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GEOLOGY OF THE CRETACEOUS ROCKS OF

OUTSHOORN AREA, CAPE PROVINCE, WITH

AN OUTLINE OF THE GEOLOGICAL STRUCTURE

OF THE OUTSHOORN BASIN

by

J.K. Whittingham

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## 1. Introduction (Ref. Folder 1)

The area mapped constitutes a N.-S. section 10 miles wide across the Oudtshoorn Cretaceous Basin, with Oudtshoorn\* in the centre of the strip, bounded to north and south by Cape System and pre-Cape rocks. The basin is elongated E.-W., parallel to the general strike direction and trends of fold axes and faults observed in the Cape and pre-Cape rocks to north and south. On the southern side of the basin, Cretaceous sediments rest unconformably on Cape System rocks (shales and sandstones of Bokkeveld Series within the limits of the area mapped). On the northern side of the basin, the boundary between the Cretaceous sediments with Cape System and pre-Cape rocks is formed by a strike fault zone running E.-W. which was initiated in pre-Cretaceous times and along which movement took place during and after the Cretaceous sedimentation. Other such faults, concealed by post-Cretaceous eluvium and talus may exist within the Cretaceous Basin, especially in the northern part. The dip of Cretaceous sediments in the strip is generally 0-30 degrees N. but steeper dips are observed at Buffelsdrif north of Oudtshoorn.

## 2. Geological Succession (Ref. Folder 1)

The rocks of the Oudtshoorn Basin may be referred to the standard geological succession given by Du Toit (1954) and Haughton (1969). The standard succession in the Cretaceous deposits is observed in Uitenhage area. (Haughton 1928) (Engelbrecht et al 1962).

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\* Throughout this report, the precise locality Oudtshoorn means the crossing point of main roads in the centre of the town by the Municipal Office. All distances and directions of places from "Oudtshoorn" are taken from this point.

	POST CRETACEOUS	Gravels, conglomerates, silcretes, ferricretes	Extensive, overlying. Cretaceous and older formations
	3. Sundays River Stage	Marine clays, sandy shales, sandstones, mudstones, thin limestones.	Not represented unless upper estuarine facies deposits are equivalent.
CRETACEOUS (Uitenhage Series)	2. Variegated marls and Wood Beds Stage	Grey/red variegated mudstones, sandstones, conglomerates.	Estuarine facies deposits widely exposed. Thickness of order 12,000 feet.
	1. Enon Stage	Conglomerates and sandstones.	Widely exposed south of Oudtshoorn. Thickness at least 2000 feet. North?
	KAROO	Not represented, unless completely covered by Cretaceous deposits.	
	3. Witteberg Series	Quartzites and shales.	May occur concealed by Cretaceous deposits. Not exposed.
CAPE	2. Bokkeveld Series	Shale and sandstone.	Exposed south of Oudtshoorn Basin. Northward extent uncertain.
	1. Table Mountain Series.	Quartzite with shale.	Exposed in places to north and south of Oudtshoorn Basin.
	? Klipheuwel Formation.	Grits, slates and phyllites.	Widely exposed immediately to north of Oudtshoorn Basin.
PRE-CAPE	Cango Formation (upper division)	Grits, slates, phyllites, conglomerates.	

A formation of conglomerate with subordinate sandstones, closely resembling those of the Enon Stage, occurs in an E.-W. belt, 5 to 10 miles north of Oudtshoorn, bounded to the north by an E.-W. fault separating those rocks from rocks of the Table Mountain Series and pre-Cape groups. These are described by Du Preez (1944) as the "Upper Enon Red Beds", succeeding

the sandstones and mudstones referred by Du Toit (1954), Haughton (1969) and herein by the writer to the Variegated Marls and Wood Beds Stage. There is, within this 10-mile wide strip, however, no conclusive evidence to show that these conglomerates and sandstones succeed the latter formation. There is, on the other hand, no conclusive evidence of a major E.-W. fault which must necessarily be inferred if the conglomerates and sandstones are correlated with the Enon Stage as defined in the Uitenhage area (Haughton 1928).

Since conclusive evidence may exist in the Oudtshoorn Basin outside the 10-mile wide strip mapped to date, both possible interpretations of the succession are depicted in profiles (Folder 1) and the merits of these interpretations are discussed below (Section 5 (iii)). For convenience, in this report, these conglomerates and sandstones may be referred to as a "Northern Enon Stage".

### 3. Geology of the Cretaceous deposits

#### A. Enon Stage (South of Oudtshoorn) and "Northern Enon Stage"

These may be described together since the rocks are very similar in appearance in the field. The typical members common to both - the transported conglomerates - would be indistinguishable from each other in their respective placings. (Plates 6, 9, 10, Specimens JKW/Oh/28, 36).

Both formations consist of conglomerates interbedded with subordinate sandstone bands. The sandstones and the sandy conglomerate matrix are ferruginised giving a characteristic brick-red colour.

Both formations may be divided into two sub-formations:-

2. Transported conglomerate, in which well-rounded fragments, varying in size and poorly sorted, consist almost exclusively of the rock type most resistant to abrasion, namely the quartzite of the Table Mountain Series.

1. Semi-indigenous conglomerate, in which fragments, varying in size, poorly sorted, and angular to sub-angular in shape consist exclusively of one rock type which, it must be inferred, is the rock formation directly underlying the conglomerate.

These sub-formations are not sharply divided but there is a transition from one to the other. At the base, conglomerates consist almost entirely of indigenous material. Upwards, the proportion of transported material increases and the degree of rounding and abrasion of semi-indigenous material also increases.

(a) Semi-indigenous conglomerates.-

- (i) In the Enon Stage (south of Oudtshoorn).

Within the 10-mile wide strip surveyed, the conglomerates of the Enon Stage directly overlie Bokkeveld shale and sandstone. The basal indigenous conglomerates are well exposed in road and railway cuttings near the George road  $1\frac{1}{2}$  to  $2\frac{1}{2}$  miles south of the Olifants River and along the Bakenskraal-Volmoed road.

At the base, platy fragments are of uniform size, usually not more than 1 inch in diameter (Spec. JKW/Oh/16). In succeeding horizons, larger fragments, sometimes more than 1 ft. in diameter occur with the smaller fragments and the deposit is poorly sorted (Plate 12). The direction of transportation is from the south.

Higher in the sequence, well rounded fragments of transported quartzite appear and shale and sandstone fragments become more well rounded. The thickness of the semi-indigenous conglomerate is difficult to estimate and probably varies considerably since it appears to have been deposited over a hilly landscape. The general order of thickness can be estimated as 500-1000 feet.

The undulating topography with conical hills which have distinct benches dipping at  $10 - 20^{\circ}N$ , where Bokkeveld shales and sandstones are now exposed at the surface for the first 2-3 miles south of the Olifants River, probably represents the original sub-Cretaceous surface formerly covered by the semi-indigenous conglomerate. The bolder E.-W. ridge topography further south was probably subjected to Tertiary-Recent erosion while the undulating sub-Cretaceous topography to the north was protected from erosion until Recent times by Cretaceous cover. (Plate 17).

Exposures of semi-indigenous shale-conglomerate, similar to the basal conglomerate described above, are found in the Olifants River at Seekoegat and north of the Kanmanassie River at Rooiheuvel. They are intercalated with sandstones and red mudstones. The stratigraphical relationship of these occurrences are not clear and the possible significance of them is discussed below (Section 3C).

(ii) In the northern Enon Stage

Semi indigenous conglomerates are not as well exposed to the north of Oudtshoorn as they are to the south. This is because, probably as a result of uplift movements along major faults during Tertiary times, much of the terrain is covered by semi-consolidated gravels of late Tertiary - Quarternary age. The best exposures are seen in the west bank of the Grobbelaars River at Schoemanshoek (north end) (Plates 3, 4). There, the conglomerate is seen to be coarse textured (blocks of 1 foot or more in diameter not uncommon) and poorly sorted consisting exclusively of sub-angular fragments of grey grit, slate and phyllite set in a red sandy matrix. Direction of transport is clearly from the north. There are some thin bands of red sandstone intercalated in the conglomerate. The fragments

resemble the grey grits, slates and phyllites of the pre-Cape systems. (Spes. JKW/Oh/3, 4, 5, 34, 35). These conglomerates are not seen to overlie solid pre-Cape formations, but since pre-Cape grits, slates, and phyllites are by no means the most resistant to transportation and abrasion, the existence of pre-Cape rocks at unknown depth directly underneath them can reasonably be inferred. Bore-holes 16 and 19 (Ref. Folder 1 & Table 1) respectively passed through 150 and 495 feet of this conglomerate - from existing drillers reports, the solid pre-Cape rocks were not reached. If it is accepted, however, that these indigenous conglomerates overlie a sub-Cretaceous topography corresponding broadly to the present topography, these deposits in the Grobbelaars River valley would be abnormally thick the deposits would probably be thinner over the hills and the sub-Cretaceous topography would most likely resemble that south of Bakenskraal and Highgate. Other exposures of this semi-indigenous grit/slate/phyllite conglomerate are found in upper Droëriver. The other occurrences of this conglomerate depicted on the map (Folder 1) are, in fact, areas over which the hillside float consists predominantly or exclusively of grit, slate, or phyllite. Such material must either directly overlie solid pre-Cape rocks or semi-indigenous conglomerate of the same material which must in turn overlie pre-Cape rocks. The most important significance of these occurrences is that the existence of pre-Cape rocks may be inferred at moderate depth to the south of the earlier supposed line of the Congo Fault (Rossouw et al 1964), which is referred to hereunder in this report as the Schoemandshoek Fault. (See Section 5).

Conglomerates consisting exclusively of sub-angular and sub-rounded fragments of T.M.S. quartzite set in a red sandy matrix were encountered in exploratory bore-holes G. 23511, G. 23512 and G. 23512a (11, 10a and 10

respectively on Folder 1 and Table 1) in Blommetjieskloof east of Schoemanshoek (See Fig. 1). The quartzite fragments vary in size from less than 1 inch to about 5 feet in diameter, indicating that the deposit is unsorted. In bore-hole G. 23512a (the vertical bore-hole this conglomerate occurred from 180 to 541 feet depth where the conglomerate rests on T.M.S. quartzite (Whittingham 1970). Simpson and Peters (1-70) observed that this conglomerate is not typical Enon conglomerate (transported type) since the fragments are usually sub-angular. This conglomerate may now be regarded as a basal semi-indigenous conglomerate of the Enon stage overlying T.M.S. quartzite.

Transitions from the semi-indigenous conglomerate upwards into the transported conglomerate are not observed, but it may be mentioned that immediately surrounding those areas where grit, slate, and phyllite float is predominant, there is a gradual transition in composition of float to dominantly transported T.M.S. quartzite, not an abrupt change.

East of the main road  $2\frac{1}{2}$  miles south of Schoemanshoek, the conglomerates consist mainly of transported, well rounded fragments of T.M.S. quartzite but subordinate to this material are sub-angular to rounded fragments of grey sandstone, shale, and slate, resembling material from T.M.S. shale, uppermost T.M.S., or Bokkeveld Series. (Plate 14, Specimen JKW/Ph/47). Direction of transportation appears to be from the north.

This would suggest that uppermost T.M.S. or Bokkeveld Series underlie the Cretaceous conglomerates at moderate depth in this locality. A similar conglomerate is seen, but not so well exposed, 100 yards north of the possible T.M.S. inlier 1 mile south of Schoemanshoek.

A mixed (Spec. JKW/Oh/26) conglomerate, not unlike the conglomerate described above is found on the eastern slopes of lower Doringkloof in superior positions to

mudstones and sandstones of the Upper Wood Beds stage, though it is not actually seen to overlies the latter or to underlie more typical Cretaceous conglomerates. This occurrence would appear to give the best grounds for suggesting that the northern Enon formation may overlies the Wood Beds. The matrix of this conglomerate is somewhat friable and from relationships which can be observed, it is by no means certain that this conglomerate is of Cretaceous age - it could be a re-worked conglomerate of later Cretaceous or Tertiary age.

On the west side of Upper Doringkloof, a concentration of diabase float with grit, slate, and phyllite is observed. This occurrence is noted on the geological map (Rossouw et al 1964). The float is probably derived from semi-indigenous conglomerate, the fragments being derived in turn from a diabase intrusive cutting pre-Cape sedimentary rocks.

(b) Transported Conglomerates.-

These conglomerates are the typical Enon Conglomerate, consisting exclusively of well rounded fragments of T.M.S. quartzite varying in size from less than 1 inch to over 5 feet diameter set in a red sandy matrix. The conglomerates are completely unsorted. (Plates 6, 9, 10). Red sandstone bands, varying from a few inches to about 5 feet in thickness, are intercalated with the conglomerate.

Direction of transportation is indistinct. Using criteria given by Pettijohn (1948 p. 62), over the same exposure, there may be a suggestion of transportation from the south or north at different horizons - more often than not, there is no discernible indication of transport.

Hills composed of this rock and individual exposures are commonly dome-shaped giving the observer the impression of plum-pudding. Erosion of this rock formation may give rise to a variety of weird land forms - well rounded tors, overhanging cliffs, caves, and natural arches (vensters).

The transported conglomerates of the Enon stage (south of Oudtshoorn) are indistinguishable in the field from those of the northern Enon stage.

Where this formation is well developed, the thickness would appear to be at least 2000 feet, but owing to poor exposures in the western part of the area mapped which is largely covered by post-Cretaceous gravels, it is not certain that this thickness is consistent. It is possible that the transported conglomerates may thin westward at the expense of thickening semi-indigenous conglomerate. (See sub-section C).

From evidence available, it is possible that there may be at least three horizons of transported conglomerate, the two lowest preceding the main Variegated Marls and Wood Beds stage with an intercalation of the latter formation between them, the highest horizon succeeding the latter stage. (Folder 1 Interpretation 2). It is also possible, in the writer's view probable, that this extraordinary formation occurs at one stratigraphical level only and that apparent repetitions are due to E.-W. strike faulting (Interpretation 1). These possibilities are discussed further below (Section 5).

South of Oudtshoorn, transported conglomerates of the Enon stage are observed to be succeeded by sandstones and mudstones of the Variegated Marls and Wood Beds stage. No Cretaceous deposits are observed to succeed the transported conglomerates of the northern Enon stage. Where the uppermost conglomerates are observed south of Rooiheuvel and in the bed of the Olifants River, the matrix is distinctly paler in colour than in the hills to the south and this may correspond to the "White Enon" mentioned by Du Toit (1954).

#### B. Variegated Marls and Wood Beds stage (W.B.S.)

The rocks of the Variegated Marls and Wood Beds stage in Oudtshoorn area are of estuarine facies and comprise the following in order of abundance:-

Upper W.B.S.	Lower W.B.S.	
80%	50%	1. Red and grey variegated mudstone and siltstone.
20%	20%	2. Thin-bedded buff-green sandstones of fine-medium texture. (Individual beds usually less than 3 feet in thickness).
Rare	25%	3. Massive buff-green sandstones of coarse-medium texture. Current bedded. Rounded pebbles of quartz or quartzite may be disseminated or concentrated in thin bands. Individual beds usually 3 to 5 feet in thickness.
Rare or absent	5%	4. Small-pebble conglomerate. Pebbles well rounded, spherical or ovate, usually not more than 1 inch in diameter but may, in thicker bands, be up to 6 inches in diameter. Moderately well sorted. Pebbles exclusively T.M.S. quartzite or, less commonly, vein quartz. Matrix buff-green sandstone. Conglomerate bands usually 1 to 3 feet in thickness but may locally develop to thicknesses of 10 feet or more.
Estimated total thicknesses		
<hr/>		
6000 ft.	6000 ft.	

The massive sandstones and small pebble conglomerates are generally better exposed than the other rock types giving the impression that they comprise a greater proportion of the sequence than they actually do. The very estimated percentages of the succession which the rock types comprise in the upper and lower W.B.S. respectively are given above. The estimated total thickness allow for probable repetition by faulting in which rocks of the Enon formation are involved but do not allow for the possibility of repetition by faulting involving rocks of the W.B.S. alone.

Throughout the sequence, the mudstones, siltstones and finer textured sandstones commonly contain capillary roots remains and small wood fragments. At certain localities:-

1. near the base of the W.B.S. south of Rooiheuvel.
2. near Caves Motel 2 miles north-north-east of Oudtshoorn.

JKW/Oh/37, 38, 39). It can be traced eastwards for  $\frac{5}{4}$  mile along strike. Similar rock has not been observed at any other horizon.

Direction of transport in the small pebble conglomerates is indistinct. The direction of transport in the sandstones, using criteria given by Pettijohn (1948, p. 126), is generally seen to vary in a N.-S. sense from horizon to horizon. In the east-west road cuttings  $2\frac{1}{2}$  to  $3\frac{1}{2}$  miles east of Oudtshoorn, the direction of transport in the sandstones generally appear to be from the west.

Exposures of the mudstones, siltstones and sandstones of the upper W.B.S. are generally poor, except in cuttings along the main Prince Albert road and in dongas near to the northern boundary. The boundary between the lower and upper W.B.S. can, however, be located with reasonable precision in Grobbelaars River valley and Perdekloof.  $2\frac{1}{2}$  miles east of Buffelsdrif,  $\frac{1}{2}$  mile north of Vergelegen road, a thin band of pale-grey sandstone is found, containing cavities which could possibly be shell casts (Specimen JKW/Oh/20). This lends to the possibility that marine bands may occur in the upper W.B.S. If so, the upper W.B.S. of Oudtshoorn area may be a dominantly estuarine stage, equivalent to the Sundays River stage of Uitenhage area. Marine bands were not observed in exposures in road cuttings along the main Prince Albert road. Since exposures of the upper W.B.S. elsewhere are generally poor, the location and mapping of marine bands or any marker horizons therein would require an extremely careful search. (The first step would, of course, be to determine whether or not there is any material of marine derivation in Specimen JKW/Oh/20 - this rock type is not commonly found).

C. Facies changes in the Cretaceous sediments

In general, rock exposures in this area are not good enough to be able to observe distinct lateral sedimentary facies changes. In the W.B.S., there is no evidence of such phenomena - small pebble conglomerate horizons in the lower W.B.S. and the arbitrary boundary between lower and upper W.B.S. can be traced for distances of 4 - 5 miles from east to west and discontinuity may be attributed to

concealment of the rocks by post-Cretaceous cover.

In the rocks of the Enon stage (south of Oudtshoorn) and the northern Enon stage, however, there is a somewhat vague indication of lateral facies change. The typical transported conglomerate in both the Enon stage (south of Oudtshoorn) and the northern Enon stage is not exposed west of longitude  $22^{\circ}11.5'$  E (the N.-S. line running through Oudtshoorn aerodrome). It is known, however, that these transported conglomerates are again exposed west of Armoed (7 miles west of Oudtshoorn)(Ref. Du Preez 1944). It is also known that they are better developed in the northern Enon stage in the area between Dysveldorp and De Rust (15 to 20 miles east of Oudtshoorn) and in the Kruis River area (20 to 25 miles west of Oudtshoorn) than anywhere in the area of investigation.

These facts indicate that the thickness of the transported conglomerates may be very variable and it is possible that they were never deposited in the north-south strip between Oudtshoorn and Armoed. There is evidence, however, that in the Highgate-Seekoegat area, the semi-indigenous conglomerates containing bokkeveld shale and sandstone fragments, are more persistent than elsewhere - not only are these rocks exposed in the bed of the Olifants River at seekoegat but also to the full depth in bore-holes 73, 74 and 75 (260, 120 and 80 feet respectively - Ref. Table 1.) In the banks of the Olifants River at Seekoegat, these shale conglomerates are observed interbedded, not only with reddish sandstones but also with buff-green sandstones and variegated sandstones, presumably belonging to the lower W.B.S.

At Rooiheuvel also, north of the Kammanassie River, shale conglomerates occur interbedded with buff-green sandstones and variagated mudstones.

It is possible that the transported conglomerate may continue westward through Safari Ostrich Farm and north of Seekoegats and that the occurrence of sandstones and mudstones resembling those of the lower W.B.S. in the semi-indigenous conglomerates may prove to be quite normal.

The chief argument against this possibility is that the Enon type transported conglomerate is where observed highly resistant to erosion and forms bold topographical features. It seems highly unlikely that any great thickness of these deposits would be completely concealed over such a wide area by post-Cretaceous gravels. It may further be noted here that bore-holes 64 and 65 at Welgevonden are reported to pass respectively through 245 and 300 feet of sandstone and mudstone (Ref. Table 1) and bore-hole 66 to the south was drilled to a depth of 130 feet in hard conglomerate with sandstone bands (presumably transported type).

The preferred explanation here is that the semi-indigenous conglomerates and transported conglomerate of the Enon stage (south of Oudtshoorn) are, in part, contemporaneous and that one type may develop locally at the expense of the other. Where shale conglomerates are observed interbedded with buff-green sandstones and variegated mudstones, it is suggested that the semi-indigenous shale conglomerates have there developed to the exclusion of the transported conglomerates and that they there lie in the transition zone between the Enon stage and W.B.S.

No such evidence of facies changes are observed in the northern Enon stage since the Cretaceous deposits are largely concealed by post-Cretaceous gravel, and there are no river-exposures there. It is highly probable, however, that similar facies changes do exist in the northern Enon stage.

#### D. Extent of sedimentation

Except in the area south of Highgate and Bakenskraal, there is little evidence to indicate that Cretaceous sediments were ever deposited far beyond the present northern and southern limits of the present day outcrop. Hill-cappings of Cretaceous deposits such as might be preserved overlying Bokkeveld shale and sandstones to the south are not observed. Along the northern foot of the Outeniqua Mountains, 15 miles south of Oudtshoorn, there is a crustal deposit, up to 20 feet thick dipping

gently northward away from the mountain flanks. It is a ferruginous cemented conglomerate composed of angular fragments, chiefly of T.M.S. quartzite and may overlie rocks of the T.M. or Bokkeveld Series. It does not resemble any of the Cretaceous deposits described above and is probably of Tertiary age. (Specs. 45, 46). In the north, the limit of Cretaceous sedimentation, following the Schoemanshoek fault is distinctly abrupt. This can be attributed to post-Cretaceous movement along this fault line. No evidence has been found, however, to show that Cretaceous sediments were ever deposited further north.

#### 4. Post-Cretaceous deposits

It was not the purpose of the present investigation to examine these rocks in detail so they may be described very briefly here.

Four main types occur in the area of investigation.

##### A. "Residual gravel"

This gravel is semi-consolidated and comprises blocks and boulders of rock derived from T.M.S. or pre-Cape formations. It is found on plateaus or ridge tops along the southern flanks and foothills of the Rooiberge, overlying Cretaceous, T.M.S. or pre-Cape rocks. The material may be derived directly from the two latter groups but may be in part re-worked Cretaceous conglomerate material. The deposit is characterised by large rounded, irregularly sloped boulders of T.M.S. quartzite which often exceed 10 feet in diameter. Their age is uncertain; but they may be late-Tertiary, related to the hillside gravels (C).

##### B. Plateau Gravels

These usually overlie sandstone and mudstones of the W.B.S. The gravel consists of well-rounded blocks and pebbles, predominantly of T.M.S. quartzite, cemented by a sandy or calcrete matrix. Direction of transport is usually indistinct but it may be inferred that the deposits were derived from the mountains to north and south, being transported towards the centre of the

Oudtshoorn Basin. They are probably of early - mid Tertiary age.

C. Plain and hillside gravels

These gravels are semi-consolidated, moderately well sorted deposits consisting of pebbles, blocks and boulders of rocks representing all the exposed Cretaceous and pre-Cretaceous formations in the area. T.M.S. quartzite fragments are the most common, probably for two reasons:-

- (i) it is the most resistant rock to abrasion and transportation;
- (ii) it is the most common material in the transported conglomerates of the Enon stage, from which much of the material may have been derived.

In the north, fragments of pre-Cape rocks are subordinate but nevertheless common. A characteristic fragment is arkosic conglomerate which is exposed in the upper Cango Formation well to the north of the Schoemanshoek fault. Direction of transportation is distinct and invariably from the north. Cement may be calcareous, ferruginous or sandy. Much of the superficial hillside material covering Cretaceous deposits (shown buff-shaded on the map) may be referred to this formation. They are well exposed in the main road cuttings at Schoemanshoek. (Plate 16). South of the Olifants River, Bokkeveld shale or sandstone fragments occur, subordinate to T.M.S. quartzite. Direction of transportation is distinctly from the south.

These gravels may directly overlie pre-Cretaceous formations to the north and south of the area mapped. They are probably of late Tertiary age.

D. Alluvial deposits

These are restricted to the main river valleys and comprise loosely cemented gravels, sands and silts.

Detailed examination of the post-Cretaceous deposits could well reveal that there are more types of deposit, especially the gravels, than have been mentioned here.

## 5. Geological Structure

The strike trend of the rocks of the pre-Cape, Cape, and Cretaceous systems in the Oudtshoorn area prevails in an E.-W. direction. This is also the strike direction of fold axial planes and of the major faults observed. (Ref. Folder 1, Du Preez (1944) and Rossouw et al 1964).

The north-south profile from Schoemanshoek to Rooiheuvel (Folder 1) illustrates two possible interpretation of the structure from the facts observed to date.

### A. Pre-Cretaceous "inliers" south of the Schoemanshoek fault (Plates 1 and 2).

For reasons given above, in areas where ridge and hillside float consists exclusively of grits, slates and phyllites of pre-Cape age, pre-Cape rocks must lie underneath at moderate depth. Such areas (shown as Cr (Ca) on map) may therefore be regarded as pre-Cape inliers. A few rock occurrences are large enough to be considered as solid rock but it would be inprudent to suggest that they are undisturbed exposures.

The "inlier" of T.M.S. quartzite immediately south of Schoemanshoek is admittedly questionable (Plate 15). It is a slab exposure, at least 10 ft x 10 ft in area, dipping northwards, downslope, at 35°. This rock is far larger in size than any of the surrounding transported material and is considered too large to have been moved for any great distance. There are a few loose boulders of T.M.S. quartzite, 4-5 feet in diameter, disposed in an E.-W. line further up the same slope.

### B. The Schoemanshoek fault. (Plates 1 and 2)

Immediately to the north of the Schoemanshoek, in places, rocks of the T.M. Series, presumably basal quartzites unconformably overlying the pre-Cape rocks, strike E.-W. and dip southwards at angles usually between 40 and 60 degrees. (Rossouw et al 1964). At four places along this fault line

1. west of Koedoepoort
2. west of Doringkloof
3. in the west bank of Grobbelaars River at Schoemanshoek
4. east of Schoemanshoek

brecciated quartzite of the T.M. Series is observed. At the first two places, the brecciated quartzite dips steeply to the north, at the third, it is almost vertical, at the last, the dip is steep to the south. To the south of where the brecciated quartzite is observed, are "inliers" of pre-Cape rocks described above.

These observations indicate that the Schoemanshoek fault follows a sharp E.-W. striking syncline in which quartzites of the T.M.S. are locally downfolded. Rocks are brecciated on the southern line of this fold - as a rule, the quartzites on the northern limb may be fractured but are not brecciated. East of Schoemanshoek, where the brecciated zone dips steeply southward, either

1. the syncline is overturned
- or
2. brecciation has extended over to the northern limb of the fold and the quartzite has been faulted out on the southern limb.

East of Doringkloof, where quartzite of the T.M.S. does not occur along the Schoemanshoek fault, a curious breccio-conglomerate occurs. (Specs. 2, 40, 41, 42, 43, 44). This rock consists of well rounded, ovate or platy fragments of quartzite (resembling that of T.M.S.), vein quartz, grey grit, slate, and phyllite, set in a coarse granular groundmass of quartz and mica. Fragments vary in size but are usually not more than 6 inches in diameter. The rock is fractured with quartz stringers. (Plate 5). The apparent dip varies from 20°S to near-vertical. In parts of the breccio-conglomerate zone, "pebbles" are absent, the rock consists of groundmass quartz and mica only and appears to dip vertically (Specs. 43, 44). The age of this breccio-conglomerate is uncertain but can reasonably be regarded as post-Cape, pre-Cretaceous in age.

#### C. Concealed structures

The observations so far indicate the following facts, regardless of the interpretation of the succession in the Cretaceous sediments:-

1. A major fault, striking E.-W., having steeply to S. or N., passes through Schoemanshoek involving rocks of Cape and pre-Cape systems.
2. Since pre-Cape rocks are exposed to the north of the fault and, it would appear, occur at moderate depth to the south of it, it is very doubtful that this can be the main Cango Fault. The sediments of the W.B.S., of the order 12,000 feet in thickness appear to be unrepresented immediately south of the Schoemanshoek fault. If the "inlier" of T.M.S. quartzite south of Schoemanshoek proves to be real, the main Cango Fault must lie at least  $1\frac{3}{4}$  miles south of the Schoemanshoek Fault.

The merits and demerits of the two interpretations of the geological structure given on Folder 1 may now be discussed. Prints in favour of the first interpretation are as follows:-

1. The transported Enon conglomerate is an extraordinary formation unlikely to be repeated. The transported conglomerate of the northern Enon stage is indistinguishable in the field from that of the Enon stage south of Oudtshoorn. In both cases, the transported conglomerate overlies semi-indigenous conglomerate.
2. An exposure of transported conglomerate  $2\frac{1}{2}$  miles E.S.E. of Schoemanshoek shows a preferred E.N.E. fracture direction in pebbles, parallel to an E.N.E.-trending fracture in the rock formation (Plate 6). Preferred fracture directions in pebbles may therefore indicate fault directions. The E.-W. preferred orientation direction in pebbles commonly observed  $2\frac{1}{2}$  miles south of Schoemanshoek may therefore indicate proximity to a major E.-W. fault.
3. Semi-indigenous conglomerate with fragments consisting exclusively of pre-Cape grits, phyllites, and slates must be regarded as basal conglomerates overlying the pre-Cape rocks in the same way as the shale conglomerates south of Oudtshoorn are observed to overlie rocks of the Bokkeveld Series.

4. Presence of shale and sandstone fragments resembling material from uppermost T.M.S. or Bokkeveld Series (Spec. 47) in conglomerates south of Schoemanshoek (notably  $2\frac{1}{2}$  miles S. of Schoemanshoek) may indicate that rocks of uppermost T.M.S. or Bokkeveld Series are situated at no great depth. If this is so, rocks of the W.B.S. must still be excluded from the Cretaceous sequence  $2\frac{1}{2}$  miles south of Schoemanshoek and the main fault must lie still further south.
5. Photogeological examination of the area south of the Schoemanshoek fault shows certain features in common with the area to the north where Cape and pre-Cape rocks are exposed.
  - (a) Linear features, oblique to the general E.-W. strike continue unbroken either side of the Schoemanshoek fault.
  - (b) Bold E.-W. trending ridges south of the Schoemanshoek fault follow the same pattern as those to the north following the strike of the pre-Cape formations. These features indicate that Cape and pre-Cape rocks underlie a Cretaceous cover not more than a few hundred feet thick. The photogeological features over northern Enon terrain can be contrasted with the almost featureless terrain where a thickness of the order 12,000 feet of W.B.S. rocks are inferred.
6. East of the main Prince Albert road, the boundary between the rocks of the northern Enon and upper W.B. stages runs straight E.-W. although the topography is sharply undulating and dips are generally less than 30 degrees.

Points which tend to favour the second interpretation are as follows:-

1. A major fault 3 miles south of Schoemanshoek is nowhere observed on the ground but since the junction between northern Enon and W.B. stages is invariably covered by loose gravel, no ground observations can be made.

2. The northern Enon stage is constantly in juxtaposition to the upper W.B.S. and there appears to be no transgression to juxtaposition with the lower W.B.S. or lower stages - this may be true within the 10-mile strip mapped but may not be so further towards De Rust or Calitzdorp - Du Preez (1966) map indicates juxtaposition of the northern Enon stage with the recognised Enon stage near Le Roux and De Rust.
3. A conglomerate is observed in superposition to mudstones and sandstones of upper W.B.S. in lower Doringkloof - as explained above (Section 3) the conglomerate in question is not actually observed to overlie the mudstones and its assignation to the northern Enon stage is very doubtful.
4. The E.-W. junction between northern Enon and upper W.B. stages does not continue west of the main Prince Albert road. There is an embayment in which upper W.B.S. rocks occur up to  $1\frac{3}{4}$  miles north of the supposed fault line - Such embayments to the north of the main Cango Fault line are not unique - there is one between Hoeko and Opsoek in Ladismith District (Seven Weeks Poort).

The points outlined above, in the writer's opinion, favour the first interpretation given in Folder 1.

Exploratory drilling would be necessary to prove which interpretation is correct.

Site 1, if drilled close to the foot of the hills 3 miles south of Schoemanshoek, would be expected to pass through northern Enon stage conglomerates directly into rocks of the Cape System if the first interpretation is correct. The bore-hole may pass through rocks of the upper W.B.S. before the conglomerates of the northern Enon stage are encountered. At site 2 a bore-hole would, if the first interpretation is correct, pass through northern Enon stage conglomerates directly into rocks of the Cape System. If the second interpretation is correct, it would be expected to encounter a great

thickness of mudstones and sandstones of upper W.B.S. below the conglomerates of the northern Enon Stage.

6. Comments on the geophysical interpretations of  
the geological structure

A. Electrical sounding profile (Ref. Van Zyl 1968)

Profile D traverses the area of the present survey from north to south. Station D9 lies about 3000 feet south of the line of the Congo Fault as inferred from interpretation 1 given above. Station D10 lies about 3000 feet to the north. If the apparent thinning of Cretaceous strata at station D9, from resistivity data, could be re-interpreted as due to lateral effects caused by proximity of the inferred Congo Fault, this geophysical interpretation would correspond very well with the preferred geological interpretation - Cretaceous deposits are inferred to be thickest in the vicinity of D. 9. A total thickness of about 800 metres (2500 feet) for the Cretaceous sediments at D. 10 corresponds well with the estimated thickness of at least 2,000 feet for the Enon stage south of Oudtshoorn.

The 95 ohm m layer at D. 10 could correspond to the transported conglomerates of the northern Enon stage while the 25 ohm m layer at D.10 and the 10 ohm m layer at D. 11 could be correlated with the semi-indigenous grit/phyllite conglomerate.

B. Seismic profiles (Ref. Beukes and Hauger 1970)

(a) Refraction profiles

(i) Schoemanshoek profile.-

The preliminary seismic interpretation from refraction shot points at Schoemanshoek (SP1 and SP2 west of Grobbelaars River) shows an interformational boundary at about 500-700 feet depth. (Velocities - upper formation 1200 ft/sec, lower formation 13500 ft/sec). This could correspond to the sub-Cretaceous boundary of the geological interpretation, 0-1200 feet below surface.

The velocity of 13,500 ft/sec appears rather low for T.M.S. or pre-Cape formations. (Velocity 19000 ft/sec. further south where Bokkeveld/T.M.S. boundary is inferred at 5-6000 feet depth) but the lower velocity here may be attributed to fracturing or weathering or both. From the same two shot points, a lower interformational boundary inferred at the order of 2000 feet depth, dipping southwards could correspond to the T.M.S./pre-Cape boundary of the geological interpretation. Weder (personal communication) has suggested from seismic interpretation that the rocks between 700 and 2000 feet depth (vel. 13500 ft/sec) could be Bokkeveld or even lower Cretaceous and that the formation below 2000 feet might be T.M.S. In the geological interpretation it is, however, considered unlikely that either Bokkeveld or lower Cretaceous formations occur between 700 and 2000 feet depth at Schoemanshoek.

(ii) Oudtshoorn-Buffelsdrif profile

North of SP.2, (Buffelsdrif area) the seismic interpretation indicates a boundary between T.M.S. quartzite (Velocity 19000 ft/sec) and younger formations at about 4000 feet depth, sloping gently northwards. The younger formations may or may not include Bokkeveld. Since this boundary, at Schoemanshoek, occurs within 2000 feet of the surface, the existence of a fault is inferred, probably in the blind zone around SP. 2 on the Schoemanshoek profile. The depth of Cretaceous sediments in the Buffelsdrif area from geological interpretation, is estimated considerably more than 4000 feet but as mentioned above this interpretation does not allow for the possibility of strike faulting within the W.B.S. outcrop and the thickness of the W.B.S. may have been overestimated.

At Oudtshoorn and further south, a total depth of Cretaceous sediments of 0-3000 feet corresponds on both seismic and geological interpretations.

A blind zone in the vicinity of SP. 2 renders the seismic interpretation of the area between Oudtshoorn and Buffelsdrif very difficult.

(b) Reflection Profile (Olifants River to Schoemanshoek)

The seismic reflection profile shows a distinct break in a formational boundary at 6000 feet depth (possibly the sub-Cape system boundary) in the vicinity of SP. 28. This could be interpreted as a major fault, north of which the boundary may be raised much nearer to the surface. The position of this seismic break is about 1 mile north of the major fault inferred from geological observations east of Grobbelaars River. If produced westward, however, this break might coincide well with the northern limit of the embayment west of Doringkloof.

A possible alternative interpretation, that the major fault is a reversed fault having northwards at about  $45^{\circ}$  degrees, is considered an unlikely one.

7. Ground water supplies in Oudtshoorn Area

Ground water supplies in the Oudtshoorn area are obtained from or could potentially be obtained from the following sources:-

- (1) Fault zones, particularly, those where brecciated T.M.S. quartzite is found.
- (2) Sandstones of the Cretaceous System.
- (3) Superficial gravels, where they persist to sufficient depth for a substantial body of water to accumulate.

The bore-holes, about which details are known to the writer, are listed in Table 1 and positions shown on Folder 1. The list is probably incomplete but it is believed that all the strong yielding or otherwise successful bore-holes are included.

A. Fault zones

Attention has been concentrated on drilling along the line of the Schoemanshoek fault, hitherto believed to be the main Cango Fault. Along this fault, in places, brecciated quartzite of the T.M.S. is found but in the low ground, where it is practicable

to drill for water, the brecciated quartzite is rarely exposed. Most bore-holes drilled to date, intended to strike thin fault zone (Nos 4, 5, 6, 7, 8, 12, 16, 17, 18, 19, 20, 21, 22, 23) have been unsuccessful or give small yields only. For this reason, 45-degree angle bore-holes G. 23511 and G. 23512 (bore-holes 11 and 10 respectively on Folder 1) were drilled in an attempt to intersect the fault zone at depth. Details of these bore-holes and a vertical bore-hole drilled on the site of G. 23512 are given in a separate report by the writer (1970). The two 45-degree angle bore-holes encountered strongly fractured, but not brecciated, quartzite respectively at 120 feet (85 feet below ground) and 402 feet (284 feet below ground)(Ref. Figure 1.).

The reason that these exploratory bore-holes struck only small yielding supplies of water is probably because they crossed above the main brecciated zone in the overlying conglomerates. (Vertical Bh 23512 missed the brecciated zone altogether). The fact that water struck rises to the surface shows, however, that supplies of water connected to that in the brecciated zone through fractures in the quartzite are artesian and that if the main brecciated zone is struck, a strong artesian flow can be expected. From exposures of the brecciated quartzite in Grobbelaars River and about  $\frac{1}{4}$  mile east of the exploratory bore-hole sites, it appears that the brecciated zone dips almost vertically, and is 50 to 100 feet in width.

Three bore-hole sites were marked along the Schoemanshoek fault (Ref. Fig. 2) and shown to the respective owners.

G. 26285 on west bank of Grobbelaars River ( C.F. Spies and H.O. Schoeman).

G. 26286  $\frac{1}{4}$  mile east of exploratory bore-holes (G. Keyter).

G. 26287 70 feet north of bore-hole G. 23511 (G. Keyter).

At the first two sites, the brecciated rock is exposed but G. 26286 would be difficult accers. At the alternative site G. 26287, it would be necessary to drill through the Cretaceous conglomerate (at least 250 feet, possibly up to 500 feet in thickness) before reaching the brecciated quartzite.

Should site G. 26285 also prove difficult of access, a site G. 26285A could be drilled on J.H. Schoeman's farm by the motor truck on top of the cliffs above the former site.

No bore-holes have been drilled along the boundary between the northern Enon stage and the W.B.S. where the Cango Fault is inferred, in the preferred structural interpretation. Drilling at exploratory bore-hole site 1 may give information on possibilities for obtaining ground water supplies from this zone.

#### B. Sandstones of the Cretaceous System

Most of the relevant information on groundwater supplies from sandstones of the Cretaceous System has been obtained from a local driller, J.R. Hayes of Kandelaars River. Table 1 shows clearly that good yields of slightly brackish water can be obtained by drilling in sandstones of the W.B.S., and in some cases from sandstone bands in the Enon stage and northern Enon stage conglomerates, especially in the basal Enon conglomerate south of Oudtshoorn.

Hayes states that it is important to strike the first strong water supplies in sandstone, where the water is reasonably fresh, since if strong water is struck first in mudstone or in conglomerate, it is generally very brackish. From figures obtained (Table 1), it appears that the first strong water may generally be expected anywhere 60 and 200 feet depth. It is further important, according to Hayes, that once strong water has been encountered in sandstone, to stop drilling as soon as mudstone or conglomerate are encountered underneath since these rocks may also contain strong water would generally be very brackish.

The results of drilling (Table 1) show that yields of water which can be obtained from sandstones is very variable (a few hundred g.p.h. to over 20,000 g.p.h.) and that certain bore-holes (and probably many others in the district not listed in Table 1) drilled through sandstones are unaccountably dry.

The quality of the water, which is usually slightly brackish or sweet to taste, is illustrated for Rooiheuvel Experimental Farm in Table 2. This water is used for irrigation.

Table 2.- Analyses of Water from Bore-holes at Rooiheuvel  
Experimental Farm (Department of Agricultural Technical  
Services)

Bore-hole No.	1	2	3
CHEMICAL ANALYSIS	(72)	(71)	(70)
ph	8.2	8.0	7.5
Conductivity in micro s/cm	3000	2800	2600
T.D.S. at 105°C in mg/L	2215	1975	1785
Total alkalinity as CaCO <sub>3</sub> in mg/l	314	372	500
Calcium hardness as CaCO <sub>3</sub> in mg/l	363	300	212
Magnesium hardness as CaCO <sub>3</sub> in mg/l	365	303	285
Chloride as Cl in mg/l	950	755	670
Fluoride as F in mg/l	0.26	0.31	0.33
Copper as Cu in mg/l	0	0.23	0
Iron as Fe in mg/l	0.1	0.1	0.2
Manganese as Mn in mg/l	0	0.2	0.6
Nitrate as N in mg/l	3.0	3.5	0
Silica as SiO <sub>2</sub> in mg/l	40	45	48
Sodium as Na in mg/l	600	480	450
Sulphate as SO <sub>4</sub> in mg/l	260	250	130
Zinc as Zn in mg/l	0	0	0
Total phosphate as PO <sub>4</sub> in mg/l	0.3	0.8	2.0
Ortho-phosphate as PO <sub>4</sub> in mg/l	0.3	0.8	2.0
Potassium as K in mg/l	12	11	13
Temperature as given on labels in °C	20.0	18.9	19.4
Physical analysis			
Odour and taste	None	None	Strong sulphide odour
Colour in Hazen units	10	10	30
Turbidity in turbidity units	4	8	20

S.A. BUREAU OF STANDARDS  
24th JUNE 1970

C. Superficial Gravels

Small, but reliable fresh water supplies are obtained from superficial gravels, notably at Schoemanshoek. These supplies generally fluctuate with the seasons, yields becoming noticeably lower during long droughts.

In most cases, water from bore-holes drilled in superficial gravels is only fresh where they are close to rivers where fresh water flows regularly, namely, the Grobbelaars River, Klip River, and Kandelaars River. In bore-holes drilled in gravels close to the Olifants River or Lower Kammanassie River, or in places away from the rivers (e.g. Westbank), the water obtained is generally brackish.

8. Recommended drilling programme - Schoemanshoek area

Bore-holes along Schoemanshoek Fault.- (Ref. Fig. 1, Fig. 2 and Section 7A above)

1. Site G26285A is selected as the most suitable site for drilling on the Schoemanshoek Fault, having the advantages of being easy of access and being in close proximity to an exposure of brecciated T.M.S. quartzite, 100 to 200 feet to the east at the foot of the cliffs by the Grobbelaars River.

In the first instance, it would be desirable to drill an inclined bore-hole to test the true dip of the brecciated zone and its persistence in depth. This angle bore-hole should be drilled 100 feet to the north of the site G26285A marked and inclined 75 degrees to the south. From the results of drilling this angle bore-hole, the optimum position for drilling a vertical bore-hole at site G26285A may be determined. The vertical bore-hole can be drilled on the optimum site position, fixed to intersect the brecciated zone at depths of 300-400 feet below river level.

Alternatively, a vertical bore-hole can be drilled in the first instance on site G26285A which is considered to be reasonably close to the optimum position.

2. Site G26286 can be drilled to a depth of 400-500 feet. This bore-hole should pass through brecciated quartzite from the surface to full depth. Its chief disadvantage is difficulty of access. Construction of an access road would be necessary.

3. Should drilling at these sites prove unsuccessful, or should it be required to drill further bore-holes along the Schoemanshoek Fault, a further attempt can be made to locate the brecciated zone, under the Cretaceous conglomerates in lower Blommetjieskloof. To locate the suspected brecciated zone, an inclined hole G26288 is advised, situated due north of G23512, and should be so sited so as to intersect vertical bore-hole G23512 at a depth of 800 feet. (See Fig. 1). It may be necessary to drill this site on the steep hillside to the north of Blommetjieskloof.

Exploratory drilling south of Schoemanshoek, (Folder 1)

The sites (marked 1 and 2 on folder 1) are recommended for testing the geological structural conditions in the area south of Schoemanshoek. (See Section 5C above). Site 2 should be drilled first to test the existence or nonexistence of a platform of Cape System or older rocks underlying the northern Enon stage conglomerates. This site lies to the north of the fault line as inducted both by geological mapping and by seismic (reflection) survey. Information from the bore-hole would be necessary to form a final seismic interpretation of the geological structure, while the optimum position for drilling a second bore-hole is, from geological interpretation, considered to be in the position of Site 1, consideration should be given to the following factors before finally deciding on this site:-

- (i) Results of drilling on Site 2.
- (ii) Final interpretation of seismic results (preliminary interpretation outlined above in Section 6B).
- (iii) Since this exploratory bore-hole would be a deep one, and the results would be of interest to DWA for ground water supplies and to SOEKOR in the interests of oil prospecting, the site selection should be considered jointly between

representatives of these organisations and the Geological Survey. The final selection of the site should be made by Geological Survey.

Geological Survey,  
Pretoria.

January 1971

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G.P.-8.

M.D. 1031.

**GEOLOGIESE OPNAME**  
**GEOFISIESE GEGEWENS BY BOORPLEKKE**

G.—No.

26286

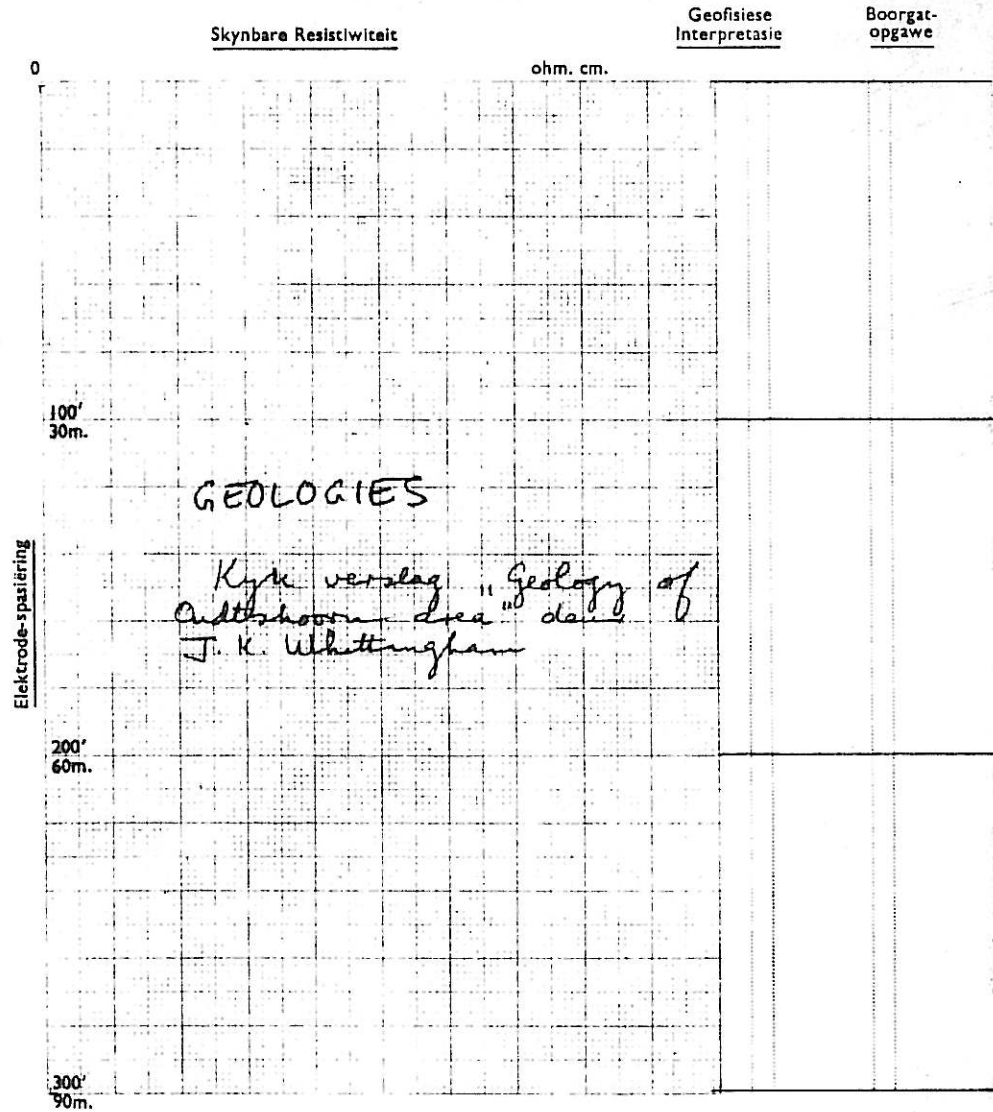
Elenaar G. KEYTER Datum aangewys. 10. 11. 70

Plaas ROODEVAL (SCHOEMANSHOEK) Datum geboor.....

Distrik OUDTSHOORN

Boorgat—No.

**ELEKTRIESE DIEPTEMETING**



Diepte Aanbevel :— 400-500 Vt.

Water

Getref op.....Vt.

Rushoogte.....Vt.

Starkte.....g.p.u.

Resistiwiteit ( $\rho$ ).....ohm. cm.

Geofisiese Waarnemings

Aantal Elektriese Dieptemeting.....

Afstand op konstante diepte gemeet.....

Aantal Magn. waarnemings.....

Lengte Mag. W—lyne.....



G.P.S.

M.D. 1031.

**GEOLOGIESE OPNAME**

**GEOFISIESE GEGEWENS BY BOORPLEKKE**

G.—No.

G.26287

Eienaar G. KEYTER

Datum aangewys 10. 11. 70

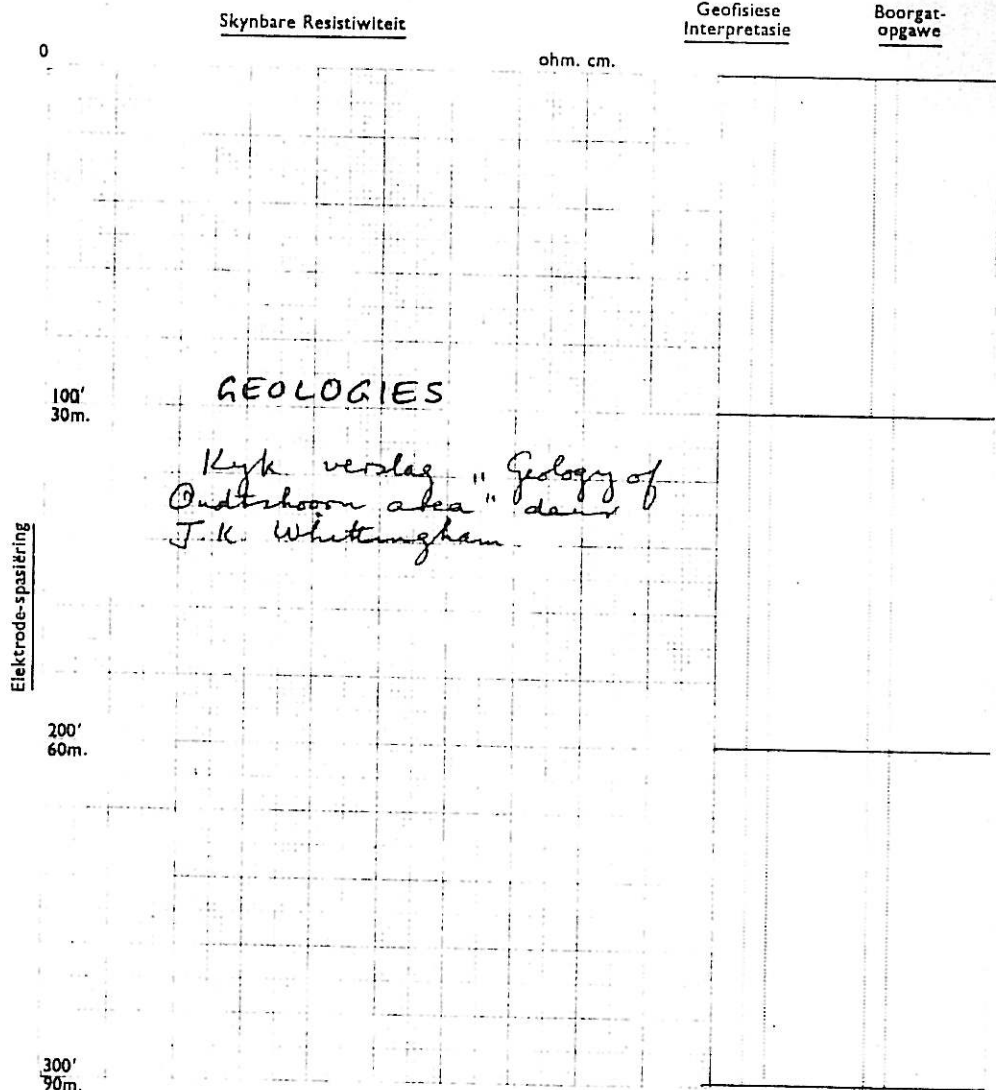
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Plaas ROODEWAL (SCHOEMANSHOEK)

Datum geboor.....

Distrik OUPTS HOORN

**ELEKTRIESE DIEPTEMETING**



Diepte Aanbeveel :— 500 Vt.

Water

Getref op.....Vt.

Rushoogte.....Vt.

Sterkte.....g.p.u.

Resistiwiteit (ρ).....ohm. cm.

Geofisiese Waarnemings

Aantal Elektriese Dieptemeting.....

Afstand op konstante diepte gemeet.....

Aantal Magn. waarnemings.....

Lengte Mag. W—lyne.....

G.P.-S.

M.D. 1031.

**GEOLOGIESE OPNAME**

G.—No.

**GEOFISIENE GEGEWENS BY BOORPLEKKE**

26285

Eienaar C.F. SPIES LHO. SCHOEMAN Datum aangewys 10. 11. 70

Boorgat—No.

Plaas ROODEWAL (SCHOEMANSHOEK) Datum geboor

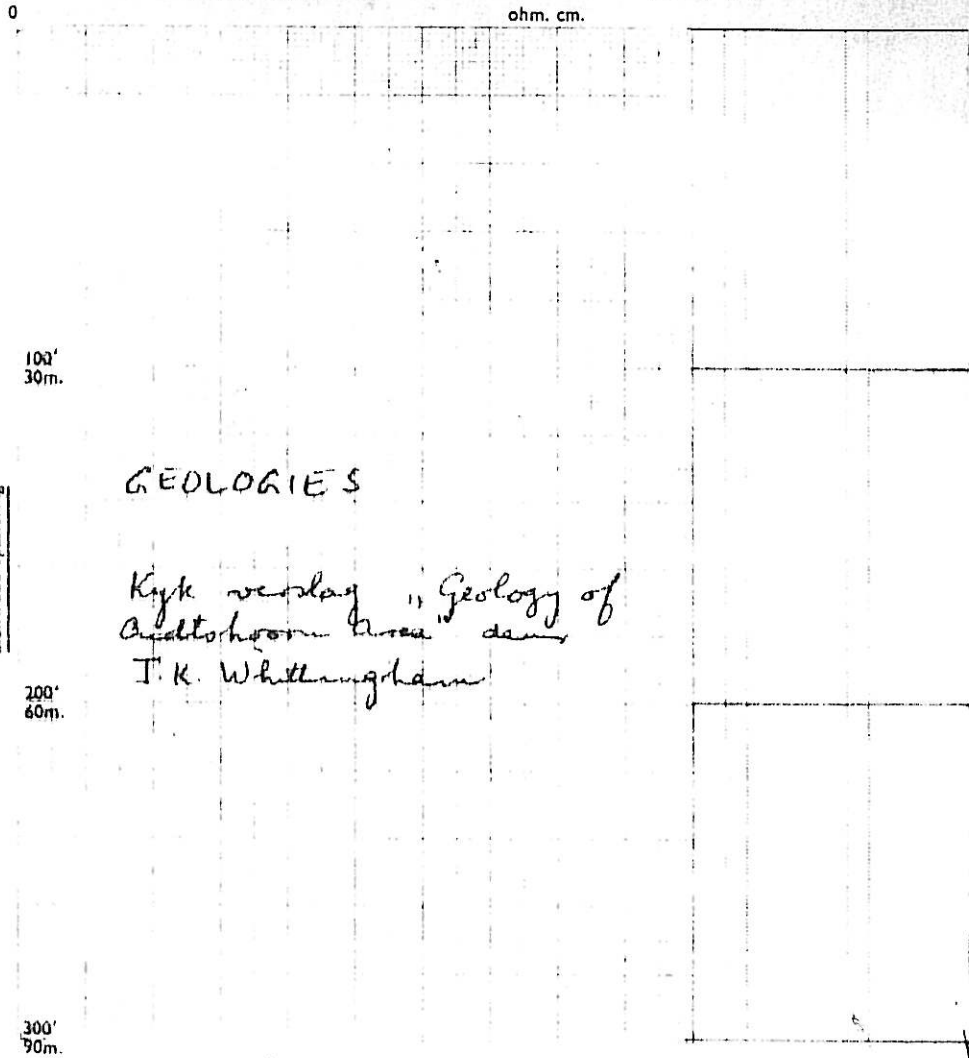
Distrik OUDTSHOORN

**ELEKTRIESE DIEPTEMETING**

Skynbare Resistiwiteit

Geofisiese Interpretasie

Boorgat-opgawe



Diepte Aanbeveel :— 300 / 400 Vt.

Water

**Geofisiese Waarnemings**

Getref op.....Vt.  
 Rushoogte.....Vt.  
 Sterkte.....g.p.u.  
 Resistiwiteit (p).....ohm. cm.

Aantal Elektriese Dieptemetinge.....  
 Afstand op konstante diepte gemeet.....  
 Aantal Magn. waarnemings.....  
 Lengte Mag. W—lyne.....



