UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG

THE DEPOSITIONAL HISTORY OF THE WOLKBERG PROTO-BASIN, TRANSVAAL

by

A. BUTTON

(Research Fellow, Economic Geology Research Unit)

ECONOMIC GEOLOGY RESEARCH UNIT

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ABSTRACT

The depositional history of the Wolkberg Group and of the Black Reef Quartzite in the eastern and northern Transvaal is outlined. In the early stages of Wolkberg sedimentation, irregularities in the basin-floor had a profound effect on the thickness and distribution of stratigraphic units. Subsequently, deposition took place on a smoothed surface, and formations varied much more gradually in thickness in response to regional tectonic controls. The angular unconformity between the Black Reef Quartzite and the underlying Wolkberg Group is of local significance only; these units being perfectly conformable and gradational into one-another over the majority of their outcrop extent. The Wolkberg Group represents the initial or proto-basinal stage of Transvaal sedimentation, and cannot logically be equated with the earlier Dominion Reef and Witwatersrand events.

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INTRODUCTION

The Wolkberg Group, developed beneath the main portion of the Transvaal succession in the area between Sabie and Potgietersrus in the eastern and northeastern Transvaal, has had a varied history of stratigraphic correlation. The earliest investigators referred to this lowest subdivision of the Transvaal Sequence as the "Black Reef Series". They recognised no significant hiatus within this succession. The strata, referred to here as the Wolkberg Group, were regarded as an overthickened facies of the Black Reef Series found elsewhere in the Transvaal.

Subsequently, the "Black Reef Series" of the earliest investigators was subdivided into a revised "Black Reef Series", a "Wolkberg System", and a "Godwan Formation". The Wolkberg was correlated with the Witwatersrand System, while the Godwan was equated with the Dominion Reef succession.

Recently, a re-appraisal of the stratigraphic position of the rocks in question has been in progress, and in certain quarters it was felt that there might have been more merit in the ideas of the earliest investigators. It became evident that the differences of opinion outlined above were largely due to a lack of information on the stratigraphy of the formations on a regional scale. In an attempt to settle the question, the writer undertook a stratigraphic study of the entire outcrop belt of the pre-dolomite strata of the eastern and northeastern Transvaal. This paper, which is based entirely on field measurements and observations, outlines the stratigraphic relationships and the broad depositional history of the Wolkberg Group and of the Black Reef Quartzite. No attempt is made here to provide the reader with a comprehensive account of the detailed stratigraphy and lithology of the units under discussion.

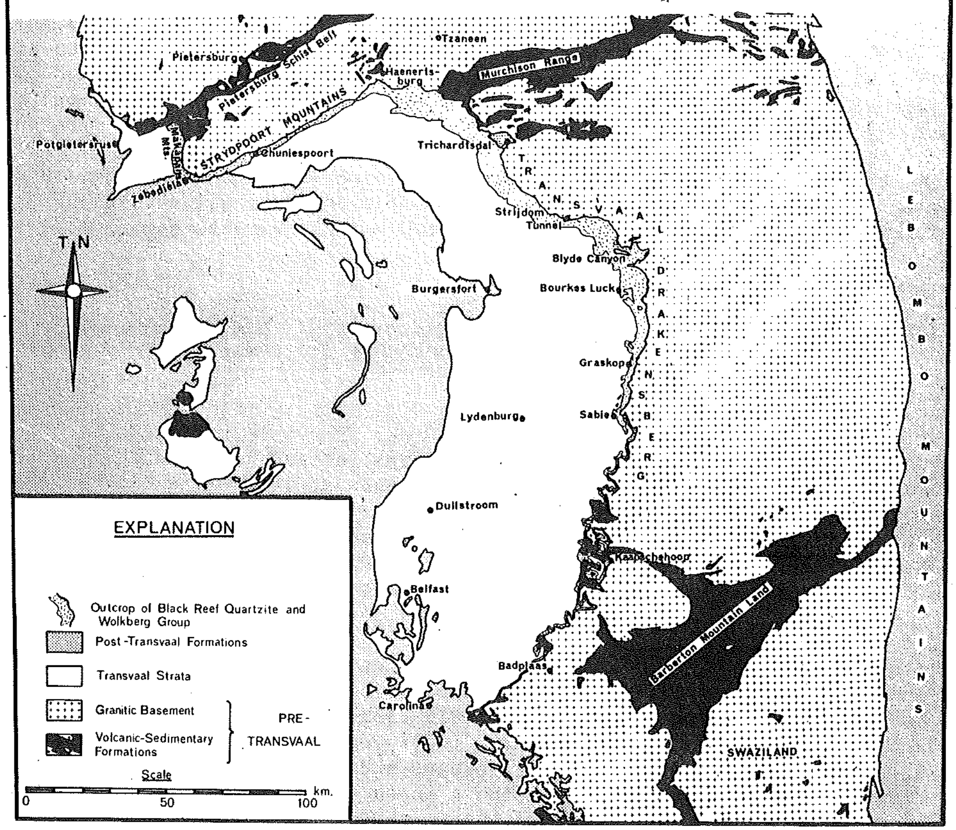
GEOLOGICAL SETTING

The area under consideration is situated in the eastern and northeastern portions of the Transvaal (Figure 1). The major elements of the regional geology of the area are reflected on this map. Extending from Swaziland in the south to near Pietersburg in the north is a broad, arcuate belt of Archaean basement terrain which comprises the Transvaal lowveld. The basement rocks consist, in essence, of a vast expanse of granitic rocks (undifferentiated on the map) with a number of greenstone remnants. The majority of the basement rocks have ages in excess of 2 600 million years. (Allsopp and others, 1962, 1969).

The basement arc is covered on the east by the Phanerozoic rocks which underlie the Lebombo Range and the Mocambique coastal plain. On its western and southern margin, the basement is overlain by the earliest Transvaal strata, variously referred to as the Black Reef Series, the Wolkberg System and the Godwan Formation. The latter two units are confined mainly to that portion of the escarpment between Potgietersrus and Sabie. They are covered by a westerly and southerly dipping succession of younger Transvaal formations which comprise the Olifants River Group (largely carbonates with banded iron formation) and the Pretoria Group (shaly rocks with quartzitic and volcanic horizons).

Structurally, the Transvaal formations are usually homoclinally disposed, dipping to the west, southwest and south. The lower formations are, however, folded along east-northeasterly-trending axes in the Mhlapitsi fold-belt. This tectonic belt coincides with the southwesterly projection of the Murchison Range.

Locality Map Fig. 1



The Transvaal Supergroup is covered, over much of its extent by the basic phase of the Bushveld Complex. In the south (around Carolina and Belfast) and near Zebediela, both the Transvaal and the Bushveld rocks are covered by Phanerozoic Karroo strata.

The Transvaal strata have an age which falls broadly within the limits of 2100 and 2300 m.y. In the central Transvaal, acid porphyries in the Ventersdorp succession (which underlies the Transvaal Supergroup) have been dated at 2300 m.y. (van Niekerk and Burger, 1964). Basic rocks of the Bushveld Complex intrude the Transvaal Supergroup. The former have yielded dates of 2037 and 2125 m.y. (Davies and others, 1969).

METHOD OF STUDY

The stratigraphy of the Wolkberg Group was studied using a Jacob staff to measure a large number of field sections. Section lines were selected from aereal photographs on the basis of accessibility, lack of structural disturbance, and outcrop quality. The section lines were traversed with the Jacob staff, thicknesses were recorded and detailed descriptions of the rock-types encountered were made. In the Wolkberg Group, a total of about 60 sections was measured and described. The cumulative thickness of the sections measured is of the order of 30 000 metres. The Black Reef Quartzite was traversed by some 80 sections between Carolina and Potgietersrus.

The positions of section lines were plotted on a base map. The sinuous outcrop configuration of the Wolkberg was then graphically straightened and the measured profiles plotted in their correct relative positions. The lithology and thicknesses of various stratigraphic units were then plotted on the profile lines and stratigraphic panel-diagrams were constructed by joining equivalent formations on adjacent profile lines. In this way, two-dimensional diagrams showing the lateral variation along the outcrop were constructed.

An attempt was made to measure as many cross-bed foreset orientations as was possible without interfering with the primary objective of the study. A total of 500 foreset orientations was measured in the Wolkberg and the Black Reef Quartzite.

HISTORICAL BACKGROUND AND PREVIOUS WORK

The term "Black Reef Series" (originally a mining term) was first used by Penning in 1891 to refer to the thin veneer of arenaceous material which unconformably overlay the earliest Proterozoic and Archaean formations of the Transvaal and graded upwards to a thick succession of carbonates known as the Dolomite Series (Haughton, 1938). When traced away from its type area, the Black Reef Series was found, in places, to comprise a thicker and more complicated succession of strata. In particular, the situation in the eastern Transvaal (the subject of this paper) was highly anomalous.

The thinking on the stratigraphy of the pre-Transvaal Dolomite succession in the eastern and northern Transvaal can be divided into three distinct periods. In the first (prior to 1947), a number of investigators (Thord-Gray, 1905; Hall, 1910; Kynaston and others, 1911; Hall, 1912, 1914; Wybergh, 1925; Willemse, 1938; and Brandt and le Roex, 1944) all agreed on the essentially conformable nature of the pre-dolomite succession in the area between Sabie and Potgietersrus. They noted a succession of shaly and arenaceous rocks with arkose, grit, conglomerate, greywacke, tuff, and lava. This heterogeneous assemblage was referred to as the "Black Reef Series", and was regarded as the initial phase of sedimentation of the "Transvaal System". Various broad proposals to subdivide this assemblage in particular areas were made (Hall, 1910, 1914; Brandt and le Roex, 1944), but no regionally effective subdivision was devised. The early investigators recognised the more striking of the changes in thickness encountered in the "Black Reef Series" as it was traced along its outcrop. They noted that the succession attained its maximum development in the area between the Blyde Canyon and Haenertsburg, and that it thinned markedly around Sabie in the south and around Potgietersrus in the northwest.

The term "Godwan Formation" has long been associated with the stratigraphic nomenclature of the escarpment regions of the eastern Transvaal. In its type area around Kaapschehoop (Figure 1), the Godwan Formation comprises a pile of sediments and volcanics which rests unconformably upon the Archaean Basement and is overlain with an angular unconformity by the base of the Transvaal Supergroup (Visser and others, 1956). The Godwan Formation was correlated (on lithological grounds) with the basal portion of the "Pongola System", the latter being regarded as an equivalent of the Dominion Reef System (Truter, 1949).

The second period in the geological thinking of the area commenced in 1947, when van Rooyen suggested that the Uitkyk Formation near Potgietersrus (now accepted as Archaean) was an equivalent of the Witwatersrand System, and that the former could be correlated with the pre-Transvaal Dolomite formations developed along the Makapans, Strydpoort, and Transvaal Drakensberg ranges. Truter (1949) went further and took the decisive steps of subdividing the pre-dolomite succession into three units. The basal volcanic-sedimentary portion of the succession was correlated with the strata beneath the Black Reef Quartzite at Kaapschehoop, and was referred to as the "Godwan Formation". The remainder of the pile of sediments was subdivided into the "Wolkberg System" and a revised "Black Reef Series". Truter favoured a correlation of the Wolkberg System with the Witwatersrand System, and of the Godwan Formation with the Dominion Reef System. He mentioned that he had evidence suggesting a time-break separating the Wolkberg from the "Black Reef Series", but he presented no concrete evidence in support of this idea.

Truter's subdivision was adopted by subsequent investigators, (Visser and Verwoerd, 1960; Schwellnus and others, 1962; and Zietsman, 1964). Schwellnus and others (1962), although they accepted Truter's subdivision, stressed the essentially conformable nature of the Godwan, Wolkberg and Black Reef strata along portions of the Drakensberg and Strydpoort ranges. Visser and Verwoerd (1960), on the other hand, presented conclusive evidence of an unconformable relationship between the Black Reef Quartzite and the underlying Godwan-Wolkberg strata in the Sabie area.

Schwellnus and others (1962) provide the most comprehensive account of the stratigraphy of the Godwan and Wolkberg successions. These investigators mapped the outcrop of the rocks in question from north of Strijdom Tunnel to Chuniespoort, a distance round the outcrop of some 120 km, or approximately one third of the total outcrop length. It is necessary to stress that, in the area studied by Schwellnus and his co-workers, the stratigraphic relationships they recognised agree fairly well with those outlined as a result of this study of the whole outcrop belt.

The third period in the thinking of the Wolkberg-Godwan problem commenced in 1964, when Pretorius suggested that the correlation of the Wolkberg and Godwan with the Witwatersrand and Dominion Reef Systems, respectively, was unsound, and that the balance of evidence favoured the early concept of these formations being an integral part of the Transvaal succession. Haughton (1969), in his review of the subject, appears to agree with Pretorius and, on his map, does not differentiate the Wolkberg and Godwan from the overlying Transvaal formations.

DEFINITION OF STRATIGRAPHIC TERMS

For the sake of clarity and in view of the changes in the stratigraphic terminology which have occurred, it is considered advisable to define at this stage the present usage of principal stratigraphic terms. The term "Godwan Formation" refers to volcanic and sedimentary rocks which rest unconformably on the Archaean basement, and which are overlain unconformably by the base of the Transvaal succession. The term is restricted in its usage to the type area (around Kaapschehoop), and is not applied to volcanics and sediments found further to the north.

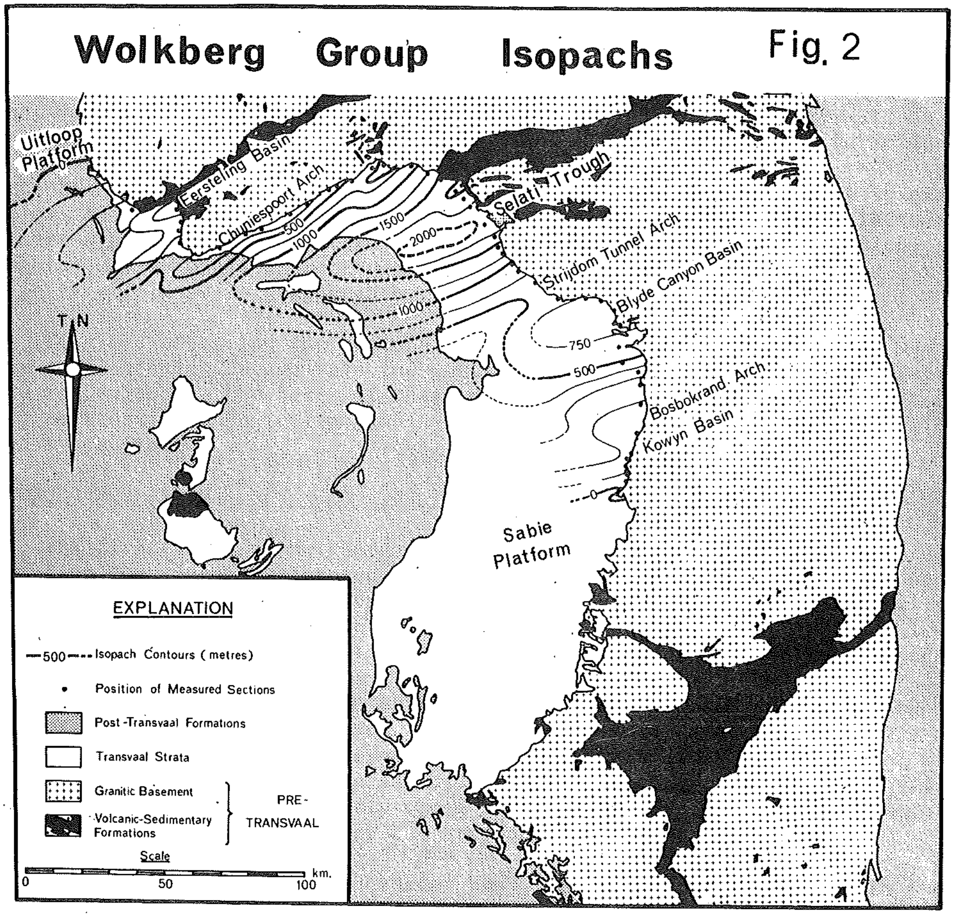
The term "Wolkberg Group" embraces the succession of sediments and volcanics which rest unconformably on the Archaean, and which are overlain conformably (except locally) by the Black Reef Quartzite. The term includes formations previously correlated with the Godwan Formation.

The Black Reef Quartzite is a body of quartzite with a lensoid intercalation of basaltic lava. The formation is overlain by the Transvaal Dolomite; it rests on the Archaean basement, on the Godwan Formation, and covers the Wolkberg Group conformably (except locally). The unit, as defined, includes a significant portion of the strata grouped within the Wolkberg System by Schwellnus and others (1962).

THE DEPOSITIONAL HISTORY OF THE WOLKBERG GROUP

As an introduction to the depositional history of the Wolkberg Group, it is instructive to examine the gross geometry of the unit. This is conveniently shown by means of the isopach map presented in Figure 2. This map, compiled from all the measured sections available, shows the variation in thickness of the Wolkberg Group over its area of outcrop. Contouring is strictly mechanical along the outcrop, but is, of necessity, interpretative in the subsurface, where no control exists. A variable contour interval was employed to avoid crowding of contours in areas of rapid thickness change.

When viewed in its broadest sense, the map shows a 190 km wide east-northeast-trending belt of accumulation and preservation of the Wolkberg Group. The limits of Wolkberg Group deposition and preservation are the two tectonically positive areas here termed the Uitloop and Sabie platforms. It will be shown that the zero isopach on the Uitloop platform represents a sedimentary pinch-out, while that on the Sabie platform represents a partial pinch-out combined with erosional truncation of Wolkberg strata in pre-Black Reef Quartzite times.



Approximately halfway between the two platforms, the area of maximum development of the Wolkberg (termed the Selati trough) is found. Measured sections in this region record thicknesses of just less than 2000 m.

The three principal floor-tectonic features outlined above are separated by a number of second-order elements. North of the Selati trough, the Eersteling basin and the Chuniespoort arch influenced the thickness of the Wolkberg, while south of the trough, decreased thicknesses are recorded over the Strijdom Tunnel and Bosbokrand arches, and increases in thicknesses are noted in the Blyde Canyon and Kowyn Basins.

These rather gentle and long-lived basin-floor tectonic elements are in sharp contrast with some palaeotopographic features which are particularly pronounced to the south of Haenertsberg. The most prominent of these features was a granite floor-high termed the "Georges Valley Mesa". This feature, represented by a sharp inflection in the 500 m isopach line, had a relief of between 100 and 200 m and probably took the form of a flat-topped mountain some 5 km across.

The relationship of various basin-tectonic features with elements of the Archaean basin floor is worthy of note. In particular, the coincidence of the Selati trough with the projection of the Murchison lineament is striking. The Murchison schist-belt must have acted as a zone of relatively rapid and persistent subsidence. The flanking granitic areas accumulated markedly less sediment in an equivalent time-span and were obviously tectonically more positive than the Murchison belt.

The foregoing discussion has outlined the gross tectonic controls on the deposition of the Wolkberg Group. In the following paragraphs, the filling of the Wolkberg basin will be illustrated by a series of stratigraphic panel-diagrams which show the thickness, variation in thickness and distribution of the successive formations which make up the group (Figures 3 and 4). In diagrams dealing with a particular formation, the underlying Wolkberg formations are not shown in detail, but are grouped together so as to focus attention on the formation being discussed. It was found necessary to exaggerate the vertical scale to illustrate some of the more subtle stratigraphic relationships. The panel-diagrams presented are plotted to a standard 20 x vertical exaggeration. Angular relationships are strongly distorted by this vertical exaggeration, and are not nearly as obvious in the field as is suggested by the diagrams.

To avoid obscuring the regional picture of the Wolkberg Group, it was found necessary to generalise extensively the wealth of local detail recorded. Stratigraphic units are recognised on the basis of their gross lithology. In many cases, it was found necessary to treat lithological assemblages as units in order to produce a regionally effective synthesis.

A. SEKORORO FORMATION

The first phase of Wolkberg deposition is represented by the Sekororo Formation. This formation comprises a heterogeneous assemblage of sediments which rests upon the Archaean basement and is overlain by the Abel Erasmus Volcanics. Lithologically, the formation is dominated by sericitic quartzite; lesser amounts of arkose, pebble-, cobble-, and boulder-conglomerate, shale, flinty tuffaceous shale, and wacke are present.

The Sekororo Formation is characterised by the lateral discontinuity in its development. One of the thickest and laterally most widespread occurrences is in the Trichardtsdal body, which extends from the Georges Valley mesa, in the north, to the vicinity of Strijdom Tunnel, in the south, a distance along strike of 70 km (Figure 3a). This body undergoes a rapid northerly wedge-out against the Georges Valley mesa and, in the south, it thins to 1 or 2 m over the Strijdom Tunnel arch.

To the south of the Trichardsdal body, the formation is present in two channel-like developments, the Strijdom Tunnel and the Blyde Canyon bodies. The latter attains the considerable thickness of 240 m and wedges out very abruptly against the Bosbokrand arch.

South of the Bosbokrand arch, thin accumulations of arkose with cobble-, boulder-, and pebble-conglomerate beds and intercalations of flinty shale and wacke are found in three laterally discontinuous bodies between Graskop and Sabie. Along the Strydpoort and Makapans ranges, the formation is encountered in a number of thin, discontinuous bodies, the most northerly of which is in the small basin structure at Eersteling.

It is evident that the Sekororo Formation was deposited on an imperfectly-peneplained surface. Local depressions in the depositional floor were filled with sediment, while positive protruberances escaped sedimentation. The lateral discontinuity in sedimentation, the channel-like geometry of some of the bodies, the immature nature of the sediments, the presence of very coarse-grained sediment, and the impermanent cover of water (as shown by mud-cracks), all suggest a fluvial origin for the majority of the sediments of the Sekororo Formation. The few cross-bed stations measured in the Strijdom Tunnel and Blyde Canyon areas indicate a source area which lay to the east of the outcrop area of the formation.

B. ABEL ERASMUS VOLCANICS

The Abel Erasmus Volcanics rest upon the Sekororo Formation and are overlain by younger Wolkberg formations. This unit consists primarily of carbonated basaltic lava (pillowed in places), with discontinuous layers of sericitic quartzite and dolomitic shale (the latter enclosing stromatolitic dolomite and chert rocks). Pyroclastic phases are present, but are volumetrically unimportant.

In Figure 3b, it is shown that the formation is developed continuously between the mesa at Georges Valley and the Bosbokrand arch, a distance along strike of 120 km. The volcanics wedge out abruptly against the Georges Valley mesa in the north, a more gradual wedge-out against the Bosbokrand arch in the south is evident. The formation attains a maximum thickness of over 500 m in the vicinity of the Selati trough; it thins rapidly onto the Strijdom Tunnel arch whence it maintains a fairly constant thickness of approximately 200 m before wedging out in the south.

In the Sabie-Graskop area, the volcanics are encountered in thin accumulations in the Kowyn basin and in a further minor basin to the south. Along the Strydpoort range, the volcanics are found in small depressions south and southwest of Haenertsburg. The volcanics are absent over the Chuniespoort arch and Uitloop platform, but are encountered in the small basin structure at Eersteling.

The distribution pattern of the Abel Erasmus Volcanics is very similar to that of the underlying Sekororo Formation, indicating that the uneven nature in the depositional floor was still present during the outpourings of the volcanics. In the vicinity of the Selati trough, a greater rate of subsidence of the basin floor resulted in the accumulation of thicker masses of lava. Extrusion of the volcanics must have taken place in a setting which was, in part, aqueous. Periods of volcanic quiescence are marked by the accumulation of impure sandy sediments and of carbonaceous and dolomitic shale, the latter showing signs of very shallow water deposition, in the form of mud-cracks and stromatolites. Extrusion of lavas sub-aqueously is indicated by the pillow-structures periodically encountered in the lavas.

C. SCHELEM FORMATION

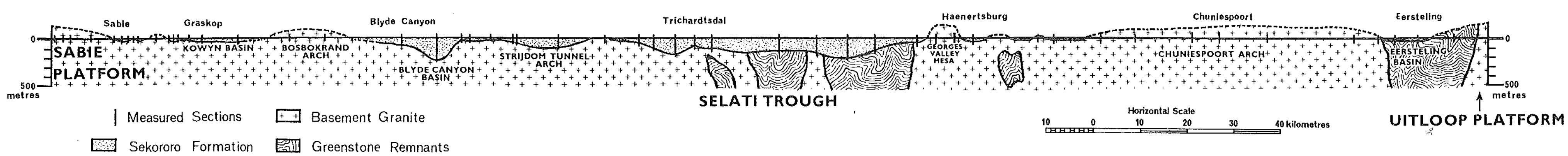
The Schelem Formation is a body of arenaceous sediment which overlies the Abel Erasmus Volcanics or (if those are absent) rests directly upon the Archaean basement. The formation is overlain by younger units of the Wolkberg Group. The Schelem Formation is composed predominantly of sericitic quartzite; also present are beds of conglomerate (boulder, cobble, and pebble), arkose, and some shaly beds.

The Schelem Formation is developed in three laterally discontinuous bodies (Figure 3c). The thickest and most extensive body is developed between Trichardtsdal and

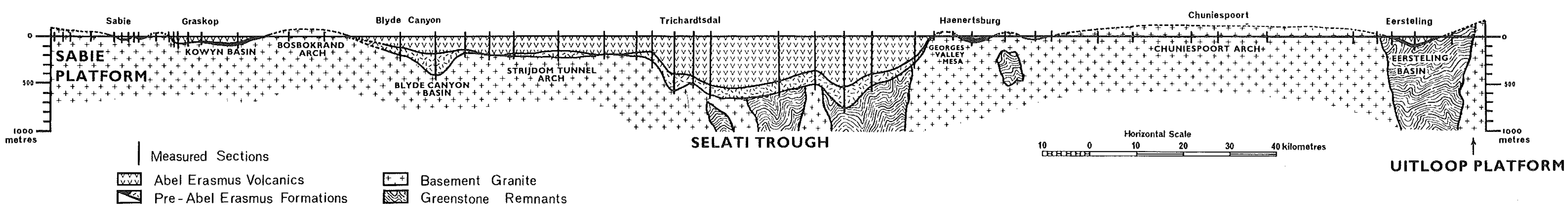
WOLKBERG GROUP - DEPOSITIONAL HISTORY

FIG. 3

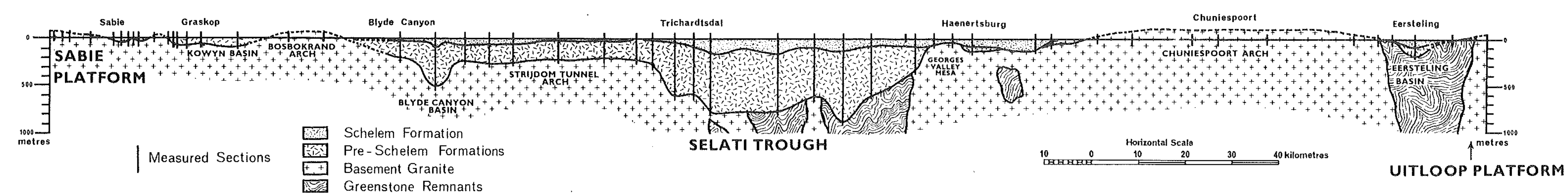
(a) SEKORORO FORMATION - LATERAL VARIATION IN GROSS THICKNESS



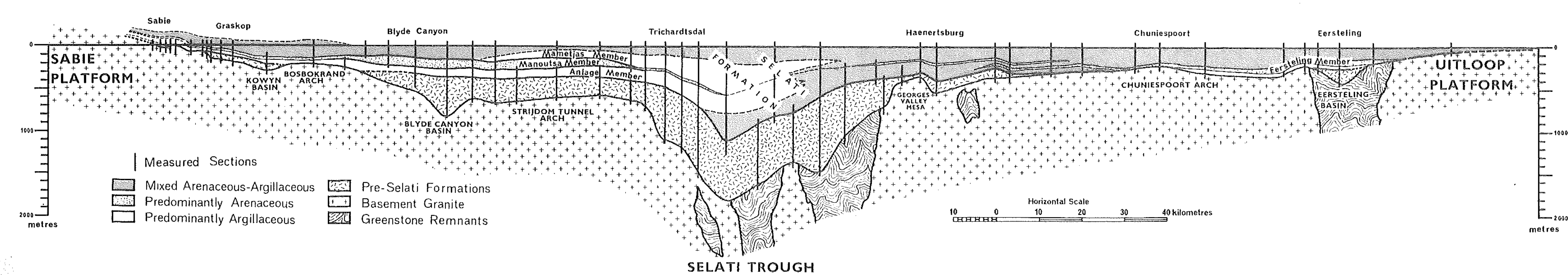
(b) ABEL ERASMUS VOLCANICS - LATERAL VARIATION IN GROSS THICKNESS



(c) SCHELEM FORMATION - LATERAL VARIATION IN GROSS THICKNESS



(d) SELATI FORMATION - LATERAL VARIATION



Haenertsburg. From near Trichardtsdal in the south, the formation thickens rapidly and, in general, maintains a thickness in excess of 100 m until the Georges Valley mesa is approached. The Schelem Formation laps onto and over the mesa where it thins abruptly to 35 m. Further to the southwest, the formation thickens to over 100 m in a channel-like body and then wedges out very rapidly onto the Chuniespoort arch. Over this arch and the Uitloop platform, the formation was not deposited. It is, however, locally well developed in the basin structure at Eersteling, where it attains a thickness of about 80 m.

To the south of Trichardtsdal, the formation is present in a further body. This development seldom exceeds 70 m in thickness. The formation includes a small but very distinct boulder-conglomerate-filled channel in the Blyde Canyon area. The channel displays a disconformable relation to the underlying Abel Erasmus Volcanics, having incised itself into the volcanics. The channel-fill includes fragments of Abel Erasmus lava in its boulder assemblage.

To the south of the Blyde Canyon, the Schelem Formation wedges out against the Bosbokrand arch. It is not developed farther to the south in the Kowyn basin or on the Sabie platform.

The Schelem Formation exhibits many of the same stratigraphic and sedimentologic features as the Sekororo Formation. The channel-like geometry of the unit is marked and is controlled, in part, by the basin floor topography. Taking account of the geometry of the unit and of its coarse nature, it is difficult to envisage any environment of deposition other than a fluvial one for the Schelem Formation.

D. SELATI FORMATION

The Selati Formation comprises a heterogeneous pile of sediments developed as a laterally continuous body confined between the Mabin Formation (above) and the Schelem Formation, Abel Erasmus Volcanics, or Archaean basement (below). In essence, the formation is composed of a mixed suite of sediments, which includes rapidly-alternating beds of shale, argillaceous quartzite, and quartzite. Within this heterogeneous assemblage, thick lenticular bodies of felspathic quartzite and of shale and mudstone are recognised.

The Selati Formation can be traced from the Uitloop to the Sabie platform (Figure 3d). The unit as a whole thins markedly onto the Uitloop platform. It thickens somewhat into a basinal structure at Eersteling and in another structure immediately to the south. Over the Chuniespoort arch, a thinning is noted, and the lowest member of the unit wedges out against the basement. When traced east-northeastward along the Strydpoort range, it thickens into the small basin structure at Haenertsburg, but thins noticeably over the buried Georges Valley mesa. South of this locality, the unit thickens markedly into the Selati trough where the arenaceous members are poorly represented.

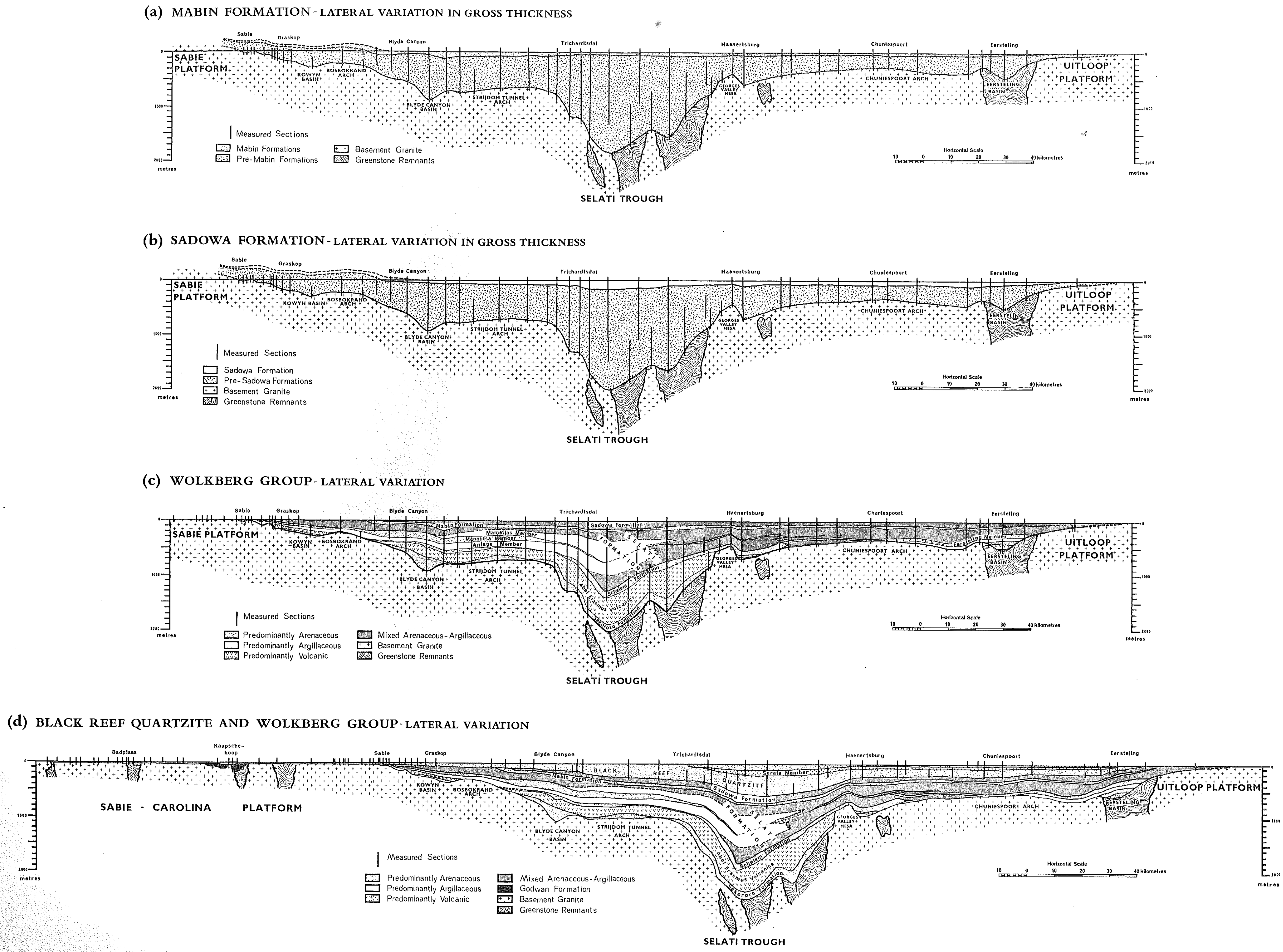
South of the Selati trough, the unit thins gradually but consistently towards Sabie. To the south of the Blyde Canyon, this purely stratigraphic thinning is augmented by pre-Black Reef Quartzite erosion. The highly-attenuated Selati Formation is finally eliminated by pre-Black Reef erosion just to the north of Sabie.

Within the widespread Selati Formation, various less extensive units may be recognised. To the south of the Selati trough, three lithological entities are present. The Anlage Member is composed principally of sandy, dolomitic and carbonaceous mudstone. It maintains a relatively constant thickness of 100 to 150 m over most of its extent, but thickens to nearly 300 m in the Selati trough and thins to some 20 m onto the Sabie platform.

The Manoutsa Member, composed largely of felspathic quartzite, has a near-perfect lens-shaped geometry, maintaining a thickness of around 100 m from the Strijdom Tunnel to the Blyde Canyon, and thinning out rapidly both north and south of this. On its southern limit, this unit was removed by erosion in pre-Black Reef Quartzite times. To the north, it pinches out into the Selati trough.

WOLKBERG GROUP AND BLACK REEF QUARTZITE - DEPOSITIONAL HISTORY

FIG. 4



The Mametjas Member is composed predominantly of carbonaceous shale and mudstone, in places dolomitic. It thickens from around 130 m in the south to over 400 m in the vicinity of the Selati trough. Over its entire extent, the Mametjas Member grades upwards to the overlying Mabin Formation through a transitional zone consisting of shale with beds of argillaceous quartzite and some quartzite.

North of the Selati trough, the Selati Formation consists of a mixed assemblage of shale with numerous beds of argillaceous quartzite and some quartzite. The Eersteling Member is the only unit differentiated in this mass. It is comprised of a felspathic quartzite which attains a maximum thickness of over 80 m in the basin at Eersteling. To the northwest it wedges out onto the Uitloop platform, while to the south and east, the Eersteling quartzitic body onlaps the underlying more argillaceous material and comes to rest directly on the Archaean basement around Chuniespoort. Farther northeastwards, along the Strydpoort range, the body is again underlain by more argillaceous strata. The Eersteling Member pinches out southwest of Haenertsburg.

From just north of the Selati axis to northeast of Chuniespoort, a thin body of more siliceous quartzite is present. This body appears to occupy a stratigraphic position similar to that of the Manoutsa Member.

The pattern of facies distribution within the Selati Formation provides useful clues with respect to the original geometry of the Wolkberg basin. It should be noted that, in the Selati trough region, the Selati Formation consists mainly of shales and mudstones. Northwest of the trough, these shaly rocks thin rapidly and undergo a very definite facies change to a mixed sedimentary assemblage which includes lenticular bodies of felspathic quartzite. South of the trough, a similar thinning and facies change is noted.

E. MABIN FORMATION

The Mabin Formation, composed largely of quartzite and felspathic quartzite (often with a thin medial zone of more argillaceous sediment), is usually encountered a short distance below the Black Reef Quartzite, and is separated from it by a thickness of dominantly shaly material (see Figure 4a). The formation is developed from near Eersteling to south of the Blyde Canyon. Around Eersteling, the formation is very thin; it loses its identity when traced to the northwest onto the Uitloop platform. From Eersteling, the unit maintains a thickness of 20 to 40 m; it thins to some 20 m in the Selati trough zone. South of the trough, the unit increases gradually in thickness and, near the Blyde Canyon, is locally over 100 m thick. Farther to the south, the Black Reef Quartzite comes to rest upon the formation and, around Bourkes Luck, the formation was eliminated by erosional truncation in pre-Black Reef times.

The Mabin Formation, in showing a distinct thinning into the Selati trough zone, behaves similarly to the arenaceous units of the Selati Formation which pinch out in this area.

F. SADOWA FORMATION

The Sadowa Formation, which consists predominantly of shale with interbedded argillaceous quartzite, may be recognised from the Eersteling area to just south of the Blyde River Canyon (Figure 4b). It rests upon the Mabin Formation and is overlain by the Black Reef Quartzite. A gradational contact between the Sadowa Formation and the Black Reef Quartzite is present from Eersteling to the Blyde Canyon area. South of the latter locality, the base of the Black Reef truncates the formation, eliminating it entirely.

The formation attains a maximum thickness of about 150 m in the vicinity of the Selati trough. In this region, the amount of arenaceous sediment in the formation is at a minimum. The Sadowa Formation thins irregularly towards the basin-edge platforms. North-east of Eersteling it wedges out onto the Uitloop platform. In these basin-edge areas, the formation comprises a greater proportion of argillaceous quartzite than elsewhere in the basin.

THE SIGNIFICANCE OF GROSS SEDIMENTARY PATTERNS IN THE WOLKBERG GROUP

In this section, an attempt is made to speculate on the nature of the depositional environments which are recorded by Wolkberg sedimentation. It is felt that the gross geometry and lithology of Wolkberg sedimentary units must reflect their depositional environment, and that a study of these parameters allows a tentative model of the sedimentary setting to be developed.

During the earliest stages of Wolkberg sedimentation, deposition was limited to discontinuous bodies of dominantly arenaceous sediment. It is probable that these deposits represent ancient fluvial channel-systems whose courses were strongly influenced by the palaeotopographic configuration of the ancient landscape. Deposition was limited to valleys, while elevated portions of the basement escaped sedimentation. The topographic irregularities in the basin-floor were gradually buried by successive periods of deposition and vulcanism, so that the later units of the Wolkberg were deposited on a relatively smooth surface.

The gross sedimentational pattern of the Wolkberg is one of transgression, the thickest and coarsest arenaceous units being developed near the base and giving way upwards, on the average, to successively finer deposits. The fluvial regimes responsible for the deposition of the coarse Sekororo and Schelem formations were covered by sediments which were deposited lower down the palaeoslope, possibly in an alluvial plane or fluvio-deltaic situation. The sedimentation patterns of the Selati, Mabin and Sadowa formations are reminiscent of a fluvio-deltaic situation with the thick argillaceous units representing deltaic deposits, and the main arenaceous units (Mabin Formation and the Manoutsa and Eersteling Members) representing the products of regressive periods, in which sands were deposited by fluvial systems built out over the finer shaly sediments.

Figure 5 shows the palaeocurrent directions measured in the arenaceous units of the Wolkberg Group, as well as a schematic representation of the gross sedimentary situation in Selati through to Sadowa formation times. It will be noted that the region of the Selati trough is dominated by argillaceous sediments. To the northwest and south of the Selati trough, mixed arenaceous-argillaceous lithologies predominate.

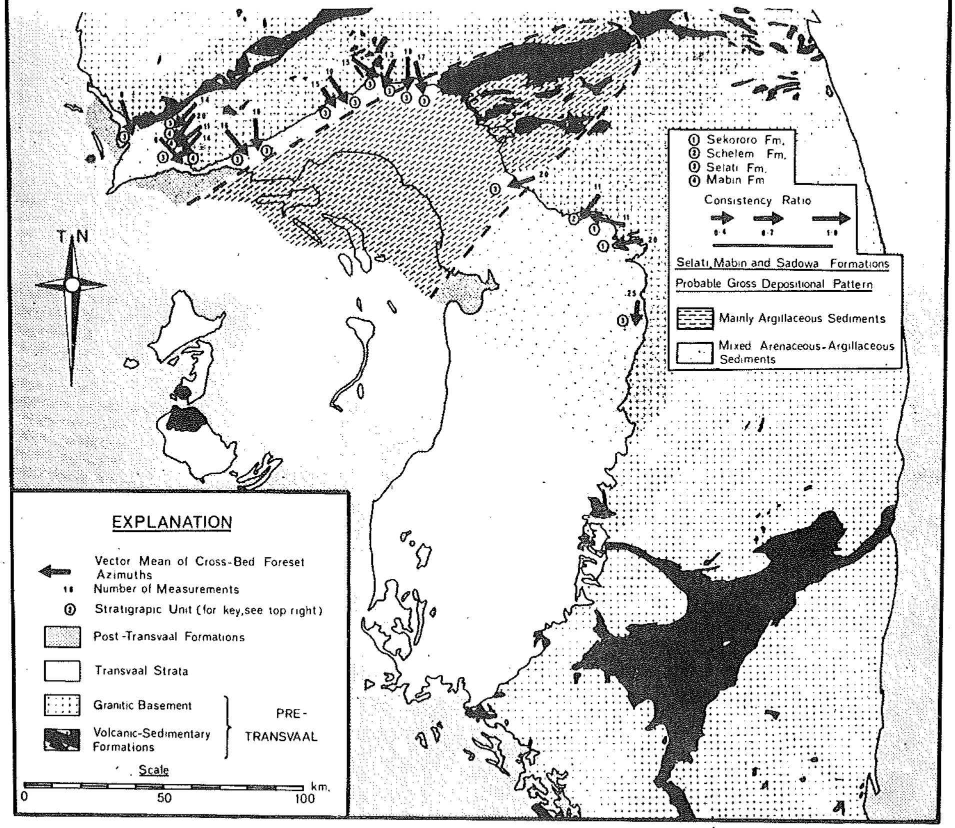
A study of the cross-bed foreset orientations (the majority of which were measured in the Selati-Sadowa interval), indicates that the broad depositional pattern is one of transport from the north into the Selati trough. South of the trough, transport is into the basin from easterly and northeasterly source areas. The probable reasons for the facies-change to argillaceous lithologies in the Selati trough is to be sought in the geometrical relationships of the provenance-areas to the Selati trough. The basin flanks, being relatively proximal to the provenance-areas, accumulated mixed arenaceous-argillaceous sediments while the rapidly-subsiding Selati trough, being further from the source-areas, accumulated a thick pile of argillaceous sediments.

THE DEPOSITIONAL HISTORY OF THE BLACK REEF QUARTZITE

The Black Reef Quartzite consists largely of mature, trough cross-bedded quartzite with minor gritty and conglomeratic phases. It includes, in the vicinity of the Selati trough, a lensoid body of basaltic lava termed the Serala Member. The formation rests on a variety of rock units, but is invariably overlain by the Malmani Dolomite (the basal formation of the Olifants River Group).

The thickness of the Black Reef has been studied from near Potgietersrus, in the northwest, to near Carolina, in the south. From more than 80 control points spread across the area, an isopach map of the unit has been constructed (see Figure 6). With the exception

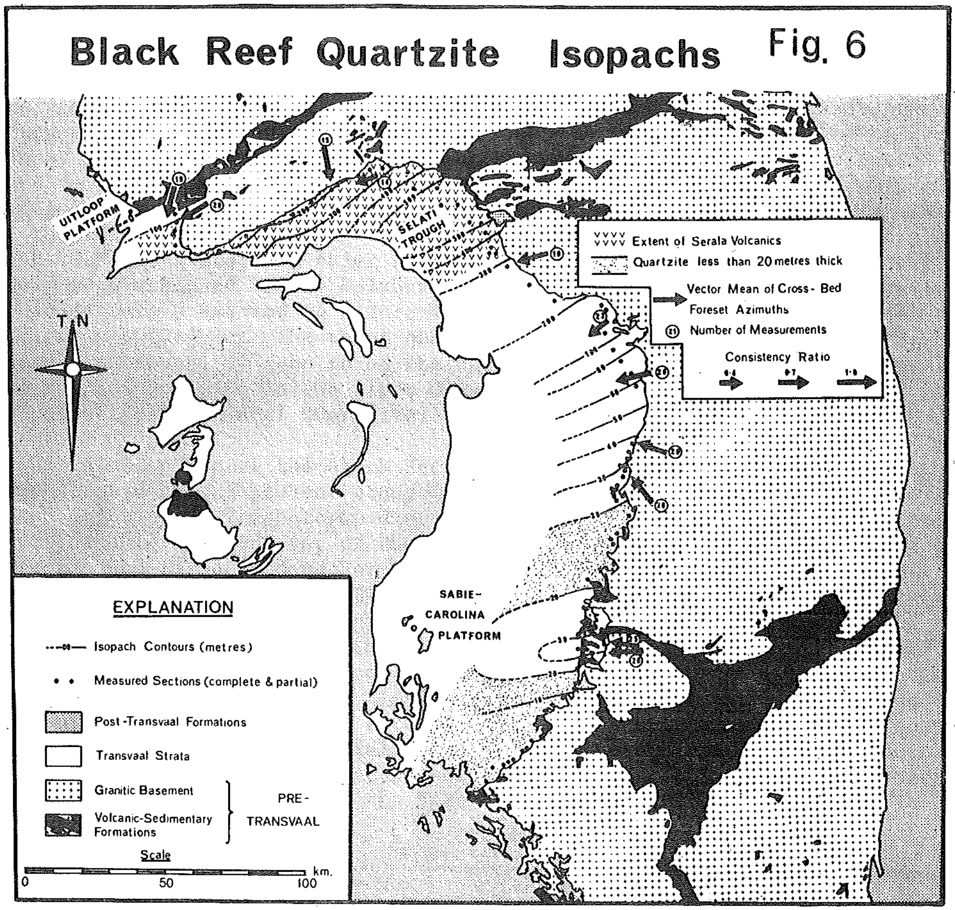
Wolkberg Group-Palaeocurrent Map Fig.5



of one borehole in the Selati trough region, the control points are all measured profiles. Due to uneven rates of thickness-change, the contour interval is not constant. Towards the south, thickness changes are gradual and necessitated a contour interval, firstly, of 20 m and, finally, of 10 m.

The isopach map shows a focus of sedimentation situated over the Selati trough. Here, the thickness of the unit exceeds 500 m. To the north of the trough, a very rapid thinning across northeast-trending isopach lines is evident. The formation pinches out completely near Potgietersrus. South of the Selati trough, thicknesses decrease less rapidly. Between Sabie and Carolina, thicknesses in excess of 20 m are exceptional. An anomalous channel-like body of slightly increased thickness is present in the Kaapschehoop area. Around Badplaas, the thickness of the quartzite is invariably less than 10 m. In this region the formation is all but missing in some instances, being represented by less than a metre of arenaceous sediment resting on the Archaean basement.

Superimposed upon the isopach map, a V-ornament shows the probable distribution of the Serala Member. The volcanics were extruded in a linear belt which was broadly parallel, and largely confined, to the Selati trough.



It is evident from the map that the Selati trough, active throughout the period of Wolkberg sedimentation, remained active and was the dominant floor-tectonic feature during Black Reef times. It was present as an elongated zone of persistent and relatively rapid subsidence which resulted in the accumulation during Black Reef times of a great thickness of arenaceous sediment, as well as a thick layer of basaltic lava.

To the north, the Uitloop platform was strongly active as a broad positive feature. Onto this elevated platform, the Black Reef Quartzite (and the Serala Member) suffered a rapid wedge-out. During Black Reef times, the Sabie platform of the Wolkberg era appears to have been subjected to subsidence for a greater distance further to the south. This mega-platform (the Sabie-Carolina platform) underwent only mild subsidence and accumulated a thin veneer of arenaceous sediment (less than 20 m) over an extensive area.

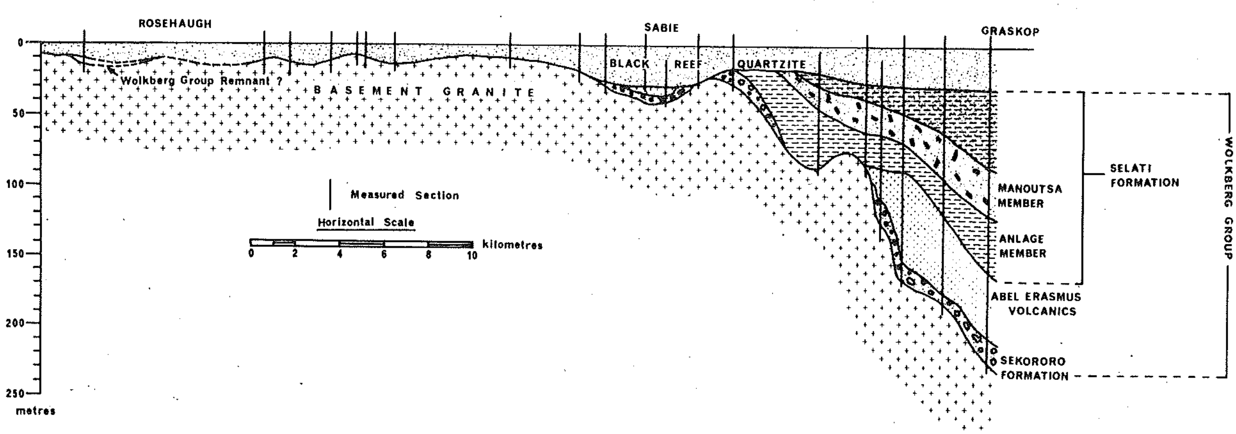
Superimposed on the isopach map are the palaeocurrent vectors determined for the Black Reef Quartzite at 11 stations around the outcrop. It is evident that the sedimentary transport was predominantly from the arcuate basement region inwards towards the basin centre. These determinations confirm, in a broad way, the sedimentary-tectonic pattern established for the Wolkberg Group. It is evident that, during the early stages of Transvaal deposition, the sedimentary filling of the basin was derived from provenance areas which were situated to the north and east of the present limits of the basin.

The isopach map is supplemented by the stratigraphic panel-diagram presented in Figure 4d. In this diagram, lateral changes in thickness of the Black Reef are shown, as well as the regional relationship of this formation to the Archaean basement, the Godwan Formation (type area), and the Wolkberg Group. An important difference in the stratigraphic correlation by the author and by Schwellnus and others (1962) is well illustrated in this panel-diagram. The latter authors were concerned with an area which extended from south of Trichardtsdal to Chuniespoort. The Serala Member is developed over all but a small portion of their map-area. They regarded the thin quartzite body above the Serala Member as the Black Reef Quartzite; the thick body of quartzite below the Serala and the Serala Member itself were assigned to the Wolkberg System. In the light of the regional stratigraphic picture presented in Figure 4d, the subdivision by Schwellnus and others (1962) is clearly untenable. The thick quartzite body found below the Serala Member, when traced towards the south, is seen to be the same body of arenaceous sediment developed beneath the Malmani Dolomite in the Blyde Canyon area and farther to the south, where it represents undoubted Black Reef Quartzite.

The relationship of the Black Reef to the underlying Wolkberg Group has been clearly demonstrated by the present study. The panel-diagram shown in Figure 4d illustrates that, for the majority of its outcrop distance, the base of the Black Reef Quartzite is perfectly conformable with the top of the Wolkberg Group. The former displays a gradational contact with the underlying Sadowa Formation; a sedimentary cycle may be traced uninterruptedly across the Wolkberg-Black Reef boundary. These stratigraphic relations imply that, over much of the Wolkberg basin, subsidence and deposition were continuous from Wolkberg into Black Reef times. To the south of Bourkes Luck, however, the continuous subsidence which resulted in the accumulation and preservation of the Wolkberg Group was reversed in immediate pre-Black Reef times. The Wolkberg was elevated above base-level and was bevelled off by erosional forces with increasing thoroughness towards the south. The thin accumulations of Wolkberg material which must have been present to the south of Sabie were almost totally removed by this erosional event, so that the Black Reef Quartzite was deposited, in this area, directly on the basement granites.

FIG. 7

BLACK REEF - WOLKBERG RELATIONSHIPS IN THE SABIE AREA



The nature of the local angular unconformity is clearly illustrated in the panel-diagram presented in Figure 7. In the Sabie-Graskop area, the Black Reef Quartzite is present as a blanket sand deposit, with a thickness varying from 30 m in the north to just over 10 m to the south of Sabie. The various members of the Selati Formation, the Abel Erasmus Volcanics, and, finally, the Sekororo Formation were truncated, as one traces the formations from the Graskop area to just south of Sabie.

In the area to the south of Rosehaugh, a thin accumulation of shaly material was found to underlie the Black Reef Quartzite. Visser and Verwoerd (1960) recorded a small occurrence of shale and conglomerate in this vicinity. It seems likely that these remnants are the most southerly preserved occurrence of Wolkberg material which escaped the pre-Black Reef erosion.

CONCLUSIONS

There can be little doubt that the Wolkberg Group is a response to a series of events which began in Sekororo times and continued upwards uninterruptedly into that portion of the stratigraphy universally accepted as being portion of the Transvaal Super-group. In earliest Wolkberg times, deposition was restricted to local depressions found in a northeast-trending belt of sedimentation some 200 km wide. The Sekororo Formation and, in later times, the Abel Erasmus Volcanics and Schelem Formation filled a number of floor-hollows and began to lap across some of the less elevated floor-highs. The upper portions of the Selati Formation were the first to lap entirely across the floor-highs, so that sedimentation was continuous over the entire 200 kilometre-wide belt. In post-Selati times, sedimentation was laterally continuous and stratigraphic units changed thickness more gradually, in response to the regional tectonic controls. This pattern of sedimentation is familiar in the main portion of the Transvaal basin, where stratigraphic units can commonly be followed for hundreds of kilometres with only the most gradual of changes being apparent.

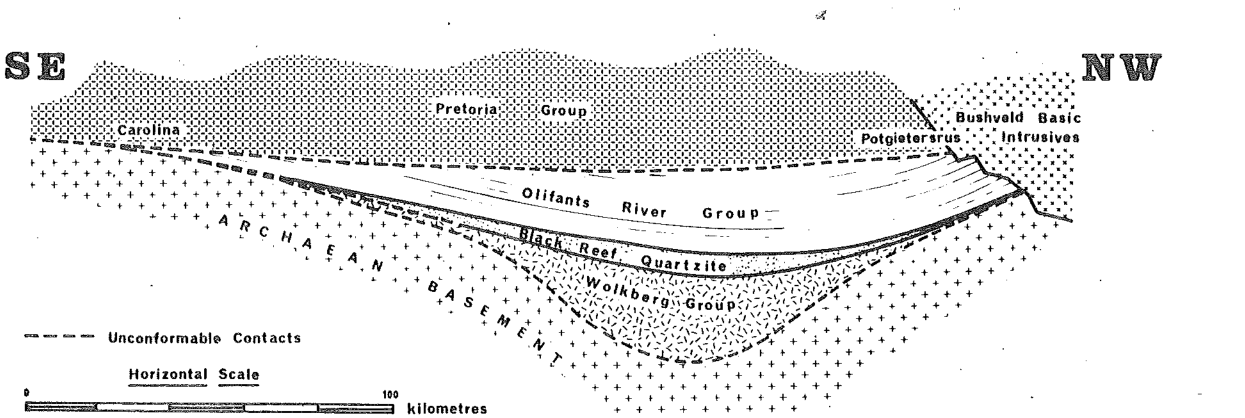
It has been shown that the Black Reef Quartzite is strictly conformable with the Wolkberg Group over the major portion of the outcrop area. The pattern of cyclical sedimentation in the Wolkberg (manifested by the alternation of argillaceous and arenaceous units) is not interrupted across the Wolkberg-Black Reef contact. This contact is in fact a zone of lithological gradation.

In arguing the stratigraphic affinities of the Wolkberg Group, it is instructive to examine the relationship of the Pretoria Group to underlying formations within the Transvaal Supergroup (Figure 8). The Pretoria Group, over its entire extent in the area studied, covers the underlying formations with an intraformational unconformity. In the extreme south, the Pretoria Group comes to rest, in places, upon the Archaean basement (Visser and others, 1956). This basin-wide intraformational unconformity is not used to separate the Pretoria Group from the underlying Olifants River Group into two different "systems". It would thus be totally illogical to divorce the Wolkberg Group from the remainder of the Transvaal Supergroup on the basis of an unconformity with an areal extent much less extensive than that separating the Pretoria from the Olifants River Group.

The facts outlined above provide evidence that the Wolkberg Group, far from being a correlative of the Witwatersrand and Dominion Reef successions, is an integral portion of the Transvaal Supergroup. The Wolkberg Group is conveniently regarded as the initial or proto-basinal stage of Transvaal deposition. It would appear that such proto-basinal assemblages are characterized by their relatively limited areal extents and by their immature sedimentary patterns (manifested by the scarcity of compositionally mature sediments and by the limited extent and rapid lateral facies-changes of lithologic units).

FIG.8

GROSS STRATIGRAPHIC SUBDIVISION OF THE TRANSVAAL SUPERGROUP, EASTERN AND NORTHERN TRANSVAAL



The gross-tectonic control on sedimentation was similar for both the Wolkberg Group and the overlying Black Reef Quartzite. In particular, the coincidence of the Selati trough with the Murchison lineament is highly significant. The Murchison linear zone has been intermittently active for a period of geologic times which probably exceeds one billion years. In the first instance, it was responsible for the accumulation of the sediments and volcanics of the Murchison schist belt at a period probably pre-dating 3000 m.y. ago. Subsequently, during deposition of the Wolkberg Group, Black Reef Quartzite, and Olifants River Group, the westerly continuation of the belt acted as a zone of accelerated subsidence and was the site of maximum accumulation of sediment within these successions. In immediate pre-Pretoria Group times, this zone was active once again, this time as a belt of tectonic disturbance which resulted in the linear, east-northeast-trending Mhlapitsi fold-belt.

A similar relationship to that described above was present along the south-westerly continuation of the Pietersburg schist belt. Here, anomalous thicknesses of Wolkberg Group material accumulated in a minor floor-hollow, the Eersteling basin. A converse relationship is shown by the granitic tract separating the Pietersburg and Murchison belts. This zone was tectonically buoyant during Wolkberg sedimentation and gave rise to the east-northeast-trending Chuniespoort arch. In post-Transvaal times, this floor-high was re-activated and resulted in the prominent anticlinal warp about which the Transvaal strata undergo a right-angled inflection in the vicinity of Zebediela. To the south of the Murchison range, the tectonically positive Strijdom Tunnel arch was also the site of a post-Transvaal anticlinal feature about which the Transvaal strata were deformed.

The effect of the depositional tectonics on sedimentary facies has been demonstrated. In particular, the Selati, Mabin, and Sadowa formations undergo facies changes within the Wolkberg proto-basin. The relatively thin, mixed arenaceous-argillaceous units developed on the flanks of the basin become progressively thicker and finer grained when traced towards the Selati trough. The major arenaceous units (Manoutsa Member, Eersteling Member, and Mabin Formation) tend to pinch out into the trough. It was concluded that the facies-changes within the Wolkberg Group could best be explained by the spatial relationships of the tectonically positive sediment-yielding provenance areas to the tectonically negative sediment-accepting Selati trough. The basin flanks, being more proximal to the provenance regions are characterized by relatively thin accumulations rich in arenaceous sediment; the inverse relationship holds for the region of the basin trough.

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Key to Figures

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