of the Mountain Land were deposited. The intensely folded and strongly banded gneisses are considered to represent the granitized remnants of some pre-Swaziland formation. The comparatively small metamorphic aureole is thought to have been caused essentially by the heat effects of the intrusion of a relatively small strip of mobilized granite (coupled probably with the effects of a partially remobilized basement migmatite), rather than by an extensive wave of granitization. It is suggested that certain isolated rafts of basic material, lying well within the granites, and identical to the contact amphibolites, represent isolated, downfolded remnants of a once much more extensive, and possibly continuous, sheet of Onverwacht rocks. It is thought that the folding might have been accentuated due to down-sagging of the amphibolites into the re-heated and semi-plastic migmatite, coupled with differential updoming of the latter in places.

It is the authors' contention that the intrusive granite represents the most mobilized part of the re-heated and plasticized Nelspruit basement migmatite, and that the presence of this strip of granite along the contact zone and the fabrics developed in it are both related to the updoming of the main body of migmatite. It is considered that intrusive material found easy avenues of access in the zones of differential shear which developed along the contact zone as a result of the updoming. The intrusive material was guided by the planes of differential movement and shearing, and this played a part in the alignment of micas within the granite. The updoming persisted after the crystallization of the granite, and continued shearing led to a strong mechanical grinding-down of the intruded material. This process, superimposed on an earlier foliation (caused by the preferred orientation of minerals during crystallization), was largely responsible for the very marked overall foliation parallel to the contact.

(c) Metamorphism Produced by the Granite

Much of the thermal metamorphism in the area is believed to have been caused by the intrusion of a mobilized marginal phase of the Nelspruit migmatite. At the time of this mobilization, the whole basement must have been reheated and plasticized to a certain extent. It is possible to subdivide the area into three distinct facies of contact metamorphism (see Figure 3). Progressively further away from the granite contact, the successive facies are (1) a hornblende-hornfels facies, (2) an albite-epidote-hornfels facies, and (3) a greenschist facies.

The characteristic minerals in the first facies are dark hornblende and plagioclase of intermediate composition, together with garnet, diopsidic pyroxene, and sillimanite. At one locality within the high temperature aureole is a rock containing a substantial amount of corundum, together with sillimanite and tourmaline. The presence of sillimanite and diopsidic pyroxene probably indicates that, where the composition of the original rocks was suitable, temperatures were locally high enough to have formed minerals characteristic of the higher-grade pyroxene-hornfels facies of Turner and Verhoogen (1960). To the south, through the Consort Mine area, as far as the Main Southern Fault on the north side of the Kaap River, is an assemblage of lower temperature minerals, including tremolite-actinolite, biotite, diopside, garnet, and andalusite, typical of the albite-epidote-hornfels facies of Turner and Verhoogen (1960). Along the Kaap River, and extending to just south of the Woodstock Mine and Noordkaap, is an assemblage consisting dominantly of carbonate-bearing talc and chlorite schists, with minor occurrences of tremolite, all characteristic of the greenschist facies of Ramberg (1952). South of this, in the "lavas", shales, and quartzites of the Eureka Syncline, and in dolomitic, or slightly talcified dolomitic, rocks around Clutha Mine, the effects of contact metamorphism are absent or, at the most, very slight.

It appears likely that the strong mechanical deformation of the crystallized granite and of some of the metasediments to the south thereof has caused a certain amount of retrograde metamorphism. This is well revealed in zones of intense shearing, where much of the original felspar has been broken down to sericite. In general, this retrograde process appears to be more-or-less confined to local zones of intense shearing, and it is a very widespread phenomenon in the area.

The marked absence of regional metamorphic effects within the Mountain Land, suggests that the Barberton rocks, as old as they are, were never buried beneath a great stratigraphic cover in the past.

THE BASAL ROCKS IN THE BARBERTON - NOORDKAAP AREA

A. ONVERWACHT SERIES

Between Barberton and Noordkaap lies a narrow strip of basic rocks, seldom exceeding a few hundred yards in width, sandwiched between the Kaap Valley Granite in the west and the Eureka Syncline in the east. Underlying the Moodies rocks of the Eureka Syncline, and only outcropping in a few localities, are banded ferruginous cherts and fine argillaceous shales of the Fig Tree Series. The basic rocks appear to lie conformably beneath the Fig Tree succession, and are considered by the authors to be members of the Onverwacht Series, and not of the Jamestown Complex. The rocks are extremely variable in type, and range from blue and green intrusive serpentinites to altered amphibolites, and from talcose and chloritic rocks to carbonate-bearing massive and schistose varieties. The carbonate rocks appear in the field to represent highly altered dolomitic rocks, or impure siliceous limestones.

The basic suite of rocks between Noordkaap and Barberton have not been subjected to the same degree, or intensity, of metamorphism as have the rocks to the north along the Nelspruit Granite contact. Despite the consequent dissimilarities in composition in some instances, the Barberton - Noordkaap sequence occupies the same stratigraphic position, and it is assumed that they are of similar origin. Chemically, both areas bear a distinct relationship. It was discussed earlier how the basic amphibole schists in the Noordkaap - Louw's Creek area could have been derived from an impure siliceous dolomite or limestone that had been subjected to contact metamorphism resultant on intrusion of the Nelspruit Granite. In this area, the intrusion of the Kaap Valley Granite probably provided the metamorphic environment, only the degree of heat involved in its emplacement must have been considerably lower than the temperatures involved with the Nelspruit Granites remobilization.

The result of this lack of intense metamorphism has, to some extent, preserved the rocks in the zone from complete transformation, leaving relict xenoliths behind. These preserved remnants often grade imperceptibly into a variety of rock-types. Thin-section study reveals the prevalence of carbonate material within most of these rocks. It is possible, but thought unlikely, that much of this might be secondary in origin. Many of the so-called carbonate rocks are made up of pure dolomite. In some instances, a poor quality marble is present. Carbonates, both dolomite and calcite, and occasionally siderite, are abundant in almost all the basic schists and the massive rocks. The manner in which the carbonate is disseminated throughout the rocks is not in accordance with a secondarily introduced constituent. Much of it is crystalline, and displays twinning. Secondary carbonates are probably present only as veinlets which are the result of precipitation in cracks and voids.

In the base of the Swaziland System between Barberton and Noordkaap, there is evidence of the same stratiform layering described for the area along the Nelspruit Granite contact. There are also present the true intrusive serpentinites of the Jamestown Series. These are not large bodies, and occur in lensoid masses mainly in the area north of Caledonian Siding. A few isolated bodies occur to the south of this, but do not constitute a significant portion of the basic zone in these areas. They are markedly different in character in the field from any other rock-type, and it is difficult to visualize them as being directly related to the remaining basic schists found in the area. The stratiform basic schists are comprised essentially of quartz-chlorite or quartz-actinolite schists. These may contain variable amounts of sericite, epidote, carbonate material, and accessory amounts of magnetite, zircon, sphene, felspar, and tourmaline. The degree of metamorphism is such that the rocks in the zone can, at times, be placed in the upper greenschist facies, or in the lower albite-epidote-amphibolite facies, as defined by Turner and Verhoogen (1960). Included within the basic schists are several weakly developed quartz-sericite schist horizons, which occur in the area directly east-southeast of Caledonian Siding, where they are developed in narrow bands resembling a stratiform sequence in outcrop. The mineral constituents, mainly quartz and sericite, are aligned parallel to the foliation developed in all the rocks in the area. Augen structures can be seen in thin-section. Bedded shales occur in a few places between the Kaap Valley Granite and the basic schists. A narrow banded chert bar with intercalated altered finely-laminated shaly horizons is also present over a strike length of about $\frac{1}{3}$-mile.

In the Clutha Mine locality, and extending southwards towards Clutha Siding, a peculiar relationship of what appears to be granite and dolomite can be found. The exposures are such that it is extremely difficult to ascertain exactly the geological field relationships between the two rock-types, and they are often so intimately interconnected that it is impossible to distinguish or differentiate the two.

Other prominent basic rocks within the zone between Noordkaap and Barberton are talc schists, massive talcose rocks, and talc-carbonate rocks. These varieties grade imperceptibly, at times, from one type to another, as well as into the amphibole schist zones, and into the serpentinite bodies. They generally have a high content of carbonate, both in fine-grained, equally disseminated form, or as cavity fillings. In several places the rocks have amygdaloidal-like patches. These patches consist of white carbonate, generally calcite, but turbid pink and brownish varieties containing siderite also occur. The groundmass of the rock normally consists of fine-grained talc laths with some chloritic material, quartz, and felspar. The weathered variety develops very characteristic pock-marked surfaces, usually filled with limonite or yellow ochre. Carbonate, talc, or chlorite may also fill the cavities.

B. RELATIONSHIP BETWEEN THE ONVERWACHT SERIES AND THE KAAP VALLEY GRANITE

The contact between the Kaap Valley Granite and basic schists is not everywhere observable, due to the heavy over-burden produced by rock and soil derived from the westerly slopes of the Eureka Syncline. The contact, however, can be seen in the South Kaap River, and in the area east of Caledonian Siding.

Contrary to the Geological Survey (Visser et al, 1956) report which states that the granite contacts are everywhere sharp, transition zones between the granite and the schists occur in the Caledonian Siding area. As the granite contact is approached, more and more femic material (chlorite), derived from the alteration of green hornblende, enters into the rock. Finally, in the contact zone itself, the granite and green chlorite schists display no cross-cutting intrusive relationships, but, instead, a kind of lit-par-lit injection has taken place, parallel to the contact and conformable with the foliation or schistosity of the adjacent basic suite. The granite at the contact, as elsewhere, shows the same coarse texture characteristic of the Kaap Valley Granite, with no chill phase. The granite in the Caledonian Siding area is a coarse-grained, mottled, green and white rock consisting mainly of green hornblende, largely, or even entirely, altered to green penninite chlorite, albite-oligoclase plagioclase, and large interlocking quartz crystals, with accessory amounts of magnetite, zircon, and sericite derived from the saussuritization of the felspars. Generally, the granite contact and the zone extending a short distance into the massif possesses a foliation and a strong mineral lineation. The attitude of the lineation, which plunges north, is identical to a similar lineation seen in the neighbouring schists, and to the marked pebble elongation in the basal conglomerate of the Moodies Series.

In the area south of Hislop's Creek there are several acid horizons within the schists. Some of these have large felspar phenocrysts, and might represent intrusive tongues of granite or felspar porphyry. Within the sedimentary succession of the Eureka Syncline are also intruded rocks similar in many respects to the Kaap Valley Granite. These granite-like bodies again consist of relict hornblende crystals, mainly altered to chlorite, andesine felspar, biotite, apatite, quartz, and sericite. In the field these granites, or quartz diorites, are entirely structureless masses, and they might, therefore, represent late-phase activity and injection subsequent to the folding, or else they might represent quartz-diorite dykes.

SUMMARY AND CONCLUSIONS

The base of the Swaziland System in the Barberton - Noordkaap - Louw's Creek area consists of two almost identical successions separated by the Main Southern Fault. Both these successions, comprising Onverwacht, Fig Tree and Moodies rocks, strike approximately east-west, and dip generally at fairly steep angles to the south. The sequence lying to the north forms the northern limb of the Lily Syncline which is truncated roughly along its axial plane by the Main Southern Fault between Joe's Luck Siding and Noordkaap. This major high-angle thrust fault has eliminated the southern limb of the Lily Syncline, as well as the anticlinal divide between the latter and the Eureka Syncline to the south. This has resulted in the northern limb of the Eureka Syncline being brought into direct contact with the northern limb of the Lily Syncline in the west, between Joe's Luck Siding and Noordkaap. The northernmost succession of the area lies in direct contact with the Nelspruit Granite, and has suffered fairly strong thermal metamorphism, while the southern assemblage has only been slightly metamorphosed.

Lying at the base of the Swaziland System, between the Nelspruit Granite and the overlying Fig Tree sequence, there occurs a stratiform suite of predominantly basic schistose rocks which the authors believe to be members of the Onverwacht Series. The succession consists of alternating amphibolites and acid schist horizons, together with intercalations of shaly material. The basic assemblage consists of dark contact amphibolites (hornblende schists), green amphibolitic schists (tremolite-actinolite), and a variety of talcose schists, talc-chlorite schists, and talc-carbonate schists. Intercalated conformable zones of quartz-sericite schists are thought to be the altered equivalents of more acid material. The assemblages, in the mass, are believed to represent a fairly strongly metamorphosed sequence of dolomites with calcareous, arenaceous, and shaly horizons, and of intercalated basic and acid extrusives.

A contact metamorphic aureole, in which three distinct facies of contact metamorphism can be recognized, is observable throughout the area, and is related to the intrusive phase of the Nelspruit Granite. The dark hornblende assemblage along the immediate contact zone belongs to the hornblende-hornfels facies, while the lower temperature assemblage of tremolite-actinolite schists, further from the granite contact, falls in the albite-epidote-amphibolite facies. Still further from the granites, the carbonate-bearing talc and chlorite assemblages belong to the lowest temperature greenschist facies. The talc, chlorite, and phyllite assemblages grade into unmetamorphosed dolomitic, argillaceous, and arenaceous units of the Swaziland System. The various metamorphic facies thus represent zones of a metamorphic aureole which decreases in intensity of alteration with increasing distance from the granite contact. Between Noordkaap and Barberton the hornblende-hornfels facies is missing, and either the albite-epidote-amphibolite facies or the greenschist facies occurs immediately adjacent to the Kaap Valley Granite. Here the succession is, on a broad scale, identical to that between Noordkaap and Louw's Creek, differing mainly in the degree of metamorphism. Thus, whereas the Onverwacht rocks of the northern succession have been converted to hornblende schists and tremolite-actinolite schists, similar rocks in the south have been changed to carbonate-bearing talc and chlorite phyllites.

The basic intrusive rocks of the Jamestown Series are now considered to be of much smaller extent than was previously thought. They are represented mainly by massive bodies of serpentinite. There is a possibility that certain of the purer talc-carbonate schists along the Kaap River were formed from Jamestown ultrabasic intrusives, but it is considered that the majority of such rock-types, as well as most of the other basic schists in the area, represent metamorphosed impure dolomitic rocks and basic lavas of the Onverwacht Series.

It is believed that the typical Nelspruit migmatite represents, for the most part, the basement upon which all the Swaziland rocks of the Mountain Land were deposited. The comparatively limited extent of the metamorphic aureole is considered to have been caused, essentially, by heat effects associated with the intrusion of a narrow mobilized marginal phase of the Nelspruit Granite. It is thought that the basic amphibolite bodies lying well within the granites are identical in all respects to the black contact amphibolites occurring at the base of the Onverwacht Series. These rafts are considered to represent isolated downfolded remnants of a once more extensive expanse of Onverwacht rocks. A gradational contact between the Kaap Valley Granite and the basic schists of the Onverwacht Series can be seen near Caledonian Siding. No cross-cutting relationships were observed, instead, the granite appears to have been intruded along cleavage planes already present in the schists.

It is concluded that the Onverwacht, and not Jamestown, rocks are in contact with the granites, and that the former were deposited on a floor represented by the Nelspruit gneisses and granites which must, therefore, constitute the oldest rocks in the area. During a late stage in the deformation of the Mountain Land, the Kaap Valley Granite was intruded, and at the same time the contact between the Onverwacht rocks and the Nelspruit granites and gneisses was remobilized to produce the presently observable intrusive relationships. Possibly only the intrusive basic and ultrabasic rocks comprising blue and green serpentinites, and magnesite-, talc-, chrysotile-, and nickel-bearing serpentinites can be regarded as constituting what the authors prefer to call the Jamestown Ultrabasic Intrusive Series.

It is believed that the above conclusions concerning the stratigraphic position of the rocks adjacent to the contact of the Swaziland System and the various granites apply to many other areas in the Mountain Land. The Onverwacht Series is far more widely developed than previously thought. The past practice of indiscriminantly grouping of every basic schistose rock into the old Jamestown Igneous Complex, without attempting a precise analysis of the structure, stratigraphy, and metamorphism may have created a misleading picture of the area.

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Acknowledgements

The writers wish to express their appreciation to the management of Eastern Transvaal Consolidated Mines Limited for the considerable assistance rendered during the undertaking of research which led to the preparation of this paper. In particular, thanks are due to the geological staff of the group, who contributed valuable information and criticism during the period spent in the Barberton area. Thanks are extended to various members of the Economic Geology Research Unit of the University of the Witwatersrand for suggestions and guidance during all aspects of the work.

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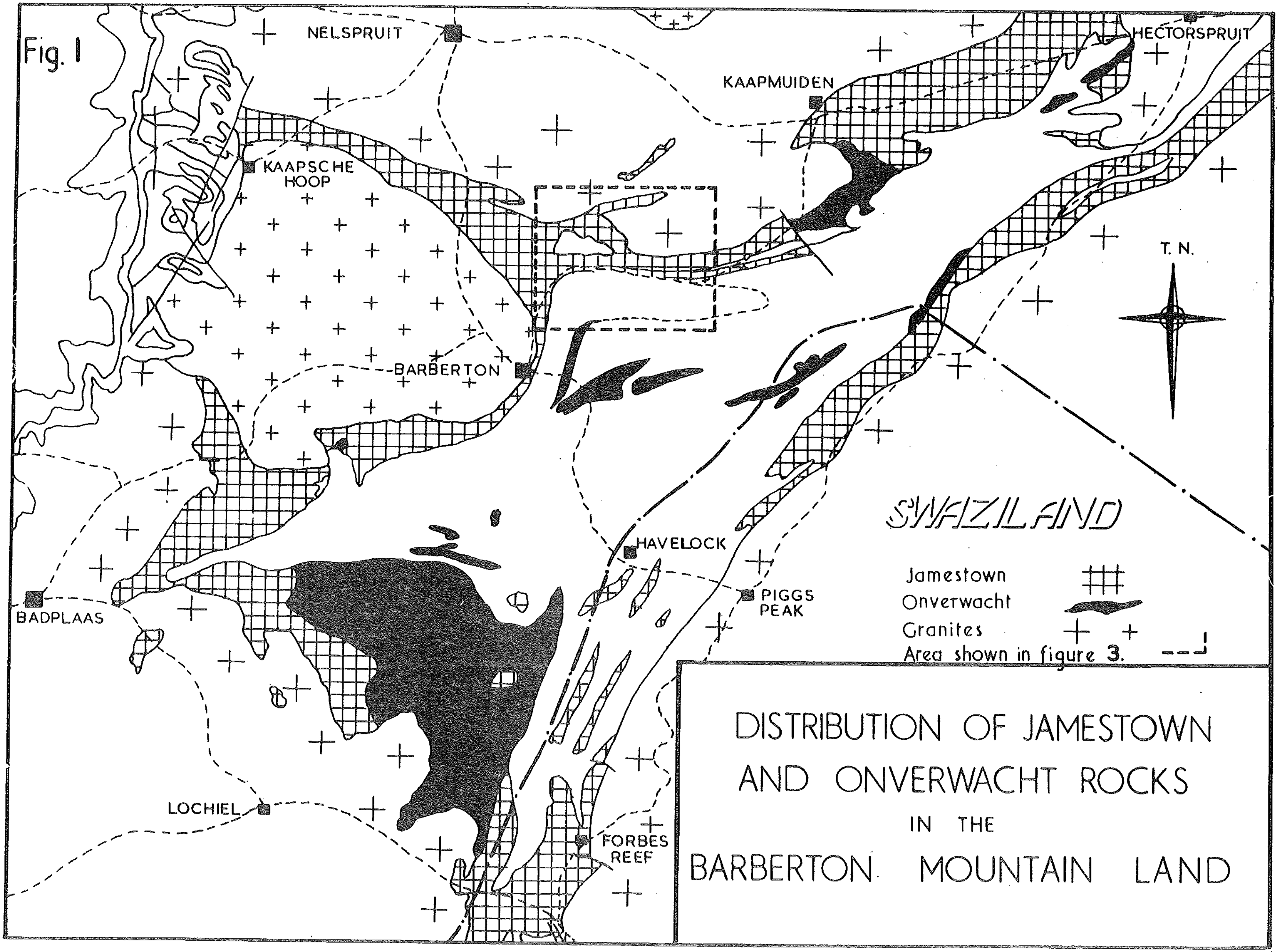
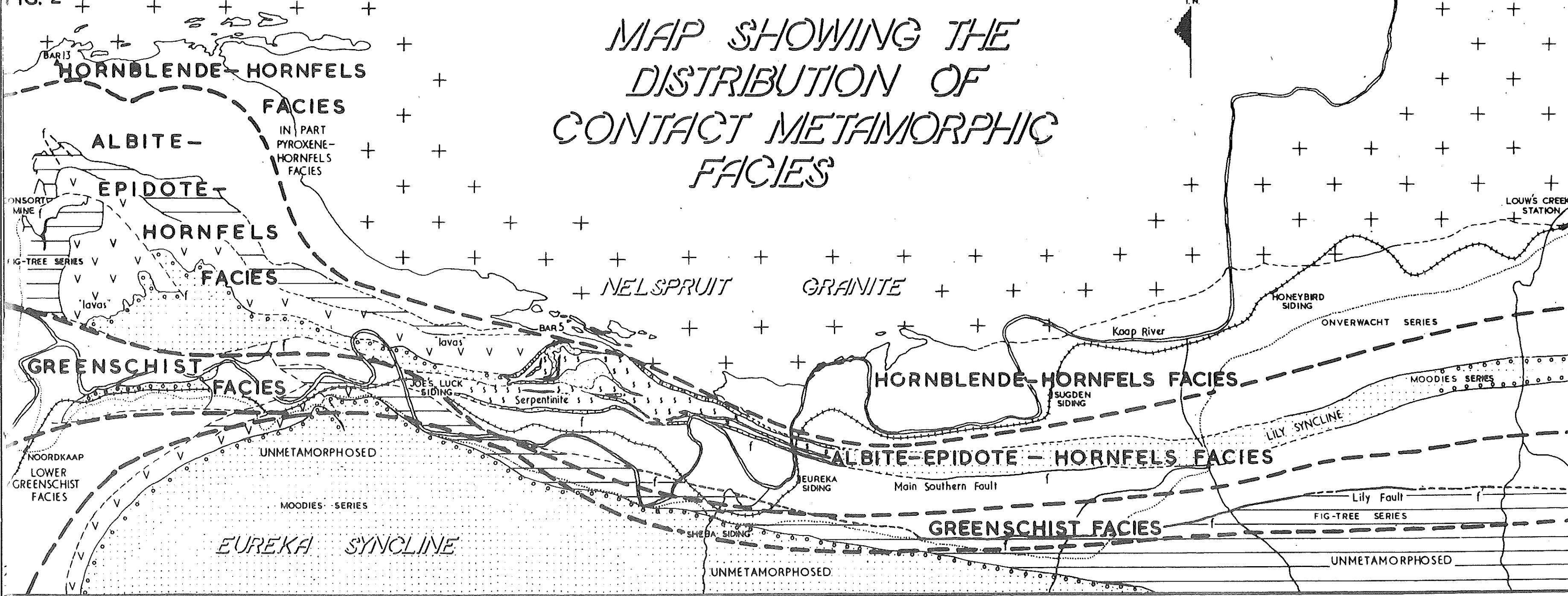
Fig. I



DISTRIBUTION OF JAMESTOWN AND ONVERWACHT ROCKS IN THE BARBERTON MOUNTAIN LAND

FIG. 2


MAP SHOWING THE
DISTRIBUTION OF
CONTACT METAMORPHIC
FACIES
T.N.
BAR 13
HORNBLENDE-HORNFELS
FACIES
IN PART
PYROXENE-
HORNFELS
FACIES
ALBITE-
EPIDOTE-
HORNFELS
FACIES
ONSORT
MINE
IG-TREE SERIES
"lavas"
GREENSCHIST
FACIES
NOORDKAAP
LOWER
GREENSCHIST
FACIES
UNMETAMORPHOSED
MOODIES SERIES
EUREKA SYNCLINE
BAR 5
lavas
JOE'S LUCK
SIDING
Serpentinite
NELSPRUIT
GRANITE
Koap River
HONEYBIRD
SIDING
ONVERWACHT SERIES
LOUW'S CREEK
STATION
HORNBLENDE-HORNFELS FACIES
SUGDEN
SIDING
MOODIES SERIES
LILY SYNCLINE
ALBITE-EPIDOTE - HORNFELS FACIES
EUREKA
SIDING
Main Southern Fault
Lily Fault
FIG-TREE SERIES
GREENSCHIST FACIES
SHEBA SIDING
UNMETAMORPHOSED
UNMETAMORPHOSED

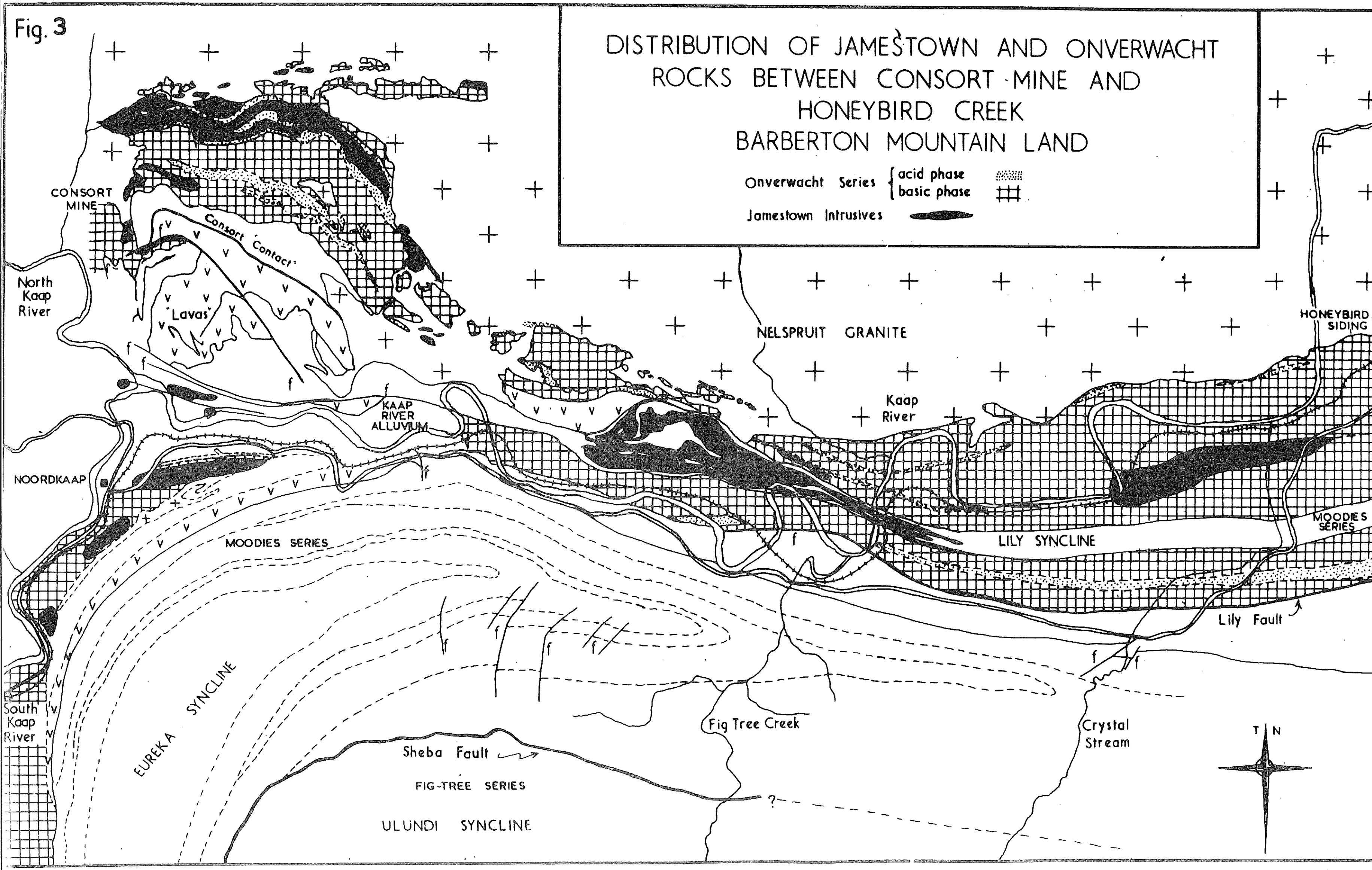


Fig. 3

DISTRIBUTION OF JAMESTOWN AND ONVERWACHT ROCKS BETWEEN CONSORT MINE AND HONEYBIRD CREEK BARBERTON MOUNTAIN LAND