CHAPTER 1.

INTRODUCTION

A. AREA AND PHYSIOGRAPHY.

Virginia and Merriespruit are the two southernmost mines exploiting auriferous bankets of the Witwatersrand System. (See fig. 1.) They surround the town of Virginia in the Orange Free State, and are bounded to the north-west by the Harmony Mine.

The town of Virginia is situated on the banks of the Sand river, where the main railway line between Bloemfontein and the Transvaal crosses it. The stream is intermittent. The flat highveld plateau slopes down gently from about 4,500 feet above sea-level to about 4,200 feet near the river. Incised meanders, steep soil embankments 30 to 50 feet high, and occasional dongas leading from almost level vleis indicate sluggish flow for a considerable period of time in the past and perhaps a recent slight rejuvenation. Local inhabitants, however, state that the vleis are occasionally flooded after heavy rains. Low sandstone and dolerite krantzes form part of the northern bank. The area is grass-covered and has limited sandstone and dolerite outcrops. Near the river and its tributaries thorn-bush abound.

B. RELATIVE POSITION IN FREE STATE GOLD-FIELD.

Generally, the Witwatersrand rocks in the Free State Gold-field form a large north-plunging syncline and an anticline in the West. This structure is complicated by many large and small faults. Two of the largest faults, the Western fault-zone and the de Bron or Welkom Fault, bound the so-called "Odendaalsrus Graben". (Borchers 1950, p.p 81-82, Feringa 1954, p.p. 19-33). Others are the Homestead fault and the Virginia fault.

The/....

The Witwatersrand System in the Virginia-Merriespruit area was preserved from subsequent denudation, because of the large downthrow of the Homestead fault. The regional dip of the Witwatersrand System in this area is towards the west. Further to the east, another block of the Upper Witwatersrand sediments, known as the G.F. Block, has been thrown down by the Virginia or Railway fault.

C. HISTORY.

Before the Second World War, options were taken up on several forms on both sides of the Sand River near the station and village of Virginia, by Middle Witwatersrand (W.A.) Limited, the prospecting Company of the Anglo-Transvaal Group. After the cessation of hostilities in 1945, active prospecting commenced.

Before drilling started in the Sand river area, fourteen bore-holes have been drilled to the east of the de Bron fault. Seven of these passed through the Leader-Basal Reef-horizon without finding payable gold-bearing beds. Most of them were drilled to the north of the present Saaiplaas Gold-mine. These bore-holes nevertheless indicated a possible extension of the Upper Division of the Witwatersrand System to the south in the direction of the farms held under option.

On the strength of these indications, it was decided that four bore-holes would be drilled, two in collaboration with Union Free State Coal and Gold Company Limited, who held options in the area, and that the options on farms not yet taken up, would be acquired. Accordingly the four bore-holes: R.U.1, H.1, M.1 and D.1, were sited in an approximate north-south line down the centre of the ground, then held by the two Companies.

Drills were in great demand at that time, because options acquired before the war, were due to lapse a year after the cessation of hostilities. When the machines finally became available, drilling had to be done in a great hurry. The core was transported to Klerksdorp, where it was logged and sampled.

Bore-hole R.U.1 was the first to intersect the "economic horizon". The composite Leader-Basal Reef intersected in this bore-hole was unpayable. A single pebble in the core ten feet below the Leader Reef in bore-hole M. 1 was not recognised as the Basal Reef during routine logging, but because the precaution was taken to sample not only the beds of conglomerate, but all the quartzite as well, the assay results revealed that the Basal Reef had been intersected. As it was the policy to split the core lengthwise and to store the one half, the split core could be re-examined and it was confirmed that it was indeed the Basal Reef. The gold value of 4.3 dwt. per ton over a sample width of 24 inches was unpayable, but it was encouraging in that it was an indication that potentially payable Basal Reef existed in the Sand river area. At that stage the options were due to lapse, and the Consulting Geologist, Dr. Hearn, recommended that the mineral rights be bought. Two weeks later, bore-hole H.1 intersected the Basal Reef, which assayed 20.9 dwts. gold per ton over a corrected width of 56.4 inches. Bore-hole D.1 passed from the Karroo System into footwall beds of the Basal Reef. Further drilling was then resorted to.

The writer assisted in the logging of nine of the bore-holes under the guidance of Mr. J.F.M. Luyt and afterwards of Messrs. D.J. Sadie and P.P. Venter. He has mapped portions of all five existing shafts, and large portions of the underground workings. The cores of the original bore-holes have all been re-examined and critical sections re-logged.

CHAPTER II.

GENERAL

A. CORRELATION.

(1) Basis of Correlation.

In the Orange Free State, the geologist is primarily dependant on bore-hole cores for data. Lately, this source of data is being supplemented by information obtained from underground exploration.

The problems of correlation peculiar to the Witwatersrand System have been summarised by Nel (1939 p.36-37) and have also been quoted by Baines (1949, p.316):

> "In this venerable mass of sediments, estimated to be about 25,000 feet thick near Parys, no fossils have been found. The classification and correlation of these beds, therefore, are dependant upon a detailed study of their lithology and sequence."

The correlation of the strata as proposed in this treatise is based on the following :

(a) Marker beds, as described in the paper by Borchers and White (1943), are indentified by their lithological character.

(b) The sediments above and below the marker beds are compared and given their zonal designation, evidence of changes in facies being noted.

(c) The true thicknesses of the beds are calculated from the cores of each borehole and compared. Isopach maps are drawn to reveal the magnitude of disconformities.

(d) Radiometric logs are compared with the descriptions of bore-hole cores.

(e) The distribution of gold in the sediments of the Upper Division of the Witwatersrand System is examined.

(f) The ratio of gold to radioactive minerals in different reefs are investigated.

(g) Microscopical characteristics of rocks of diagnostic value are noted.

(h) Heavy mineral concentrates are prepared and investigated for significant differences

The results of these investigations are described in later chapters.

(2) Schemes of Correlation.

Although the regional correlation has been fairly well established, there are differences of opinion on some of the details. The accepted boundaries of the Main-Bird and Kimberley-Elsburg Series as defined by Mellor (1915,p.13) are not considered to coincide with the major "breaks" in the succession as revealed by recent discoveries in the Klerksdorp and Orange Free State Gold-fields. Sharpe (1949) and Feringa (1954) have tentatively proposed new subdivisions for the Upper Division of the Witwatersrand System. The writer is of the opinion that although there is a strong case for the use of the new subdivisions, the accepted division into series should be retained. Mellor (1915, p.13), when he decided upon the division of the Witwatersrand System into series, based his classification on lithology and sequence. At the same time he realised that there were breaks in the sedimentation that did not coincide with his boundaries. To change his subdivision would create unneccessary confusion and would set a precedent for changing the existing formational boundaries in other geological systems in the country.

A further argument against changing the existing bases of subdivision is that most of the disconformities are discontinuous. The failure of Sharpe to recognise this fact has led him to the correlation of the Vaal-Basal Reef with the Main Reef (Sharpe 1949, p.286). It is well-known that disconformities may disappear as one proceeds down the dip from the margins of sedimentary basins. (Krumbein W.C. and Sloss, L.L., 1953, p.20). The lack of disconformities in the Vredefort area may be explained in this way.

The draw-back of the accepted subdivision of the Witwatersrand System is that, owing to the mass of data now available, the need is felt for greater detail. Feringa 1954, p. 8) has broken away from convention by including four series in the Upper Division, as

TABLE I

SCHEMES OF CORRELATION ORANGE FREE STATE GOLD-FIELD

BORCHERS & WHITE 1943		FROST, ETC. 1946	BAINES & SHARPE, 1949		BORCHERS 1950		FERINGA 1954			SUBDIVISIONS NOW PROPOSED		Zone Symbol	Reef Designations
V.S.1	Ventersdorp Sediments	Ventersdorp Basal Conglom.; Lower Ventersdorp or Upper Witwatersrand System; Upper Witwatersrand System; Ventersdorp System?	Upper Elsburg Beds	Elsburg Series	Kimberley-Elsburg Series	V.S.1	Elsburg Series	V.S.1		Kimberley-Elsburg Series	Elsburg Stage	V.S.1	
V.S.2			Middle Elsburg Beds			V.S.2		V.S.2-4				V.S.2/3	
V.S.3						V.S.3							
V.S.4						V.S.4						V.S.4	
V.S.5						V.S.5		V.S.5				V.S.5	V.S.5 Conglomerate Gold Estates Leader
T.1	Transition Quartzite	St. Helena Reef Zone; Gold Estates Series	Lower Elsburg Beds			T.1	Kimberley Series	Upper Kimber-ley	U.K.1		Upper Kimberley Stage	U.K.1	
									U.K.2			U.K.2	
									U.K.3			U.K.3	"A" Reef
E.C.1						E.C.1		Middle Kimber-ley	M.K.1		Middle Kimberley Stage	M.K.1	
									M.K.2			M.K.2	Alpha Reef?
E.C.2	Big Pebble Conglomerate					E.C.2			M.K.3			M.K.3	Big Pebble Reef
									M.K.4			M.K.4	Big Pebble Reef
E.C.3						E.C.3		Lower Kimber-ley	L.K.1		Lower Kimberley Stage	L.K.1	
E.C.4						E.C.4			L.K.2			L.K.2	
									L.K.3			L.K.3	"B" Reef
E.S.1	Upper Shale Marker		Kimberley Beds	Main-Bird Series	Main-Bird Series	E.S.1	Bird Series	Kimberley Shale		Main-Bird Series		E.S.1	
E.S.2	Leader Reef at base	St. Helena Series	Main-Bird Beds			E.S.2		Upper Bird Group				E.S.2	
E.S.3						E.S.3						E.S.3	Leader Reef
E.L.1	Khaki Shale Marker					E.L.1						E.L.1	
E.L.2						E.L.2						E.L.2	
E.L.3	Basal Reef					E.L.3						E.L.3	Basal Reef
E.F.1.		Speckled Footwall Quartzite				E.F.		Lower Bird Group			Upper Footwall Beds	U.F.1	
												U.F.2	
												U.F.3	
												U.F.4	Intermediate Reefs
		Kimberley Elsburg Quartzite					Main Reef Series	Main Reef Quartzite Group			Middle Footwall Beds	M.F.1	
												M.F.2	
												M.F.3	
								Main Reef Conglomerate Group			Lower Footwall Beds	L.F.1	Commonage Reef
			Basal Reef									L.F.2	Ada May Reef - Main Reef
		Prairie Quartzite		Jeppestown Series			Jeppestown Series				Main Reef Footwall Quartzite	M.R.F.	

four series in the Upper Division, as indicated in his scheme in table I. These detailed subdivisions form a very satisfactory framework on which stratigraphical descriptions can be based, and his scheme for the Kimberley beds have proved to be the most practical one for this area. The last column in table 1 represents the adaptation that will be used in this thesis.

The zone-symbols proposed by Borchers and White (1943, p.p.134-144, also p.p.150-151) have been widely used in the Free State. (Table I.) In common with the practice of others (Baines 1949, p.307, Borchers 1950, p.30) these symbols will be retained; although it must be emphasised that they are no longer considered as abbreviations of a time-rock scheme of classification, but merely as local rock units of division. (Krumbein and Sloss 1953, p.23).

The zone-symbols used for the footwall beds of the Basal Reef have been adopted from an unpublished column drawn up by Mr. G.W.S. Baumbach. A similar scheme, with minor differences is used by the geologists of the Anglo-American Group. For the sake of uniformity, therefore, the scheme according to Baumbach will be used in this treatise.

The Kimberley-Elsburg Series has been subdivided into a Kimberley Stage and an Elsburg Stage on the basis of a distinct difference in the character of the sediments of the two stages, a difference which has been remarked upon in most of the publications dealing with the stratigraphy of the Witwatersrand System in the Free State.

B. DEFINITIONS.

As in most metallogenetic provinces, local terms which differ in meaning from the strict scientific term have also arisen in the Free State Gold-field and as there are discrepancies in the usage and definition of certain terms among authors on sedimentary rocks, it appears advisable to define some of those in use.

Regarding the grain-size of sediments, the Wentworth grade-scale corresponds closely to the one used in this thesis, but with additional subdivisions. (Table II)

TABLE II.

Wentworth		Additional subdivisions	
	Boulders		
256 mm.			
	Cobbles		
64 mm.		Large	...... 44 mm.
		Medium	...... 22 mm.
		Small	
4 mm.			
	Granules		
2 mm.			
	Sand	Coarse	...... 1 mm.
		Medium	...... ½ mm.
		Fine	
1/16 mm.			
	Silt		
1/256 mm.			
	Clay		
0.0001 mm.			

For a sedimentary rock composed of granules, the term "grit" is widely applied among geologists on the Witwatersrand Gold-fields.

The texture of a sedimentary rock is the size, shape and arrangement of the component particles.

Structure deals with the large features of the rock such as bedding, ripple-marking, etc.

Roundness is a measure of the sharpness of the edges and corners of particles. The visual method of judging the degree of roundness and the sphericity of sedimentary particles described by Rittenhouse (1943, p.p. 79 and 81) (Krumbein and Sloss, 1953 p. 81) have been applied in the treatise.

The term "mineralisation" with qualification, is used as a measure of the quantity of pyrite, other sulphides, thucolite or gold that is visible in the pebble-band or reef. As pyrite is predominant, the amount of this mineral serves as an indication of the degree of mineralisation thus:

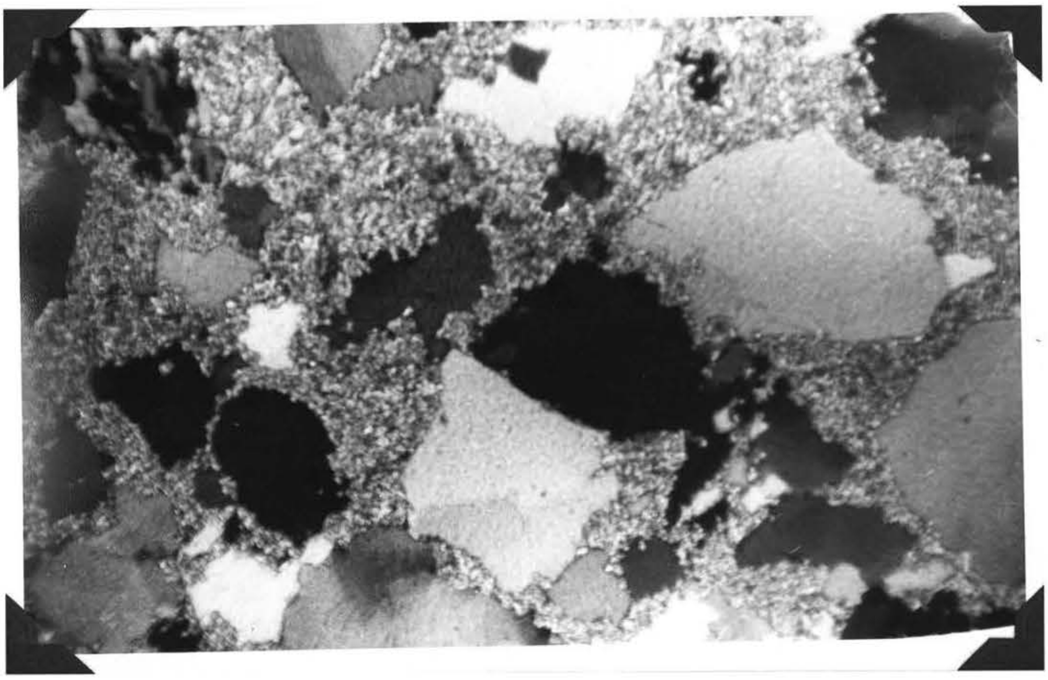
Poor	mineralisation	is	represented	by	approx.	1% pyrite
Fair	"	"	"	"	"	2% "
Good	"	"	"	"	"	4% "
Very Good	"	"	"	"	"	6% or more "

When the matrix of a quartzite or conglomerate is rich in sericitic and chloritic material, the term "argillaceous" is applied. "Siliceous" designates that the cement of a quartzite consists predominantly of silica.

The term "carbon" for the uraninite-bearing hydrocarbon mineral "thucolite" is still widely used. These terms have, therefore, been used interchangeably.

As there is considerable confusion regarding the use of terms relating to non-conformable contacts, the following extract from "Stratigraphy and Sedimentation" by Krumbein and Sloss, 1953, p. 97, is included to define the terms used in this treatise:-

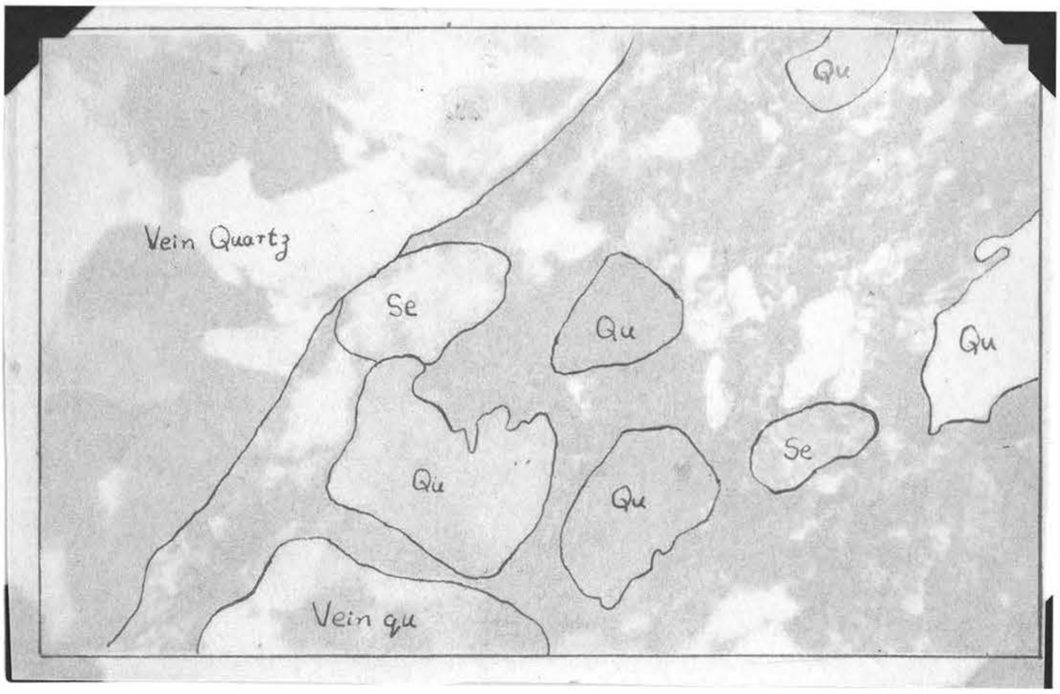
> "An unconformity is a surface of separation between two groups of strata, representing an interruption in sedimentation. Several types of unconformity are recognised for the purpose of taking account of the magnitude or importance of the break. An interruption in sedimentation accompanied by some disturbance of the rocks, and followed by subaerial erosion, is an angular unconformity. Withdrawals of the sea followed by subaerial erosion, but not accompanied by folding, produce a disconformity. Minor interruptions in sedimentation, which may represent merely a cessation of deposition, give rise to a diastem."



Photomicrograph 1.

Quartzite, zone L.K.2. Sericitic minerals replace borders of quartz grains.

Crossed nicols (X 55) Section 28.



Photomicrograph 2.

Subgreywacke, zone V.S.1. Poorly rounded grains, mostly quartz, are embedded in a chloritic and sericitic matrix. Partly replaced grains of sericitic and chloritic rocks lie near the centre. Part of a large grain of vein-quartz appear in the top left hand corner.

Crossed nicols (X 55) Section 36.

C. MICROSCOPICAL OBSERVATIONS.

Although it is not the purpose of this treatise to provide a detailed petrographical analysis of the Witwatersrand sediments, certain general characteristics were revealed by microscopical work on thin sections and will be described before dealing with the stratigraphy.

(1) The Quartzite of the Upper Division of the Witwatersrand System.

The grains of the quartzite of the Upper Division consist predominantly of quartz, chert being the most important other constituent. They range in shape from subrounded to angular, but a false impression of angularity is given in instances where the quartz grains have been corroded and partially replaced by sericitic minerals (photomicrograph 1, section 28).

In beds where the grains are closely packed, they are "welded" together, and frequently form sutured contacts. The "welded" effect is probably the result of partial solution of silica under pressure. The silica recrystallised between the quartz grains and formed a cement of secondary chert and microcrystalline quartz. (section 2).

It is possible that most of the quartz cement in a quartzite has formed during diageneses.

Most commonly a layer of sericitic and chlorite minerals separate the grains. In the argillaceous quartzite beds, the grains are widely separated. (sections 3 and 4).

In some sections (section 36, photomicrograph 2) cut perpendicular to the stratification, a faint dimensional orientation of the grains is discernable. This orientation is caused by grains settling on their largest surfaces.

Grains of chert consist of microcrystalline to cryptocrystalline aggregates of quartz. Common impurities and inclusions in the chert are chlorite, serite and rutile. Banded chert contains layers of grains of different sizes and different degrees of purity. The occurance of secondary chert has been described above. Even in quartzite containing abundant sericitic material, chert has been deposited in the matrix. The distinction between authigenic and allogenic chert is difficult in examples where sericite and chlorite have replaced the edges of existing chert grains.

Grains of red jasper, which abound locally, raises an interesting question regarding their origin. It is significant that pebbles of red jasper are most abundant close to the surface of pre-Karroo erosion, whereas the same horizons away from pre-Karroo outcrops contain mostly pebbles of black chert. There are jasper pebbles with red cores and others with red rims. In one thin section (section 5), there are two grains of red jasper, in one of which the core only is red, although a faint red dust is discernable around the periphery. The other grain contains a black dusty impurity, which appears red when light is allowed to fall onto the upper surface of the slide. Dust, reflecting black, appears in some chert grains in a section cut from a slightly lower horizon in the core of bore-hole W.N.1 (section 6). Some chert pebbles are partially replaced by pyrite.

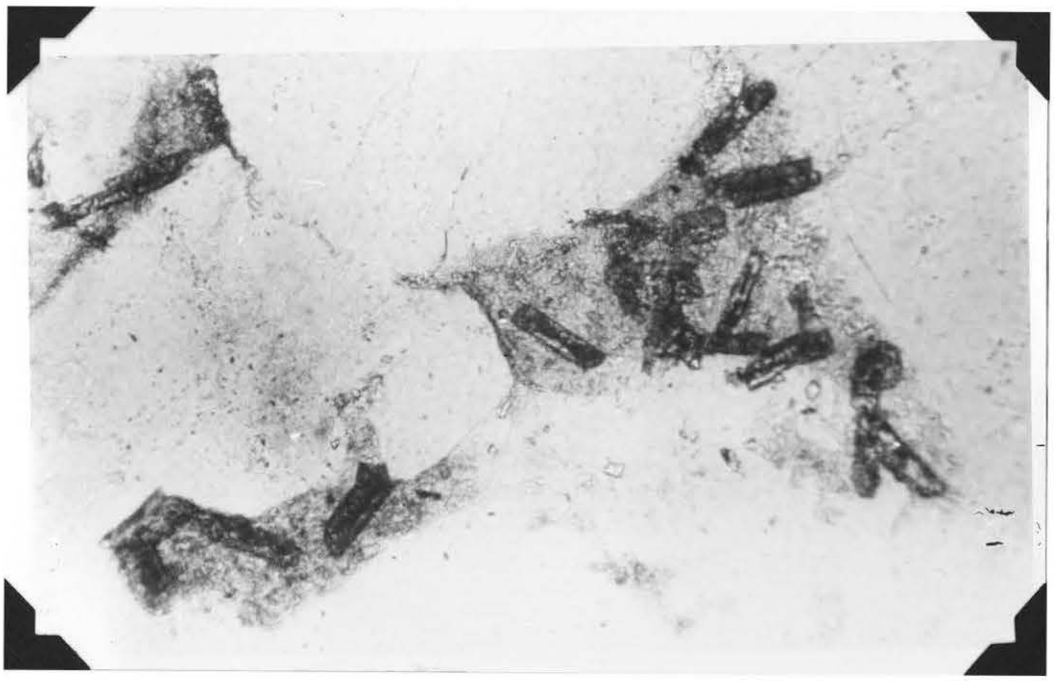
It is suggested that jasper was introduced into the sediments in the oxidised state, reduced to black jasper during a period of pyritisation, and subsequently oxidised a second time where the sediments were exposed to weathering. Some of the pebbles resisted complete change and remained partially altered. Black rims on many jasper granules close to the sub-outcrop below the Karroo System indicate that the reducing conditions again prevailed to a slight extent in post-Karroo time.

It may be mentioned here that argillaceous quartzite forming pre-Karroo outcrops is oxidised to various shades of maroon to as much as 500 feet.

The matrix of the quartzite of the Upper Division of the Witwatersrand System consists mostly of sericitic and chloritic minerals. Chlorite is abundant in dark-grey quartzite, whereas sericite is predominant in yellow-grey varieties. The distance from a source of higher-grade metamorphism or a source of metasomatism such as a fault or an intrusion, affects the ratio of chloritic to sericitic minerals in the matrix. As an intrusion is approached, the rock at first becomes more intensely yellow, then turns a very dark-grey, the latter colour being due to greater chlorite development. A green tinge tinge is evident in some strata, especially in the siliceous beds. The colour of a quartzite is, therefore, often of doubtful diagnostical value, especially where exposures are limited. On the other hand, abnormal colouration of quartzite is an indication of possible structural complications ahead of the exposure underground. Due to the removal of chloritic and sericitic minerals and the addition of quartz to quartzite in the vicinity of igneous bodies, a dull,argillaceous quartzite sometimes changes into a siliceous one.

Whether the changes in the quartzite is a simple contact-metamorphic effect or whether it is a metasomatic effect involving emanations from solidifying magma is beyond the scope of this treatise. Suffice be it to say that the width of the zone of alteration ranges from a few feet for some intrusions to about 150 feet from the Harmony Sill. The quartzite close to Intrusive "C", south of Merriespruit No. 1 Shaft, and the de Bron fault, west of that shaft, has been altered in this way. Sections 13 and 14 were taken in zone E.L. 1 in the shaft and two feet from the fault respectively. A dyke has intruded into the de Bron fault.

The minerals of the chlorite group range from penninite (low birefringence, anomalous "berlin blue" interference colour, also olive-green next to pyrite and purple in contact with chromite) through optically positive varieties towards prochlorite, by an increase in the aluminium and iron content of the molecule. (Winchell,1946. p. 278)



Photomicrograph 3.

Chloritoid in quartzite of zone L.F.1.
The hourglass structure is only rarely seen.

Plain light. (X 160) Section 10.

Sericitic minerals are represented by shreds of sericite, isolated curved shredded plates of pyrophyllite, identified as such by Dr. Liebenberg of the Government Metallurgical Laboratories, and possibly by talc. Beds of argillaceous quartzite are very rich in sericite.

Coloured specks are almost ubiquitous in the quartzite of the Upper Division. In different beds they have a large range in size, variety and concentration. These specks are grains of black chert, yellow silicified sericitic shale, red jasper and other schistose rocks consisting mainly of chlorite, quartz and sericite in varying proportions, their sizes being comparable with the associated quartz grains. Concentrations of chlorite, sericite, chert, rutile and leucoxene also give rise to coloured specks. As these concentrations have indistinct contacts, it is difficult to decide which of these represent altered detrital rock fragments and which are segregations of secondary minerals.

Rutile appears in most of the sediments as yellow, acicular crystals. Geniculated twins are common. Concentrations of of rutile cause bright orange-yellow specks,that are common in some types of quartzite. It appears as if at least some of the rutile is derived from the alteration of ilmenite. The first step in the alteration of ilmenite is leucoxene, which forms dull-yellow specks in the quartzite. In a further stage of alteration, crystals of rutile protrude from a rather indefinite mass of leucoxene, and in still other examples, a mat of rutile crystals contain cloudy whisps of leucoxene.

Chloritoid is confined to particular strata and may therefore constitute a valuable index mineral. The chloritoid-bearing beds are marked on Plate A. It appears that portions of the Lower Footwall beds are chloritoid-bearing whereas the Middle Footwall beds are free from the mineral. The Khaki Shale (E.L. 2,section 22, photomicrograph 3) and Upper Shale Marker (E.S. 1, section 25) are also chloritoid-

TABLE III

Heavy Minerals in Pyritic Stringers

Mineral	Colour		Diagnostic Features	Shape	Abundance*
	Transmitted Light	Reflected Light			
Pyrite	Opaque	Brass-Yellow	Colour	Rounded	"Flood"
Ilmenite	Opaque	Black	Violet translucence on thin edges, alteration to leucoxene	Rounded	Very Common
Leucoxene	Opaque	Pale Yellow	Colour, shape. Alteration from ilmenite or to rutile	Ragged	Very Common
Rutile	Deep Yellow	Yellow	Crystalline, acicular habit, geniculated twins	Crystalline	Very Common
Chromite	Opaque	Black	Brown translucence on thin edges	Rounded	Common
Magnetite	Opaque	Black	Sometimes has a superficial film of red haemetite	Rounded	Scarce
Zircon	Colourless, pink, brown, yellow	Colourless, resinous	High birefringence, strong relief	Crystalline and rounded	Common

* According to descriptive scale, Milner, H.B., 1952, p.457

Note: The cracks in the broken grains have subsequently been filled in with secondary minerals.

bearing. Two other occurences of chloritoid in the Upper Footwall and in the V.S. 1 zone are the exception, as adjoining slides in similar strata do not contain chloritoid. (sections 21 and 42 compared with 12,16,40, 41 and 43) It is possible that the bulk composition of the matrix favoured the formation of chloritoid in localised spots which are separated from reaction with the remainder of the matrix during metamorphism by an excess of quartz. It is therefore desirable to examine more than one specimen of any suspected chloritoid-bearing bed before accepting the result.

Tourmaline, which is a rare constituent of argillaceous quartzite, is probably of secondary origin as it is never found as rounded grains, but always as clear crystals of schorlite intimately associated with other minerals forming the groundmass.

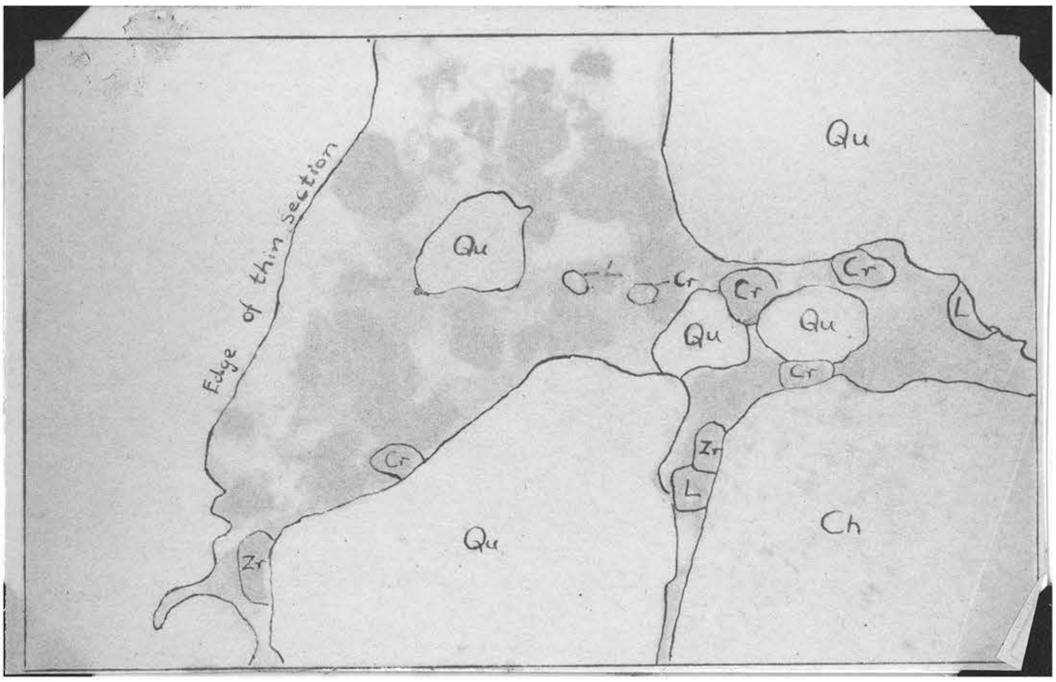
A few grains of a mineral which may be hornblende were encountered. (sections 12 and 30.)

In the quartz grains, inclusions of the following minerals were noticed:- biotite, zircon and tiny acicular inclusions. (section 5).

2. Pyrite.

It is not the writer's intention to delve into the origin of the pyrite in the Witwatersrand sediments, but observations on some pyritic stringers indicate strongly that "buckshot" or rounded pyrite is pseudomorphic after minerals such as magnetite, haematite and ilmenite, commonly found in black sands, or that the pyrite is a primary detrital mineral. (See Liebenberg 1955, p. 204). See also table III.

Pyritic stringers are ubiquitous in the sediments of the Upper Division. They never cut across sedimentary layers, although they frequently follow the foreset beds in cross-bedding. The pattern of distribution in the black heavy minerals in unconsolidated sand deposits, is similar to that formed by pyritic stringers in Witwatersrand sediments. (photomicrograph 4.)



Photomicrograph 4.

Typical pyritic stringer in quartzite of zone L.F.1 Many opaque minerals are rounded and all "heavy" minerals occur in the matrix. Some, near the right, are crushed, others protrude slightly into quartz and chert grains.

Q = quartz
Ch = chert
Cr = chromite
L = leucoxene
Z = zircon
Pyrite is not indicated.

Plain light. (X 12) Section 5.

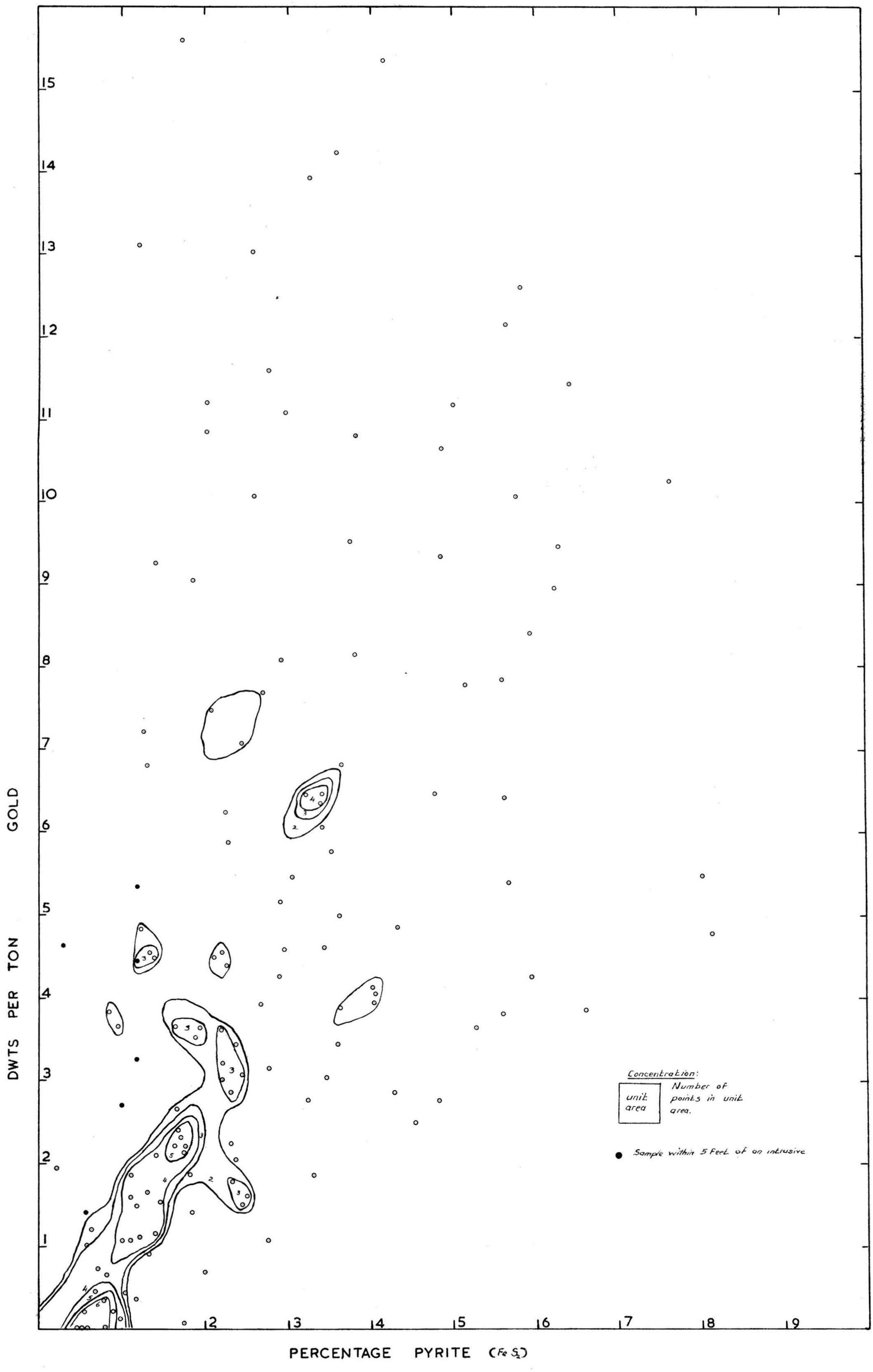


FIG. 2.

Pyrite-gold relationship in Basal Reef.

It is noteworthy that the pyrite of stringers in quartzite far removed from conglomerate is also rounded.

In the banket, the rounded pyrite is generally of a large size. The average size of the pyrite grains are 3 mm. in diameter near the base, and 1 mm. towards the top of the Basal Reef. Rounded pyrite of larger than average size is an indication of high gold values. Grains larger than 3 mm. are locally found in some reefs. They have the shape of water-worn pebbles and granules.

Rounded grains of pyrite less than 0.08 mm. diameter are not found in quartzite. Smaller grains are either crushed grains or secondary pyrite. According to theory, abrasion should be negligible for particles smaller than 1/16 mm. in diameter (0.06 mm) (Twenhofel, 1939, p.199). The evidence is, therefore, strong that the rounded mineral, that is now pyrite has a detrital origin and is not oolitic.

It has often been stated that an increase in the pyrite content in a reef is an indication of high gold values. (Macadam 1935, p.79). A direct comparison between the gold and the pyrite content of the Basal Reef on the Merriespruit mine is now possible because sections sampled at 50 feet intervals are assayed for both gold and pyrite. The results of these assays have been plotted on a graph, fig. 2, and indicates that there is a linear increase of pyrite with increase in the gold tenor of the Basal Reef.

Microscope examination reveals that some of the grains in the pyritic stringers have been fractured and others crushed. Most of the fractures are filled with quartz. Liebenberg has also commented on these fractured grains (1955, p.170).

Grains of rounded pyrite have been pressed into quartz by selective solution of the latter under pressure,(section 7 and others. Note that this effect is best seen in hand specimen against the contacts of the large grains.)

but are always found in the matrix, whereas secondary hackly or crystalline pyrite may partly replace quartz grains.

Whatever the original constitution of rounded pyrite, the grains were already pyritic before silicification occurred. The rarity of magnetite and haematite in the heavy mineral concentrate suggests that the rounded pyrite originally consisted of these minerals and that the pyritic stringers originally were stringers of black sand.

Flaky, ragged and euhedral, crystalline pyrite is commonly found near intrusions, but very close to a dyke the pyrite in a reef is almost completely absent. The shaded circles in fig. 2 represent the composition of samples taken close to intrusions. Note that the percentage of pyrite in these samples are all less than normal. A little further away flakes and concentrations of pyrite occur both in the reef and in the adjacent quartzite. This zone is followed by one enriched in secondary and containing also primary rounded pyrite. Approximately coinciding with this zone is the end of the dark, chloritized quartzite. Further away from the dyke, normal rounded pyrite predominates.

TABLE IV

SUMMARY OF DETAILED CHARACTERISTICS OF THE DIFFERENT BEDDING UNITS COMPRISING THE

UPPER DIVISION OF THE WITWATERSRAND SYSTEM.

BORE HOLE	ZONE	UNIT	Particle size – Grains – Fine	Grains – Medium	Grains – Coarse	Granules – Small	Granules – Large	Pebbles – Small	Pebbles – Medium	Pebbles – Large	Colour – Yellow-brown	Colour – Light-grey	Colour – Dark-grey	Colour – Green	Speckling in quartzite – Yellow	Speckling – Black	Speckling – Green	Speckling – Milky	Matrix and groundmass – Siliceous	Argillaceous sericitic	Argillaceous chloritic	Shaly	Composition – Quartz	Chert	Shale	Quartzite	Banded jasper	Opalescent blue quartz	Packing – Close	Loose	Scattered	Roundness – Angular	Subangular	Subrounded	Rounded	Pyrite – Size – < 1 mm	Size – > 1 mm	Quantity – Very well mineralised	Well "	Fair "	Poor "	REMARKS
VZ3	VS1	type 2	x	X	X	x	X	x					X		X	X		x		x	X		X	x	X	x		x		X		X	X			X				X	X	The two types are inter bedded. Pebbles of quartz-porphyry rare.
"	VS1	type 1	x	X	X	x	x					X			X	X		x	X	x	x		X	x	x			x	X				X	X		X					X	" " " "
"	VS2/3		X	X								X	X			X		x			X	x	X	x	x			x	X	x			X	X								Dark, shaly zone near centre
"	VS4		X	x								X				x			X				X	x				x	X				X	X								Siliceous, sub-conchoidal fracture
"	VS5	Conglom.		X			x	x	X	x			X		X	X				x	X		X	x	x	x		x	X	X		x	X	x		X					X	
"	VS5	Quartzite	x	x		x						X			X	X			X				X	x					X				X	x								Sharp change in sedimentation at base.
M2 Shaft	VS5	G.E.L.		X				X	X			X			X	X			X				X	x	x	x		x	X				x	X	X		X		X			Gold Estates Leader Reef.
	UK1		x	X	X			X	x		x	X			X	X		x	X	X	x		X	X	x					X			x	X		X					x	Small-pebble conglomerate bands in quartzite.
	UK2		x	X	X	x					x	X			X	X		x	X	X	x								x	X			x	X								Evenly distributed specks.
	UK3		X					X	X		x	X			X				X	X			X	x	x				X	x			X	X	X	X	X		X			"A" Reef
	MK1		x	X	x						X	X			X	x			X	x			X	x	x				X	X			x	X								Regularly spaced coloured grains. Siliceous quartzite and conglomerate lenses
	MK2		x	X	X				X	X	X	X			X	X			X	X			X	x	x					X			X	X	x	X	X		X	X		Lenticular large-pebble conglomerate
	MK3			X	x			x			X				X	X				X			X	X	x					X			X	X	x							Lenses of rounded quartz-pebble conglomerate
	MK4		x	X	x				x	X		X			x	x			X				X	x	x				X	X	x		x	X	x	X					X	"Big Pebble Reef"
	LK1			X	X	X	x	x	X		X	x			X	X				X			x	X	X	x		x		X		x	X	X								Large coloured granules. Oligomictic conglomerate bodies.
	LK2			x	x			x			X				x	x				X			X	X	X	x		x		X		x	X	X								
	LK3	3		X	X	x	x	X	X		X	x			X	X			x	X			X	x	x	x		x		X		x	X	X								"Mixed pebble", oligomictic conglomerate.
									x		X				X	x				X			X	X	X	x		x		X		x	X	X								Yellow grey quartzite. Scattered pebbles near top of zone.
	"	1		X	X	X	X	X	X		X				X	x			x	X			X	X	X	X		x	x	X	x	x	X	x		X	x			X		"B" Reef at base
	ES1		X	x							X				X	x			x	X		X	X	X	X	X			x	X	x	x	X									Arenaceous shale and argillaceous quartzite
	ES2		·	X	X	x	X	x			X				X	X				X			X	x	x	x	x	x	x	X		x	X	x		X				X		
				X	X	x	X	X	X		X	x			X	X			x	X			X	X	x	x	x	x	X	x		x	X	x	x	X	x		x			Leader Reef at base.
	EL1		X		x			x			X									X			X	x				x		x		x	X	x								Unstratified
	EL2		x								X											X	x								X		X									Khaki Shale marker.
	EL3		x	X	x	x			X		x	X			X	X		x	X	x			X	x	x		x	x	X				x	x	X	X	X	X				Basal Reef
	UF1	3	x	X	X	x						X	X		x	X		X	X				X	x	x			x	X				X	X								
	"	2	x	x	x	X	x					x			x	X		x	X				X	x	x			x	X				X	X								
KA2	"	1	x	X	x							X			x	X		x	X				X	X	x			x	X				X	X								
"	Upper UF2		X	X	X	X						X			x	X		x	X	x			X	x	x			x	X	x			X	X								Contains dull, yellow, argillaceous quartzite beds.
"	Lower UF2	2	X	X	X	X	x				x	X			X	X		x	X	x			X	X	X	x		x	X	X			X	X								Thin beds of grit make an appearance
"	"	1	x	X	X	X	x				X		X		x	X			x	X	X		X	x	x			x	X	X		X	X	X								Siliceous quartzite followed by argillaceous, gritty quartzite.
"	Upper UF3		X	X	x						x	X			x	X			X	x			X	x				x	X	x			X	X								Thin beds of grit.
	Lower UF3	5		X	X	X	x				x	X			X	X			X	X			X	x	x			x	X				X	X								Gritty and slightly argillaceous.
"	"	4		X	X						X				X	X				X			X	x				x	X				X	X								
"	"	3	x	X	X							X			X	x			X				X	x				x	X				X	X								
"	"	2	x	X	X	x					X	X			x	X			X	X			X	x	x				X	x			X	X			X					X	
"	"	1	x	X	x	X					X				X	X				X			X	X	x	x				X			X	X								
	UF4		x	X	X	X	X	x			X	X			X	X			x	X			X	x	x	x		x		X			X	X		X					X	Alternating highly speckled argillaceous and somewhat siliceous quartzite.
"	MF1	2	x	X	x						X				X	X			X	x			X	x	x				x	X			X									Layers of grit near top.
"	"	1	X	x								X							X				X						X				X	X								
D1	MF2	3	X	X							X	X			x	x			x	X			X	x					X				X	X								
"	"	2	X	X	X	X					X	X			x	x		x	X	X			X	x	x				X	X			X	X								Streaks of siliceous quartzite.
"	"	1	x	X	X						X				X	X				X			X	x	x			x		X			X	X								
	MF3	2	x	X								X	X		x	X		X	X				X	x	x				X				X	X								
		1		X	X	X						x	X		x	X			X		X		X	X	x			x	X				X	X								
"	LF1	7		X	X	X	X					x	X			X	x		X		X		X	x				x	X				X	X		X				X		Few shale pebbles present. Small, densely packed black specks.
"	"	6		X	X	X	x					x	X		x	X			x		X		X	x	x	x		x	X				X	X								Rare granules of quartz-porphyry
		5		X	x	x	X	x				x	X		x	X	x		x		X		X	X	x	x	x	x	X	x		X	X	X		X					X	" " " " ", also milk-white chert.
"	"	4		X	X	X						x	X		x	X			x		X		X	X	x	x	x	x	X	x		X	X	X								
"	"	3		x	x	x	X	x					X			X					X		X	X	x	x	x	x		X		x	X	X		X					X	Very dark, shaly bedding.
"	"	2		X	x								X			X					x		X	x				x		X		X	X	X								
"	"	1			x	x	X	x					X			x					x		X	X		x	X	x	X	x		x	X	X		X					X	Flakes of a micaceous mineral on cleavage planes.
"	LF2	9	X	X								X	X			X	x		X		X		X	x				x	X	x			X	X								Prominent bands of argillaceous quartzite
"		8	X								X		X	X	x	x	x					X	x						X	x			X	X								
"	"	7			X	X	X				x	X		x	X	x	x		X	x			X	X			X	x			X		X	X								
"	"	6		x	X	X	x	X				X			X	X	x		X				X	X	x	x	X		x				X	X		X					X	Chert Marker. Some pebbles of quartz-porphyry.
"	"	5	X								x			X	X	x	x			X	X	X	X						X	x		x	X	X								
"	"	4	X	X		X					X	x		X	x	x	x		X	X	X		X	x	X					x	X		X	X								Pebbles of quartz-porphyry common
"	"	3	X	X		X	X	X				X			x	X	x		X	x	x		X	x				x	X	x			X	X		X				x	X	
"	"	2	X	X				·				X				x			X				X	x					X				X	X								
"	"	1		X	X	X	X	X				X			x	X	x		X				X	x		x		x	X				X	X	x	X				X		
"	MRF		x	X	X							X		x	x	x	X	x	X	x	x		X	x				x	X	x			X	x								

CHAPTER III.

THE STRATIGRAPHY OF THE MAIN-BIRD SERIES.

The general geological column of the Upper Division of the Witwatersrand System in the Virginia and Merriespruit mining areas, is shown on plate A. Owing to non-deposition of some beds and to disconformities, the complete succession has not been encountered in any single bore-hole, but has been completed after careful study of the cores of all the bore-holes in the area.

In the forthcoming descriptions the local units of division will be used. The relation between the local and regional correlation, and the thicknesses of the strata are also shown on plate A.

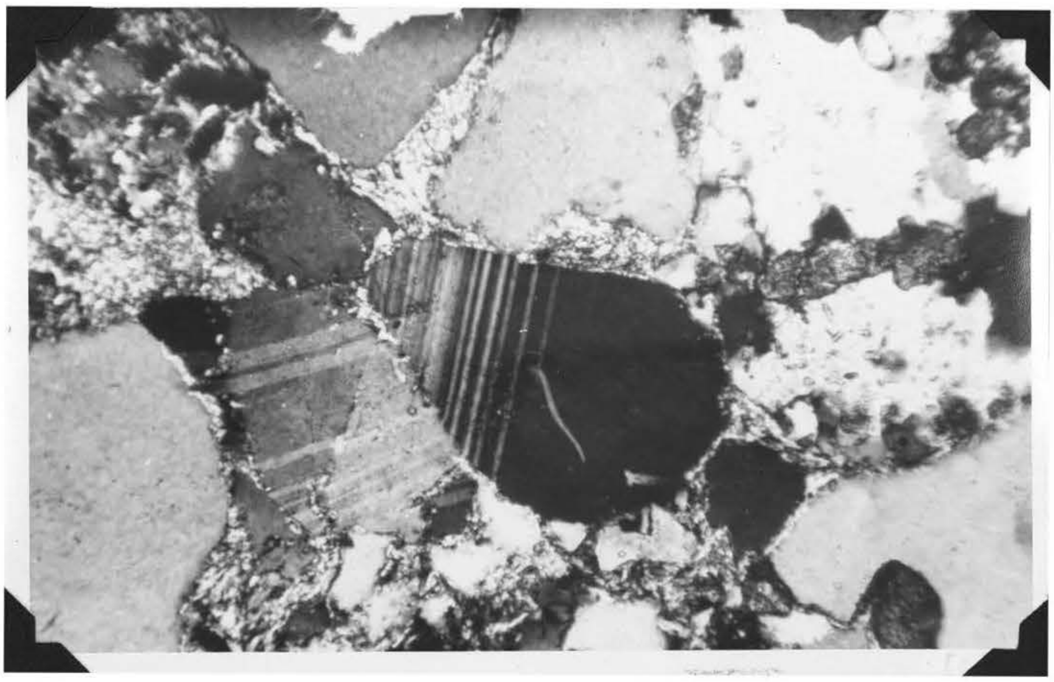
Plate B is a diagrammatical representation of the bore-hole data, drawn with the base of the Elsburg Stage as a reference line, and arranged so that the most complete columns are on the left.

A. FOOTWALL BEDS - ZONE E.F.

The strata underlying the Basal Reef is collectively known as Footwall beds or as the E.F. zone, the latter after the scheme of Borchers and White (1943).

Since drilling was directed to explore the Basal and Leader-Basal Reefs, the number of bore-holes that penetrated some depth into the Footwall beds are limited. The chief characteristic of the Footwall beds is the prevalence of gradational changes between adjacent beds, and the repetition of similar types of quartzite and conglomerate.

In table IV opposite the detailed characteristics of the individual bedding units that comprise the Footwall beds, are given. The units are also numbered in Plate A, so that quick comparison between the stratigraphical column and detailed descriptions is possible.



Photomicrograph 5.

Main Reef Footwall Quartzite. Rounded and cracked grains of plagioclase are surrounded by quartz grains in a matrix consisting mainly of sericite. The inclusion-filled quartz in the upper right hand corner is possibly secondary. The small dark-grey grains near the right hand edge are of epidote.

Crossed nicols. (X 175) Section 17.

The cores of only three bore-holes were available for the study of the lower 1,400 feet of the Upper Division. They are bore-holes D.1 on the farm Dora 287, included in the Merriespruit Lease Area, W.N.1 on Welgelegen 382, 6 miles south of Merriespruit, and E.X.1 on Excelsior 866, 12 miles south-west of Merriespruit. Descriptions of the cores of bore-holes W.Z.1 and C.B.1, logged by Mr. D.J. Sadie, were available for comparison (See plate B). These two bore-holes are situated east of Merriespruit.

Small changes in facies, the effect of intrusions and of possible faulting increased the difficulty of correlation.

(1) The Main Reef Footwall Quartzite (M.R.F.)

The name applied to this quartzite is that used in the Central and West Rand, as nobody has yet given a specific local name to the quartzite.

The green tinge of this quartzite is characteristic and is most distinct near the Jeppestown shale but becomes very faint towards the top. The change from Jeppestown shale to quartzite is gradational through a zone of alternating layers of quartzite and shale of variable thickness. The top of the transitional zone marks the base of the Upper Division, but this point, in many bore-holes, is somewhat arbitrary.

The lowermost green quartzite is probably the equivalent of the "Red bar" of the Central Rand. In the Free State the rock is of course encountered in the reduced state. The most prominent feature of this quartzite under the microscope (section 17, photomicrograph 5.), is the presence of fresh grains of feldspar. The feldspar is a plagioclase in the range albite-oligoclase, as determined by the Michel-Levy method of measuring maximum extinction angles of albite twins in sections normal to (010). The presence of feldspar is remarkable in that it is the only occurence in the entire series of slides examined. Borchers (1950, pp. 47,112) refers to feldspar in the Lower Division, which indicates that this quartzite shows petrographic affinities with these sediments. The green colour of the quartzite is probably due to the preponderance of chloritic over sericitic minerals. Epidote and ragged grains of pyrite form accessories. The presence of epidote is also unique in the series of slides examined. No rutile occurs in the slide.

Interbedded with the green quartzite are bands of pure, white quartzite of a larger grain-size from about 60 feet, becoming prominent at about 260 feet from the base, where the quartzite forms a fairly consistent, light-coloured zone.

Over the uppermost 160 feet the quartzite gradually changes in composition until it becomes almost identical with the quartzite within the L.F. 1 zone. The colour darkens to gray and the green tinge is very faint. The quartzite is coarser, being medium-grained. Small black chert fragments and yellow sericitic specks appear. Blue opalescent grains of quartz are also common. Interstratified with the quartzite are thin beds of argillaceous quartzite that form the most distinct bedding feature of the quartzite of the Upper Division. They change upwards from green to dark-grey. Current-bedding becomes noticeable and also remains a feature of most of the quartzite of the Upper Division. Narrow pyritic stringers lie in the current-bedded sediments. Sericite is more abundant than at the base and minute needles of rutile occur sporadically and in groups. (section 18.)

Over the upper 60 to 100 feet there are some narrow, mineralised layers of grit.

(2) <u>The Lower Footwall Beds (Zones L.F.2 and L.F.1)</u>

The Lower Footwall beds are characterised by groups of of small-pebble conglomerate and grit alternating with quartzite. There is a striking similarity between these beds and the Commonage-Ada May quartzite and conglomerate beds in the Klerksdorp Area, judging from cores logged by Sadie and Baumbach. (Plate B). For this reason, the correlation of these beds with the Main Reef Group of conglomerates is fairly certain.

The of zone L.F.2 is formed by the small-pebble conglomerate beds of the Ada May Reef. The conglomerate consists mainly of quartz pebbles and some bands are well-mineralised. Individual bands are, however, less than a foot in thickness and alternate with quartzite. The conglomerate is not sharply demarcated from quartzite. In the Free State this conglomerate is not auriferous. The lower contact of zone L.F.2 is sharp, but there is no change in the characteristics of the quartzite below and between the beds of conglomerate. The even thickness of the Main Reef Footwall quartzite in the central Free State Gold-fields indicate that there is no disconformity at the base of the Ada May Reef. Bore-holes C.B.1 and E.X.1 to the east and south of Merriespruit Mine respectively, have intersected progressively smaller thicknesses of this quartzite. There is, therefore, fairly strong evidence that a disconformity exists near the margin of the basin of deposition at this horizon. This is not, however, accompanied by a change in the character of the Ada May Reef.

At about 25 feet from the ase of zone L.F.2 there are small-pebble conglomerates and coarse grits that contain a remarkable amount of silicified quartz-porphyry pebbles. The equivalent horizon in the Klerksdorp Area was not recognised by Sadie, but Baumbach (unpublished logs) described a comparable horizon in bore-hole T.L.6 on Klerksdorp Townlands as containing "igneous" pebbles.

At about 150 feet from the base of zone L.F.2, small-pebble conglomerates and coarse grits again occur, in which pebbles of chert are more abundant than any other pebble constituent. This bed, the Chert Marker, has been used as a key bed both in the Orange Free State and in the Klerksdorp Goldfields.

A similar cycle of sedimentation to that which produced the sequence of quartzite and grit up to the Chert Marker has been repeated in the sediments occurring towards the top of this zone.

Zone L.F.1 begins with thin grit and small-pebble conglomerate bands correlated with the Commonage Reef in the Klerksdorp Area. In the cores of the three bore-holes available, the Commonage Reef zone is no more prominent than any of the succeeding coarse members of zone L.F. 1. Pebbles of black chert are conspicious but although chert is a common pebble constituent, it is subordinate to quartz. These coarse constituents remain fairly similar in composition throughout zone L.F.1 except that a flinty chert becomes prominent high up in the succession (see plate A) and that the quartz pebbles are predominant in the uppermost small-pebble conglomerate beds.

The quartzite, although similar to that in zone L.F.2, is mainly coarse-grained and contains grains of chert in approximately the same proportion as in the grit members.

Grains and pebbles of red jasper occur in the core of bore-hole E.X.1 above the Commonage Reef and persist in the remainder of the Footwall beds.

(3) <u>The Middle Footwall Beds. (Zones M.F.3,M.F.2 and M.F.1)</u>

The Middle Footwall beds are the most difficult to subdivide as they contain thick accumulations of dull, somewhat argillaceous quartzite. Where they change into finer- or coarser-grained beds, the change is gradational. Two beds of very light-grey pure quartzite are the most easily recognisable. They have locally been called the Lower and Upper White bands.

The quartzite of zone M.F.3 is mainly dull and somewhat argillaceous, and terminate with the siliceous quartzite bed of the Lower White band.

The variations in the quartzite in Zone M.F.2 is greater than in zone M.F.3, there being alternations of dull,argillaceous and light, siliceous bands. Narrow lenticular beds of grit are also present. Grit bands about 175 feet from the base of zone M.F.2 have been correlated by Feringa with the Livingstone-Johnstone reefs. (Feringa 1954, p.14). Examination of detailed bore-hole logs reveals that the grit beds change in facies in an easterly direction to quartzite.(Plate B, bore-holes M.O.2, M.2, M.1 and C.A. 1). It is possible that this change also occurs in a southerly direction, because bore-hole W.N.1 has no grit bands in the relevant position.

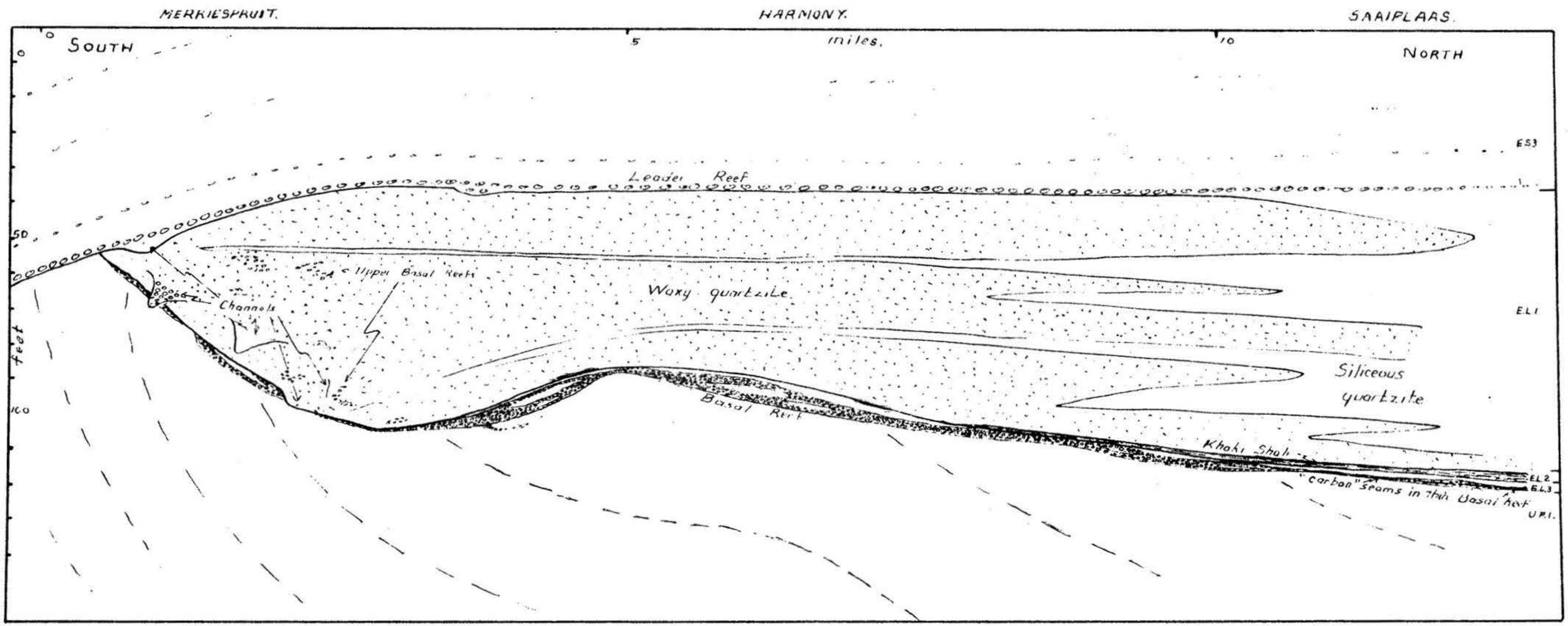
The Upper White band forms the base of zone M.F.1 and is succeeded by coarse argillaceous quartzite. In some intersections this contact is sharp, but in many it is gradational. The same can be said of the contact of the argillaceous quartzite with the Intermediate Reefs.

(4) <u>The Upper Footwall Beds (Zones U.F.4 to 1)</u>.

The Intermediate Reefs at the base are followed by quartzite containing layers of grit and then by speckled, siliceous quartzite.

The zonal subdivision employed by geologists of the Anglo-American Corporation in the Free State differs from that of Baumbach in that they class the Intermediate Reefs as zone M.F.1 and Baumbach's zone M.F.1 as zone M.F.2, etc. The divisions for the remainder of the Upper Footwall are the same in both schemes.

The Intermediate Reefs comprise narrow grit and small-pebble conglomerate bands intercalated with variable thicknesses of argillaceous, brownish-grey and siliceous, grey quartzite. The pebbles are poorly sorted. They consist, amongst others, of rounded and subangular quartz, subangular and tabular black chert, grey and green chert, irregularly shaped yellow metamorphosed shale and green quartzite. A few pebbles of silicified quartz-porphyry, red jasper and blue opalescent quartz have also been noticed. Some of the conglomerate bands contain a fair amount of pyrite. The gold tenor is very low, the concentration rarely exceeding 1 dwt. per ton. The reefs



<u>Fig.3.</u>

Diagrammatic profile of Upper Bird Reefs, from Merriespruit to Saaiplaas, O.F.S.

are, however, remarkable for their relatively high content of uranium-bearing minerals.

The quartzite near the top of zone U.F.4 is siliceous, the change upwards being gradational from the argillaceous, brownish-grey, gritty quartzite that predominates toward the base.

The grit beds of zones U.F.3 and U.F.2 are characterised by scattered black, angular granules of chert.

The quartzite of the Upper Footwall beds is variously speckled and siliceous. The details of each bed is presented on plate A and Table IV.

A variable thickness of Footwall Beds have been eroded prior to the deposition of the Basal Reef. In plate B, one can clearly see that the sediments overlie the Footwall beds disconformably.

B. <u>ZONES E.L.3 TO E.L.1 AND E.S.3 TO E.S.2</u>.

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

(1) <u>The Basal Reef(Zone E.L.3)</u>.

The Basal Reef and the quartzite between the Khaki Shale and the Basal Reef has been given the zone-symbol E.L.3 by Borchers and White (1943, p.143).

In the extreme south of the Orange Free State Gold-field the Basal Reef is a well-developed conglomerate of the type that would be classified by Pettijohn (1949, p.207) as oligomictic. It is characterized in this area by the rarity of carbon seams. From the Harmony Mine northwards the reef decreases in thickness and carbon seams become more prominent. The "carbon seam" type of reef is characteristic of the Saaiplaas mine. (See fig. 3).

The Basal Reef ranges in thickness from zero to more than ten feet. Where its maximum development is attained, the Basal Reef consists of several conglomerate bands separated by lenses of quartzite. The quartzite is similar in appearance and in bedding structures to the footwall quartzite, but the

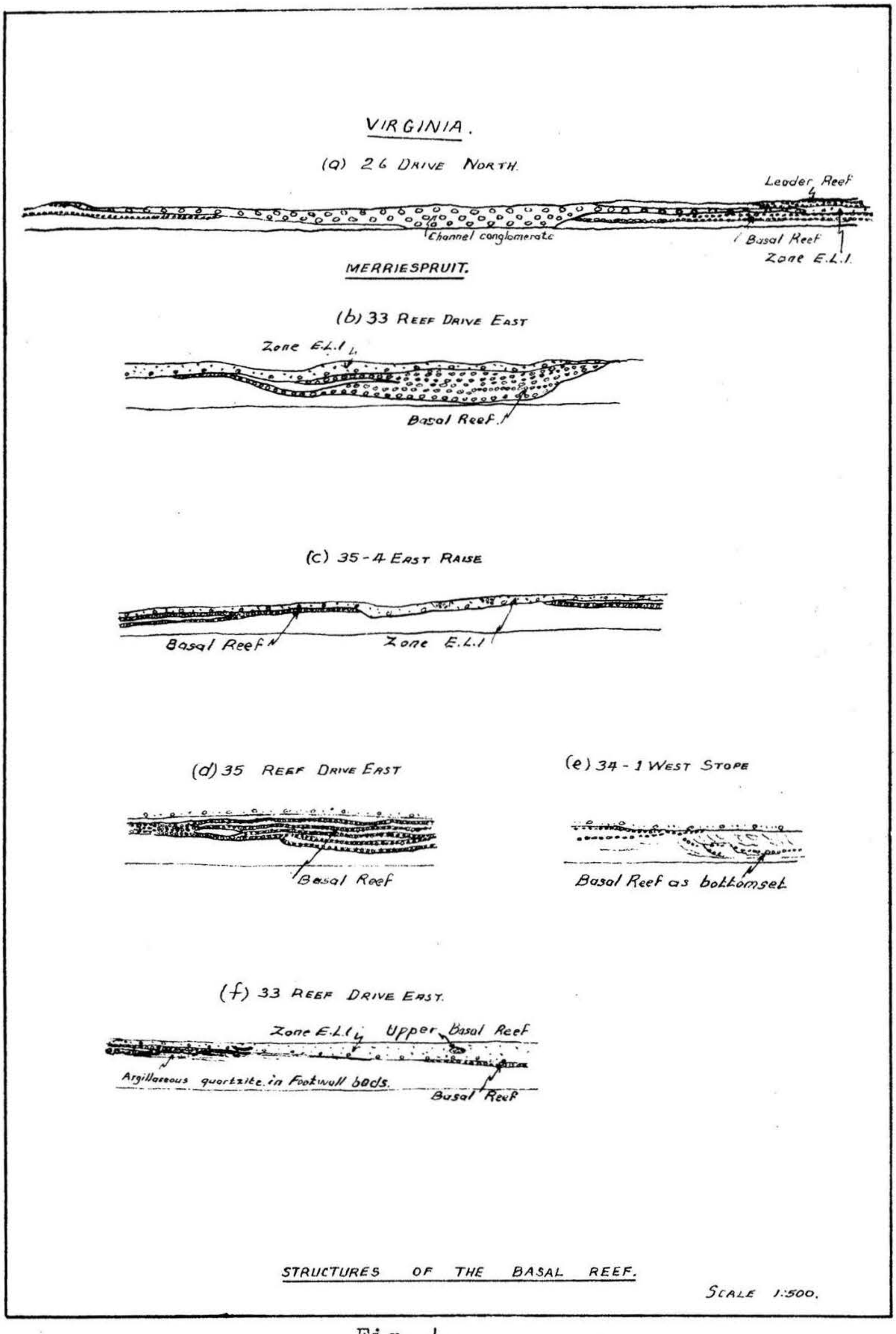


Fig. 4.

Sedimentary structures involving the Basal Reef.

beds with the Main Reef Group of conglomerates is fairly certain.

The of zone L.F.2 is formed by the small-pebble conglomerate beds of the Ada May Reef. The conglomerate consists mainly of quartz pebbles and some bands are well-mineralised. Individual bands are, however, less than a foot in thickness and alternate with quartzite. The conglomerate is not sharply demarcated from quartzite. In the Free State this conglomerate is not auriferous. The lower contact of zone L.F.2 is sharp, but there is no change in the characteristics of the quartzite below and between the beds of conglomerate. The even thickness of the Main Reef Footwall quartzite in the central Free State Gold-fields indicate that there is no disconformity at the base of the Ada May Reef. Bore-holes C.B.1 and E.X.1 to the east and south of Merriespruit Mine respectively, have intersected progressively smaller thicknesses of this quartzite. There is, therefore, fairly strong evidence that a disconformity exists near the margin of the basin of deposition at this horizon. This is not, however, accompanied by a change in the character of the Ada May Reef.

At about 25 feet from the ase of zone L.F.2 there are small-pebble conglomerates and coarse grits that contain a remarkable amount of silicified quartz-porphyry pebbles. The equivalent horizon in the Klerksdorp Area was not recognised by Sadie, but Baumbach (unpublished logs) described a comparable horizon in bore-hole T.L.6 on Klerksdorp Townlands as containing "igneous" pebbles.

At about 150 feet from the base of zone L.F.2, small-pebble conglomerates and coarse grits again occur, in which pebbles of chert are more abundant than any other pebble constituent. This bed, the Chert Marker, has been used as a key bed both in the Orange Free State and in the Klerksdorp Goldfields.

A similar cycle of sedimentation to that which produced the sequence of quartzite and grit up to the Chert Marker has been repeated in the sediments occurring towards the top of this zone.

Zone L.F.1 begins with thin grit and small-pebble conglomerate bands correlated with the Commonage Reef in the Klerksdorp Area. In the cores of the three bore-holes available, the Commonage Reef zone is no more prominent than any of the succeeding coarse members of zone L.F. 1. Pebbles of black chert are conspicious but although chert is a common pebble constituent, it is subordinate to quartz. These coarse constituents remain fairly similar in composition throughout zone L.F.1 except that a flinty chert becomes prominent high up in the succession (see plate A) and that the quartz pebbles are predominant in the uppermost small-pebble conglomerate beds.

The quartzite, although similar to that in zone L.F.2, is mainly coarse-grained and contains grains of chert in approximately the same proportion as in the grit members.

Grains and pebbles of red jasper occur in the core of borehole E.X.1 above the Commonage Reef and persist in the remainder of the Footwall beds.

(3) The Middle Footwall Beds. (Zones M.F.3,M.F.2 and M.F.1)

The Middle Footwall beds are the most difficult to subdivide as they contain thick accumulations of dull, somewhat argillaceous quartzite. Where they change into finer- or coarser-grained beds, the change is gradational. Two beds of very light-grey pure quartzite are the most easily recognisable. They have locally been called the Lower and Upper White bands.

The quartzite of zone M.F.3 is mainly dull and somewhat argillaceous, and terminate with the siliceous quartzite bed of the Lower White band.

The variations in the quartzite in Zone M.F.2 is greater than in zone M.F.3, there being alternations of dull,argillaceous and light, siliceous bands. Narrow lenticular beds of grit are also present. Grit bands about 175 feet from the base of zone M.F.2 have been correlated by Feringa with the Livingstone-Johnstone reefs. (Feringa 1954, p.14). Examination of detailed bore-hole logs reveals that the grit beds change in facies in an easterly direction to quartzite.(Plate B, bore-holes M.O.2, M.2, M.1 and C.A. 1). It is possible that this change also occurs in a southerly direction, because bore-hole W.N.1 has no grit bands in the relevant position.

The Upper White band forms the base of zone M.F.1 and is succeeded by coarse argillaceous quartzite. In some intersections this contact is sharp, but in many it is gradational. The same can be said of the contact of the argillaceous quartzite with the Intermediate Reefs.

(4) The Upper Footwall Beds (Zones U.F.4 to 1).

The Intermediate Reefs at the base are followed by quartzite containing layers of grit and then by speckled, siliceous quartzite.

The zonal subdivision employed by geologists of the Anglo-American Corporation in the Free State differs from that of Baumbach in that they class the Intermediate Reefs as zone M.F.1 and Baumbach's zone M.F.1 as zone M.F.2, etc. The divisions for the remainder of the Upper Footwall are the same in both schemes.

The Intermediate Reefs comprise narrow grit and small-pebble conglomerate bands intercalated with variable thicknesses of argillaceous, brownish-grey and siliceous, grey quartzite. The pebbles are poorly sorted. They consist, amongst others, of rounded and subangular quartz, subangular and tabular black chert, grey and green chert, irregularly shaped yellow metamorphosed shale and green quartzite. A few pebbles of silicified quartz-porphyry, red jasper and blue opalescent quartz have also been noticed. Some of the conglomerate bands contain a fair amount of pyrite. The gold tenor is very low, the concentration rarely exceeding 1 dwt. per ton. The reefs

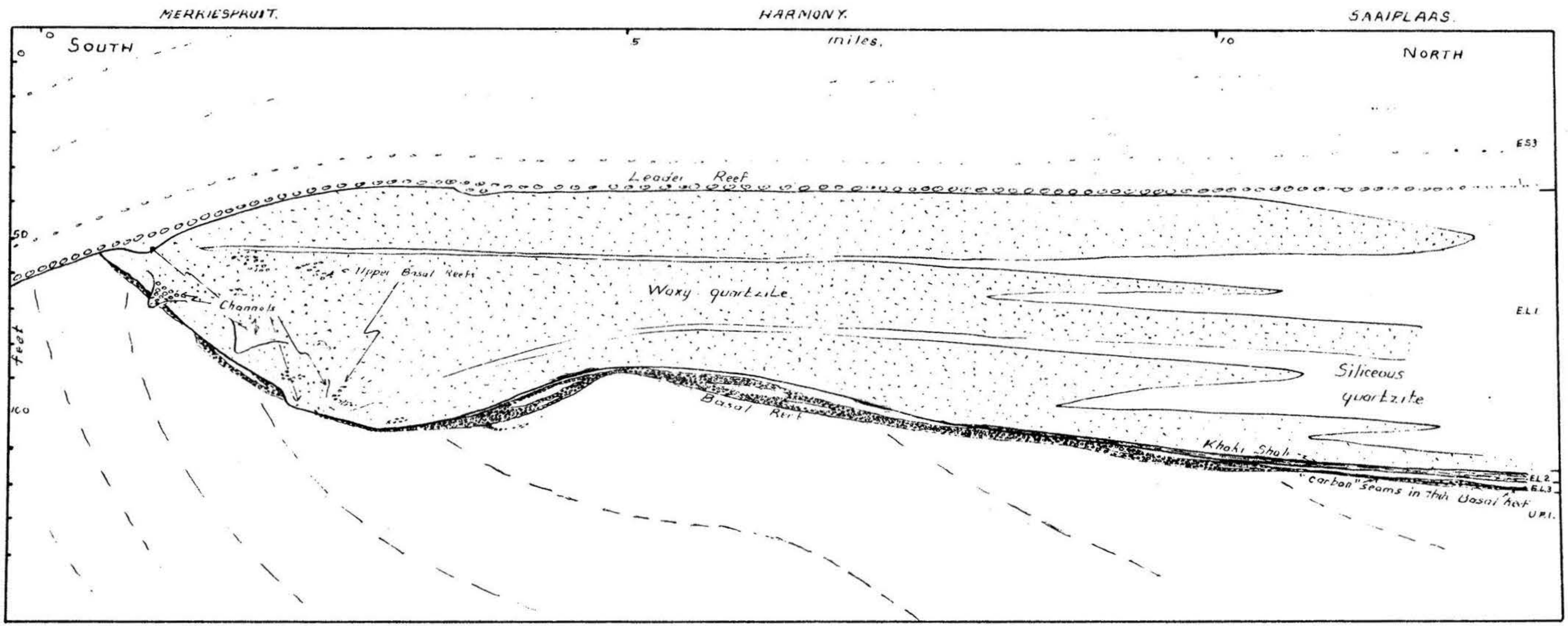


Fig.3.

Diagrammatic profile of Upper Bird Reefs, from Merriespruit to Saaiplaas, O.F.S.

are, however, remarkable for their relatively high content of uranium-bearing minerals.

The quartzite near the top of zone U.F.4 is siliceous, the change upwards being gradational from the argillaceous, brownish-grey, gritty quartzite that predominates toward the base.

The grit beds of zones U.F.3 and U.F.2 are characterised by scattered black, angular granules of chert.

The quartzite of the Upper Footwall beds is variously speckled and siliceous. The details of each bed is presented on plate A and Table IV.

A variable thickness of Footwall Beds have been eroded prior to the deposition of the Basal Reef. In plate B, one can clearly see that the sediments overlie the Footwall beds disconformably.

B. <u>ZONES E.L.3 TO E.L.1 AND E.S.3 TO E.S.2</u>.

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

(1) <u>The Basal Reef(Zone E.L.3)</u>.

The Basal Reef and the quartzite between the Khaki Shale and the Basal Reef has been given the zone-symbol E.L.3 by Borchers and White (1943, p.143).

In the extreme south of the Orange Free State Gold-field the Basal Reef is a well-developed conglomerate of the type that would be classified by Pettijohn (1949, p.207) as oligomictic. It is characterized in this area by the rarity of carbon seams. From the Harmony Mine northwards the reef decreases in thickness and carbon seams become more prominent. The "carbon seam" type of reef is characteristic of the Saaiplaas mine. (See fig. 3).

The Basal Reef ranges in thickness from zero to more than ten feet. Where its maximum development is attained, the Basal Reef consists of several conglomerate bands separated by lenses of quartzite. The quartzite is similar in appearance and in bedding structures to the footwall quartzite, but the