T H E R A I N B O W R E E F S
O F T H E
V A N D E N H E E V E R S R U S T A R E A
N O R T H - W E S T O F
O D E N D A A L S R U S

B Y

G.P. VAN DER VYVER.

Presented in Partial Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Science, University of Pretoria, Pretoria.

West Rand Consolidated
Mines, Limited.

January, 1956.

CONTENTS

****

A B S T R A C T

The geological succession in the north-western portion of the Orange Free State Gold-fields, as disclosed by twenty-one bore-holes, is described.

Special attention is paid to the Rainbow Reefs, occurring in the strata between the Lower Division of the Ventersdorp System and zone V.S.5. The reef at, or near, the base of zone V.S.1C is correlated with the Ventersdorp Contact Reef on the Rand and the Orkney Reef in the Klerksdorp area.

Thin sections of the quartzite from all zones between V.S.1A and E.F.1 were examined and microscopic differences were detected, which may be of diagnostic value for correlation purposes.

A stratigraphical break at the base of zone V.S.1C is suggested and substantiated by the evidence obtained from a study of the zircon grains in zones V.S.1A to E.C.1.

****

I. I N T R O D U C T I O N

This paper deals with a narrow strip of ground near the northwestern corner of the Orange Free State Gold-fields, about halfway between Allanridge and Odendaalsrus.

The account given in the following pages is based on the study of bore-hole cores. The bore-holes were drilled during the years 1946 to 1953. Altogether twenty-one bore-holes were drilled in the area to penetrate the quartzites of the Witwatersrand System. In addition to these holes some six bore-holes were drilled down as far as the base of the Karroo System with the object of investigating the Coal Measures.

II. T O P O G R A P H Y

This area, like the Orange Free State Gold-fields in general, is one of low relief. It consists mainly of flat, treeless, sandy, grass-covered veld, underlain by shales of the Karroo System. The elevation ranges from 4,250 feet to 4,350 feet above sea level. A few pans are scattered over the area, which are dry for the greater part of the year.

III. H I S T O R Y

As a result of the encouraging results obtained by other companies, it was decided by General Exploration, Orange Free State, Limited and Middle Witwatersrand, Limited, who acquired the options on this block of ground, to sink jointly a bore-hole with the object of prospecting the area for the economically important Basal Reef of the Upper Division of the Witwatersrand System, which was known to exist farther east.

The first bore-hole, V.D.H.1, was commenced towards the end of 1946 on the farm Van den Heeversrust, 419 near the corner beacon common to Van den Heeversrust, Rosedale, and Spes Bona. (Fig. 1.)

At the time the nearest bore-holes that had encountered the Basal Reef were about two miles away to the east on the Freddies North Lease Area, Limited, and about 2½ miles to the north on Kromdraai 586.

The two nearest bore-holes which did not encounter the Upper Witwatersrand formation were drilled by Witwatersrand Extensions. The closest one, bore-hole W.E.9 on Weltevreden 205, about 1½ miles to the west, was stopped at a depth of 5,560 feet in Ventersdorp Lava. This hole, it might be mentioned here, was deepened during the year 1949. Directly underlying the lava, at a depth of 6,662 feet, followed the normal V.S.1 conglomerate to a depth of 6,714 feet. Below this a greenish-grey quartzite with argillaceous bands was encountered, which is regarded as being the lower portion of the Main-Bird Series. At a depth of 7,853 feet the hole passed into shale and argillaceous quartzite of the Upper part of the Jeppestown Series, in which it was finally stopped at a depth of 8,102 feet.

The other negative bore-hole, W.E.2, drilled in the vicinity is about three miles to the west of bore-hole V.D.H.1 on the farm Dammetjie 247. This hole was reported to have been stopped at a depth of 2,625 feet in shales of the Lower Division of the Witwatersrand System. This core is unfortunately not available for inspection but it is doubted whether the Lower Witwatersrand beds could have been encountered at such a shallow depth. It is therefore probable that the hole was stopped in black, contorted, tuffaceous shale of the Upper Division of the Ventersdorp System, which often closely resembles the shale of the Lower Division of the Witwatersrand System.

IV. GEOLOGY

A. GENERAL.

Almost the entire area is covered by Dwyka and Ecca beds of the Karroo System, between 400 and 600 feet thick. Towards the northeast the Karroo beds thin out and on Bandon 634 an inlier of Upper Ventersdorp beds outcrops, forming a low ridge.

A few dolerite dykes cut across the area, but are almost invariably deeply weathered and covered by a thick overburden. These dykes give rise to magnetic anomalies by means of which they were traced. (Fig. 2.)

Below the cover of Karroo beds bore-holes penetrated the Ventersdorp and Witwatersrand Systems. None of these holes went down deep enough to penetrate the Pre-Witwatersrand formations. The closest bore-holes drilled in the vicinity that penetrated Pre-Witwatersrand formations are between five to ten miles to the southwest. Two of these holes, namely, J.K.1 on Jakhalspan 820 and M.R.1 on Merino 714, penetrated highly altered rock types, considered by the writer to be acid lavas of Dominion Reef age. Bore-hole P.L.K.1 on Palmietkuil 176 was stopped in Archaean Granite. Bore-hole M.N.1 on Modderfontein 343 is described by Feringa (1954, page) to have been stopped in Archaean Granite. According to Dr. N.R. Schindler (verbal communication), however, who examined thin sections of this rock, the grains of the constituent minerals exhibit a certain amount of abrasion, suggesting a sedimentary origin. It is, therefore, in all probability an arkose of Upper Ventersdorp age, very similar to that encountered in borehole E.W.1 on Erfdeel 657. (Fig. 1.)

B. DESCRIPTION OF FORMATIONS.

(i). The Karroo System:

As previously mentioned the thickness of the Karroo System varies from 400 feet to 600 feet and it is represented by the Lower part of the Ecca and the Dwyka Series.

The Ecca Series consists predominantly of dark, micaceous, bluish-black, fissile shale, often with a distinct banded appearance due to rapidly alternating, more arenaceous, lighter grey bands and less arenaceous, darker grey bands. The upper 60 feet to 120 feet are usually weathered to a soft, friable, yellowish, khaki-coloured rock. Near the base of the Series there is a medium-grained, light-grey sandstone band with two coal seams; the one at the top of the sandstone is overlain by dark shale and is in places up to 20 feet thick. This upper coal seam is economically of greater importance than the lower seam, which rests directly on the Dwyka Tillite and seldom exceeds three feet in thickness.

The Dwyka Series varies from a few feet to about 50 feet in thickness, and consists predominantly of tillite with occasional thin intercalated mudstone bands. The tillite has mostly a purplish-brown, sandy matrix through which are scattered large boulders, rounded and angular pebbles, and small fragments of a great variety of rocks.

(ii). The Ventersdorp System:

(a). The Upper Division.

Within the Ventersdorp System, in the Orange Free State Gold-fields area, there is a major unconformity. This fact was clearly observed and established during the period when several hundreds of bore-holes were drilled. It is therefore recommended that the Ventersdorp System be sub-divided into an Upper Division and a Lower Division.

The Upper Division consists of several flows of fine-grained, greenish-grey, amygdaloidal and non-amygdaloidal, andesitic lava, separated by interbedded layers of conglomerate and/or quartzite and/or tuffaceous shale, in other words, the lava flows alternate with sediments which can consist either of a single layer of conglomerate, quartzite or tuffaceous shale, or alternating bands of two or all three of the members can be encountered. It is not possible to establish whether the epoch of formation of the Upper Division was initiated by an age of sedimentation or of volcanic activity. It is equally impossible to resolve by which one of the two ages the epoch was terminated - due to the diversity of bore-hole information.

The thickness of the various bands may vary from a couple of feet to several hundreds or thousands of feet.

This system was found to rest unconformably on older formations.

(b). The Lower Division.

This Division consists of greenish-grey, fine-, and medium-grained, amygdaloidal and non-amygdaloidal, andesitic lava. As distinct from the Upper Division this Division is characterised by the complete absence of intercalated sedimentary layers; otherwise, it is almost impossible to differentiate between lava of this Division and the lava of the Upper Division. From the numerous bore-hole cores investigated it was noticed that the large, irregular amygdales, measuring more than one inch across, as well as the reddish jaspery amygdales are characteristic of the lava of the Upper Division. But, as can be expected of a lava, all sorts of irregularities and abnormalities can occur and this criterion is by no means infallible. A purplish-brown lava, known as the Purple Marker, occurs in the lava of the Lower Division about 200 feet from its base. This Purple Marker is roughly 10 to 20 feet thick and has small, scattered amygdales, which are round, less than $\frac{1}{8}$ inch across and filled with chlorite. Unfortunately this marker cannot always be recognised in the core; or alternatively it might be absent in some sections.

The lava of the Lower Division has so far been found, without a single exception, to overlie conformably the sediments occupying the V.S.1 zone and it appears that there has been no time-lag between the deposition of the V.S.1 sediments and the subsequent effusion of the lower lava. These two groups of rocks must therefore belong to the same system, This will be discussed later in greater detail.

Below the lower lava follow the sediments of the Upper Division of the Witwatersrand System, which were originally sub-divided into zones by Borchers and White (1943). This classification is still the recognised classification on most of the mines in the Orange Free State and will therefore be adhered to in this paper. Owing, however, to a change of facies of the sediments, general thickening of strata with the introduction of coarser material and conglomerate bands, as can be expected near the margin of a geosyncline, several sub-divisions of the existing classification had to be introduced. This paper deals only with the strata down to zone V.S.5. The various zones below the V.S.5 zone in this area are very similar to the zones in the central area of the Orange Free State Gold-fields, and have been described so admirably by Borchers and White (1943 pp. 139-141) that descriptions will not be repeated here.

The following is a detailed description of the strata between the lower lava and the V.S.5 zone; the strata in which the Rainbow Reefs occur. The various zones and their sub-divisions compared with the classification by Borchers and White are tabulated below:-

<u>Borchers and White</u>.	<u>V.D.H. Area</u>.
V.S.1	V.S.1A V.S.1B L.AG. V.S.1C
V.S.2 V.S.3. V.S.3A V.S.4	V.S.2-4 Upper Beds V.S.2-4 Middle Beds V.S.2-4 Lower Beds
V.S.5	V.S.5

(iii). <u>Zone V.S.1A</u>.

This zone consists of a very characteristic, dark greenish, poorly sorted, large pebble conglomerate. The variegated pebbles and boulders are usually fairly well rounded, and vary in size from small fragments to boulders over seven inches in diameter. The pebbles and boulders consist of a great variety of rocks of which the most common types are in approximate order of abundance:-

1. Dark green and yellow shales
2. White quartz.
3. Black and grey cherts.
4. Acid lavas.
5. Red jaspers.

It may be of interest to mention here that the uppermost 50 to 100 feet of the conglomerate is usually very dark owing to the preponderance of dark green shale pebbles. The presence of scattered, bright red jasper pebbles in the upper portion is also remarkable. The lower half of the conglomerate is lighter in colour owing to the predominance of yellow shale and white quartz pebbles. Red jasper in the lower portion of the conglomerate is very sparsely distributed and is more often totally absent.

Thin bands of dark greenish-grey, impure quartzite, intercalated in the conglomerate, are nearly always present. These quartzite bands seldom exceed 10 feet in thickness; are usually very coarse-grained and consist, like the conglomerate, of variegated fragments of a great variety of rocks.

The pebbles of igneous rock present in the conglomerate are mostly derived from acid lavas of the type encountered in bore-holes J.K.1 and M.R.1 to the west of the area (Fig. 1.). The presence of these acid lavas in the V.S.1 conglomerate thus suggests that the sedimentary material was derived from the west. Another deduction that can be made from the presence of these lava pebbles in the V.S.1A conglomerate, is that the acid lavas encountered to the west in bore-holes M.R.1 and J.K.1 are of Pre-Witwatersrand age and most probably belong to the Dominion Reef System.

On the whole the V.S.1A conglomerate is poorly mineralised, although a concentration of sulphides without gold is present in some places. At or very close to the base of the conglomerate is a section more or less 24 inches wide which is sometimes auriferous. This auriferous horizon is indistinguishable from the rest of the conglomerate; the pebbles are variegated, the matrix is impure and hardly better mineralised than any section of the conglomerate.

This is the first of the series of auriferous reefs between the lower lava and the V.S.5 zone, which are collectively known as the Rainbow Reefs. The writer prefers the term 'Rainbow Reefs' as the term 'Van den Heeversrust' appears to be too localised. Moreover, although the first bore-hole that intersected the Rainbow Reefs was sited on Van den Heeversrust, a very small proportion of these reefs are actually present on this farm. To call the reefs 'Upper Reefs' might lead to confusion, especially when mining operations are commenced.

The name 'Rainbow Reefs' was initially given to the auriferous conglomerates with the variegated pebbles.

It should, however, be noted that the coloured pebbles are present only in zone V.S.1A and zone L.AG.

The other reefs usually consist of clean quartz and chert conglomerates. A few assay values of the auriferous V.S.1A reef are given below:-

Bore-hole	Dwt./Ton	Width Inches	Inch Dwt.
Rosedale 2	34.5	24	828
V.D.H.1	14.8	24	355
T.V.3	5.13	24	123
Spes Bona 2	2.0	48	96

(iv). Zone V.S.1B.

This is a relatively thin but fairly persistent zone. It consists predominantly of a clean, light grey, sub-glassy quartzite. It may be fairly coarse-grained in places and two or more, often auriferous, quartz-chert conglomerate bands may occur. In some places this zone has at its top, or at its base, or both at the top and the base, a band of coarse, impure, greenish quartzite, similar to the quartzite bands intercalated in the V.S.1A conglomerate.

The auriferous conglomerate bands of which there are two, are almost invariably confined to the clean, light grey, sub-glassy quartzite. Assay values of interest obtained from this zone are as follows:-

UPPER BAND

Bore-hole	Dwt./Ton	Width	Inch Dwt.	Position
Rosedale 2	27.3	12"	327.6	5"-17" from top
Rosedale 1	3.8	10"	38.0	30"-40" from top
Spes Bona 3	1.4	20"	28.0	20"-40" from top

LOWER BAND

Bore-hole	Dwt./Ton	Width	Inch Dwt.	Position
Rosedale 1	18.7	24"	488.8	24'-26' from base
	11.7	123"	1439.1	
T.V.3	2.1	15"	31.5	3'8"-4'11" from base
K.1	3.1	12"	37.2	32' 32' from base
	2.5	12"	30.0	19' 19' from base
	23.7	24"	568.8	14' from base

(v). Zone L.AG.

This zone, the symbol of which means Lower Agglomerate, consists, in its normal development, of two variegated-pebble conglomerate bands separated by impure, dark grey quartzite. In very exceptional cases a thin

Dolerite Dykes in the van den Heeversrust Area as traced by means of Magnetometer Traverses.

Scale 1:10,000.

Fig 2.

FIG. 3.

DETAILED BOREHOLE SECTIONS SHOWING THE CLASSIFICATION AND CORRELATION OF THE "VS" SEDIMENTS IN THE VAN DEN HEEVERS RUST AREA.

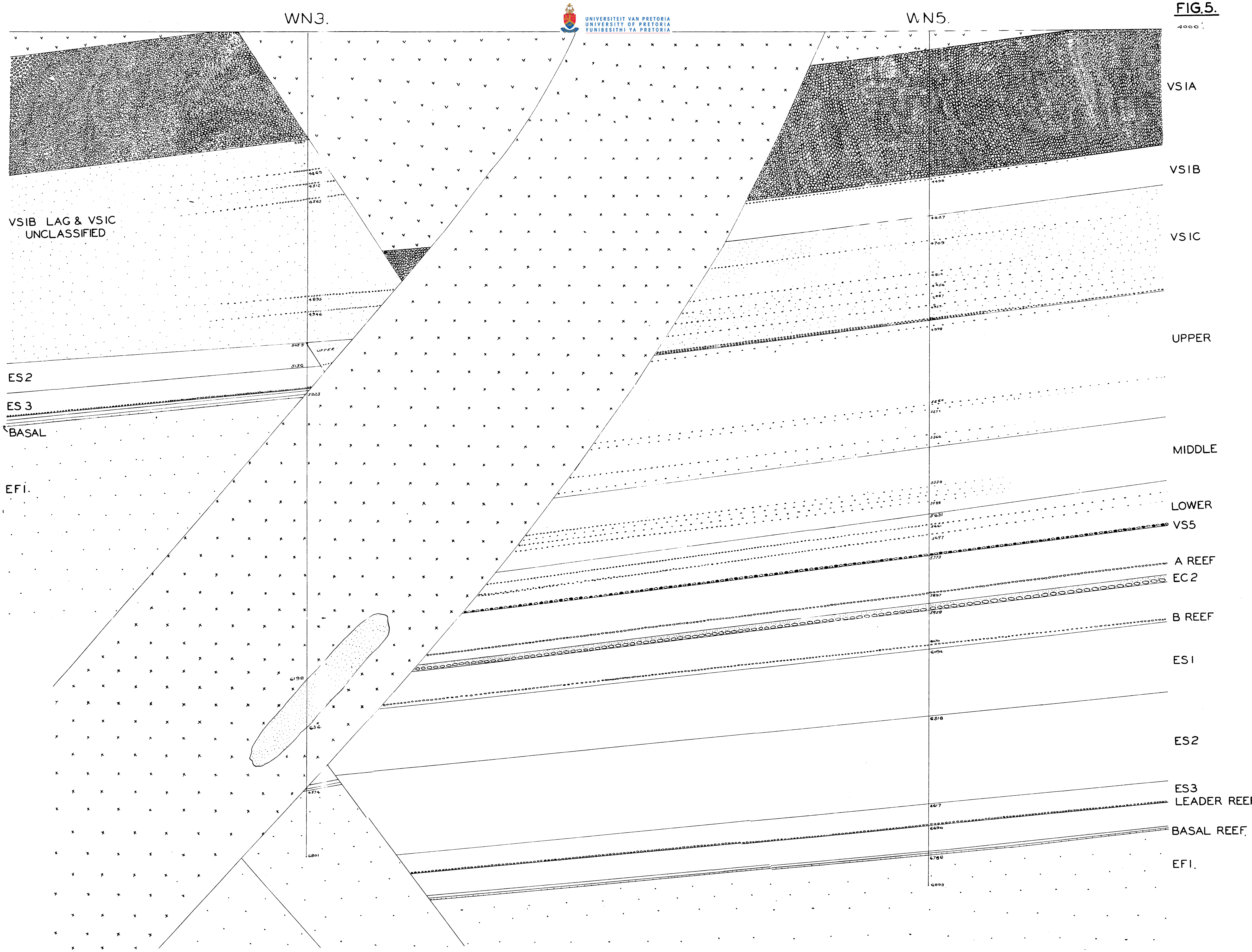
VERTICAL SCALE 1:1000.

FIG.4.

LOCATION OF BOREHOLES AND ESTIMATED EXTENT OF THE RAINBOW REEFS IN THE VAN DEN HEEVERSRUST AREA.

SCALE 1:10,000.

FIG.5.

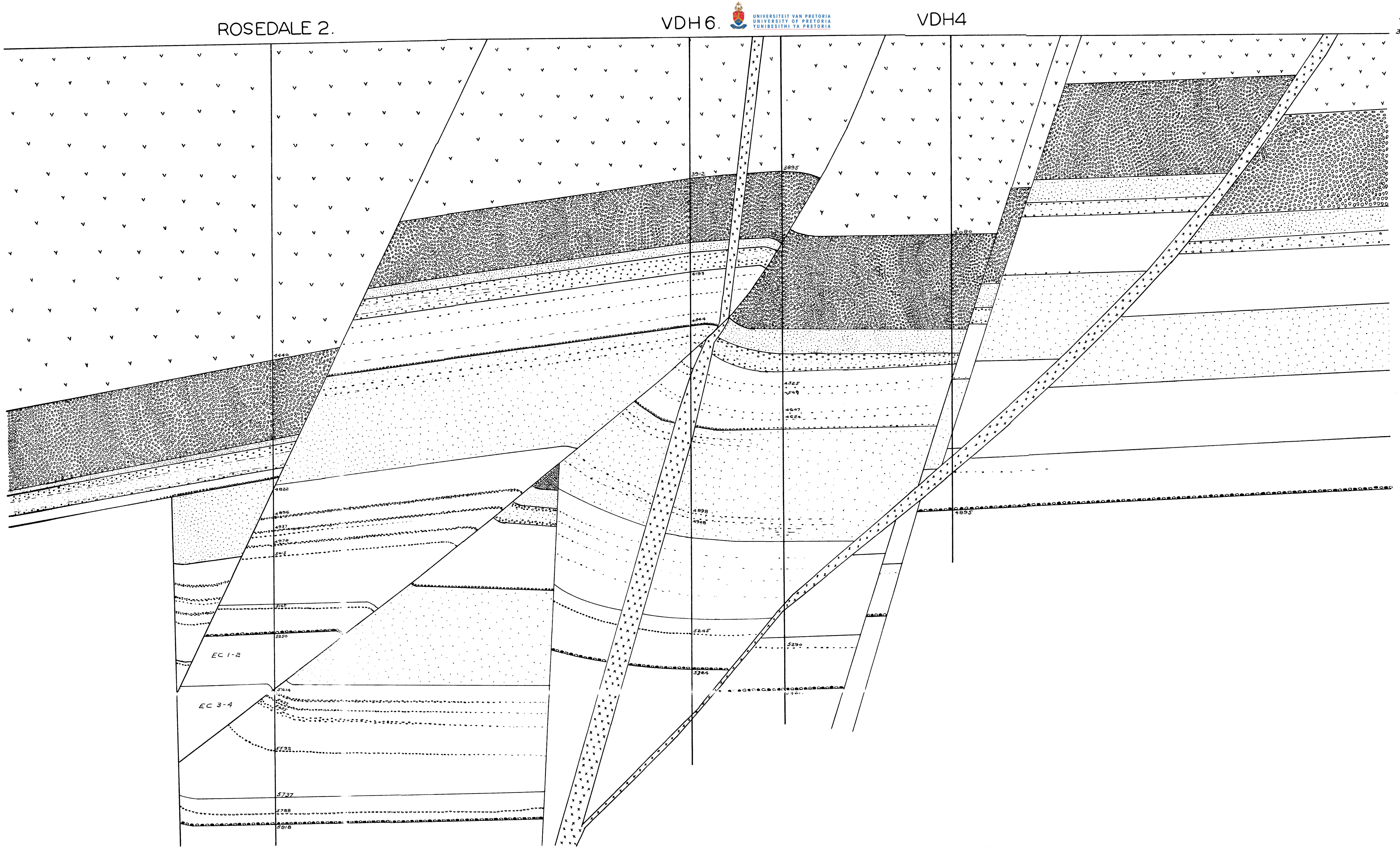


IDEALISED SECTION BETWEEN BOREHOLES

WN3 AND WN5.

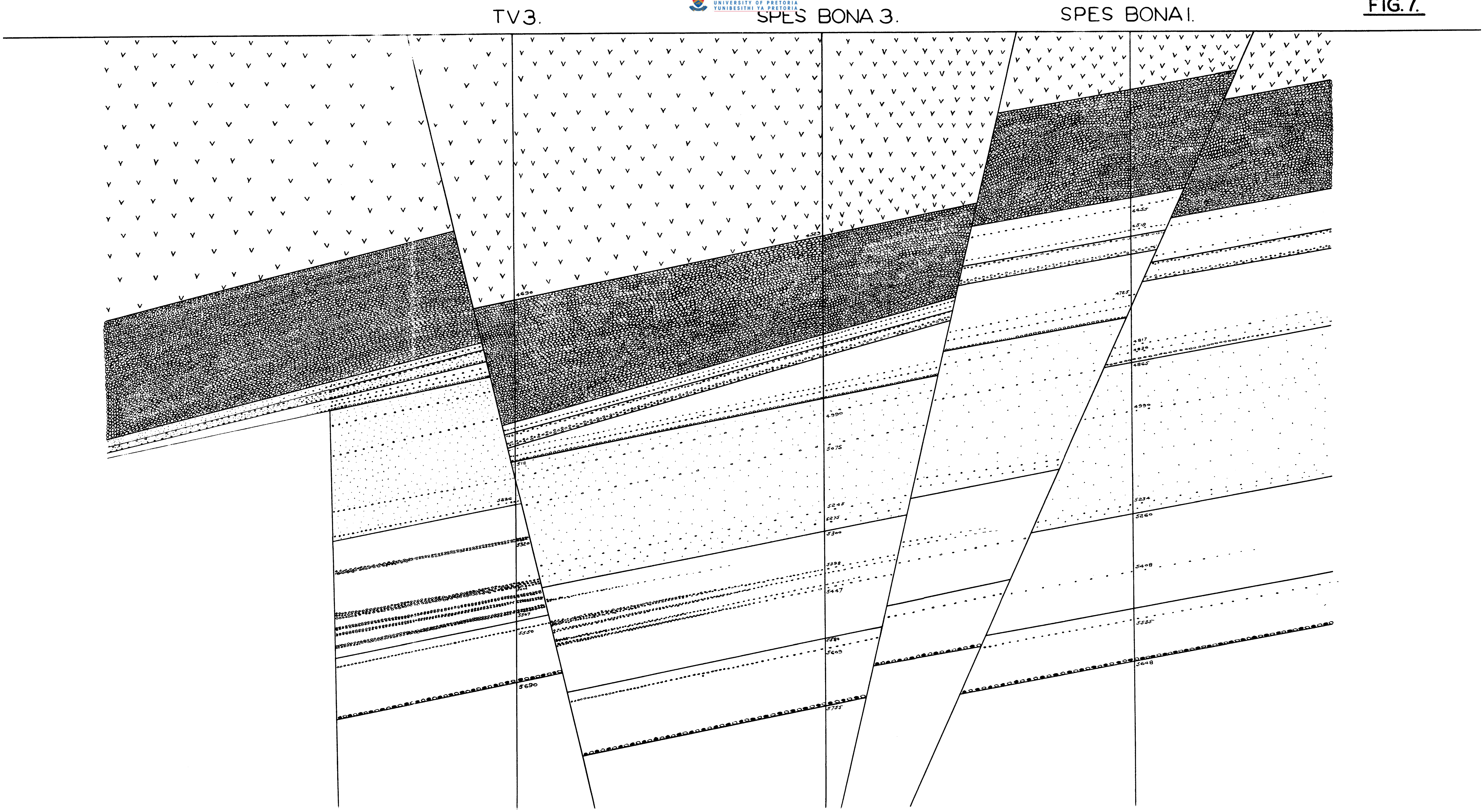
SCALE: 1:2000.

FIG. 6.



IDEALISED SECTION BETWEEN BOREHOLES
ROSEDALE 2 AND VDH4.
SCALE :- 1: 2000

FIG. 7.



IDEALISED SECTION BETWEEN BOREHOLES
T.V. 3 AND SPES BONA 1.

SCALE :- 1: 2,000.

TABLE 8.

BORE-HOLE.	THIN SECTION Nº.	ZONE	QUARTZ GRAIN SIZES. MINIMUM GRAIN SIZE	AVERAGE GRAIN SIZE	MAXIMUM GRAIN SIZE	UNEVEN GRAINED.	SHAPE OF QUARTZ GRAINS ANGULAR.	SUB-ROUNDED.	ROUNDED.	EXTINCTI… QUARTZ G… NORMAL	UNDULOSE.	…F …AINS IN QUARTZ GRAINS	QUARTZ GRAINS	INTERLOCKING GRAINS	GRAINS RIMMED.	GRAINS SCATTERED	MATRIX SERICITIC	CHLORITIC	SILICEOUS	CLAYEY.	OTTRELITE	SERICITE CLUSTERS.	ACCESSORY MINERALS RUTILE ALLOGENIC	RUTILE AUTHIGENIC	ZIRCON RARE	ZIRCON ABUNDANT	TITANITE RARE	TITANITE ABUNDANT.
T.V.3.	83	V.S.1A.	0·14	0·28	0·62	—	—	x	—	—	x	x	—	—	—	x	x	x	—	x	—	—	—	x	x	—	x	—
S.B.3.	186	V.S.1A	0·15	0·30	0·65	—	—	x	—	—	x	x	—	—	—	x	x	x	—	x	—	—	—	x	x	—	x	—
S.B.1	215	V.S.1A.	0·14	0·25	0·65	—	—	x	—	—	x	x	—	—	—	x	x	x	—	x	—	—	—	x	x	—	x	—
T.V.2.	158	V.S.1A	0·16	0·28	0·62	—	—	x	—	—	x	x	—	—	—	x	x	x	—	x	—	—	—	x	x	—	x	—
T.V.3.	87	V.S.1B	0·11	0·21	0·35	—	—	x	—	—	x	x	—	x	—	—	x	—	x	—	x	—	x	x	x	—	x	—
S.B.3.	187	V.S.1B	0·15	0·25	0·35	—	—	x	—	—	x	x	—	—	x	—	x	—	x	—	x	—	—	x	x	—	x	—
S.B.1.	218	V.S.1B	0·11	0·25	0·35	—	—	x	—	—	x	x	—	—	x	—	x	—	—	x	x	—	—	x	x	—	x	—
T.V.2.	159	V.S.1B	0·11	0·21	0·35	—	—	x	—	—	x	x	—	x	—	—	x	—	—	x	—	—	—	x	x	—	x	—
T.V.3.	89	L.AG	0·07	0·35	0·49	—	—	x	—	—	x	x	—	—	x	—	x	—	—	—	x	—	—	x	x	—	x	—
S.B.3.	188	L.AG	0·07	0·40	0·50	—	—	x	—	—	x	x	—	—	—	x	—	—	—	x	x	—	—	x	x	—	x	—
S.B.1.	219	L.AG	0·09	0·35	0·45	—	—	x	—	—	x	x	—	—	—	x	—	—	—	x	x	—	—	x	x	—	x	—
T.V.2.	160	L.AG	0·07	0·35	0·49	—	—	x	—	—	x	x	—	—	—	x	—	—	—	x	—	—	—	x	x	—	x	—
T.V.3.	90	V.S.1C	0·10	0·42	0·77	x	—	x	—	—	x	x	x	—	—	x	—	—	—	x	—	—	—	x	x	—	x	—
S.B.3.	189	V.S.1C	0·10	0·44	0·80	x	—	x	—	—	x	x	—	x	—	—	x	—	—	—	—	x	—	x	x	—	x	—
S.B.3.	190	V.S.1C	0·14	0·45	0·75	x	—	x	—	—	x	x	—	—	—	x	—	—	—	x	—	x	—	x	x	—	x	—
S.B.1.	221	V.S.1C	0·13	0·42	0·77	x	—	x	—	—	x	x	—	x	—	—	x	—	—	—	—	—	—	—	x	—	x	—
S.B.1.	220	V.S.1C	0·10	0·44	0·77	x	—	x	—	—	x	x	—	—	—	x	—	—	—	x	—	—	—	—	x	—	—	x
T.V.3.	91	VS2·4Up	0·07	0·42	0·70	x	—	x	—	—	x	x	x	—	x	—	x	—	x	—	—	—	x	x	x	—	—	x
S.B.3.	223	VS2·4Up	0·07	0·45	0·70	x	—	x	—	—	x	x	x	x	—	—	x	—	x	—	—	x	x	—	x	—	—	x
S.B.1.	191	VS2·4Up	0·07	0·47	0·75	x	—	x	—	—	x	x	—	x	—	—	x	—	x	—	—	x	x	x	x	—	x	—
T.V.2.	161	VS2·4Up	0·06	0·42	0·70	x	—	x	—	—	x	x	—	—	x	—	x	—	x	—	—	x	x	x	x	—	x	—
R.D.2.	129	VS2·4Up	0·07	0·45	0·70	x	—	x	—	—	x	x	x	—	x	—	x	—	x	—	—	x	x	x	x	—	x	—
T.V.3.	94	VS2·4Mid	0·21	0·28	0·38	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
S.B.3.	193	VS2·4Mid	0·22	0·28	0·38	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
S.B.1.	226	VS2·4Mid	0·25	0·28	0·38	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
T.V.2.	167	VS2·4Mid	0·22	0·28	0·38	—	x	—	—	—	x	x	—	x	—	—	x	—	—	—	—	x	x	x	x	—	x	—
R.D.2.	131	VS2·4Mid	0·21	0·28	0·38	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
T.V.3.	99	VS2·4Low	0·07	0·28	0·35	x	x	—	—	—	x	x	x	x	—	—	x	—	x	—	—	x	—	x	x	—	x	—
S.B.3.	198	VS2·4Low	0·07	0·28	0·35	x	x	—	—	—	x	x	x	x	—	—	x	—	x	—	—	x	—	x	x	—	x	—
S.B.1.	228	VS2·4Low	0·09	0·28	0·35	x	x	—	—	—	x	x	x	x	—	—	x	—	x	—	—	—	—	x	x	—	x	—
T.V.2.	174	VS2·4Low	0·10	0·28	0·40	x	x	—	—	—	x	x	x	x	—	—	x	—	x	—	—	x	—	x	x	—	x	—
T.V.3.	104	E.C.1.	0·10	0·35	0·56	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
S.B.3.	201	E.C.1	0·10	0·34	0·55	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
S.B.1.	230	E.C.1	0·09	0·35	0·57	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
T.V.2.	176	E.C.1	0·14	0·40	0·55	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
R.D.2.	141	E.C.1.	0·10	0·33	0·56	—	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	x	x	x	x	—	x	—
T.V.3.	105	E.C.2	0·11	0·24	0·35	—	—	x	—	—	x	x	x	x	—	—	x	—	—	—	—	x	x	x	x	—	x	—
S.B.3.	202	E.C.2	0·11	0·25	0·36	—	—	x	—	—	x	x	x	x	—	—	x	—	—	—	—	x	x	x	x	—	x	—
S.B.1.	232	E.C.2	0·11	0·25	0·35	—	—	x	—	—	x	x	x	x	—	—	x	—	—	—	—	x	x	x	x	—	x	—
R.D.2.	142	E.C.2	0·11	0·25	0·35	—	—	x	—	—	x	x	x	x	—	—	x	—	—	—	—	x	x	x	x	—	x	—
T.V.3.	106	E.C.3-4.	0·07	0·35	0·70	x	x	—	—	—	x	x	x	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
S.B.1.	234	E.C.3-4.	0·07	0·36	0·75	x	x	—	—	—	x	x	x	—	—	x	x	—	—	—	x	—	x	x	x	—	x	—
T.V.2.	179	E.C.3-4.	0·07	0·36	0·75	x	x	—	—	—	x	x	x	—	—	x	x	—	—	—	x	—	x	x	x	—	x	—
R.D.2.	152	E.C.3-4	0·07	0·36	0·75	x	x	—	—	—	x	x	x	—	—	x	x	—	—	—	x	—	x	x	x	—	x	—
T.V.3.	107	E.S.1.	0·03	0·07	0·10	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	x	—	x	x	x	—	x	—
S.B.1.	235	E.S.1.	0·03	0·07	0·10	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	x	—	x	x	x	—	x	—
T.V.2.	180	E.S.1.	0·03	0·07	0·10	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
R.D.2.	154	E.S.1.	0·03	0·07	0·10	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	—	—	x	x	x	—	x	—
T.V.3.	108	E.S.2.	0·11	0·42	0·98	x	x	—	—	—	x	x	x	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
S.B.3.	207	E.S.2	0·11	0·44	0·89	x	x	—	—	—	x	x	x	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
S.B.1.	236	E.S.2	0·11	0·50	0·95	x	x	—	—	—	x	x	x	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
T.V.2.	181	E.S.2	0·11	0·45	0·94	x	x	—	—	—	x	x	x	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
R.D.2.	156	E.S.2	0·11	0·44	0·98	x	x	—	—	—	x	x	x	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
S.B.3.	209	E.S.3.	0·11	0·20	0·28	—	—	x	—	—	x	x	—	x	—	—	x	—	x	x	—	—	—	x	x	—	x	—
S.B.3.	208	E.S.3	0·11	0·28	0·63	—	—	x	—	—	x	x	—	—	—	x	x	—	x	x	—	—	—	x	x	—	x	—
S.B.1.	239	E.S.3.	0·11	0·25	0·35	—	—	x	—	—	x	x	—	—	—	x	x	—	x	x	—	—	—	x	x	—	x	—
S.B.1	238	E.S.3.	0·11	0·25	0·55	—	—	x	—	—	x	x	—	—	—	x	x	—	x	x	x	—	—	x	x	—	x	—
S.B.3.	210	E.L.1.	0·14	0·21	0·35	—	—	—	x	—	x	x	x	x	—	—	x	—	x	—	—	x	x	x	x	—	x	—
S.B.1.	240	E.L.1	0·11	0·25	0·40	—	—	—	x	—	x	x	x	x	—	—	x	—	x	—	—	x	x	x	x	—	x	—
T.V.2.	182	E.L.1	0·14	0·22	0·35	—	—	—	x	—	x	x	—	x	—	—	x	—	x	—	—	x	x	x	x	—	x	—
T.V.3.	109	E.L.2.	0·02	0·04	0·06	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	x	—	—	x	x	—	x	—
S.B.3.	211	E.L.2	0·02	0·04	0·06	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	—	—	—	x	x	—	x	—
S.B.1.	241	E.L.2.	0·02	0·04	0·10	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	x	—	—	x	x	—	x	—
T.V.2.	183	E.L.2.	0·02	0·04	0·04	—	x	—	—	—	x	x	—	—	—	x	x	—	—	—	—	—	—	x	x	—	x	—
S.B.3.	212	E.L.3	0·11	0·25	0·40	—	—	x	—	—	x	x	x	x	—	—	x	—	x	—	—	x	—	—	x	—	x	—
S.B.1.	242	E.L.3.	0·11	0·25	0·50	—	—	x	—	—	x	x	x	x	—	—	x	—	x	—	—	x	—	—	x	—	x	—
T.V.3	110	E.F.1.	0·14	0·49	0·84	x	—	x	—	—	x	x	—	x	—	—	x	—	x	—	—	—	—	x	x	—	x	—
S.B.3	213	E.F.1.	0·14	0·49	0·84	x	—	x	—	—	x	x	—	x	—	—	x	—	x	—	—	—	—	x	x	—	x	—
S.B.1	243	E.F.1.	0·14	0·50	0·85	x	—	x	—	—	x	x	—	x	—	—	x	—	x	—	—	—	—	x	x	—	x	—

MICROSCOPIC DATA OF QUARTZITES OF ZONES V.S.1A TO E.F.1.

light grey quartzite, interbedded in the dark grey quartzite, is also present. The two conglomerate bands are very similar and cannot usually be differentiated. In some places the intervening quartzite is altogether absent and then this zone consists of a single conglomerate layer. The pebbles, like the V.S.1A conglomerate, consist of a great variety of rocks and the only difference between the V.S.1A conglomerate and the conglomerates of this zone is that the pebbles of the latter seldom exceed one inch or 1½ inches in diameter and also include a larger number of quartz and chert pebbles. In this zone values of interest have again been obtained at two horizons, one at the top and one near the base, as follows:-

Bore-hole	Dwt./Ton	Width	Horizon
E.R.K.1	9.7	17.5"	At top
Rosedale 1	1.5	33"	At top
T.V.3	(4.1 (5.2	24" 48"	8' Above base At base
Spes Bona 3	2.8	12"	At base
V.D.H.4	2.5	12"	Near base
Spes Bona 1	1.8	24"	Near Base.

(vi) Zone V.S.1C.

Reference to the bore-hole sections in Fig.3 will immediately disclose that this zone is, as far as thickness is concerned, very variable and may, over short distances, vary in thickness from a few feet to several humdreds of feet. The general tendency is, however, for this zone to increase in thickness towards the east.

This zone consists of rapidly alternating bands of a very dark grey, impure quartzite and clean, light grey, glassy quartzite. A great number of compact conglomerate bands are present, occurring in both the glassy and the dark, impure quartzite. Contrary to the conglomerate bands encountered above, these bands are usually well mineralised; the pebbles are well rounded, well sorted, and consist only of quartz and chert. Low gold values are often obtained in some of these conglomerate bands. At the base, or very close to the base of this zone, occurs a clean quartz-chert conglomerate band with consistently good gold values. This reef also appears to have a very wide distribution, and the writer is of the opinion that stratigraphically this reef occupies the same horizon as the Ventersdorp Contact Reef. This will be discussed in greater detail later on.

(vii). Zone V.S.2-4, Upper Beds.

The change from zone V.S.1C to this zone is very abrupt. There is also a marked change in the physical character of the sediments, suggesting that a break or interruption in the course of sedimentation has occurred. This zone is characterised by a very uniform, clean, light grey, glassy quartzite. It contains here and there a few grit and poorly developed pebble bands, particularly near the base. No values of interest have been encountered, with the single exception of a value of 4.9 dwt. gold over 12 inches in bore-hole V.D.H.1.

(viii). Zone V.S.2-4, Middle Beds.

As far as the Rainbow Reefs are concerned, this zone is the most important economically. Near the middle of this zone occurs one or more wide, heavily mineralised quartz-chert conglomerate bands, often with very high gold content. The quartzite of this zone is characterised by its distinct argillaceous nature and yellowish colour due to the presence of a high percentage of sericite. The quartzite is easily distinguishable from the overlying, clean, glassy quartzite of zone V.S.2-4 Upper, although in some bore-holes the argillaceous nature of the quartzite is confined only to thin bands and partings within a sugary type of quartzite. Roughly, in the middle of this zone occurs a clean, rather highly siliceous quartzite horizon containing the auriferous conglomerate bands. Payable values have been intersected in the following bore-holes:-

Bore-hole	Gold/Dwt./Ton	Width
T.V.2	5.1	31"
	3.9	24"
T.V.3	4.2	47"
	1.0	60"
	7.8	125"
	15.4	65"
	57.2	72"
	0.3	14"
	5.7	83"
Rosedale 2	3.3	60"
	0.4	76"
	3.6	24"
	0.2	39"
	0.2	41"
V.D.H.1	12.2	144"
	13.5	108"
	5.0	48"
	4.8	144"
	6.4	48"

(ix). Zone V.S.2-4, Lower Beds.

This zone consists throughout of a fairly clean siliceous quartzite and commonly possesses a fine, saccharoidal texture and shows cross-bedding. The change from the Middle to the Lower Beds can always be discerned without any difficulty and is much more apparent than the change from the Upper to the Middle Beds. At the base, or very close to the base of this zone, occurs a characteristic, highly speckled, dark, sub-glassy quartzite, which might in the future, during mining operations, prove to be of great use as a marker. This speckled quartzite bed is from 25 feet to 35 feet thick and closely resembles the immediate foot-wall quartzite of the Basal Reef. The specks consist largely of elongated green and yellow chert fragments. Near the top of this zone and about 100 to 120 feet above zone V.S.5, occurs a persistent, compact, moderately mineralised small-pebble conglomerate band, about two feet thick. This reef is widely distributed over more or less the entire area, but intersections giving payable values are limited to the following bore-holes:-

Bore-hole	Gold/Dwt./Ton	Width
T.V.2	{ 103.9	39"
Duplication	{ 26.1	23"
E.R.K.1	22.7	44.3"
Rosedale 2	6.4	46"

(x). Zone V.S.5.

This relatively narrow zone is very persistent, with a wide distribution, not only in the Van den Heeversrust area, but all over the Orange Free State Gold-fields. In the Van den Heeversrust area, in particular, it usually consists of a variegated-pebble conglomerate. The pebbles are fairly well rounded, mostly less than two inches in diameter and consist of quartz, black, grey and yellow chert and yellowish shale. This conglomerate cannot be compared with the conglomerate of zone V.S.1A. It bears much more resemblance, however, to the mixed-pebble conglomerate of zones E.C.1 to E.C.4 encountered lower down in the succession, from which it was most probably derived during the period of denudation which gave rise to the unconformity between the sediments of zones E.C.1 and V.S.5. In some bore-holes, T.V.3 for instance, the conglomerate of zone V.S.5 is seen to consist of clean quartz and chert without coloured pebbles, but this can be expected of a basal conglomerate, depending on the source from which the material was derived. Sporadic low gold values have been encountered in this zone, the highest being 4.4 dwt. per ton over 24 inches in bore-hole T.V.3.

V. GENERAL STRUCTURAL FEATURES OF THE AREA

Both Borchers (1950) and Feringa (1954) have dealt extensively with the geological structure and history of faulting of the Orange Free State Gold-fields as a whole, but have referred only briefly to the Van den Heeversrust area. The writer will therefore confine himself to a more comprehensive account of the Van den Heeversrust area in particular.

The Rainbow Reefs are known to exist only in the Van den Heeversrust area and therefore have a very limited distribution. From bore-hole information it was possible, to some extent, to demarcate the limits of these important reefs. They occur in a narrow strip of ground trending northsouth from bore-hole K.1 on Kromdraai 586 in the north to bore-hole E.R.K.1 on Enerie 896 in the south, a distance of some 25,000 feet. On the west these reefs are abruptly terminated by a large fault, striking roughly northsouth, with an estimated downthrow on the east of between 2,000 feet and 8,000 feet. This fault will hereafter be referred to as the Weltevreden fault. The eastern pay-limit of the reefs is not straight, but is a more or less sinuous line (Fig.4). The position of the Weltevreden fault is generally regarded as the western edge of the Witwatersrand basin, but originally the edge of the basin must have been a considerable distance to the west of this fault, because the gold and sedimentary material of the Rainbow Reefs is considered to have been introduced from the west and was derived from the denudation of existing high-lying Upper Witwatersrand Sediments. The Witwatersrand beds have repeatedly been subjected to intense compressional and tensional forces, which have produced both reverse and normal faulting. The majority of faults in the area have a northsouth strike, suggesting that the forces must have been in an eastwest direction.

Nearly all the faults are younger than the Lower Division of the Ventersdorp System, because the lower lava has also been affected by the faults, but the Weltevreden fault is younger than the E.C.1 beds and older than the Ventersdorp System, because all bore-holes drilled to the west of this fault penetrated the V.S.1 sediments and then passed into different horizons of the foot-wall quartzite below the Basal Reef, depending upon the amount of erosion that had taken place. It is also believed that movement on the Weltevreden fault occurred gradually and during the period of deposition of the V.S.2-4 sediments. Owing to this gradual subsidence of the ground on the eastern side of the fault, the resulting high Witwatersrand beds on the western side were eroded rapidly and transported by torrential streams. The material was reworked by wave action and the gold derived from the A, B and Basal Reefs was redeposited with the coarser, heavier pebbles to form the Rainbow Reefs. It is also quite possible that there might still be areas of Basal Reef to the west of the Weltevreden fault which have not been eroded. This is probably the case in the vicinity of the bore-hole W.N.3. (Fig. 5.)

In general, folding in the Witwatersrand beds in the Orange Free State is of a mild nature, but it appears to be more intense in the Van den Heeversrust area near the Weltevreden fault. It is due to a big anticlinal fold that the strata in the Van den Heeversrust area dip to the west at approximately 15°. Over the major part of the Orange Free State Gold-fields the dip of the strata along the western edge of the geosyncline is to the east.

Many conflicting views are still held with regard to the origin and mode of deposition of the Rainbow Reefs. Some are of the opinion that the Rainbow Reefs are channel deposits, but this does not appear to fit the observed facts. It is more likely, as already described, that they have been deposited normally from material derived from the rapid erosion of a belt of high-lying ground situated on the western margin of the area and trending northsouth. An important characteristic of the conglomerates is the contrast between their great vertical distribution and very limited extent, particularly in an eastwest direction, that is, normal to the postulated Weltevreden fault. Three idealised sections across the area at right angles to the strike were drawn from bore-hole information. (Figs. 5,6 and 7.) These sections also serve to illustrate the fact that the thick Rainbow Reefs thin out rapidly towards the east, become very attenuated with a low gold content and eventually peter out altogether. Taking the Weltevreden fault to be 1,000 feet west of, and parallel to, a line joining bore-holes V.D.H.1 and K.1 and assuming that the average eastern pay-limit of the Rainbow Reefs is a straight line 500 feet east of the Weltevreden fault and also assuming an average dip of the strata of 15°, the payable tonnage of Rainbow Reefs available is estimated to be as follows:-

ZONE	DIP $\frac{1}{4}$ FMS.	S.W.*	TONS	% PAY	TONS
V.S.1A	24877.51	x 36"=	8,955,900	50	4,477,950
V.S.1B	"	x 30"=	7,463,250	25	1,865,810
V.S.1C	"	x 30"=	7,463,250	80	5,970,600
V.S.2-4 Middle	"	x 60"=	14,926,500	80	11,941,200
V.S.2-4 Lower	"	x 36"=	8,955,900	80	7,164,720
			47,764,800		31,420,280

(* S.W. = Stoping Width.)

VI. UNCONFORMITIES

It is often very difficult to detect unconformities. or to differentiate between faults and unconformities. In bore-hole cores it is even more difficult and more often than not one cannot justifiably be specific. It is, therefore, with a certain amount of hesitation that the writer wishes to propose that either the Lower Ventersdorp lava be included in the Upper Division of the Witwatersrand System, or alternatively the sediments below the Lower Ventersdorp lava down to the base of zone V.S.1C be included in the Lower Division of the Ventersdorp System. The sediments below the lower lava, as far down as the base of zone V.S.1C would, therefore, be correlated with the horizons occupying the Ventersdorp Contact Reef on the Rand and the Orkney Reefs in the Klerksdorp area.

In the Van den Heeversrust area the first major unconformity encountered, in descending order, is the break between the Karroo formation and the older formations, which were eroded to a peneplain prior to the deposition of the Karroo sediments.

The Transvaal System is absent in the Odendaalsrus area and the Karroo reposes on Pre-Transvaal formations, for example, the Upper Division of the Ventersdorp System, Lower Division of the Ventersdorp System and Witwatersrand

System. The writer is, however, not aware of any place in the vicinity of Odendaalsrus where the Karroo formation directly overlies Archaean Granite.

The second major unconformity is the one between the Upper Division and the Lower Division of the Ventersdorp System. The Upper Division is seen, as already mentioned, to rest on any older formation including the Archaean Granite. The Upper Division has also one, two or more sedimentary horizons intercalated in the lava, which are never found in the lower lava. The writer suggests that this Upper Division alone be regarded as the Ventersdorp System. Bore-hole information from all over the Orange Free State Gold-fields proves that there is no stratigraphical break between the lower volcanic beds and the sediments of the V.S.1A zone. Wherever the lower lava was penetrated in a bore-hole the V.S.1A conglomerate horizon was, without a single exception, encountered directly underlying the lava. Borchers (1950 page 82) also states:- "The Ventersdorp Lower Lava is seen to rest with regional conformity on the Upper Witwatersrand.", and on page 92 he states:- "The Ventersdorp Lavas, poured out over these flat lying beds, terminated the great period of sedimentation". Having now established that there is no break between the lower lava and the sediments of the zone V.S.1A, we proceed lower down the stratigraphical succession and find that the sediments of zone V.S.1A rest unconformably on various older formations, for example, in bore-holes W.E.9, G.G.1, T.H.1 and L.F.1. Frost, McIntyre, Papenfus and Weiss state (1946 page 13) "All the holes penetrated a massive Ventersdorp basal conglomerate. The Theronia and La France holes then passed through an unconformity into quartzite which was correlated as either Lower Witwatersrand or possibly Prairie".

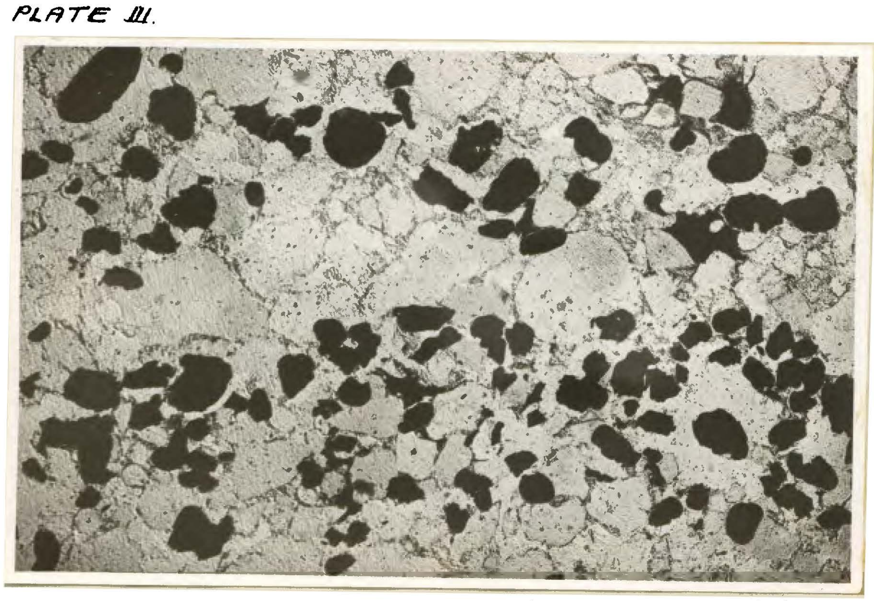
PLATE I.

Photomicrograph of quartzite showing laths of ottrelite. Crossed nicols; X 100.

PLATE II.

Photomicrograph of quartzite showing sub-rounded quartz grains, rimmed with sericite. Crossed nicols; X 100.

PLATE III.



Photomicrograph of quartzite showing thin layer of sub-rounded heavy minerals. Ordinary light; X 40.

The zones V.S.1B, L.AG. and V.S.1C may be very thin and have the same lithological characters as zone V.S.1A. They are considered to be locally developed phases near the margin of the geosyncline and may be absent. The stratigraphical break occurs, therefore, at the base of zone V.S.1A, or if the other zones have developed, at the base of zone V.S.1C. Should this break be a marginal unconformity as postulated by Borchers (1950 page 92), then it is suggested that the lower lava be included in the Upper Division of the Witwatersrand System. Otherwise, the strata from zone V.S.1C upwards should be correlated with the Ventersdorp System.

Lower down in the sedimentary succession the next unconformity encountered is at the base of the conglomerate of zone V.S.5, which demonstrates a less pronounced, but extensive effect. The unconformities encountered still lower down in the succession are beyond the scope of this investigation and will not be dealt with.

VII. MICROSCOPIC STUDY

Thin sections of quartzite from all the zones in the succession as far down as zone E.F.1 were prepared and investigated; the primary object being to detect microscopic differences, which might be of diagnostic value. A certain amount of success has been achieved. It was observed that the mineral ottrelite, for instance, is confined to specific horizons and might be useful as an index-mineral. Other differences, such as, a clayey matrix, angular quartz grains, and quartz grains with a blue colour may also be of assistance in differentiating between the different horizons. The results obtained are summarised in Table 8. Table 9 is an extract of Table 8

PLATE IV.

Photomicrograph of quartzite showing inter, locking quartz grains. Crossed nicols. X 100.

PLATE V.

Photomicrograph of quartzite showing rounded quartz grain replaced by sericite. X100.

PLATE VI.

Photomicrograph of quartzite showing scattered angular quartz grains in sericite matrix. X 100.

showing only data of correlative value.

A large percentage of the quartz grains in all the horizons show undulose or wavy extinction under crossed nicols, due to strain. Practically all the quartz grains have minute colourless inclusions, which appear to be gaseous or air-filled chambers.

From, and including the zone V.S.2-4, Upper Beds downwards, with the possible exception of zones E.S.2, E.L.2 and E.F.1, some of the grains are blue or have mottled blue areas. The cause of this has not been established. The quartz grains vary in size from 0.10 millimeter to 0.98 millimeter and are fairly well graded or sorted except for zones V.S.1C, V.S.2-4 Upper, V.S.2-4 Lower, E.C.3-4 and E.F.1.

The quartz grains usually exhibit some degree of abrasion or are, as a rule, fairly well rounded, but in zones V.S.2-4, Middle Beds, V.S.2-4, Lower Beds, E.C.1 and E.C.3-4 the grains are remarkably angular and it strengthens the impression that they have been extensively corroded. These angular grains usually occur widely scattered in a mass of sericite. Chloritic material is fairly common in zone V.S.1A, but altogether absent in all the other zones. The rocks comprising zones V.S.1A, V.S.1B, L.AG. and V.S.1C are characterised by a dark clayey matrix. In all the other zones the matrix is constituted mainly of minute flakes of mica. The siliceous or glassy quartzite bands are seen to consist of mutually interfering or interlocking quartz grains without any discernable matrix (Plate 1V). In some places each individual quartz grain is rimmed with a thin film of sericite (Plate II The sericite in the matrix of zone V.S.2-4, Upper Beds, to zone E.C.2 occurs in radiating clusters or spheres and appears to be an alteration product of pre-existing minerals.

Accessory minerals, such as, rutile, zircon and titanite are nearly always present. Of these, authigenic rutile in minute acicular crystals, frequently showing geniculate twinning, is by far the most common. The pink, yellow and colourless zircons are invariably of allogenic origin. The grains are usually rounded and have often been noticed to be concentrated in thin layers, together with globular pyrite, magnetite, ilmenite and other heavy minerals.

VIII. H E A V Y   M I N E R A L   A N A L Y S E S

(a). TECHNIQUE.

In order to obtain a greater degree of clarity regarding the correlation of the Rainbow Reefs, heavy mineral analyses were performed on samples of quartzite from the various zones occurring between the Lower Ventersdorp Lava and zone E.C.1.

About 18 inches of split, size B standard core, of each zone intersected by bore-hole T.V.3, was crushed to pass through a 200 mesh Tyler screen. The dust was then removed by washing and decanting. After drying, the samples were passed through a Franz isodynamic separator. The magnetic portions were discarded and the heavy minerals were separated by means of bromoform. The concentrates were then treated with nitric acid in order to remove the abundant iron pyrites. The remaining portions of the heavy residues were mounted in canada balsam for microscopic examination. This heavy mineral investigation was confined to the grains of zircon, which are not in any way affected by the acid.

With the aid of a mechanical stage fitted to the microscope table, 150 zircon grains were examined in each concentrate. Grains were examined along traverses equally spaced in such a way as to cover the complete field of the mount. This regular spacing was found necessary by Koen, who states (1955 page 20):- "When a heavy crop is mounted in canada balsam it can often be observed that the differently shaped grains tend to segregate when the cover glass is pressed into position".

In this investigation the length and breadth ~~was~~ were measured of each grain examined, and in addition special attention was paid to the zoning, the shape and the colour of the grains. The results are summarised in the following table. The values are presented on the basis, zircon = 1,000.

SMPL No.	ZONE	ZONING		SHAPE			COLOUR		DEPTH IN BH.
		Zoned	Un-Zoned	Rounded	Ang-ular	Idio-mor-phic	Colour less	Pinkish Purple	
1.	VS1A	476	524	856	100	44	412	588	4940'
2.	VS1B	196	804	868	124	8	264	736	5023'
3.	L.AG	72	928	788	196	16	488	512	5066'
4.	VS1C	120	880	900	56	44	604	396	5084'
5.	VS2-4 Upper	448	772	840	112	48	528	472	5136'
6.	VS2-4 Mid.	212	788	796	148	56	280	720	5267'
7.	VS2-4 Lower	200	800	888	96	16	248	752	5598'
8.	EC1	280	720	684	264	52	436	564	5700'

T A B L E "A"

(b). <u>ZONING OF ZIRCON CRYSTALS</u>.

From the above table "A" it will be noticed that in all the stratigraphical zones there is a distinct preponderance of unzoned grains in relation to zoned ones, except in zone V.S.1A where very nearly half of the grains are zoned. With depth there is a general quantitative decrease of zoned grains, except between zones V.S.1C and V.S.2-4, Upper Beds, where a rapid increase suggests a probable break in sedimentation. (Fig.10)

There are three distinct types of zoning in the zircon grains.

(i) <u>Geometrically perfect type</u>:- The traces of the zones are arranged parallel to the original crystal faces.

(ii) <u>Ellipsoidal type</u>:- The zones are ellipsoidal in outline.

(iii) <u>Irregular type</u>:- The zones are irregular and assymmetrical in outline.

The grains are usually perfectly zoned throughout, but some have only a zoned core, whereas others again exhibit peripheral zoning.

Table "B" gives an indication of the quantitative relation between the various types of zoning encountered. The number of zircon grains counted per sample has in each case been recalculated to a thousand. (See page 26.)

(c). <u>COLOUR OF ZIRCON GRAINS</u>.

The colour of the zircon grains in the mounts examined vary from colourless, through pale yellow and pale pink to purplish pink. Difficulty was experienced in classifying the pale yellow and pale pink grains. Also the boundary between colourless and pale yellow grains is often very dubious. It was therefore decided to resort to two main sub-divisions, namely, colourless and pink.

Sample No.	Zone	Geometrically Perfectly Zoned	Ellipsoidally Zoned	Irregularly Zoned	Zoned Throughout	Central part of grains Unzoned	Zoned Core Only
1.	V.S.1a	347	149	4	276	220	4
2.	V.S.1B	490	10	0	69	431	0
3.	L.AG.	263	237	0	447	53	0
4.	V.S.1C	400	100	0	233	267	0
5.	V.S.2-4 Upper	454	13	38	155	340	0
6.	V.S.2-4 Middle	368	132	0	198	302	0
7.	V.S.2-4 Lower	479	21	0	156	344	0
8.	E.C.1	432	43	29	281	215	0

T A B L E "B"

Pale yellow grains were classified as colourless and pinkish-yellow grains as pink.

From Fig.10 can be deduced that there is a general tendency of the colourless grains to increase, quantitatively with depth, attaining a peak at zone V.S.1C, below which there is again a quantitative decrease of the colourless grains, thus, strongly suggesting a stratigraphical break at the base of zone V.S.1C.

(d). SHAPE OF ZIRCON GRAINS.

In this study the grains are subdivided into the following three categories:-

(i) Rounded: All the grains that are rounded or even show the slightest sign of attrition are included in this group. Very few of the grains are spherical. Oval shaped grains are fairly common, but the majority possess recognisable crystal forms; only the protruding crystal edges are lightly abraded. This group greatly predominates over the other two subdivisions, and attains a peak of 90% in zone V.S.1C. However, no quantitative variation with depth is discernable from the shape of the zircon grains and the break between zones V.S.1C and V.S.2-4, Upper Beds, is not apparent (Fig.10).

(ii) Angular: The great majority of angular grains probably represent idiomorphic or rounded grains fractured during the disaggregation of the samples. No diagnostic value can, therefore, be attached to the relative abundance of these grains.

(iii) Idiomorphic: Perfectly shaped idiomorphic grains are very rare. The frequency fluctuates from 8 grains per 1,000 zircons in zone V.S.1B to 56 grains in zone V.S.2-4, Middle Beds. The zircons with euhedral development are usually prismatic crystals, terminating in bipyramids.

The breadth and length of 150 unfractured zircon grains were measured in each heavy concentrate and the results plotted on the diagrams designed by Smithson (1939, pp.351-353), (Figs.11-18). In addition elongation-frequency curves were drawn for comparison (Figs.19-26). The results obtained are summarised in the following Table:-

Sample No.	Zone	Bore-hole Depth	Median Grain Size in Millimeters	Median Elongation
1.	VS1A	4940'	0.09 x 0.06	1.5
2.	VS1B	5023'	0.14 x 0.08	1.7
3.	L AG	5066'	0.09 x 0.06	1.5
4.	VS1C	5084'	0.07 x 0.05	1.4
5.	VS2-4 Upper	5136'	0.13 x 0.07	1.9
6.	VS2-4 Middle	5267'	0.10 x 0.06	1.7
7.	VS2-4 Lower	5598'	0.13 x 0.09	1.4
8.	EC1	5700'	0.16 x 0.10	1.6

It is evident from this table that there is not much variation between the various heavy concentrates and therefore does not provide a means for proof of an unconformity.

(e). <u>CONCLUSION</u>.

This heavy mineral analysis was conducted, primarily, to establish the suspected stratigraphical break at the base of zone V.S.1C. Although it can not be claimed that the analysis is a comprehensive one, it is felt that this point is successfully proved.

A C K N O W L E D G E M E N T S

The writer wishes to express his sincere thanks to Drs. D.J.L. Visser and G.M. Koen of the Department of Geology, University of Pretoria, under whose guidance this work was carried out. His thanks are also due to the management of General Exploration Orange Free State, Limited and Middle Witwatersrand, Limited for permission to incorporate this information in a thesis.

A special word of thanks is due to members of the Geological Department, West Rand Consolidated Mines, Limited for their valuable assistance.

R E F E R E N C E S

BORCHERS, R, 1950. The Odendaalsrus-Virginia Gold-field and its Relation to the Witwatersrand.

BORCHERS, R., WHITE, C.V., 1943. Preliminary Contribution to the Geology of the Odendaalsrus Gold-field. Trans., Geol. Soc. South Africa, Vol. XLVI.

FERINGA, G., 1954. The North-Western Free State Gold-field.

KOEN, G.M., 1955. Heavy minerals as an aid to the correlation of sediments of the Karroo System in the northern part of the Union of South Africa. Trans., Geol. Soc. South Africa, Vol. LVIII.

FROST, A., MCINTYRE, R.C., PAPENFUS, EDW.B., and WEISS, O., /1946. The discovery and prospecting of a potential Gold-field near Odendaalsrus in the Orange Free State, Union of South Africa. Trans., Geol. Soc. South Africa, Vol. XLIX.

BAINES, VIVIAN, 1949. The Geology of the Odendaalsrus Gold-field in Relation to that of the Klerksdorp District, and Notes on the Correlation of the Upper Division of the Witwatersrand System. Trans., Geol. Soc. South Africa, Vol. LII.

BEETZ, P.F.W., 1936. Contributions to the Geol. of the Klerksdorp District from the Results of the Drilling Activities by the Western Reef Exploration and Development Co., Limited. Trans., Geol. Soc. South Africa, Vol. XXXIX.

SMITHSON, F., 1939. Statistical Methods in Sedimentary Petrology. Geol. Mag., Vol.76, Part I, pp. 297-309; Part II, pp. 348-360; Part III, pp. 417-427.

COETZEE, C.B., 1941. The Petrology of the Goodhouse Pella area, Namaqualand, South Africa. Trans., Geol. Soc. South Africa, Vo. XLIV, pp. 167-206.

DE KOCK, W.P., 1948. The Carbon Leader of the Far West Rand with Special Reference to the Proportion of the Gold Content of this Horizon Recovered in Drilling.

DANA E.S. A Textbook of Mineralogy. John Wiley & Sons, Inc., New York.

TWENHOFEL, W.H., 1939. Principles of Sedimentation. McGraw-Hill Book Co., Inc., New York.

MILNER, H.B., 1952. Sedimentary Petrography. Thomas Murby & Co., London.

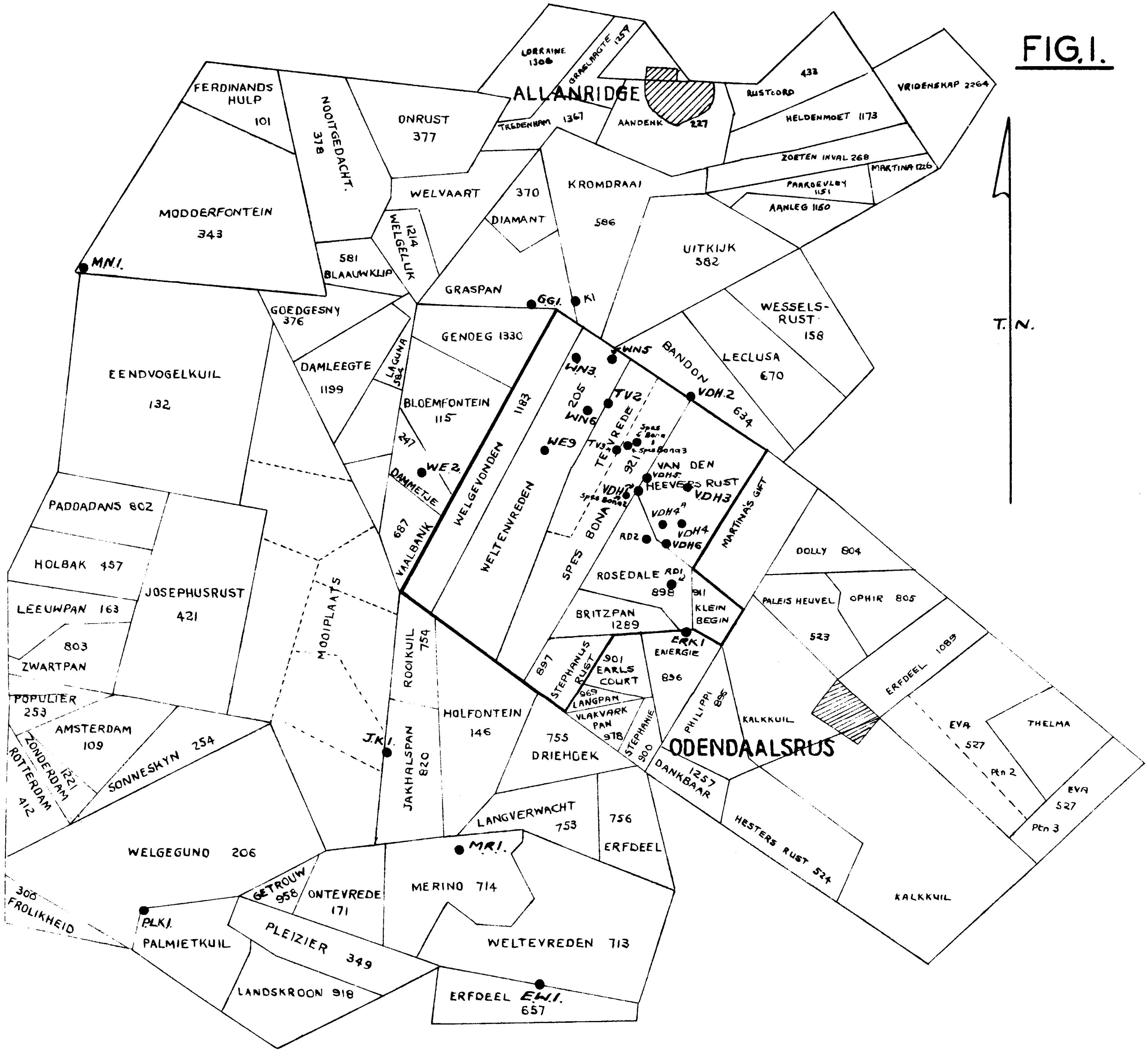
****

TABLE 9.

ZONE	MATRIX				CONFIGURATION OF QUARTZ GRAINS			OTTRELITE	SERICITE CLUSTERS.	BLUISH QUARTZ GRAINS.	CORRODED ANGULAR QUARTZ GRAINS.
	CHLOR-ITIC.	SERICI-TIC.	CLAYEY	SILICE-OUS	INTER-LOCKED	RIMMED WITH SERICITE	SCAT-TERED				
V.S 1 A	x		x								
V.S 1 B						x		x			
L. AG.			x				x	x			
V.S 1 C.			x						x		
VS2-4 Up Beds						x			x	x	
VS2-4, Mid Beds							x		x	x	x
VS2-4, Low Beds					x				x	x	
EC 1							x		x	x	x
EC 2					x				x	x	
EC 3-4							x	x		x	
ES 1							x	x			
ES 2			x				x			x	
ES 3							x		x		
EL 1					x				x	x	
EL 2							x	x			
EL 3					x				x	x	
EF 1					x						

EXTRACT FROM TABLE 8 SHOWING SUCH DATA AS MAY BE OF CORRELATIVE VALUE.

FIG. I.



BORE-HOLES DRILLED IN THE VAN DEN HEEVERSRUST AREA.

SCALE 1:100,000.

QUANTITATIVE VARIATION OF ZONED, COLOURLESS AND ROUNDED ZIRCON GRAINS WITH DEPTH.

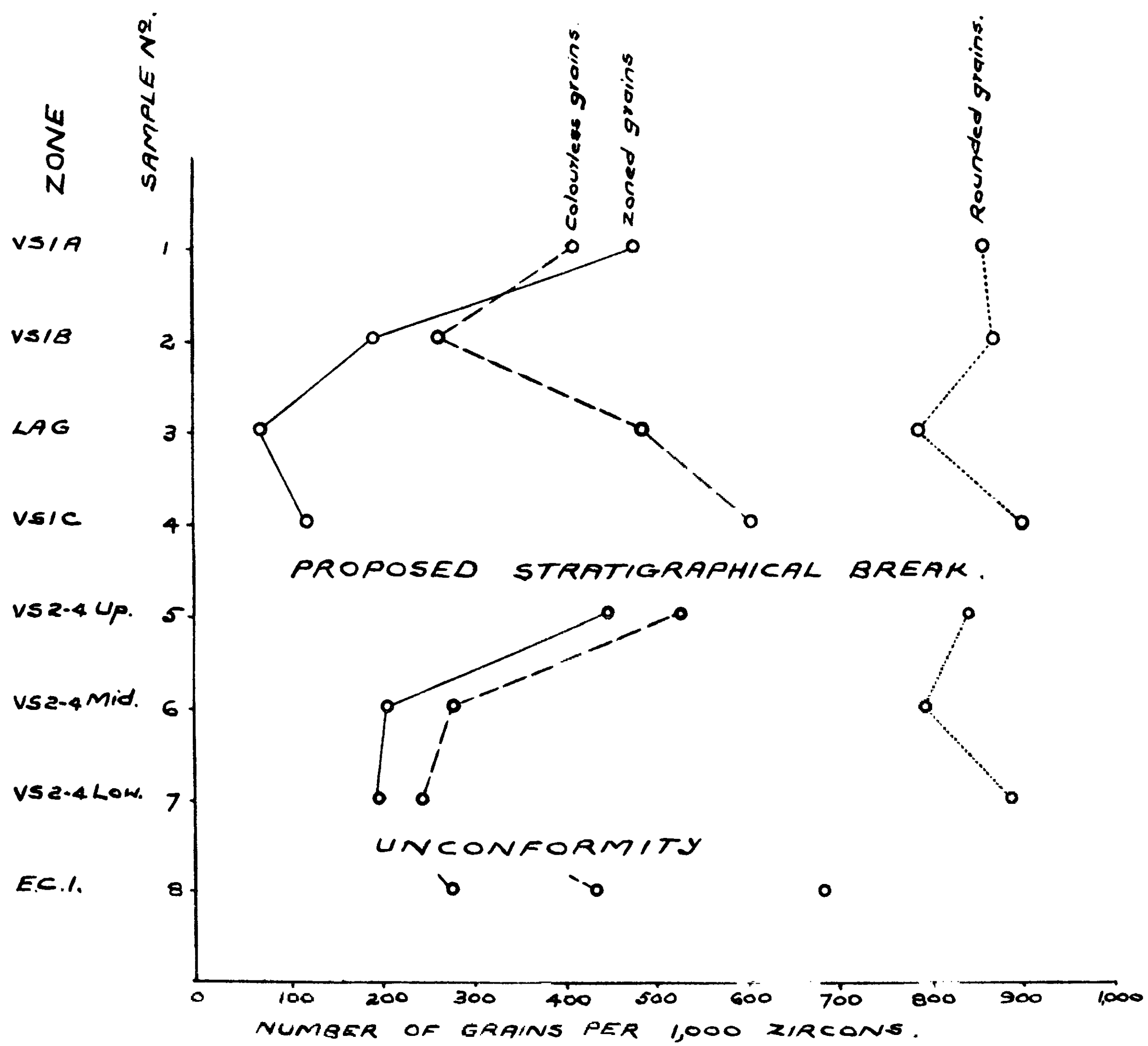
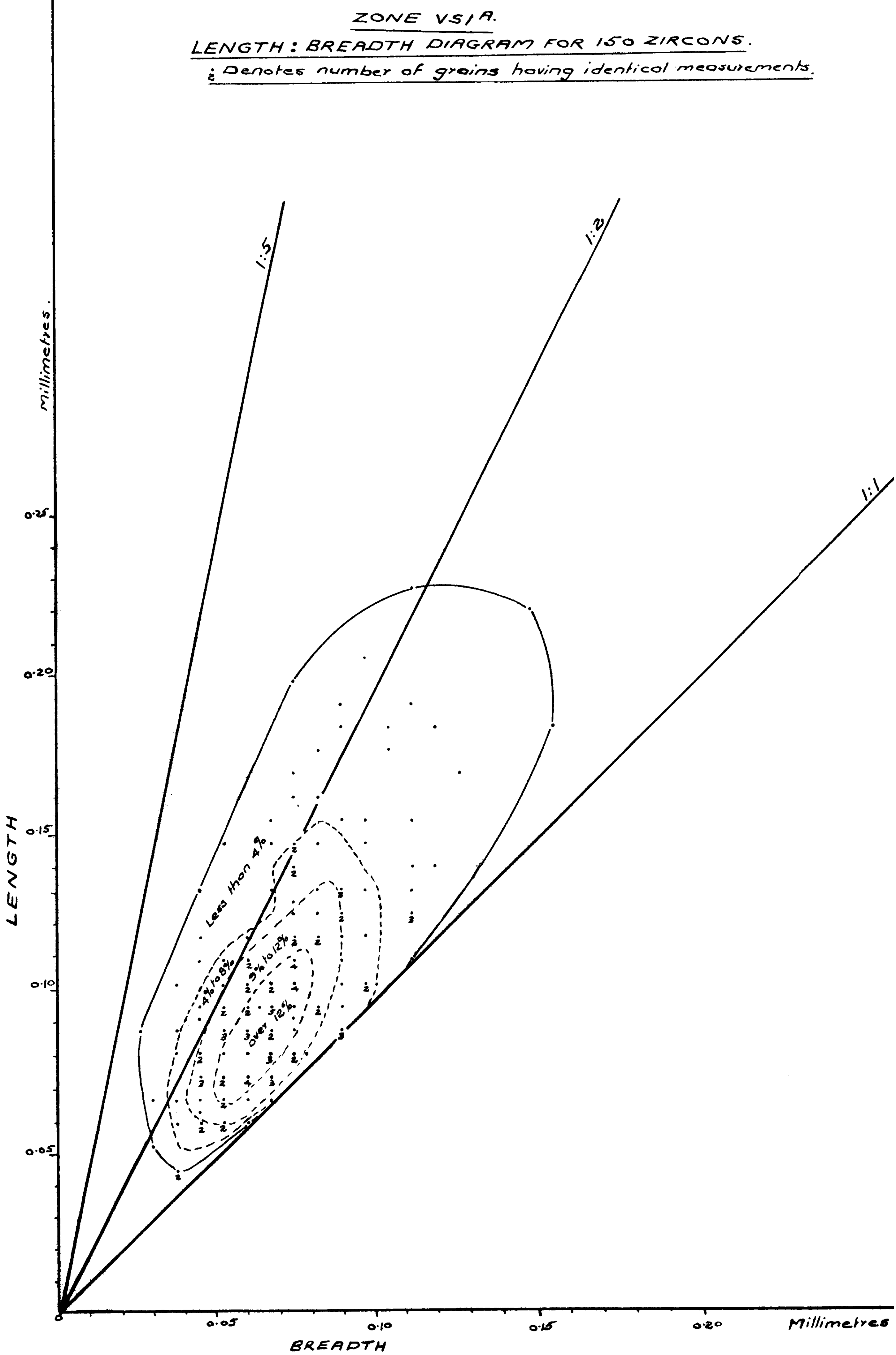


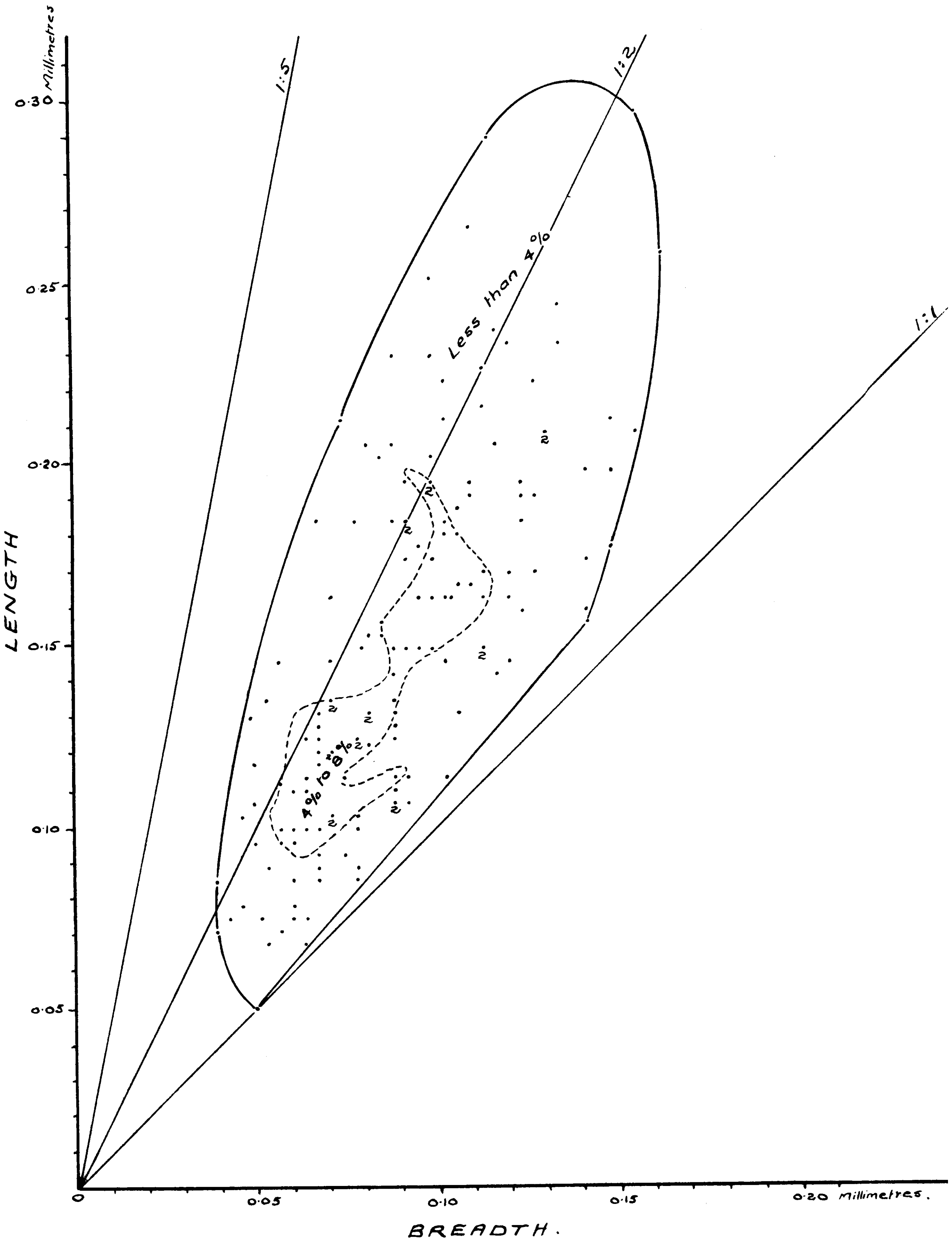
FIG.10.


ZONE VS/A.
LENGTH : BREADTH DIAGRAM FOR 150 ZIRCONS.
2 Denotes number of grains having identical measurements.
1:5
1:2
1:1
Less than 4%
4% to 8%
8% to 12%
over 12%
LENGTH
Millimetres.
BREADTH
Millimetres
0.05
0.10
0.15
0.20
0.25
0

ZONE VS1B.

LENGTH:BREADTH DIAGRAM FOR 150 ZIRCONS.

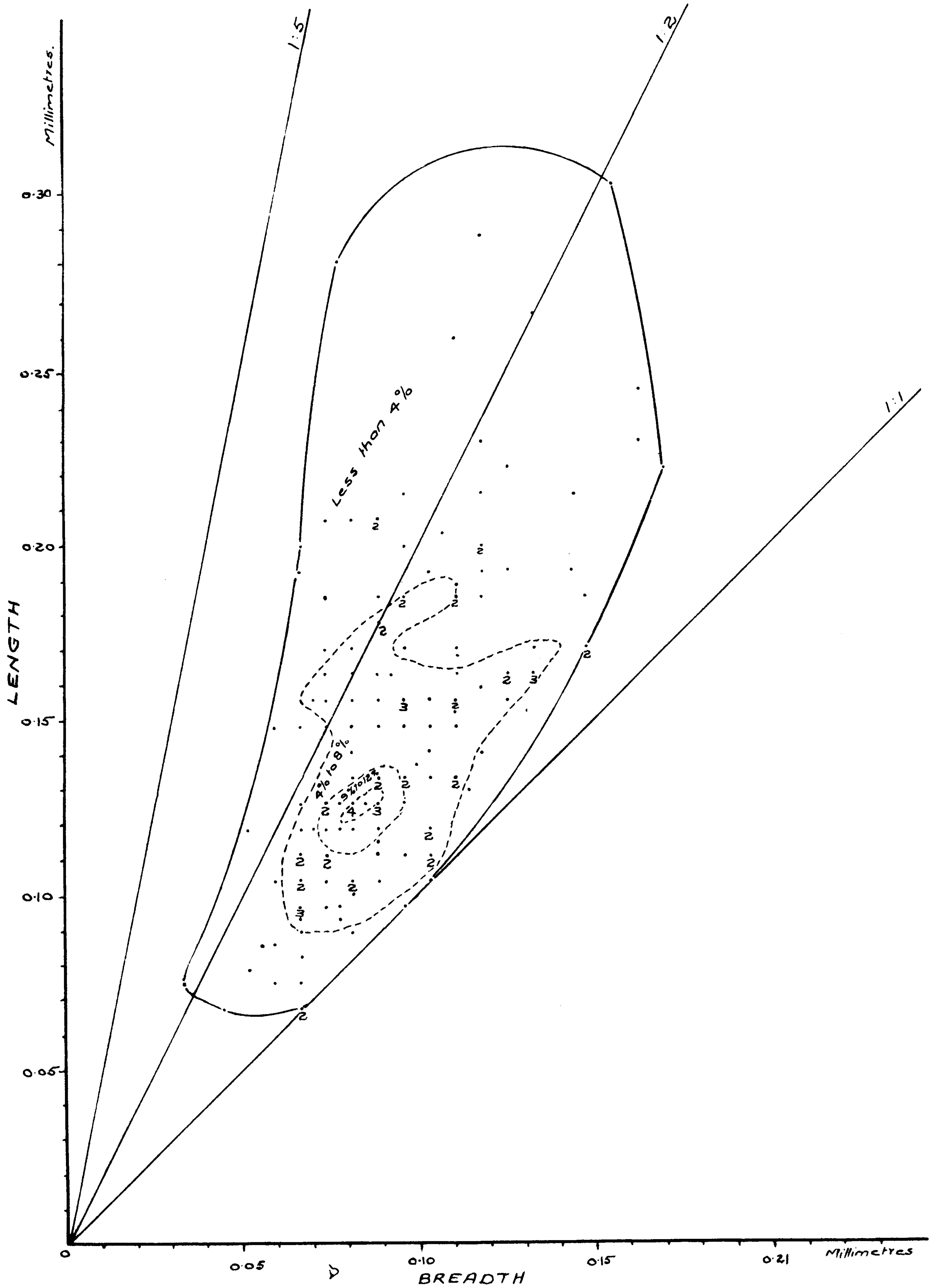
2 Denotes number of grains having identical measurements.



ZONE VS 2-4 LOWER

LENGTH: BREADTH DIAGRAM FOR 150 ZIRCONS.

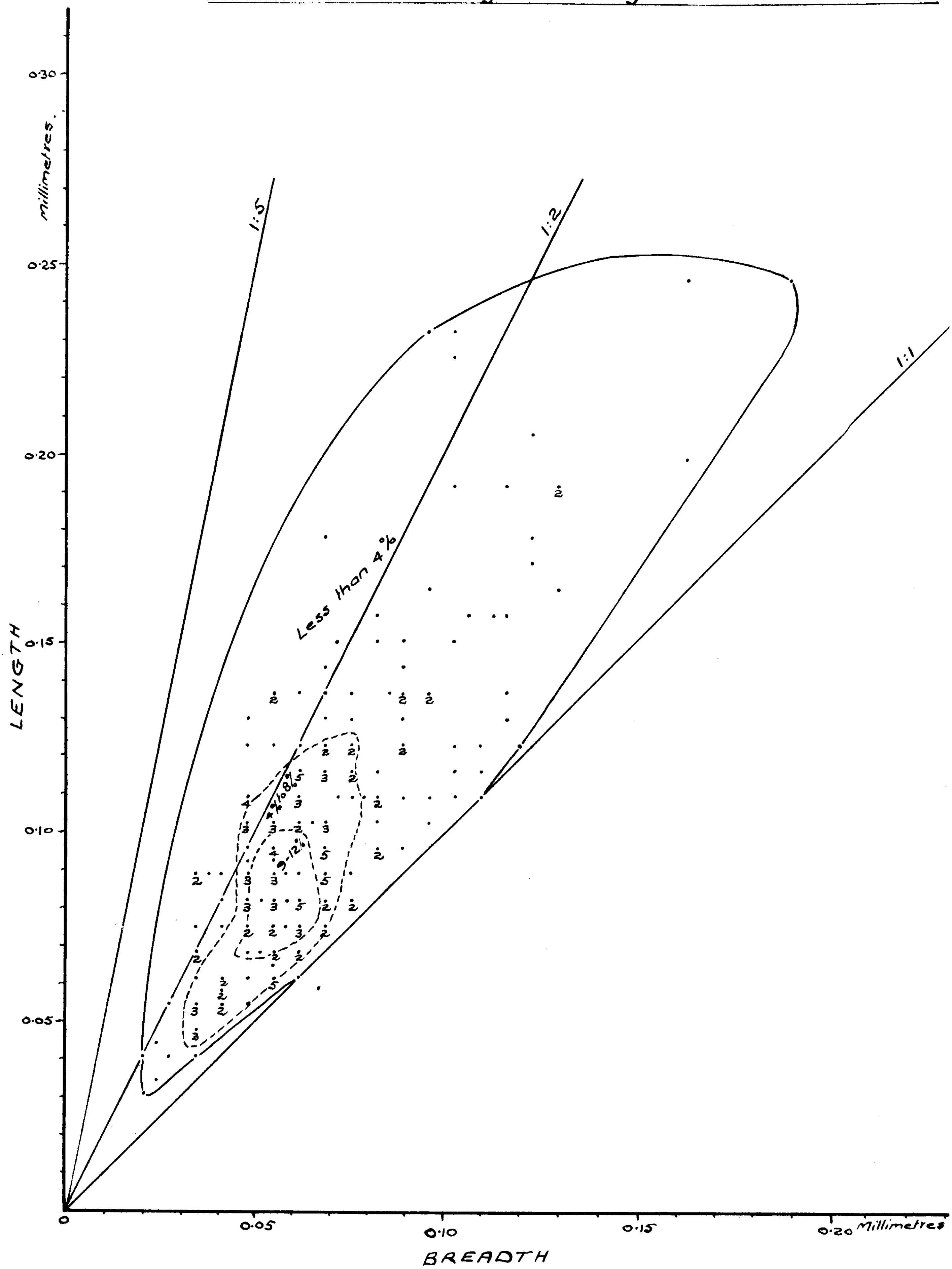
2 Denotes number of grains having identical measurements.



ZONE LAG.

LENGTH: BREADTH DIAGRAM FOR 150 ZIRCONS.

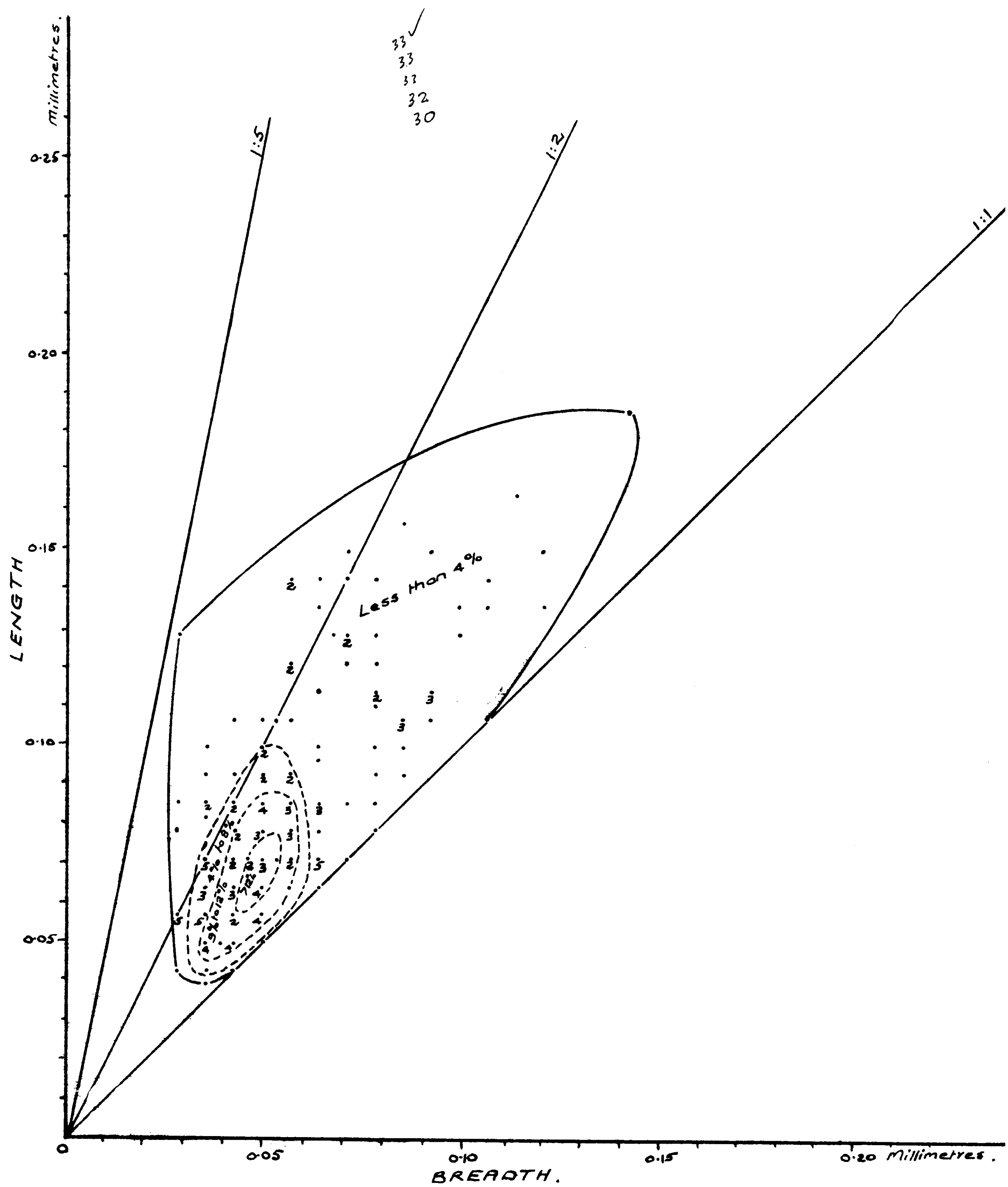
2 Denotes number of grains having identical measurements.



ZONE VS/C

LENGTH: BREADTH DIAGRAM FOR 150 ZIRCONS.

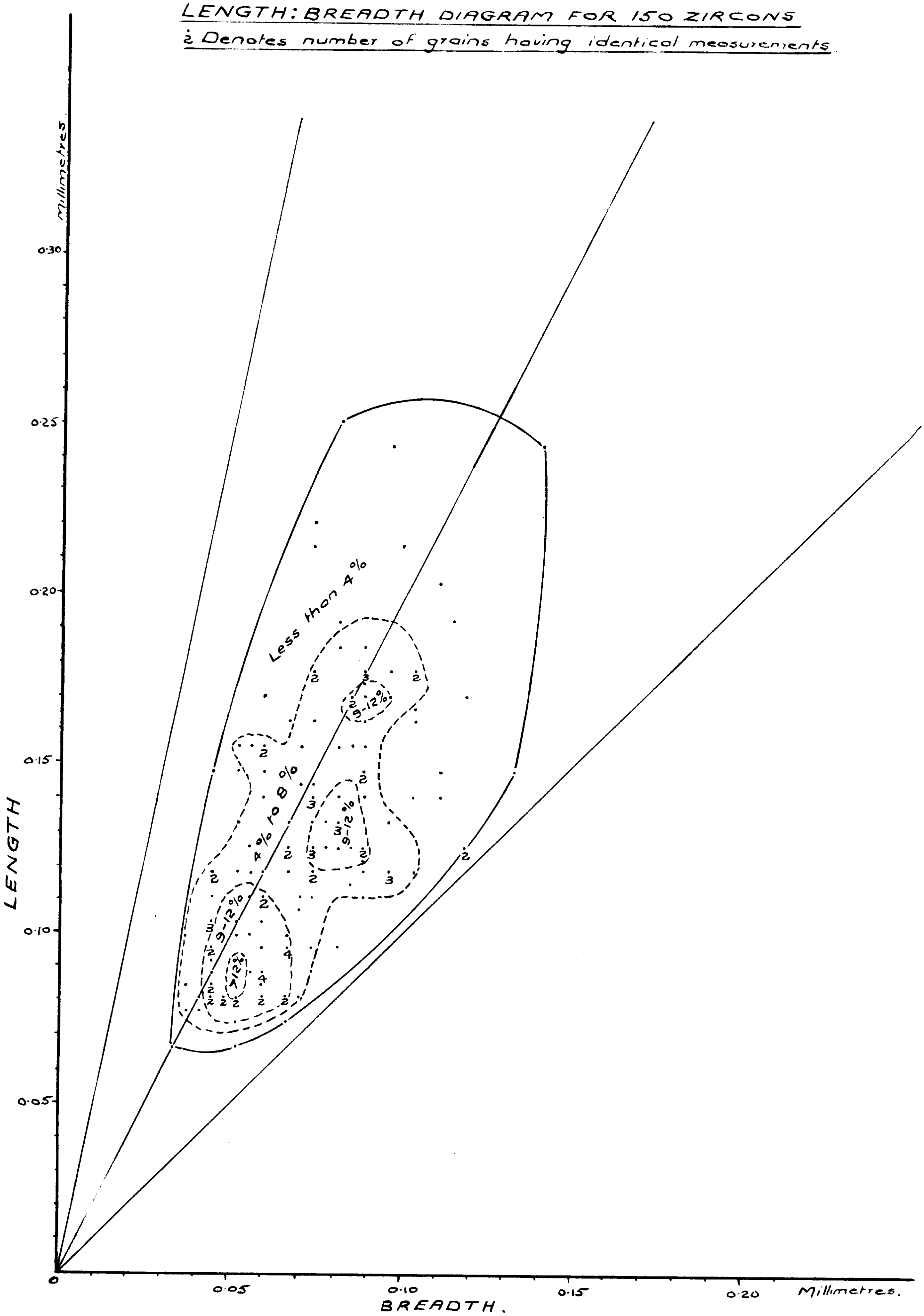
2 Denotes number of grains having identical measurements



ZONE VS 2-4 UPPER

LENGTH: BREADTH DIAGRAM FOR 150 ZIRCONS

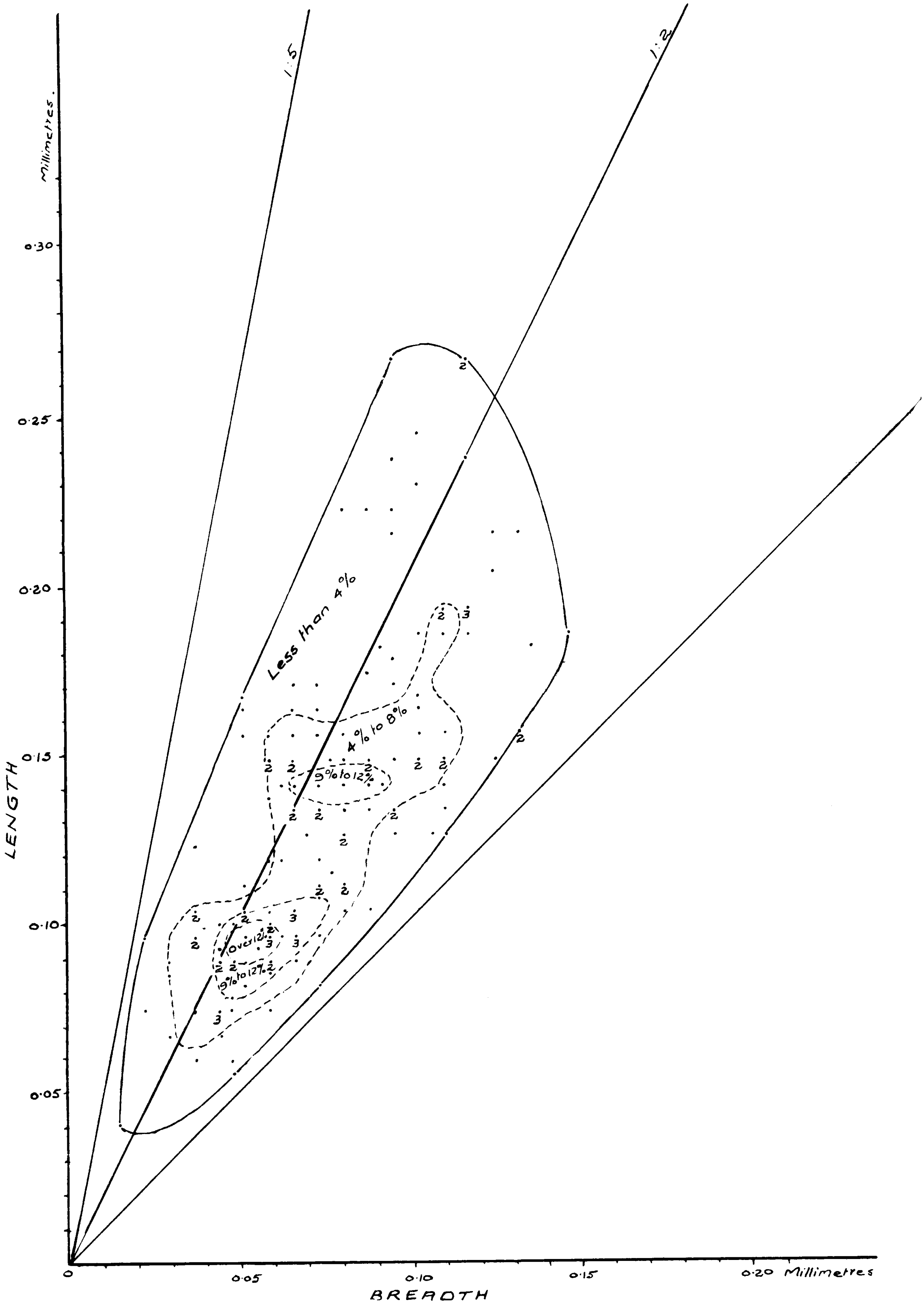
2 Denotes number of grains having identical measurements.



ZONE VS 2-4 MIDDLE

LENGTH: BREADTH DIAGRAM FOR 150 ZIRCONS.

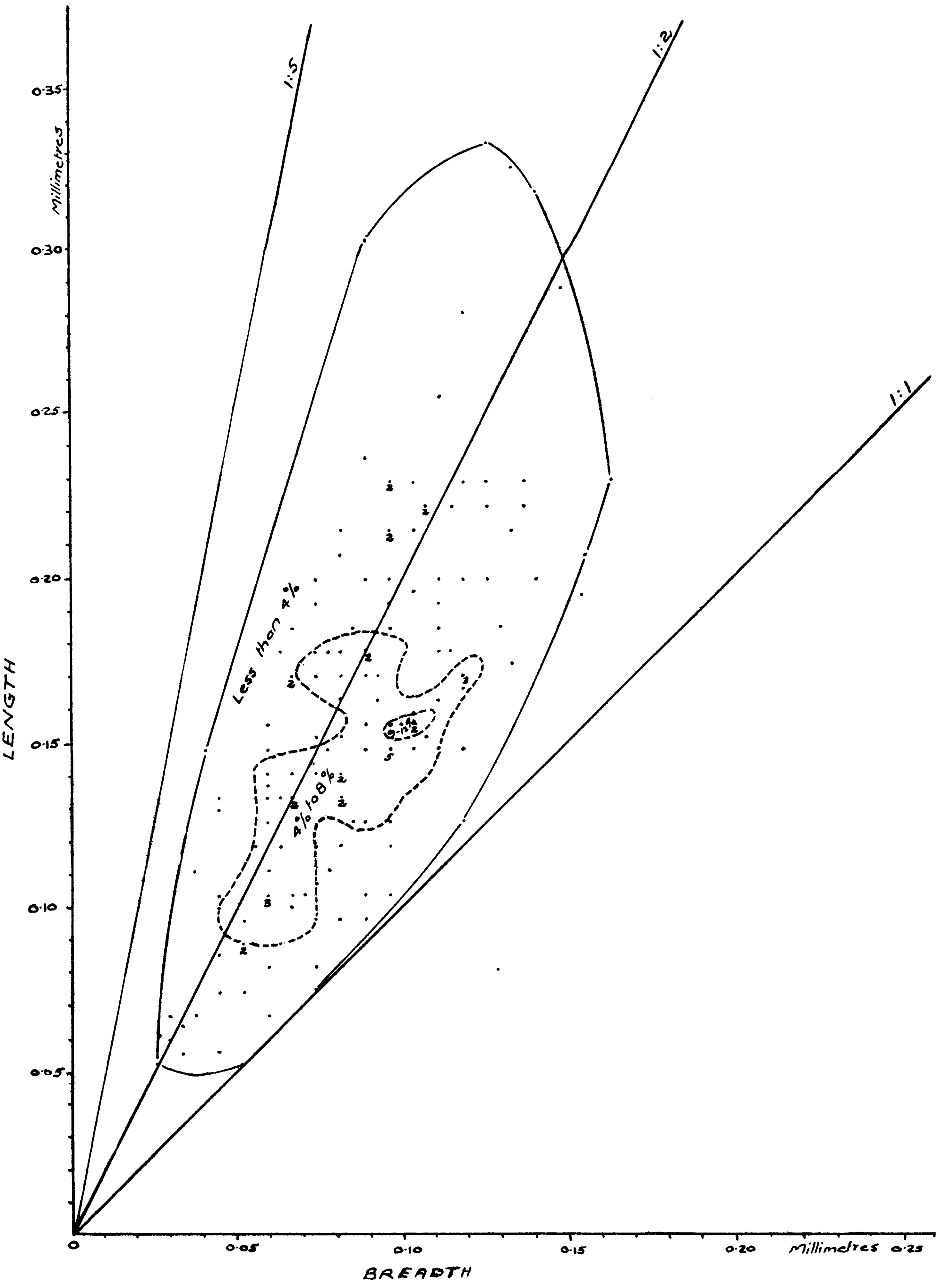
2 Denotes number of grains having identical measurements.



ZONE E.C.I.

LENGTH : BREADTH DIAGRAM FOR 150 ZIRCONS.

2 Denotes number of grains having identical measurements.



ZONE VS1A.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE.

150 GRAINS WERE MEASURED.

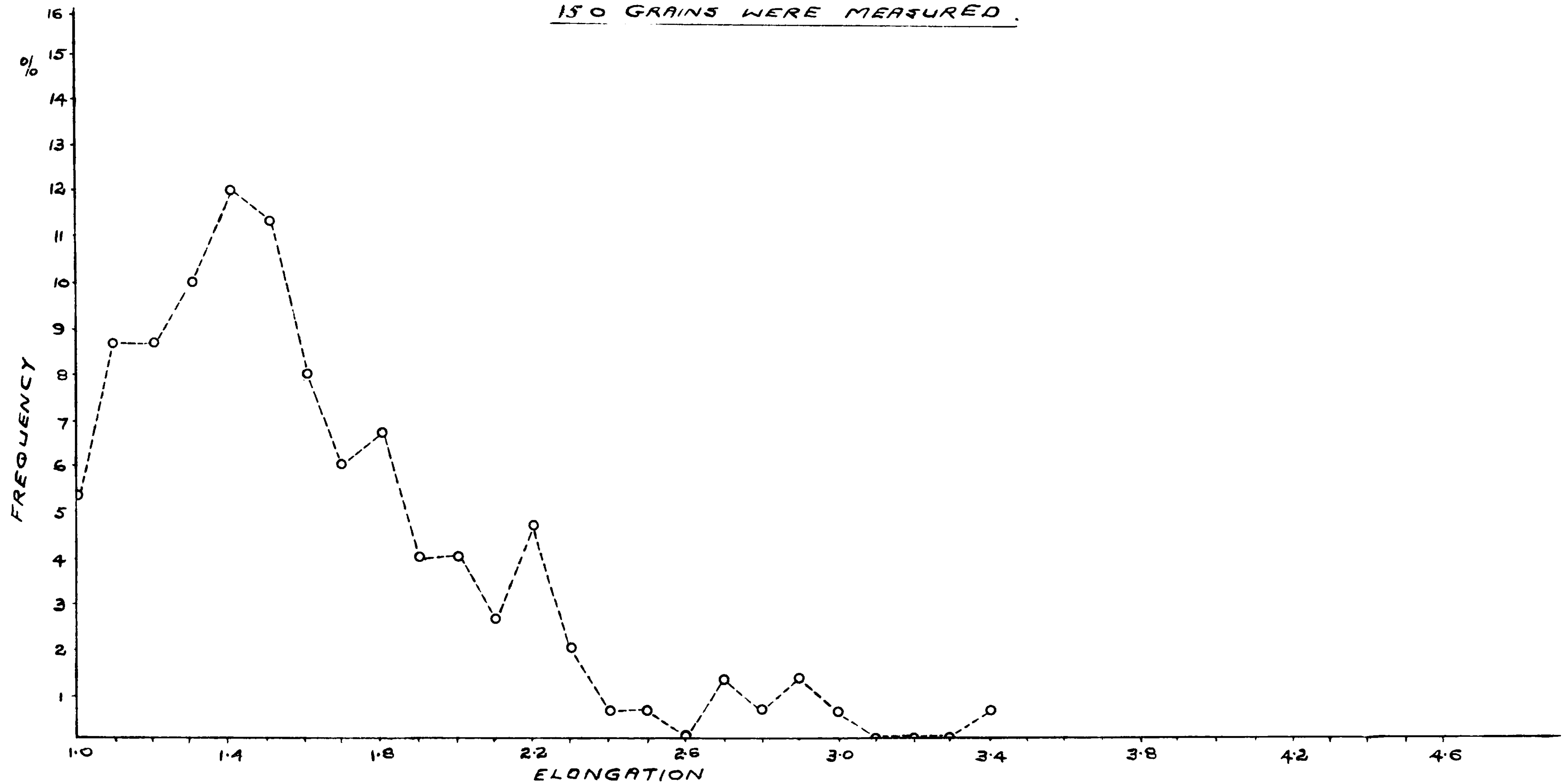


FIG. 19.

ZONE VSIB.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE.

150 GRAINS WERE MEASURED.

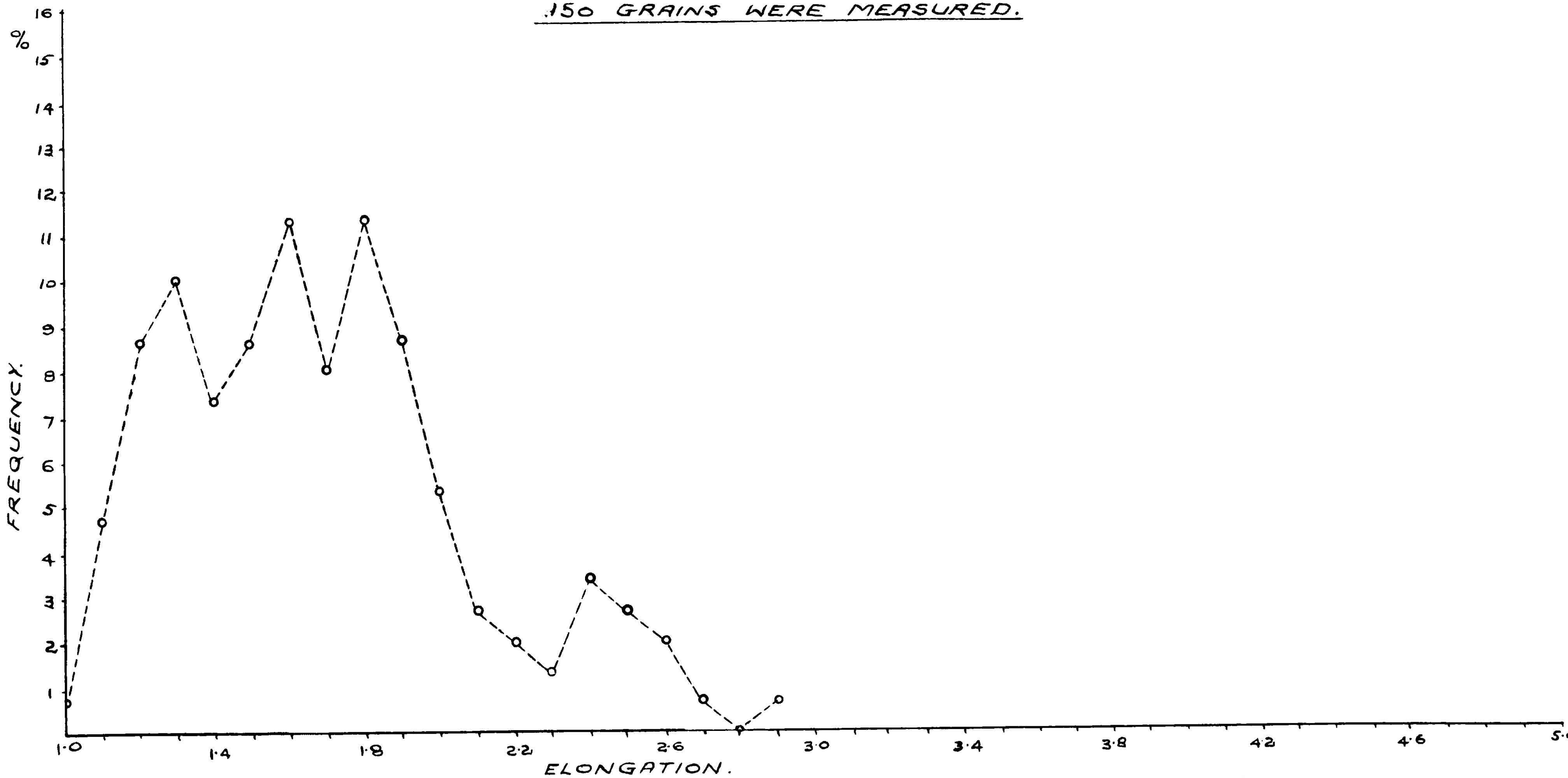


FIG. 20.

ZONE LAG.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE.

150 GRAINS WERE MEASURED.

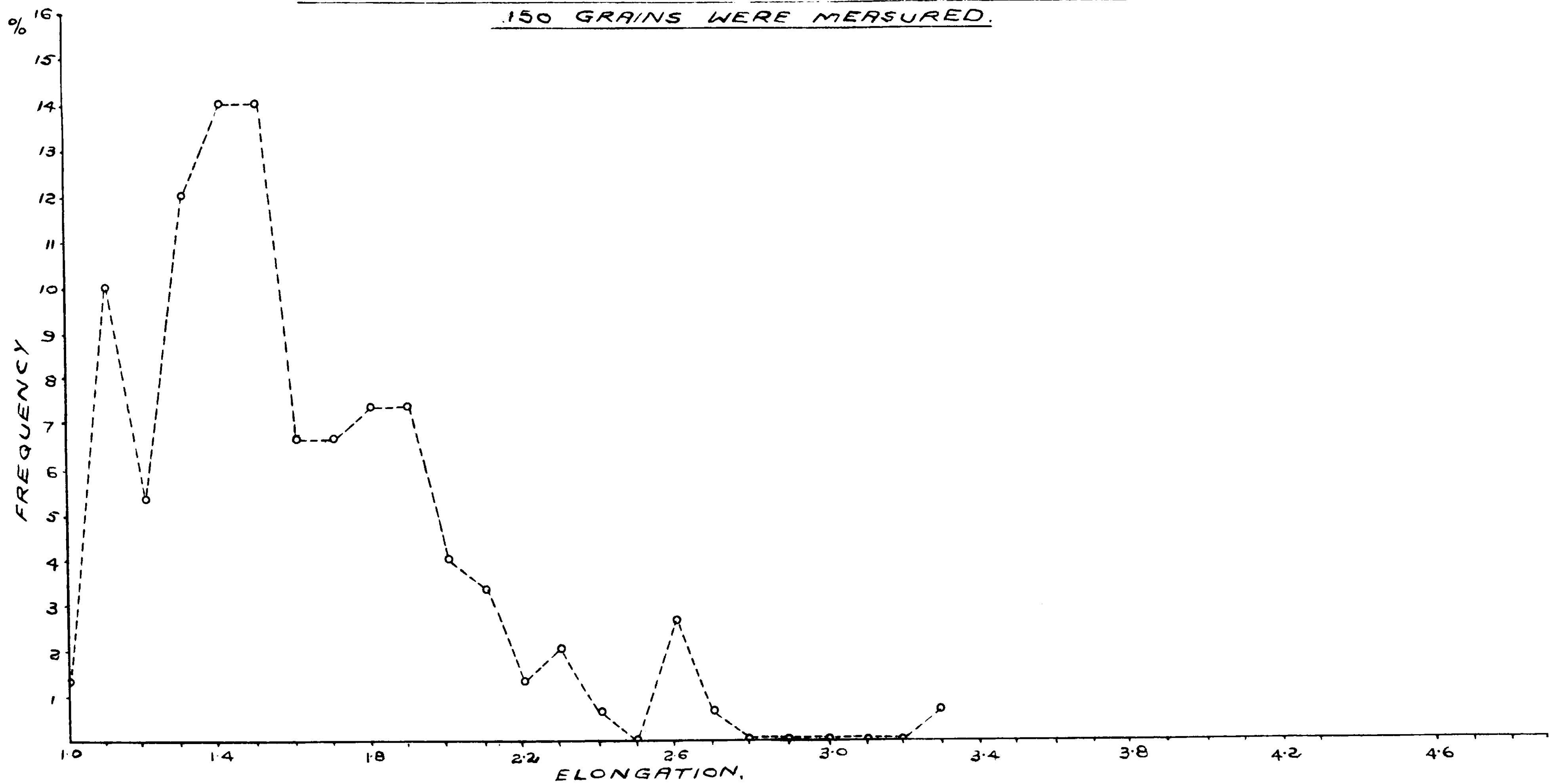


FIG. 21.

ZONE V.S.I.C.

ELONGATION – FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE

150 GRAINS WERE MEASURED.

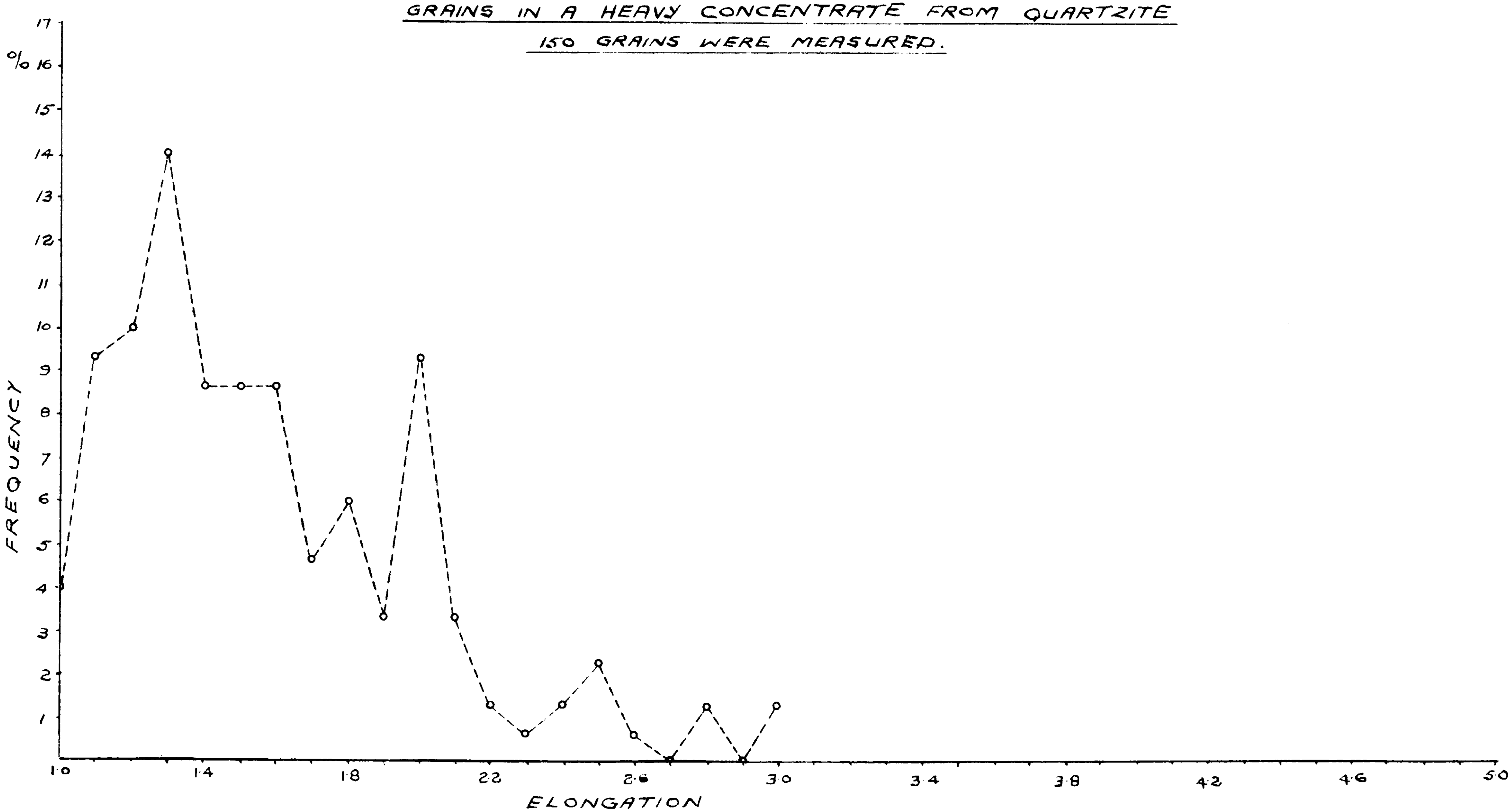


FIG. 22.

ZONE VS 2-4 UPPER

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE

150 GRAINS WERE MEASURED

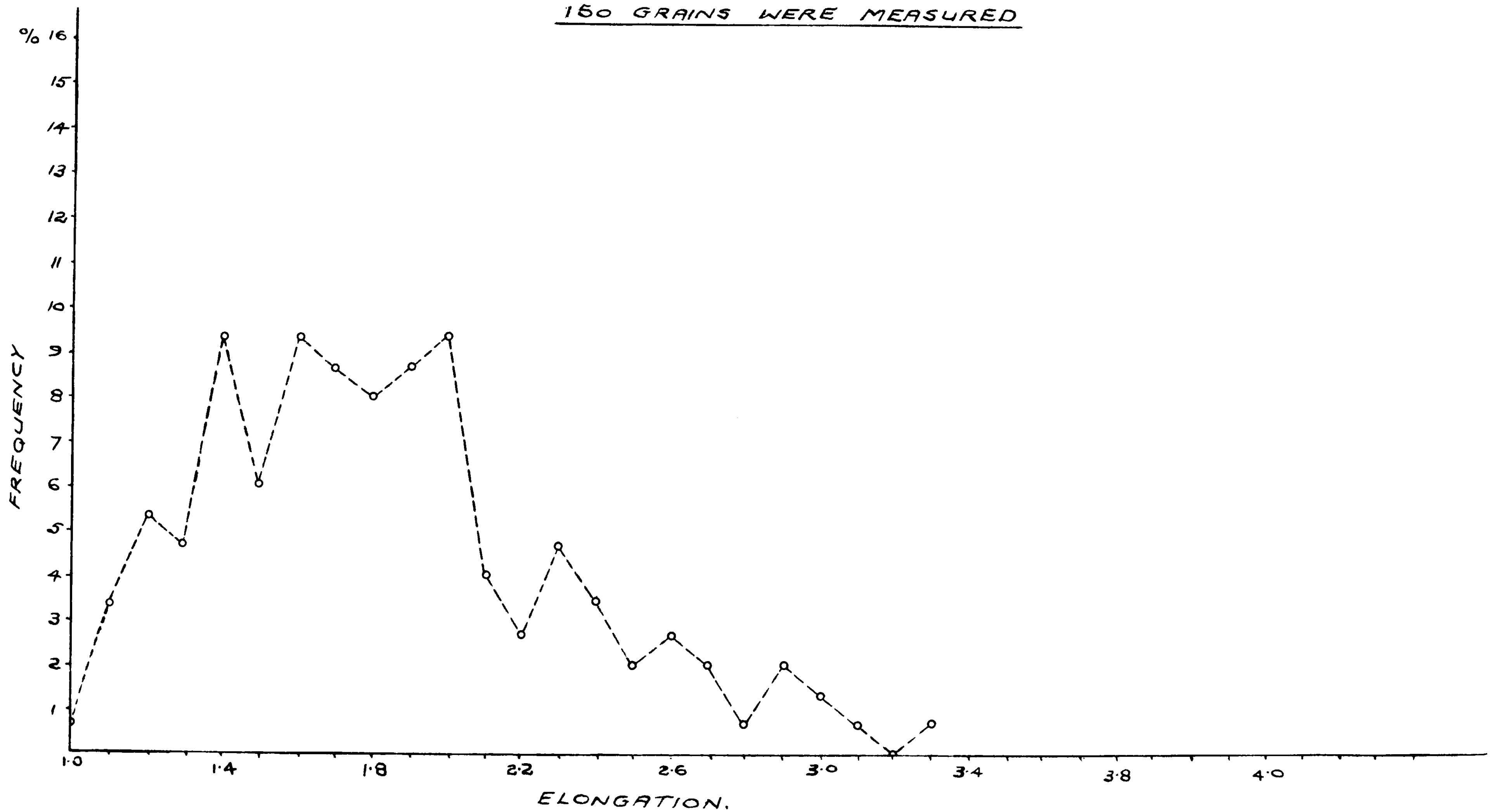


FIG. 23.

ZONE VS 2-4 MIDDLE.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE.

150 GRAINS WERE MEASURED.

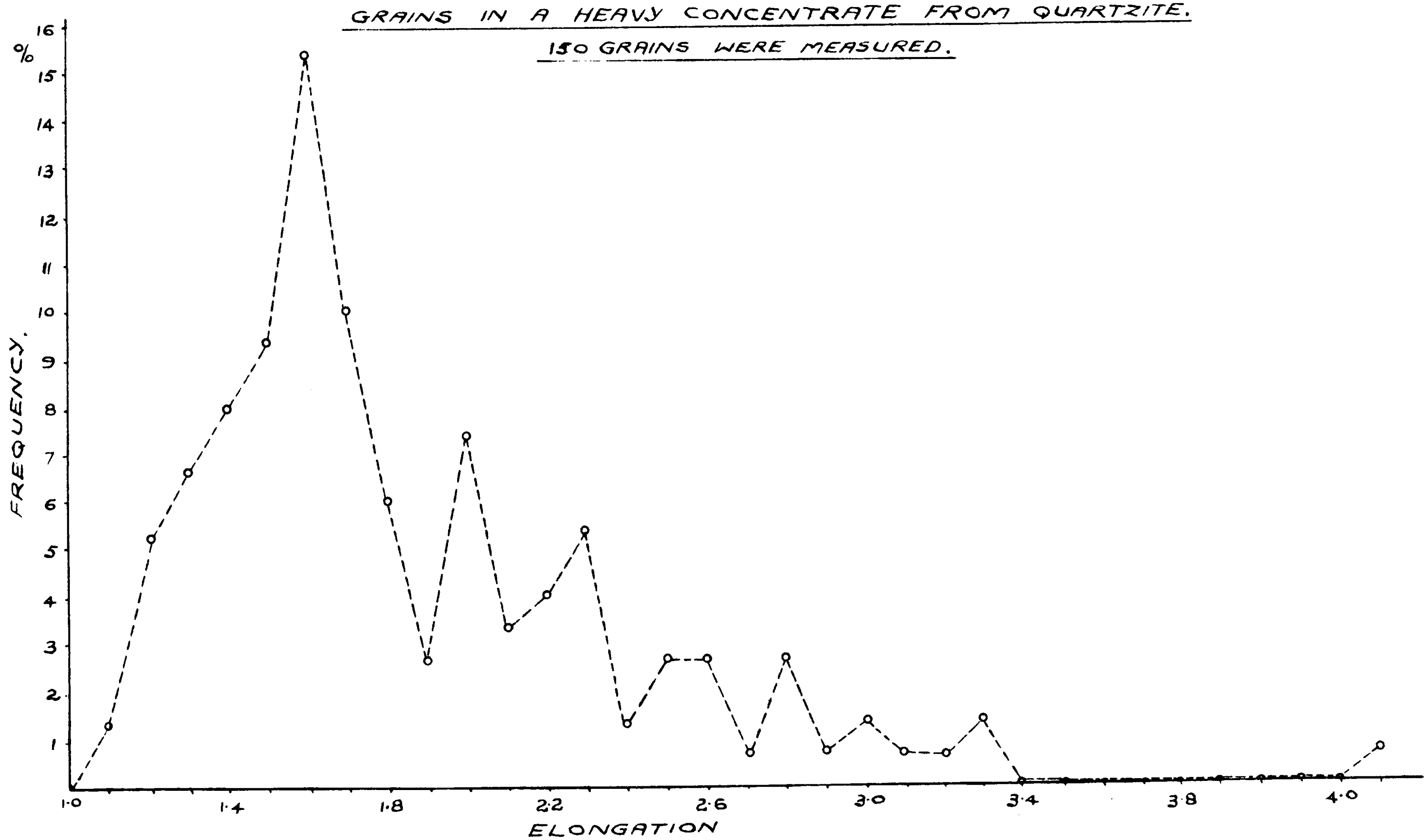


FIG.24.

ZONE VS 2-4 LOWER.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE.

150 GRAINS WERE MEASURED.

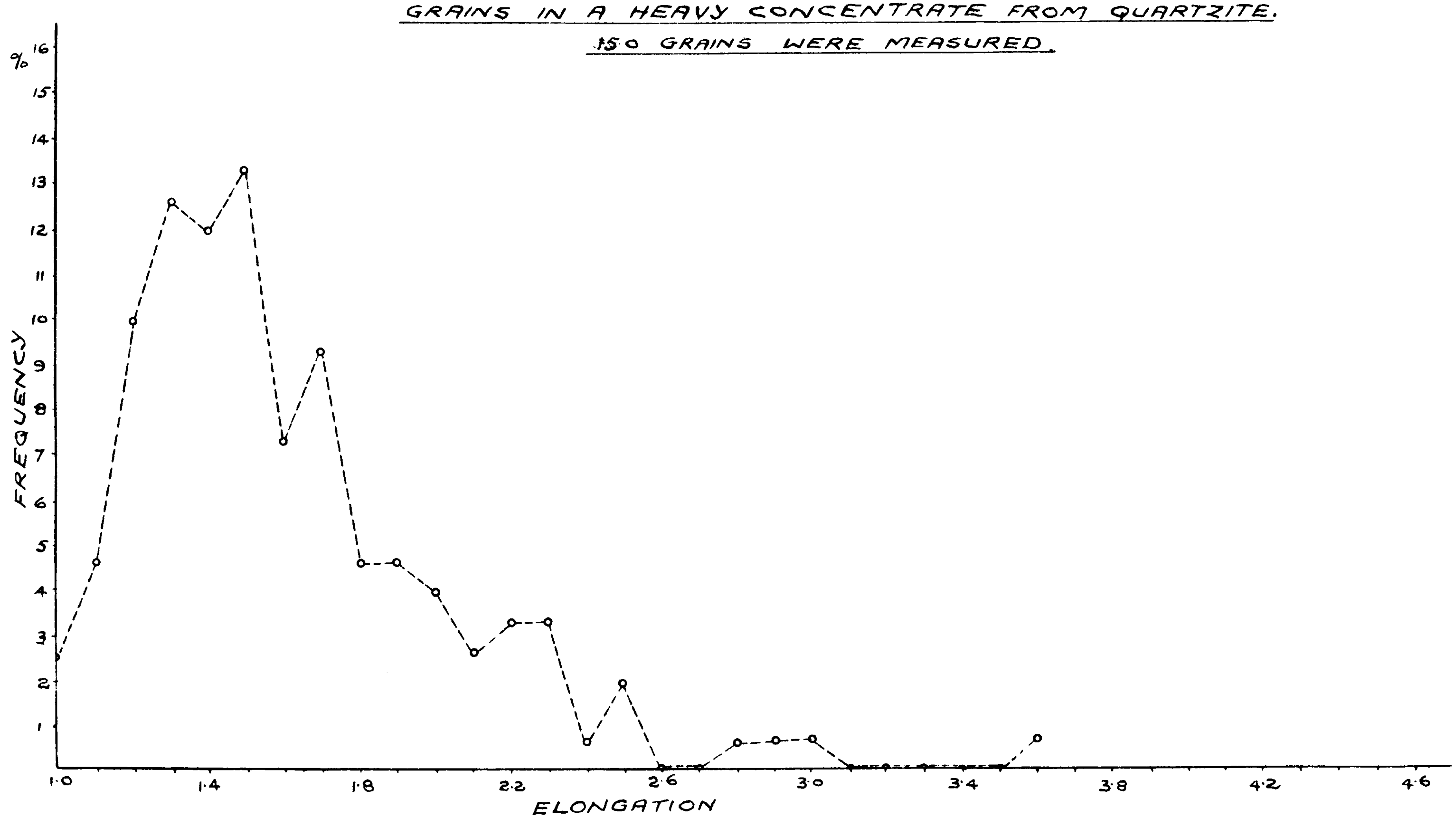


FIG. 25.

ZONE E.C.1.

ELONGATION - FREQUENCY DISTRIBUTION OF ZIRCON GRAINS IN A HEAVY CONCENTRATE FROM QUARTZITE

150 GRAINS WERE MEASURED.

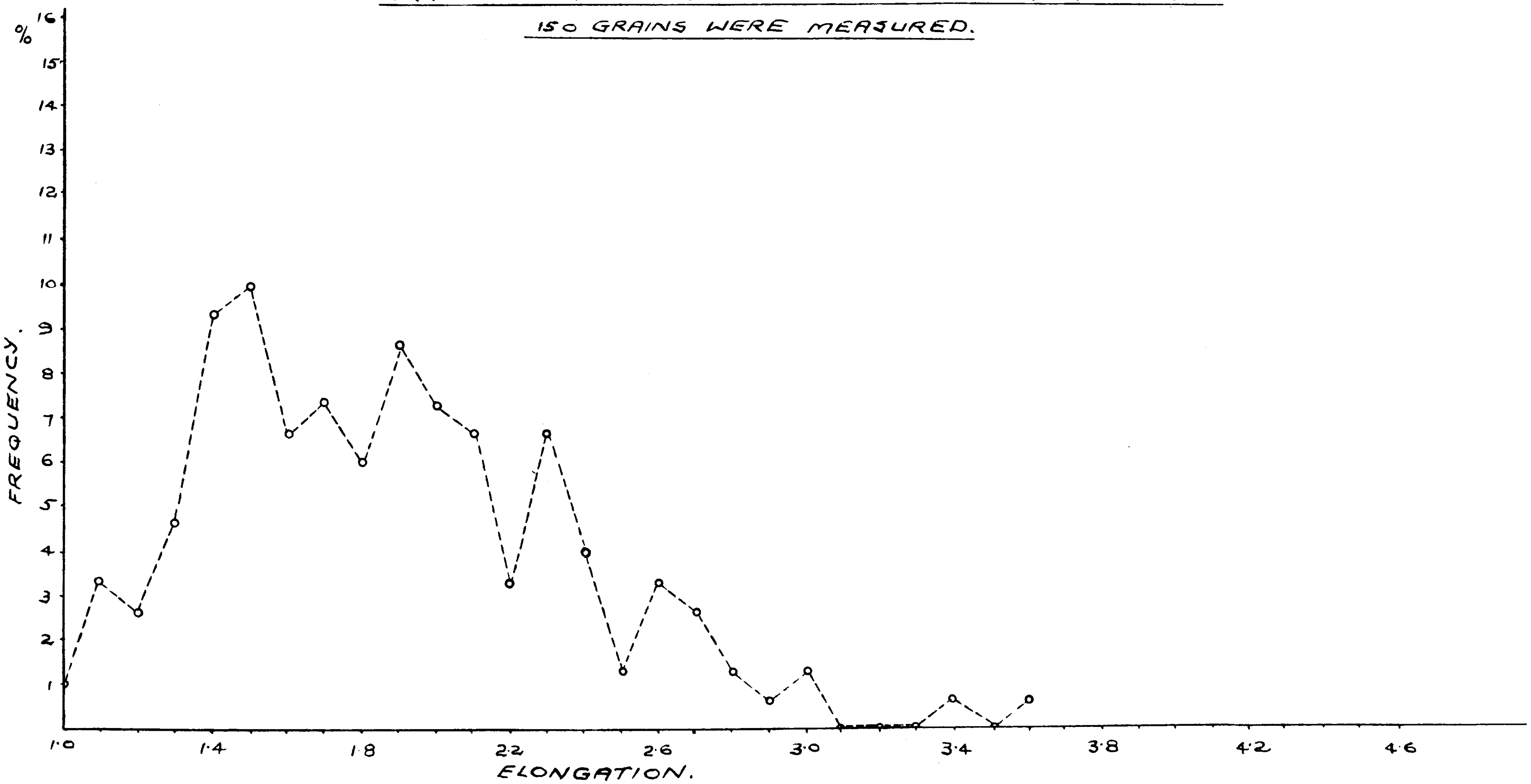


FIG. 26.