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DEPOSITIONAL SEDIMENTARY ENVIRONMENTS WITHIN THE BLACK REEF QUARTZITE OF THE WEST-CENTRAL TRANSVAAL

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by

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ABSTRACT

The Black Reef Quartzite of the Proterozoic Transvaal Supergroup in the west-central Transvaal comprises a laterally-persistent, heterogeneous sand-sheet with a remarkably consistent thickness of 40-50 m. It extends along a 175 km-long exposure-belt, from Botswana's southeastern border, in the vicinity of Ramotswa, to north of Thabazimbi, where pre-Chuniespoort Group erosion has truncated the clastic sediments, such that the dolomites rest directly on the Buffalo Springs Group. Arenites, wackes, and lesser amounts of conglomerate (both cobble and small-pebble), siltstone, and shale comprise the Black Reef Quartzite.

Where the Black Reef Quartzite rests unconformably on the underlying strata, an early phase of braided-stream sedimentation is well established locally. In the west-central Transvaal, fluvially-deposited sediments in the Black Reef occur largely above the Ventersdorp Supergroup and, to a lesser extent, above the margins of the Buffalo Springs Group, where basin-edge unconformities have been recognized. Facies within the braided-stream environment present in the Black Reef Quartzite are massive gravels, originating in a process of clast-by-clast accretion as longitudinal bars or channel-lags, matrix-supported gravels, which suggest debris-flood deposition, bedform-migration-generated cross-laminated arenites, horizontally-bedded arenites, resulting from upper-flow-regime conditions, and mud-drapes and overbank deposits, which developed by standing-water accretion processes.

A marine transgression followed the initial phase of braided-stream sedimentation, allowing coastal sands to rest directly upon fluvial sediments. Arenites within the Black Reef were deposited along, and seawards of, a steeply-sloping beach, in a non-barred, high-energy, near-shore setting. Facies of deposition recognized within the coastal sands of the Black Reef Quartzite extend from beach sediments, through the inner rough facies, the outer planar facies, and the lower shoreface, to the transition-zone between coastal sands and shelf-muds. Some evidence for brief periods of regression has been observed. Storms appear to have played an important role in the genesis of the Black Reef Quartzite.

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A. GENERAL STATEMENT

In the west-central Transvaal, the Black Reef Quartzite of the Proterozoic Transvaal Group is exposed along a 175 km-long strike-belt which extends from 12 km northwest of Thabazimbi to the Botswana border in the vicinity of Ramotswa (Figure 1). From Thabazimbi to Ganskuil, the belt strikes northeast-southwest; west of Ganskuil, the strike changes to east-west. Beyond the international boundary, the Black Reef Quartzite swings towards the south and may be followed, without a break, into the Republic of South Africa. A second belt of Black Reef Quartzite outcrops east of Derdepoort. This belt is rather poorly exposed, but may be traced eastwards from Derdepoort over a strike-length of 12 km (Figure 1). In the Thabazimbi area, the Black Reef Quartzite is moderately-well exposed along the summit and down the east-facing dip-slopes of the western range of the Witfonteinrant. In the west, the Black Reef forms a low-relief escarpment of moderate outcrops. The two exposures are separated, in the Ganskuil area, by a region of negligible relief, sand-cover, and very poor outcrop. The basal contact of the Quartzite sheet is well exposed on west- or north-facing, steep hillslopes. Upper contacts with the chemical sediments of the Chuniespoort Group invariably occur at the base of dip-slopes and, in general, are scree- or sand-covered.

The thickness of the sand sheet is a remarkably consistent 40-50 m. Thinning over pre-Black Reef palaeohighs, particularly towards the west, has been recognized, and, in two instances, the Black Reef Quartzite pinches out completely. A maximum thickness of almost 60 m is developed above the Buffalo Springs Group (Tyler, 1978). The Black Reef Quartzite comprises a laterally-persistent sheet of heterogeneous clastic sediments which are overlain by the chemical sediments of the Chuniespoort Group and which rest unconformably on the Archaean basement and on the Ventersdorp Supergroup. The quartzite is composed of arenites and wackes, with lesser amounts of conglomerates (both small-pebble and cobble), siltstones, and shales.

Where the Black Reef Quartzite overlies the Kransberg Quartzite of the Buffalo Springs Group, the basal contact is gradational. Elsewhere, the contact is sharp and may be separated from underlying volcanic units, particularly Ventersdorp volcanics, by a thin palaeosoil horizon. The upper contact of the quartzite layer is very poorly exposed, but, in the few areas of relatively good outcrop, the contact is sharp. In addition, the far-northern exposures of the Black Reef Quartzite north of Thabazimbi have been erosionally truncated, so that the dolomites of the Chuniespoort Group rest directly upon the lower sediments of Hampton Formation of the Buffalo Springs Group (Figure 2).

B. HISTORICAL BACKGROUND

The basal units of the Transvaal Supergroup were first studied in the central Transvaal where, according to Button (1973), early investigators encountered a thin arenaceous unit covering a regional unconformity. This quartzite grades upwards to the carbonates of what was originally termed the Dolomite Series and contains thin conglomeratic phases, some of which are locally auriferous. Because of its dark colour, one such auriferous conglomerate was called the Black Reef - a mining term that was subsequently extended to include the arenaceous layer, as a whole, which became known as the Black Reef Series (Haughton, 1938, quoted in Button, 1973).

Hatch (1904) was one of the first investigators to report on the presence of the Black Reef Series in the west-central Transvaal, but merely described the geographic locality of the quartzites. In 1911, Kynaston reported the northern extensions of the Black Reef Series as "rather feldspathic quartzites varying from fine-grained to coarse, often with pebbly bands" (p. 69). Strike-fault duplication of the succession was also recognized. During the following year, Kynaston (1912) described the Black Reef Series in the Derdepoort area, stating that it consisted of "light coloured hard quartzites with occasional thin bands of conglomerate and often with flaggy beds and sandy shales near the base". Kynaston (1912) estimated that the beds were no more than 16 m (50 feet) thick.

In 1925, Wagner and Ross examined, in detail, the arenaceous deposits that overlie the Ventersdorp volcanics of the Derdepoort belt. Their interest in the quartzites had been stimulated by the discovery, in 1922, of a basal conglomerate which was gold-bearing, in places. Prior to their investigation, Kynaston (1912) was of the view that the sediments should be assigned to the Ventersdorp System. Wagner and Ross (1925) recognized that the conglomerate was separated from the underlying rocks by an unconformity and concluded that the auriferous conglomerate, and the clastics and shale overlying it, should be correlated with the Black Reef Series. The basal conglomerate was shown to be thin and impersistent, with low and erratic gold-values. Wagner and Ross (1925) concluded that the total quantity of workable ore exposed in the workings of the Batavia Goldfields was too small to justify mining operations on any scale.

Schutte et al. (1960) mapped the area in the vicinity of the Crocodile River, west of Thabazimbi, and stated that, in the north, the Black Reef Series transgressed the underlying volcanics,

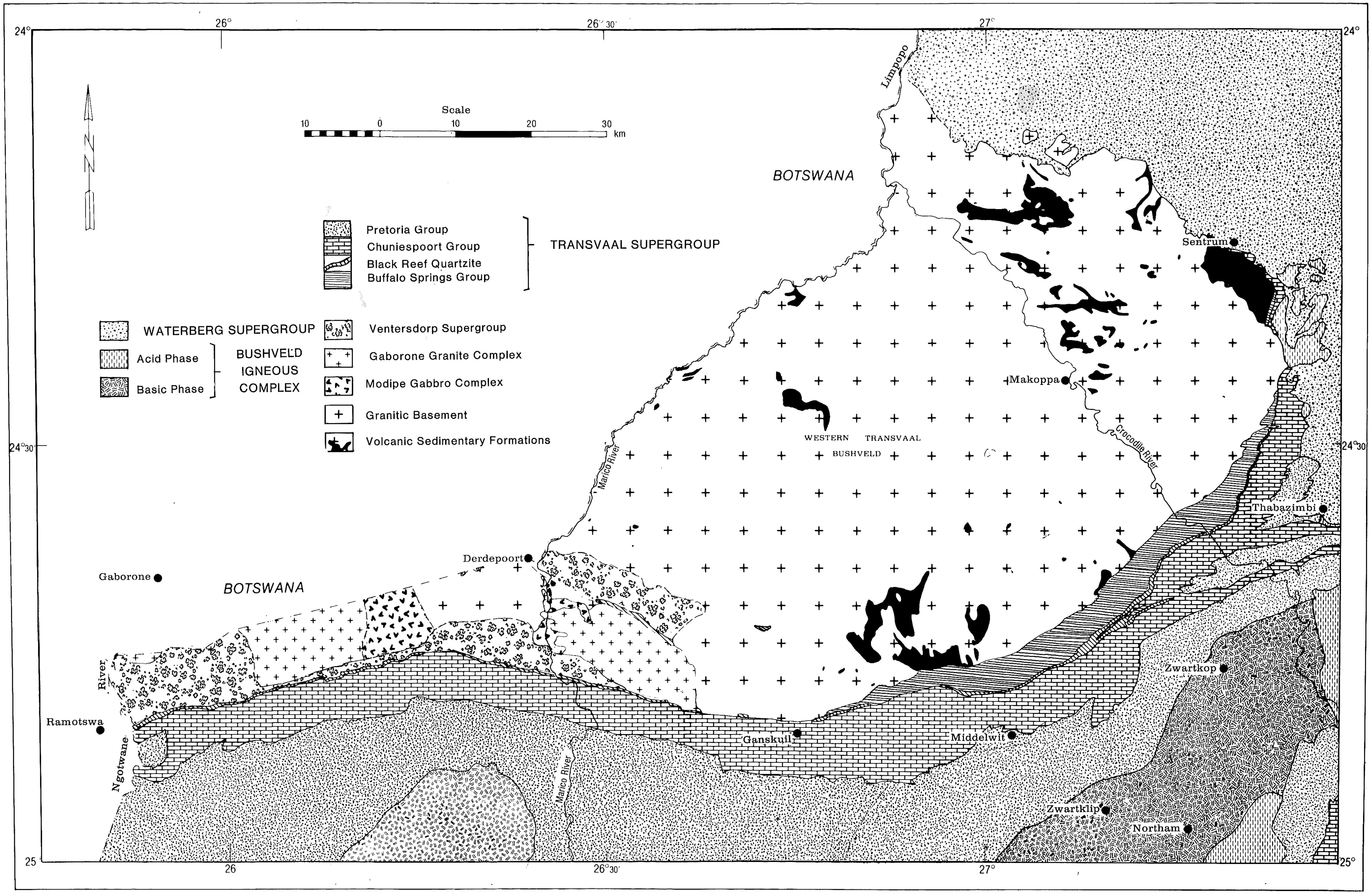

Figure 1 : *Location and geological setting of the Black Reef Quartzite in the west-central Transvaal.*

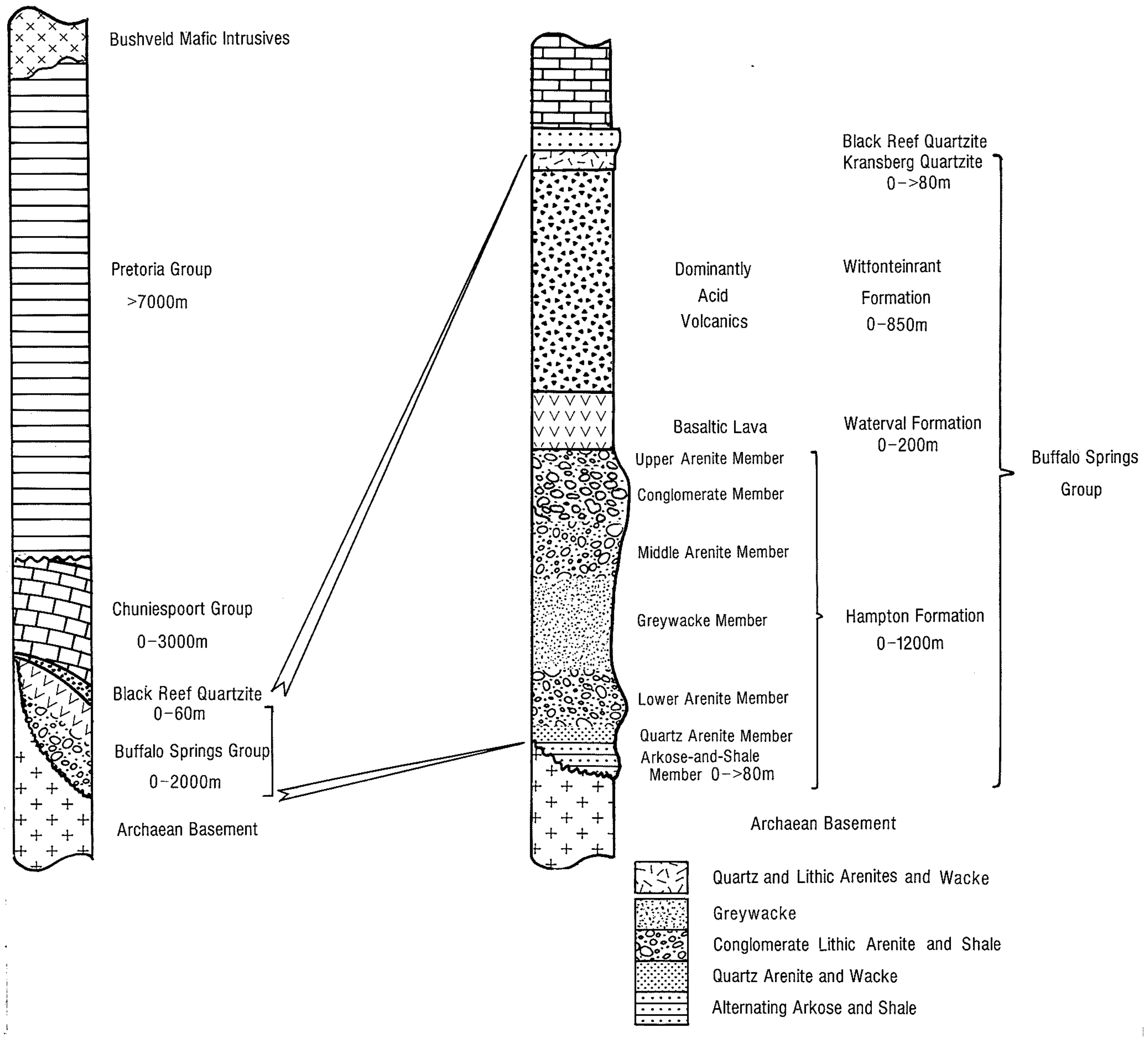

Figure 2 : *Stratigraphic setting of the Black Reef Quartzite in the Thabazimbi area of the west-central Transvaal.*

to rest on the basal sediments (that had been correlated with the Dominion Reef System). This relation was not observed in the present study, and the writer is of the opinion that the Black Reef Quartzite has been removed by pre-Chuniespoort erosion. As a result, the dolomites of the Chuniespoort Group, if not resting on the Black Reef Quartzite, directly overlie the Greywacke Member of the Hampton Formation (Figure 2). Schütte et al. (1960) reported on the presence of the Black Reef Quartzite in the vicinity of the Marico River, north of the Dwarsberge, and recognized thin, intercalated, shale bands within the quartzite that overlies a thin, impersistent, conglomerate band. They suggested that the arenites that occur above the volcanics of the Derdepoort belt, assigned to the Black Reef Series by Wagner and Ross (1925), had four possible correlations : the Moodies System, the Dominion Reef System, the Wolkberg Formation, or the Black Reef Series.

During 1967 and 1968, Marais reported on the presence of the pre-Black Reef Kransberg Quartzite in the Thabazimbi District. Previously, the Kransberg arenites had not been distinguished from the Black Reef Quartzite. The Thabazimbi sheet, published by the Geological Survey of South Africa (1974), separates the Kransberg Quartzite from the Black Reef Quartzite. In the explanatory notes on the sheet, Jansen (1974) stated that "the Black Reef Series forms an almost continuous belt along the northern boundary of the (Transvaal) basin. Along the Derdepoort ridge, sediments, including an auriferous conglomerate, which unconformably overlie the Ventersdorp beds, are also correlated with the Black Reef".

C. STRUCTURE

Faulting is the dominant form of structural expression in the Black Reef Quartzite. Relatively small-scale, transverse faulting is commonly observed in the Thabazimbi area, where left-lateral displacements range from a few centimetres to hundreds of metres. West of the Marico River, both left- and right-lateral displacements have been observed. Transverse faulting within the Black Reef Quartzite results in partially-brecciated arenites in close proximity to the displacement and the obliteration of primary sedimentary structures. Matrix-rich greywackes are less affected by the faulting.

Thrusting has caused duplication of the quartzite in the northern outcrop in the vicinity of Thabazimbi (Figure 1). Gentle synclinal and anticlinal drag-folding accompanies this faulting. Duplication of the auriferous Black Reef arenites in the Derdepoort graben (Tyler, 1978) is also thought to result from small-scale, thrust faulting.

II. DESCRIPTION OF ROCK-TYPES

Representatives of the persistent Black Reef Quartzite may be followed, almost without a break, from north of Thabazimbi to the Ngotwane River. Along this strike-length, the unit is dominantly arenaceous, although impersistent argillaceous phases have been observed, commonly in contact with dolomites of the overlying Chuniespoort Group. Both matrix and clast-supported conglomerates are present, and, in the Derdepoort area, the basal rudaceous phase has been worked for gold. No correlatives of the Serala Volcanic Member, developed in the Black Reef Quartzite of the northeastern Transvaal (Button, 1973), are present in the study-area.

A. CONGLOMERATE

Matrix-supported conglomerates outcrop directly above the acid volcanics of the Witfonteinrant Formation, forming a persistent band of 23 km strike-length. The rudaceous phase either occurs at the basal contact of the Black Reef Quartzite or rests upon a thin, impersistent, granular sand. Clasts are poorly-sorted, generally well-rounded, and are commonly of vein-quartz, comprising up to 30 per cent of the rock. Towards the centre of the band, large clasts, in excess of 10 cm, are present. Elsewhere, the pebbles range between 1 and 4 cm. Locally, volcaniclastic conglomerates, with clasts comprising up to 40 per cent of the rock (by visual estimate), are present. Both the volcanic-clast and quartz-clast conglomerates have crude, imbricate structures, with the long axes of pebbles aligned subparallel to the bedding. The upper contacts of individual conglomerate bands are generally sharp and are scoured into by subsequent conglomerates. Only rarely is an upward-fining relation observed. The matrix of the conglomerate is poorly-sorted, coarse sand, consisting of rounded quartz and volcanic grains. Weathered surfaces are generally brown-coloured, but purple-brown and black faces have been observed. Bedding is massive, although occasional trough-crossbed sets are present.

The basal conglomerate varies between 4 and 8 m in thickness. In the far-northern exposures of the Black Reef Quartzite, the basal conglomerate is directly overlain by the dolomites of the Chuniespoort Group. The Black Reef Quartzite in this region has an irregular thickness, varying between 5 and 15 m. Still farther north, the Black Reef Quartzite thins until it is completely removed, such that the dolomites rest directly on the Greywacke Member of the Hampton Formation (Figures 1 and 2).

A second, major rudaceous phase is developed along the south side of the Derdepoort graben (Tyler, 1978), where the Black Reef Quartzite unconformably overlies the Ventersdorp Supergroup (Figure 1). The basal conglomerate at this locality varies between a maximum of 7 m and zero metres thick. Subrounded-to-rounded clasts in the cobble conglomerate are poorly sorted, range up to 16 cm in diameter, and are composed of vein-quartz, arenite, porphyritic felsite, and tuff. The conglomerate is well-packed and is clast-supported. The matrix is composed of granule-sized, angular, volcanic, quartz, and arenite grains in a sericitic groundmass. Conglomerates of the Black Reef in the Derdepoort area grade both vertically and laterally into arenites with scattered pebbles. The lateral gradation occurs over a width of 100 m, but, if continued laterally for another 100 m, the arenites grade, in turn, into siltstones and shales.

Thin, impersistent conglomerate bands are not restricted to the base of the Black Reef Quartzite. Intercalated conglomerates were observed where the Black Reef scavenges older sedimentary formations, notably above the intercalated sediments within the lower acid volcanic zone of the Seokangwana belt of the Ventersdorp Supergroup (Tyler, 1978). Here, the Black Reef Quartzite may easily be mistaken for the sediments of the underlying Ventersdorp succession, but for an increase in the rounding and sorting of the clasts.

B. ARENITE

Poorly-sorted, light-weathering arenite is the dominant rock-type in the Black Reef Quartzite. The arenites are best exposed to the west of the Ganskuil Platform, although arenite bands also outcrop within the Black Reef above the Buffalo Springs Group. Grain-size varies between granule gravel and fine sand, and individual grains are generally well-rounded. The most common constituents of the compositionally-mature rocks, other than quartz, are volcanic clasts and pyrite specks. Well-rounded, blue-tinged, quartz grains often are observed. Most of the arenites may be strictly termed sublith-arenites, although quartz arenite bands are often present. Small, scattered pebbles, generally of vein-quartz, are common within the arenite bands. In the finer-textured varieties, a sericitic matrix is common. Microscopic examination confirms that the coarser arenites are very well packed, with well-rounded grains in which overgrowths are common. The coarser arenites are both texturally and compositionally mature. Finer-grained arenites are poorly-sorted and only moderately packed. The angularity of grains decreases with increasing grain-size. Commonly, in the sublith-arenites, a thin film of sericitic matrix separates adjacent grains, and interstitial, black, carbonaceous material is often present in varying amounts. Primary sedimentary structures abound within the arenites. Trough and tabular crossbeds, ripple cross-lamination, swash lamination, and plane beds, often with scattered pebbles, are present. Mud-drapes are a common, but accessory, constituent.

C. WACKE

Wackes are commonly found above the Buffalo Springs Group, north of the Ganskuil Platform, and as greywacke bands within the arenites, west of Ganskuil. Intercalated within the wackes are occasional arenite units up to 1 m thick, which stand out as resistant bands in the easily-weathered, wacke-underlain Black Reef plateau. The greywackes are generally fine-grained, reddish-brown-weathering rocks which, when fresh, are dark-grey in colour. Bedding-planes often have scattered mica flakes. The wackes are texturally and compositionally immature rocks, with subrounded quartz, rock-fragment, and occasional, angular, orthoclase grains in a sericitic matrix. Grains are poorly-packed and ill-sorted.

The wackes are commonly plane-bedded, with occasional low-angle trough and tabular crossbeds of maximum observed thicknesses of between 10 and 15 cm. Symmetrical ripple-marks, with wave-lengths of 10 cm and amplitudes of 3 cm, and flat-topped asymmetrical ripples, with wave-lengths of 30 cm and amplitude of 5 cm, have been observed. Thin mud-drapes and lenses of coarser arenites are often present in the wackes.

D. SILTSTONE AND SHALE

Siltstones and shales are occasionally found at the base of the Black Reef dip-slopes. Unfortunately, the shale-dolomite contact was not observed. The argillites are finely laminated, reddish-brown-to-black-weathering rocks which have greyish-black fresh surfaces. Only one poor example of lenticular bedding, consisting of linked flat lenses of clastic material in a shale groundmass, was observed. The siltstones are also dark-coloured and carbonaceous rocks which are often ripple-marked. Microscopic examination reveals angular, quartz grains, separated by a black, carbonaceous matrix. Fine-grained sericite also acts as a matrix-constituent. Accessory minerals are brown and green biotite and authigenic muscovite.

E. DOLOMITE

In the upper parts of the Black Reef Quartzite, rare lenses and occasional thin bands of dolomite were encountered. The dolomite is light-grey-coloured, both when fresh and weathered, and is interbedded within the arenites. The dolomite was observed to carry scattered quartz grains. Bedding within the thin bands (only a few centimetres thick) is flat. Planar-bedding also characterizes the lenses which have a maximum thickness of 1,5 m.

III. PALAEOCURRENT DIRECTIONS WITHIN THE BLACK REEF QUARTZITE OF THE WEST-CENTRAL TRANSVAAL

Palaeocurrent directions were measured at thirteen stations (Figure 3) along the strike of the Black Reef Quartzite. Although the majority of stations had unimodal current directions, those with low consistency ratios had bimodal palaeocurrent patterns (Table 1). The vector-mean direction of the foresets is shown by a heavy black arrow, the length of which is proportional to the consistency ratio. Sediment transport was southwards, towards the centre of the basin, with two exceptions which have vectors oriented northwards, or out of the basin.

Station	No. of Foresets	Vector Mean (Degrees True)	Consistency Ratio
27	11	184	0,81
89	11	333	0,42
69	13	200	0,74
71	11	172	0,43
77	10	126	0,40
68	5	158	0,90
60a	7	153	0,90
61A	8	224	0,82
61b	6	129	0,82
24D	16	025	0,66
Bt(W)	7	118	0,78
Bt(E)	3	208	0,98
Km	13	068	0,90

Table 1 : Palaeocurrent Statistics for the Black Reef Quartzite.

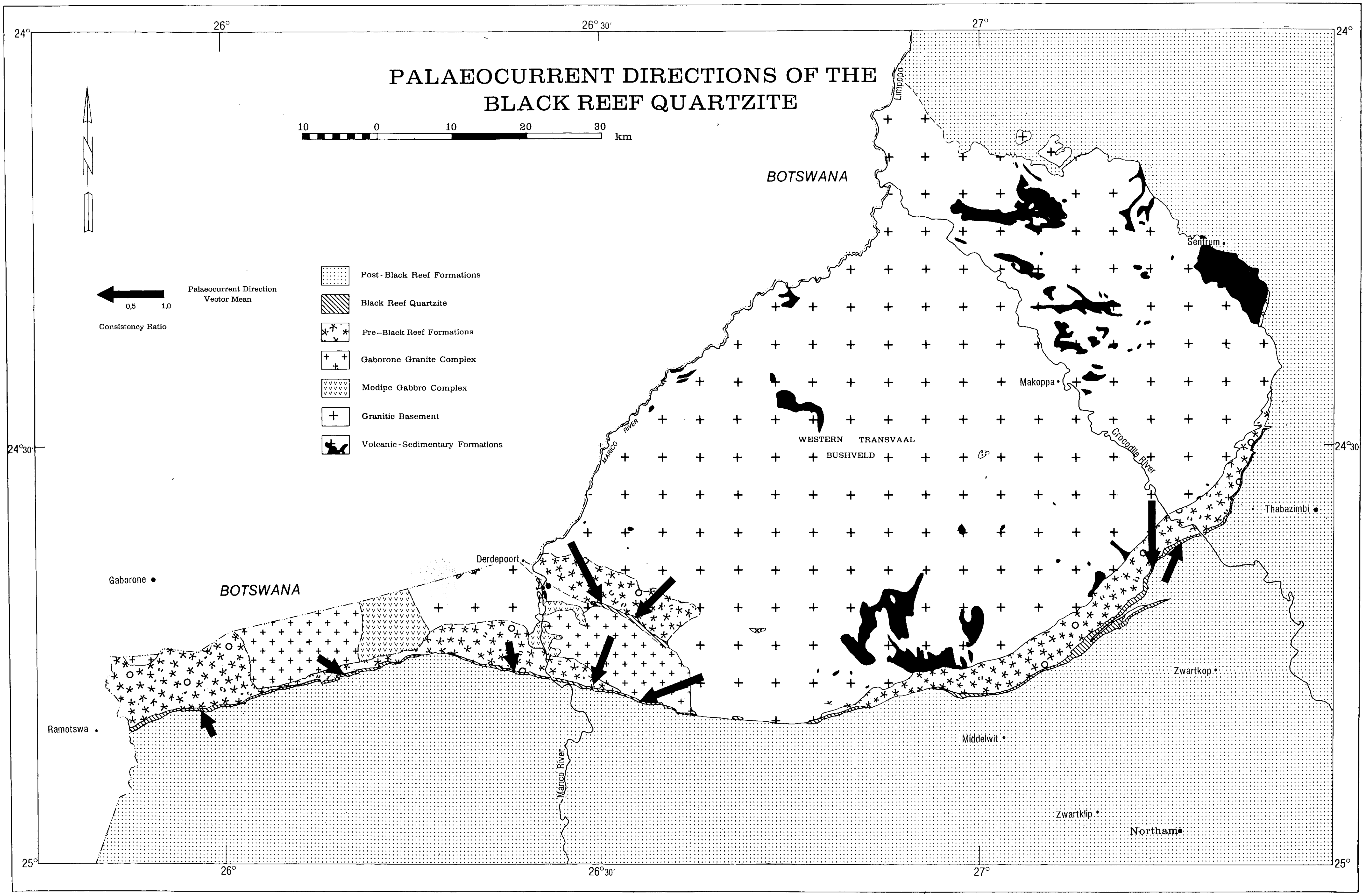

Figure 3 : *Palaeocurrent directions of the Black Reef Quartzite.*

The dispersive currents acting during the formation of the Black Reef Quartzite were essentially unimodal and consistent over the whole development of the rocks in the west-central Transvaal. Low consistency ratios at some of the stations are a function of primary sedimentary structures in the near-shore environment, which is the suggested depositional setting of the upper units of the Black Reef Quartzite in the west-central Transvaal.

IV. THE DEPOSITIONAL SETTINGS OF THE BLACK REEF QUARTZITE IN THE WEST-CENTRAL TRANSVAAL

The work of Button (1973), in the eastern Transvaal, revealed that the Black Reef has numerous palaeo-environmental indicators, many of which have been encountered and considered important in the west-central Transvaal. These are summarized below, in their approximate order of importance :

(i) the Black Reef Quartzite is an extremely widespread unit;

(ii) over the Wolkberg proto-basin, the Black Reef grades downwards to the shaly sediments of the Sadowa Formation; Button (1973), therefore, considered that the basal sands of the Black Reef are a portion of a regressive cycle in which a sand-depositing environment was built out over a mud-depositing setting; in the west-central Transvaal, the Black Reef grades downwards to the arenites of the Kransberg Quartzite which are inferred to have originated in a high-energy, near-shore environment (Tyler, 1978); the Kransberg Quartzite, in turn, rests upon volcanics and sediments which were subaerially deposited; thus, in the west-central Transvaal, the Black Reef Quartzite is part of a continuing marine transgression;

(iii) outside of the Wolkberg and Buffalo Springs basins, the Black Reef covers a regional unconformity;

(iv) the Black Reef, in the eastern Transvaal, consists of a compositionally-mature sand; in the Thabazimbi-Ramotswa area, conglomerates, arenites, immature greywackes, and volcaniclastic sediments are encountered; and

(v) when the Black Reef rests unconformably on older rocks, its character is strongly influenced by the nature of the underlying formations.

Button (1973) concluded that, where the Black Reef rests on an erosional surface, an early phase of braided-stream sedimentation was well established, locally. This initial phase was subsequently covered by an extensive sand-sheet which Button regarded as a shallow-marine shelf deposit. In the west-central Transvaal, the lower parts of the Black Reef Quartzite, that overlie the Ventersdorp succession south of the Derdepoort graben, the conglomerates overlying the Buffalo Springs Group north of the Crocodile River, and the basal conglomerates and shales resting on the Ventersdorp volcanics to the south of Gaborone, all have many characteristics in common with a fluvial setting. The clast-supported conglomerate, which scours into the Ventersdorp volcanics south of the Derdepoortrant, grades both laterally and vertically into trough-crossbedded arenites with scattered pebbles. In turn, the arenites grade into siltstones and shales. The vertical succession of primary sedimentary structures developed within this upward-fining, graded cycle is shown in Figure 4. A basal conglomerate is succeeded by a sequence of trough and tabular crossbed-sets and flat-bedded sands, terminating with a mud-cracked shale. Thr matrix-supported conglomerates outcropping directly above the Witfonteinrant Formation of the Buffalo Springs Group in the Thabazimbi-area comprise well-rounded, but ill-sorted, quartz and volcanic clasts in a quartz, volcaniclastic, and sericite matrix. Bedding within these conglomerates is generally massive, although trough crossbedding has been observed.

The depositional setting of the impersistent, basal conglomerates of the Black Reef Quartzite, in the west-central Transvaal, is considered to be the equivalent of the early, braided-stream phase of sedimentation observed by Button (1973) in the eastern Transvaal. Following the terminology used by Miall (1977), in his review of the braided-river depositional environment, several facies have been recognized within the conglomerates and overlying fluvial sediments (Figure 4). The basal, massive-gravel facies is considered to have originated in a process of clast-by-clast accretion as longitudinal bars or channel-lags. Clast-supported gravels indicate that the matrix filtered into the interstices following deposition. Matrix-supported conglomerates, such as those overlying the northern parts of the Buffalo Springs Group, suggest debris-flood deposition (Miall, 1977).

The trough and tabular crossbedded arenites (Facies St, Sp), into which the conglomerates grade both laterally and vertically, were formed during the process of bedform-generation and -migration. Trough crossbedded sands form by the migration of lobate mega-ripples and tabular crossbeds by the migration of lunate mega-ripples. Horizontally-bedded or planar-bedded sands (Facies Sh) occur under upper-flow-regime conditions in shallow water or during flood-stages. Under these conditions, the channel-floor becomes a traction-carpet, with virtually-continuous particle movement (Miall, 1977). Fine silt- and mud-drapes (Facies Fm) form under standing-water accretion processes. According to Miall, at the lowest water-levels, pools of standing-water are left in abandoned channels and fine silt and mud settle out, forming lenticular drape deposits. The Black Reef arenites developed south of the Derdepoortrant grade laterally, and occasionally vertically, into thinly-laminated shales. These are interpreted as overbank sediments which Miall (1977) states are most common in the more-distal parts of a braided-stream system.

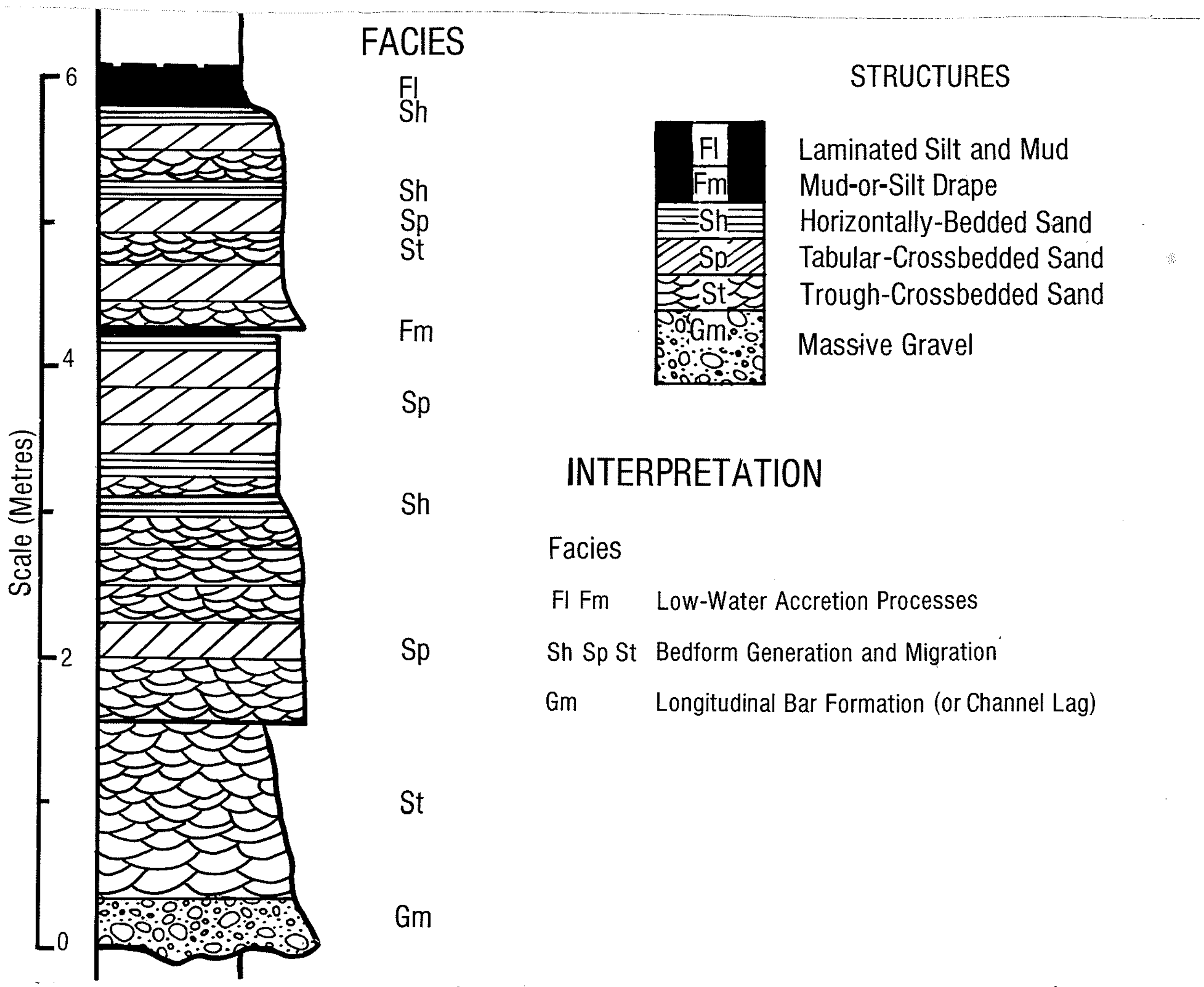

Figure 4 : *Detailed measured section through the initial fluvial phase of Black Reef sedimentation (Batavia 176 KP).*

Overlying the initial fluvial phase of Black Reef sedimentation is a succession of arenites, wackes, and shales. The arenites are generally coarse-to-fine-grained, ill-sorted sands which range from compositionally mature to immature. Primary structures within the arenites include cross-stratification, swash-lamination, planar-bedding, and mud-drapes. Greywackes are dominantly planar-bedded, immature rocks, with flat-topped current-ripples and symmetrical wave-ripples. Swash-laminae (parallel-bedding separated by low-angle discordance, Figure 5) within the compositionally-mature arenites indicate that the sediments were partly deposited in a beach environment. Less-mature Black Reef arenites, characterized by basinward-dipping plane-beds with scattered pebbles, are common within the beach-setting (Clifton et al., 1971). Many of the other features observed within the arenites are common to contemporary near-shore environments. Immediately seaward of the beach or swash-zone is a facies of bed-irregularity, designated the inner rough facies by Clifton et al. (1971). The inner rough facies, off steep beaches, consists of a series of 20 cm-high, symmetrical ripples of coarse sand, with internal laminae that may dip landward or seaward. Such cross-stratification structures recognized in the Black Reef arenites, coupled with the bimodal palaeocurrent patterns and low consistency ratios of some of the palaeocurrent stations, suggest that the inner rough facies was an important feature in the genesis of the Black Reef Quartzite.

In modern near-shore environments, seaward from the inner rough facies is the outer planar facies, which occurs under the outer portion of the surf-zone and the inner portion of the zone of wave-build-up. The sand here is finer-grained and is horizontally laminated. Small, solitary sand-ripples may be present (Clifton et al., 1971). In the Black Reef Quartzite of the west-central Transvaal, the superimposition of the outer planar facies over the inner rough and inner planar, or beach, facies has been recognized (Figure 5). Thus, the basal fluvial phase of sedimentation was succeeded by a marine transgression. The upper parts of the cycle (Figure 5) show evidence for a brief regression, with the inner rough facies and planar facies resting on the outer planar facies.

The depositional setting of the fine-grained, plane-bedded wackes is thought to be a more-distal facies of coastal sand, such as the lower shoreface, where laminated sand is the most common sedimentary structure (Reineck and Singh, 1973). Similar deposits are documented from many modern, off-shore environments and are attributed to sedimentation dominated by wave-surge (bottom-currents caused by passing waves), seaward of the line of breakers (Vos and Hobday, 1977). Medium-to-coarse-grained arenite bands within the lower-shoreface wackes are thought to be a result of re-sedimentation during storms. Storm-wave currents transported sand out from the shoreface, to be deposited in deeper waters. An analogous situation has been described by Vos and Hobday (1977) in Ecca sandstones in the Bothaville area of the Orange Free State. Asymmetrical ripples have been reported in the offshore environment by Clifton et al. (1971). It is suggested that strong storm-wave surge-currents are sufficient to plane off the crests of ripples during storms that deposit coarse, foreshore sediments in the lower-shoreface setting.

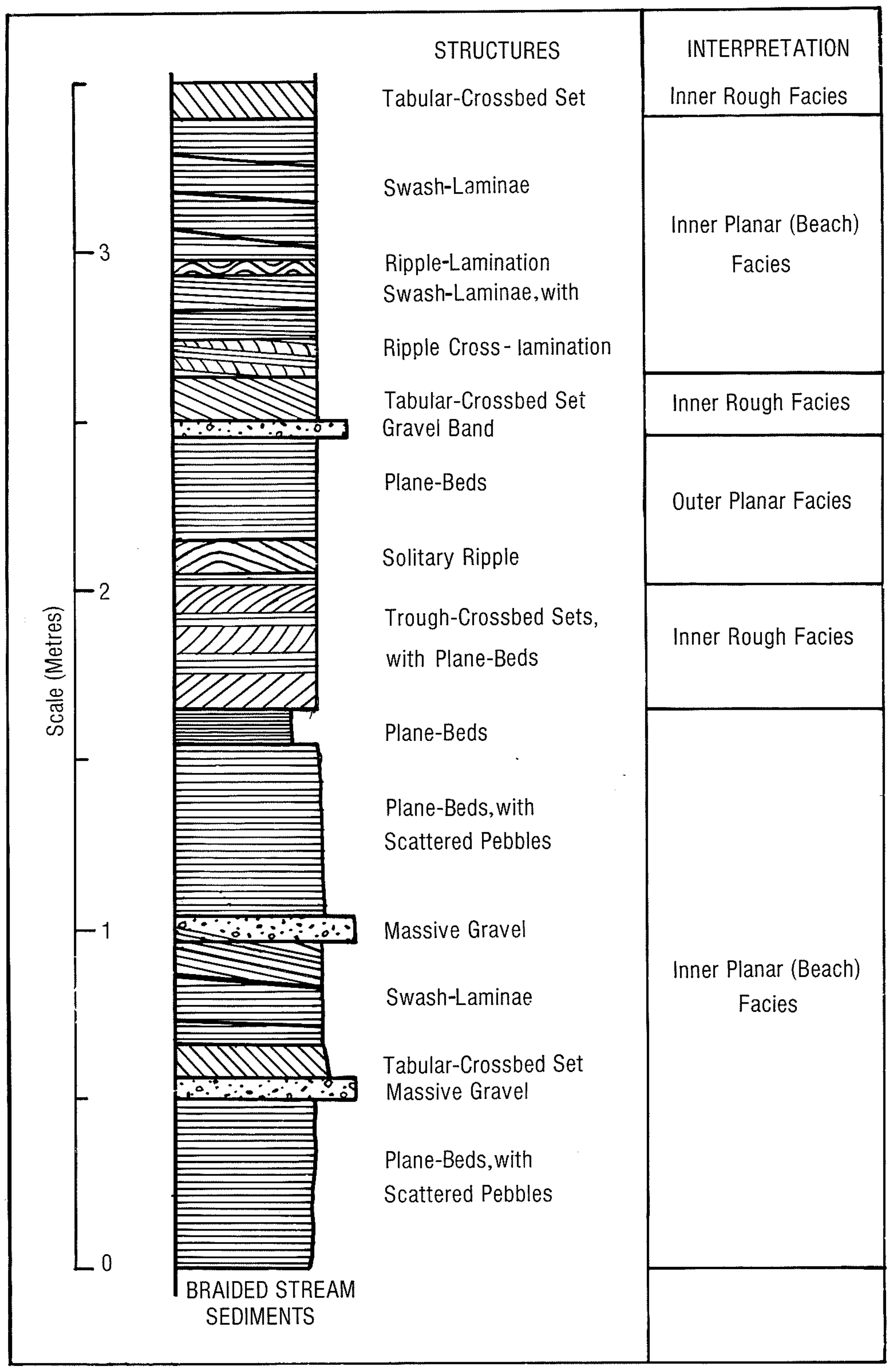

Figure 5 : *Detailed measured section through the near-shore sediments of the Black Reef Quartzite (Kromdraai 144 KP).*

The shales that are occasionally found overlying the Black Reef wackes are inferred to have been deposited in the transition-zone between coastal sands and shelf-muds. Near-shore, shelf-mud deposits often contain layers of fine sand, known as storm-sand layers, which originate during heavy storms (Reineck and Singh, 1973). These sand layers are similar in appearance to the connected, thick, sandy lenses in the typical lenticular bedding of the tidal-flat environment.

The palaeocurrent pattern of the Black Reef Quartzite in the study-area was strongly affected by the initial phase of fluvial sedimentation. In general, those stations with moderately-high consistency ratios and unimodal current patterns directed towards the centre of the basin were observed on the lower parts of the Black Reef Quartzite and represent fluvial sedimentation. The stations with bimodal current patterns and low consistency ratios represent sedimentation in the near-shore setting. Large, symmetrical ripples within the inner rough facies of modern, non-barred, high-energy, near-shore environments, notably off steep beaches, have seaward- or landward-dipping internal laminae (Clifton et al., 1971). It is suggested that Black Reef sediments deposited in this setting would have bimodal palaeocurrent patterns and low consistency ratios. Occasionally, the symmetrical ripples within the inner rough facies migrate in a shoreward direction, producing landward-dipping foresets (Clifton et al., 1971). The writer considers that the two palaeocurrent stations which have vectors directed out of the basin (or landwards) were strongly influenced by landward-migrating, symmetrical ripples of the inner rough facies of a near-shore environment.

In summary, the initial phase of deposition of the Black Reef Quartzite in the west-central Transvaal occurred in a braided-stream setting. A marine transgression followed, allowing coastal sands to rest directly upon fluvial sediments. Arenites within the Black Reef were deposited along, and seawards of, a steeply-sloping beach in a non-barred, high-energy, near-shore setting. Planar-bedded wackes were deposited in a lower-shoreface environment, while the impersistent shales of the upper parts of the Black Reef Quartzite were laid down in the transition-zone between coastal sands and shelf-muds. Some evidence for brief periods of regression has been observed. Storms appear to have played an important role in the genesis of the Black Reef Quartzite.

V. CONCLUSIONS

Unconformably overlying the Archaean basement and Ventersdorp Supergroup and conformably succeeding the Buffalo Springs Group in the west-central Transvaal is a sequence of clastics, shales, and accessory dolomite, which has been correlated with the Black Reef Quartzite. The assemblage outcrops along a 175 km-long strike-belt and attains a maximum thickness of 60 m, where it rests on the Buffalo Springs Group. The depositional setting of the sand-sheet is considered to have been influenced by an early phase of fluvial sedimentation, followed by sedimentation in a high-energy, near-shore environment. Primary structures indicate that deposition occurred in the beach, inner-rough, outer-planar, and lower-shoreface faices of the near-shore environment. Suspension sedimentation in the transition zone between coastal sands and shelf muds played an important role in the later stages of Black Reef sedimentation. Palaeocurrent directions within the study-area indicate that the source-area of Black Reef deposition lay towards the north and northwest.

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