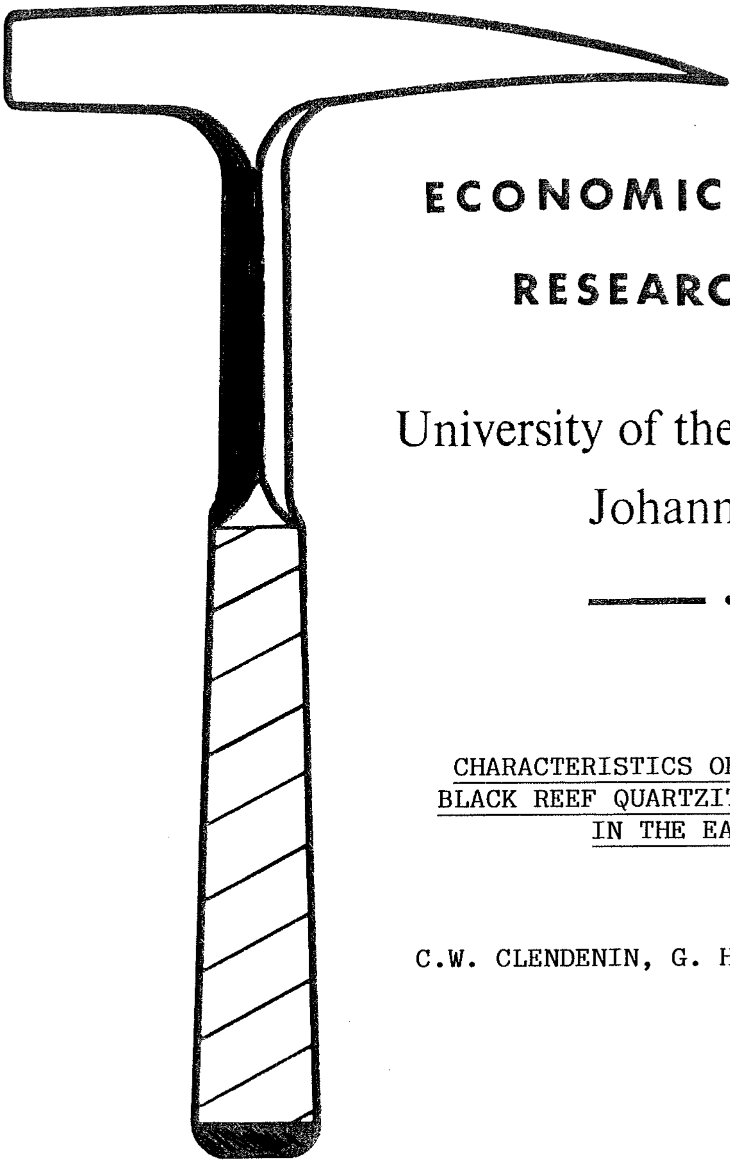

ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

CHARACTERISTICS OF AND INFLUENCES ON THE BLACK REEF QUARTZITE STRATIGRAPHIC PACKAGE IN THE EASTERN TRANSVAAL

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by

C.W. CLENDENIN, G. HENRY AND E.G. CHARLESWORTH

(Department of Geology, University of the Witwatersrand, P.O. Wits 2050, Johannesburg, South Africa)

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ABSTRACT

Field relationships are used to establish the Black Reef Quartzite stratigraphic package in the eastern Transvaal. This stratigraphic package is a thin unit of fluvial siliciclastics, which developed below the Chuniespoort Group carbonates, and is bounded by regionally correlatable stratal surfaces. A subtle angular unconformity separates the Black Reef package from Archaean and Wolkberg Group strata over parts of the eastern Transvaal. In the Selati Trough, a newly recognised unconformity-bounded package, here informally referred to as The Downs stratigraphic package, separates Wolkberg Group strata from the Black Reef package. Recognition of The Downs package clearly indicates that the Black Reef Quartzite package and the Wolkberg Group are not conformable in the Selati Trough. Interpretations of syndepositional tectonics also imply that both regional and local vertical crustal movements developed the different regional unconformities.

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1. INTRODUCTION

Successful interpretation of a basin's history requires the establishment and regional correlation of genetic stratigraphic units or packages. Once these units are established, basin analysis is reasonably straight forward, but the identification of a genetic unit can be difficult. In particular, difficulties may arise because of litho-stratigraphic misconceptions due to a lack of established regional facies relationships and depositional systems, and to the lack of identification of stratal-bounding surfaces. Given a choice of possible bounding surfaces, those which reflect major reorganizations of a basin's structure should be emphasized (Galloway, 1989). With recognition of such surfaces, a clear and pragmatic approach to stratigraphic analysis can be established because interpretations of epeirogeny can be no better than the stratigraphic observations upon which they are based (ISSC, 1987; Galloway, 1989).

Recently, Clendenin *et al.* (1988a, b) established a direct relationship between the Ventersdorp Supergroup rifting event and thermal subsidence of the Chuniespoort/Ghaap Group sea. Regional stratigraphic relationships over the Transvaal show that the depocentre of this particular successor basin sequence was along a north-south line east of Vryburg (Figure 1). Such a delineation appears to contradict Button's (1973) proposed proto-basin associated with the east-west-striking Selati Trough in the northeastern Transvaal (Figure 1). The interpretations of both Button (1973) and Clendenin *et al.* (1988a, b) are based on marginal unconformities that pass into apparently conformable sequences and on sedimentary units that thicken toward a depocentre. For example, measured sections in the Chuniespoort Group indicate that approximately 45% more carbonate sediment accumulated in the western Transvaal than in the Selati Trough (Clendenin and Maske, 1986). However, Button (1973) showed that the Black Reef Quartzite Formation, here referred to as the Black Reef Quartzite, is over 500 m thick in the Selati Trough. Elsewhere in the Transvaal, the Black Reef Quartzite is only a few metres thick, where it underlies the Chuniespoort/Ghaap Group carbonates.

To resolve these apparent stratigraphic contradictions, contacts between the Black Reef Quartzite and underlying and overlying units were re-examined at several localities in the eastern Transvaal (Figure 1). Detailed observations were made of the basal contact so that a genetic stratigraphic unit could be correlated over the region. In this paper, the authors report these observations, establish other genetic stratigraphic units that were identified, and discuss the implications for the syndepositional tectonics of the protobasinal events of the Chuniespoort/Ghaap Group sea. Detailed facies descriptions of the Black Reef Quartzite stratigraphic unit will be presented later by Henry *et al.* (in prep.).

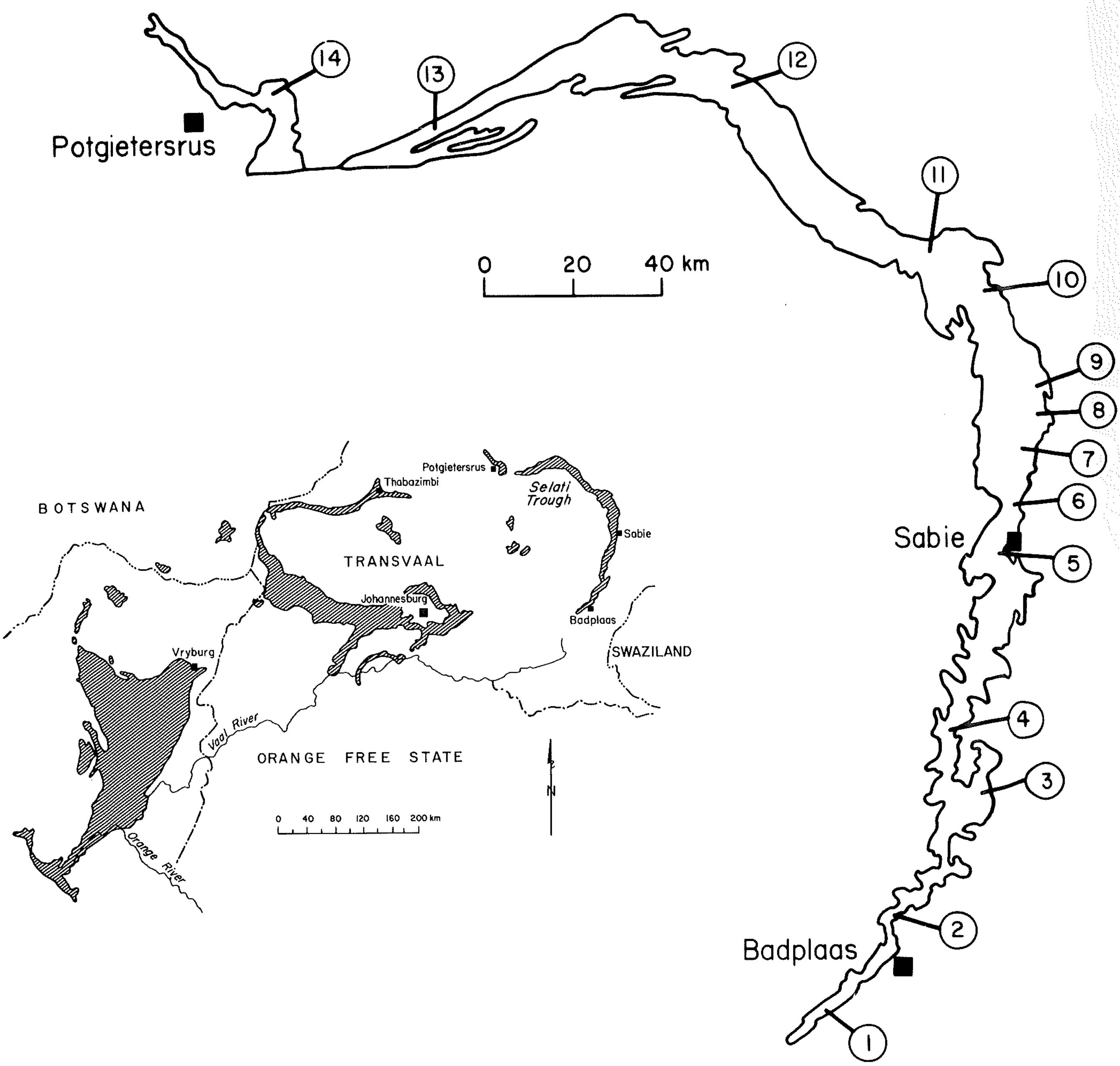

Figure 1. Locality map showing outcrop of the Chuniespoort and Ghaap Groups of the Transvaal Sequence. Measured section localities are: (1) Buffelspruit 22IT; (2) Grootkop 617JT; (3) Kaapsehoop; (4) Sudwala Caves; (5) Sabie; (6) MacMac Falls; (7) Lisbon Falls; (8) Erasmushoop 45KT; (9) Bourke's Luck; (10) Blyde River Canyon; (11) Abel Erasmus Pass; (12) The Downs 34KT; (13) Chuniespoort; and (14) Makapansgat 39KS.

11. FIELD RELATIONSHIPS

In his review of the previous work on the Black Reef Quartzite, Button (1973) indicated that, as originally proposed by early workers, e.g. Thord-Gray (1905), Hall (1910, 1912, 1914) and Kynaston *et al.* (1911), the unit comprises a veneer of arenaceous material that forms the basal unit of the Transvaal Sequence, and which unconformably overlies earlier stratigraphic units over much of the western and central Transvaal. However, Button (1973) reported a conformable relationship between the Black Reef Quartzite and the underlying Wolkberg Group in the eastern Transvaal. The Wolkberg Group, first recognised and mapped by Schwellnus *et al.* (1962), is confined to the north-eastern Transvaal and consists of a 2 630 m-thick package of siliciclastic sedimentary rocks and minor basic volcanics. SACS (1980) has subsequently defined the Black Reef Quartzite as comprising quartzite with lenses of grit and conglomerate, which has an unconformable base where the Wolkberg Group is not present and a conformable one where it is. A consequence of these suggested relationships is that SACS (1980) currently regards the Wolkberg Group as part of the Transvaal Sequence.

In order to test this assertion and to delineate the genetic stratigraphic units, the following field observations were made of the contact relationships at 15 sample sites in the eastern Transvaal (Figure 1). Observed relationships are documented below from south to north.

The most southerly documented occurrence of the Black Reef Quartzite crops out 25 km west of Badplaas on Buffelspruit 22IT, as a veneer of quartzite less than 1 m thick. The basal contact of this thin unit is an unconformity where the quartzite overlies Archaean granitic rocks. Locally, pebble-conglomerate filled channels have eroded into this contact. The upper contact of the genetic unit is marked by a zone of carbonaceous shale, and this relationship was noted to be fairly constant over the eastern Transvaal. On Grootkop 617JT, 25 km north of Badplaas, a sharp nonconformable contact with Archaean granitic rocks is exposed. A robust conglomerate is present on the contact, but along strike, conglomerates are only present about 1 m above the contact (Figure 2a). These conglomerate units appear to have been deposited in channels. An unconformable contact is also well exposed along the escarpment at Kaapsehoop. Locally along this contact, robust conglomerates were deposited in channels incised into this contact. Channel widths vary from a few metres to hundreds of metres and cobbles up to 18 cm in diameter are present within them. Where channels are not developed, a small-pebble conglomerate or trough cross-laminated quartzarenite is nonconformable with the granite basement.

In the vicinity of Sudwala Caves, a 5 m thick, coarse-grained quartzarenite lies above a chertified shale unit of the Godwan Formation. A shallow angular unconformity is developed between the two units and contact relationships are clearly erosional. Coarse-grained quartzarenite is also present above a distinct erosional contact with a volcanic unit at Sabie. Button (1973) correlated this volcanic unit with the Abel Erasmus volcanics of the Wolkberg Group and identified an angular unconformity with the Black Reef Quartzite.

Figure 2a. *Robust Black Reef Quartzite conglomerate unit deposited approximately 1m above the base of the package on Grootkop 617JT.*

Figure 2b. *Small-pebble conglomerate marking base of the Black Reef stratigraphic package at Abel Erasmus Pass.*

Figure 2c. Lower contact of The Downs stratigraphic package marked by a pebble conglomerate at The Downs 34KT.

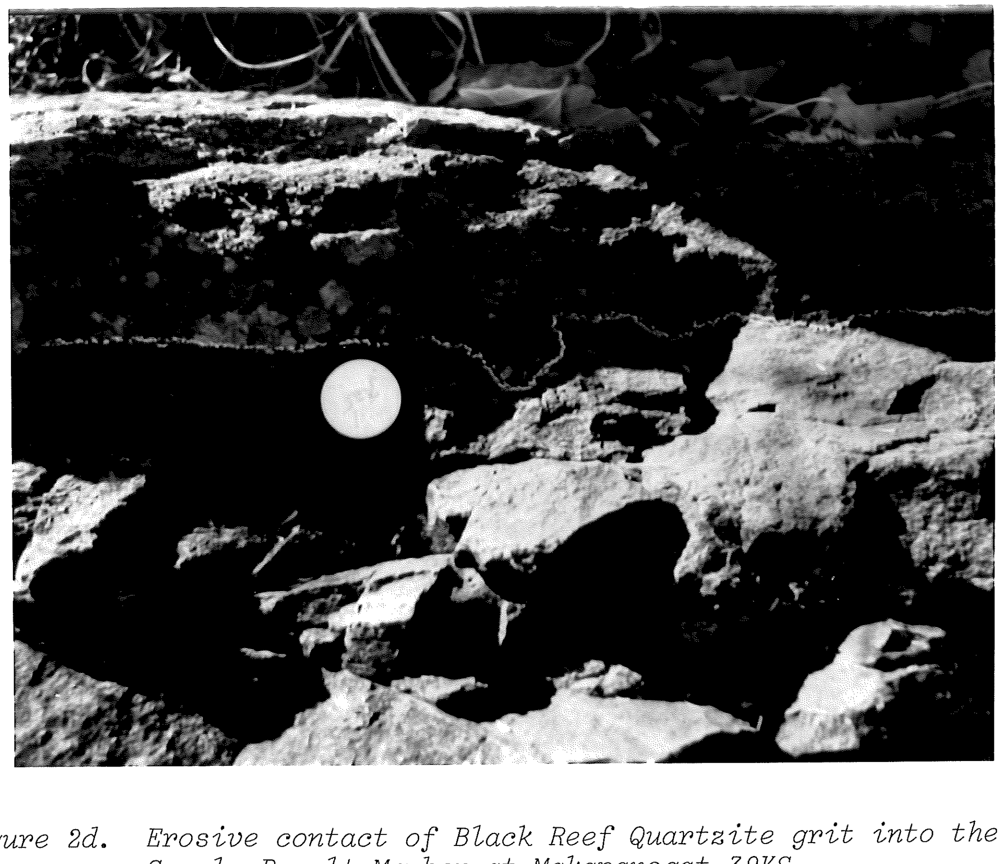

Figure 2d. Erosive contact of Black Reef Quartzite grit into the Serala Basalt Member at Makapansgat 39KS.

Further to the north at MacMac Falls, Lisbon Falls, Erasmus-hoop 457KT, Bourke's Luck, Blyde River Canyon, and Abel Erasmus Pass (Figure 2b), the basal contact is consistently marked by either a single pebble lag or a 10 cm thick, clast-supported pebble conglomerate. Locally, coarse-grained quartzarentite or small-pebble conglomerate may be present on the unconformity surface. Pebbles are dominantly vein quartz and are up to 4 cm in diameter. The contact is clearly erosive and broad, shallow channels identified on it are seldom over 10 cm deep. From MacMac Falls to Abel Erasmus Pass, the contact is commonly developed on a mature, trough cross-laminated quartzite. In the field, this mature quartzite is easily distinguished from the coarse-grained quartzarenites and granulestones of the Black Reef Quartzite, which can be greater than 20 m thick near Bourke's Luck.

At The Downs 34KT, two erosional contacts were identified. The lower contact is developed on a mature, trough cross-laminated quartzite and is marked by either a pebble conglomerate or a poorly sorted granulestone (Figure 2c). The upper contact is developed on the Serala Basalt Member (SACS, 1980) that wedges in north of Abel Erasmus Pass. This upper contact is also overlain by either clast-supported pebble conglomerates or poorly sorted granulestones. Both erosional contacts are present further to the north at Chuniespoort as well as on Makapansgat 39KS. Findings at these localities were similar to those observed at The Downs 34KT; erosional contacts are developed on both a mature, trough cross-laminated quartzite and the Serala Basalt Member (Figure 2d). At Chuniespoort, the character of the lower contact, and the associated pebble lag marking it, closely resembles that identified at Abel Erasmus Pass, where the Serala Basalt Member is absent. The contact between the underlying conglomerate-quartzarenite and the lava unit is not always exposed, but at Makapansgat 39KS, conglomerate flame structures are developed along the contact and can be attributed to loading of the sediment by the lava. The quartzarenite unit above the Serala volcanic thins to the north from 30 m at The Downs 34KT to 20 m at Chuniespoort (Schwellnus *et al.*, 1962) and then to 2 m at Makapansgat 39KS. Button (1973) indicated that north of Makapansgat 39KS the quartzarenite pinches out completely on what he termed the Uitloop Platform.

111. GENETIC STRATIGRAPHIC PACKAGES

Button (1973) described the Black Reef Quartzite as consisting largely of mature, trough cross-laminated quartzite with minor gritty and conglomerate phases. However, this description is inconsistent with our identified field relationships. In the vicinity of The Downs 34KT, two erosional contacts separate the mature, trough cross-laminated quartzite that Button (1973) described as the Black Reef Quartzite, from the genetic stratigraphic unit that the writers recognize as the Black Reef Quartzite at the base of the Chuniespoort/Ghaap Group carbonates. Schwellnus *et al.* (1962) had originally identified this thin quartzarenite body above the Serala Basalt Member as Black Reef Quartzite, but Button (1973) argued that such a designation was unacceptable based on regional relationships. Button (1973) based his arguments on field relationships in the Blyde Canyon area where the Serala Basalt Member is missing and the two siliciclastic units have similar sedimentary structures. However, when traced south of The Downs 34KT, the thick, mature quartzite body found in the Selati Trough is not the same unit as the Black Reef Quartzite as argued by Button (1973). An erosional unconformity clearly separates the two at Abel Erasmus Pass and in the Blyde Canyon area. The presence of these erosional contacts indicate that Button (1973) was also mistaken that the base of the Black Reef Quartzite was perfectly conformable with the Wolkberg Group and that subsidence and deposition were continuous from Wolkberg into Black Reef Quartzite times over parts of the region.

Identified field relationships show that the Black Reef Quartzite is a stratigraphic package of genetically related sedimentary rocks (Figure 3). This package is bounded by a lower surface which is a correlatable erosional unconformity, while the upper surface is a zone of carbonaceous shale. This shale represents a regional transition between siliciclastic depositional systems of the Black Reef Quartzite and carbonates of the Chuniespoort/Ghaap Group sea. Siliciclastics within the Black Reef Quartzite package consist of coarse quartzarenites and granulestones with minor amounts of conglomerate near the base. These sediments are interpreted to be fluvial in origin (Henry *et al.*, in prep.). Stratigraphic thicknesses increase toward the Selati Trough where a maximum of 30 m is recorded, in contrast to the thickness of over 500 m proposed by Button (1973).

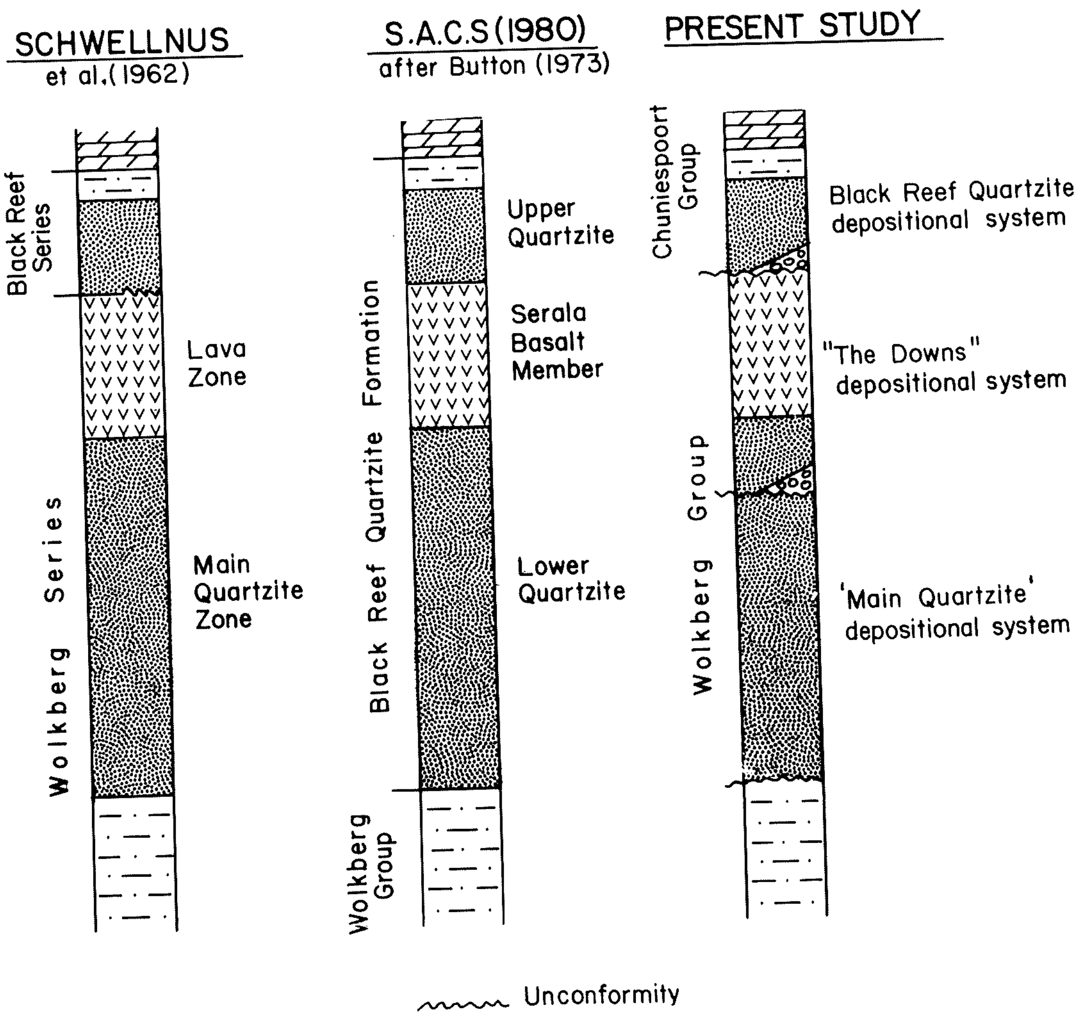

Figure 3: Stratigraphic sections for the Selati Trough area showing previous and present interpretations of correlations between the Wolkberg and Black Reef Quartzite stratigraphic packages.

The Black Reef Quartzite package is distinct from a second, underlying unconformity bounded unit developed north of Abel Erasmus Pass. This unit is informally referred to here as The Downs stratigraphic package (Figure 3). The Downs package is bounded by a lower erosional contact with the thick, mature, trough cross-laminated quartzite described by Button (1973) and by the overlying, basal Black Reef Quartzite unconformity. At The Downs 34KT, the package is probably not over 15 m thick and consists of an underlying coarse quartzarenite-conglomerate and an overlying volcanic (Serala Basalt Member). The lower zone of siliciclastics is very similar to those found in the Black Reef Quartzite package and are also interpreted to have had a fluvial origin. In the field, these two similar siliciclastic bodies can be easily confused if the Serala Basalt Member does not separate them.

Closer examination of the Black Reef Quartzite package reveals that it consists of both an eroding and a depositing sequence. Eroding sequences are rarely preserved, but when they are, such sequences are good indicators of syndepositional tectonics. Depositing sequences are those which account for stratigraphic accumulations and, in many cases, subtle lithological similarities between different depositional sequences result in mistakes in lithostratigraphic correlations. In the Black Reef Quartzite package, the eroding sequence is characterized by robust conglomerates and incised channels, while the depositing sequence is characterized by blanket-like, coarse quartz arentite deposits and unconfined channels. Isopachs presented here are based primarily on the depositing sequence (Figure 4).

1V. INTERPRETATIONS OF SYNDEPOSITIONAL TECTONICS

Identification of two genetic stratigraphic packages in the eastern Transvaal above the unit Button (1973) described as the Black Reef Quartzite leads to a number of interesting interpretations of syndepositional tectonics. Clendenin *et al.* (1988b) proposed that the opening of the Selati Trough was related to regional extensional stress, which resulted in the Ventersdorp Supergroup rifting event, and that the Wolkberg Group was correlatable with the Ventersdorp Supergroup. A rift unconformity separates the Ventersdorp Supergroup from the Bothaville-Allanridge Formation package in the western Transvaal (Clendenin *et al.*, 1988b). Mechanical subsidence is commonly followed by thermal subsidence and the rift unconformity between the mechanical and thermal sag sequences represents an excellent marker (Etheridge, 1986). Such a marker would represent a regional reorganization of the basin.

Fluvial siliciclastics of the Bothaville Formation were deposited above the rift unconformity and were subsequently overlain by Allanridge Formation volcanics (Clendenin *et al.*, 1988b). Although condensed, this stratigraphic pattern is mimicked exactly by The Downs stratigraphic package, in that fluvial siliciclastics deposited above a correlatable unconformity are overlain by basalt flows. Buck (1980) interpreted the Bothaville Formation in the western Transvaal as deposited on a broad fluvial plain that was influenced by a southern tilt. Crustal reorganizations, which produced this tilt, are interpreted to have also produced the unconformity between The Downs package and the underlying trough cross-laminated quartzite. Following this modification of the basin's infrastructure, The Downs package accumulated prior to subsequent regional epeirogenic movements.

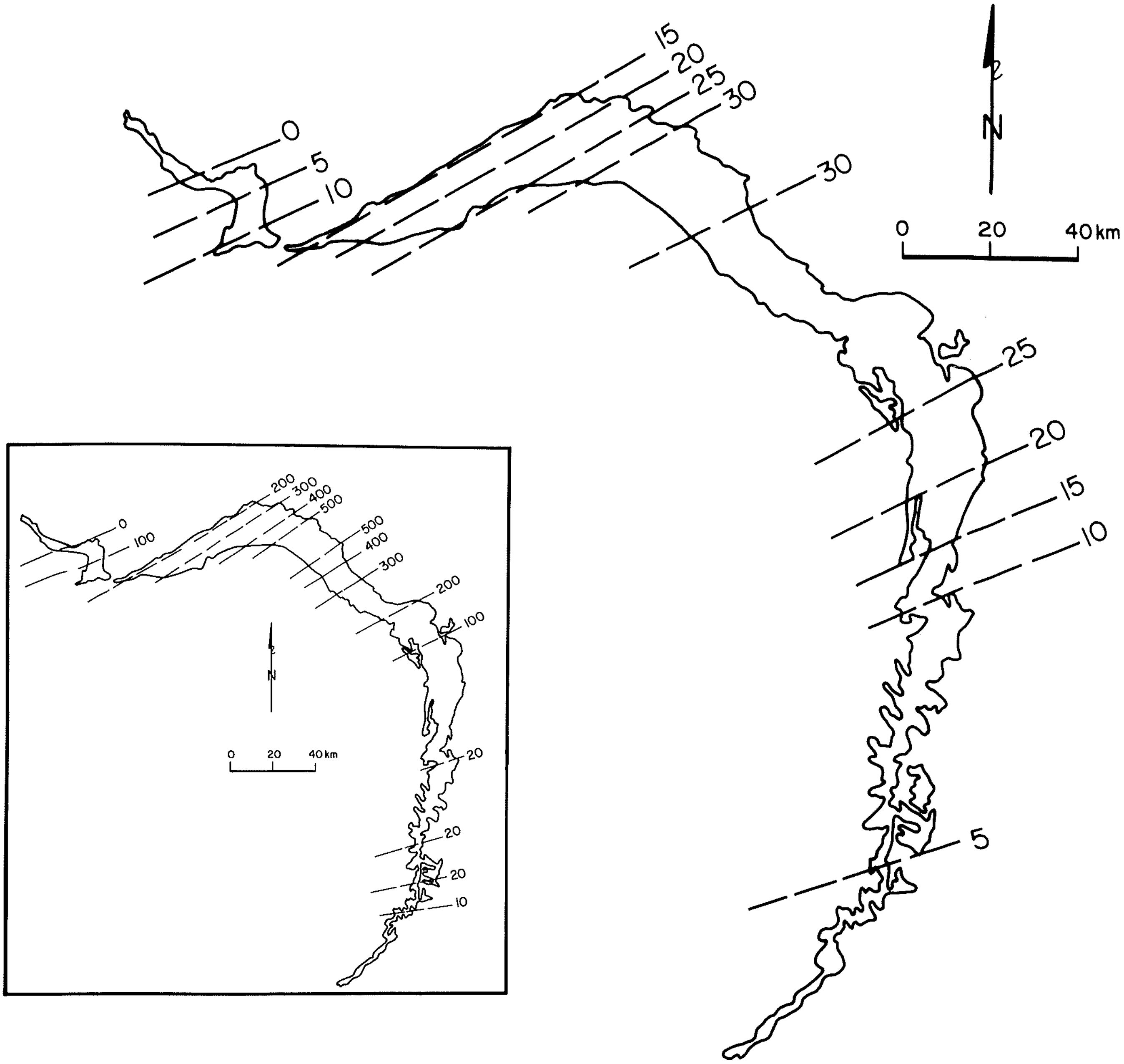

Figure 4: Isopach map showing thickness of the Black Reef Quartzite stratigraphic package in the eastern Transvaal.

Field relationships show that a new pattern of syndepositional tectonics began to affect the eastern Transvaal just prior to deposition of the Black Reef Quartzite package. These epeirogenic movements differentially uplifted the southeast portion of the Transvaal and superimposed a northerly tilt on the region. Differential tilt produced an angular unconformity between the Black Reef Quartzite package and underlying, older stratigraphic units, i.e. this angular unconformity can be traced northwards from south of Badplaas towards Abel Erasmus Pass. Although subtle, the angularity of the unconformity is marked in a northern direction by the Black Reef Quartzite package being deposited on progressively younger stratigraphic units from Archaean basement in the south to The Downs stratigraphic package in the north. Absence of The Downs package south of the Selati Trough substantiates the timing between this older unit and the Black Reef Quartzite package, as well as differentiates the syndepositional tectonics which affected both of them.

Development of incised channels is prominently observed in only the southern portion of the eastern Transvaal and indicates that southeast uplift was due to an episode of tectonic tilting instead of extension faulting. Fault-induced movements are not characterized by one-sided incision, but would be indicated by incision of both the low-gradient hanging wall and high-gradient footwall. Any tilting would have had almost instantaneous effects on fluvial systems as streams flowed down the tilted surface and incision would occur above the hinge line (Alexander and Leeder, 1987). Although the entire area south of Abel Erasmus Pass was affected by the northern tilt, the occurrence of such a hinge line between Kaapsehoop and Sudwala is indicated by incised channels developed by the eroding sequence at Kaapsehoop, in contrast to only the depositing sequence being present at Sudwala.

Differential southeast uplift would have reorganized local basining events and affected the surface on which the Black Reef Quartzite package accumulated as just described. Such reorganizations would have also induced avulsion and migration of the Black Reef Quartzite fluvial systems into the Selati Trough. Stratigraphic thicknesses indicate that the 'low-seeking' fluvial system occupied the Selati Trough and that the Selati Trough was the axis of subsidence during Black Reef Quartzite times. However, thicknesses also indicate that the Selati Trough was only a local depocentre and not the protobasin to the Chuniespoort/Ghaap Group sea as proposed by Button (1973) because it was filled by the beginning of Lyttelton Formation, Chuniespoort Group, time.

V. CONCLUSIONS

In this study, the writers have used field relationships to define the Black Reef Quartzite stratigraphic package in the eastern Transvaal. The package is a thin unit of fluvial siliciclastics bounded by regionally correlatable stratal surfaces. The package reaches its maximum thickness of 30 m in the Selati Trough and a subtle angular unconformity separates it from older, underlying stratigraphic units.

These relationships indicate that Button (1973) was mistaken in his identification of the basal Black Reef Quartzite contact north of Blyde Canyon. Two correlatable stratigrapahic packages, The Downs and Black Reef Quartzite, are developed above the mature siliciclastic unit Button (1973) described as the Black Reef Quartzite. Although isopachs support Button's (1973) interpretation that the Selati Trough was an axis of subsidence, they do not support any interpretations that it was the protobasin to the Chuniespoort/Ghaap Group sea. However, field relationships clarify proposed relationships between the Ventersdorp Supergroup rifting event and subsidence of the Chuniespoort/Ghaap Group sea as proposed by Clendenin *et al.* (1988a, b).

The recognition of The Downs and Black Reef Quartzite stratigraphic packages also clarifies the relationship of the Wolkberg Group to the Transvaal Sequence. The identification of unconformities separating these packages from the Wolkberg Group in the Selati Trough clearly indicates that the Wolkberg Group and its tectonic controls were not related to either tectonic subsidence or thermal subsidence of the Chuniespoort/Ghaap Group sea (Clendenin *et al.*, 1988b). Relationships do, however, support the proposal of Clendenin *et al.* (1988a), based on timing of regional tectonics, that the Wolkberg Group is correlateable with the Ventersdorp Supergroup.

The syndepositional tectonics, which affected the two identified stratigraphic packages, can be related to both cratonic and local crustal movements. At the end of the Ventersdorp Supergroup rifting event, initial crustal reorganizations developed a cratonic-scale unconformity and a southerly tilt to the Kaapvaal Craton. Syndepositional tectonics affecting the Black Reef Quartzite indicate that flexural subsidence and existing tilts did not initially determine the palaeogeographic surface upon which the package was deposited. Basement response to differential syndepositional tectonics, not sedimentary loads as assumed in models, controlled the geometry of the Black Reef Quartzite following mechanical subsidence of the Ventersdorp Supergroup rift. Interpreted 'thermal subsidence' over the Kaapvaal Craton (Clendenin *et al.*, 1988a, b) was, therefore, the product of multiple processes and not just lateral heat flow related to the cooling rift.

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