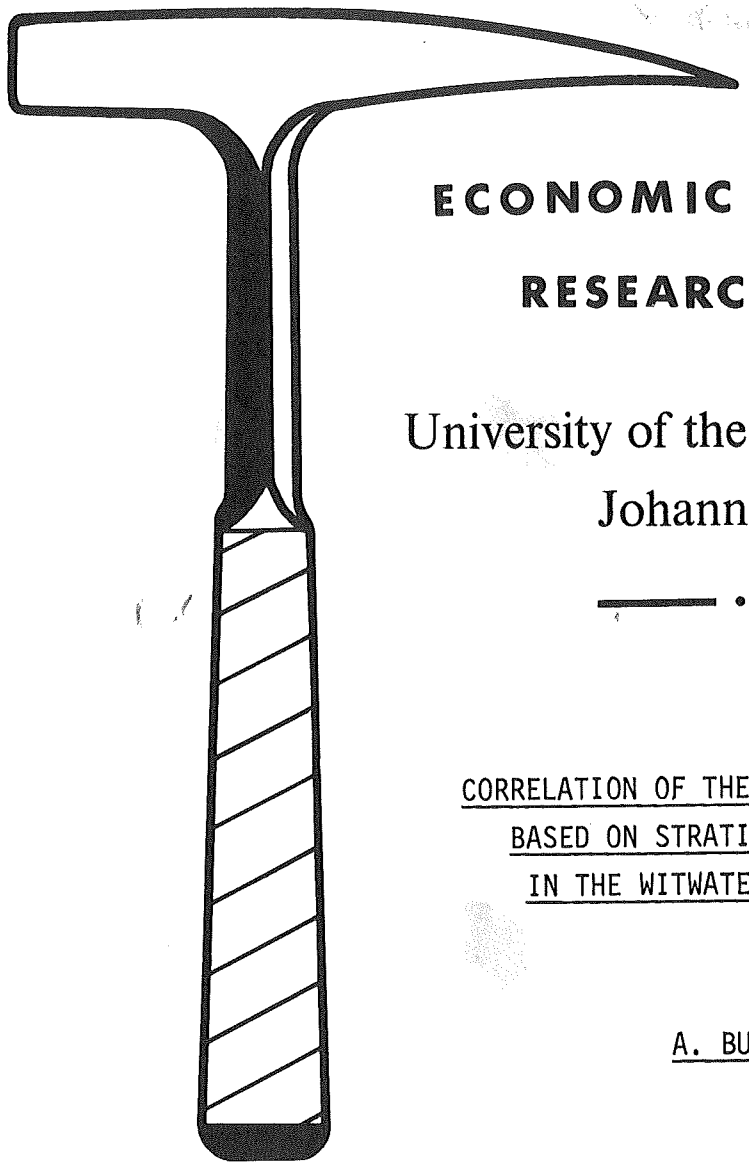

ECONOMIC GEOLOGY

RESEARCH UNIT

University of the Witwatersrand

Johannesburg

CORRELATION OF THE GODWAN FORMATION BASED ON STRATIGRAPHIC TRENDS IN THE WITWATERSRAND BASIN

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UNIVERSITY OF THE WITWATERSRAND
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by

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ABSTRACT

The Witwatersrand Supergroup shows a number of coherent trends when traced eastwards from the Central Rand. The gross thickness decreases markedly. The unconformity separating the upper from the lower division truncates successively lower units towards the east; projections suggest the Upper Witwatersrand will come to rest on the Archaean basement east of the Evander Goldfield. The size of the pebbles, and the proportion of coarse-grained material in the Upper Witwatersrand, decreases. The thickness of the Bird lavas increases appreciably. An Upper Witwatersrand equivalent east of the Evander basin is likely to rest directly on the Archaean basement, to be relatively thin and fine-grained, and to comprise a greater proportion of volcanic material than is usual for that unit.

In the Kaapsehoop area of the Great Escarpment, a succession of arenaceous and volcanic rocks rests unconformably on the Archaean basement, and is unconformably covered by the Black Reef Quartzite. This succession, known as the Godwan Formation, has suffered pre-Black Reef folding, faulting and sill intrusion. Its basal conglomerate is locally auriferous, while the overlying Black Reef Quartzite contains pyrite, gold and uranium mineralization in conglomerates re-worked out of an older formation. The evidence assembled suggests that the Godwan Formation is the easternmost outcrop of the Upper Witwatersrand basin. The covered region between Kaapsehoop and Evander is thus potentially underlain by structural basins of auriferous-uraniferous upper Witwatersrand material. This region is largely inaccessible to drill-hole exploration, except in a triangular region between Kaapsehoop, Machadodorp and Moedig siding, where the cover formations will range in thickness from 0 to about 2 500 metres.

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1. INTRODUCTION

In the Kaapsehoop area of the eastern Transvaal (location 5 of Figure 1), the Black Reef comprises quartzite and conglomerate, the latter mineralized by pyrite, gold and uranium (De Waal and Herzberg, 1968). Elsewhere in the Transvaal Basin, the Black Reef is significantly mineralized only where it rests on (and reworks) conglomerates of the Upper Witwatersrand (Papenfus, 1964). In the Kaapsehoop area, the Black Reef rests on the Kaap Valley Granite, on parts of the Jamestown Schist Belt, and on the Godwan Formation, a volcanic and sedimentary formation hitherto correlated with the Pongola System (Visser, 1956). The source of the Black Reef mineralization is puzzling, unless the possibility is considered that the Godwan Formation is a Witwatersrand extension. However, it is a relatively thin succession, and comprises none of the magnetic shales characteristic of the Witwatersrand. It contains only minor amounts of conglomerate, and a relatively large proportion of basic volcanic. To see if the Godwan Formation could represent Witwatersrand material, the stratigraphic variation of the Witwatersrand Basin east of the Central Rand was studied to see if any coherent trends emerged, which could be projected eastwards into the Kaapsehoop area. This paper describes the results of the analysis, and the conclusions drawn therefrom.

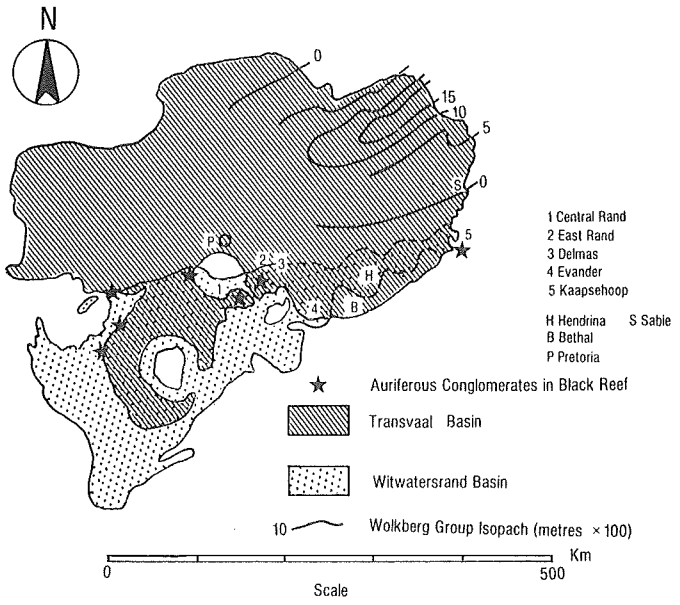

Figure 1 : Map showing distribution (known and inferred) of Witwatersrand and Transvaal basins, and location of mineralized conglomerates in the Black Reef.

2. PREVIOUS WORK ON THE GODWAN FORMATION

Although the Kaapsehoop area was mapped by Hall in 1905 and 1918, it was not until 1929 that he clearly recorded a pre-Black Reef, post-Archaean succession. This succession comprises quartzite and shale, overlain by amygdaloidal lava. Hall thought that it might be a Ventersdorp equivalent preserved in a hollow in the Archaean basement.

Following a mapping programme by the Geological Survey, the succession was found to outcrop over a larger area, and was correlated by Truter (1949) with the Insuzi Series of the Pongola System, which was, in turn, thought to be a Dominion Reef equivalent. At present, this is still the official interpretation.

The most thorough description of this pre-Black Reef succession, which became known as the Godwan Formation, is given by Visser (1956). The distribution, thickness, structure, lithology and stratigraphy are described. No definite correlation was made, but the Godwan was shown to post-date the Archaean and to be unconformably overlain by the Black Reef Quartzite.

3. REGIONAL STRUCTURAL TRENDS IN THE WITWATERSRAND BASIN

The regional structural geology of the Witwatersrand Basin has been summarized by Pretorius (1974). The principal fabric of the basin trends northeast, but has been deformed into an arcuate pattern by folding about northwesterly axes (Figure 2). Thus, in the Welkom Goldfield the fabric trends north-south, swinging to northeast at Klerksdorp, east-west on the Central Rand to southeast at Evander. East of Evander, the Witwatersrand fabric is cut by the northwest-trending Palala Syncline. Pretorius suggested that the Witwatersrand fabric will swing northeasterly; so that Witwatersrand preservation should be in a belt trending northeast of the Evander Goldfield. The Godwan Formation outcrops more-or-less on the line of this projection (Figure 2), so that a Godwan-Witwatersrand equivalence is not unlikely on regional structural grounds.

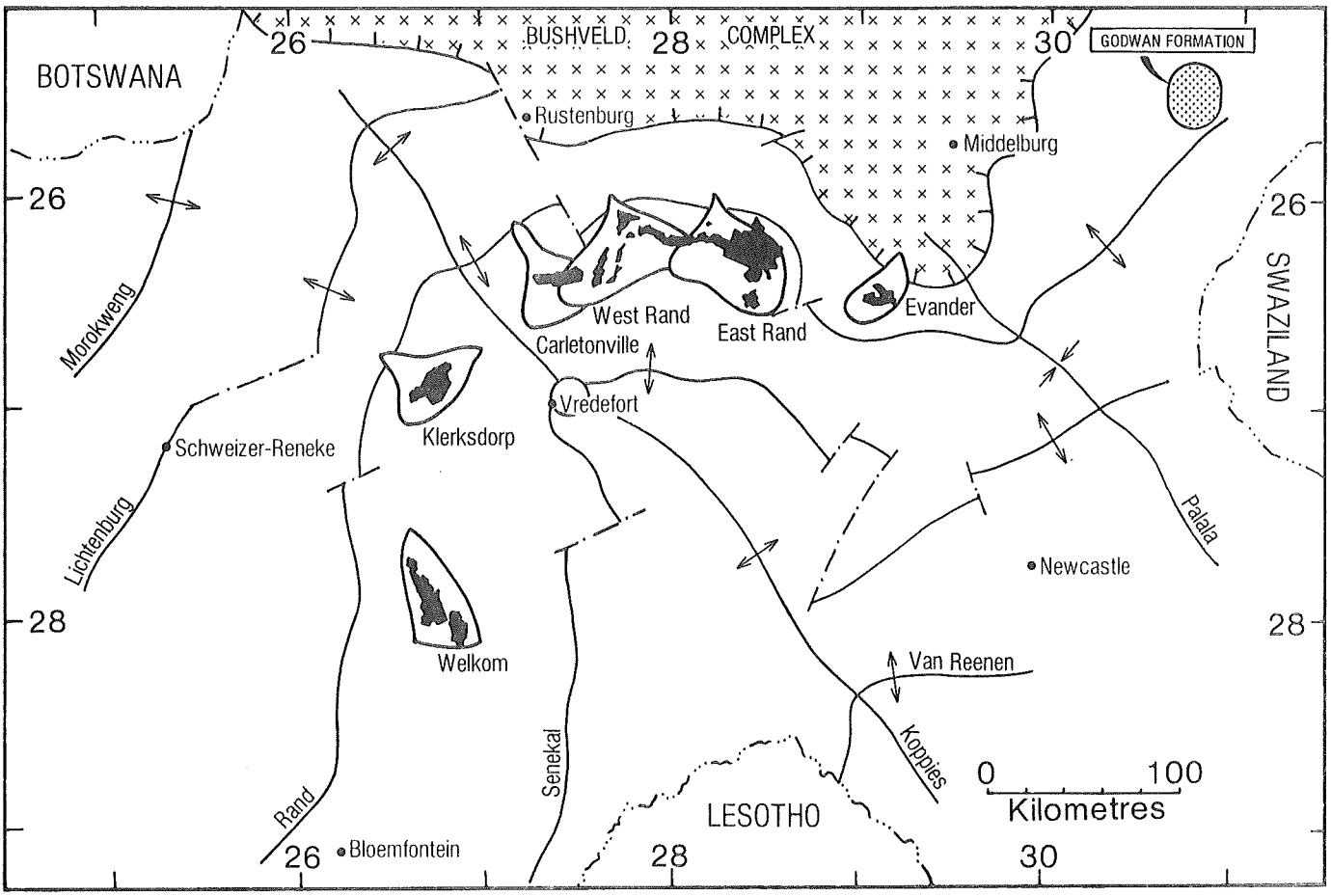

Figure 2 : Structural synthesis of the Witwatersrand Basin (modified after Pretorius, 1974).

4. TRENDS IN WITWATERSRAND STRATIGRAPHY EAST OF THE CENTRAL RAND

(i) Relation of Upper and Lower Divisions of the Witwatersrand Supergroup

There is a well-defined angular unconformity at the base of the upper division of the Witwatersrand Supergroup. The unconformity cuts downwards in the stratigraphic succession when traced in an easterly direction from the Central Rand (Figure 3.1).

On the Central Rand, Cousins (1965) showed that about 105 m of arenaceous sediment separates the Main Reef from the uppermost Jeppestown shale. Towards the east, the arenaceous unit is truncated, so that the Main Reef of the East Rand rests largely on uppermost Jeppestown shale. The shale and overlying arenaceous shale are reduced in thickness when traced across the East Rand, from 167 m in the west (Antrobus, 1964) to 90 m (and locally 0 m) in the east (Antrobus and Whiteside, 1964). Further evidence for the unconformity is a discolouration of the Jeppestown shale below it (an ancient weathering profile) and angular discordances of up to 60 degrees (Antrobus and Whiteside, 1964).

In the Delmas area, the uppermost Jeppestown shale is further truncated, from 46 m in the west to 12 m in the east (Button, 1968). The easterly truncation of lower division beds continues into the Evander Goldfield, where the unconformity is cut across the blue grit member of the Government Reef unit (Tweedie, 1968). From the Central Rand to the Evander area, the unconformity has erosively truncated about 1 000 m of the lower division stratigraphy, some 8 m per km over the 120 km separating the areas.

At Evander, the remaining thickness of the lower division sediments is estimated to be about 700 m (E. Tweedie, personal communication, 1977). If the rate of truncation remains approximately constant, the entire lower division is likely to have been removed well before Kaapsehoop, 190 km northeast of Evander. It seems highly probable that the upper division will eventually come to rest directly on the Archaean basement some distance east of Evander (Figure 3).

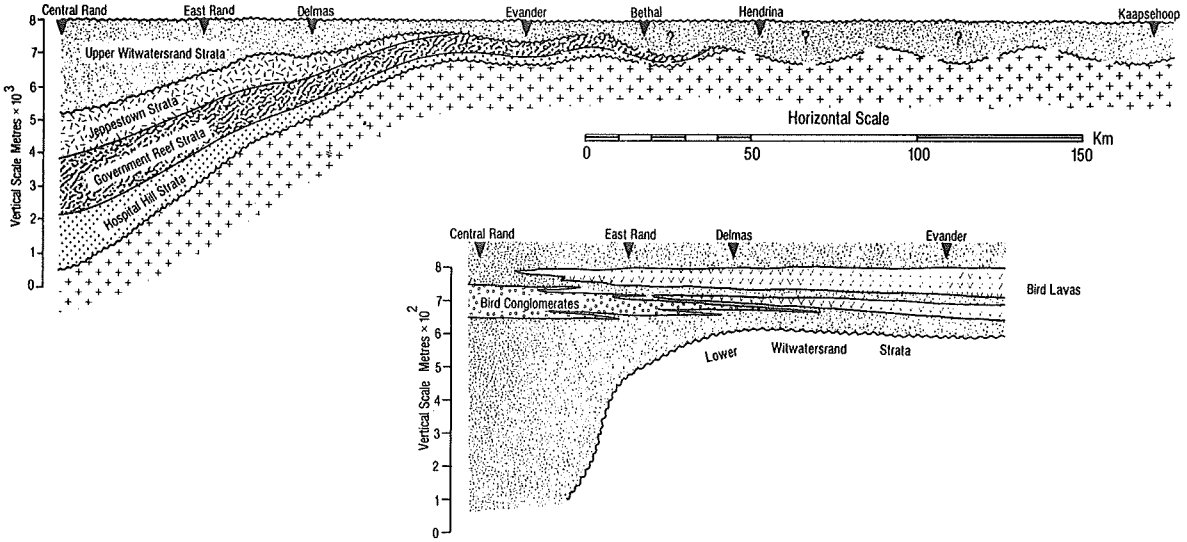

Figure 3.1 : *Generalized stratigraphic relationships east of the Central Rand.*

Figure 3.2 : *Relationships in the Bird Lavas and conglomerates between the Central Rand and Evander.*

(ii) Thickness of the Upper Witwatersrand

On the Central Rand, the upper division of the Witwatersrand has a thickness of some 2 860 m (Brock and Pretorius, 1964). This figure has been reduced to some 1 600 m in the East Rand (Antrobus, 1964). At Delmas, the unit is not fully developed, being truncated by the Black Reef, but is somewhat over 713 m thick (Button, 1968). In the Evander region, the upper division averages about 550 m (Tweedie, 1968), and attains a maximum thickness of 730 m (E. Tweedie, personal communication, 1977). If this trend is continued, any upper division equivalent developed further east is likely to be a highly attenuated version of the section known from the Central Rand.

(iii) Thickness of Bird Lava, and Proportion of Lava in the Upper Witwatersrand

The Bird Lava is not developed on the Central Rand. Over most of the East Rand, one unit of lava is developed with a thickness of 35 to 75 m (Figure 3.2). It averages about 60 m in thickness. At Delmas, two units of lava are present, and measure 65 m (upper unit) and 20 m (Button, 1968). In the Evander basin, the lavas are respectively 84-133 m and 32-58 m thick (E. Tweedie, personal communication, 1968). The proportion of lava in the upper division ranges from about 4 per cent in the East Rand to 24 per cent at Evander. Upper Witwatersrand equivalents east of Evander are likely to comprise a succession which may well be dominated by volcanics. If further consideration is given to the fact that the Ventersdorp lavas are converging with the Bird lava in an easterly direction (they are separated by 1 300 m on the East Rand, by only 330 m at Evander), this possibility is further strengthened.

(iv) Proportion of Conglomerate in the Upper Witwatersrand

In the East Rand, the cumulative thickness of conglomeratic zones in the Upper Witwatersrand is about 492 m, or 31 per cent of the upper division (Antrobus and Whiteside, 1964). Equivalent figures at Delmas are 112 m (16 per cent), and at Evander about 60 m (11 per cent). This trend is illustrated in the case of the Bird conglomerates (Figure 3.2) which are well developed on the Central Rand, and finger out into arenites between Delmas and Evander.

East of Evander, upper division equivalents are likely to comprise arenaceous sediments with a rather low proportion of conglomerate.

(v) Summary of Stratigraphic and Lithologic Trends

Equivalents of the Upper Witwatersrand east of Evander are likely :

(a) to rest directly on the Archaean basement, with no development of lower division sediments (and thus, no magnetic anomalies for structural interpretations);

(b) to comprise a higher proportion of intermediate-to-basic volcanic material than elsewhere in the basin; and,

(c) to comprise relatively thin arenaceous formations, with poorly-developed conglomeratic intervals.

5. STRUCTURAL GEOLOGY AND HISTORY OF INTRUSION OF THE WITWATERSRAND RELATIVE TO THE TRANSVAAL SUPERGROUP

Throughout the Witwatersrand Basin, sediments are relatively strongly deformed. Dips are steep to moderate, folding is appreciable, and faulting is normally intense. In the Evander basin, for example, Witwatersrand strata are folded about northerly to north-northwesterly axes, and are overturned on the eastern margin. While some of the faults and folds in the Witwatersrand beds affect Transvaal strata, the latter are usually far less intensely deformed.

On the East Rand, the Transvaal Supergroup is intruded by three suites of dykes and sills, those related to the Bushveld Complex, Pilanesberg and the Karoo. In the same region, the Witwatersrand is intruded by the above suites, plus a further five pre-Transvaal types, most of them probably related to the extrusion of the Ventersdorp lava (Antrobus and Whiteside, 1964).

In summary, the Witwatersrand beds are usually more strongly deformed, and more complexly intruded, than the Transvaal Supergroup. Witwatersrand equivalents east of Evander should conform to this generalization.

6. STRATIGRAPHY, STRUCTURE AND INTRUSIVE HISTORY OF THE GODWAN FORMATION

The only significant stratigraphic study of the Godwan Formation is that by Visser (1956). The succession was estimated to be about 1 500 m thick, inclusive of three basic sills. It is subdivided into three units, a basal sedimentary assemblage, a volcanic suite, and an upper sedimentary assemblage (Figure 4).

The basal sediments comprise medium-grained felspathic quartzites and shales, with a lenticular locally auriferous basal conglomerate. The volcanic suite comprises amygdaloidal lava with some tuff and agglomerate. An analysis of a lava indicates a composition intermediate between andesite and basalt (Visser, 1956, p. 98). The upper sedimentary unit is composed mainly of felspathic quartzite, with minor shaly and tuffaceous beds.

Visser's stratigraphic column and accompanying description appear to be oversimplified when compared to the map and map legend. A second major volcanic unit is developed, mainly in the western half of the Godwan outcrop area.

In summary, the Godwan stratigraphy is not well established. It comprises two principal volcanic units in a pile comprised mainly of felspathic quartzite, with minor shale and a little conglomerate. This assemblage is not unlike that predicted by the projection of stratigraphic trends east of Evander. In particular, the characteristic orthoquartzites and magnetic shales of the Lower Witwatersrand are absent.

The Godwan Formation strikes mainly northeast, and dips northwest at angles of from 15 to 80 degrees. The strata are distinctly folded in places. They are cut by faults trending northeast, northwest, and more-or-less east-west. Many of the faults can be shown to be pre-Black Reef in age (Visser, 1956). There is a distinct angular unconformity between the Black Reef and Godwan Formation,

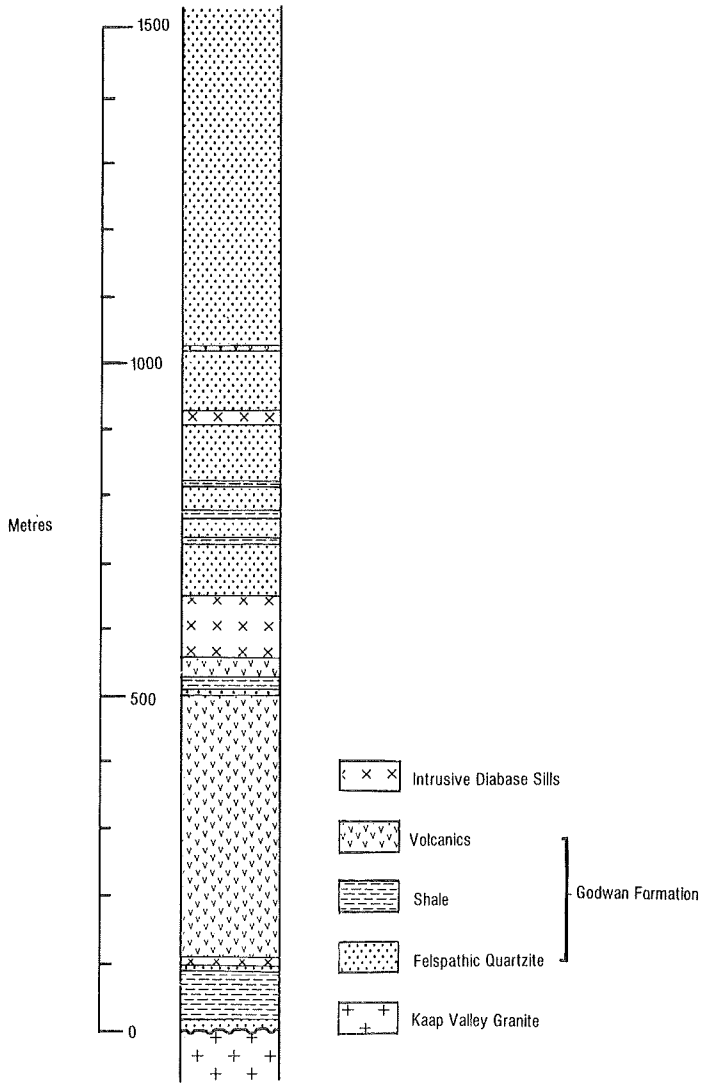

Figure 4 : *Stratigraphy of the Godwan Formation (modified after Visser, 1956).*

the former dipping westwards at a uniform angle of about 5 degrees. Visser also showed that the Godwan Formation is intruded by a set of pre-Transvaal diabasic sills. The structural and intrusive history of the Godwan Formation relative to the Black Reef is consistent with a Godwan-Upper Witwatersrand correlation.

7. CIRCUMSTANTIAL EVIDENCE

(i) Mineralization in Conglomerates of the Kaapsehoop Area

The Black Reef conglomerates near Kaapsehoop are known to be mineralized with pyrite, gold and uranium (Visser, 1956; De Waal and Herzberg, 1968). Clasts in the conglomerates comprise vein quartz with chert, jasper and quartzite. Some of the quartzite pebbles are uraninite-bearing (De Waal and Herzberg, 1968). It has been assumed that the pebbles, plus the gold, uranium, and pyrite were derived directly from the Archaean basement. The uraniferous quartzite pebble, for example, was thought to be derived from the Moodies Group in the Barberton Mountain Land, despite the fact that radiometric surveying revealed no uraniferous quartzites in this unit.

Papenfus (1964) reviewed the mineralization in the Black Reef conglomerate, and showed that significant deposits can usually be linked to sub-outcropping Witwatersrand conglomerates (see Figure 1). The suggestion is made here that the Black Reef mineralization at Kaapsehoop was derived by erosion of a Godwan Formation auriferous-uraniferous conglomerate in pre-Black Reef times. Such mineralized Godwan conglomerates are likely to be preserved beneath Black Reef cover west and southwest of the Godwan outcrop belt.

(ii) Thickness of the Black Reef Quartzite

Numerous authors have shown that the tectonic pattern of the Witwatersrand is frequently repeated by the overlying Transvaal cover rocks. Thus, for example, both the Malmani Dolomite and the Black Reef Quartzite attain anomalous thicknesses over the Delmas Syncline, in which Upper Witwatersrand sediments are preserved (Button, 1968).

Along the eastern escarpment, between Sabie and Badplaas, the regional thickness of the Black Reef Quartzite is less than 10 m (Button, 1973). In the Kaapsehoop area, the Black Reef has an anomalous thickness, in excess of 30 m. Visser (1956) estimated thicknesses of up to 45 m locally.

The anomalous large thickness of the Black Reef around Kaapsehoop suggests that it was an area of relatively rapid subsidence during deposition. Elsewhere in the Transvaal, such anomalies are frequently superimposed on synclines or synclinoria in which Witwatersrand sediments are preserved.

(iii) Thickness of the Wolkberg Group

An alternative correlation of the Godwan Formation would be that it is a southerly extension of the Wolkberg basin. Such a correlation is dismissed for a number of reasons. Firstly, a 1 500 metre thickness of Godwan Formation at Kaapsehoop cannot be reconciled with the regional isopach pattern for the Wolkberg Group, shown in Figure 1. Secondly, the Wolkberg Group has not undergone episodes of pre-Black Reef folding, faulting and sill intrusion. Thirdly, the angular unconformity between the base of the Black Reef and the Godwan Formation is much more pronounced than the gentle, basin-edge unconformity between the Wolkberg and the Black Reef in the Sabie area. Finally, Wolkberg lithology is unlike the Godwan. In particular, there is much more shale in the Wolkberg, and Wolkberg volcanics are basaltic and are invariably carbonated (Button, 1973).

8. RECONCILIATION

The Godwan Formation is clearly not a member of the Transvaal Basin, nor can it logically be considered to be a Wolkberg equivalent. There is little evidence to support either a Dominion Reef or a Pongola correlation. The Dominion Reef is a locally-developed formation, found at the base of the deepest parts of the Witwatersrand Basin. The nearest Pongola sediments are in the Amsterdam area, 110 km south of Kaapsehoop, across the tectonic grain of the Kaapvaal craton. A Ventersdorp correlation is not favoured for the bulk of the Godwan, because the nearest known Ventersdorp, at Evander, does not contain significant thicknesses of sediment (E. Tweedie, personal communication, 1977). A Lower Witwatersrand correlation is rejected because the Godwan contains no magnetic shales and ortho-quartzites. Two alternatives remain; that the Godwan is a formation unrelated to any other in the Transvaal, or that it is the easternmost exposure of the Upper Witwatersrand basin. The structural, stratigraphic and lithologic data assembled supports the latter suggestion.

9. RECOMMENDATIONS

An integrated field mapping project on the Godwan Formation should be undertaken, with emphasis on structure, stratigraphy and sedimentation characteristics. On the basis of such a study a decision could be made whether to proceed with an exploration programme, which could then be intelligently planned. Exploration would probably be concentrated in a triangular area between Kaapsehoop, Machadodorp and the Moedig siding, where thickness of cover is unlikely to exceed 2 500 m. If positive results were to be obtained, exploration further afield, and at greater depths, could probably be attempted. In all probability, the largest portion of the covered region between Evander and Kaapsehoop will never be explored because of the large thicknesses of cover formations, including Karoo, Bushveld Complex (both acid and mafic phases), Transvaal Supergroup, and, possibly, Ventersdorp Lava.

10. ACKNOWLEDGEMENTS

Professor D.A. Pretorius focussed the writer's attention on the Godwan Formation, and suggested that the official correlation, with the Dominion Reef System, was probably incorrect.

Mr. E. Tweedie supplied stratigraphic data from the Evander Goldfield.

11. REFERENCES

Antrobus, E.S.A. (1964). Notes on the geological column of the East Rand. In Haughton, S.H., Ed. The Geology of Some Ore Deposits in Southern Africa : Geol. Soc. S. Afr., vol. 1, 113-123.

Antrobus, E.S.A. and Whiteside, H.C.M. (1964). The geology of certain mines on the East Rand. In Haughton, S.H., Ed. The Geology of Some Ore Deposits in Southern Africa : Geol. Soc. S. Afr., vol. 1, 125-160.

Brock, B.B. and Pretorius, D.A. (1964). The geology of the Central Rand Goldfield. In Haughton, S.H., Ed. The Geology of Some Ore Deposits in Southern Africa : Geol. Soc. S. Afr., vol. 1, 63-108.

Button, A. (1968). Subsurface stratigraphic analysis of the Witwatersrand and Transvaal sequences in the Irene-Delmas-Devon area, Transvaal : Unpub. M.Sc. thesis, Univ. Witwatersrand, 120 pp.

Button, A. (1973). A regional study of the stratigraphy and development of the Transvaal Basin in the eastern and northeastern Transvaal : Unpub. Ph.D. thesis, Univ. Witwatersrand, 352 pp.

Cousins, C.A. (1965). Disconformities in the Main Reef Zone of the Witwatersrand System, and their bearing on a reef correlation, with particular reference to the east, central and west Witwatersrand : Trans. geol. Soc. S. Afr., 68, 121-142.

De Waal, S.A. and Herzberg, W. (1968). Uranium and gold mineralization of the Black Reef Series in the Kaapsehoop area, Nelspruit district, eastern Transvaal : Ann. Geol. Surv. S. Afr., 7, 111-124.

Hall, A.L. (1905). Report on a survey of the country between Lydenburg and the Devil's Kantoor. Report, Geol. Surv. Transvaal.

Hall, A.L. (1918). The geology of the Barberton gold mining district : Mem. Geol. Surv. S. Afr., 9.

Hall, A.L. (1929). The Devil's Kantoor in the Great Eastern Escarpment of the Transvaal Drakensberg : Int. Geol. Congr. 15, Pretoria, Guide Book C16.

Papenfus, J.A. (1964). The Black Reef Series within the Witwatersrand Basin with special reference to its occurrence at Government Gold Mining Areas. In Haughton, S.H., Ed. The Geology of Some Ore Deposits in Southern Africa : Geol. Soc. S. Afr., vol. 1, 191-218.

Pretorius, D.A. (1974). The nature of the Witwatersrand gold-uranium deposits : Econ. Geol. Res. Unit, Inf. Circ. 86, 50 pp.

Truter, F.C. (1949). A review of volcanism in the geological history of South Africa : Proc. geol. Soc. S. Afr., 52, xxix-lxxxix.

Tweedie, K.A.M. (1968). The stratigraphy and sedimentary structures of the Kimberley Shales in the Evander Goldfield, eastern Transvaal, South Africa : Trans. geol. Soc. S. Afr., 71, 235-256.

Visser, D.J.L. (Compiler) (1956). The geology of the Barberton area : Spec. Publ., Geol. Surv. S. Afr., 15, 253 pp.

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