

C H A P T E R IV.

THE STRATIGRAPHY OF THE KIMBERLEY - ELSBURG SERIES.

A. THE KIMBERLEY STAGE.

(See bore-hole columns, plates E, F, and G.)

An impure yellow-grey quartzite, abundance of conglomerate beds and a number of disconformities are general characteristics of this stage.

The general sequence of the strata of this stage is shown in plate A.

Mellor (1915, p.30) chose the lower contact of the Kimberley Shale as the base of the Kimberley - Elsburg Series because he could not find any signs of a disconformity at the upper contact of this shale on the Central and West Rand and because the Kimberley Shale was usually associated with the Kimberley Reefs.

The symbols proposed by Feringa (1954, p.51) have been used as these lend themselves well to application in the southern area of the Free State Gold-field.

Localised lagoonal fluvial and estuarine deposits occur in this stage and will be described in detail.

(1) The Upper Shale Marker (Zone E.S.1).

In the two mines studied, the Upper Shale Marker, as this zone is called in the Orange Free State, has been encountered only in the vicinity of No. 1 Shaft at Virginia Mine. It is the most reliable marker in the Upper Division of the Witwatersrand System and is correlated with the Kimberley Shale of the Central Rand with reasonable certainty. On account of the overlap of the "B" Reef and owing to the fact that coarse sediments were deposited close to the original shore-line, this zone thins out from over 70 feet in the north-western corner of the Harmony mine to about 7 feet at Virginia, No.1 Shaft. Before Virginia No. 2 Shaft is reached, the zone has petered out. The isopach map (fig. 7, Chapter V) indicates the approximate limit of this zone.

The Upper Shale Marker is a phyllitic, highly arenaceous shale alternating with laminae of phyllite and argillaceous quartzite. Slickensided slip-planes parallel to the bedding are common in the phyllite. The predominant minerals are quartz, sericite and some pyrophyllite. Accessory minerals are zircon, rutile, tourmaline and leucoxene. A few small laths of chloritoid cut across the schistosity and in one case shreds of sericite have been pushed out of the way by the force of crystallisation of the chloritoid. Rutile is not so abundant that it may be termed characteristic of this bed. (section No. 25).

Lenticular slickensided quartz veins occur sporadically on the surface between the Upper Shale Marker and the "B" Reef.

(2) The Lower Kimberley Substage (Zones L.K.3 to L.K.1)

This substage, which is the equivalent of zones E.C.3 and E.C.4 of Borchers and White, is divided into three zones, the boundaries of which in some localities, is somewhat arbitrary.

(a) Zone L.K.3.

The "B" Reef lies at the base of this zone, or is separated from the base by a few inches of fairly pure quartzite. The reef is a zone of polymictic conglomerate beds and thin intercalations of quartzite. Closely-packed pebbles form the thickest bands near the base, whereas loosely-packed pebbles occur in the uppermost bands. The pebbles are poorly sorted, many are poorly rounded and have a variety of shapes. Some of the bands contain an abundance of yellow, partly silicified sericitic shale pebbles. Many of these are lath-shaped or discoidal, others are compressed between harder pebbles. The quartzitic matrix is less sericitic than the quartzite overlying the "B" Reef.

The mineralisation is sporadic. Fairly large rounded grains of pyrite (up to 3/16 inch in diameter) and "carbon" specks can be seen in the gold-bearing portions of the reef, these being usually found near the base. It is significant that the mineralised portions of the reef are oligomictic in character.

The meagre evidence obtained from bore-hole cores seems to indicate that the "B" Reef is well-developed in a wide zone running in a north-north-westerly direction from the common boundary point of the three mines bordering on the Sand River. The Reef becomes less robust to the north and south of this zone, and contains a higher proportion of intercalated quartzite. The "B" Reef is probably not developed in the south-western part of the Merriespruit Mine. In bore-hole K.A.3 the Reef is so thin that it could only be distinguished positively by means of its radiometric anomaly, the quartzites above and below being indistinguishable. In bore-holes M.O.2 and M.O.3 the "B" Reef cannot be identified with certainty.

In the south-eastern part of the Merriespruit Mine, the "B" Reef has promising gold values and the disconformity below the reef is more pronounced than elsewhere.

The lenses of small-pebble conglomerate and grit overlying the "B" Reef is similar in composition to the reef itself. The quartzite in which they are found is similar to that of zone E.S.2. The tendency for grains to be orientated is not so strong and the sorting is poorer than that of zone E.S. 2. (sections 15, 26 and 27.)

Up to about 30 feet from the base of the "B" Reef the texture becomes progressively finer. At this elevation in the stratigraphical column a set of lenticular beds of non-auriferous polymictic conglomerate occur.

A light yellow-grey quartzite containing large scattered black and yellow granules rests on this conglomerate. The upper part of this quartzite is characterised by scattered pebbles, consisting mostly of black quartz and chert.

Another set of lenticular polymictic conglomerate beds follows on the pebbly quartzite and marks the end of zone L.K.3.

(b) Zone L.K.2.

This zone is composed of highly sericitic quartzite. The lower boundary of this zone may be either sharp or ill-defined.

It varies from medium-grained to coarse-grained and is yellow-brown. The quartz grains seldom touch each other and the edges of the grains are embayed, owing to replacements by sericitic material. (photomicrograph 1, section 28). Various aggregates of chlorite, sericite, chert and other minerals as described in Chapter II and isolated grains of chert and microcrystalline quartz are encountered in the matrix. Chlorite is only locally present. Small acicular crystals of rutile are common. Coloured grains are inconspicuous in the hand specimen.

Lenses of conglomerate or grit are rare in this zone. In the upper section the quartzite contains isolated rounded pebbles of quartz.

(c) Zone L.K.1.

Lenticular polymictic beds of conglomerate occur at the base of this zone. It is enclosed and succeeded by a yellowish grey, gritty quartzite containing coarse-grained black and yellow granules of chert and shale. (section 29)

Layers of grit mark the coarsest phases of this quartzite.

(3) The Middle Kimberley Substage (Zones M.K.4 - M.K.1)

The base of this substage is demarcated by the disconformity underlying the "Big Pebble" Reef.

Feringa (1954, p.51) has subdivided this stage into four zones. Correlation of data is very difficult, because the average thickness of this substage intersected by the bore-holes on the Virginia and Merriespruit Mines is only 20 feet and 9 feet respectively, and especially as all the zones are rarely encountered in a single bore-hole. The equivalent of this substage in the scheme of Borchers and White is zone E.C.2.

A feature of this substage is the coarse texture of the quartzite and the oligomictic large-pebble conglomerate beds.

(a) The Big Pebble Reef (Zone M.K.4).

Large, well-rounded pebbles 1 inch to 4 inches in

average diameter, chiefly composed of milky white quartz, but also of flint and dark chert, lie scattered in a matrix of light-grey quartzite with very little argillaceous material. The quartz grains are closely packed and sub-angular. Many are "welded" together, the contacts being sutured. Black, impure grains of chert and some concentrations of sericite and rutile give rise to coloured specks. (section 30.)

There are one or more bands of conglomerate. Quartzite, similar to that occurring in the matrix, may separate the conglomerate locally from the underlying disconformity. The contact between this quartzite and the quartzite of zone L.K.3 is fairly sharp, but the two rock-types cannot easily be split on the plane of the contact.

Pyrite is rare, and occurs in isolated patches at the base and in the reef itself. Gold is associated with the mineralised patches. The only economic concentration of gold was in bore-hole V.Z.3, which assayed 3.25 dwts. over a width of 46.4 inches. The gold content is low, but consistent in the south-eastern part of the Merriespruit area.

The maximum pebble dimensions of the conglomerate beds of the Middle Kimberley substage decreases in a south-westerly direction from approximately 4 inches to 2 inches with the result that the importance of the "Big Pebble Reef" as a marker bed is lost.

The thickness of this zone ranges from zero to 30 feet.

(b) Zone M.K.3.

This zone consists of a sericitic, yellow-grey quartzite. The coloured grains are similar to those in the previous zone. Thin lenses of rounded quartz-pebble conglomerate are present.

(c) Zone M.K.2.

Zone M.K.2 is largely conglomeratic. The matrix is a little more argillaceous than that of zone M.K.4. Well-rounded pebbles averaging 2 inches in diameter occur in this zone. These were first described by Feringa (1954 p.40), who states

that they are the product of the reworking of unconsolidated sediments. They are well-mineralised and contain rounded grains of carbon. This reef can easily be confused with the "A" Reef. Encouraging, but no payable gold values have been obtained from the reef, which must occur in limited areas only, as it is recognised in the core of only a few bore-holes. The best example was intersected in bore-hole Z.V.1, 9000 feet north of Virginia.

(d) Zone M.K.1

A medium-grained grey quartzite which has a very slight yellow tinge forms the main feature of this zone. Grains of black chert and yellow silicified shale form scattered coloured specks in the quartzite. Thin beds of siliceous quartzite and lenses of loosely-packed large-pebble conglomerate are interstratified with the quartzite.

(4) The Upper Kimberley Substage (Zones U.K.3 - 1).

The substage is divided, according to the scheme proposed by Feringa into three zones, as indicated in Table I and Plate A.

They correspond to the Zones T.I and E.C.I in the scheme of Borchers and White.

A disconformity below the "A" Reef has been proved in the Odendaalsrus area of the Orange Free State Gold-fields (Feringa 1954, p.42) and also in the Virginia-Merriespruit area (Feringa 1954, p.54.)

The correlation within this substage, again, must be considered as tentative. The beds are discontinuous and the average thickness, calculated from bore-hole data, is only 6 feet. The short distance between disconformities indicate that shallow-water conditions prevailed when these sediments were being formed.

Over large areas the Upper Kimberley Stage has been eroded away prior to deposition of the Elsburg Stages.

(a) The "A" Reef (Zone U.K.3).

The conglomerate which constitutes this zone is known

as the "A" Reef. It varies in thickness from a single string of pebbles to 2 feet 7 inches and consists of well-rounded pebbles, the average diameter of which is $\frac{1}{2}$ inch. The pebbles consist of clear, dark, smoky and white quartz, the quartz being exceptionally well-rounded. Some quartz pebbles are dark-rimmed. Black and dark-grey chert pebbles occur in minor amounts. Pebbles about $\frac{1}{4}$ inch in diameter occur in portions of the conglomerate. The pebbles are compact and well-sorted. The matrix is yellow and sericitic, resembling the quartzite above the conglomerate. In the Virginia No. 1 Shaft, the matrix of the Reef contains abundant sericite and bright orange-yellow specks. The pebbles are coated with sericite and as this coating forms a surface of weakness, the rock tends to break around some of the pebbles in the reef.

As certain bore-holes (e.g. M.1) intersected more than one band of conglomerate in the "A" Reef horizon, it is possible that the reef, in some areas, is multi-banded.

Pyrite is abundant, rounded in shape and less than 1 mm. in size. Disseminated thucolite has discoloured the matrix. The values obtained from the few intersections indicate that the ratio of uraninite to gold will be high. A hand specimen taken adjacent to a sample which had a gold value of 3 dwts. per ton, gave an appreciable count on a Geiger-Muller Counter.

The "A" Reef is confined to the area where the discontinuity at the base of the Elsburg Stage has not cut down appreciably into the underlying sediments. The Reef is poorly developed towards the south-east. It is potentially an economic reef of the patchy type, although so far there are no payable bore-hole intersections of this Reef in the Virginia-Merriespruit area. The nearest payable intersection of the "A" Reef is that of bore-hole Z.V.1.

(b) Zone U.K.2.

The quartzite constituting this zone is light-grey and has a definite yellow tinge, which varies according to the

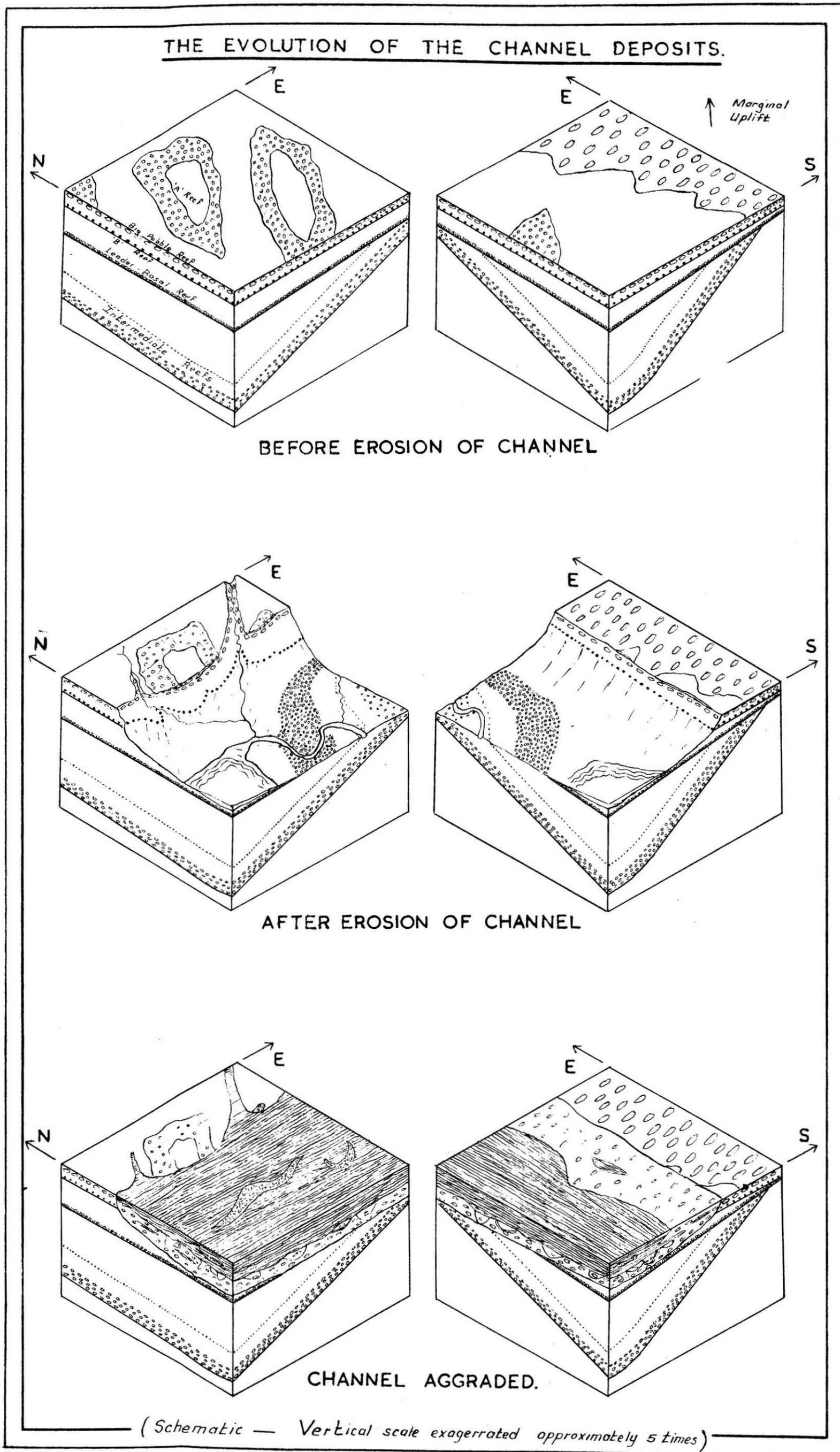


Fig. 5.

amount of sericite in the rock. The grains are packed in such a way that they often touch, but there is space between grains for sericite, chlorite and fine-grained quartz to be present. Concentrations of sericite, chert, acicular yellow rutile and leucoxene give rise to coloured specks which are fairly evenly distributed through the rock. Some of the grains are elongated parallel to the bedding (section 30) Large granules are sparsely scattered through the quartzite. Pyritic stringers are present. Strata of argillaceous quartzite less than 5 inches in thickness, lie at intervals of 2 to 3 feet. No current-bedding has been noticed in the bore-hole cores.(section 32.)

(c) Zone U.K.1.

An upper small-pebble conglomerate containing loosely packed pebbles up to $1\frac{1}{2}$ inches in diameter, has been intersected in bore-hole K.A.2. Feringa 1954 (p.38) has called the correlate of this reef the "A" Reef Leader. The matrix of this conglomerate is of similar composition to the quartzite of Zone U.K.2. The reef is poorly mineralised and the gold content is low.

A stratum of highly argillaceous quartzite, up to 6" thick, appears immediately below the lowest bed of the Elsburg Stage, in bore-holes M.O.1, K.A.2, K.A.3 and S.E.1. This stratum appears to overlie different beds of the Kimberley Stage. Should this bed be continuous, it might represent a fossil soil.

(5) "Channel" Deposits of Kimberley Age.

A wide valley, striking east-west across the central part of the Merriespruit Mine, was eroded into the underlying formations and subsequently filled in with a wide range of sediments. (See fig. 5).

According to a tentative correlation set out in plate G, the earliest sediments formed after the "channel" deposits belong to zone M.K. 1. The correlations within the Middle and

Upper Kimberley Stages are tentative, but one can establish an upper limit to the possible age of the "channel" deposits as pre-V.S.5, by the fact that the deposits underlie the discontinuity at the base of the Elsburg Stage.

In the most easterly intersection of these deposits on the Merriespruit Mine, that of bore-hole M.2, the thickness of the channel deposit, corrected for intrusives, is 245 feet and in No. 1 Shaft, the most westerly intersection, the thickness is 105 feet. An extensive portion of the Leader Basal Reef to the east of Merriespruit No. 2 Shaft has been scoured away (see fig. 5, plates B and I.)

The basal portion of the deposit consists of numerous small channels, partly filled with conglomerate and partly with siliceous, light-grey quartzite. Younger channels have been cut into the first-formed ones with the result that a profile transverse to the general direction of elongation of the channels reveals a cross-bedded structure on a large scale. The small channels trend in the same direction as the main valley. They give the base of the "channel" deposit a scalloped outline.

Lenticular bodies of all grades of particle size from sand to boulder dimensions are represented, reflecting the variable competencies of the stream-currents.

The quartzite is usually siliceous. The pebbles in the conglomerate lenses are rounded. They consist mainly of quartz, chert and a few silicified shale pebbles. Mineralisation is usually very poor, although pyritic stringers appear locally. Occasional concentrations of gold have been found near the base of these deposits. A notable peculiarity of some of the quartzite is the presence of sparsely scattered, rounded, dark pebbles of quartz.

Lenticular shale beds appear high up in the succession, and some of the upper channels are lined with thin beds of shale. Arenaceous shale is common high up in the succession and is predominant in the upper half. Lenticular bodies of poorly mineralised conglomerate, carrying a fair amount of silicified shale

pebbles, were found near the base of the shale in Merriespruit No. 2 Shaft. At this horizon, scattered boulders of quartz lie in the shale or in argillaceous quartzite.

The shale is well-bedded, somewhat graded and arenaceous. The bedding planes part easily, and has smooth, somewhat polished surfaces. Minor slickensiding appears on some of these planes. The shale breaks into slabs varying in thickness from less than an inch to over a foot. Small penecontemporaneous slips, folds and local abnormal inclinations of bedding are features of this shale. Tongues and lenses of fine-grained silty quartzite are irregularly spaced. The arenaceous shale terminates suddenly upward, and forms the upper contact in the majority of the bore-holes that intersect the channel deposits. In bore-hole S.E.2 conglomerate, quartzite and sharply defined tongues and lenses of shale dipping at variable angles indicate a repetition of the quartzite-conglomerate facies of the channel in the upper portion of the deposits. There is a possibility that it is this facies that has been intersected above the shale in bore-holes S.E.1 and K.A.2 (plate G.)

A subsidiary channel has been intersected in bore-hole V.4.

In a thin section of the arenaceous shale (section 31), there are alternating laminae containing particles in the size range of silt and mud. Quartz grains are most common in the coarse-grained, whereas flakes of sericitic material are more abundant in the fine-grained laminae. Large flakes of a sericitic mineral (probably pyrophyllite) are orientated parallel to the bedding planes and are partially altered to chlorite.

B. THE ELSBURG STAGE (ZONES V.S.5 - V.S.1).

There is a marked difference between the quartzite of the Elsburg Stage, and that of the underlying Kimberley Stage. The feature that strikes an observer at once is that the yellowish-brown tinge is absent in the quartzite of the Elsburg Stage. Inspection of thin sections reveals that this is so because the sericitic minerals form a smaller proportion in the matrix compared with quartzite of the

Kimberley Stage. (Compare sections 32 and 33, only 1 ft. difference in elevation).

The quartzite is strongly current-bedded and is also ripple-marked on some bedding-planes. Bedding-planes are well-defined and are usually accentuated by thin layers of argillaceous quartzite, which are found at intervals of about two and three feet throughout the quartzite. The current-bedding is exhibited by laminae of varying grain-size and varying amounts of impurities. There are pyritic stringers in some of these laminae.

The Elsburg Stage is divided into five zones as indicated in Table I and Plate A.

(1) Zone V.S.5.

After this zone has been intersected in the No. 2 Shaft of Merriespruit, it was established that two entirely different varieties of conglomerate are developed in it. This intersection may be taken as the type section of zone V.S.5: a compact, well-rounded quartz-pebble conglomerate having an average thickness of 24 inches immediately overlies the "channel" shale. After the deposition of the conglomerate, some of the mud has been squeezed in between the lowermost pebbles. The pebbles are mostly constituted of clear to grey, smoky quartz, some being dark-rimmed, and grey quartzite. A few pebbles of chert and green and yellow sericitic quartzite also occur in this reef. The colour of the quartzitic matrix is grey or dark-grey. The reef is well-mineralised and the pyrite, less than $\frac{1}{8}$ inch in longest dimension, has a dull lustre. Thucolite forms very small, disseminated, dust-like specks in the matrix. A layer of quartzite, 1 inch thick, splits the reef into two bands along the westerly section of the shaft. The average gold value of the reef in the shaft is 6.8 dwts. per ton, and the uraninite-gold ratio is high.

A bed of quartzite ranging from 9 to 12 inches in thickness separates the lower conglomerate from the upper and there is no parting which could indicate an hyatus between the conglomerate and the quartzite. As this quartzite is essentially similar to

the quartzite of zone V.S.4, the detailed description of the quartzite will not be given here. The upper contact is also conformable, the coarse current-bedded laminae near the top of the quartzite carrying granules and small pebbles typical of the overlying conglomerate. The currents responsible for the current-bedding flowed from west to east.

The upper conglomerate, the one usually known as the V.S.5 Conglomerate, has a thickness of 5 to 7 feet in the shaft intersection. The pebbles are loosely packed, poorly sorted and range from sub-angular to sub-rounded. Numerous milky-white pebbles of quartz contrast with the dark-grey quartzitic matrix, and pebbles of clear and blue opalescent, quartzite, dark-grey chert, pale-yellow silicified shale and quartz-porphry, give this reef its characteristic appearance. Many chert and shale pebbles are tabular and wedge-shaped, and some shale pebbles are compressed between harder pebbles. The matrix of the conglomerate is formed of small pebbles, granules and grains of quartz and chert, and aggregates of chert, chlorite, sericite and rutile in varying proportions. The interstitial material is an aggregate of chlorite, microcrystalline quartz and chert, small shreds of sericite and an opaque black dust. The grains are closely packed. Occasional sub-rounded grains of pyrite and rounded grains of zircon occur in the matrix. Pyrite also occurs in stringers. (sections 33 and 34.)

In bore-hole K.A.2, the pyrite is concentrated locally in a well-sorted section of the V.S.5 Conglomerate. This section occurs away from the contacts of the conglomerate and contains 2.35 dwts. gold over a sampled width of 4 inches.

In all the other intersections of the V.S.5 Conglomerate the gold values are negligible.

In the short interval of 10 feet an oligomictic, auriferous conglomerate and a polymictic non-auriferous conglomerate occur together, the former lying disconformably on "channel" shale. (The disconformity will be discussed in a later chapter.) The

The interesting point about these two conglomerates is that the former has most of the characteristics of a potentially economic gold-bearing reef, whereas the latter is typical of a non-auriferous conglomerate.

The lower conglomerate is lenticular. It was intersected in only 7 out of 18 bore-holes drilled on the Merriespruit Mine, and the reef has not been positively identified in the Virginia Mine, except as a layer of coarse grit in the intersection of No. 1 Shaft. Bore-hole Z.V.1, north of Virginia Mine (fig.9) passed through both these reefs as well as the "A" Reef. In 4 other bore-hole intersections on Merriespruit Mine, the horizon of this conglomerate was recognised as a layer of rounded quartz pebbles. The value obtained in the Merriespruit No. 2 Shaft intersection is the highest encountered in the two mines and in the surrounding area.

The lower conglomerate can be correlated with the "Gold Estates Leader" of the G.F. block. The correlation is based on the following criteria:-

- (a) The appearance of the reef agrees with Feringa's description of the "Gold Estates Leader". (1954, p.56).
- (b) The reef is overlain by the V.S.5 Conglomerate, which Feringa calls the "Elsburg Basal Grit."
- (c) The reef lies directly on the disconformity, which marks the base of the Elsburg Stages, in both the G.F. Block and in the Virginia-Merriespruit area.
- (d) It cannot be the "A" Reef as that reef had been eroded away south of bore-hole G.F.5 before the sediments of the Elsburg Stage were formed. (See the isopach map, fig. 9, in the next chapter.)
- (e) Bore-hole Z.V.1 has intersected the V.S.5 Conglomerate and also both the "Gold Estates Leader" and the "A" Reef.
- (f) The reef lies directly on "channel" shale, both in Merriespruit No. 2 Shaft and in bore-hole V.B.K.1 in the G.F. block. (Feringa 1954, p.58)

Feringa considers the narrow conglomerate underlying the Elsburg Basal Grit, followed by normal Kimberley formations in bore-hole G.F.5, to be the "A" Reef. Considered in the light of the succession revealed in the Merriespruit No. 2 Shaft intersection, the writer is of the opinion that the conglomerate is

not the "A" Reef, but the "Gold Estates Leader". Fortunately, this does not detract from Feringa's arguments concerning the age of the "Gold Estates Leader", and it must be concluded that the "Gold Estates Leader", and not the V.S.5 Conglomerate, forms the basal conglomerate of the Elsburg Stage.

The V.S. Conglomerate varies from a thin grit to a well-developed conglomerate 15 feet in thickness. The conglomerate is the widest and most robust in the western portion of the common boundary of the Virginia and Merriespruit Mines. On moving away from this area, one finds that it becomes thinner, develops more intercalated quartzite lenses and that the average size of the pebbles decreases. Some of the intercalated quartzite lenses are silicious, and resemble the quartzite of zone V.S.4, and others are argillaceous, dark-grey and densely speckled, containing small grains of the same composition as those described in the matrix of the V.S.5 Conglomerate. (section 34).

The lateral variation which this conglomerate reveals is illustrated in bore-hole M.O.3, in which zone V.S.5 was repeatedly intersected due to overfolding and faulting. It is interesting that in one case no conglomerate is developed, but the argillaceous, dark-grey type of quartzite is present.

Beds belonging to zone V.S.5 were not intersected in bore-holes M.2 and M.5, but it is possible that this zone is faulted out or that the core has been ground away as in bore-hole M.3. In bore-holes M.U.2, the V.S.5 Conglomerate is narrow and small-pebbled. North of the G.F. Block, in the Hennenman-Whites area, the V.S.5 exists as a poorly developed grit. It is, therefore, quite feasible that the V.S.5 Conglomerate is not developed in the southern area of the G.F. Block and in the eastern area of the Merriespruit Mine.

(2) Zone V.S.4.

The quartzite mainly composing this zone is fine-grained, grey and siliceous, the grain-size varying from 0.1 to 0.3 mm. The finest-grained beds are very tough and break with a

subconchoidal fracture. Thin sections (section 2) reveal that the toughness is due to interlocking of the quartz grains except for occasional openings which were subsequently partly filled with a quartz cement.

Loosely packed grit beds occur a few feet above zone V.S.5 in bore-holes M.U.1 and S.M.1. A few inches of quartzite at the base of zone V.S.4 are often a dark-grey, and may be compared with the argillaceous quartzite of zone V.S.5. In fact, this dark quartzite might conceivably be considered as part of zone V.S.5.

The effect of pressure on bedding-planes in the V.S.4 quartzite has resulted in stylolites being developed. The change from zone V.S.4 to the overlying quartzite is gradual, and is especially difficult to establish near intrusives, where the rock is silicified.

(3) Zone V.S.2/3.

In the Welkom area the following subdivisions were recognised:-

Borchers and White, 1943, fig. 1 opp. p.134).

V.S.2 Ventersdorp dark-grey quartzite.

V.S.3 Ventersdorp alternating dark and light-grey quartzite.

V.S.3(a) Ventersdorp small-pebble agglomerate-conglomerate.

As there is no sharp distinction in this area between the various zones mentioned in Borchers' and White's paper, the zones have been grouped together as zone V.S.2/3.

A mineralised grit containing sub-rounded granules of quartz in a dark grey quartzitic matrix was intersected in bore-hole Z.V.1, north of Virginia, at a distance of 42 feet above the base of zone V.S.4. This is the only occurrence in the Virginia-Merriespruit area that can possibly be correlated with zone V.S.3(a).

The quartzite of zone V.S.4 gradually becomes coarser-grained and banded, the coarser bands being dark-grey. The

average grain size of zone V.S.2/3 is 0.3 mm.. A dark-grey, slightly argillaceous quartzite in zone V.S. 2/3 can be distinguished in the northern half of Merriespruit Mine and the western half of Virginia Mine. This zone is no doubt the equivalent of zone V.S.2 in the type area. The quartzite of zone V.S.2/3 grades into the quartzite of zone V.S.1. The thickness of this zone should, therefore, be regarded as approximate.

In the quartzite, sub-angular grains of quartz and isolated grains of chert are fairly tightly packed and are often interlocked. The matrix consists mainly of fine-grained quartz, and small shreds of chlorite and sericite. Segregations of chlorite and chert in the matrix are common, some containing a multitude of acicular rutile. Genuculated twins of the same mineral are also present. (section 35).

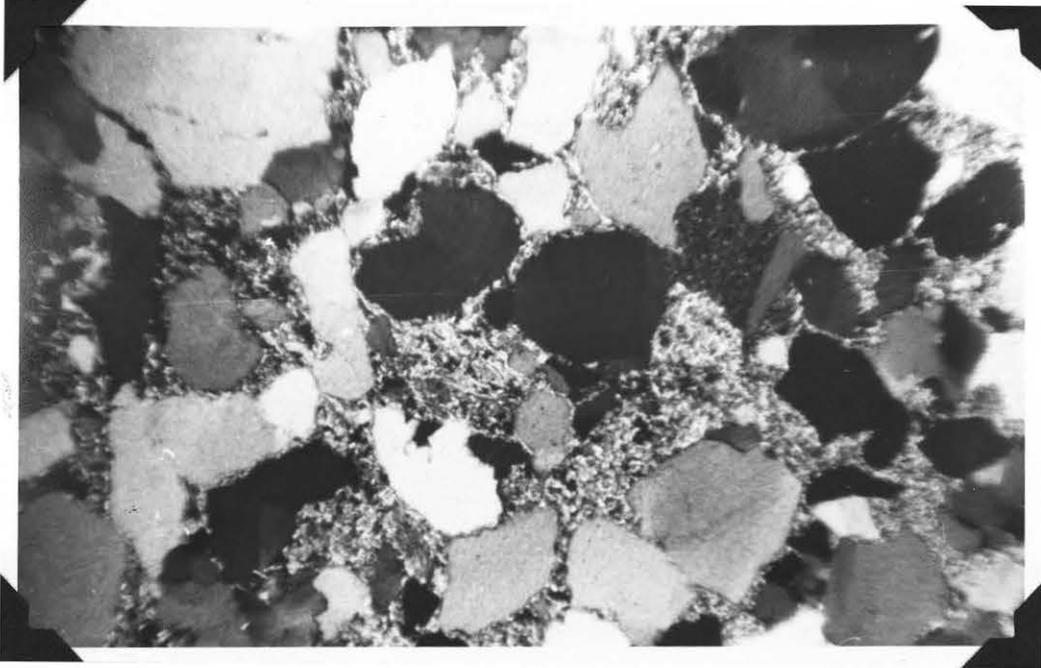
The argillaceous quartzite layers contain a larger amount of sericite and other minerals in the matrix.

A few thin beds of grit appear near the top of zone V.S.2/3.

(4) Zone V.S.1.

The base of this zone has been arbitrarily chosen as the lowermost well-developed bed of grit in a zone which is predominantly of a gritty nature. This zone is the equivalent, in the Virginia-Merriespruit area, of the so-called Ventersdorp agglomerate-conglomerate of zone V.S.1 described by Borchers and White (1943, p.137). Beds of grit increase in size and frequency up to about 80 feet from the base of this zone, where coarse grits and scattered small pebbles are encountered. As one proceeds towards the top of the column, several bands of coarse grit are encountered. The 145 feet of quartzite immediately preceding the V.S.1 conglomerate, is, however, not gritty. The zone is terminated by the V.S.1 Conglomerate, which appears at or close to the lower contact of the Ventersdorp Lava.

There are two interbedded varieties of quartzite in zone V.S.1. The first variety is identical with the quartzite of



Photomicrograph 7.

Quartzite, zone V.S.1. The matrix consists of finely divided sericite and chlorite. The dark spot in the matrix on the left is a concentration of chlorite containing very tiny needles of rutile. The sorting and rounding of the grains are much better than that of the subgreywacke in this zone (photomicrograph 2).

Crossed nicols (X 170)

Section 37.

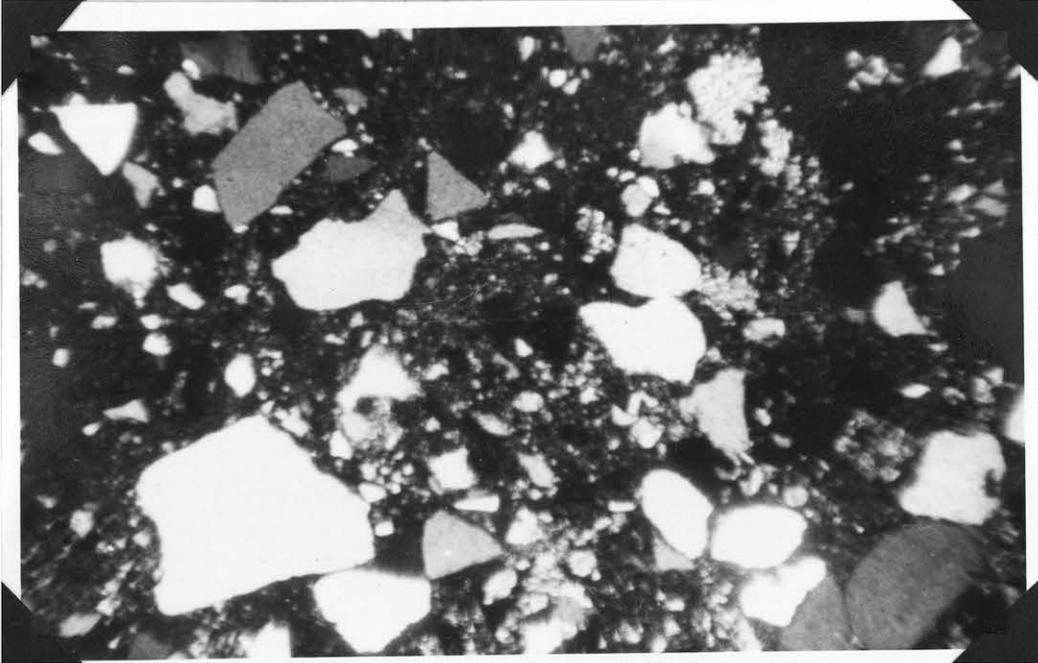
zone V.S.2/3.(section 37, photomicrograph 7) The second variety can be considered as a subgreywacke, as defined by the American geologists (Krumbein and Sloss, 1953, p.132). Poorly sorted, sub-angular grains of quartz, chert and different varieties of silicified shale, hornfels and other metamorphic rocks are loosely packed in a matrix consisting of aggregates of quartz, chloritic and sericitic minerals, and a black dust. The grain-size varies from approximately 0.03 mm. to pebbles of over 2 cm. in longest diameter. Clusters of rutile crystals give rise to yellow specks. (section 36, photomicrograph 2). In hand specimen the quartzite is dark-grey, and contains some blue opalescent quartz grains. Grains of pyrite are angular and have crystal faces. The pyrite, together with leucoxene, is widely scattered throughout the matrix and is concentrated in sinuous stringers consisting of minerals commonly forming the matrix of the quartzite.

The pebbles in the grit bands are similar to those of zone V.S.5, and are the coarse equivalent of the second variety of quartzite described above. A fair amount of pyrite of average grain-size of 0.07 mm. are often found in the grit. The most robust development of grit and pebble bands occur in the southwestern area of Merriespruit.

The V.S.1 Conglomerate is very poorly sorted, consisting of pebbles up to 3 inches in longest direction. The pebble varieties are similar to that of zone V.S.5, but the pebbles are more angular. The matrix is dark and gritty. Bands of conglomerate are intercalated with a dark, gritty quartzite and grade laterally into grit and quartzite. The conglomerate is not auriferous.

It is possible that this conglomerate is the correlative of the Ventersdorp Contact Reef, in which case it should be considered as the basal conglomerate of the Ventersdorp System.

The quartzite between the conglomerate and the lava has a highly chloritic matrix containing a black dust, similar to the matrix of tuff beds of Ventersdorp age occurring to the west of



Photomicrograph 8.

Subgreywacke, zone V.S.1. Possibly tuffaceous, immediately underlying the Ventersdorp lava. The matrix consists of chlorite and a fine black dust. The grain in the upper right hand corner is completely chloritised.

Crossed nicols

(X 200)

Section 38.

the de Bron fault in the Merriespruit Mine. (section 38, photomicrograph 8)

The extremely coarse development of the sediments in zone V.S. 1, called the "Ventersdorp Basal Conglomerate" by Frost (1946, p.19) and the "agglomerate-conglomerate" by Borchers and White (1943, p.137) is not known from the Virginia-Merriespruit area. The development of grit and small-pebble conglomerate beds in zone V.S.1, however, becomes less robust in a direction away from the St. Helena Mine. The subgreywacke also loses its prominence and merges with the V.S.2/3 type of quartzite in the same direction.

As the composition of the "Ventersdorp Basal Conglomerate" is that of the rudaceous equivalent of a greywacke, the subgreywacke occurring as interfingering beds in the Virginia-Merriespruit area, could be considered as belonging to a facies of the Ventersdorp Basal Conglomerate further removed from the distributive province.

average grain size of zone V.S.2/3 is 0.3 mm.. A dark-grey, slightly argillaceous quartzite in zone V.S. 2/3 can be distinguished in the northern half of Merriespruit Mine and the western half of Virginia Mine. This zone is no doubt the equivalent of zone V.S.2 in the type area. The quartzite of zone V.S.2/3 grades into the quartzite of zone V.S.1. The thickness of this zone should, therefore, be regarded as approximate.

In the quartzite, sub-angular grains of quartz and isolated grains of chert are fairly tightly packed and are often interlocked. The matrix consists mainly of fine-grained quartz, and small shreds of chlorite and sericite. Segregations of chlorite and chert in the matrix are common, some containing a multitude of acicular rutile. Genuculated twins of the same mineral are also present. (section 35).

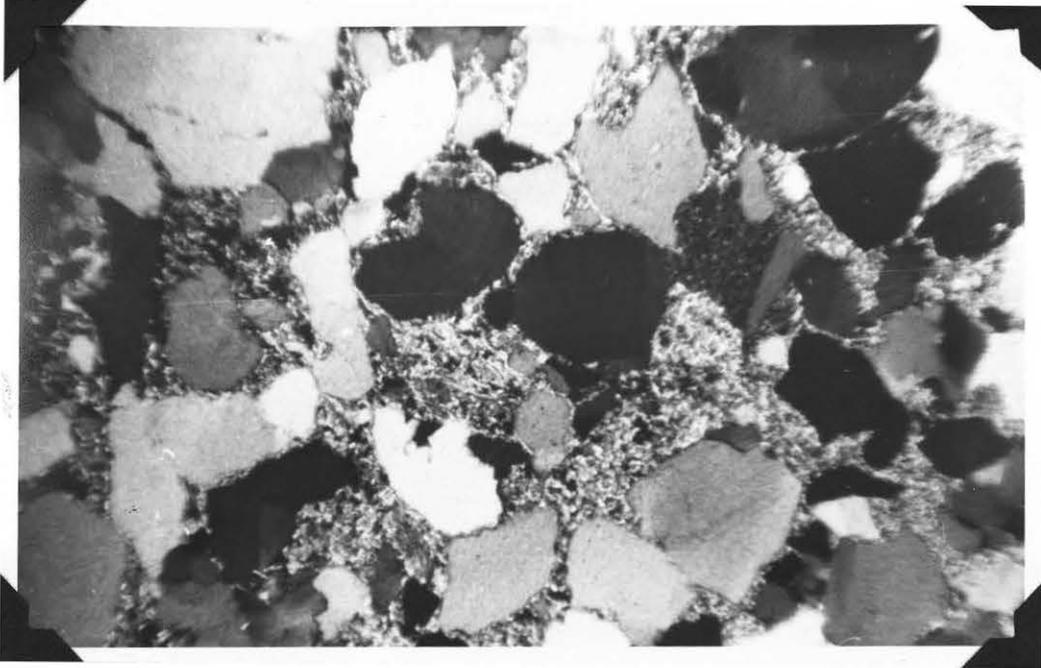
The argillaceous quartzite layers contain a larger amount of sericite and other minerals in the matrix.

A few thin beds of grit appear near the top of zone V.S.2/3.

(4) Zone V.S.1.

The base of this zone has been arbitrarily chosen as the lowermost well-developed bed of grit in a zone which is predominantly of a gritty nature. This zone is the equivalent, in the Virginia-Merriespruit area, of the so-called Ventersdorp agglomerate-conglomerate of zone V.S.1 described by Borchers and White (1943, p.137). Beds of grit increase in size and frequency up to about 80 feet from the base of this zone, where coarse grits and scattered small pebbles are encountered. As one proceeds towards the top of the column, several bands of coarse grit are encountered. The 145 feet of quartzite immediately preceding the V.S.1 conglomerate, is, however, not gritty. The zone is terminated by the V.S.1 Conglomerate, which appears at or close to the lower contact of the Ventersdorp Lava.

There are two interbedded varieties of quartzite in zone V.S.1. The first variety is identical with the quartzite of



Photomicrograph 7.

Quartzite, zone V.S.1. The matrix consists of finely divided sericite and chlorite. The dark spot in the matrix on the left is a concentration of chlorite containing very tiny needles of rutile. The sorting and rounding of the grains are much better than that of the subgreywacke in this zone (photomicrograph 2).

Crossed nicols (X 170)

Section 37.

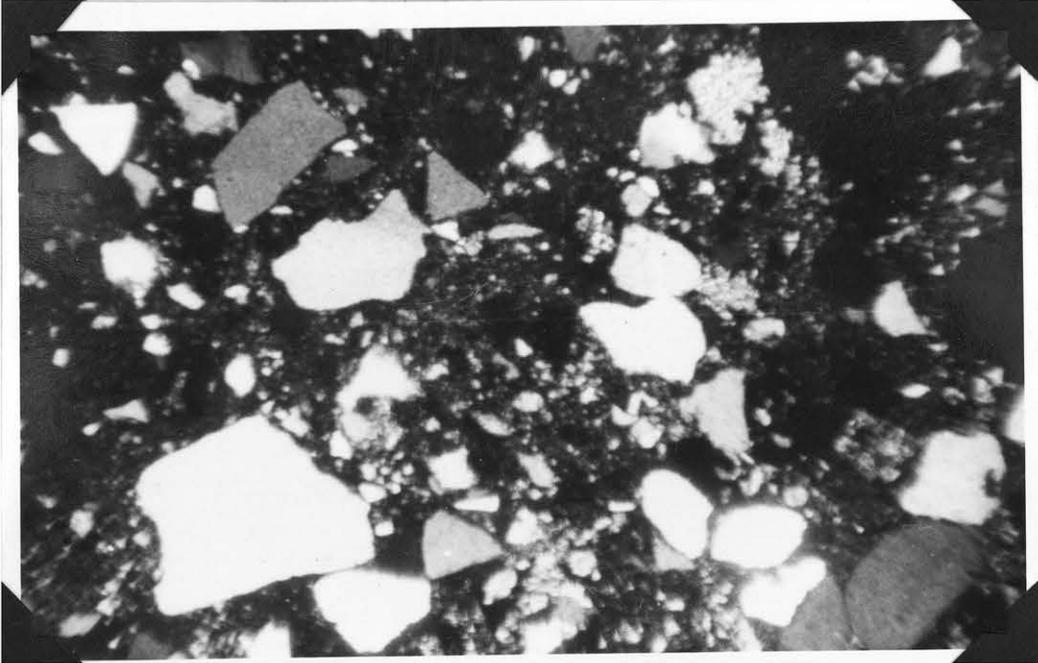
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Photomicrograph 8.

Subgreywacke, zone V.S.1. Possibly tuffaceous, immediately underlying the Ventersdorp lava. The matrix consists of chlorite and a fine black dust. The grain in the upper right hand corner is completely chloritised.

Crossed nicols

(X 200)

Section 38.

the de Bron fault in the Merriespruit Mine. (section 38, photomicrograph 8)

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C H A P T E R V

DISCONFORMITIES.

Geologists soon noticed, as drilling progressed, that disconformities are more prominent in the Virginia-Merriespruit area than in the Welkom area of the Orange Free State Gold-fields. In order to obtain quantitative data on these disconformities, a series of isopach maps have been compiled. (See figs. 6 to 10). These maps give the variations in thickness of the strata between disconformities or between a disconformity and a marker bed.

Dr. Borchers (1950, p.88) is of the opinion that these disconformities are "marginal unconformities" of the Witwatersrand geosynclinal basin. Analysis of these disconformities show that the magnitude of all the breaks in the sedimentation increases towards the south and the east, indicating that shore-lines must have existed in these directions. The curves of the isopachs give us some idea of the shape of the basin during different times.

In general, it will be noticed that the curves of the isopachs conform roughly to the present strike of the Upper Witwatersrand beds. One would expect this to be the case in a geosyncline which was not afterwards subjected to extreme orogeny.

A study of the spacing of the isopachs show that warping took place near the margin of the basin and that the isopach lines which mark the beginning of extensive disconformable relationships, are within a mile or two from each other.

Where the transgression of the overlying conglomerate is regular, the contours of the isopachs are also regular. Irregular isopachs would indicate that there is little transgression, or else it may reveal faulty correlation.

The position of the zero isopach outlines the limits of a marker bed or of the conglomerate associated with the lower disconformity.

The channel deposits are cut so deeply into the footwall

of the Leader-Basal Reef in the eastern part of Merriespruit, partly because of the greater magnitude of the hyatuses towards the east and partly because of the greater depth of the channel.

The disconformities are called after the sedimentary unit which immediately overlies such disconformity.

A summary of the effects of individual disconformities are listed below:-

A. THE BASAL REEF DISCONFORMITY.

The Basal Reef in the Virginia-Merriespruit area lies upon the lower portion of zone U.F.1. Unfortunately, this portion of the succession lacks definite markers, with the result that the amount of transgression is difficult to assess.

According to the information presented in table V below, there is evidence that the relation between the Basal Reef and the Footwall quartzite in this area is disconformable. The greater thickness between the Intermediate Reefs and the Basal Reef in the Welkom area is further proof that the Basal Reef lies disconformably on the Footwall beds.

TABLE V

Thickness of Succession between Basal and Intermediate Reefs

BORE-HOLE	THICKNESS	REMARKS
R.U.1*	685	Corrected for intrusives
M.1	613	
K.A.2	600	
S.E.1	500	Corrected for intrusives
WELKOM AREA	875	

* Bore-hole R.U.1 passed through the Leader-Basal Reef close to the limit of the Basal Reef. The true distances would therefore be slightly greater than that given above.

B. THE E.L.1 DISCONFORMITY.

The disconformable relation of zone E.L.1 to the Basal Reef is indicated by local truncation of the latter

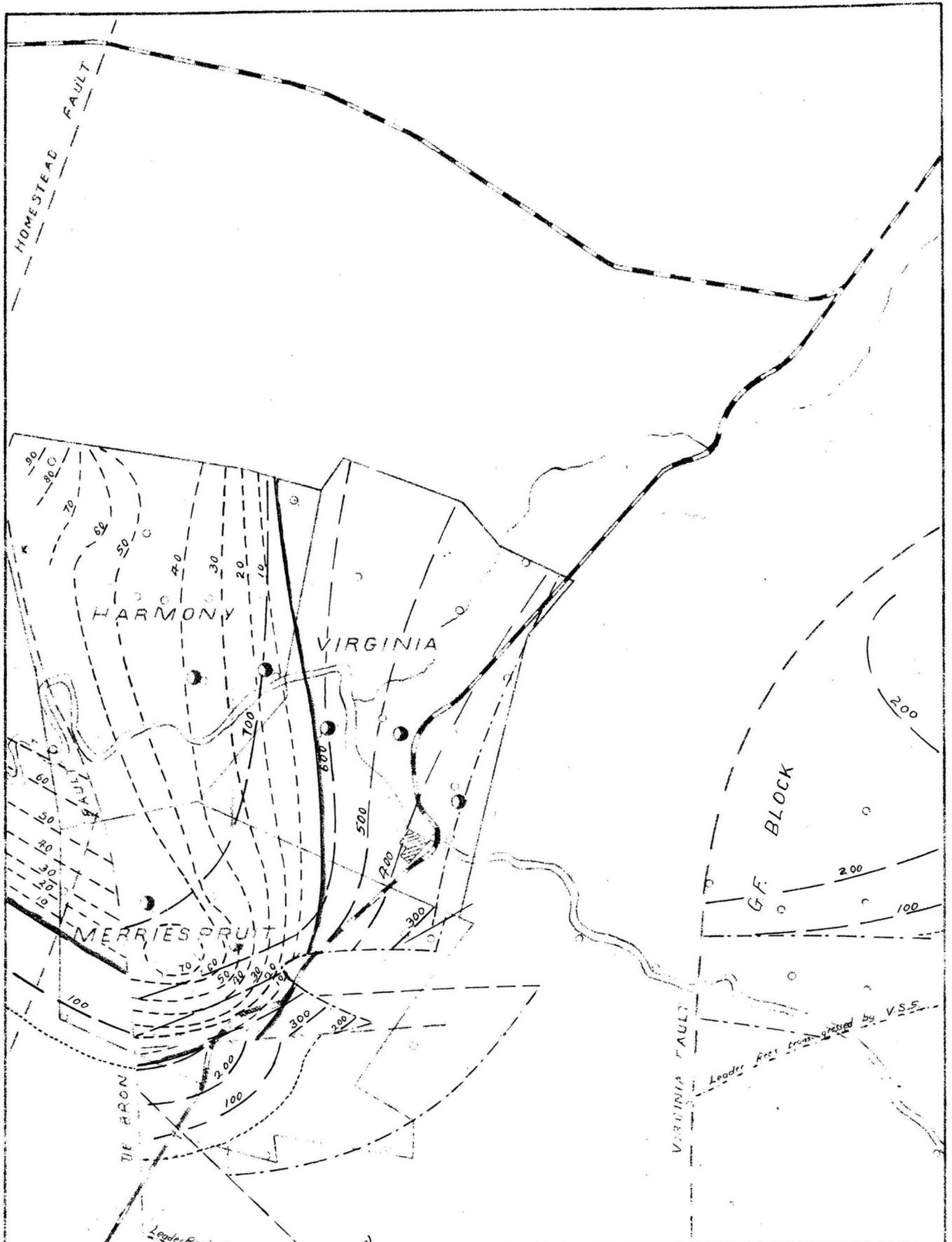


FIG. 6. ISOPACH MAP.

THE LEADER REEF DISCONFORMITY.

- 100ft Isopachs, Leader Reef to Intermediate Reefs.
- 10ft Isopachs of zone E.L.I.
- Limit of Basal Reef.
- - - - - Limit of Intermediate Reefs.
- - - - - Sub-outcrop of Leader Reef against Karroo System.

SCALE: - 1:100,000.

and by channels in the plane of the disconformity. The highly irregular patches of Upper Basal Reefs could represent reconcentrated material derived from the erosion of the Basal Reef.

It is not yet known to what extent the Basal Reef has been transgressed in the southern and the south-eastern extremity of the area known to be underlain by quartzite of zone E.L.1. Bore-holes S.E.1 and K.A.3 both passed directly from zone E.L.1 into Footwall quartzite without indications of faulting on the contact. Whether these bore-holes have penetrated isolated area where the E.L.1 quartzite has transgressed the Basal Reef or whether the Basal Reef in that area has been completely overlapped, can only be determined by underground exploration. In the chapter dealing with the geological history it will be seen that the Basal Reef and E.L.1 disconformities form part of a continuous sequence of events that terminates with the E.L.1 disconformity.

C. THE LEADER REEF DISCONFORMITY.

From the isopach map (fig. 6) and the stratigraphy the following features are deduced:-

- (1) Beyond the line of transgression of the Leader Reef over the Basal Reef, towards the margin of the basin in a southerly direction, the angle between the disconformity and the Footwall beds increase to 6 degrees, as calculated from the distances between isopach lines.
- (2) The angle between the disconformity and the Footwall beds in a profile from west to east at the northern boundary of the Virginia Mine is only two degrees, as calculated from the distances between isopach lines.
- (3) The Leader Reef is transgressed by sediments of zone V.S.5 (the "Gold Estates Leader") in the G.F. Block and probably by the "B" Reef south of Merriespruit Mine.

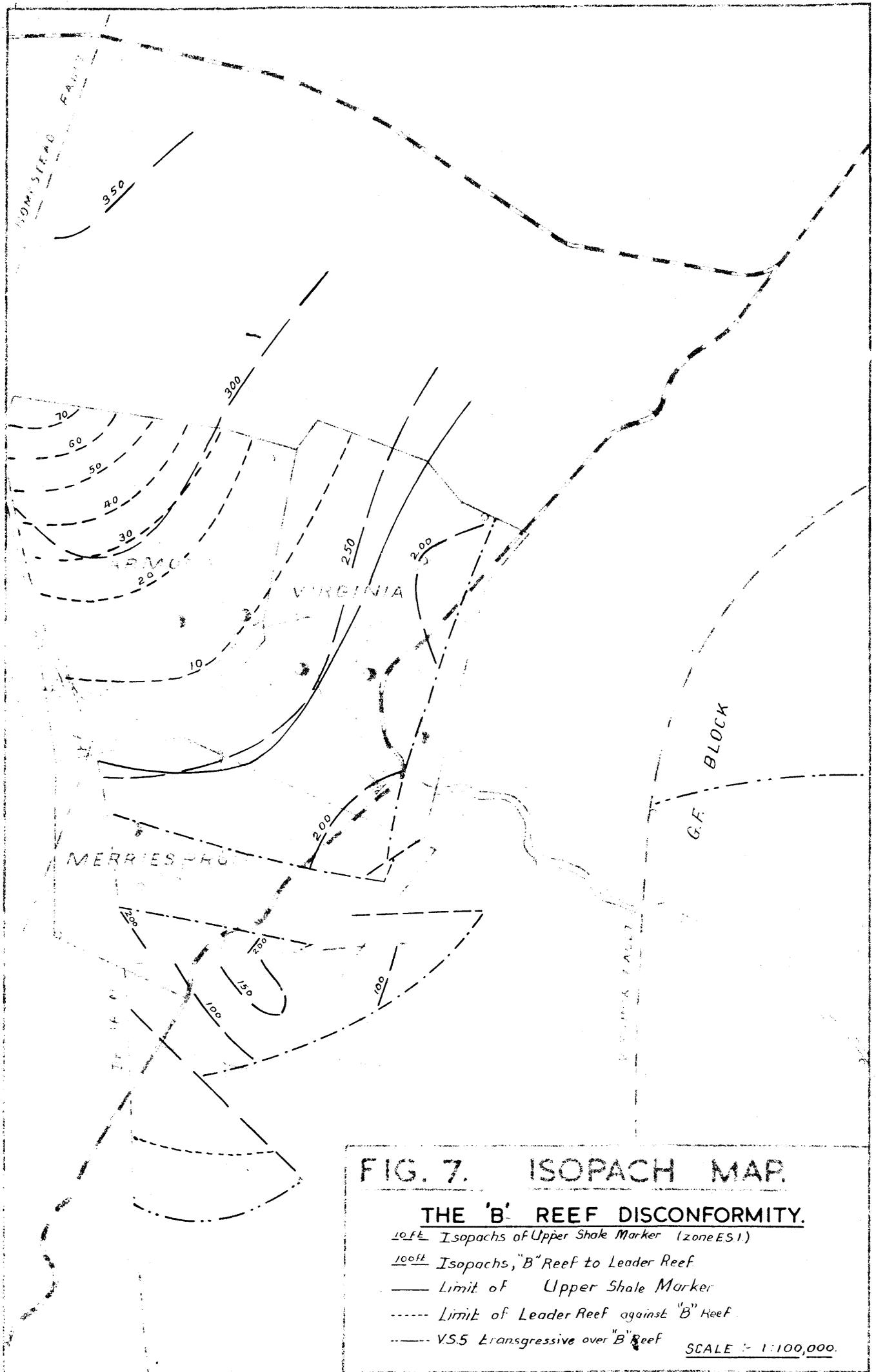


FIG. 7. ISOPACH MAP.

THE 'B' REEF DISCONFORMITY.

- 10 ft. Isopachs of Upper Shale Marker (zone ES1)
- 100 ft. Isopachs, "B" Reef to Leader Reef
- Limit of Upper Shale Marker
- Limit of Leader Reef against "B" Reef
- · - · VS.5 Transgressive over "B" Reef

SCALE = 1:100,000.

- (4) The displacement of the isopachs on the de Bron fault indicate relative lateral movement of the western fault block towards the north.
- (5) Comparison of the areas of Leader-Basal Reef removed by channels of late Kimberley age, indicates that large lateral movements, such as described by Feringa (1954, p.32) could not have taken place on the Virginia fault. The curvature of the isopachs to the north in the Virginia Mine explains the pronounced relationships in the G.F. Block.
- (6) The displacements of the isopachs on the Merriespruit thrust fault can be explained by overthrusting from the north.
- (7) The lower angle of unconformity on the Virginia Mine has enabled a better sorted conglomerate to be developed on the disconformity on that mine than on the Merriespruit Mine.

D. THE "B" REEF DISCONFORMITY.

From the isopach map (fig. 7) and from the stratigraphy, the following features are deduced:-

- (1) The "B" Reef transgresses the Leader Basal Reef south of the Merriespruit Mine but is overlapped by the "Gold Estates Leader" Reef (V.S.5) before transgressing the Leader Reef in the G.F. Block.
- (2) The "B" Reef transgresses the Upper Shale Marker fairly far from the margin of the basin. This may be the combined effect of erosion and of thinning out or of a change in facies of the Upper Shale Marker.
- (3) Reef in cores of bore-holes west of the de Bron fault in the Virginia-Merriespruit area have not been definitely correlated with the "B" reef and this reef is very poorly represented in bore-hole K.A.3. It is therefore highly probably that the "B" Reef is not developed west of Merriespruit Mine, or that it is

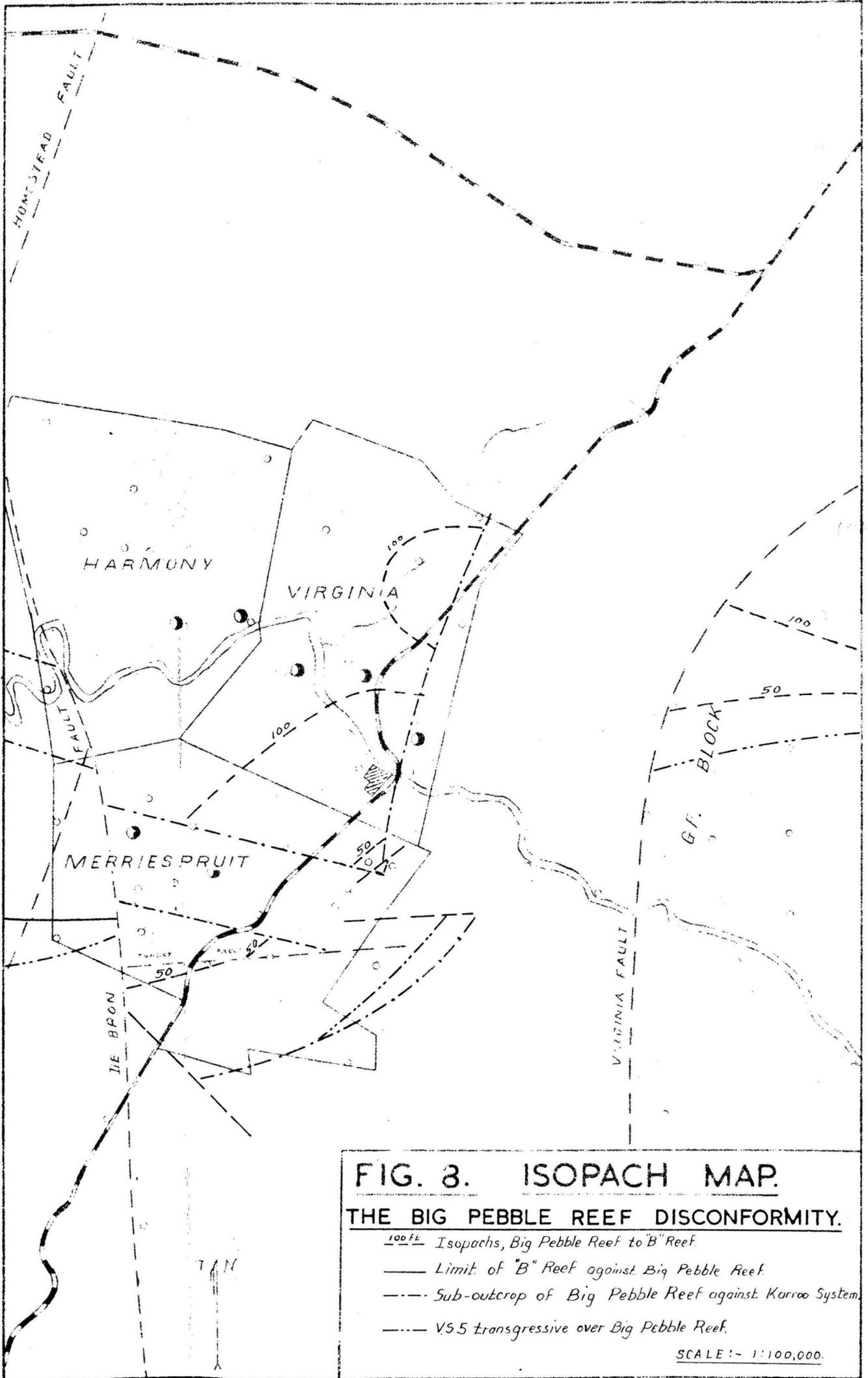


FIG. 3. ISOPACH MAP.
THE BIG PEBBLE REEF DISCONFORMITY.

- 100 ft* - Isopachs, Big Pebble Reef to "B" Reef.
- Limit of "B" Reef against Big Pebble Reef.
- - - - Sub-outcrop of Big Pebble Reef against Karroo System.
- - - - V.S.S. transgressive over Big Pebble Reef.

SCALE: ~ 1:100,000.

transgressed by the Big Pebble Reef.

- (4) Lateral movements on the de Bron fault is proved by the fact that the "B" Reef horizon is scoured away by a channel of later Kimberley age, intersected in bore-hole L.R.1.

E. THE BIG PEBBLE REEF DISCONFORMITY.

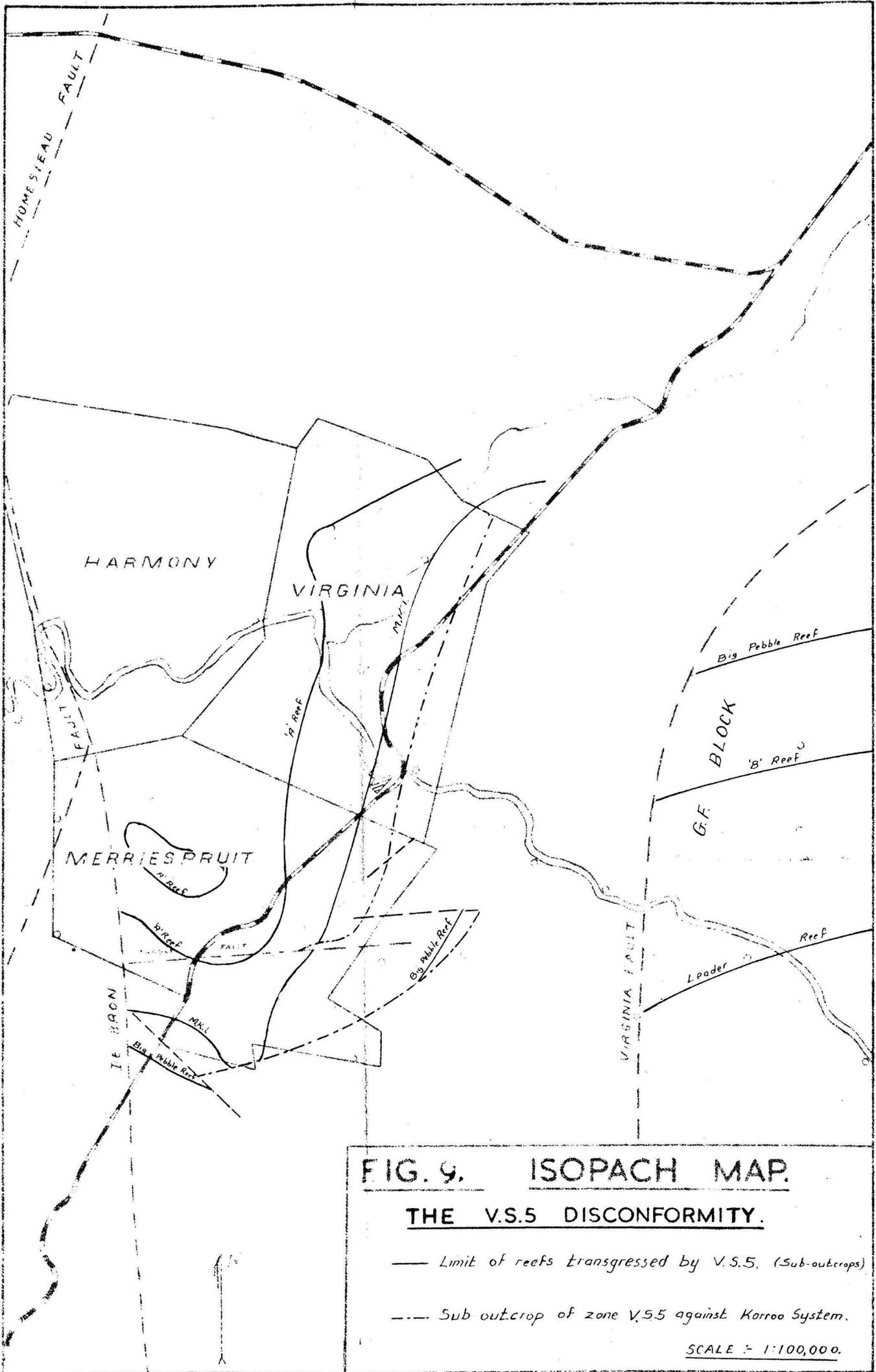
From the isopach map (fig. 8) and the stratigraphy, the following features are deduced:-

- (1) The irregular curves of the 100 feet isopach indicates that the transgression of the Lower Kimberley beds are so slight that irregularities in the thickness of these beds have a marked effect on the position of this line.
- (2) The large distances between the isopach lines point to a very low angle between the disconformity and the foot-wall beds, and the smooth curve of the 50 ft. isopach indicates that the transgression of the Big Pebble Reef over the Lower Kimberley beds, though slight, is steady. An exposure where the Big Pebble Reef overrides the uppermost bed of conglomerate in zone L.K.1 has been encountered in the No. 2 Shaft area of Virginia Mine. At the shaft, the Big Pebble Reef disconformity is separated from this conglomerate by about 5 feet of quartzite. At approximately 1,200 feet further east, the reef transgresses the underlying conglomerate, enclosing in its lower band pebbles of this totally different variety of conglomerate for some distance east of the line where the transgression of the conglomerate was completed. Coarse material must therefore have moved in the direction of the transgressing shore-line.
- (3) The Big Pebble Reef is overlapped by sediments of zone V.S.5 along a line further into the basin than the line where the former would have overlapped the "B" Reef.

TABLE VI

The Relation between the "A" Reef and its Footwall Beds

BORE-HOLE NUMBER	CORRELATION	DEPTH OF "A" REEF IN BORE-HOLES	GOLD VALUE	REMARKS
M.O.1	"A" on M.K.1	3874	0.75/24	
M.O.3	"A" on M.K.1			
A.D.1(a)	"A" on possible M.K.1	2854	1.8/5.8	Alternative correlation, U.K.1 conglomerate on U.K.2
S.E.1	Possible "A" on possible M.K.1	2067		M.K.1 underlain by "Charnel" deposits
K.A.2	Possible "A" on "Charnel" deposit	2579	0.78/2.4	
S.F.3	Possible "A" on possible M.K.1	1344		M.K.1 underlain by M.K.4
M.O.2	"A" on M.K. 2 or M.K.3			
M.O.4	"A" on M.K.2	3321	1.42/25	"A" Reef underlain by 6 inches of argillaceous quartzite
V.Z.1	Possible "A" on M.K.3	1961		Correlation according to Feringa
V.Z.3	"A" on M.K.3	3343		
M.1	"A" on M.K.4	2465		Correlation according to Feringa
M.U.2	"A" on M.K.4	1580	0.7/12	"A" Reef underlain by 6 inches of quartzite
M.U.3	"A" on remnant of M.K.4	3096		Correlation according to Feringa



For that reason, one does not expect to find the Big Pebble Reef directly overlying rocks older than the "B" Reef. West of the de Bron fault, however, the Big Pebble Reef does seem to lie directly on rocks older than the "B" Reef, as revealed in bore-hole M.O.2.

F. THE "A" REEF DISCONFORMITY.

The distance between the "A" Reef and the Big Pebble disconformity is small, and so variable that an isopach map cannot be drawn with the limited number of control points available.

The "A" Reef has not been intersected in all the bore-holes. The reason could be that deposition of the "A" Reef might have been limited to basins in an undulating floor and that local transgression of sediments of zone V.S.5 over beds of the Upper Kimberley Stage has taken place. The "A" Reef has not been found to lie directly upon Lower Kimberley beds. Signs of a disconformable relationship between the "A" Reef and the underlying rocks are difficult to detect. The writer believes that the true relationships between the different beds of the Upper and Middle Kimberley Stages can only be elucidated after careful mapping of underground exposures of the "A" Reef.

Table VI is an attempt to indicate a disconformable relationship between the "A" Reef and its footwall beds.

G. THE V.S.5 DISCONFORMITY.

From the isopach map (fig. 9) and the stratigraphy the following features are deduced:-

- (1) Although the extent of erosion of the sediments underlying the disconformity in the Virginia-Merriespruit area is not very great, a basal conglomerate is sporadically developed in the south-eastern part of the Merriespruit Mine. This basal conglomerate is called the "Gold Estates Leader".

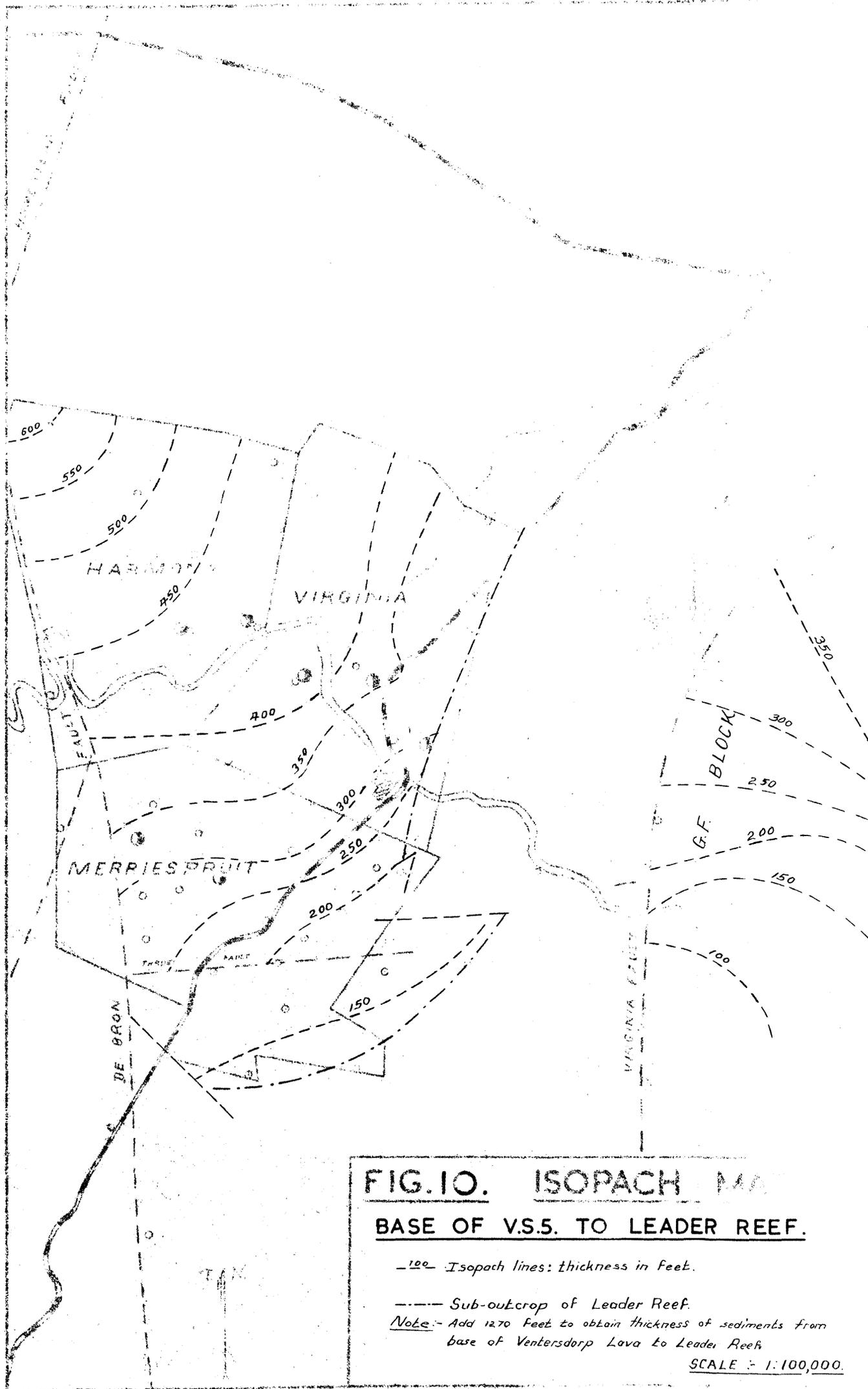
- (2) In the G.F. Block, the sedimentary break represented by this disconformity is extensive: the "Gold Estates Leader" has transgressed the Big Pebble Reef, the "B" Reef and Leader Reef disconformities until, in the far south, "Gold Estates Leader" directly overlies quartzite of the Middle Footwall beds.
- (3) Extensive stretches of "A" Reef have been eroded away prior to deposition of sediments of zone V.S.5.
- (4) The so-called "A" Reef south of bore-hole G.F.5 in the G.F. Block is really the "Gold Estates Leader".

H. THE BASE OF THE VENTERSDORP LAVA.

The Ventersdorp lava in the Virginia-Merriespruit area and the Witwatersrand sediments are apparently conformable. In fact, the thickness of the Elsburg Stage remains remarkably constant over the area. The average thickness of the Elsburg Stage in the Welkom area, 12 miles north of the Sand river, is 1400 feet (Borchers and White, 1943, p.44) in the Virginia-Merriespruit area 1270 feet, and on the farm Monstari 1798, 10 miles south of the Sand river, it is 1100 feet. The diminution of the thickness of the Elsburg Stage towards the edge of its basin of deposition can be explained as a thinning out of the sediments. The V.S.1 conglomerate occurs directly below the lava along the whole of the distance from Welkom to the Monstari bore-hole.

I. SUMMARY.

A calculation of the differences in thickness of the Upper Division from the most northerly to the most southerly point on the Merriespruit Mine reveals that about a thousand feet of sediments, a fifth of the total thickness, is missing at the southernmost point. The thousand feet represent the increase in the magnitude of the breaks in the sedimentation across the mine area. It is clear that the greatest portion of this increase in the magnitude of



the break took place in the southern portion of the Mine, the lowest disconformity being at the Basal Reef and the uppermost at the base of zone V.S.5. We must therefore conclude that erosion took place periodically in the marginal area of the basin prior to the deposition of zone V.S.5.

The isopachs between the base of zone V.S.5 and the Leader Reef has been given separately in figure 10. This map is useful in the drawing of profiles and also shows that the combined effect of the several disconformities enclosed between these strata is to shorten the stratigraphical column of the Upper Division of the Witwatersrand system in directions opposite to the general dip of the strata.

Finally, the isopach maps prove that disconformities, and not changes of facies, were responsible for the large differences in the footwall quartzite of the Leader -Basal Reef in bore-holes drilled in the south-eastern portion of the Merriespruit Mine.

CHAPTER VI

CORRELATION BY METHODS OTHER THAN PURELY STRATIGRAPHICAL

A. HEAVY MINERAL ANALYSIS.

A heavy mineral investigation of the quartzite in zones E.S. 3 and U.F.4 was carried out in order to find confirmation for the correlation of controversial bore-hole intersections of the Leader-Basal Reef and of the Intermediate Reefs in the south-eastern portion of the Merriespruit Mines. Concentrates from zones E.L.1 and U.F.1 were also prepared as a control.

The heavy mineral concentrates are characterised by a flood of pyrite, abundant zircon, and smaller amounts of opaque detrital minerals. These opaque minerals include ilmenite, chromite, magnetite, iridosmine, uraninite and thucolite in approximate order of abundance. Accurate quantitative identification of these minerals, mounted on glass slides, is extremely difficult. Rare tourmaline occurs only in splinters and is probably authigenic. No garnet appears in the suites.

As ilmenite is prone to alteration and obliteration, the ratio of opaque minerals to zircon cannot be relied upon. Therefore the only hope of finding sufficient differences in the concentrates lie in a quantitative study of the varieties of zircon.

Considerable basic research in this direction is necessary before any results of correlative value will be available.

B. RADIOMETRIC LOGGING.

In a series of papers Dr. D.J. Simpson has shown that radiometric logs can be utilized to solve problems of correlation in the Witwatersrand System (1950, 1951 and 1952).

In his paper: "Some results of radiometric logging in the bore-holes of the Orange Free State Goldfields and

neighbouring Areas", 1951, (pp. 121 to 128), he discussed the correlation of reefs in some abnormal bore-hole intersections in the area south of the Sand river. He came to the conclusion that the reef horizon correlated as the Intermediate Reefs by local geologists, was a modification of the Leader-Basal Reef. The correlation according to local geologists can, however, be justified without violating the principles on which Dr. Simpson's correlation was based. His deductions were based on a composite radioactivity log (1951, plate XXII, fig. 6), which was derived from bore-holes M.O. 4 and W.N.1, neither of which intersected the Intermediate Reefs (see plate B) with the result that a wrong impression of the radioactivity anomaly was obtained.

When the radiometric log of bore-hole K.A.2 became available in July, 1953, this gap could be closed since this bore-hole intersected both the Leader Reef and the Intermediate Reefs horizon. The sequence between these horizons compare well with that in the core of bore-hole M.1; therefore one can safely assume that the log was derived from a succession unaffected by faulting.

The new composite radiometric log is compared with the old composite log of Dr. Simpson in plate H, and the radiometric and geological logs of the controversial bore-holes are added, giving the revised correlation.

It is clear that the correlation of the reefs in bore-holes M.5 and S.E.2 with the Intermediate Reefs is in accordance with the anomalies to be expected at that horizon.

In table VII, the statements on the correlation of the southern area of the Free State Gold-fields proposed by Dr. Simpson (1952, p. 121), are compared with the correlation suggested on plate H.

TABLE VII

Dr. Simpson's Correlation (quoted from page 121)	Comments
<p>(1) Radiometric logging suggests that the true Intermediate Reef zone as developed in the central area does not exist in the far south area, and that the "Intermediate Reef" in this area is actually the upper cycle R.5</p>	<p>(1) As can be seen in the radiometric log of bore-hole K.A.2, a distinct Intermediate Reefs anomaly (R.7) does exist, and it is the R.5 anomaly that is poorly developed.</p>
<p>(2) The Leader-Basal Reef (R.3.C sub-cycle) is sometimes logged as Intermediate Reef due to facies changes.</p>	<p>(2) Only the Leader-Basal Reef in bore-hole M.U.3 was originally logged as Intermediate Reefs zone. The characteristic gold values and the gold-uranium ratio proves that this happened</p> <p style="padding-left: 40px;">It is also to be expected, from the isopach map (fig. 6), that the Leader-Basal Reef would overlies the Intermediate Reefs. The anomaly in bore-hole M.5 compares very well with the R.7 cycle.</p>
<p>(3) The Leader-Basal Reef zone is sometimes missed in bore-holes due to de-generation of the Leader</p>	<p>(3) This happened in the case of bore-hole M.U.3 only. Dr. Simpson's correlation of the Intermediate Reefs</p>

<p>conglomerate into grits, and the lack of gold values. Radiometric logs show this horizon to be present in the so-called "Footwall beds".</p> <p>(4) No R.3.A.1 inner cycle (V.S.5 conglomerate) exists in the Virginia area, and the conglomerate logged as V.S.5 is in reality the upper zone at the "A" Reef cycle developed locally.</p>	<p>in bore-holes M.2, M.5 and S.E.3 have been disputed by different methods, and the radioactivity anomalies fit in very well with the R.7 cycle.</p> <p>(4) This anomaly evidently originates from the "Gold Estates Leader", the reef lying at the base of the Elsburg stage and between the V.S.5 conglomerate and the "A" Reef.</p>
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C. GOLD.

As the cores of most of the sediments of the Upper Division of the Witwatersrand System was assayed, it was possible to draw a graph of the variation of the gold content with depth. This "log" supplies one with an additional criterion on which to base correlation.

From a study of plate H, it became apparent that the Basal Reef, the Leader Reef and the Intermediate Reefs each have a different average Gold : Uranium ratio.

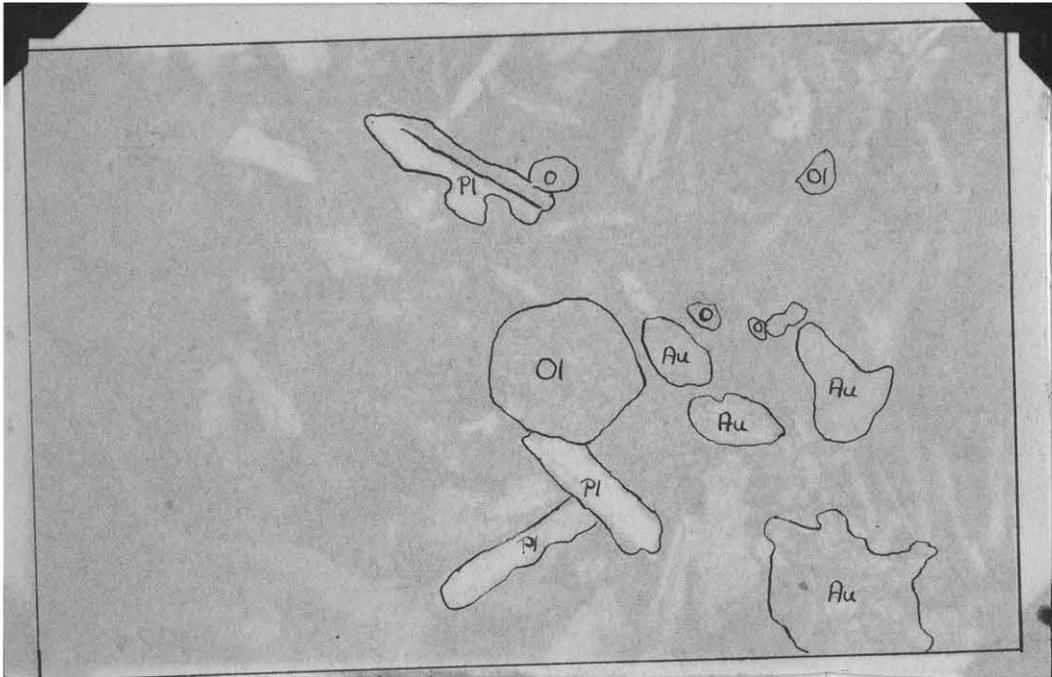
A characteristic graph of this ratio can be obtained for each reef by plotting gold values against uranium values. The assay results of a reef of doubtful correlation can then be plotted on the graph and its identity revealed. This method of correlation would fail in the case of a reef which has derived material from an underlying reef by erosion.

CHAPTER VIIINTRUSIVE ROCKS

Up to the time of writing, quartz-rich intrusive rocks have not been encountered in the Virginia-Merriespruit area. The original minerals of most of the mafic rocks have been altered by metamorphism to minerals that are stable in conditions of low grade regional metamorphism, thus rendering detailed classification as igneous rocks impossible. Much importance is therefore attributed to textures and to the degree of alteration of the constituent minerals. Although these two criteria may vary on approaching a chilled zone and in areas where an igneous body has been locally subjected to shearing stress or prophyllitisation, such variation can be kept to a minimum by careful selection of specimens, and it has been found that individual intrusions can be correlated over considerable distances by means of the microscope.

Besides the petrographical characteristics, the following features are taken into account to aid in the correlation of individual intrusive bodies over different sections of the mines : the shape of the intrusive, the nature of the contacts with the host rock, the nature of the chill zone, the degree of contact metamorphism of the host rock, the granularity of the igneous rock, the spacing and mineral composition of veinlets, the presence of xenoliths, phenocrysts and amygdales, mottling, shearing, flow structure, the nature of displacements of the host rock and the relative age with respect to faults and other intrusives.

The amount of shearing on the contacts and in the body of an intrusive determines its water-bearing potentialities. It is therefore of great practical importance to be able to recognise intrusives which may cause dangerous inflows of water in one intersection although bone-dry in an adjoining intersection. Some of the most prominent intrusives discussed are shown on the structure contour map (plate 1).



Photomicrograph 9.

Olivine dolerite, bore-hole K.A.2.

The olivine is partly altered to antigorite.

pl = plagioclase au = augite

ol = olivine o = ore

Crossed nicols (X 150) Section 44.

The intrusives are discussed in the abnormal order from the youngest to the oldest, because we know the age of the youngest as being post Karroo, whereas the oldest are of doubtful age.

A. DOLERITE.

Although dolerite abounds in the Karroo System, and is in fact the only type of igneous rock intruded into that System within this area, the occurrences of dolerite in the Witwatersrand System encountered in bore-holes drilled from the surface are confined to Witwatersrand sediments directly underlying the Karroo System. In bore-holes K.A.1, K.A.2 and K.A.3 thin sills are found in zone V.S.1.

The dolerite is a very dark-grey medium-grained, porphyritic rock (section 44 photomicrograph 9 from a specimen taken near the centre of a sill in bore-hole K.A.2).

TABLE VIII

Optical Properties of Dolerite from Sill
in Bore-hole K.A.2 (section 44)

MINERAL	2V _v	$\delta \wedge C$	COMPOSITION	ZONING
olivine	96°		Fa ₂₉	slightly zoned
augite	48°	40°		zoned
pigeonite				strongly zoned
bytownite			An 78-82	zoned
labradorite			An 52-68	zoned

The presence of approximately 8% by volume of olivine, altered largely to bowlingite, indicates that the intrusive is an olivine dolerite. The sub-ophitic relationship between augite and labradorite is not as clear in the case of pigeonite. Zonal augite is common and is evidenced by a decrease in the optic axial angle towards the margin. The zoning in the pigeonite is such that the optic axial angle increases from zero at the core to an angle of approximately 20° at the margin. The pigeonite is therefore the

the ferriferous brown variety, described by Walker and Poldervaart (1949, p. 639). Twinning on the composition plane (100) is common in the pyroxene.

There are two generations of plagioclase: the older more calcium-rich bytownite occurs as glomeroporphyritic aggregates and started its crystallisation before the mafic minerals, and the younger labradorite occurs as laths producing a sub-ophitic texture with pyroxene.

Both generations of feldspar are zoned. Twinning according to the albite and carlsbad laws are most common. The crystals of bytownite are tabular and the labradorite lath-shaped, the average length of the laths being 0.4 m.m. Superficial saussuritisation of the plagioclase occur mostly in the bytownite. Magnetite is an accessory mineral. This dolerite is an example of the Blaauwkrans type of Walker and Poldervaart (1949, p. 616).

The dolerite between 1748 and 1755 feet in bore-hole S.M.1 is the basaltic contact phase of the above type. The texture is intersertal, the ground mass being rich in grains of an opaque ore (section 45).

The average length of the plagioclase laths is 0.25 m.m. The following optical constants compare well with the previous example:-

TABLE IX

Optical Properties of Dolerite from Bore-hole S.M.1
(section 45)

MINERAL	2V _x	χ^{\wedge} / C	COMPOSITION	ZONING
olivine	94-96°	41°	Fa ₂₄₋₂₉	slightly zoned
augite	49-51°			zoned
pigeonite	0-20°			strongly zoned
bytownite			An 69-88	zoned
labradorite			An 58-68	zoned

The majority of the dolerites occurring in the Karroo System in the Virginia-Merriespruit area belong to the Blaauwkrans type, but a near-surface sill on the farm Merriespruit 219 is of the Perdekloof type. Both types contain some olivine.

There is little doubt that the dolerite that occurs in the Upper Division of the Witwatersrand System is of late-Karroo age.

B. EPIDIORITE.

Although epidiorite is known in the Central Witwatersrand, only one occurrence has so far been encountered in the Virginia-Merriespruit area. Usually the feldspars of the intrusives older than the dolerites are also altered and for that reason the rocks are not classified as epidiorite. (Compare McDonald, 1911, p. 92).

The one occurrence is an intersection in bore-hole C.A.1 between 3336 feet and 3345 feet of an intrusive dipping approximately 25° in a direction coinciding with the dip of the strata.

TABLE X

Epidiorite from Bore-hole C.A.1.
(section 46, photomicrograph 10)

PRIMARY MINERALS	SECONDARY MINERALS
augite	{ uralite, chlorite (
pigeonite	
plagioclase	saussurite, a carbonate mineral, quartz, chlorite
ilmenite	leucoxene
pyrite	



Photomicrograph 11.

Uralite diabase, Harmony sill, bore-hole K.A.2.
Large crystals of uralitised pyroxene lie in a
groundmass consisting mainly of chlorite, quartz
and some ankerite.

qu = quartz

u-px = uralitised pyroxene

il = ilmenite

f = saussuritised feld-

u = uralite

spar.

Crossed nicols

(X 44)

Section 53.

C. URALITE DIABASE.

The outstanding example of this type of intrusive is the Harmony Sill. It is a domical sheet and has an average thickness of 110 feet. In Harmony Mine it is present in the Ventersdorp Lower Lava and in the Ventersdorp Upper Sediments, and it cuts through the economic horizon in Virginia and Merriespruit Mines. It is also known from bore-holes on Saaiplaas Mine (Verbal communication, A. Kriek). The structure contour map indicates its intersection with the Basal and Leader-Basal Reefs (plate I). The block diagram of the Virginia Mine also features this sheet (plate J).

The origin of this sheet is assumed to be similar to that of the Marievale type of intrusion on the Far East Rand (Ellis 1940, 1944). The displacement of the surrounding strata is always equal to the thickness of the sill. It therefore obeys the law of minimum lateral thrust (Blignaut and Furter, 1940, p. 48) and the sediments underlying the sheet have subsided, similar to the "bell-jar" dolerite intrusions in the Eastern Karroo (Walker and Poldervaart, 1949, p. 610). Steeply inclined sections of this intrusion are not common, although they have been encountered in 21 Level Haulage North on the Virginia Mine. The the West of No. 1 Shaft in Merriespruit Mine, the Harmony Sill cuts through the de Bron fault into the Ventersdorp Upper Sediments without being displaced. It is therefore younger than both these sediments and the fault.

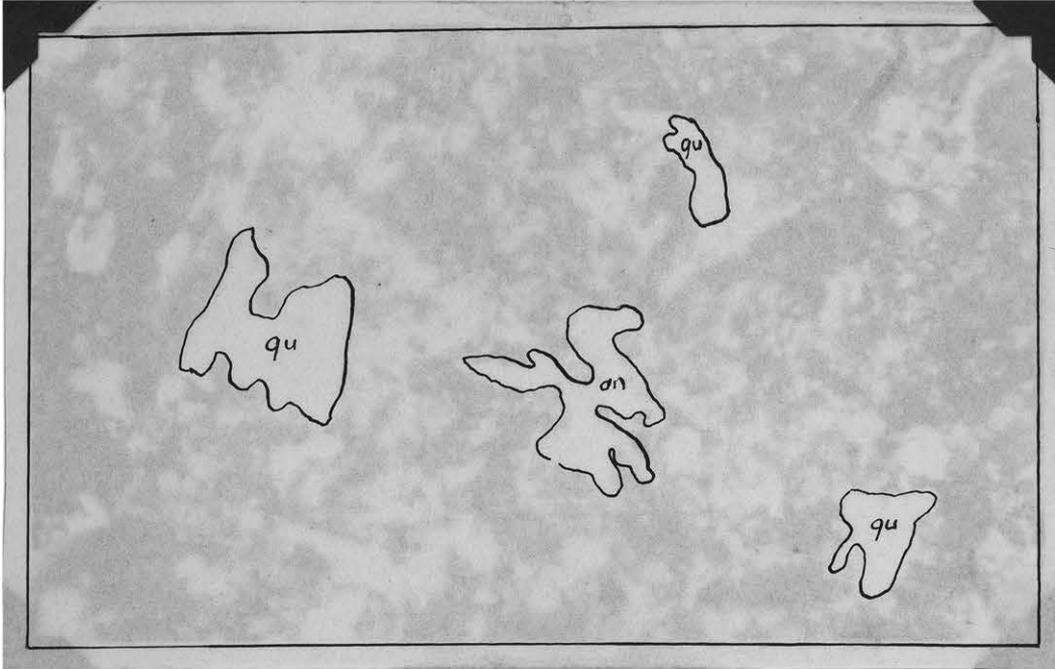
Thin sections of this intrusion in bore-hole K.A.2 were made of specimens taken at approximately ten feet intervals (sections 44-60, photomicrograph 11). There are no indications of magmatic differentiation. The rock is greyish-green, ranging from fine-to medium-grained and has an intergranular texture. White feldspar

laths, usually clustered around indistinct centres, can be seen in the hand-specimen. A pseudo-stratification is caused by the segregation of mafic and felsic minerals into narrow bands. A lineation, parallel to a set of steep joints, is also visible in some portions of the sheet. Thin veinlets, the majority having the same attitude as the contacts of the intrusive, are composed of the following secondary minerals, quartz, carbonate, epidote, chlorite, chalcopyrite, pyrite and galena. The contacts with the host rock are "frozen", that is, not affected by subsequent shearing. The chill zone is 3 feet thick and is followed by a fine-grained zone 9 feet thick.

The original minerals have, to a large extent, been converted to secondary ones. The pyroxene or its alteration product is partly penetrated by laths of saussuritised feldspar, proving that the original texture was sub-ophitic. A few fresh grains of pyroxene possess the optical features of augite ($2V_{\gamma} = 42^{\circ} - 43^{\circ}$, $\gamma \wedge C = 35^{\circ}$, twinning on (100)). The first stage of alteration of the augite is hornblende. ($\gamma \wedge C = 15^{\circ} - 17^{\circ}$, pleochroism: x = yellow, y = brown, z = green, absorption: Y>X, characteristic amphibole cleavage). The hornblende in turn has been converted to a pale green chloritic mineral with a weak birefringence giving grey and white interference colours. It has a small, variable optic axial angle with negative sign.

The alteration products of feldspar are quartz, chlorite, carbonate, zoisite, and sericite, and perhaps other minerals, forming an aggregate usually known as saussurite.

Quartz forms 3% of the rock by volume. The variable size, the shape and the inclusions of secondary minerals all indicate that the quartz is secondary, and one of the last minerals to have formed.



Photomicrograph 12.

Uralite diabase, Intrusive "C", Merriespruit No.1 Shaft.
Most original minerals are altered beyond recognition.
Small shreds of pyroxene show up as white specks. Some
shreds are altered to uralite. The dark groundmass is
mainly chlorite. Quartz and ankerite are prominent
secondary minerals.

Crossed nicols. (X 190) Section 61.

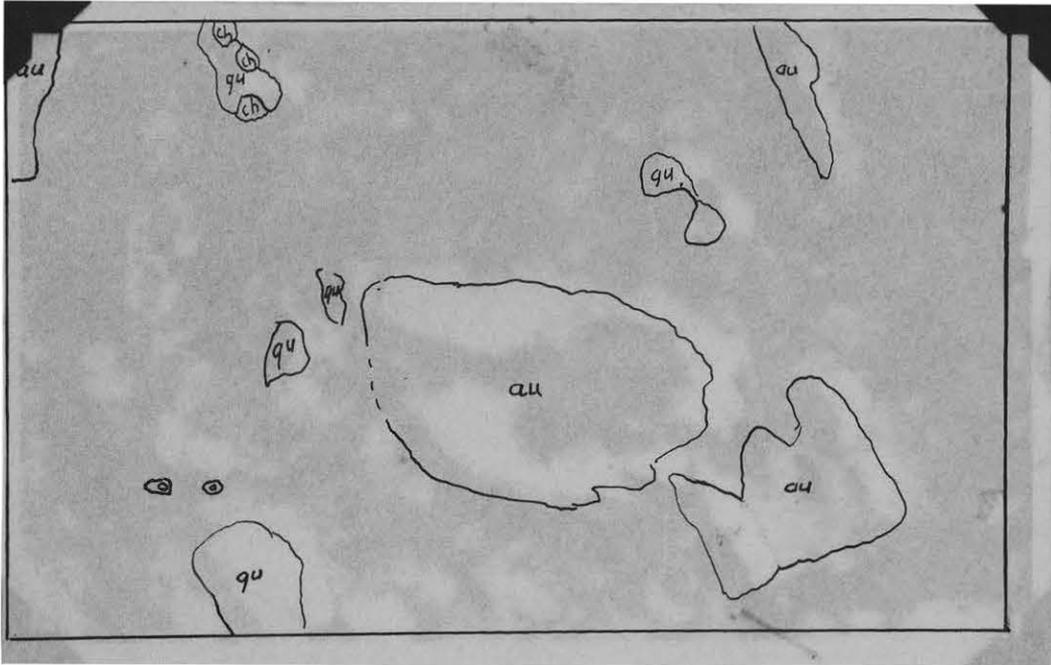
Epidote has been found in appreciable amounts in some of the thin sections.

Ilmenite, approximately 4% by volume, is present as large skeletal crystals. It is partly altered to leucoxene.

Although quartz and ilmenite are conspicuous they are not so abundant that they warrant the prefixes quartz and ilmeno to be applied to the name of the rock-type.

The chill zone is highly altered. Chlorite, carbonate quartz, epidote and leucoxene are the principle minerals. A faint, felty, relict igneous texture is visible in ordinary light, proving that each rock-forming mineral has given rise to a characteristic aggregate of metamorphic minerals. The thin section was taken at a distance of one foot from the lower contact.

A finer-grained intrusion of uralite-diorite which could possibly be older than the Harmony Sill has been encountered in Merriespruit Mine and has been called intrusive "C" (section 61, photomicrograph 12). This intrusive has an intergranular texture. The rock is transitional to the pyroxene diorite described below. The pyroxene still occurs as shreds and cores in the chloritic alteration product and a few crystals of secondary hornblende are present. Secondary quartz and a microperthitic intergrowth of quartz and chlorite is prominent. Epidote is fairly common. The contact with the host rock is unshattered. It exhibits a dense, grey, chill phase approximately $\frac{1}{2}$ inch in thickness. The structure of the intrusive is similar to the Marievale dykesills, as steeply transgressive dyke-like sections alternate with concordant sections. It is chilled against intrusive "D" (see below), but is displaced by a strike-slip fault in 35 Haulage East. Its thickness in the transgressive portions is approximately 25 feet. The concordant portions are nowhere completely exposed.



Photomicrograph 13.

Pyroxene diabase, bore-hole D.1.

Partly altered pyroxene (augite and pigeonite) occur
in a groundmass of secondary quartz, chlorite and
a grey, semi-opaque dust.

au = augite

ch = chlorite

qu = quartz

o = ore, probably ilmenite

Crossed nicols. (X 50)

Section 63.

C. PYROXENE DIABASE.

The medium-grained diabase which appeared in bore-hole D.1 at a depth of 4797 feet and in which this hole was stopped at 4887 feet, is typical of the relatively thick intrusions of diabase, probably sills, occurring in or close to the Jeppestown Series in this area (section 63, photomicrograph 13).

Augite and pigeonite are the only minerals not completely metamorphosed. The crystals occur in tabular subhedral form and as long slender euhedral laths. One of the laths measured 2 mm. by 0.3 mm.

Most of the augite ($2V_{\gamma} = 49^{\circ} \pm 1^{\circ}$, $\gamma \wedge C = 42^{\circ}$, twinning on (100) common) is altered to chloritic minerals. Uralite is rarely encountered.

The feldspars have been completely saussuritised. Secondary quartz and carbonate are beginning to segregate from the saussurite.

Ilmenite, partly altered to leucoxene, occurs as small, ragged crystals.

An intrusive, intersected in the same bore-hole at a depth of 3517 to 3631 feet, has a similar composition to the one described above, but the pyroxene is not lath-shaped (section 64).

A further intrusive of this group (section 65) has been intersected between 1630 feet and 1751 feet in bore-hole S.E.2. The fresh pyroxene in this specimen is probably pigeonite, on account of its small positive optic axial angle. Alteration to uralite has only taken place at the margins of the pyroxene. Pale-grey mottling in the hand specimen, which differentiates this intrusive from others of this kind, are revealed in thin sections as patches of opaque dust, pale-yellow in reflected light. Small rods of leucoxene occur in these patches. The absence of large

crystals of leucoxene suggests that the dust consists of leucoxene. A thin veinlet of zoisite is also present in the slide.

E. CHLORITE DIABASE.

These fine-grained and medium-grained diabasic intrusions are characterised by the complete alteration of both the mafic and the felsic minerals to quartz, biotite, epidote and a carbonate mineral although they retain the intergranular texture. It is proposed to call them chlorite diabase by analogy to the uralite diabase and pyroxene diabase in the previous groups and to distinguish them from the group of intrusives known as Ventersdorp diabase.

It has not yet been ascertained whether some of the rocks have been completely altered because of the small granularity or whether they are all older and in a more advanced metamorphosed state, than other types. The similarity between the chill and fine-grained phases of the Harmony Sill and some of these intrusions indicate that fine-grained intrusions are more apt to be completely reconstituted than ones with a coarse granularity. Unfortunately, the age-relation between the latter type of diabase and the Harmony Sill is not yet known.

TABLE XI

Examples of Chlorite Diabase Intrusives

BORE-HOLE NUMBER	DEPTHS IN FEET BELOW SURFACE	THIN SECTION NUMBER	REMARKS
S.E. 2	1807-1847	66	
S.E. 3	1974-2026	67	
M.5	1636-1756	68	Ilmenite abundant
V.Z. 2	3537-3555	69	

F. VENTERSDORP DIABASE.

These intrusives numerically comprise the most important series of dykes. They are dense, green-grey and superficially resemble the Ventersdorp andesitic lava. Veins consisting of quartz, chalcedony, carbonate, chlorite and pyrite are more common than in the other types of intrusive, indicating that percolating solutions had a great influence in producing the mineralogical changes. Veins occupying joints parallel to the contacts of the intrusive are numerous.

In the unravelling of the structure of intrusive "D" south of Merriespruit No. 1 Shaft, for instance, the fact that most of the veinlets trend parallel to the contacts of the intrusive was used to predict where the intrusive became transgressive, even when no contacts were exposed. Chlorite is very abundant in shear fractures.

Shearing and brecciation is common both in the body of the intrusive and on the contacts, the intrusive forming a zone of weakness on which adjustments of stress could take place. In general, the oldest intrusives have been the most intensely deformed. Water is almost invariably stored in the shear fractures. In places where the contacts are solid against the adjoining rock there is a thin, grey, chill zone. Many intrusives are mottled close to the contacts due to spherical patches of pale-green material rich in a carbonate mineral.

In thin section, the rock is a crystalloblastic aggregate of chloritic minerals, a carbonate mineral and quartz, and has leucoxene and pyrite as accessories. Minerals of the epidote group are not present in these highly altered intrusives.

There appears to be several varieties of chlorite. A pale-green chlorite has the anomalous "berlin blue"

interference colour characteristic of penninite (Winchell II, 1946, p. 282). Another variety, closely resembling penninite, has an olive-green anomalous interference colour. This variety has been found in the "Iron Curtain" intrusive dyke (section 70) and in intrusive "C" (section 61), and it also surrounds grains of pyrite in pyritic stringers (section 5 and 7). Other chlorites with higher birefringences than the penninite have been noticed.

The carbonate mineral occurs as aggregates or, more rarely, as euhedral crystals. It is the first mineral to form independently of the boundaries of the original igneous minerals. In a slide of an intrusive in bore-hole M.2 (section 71) which underwent weathering prior to the formation of the Karroo System, the carbonate mineral is reddish-brown indicating that the molecule contained ferrous iron which had become oxidised. A specimen of an intrusive intersected immediately below the base of the Karroo System in bore-hole O.W.1 was sent to the Union Geological Survey for identification. Their report mentioned ankerite as being a prominent constituent. It is possible therefore that the carbonate mineral in all the intrusives is ankerite.

The variety of quartz present is mainly chalcedony. In many of these intrusives it is impure, containing very small grains of chlorite and opaque minerals. Some of the quartz is coarse-grained and clear.

The Ventersdorp intrusives can be subdivided into three groups:-

(a) Palimpsest Igneous Texture Visible.

The original feldspar crystals are altered to chalcedony containing finely disseminated leucoxene.

The latter also occurs as rods and angular crystals.

In some intrusives, chlorite is intergrown with

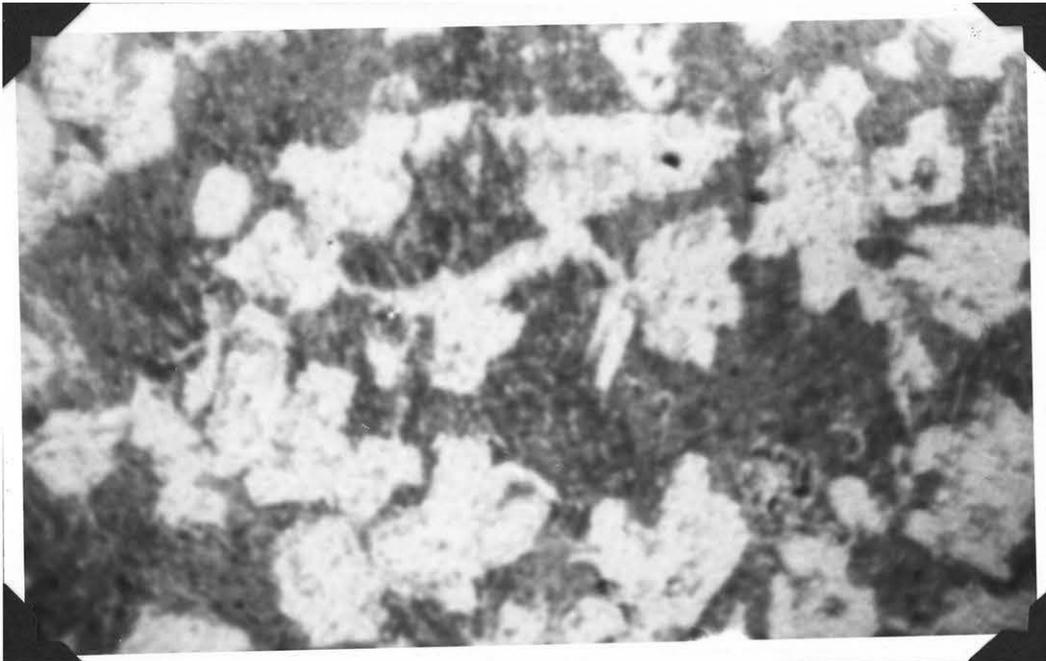
TABLE XII

Examples of Ventersdorp intrusives with palimpsest igneous texture.

Local Designation	Locality	Thick-ness	Slide	Characteristic Features	Form of Intrusion	Age Relationship
1. Ilmenite Diabase	Virginia No.1 Shaft area (north-east) (Plate I)	15 feet	72	Mafic minerals altered to a dirty brown chloritic aggregate. Abundant ragged and rod-shaped aggregate of leucoxene apparently pseudomorphous after ilmenite, similar to "ilmenite-diabase" described by Ellis (1940).	Dyke system: contacts with jagged outlines and locally slickensided; dip for each dyke constant, but different in adjacent dykes	Intruded by Harmony Sill, but cuts through sill of other Ventersdorp diabase (group F(b)) seemingly without disturbance (intersection not exposed). Less altered than other Ventersdorp intrusives and probably younger than lower Ventersdorp lava.
2. 25 Level Station Dyke	Virginia No.1 Shaft area, at 25 Level Station	1 - 2 feet	73	Mafic minerals altered to dirty brown chloritic aggregate. Leucoxene rod-like and angular, after ilmenite.	Dyke P.T.O.	Unknown

TABLE XII (Contd.)

Local Designation	Locality	Thick-ness	Slide	Characteristic Features	Form of Intrusion	Age Relationship
3. 27 Level Strike Dyke.	Virginia No.1 Shaft area on 27 Level, reef intersection.	5 feet	74	Mafic minerals altered to dirty brown chloritic aggregate. Leucoxene rod-like and angular, after ilmenite. Contains amygdales of carbonate, quartz and chlorite, and inclusions of quartzite.	Dyke, intruded into brecciated quartzite. "Frozen" chill contacts. Parallel to strike of Basal Reef; dips 80° west. Downthrow to west on dyke is 4 feet.	Unknown.
4. Intrusive "D".	Merriespruit No.1 Shaft area, south of shaft.	2, feet	75 photo- micro- graph 40	The light-grey palimpsest mineral aggregate lies in subophitic relationship to the dark-grey palimpsest mineral aggregate. Leucoxene very finely divided.	Compound intrusion of the Mariévale type (Ellis, 1944)	Intruded by a uralitediabase, intrusive "C".



Photomicrograph 14.

Ventersdorp intrusive, type a, Intrusive "D", 31 Reef
Drive East, Merriespruit Mine.

Composed chiefly of chlorite and quartz; ore dust in
the dark portions. It exhibits a relict igneous texture
that is not visible under crossed nicols.

Plain light. (X 195)

Section 75.

chalcedony and forms a feathery texture resembling feldspar microlites in an aphanitic rock. In most of the thin sections, this feathery texture is orientated in such a way that the microlite "feathers" trend in the same direction. A very faint pattern of plagioclase was visible on an X-ray film of these microlites.

Examples of this group are given in table XII.

Intrusives belonging to this group have been intersected in the following bore-holes:-

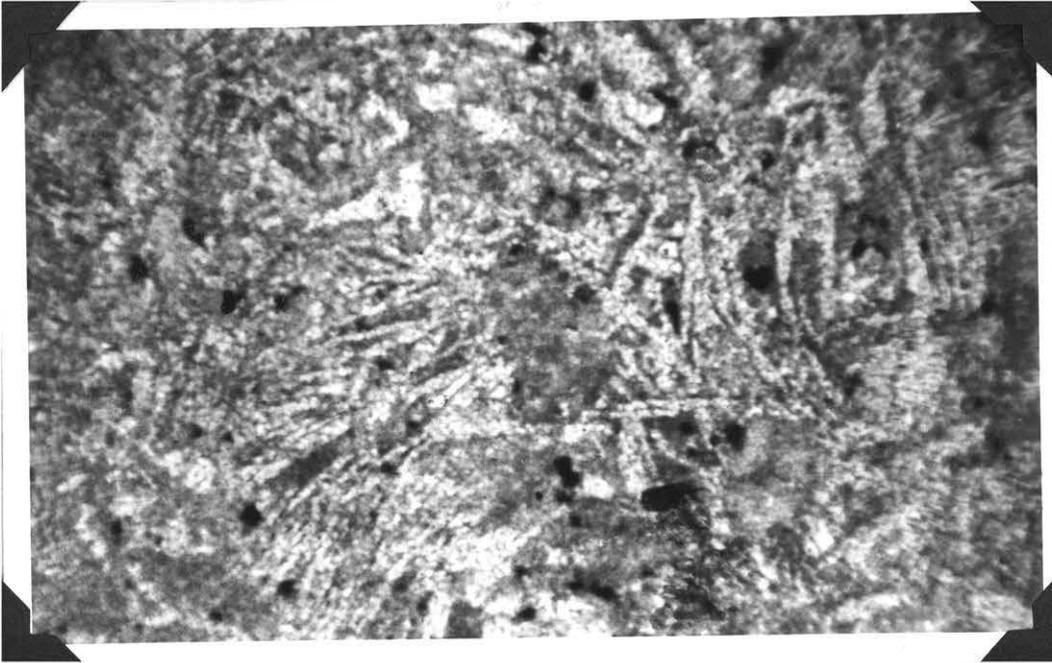
TABLE XIII

BORE-HOLE NO.	DEPTH IN FEET	SECTION NUMBER	REMARKS
A.D.1(a)	2633-2664	76	Correlated with the dyke north of the "Iron Curtain" dyke.
M.2	1365-1429	77	
K.A.1	1668-1736	78	Contains numerous veinlets
K.A.2	5095-5138	79	

(b) All Igneous Textures Destroyed.

The only texture visible in thin sections is the feathery texture mentioned in the previous section. It is accentuated in some intrusives by the irregular distribution of dust and small crystals of leucoxene. In some thin sections, careful inspection will reveal a very faint relict igneous texture, implying that there is a gradational relationship, as far as degree of alteration is concerned, between intrusives of groups F (a) and F (b).

The most notorious dyke in the Virginia Mine is,



Photomicrograph 15.

Ventersdorp intrusive, type b, "Iron Curtain Dyke",
Virginia No.1 Shaft.

Chlorite, quartz and ore are intimately intergrown
The feathery texture resembles feldspar microlites.

Plain light. (X 165) Section 70.

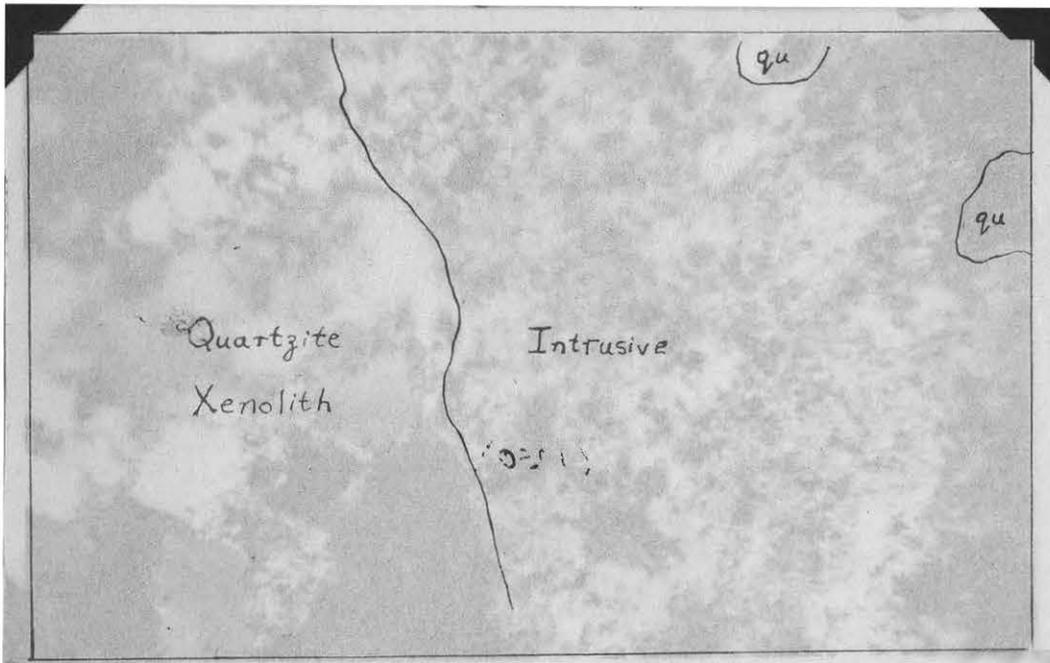
no doubt, the "Iron Curtain" dyke, (plate I, photomicrograph 15), which has delayed the initial development of the mine because of the considerable quantities of water stored up against its sheared contacts and in shear-planes in the body of the intrusive. In plan it is a fairly straight dyke striking east-west, but where it traverses the much faulted ground around No. 2 Shaft, it is broken up into a series of en echelon dykes.

A sill of this group having an average thickness of 35 feet overlies the reef in the area around the No. 1 Shaft of Virginia Mine. The sill does not remain on the same horizon, however, but transgresses the strata in a highly irregular way, in places cutting through the reef and recrossing the reef a little further on. Irregular tongues protrude from the main body into the adjacent quartzite. The sill has been traced as far as the No. 2 Shaft area. The magma appears to have been intruded into the Upper Division of the Witwatersrand System not long after a main period of tectonic activity, releasing unbalanced stresses by the injection of magma into planes that were locally under diminished pressure.

An intrusive belonging to this group has been intersected in bore-hole M.2 between 1231 feet and 1238 feet (section 71) and in bore-hole M.U.1 at 1455 feet (section 80).

(c) Dykes Associated with Faults.

The fault east of Virginia No. 2 Shaft, the de Bron fault and the Merriespruit thrust fault are all occupied by such dykes. These dykes are dense, green-grey and badly sheared. They have peculiar elongated zones of lighter-coloured intrusive material rich in carbonate



Photomicrograph 16.

Contact of Ventersdorp intrusive of type with a xenolith of quartzite. The chilled zone is absent and relict grains of quartz appear in the intrusive. Bore-hole C.A.1 at 2581 feet.

Crossed nicols. (X 150) Section' 82.

which resembles a flow structure. Many dykes of this type have been described as mylonites by field geologists. In thin section they are similar to the Ventersdorp intrusives (section 81).

The intrusions of group F is regarded to be of Ventersdorp age by the majority of geologists who have studied the intrusive rocks in the Witwatersrand System, as these intrusives closely resemble the Ventersdorp lava petrographically. Among these are Horwood (1910) Ellis (1946) and Pegg (1950).

Pegg believes that some of these may have been feeders to the Bird Amygdaloid, but as this lava flow is not present in the Orange Free State, this probability is remote.

G. CONTACT PHENOMENA.

A Ventersdorp intrusion of type (a) immediately underlying the Leader-Basal Reef in bore-hole C.A.1 at a depth of 2577 to 2590 feet, has assimilated portions of the surrounding quartzite. In the slides (sections 82 and 83, photomicrograph 16) of the contact between the intrusive and a partly resorbed xenolith of quartzite, there is no sign of a chill contact. Calcitic and chloritic materials derived from the intrusion have migrated into the quartzite, replacing all but the large grains of quartz. The rim of the quartzite xenolith is more chloritic and calcitic than the core, indicating hydrothermal solutions rich in magnesium, aluminium, iron and calcium have permeated the quartzite in contact with the igneous rock. Some more resistant xenoliths of sedimentary material within the igneous rock have been altered to coarsely crystalline calcite containing some quartz, sericite and a few shreds of biotite. It is possible that the "amygdales" found in the "27 Level Strike Dyke" are reconstituted xenoliths. No examples of rheomorphism and syntexis have so far been encountered.

H. AGE RELATIONS.

The various groups of intrusive rock have been discussed, as far as the writer was able to determine, in the order proceeding from the youngest to the oldest rocks. Their age relations still require a great deal of study. It is probable for instance, that the Harmony Sill is much younger than intrusive "C" although they are both uralite diabase, because, in the hand-specimen, the Harmony Sill seems less altered. On the other hand, representatives of the pyroxene and chlorite diabase group may be of the same age as intrusive "C", but only more intensely metamorphosed. Some of the Ventersdorp diabase intrusives may originally have been very fine-grained, with the result that their alteration was completed at an earlier stage than the coarser intrusives, or with the result that their alteration gave rise to that particular type. Also the dykes occupying fault-zones of diabase could have been completely reconstituted much more rapidly than the others as a result of shearing stress.

It is the writer's experience that individual intrusives can be recognised by minor textural details. Polished or shellac-coated planes on hand-specimens are often useful in revealing details of texture, and individual intrusives can often be correlated in this way before thin sections are made.

I. COMPARISON WITH PUBLISHED LITERATURE.

In table XIV information from various publications are compared.

The importance of quartz in many of these intrusives seems to have been over-emphasised. The presence of approximately 3 per cent of quartz in uralite diabase may be considered by some geologists as ample justification to use a term such as quartz diabase, as long as the silica

TABLE XIV

Comparison of Intrusives as described by various authors

Mc Donald, D.P. 1911	Nel, L.T. 1935	Ellis, J 1940 - 1944	Pegg, C.W. 1950	O.F.S. Virginia-Merriespruit Area	General Physical Characteristics
Dolerite (1) Olivine-bearing (2) Olivine-free Karoo		Dolerite Karoo	Dolerite Karoo	Olivine-bearing dolerite Karoo	Rock-forming minerals mainly fresh. Contacts not sheared
	Basic sheets Transvaal	Quartz dolerite Bushveld		Uralite diabase Post-Ventersdorp	Domical sheets, en echelon dykes, Maryvale types. Contacts locally sheared.
Granophyre Bushveld		Granophyre, syntectic, Bushveld			
Tonalite Bushveld	Feldspar porphyry and Quartz porphyry	Syenite dykes Bushveld	Quartz porphyry Bushveld		
Epidiorite Ventersdorp				Epidiorite	Unknown, possibly thick sills
	Basic sheets Transvaal	Ilmenite diabase Post-Transvaal	Ilmeno-dolerite Karoo?	Ventersdorp diabase, Pyroxene-diabase Chlorite-diabase	En echelon dykes, ragged, sheared contacts, sheets

TABLE XIV contd

Mc Donald, D.P. 1911	Nel, L.T. 1935	Ellis, J 1940-1944	Pegg, C.W. 1950	O.F.S. Virginia-Merriespruit Area	General Physical Characteristics
Completely metamorphosed intrusives, and intrusives showing relict igneous texture. Ventersdorp Ventersdorp	Aphanitic intrusives connected with Ventersdorp lavas Pre-Transvaal	Ventersdorp diabase Ventersdorp		Ventersdorp diabase Ventersdorp?	Sills, dykes, Maryvale-type compound intrusions irregularly-shaped intrusions sheared contacts.
			Chloritoid-bearing dykes (1) Ventersdorp (2) Bird Amygdaloid		
	Xenolithic diabase Pre-Transvaal?		Amygdaloidal diabase Pre-Transvaal	Xenolithic diabase also amygdaloidal?	Dykes, contacts not sheared

is of primary origin. (Shand S.J., Eruptive Rocks, 1947, p. 226). As it is most likely that the quartz is of secondary origin, the writer prefers not to use the prefix.

The writer also finds that sericite in these intrusives are rare and surmises that calcite in fine-grained form could easily have been confused with sericite.

No chloritoid appeared in any of the slides examined.