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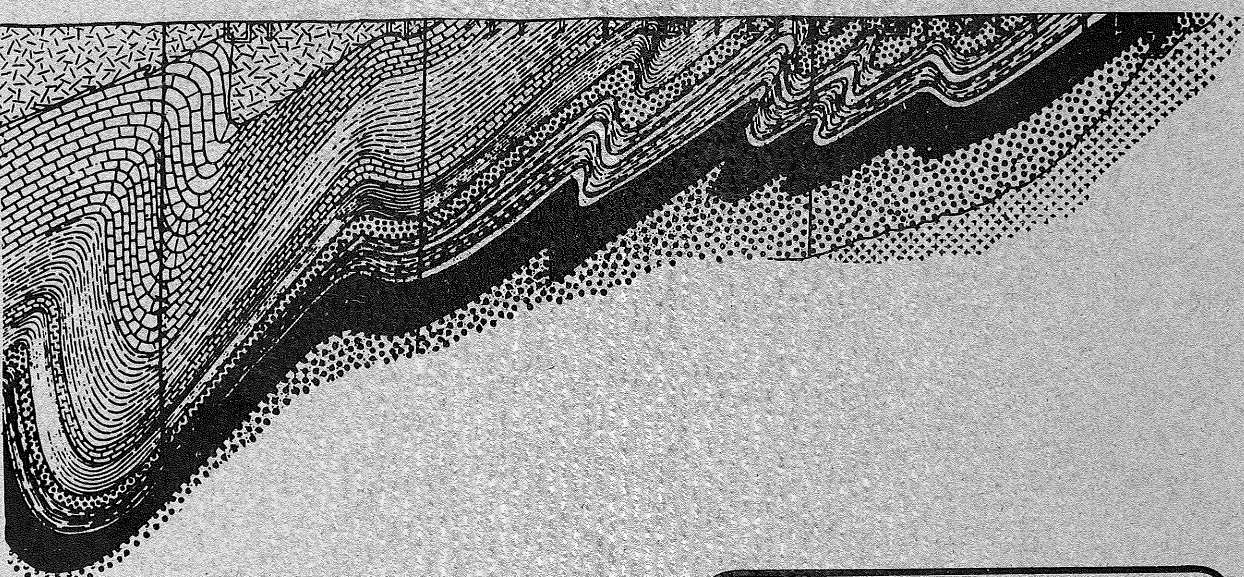

ECONOMIC GEOLOGY

RESEARCH UNIT

UNIVERSITY OF THE WITWATERSRAND

JOHANNESBURG

THE GEOLOGY OF THE VIRGINIA SECTION OF THE ORANGE FREE STATE GOLDFIELD

by

H. DE LA R. WINTER

Research Fellow

Economic Geology Research Unit

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ABSTRACT

The stratigraphy and structure of the Upper Division of the Witwatersrand System in the southernmost mines of the Orange Free State Goldfield are briefly outlined.

Several breaks in the succession are analysed with the aid of stratigraphical maps and are interpreted as disconformities associated with either a transverse swell in the sedimentary basin or with the southern extremity of the basin itself. Towards the east the Virginia Section borders against the limit of the basin furthest removed from the original geanticlinal area. The land on this side is assumed to have had a very low relief and to have contributed very little sedimentary material to the basin. The limits of the basin varied widely during Upper Witwatersrand times, being at their narrowest between Basal Reef time and the end of the Kimberley stage.

It is contended that most bankets were formed in a neritic environment, closely associated with marginal unconformities and disconformities, the surfaces of which were profiles of equilibrium. Close to these planes conditions favoured the concentration of heavy minerals and it is under these conditions that payable concentrations of gold and uraninite accumulated.

The geological history is described with the aid of a series of paleogeological block diagrams.

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THE GEOLOGY OF THE VIRGINIA SECTION OF THE ORANGE FREE STATE GOLDFIELD

INTRODUCTION

A. LOCATION

This Information Circular describes the geology of the Upper Division of the Witwatersrand System in the southern section of the Orange Free State Goldfield, where the mines occur around the town of Virginia.

The four mines, Free State Saaiplaas Gold Mining Company, Limited; Harmony Gold Mining Company, Limited; Merriespruit (O.F.S.) Gold Mining Company, Limited; and Virginia O.F.S. Gold Mining Company, Limited, at present form the southernmost limit of the Witwatersrand goldfield (fig. 1). The section is bounded on the west by the De Bron Fault. The area west of this fault is underlain by the Upper Division, but the low grade of the Basal Reef, the presence of major faults, the local great depth of reef, and the development of marginal unconformities, have not favoured the establishment of a mine immediately west of the fault. Further to the northwest are the mines of the Welkom section of the Orange Free State Goldfield.

Between Welkom and Virginia is a triangular horst block between the De Bron and Homestead faults. The Basal Reef horizon has been completely eroded from this block, except in some narrow strips of ground immediately adjacent to the Homestead Fault. Generally, beds of the Ventersdorp Sedimentary Stage (Coetzee, 1960, p. 88), formerly known as Ventersdorp Upper Sediments, lie directly on the Lower Division of the Witwatersrand System.

North of the mines, boreholes indicate that Basal Reef of moderate grade occurs at depths of the order of 6,000 feet below surface. To the east and south, the Reef Zone (which includes all or some of the following: Basal, Leader, "B", Big Pebble, "A", and the Gold Estates Leader) curves upwards to form a sub-outcrop against the Karroo System. Still further to the east, an area of the Upper Division known as the G.F. Block, is preserved on the downthrow side of the Virginia Fault.

B. GENERAL GEOLOGY

The Upper Division of the Witwatersrand System in this area takes the form of a plunging syncline. Because of the great thickness of competent, brittle quartzite involved, the fold is open and dips seldom exceed 20 degrees. The western limb is dislocated by the De Bron

Fault and eventually becomes the easterly-dipping portion of the Welkom area. Compared with other parts of the Orange Free State Goldfield, faulting is much less intense. Large, relatively unbroken blocks are bounded by a few faults of considerable throw. Adjustments to stresses within the fault-blocks were achieved by folding and minor faulting, the latter having displacements of the order of a few tens of feet. A major thrust fault strikes east-west across Merriespruit.

The Karroo System covers the entire area. It is thickest over the soft shales of the Ventersdorp Sedimentary Stage west of the De Bron Fault, where it fills a deep valley described by Cousins (1950, p. 239) as a glacial valley. The cover is thinnest over the Ventersdorp volcanics, which formed ridges in pre-Karroo times, and may be only 600 feet thick. Towards the Lower Witwatersrand sub-outcrops in the south-east the cover thickens to about 1,600 feet. The Dwyka Series fills the depressions and covers the deepest portions, but is absent on the pre-Karroo hills. The overlying sediments are somewhat attenuated over the buried hills, but far less so than the Dwyka Series. Where the Karroo is thicker than about 1,000 feet, coal occurs in the Ecca Series. A thin cover of Beaufort sandstone occurs at the surface. Sills of Karroo dolerite outcrop in several places. One, of Blaauwkrans-type (Walker and Poldervaart, 1949, p. 615-616), is found on surface at the Harmony and Virginia mines and another, of Perdekloof-type, forms a small koppie on the eastern portion of Merriespruit.

From the duplications of the Ventersdorp Lower Lava (now Lower Volcanic Stage) in boreholes MU.1, RU.1 and MO.2, it can be deduced that major faulting took place after the extrusion of at least 2,000 feet of lava. Borchers (1950 pp. 75-77) proved that there is a major unconformity between the Lower Volcanic Stage and the Sedimentary Stage. The Sedimentary Stage (formerly known as Ventersdorp Upper Sediments and abbreviated to V.U.S.) consists of massive conglomerates, containing many pebbles of lava some of which are of porphyritic varieties, dark grey quartzites, dark shales and agglomerates, the two last-mentioned being more abundant west of the De Bron Fault, where the trough is filled with these sediments (fig. 2, section AA). The Upper Volcanic Stage, up to 900 feet thick, overlies the Sedimentary Stage on Saaiplaas and the north-western part of Harmony, and consists of green-grey amygdaloidal lava similar to that of the Lower Volcanic Stage.

The Upper Division of the Witwatersrand System thins out to the south and east. The reduction is effected mainly by a series of disconformities and marginal unconformities, confined to the interval between the Basal Reef and the base of the Elsburg Stage. Sediments generally tend to be of finer grain-size in a northeasterly direction. A linear channel, about 5,000 feet wide, was scoured out of unconsolidated sediments in late Kimberley time and was filled with pebbly, sandy and muddy deposits. The trend of the channel is east-west across Merriespruit and its effect can be seen in fig. 1, where it cuts out the Leader Reef north of the thrust fault. The Leader Reef overlaps the Basal Reef in the Saaiplaas, Virginia and Merriespruit mines to form, locally, a composite conglomerate known as the Leader-Basal Reef. As this is a facies of the transgressing Leader Reef, the latter term will normally be used to describe the conglomerate occurring south and east of the Basal Reef sub-outcrop.

Sediments of the Main-Bird series have been intersected south and east of the mines, and also in the triangular horst near the Homestead Fault. The equivalent of the Main Reef Zone consists of barren, small-pebble conglomerates. The succession bears a striking resemblance to that of the Klerksdorp area.

Still further south and east, boreholes have penetrated the Lower Division as far as the Government Reef Series tillite. The Jeppestown Amygdaloid is about 280 feet thick (Winter, 1957, Pl. J), but appears to increase to 520 feet twelve miles southwest of Merriespruit (borehole EX.1 on the farm Excelsior 866).

UPPER DIVISION OF THE WITWATERSRAND SYSTEM

A. SUCCESSION

The succession in this section of the field is summarized in the generalized geological column (fig. 13) which was originally drawn up for the Virginia and Merriespruit mines (Winter, 1957, Pl. A). Coetzee (1960, pp. 29-30 folder 3), in his suggested correlation for the O.F.S. Goldfield, has accepted the subdivision of the Kimberley-Elsburg Series, and of the Main-Bird Series, taking the boundary between the Main Stage and the Bird Stage as the Upper Footwall Beds. On Harmony Mine, extra subdivisions near the Basal Reef, Zones EL. 3 and 4, are recognised, and will be described later. The Upper Shale Marker on Free State Saaiplaas reaches a thickness of 100 feet in the northwestern part of the mine.

The geological column is shorter than the one published by Borchers and White (1943, p. 134, fig. 1) for the Welkom area. The shortening can be attributed partly to the thinning out of sediments away from the axis of the sedimentary basin and the source area, and partly to unconformities. Because of the complications introduced by unconformities, the column (fig. 13) represents the most complete section available for this portion of the field, and shows the maximum thicknesses attained on the common boundaries between Harmony, Merriespruit and Virginia.

Borchers and White did not subdivide the Footwall Beds, to which they referred as Zone EF.1. The zone-symbols used in this study for the Footwall Beds have been adopted from a widely-known, but unpublished column, by G.W.S. Baumbach. Coetzee in his memoir on the geology of the Orange Free State Goldfield (1960, pp. 42-44), has accepted this subdivision by including the Intermediate Reefs into the Upper Footwall Beds. The scheme for the Footwall Beds, used by the Anglo-American Corporation of South Africa, Limited, in the Free State, is based on an earlier column drawn up by Baumbach, and modified when data became available from underground exploration. His two schemes, therefore, have both come into use, the earlier one in the Odendaalsrus-Welkom area, and his revised scheme in the Virginia area. Both are shown on the generalised geological column (fig. 13).

A generalized geological column of the O.F.S. Goldfield was compiled, in 1960, by geologists of all the mines and submitted to the Third Annual Congress of the Geological Society of South Africa. For this column, the scheme applied to the mines in the Odendaalsrus-Welkom area was adopted.

B. LITHOLOGY

A condensed summary of detailed lithological descriptions, given in a thesis on the Virginia and Merriespruit Mines (Winter, 1957, pp. 16-49), follows below. To illustrate variations in the composition of the matrix in the different beds, as determined from thin sections, symbols were devised and placed in a column opposite the relevant horizon (fig. 13). The distribution of chloritoid, especially, is of interest as it is apparently restricted to particular beds, and may prove, with further work, to be a useful index mineral for regional correlation.

	Thickness in Feet
(a) Footwall Beds	3440
(i) Green Quartzites	530
Unit 1: quartzite, green, fine-grained, evenly sorted; equivalent to "Red Bar" of Central Rand; microscopic: grains mainly quartz in matrix of chlorite and some sericite;	60

Thickness in Feet

plagioclase (albite-oligoclase), rounded and fractured (only occurrence in Upper Division, but Lower Division has felspar at several horizons, Borchers, 1950, pp. 47, 112); in matrix, epidote is unique, could be cause of green colour; ragged grains of pyrite; no rutile; some biotite, mainly altered to chlorite; secondary carbonate; gradational change from Jeppestown shale through a variable thickness of alternating beds to quartzite.

Unit 2: quartzite, interbedded green and white; grain size slightly larger for pure white bands. 200

Unit 3: quartzite, light-coloured bands abundant, almost pure quartzite towards top. 110

Unit 4: quartzite, light grey, green tinge disappears upwards; medium-grained; contains small black chert and yellow sericite grains; some blue opalescent quartz grains; thin beds of argillaceous quartzite on bedding-planes and noticeable cross-bedding (almost all quartzites of the Upper Division have these latter features; narrow pyritic stringers accentuate the current-bedded structure; sericite becomes more abundant and rutile is present; pyritic stringers also occur in almost all quartzites, never cutting across sedimentary features; many of the grains are rounded, those in conglomerate bands larger than those in quartzite; constituents of stringers in order of abundance are: pyrite, ilmenite, leucoxene, rutile, chromite, zircon and, possibly, magnetite); narrow pyritic grit bands in upper 100 feet; near top, quartzite is indistinguishable from overlying types. 160

(ii) The Lower Footwall Beds 800

Chloritoid is present in most thin sections and chloritic minerals are more abundant than sericitic minerals.

1. Zone LF.2. 340

Groups of small-pebble conglomerate and grit in quartzite of various shades of grey, reflecting amount of impurities in quartzite, are the dominant rock-types present.

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	Thickness in Feet
Unit 1: small-pebble conglomerate bands; no sharp contacts except at base; pebbles mainly of quartz; pyrite fairly abundant in some conglomerate bands; negligible gold.	20
Unit 2: quartzite, fairly pure, almost white.	5
Unit 3: zone of small-pebble conglomerate bands containing abundant quartz porphyry or silicified lava pebbles; not known in Klerksdorp area, but Baumbach recognised this unit on Klerksdorp Townlands (borehole TL.6)	15
Unit 4: quartzite, light grey, containing dull grey, somewhat argillaceous, phases near the base and at the top; some coarse-grained beds.	105
Unit 5: quartzite, dull shaly.	5
Unit 6: Chert Marker: small-pebble conglomerate and grit gands; pebbles of chert more abundant than any other constituent; a key bed both in the Orange Free State and the Klerksdorp fields.	20
Unit 7: quartzite, grey, siliceous, gritty, especially towards top.	85
Unit 8: quartzite, grey, fine-grained argillaceous	15
Unit 9: quartzite, grey, light grey band near top, followed by dull, dark grey quartzite; grains of quartz, with tiny black and green rock fragments.	70
2. Zone LF.1	460
Unit 1: Commonage Reef Horizon: grit bands, coarse-grained, some pebble-washes; pebbles of quartz and black chert predominant; poorly mineralised.	20
Unit 2: quartzite, dark grey.	50
Unit 3: grit, resembling Unit 1	25
Unit 4: quartzite, light grey, gritty, contains dull bands.	180

	Thickness in Feet
Unit 5: grit, granules of chert and flint, weathering to a porcelain-white colour; some bands are mineralised.	25
Unit 6: quartzite, light grey, gritty.	60
Unit 7: grit, occasional small pebble-washes; quartz pebbles much more abundant than chert.	100
(iii) Middle Footwall Beds	1425
1. Zone MF.3	782
Unit 1: quartzite, dull, grey, faint black speckling, alternating medium- and coarse-grained, somewhat argillaceous; near top of zone, dull and argillaceous, gritty at top.	702
Unit 2: Lower White Band: quartzite, pure quartzose matrix; very rare black specks of chert and concentrations of chlorite.	80
2. Zone MF.2	453
Unit 1: quartzite, dull, grey, coarse-grained, gritty at base.	90
Unit 2: quartzite, streaky, dull, alternating with siliceous variety.	85
Unit 3. quartzite, dull, grey, coarse-grained; grits at base containing small quartz and chert pebbles (correlated by Feringa, 1954 p. 14, as Livingstone-Johnstone Reefs horizon; more likely Johnstone Reefs horizon, with Intermediate Reefs at the Livingstone Reefs horizon, Baumbach, 1962, personal communication); grits change to quartzite eastwards and southwards; very coarse phase near centre; more quartzose upwards.	278
3. Zone MF.1	190
Unit 1: Upper White Band: quartzite, pure, quartzose matrix.	35

	Thickness in Feet
Unit 2: quartzite, dull, dark grey and brown-grey, medium- and coarse-grained, argillaceous, speckled; sericite somewhat more abundant in matrix than in underlying quartzite; siliceous bands near base; grain-size increases upwards; narrow grit bands near top; gradational changes.	155
(iv) Upper Footwall Beds	685
1. Zone UF.4	75
Unit 1: Intermediate Reefs: narrow grit and small-pebble conglomerate bands alternating with brownish-grey argillaceous and siliceous quartzite; pebbles of poorly sorted, rounded and subangular quartz, subangular and tabular black chert, grey and green chert, irregularly shaped yellow silicified shale, green quartzite; rare pebbles of silicified quartz porphyry or lava, red jasper, blue opalescent quartz; pyrite sparse; gold tenor low; uraninite content relatively high; quartzite near top mainly siliceous.	
2. Lower Zone UF.3	100
Unit 1: quartzite, slightly argillaceous, medium-grained, speckled.	20
Unit 2: grit; conspicuous dark angular chert granules, loosely packed in siliceous quartzite.	24
Unit 3: quartzite, light grey, siliceous.	10
Unit 4: quartzite, speckled, slightly argillaceous	18
Unit 5: quartzite, very coarse, slightly argillaceous	28
3. Upper Zone UF.3	53
Unit 1: quartzite, light grey, some grey and yellow-grey bands; very thin quartzose grit beds.	

	Thickness in Feet
4. Lower Zone UF.2	200
Unit 1: quartzite, yellow-grey, coarse-grained, argillaceous	27
Unit 2: quartzite, pure, light grey, fine-grained, followed by medium-grained grey quartzite containing dark, argillaceous bands; narrow bands of grit composed of quartz and black chert granules.	178
5. Upper Zone UF.2	70
Unit 1: quartzite, dull, yellow, argillaceous, fine- to medium-grained; contains small colourful rock fragments; black, yellow and green conspicuous.	
6. Zone UF.1	180
Unit 1: quartzite, siliceous, fine- to medium-grained; tiny black fragments; subordinate dull, grey quartzite, slightly more impure; matrix mainly of sericite and chlorite between well-compacted grains of quartz.	95
Unit 2: quartzite, as above, gritty.	15
Unit 3: quartzite, grey, dark bands; medium- to coarse-grained; scattered grains of black chert and yellow silicified shale.	70
(b) <u>Basal Reef to Zone ES.2</u>.	335
(i) Basal Reef, and Accompanying Quartzite	10

Pebbles mainly of milky, clear, smoky-grey and black quartz, many dark-rimmed, some blue opalescent; diameter smaller than 2 inches, rounded and well packed, in quartzitic matrix; chert and other rarer pebble types occur, especially towards the top in some areas; largest pebbles mostly near base, most compact locally towards top; pyrite abundant, rounded; carbon seams rare; lenticules of quartzite resembling UF.1 types split conglomerate into bands;

	Thickness in Feet
reef usually overlain by quartzite similar to Zone UF.1.	
(ii) Zone EL.2	
Khaki Shale: shale, small isolated lenses; disconformable on Basal Reef zone.	5"
(iii) Zone EL.1	77'
bounded by unconformities at both contacts; quartzite, yellow to brown-grey, peculiar "waxy" lustre due to reflecting surfaces of quartz grains in a dull matrix; isolated rounded pebbles; poorly bedded, no cross-bedding; contains lenticular, highly irregular pebble washes, some containing much gold; patches and narrow beds of pure quartzite; sericite, rutile and zircon common in matrix.	
(iv) Zone ES.3	
Leader Reef at base; quartz and subordinate chert pebbles; sharp lower contact, more gradational upper contact followed by rhythmic succession of small-pebble and grit bands in alternating light grey quartzite and yellowish grey, speckled, bedded quartzite; the upper conglomerate bands not sharply defined from the remaining quartzite; pebble-bands abundant 20 feet above base of zone, and near the top; angular, black chert granules prominant.	45
(v) Zone ES.2	
quartzite, dirty, yellow-grey speckled, somewhat argillaceous; lenticular pebble bands; pebbles of different rock-types, including quartz, chert, jasper, quartzite, silicified shale, hornfels and lava; pebble bands occur more frequently (about 100 feet above the base) than elsewhere; near top, discoidal pebbles of yellow sericitised shale are abundant.	
Total thickness of Main-Bird Series:	3775

	Thickness in Feet
(c) The Kimberley Stage	173
Characterized by impure yellow-grey quartzite; abundant sericitic minerals in matrix; numerous comglomerate beds; a number of disconformities and deposits of flood-plain, fluvial and estuarine environments also of importance.	
(i) Zone ES.1	
Upper Shale Marker: shale, arenaceous to phyllitic, alternating with quartzite, argillaceous, very fine-grained, highly sericitic; quartzite bed 15 to 30 feet thick separates two shale beds in Free State Saaiplaas.	10
(ii) Lower Kimberley Substage	110
1. Zone LK.3	
quartzite; sericitic, lenticular polymictic conglomerate and grit beds, the most robust being the "B" Reef at the base; bright yellow shale pebbles abundant; "B" Reef has an unconformity at base, is oligomictic and contains abundant rounded pyrite only in the gold-bearing areas; prominent conglomerate bands also about 30 feet from base and near top.	60
2. Zone LK.2	30
quartzite, highly sericitic, yellow, coarse-grained, polymictic rock fragments; individual grains separated and corroded by sericitic minerals.	
3. Zone LK.1	20
quartzite, yellow-grey, somewhat sericitic, containing colourful rock fragments; Lenticular polymictic conglomerates near base.	

Thickness in Feet

(iii) Middle Kimberley Substage 28

All zones rarely encountered in one area, due to affect of disconformities; pebble bands of oligomictic type; thicknesses highly variable.

1. Zone MK.4

Big Pebble Reef: pebbles 1 to 4 inches in diameter, chiefly of milky quartz, flint and dark chert, in a light grey siliceous quartzite, containing coloured fragments; several bands of quartzite may alternate with conglomerate, and quartzite may occur between disconformity at base and conglomerate; gold occurs in rare, isolated patches containing pyrite.

2. Zone MK.3

quartzite, sericitic, yellow-grey, contains some black chert and yellow silicified shale grains; narrow conglomerate lenses.

3. Zone MK.2

conglomerate bands containing pebbles averaging 2 inches in diameter in slightly argillaceous, speckled quartzite; some bands fairly well mineralised.

4. Zone MK.1

quartzite, grey, medium-grained; very slight yellow tinge; evenly scattered grains of black chert and yellow shale in quartzite; contains thin bands of siliceous quartzite and lenses of loosely-packed large-pebble conglomerate.

(iv) Upper Kimberley Substage 25

1. Zone UK.3

"A" Reef: well-rounded quartz pebbles, averaging

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Thickness in Feet

½" diameter, and some black chert pebbles in yellow-grey, somewhat sericitic quartzite; pebbles coated with sericite; abundant rounded pyrite, about 1/32 inch diameter, and disseminated carbon; gold content sporadic.

2. Zone UK.2

quartzite, light grey, tinged yellow by sericite, coloured specks evenly distributed; sparsely scattered large granules.

3. Zone UK.1

conglomerate, small quartz and chert pebbles, loosely packed in quartzite of Zone UK.2 type.

(v) Channel Deposits of Late Kimberley Age — 0 to 245

lenticular channel-shaped bodies of oligomictic conglomerate, siliceous quartzite, flaggy dark grey shale and siltstone; some unusual combinations such as cobbles embedded in shale and shaly quartzite; shale mainly in upper portion.

(d) <u>Elsburg Stage</u> — 1262

Quartzite generally grey; argillaceous material dark grey to black; chloritic minerals more abundant than sericitic minerals; bedding-planes well-defined; ripple marks and cross-bedding present.

(i) Zone VS.5

conglomerate separated by dark grey argillaceous quartzite or light grey siliceous quartzite bands; pebbles of quartz, mainly milky-white, quartzite, dark grey chert, pale yellow shale, hornfels and bleached lava; range in size from grit to cobbles; subangular to subrounded, poorly sorted, loosely packed; at base, a lenticular — 15

Thickness in Feet

development of Gold Estates Leader, a quartz-pebble conglomerate; quartz mainly colourless, smoky and rimmed; well-mineralized; pyrite less than 1/8 inch in diameter; lower contact sharp and distinct; locally has an economic gold content.

(ii) Zone VS.4 — 42

quartzite fine-grained, grey, siliceous, very tough, breaking with a subconchoidal fracture; in thin section, quartz grains interlocking and secondary quartz developed in occasional openings (this is the equivalent of Denny's White Quartzite of the Klerksdorp Goldfield); in MU.1 and SM.1 grit bands occur a few feet above Zone VS.5; stylolitic contacts on bedding-planes a feature.

(iii) Zone VS.2/3 — 495

quartzite medium-grained, containing variable amounts of chloritic material; grey, somewhat darker generally towards upper half; equivalent of Zone VS.2 in the type area around Welkom is dark grey slightly argillaceous quartzite; in borehole ZV.1 a quartz grit is developed at the base.

(iv) Zone VS.1 — 710

alternate beds of VS.2/3-type quartzite and subgreywacke; grain size ranges from fine-grained to conglomerate; pebbles up to one inch in diameter; conglomerate and grit bands disappear about 145 feet below the VS.1 conglomerate; subgreywacke can be described as a sedimentary rock containing poorly rounded quartz grains embedded in a chloritic and sericitic matrix and containing numerous small fragments of shale, hornfels, basic lava, chert and other materials; matrix also contains black dust; VS.1 Conglomerate: 10 feet; rudaceous equivalent of subgreywacke; sparsely mineralised; possibly equivalent of Ventersdorp Contact Reef; locally a few feet of quartzite developed between conglomerate and lava; quartzite has tuffaceous appearance but vitreous shards lacking, possibly as result of devitrification.

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C. STRUCTURE

The reefs on these mines generally dip less than 10 degrees and are located on the flanks of a very broad, plunging syncline (figs. 1 and 2). The syncline is cut by major faults and a few of lesser magnitude. Folding and faulting are intimately associated, the latter often following after the former.

(a) Folding

The broad syncline is cut immediately west of its north-plunging axis by the De Bron Fault. Dips close to the axis are very gentle, being mostly less than 5 degrees. Towards the sub-outcrop the dips increase to about 15 degrees. The folding is, therefore, merely an accentuation of the warping of the basin whilst it was receiving sediments.

The thickness of the Lower Volcanic Stage increases from about 1300 to 1800 feet in the direction of the plunge of the fold. As most of the increase in thickness of the Ventersdorp succession, i.e. from 500 to 2000 feet, is taken up by the Sedimentary Stage, it is concluded that the northward plunge was imposed on the syncline mainly at the time the Ventersdorp sediments were deposited.

A major anticlinal fold with an east-west axis was intersected in boreholes MU.1 and SE.3. The folding is of concentric-type involving great thicknesses of quartzite, with the result that relief of pressure in the core was effected by thrusting, and the Merriespruit Thrust Fault was formed. The mechanism of this type of structure is described in detail by De Sitter (1956, pp. 239-246). It is considered that this fold was structurally controlled by the rapid thinning out of the Upper Witwatersrand beds southwards in this vicinity, which would have brought the basement closer to surface, thus causing it to act as a resistant block to pressure from the north.

Borehole MO.3 penetrated a steep, faulted monoclinal structure (fig. 3). This structure has an appearance similar to the drag folding associated with the overlap of the Merriespruit Thrust Fault. Considering the displacement of a channel of Kimberley age, and the position of the limit of the Basal Reef, a northward dextral shift of 9,000 feet can be postulated along the De Bron Fault. If the Merriespruit Thrust is moved northwards by about 9,000 feet, the monoclinal structure of borehole MO.3 can be interpreted as the steep limb of the fold. The Leader Reef at 4,911 feet and the Basal Reef horizon some 40 feet lower down dip at about 50 degrees towards a fault at 4,980 feet, which is considered to be the thrust fault. Almost vertical, folded beds occur below the fault, with the result that the VS.5 conglomerate and the Big Pebble Reef are repeated several times in the core up to the point where the dip flattens out below 6,000 feet and the Leader Reef is intersected at 6,138 feet, followed by the Basal Reef horizon at 6,174 feet. The apparent dip of the Footwall Beds near the bottom of the hole is 26 degrees.

To account for the depth of the Leader Reef in borehole MO.2, it is necessary to increase the throw of the 650-feet normal fault intersected in borehole MU.3, and to shift this fault 9,000 feet northwards, west of the De Bron Fault. It then coincides with two normal faults at 4,540 and 4,900 feet in borehole MO.3 which have a combined throw of 1,600 feet. In the upper diagram of fig. 3, the MU.3- normal faults have been restored in order to illustrate the resemblance of the pre-normal fault structure to the Merriespruit Thrust as it appears in fig. 2, section BB. A reverse fault, duplicating the Ventersdorp Lower Volcanic Stage at 4,560 feet in borehole MO.3, is considered to be the shifted continuation of the reverse fault of borehole KA.2.

At Merriespruit No. 1 Shaft a monoclinal fold occurs which trends N 40° W. Although of considerable importance in the interpretation of the structure in the vicinity of this shaft, the feature is too small to be shown on fig. 1, but the sharp curve of the -5,000 feet contour is a consequence of this monocline. The continuation of this fold could explain the steeply dipping section of Zone VS.1 in borehole SE.3.

A peculiar zone of disturbance trends N 25° W through Virginia No. 2 shaft. It consists of irregular tight folds and numerous small faults. Such structures have been described by Anderson (1951, pp. 64-71) as being similar to wrench faults in their relation to the stress field. The superimposed monoclinal fold at Merriespruit No. 1 Shaft has a parallel trend, and may be the result of the same force.

An east-west anticlinal warp can be followed across Harmony mine, from borehole LR.4 to borehole H.3. A dyke is intruded along its axial plane.

(b) Faulting

The most prominent fault in this area is the De Bron Fault, which forms the eastern boundary of the central section of the goldfield, and strikes almost north-south near the western boundaries of Harmony and Merriespruit mines. It dips 65° to the west, and from five intersections at Merriespruit, can be proved to have a slightly sinuous strike. The strata within 1,500 feet of the fault at Merriespruit No. 1 Shaft change slightly in strike, showing that some folding accompanied the faulting. The strata curve downward in a sharp drag in the five feet adjacent to the fault-plane. The fault-plane is occupied by a dyke. Within about 1,500 feet of the fault, argillaceous sediments have been altered from yellow-brown to dark grey.

A most striking feature of this fault is its dextral shift of 9,000 feet. Mention has been made of the manner in which it has affected the positions of all the older geological features, both structural and sedimentational. As a result of this horizontal shift, the vertical displacement on the fault varies rapidly along its length. The greater part of the movement on the De Bron Fault took place during V.U.S. time. Abnormally great thicknesses of agglomerate, tuff, greywacke and quartzite accumulated in the trough.

The Homestead Fault strikes N 15° E and meets the De Bron Fault near the common western corner of Free State Saaiplaas and Harmony. It is significant that a kimberlite pipe, the Kaalvallei Diamond Mine, is situated on this structural weak-spot. The Homestead Fault passes between boreholes HS.3 and HS.2. Coetzee (1960, pp. 124-125 and Map 2) presents evidence for the existence of two parallel downthrow faults, intersected in boreholes DA.1 and DNK.2 just north of this section, and also for a reverse fault at 2,478 feet in borehole SAP.3, which duplicates the Upper Volcanic Stage. He concludes that the horst between the Homestead Fault and the De Bron Fault first moved upwards and later downwards, and points out that reverse faults also occur with the De Bron Fault where it bounds the horst.

A normal fault with a downthrow to the south of 650 feet cuts through borehole MU.3 at 3,096 feet. This fault is considered to pre-date the De Bron Fault and to have been intersected again in borehole MO.3, where it occurs as two parallel fractures. The Reef zone south-east of the MU.3-Fault consequently occurs south of the mining area and is displaced still further southwards in the block west of the De Bron Fault.

A reverse fault, which duplicates the Intermediate Reefs in the intersection of borehole KA.2, is probably related to the deformation of the Merriespruit Thrust, in an association reminiscent of reverse faults in over-thrust blocks in the Scottish Highlands. The fault shown between boreholes SE.1 and SE.3 is similar to that of KA.2, and explains the shallower intersection of the Intermediate Reefs in borehole M.2 compared with borehole SE.2. Another such fault duplicates the "B" Reef in borehole SE.3. A normal fault, with a downthrow of about 350 feet to the west, was encountered in underground development between No. 2 and No. 3 Shafts of Virginia Mine. This fault has now been correlated with one occurring at the boundary between Virginia and Merriespruit mines. At Virginia No. 2 Shaft, a dyke occurs in the fault-plane.

A normal fault is placed between boreholes M.3 and M.4, to account for the displacement of the sub-outcrop position west of the latter borehole. North of Harmony No. 2 Shaft a fault containing a dyke strikes N 60° E and has a downthrow to the northwest.

There is a duplication of the Lower Volcanic Stage in borehole RU.1. A reverse fault to account for this would have to strike east-west and pass south of the borehole. An east-west fault, near the boundary, with a downthrow to the north of some 300 feet would account for most of the facts, but faults of this nature have not yet been encountered in this portion of the field. The reverse fault is, therefore, assumed to die out at depth. An alternative solution to the structure between Harmony and Saaiplaas mines is presented in fig. 1.

Near No. 2 Shaft of Free State Saaiplaas, a normal fault with a downthrow of 200 to 250 feet to the south-east strikes S 35° W. It appears to continue into Harmony, curving slightly westwards. Borehole WLD.3 is considered to be situated to the east of this fault, on the basis of the thickness of the Lower Volcanic Stage. A succession of step faults, striking N 10° E and with displacements not exceeding 200 feet, forms the other flank of a triangular graben between the two shafts on Saaiplaas. These faults do not continue into Harmony. When thicknesses of the Lower Volcanic Stage, and the contours of the lower contact are considered, it would appear that borehole DS.2 is situated immediately west of a N 35° W normal fault, and that this could be responsible for the relatively high intersection of reef in borehole LR.2.

A reverse fault duplicates the 'A' Reef in borehole SSD.1, in the northern section of Free State Saaiplaas. It is considered to strike east-west, with a downthrow of some 350 feet to the south, and may possibly be related to the reverse faults of Merriespruit.

(c) Age Relationships

The warping of the broad north-south syncline appears to be the oldest structural feature, followed by folding, thrusting, and reverse faulting of the Merriespruit Thrust-type. The fault through borehole MU.3 is early, pre-dating the De Bron Fault, which underwent its main normal displacement in Ventersdorp Sediments' time. Small-scale features and the intrusion of a dyke in the fault-plane indicate that the horizontal movement on the De Bron Fault is earlier than the vertical movement. Reversed movements only occurred against the De Bron - Homestead horst.

The dating of the Homestead Fault, with respect to the De Bron Fault is difficult. There is a wedge of coarse conglomerate of the Sedimentary Stage on its southeastern block, which indicates contemporaneity with the normal phase of the De Bron Fault. The base of the Upper Volcanic Stage in the southeast block (SAP.4) is at a borehole depth of 1,812 feet, and, in the northwest block on the horst (SAP.3), only about 3,000 feet away, is at a borehole depth of 2,349 feet, showing that the reverse movement was dominant after the emplacement of the Upper Volcanic Stage, which also tends to thicken towards the horst.

Thus, the difference in the ages of the two major faults cannot be very great. However, it cannot be proved that the Homestead Fault occurs west of the De Bron Fault, and if so, whether it has been displaced northwards. Two recent (1960) boreholes on the farm Video 305 have intersected the Basal Reef at depths of the order of 8,000 feet below surface (Coetzee, 1960, Map 2). It is possible that the Homestead Fault occurs between boreholes KP.5 and V.1 in the north, and also between VK.3 and VK.1, if it is displaced northwards on the De Bron Fault, an interpretation which may cast doubt on the relative ages of the horizontal and vertical movements on the latter fault.

D. INTRUSIVES

Intrusives are important in this section of the field because water-bearing fissures may be associated with the older type of dyke, especially those trending east-west, and because inclined sheets, where they cut through the reef, cause considerable disruption of the normal development pattern in this flat-dipping area.

The oldest dykes trend in the direction W 20° N. They are dense, completely chloritised, steeply-dipping dykes with sheared contacts. Some have relict igneous textures, which differ from dyke to dyke, and which may be used for their identification. They are displaced by faults sympathetic to the Homestead Fault. They may be related to the earliest episode of folding.

A dyke trending parallel to a fault sympathetic to the Homestead Fault, near Saaiplaas No. 2 Shaft, appears to displace the N 10° E antithetic faults, which makes the faults older than the dyke. A dyke trending N 15° W from borehole H.1 to borehole LR.6, parallels the De Bron Fault, whereas one striking about E 20° N from Harmony No. 2 Shaft is parallel to the "ilmenite diabase" dyke (not shown in fig. 1) near Virginia No. 1 Shaft, and to the fault at the boundary of Virginia and Merriespruit mines. They seem to be of different ages, but are intensely altered, the E 20° N type cutting through a completely altered sheet near Virginia No. 1 Shaft, and being possibly the youngest of these structures.

The frequency with which the dykes parallel major faults, their steep dips and their slight differences in age, suggest that they are dykes intruded into the tensional planes of the stress systems which produced these faults (Anderson, 1951, pp. 23-26).

An extensive sheet, about 200' - 250' thick, cuts through Basal Reef to the north of the present workings on Saaiplaas. This sill is split into two sections in the area of borehole DS.2. One of the antithetic faults mentioned above displaces this intrusive. Intrusions of similar general strike and dip are found in the Merriespruit No. 1 Shaft area. They are of different ages, since they cut through each other, the younger and coarser-grained ones exhibiting chilled phases against the older ones. The latter two are known to change locally to dykes and, in general, to behave as bell-jar intrusions. The Harmony sill, which is considered to be younger than these, also has a tendency to develop local dyke phases. The space these sheets fill is, therefore, caused by subsidence of the block underlying the sheet. This is proved by the attitude of displaced marker beds.

A swarm of kimberlite dykes occurs near No. 1 Shaft, Saaiplaas. They are all less than 4 ft. thick, have chilled contacts, are vertical, and are often water-bearing. They trend east-west, are connected with the Kaalvallei pipe, have been examined on the surface by Coetzee (1960, p. 120) and traced by airborne magnetometric survey (Winter, 1957, p. 78).

E. WATER-BEARING FISSURES

The water-bearing fissures of this area trend predominantly in an east-west direction. They are relatively young joints and fractures showing very little relative movement on the walls. They are distinct from shear fractures which are striated, and are considered to be tension fractures. The old east-west dykes with sheared contacts, which trend parallel to the east-west fissure direction, are water-bearers.

Fissures tend to be open and are numerous in the upper levels where tensional conditions are more prevalent. The crests of superimposed anticlines, if the axes are near the east-west direction, favour the localisation of fissures. For instance, fissures occur with greater frequency and intensity south of Merriespruit No. 1 Shaft than elsewhere, because of tensional conditions in the anticlinal crest on the overlap of the Thrust Fault. Even a slight anticlinal feature, such as the one between boreholes LR.4 and H.3, where a dyke occupies the axial plane, can become the locus of water-bearing fissures. Where older dislocations cross the east-west fissures, these have been reopened for considerable distances and have become water-bearing.

There is an almost complete absence of water in north-south fractures. This feature indicates that the greatest direction of stress was vertical, and the least was north-south. Their structural relationships prove their youth. The fractures are the youngest, post-dating the kimberlite dykes of Free State Saaiplaas, with the stress pattern of which the trend of the fissures is in harmony.

The water contained in the fissures has a salt content of over 3,000 parts per million, which is an indication that these are "fossil" waters. Methane gas and helium are dissolved in the water under pressure (Coetzee, 1960, pp. 138-140, 161). The temperature of the water is usually a degree or two higher than the surrounding rock temperature, an effect that can be attributed to convection currents.

ECONOMIC GEOLOGY

A. REEFS WORKED

On Harmony and Free State Saaiplaas the Basal Reef is the only one worked. Limited amounts of stoping have been done on the

Leader Reef in the Virginia and Merriespruit Mines.

On the Virginia Mine, the composite conglomerate known as the Leader-Basal Reef is being mined to the limit of its payability. The Leader Reef alone is not of sufficiently high grade to warrant its exploitation, hence it has been stoped only in payable areas underlain by the Basal Reef. Other reefs, such as the "B" Reef, the Big Pebble Reef, the "A" Reef and the Gold Estates Leader, contain gold sporadically, but the frequency of payable intersections is so low as to prevent them from being of economic importance.

Marginal unconformities or disconformities are associated with all the reefs mentioned above, and a detailed sedimentary and stratigraphical analysis of each of these is necessary in order to interpret their economic significance, as well as their relationship with sedimentary structures and mineralisation.

Fig. 4 gives the relationships, in section, between the successive formations overlying those marginal unconformities or disconformities. Antrobus (1956, p. 7 and pl. III) studied these unconformities west and southwest of Merriespruit Mine, and found them to be almost identical with those present in the area described in this paper. He also stressed the association of auriferous reefs and disconformities.

B. ELSBURG STAGE

The average thickness of the Elsburg Stage diminishes from 1,400 feet in the Welkom area (Borchers and White, 1943, p. 144) to 1,270 in the Virginia area, and decreases further to 1,100 feet on the farm Monstari 398, 10 miles south of the Sand River. The decrease can be attributed to normal thinning out.

The VS.1 conglomerate occurs directly below, or within a few feet of, the Lower Volcanic Stage throughout this area. It is of subgreywacke composition, containing much chloritic material in the matrix. This conglomerate is barren and conformable with its footwall. The small-pebble conglomerates of Zone VS.1 in the west decrease in pebble-size to grits in the east.

Zone VS.5 in this area consists of two conglomerate bands, the lower one of which is erratic, lies upon a well-defined surface of disconformity, is oligomictic, and contains "buckshot" pyrite. In contrast, the upper conglomerate is a polymictic type. The lower conglomerate is correlated with the Gold Estates Leader, and the upper with the VS.5 conglomerate of the Welkom area. Arguments in support of the existence of this reef have been presented by Feringa (1954, p. 56), Winter (1957, p. 44), and have been summarised by Coetzee (1960, pp. 35-37).

The Gold Estates Leader was discovered in the course of exploration of the G.F. Block, to the east of Virginia. It is of note that this well-sorted, auriferous conglomerate only occurs where the base of the Elsburg Stage begins to show definite signs of a disconformity with its underlying formations. It occurs mainly in the south of Merriespruit, but has not been identified in Virginia. It is well-developed in the G.F. Block, where the disconformity is of appreciable magnitude.

The VS.5 conglomerate is robust in the west, but dwindles to a small-pebble conglomerate in the vicinity of borehole MU.2, and a poorly developed grit in the Hennerman-Whites area and in part of the G.F. Block. Thus, in agreement with the reduction in grain-size of the higher-lying units of the Elsburg Stage, the VS.5 conglomerate diminishes in thickness and pebble-size eastwards. Cross-bedded strata in Merriespruit substantiate the conclusion that the sediments of this stage were derived from the west. In a few places the VS.5 conglomerate is oligomictic and auriferous. On Free State Saaiplaas two conglomerate bands occur in the VS.5 Zone, and it is not certain whether the lower conglomerate is the Gold Estates Leader. However, such a correlation appears definite in the core of borehole ZV.1.

The relationships between the Elsburg Stage and the underlying formations are depicted in fig. 5, which is drawn on the same scale as the structure contour map. The map shows that the Elsburg Stage gradually transgresses the Kimberley Reefs and, eventually, the Leader Reef in the G.F. Block, finally coming to rest on Middle Footwall Beds to the south and southeast of the mines. The VS.5 conglomerate deteriorates and the Gold Estates Leader forms the basal conglomerate in this section. If the section on fig. 4 is extended further southward, it can be seen clearly how the Gold Estates Leader comes to lie on Middle Footwall Beds after transgressing the Leader Reef.

C. KIMBERLEY STAGE

(a) Succession and Lithology

The succession is much attenuated when compared with the Welkom area, and many of the units have become so thin that they are difficult to correlate, especially where there are variations in facies. In the northwest, the correlation of these beds is relatively simple, since the Upper Shale Marker is present, and all the overlying units are represented, but towards the south it becomes complicated, owing to vertical and lateral variations in the intensity of the disconformities.

There are several unconformities in the Kimberley Stage, most of these being of such minor magnitude as to warrant the use of the term "disconformity" rather than "marginal unconformity".

The reefs are generally oligomictic, with the exception of the "B" Reef, which is only locally so, and this facies is accompanied by a greater concentration of gold. Other conglomerate bands, not associated with disconformities, are polymictic and generally lenticular. Pyrite occurs in "buckshot" form.

To complicate the correlation of the succession still further, some borehole cores have an abnormal succession of dark shales, quartzites and conglomerates, which appear a few feet below the base of the Elsburg Stage, and which take the place of a variable thickness of the normal succession.

(b) Sedimentational and Structural Aspects

(i) "A" Reef Disconformity

The distance between the "A" Reef and the Big Pebble Reef is small and highly variable, and the "A" Reef seems to overlie different types of quartzite. A disconformity may, therefore, exist at the base.

The "A" Reef has not been intersected in all the boreholes. The reason could be that deposition of the conglomerate was limited to basins on an undulating floor, and that local transgressions of Zone VS.5 occur over eroded Upper Kimberley beds. It has nowhere been found to lie directly on Lower Kimberley beds.

(ii) Big Pebble Reef Unconformity

Fig. 6 is an isopach map of the distance between the base of the Big Pebble Reef and the "B" Reef. The succession generally thins out to the southeast, conforming with the shape of the syncline, and the Big Pebble Reef is transgressed by the Elsburg Stage before the zero isopach is reached.

In the block to the west of the De Bron Fault, the relationships are obscured by the fact that the "B" Reef has not been definitely identified. The "B" Reef is poorly developed in borehole KA.3 and may have petered out westward, but it is also possible that the Big Pebble Reef has truncated the "B" Reef, and that the succession in the log of borehole MO.2 reads as follows: Zone VS.5 at 7,881 feet, the Big Pebble Reef at 7,920 feet, the Leader Reef at 7,984 feet, and the Intermediate Reefs at 8,060 feet.

Borehole HAK.1, some 17,000 feet northwest of borehole MO.2, shows

4,436 - 4,609 feet:	VS.5 and EC Zones
4,609 - 5,007 feet:	Footwall Beds with Intermediate Reefs from 4,792 to 4,935 feet.

The correlation of Feringa (1954) and Coetzee (1960, p. 73) suggests that the magnitude of the Big Pebble Reef unconformity increases in that direction, and that it transgresses not only the "B" Reef, but also the Leader Reef before it, in turn, is truncated by the Gold Estates Leader at the base of the Elsburg Stage. The succession in boreholes on the farm Vermeulenskraal Noord 480, west of Harmony Mine, tends to substantiate the above possibility.

The irregular contour of the 100 feet isopach in Fig. 6 indicate that no more than a disconformity can be expected between that contour and the centre of the basin. The long distances between isopachs indicate a very low angle of unconformity beyond this contour, but the shorter distance between the 100 feet and 50 feet isopachs shows that a marginal unconformity has developed.

The Big Pebble Reef overrides the uppermost polymictic conglomerate of Zone LK.1 in an exposure at Virginia No. 2 Shaft on 12 Level. At the shaft, the plane of unconformity is separated from the conglomerate by 5 feet of quartzite. Approximately 1,200 feet eastwards, the Big Pebble Reef transgresses the underlying conglomerate, enclosing in its lower band pebbles of the lower conglomerate. The maximum pebble dimensions of the Big Pebble Reef decrease in a south-westerly direction from an average of 4 inches to 2 inches, and thus its distinctive feature is lost in the southern part.

Some borehole cores and underground intersections have an abnormal succession of dark shales, flagstones, quartzites and conglomerates, instead of the normal sequence. The boreholes occur mainly on Merriespruit Mine in a linear zone marked "channel" in fig. 6. A wide valley, striking east-west across the central part of Merriespruit, was eroded into the underlying formations, and was subsequently filled with a wide range of sediments, conglomerate predominating at the base and flagstone at the top. Subsidiary channels, such as that encountered in borehole V.4, occur in the area. They were cut at some time between deposition of the Big Pebble Reef and the base of the Elsburg beds.

The basal portion of the deposit consists of numerous small channels, filled partly with conglomerate and partly with 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 scour-and-fill structure on a large scale. Lenticular bodies of all grades of particle size are represented, reflecting the variable competencies of the stream-currents. Higher up in the succession, where flagstone is predominant, subsidiary channels rarely occur, but there are lenses of argillaceous sandstone. Over part of the area conglomerate again occurs towards the top.

These deposits are typical of a fluviatile environment.

The channel has been shifted northwards, in the block west of the De Bron Fault, by about 9,000 feet.

(iii) "B" Reef Unconformity

The isopachs of the interval between the base of the "B" Reef and the base of the Upper Shale Marker, and also the isopachs of the interval between the base of the "B" Reef and the base of the Leader Reef, show a decrease in thickness in a general direction towards the present sub-outcrops of the Leader Reef (fig. 7, compare with fig. 1). The "B" Reef is truncated by the Elsburg Stage in the G.F. Block, but by extrapolation of isopachs, it would seem that, south of Merriespruit, the "B" Reef might truncate the Leader Reef so that the Elsburg Stage might overlap from "B" Reef onto Middle

Footwall Beds. South of Merriespruit and east of the De Bron Fault, these relationships are obscured by pre-Karroo erosion. The core of borehole WN.1 shows that the Gold Estates Leader is in sedimentary contact with Footwall Beds below the Intermediate Reefs in this block, just south of the map.

In the block west of the De Bron Fault, the difficulty of correlation of the attenuated succession, the structural complexity of borehole MO.3, and the channel deposits in borehole LR.1, combine to make any definite conclusions impossible. A tentative sub-outcrop position of the "B" Reef against the Big Pebble Reef and the VS.5 transgression over the Big Pebble Reef is presented in fig. 6. In this block, boreholes to the south reveal that the Gold Estates Leader eventually comes to overlie Middle Footwall Beds.

The erosion by the late Kimberley river forms a marked feature across the map.

The evidence obtained from boreholes 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 Harmony, Virginia and Merriespruit. It is similar to the Leader Reef in sedimentary structure.

(c) Distribution Pattern of Gold and Uranium Values

Gold is eratically distributed through the oligomictic conglomerates associated with unconformities, whereas the polymictic conglomerates are barren. On the "B" Reef, gold is present close to the surface of the unconformity, even though the remainder of the reef is unsorted. In isolated patches, the lower few inches of conglomerate are winnowed of shaly and soft materials. "Buckshot" pyrite, up to 3/16-inch in diameter, is abundant in the mineralized portions of the reef.

The relative quantity of uranium to gold is usually higher than that of the underlying Bird reefs. The percentage payability is, however, so low, judged from borehole and underground intersections, that the reefs are not at present of sufficient interest to warrant their further exploration.

D. BIRD STAGE

The conglomerates of economic importance in this subdivision are the Leader and Basal Reefs, of which the latter is by far the more important.

(a) Succession and Lithology

A well-defined parting marks the base of the Leader Reef. In some areas a narrow band of quartzite separates the unconformity from the conglomerate. Variable amounts of gold are found above the plane, even in the quartzite. The average pebble size is greater in the lower bands than in the upper ones which, in turn, have a greater variety of pebble types. Over most of the area the reef consists of a number of conglomerate bands which converge and divide over such short distances that it is difficult to correlate individual bands, especially since quartzite and conglomerate bands are not sharply defined. Small-pebble conglomerate and grit bands occur in the hanging-wall quartzite. Gold is not confined to any particular band, but the lower contact usually carries the highest values.

The impure, "waxy" sediments forming the bulk of Zone EL.1 are unstratified and contain numerous small channels and potholes that were filled with pure, well-washed sand and pebble detritus. The pebbles in these Upper Basal Reefs (UBR) resemble those in the higher-lying bands of the Basal Reef. Their gold and uranium content is high, even where pebbles are loosely packed and rounded pyrite is scarce. The patches are most abundant towards the south and in areas where the Basal Reef is eroded.

There are numerous channels in this zone. Some are recognisable only as a veneer of argillaceous matter covering the original stream bed, or as a lens of pure sandy material. Others, filled with pure quartzite and barren conglomerate, actually scoured their channels through the Basal Reef. A narrow layer containing rounded pyrite has been seen at the base of one such channel, and isolated gold values on the contact indicate that Basal Reef material, already gold-bearing at that time, was redistributed along the channel. Isolated blocks of mineralized Basal Reef have been encountered in these channels. (Brock, Nel and Visser, 1957, p. 295). Small amounts of gold also occur sporadically near or at the top of the channels at Free State Saaiplaas.

A group of these channels trends slightly west of north from the vicinity of Virginia No. 1 Shaft through a portion of the Harmony Mine, where they occur mainly above the Basal Reef, into the area between No. 1 and 2 Shafts of Saaiplaas, thus making an acute angle with the line of overlap of the Leader Reef onto the Basal Reef. The channels appear to have been eroded shortly after the deposition of the first sediments of Zone EL.1. They cut through the Khaki Shale where that is developed, and have scooped out troughs through the Basal Reef where erosion was deep enough. Fragments of Khaki Shale are abundant.

Trough or festoon cross-bedding is predominant in the channels, in the Basal Reef and in the contiguous Footwall Beds. The most prevalent type elsewhere is planar or torrential cross-bedding. The axes of ripple marks on the floors of channels are transverse to the direction of elongation of the deposit, and they differ from those in the Khaki Shale. Current ripple marks prove that the flow was to the north.

On Virginia, the channels meander to some extent and two converge. In some places the channel walls are steep, even overhanging in places, but generally the slope is gradual and the channel is wide. Channel walls shown in fig. 10(a) have a gradual slope, but in the thicker portion the walls are steep.

The EL.1 Zone in this area is probably a deltaic deposit, the channels being rapidly aggrading distributaries. A few narrow stratified beds of pure quartzite could represent deposits during sandstorms, or wave-washing of the delta surface during exceptionally severe storms and high tides. The Upper Basal Reefs, intersected in boreholes KA.2 and KA.3, as much as 40 feet above the base of the delta, could represent material derived from the Basal Reef tilted above the base level of erosion further south where the disconformity had become of greater magnitude.

The Khaki Shale Marker does not exist on Merriespruit and Virginia, except for isolated patches less than 3 inches in thickness. In the Harmony and Saaiplaas mines, the shale becomes a narrow, continuous bed, increasing in thickness northwestwards to about 3 feet. In the eastern section of Saaiplaas the shale is black, but towards the west on the same property the black shale is underlain by khaki-coloured shale. Ripple marks on the Khaki Shale are orientated with their axes parallel to the limit of the Basal Reef, i.e. to the supposed direction of the shore-line.

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In Harmony Mine, the stratigraphic sequence near the Basal Reef is the most oomplete, and it has been sub-divided as illustrated in fig. 8. Zones EL.1 and EL.2 (the Khaki Shale) have been described. Zone EL.3 is a yellow-brown argillaceous quartzite with a "waxy" lustre and grades into Zone EL.4, which is characterized by rounded pebbles increasing in number downwards. The pebbles are surrounded with sericitic material, and the rock, therefore, tends to break round the pebbles, leaving them protruding above the fractured surface. There is a sharp break beneath this sub-division on a disconformable surface which becomes more prominent in Merriespruit.

The quartzite between Zone EL.4 and the Basal Reef is derived from a clean, well-sorted, fine-grained sand, somewhat purer than the underlying footwall quartzite, but otherwise similar in appearance.

The Basal Reef has been described in detail by Coetzee (1960, pp. 47-48). It is an oligomictic conglomerate containing abundant "buckshot" pyrite in its thickest sections and "carbon" seams where it is generally thinner. Pebbles of silicified shale occur near the top of the reef in some localities. In others, the top of the reef contains much of the gold and the pebbles are better sorted than the rest. For the most part, however, the conglomerate is richest in heavy minerals close to the base. Quartzite lenses in the reef resemble the underlying quartzites.

(b) <u>Sedimentational and Structural Aspects</u>

(i) Leader Reef

The Leader Reef is a typical basal conglomerate of a sedimentary cycle. It overlies a sharply defined break in the sedimentation, is coarsest towards the base, and grades into a cyclical succession of small-pebble conglomerates and grits which, in turn, grade into quartzite. Channel-shaped depressions on the erosional surface are filled with sediments of Zone ES.3-type.

The nature of the unconformity between the Leader Reef and underlying formations is depicted in fig. 9. Here again, the isopachs roughly conform to the shape of the pitching syncline, showing that the shape of the depositional basin was similar to the syncline. The Leader Reef transgresses, firstly, the sediments of Zone EL.1, then overlaps the Basal Reef, then transgresses a succession of about 550 feet of Upper Footwall Beds, before cutting across the Intermediate Reefs in the southeastern part of Merriespruit. The shape of the unconformity in section is that of a profile of erosion, such as would be made by a transgressive shore-line (fig. 4). The sub-outcrop of the Leader Reef against various Witwatersrand formations, and against the Karroo System, is also shown on the map.

In the eastern part of Merriespruit and in the G.F. Block, the Leader Reef and part of the underlying Footwall Beds were removed by erosion caused by the late-Kimberley river. Had it not been for the thinning of the succession eastward, the depth of erosion of the river channel could not have reached the Leader Reef.

(ii) Basal Reef

Owing to the absence of marker horizons in the Footwall Beds, and to the fact that most boreholes were stopped a short distance below the Basal Reef, it is not possible to draw an isopach map showing the relation of the reef to the Footwall Beds. According to the data presented below, the Basal Reef transgresses its underlying formations as it does in the Welkom area (Antrobus, 1956, p. 7) and in the Odendaalsrus area. The thicknesses tabulated are those of the strata between the Basal and Intermediate Reefs.

Borehole	Thickness	Remarks
RU.1*	685	Corrected for intrusives
M.1	613	
KA.2	600	
SE.1	500	Corrected for intrusives
Welkom Area	875	

* Borehole RU.1 passed through the Leader-Basal Reef close to the limit of the Basal Reef. The true thickness before erosion would, therefore, have been slightly greater than that given above.

The restriction of an alternation of clean, light-grey, siliceous quartzite and yellow-grey argillaceous quartzite to the Footwall Beds immediately beneath the Basal Reef in the Harmony and Saaiplaas mines, is a further indication that the Basal Reef is transgressive. There is a sharp disconformable plane above the Basal Reef in Merriespruit and Virginia, where the Khaki Shale is absent, indicating that the new cycle of sedimentation commenced with Zone EL. in this area.

Fig. 10 illustrates some of the sedimentary structures, as they appear on the side walls of drives on the Basal Reef in Virginia and Merriespruit. Fig. 10(a) shows a channel of EL.1 age locally cutting through the Basal Reef. The Leader Reef can be seen above the channel at the right. In fig. 10(b), the Basal Reef itself lies in a channel-shaped depression trending northeast. The higher-lying portions to the left and right have been removed by erosion prior to deposition of Zone EL.1. Fig. 10(c) shows the Basal Reef removed at a depression on the disconformity. Near the base of Zone EL.1 irregular patches of gold-bearing conglomerate can be seen. The Basal Reef in fig. 10(d) is thick, and splits into several bands, the bottom one lying on a foreset bedding-plane, such as is found in the Footwall Beds. A narrow layer of quartzite between the reef and the disconformity has all the characteristics of the Footwall quartzite. Fig. 10(e) shows an area where the reef is poorly concentrated, and where the pebble bands conform to the current-bedding of the quartzite. In the final diagram, fig. 10(f), a former muddy layer in the Footwall Beds, being more cohesive than the sand, formed a ridge against which the conglomerate narrowed rapidly. The conglomerate that rested on the shaly lamina at a slightly higher elevation was subsequently eroded and remnants of the reef now form patches of Upper Basal Reef in Zone EL.1. Recently, some very distinct conglomeratic channel fillings were discovered lying directly beneath the Basal Reef in the boundary area of Virginia and Merriespruit. The majority of these trend about W 15° N, nearly down the dip and almost perpendicular to the assumed direction of the shore-line. Their gold content is not high and they are generally not more than about ten feet in cross-section.

A generalised facies map of the Basal Reef in this part of the field is illustrated in fig. 11. It can be seen that the robust conglomerate facies is adjacent to the region shown in the isopach map (fig. 9) where disconformities become effective, and that this facies would, therefore, be the one closest to the shore-line of that time. The Basal Reef in the northern part consists of a small-pebble conglomerate less than a foot in thickness, containing a prominent "carbon" seam at the base, whereas the facies in between is intermediate, in that "carbon" seams occur in conglomerate averaging more than a foot in thickness.

The average pebble size and the average thickness of the conglomerate decrease generally in a northeasterly direction, in accordance with the direction of currents as measured by cross-bedding. Thus it would seem that sedimentary material entered this portion of the basin mainly from the southwest, which is in agreement with the facies of the Basal Reef at St. Helena (Frost, et al., 1946, pp. 20-21) and with the existance of high ground trending north-south to the west of St. Helena and west of this area (Frost, et al., 1946, p. 23; Borchers, 1950, p. 31; Borchers, 1960, p. 93; Brock, 1954, pp. 7-9; Antrobus, 1956, p. 22; Coetzee, 1960, p. 67; Brock, Nel and Visser, 1957, pp. 279-280). It is obvious that coarse detritus did not enter the basin from the vicinity of the De Bron-Homestead horst.

A paleogeographic map of the Basal Reef, illustrating the features which controlled the denudation, transport and deposition of material at that time, has been reconstructed (fig. 12). Although the region south and east of this portion of the field was exposed to erosion, it was a region of low relief that contributed very little sedimentary material to the basin. Sediments that did enter from that side and were preserved in channels, consist of materials reworked from unconsolidated underlying units.

(c) Distribution Pattern of Gold and Uranium Values

Gold in the Leader Reef is concentrated predominantly at the base, and rarely in well-sorted conglomerates forming a higher band of the reef. In the Basal Reef gold is concentrated locally near the top, but predominantly at the base, but with this difference that gold in the top band is concentrated at its upper contact, in very close proximity to the plane of disconformity. In the channel deposits, gold is concentrated only in the patchy Upper Basal Reefs, and then the associated pebbles are usually small. The thicker and more continuous channel conglomerates, that carry pebbles of a size comparable with those of the Basal Reef, are generally barren (Brock, Nel and Visser, 1957, p. 293).

The few payable areas of the Leader Reef co-incide with areas of higher-than-average value in the underlying Basal Reef, where both reefs occur.

The uranium values follow the trend of gold values, but the relationship varies over large areas and is very erratic. The ratio of uranium to gold is higher in the Leader Reef than in the Basal Reef, and the concentration of uraninite in the patches of Upper Basal Reef is very high.

In the Merriespruit Mine and areas on the Basal Reef where the sedimentational pattern was similar, lithotopes (Krumbein and Sloss, 1953, p. 194), trend in a northeasterly direction, and co-incide with gold value trends (Winter, 1957, pp. 88-89, pl. D). The trends are plotted on the paleogeographic map (fig. 12) as pay-streaks, where they seem to lie perpendicular to the shore-line and parallel to the transportation direction of streams from the distributive province. These trends are, however, far less definite elsewhere in this portion of the field.

It is tentatively suggested that the erratic distribution of payable areas is due to interference between original transportation currents, giving rise to paystreaks, and long-shore currents in the inland sea giving rise to payshoots. The paystreaks are contained in the payshoots as extra-rich areas. The curve in the shore-line might have added to the complexity of sedimentational conditions during Basal Reef time and, hence, to value distributions within the Reef. The trends of payshoots co-incide with those drawn by Tipping (1954, pp. 27-30) from borehole results throughout the Orange Free State Goldfield. Borchers (1950, pp. 79-81) showed that a definite directional value trend from northwest to southeast exists on the Basal Reef. The trends of the most prominent pay-shoots shown on his value contour map (Diagram No. 15) have been added to fig. 12 to illustrate the relationships of value trends between the Virginia and Welkom areas.

Regionally, gold values tend to deteriorate northeastwards, according to the borehole results, and if payshoots do occur in this area, they have not been located accurately by the limited number of intersections.

TECTONICS AND SEDIMENTATION

A. GEOLOGICAL HISTORY

The isopach maps reveal that unconformable relationships between different sub-divisions, ranging from the Basal Reef to the VS.5 conglomerate, increase in magnitude to the south and east, and that the sedimentary basin defined by these isopachs conforms roughly to the shape of the structural basin. The inference is that shore-lines existed in the directions of increase of magnitude of these unconformities.

The sedimentary material came from an elevated area to the west and southwest of this portion of the field, not only during Basal Reef time, but throughout Upper Witwatersrand time. This is shown by the directions of diminution of grain-size and by the current directions deduced from sedimentary structures. Brock (1954, p. 7), and others, have pointed out that the depositional basin was much restricted at the beginning of Upper Witwatersrand time, and that material was derived not only from pre-Witwatersrand rocks, but also from rocks of the Lower Division.

Sedimentary structures indicate that the detritus was deposited under water. The general shape of sedimentary units, their regular stratification, variations in facies, and their relationships to each other, fit into an environment of a shallow inland sea. Naturally, under such conditions, the imprint of deltaic, estuarine, beach and even fluviatile environments may alternate at specific times in response to changes in the shape of the depositional basin.

Because of rising uplands and of the approach to the base-level of deposition in the depositional basin (Twenhofel, 1939, p. 29), coarse sediments form the bulk of the material deposited. In this part of the Free State, submergence kept pace with the influx of detritus, although the presence of pebble bands in the Lower Footwall beds indicates that the base-level was approached and, perhaps, actually reached for short intervals.

Throughout pre-Basal Reef time, normal sedimentation in a neritic environment is postulated to have taken place in the Free State Goldfield. Owing to isostatic adjustments, the sedimentary basin was periodically depressed and the distributive province elevated, resulting in periodic rejuvenation which, in turn, affected the composition, volume and coarseness of the sediments. The result was cyclical sedimentation, the sands ranging from clayey to pebbly. The conglomeratic units in the Lower Footwall Beds and in the Intermediate Reefs represent culminations in diastrophism, or crests in the cycles of sedimentation (Sharpe, 1949, p. 270).

The limits to the south and east of the basin during this time were far beyond this area. More than 20 miles south of Virginia, boreholes have intersected the Main-Bird Series (EX.1, W.1). Eastwards, the evidence beyond the G.F. Block has been removed by erosion.

The isopach maps show that the size of the depositional basin was further diminished during the period of time commencing with the unconformity associated with the Basal Reef. This was accomplished by a slow upwarp south and east of the mines, so slow that a wave-cut surface could be maintained at all times. No increase in general grain-size heralded this uplift. On the wave-cut surface, only the coarsest, most resistant, and heaviest particles were not swept away, remaining behind to form the Basal Reef. This reef forms part of the underlying sequence, although unconformable in relation to the bedding of that sequence, and is, therefore, a marginal or terminal conglomerate (Twenhofel, 1939, pp. 27 and 30), or a regressional conglomerate. Reflecting quieter conditions between storms, a narrow layer of winnowed sand generally covers the conglomerate, as is found in many recent marine placer conglomerates.

During this interval, up to 300 feet of sand-grade material was winnowed out and deposited further into the basin. Soft pebbles were ground away and large ones rounded and comminuted. Heavy minerals were concentrated with the pebbles. The largest pebbles remained close to the shore-line, which was slowly receding from the land. Extensive footwall areas may have been uncovered and subjected to erosion, but these areas were not elevated to appreciable heights and, therefore, did not contribute great quantities of sediment. The east-west pre-Basal Reef channels at the southern boundary of Virginia prove that streams did carry material from the east, but that the material was mostly reworked into a sheet-like deposit covering the wave-cut surface. Diagram 1 in fig. 14 depicts conditions reigning at this time.

A slight marginal uplift exposed the higher-lying portions of the Basal Reef near the shore-line to erosion. These higher-lying portions were areas somewhat elevated relative to areas where the undertow or off-shore currents were the strongest. They were, therefore, also elongated in a northeasterly direction. The material of the Basal Reef was washed into the initial sediments that formed during the ensuing period of subsidence.

The basin must have sagged rapidly then for about 70 feet, and a deltaic deposit was formed, with was criss-crossed by rapidly aggrading distributaries, leaving small channels and potholes of conglomerate in their courses. The fact that these conglomerates are rich in gold and uraninite suggests that these are of detrital origin. The clayey suspension load of the distributaries slowly settled beyond the confines of the deltas, and formed a bottomset of shale - the well-known Khaki Shale Marker. As the delta grew, the bottomsets were covered with deltaic materials. Further into the basin, deltaic deposits interfingered with stratified marine sediments. Some of the chief distributaries cut their way through the deltaic deposits and left a coarse infilling. These streams came from the south. Diagram 2 of fig. 14 illustrates the deltaic phase.

Fresh, coarse detritus from the elevated area was brought into the subsiding basin to form the basal and succeeding conglomerates of a new cycle (diagram 3, fig. 14). The Leader Reef is, therefore, a basal conglomerate formed on a transgressing shore-line, whilst progressively finer-grained sediments were being deposited deeper into the basin (diagram 4, fig. 14). As the basal conglomerate moved outwards, the finer-grained sediments covered the conglomerate at the base, and were succeeded by the argillaceous Upper Shale Marker beds. The period during which the Leader Reef was subjected to sorting agencies was, therefore, much shorter than that of the Basal Reef. Channels on the upper contact of the delta were filled with the new material. Where the Leader Reef transgressed onto the Basal Reef, a zone was formed in which the constituents of both conglomerates were mixed.

A similar cycle of deposition to the previous one was repeated with the "B" Reef as the basal conglomerate, (diagram 5, fig. 14 depicts this overlap), but very little time elapsed before a fresh upheaval in the rising area brought the very coarse sediments of the Big Pebble Reef (diagrams 6 and 7, fig. 14). From this time onwards, shallow-water conditions prevailed, accompanied by periods of non-deposition and erosion, when well-rounded pebbles of durable compositions formed lenses of both terminal and basal conglomerates in a greatly restricted basin, and when rivers cut deep estuaries or valleys into the soft sediments (diagram 8, fig. 14). The rivers aggraded, at first quickly, with coarse material, then slowly, as mud-flats developed and the stage of maturity was approached.

The sericitic quartzite of the Kimberley Stage indicates that the source material might have been of granitic origin, not far from the present margin of the Upper Division. Such an area does occur to the west (Frost and others, 1946). On the other hand, being redeposited sediments, chloritic material might not have been able to withstand the repeated weathering and erosion that these beds must have undergone. At the close of the Kimberley epoch a widespread steady subsidence commenced over an extensive area. A basal conglomerate, the Gold Estates Leader, formed patchily on the shallow shore-line in the Merriespruit area, and became robust as the shore-line advanced. The limits of this transgression are not known. Elsburg beds occur south of Welgeleë Station and, as far east as these sediments are preserved from erosion, (diagram 9, fig. 14), this area must have remained of low relief.

Immediately after the Gold Estates Leader was formed, a gravel of subgreywacke composition was spread out over the floor from the west, to reach as far as the locality east of Merriespruit. This was followed by pure quartzose sediments which later became mixed with coarser materials of subgreywacke composition (diagram 10, fig. 14). A subgreywacke conglomerate terminates the succession and fills the basin. The impure sediments of the Elsburg Stage are of a more unstable type than the sediments of the Kimberley Stage. Even the quartzose sediments contain grains of rock-types found abundantly in subgreywacke. The close alternation of subgreywacke and quartzite in Zone VS.1 indicates that the quartzite is a sorted subgreywacke. The source province was, therefore, more diversified at that time and included mafic rocks.

Finally, the crust fractured, magma was forced up, lava poured out and the Witwatersrand deposits slumped into a structural accentuation of the basin.

B. RELATIONSHIP BETWEEN TECTONIC STRUCTURES, SEDIMENTARY STRUCTURES AND MINERALISATION

In the chapter dealing with marginal unconformities, some reasons were given why the majority of the sediments of the Upper Division are thought to have been deposited in the neritic environment. Deltaic and fluviatile environments noted in portions of the sequence are transitional environments that fit logically into the sequence, coming into prominence in periods when the depositional basin is thought to have been at its smallest. Cyclic deposition is a natural result of sedimentation in a basin subject to periodical subsidence, and it is only in a neritic environment that such wide ranges in grain size, coupled with such a general lateral continuity, can be expected. Facies changes are gradual and in keeping with the tectonic framework of a marine environment.

In a neritic environment winnowing and sorting agents were at work to produce the phenomena that accompany most bankets. Under arid or glacial continental conditions, rounded, oligomictic conglomerates accompanied by concentrations of heavy minerals that occur sparsely scattered in the unsorted detritus, cannot be expected. Sedimentary units in other continental environments are highly lenticular and contain sediments that are relatively unsorted. In a marine environment adjacent to a glaciated land mass, erratic rock fragments would be rafted by icebergs and be deposited with the normal marine sediments. This kind of deposit is now being formed near Antarctica (Stetson and Upson, 1937, pp. 55-66). Sediments containing erratic rock fragments are unknown in this area.

All the potentially economic conglomerates or bankets in this area are associated with unconformities, those subjected to sorting agents for the longest period being the most promising. The sediments in the units in which reefs occur, are best sorted in the vicinity of such a reef.

Factors of importance may be whether there is developed an area of overlap of a gold-bearing conglomerate by another, and whether material derived from the underlying conglomerate was concentrated a second time or was dispersed owing to admixing which fresh detritus of a different composition. The Leader-Basal Reef is an example of an enriched zone where material derived from the eroded Basal Reef is mixed with that of the Leader Reef.

It seems clear that gold is concentrated in sediments wherever heavy minerals are expected to concentrate. The abundance of pyrite, and presence in quantity of minerals such as chromite and zircon in gold-bearing conglomerates, also point to that conclusion (Winter, 1957, pp. 13-15). Radioactive minerals are also closely associated with features of sedimentary origin (Brock, Nel and Visser, 1957, p. 288; Simpson, 1952, p. 151). As gold is present in isolated patches of conglomerate, is absent from linear conglomeratic channel-fillings cross-cutting gold-bearing reef, and is closely linked with erratic and isolated sedimentary structures, the obvious conclusion is that the gold is detrital.

It has been shown that the Basal Reef is a terminal conglomerate simultaneously formed over a large area, marginal to the basin where the powers of erosion were able to keep pace with the rate of marginal uplift. It appears that there might have been some relationship between the distance from the shore-line and the type of heavy mineral that was concentrated in a terminal conglomerate, as shown in fig. 11. Coarse "buckshot" pyrite is abundant near the shore-line, gold somewhat further in the basin, and uraninite still further. Antrobus (1956, pp. 12-14) recognised the trend of gold values relative to the margin of the basin on the Basal Reef in the Welkom area. The quantity of gold per ton of reef increases inwards from the margin to a peak and then decreases to nothing as the reef degenerates.

The Leader Reef and the "B" Reef are typical basal conglomerates formed in a subsiding basin accompanied by a rapidly transgressing shore-line. They are followed by a succession of conglomerates which become progressively finer-grained upwards. They occur in the first sediments to be deposited in a new cycle of deposition. The gravel near the centre of the basin would have been older than that deposited close to the margins, and the size-distribution of the

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constituents would now reflect the nature of the detritus and the medium of transport, rather than the power of the sorting agents in the depositional environment. The time interval during which the gravel was subjected to the action of sorting agents was also restricted, and depended on the rate of subsidence and of influx of detritus. A too rapid rate of either would have inhibited the concentration of heavy minerals. The low original gold content of truncated gravels traversed is the reason for the lack of gold in economic quantities in channels of EL.1 and late Kimberley age.

The mineralized conglomerates in this section of the field are now situated some distance from the source area, and their constituents were spread out and swept along shores bounding a low-lying area to the south and east, which had previously received sediments. Grain-size and mineralisation deteriorates away from the source area. There is no definite proof that this area constitutes the southern margin of the Upper Witwatersrand basin, and that the thinning out of certain strata does not merely reflect a transverse warp in a basin that continued further south. Isolated boreholes as far south as Brandfort have not intersected sediments of demonstrably Witwatersrand age (Borchers, 1961, p. 507, diagram 2).

Conglomerates associated with breaks in the sedimentation would improve if followed westward to the source area, and terminal conglomerates would be more favourable as sources of ore than basal conglomerates. Even conglomerates in uninterrupted cycles of sedimentation, such as the Intermediate Reef or the Ada May Reef (Main Reef), if traced to their sub-outcrop positions towards the source area, would be associated with unconformities and become of economic significance.

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KEY TO FIGURES

<u>Fig. 12</u>: Paleogeographic map of portion of the Orange Free State Goldfield during Basal Reef time.

<u>Fig. 13</u>: Generalized geological column of the Virginia Section of the Orange Free State Goldfield.

<u>Fig. 14</u>: Schematic block diagram illustrating stages in the evolution of the Upper Division of the Witwatersrand System in the southern portion of the Orange Free State Goldfield.

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