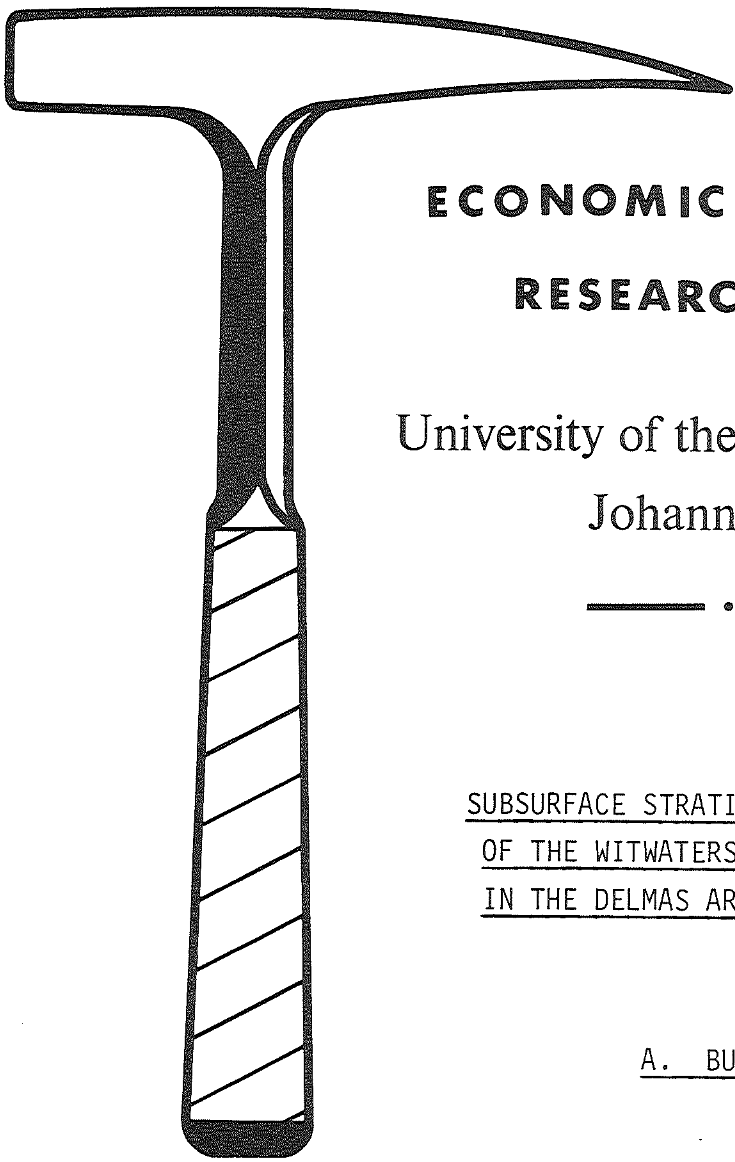

ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

SUBSURFACE STRATIGRAPHIC MAPPING OF THE WITWATERSRAND SEQUENCE IN THE DELMAS AREA, TRANSVAAL

A. BUTTON

INFORMATION CIRCULAR No. 59

UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG

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by

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CONTENTS

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SUBSURFACE STRATIGRAPHIC MAPPING OF THE WITWATERSRAND SEQUENCE IN THE DELMAS AREA, TRANSVAAL

ABSTRACT

In the area lying to the north of the Devon Dome and between the East Rand and Evander goldfields, boreholes have intersected Upper Witwatersrand strata beneath a cover of Transvaal Sequence sediments. Structure-contour maps and a map showing the distribution of pre-Transvaal formations indicate that the gold-uranium-bearing Upper Witwatersrand sediments are preserved in the Bultfontein and Middelbult structural basins, which lie along the trace of the north-northwest-trending Delmas Syncline. Further Upper Witwatersrand strata could be preserved along an undrilled section of the Delmas Syncline lying to the south of the Middelbult Basin. The north-northwest-trending Sundra and Winterhoek anticlines separate the Delmas Syncline from the East Rand and Evander goldfields, respectively. Tectonic elevation brought about by these folds was responsible for the stripping away of Upper Witwatersrand rocks during a period of pre-Transvaal erosion.

To the north of Delmas, stratigraphic units in the Witwatersrand Sequence thin out towards the east. Arguments are presented which favour the sediments of the Bultfontein Basin as having entered the Witwatersrand Basin via the well-established East Rand entry point, and as having been transported eastwards to their site of deposition. On the basis of the distance from the entry point, it was concluded that the low gold-values found in the Main Reef Horizon conglomerate are a true indication of the sub-economic nature of the reef in this area.

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SUBSURFACE STRATIGRAPHIC MAPPING OF THE WITWATERSRAND SEQUENCE IN THE DELMAS AREA, TRANSVAAL

INTRODUCTION

A. LOCATION OF AREA

The area considered in this study is outlined in Figure 1. It is situated in the south-central Transvaal, in an area bounded by the towns of Irene, Bronkhorstspruit, and Leslie, and by the East Rand Goldfield. Within this area, the subsurface studies carried out excluded the East Rand Goldfield, the Johannesburg Dome, and the triangular area in the northeast in which there is no borehole control.

B. REGIONAL GEOLOGICAL SETTING

The East Rand Basin, in which Witwatersrand, Transvaal, and Karroo Sequence strata are preserved, is situated in the southwestern portion of the area studied. This basin is cradled between the Johannesburg and Devon granite domes, which lie, respectively, to northwest and southeast of the basin. To the east of the Devon Dome, just east of the eastern boundary of the area studied, lies the Evander Basin. This basin preserves the same succession of strata as the East Rand Basin.

The majority of the pre-Transvaal rocks in the area are covered by Transvaal Sequence strata which cross the area in a northwest-southeast-trending outcrop belt which varies in breadth between 20 and 40 miles. The Transvaal rocks dip to the northeast at angles ranging from 10 to 30 degrees. In the northwestern portion of the area, intrusives allied to the Bushveld Igneous Complex are, in places, exposed. In the extreme northwest, near Balmoral, northeast-dipping Waterberg Sequence strata are developed. The ragged northwestern edge of the Karroo Basin passes through the area in a northeast-south direction. This results in the blanketing of most pre-Karroo formations in the eastern and southeastern portions of the area.

C. PREVIOUS WORK

A number of stratigraphic maps of various aspects of the Witwatersrand Sequence in the East Rand Basin have been published. Of consequence to this study are a structure-contour map prepared by Cluver (1957), an isopach map by Cousins (1965), and a variety of stratigraphic maps by Armstrong (1965). In the East Rand, recent published accounts of paleocurrent studies include those by Hargraves (1962) and by Armstrong (1965). A paper by Tweedie (1968) deals with some paleocurrent features developed in the Kimberley Shale horizon in the Evander Basin.

The results of a geophysical and drilling exploration program in the area around Leslie were described by Fox (1939). In his description of the Witwatersrand Basin as a whole, Borchers (1964) touched briefly on some aspects of the Witwatersrand geology in the area between the East Rand and Evander goldfields. Venter (1934), in his account of the geology of the country between Springs and Bethal, briefly described the scattered outcrops of presumed Hospital Hill Quartzites in the area to the south of Delmas. Although there has been a considerable amount of exploration activity in the area, there is a complete lack of published accounts of the Witwatersrand geology revealed by diamond-drilling.

D. SCOPE AND AIMS OF PRESENT INVESTIGATION

Since the East Rand Basin was discovered early in this century, a number of exploration programs have been executed with the aim of finding preserved Upper Witwatersrand strata beneath Transvaal and Karroo cover to the east, northeast, and north of the East Rand Basin. The discovery, in the 1950's, of the Evander Goldfield was the outcome of one such exploration program. The remaining exploration attempts failed in their primary aim, which was to discover economically exploitable concentrations of gold and uranium, but Upper Witwatersrand sediments, which are normally the host to the mineralization, were intersected in a number of boreholes.

In this study, it was attempted to make use of all available information in defining the pattern of distribution of the pre-Transvaal rocks. In this way, the structural elements controlling preservation were outlined, and predictions of untested localities of possible preservation of Upper Witwatersrand rocks were made. Isopach maps and gold-distribution maps were used in attempting to ascertain whether the Upper Witwatersrand rocks preserved in the Delmas area are associated with the Evander or East Rand goldfields, or whether they represent portions of a goldfield hitherto not suspected.

STRATIGRAPHIC MAPS OF THE WITWATERSRAND SEQUENCE

Stratigraphic mapping of an unexposed sedimentary assemblage, such as the Witwatersrand Sequence in the area under review, may allow the elucidation of structure and of the relationship of buried strata to overlying unconformities. In addition, an insight may be gained of the geometry of lithologic units, the tectonic framework, and the sedimentary conditions of deposition.

A. STRUCTURE-CONTOUR MAPS

A structure-contour map shows the geometric configuration of a rock surface by contour lines passing through points of equal elevation above or below a selected datum (Krumbein and Sloss, 1963). In this study, all elevations have been corrected for the deflection of the borehole from the vertical, and are in feet above or below sea-level. A contour interval of 250 feet was found to be convenient to the scale of mapping, the dips present, and the accuracy of control elevations. The "ghost structure-contour" principle (Button, 1968) was used in determining the position of the sub-outcrop of the key horizon beneath the base of the Transvaal Sequence.

A structure-contour map of the Main Reef Horizon is shown in Figure 2. This horizon is the lithologic equivalent of the economic conglomerate developed on the East Rand and there known as the Main Reef Leader or Nigel Reef. It forms the line of demarcation separating Upper and Lower Witwatersrand strata. To the north of Delmas, Upper Witwatersrand rocks are seen to be preserved in a north-plunging portion of the Delmas Syncline. The axis of the syncline plunges at angles varying from 15° in the south to 10° in the north, and trends in a direction 15° west of north. The western limb of the syncline dips at 13° in a direction 29° east of north, and the eastern limb at 17° in a direction of 61° west of north. The lines of sub-outcrop of the key horizon beneath the Transvaal Sequence trend in directions N68°W and N2°E. To the west of a line joining Boreholes OL.1 and OL.2, the paucity of control points makes the position of the sub-outcrop tentative.

A comparison of the stratigraphy developed in Boreholes KST.1 and KST.2 suggests that these boreholes are separated by a fault with a total vertical displacement of the order of 3500 feet. The strike of this fault is unknown, but is shown here as trending east-northeast, in conformity with the suggestion that this fault could represent an easterly extension of the Rietfontein group of faults developed in the East and Central Rand areas. The Rietfontein faults, which have an east-northeast trend, become concealed beneath the Transvaal Sequence to the east of Kempton Park. The possibility exists that the fault shown in Figure 2 is the southern fault of a set of two faults which enclose a horst block and that Upper Witwatersrand rocks might be preserved at some distance to the north of Borehole KST.1.

To the north of Delmas, the plunge of the axis of the Delmas Syncline decreases until, in the extreme north, the Witwatersrand strata are approximately parallel to the overlying Transvaal Sequence sediments. This observation suggested that an inflection point in the synclinal axis is present near its northern limit, and that, prior to the major faulting, the synclinal axis might have reversed its direction of plunge. This, in turn, was taken as indicating that a second syncline, trending at an oblique angle to the first, might intersect the Delmas Syncline near Borehole KST.2, and that the present V-shaped sub-outcrop might originally have appeared as a diamond-shaped basin. This postulated structural basin has been called the Bultfontein Basin.

To the southwest of Delmas, Upper Witwatersrand rocks are preserved in the Middelbult Basin. In this, the structure indicated by depth-contours is that of a syncline with its axis trending slightly west of north, and with limbs dipping 26° easterly and 37° westerly. The absence of surrounding control points made it impossible to fix the position of the sub-outcrop of the key bed. For this reason, the extent of the area underlain by Upper Witwatersrand strata is unknown, but must be appreciably larger than that shown contoured in Figure 2.

It is seen that the axis of the Delmas Syncline to the north of Delmas is offset with respect to the synclinal axis southwest of the town. This could be due to the inaccuracies of subsurface mapping or, alternatively, the synclinal axis could be offset by a dextral wrench fault similar to the Vogels or Jeffrys wrench faults developed in the East Rand Basin.

At Borehole SW.1, some distance south of the Middelbult group of boreholes, a horizon which was tentatively correlated with the Main Reef was intersected. This correlation rested on the presence of an amygdaloidal lava found to underlie the Transvaal Sequence. This lava, which could be either of the Bird or Jeppestown amygdaloids, lies at no great distance above or below the Main Reef Horizon. In either case, Borehole SW.1 must be in the proximity of a sub-outcrop of the Main Reef Horizon.

In Figure 3, a structure-contour map of the base of the Bird Reef Zone is presented. The area of preservation of the Bird Reef is visibly smaller than that of the Main Reef Horizon. The axis of the Delmas Syncline to the north of Delmas plunges at an angle varying between 18° and 9° in a direction 13° west of north. The western limb of the syncline dips 15° towards N34°E, and the eastern limb 16° towards N60°W. Traces of sub-outcrop of the Bird Reef Zone against the base of the Transvaal Sequence trend N56°W and N1°W.

In the Middelbult Basin, structure-contouring indicated a narrow, north-northwest-trending syncline, with limbs dipping 24° easterly and 27° westerly. Extrapolation of structure-contours a short distance to the northeast of the control points indicated the possible position of the sub-outcrop of the key horizon beneath the Transvaal Sequence.

A structure-contour map of the Kimberley Reef is shown in Figure 4. In the Delmas area, the Kimberley Reef is a thin, compact conglomerate which is found resting upon the equivalents of the Middle Kimberley sediments of the East Rand Basin. In the Bultfontein Basin, the axis of the Delmas Syncline plunges at an average angle of 10° in a direction 12° west of north. The western limb of the syncline dips at 15° in a direction 31° east of north. The traces of the sub-outcrop trend N43°W and N4°W. The portion of the Middelbult Basin known to be underlain by the Kimberley Reef is small. All indications are that the sub-outcrop of the Kimberley Reef against the base of the Transvaal Sequence closes to the north. The area of preservation of the Kimberley Reef could, however, extend significantly further to the south than shown.

The structural features outlined above have been summarized in the two structural cross-sections shown in Figure 5. The positions of the cross-sections are indicated in Figure 6. The first cross-section (Figure 5a) depicts a shallow basin of dolomite on the East Rand, which is mirrored by the extensive area underlain by Upper Witwatersrand strata. East of this, the broad tract from which Upper Witwatersrand rocks were stripped in pre-Transvaal times clearly indicates the presence of the Sundra Anticline. Along the Delmas Syncline, Upper Witwatersrand strata are again preserved. The activity of the Winterhoek Anticline in the area to the east of the Delmas Syncline is indicated by the non-preservation of Upper Witwatersrand sediments. This anticline is the structural feature which separates the Delmas Syncline from the Evander Basin.

The second cross-section shows a possible basin structure in the Malmani Dolomite to the south of the Middelbult group of boreholes. To the north of this, the dolomite and the overlying Pretoria Group dip at moderate angles to the north. In the underlying Witwatersrand rocks, the Bultfontein and Middelbult Basins would appear to be separated by an anticline. The northern bounding fault of the Bultfontein Basin is shown as a normal fault with an upthrow to the north of the order of 3500 feet.

The only serious prospecting gap along the trace of the Delmas Syncline falls between the Middelbult Basin and Borehole SW.1. Upper Witwatersrand strata could well be preserved in this gap. Whether or not the sediments preserved there extend stratigraphically upwards as far as the Kimberley Reef is a matter for conjecture.

B. THE DISTRIBUTION OF PRE-TRANSVAAL FORMATIONS

The distribution of pre-Transvaal formations, whether outcropping or covered by Karroo or Transvaal Sequence strata, is shown in Figure 6. Such a map, in showing the broad-scale pattern of the distribution of pre-Transvaal rocks, provides an insight into the regional structural elements controlling the pattern of preservation of these rocks.

In the extreme southeast of Figure 6, the geology shown does not differ significantly from a similar map presented by Borchers (1961). This reflects the fact that no new subsurface information for that area has become available since that time.

The triangular area in the northeast of Figure 6 was excluded from the map because of lack of any subsurface data. The northwest-southeast-trending line showing the limit of borehole control roughly coincides with an 8000 feet-below-surface contour for the base of the Transvaal Sequence. Prospecting to the northeast of this line would involve drilling through excessive thicknesses of Transvaal and younger cover.

It is evident that, when applied to the granite massif north of Johannesburg in pre-Transvaal times, the word "dome" is perhaps a misnomer. The present roughly circular shape of the granite outcrop is mainly a reflection of post-Transvaal tectonism on an originally more-or-less linear mass of granite trending northeast-southwest, parallel to the Witwatersrand Basin as a whole. The contact of the granite and the Lower Witwatersrand strata was inferred to have synclinal and anticlinal indentations. The position of these indentations was obtained by extrapolation, towards the north, of known structural elements delineated further to the south.

The outcrop of Lower Witwatersrand sediments found to the southeast of Kaalfontein is thought to be portion of a synclinal remnant separated from the main mass of the Lower Witwatersrand by the considerable horsts and grabens associated with the Rietfontein faults. The tongue of granite which extends southwards and westwards into the bevelled rim of the Lower Witwatersrand Basin probably represents a horst block from which Lower Witwatersrand strata were stripped in pre-Transvaal times.

The shape of the tongue of Ventersdorp lava and sediments, where they extend beneath the Transvaal Sequence to the east of Kempton Park, was adapted from an unpublished map by D.A.M. Smith of the Anglo American Corporation of South Africa, Limited. Smith's interpretation of the shape of the tongue of lava was based on the results of a limited amount of gravity surveying, plus the results of the three KPK boreholes. This body of lava and sediments is probably a fault-bounded block which has been preserved by a considerable downthrow. On its southern side, it is bounded by the Rietfontein Fault which has been estimated by Engelbrecht (1957) to have a vertical displacement of some 14000 feet. The nature of the fault which bounds the tongue of lava on its northern side is not known.

The roughly northeasterly-trending strip of Lower Witwatersrand rocks marked "probably structurally complex" in Figure 6 represents the bevelled rim of the Lower Witwatersrand Basin which is normally found on the northwestern and northern edges of the basin. Such bevelled rims are commonly structurally complex, being affected by peripheral faults and often showing steep dips and even overturning of strata. The possibility of small fragments of the Upper Witwatersrand Basin being preserved in this rim cannot be discounted. In this respect, the area lying to the south of Bapsfontein along a synclinal axis might be favourable. In addition, as mentioned earlier, if the bounding fault of the Bultfontein Basin is one of a pair of faults which enclose a horst block, further Upper Witwatersrand strata might be found north of the Bultfontein Basin along the trace of the Delmas Syncline.

The evidence for the presence of three northwest-trending folds in the vicinity of Delmas has been dealt with previously. Further to the south, the effects of these folds are seen in the synclinal and anticlinal indentations of the contact of the granite of the Devon Dome and the Lower Witwatersrand strata. The Winterhoek Anticline is probably responsible for the elongate sub-outcrop of granite due north of Eendrag.

On the broad scale shown in Figure 6, there would appear to be three target areas for the preservation, beneath the Transvaal Sequence, of Upper Witwatersrand strata. They are the synclinal area to the south of Bapsfontein, the entire extent of the Delmas Syncline, and the synclinal area which should exist east of the Winterhoek Anticline. The last-mentioned has been thoroughly prospected and the Evander Goldfield established. To the north of the Middelbult boreholes, the Delmas Syncline has been fairly thoroughly prospected; south of this, exploration is patchy. Of the untested localities, this is considered to be the most favourable, especially since the thickness of cover is not expected to be in excess of 1000 feet. The probable structural complexities associated with the area south of Bapsfontein make it a less attractive proposition.

C. ISOPACH MAPS

An isopach map shows the varying thickness of a stratigraphic unit by contour lines drawn through points of equal thickness (Krumbein and Sloss, 1963). Isopach mapping of stratigraphic units in the upper portion of the Witwatersrand Sequence allowed conclusions to be drawn regarding the place of the sediments preserved in the Bultfontein Basin within the geometry of the Witwatersrand Basin as a whole.

In the construction of isopach maps, thicknesses intersected in boreholes were corrected for dip of strata. Where faults or dykes affected thicknesses at a control point, that control point was not considered in the contouring of the isopach map. A large number of isopach maps were prepared; since the majority show essentially the same pattern, only a selected few are presented here.

In Figure 7, a map of the variation in thickness of the Bird Reef Zone in the Bultfontein Basin is presented. Isopach contours trend slightly west of north. There is a decrease in thickness from 35 feet in the west to 13 feet in the east. This change, which occurs over a distance of 3.2 miles, represents a rate of thinning of 7 feet per mile.

An isopach map of the Main Stage to the north of Delmas is shown in Figure 8. This unit extends from the base of the Bird Reef Zone to the Main Reef Horizon. The thickness is seen to decrease towards the northeast, east, and southeast, from a maximum of 290 feet in Borehole OL.2 to a minimum of 180 feet in the southeast, at Borehole LP.4. The isopach contours protrude in a lobate fashion towards the east, possibly suggesting gentle channelling in this direction.

Cousins (1965) presented evidence for the correlation of the Main Reef Leader of the East Rand with the South Reef of the Central Rand, and proposed that the former reef be referred to as the "South Reef". He compiled an isopach map of the stratigraphic interval between the base of the Bird Amygdaloid and the South Reef. This map, extended to include the Bultfontein Basin to the north of Delmas, is presented in Figure 9.

The stratigraphic interval mapped shows a maximum thickness of over 1700 feet in the area to the north of Brakpan in the East Rand Basin. From this point, thicknesses decrease towards the east, west, and south. In an easterly direction, the rate of thinning diminishes suddenly at the 900-feet contour. Eastwards of this, the thickness of the unit decreases slowly and evenly. The isopach contours trend, on the average, just to the east of north.

On examination of the 300-feet contour, it was seen that it ran out of the East Rand Basin in a north-south direction, and re-appeared in the Bultfontein Basin, again trending roughly north-south. It was evident that, where it left the East Rand Basin, the 300-feet contour had to curve sharply to the east, before reverting to its north-south trend. The probable trace of this contour in the area between the East Rand and Bultfontein basins is shown in Figure 9. The inflection point in the contour near Sundra probably indicates the activity of the Sundra Anticline in the time-span associated with the stratigraphic unit under study.

Within the Bultfontein Basin, the thickness variation is seen to be from 370 feet, in the west, to some 230 feet, in the east and southeast. This corresponds to a thickness decrease rate of some 50 feet per mile, and may be contrasted with the average figure of 100 feet per mile for the eastern portion of the East Rand Basin and the extremely high value of 450 feet per mile in the area between Brakpan and Boksburg.

The most significant fact to emerge from a study of isopach plans is that the stratigraphic units of the Bultfontein Basin show significant decreases in thickness in an easterly direction. Isopach contours, in general, trend north-south. The rate of thinning, in comparison with that on the East Rand, is small.

In Figure 9 are plotted paleocurrent directions, as determined from cross-bedding foreset measurements by Hargraves (1962) in the Main-Bird quartzites of the East Rand Basin. Of particular interest to this study is the relationship of paleocurrent directions and isopach contours in the northeastern section of the East Rand Basin. It is seen that the directions are approximately perpendicular to isopach lines, and that the sedimentary transport is in the direction of thinning of sediment. Extending this reasoning to the Bultfontein Basin, it can be speculated that the direction of transport of sediments in this basin was from west to east, perpendicular to isopach contours and in the direction of thinning of sediments. From this, the Bultfontein Basin would appear to be a downfolded and preserved portion of the East Rand sedimentological unit. The Bultfontein sediments would thus have entered the East Rand Basin through the well-established East Rand entry point, which lies to the north of Brakpan.

In a qualitative way, it has been established that the gold potential, or the percentage payability, of a segment of the East Rand Goldfield is inversely proportional to the distance from the entry point. On this basis, the Main Reef Horizon of the Bultfontein Basin should have an economic potential similar to that of an area surrounding Heidelberg, both areas being equidistant from the entry point. The gold potential of the Main Reef Horizon in the Heidelberg area is small, narrow payshoots being separated by large areas of unpayable ground. It would thus appear that the low gold values associated with the Main Reef Horizon in the Bultfontein Basin are a true indication of the nature of this reef.

Another observation concerning the distribution of gold in the Main Reef Horizon on the East Rand Basin is that the percentage payability on the reef decreases as the thickness of the stratigraphic unit of Figure 9 decreases. In the Heidelberg area, this unit is 870 feet thick (Pretorius, 1964), whereas it averages 300 feet in the Bultfontein Basin. On this basis, the Bultfontein Basin should rather be compared with the Heidelberg-Roodepoort Mine in the South Rand Goldfield, where the stratigraphic unit has a thickness of 280 feet (Pretorius, 1964). In the latter area, the Main Reef Horizon is virtually devoid of mineralization.

Thinning of stratigraphic units to the east indicates that, to the east of the Bultfontein Basin, a positive tectonic feature was active during Upper Witwatersrand times. The positioning of this tectonic element makes it probable that it was the Winterhoek Anticline. In addition, it is likely that the same positive element was responsible for the westward wedging of Upper Witwatersrand sediments in the Evander Basin, recorded by Tweedie (1968). The Winterhoek Anticline would thus appear to be the true dividing line between the East Rand and Evander sedimentological cells.

SUMMARY AND CONCLUSIONS

In the area under consideration, Upper Witwatersrand strata are preserved in two structural depressions which lie along the trace of the north-northwest-trending Delmas Syncline. To the north of Delmas, the remaining portion of the Bultfontein Basin plunges at an angle which varies between 18° and 9° to the north-northwest. The northern limit of the basin is marked by a fault, thought to trend roughly east-northeast, which has an upthrow on its northern side of about 3500 feet. This fault could be the southern one of a pair of faults which enclose a horst block from which Upper Witwatersrand strata were stripped in pre-Transvaal times. If this is the case, further Upper Witwatersrand sediments might be found preserved north of the Bultfontein Basin at some unknown distance.

To the southwest of Delmas, the axis of the Delmas Syncline appears to have been offset by a dextral wrench fault. The Middelbult Basin was inferred from structure-contouring to be an elongated structural depression with limbs dipping east and west at angles of the order of 30°. The precise area underlain by Upper Witwatersrand sediments in this basin could not be accurately determined. It is likely that the basin extends further to the south than indicated by the boreholes drilled to date.

Two roughly parallel anticlines, the north-northwest-trending Sundra and Winterhoek anticlines, separate the Delmas Syncline from the East Rand and Evander basins, respectively. Along these folds, Upper Witwatersrand and, in places, Lower Witwatersrand strata were removed by erosion in pre-Transvaal times.

Isopach maps reveal that, in the Bultfontein Basin, stratigraphic units thin gently to the east. The pattern of thinning is thus in the same sense as that for stratigraphic units of the East Rand Basin. In the northeastern section of the East Rand Basin, paleocurrent and isopach studies have revealed that the transport direction of sediments is perpendicular to isopach contours and in the direction of thinning of strata. Extending this reasoning to the Bultfontein Basin, it was deduced that the sedimentary transport direction in this basin was from west to east. Consequently, the sediments of the Bultfontein Basin probably entered the Witwatersrand Basin via the East Rand entry point. By analogy with the well-documented relationship of gold mineralization to the distance from the entry point of the East Rand Basin, it can be deduced that the gold potential of the Main Reef Horizon in the Bultfontein Basin is low. This prediction is consistent with the actual gold values found associated with the Main Reef Horizon in the Delmas area.

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Key to Figures

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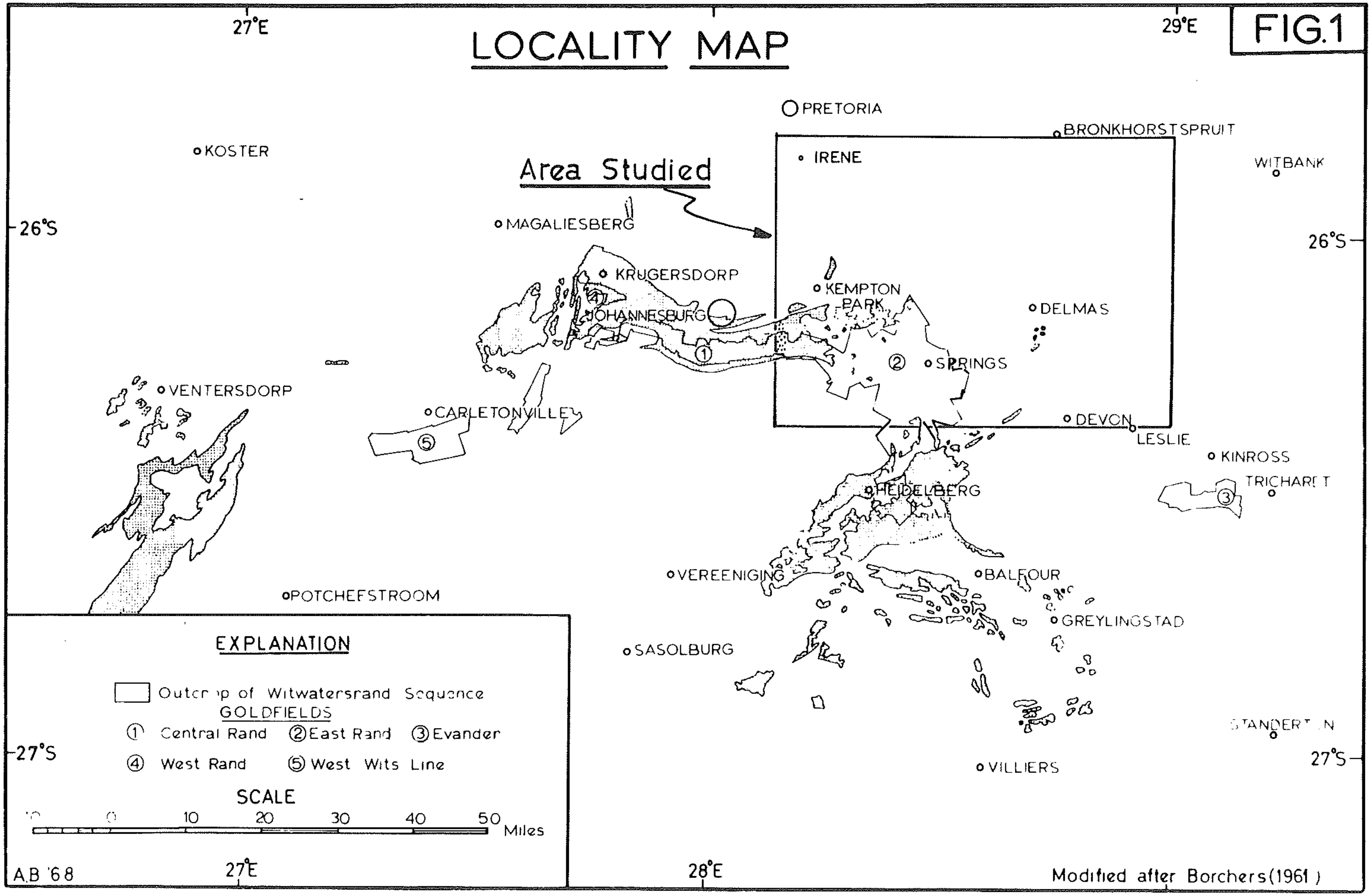
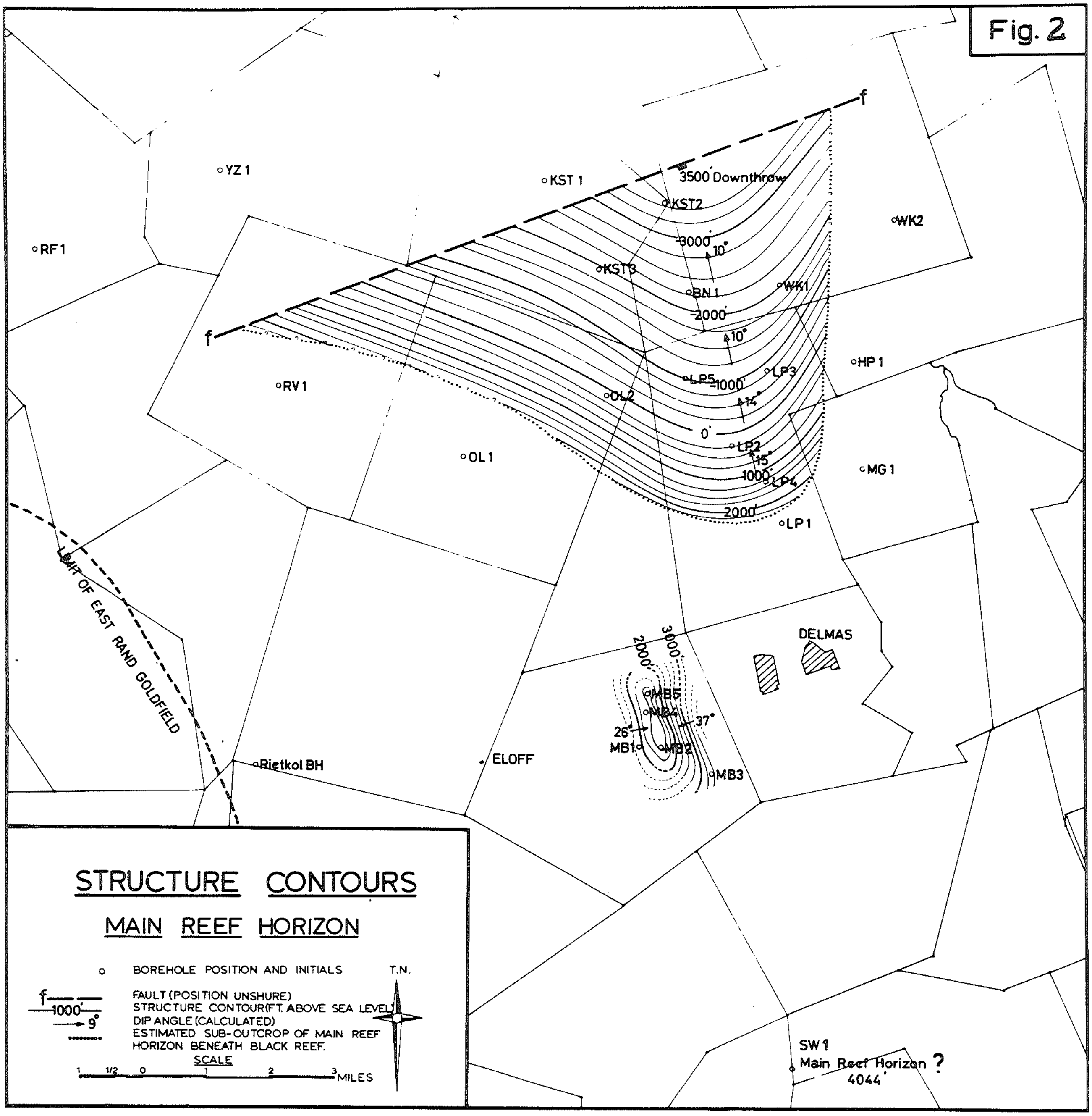


FIG.1
LOCALITY MAP
Area Studied
27°E
29°E
26°S
27°S
28°E
PRETORIA
BRONKHORSTSPRUIT
IRENE
WITBANK
KOSTER
MAGALIESBERG
KRUGERSDORP
KEMPTON PARK
JOHANNESBURG
DELMAS
SPRINGS
VENTERSDORP
CARLETONVILLE
DEVON
LESLIE
KINROSS
HEIDELBERG
VEREENIGING
BALFOUR
POTCHEFSTROOM
GREYLINGSTAD
SASOLBURG
VILLIERS
EXPLANATION
GOLDFIELDS
① Central Rand ② East Rand ③ Evander
④ West Rand ⑤ West Wits Line
SCALE
10 20 30 40 50 Miles
A.B '68
Modified after Borchers (1961)


STRUCTURE CONTOURS
MAIN REEF HORIZON
BOREHOLE POSITION AND INITIALS
FAULT (POSITION UNSHURE)
STRUCTURE CONTOUR (FT. ABOVE SEA LEVEL)
DIP ANGLE (CALCULATED)
ESTIMATED SUB-OUTCROP OF MAIN REEF HORIZON BENEATH BLACK REEF.
SCALE
1 1/2 0 1 2 3 MILES
T.N.
YZ 1
RF 1
KST 1
KST2
KST3
3500' Downthrow
3000'
2000'
1000'
0'
10°
14°
15°
WK2
WK1
BN 1
LP5
LP3
LP2
LP4
LP1
HP 1
MG 1
RV 1
OL 1
OL2
LIMIT OF EAST RAND GOLDFIELD
DELMAS
MB5
MB4
MB1
MB2
MB3
26°
37°
Rietkol BH
ELOFF
SW 1
Main Reef Horizon ?
4044'
Fig. 2

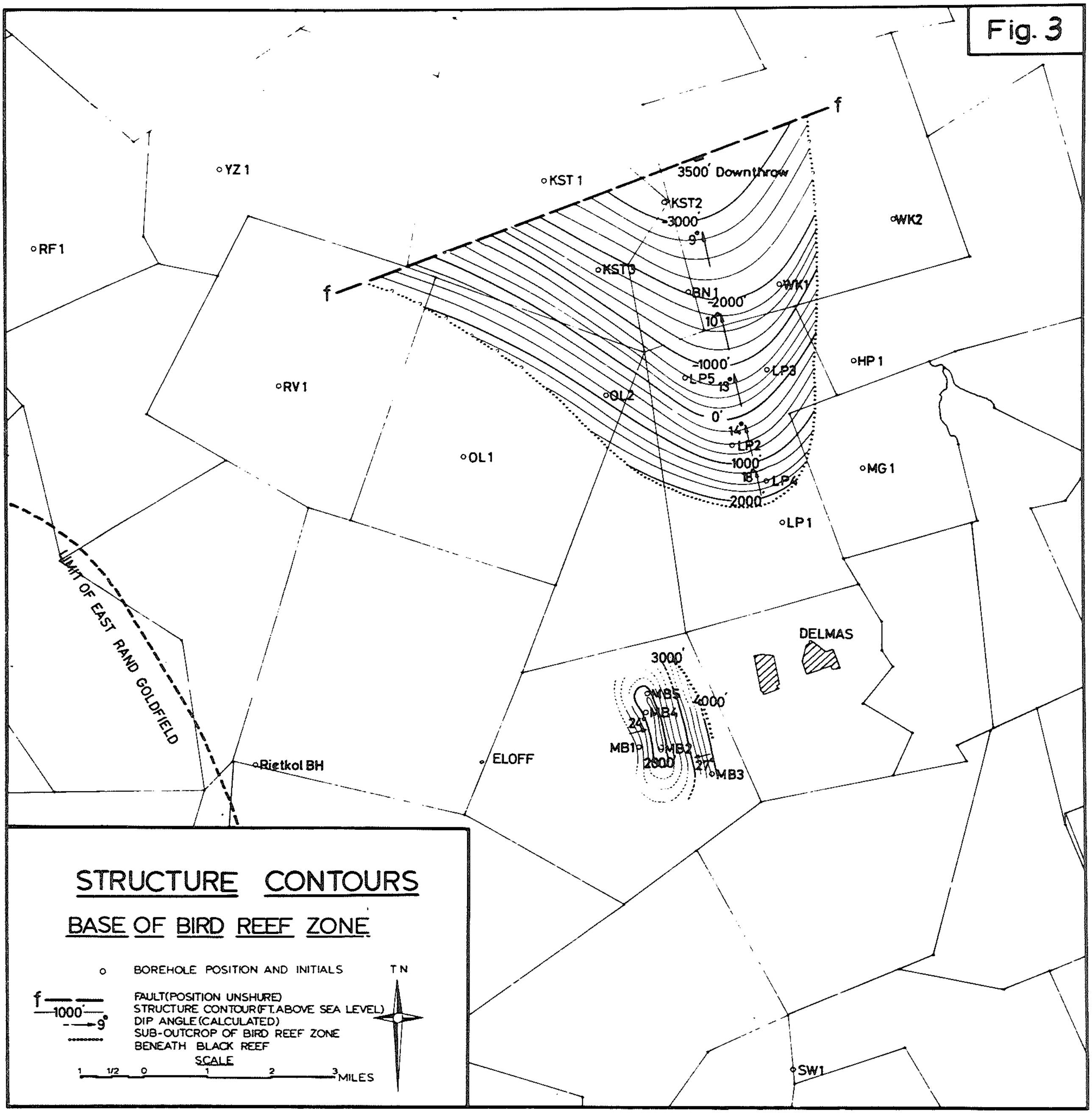


Fig. 3
STRUCTURE CONTOURS
BASE OF BIRD REEF ZONE
BOREHOLE POSITION AND INITIALS
FAULT(POSITION UNSHURE)
STRUCTURE CONTOUR(FT. ABOVE SEA LEVEL)
DIP ANGLE (CALCULATED)
SUB-OUTCROP OF BIRD REEF ZONE
BENEATH BLACK REEF
SCALE
MILES
TN
3500' Downthrow
YZ 1
KST 1
KST2
KST3
RF 1
WK2
WK1
BN1
RV1
OL2
OL1
LP5
LP3
LP2
LP4
LP1
HP 1
MG 1
LIMIT OF EAST RAND GOLDFIELD
DELMAS
MB5
MB4
MB1
MB2
MB3
ELOFF
Rietkol BH
SW1

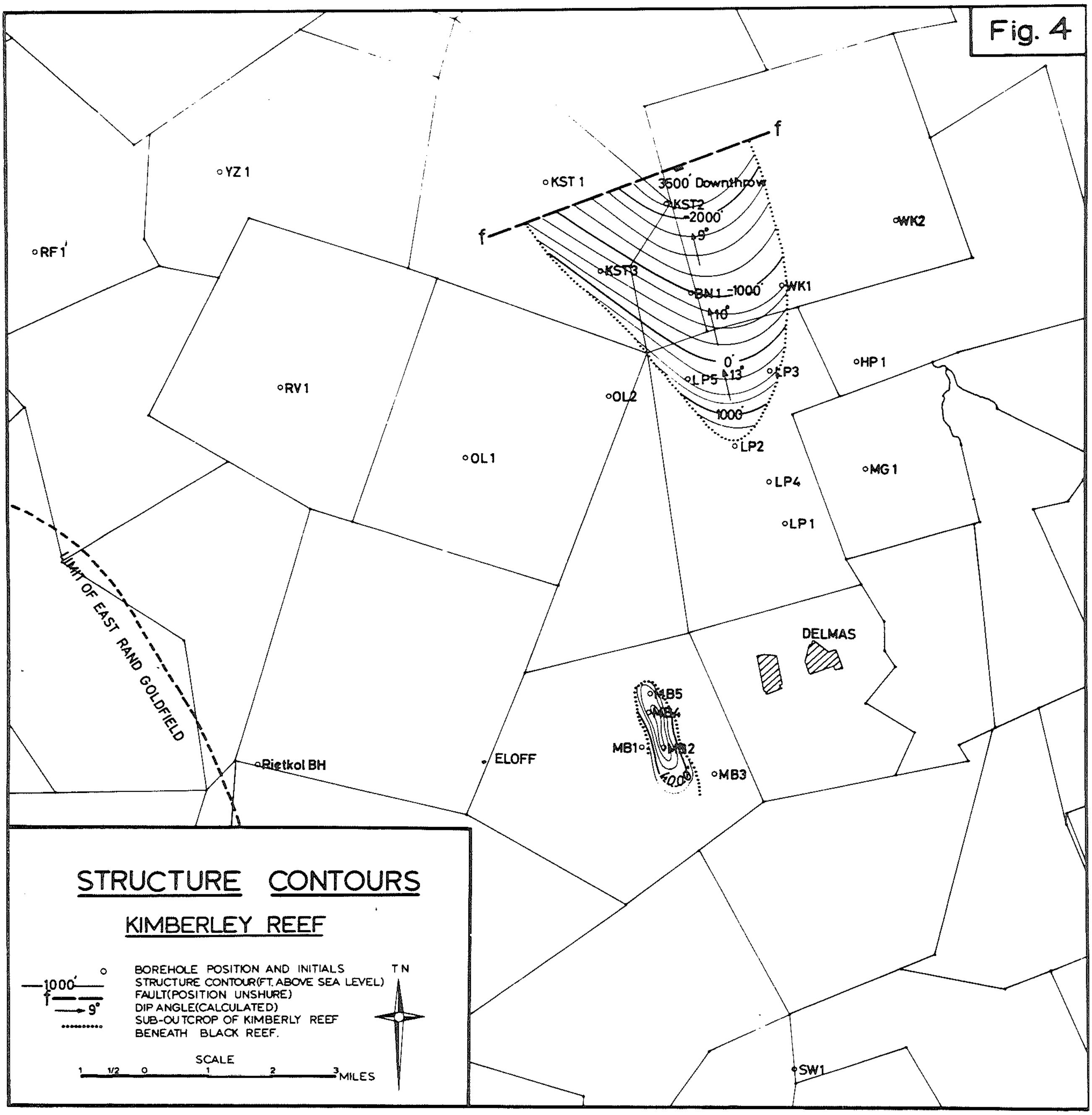


Fig. 4
STRUCTURE CONTOURS
KIMBERLEY REEF
BOREHOLE POSITION AND INITIALS
STRUCTURE CONTOUR(FT. ABOVE SEA LEVEL)
FAULT(POSITION UNSHURE)
DIP ANGLE(CALCULATED)
SUB-OUTCROP OF KIMBERLY REEF
BENEATH BLACK REEF.
1000'
f
9°
SCALE
1 1/2 0 1 2 3 MILES
T N
3600' Downthrow
-2000'
-1000'
0'
1000'
4000'
9°
10°
13°
KST 1
KST2
KST3
BN1
WK1
WK2
LP1
LP2
LP3
LP4
LP5
HP 1
MG 1
OL1
OL2
RV 1
YZ 1
RF 1
MB1
MB2
MB3
MB4
MB5
SW1
DELMAS
ELOFF
Rietkol BH
LIMIT OF EAST RAND GOLDFIELD

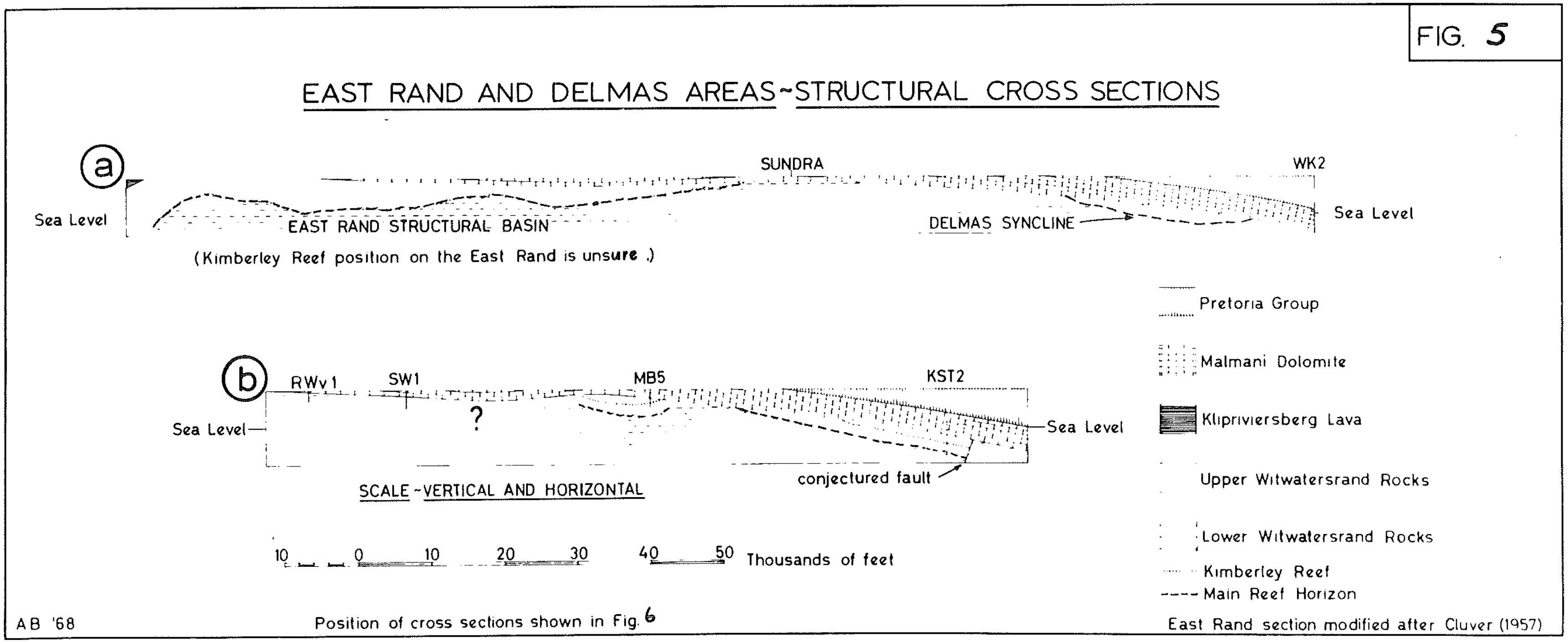
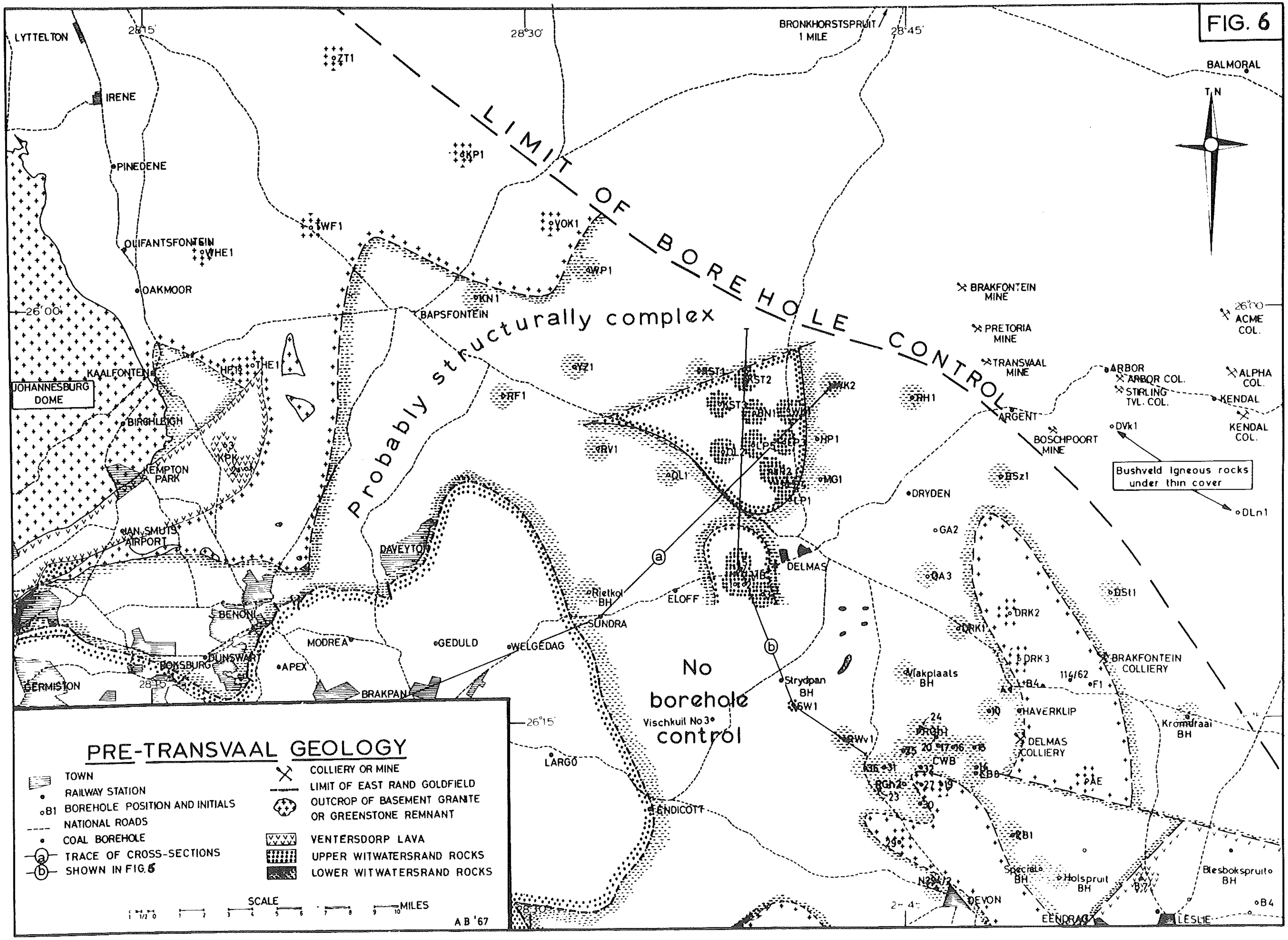


FIG. 5
EAST RAND AND DELMAS AREAS~STRUCTURAL CROSS SECTIONS
a
SUNDRA
WK2
Sea Level
EAST RAND STRUCTURAL BASIN
DELMAS SYNCLINE
Sea Level
(Kimberley Reef position on the East Rand is unsure.)
Pretoria Group
b
RWv1
SW1
MB5
KST2
Malmani Dolomite
Sea Level
?
Sea Level
Klipriviersberg Lava
conjectured fault
SCALE ~ VERTICAL AND HORIZONTAL
Upper Witwatersrand Rocks
Lower Witwatersrand Rocks
10 0 10 20 30 40 50 Thousands of feet
Kimberley Reef
Main Reef Horizon
AB '68
Position of cross sections shown in Fig. 6
East Rand section modified after Cluver (1957)

FIG. 6


PRE-TRANSVAAL GEOLOGY
TOWN
RAILWAY STATION
B1 BOREHOLE POSITION AND INITIALS
NATIONAL ROADS
COAL BOREHOLE
TRACE OF CROSS-SECTIONS
SHOWN IN FIG.5
COLLIERY OR MINE
LIMIT OF EAST RAND GOLDFIELD
OUTCROP OF BASEMENT GRANITE
OR GREENSTONE REMNANT
VENTERSDORP LAVA
UPPER WITWATERSRAND ROCKS
LOWER WITWATERSRAND ROCKS
SCALE
MILES
AB '67
LIMIT OF BOREHOLE CONTROL
Probably structurally complex
No borehole control
Bushveld Igneous rocks under thin cover
JOHANNESBURG DOME
LYTTELTON
IRENE
PINEDENE
OLIFANTSFONTEIN
OAKMOOR
KAALFONTEIN
BIRCHLEIGH
KEMPTON PARK
JAN SMUTS AIRPORT
BENONI
BOKSBURG
DUNSWART
GERMISTON
APEX
MODREA
BRAKPAN
DAVEYTON
GEDULD
WELGEDAG
SUNDRA
ELOFF
DELMAS
BAPSFONTEIN
ENDICOTT
LARGO
DRYDEN
ARGENT
BOSCHPOORT MINE
BRAKFONTEIN MINE
PRETORIA MINE
TRANSVAAL MINE
ARBOR
ARBOR COL.
STIRLING TVL. COL.
ALPHA COL.
ACME COL.
KENDAL
KENDAL COL.
BALMORAL
BRONKHORSTSPRUIT 1 MILE
BRAKFONTEIN COLLIERY
HAVERKLIP
DELMAS COLLIERY
Kromdraai BH
Blesbokspruit BH
Holspruit BH
EENDRAG
LESLIE
DEVON
Strydpan BH
Vlakplaats BH
Rietkol BH
Vischkuil No 3
28°15'
28°30'
28°45'
26°00'
26°15'

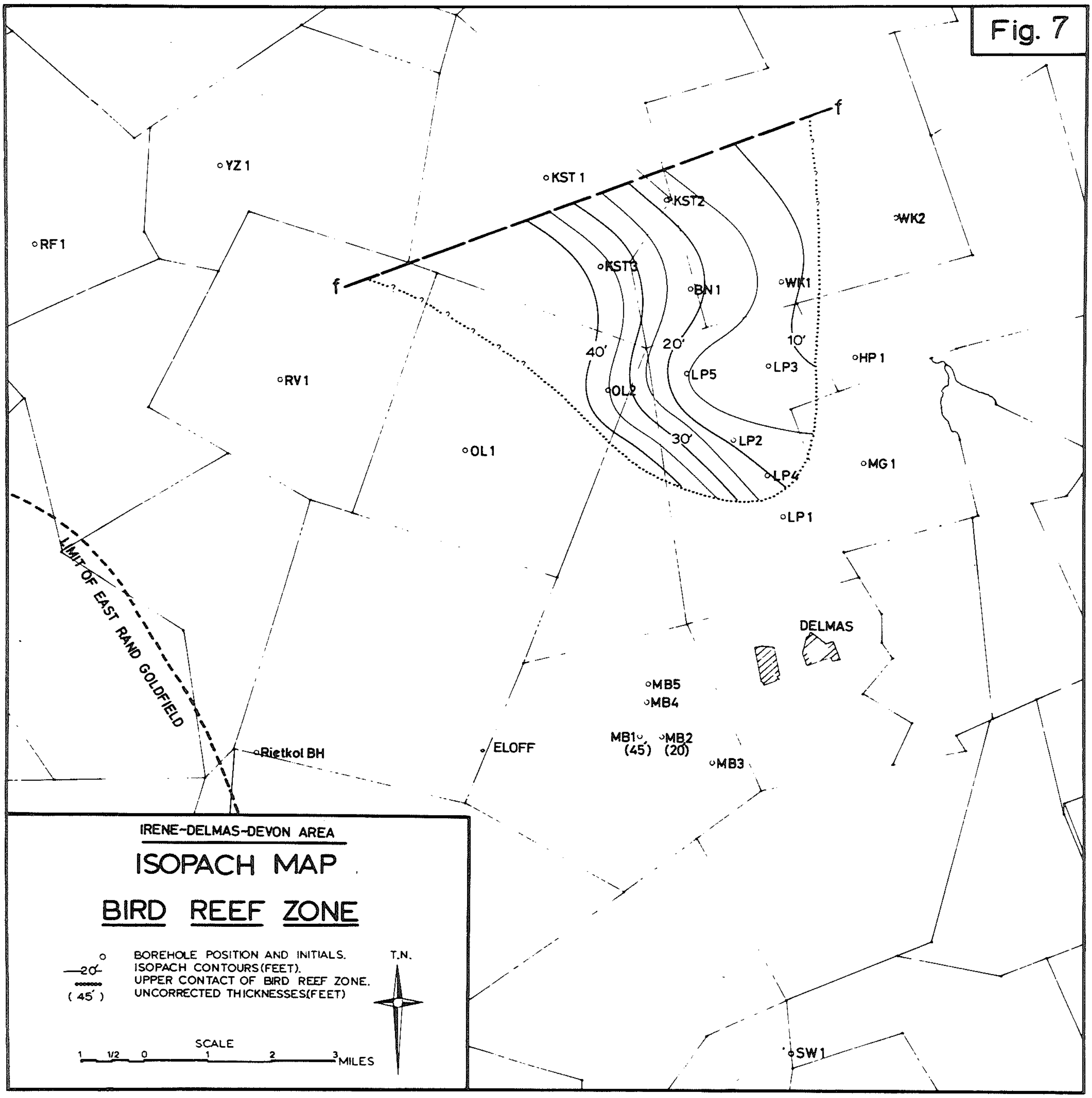


Fig. 7
f
f
YZ 1
KST 1
KST2
WK2
RF 1
KST3
BN 1
WK1
40'
20'
10'
HP 1
RV 1
LP5
LP3
OL2
OL 1
30'
LP2
MG 1
LP4
LP 1
LIMIT OF EAST RAND GOLDFIELD
DELMAS
MB5
MB4
MB1
(45')
MB2
(20)
MB3
Rietkol BH
ELOFF
SW1
IRENE-DELMAS-DEVON AREA
ISOPACH MAP
BIRD REEF ZONE
BOREHOLE POSITION AND INITIALS.
20
ISOPACH CONTOURS (FEET).
UPPER CONTACT OF BIRD REEF ZONE.
(45')
UNCORRECTED THICKNESSES (FEET)
T.N.
SCALE
1 1/2 0 1 2 3 MILES

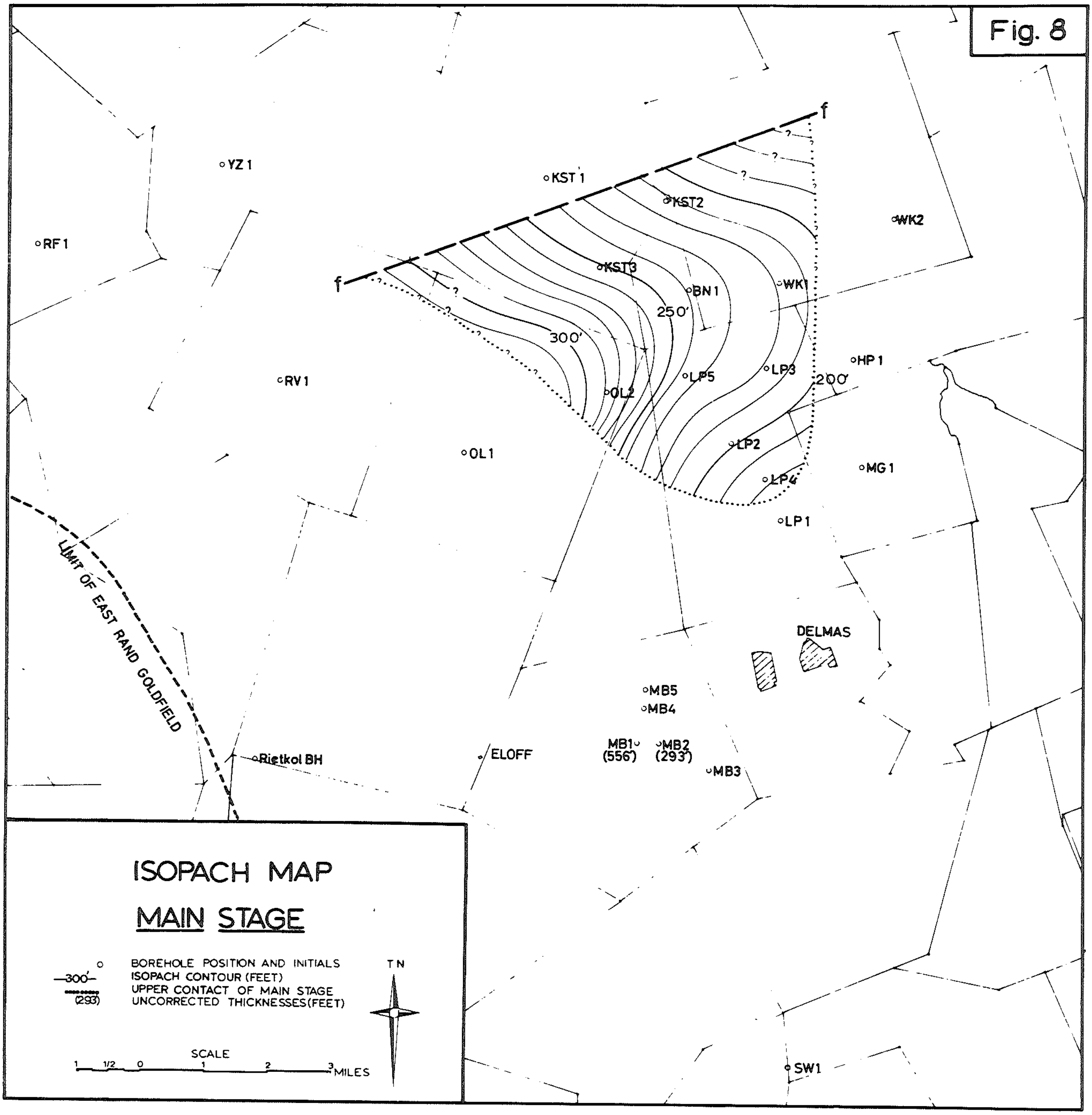


Fig. 8
f
f
KST 1
KST2
KST3
BN 1
WK1
WK2
YZ 1
RF 1
RV 1
OL1
OL2
LP5
LP3
LP2
LP4
LP1
HP 1
MG 1
250'
300'
200'
LIMIT OF EAST RAND GOLDFIELD
DELMAS
MB5
MB4
MB1
(556')
MB2
(293')
MB3
ELOFF
Rietkol BH
SW1
ISOPACH MAP
MAIN STAGE
BOREHOLE POSITION AND INITIALS
300'
ISOPACH CONTOUR (FEET)
UPPER CONTACT OF MAIN STAGE
(293)
UNCORRECTED THICKNESSES(FEET)
TN
SCALE
1 1/2 0 1 2 3 MILES

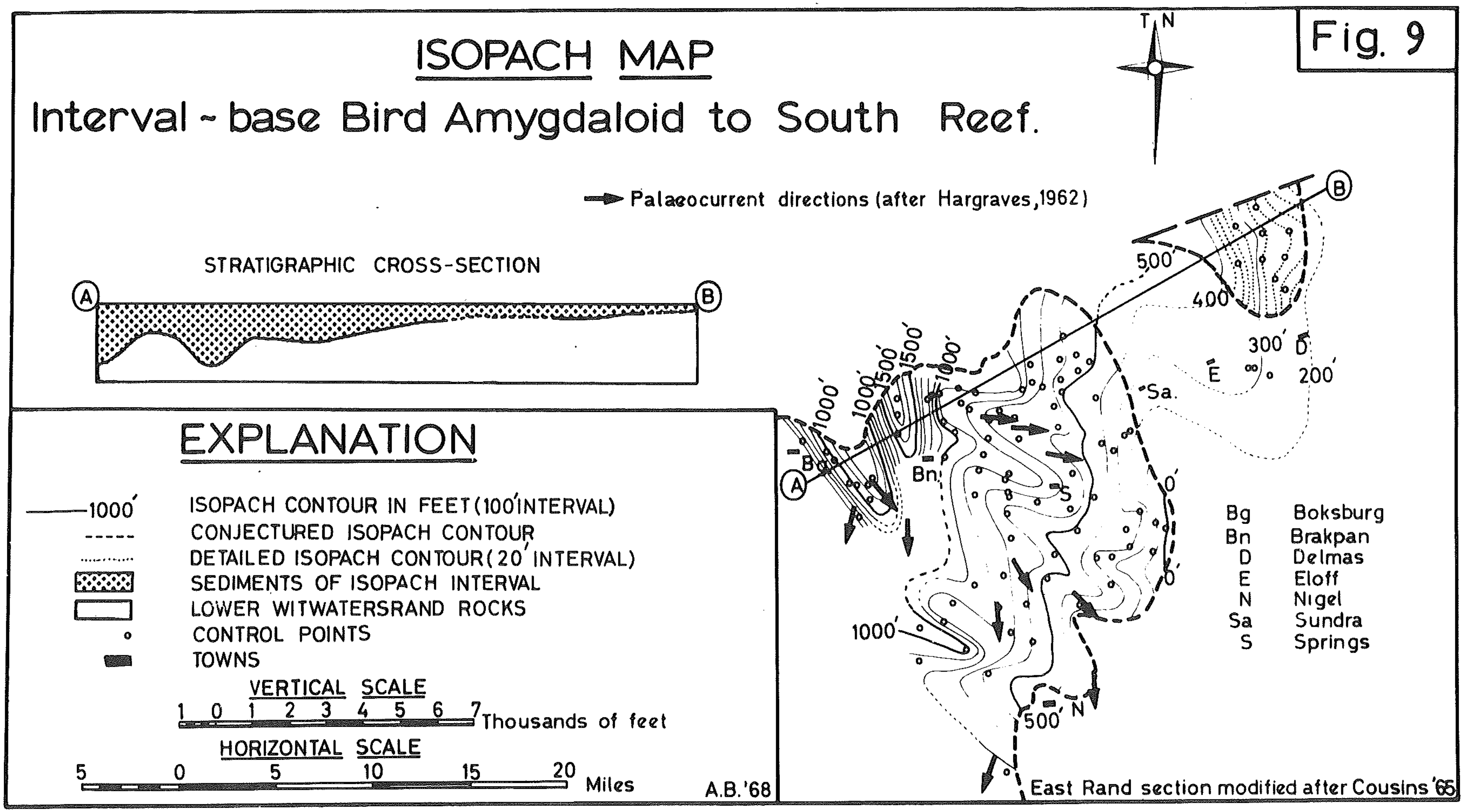


Fig. 9
ISOPACH MAP
Interval ~ base Bird Amygdaloid to South Reef.
T N
Palaeocurrent directions (after Hargraves, 1962)
STRATIGRAPHIC CROSS-SECTION
A
B
EXPLANATION
1000′ ISOPACH CONTOUR IN FEET (100′ INTERVAL)
CONJECTURED ISOPACH CONTOUR
DETAILED ISOPACH CONTOUR (20′ INTERVAL)
SEDIMENTS OF ISOPACH INTERVAL
LOWER WITWATERSRAND ROCKS
CONTROL POINTS
TOWNS
VERTICAL SCALE
1 0 1 2 3 4 5 6 7 Thousands of feet
HORIZONTAL SCALE
5 0 5 10 15 20 Miles
A.B.'68
500′
400′
300′
200′
1000′
1500′
0′
Bg
Bn
S
Sa.
E
D
N
Bg Boksburg
Bn Brakpan
D Delmas
E Eloff
N Nigel
Sa Sundra
S Springs
East Rand section modified after Cousins '65