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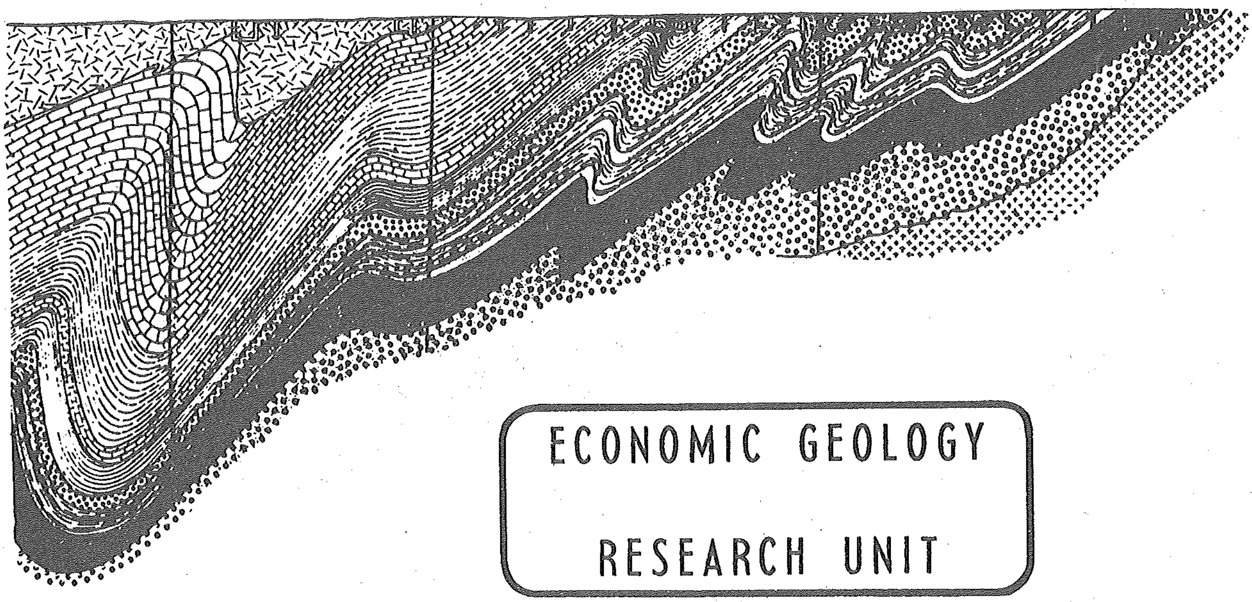

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A REASSESSMENT OF THE ONVERWACHT SERIES IN THE KOMATI RIVER VALLEY

M. J. VILJOEN and R. P. VILJOEN

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by

M. J. VILJOEN and R. P. VILJOEN
Research Officers.
Upper Mantle Project
Council for Scientific and Industrial Research
Pretoria.

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ABSTRACT

A detailed investigation of the Onverwacht Series in the Komati River Valley in the southwestern portion of the Barberton Mountain Land, has led to a much clearer understanding of this important volcanic sequence. A threefold stratigraphic subdivision of the Series has been proposed and a new type section, representative of most of the Series, is suggested. The subdivision into three stages is based on distinctive rock-types and associations. The Lower Onverwacht or Theespruit Stage, comprises a sequence of meta-basalts with numerous narrow, interlayered, siliceous, sedimentary horizons and several interlayered ultrabasic bands. The Middle Onverwacht or Komati River Stage, is characterized by alternating pillow basalts and ultrabasic bands. The Upper Onverwacht or Hooggenoeg Stage, consists essentially of basalts and andesites, but contains distinctive, interlayered, narrow horizons of more acidic lava as well as chert bands. The upper portion of the Hooggenoeg Stage consists dominantly of acid volcanic rocks. The Series is bounded to the south, by a homogeneous, intrusive granite and to the north, by banded cherts and greywackes of the Fig Tree Series. Evidence is presented which invalidates the previously held concept of the intrusive Jamestown Igneous Complex. It is now clear that the majority of the basic schists surrounding the Mountain Land represent, for the most part, the metamorphosed equivalents of the Onverwacht Series.

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A REASSESSMENT OF THE ONVERWACHT SERIES IN THE KOMATI RIVER VALLEY

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A REASSESSMENT OF THE ONVERWACHT SERIES IN THE KOMATI RIVER VALLEY

INTRODUCTION

This paper embraces some of the preliminary results of portion of a programme which forms part of South Africa's contribution to the International Upper Mantle Project. The object of the initial phase of this programme in South Africa, is the detailed consideration of some of the most ancient basaltic lavas and ultramafic rocks occurring in the Precambrian granitic terrain of the Eastern Transvaal. It is hoped that a study, particularly of the field relationships and the geochemistry of these rocks, will provide some useful data regarding the composition and type of magma which was derived from the upper mantle of the earth some 3.2×10^9 million years ago. It is envisaged that significant data concerning the early evolution of the earth's crust and mantle, as well as additional data on the early history of our planet may become available (Engel, 1966).

The Barberton Mountain Land was chosen for examination and study, mainly because of the well-known stratigraphy, the excellent preservation in certain areas, and the great age of the rocks. In addition, a detailed regional Geological Survey map of the area exists and a considerable amount of new data has recently accumulated as a result of the work done by the Economic Geology Research Unit of the University of the Witwatersrand, the mining companies operating in the area, and the Swaziland Geological Survey.

A reconnaissance investigation was carried out mainly in the southern part of the Mountain Land in the Komati and Steynsdorp valleys. A search was made for a section where a representative succession of the Onverwacht volcanic sequence at the base of the Swaziland System could be mapped and studied in detail. Use was made of aerial photographs in an endeavour to locate an area of good outcrop and clear geological trends where no structural disturbances, such as faults and folds, were apparent. Care was taken in the selection of a section containing a substantial development of all the constituent units present in the Series and one which was not too strongly metamorphosed. An area straddling the Komati River in the southwestern part of the Mountain Land was eventually chosen as one best fitting these requirements.

This paper provides a comprehensive geological description of the area, and proposes a new threefold subdivision of the Onverwacht Series. The new subdivision is compared with the ideas of the Onverwacht Series held by Hall (1918), and those of the Geological Survey (Visser et. al., 1956). The investigation has clearly indicated that the concept of the Jamestown Igneous Complex, as envisaged by the Geological Survey, is completely untenable, and it is suggested that the term "Jamestown Igneous Complex" be excluded from further use in the literature. Other reasons for this proposal have been discussed by Anhaeusser, et. al., (1965, 1966), and Viljoen and Viljoen (1965).

REGIONAL SETTING

A. LOCATION AND PHYSIOGRAPHY OF THE AREA

The mapping covered an area of approximately 25 square miles in the south-western part of the Mountain Land (Figure 1). The investigation was carried out on the farms Hooggenoeg 731 JT., Theespruit 156 IT., Avontuur 721 JT., and the eastern portion of Tjakastad 730 JT. The Komati River, at an average elevation of just under

3,000 feet, follows a rather sinuous west to east course through the southern portion of the area and is joined by one of its main tributaries, the Theespruit, in the extreme southeastern corner. Proceeding northwards from the Komati River, the ground rises, at first fairly gently, and then steeply to a prominent mountain range known as the Buck Ridge that forms the northern boundary of the area. The average elevation here is just under 6,000 feet and the trigonometrical beacon Geluk (5,992 feet), occurs on top of the range in the extreme northeastern part of the area.

B. GEOLOGICAL SETTING

Most of the area discussed in this paper covers a region mapped and described by the Geological Survey (Visser et. al., 1956) as belonging to the Onverwacht Series of the Swaziland System (Figure 2). The type section of the Series defined by the Geological Survey is situated on the farm Onverwacht (733 JT) some four miles to the east of the newly proposed section, and consists of a lower, essentially basic volcanic phase and an upper, predominantly acid volcanic phase. The southern and western portions are, however, indicated on the Survey map as part of the basic intrusive phase of the Jamestown Igneous Complex (Figure 2).

Hall (1918), described a sequence of rocks on the farm Onverwacht (733 JT) which he considered to be typical and representative of the entire Onverwacht Series. The Geological Survey (Visser et. al., 1956) made no attempt to describe or subdivide the stratigraphy of the Onverwacht Series and retained the section on the farm Onverwacht as the type sequence. The latter section, however, covers only about one third of the total development of the Series in the Komati Valley (Figure 2). In addition, the Onverwacht volcanic suite extends to the east and west of the area described by the Geological Survey and the so-called basic intrusive rocks of the Jamestown Igneous Complex do not exist in this area (Figure 2).

The section described in the present paper, represents almost the complete stratigraphy of the Onverwacht Series in a well-developed, slightly metamorphosed, and structurally uncomplicated region. For these reasons, therefore, it is proposed that this be regarded as the type area for the Onverwacht Series.

C. SUBDIVISION OF THE AREA

In the south, the Onverwacht Series is bounded by an intrusive granite pluton belonging to the complex granitic terrain of the Badplaas-Lochiel area. It was found convenient to subdivide the Onverwacht volcanic suite into three major divisions viz., (i) the Lower Onverwacht or Theespruit Stage, consisting essentially of meta-basalts with ultrabasic bands towards the base, and characterized by up to 16 siliceous horizons, together with minor cherts, (ii) the Middle Onverwacht or Komati River Stage, consisting of a suite of interlayered pillow basalts and ultrabasic horizons and characterized by the lack of siliceous bands or cherts, and (iii) the Upper Onverwacht or Hooggenoeg Stage, consisting mainly of basaltic to intermediate pillow lavas with interlayered more acid types, the latter often associated with well-developed banded chert horizons and carbonate rocks, and an upper, essentially acidic zone, consisting of volcanic, pyroclastic and sedimentary material.

The entire sequence, which forms a regular succession, strikes roughly east-west and dips at steep angles to the north. There is a marked thinning from over 35,000 feet in the east to 21,000 feet in the extreme west, the general regularity being complicated by three major strike faults. Numerous intrusive bodies of quartz and felspar porphyry are present in the Komati River Stage, these being poorly represented in the Upper and Lower Stages of the Onverwacht Series. The entire volcanic sequence is overlain by a banded black and white chert followed by a ferruginous greywacke, a banded ironstone formation and finally a greywacke which forms the base of the Fig Tree Series.

Recent work in the southeastern portion of the Mountain Land has confirmed that the three major subdivisions proposed in this paper can be traced to the east, as far as the Swaziland border, where they are overlain by Fig Tree and Moodies rocks. It should be pointed out however, that in this area, a sequence of cherts, basalts, ultrabasics and acid lavas are represented, and apparently overlie the upper acid horizon of the Upper Onverwacht. As yet, the exact stratigraphic position, tectonic setting, and relationship of these rocks to the Onverwacht sequence is not known. There is no doubt as to the predominantly volcanic nature of this sequence of rocks and it is probable that they may represent an extension of the series lying above the Onverwacht sequence as defined in the type area. Following further detailed investigations it may prove to be necessary to redefine the limits of the Upper Onverwacht Series in the south-eastern portion of the Mountain Land.

DETAILED GEOLOGICAL DESCRIPTION

In reading the following geological description, reference should be made to the accompanying map (Figure 1) and stratigraphic columns (Figure 3). All thicknesses referred to in the test, except the average thicknesses of various zones or horizons, apply to the section lines indicated. A description is given of the granite, followed by a detailed description of the entire Onverwacht succession from the base upwards. Also included are accounts of the lower portion of the Fig Tree Series as well as rocks intrusive into the succession. Although all of the rock types have been described, a more comprehensive and detailed petrological investigation has yet to be carried out, together with detailed geochemical investigations.

A. THE GRANITE

The intrusive granite which borders the Onverwacht Series to the south, forms part of the large, unmapped granitic terrain of the Badplaas-Lochiel area. Investigations along the immediate southern contact indicate that the granite is a somewhat leucocratic, homogeneous, intrusive variety, the most characteristic feature being a foliation which parallels the contact. It is intrusive into the Lower Onverwacht or Theespruit Stage and successively truncates higher members of the latter succession from east to west. In general, it is not very resistant to erosion and is poorly exposed, being covered by a greyish, sandy soil. Outcrops are confined to a number of fairly large, resistant, domical masses. In addition, good exposures occur on both sides of large, resistant dykes which cut through the terrain in the south. These dykes have clearly protected the adjacent granites from erosion.

The intrusive relationships are well-displayed in the southeast where tongues and lenses of granitic material occur in abundance. In the extreme southern portion of the region, a large body of granite intrudes into, and effectively isolates, a huge, oval-shaped mass of the lowermost portion of the Theespruit Stage. Granitic tongues invariably intrude parallel to the foliation and the contact between these bodies and the meta-basalts is usually sharp. The most outstanding feature of the granite is the presence of an overall foliation, observed in many outcrops and caused by the preferred orientation of constituent platy minerals. This foliation is more noticeable as the contact with the meta-basalts is approached and becomes progressively more intense as a result of shearing close to the immediate contact. The foliation dips at steep angles to the north, thereby also paralleling the layering of the meta-basalts.

Amphibolitic xenoliths are frequently encountered throughout the granitic terrain. The xenoliths, generally oval in shape, range in length from a fraction of an inch to a few feet, the average length being several inches. They are often well-aligned, and generally parallel the foliation in the granite. In addition to the numerous small xenoliths, a number of larger ones, ranging up to 500 feet in length, occur close to the contact in the south. Three large bodies form an aligned train which can be followed from the granite into a zone of more resistant, amphibolitized lava which constitutes part of the lower Theespruit Stage. Sheared pillow structures within these bodies testify as to their original volcanic nature. The xenoliths are clearly "in situ" indicating that the granite must have intruded by a process of injection parallel to an earlier foliation within the meta-basalts. A type of intrusion is visualized, whereby tongues of granite "prized-off" successive layers of the Lower Onverwacht, eventually incorporating them as xenoliths in the main granite mass. The size and abundance of the xenoliths appears to decrease towards the centre of the granite boss.

Several subtly different varieties of the intrusive granite are present. The dominant type is a well-foliated rock, often containing scattered xenoliths. This is intruded by a younger, essentially similar, yet weakly foliated granite. Pegmatites are not present but alaskitic and aplitic veinlets, as well as quartz veins are developed to a limited extent. The granite is white, except for the ferromagnesium minerals which are evenly distributed throughout, and constitute about 20-25 per cent of the total volume of the rock. The main minerals are oligoclase; occurring as large, somewhat sericitized crystals, quartz; as smaller-grained aggregates, and biotite. The latter mineral often has a pronounced alignment which is responsible for the foliation observed in hand specimen. Zoisite was observed in almost every thin section and probably originated from the breakdown of pyroxenes. Other constituents occurring in smaller amounts include chlorite, microcline and orthoclase. The younger intrusive granite is identical in mineralogical composition to the type described above, but contains less ferromagnesian material and is finer-grained. The xenoliths are mainly amphibolitic and are very similar in composition to the meta-basalts at the base of the Lower Onverwacht. The main mineral is actinolite, with smaller amounts of interstitial quartz and felspar. Clinopyroxene is fairly abundant in some specimens. Hornblende may also be locally of importance.

A review of a brief reconnaissance study carried out in the Badplaas-Lochiel granite terrain has been presented elsewhere (Viljoen and Viljoen, 1965). The investigation indicated that a number of homogeneous plutons are intrusive into the Onverwacht Series in the southern part of the Mountain Land. These are partly separated from each other by narrow belts of metamorphosed Onverwacht volcanics. One of these plutons intrudes the Lower Onverwacht succession in the area described in this paper. This pluton appears to be an elongated body about five miles wide and ten miles long. The granite, typical of the centre of the pluton, is very similar to the border-phase described above. The significance of intrusive border-phases of the Nelspruit Granite in contact with the Swaziland System has been dealt with by Anhaeusser (1966), Anhaeusser and Viljoen (1965), and Viljoen and Viljoen (1965), and will not be discussed here.

B. THE LOWER ONVERWACHT OR THEESPRUIT STAGE

The name for the Lower Onverwacht succession is derived from the farm Theespruit (156IT), and the Theespruit stream itself, which enters the Komati River at a point where the sequence attains its maximum development. The relative relief is not great and the entire sequence forms a series of low hills to the south of the Komati River. Outcrops are generally good, except in the west, and geological trends are clearly seen on aerial photographs.

The succession consists essentially of a sequence of thermally metamorphosed basalts, in which pillow structures are present, together with interlayered siliceous sediments and a few narrow cherts. Serpentinized ultrabasic zones, in the form of lenses and bands, are typical. The rocks have all been moderately metamorphosed due to the intrusion of the granite, and constitute the entire succession previously regarded as part of the Jamestown Igneous Complex by the Geological Survey (Visser et. al., 1956). The thickness of the Stage is variable, partly because of the stratigraphic thinning to the west. In addition, two large strike faults, the Theespruit Fault and the Komati River Fault, have influenced the true thickness of the zone. The thickness varies from 4,300 feet in the west to 8,400 feet in the east, the latter figure probably approaching the maximum thickness of the Theespruit Stage.

It is clear that an unknown amount of the lower portion of the Stage has been incorporated into, or assimilated by, the large boss of intrusive granite referred to previously. Despite this, however, it has been possible to divide the Theespruit Stage into seven sub-stages according to characteristic lithology. The subdivision is not always clear because of the influence of the two large strike faults mentioned above. The following description applies mainly to the eastern portion of the area under consideration, where the Theespruit Stage attains its maximum development.

(a) Sub-Stage 1

This sub-stage constitutes the lowest portion of the Theespruit Stage and consists entirely of amphibolitized basaltic lavas containing sheared pillow structures and amygdales, together with a large, oval-shaped xenolith of low-lying black hills in the extreme southeast, and is almost completely surrounded by the intrusive granite. The maximum thickness of the sub-stage in the extreme east is 1,900 feet. Vague banding is apparent and some of the more resistant horizons extend into the granite as a series of disconnected xenoliths. Sheared pillow structures and amygdales were observed in these xenoliths. Two apparently interlayered serpentinite bands are present in the sub-stage, the lower being 80 feet, and the upper 130 feet thick. These two horizons act as useful markers in the massive, amphibolitized lavas and their frequent displacement indicates that faulting has taken place.

The basalts are composed mainly of a mesh of dark greenish-black actinolite with smaller amounts of hornblende. These minerals impart a characteristic "satiny" lustre to the rocks. Interstitial quartz and/or felspar is present in varying amounts from a few per cent of the total, up to about 40 per cent. Carbonate is generally absent but a few isolated, apparently secondary, grains and veinlets were observed in some specimens. The original mineralogy and texture of the rock has almost completely been destroyed, but in some sections relict pyroxene (up to 35 per cent of the total volume of the rock) is present. The mineral appears to be augitic to diopsidic in composition. There is often a strong alignment of the amphiboles and the resultant lineation almost invariably parallels the granite contact. The lowermost serpentinite band is a dark, greenish-blue rock composed of elongated, oval masses of antigorite with abundant iron-ore. These oval lenses probably represent original olivine crystals, and are sheathed by sinuous clusters of elongated tremolite crystals. The petrology of the uppermost band is similar, with relict olivine crystals being more apparent. It appears certain that both these horizons were derived from original dunites.

(b) Sub-Stage 2

This sub-stage is only present in the central portion of the southern area, being largely eliminated to the east and west by intrusive granite. It forms a narrow ridge and consists of a number of relatively thin and closely spaced, white, siliceous horizons, interlayered with amphibolitized lava and serpentinite. The thickness of the sub-stage along strike is fairly constant, averaging 430 feet. It contains six siliceous horizons, the upper three of which vary in thickness from 12 to 25 feet and can be followed for long distances along strike. The three lower horizons (not all indicated on the map or stratigraphic column), vary in thickness from $1\frac{1}{2}$ to 7 feet and form less persistent bands.

The mineralogy of these generally massive, siliceous bands is practically identical, the main minerals being fine-grained, crystalline quartz, with varying amounts of interstitial sericite in the form of small, roughly aligned flakes. The grey coloured uppermost siliceous horizon differs slightly from the others, owing to the presence of more sericite, and small amounts of banded, carbonaceous, shaly and cherty material, together with bands of impure siliceous material. This banded rock marks the top of sub-stage 2. A few narrow and impersistent bands of black, carbonaceous chert are also present in the sub-stage. The latter are sporadically developed, are a few inches thick, and usually lie above the upper siliceous horizons. A two feet wide band was also encountered in the lavas. These cherts consist of an interlocking mosaic of quartz grains, with carbonaceous particles scattered throughout, but often tending to concentrate in layers. Two distinctive horizons of ultrabasic material (not indicated on the map or stratigraphic columns) are present, one (34 feet thick) near the base and the other (18 feet thick) in the middle of the sequence. The mineralogy of these rocks and of the amphibolitized lavas is almost identical to that of similar rocks in sub-stage 1.

(c) Sub-Stage 3

This sub-stage consists almost entirely of amphibolitized lava. It attains a maximum thickness of 1,500 feet in the west, where it is truncated by the intrusive granite. The zone is continuous to the east, but in this area, has an average thickness of only 500 feet. It commences with a 20 feet-thick horizon of slabby, fairly basic, amphibole lava. This rock is composed of an intergrowth of stubby crystals of grunerite with very small amounts of quartz and felspar. A narrow, discontinuous band of black chert with associated siliceous material (about one foot thick), overlies this basal horizon. The chert in turn, is succeeded by a large mass of amphibolitic lava in which at least three distinct zones of amygdales are present. Some structures which could possibly represent pillows were also observed. These rocks have all been amphibolitized and consist dominantly of an intergrowth of coarse-grained actinolite crystals with minor amounts of interstitial quartz and felspar. In some cases the crystals are poeciloblastic, the inclusions being composed of about equal proportions of quartz and carbonate. In general, however, the carbonate content is very low. Iron-ores are usually conspicuous.

(d) Sub-Stage 4

This sub-stage contains the best development of siliceous horizons (up to seven bands) in the Theespruit Stage. The first two, henceforth referred to as the A marker (lower) and the B marker (upper), are very persistent and form good marker horizons extending almost across the entire area. The stratigraphy above these horizons is, however, completely variable from east to west. This is due to (i) a wedging out of certain horizons towards the west and (ii) the influence of the Theespruit strike fault. In the east where the sub-stage attains a thickness of 1140 feet, Marker B is conformably overlain by a zone of amphibolitized basalts containing five interlayered siliceous horizons, the latter wedging out towards the west. In the west where the sub-stage is 2,900 feet thick, Marker B is conformably overlain by a broad zone of amphibolitized lavas which contain a large interlayered ultrabasic horizon and two substantial siliceous horizons. The total strike length of the latter sequence is small due to the influence of the intrusive granite in the west and the Theespruit fault in the east.

Marker A which averages 110 feet in thickness, consists essentially of clean, white, siliceous material similar to that of the siliceous horizons of sub-stage 2. It outcrops as a resistant, low, white ridge, being truncated by the intrusive granite in the west but persisting to the east where it is intruded, and in places completely eliminated, by a dyke. In the central portion where Marker A reaches its maximum development of 135 feet, it commences with a narrow zone of siliceous material with characteristic large quartz blebs. This is succeeded by white to reddish-white siliceous material with replacement blebs, lenses and bands of black, carbonaceous, slaty-chert near the top. The latter is followed by a broad zone of clean, white, siliceous material which forms the top of the marker and which is capped by a narrow band of black, carbonaceous chert. The white, siliceous material of Marker A consists almost entirely of recrystallized quartz grains forming a mosaic with small blades of sericite. A few large crystals of muscovite are usually present. Near the granite contact in the west, the rock has been entirely recrystallized and is comprised of an irregular mosaic of quartz grains and has the appearance of a quartzite. Most of the sericite has been reconstituted into fairly large, muscovite crystals and a few ragged grains of staurolite are generally present. Apatite is a fairly common constituent and a grain, probably of zircon, was also noted. The reddish colouration of the siliceous material, in places, is probably due to small amounts of iron oxide. The black, carbonaceous, slaty-cherts consist dominantly of small quartz grains with abundant carbonaceous material. The cherts are generally well-foliated, and scattered throughout, there occur well-aligned grains of staurolite and andalusite, filled with black (carbonaceous) inclusions, and forming porphyroblasts which, in some cases, have been rotated. A few scattered flakes of sericite are also present.

Marker A is followed by a zone consisting dominantly of amphibolitized basalt. Apart from the first 24 feet, these lavas are carbonate-bearing and are of significance in that they contain the first conspicuous carbonate in the Onverwacht sequence. Typically the carbonated lava has a distinctly pitted appearance due to the weathering-out of the carbonate blebs. Petrologically, the rock is composed of a felted mass of tremolite-actinolite with radiating crystals, broken every now and again by roughly spherical masses of almost pure carbonate with invariable iron staining. In some places along strike, banded, carbonate-rich rocks occur which probably represent carbonate "sweats" from the lava.

The second siliceous horizon in sub-stage 4 (Marker B) is one of the best-developed of all the siliceous horizons in the Theespruit Stage. It extends almost entirely across the area mapped and has an average thickness of 250 feet in the west. In the extreme west it is truncated by the intrusive granite. To the east it appears to be thinner and more irregular, due to the influence of large bodies of serpentinized peridotite and talc schist which apparently truncate the horizon in certain parts. Marker B is distinctive, in that it consists of a monotonous, somewhat massive and homogeneous, non-banded accumulation of siliceous material, subtly different to all the siliceous horizons lying above and below. In the central portion of the area where it is best developed, it is 325 feet thick, with an irregularly developed, three foot thick black chert at the top. Some of the material contained in the marker is comparable to the siliceous material composing Marker A, with the exception of sericite which is far more abundant. Small amounts of staurolite and andalusite are also present. Typically the rock consists of a fine-grained, cherty, quartz mosaic containing sericite in which occur large, irregular, angular to rounded minerals, including quartz, biotite and felspar (twinned and untwinned). Most of this felspar is either, albite or, oligoclase. Scattered crystals of andalusite and staurolite occur throughout. It is probable that the rock is a type of salic tuffaceous agglomerate, this conclusion being strengthened by the fact that some large, macroscopically visible, angular mineral fragments are present.

In the east, Marker B is overlain, and partially eliminated by a zone of ultra-mafic material which in most places has been serpentinized or converted to a talc-carbonate rock. In this area the ultrabasic appears to be closely associated with a fairly extensive gabbroic body. In the west, a large, conformable zone of ultrabasic (650 feet thick) occurs in a similar stratigraphic position to that of the ultrabasic just described. Irregular zones of berberite, or laterite, have formed over the ultrabasic and could possibly have given rise to trace element concentrations.

In the east, the ultrabasic zone is overlain by five distinct siliceous horizons which thin stratigraphically and wedge out in a westerly direction, only one horizon persisting into the western part of the area. The composition and appearance of all these horizons is practically identical, occurring as white-weathering, well-foliated and "slabby" interlayers. They consist principally of quartz, with minor amounts of sericite. Staurolite and andalusite are sometimes present. Chert is not typical, but some bands may have fairly well-developed cappings of black, carbonaceous chert layers. Small blebs and lenses of chert are sometimes also encountered within individual horizons. These siliceous bands form continuous horizons between carbonated and amphibolitized basaltic lava in which pillow structures and amygdales are sometimes observed. Strongly carbonated layers and bands, together with pure carbonate lenses, are frequently present in the lavas and have probably been "sweated" out from the latter rocks.

To the west, the five siliceous horizons described previously, disappear and the large ultrabasic body, referred to above (overlying Marker B), is followed by a zone of amphibolitized lava containing two large, interlayered siliceous bands. Tremolite-actinolite are the main minerals encountered in the lavas, together with small amounts of quartz and felspar. Carbonate is generally not conspicuous. The lowermost siliceous horizon is one of the largest encountered in the entire area. It is 290 feet thick and consists dominantly of moderate to poorly bedded, white, siliceous material composed essentially of quartz with smaller amounts of sericite. A second 100 feet wide siliceous interbed, occurs higher up in the sequence and is composed dominantly of quartz with smaller amounts of sericite. These siliceous interbeds are confined to the western part of the area and cannot be correlated with comparable horizons to the east.

(e) Sub-Stage 5

This sub-stage is only developed in the central and eastern parts of the area, attaining a thickness of 1,400 feet in the east. It wedges out towards the west, where it is eliminated by the Theespruit Fault. The rapid thinning of the zone towards the west is also partly due to a stratigraphic effect. In the central and western part of the area, the lavas tend to be rather carbonated and become extremely sheared as the Theespruit fault-zone is approached. These sheared rocks display characteristic, jagged outcrop patterns, and secondary carbonate "sweats" and bands are commonly encountered. In the east, the lower portion of the sub-stage is composed of amphibolitized lavas with small amounts of carbonate. The upper portion of the sub-stage contains conspicuous amounts of carbonate in the form of discrete particles or as cross-cutting veinlets. Some sheared, finely banded horizons within the lavas of this zone, could possibly represent mafic tuffs. In general, however, pillow structures and zones of amygdales can be seen but become sheared as the fault zone is approached. Carbonate material is characteristic of the interstices between pillows and could possibly represent an original, impure, carbonate-rich oceanic ooze, into which the lavas were extruded.

(f) Sub-Stage 6

This sub-stage contains the uppermost siliceous horizons of the Theespruit Stage. It varies in thickness from 340 feet in the west, where it has been partially eliminated by the Theespruit Fault, to 950 feet in the east, where it attains its maximum development. In all, three siliceous horizons are developed, the upper and lower of which are persistent, and form low, white ridges constituting good marker horizons. The lowermost horizon occurs just north of the Theespruit fault-zone, and is fairly narrow with an average thickness of about 25 feet. In the west, it is truncated by the Theespruit Fault. It is closely associated with a dyke which, for the most part, runs parallel to it but which, in the western portion, is clearly cross-cutting. Mineralogically it is very similar to previously described siliceous horizons and may occasionally contain small blebs of chert.

The abovementioned interbed is overlain by a uniform thickness of amphibole and carbonate-bearing lavas which give rise to the well-developed and persistent, uppermost siliceous horizon of the Theespruit Stage. The latter horizon, which forms a distinct ridge extending across the entire area, varies in thickness from 140 feet in the west, where it has been intruded and split by a dyke, to 137 feet in the central portion of the area. It increases in thickness towards the east, and in the extreme eastern portion of the area attains a thickness of 600 feet. The horizon is unique in that it contains well-developed chert bands and a possible acidic-lava zone, features generally not typical of the Theespruit Stage. In the central portion this horizon commences with 79 feet of clean, siliceous material consisting entirely of an interlocking quartz mosaic with small flakes of sericite. This is followed by a nine-feet zone of cherts and carbonate-bearing siliceous sediments. This cherty assemblage is followed in some areas by an acidic rock which could either be a lava, or a quartz porphyry. The distribution of this rock-type is definitely irregular along strike, and it could not be positively identified as a stratigraphic unit. It has a fine-grained, cherty matrix, with small amounts of sericite and what appears to be andalusite, as well as tremolite-actinolite. Within this groundmass occur large, subhedral masses of quartz and felspar that possibly represent phenocrysts. Most of the felspar has a type of exsolution or perthitic texture, and appears to be rather sodic in composition. In the part under discussion, this zone is 43 feet thick and is overlain by a six feet band of black chert which forms the top of the siliceous horizon. In some parts this upper horizon is characterized by what appears to be an interlayered, sill-like body which in places gives rise to a peculiar brecciated rock. The latter contains angular fragments of chert, varying in size from a few mms. to well over 10 cms, set in a fine-grained matrix. This rock usually occurs near the top of the horizon and frequently contains carbonate, as well as abundant sulphides in certain areas.

(g) Sub-Stage 7

This sub-stage constitutes the top of the Theespruit Stage and varies in thickness from about 750 feet in the west, to 1,740 feet in the east. The upper boundary (also the upper boundary of the entire Theespruit Stage) is defined by the Komati River strike fault which has also probably influenced the thickness of sub-stage 7.

The sub-stage consists essentially of rather talcose lavas which are generally very sheared and carbonated with "sweats" and veinlets of almost pure carbonate being conspicuous in places. Tremolite-actinolite is the main mineral component of these lavas although in some sections small remnants of what appears to be augite, are present. Of interest in some specimens is the development of chlorite, to the almost complete exclusion of amphibole. This chlorite, which tends to surround the generally elongated crystals of felspar, is probably a manifestation of a lower degree of metamorphism. Small amounts of quartz and felspar are commonly observed in the matrix, the latter being plagioclase of sodic composition. Carbonate specks occur scattered throughout all sections examined. Siliceous horizons are virtually absent, although isolated siliceous lenses and discontinuous chert bands, which could have represented former narrow and poorly developed horizons, are sometimes observed, especially in the eastern portion of the region. In addition to the siliceous sediments there is also the suggestion of the development of discontinuous zones of more acidic lava. Quartz and felspar porphyries start making their appearance in the upper portion of sub-stage 7 but appear to be associated mainly with the Komati River Fault.

(h) Structure of the Theespruit Stage

The rocks of the Theespruit Stage have an average strike of E35°S and dip at steep angles (between 70° — vertical) to the north. No major folds are present, although minor structures, in the form of minor crenulation folds and lineations, were often encountered in the sedimentary interbeds. The stratigraphy of the stage has been considerably complicated by the two strike faults mentioned earlier, which are the main structural features in the area.

(i) The Theespruit Strike Fault

This fault, which extends across the entire area, is rather difficult to trace in the east where it strikes parallel to the general stratigraphy. In the western portion, however, near the common boundary between Tjakastad (730JT) and Theespruit (156IT), the fault makes a marked inflection to the north, but regains its previous strike-direction further west. From this point westwards, the truncating effect of the fault is clearly seen. Here the stratigraphic units to the north parallel the fault plane, but to the south are clearly truncated and bear a marked angular relationship to the fault.

The fault appears to be a high-angled thrust that probably experienced, in addition, a horizontal-wrench component. The amount of movement on the fault could not, however, be determined. The fault trace is readily recognizable in the field by aligned, elongated lenses of pure-white, milky quartz. Individual lenses are generally up to about 50 feet long and 10 feet wide but some masses may be considerably larger than this. The fault zone is normally 200 to 300 feet wide and is characterized by extremely sheared rocks giving rise to very jagged outcrops. Some of the sheared lavas appear to be finely bedded mafic tuffs. Second-order gash veins are sometimes present and are filled either by quartz or carbonate. The fault zone is closely associated with a dyke which trends parallel to it at a constant distance of about 300 feet to the north of the fault plane itself. The dyke intrusion probably used the disturbance in the fault zone as a channel of access.

(j) The Komati River Fault

The Komati River Fault separates the Theespruit Stage from the Komati River Stage and persists across the entire area. It has a similar inflection to that of the Theespruit Fault, again occurring in about the same position as the latter. The fault zone is not as clear as that of the Theespruit Fault, and for the most part, appears to trend parallel to the stratigraphy; there being no suitable marker horizon to indicate any truncation. The fault is also a high-angled thrust, but no doubt experienced some wrench movement, as is indicated by numerous second-order gash-veins of quartz. These quartz veins do not mark the actual trace of the fault as in the case of the Theespruit Fault, but occur on either side of it. The veins bear an angular relationship of about 31° to the fault plane. This angular relationship is particularly evident where the fault has its major inflection. The veins are filled with a variety of secondary material, the most common being quartz and carbonate. In the east, bodies of quartz and felspar porphyry are also closely associated with the fault. An old gold prospect is situated on a second-order quartz gash-vein to the south of the fault in the vicinity of its major inflection. The fault zone consists of sheared basaltic lavas in the south, and sheared ultrabasic material in the north. Slip-fibre asbestos development in the latter is fairly common. Like the Theespruit Fault, the Komati River Fault is associated with a persistent dyke lying at a fairly constant distance to the south and following the same trend as the fault trace.

C. THE MIDDLE ONVERWACHT OR KOMATI RIVER STAGE

This Stage derives its name from the Komati River, which, for a large part of its course through the area, traverses the southern (lower) part of the Stage. It comprises a substantial sequence of alternating pillow basalts and ultrabasic horizons, and, unlike the Upper or the Lower Onverwacht Stages, is characterized by the complete absence of interlayered siliceous or acidic material. It is bounded in the south by the Komati River Fault and in the north by a sedimentary horizon forming the base of the Upper Onverwacht sequence. The succession thins stratigraphically from approximately 11,800 feet in the east, to 6,200 feet in the western part of the area. A feature of the stage is the presence of numerous intrusive bodies of quartz and felspar porphyry.

The stratigraphy is complicated by a large transverse fault in the east, which horizontally displaces the sequence by 2,000 feet. Other structural features are confined to zones of strong disturbance and shearing, mainly in the environs of two major strike faults (viz., the Komati River Fault and the Violet Fault). In the east, the Middle Onverwacht forms a series of hills where the perfectly banded nature of the sequence is clearly seen. The ultrabasic bands outcrop as slightly more resistant ridges, but certain layers within particular basaltic zones may also give rise to discernable topographic features. Proceeding westwards, the ground becomes flatter and the outcrops poorer. Here the ultramafic rocks are often altered and are less resistant to weathering than the basalts. The Komati River Stage has been divided into two sub-stages viz., a lower, essentially ultrabasic zone comprising about two-thirds of the total thickness, and an upper, essentially basaltic zone.

(a) Sub-Stage 1 (The Lower Ultrabasic Zone)

This sub-stage consists essentially of three major ultrabasic zones and two well-developed bands of amphibolitized pillow basalts. The two lower ultrabasic zones are relatively narrow and stand out as resistant ridges composed of fine-grained, dense, ultramafic material. The broad upper ultrabasic zone, however, contains a number of generally narrow, interlayered amphibolitized pillow basalts. A striking characteristic of the sub-stage is the marked thinning from 5,150 feet in the east, to 2,700 feet in the west. Not only does the entire zone thin out, but the individual bands of basalt and ultrabasic, comprising the sequence, thin sympathetically as well. This indicates a stratigraphic narrowing, rather than elimination and thinning due to faulting. The total thickness of ultrabasic material in the east is about 3,000 feet and in the west it is about 1,700 feet.

The petrology of the various ultramafic horizons in sub-stage 1 is almost identical, with the result that the following descriptions are applicable to all these ultramafic rocks. The interlayered basaltic lavas are also similar to one another in composition and once again, a general description of the petrology of these rocks is adequate. The ultramafics are typically fine- to medium-grained, dense, bluish-black rocks representing, for the most part, altered dunites. In the vicinity of the type section in the east, they attain their best development and are remarkably fresh and well-preserved. One of the least altered specimens encountered near the base of the uppermost ultrabasic horizon consists entirely of a mass of small, closely packed, olivine remnants with discernable crystal outlines. These are altered to iddingsite around the edges. Other minerals present in the rocks include antigorite, tremolite and secondary magnetite. In most cases the original olivine crystals have been completely altered and the main minerals encountered are antigorite and tremolite. Secondary magnetite, derived from the breakdown of olivine, is invariably present and magnetite rims often surround original crystals of olivine, the latter now completely altered to antigorite. In some instances original olivines are frequently split into a number of ovoid "islands", each containing a core of the brownish serpentine mineral, iddingsite. Antigorite crystals often radiate from, and form substantial rims around, these kernels. In places, numerous ovoid bodies of magnetite enclose cores of the serpentine mineral serpophite. A specimen from the central part of the upper ultrabasic zone consists mainly of antigorite with magnetite partings and a substantial amount of highly birefringent clinopyroxene. Pyroxenes, however, were rarely encountered in these ultramafics. In specimens containing abundant tremolite it is possible that some of the material may have been derived from original pyroxenes. Towards the west most of the ultrabasic horizons are locally steatized and carbonated. Talc and some carbonate may constitute important constituents of the rocks.

A number of chrysotile asbestos occurrences were encountered in the lower half of the upper ultrabasic zone. In many cases the cross-fibre appears to be very closely associated with near-vertical joints which are common throughout the zone. The chrysotile veinlets, which generally average about one-eighth of an inch in length, often develop in these joint planes. Trains of magnetite are closely associated with the fibre, the latter often appearing to cut through these grains. In the west, immediately south of the Komati River and close to the Theespruit—Tjakastad boundary, asbestos veinlets are developed in a peculiar, almost amygdaloidal-looking serpentinite. This rock contains oval patches, half a centimeter in diameter, of a dark green mineral often almost completely replaced by limonitic material. The main mineral in the rock is coarse-grained antigorite, often rimmed by magnetite. The amygdale-like patches consist of a light greenish-brown mineral replaced around its edges by antigorite needles and cut by chrysotile veinlets. The mineral is isotropic and is clearly secondary, having filled original cavities in the dunite.

The narrow, interlayered basaltic horizons are all very similar in character. Typically the lava is green to dark green in colour, and consists of a felted mass of fine- to medium-grained amphibole crystals. Pillow structures and associated amygdales were encountered in every horizon. In the east the pillows are well-developed and form ovoid bodies varying in length from about six inches to several feet, the average being about 18 inches. The outer zones of the pillows generally contain scattered, ill-defined, light coloured amygdales which average about one cm in diameter. Common in some of the pillows are huge, elongated gas cavities, situated in the centre of individual structures and paralleling the long axes of the pillows. These large gas vesicles are filled, for the most part, with white quartz (Plate 1, Figure 1). The main amphibole encountered was tremolite-actinolite, although some cummingtonite was also found. Finer-grained aggregates of interstitial quartz occur and probably formed as a result of the release of silica during alteration. Fine-grained, often sericitized felspar grains as well as chlorite were noted. Towards the west where the lavas are more highly sheared and altered, chlorite, talc, anthophyllite and carbonate, together with quartz, sericitized felspar and secondary iron oxides, become the dominant minerals, although tremolite-actinolite amphiboles are still encountered.

Apart from the two well-developed and persistent lava horizons which separate the three main ultrabasic zones of sub-stage 1, there are narrow lava bands which occur within the large upper ultrabasic zone. These horizons attain their best development in the east, and thin towards the west, although it is often difficult to trace individual horizons continuously. There is evidence that one or two smaller horizons may also be present. In the west, in the vicinity of the Komati River road bridge, a somewhat wider and partly carbonated lava horizon is present. Outcrop is poor but it is possible that some of the narrow bands mentioned above, coalesce to form a composite lava band in this area. No contact metamorphic effects were observed in the lavas or in the surrounding ultrabasics, and the contacts between the two rock-types are generally fairly sharp.

(b) Sub-Stage 2 (The Upper Basaltic Zone)

The upper part of the Middle Onverwacht consists largely of amphibolitized pillow basalts, identical to the ones described from sub-stage 1. The thickness decreases from 6,660 feet in the east, to 3,450 feet in the west. A number of ultrabasic horizons are also present, but these are much narrower and not as continuous as those in sub-stage 1. Two fairly persistent bands, averaging about 100 feet in thickness occur in the lower half of the zone and are traceable for long distances. Numerous other ultrabasic bodies are also encountered but they generally occur as rather small, isolated bands and lenses, frequently aligned and giving the impression of representing a discontinuous horizon.

Pillow structures are well-developed near the base of the zone, but, due to strong shearing, have often been destroyed in the upper part (Plate 1, Figure 2). In the relatively unsheared basal portion, the main minerals are tremolite-actinolite, together frequently, with substantial amounts of chlorite and anthophyllite. Other minerals usually encountered include magnetite and some felspar and quartz, together with secondary carbonate. One specimen contained chlorite and clinopyroxene, as well as some tremolite. Proceeding northwards into the sheared, upper part of the zone, talcose rocks become conspicuous, and chlorite and talc, together with tremolite-actinolite and more rarely, anthophyllite, are present. In a number of localities within these lavas resistant zones are sometimes encountered. They form jagged outcrops and consist of well-aligned, extremely long (up to four inches) amphibole needles. Most of this amphibole is tremolite-actinolite, occurring in an interstitial aggregate of chlorite. The bands and lenses of interlayered ultrabasic material are very similar in appearance and composition to the ultrabasics of sub-stage 1. A characteristic weathering pattern, due to solution along joint planes, and closely resembling the weathering pattern of dolomite or limestone, is often encountered (Plate 2, Figure 1). This type of weathering is also characteristic of most of the ultramafic material occurring within the Middle Onverwacht sequence.

In the more persistent horizons, the ultramafics clearly represent altered dunites. Most of the olivine has been altered to antigorite and tremolite, the original crystals being surrounded by rims of magnetite. They differ from most of their counterparts in the lower zones, however, in that they contain some clinopyroxene (often only partly altered). In general, the quantity of magnetite is also less. Many of the isolated bands and lenses are steatized and consist essentially of antigorite and talc with smaller amounts of magnetite and tremolite. In the field, substantial bodies often terminate abruptly against amphibolitized lava, with stringers, or narrow protruberances of ultrabasic material sometimes persisting into the sheared basalt. If the projection of one of these bodies is followed along strike, a similar type of lensoid band is often encountered. These isolated but well-aligned occurrences give the impression of once having represented continuous bands.

(c) Structure of the Komati River Stage

The Middle Onverwacht sequence forms a very regular, east-west-striking assemblage of basaltic lavas and ultrabasic interlayers. No layered or banded sedimentary horizons exist, and it is therefore, difficult to determine the dip of the rocks. The immediately overlying basal sedimentary horizon of the Upper Onverwacht, however, dips almost vertically or very steeply to the north. This, coupled with the attitude of the pillow structures suggests that much of the Middle Onverwacht sequence is vertically or very steeply north-dipping. Aerial photographs reveal a distinct banding within most of the ultramafic horizons, although this subtle layering could not be determined either in the field, or microscopically, there being no change in the character of the ultrabasic bands from top to bottom.

The Komati River Fault, which defines the base of the Stage, has been described previously. It marks the base of the Middle Onverwacht, thus making it difficult to give the true thickness of the lower ultrabasic band. It is thought, however, that little, if any, of the material has been faulted out, the narrowing towards the west being due more to a stratigraphic effect. Zones of intense shearing, together with veins and replacement bodies of quartz and carbonate, mark the position of the poorly exposed fault trace and are also found occupying second-order structural features in the environs of the fault. The increased shearing towards the top of the Stage is probably indicative of considerable movement and faulting along the upper contact. The latter fault or zone of strong shearing, which is difficult to locate accurately, has been termed the Violet Fault. As noted above, isolated but aligned ultrabasic bodies in the upper part of the Stage give the impression of once having represented more-or-less continuous bands that were broken up as a consequence of this shearing.

In addition to the two major zones of movement already described, numerous transverse faults, all striking roughly northeast, and with right-lateral movement, displace the layered sequence by varying amounts. The largest of these faults occurs towards the east and has a horizontal displacement of 2,200 feet. Its position is marked by a zone of intense shearing, and by a substantial displacement of the trend, the latter clearly visible on aerial photographs. Most of the smaller faults have displacements of about 100-200 feet. A significant feature of all these faults is that they cannot be traced into the Lower or the Upper Onverwacht sequences. This seems to indicate that all the movement, which is consistently right-lateral, was caused by a "shear-couple" which was operative between the Komati River Fault at the base, and the Violet Fault at the top of the Middle Onverwacht Stage.

D. THE UPPER ONVERWACHT OR HOOGGENOEG STAGE

This Stage derives its name from the farm Hooggenoeg (731 JT) where the succession reaches its maximum development and is relatively undisturbed. It has been divided into two major divisions; a Lower and an Upper division. The Lower Hooggenoeg Stage consists essentially of a sequence of basic to intermediate lavas with well-developed pillow structures. Interlayered with these, are a number of relatively narrow horizons of intermediate to acidic lava, the latter often associated with banded cherts and carbonate-bearing sediments. The Upper Hooggenoeg Stage is comprised mainly of massive, acidic material forming a large, rather irregular zone.

In general the sequence is extremely inaccessible, forming deeply incised country which rises steeply to a high ridge of Fig Tree cherts (elevation 6000 feet) in the northern part of the area. The basaltic rocks of the lower division are not very resistent to erosion and form rounded hills. The interlayered more acidic horizons, however, and particularly the banded cherts, often stand out as resistent, white-weathering ridges and form useful marker horizons (Plate 7, Figure 2). The upper acidic zone forms a rugged white-weathering topographic feature.

The base of the Hooggenoeg Stage commences at a resistent chert, carbonate and carbonaceous, shaly-chert horizon which persists across the entire area and immediately overlies the basaltic and ultrabasic assemblage of the Middle Onverwacht. The top of the Stage however, needs some consideration. Previously, the Geological Survey (Visser, et. al., 1956) included a massive, white-weathering zone in the Onverwacht Series. They considered this to be representative of the upper acid volcanic-phase of the latter succession. This complex zone, although containing some minor acid- to intermediate-lava horizons with unequivocal pillow structures, also contains rocks of undoubted sedimentary origin. Most of the material, however, is massive and structureless, and of doubtful origin. Except for the minor unequivocal lava horizons it is distinctly different in character from the narrow, interlayered, acid- to intermediate-pillow lavas occurring in the lower division. In addition, the upper division contains no basaltic lava, and overlies the lower, basic lava suite with a marked angular unconformity, transgressing progressively across the latter from east to west.

As a result of the greater amount of probable volcanic and volcanically derived material, as opposed to definite sedimentary material, it was considered more satisfactory, despite the unconformable relationship and different petrological character, to include this acidic-zone in the Onverwacht Series. Recent mapping to the east has confirmed this classification, and has indicated affinities with a salic, crystalline tuff. Thus defined, the Hooggenoeg Stage varies in thickness from 15,000 feet in the east to 10,450 feet in the west.

(a) <u>The Lower Division of the Hooggenoeg Stage</u>

Although very similar to both the Lower and Middle Onverwacht sequences, in that it also consists for the most part of basaltic pillow lavas, the lower division of the Hooggenoeg Stage differs fundamentally from the former two stages in a number of important ways. In general, the degree of metamorphism is much lower and the lavas are often strongly carbonitized. Instead of amphibole, chlorite, altered sodic-plagioclase and carbonate are the main minerals encountered. Unlike the Lower Onverwacht or Theespruit sequence, with its siliceous sedimentary horizons and narrow, slaty-chert interlayers, the lower division of the Hooggenoeg Stage contains essentially acidic lavas which are invariably capped by well-developed chert horizons (Plate 7, Figure 2).

The lower division is thus composed of an enormous thickness of lava, varying in thickness from 7,660 feet in the west to 11,560 feet in the east, the thinning being due almost entirely to the transgressive nature of the overlying acidic material of the upper division. A stratigraphic thinning to the west is not as apparent in this Stage as it is in the Middle and Lower Onverwacht sequences. The lower division of the Hooggenoeg Stage can conveniently be divided into five sub-stages. Each of these appears to constitute a definite cyclic sequence, starting with a broad zone of essentially basic to intermediate lava and followed by a relatively narrow horizon of intermediate to acid lava. In most cases the latter is overlain by a substantial chert horizon, sometimes associated with carbonate-bearing sediments.

Four such cycles are well-developed, and can be traced across the entire area. The largest occurs at the base, and individual cycles decrease in size upwards. It is probable that two or three further cycles exist above the four already mentioned but, due to transgression of the overlying acidic material, coupled with poor exposures, they are difficult to distinguish with certainty. For this reason they are grouped together in the fifth sub-stage.

(i) <u>Sub-Stage 1</u>

This sub-stage is the best developed and thickest of all the cycles of the lower division of the Hooggenoeg Stage, averaging about 4,500 feet in thickness and having little variation in width from east to west. The sub-stage commences with a distinctive sedimentary horizon which represents a useful marker, in that it is the first sedimentary band found above those in the Theespruit Stage. This horizon does not form part of the first cycle of the Hooggenoeg Stage but for convenience is grouped in sub-stage 1. It varies in thickness from about 90 feet in the east to 20 feet in the west. It is lithologically variable along strike but is always recognizably well-bedded. The horizon often commences with, or is immediately underlain by, generally massive, almost pure carbonate rock containing green, angular, chloritic fragments of all sizes. This is followed by a sequence of very finely banded, dark grey to black, almost slaty-looking carbonaceous sediments. The latter rock is composed largely of carbonate with numerous small, black, presumably carbonaceous, particles scattered throughout, together with fine shreds of chlorite. Often the carbonate and the carbonaceous material is differentiated, and results in bands of pure carbonate with generally narrower interlayers of almost pure carbonaceous material. In places large, rather massive zones of fine-grained, impure carbonate-bearing material, generally characterized by numerous, small, pyrite crystals, were encountered. Two chert bands, averaging about four feet in thickness are developed near the middle and near the top of the horizon. The lower band is of the light greyish-green, banded variety, and the upper band consists of banded black and grey chert. In the latter, numerous coarser-grained, grey, clastic lenses, consisting of fragments of chert and carbonaceous particles, occur in a fine-grained cherty matrix.

The sedimentary horizon is immediately overlain by a sequence of basic to intermediate lavas which constitute the initial phase of the first cycle. This succession of lavas represents the largest of all such basic zones of the various cycles of the entire Hooggenoeg Stage, and has a fairly constant thickness of about 4,400 feet across the area. Pillow structures and amygdales are common throughout the zone, but coarser-grained, massive, jointed phases, representing the centres of individual flows, are also present and it is clear that a number of lava flows exist. Lack of suitable exposures, however, makes these difficult to trace or distinguish. The lava is typically a fine- to medium-grained, dense rock, varying in colour from green to greyish-green. It is composed mainly of chlorite and partly altered sodic plagioclase needles, together with some quartz and leucoxene. Some pyroxene remnants were also encountered. Carbonate is generally conspicuous and pervades the rock to a greater or lesser degree. Amphibole, mainly in the form of tremolite-actinolite, and occasionally anthophyllite, was also noted, occurring in greater abundance towards the base of the zone.

A number of ultrabasic bodies, in the form of narrow bands parallel to the overall foliation, occur in the upper half of this zone but could not be traced laterally for long distances. In the central part of the area, a large ultrabasic band appears to transgress the foliation at a slight angle and may represent a dyke. Close to the base of the zone in the vicinity of the Violet Fault, are a number of small, intrusive, porphyry bodies and quartz veins. Mineralization is often associated with the quartz veins and two old gold mines also occur in the zone. Further evidence of strong disturbance in this vicinity is afforded by the presence of a large, weathered, intrusive body of granitic material. One of the largest quartz porphyry bodies in the area is also associated with the fault zone, and occurs along the contact between the Lower and Middle Onverwacht sequences. The locus of a large, differentiated diabase dyke, with numerous off-shoots, is also situated in the fault zone. Towards the top of the basic lava pile in the west, lighter-coloured, acidic lava horizons start making an appearance.

The top of the first cycle is defined by a distinctive, white-weathering zone of acid volcanic material that has a fairly constant thickness of 150 feet across the area. This horizon is sheared in the west and is a nondescript, somewhat massive, light greenish-grey rock consisting essentially of a fine-grained groundmass of felspar with quartz and numerous, small, sericite needles. Within this groundmass occur a number of strongly sericitized, subhedral and partly corroded phenocrysts of sodic plagioclase. Some aggregates of chlorite and a few larger quartz grains, were also observed. Towards the east, structures resembling pillows are evident while in the extreme eastern part some perfectly formed, white-weathering pillow structures occur that are generally rimmed by amygdales. These pillows are composed of abundant, small, twinned and partly sericitized laths of sodic felspar in a groundmass containing chlorite and carbonate, together with some felspar and quartz. Numerous fine needles of an opaque mineral, probably leucoxene, are also present. It is possible, owing to the lack of pillow structures in the west, that some of the material comprising the acid horizon, may represent some type of acid-tuff rather than lava. Isolated, small, lenticular and brown-weathering carbonate bodies were noted within the acidic material in this area. A black, carbonaceous, chert horizon of variable thickness occurs at the top of the acidic zone. This chert is narrow, with an average thickness of six inches, and does not persist across the whole area. It is thus the most poorly developed of the chert horizons that overlie the various volcanic cycles of the Hooggenoeg Stage.

(ii) Sub-Stage 2

This sub-stage is the second largest of the four well-developed sub-stages of the Hooggenoeg Stage, but unlike the others, has a poorly developed upper acid lava phase. The latter, however, is associated with a thin, persistent chert horizon which can be traced across the entire area and which forms the top of the sub-stage. The average thickness is fairly constant, being about 1,800 feet, although in the east, it widens to 2,200 feet due to faulting. The lower basaltic lavas are similar in appearance to the basic lavas of sub-stage 1 and, like the latter, are characterized by the excellent development of pillow structures. Examples of these structures, and the variations which occur, are shown in Plates 2, Figure 2, and Plates 3, 4, 5, and 6. These examples are typical of the majority of pillow structures encountered throughout the Onverwacht Series.

The lavas are generally greyish-green in colour, fine-grained and fairly dense. They are composed of variable amounts of sericitized sodic felspar, chlorite and some quartz. Carbonate is invariably scattered throughout and replaces all the above-mentioned minerals. A narrow layer near the top of the zone contains abundant carbonate and only small remnants of chlorite and sericitized felspar remain. Pyroxene remnants were encountered in a few specimens. In the upper part of this intermediate to basic zone, a rather ill-defined lava horizon occurs in which laths of tremolite-actinolite, constitute much of the rock. Interstitial quartz and a few small, altered felspar laths also occur, together with minor amounts of carbonate and epidote.

An apparently layered or sill-like ultrabasic horizon averaging about 110 feet in thickness was encountered near the base of the sub-stage in both the west and east. This band could, however, not be traced in the central region although its presence there is, nevertheless, suspected. In the west it is finely banded and consists mainly of antigorite (derived from original olivine) together with some magnetite. Partly altered pyroxene crystals and tremolite were also observed. In close proximity to this ultrabasic layer in the east, occur two narrow, and apparently interlayered, discontinuous bands of felspar porphyry. These rocks, grey in colour and massive, could either be of intrusive or extrusive origin. They consist of a fine-grained groundmass of partly sericitized felspar and quartz in which are scattered numerous subhedral to euhedral, strongly sericitized and corroded plagioclase phenocrysts. Some chlorite laths, and a few orthoclase phenocrysts, are also present. Small amounts of carbonate occur scattered throughout the rock.

An indistinct, poorly exposed and narrow acidic horizon represents the upper lava phase of sub-stage 2. This is the most poorly developed of the acidic lavas of the Hooggenoeg Stage but it is, nevertheless, overlain by a narrow and persistent chert horizon. This chert, which forms a very useful marker, is banded and varies in colour from black to white to greyish-green. It averages about 12 feet in thickness and in places is associated with carbonate-bearing sediments.

(iii) Sub-Stage 3

The average thickness of this sub-stage is 1,000 feet. Both basic and acid lavas are well-developed, and a persistent chert horizon forms the top of the cycle. The pillow basalts bear a marked similarity to those of the earlier cycles. They are, however, slightly darker, being generally of a dark greenish-grey colour. Chlorite, as an alteration product of a highly birefringent mineral probably representing an original pyroxene, is common. Partly sericitized laths of sodic plagioclase, epidote, and small, black, opaque needles (possibly leucoxene) are also present, and are set in a finer-grained matrix containing chlorite and some quartz. The lavas invariably contain much carbonate, and this mineral occurs scattered throughout the rock as large grains and finer-grained aggregates. Amygdales are conspicuous in some of the pillows, being light in colour and consisting mainly of carbonate, with some chlorite and laths of a black, opaque mineral.

Zones of amphibolitized material, apparently forming an integral part of the lava sequence, were encountered. These do not form resistant outcrops as do many of the dykes. No pillow structures were observed in these medium-grained amphibolites but it is possible that they represent the cores of lava flows. The main mineral is tremolite-actinolite, often partly altered to chlorite, and is set in a fine-grained mass of quartz and chlorite. Some highly birefringent specks, probably representing original pyroxene crystals, were also encountered. The basic lavas grade abruptly upwards into a well-developed zone of white-weathering acidic lava (Plate 7, Figure 1). The average thickness of the latter is 140 feet but in the extreme east, the zone attains a thickness of 1,000 feet. This is probably due to a marked stratigraphic thickening in addition to faulting. The lava is light greenish-grey in colour and has pillow structures with amygdales developed throughout. The rock is tough and generally has a fine-grained, felted-texture. Original felspar, occurring as partly sericitized and elongated laths, is a dominant mineral and is found in a fine-grained mosaic consisting mainly of felspar and quartz. A dark opaque mineral, occurring as needles and loosely knit grains, is frequently encountered. Small chlorite specks, as well as smaller amounts of carbonate, are scattered throughout the rock. A brown-weathering material occurs frequently as interstitial, wedge-shaped masses between adjacent pillow structures. This probably represents some original primitive clay or "ooze" which was caught up between individual pillows at the time of extrusion and consolidation of the lavas. The material consists mainly of coarse-grained carbonate together with quartz aggregates and large sericite masses which stand out on weathered surfaces as more resistant, light-green patches and flakes. A substantial amount of secondary iron oxide is also present.

A well-developed eight-feet wide chert band overlies the acidic lava and marks the top of sub-stage 3 (Plate 7, Figure 1). The chert is generally light greyish-green in colour, but the upper part of the band consists of a banded black and white variety. The contact between the lava and the overlying chert is often preceeded by interlayered lenses and bands of finely banded chert within the acid lava (Plate 7, Figure 2).

(iv) Sub-Stage 4

This sub-stage represents the uppermost of the four well-developed cycles of the Hooggenoeg Stage. The thickness is fairly constant from east to west, averaging about 1,100 feet. The basaltic and acidic phases are well-developed, but the upper chert horizon is only sporadically present. As before, pillow structures and amygdales are developed in both the basic and acid lavas. The basic lava is generally fine-grained and light-green to dark-green in colour being intermediate to basic in composition. It is characteristically carbonate-rich, the carbonate content varying from 0 to 80 per cent of the total-rock, the average being about 50 per cent. Besides the carbonate, chlorite is a common constituent and has characteristic, anomalous-blue interference colours. Small amounts of quartz and felspar occur in every sample, and in some cases original felspar laths are still discernable. In other instances, tabular crystals of a fairly high birefringent mineral probably represent original amphiboles or pyroxenes. In a few sections a mesh to amphibole was seen with small amounts of interstitial felspar and quartz.

The basic lava rapidly gives way to the upper acidic lava zone forming the top of the cycle. This extends across the entire area and has an average thickness of 190 feet. In the east, this horizon appears to terminate abruptly and has probably been faulted. Here also the rock is fresh and is light greenish-grey in colour, forming white-weathering outcrops. Pillow structures and amygdales are present but are generally not as clear as the pillows developed in the basaltic lavas. To the west, the lavas become weathered and identification of the zone is difficult. The rock is composed mainly of a mass of euhedral, felspar phenocrysts, which are altered to a low birefringent mosaic, and set in a fine-grained, brownish, nondescript matrix. A narrow and sporadically developed black chert marks the top of the sub-stage.

(v) Sub-Stage 5

The thickness of this sub-stage is extremely variable, ranging from an average of a little over 200 feet in the east, to an average of 600 feet in the west. In the extreme west, it is entirely eliminated by the unconformably overlying upper division of the Hooggenoeg Stage. Acidic lava zones and chert horizons, although locally developed, could not be traced over long distances. Poor exposures make it difficult to divide this zone into various cyclic events, although it is probable that three cycles are present.

In the west the sub-stage consists essentially of altered basaltic lavas with a 100 feet wide acidic horizon towards the top. The basalt is characterized by an abundance of carbonate, together with conspicuous amounts of chlorite and smaller amounts of felspar and possibly some quartz. The acidic lava zone grades westwards into a sheared, green, siliceous material, the latter consisting of a fine-grained aggregate of quartz, with larger patches of the same material scattered throughout. Small sericite flakes are abundant and, in general, the rock is not unlike some of the quartz-sericite horizons of the Theespruit Stage.

In the east the width of sub-stage 5 is variable due to the marked undulatory contact with rocks of the overlying acidic horizon. It consists mainly of basaltic lava with some well-developed chert bands in the extreme east, together with a few zones of acidic lava, and siliceous sediments. The basalts which are fresher than their counterparts to the west, are greenish-grey in colour and resemble the basalts of the lower sub-stages. Well-developed pillow structures are present, and the rock consists mainly of chlorite masses together with altered felspar laths and smaller amounts of fine-grained felspar and quartz. Carbonate is generally conspicuous and occurs in varying amounts throughout the rock. Amygdales are composed mainly of quartz with abundant, dark, opaque, needles and variable amounts of chlorite and zeolite minerals. Amphibolitized zones of basaltic lava were encountered in some areas. The amphibole, in the form of needles or long laths of tremolite-actinolite, are often partly altered to chlorite. Discrete chlorite masses also occur and, together with the amphiboles, are set in a low birefringent groundmass consisting of altered felspar and quartz.

The somewhat impersistent and narrow acidic horizons are, in general, rather similar to the acidic lavas of the lower sub-stages. In the east, one of these horizons is cherty, and is green, giving the impression of greenschist, and probably represents a mixture of acid lava and siliceous sediment. Up to four, substantial chert bands occur in the extreme east. These horizons are generally discontinuous over large distances and occur as isolated outcrops. They are mainly of the black and white banded variety.

(b) The Upper Division of the Hooggenoeg Stage

The somewhat problematical origin and nature of the broad, upper acidic zone of the Hooggenoeg Stage has been briefly referred to previously. The reasons for classing it in the Onverwacht Series, and not into the basal part of the Fig Tree Series, have also been given. It should be pointed out, however, that because of the obscure nature of this massive, generally structureless rock, chemical data will undoubtedly prove the most useful aid in classifying the zone. It is possible that the rocks may be more favourably accommodated in the Fig Tree Series. The zone is more resistant to erosion than the predominantly basaltic lavas which it overlies with a definite unconformity, and as a result, forms a marked topographic feature, characterized by massive, white-weathering outcrops, rising steeply from the undulating and smooth basalt hills of the lower division of the Hooggenoeg Stage to the south. The lower contact of the zone is rather undulatory, and in the east faulting may have accentuated the unconformable nature of the contact. The upper contact is clear and is taken at the base of a substantial, banded black and white chert which forms the crest of the high ridge to the north. The zone is variable in thickness due to the above-mentioned factors and, where best developed in the centre of the area, attains a thickness of 4,000 feet. In the east the average thickness of the zone is 3,400 feet and in the west it diminishes to 2,800 feet.

The zone consists of about six major varieties of essentially acidic rock-types, some with minor variations. Individual-types do not form distinct bands but occupy poorly defined zones generally in constant positions. Gradations between many of the different rock-types are encountered and contacts are rarely well-defined. A banded black and white chert at times forms the base of the zone, but in most areas the acidic material lies directly on the basic lavas. The assemblage usually commences with a variable, but generally narrow, white-weathering, massive, grey, porphyritic rock characterized by numerous conspicuous felspar phenocrysts. The latter are mainly large, euhedral, polysynthetically twinned sodic plagioclase, together with a few smaller, subhedral to euhedral quartz phenocrysts. In many cases the felspar phenocrysts are almost entirely sericitized and tend to have diffuse borders, sometimes partly merging with the groundmass. They are set in a fine-grained groundmass of felspar, sericite and quartz. Apatite crystals, together with small amounts of secondary carbonate, were also noted.

In the west, the basal part of the zone contains large inclusions of dark grey chert and possibly represents a variety of acid pyroclast. In the east, large patches and zones of darker lava or dyke-like material appear to represent inclusions. In general, this rock is very similar in appearance and composition to the intrusive bodies of felspar porphyry that are developed in the Komati River Stage, although there is insufficient evidence to suggest that this rock is intrusive. The felspar porphyry zone passes gradationally upwards into a fine-grained, dense, light-grey to slightly greenish, partly sheared rock forming a broad band. This is also variable in thickness but is generally well-developed and constitutes the largest part of the upper division of the Hooggenoeg Stage. Large, diffuse patches of sericite, set in a fine-grained groundmass of quartz, felspar, and sericite, are typical. As a result of shearing, the sericite is often drawn out and forms irregular, aligned wisps. In places, large sericite aggregates are encountered which clearly represent original felspar phenocrysts. From the above, it appears that much of this rock represents a highly altered, original felspar porphyry, probably similar to the lower felspar porphyry zone. A feature of the zone is the abundance of chert, occurring as small bands of black and white banded material scattered throughout, and also as very irregular, often concentrically banded, ovoid bodies, varying in size from a few inches to several feet. The latter type, which is more abundant near the top of the zone, is generally grey, white or black in colour and is clearly of secondary origin. It is possible, however, that the isolated, well-layered occurrences might represent fragments of originally continuous banded chert horizons. Bands and lenses of cherty greenschist were also encountered in some parts.

A few substantial bands and lenses of intermediate lavas, with discernable pillow structures, also occur in this zone. The largest body is approximately 3,200 feet in length and 270 feet in thickness and appears to terminate fairly abruptly against acid material. The rock is light greyish-green in colour, the main minerals being altered felspar in the form of small needles, together with chlorite and thin needles of a black, opaque mineral.

All the above essentially porphyritic material, passes upwards into a narrow, poorly defined zone consisting of a variety of apparently acid pyroclastic and sedimentary rocks. Towards the east the dominant variety is a massive, white-weathering and light, greyish-green rock characterized by conspicuous glassy quartz grains. The rock consists of large, structureless blebs of sericite with numerous, often angular and generally corroded quartz grains of varying size. Smaller quartz grains with scattered sericite needles, together with much finer-grained material, constitute most of the groundmass. Some types have a distinct bedded-appearance and consist of angular quartz and chert fragments of varying size, together with patches and grains of chlorite in a finer-grained quartz matrix. These grade to quartz-sericite varieties which contain green, black, and white, chert fragments of varying size.

All of the rock-types described above constitute the major part of the upper division of the Hooggenoeg Stage and are overlain by a 90 feet wide, continuous, black- and white-banded chert horizon. Towards the west, however, this chert band thickens to about 400 feet. Here too, the chert is often admixed with coarser-grained acidic material, the latter forming elongated, narrow, tapering lenses and bands within banded chert. At times, as in the extreme east, this material may constitute most of the horizon, to the near exclusion of fine-grained cherty material. These coarse lenses often contain fragments of sericitized felspar, quartz, and chert, and probably represent siliceous sediments composed largely of acid igneous material together with some acid pyroclastic material.

The above chert is overlain by a well-defined zone consisting predominantly of intermediate lavas and constituting the uppermost member of the upper division of the Hooggenoeg Stage. The zone, which is variable in thickness but which averages 650 feet, is bounded in the north by a well-developed, banded black and white chert which forms the base of the Fig Tree Series. These upper intermediate lavas are thus confined between persistent, sedimentary chert bands, and form a well-defined zone. The lavas weather to a white- or light-brown colour, the brownish colour indicating a somewhat more basic variety. When weathered the rocks may closely resemble greywackes. Unequivocal pillow structures, however, leave no doubt as to their volcanic origin. The rock, when fresh, varies in colour from light greyish-brown through greenish-brown to greenish-grey. The main minerals constituting the lighter-coloured varieties are altered felspar laths, chlorite, sericite and quartz, together with needles of a black opaque mineral. The darker colour is due mainly to an increase in the amount of chlorite. The rocks of this zone, together with similar lenses lower in the sequence (referred to above), contain pillow structures and are the only rocks of unequivocal extrusive origin occurring in the upper acidic zone of the Hooggenoeg Stage.

(c) Structure of the Hooggenoeg Stage

As with the Lower and Middle Stages of the Onverwacht Series, the Upper or Hooggenoeg Stage consists of a regular, well-layered sequence, dipping at very steep angles to the north. The only obvious disturbances are the numerous small faults which displace the interlayered acidic lavas and associated chert horizons. These faults probably persist into the basic lavas but are only apparent in the acidic lavas and cherts because of the resistant nature of the latter.

The pillow structures of the Hooggenoeg Stage have suffered no dynamic metamorphism (except locally) and are invariably well-preserved. A zone of strong structural disturbance does, however, occur close to the base of the Stage. In this area, due to the influence of the Violet Fault which occurs near the top of the Komati River Stage, a variety of intrusive bodies are found. These consist of quartz and felspar porphyries, dykes, quartz and carbonate veins. Two old gold mines, the Violet and the C.L.S. Syndicate, as well as a number of gold prospects are situated on quartz veins within this zone.

The upper division of the Hooggenoeg Stage overlies the lower division unconformably, but it is possible that this effect has been accentuated, particularly in the eastern area, by faulting. Large faults have caused the displacement of blocks of the overlying Fig Tree Series. When projected southwards these fault traces appear to bound possible faulted blocks of the upper division of the Hooggenoeg Stage.

E. THE FIG TREE SERIES

The Fig Tree Series commences with a well-developed banded black and white chert which forms the crest of the prominent ridge in the northern part of the area. This broad band forms a persistent, marker horizon which can be traced across the entire area. Where undisturbed in the east, the band has a thickness of 370 feet. It grades locally into zones containing small amounts of ferruginous material, the latter often closely associated with, or replacing, the black carbonaceous bands. Towards the west a narrow band of greywacke is interlayered in the chert.

The basal chert is overlain by a poorly exposed zone of variable thickness consisting of nondescript, weathered material which appears to be mainly ferruginous shale and banded ferruginous chert, together probably with some greywacke. The zone averages about 300 feet in the east and about 600 feet in the centre of the area where the thickness is very variable. In the west it pinches out entirely. The zone is overlain by a well-developed banded ferruginous chert or banded ironstone which can be traced across the area and which varies in thickness from 220 feet in the east to a maximum of 600 feet in the west. In the latter area, due to the pinching out of the ferruginous zone referred to above, this banded ironstone formation lies in direct contact with the lowermost banded black and white chert and appears to grade upward from the latter. A narrow, 40 feet wide black and white banded chert horizon overlies the banded ferruginous chert zone and forms a useful marker. This, in turn, is overlain by Fig Tree greywackes.

It should be noted that the rock-types described above are typical of the Fig Tree sequence as developed in other parts of the Mountain Land. The 1:50,000 Geological Survey map, however, indicates Onverwacht volcanic material lying above this cherty assemblage to the east of the type area. Whether these Onverwacht lavas occupy this position as a result of folding or faulting, or whether the cherts, ferruginous cherts, and greywackes actually constitute part of the Onverwacht assemblage is not known at this stage.

(a) Structure of the Fig Tree Series

The banded chert horizons of the Fig Tree Series form resistant and persistent marker horizons and provide useful information regarding the structure of the Series. Numerous transverse faults have broken the sedimentary sequence into more than twelve separate blocks. No particular fault pattern is apparent and movement is both left and right lateral. In the west it appears that wedge-shaped blocks have been moved either to the north or the south under the influence of a lateral east-west compression. A number of these fault zones are occupied by dykes, many of which are of pyroxenitic or dunitic composition.

F. INTRUSIVE ROCKS

(a) Dykes

A variety of dykes, varying considerably in age and petrological characteristics, are present. They are usually conspicuous and form resistant, bush-clad ridges which are particularly prominent in the granite terrain to the south. There is a marked conformity of strike of the various dykes, the main direction being, in common with the majority of dykes of the Barberton Mountain Land (Visser, et. al., 1956), approximately northwest. Another prominent direction of strike is roughly northeast, or approximately at right angles to the above-mentioned trend. In a number of instances both transverse- and strike-fault zones clearly control dyke directions. In the majority of cases, however, it appears that jointing is the major controlling factor.

Nearly all the dykes are vertical or dip at very steep angles and generally have linear, rather than, irregular trends. In a number of cases, however, small offshoots may radiate from the main body and some individual dyke-masses may swell into extremely large bodies of irregular shape and dimension. For convenience, and where mineral associations allowed, the dykes have been divided into various types according to their petrological characteristics and age. The mineralogical composition of many of the dykes, particularly the basic varieties, is often very similar, irrespective of age. This makes classification difficult at times. In addition, a variety of rock-types, often of a gradational nature, are produced by the differentiation of the larger bodies. Five main varieties have been recognized and will be discussed in turn.

(i) Diabase Dykes

Diabase dykes constitute by far, the greatest proportion of all the hypabyssal rocks present, being mainly of pre-Transvaal age (Visser, et. al., 1956). They are distinctive, dense, usually medium-grained, light greyish-green coloured rocks. Coarse- and fine-grained varieties also occur. The most prominent and persistent diabase dykes in the area include the large northwest-trending dyke in the granite, the two northwest-trending dykes associated with the Theespruit and Komati River strike faults, and the large north-northeast-trending dyke in the west (Figure 1). These dykes have an average thickness of 70 feet, and are medium- to coarse-grained with chilled margins and often contain conspicuous inclusions of quartz (especially those associated with the strike faults mentioned above). All the dykes are mineralogically similar, being composed mainly of pyroxene (augite and enstatite in varying proportions) and plagioclase (usually labradorite). Titanium minerals, iron-ores and sulphides are common and granophyric intergrowths of quartz in the interstices between earlier formed pyroxene and plagioclase crystals are typical. Some dykes, for example the large dyke in the granite to the south, tend to be slightly porphyritic, the main phenocrysts being enstatite. In other instances variations in the relative proportions of the component minerals along strike is apparent and a diabasic dyke may grade laterally into a rock composed essentially of pyroxene. Some of the dykes are altered and amphibolitized with sericite and actinolite occurring as prominent constituents. Amphibole appears to result from the alteration of clinopyroxene. Granophyric intergrowths and free-quartz are usually confined to the coarser-grained varieties but may also occur to a limited extent in the finer-grained dykes as well.

(ii) Differentiated Diabase Dykes

One of the most distinctive features in the area is the presence of a huge, irregular dyke-mass, some 6,000 feet long and 4,000 feet wide on the southern portion of the farm Hooggenoeg 731JT. Radiating from this body is an intricate network of subsidiary, irregular dykes which, nevertheless, remain controlled by the two major directions referred to previously. A peculiar feature of the body is its apparently passive mode of emplacement, with little, or no disruption of the rocks into which it was intruded. The centre of the dyke-mass lies immediately north of the Violet Fault. This fault zone has been the locus of the intrusion of other large bodies of igneous material, and it seems probable that the intrusion of this dyke mass was also largely fault controlled. The dyke is characterized by xenoliths of ultrabasic and basic material, presumably representing "stoped" fragments of the invaded country rock. The body is probably closely related to the diabase dykes described previously but, due to its large size, has undergone differentiation and, because of the slow cooling, is generally coarse-grained and is unlike the normal diabase in appearance. The centre of the dyke-mass is composed of a very coarse-grained leucocratic rock consisting dominantly of altered felspar with a peculiar cellular structure, together with well-preserved augite. Alteration products include chlorite, actinolite, sericite and leucoxene. The chlorite and actinolite was probably derived from orthopyroxene. Small amounts of carbonate occur scattered throughout.

The petrology of the rock remains essentially similar, as the outer edge of the body is approached. In many cases actinolite is seen replacing orthopyroxene and in some instances, the orthopyroxenes appear surrounded by rims of clinopyroxene. Conspicuous micrographic intergrowths of quartz and scattered quartz grains make their appearance in the outer zone of the dyke-mass. The petrology of the dykes radiating from the main body is essentially similar to that of the outer zone of the main mass, with micrographic intergrowths of quartz being common. Another distinctive dyke-rock, which grades into one of the above radiating dykes, has a blotchy appearance due to the colour contrast between the dark ferromagnesian minerals and the almost white felspathic minerals. The rock is composed of hornblende, altering to chlorite with distinctive anomalous blue interference colours, and clinopyroxene altering to actinolite. Large amounts of fresh felspar are present and the rock contains abundant quartz in the form of micrographic intergrowths.

(iii) Pyroxene-Amphibole Dykes

The pyroxene-amphibole dykes in the area are almost solely confined to the Hooggenoeg Stage and the lower portion of the Fig Tree Series. They are distinctive in that they usually consist entirely of an intergrown mass of either pyroxene or amphibole. The amphibole appears to be an alteration product of the pyroxene. Individual dyke-bodies are generally irregular in shape and are never continuous for long distances. The age relationships of the pyroxene-amphibole dykes to the other dykes occurring in the area is obscure, although in one instance a pyroxene-amphibole dyke can clearly be seen cutting the major north-northeast-trending diabase in the western portion of the area. In other cases it appears as though there is a close relationship between the pyroxene-amphibole dykes, the differentiated diabase dykes, and the ultrabasic dykes. The pyroxene-amphibole dykes appear to be gradational into both the latter types. In the case of the differentiated diabase body most of the pyroxenitic material is apparently associated with the irregular dyke offshoots. All stages in the alteration of a dominantly pyroxene rock to a dominantly amphibole rock appear to be present. Thus a rock consisting mainly of augite with smaller amounts of amphibole, gives rise to one consisting dominantly of amphibole, with remnants of pyroxene, together with a distinctive brown hornblende. In a few cases much of the amphibole has been altered to chlorite.

(iv) Ultrabasic Dykes

Apparently intrusive ultrabasic bodies are almost entirely confined to the Hooggenoeg Stage of the Onverwacht Series and to the Fig Tree Series. Only one cross-cutting body was observed in the Middle Onverwacht succession. As in the case of the pyroxene-amphibole dykes, the ultrabasic intrusives form irregular and isolated outcrops and are never continuous along strike. In addition to the undoubted intrusive bodies, a number of ultrabasic occurrences with a moderate strike-length, and generally lying sub-parallel to the strike of the lavas and cherts, could either represent inter-layered bands or intrusives. These bodies have been referred to previously in the section on the Hooggenoeg Stage.

In general, the ultrabasic dykes are very similar in appearance to the inter-layered ultrabasic bands of the Middle Onverwacht Series. They are, however, characteristically rather granular and coarse-grained. This renders them fairly susceptible to weathering with the result that very fresh specimens are rarely obtained. Mineralogically they consist mainly of rounded, oval-shaped antigorite masses set in a matrix consisting dominantly of tremolite, and smaller amounts of antigorite. Pyroxene, often fairly altered, is present in some specimens. The oval-shaped antigorite masses are frequently associated with magnetite grains which occur either in the core, or as a concentration around the edge, within the tremolite matrix.

The ultrabasic dyke, intrusive into the Middle Onverwacht, has a mineralogical composition slightly different to that of the ultrabasic bands into which it intrudes. It contains small amounts of pyroxene that are typical of the ultrabasic interlayers in the upper portion of the Middle Onverwacht. This suggests that the dyke may represent a feeder to one of the overlying ultrabasic bands.

(v) Karroo Dolerite Dykes

Karroo dolerite dykes are well-represented in the area mapped. They are especially prominent in the homogeneous granite terrain in the south where the majority appear to be related to a large east-west-trending dyke. The latter dyke is 190 feet wide and has a distinct chill-phase at the contacts. The strike directions of the dykes are rather haphazard, although there is a definite tendency for alignment parallel to the two major directions of the diabase dykes viz., northeast and northwest. Joint control of the dykes is usually fairly pronounced. Except for the large body to the south, all the other dolerite dykes are narrow. They stand out as low ridges of spheroidally weathered boulders with smooth, greyish-brown surfaces. The fresh rock is a distinctive, fine-grained, dark blue-grey variety, in which occasional laths of plagioclase are sometimes seen.

The rock is totally unlike the greenish coloured diabases and is characteristically fresh and unaltered. The diabases, more commonly, contain slightly discoloured and turbid felspars, whereas the plagioclase of the dolerites (generally labradorite) is often white to transluscent. The pyroxenes are likewise little affected by alteration. The rock is generally holocrystalline and fine-grained and characterized by ophitic intergrowths of felspar and pyroxene. Only one pyroxene (pigeonite) is usually present but orthopyroxene was also observed. In some instances a marked poeciloblastic texture of the felspar needles is caused by small enclosed pyroxenes. Accessory minerals characteristic of the Karroo dolerite dykes include biotite, apatite and iron-ores.

(b) Quartz and Felspar Porphyries

Intrusive bodies of both quartz and felspar porphyry are well-represented in the area under consideration. There is a definite confinement of these bodies to the Komati River Stage and occurrences in the Upper and Lower Onverwacht sequences are rare. In the latter stages of the Onverwacht succession, they appear to be associated with faults, and in some cases, as in the Upper Onverwacht, they are associated with the acid volcanic interlayers.

The porphyry bodies generally occur as elongated lenses lying parallel to the overall schistosity, and often tend to remain in one stratigraphic position for long distances. They appear to have no preference for the rock-type into which they intrude, and occur with the same frequency in the basalts and the ultrabasic horizons. The most favourable position, however, is the central portion of the Komati River Stage. The size of individual bodies is very variable, ranging from a few feet up to 5,000 feet in length. The bodies are readily identified in the field by their distinctive brownish-white outcrops which contrast strongly with the brown and black outcrops of the surrounding basalts and ultrabasics. The quartz- and the felspar-bearing varieties are represented in about equal amounts, with a mixture of the two being more common. Phenocrysts of felspar and quartz are clearly seen on fresh and weathered surfaces. When fresh, the rock is typically of a pale, bluish-white hue with distinctive, subhedral, slightly cream-coloured felspar phenocrysts, and transluscent, angular to rounded quartz phenocrysts.

In thin section the variably sized quartz and felspar phenocrysts occur in a matrix consisting dominantly of fine-grained quartz and sericite. Most of the felspar is albitic in composition. The close association of the porphyries with the basalts and ultrabasics is marked, and it is unlikely that these bodies are related to the intrusive granite. The association of quartz porphyry bodies with the ophiolites, and more particularly the basalts of the ophiolites, is a world-wide phenomenon. This association, as it applies to the Onverwacht succession, has been described elsewhere (Viljoen and Viljoen, 1965). The age relationships of the porphyries to the acid and basic lavas is described later in this paper.

PREVIOUS VIEWS REGARDING THE STRATIGRAPHY OF THE ONVERWACHT SERIES

Prior to the renewed investigations, all previous workers have divided the basic and ultrabasic rock assemblages of the Barberton Mountain Land into two parts viz., the Onverwacht Volcanic Series, regarded as being of pre-Fig Tree age, and the Jamestown Series or Jamestown Igneous Complex, which has been classed as an intrusive suite of basic rocks, unrelated to the Onverwacht Series. The present work has shown, however, that the so-called basic intrusive rocks of the Jamestown Complex merely represent thermally metamorphosed and sheared equivalents of the Onverwacht Series. A complete review of the previous ideas regarding the Onverwacht Series (as defined in this paper), necessitates a discussion of the so-called Jamestown Series of Hall (1918), and the Jamestown plutonic complex of the Geological Survey (Visser, et. al., 1956).

A. HALL'S VIEWS

(a) The Jamestown Series

According to Hall (1918) the Jamestown Series is widely distributed in the Barberton Mountain Land and can be followed for many miles along the northern and southern contacts. He regarded the rocks as being intrusive into his "Moodies Series" (subsequently reclassified into the Fig Tree Series and Moodies System by the Geological Survey (Visser, et. al., 1956), and occupying a position between the latter and the granite. The granite in turn was regarded as intrusive into the Jamestown Series, resulting in thermal and dynamic metamorphism of the basic rocks.

The rocks of the Jamestown Series, which comprise a variety of talcose, chloritic and hornblendic schists, together with serpentine, carbonate rocks, and massive, talcose rocks, have their best development in the Jamestown Schist Belt, which Hall regarded as the type area. Mention is made of two or three intercalations of sedimentary rocks in the form of slaty quartzites. He found it difficult to distinguish between the rocks of the Jamestown Series and the Onverwacht Series and did not indicate the former in the Komati River Valley. Intrusive contacts with the volcanic rocks were not convincing and Hall gave no thickness to the Jamestown Series.

(b) The Onverwacht Volcanic Series

To Hall (1918), the Onverwacht Series was almost entirely restricted to the Komati River Valley where he described basic amygdaloidal volcanic rocks closely associated with basic schists and talc-carbonate rocks. These rocks are especially well-developed on the farm Onverwacht (733 JT) and adjacent areas and this was thus taken as the type locality (Figure 2). Hall regarded the Series as constituting a complex province of many rocks, largely volcanic, but including representatives of the Jamestown Series apparently in the form of intrusive tongues within the volcanics. He also described intrusive apophyses and tongues of granitic material derived from the surrounding old granites, as well as quartz porphyries.

The detailed petrological description of the various rock-types, composing the Series, as defined by Hall (1918), applies to igneous rocks encountered on a traverse-line which commences near the common boundary beacon of the farms Laaggenoeg, Rosentuin and Onverwacht, north of the Komati River. The traverse-line runs approximately along the common boundary between the farms Onverwacht and Laaggenoeg, to the old Onverwacht Gold Mine, a distance of approximately two miles (Figure 2). This is the only reference to any thickness and, as his description applies mainly to this area, it is assumed that this section was regarded as the type sequence of the entire Onverwacht succession. Hall does, however, mention that the sequence extends further northwards to the northwestern corner of the farm Onverwacht, an additional three to four miles. No detailed description of the rock types was given in this section. In the two mile detailed section on Onverwacht, Hall recognized 18 distinct bands of igneous rock, including nine bands of quartz porphyry, the remainder being basic varieties, serpentinites and greenstones with nodular structures. From this he concluded that two main groups of rock were present; an acid or quartz porphyry group, and a basic amygdaloidal group, with which were presumably included the ultramafic rocks. The basic greenstones were thought to be of volcanic origin, and the nodular structures were regarded as the manifestations of original amygdales. All the quartz porphyries were regarded as of intrusive origin, and attention was drawn to their marked similarity to other quartz porphyry occurrences in the Komati Valley, the Barberton area, and in the region to the south of Hectorspruit. He considered all these rocks to be derivatives of the intrusive granites, represented as intrusive apophyses and cross-cutting bodies.

The rocks described from the type locality were traceable to the east and to the west. To the east, in the direction of Steynsdorp, Hall's description clearly indicates that the stratigraphy of the Onverwacht is markedly different from that in the type locality. In this area, the volcanic rocks are associated with basic schists and hard cherty bars, in part ferruginous, standing out as resistant ridges, and traceable over large distances. According to Hall these hard cherty bars may have represented either sediments, as suggested by their occasional similarity to analogous rocks in the Moodies, or possible sheared ash-beds. It was suggested nowhere that these rocks may have represented a different portion of the Onverwacht succession. Mention was made of the problematic upper acid zone of the Onverwacht (see earlier), although it was not described or discussed in connection with the rocks occurring in the type locality. Hall regarded these rocks, which are, in fact, very variable, as an extreme phase of a highly acid, fine-grained intrusive, which elsewhere consolidated as fine-grained quartz porphyry. He suggested that the rocks could also represent a finely comminuted volcanic ash.

B. VIEWS OF THE GEOLOGICAL SURVEY

(a) The Jamestown Igneous Complex

The Jamestown Igneous Complex (sometimes referred to as a Plutonic Complex) is, according to the Geological Survey (Visser, et. al., 1956), divisible into an earlier basic phase of differentiated plutonic rocks, and a later, acid phase, the Kaap Valley Granite. Hall's view, that the Jamestown Series formed part of the Swaziland System, was rejected and the Series, renamed the Jamestown Igneous Complex, was grouped into the category of later intrusive rocks. This was done because the rocks of the Complex were considered to be intrusive into both the Swaziland and Moodies Systems and, therefore, belonged to a younger igneous event.

Following Hall, the Geological Survey has taken the Jamestown Schist Belt as being the type area of the Complex. In this zone, as in other similar occurrences around the Mountain Land, they describe bodies of basic rock intrusive into sediments of the Fig Tree and Moodies Systems. A type of pseudostratification is reported to be well-developed in the basic schists and four main rock-types were mapped. These are green serpentinite, blue serpentinite, diabase, and basic schist derived from the three intrusive types.

In the area described in this paper, the Geological Survey (Visser, et. al., 1956) reported the presence of basic schists of the Jamestown Complex. They regarded these as occupying an extensive area between Theespruit in the east and Vergelegen in the west (Figure 2). Where the basic schists lay in contact with the Onverwacht volcanics, the position was apparently very obscure and the lava was reputed to be so strongly sheared, that it closely resembled the schists. Rocks composed of talc and ankerite as well as lens-shaped bodies of quartz and quartz-sericite schist were noted in the basic schists. Thus, quartz schist is described from the farm Vergelegen, and quartz-sericite schist is described from the farm Tjakastad. No mention was made as to the origin of these bands although similar horizons in the Jamestown Schist Belt were regarded as xenoliths of either the Fig Tree or Moodies assemblages. The basic rocks described above, sweep around the western end of the Mountain Land on Sterkspruit and become coextensive with the large triangular area of basic rock of the Nelshoogte belt (Figure 2). These rocks are also regarded as members of the Jamestown Complex. No thicknesses were mentioned.

(b) The Onverwacht Series

Like Hall (1918), the Geological Survey (Visser, et. al., 1956) considered the main occurrence and type area of the Onverwacht Series to be in the Komati River Valley. No specific type section was, however, given. In addition to this major occurrence, small isolated patches of Onverwahct were mapped in other parts of the Mountain Land where they occur as inliers in younger sediments, or as inclusions in later intrusive rocks.

According to the Geological Survey, the Onverwacht succession, which extends from Diepgezet in the east, to Avontuur in the west, is five miles wide in the type area and consists of both acid and basic rock-types. The basic assemblage is composed mainly of massive, fine-grained andesitic lavas in which flow layers and amygdales may still be seen, while the acid assemblage is regarded as being entirely extrusive, consisting of quartz and felspar porphyries. The latter rocks, which are apparently confined mainly to the upper portion of the sequence, show no intrusive relationships with the overlying sediments and underlying basic lavas and could be traced for moderate distances. The Geological Survey is thus not in agreement with Hall's intrusive porphyries.

C. DISCUSSION

The authors are of the opinion that the problematic question as to the origin, mode of formation, and nature of the basic rock assemblages in the Barberton Mountain Land has been grossly complicated and confused by the introduction of the concepts firstly, of the Jamestown Series by Hall (1918) and secondly, of the Jamestown Igneous Complex by the Geological Survey (Visser, et. al., 1956). The most convenient manner of demonstrating the shortcomings of previous arguments, which have led to the separation of the Onverwacht rocks from those of the Jamestown Complex, is by an objective appraisel of available facts. In the discussion that follows an attempt is made to stress the inadequacy of previous observations and conclusions. An attempt is made to reconcile these earlier observations with the present data and the ideas developed therefrom.

A few of the most obvious deficiencies in the descriptions of the Onverwacht Series, and the Jamestown Series or Jamestown Complex, given by both Hall and the Geological Survey, is the complete lack of any definitive thicknesses, rock associations, clues to the origin, or views concerning the possible relationship of the basic rock assemblages to the other rocks of the Mountain Land with which they are intimately associated. Thicknesses for the Jamestown Series are completely lacking, even in the Jamestown Schist Belt which is regarded as the type locality by both Hall and the Geological Survey. This is probably due to the similarity between the so-called intrusive Jamestown rocks and the sheared Onverwacht lavas, as well as the lack of convincing intrusive contacts, both of which features were stressed by Hall and the Geological Survey.

No attempt has been made to trace individual rock units or rock assemblages, although both Hall and the Geological Survey conceded that the Jamestown possessed a very pronounced stratification. Detailed descriptions of isolated and selected rock-types are given, and mention is made of interlayered siliceous sediments and cherts which are generally regarded as being xenoliths of Fig Tree or Moodies rocks, caught up in the invading magma; this despite the fact that they can, in many instances, be traced for long distances with no major disturbances. Isolated patches of Onverwacht rocks mapped in the Jamestown Schist Belt, and shown on the 1:50,000 Geological Survey map, are likewise regarded as remnants of Onverwacht within the invading Jamestown magma, although petrologically these "Onverwacht" rocks are identical to the surrounding Jamestown rocks.

In the light of the recent work carried out in the Komati River Valley, and described in this paper, as well as reconnaissance mapping of many areas formerly regarded as belonging to the Jamestown Complex, it is obvious that all these rocks can be fitted into one or other of the sub-divisions of the Onverwacht Series. The correlation of the latter rocks with those of the Jamestown Complex has been discussed at length elsewhere (Anhaeusser, Viljoen and Viljoen, 1966), and will not be elaborated upon here. Suffice it to say that most of the Jamestown group of rocks can be classed into either the Lower or Middle Onverwacht successions. Rocks formerly classed with the Jamestown Complex in the southern portion of the Mountain Land have clearly been shown to belong to the Onverwacht Series (Viljoen and Viljoen, 1965). From Figure 2 it can be seen how all the characteristic stratigraphic marker units of the Onverwacht Series trend at right angles to the Jamestown - Onverwacht contact indicated on the 1:50,000 Geological Survey map of the area. The markers then continue across the so-called "contact" and can be traced laterally for miles.

Both Hall and the Geological Survey regarded the type area of the Onverwacht Series as the Komati River Valley, and they mentioned only small isolated occurrences from other parts of the Mountain Land. Hall took a section on the farm Onverwacht as his type section. It is not clear whether he regarded this two-mile section as being representative of the whole Onverwacht Series or not. The Geological Survey following Hall, also included the farm Onverwacht in their type section but considered the whole Series to be five miles thick. The authors are in agreement with the choice of the Komati Valley area as a suitable location for the type area of the Onverwacht Series, because of the excellent preservation and development of component rock units in this area. The choice of the type section on the farm Onverwacht, is however, regarded as undesirable. Reference to the accompanying map (Figure 2) indicates that the Onverwacht succession on the farm Onverwacht and the immediate environs thereof, has been subjected to severe structural disturbance. The rocks occur near to a major northeast-southwest-trending fold axis, and true thicknesses of the three stages of the Onverwacht Series have altered considerably. The proposed new type section, on the farms Hooggenoeg and Theespruit, has been described earlier in this paper.

As in the case of the Jamestown Complex, descriptions of the stratigraphy of the Onverwacht Series are almost completely lacking although a basic phase and an acidic phase have been recognized. Hall gave a detailed description of the rocks occurring in his two-mile type section. These rocks actually represent less than one-third of the total Onverwacht succession and correspond approximately with the Middle Onverwacht sequence. No detailed description of rocks occurring above or below this section was given. Further to the west in the Steynsdorp area, Hall attempted to equate volcanic rocks, belonging to the Upper Onverwacht Stage with rocks occurring in his type area. He regarded the characteristic interlayered cherts as either intercalated sediments or sheared ash-beds.

As in the case of the Jamestown Complex, only isolated samples have been described in detail by the Geological Survey and no attempt has been made to map the Onverwacht Series according to the well-developed stratigraphy. As a result, variations in thickness, laterally from the type section, are not known. It is clear, however, that in the southern portion of the Mountain Land, most of the Lower Onverwacht (as now defined) was regarded as belonging to the Jamestown Complex and Hall also mentioned patches (presumably intrusive tongues) of the Jamestown Series within the Onverwacht volcanics in this area.

A great deal of confusion has arisen over the exact stratigraphic position of the interlayered acid horizons occurring within the Onverwacht Series, the intrusive quartz and felspar porphyries, and the intrusive porphyries associated with the younger homogeneous granites. Hall regarded the intrusive quartz porphyries, shown now to be mainly confined to the Middle Onverwacht, as representative of the acid phase of the Onverwacht. The Geological Survey, possibly misunderstanding Hall's ideas, disagreed and regarded the acid phase of the Onverwacht as representing the thick occurrence of so-called quartz porphyry above the dominantly basaltic lavas of the upper division of the Hooggenoeg Stage and below the first major chert horizon of the Fig Tree Series. The latter zone was re-examined by the authors and was found to consist of large amounts of apparently sheared quartz and felspar porphyry together with fresh porphyry. In addition, acid and basaltic lavas were identified, as well as unmistakable sediments in the form of greywackes and agglomerates. Whatever their original nature, these rocks appear to be conformable and not intrusive.

Although not described in his type section of the Onverwacht, Hall did refer to acid rocks occurring near the top of the Onverwacht Series. He related these rocks to the intrusive quartz porphyries and considered them to be an extremely acid phase of the latter. Thus, the age of the quartz porphyry bodies intrusive into the Middle Onverwacht, and described by Hall, and the age of the upper acid phase of the Onverwacht described by the Geological Survey, are of importance. Evidence exists of pre-Moodies quartz porphyry bodies. Pebbles of the latter material have been found in the autolith zone (probably a greywacke conglomerate) at the top of the Fig Tree succession in the Clutha Mine area. This material is almost identical to the bodies of quartz porphyry occurring in the Middle Onverwacht sequence of the Jamestown Schist Belt (Anhaeusser, Viljoen and Viljoen, 1966). The latter bodies are in turn almost identical to the quartz porphyry bodies occurring in the Middle Onverwacht of the Komati River Valley. Some porphyry pebbles could also have been derived from the upper acid division of the Hooggenoeg Stage. Hall considered these, and other porphyry bodies in the Hectorspruit area, to be related to the intrusion of the homogeneous granites. The authors, however, favour the idea that the quartz porphyries were formed prior to the emplacement of the younger granite plutons, and are therefore, not related to the granites. Evidence for this is furnished by the distribution of the quartz porphyries in the Komati River Valley. Here they are confined almost entirely to the Middle Onverwacht sequence. Had they been related to the intrusive granite pluton to the south, which is similar in many respects to the Kaap Valley Granite, one would have expected the bodies to be fairly close to the granite and not in a zone some two miles away.

In addition to the porphyries described above, some porphyry bodies, unequivocally related to the intrusion of the Kaap Valley Granite, occur along the southern portion of the Jamestown Schist Belt north of Barberton. These bodies although petrologically similar to the quartz porphyries intrusive into the Middle Onverwacht appear to be significantly different and may be related to a much younger magmatic event.

PROPOSED TYPE SECTION AND STRATIGRAPHIC COLUMN FOR THE ONVERWACHT SERIES

From the above discussion it is clear that all previous references to a type section or type area of the Onverwacht Series have thus far been vague and incomplete. The detailed section of the Onverwacht Series described in this paper represents, in the opinion of the authors, the most complete sequence of Onverwacht volcanics to be found anywhere in the Mountain Land. In the first instance, pre-Fig Tree rocks from all parts of the Mountain Land, except in the Komati River and Steynsdorp Valleys in the south, have suffered strong thermal and dynamic metamorphism, rendering them worthless as possible type areas. In the south, the Onverwacht Series attains its best development and is relatively unaltered. In the extreme southwest, however, the sequence has thinned markedly and exposures become poor (Figure 2). Towards the southeastern part of the Mountain Land, structural disturbance (mainly in the form of folding), together with poor exposures also provide an incomplete area for study. Here also, the majority of the lavas belong solely to the Upper Onverwacht or Hooggenoeg Stage (Figure 2). Only one possibility thus remained for the choice of a type area, viz., the area in the south-western part of the Mountain Land and described in this paper (Figures 1 and 2).

The sediments associated with the lavas in the type area are invariably siliceous rocks in the form of quartz-sericite sediments or cherts and are almost totally devoid of ferruginous or clay components. They probably represent accumulations of volcanic emmanations and contain very little transported, sedimentary material derived from erosion of surrounding land areas. Shaly sediments and ferruginous cherts are lacking, yet brief reconnaissance work, and descriptions by other authors, indicates that this type of sediment is closely associated with lavas in some other areas of the Mountain Land. It is therefore to be expected that further detailed work will reveal local phases, containing this type of sediment, together possibly with other material not found in, or typical of, the area described. The authors are confident, however, that the subdivisions, suggested in this paper form a convenient, standard with which to compare and correlate all pre-Fig Tree rocks. The proposal is made that henceforth, the area described in this paper be regarded as the new type locality and type section of the Onverwacht Series.

The three stratigraphic columns depicted in Figure 3, give a summarized version of the proposed type section. Section lines A-F, G-I, and J-L shown in Figures 1 and 3, represent stratigraphic columns of the eastern, central, and western parts of the type area respectively. Section A-F in the east is regarded as the most complete type section of the Onverwacht Series. It represents a section across an area of approximately maximum development and exposure of the sequence where all the sub-stages described in the paper are present. Here too, the Series attains the enormous thickness of 35,130 feet. It is possible that the Series attains a slightly greater thickness immediately east of section A-F, but poor exposures, coupled with structural disturbance, and granite intrusion, makes this an unsatisfactory region for a type section (Figure 2). Sections G-I (27,350 feet) and J-L (20,960 feet) give an indication of the amount of thinning of the sequence in a westerly direction, and, they include parts of some sub-stages of the Theespruit Stage which are eliminated by faulting in the type section. Figure 3 further provides a summary of the petrology of the Onverwacht Series.

CONCLUSIONS

Detailed remapping of portion of the Onverwacht Series in the southwestern portion of the Barberton Mountain Land, revealed a huge thickness of dominantly basaltic pillow basalts. Interlayered within this sequence of basaltic rocks occur numerous bands of ultrabasic and acid volcanic rocks, as well as narrow, siliceous sediments. The sequence attains a thickness of 35,000 feet in the area investigated, and is relatively undisturbed and unmetamorphosed. Original structures such as pillows, amygdales and bedding are clearly discernable. The latter sequence has been proposed as a new type section for the Onverwacht Series and has been divided into three major subdivisions readily distinguishable by characteristic rock-types and associations. The investigation has clearly shown that the Jamestown Complex does not exist in the area mapped and that strongly dynamically and thermally metamorphosed rocks from other parts of the Mountain Land, also formerly regarded as belonging to the Jamestown Igneous Complex, can very readily be equated with one or more of the subdivisions of the Onverwacht Series in the new type area.

No detailed stratigraphic descriptions, definitive thicknesses or distribution of rock-types could be found in the literature for either the Jamestown Complex or the Onverwacht Series. Hall (1918) presented a fairly detailed description of the Onverwacht Series in the Komati River Valley, which, as the writers have shown, applies only to the Middle Onverwacht sequence. The Geological Survey (Visser, et. al., 1956), provided a broader definition of the Onverwacht Series, and divided it into a Lower basic-phase, and an Upper acid-phase. The type area for the Series, chosen by Hall and the Geological Survey in the vicinity of the farm Onverwacht, is close to the axis of a major fold and the sequence has, therefore, been greatly disturbed. In addition only the Middle and Upper sequences of the Onverwacht Series are present in these areas, the lower member having been entirely eliminated. For these reasons a new type section was sought for the Onverwacht Series where the entire succession is well-represented, and well-developed, and where structural complexities and metamorphism did not confuse the stratigraphy.

* *

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In addition, the authors would like to thank the members of the Economic Geology Research Unit of the University of the Witwatersrand, for helpful criticisms, advice and discussion, during the course of the investigation.

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* *

Key to Figures

Figure 1 : Geological and locality map of the Onverwacht Series in the proposed type area.

Figure 2 : Map of the southwestern portion of the Barberton Mountain Land showing past and present type areas and stratigraphic interpretations.

Figure 3 : Stratigraphic columns of the Onverwacht Series.

* *

Key to Plates

Plate 1

Figure 1 : Vein-quartz filling original gas cavities in the centre of a pillow structure. Middle Onverwacht or Komati River Stage.

Figure 2 : Sheared pillow basalts. Upper portion of the Middle Onverwacht.

Plate 2

Figure 1 : Typical weathering pattern of ultrabasics. Upper portion of the Middle Onverwacht.

Figure 2 : Typical bulbous forms of basic pillow lavas. Upper Onverwacht.

Plate 3

Figure 1 : Single pillow with chilled, fine-grained outer-edge. Lower part of Hooggenoeg Stage.

Figure 2 : Group of well-developed pillow structures showing radial jointing. Lower part of Hooggenoeg Stage.

Plate 4

Figure 1 : Group of pillow structures with carbonate filling the interstices between the individual pillows. Lower part of Hooggenoeg Stage.

Figure 2 : Pillow with downward protruberance indicating the direction of ageing. Hooggenoeg Stage.

Plate 5

Figure 1 : Oval pillow with outer amygdaloidal zone. Hooggenoeg Stage.

Figure 2 : Elongated pillow with outer amygdaloidal zone. Hooggenoeg Stage.

Plate 6

Figure 1 : Single ovoid pillow containing abundant spheroidal amygdales. Hooggenoeg Stage.

Figure 2 : Outer portion of a pillow showing zoning as well as an increase in the size of amygdales from the outer edge (left) to the centre of the pillow (right). Hooggenoeg Stage.

Plate 7

Figure 1 : Persistent, narrow, banded chert horizon (left) overlying narrow, acid lava zone marking the top of the third cycle (sub-stage 3) of the Upper Onverwacht or Hooggenoeg Stage.

Figure 2 : Acid lava (bottom), giving rise to finely banded chert horizons (top). Hooggenoeg Stage.

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GEOLOGICAL MAP OF THE ONVERWACHT SERIES IN THE PROPOSED TYPE AREA

FIG. 1

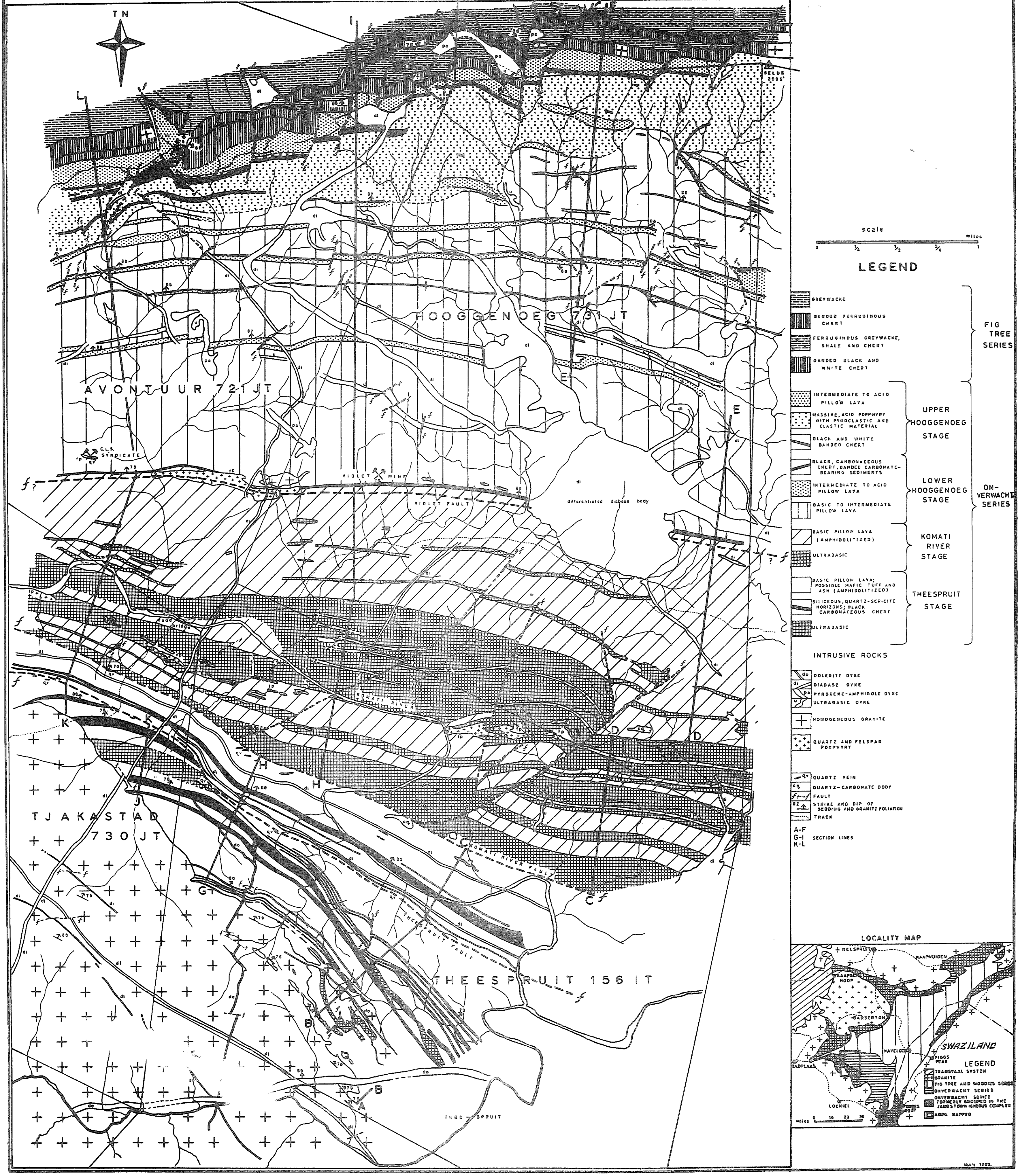


FIG. 2

A RECONNAISSANCE MAP OF THE SOUTHWESTERN PORTION OF THE BARBERTON MOUNTAIN LAND SHOWING PREVIOUS AND PRESENT TYPE AREAS AND STRATIGRAPHIC INTERPRETATIONS.

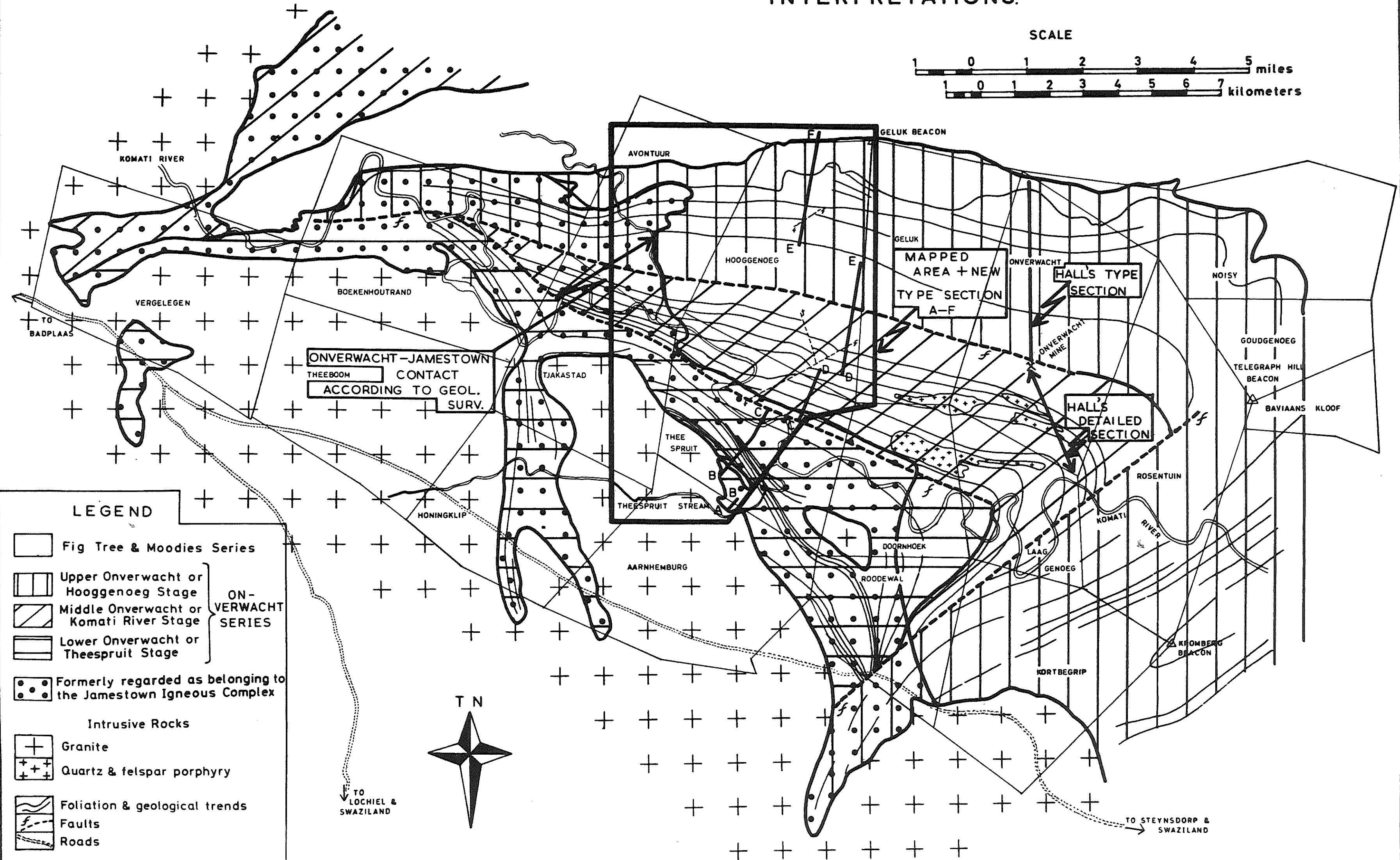


FIG. 3

STRATIGRAPHIC COLUMNS OF THE ONVERWACHT SERIES.

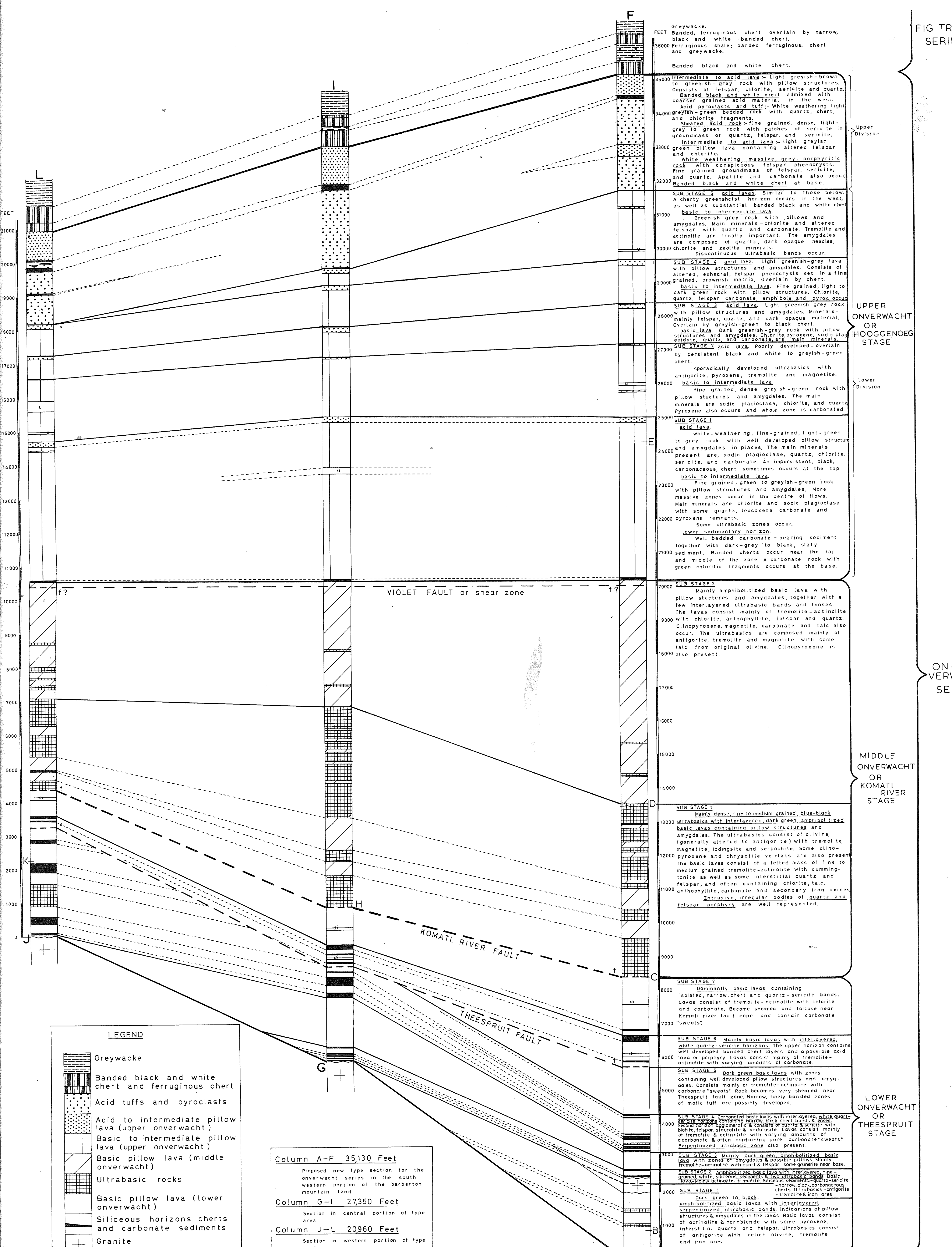


PLATE 1

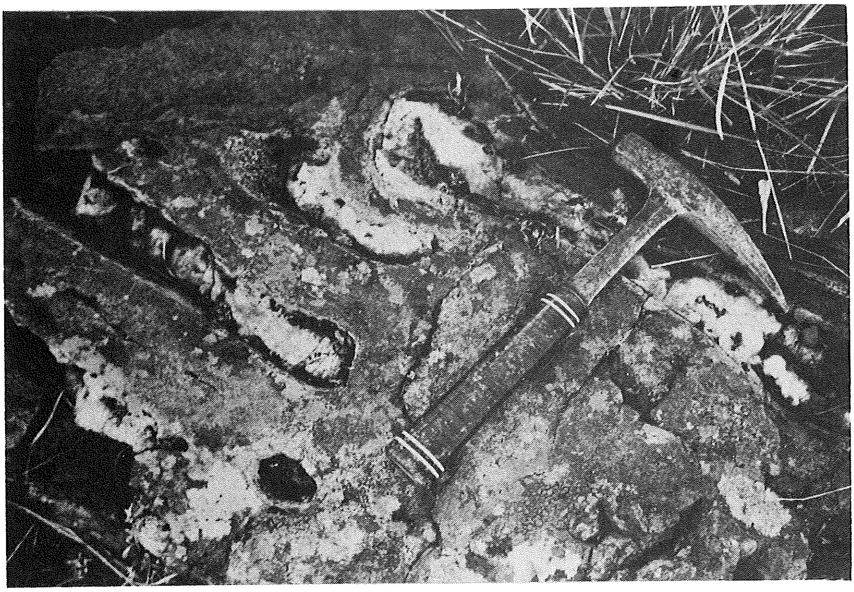


Fig. 1

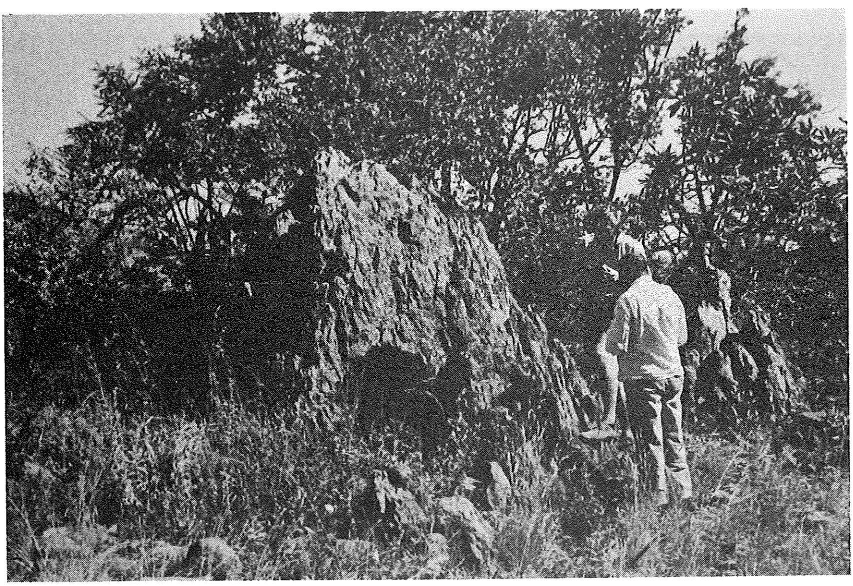


Fig. 2

PLATE 2

Fig. 1

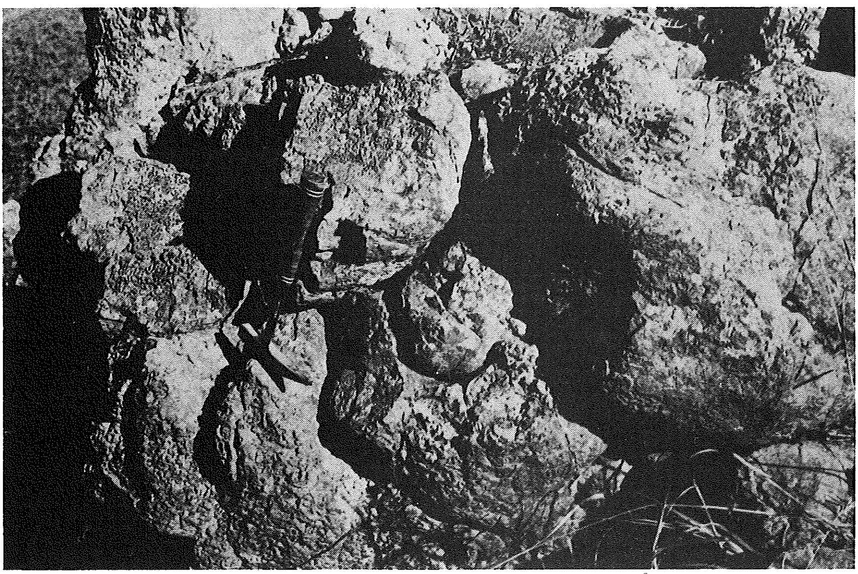


Fig. 2

PLATE 3

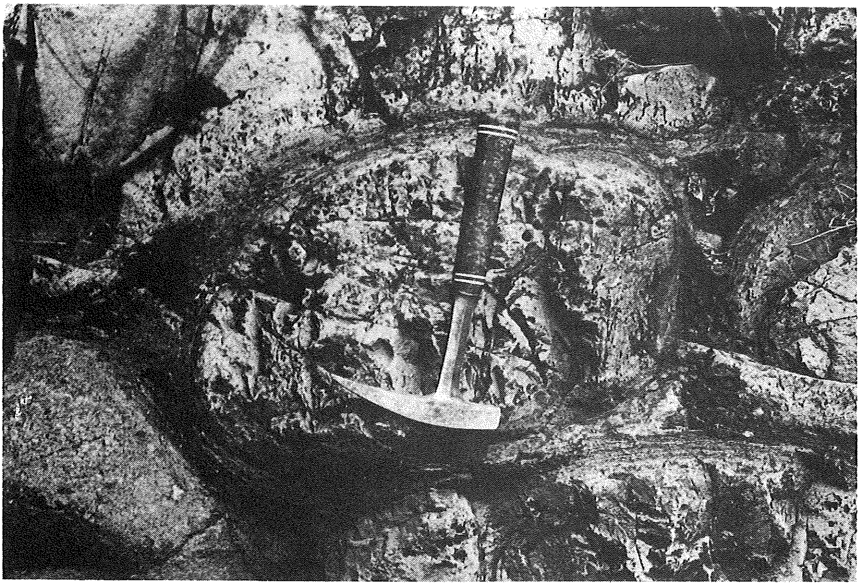


Fig.. 1

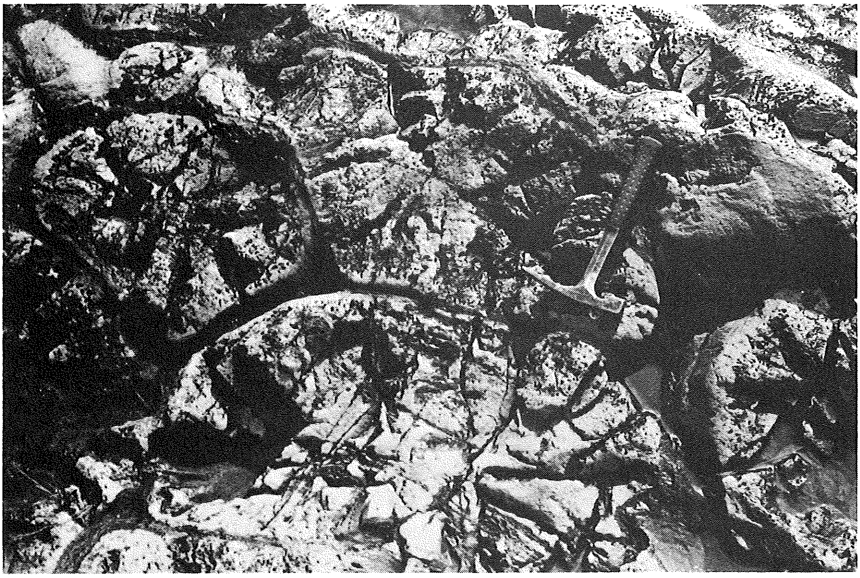


Fig. 2

PLATE 4

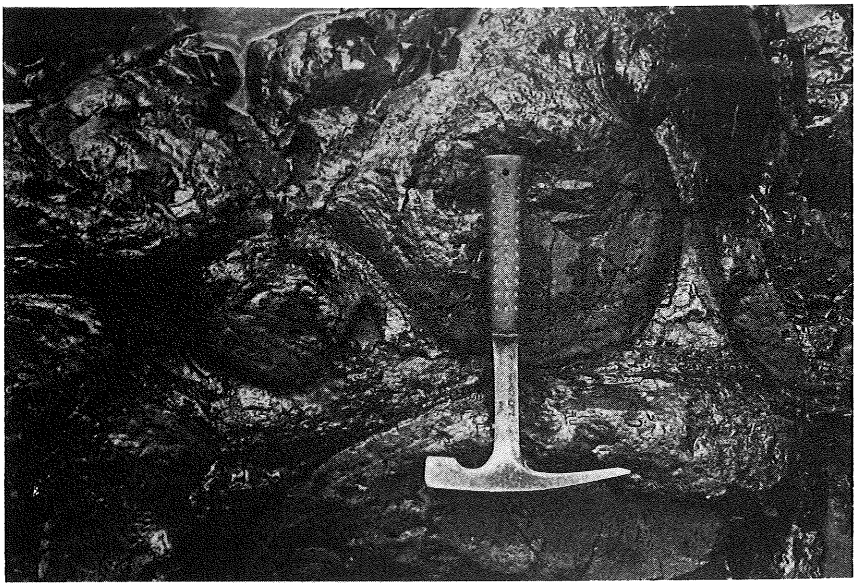


Fig. 1

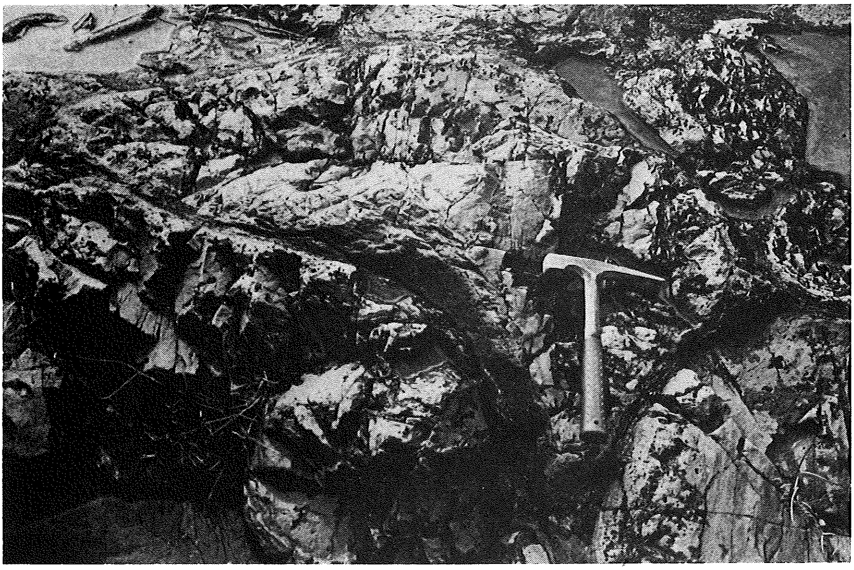


Fig. 2

PLATE 5

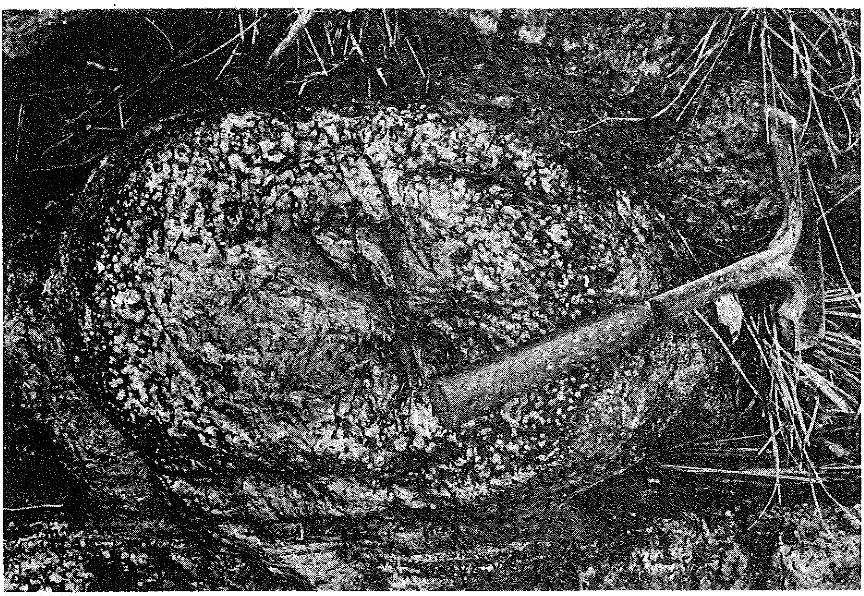


Fig. 1

Fig. 2

PLATE 6

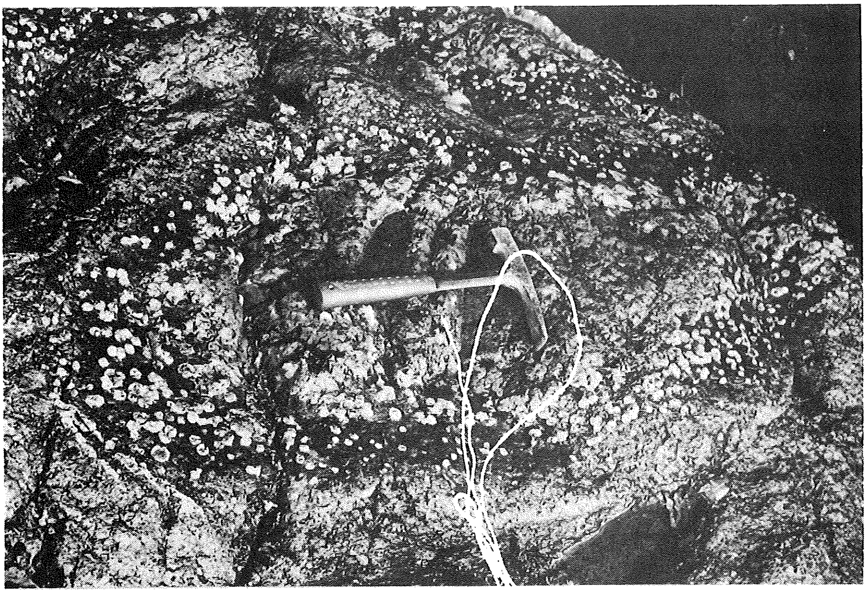


Fig. 1

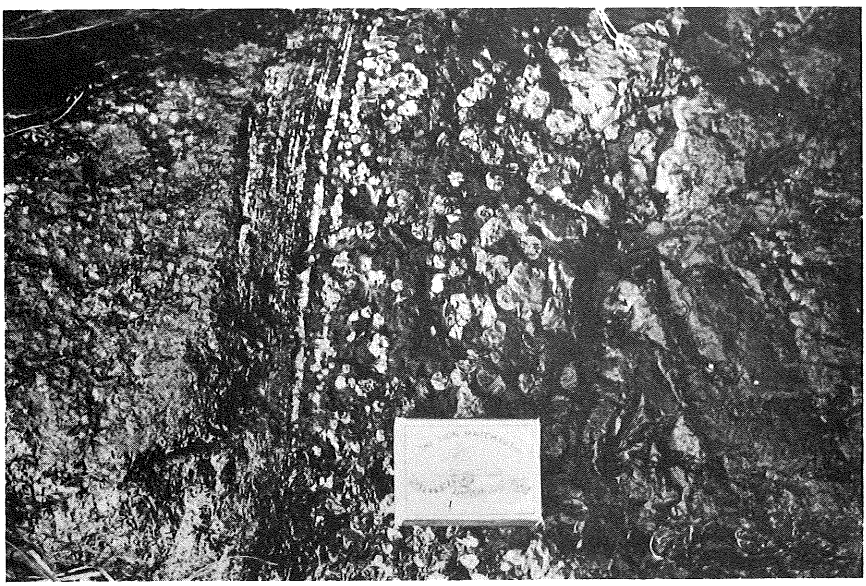


Fig. 2

PLATE 7

Fig. 1

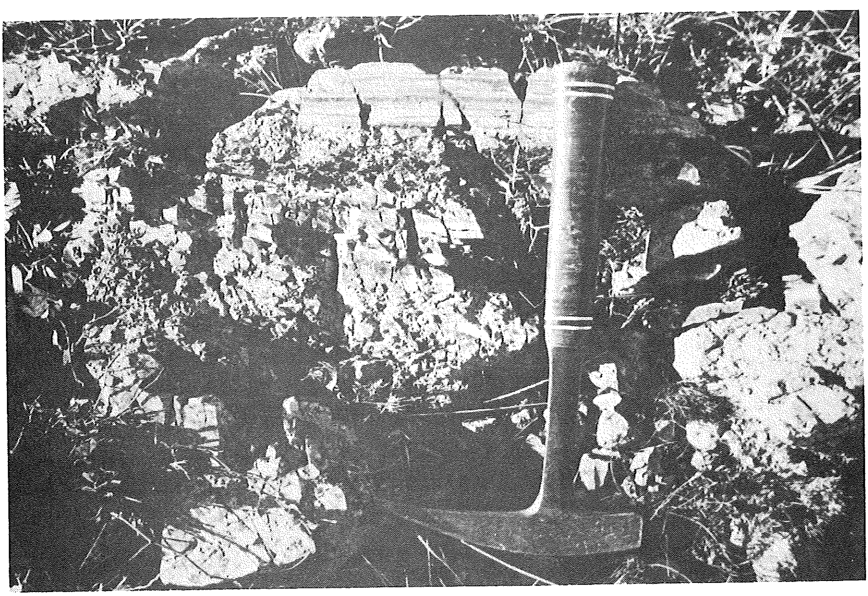
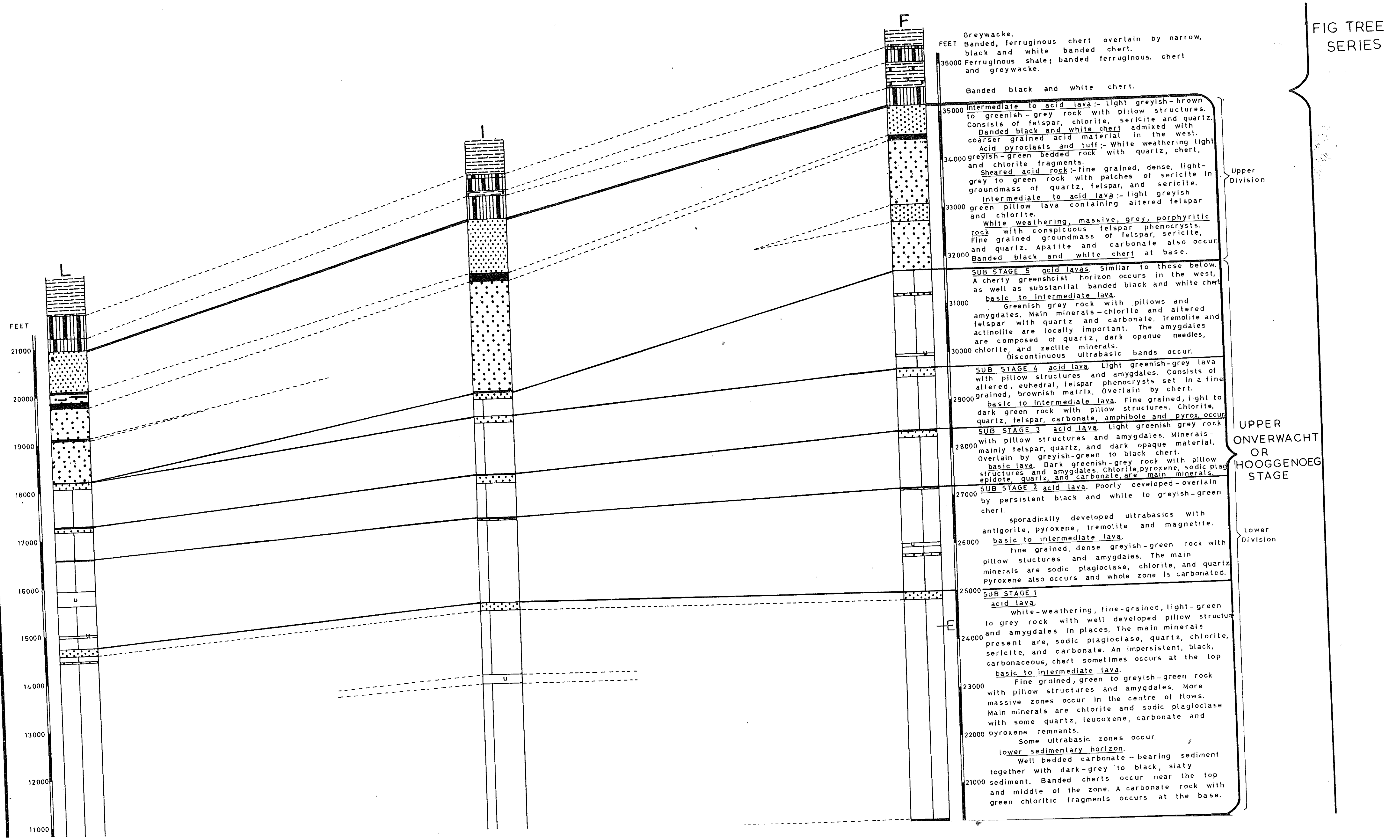


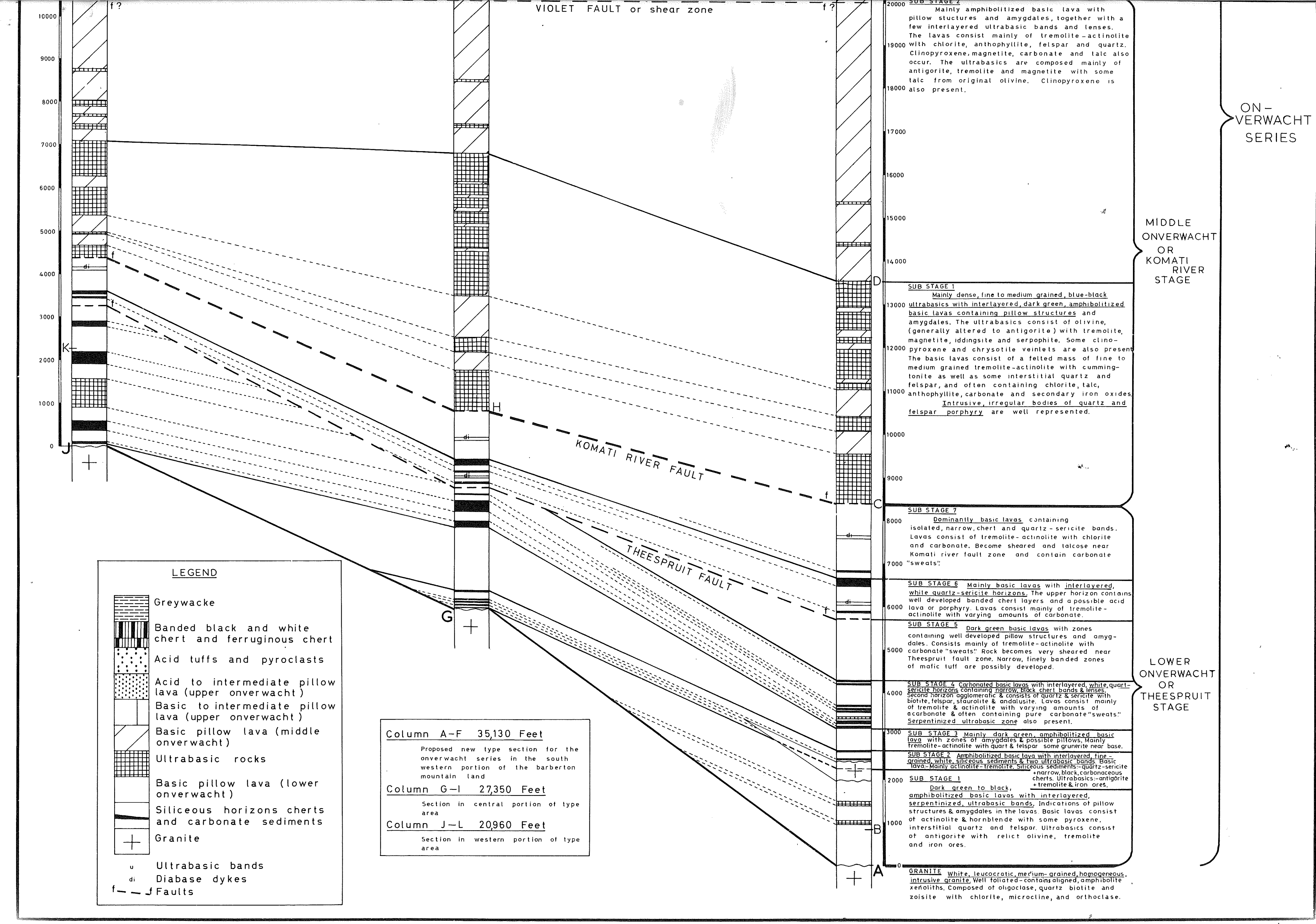
Fig. 2

S/S

STRATIGRAPHIC COLUMNS OF THE ONVERWACHT SERIES.

FIG. 3




VIOLET FAULT or shear zone
f?
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
J
K
H
G
D
C
B
A
f
di
KOMATI RIVER FAULT
THEESPRUIT FAULT
SUB STAGE 2
Mainly amphibolitized basic lava with pillow stuctures and amygdales, together with a few interlayered ultrabasic bands and lenses. The lavas consist mainly of tremolite-actinolite with chlorite, anthophyllite, felspar and quartz. Clinopyroxene, magnetite, carbonate and talc also occur. The ultrabasics are composed mainly of antigorite, tremolite and magnetite with some talc from original olivine. Clinopyroxene is also present.
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
SUB STAGE 1
Mainly dense, fine to medium grained, blue-black ultrabasics with interlayered, dark green, amphibolitized basic lavas containing pillow structures and amygdales. The ultrabasics consist of olivine, (generally altered to antigorite) with tremolite, magnetite, iddingsite and serpophite. Some clino-pyroxene and chrysotile veinlets are also present. The basic lavas consist of a felted mass of fine to medium grained tremolite-actinolite with cumming-tonite as well as some interstitial quartz and felspar, and often containing chlorite, talc, anthophyllite, carbonate and secondary iron oxides.
Intrusive, irregular bodies of quartz and felspar porphyry are well represented.
SUB STAGE 7
Dominantly basic lavas containing isolated, narrow, chert and quartz-sericite bands. Lavas consist of tremolite-actinolite with chlorite and carbonate. Become sheared and talcose near Komati river fault zone and contain carbonate "sweats".
SUB STAGE 6 Mainly basic lavas with interlayered, white quartz-sericite horizons. The upper horizon contains well developed banded chert layers and a possible acid lava or porphyry. Lavas consist mainly of tremolite-actinolite with varying amounts of carbonate.
SUB STAGE 5
Dark green basic lavas with zones containing well developed pillow structures and amygdales. Consists mainly of tremolite-actinolite with carbonate "sweats." Rock becomes very sheared near Theespruit fault zone. Narrow, finely banded zones of mafic tuff are possibly developed.
SUB STAGE 4 Carbonated basic lavas with interlayered, white, quart-sericite horizons containing narrow, black chert bands & lenses. Second horizon agglomeratic & consists of quartz & sericite with biotite, felspar, staurolite & andalusite. Lavas consist mainly of tremolite & actinolite with varying amounts of acarbonate & often containing pure carbonate "sweats." Serpentinized ultrabasic zone also present.
SUB STAGE 3 Mainly dark green, amphibolitized basic lava with zones of amygdales & possible pillows. Mainly tremolite-actinolite with quart & felspar some grunerite near base.
SUB STAGE 2 Amphibolitized basic lava with interlayered, fine-grained, white, siliceous sediments & two ultrabasic bands. Basic lava:- Mainly actinolite-tremolite. Siliceous sediments:- quartz-sericite + narrow, black, carbonaceous cherts. Ultrabasics:- antigorite + tremolite & iron ores.
SUB STAGE 1
Dark green to black, amphibolitized basic lavas with interlayered, serpentinized, ultrabasic bands. Indications of pillow structures & amygdales in the lavas. Basic lavas consist of actinolite & hornblende with some pyroxene, interstitial quartz and felspar. Ultrabasics consist of antigorite with relict olivine, tremolite and iron ores.
GRANITE White, leucocratic, medium-grained, homogeneous, intrusive granite. Well foliated - contains aligned, amphibolite xenoliths. Composed of oligoclase, quartz biotite and zoisite with chlorite, microcline, and orthoclase.
MIDDLE ONVERWACHT OR KOMATI RIVER STAGE
LOWER ONVERWACHT OR THEESPRUIT STAGE
ON-VERWACHT SERIES
LEGEND
Greywacke
Banded black and white chert and ferruginous chert
Acid tuffs and pyroclasts
Acid to intermediate pillow lava (upper onverwacht)
Basic to intermediate pillow lava (upper onverwacht)
Basic pillow lava (middle onverwacht)
Ultrabasic rocks
Basic pillow lava (lower onverwacht)
Siliceous horizons cherts and carbonate sediments
Granite
u Ultrabasic bands
di Diabase dykes
f Faults
Column A-F 35,130 Feet
Proposed new type section for the onverwacht series in the south western portion of the barberton mountain land
Column G-I 27,350 Feet
Section in central portion of type area
Column J-L 20,960 Feet
Section in western portion of type area