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# HEAVY MINERAL ANALYSIS OF PERMIAN SANDSTONE UNITS, SPRINGSURE 1:250,000 SHEET AREA, QUEENSLAND.

by

D.E. Mackenzie

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## SUMMARY

Heavy minerals were concentrated from specimens of the Lower Permian Staircase, Aldebaran, Catherine and Colinlea Sandstones in the Springsure 1:250,000 Sheet area. The results of a heavy mineral analysis for each unit are set out in zircon:tourmaline:rutile diagrams, as graphs of zircon, tourmaline and rutile percentages against stratigraphic height of the sample (above the base of the units) and as histograms showing percentages of accessories. A table of percentages of all heavy minerals present is included.

Source rocks of the Lower Permian sandstones are igneous and metamorphic with some sedimentary and volcanic rocks. These source rocks formed highs in the north and in the south, about 100 miles apart. The northern one provided most of the detritus in sections S5, S6, S15 and S11, while the southern one provided most in sections S16 and S21. (See figure 1 for measured section locations).

The results support correlation of the bulk of the Colinlea Sandstone with the Aldebaran Sandstone and of the top of the Colinlea Sandstone with the Catherine Sandstone. They also suggest that the lower part of the Catherine Sandstone was produced by reworking of older sandstone units, possibly including the Colinlea Sandstone, on the Springsure Shelf to the west of the Denison Trough.

## INTRODUCTION

Heavy minerals of some specimens of Lower Permian sandstones from the Springsure 1:250,000 Sheet area were analysed to supplement petrographic work on the same units by Bastian (1965). The sandstone specimens were collected from the Staircase Sandstone (measured section S11), the Aldebaran Sandstone (measured sections S15 and S16), the Catherine Sandstone (S15 and S21) and the Colinlea Sandstone (S5 and S6). The location of each measured section and the distribution of the units are shown in Figure 1.

Bastian collected the rock specimens and prepared and mounted heavy mineral concentrates from 5 gram rock samples. Forty-nine of these heavy mineral concentrates were analysed by the author, using a mechanical stage to traverse systematically over each slide. Fourteen heavy minerals were identified in the analysis. Magnetite, ilmenite, pyrite and other opaque grains were collectively termed "opaques". Various unidentified transparent minerals, as well as quartz and feldspar, were classed as "others"; this category may include in a few cases some heavy minerals such as barite, siderite, and ?glaucophane.

The percentage of heavy minerals present in each concentrate are listed in Table 1. The results for specimens from each formation are presented in three sets of diagrams:

(1) triangular zircon: tourmaline: rutile (ZTR) diagrams showing the compositions of this ultrastable heavy mineral suite and permitting comparison of different formations;

(2) graphs of zircon, tourmaline and rutile percentages against the stratigraphic height of the sample locality above the base of the unit;

(3) histograms of the composition of accessory heavy mineral suites drawn in approximate stratigraphic sequence.

The results of the analysis are summarized for each formation leading to a discussion of inferences as to the correlation and relationships of the formations and to the nature of the provenance.

1. STAIRCASE SANDSTONE

The Staircase Sandstone (ZTR diagram, Fig. 2) is high in zircon and higher in rutile than in tourmaline. SP111/B may not be representative of its particular portion of the section, since it contained large amounts of undisintegrated rock material and was incompletely separated. The diagram to the left of the ZTR diagram gives the stratigraphic positions of each specimen.

Comparison of the ZTR diagrams shows that the Staircase Sandstone field is quite different from those of the other formations. The zircon is mainly euhedral with some round and subround grains, average size being about 0.075 mm. (along c- axis). Tourmaline is mainly green and brown, with minor pink and blue grains.

Figure 3(a) shows that zircon varies greatly with stratigraphic height. The graphs of the tourmaline and rutile percentages generally parallel that of the zircon; the tourmaline graph deviates from the trend between 10 and 75 feet, and the rutile graph, between 400 and 700 feet also deviates from parallelism.

The proportions of the accessory heavy minerals are shown in Fig. 3(b). Biotite is present in all specimens, and apatite in all but those from 230 and 270 feet above the base of the formation. Epidote and spinel are present in specimens from near the base and top of the formation; garnet is present only in specimens from near the top of the unit.

The nature of the heavy minerals suggests that the two lowest specimens were derived mainly from igneous rocks and that the higher specimens had a metamorphic provenance. The proportion of rounded zircon grains and the abundance of limonitic grains in the "opaques" suggest that sedimentary rocks supplied some detritus to the Staircase Sandstone.

2. ALDEBARAN SANDSTONE.

Two sets of specimens from the Aldebaran Sandstone were studied; one from Reid's Dome (S16) and the other from a section in Aldebaran Creek (S15) about 25 miles north north west of S16.

The two sets of specimens occupy very different fields in the ZTR diagram (Fig. 4), the Reid's Dome specimens being much higher in zircon. (Specimen SP112/1B is considered non-representative as separation was incomplete).

The graph (figure 5(a)) also shows that zircon is higher in S16 than in S15, while tourmaline and rutile are lower. There is a rough parallelism between the zircon "curves" of the two sections, but the tourmaline and rutile "curves" show no such agreement. There is a parallelism between the zircon, tourmaline and rutile curves of the section S15 specimens, and high percentages of zircon are usually associated with some garnet (Fig. 5 (b)). Apart from garnet, the accessories are constant in section S15 specimens. A large proportion of biotite is associated with the very low zircon, and the high tourmaline and rutile percentages in SP112/1A. Presence of epidote, apatite, garnet and sphene indicate igneous and metamorphic source rocks.

Zircon and tourmaline in section S16 show roughly opposite trends, zircon increasing and tourmaline decreasing towards the middle of the section from both the top and the bottom. These trends are accompanied by increases in the importance of the heavy minerals typically of metamorphic origin, biotite, hornblende, corundum and garnet towards the central portion of the section. Sphene is present in most of the specimens of S16, as well as garnet and corundum.

The zircon grains are mainly subround to round in section S16 specimens, and euhedral in S15 specimens. The tourmaline grains in section S16 are dominantly pink and blue, indicating igneous (plutonic) origin, while in S15, they are green-brown and green, indicating metamorphic origin.

## 3. CATHERINE SANDSTONE.

Specimens from two measured sections, S15 and S21 in the Catherine Sandstone were analysed. The ZTR diagram (Fig. 6) shows that both sets of specimens are low in rutile and generally high in zircon, but with wide ranges in zircon: tourmaline: rutile ratio. Specimens from section S21 have a higher average zircon percentage than those from S15. Specimens SP134/IF and SP134/IG are high in tourmaline.

The graph (Fig. 7 (a)) shows that there is a striking degree of parallelism in variations of zircon percentages between the two sections. Tourmaline trends are quite different. The great increase in tourmaline towards the top of section S15 is particularly interesting - the tourmaline is mostly brown and therefore considered to be of metamorphic origin. Rutile remains essentially constant.

Figure 7(b) shows that in section S21, biotite, and, in particular, hornblende tend to be more abundant towards the base of the formation. Epidote, apatite and monazite are constant; garnet occurs only in minor quantities in some specimens, and corundum is significant only in SP129/1B.

Zircon grains in section S21 are mostly round to subround; tourmaline grains are green, brown, blue and pink, the blue and pink grains being most abundant near the base.

Measured section S15 (see Figure 7(b)) shows a rise in biotite from 1910 feet to 2090 feet, and an accompanying decrease in, and final disappearance of apatite. This trend may also occur from 1910 feet downwards, but only one heavy mineral concentrate is available from that interval.

The heavy minerals of the Catherine Sandstone form a far greater percentage of total rock, and are finer-grained and better rounded than are the heavy minerals in the other formations.

## 4. COLINLEA SANDSTONE.

Nine specimens from measured section S6, and one from section S5 were studied.

The ZTR diagram (Figure 8) shows that except for two specimens, the Colinlea Sandstone occupies a very small field. Specimen SP118/B from section S5 is quite separate from this field. The grouping of points on this diagram is similar to that of the Catherine Sandstone specimens.

Figure 9(a) shows that the sigmoid shape of the zircon "curve" is reflected, in a subdued fashion, by the tourmaline and rutile "curves". SP118/B is low in zircon and high in tourmaline relative to the specimens from the same stratigraphic level in S6.

Figure 9(b) reveals only irregular fluctuations in percentage and mineralogy of the accessory heavy mineral suite. The high proportions of corundum and sphene in SP126/1B may be due to temporary supply of material from igneous or metamorphic rocks of unusual mineralogy. The sphene is euhedral and the corundum angular, which indicates a nearby source.

Zircon grains are mainly subround to round or subangular. Tourmaline grains are brown, greenish brown, green, pink and blue, the blue and pink grains being more abundant near the base and top of the section.

## CONCLUSIONS.

The distribution of the Lower Permian units indicates that two main source areas supplied detritus to the Denison Trough and the Springsure Shelf of the Bowen Basin during deposition of the sandstone units studied. One, to the north-west, consisted of the Anakie Metamorphics, the Retreat Granodiorite and sediments and volcanics of the Drummon Basin sequence. The second is located about 100 miles to the south and is known only from well information. It includes low grade metamorphics of the Timbury Hills Formation and large areas of acid igneous rocks.

The Staircase Sandstone, the oldest unit studied, contains a higher percentage of rutile than the other formations, which indicates plutonic source rocks. The abundance of biotite in the accessory heavy minerals indicates low-grade metamorphic and/or igneous source rocks. ~~Garnet~~ (almandine) in the upper parts of the unit could have come from either an igneous or amphibolite facies metamorphic rocks. The apatite is probably of igneous origin; the epidote could be either of igneous or low-grade (greenschist facies) metamorphic origin. The occurrence of euhedral and well-rounded zircons together suggests some reworking of older sediments (or low-grade metamorphic rocks), while the dominance of brown and green tourmaline grains over blue and pink grains indicates a provenance of metamorphic rocks. Volcanic rocks may have contributed some euhedral zircon grains (Folk, 1965).

The dominant source of the detritus of the Staircase Sandstone was igneous, low-grade metamorphic, sedimentary and volcanic rocks, probably belonging to the northern source area.

The Aldebaran Sandstone has a much more complex heavy mineralogy than does the Staircase Sandstone. The suites of samples from the two widely separated sections S15 and S16, show some differences which probably reflect differences in the detritus shed by the two postulated source areas. Measured section S15, close to S11 (Staircase Sandstone) has a fairly consistent heavy mineralogy which indicates igneous and low-grade metamorphic source rocks. No systematic changes can be observed in the proportions of the accessory heavy minerals. Abundance of zircon and the colour of tourmaline grains (high zircon percentage, pink and blue tourmaline grains abundant indicate plutonic igneous source rock, low zircon and green and brown tourmaline indicate metamorphic rocks) show that the unit was derived mainly from low-grade metamorphic rocks, and igneous rocks, with occasional drops in the proportion of detritus from the metamorphic rocks. The proportions of biotite reflect the changes from low grade metamorphic and igneous to dominantly igneous source rocks. The source area was apparently the block to the north-west, as in section S11 (Staircase Sandstone).

Measured section S16, to the south, has a different heavy mineralogy to that of section S15: the percentage of zircon is higher, tourmaline and rutile are less important, and garnet and sphene are prominent in the accessories, as is hornblende, which is absent from the section S15 specimens. These changes are possibly due in part to the distance from the north-west source, the greater transport distance having increased the percentage of zircon at the expense of tourmaline and rutile and produced better rounding of the zircon grains. In addition, detritus from the south has included garnet, sphene, biotite and hornblende from the igneous and metamorphic rocks of the southern source area. The pink and blue tourmaline grains of section S16, which contrast with the dominantly green and brown grains of section S15, may be derived from the southern source area, as may the euhedral zircon grains present in some parts of section S16.

The Aldebaran Sandstone received detritus from two source areas, the high to the north-west contributing most of the detritus to the northern parts of the Formation, the southern high contributing most to the southern part of the Formation.

Heavy minerals from the Catherine Sandstone indicate virtually the same source areas as for the Aldebaran Sandstone, with plutonic igneous and medium-grade metamorphic minerals dominating in the south, and plutonic igneous, low-grade metamorphic, volcanic and sedimentary detritus predominating in the north. The great fluctuations in zircon percentages, in particular, and the high percentage of heavy minerals in the rock as a whole may be the result of reworking of older sandstone units. Reworking of older sandstone units is also suggested by the better rounding and the finer grainsize of the heavy mineral grains of the Catherine Sandstone, as compared to the rounding and grainsize of heavy minerals from the other formations.

Section S15 shows some internal mineralogical changes, including an increase in the importance of biotite and hornblende near the top, and a great influx of brown and green tourmaline grains. These changes indicate increasing contribution of detritus from low grade metamorphics from the high to the north-west, and, together with the fact that the zircon grains towards the top are less well rounded, indicate a rapidly decreasing contribution of detritus from older sediments.

Section S21 shows the general changes discussed above, and also a decrease in importance of hornblende and biotite upwards, and a change from dominantly rounded zircon grains at the bottom to dominantly subrounded grains at the top. Zircon and tourmaline percentages tend to drop towards the top of the section. These changes also probably reflect, in part, the decreasing contribution of detritus from older sediments.

The Colinlea Sandstone (measured sections S5 and S6) was deposited on the Springsure Shelf and was probably subjected to considerable reworking; the other units were deposited in the more rapidly subsiding Denison Trough. The mineralogy is much like that of the Aldebaran Sandstone in section S15, except for the presence of appreciable amounts of sphene in some specimens of the Colinlea Sandstone. Low in section S6, sphene is an abundant accessory heavy mineral; it is less important near the middle of the section, being absent from the upper part of the middle of the section; sphene appears again near the top of the section. These changes are accompanied by corresponding rises and falls in zircon, tourmaline and rutile percentages, and, to some extent, by opposing changes in the percentage of biotite. They suggest a decrease of igneous detritus and an increase in low-grade metamorphic detritus about the 560 feet level in section S6.

Section S5, or at least the one specimen studied, is low in zircon, high in tourmaline and contains typically plutonic heavy minerals, indicating a plutonic igneous source. Angularity of the grains suggests that the source is nearby.

The gross mineralogy of the heavy minerals of the Colinlea Sandstone, and its distribution, indicates that it was probably derived from the source area to the north.

Correlation, as proposed in Bastian (1965) of the bulk of the Colinlea Sandstone with the Aldebaran Sandstone, and of the top of the Colinlea Sandstone with the Catherine Sandstone is supported in most respects by these heavy mineral studies. The gross heavy mineralogies are similar, and there is a very good degree of correspondence on the Z:T:R diagrams. Minor differences have been explained above, or can be explained by the fact that the Colinlea Sandstone was deposited closer to the source area than were the

Aldebaran or Catherine Sandstones.

The Aldebaran and Catherine Sandstones cannot be separated, with any certainty, on the basis of heavy mineral analysis.

## References

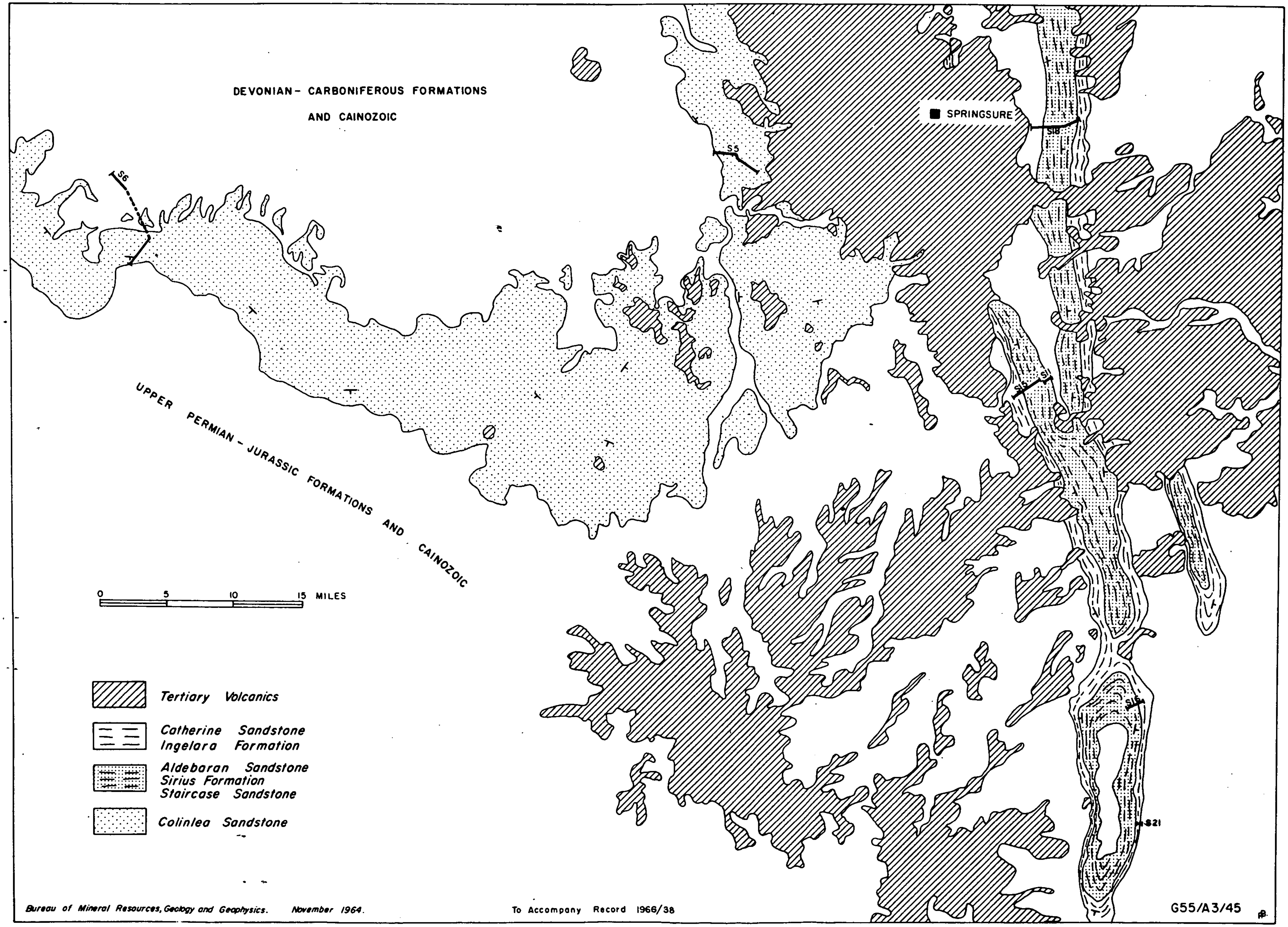
BASTIAN, L.V., (1965) Petrographic Notes on Permian Sandstones of the Springsure 1:250,000 Sheet Area, Queensland. Bur.Min.Res.Aust.Rec. 1965/230.

FOLK, R.L., (1965) Petrology of Sedimentary Rocks,

FIGURE 1.

# SPRINGSURE 1:250,000 Sheet Area

## Generalized geological map showing location of sections



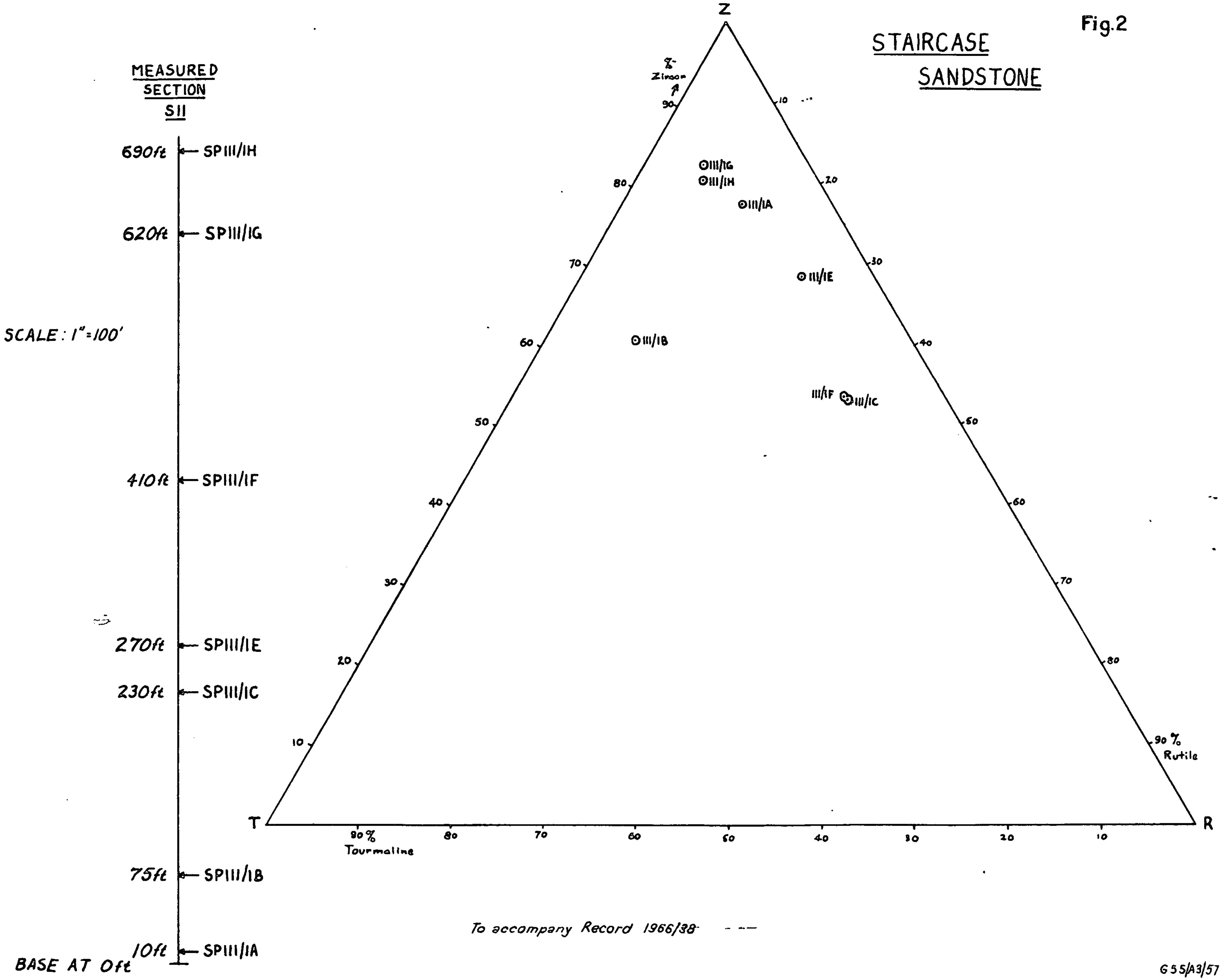

Bureau of Mineral Resources, Geology and Geophysics. November 1964.

To Accompany Record 1966/38

G55/A3/45

Fig.2

STAIRCASE SANDSTONE




To accompany Record 1966/38

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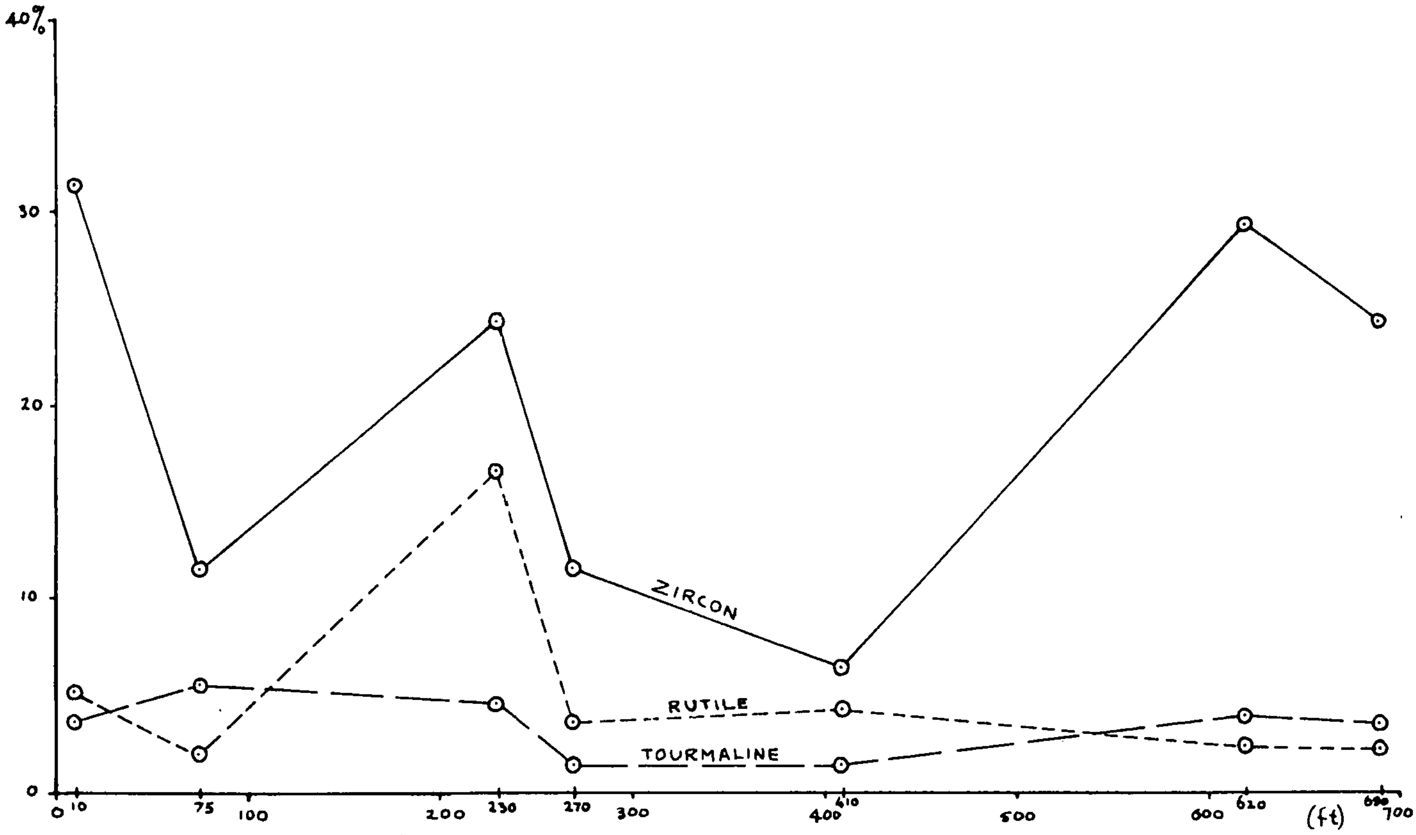
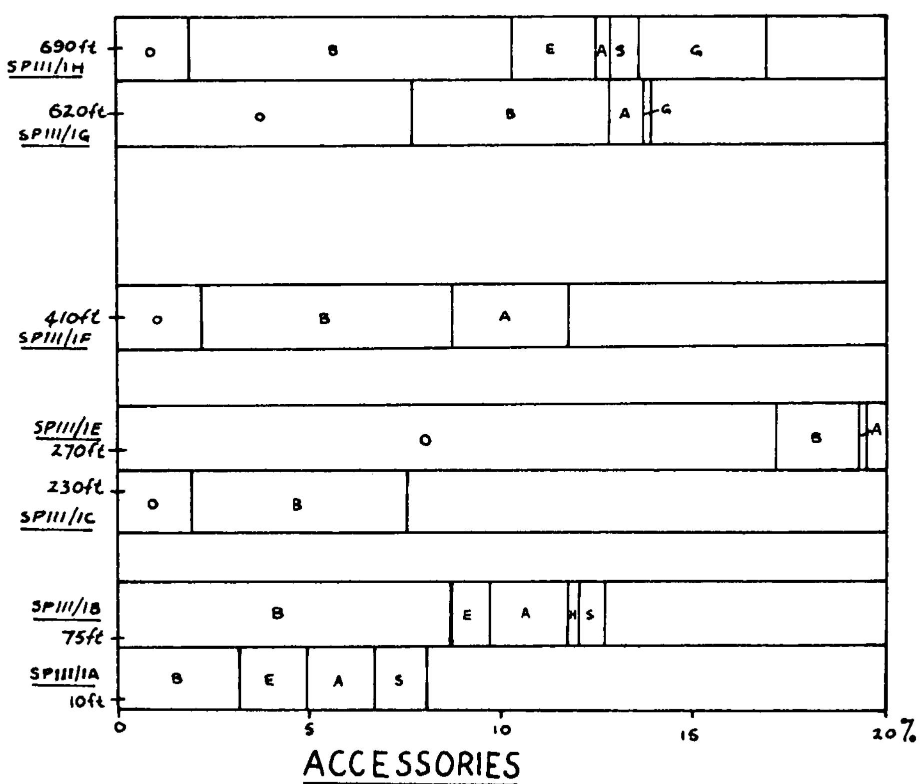
Fig. 3

# STAIRCASE SANDSTONE




A. GRAPH SHOWING VARIATION IN ZIRCON, TOURMALINE AND RUTILE AS PERCENTAGES OF TOTAL HEAVY MINERALS WITH STRATIGRAPHIC HEIGHT ABOVE THE BASE OF THE UNIT.

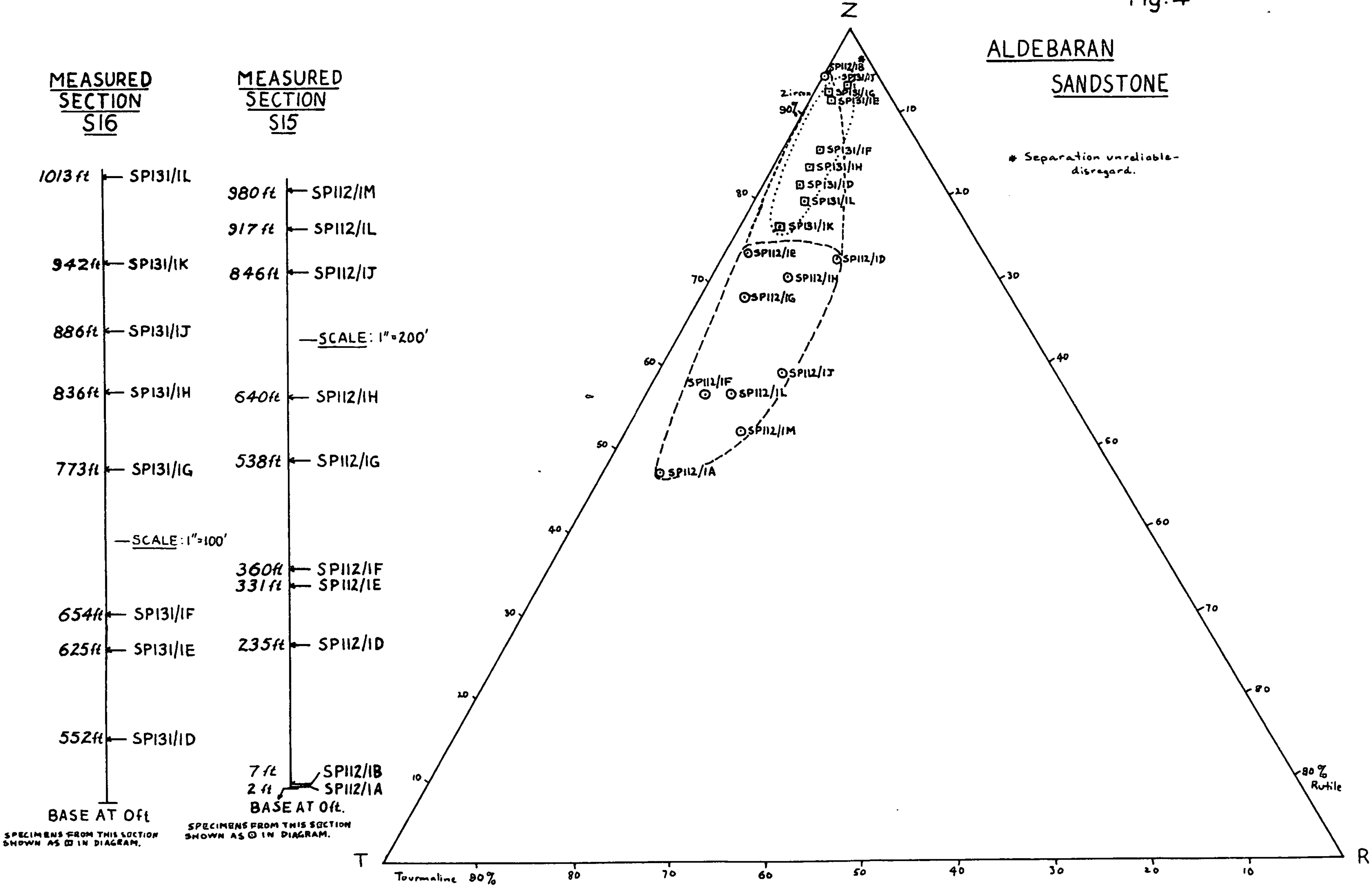



B. ACCESSORY HEAVY MINERAL SUITES DRAWN IN THEIR RELATIVE STRATIGRAPHIC POSITIONS TO SHOW VERTICAL VARIATIONS. A - Apatite, B - Biotite, E - Epidote, G - Garnet, H - Hornblende, O - Others (incl. some possible quartz and feldspar - see note in Introduction), S - Spinel; EXPRESSED AS PERCENTAGES OF TOTAL HEAVY MINERALS.

*To accompany Record 1966/38*

G55/A3/58

Fig. 4

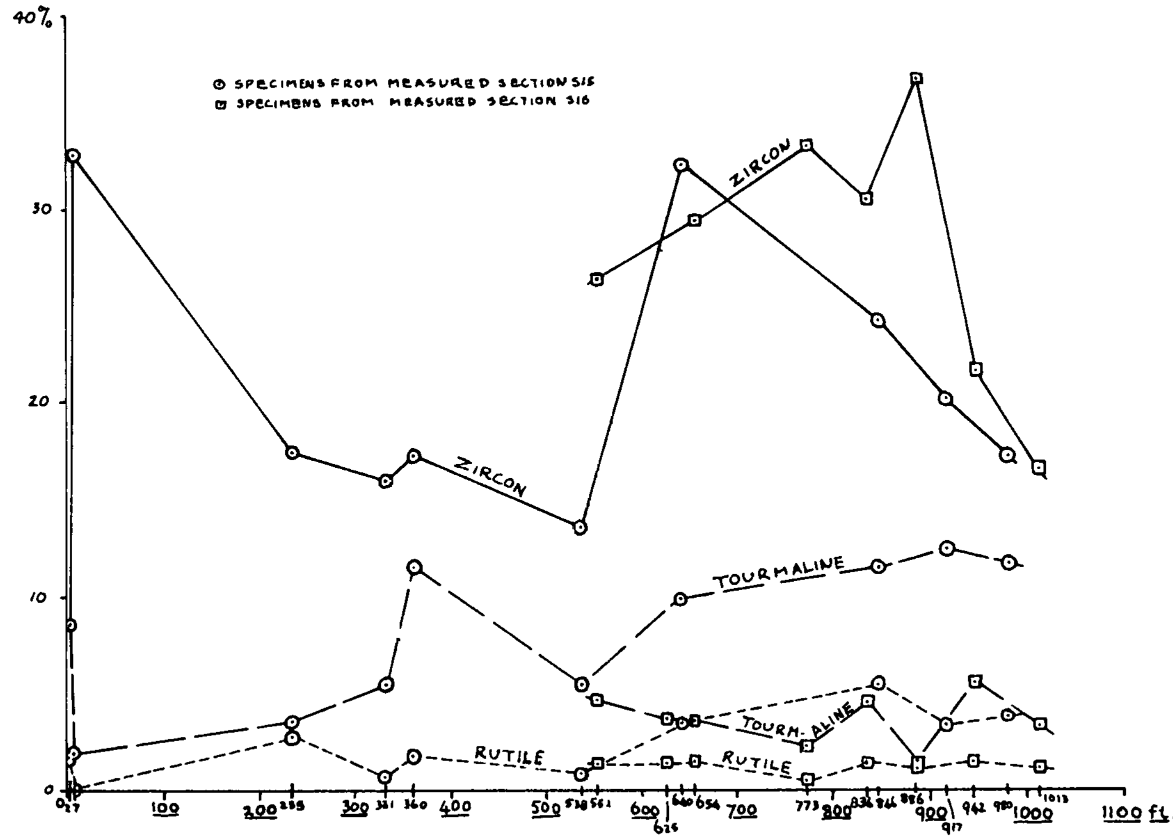



To accompany Record 1966/38

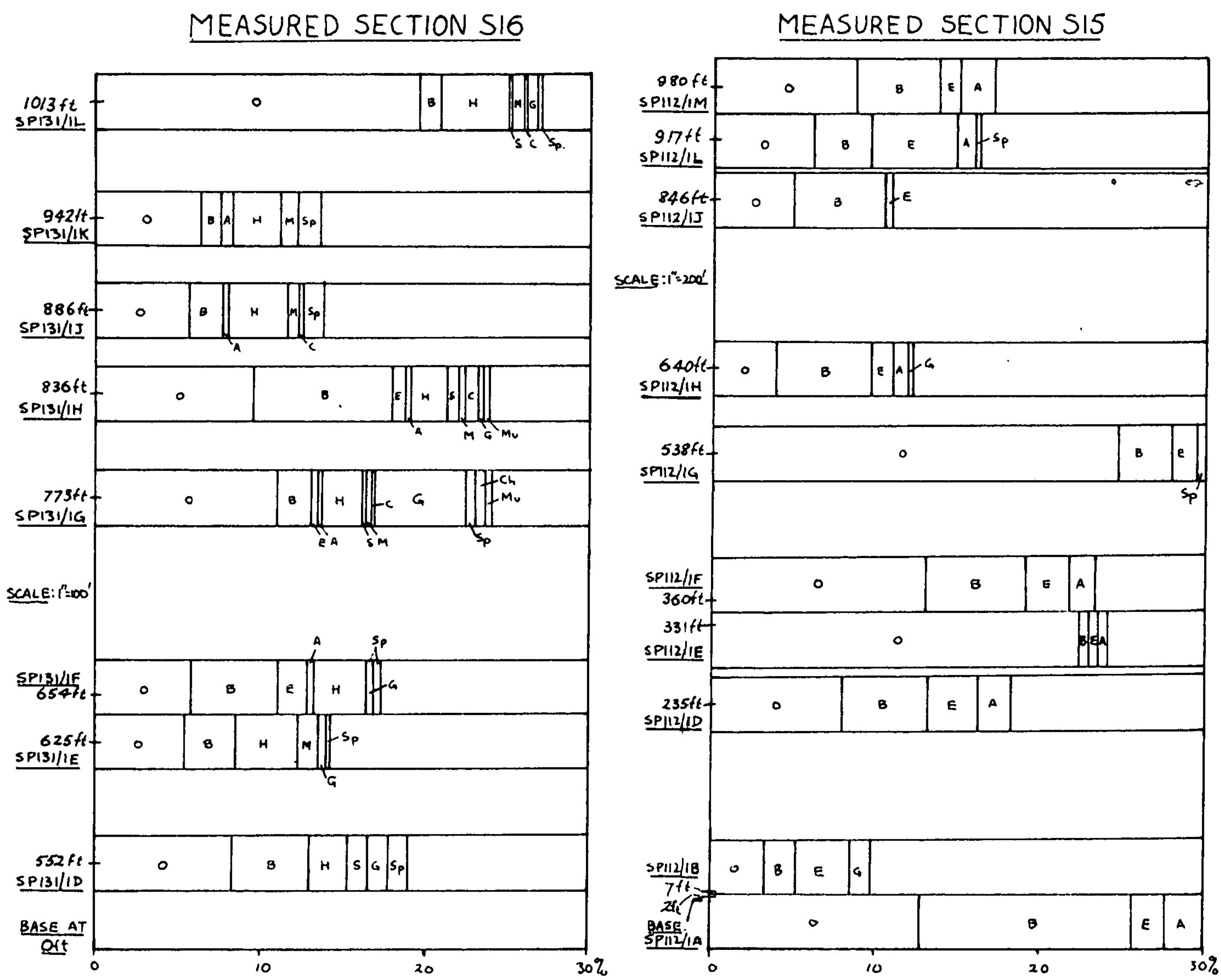
G55/A3/59

# ALDEBARAN SANDSTONE

Fig.5




A. GRAPH SHOWING VARIATIONS IN ZIRCON, TOURMALINE AND RUTILE, AS PERCENTAGES OF TOTAL HEAVY MINERALS, WITH STRATIGRAPHIC HEIGHT ABOVE THE BASE OF THE UNIT.




## ACCESSORIES

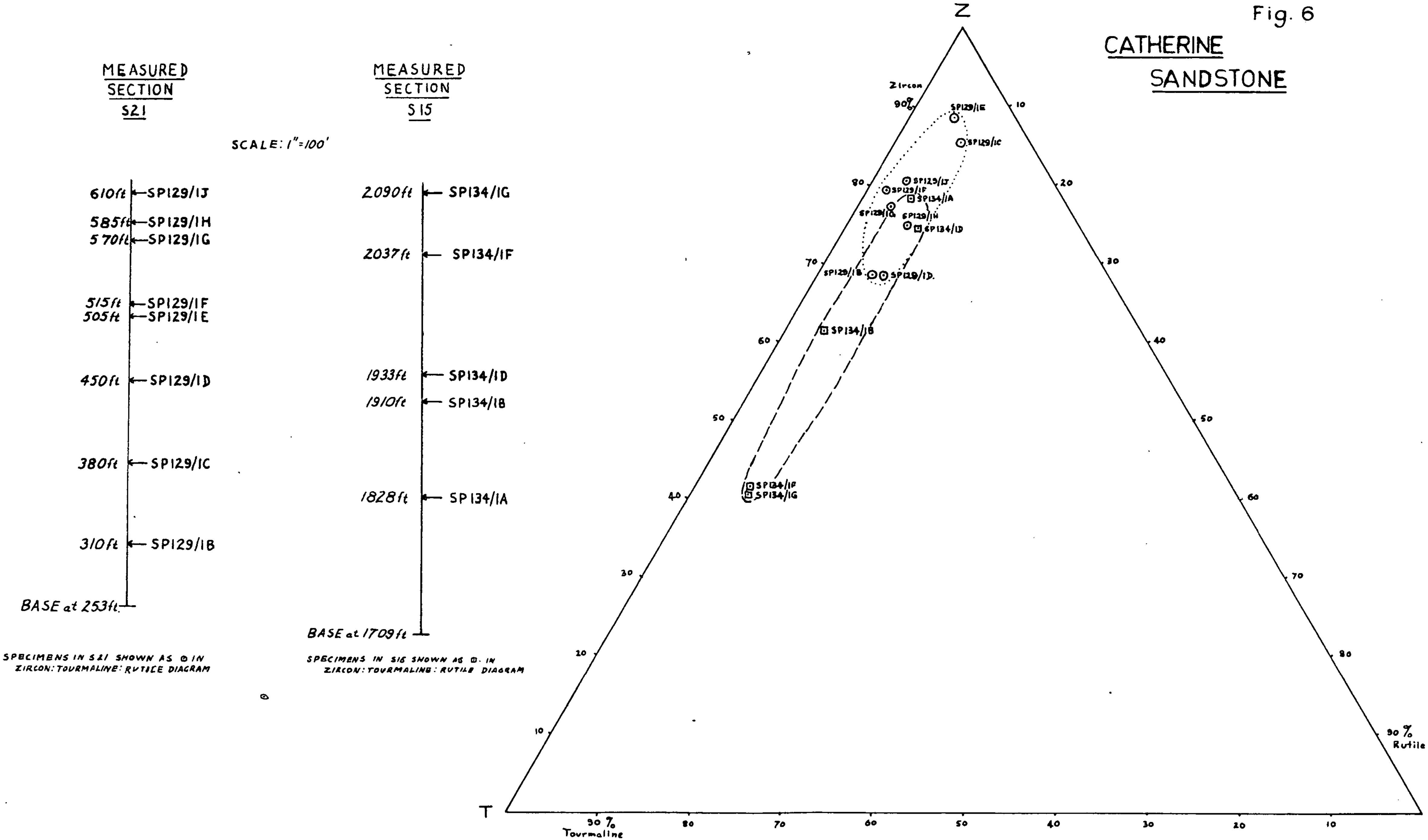
B. ACCESSORY HEAVY MINERAL SUITES DRAWN IN THEIR RELATIVE STRATIGRAPHIC POSITIONS TO SHOW VERTICAL VARIATIONS. A-Apatite, B-Biotite, C-Corundum, E-Epidote, G-Garnet, H-Hornblende, M-Monazite, Mu-Muscovite, O-Others (See note in Introduction), S-Spinel, Sp-Sphene, Ch-Chlorite; EXPRESSED AS PERCENTAGES OF TOTAL HEAVY MINERALS.

*To accompany Record 1966/38*

G55/A3/60

Fig. 6

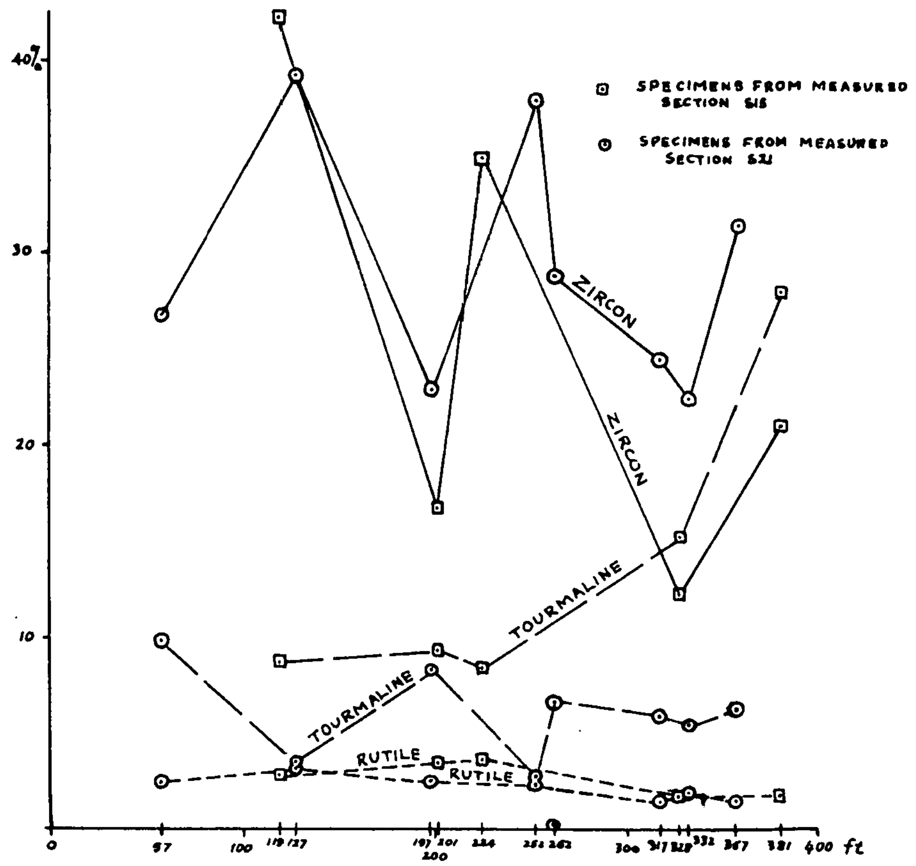
## CATHERINE SANDSTONE



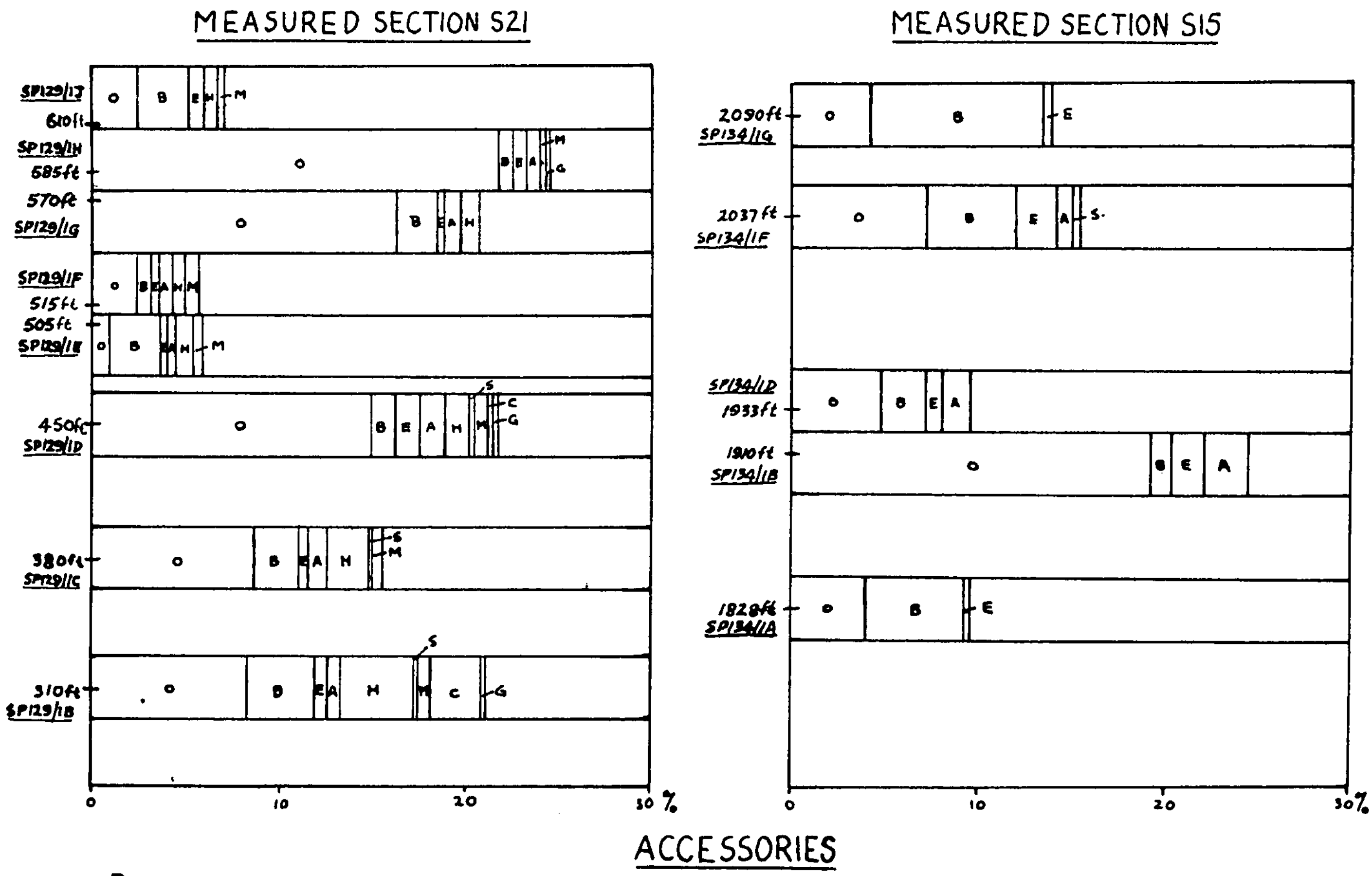

To accompany Record 1966/38 655/A3/61

Fig. 7

# CATHERINE SANDSTONE




A. GRAPH SHOWING VARIATIONS IN ZIRCON, TOURMALINE AND RUTILE AS PERCENTAGES OF TOTAL HEAVY MINERALS WITH STRATIGRAPHIC HEIGHT ABOVE THE BASE OF THE UNIT.



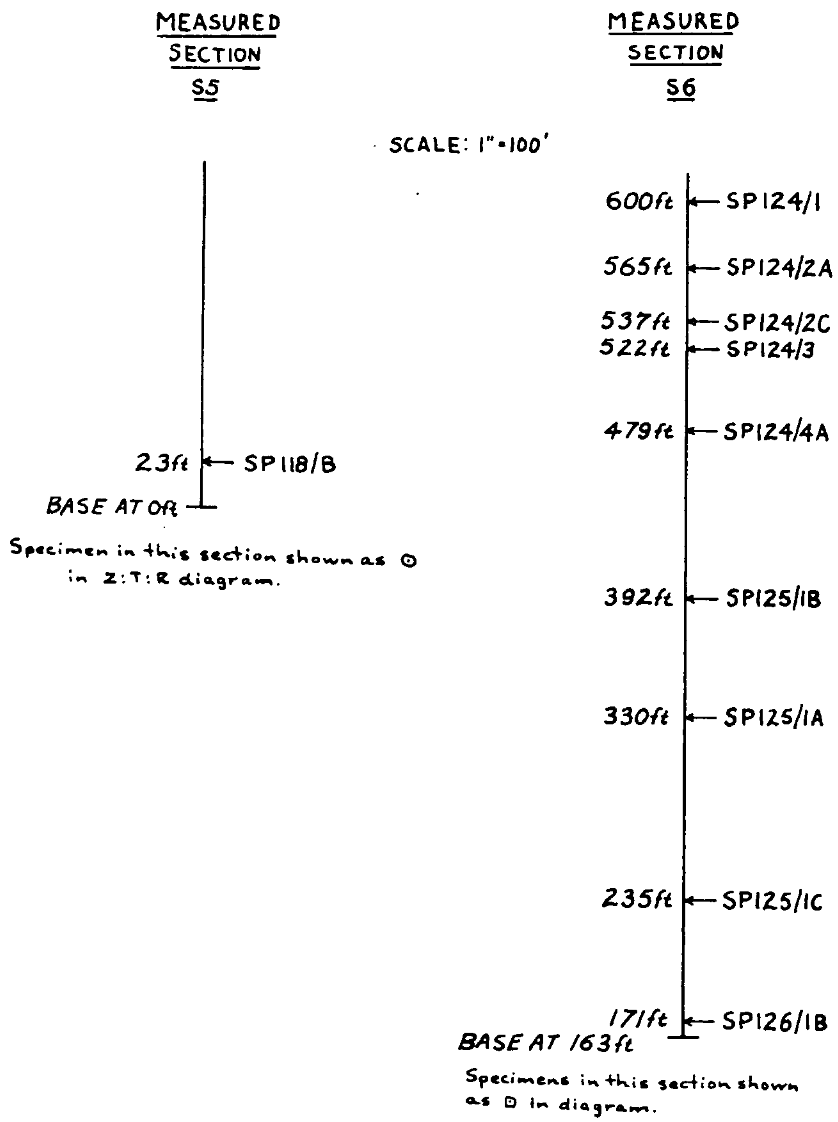

B. ACCESSORY HEAVY MINERAL SUITES DRAWN IN THEIR RELATIVE STRATIGRAPHIC POSITIONS TO SHOW VERTICAL VARIATIONS. A - Apatite, B - Biotite, C - Corundum, E - Epidote, G - Garnet, H - Hornblende, M - Monazite, O - Others (incl. some feldspar in some cases), S - Spinel; EXPRESSED AS PERCENTAGES OF TOTAL HEAVY MINERALS.

*To accompany Record 1966/38*

G55/A3/62

Fig. 8

# COLINLEA SANDSTONE



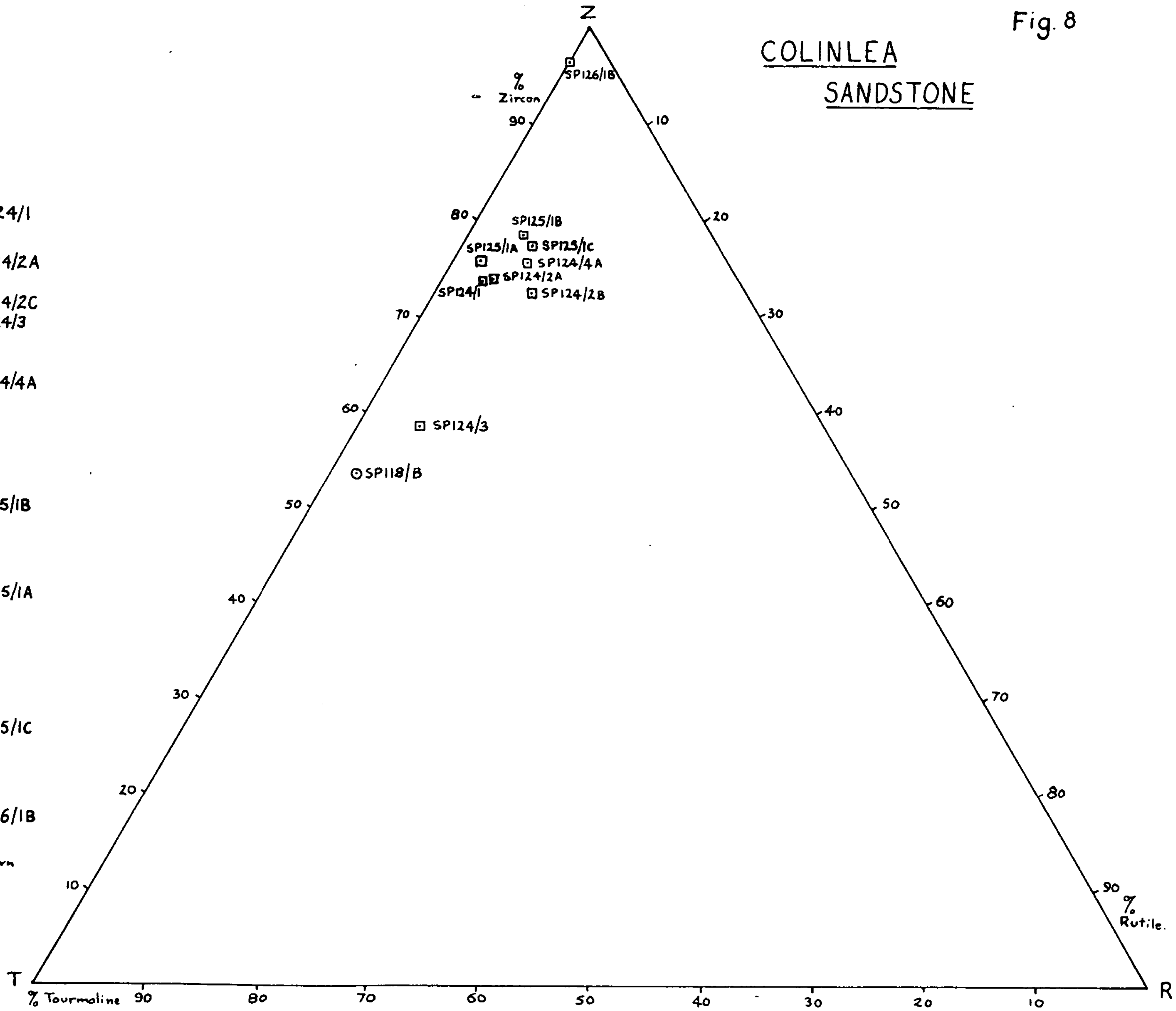




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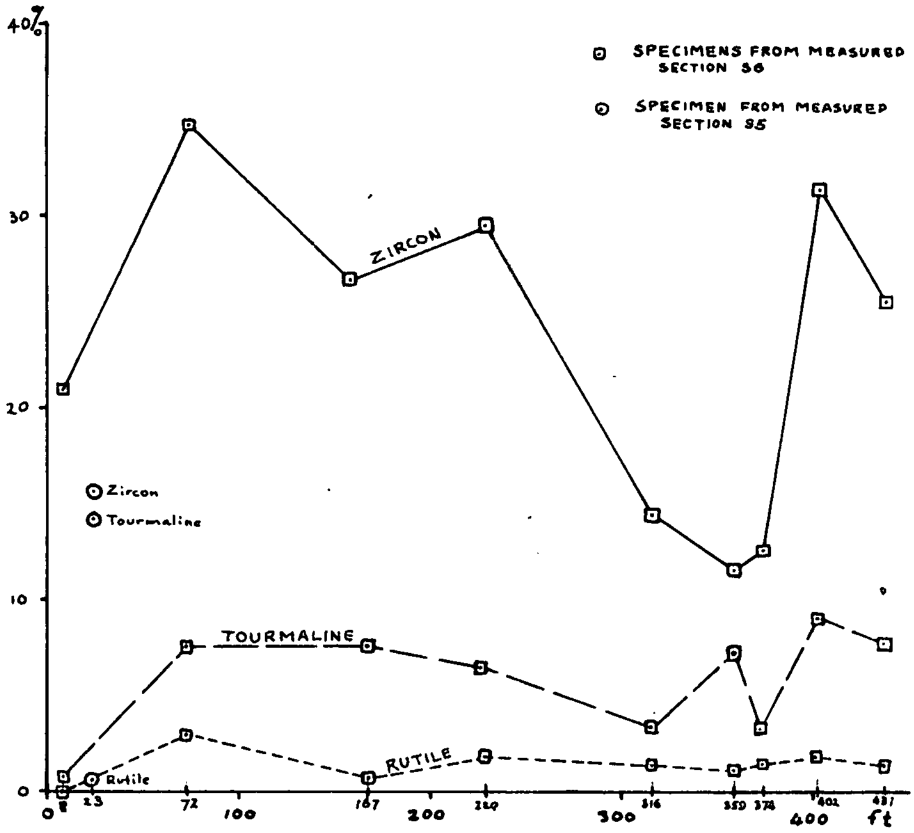
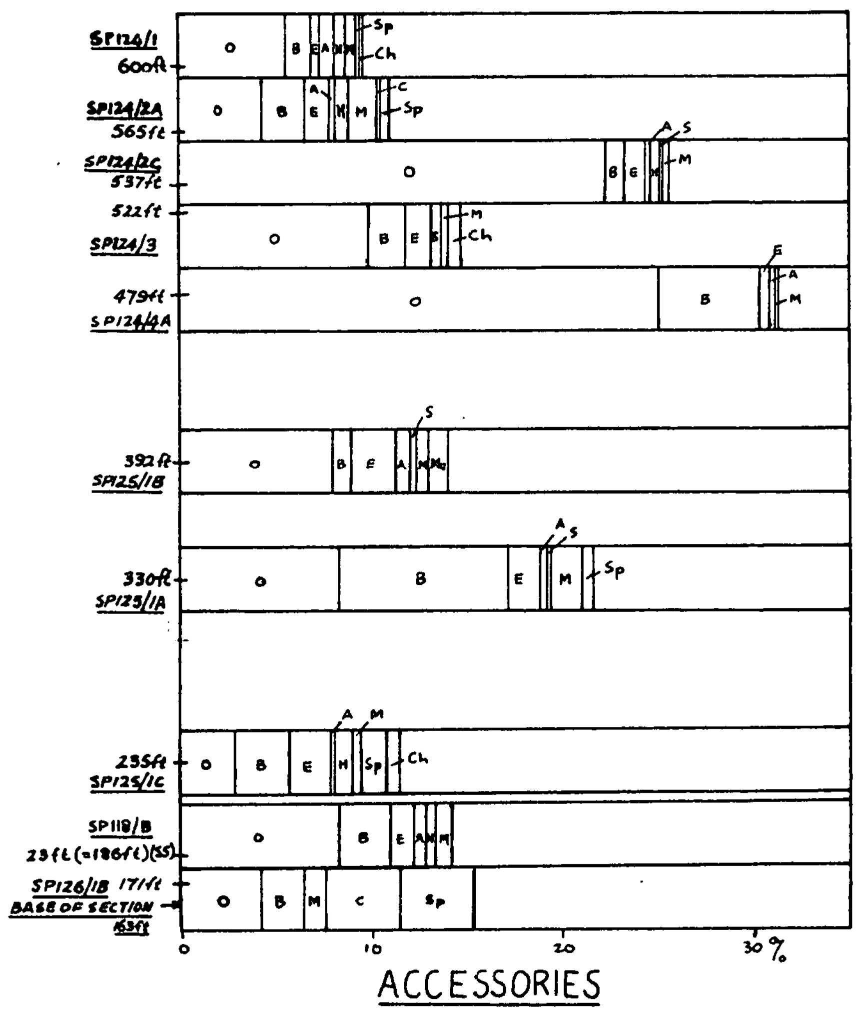
Fig. 9

# COLINLEA SANDSTONE




A. -GRAPH SHOWING VARIATIONS IN ZIRCON, TOURMALINE AND RUTILE, AS PERCENTAGES OF TOTAL HEAVY MINERALS, WITH STRATIGRAPHIC HEIGHT ABOVE THE BASE OF THE UNIT.




B. -ACCESSORY HEAVY MINERAL SUITES DRAWN IN THEIR RELATIVE STRATIGRAPHIC POSITIONS TO SHOW VERTICAL VARIATIONS. A-Apatite, B-Biotite, C-Corundum, Ch-Chlorite, E-Epidote, G-Garnet, H-Hornblende, M-Monazite, Mu-Muscovite, O-Others (See note in Introduction), S-Spinel, Sp-Sphene; EXPRESSED AS PERCENTAGES OF TOTAL HEAVY MINERALS.

*To accompany Record 1966/38*

655/A3/64

Table 1

## HEAVY MINERAL ANALYSES

| Unit | Specimen Number | Zircon (%) | Tourmaline (%) | Rutile (%) | Monazite (%) | Spinel (%) | Sphene (%) | Hornblende (%) | Biotite (%) | Chlorite (%) | Muscovite (%) | Apatite (%) | Garnet (%) | Corundum (%) | Epidote (%) | Opaques (%) | Others (%) (incl. some quartz & feldspars) | ? Azurite (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAIRCASE SANDSTONE | SP111/1A | 31.47 | 3.85 | 5.24 | * | 1.40 | | + | 3.15 | ‡ | | 1.75 | | | 1.75 | 51.40 | ǂ | |
| | SP111/1B | 11.74 | 5.70 | 2.01 | * | 0.67 | | 0.34 | 8.72 | ‡ | | 2.01 | | | 1.01 | 47.99 | ǂ | |
| | SP111/1C | 24.30 | 4.67 | 16.82 | * | | | + | 5.61 | ‡ | | | | | | 46.73 | 1.87 | |
| | SP111/1E | 11.75 | 1.27 | 3.80 | * | | | + | 2.17 | ‡ | | 0.20 | | | | 63.29 | 17.18 | |
| | SP111/1F | 6.55 | 1.31 | 4.37 | * | | | + | 6.55 | ‡ | | 3.06 | | | | 75.98 | 2.18 | |
| | SP111/1G | 29.44 | 3.97 | 2.34 | * | | | + | 5.14 | ‡ | | 0.93 | 0.20 | | | 50.23 | 7.71 | |
| | SP111/1H | 24.17 | 3.66 | 2.20 | * | 0.74 | | + | 8.42 | ‡ | | 0.37 | 3.30 | | 2.20 | 53.11 | 1.83 | |
| ALDEBARAN SANDSTONE, REIDS DOME | SP131/1D | 26.19 | 4.76 | 1.19 | | 1.19 | 1.19 | 2.38 | 4.76 | | | | 1.19 | | | 48.81 | 8.33 | |
| | SP131/1E | 55.55 | 3.77 | 1.26 | 1.26 | | 0.21 | 3.77 | 3.14 | | | | 0.42 | | | 25.16 | 5.45 | 0.21 |
| | SP131/1F | 29.20 | 3.54 | 1.33 | | | 0.44 | 3.10 | 5.31 | | | 0.44 | 0.44 | | 1.77 | 48.67 | 5.75 | |
| | SP131/1G | 33.19 | 2.16 | 0.43 | 0.29 | 0.19 | 0.43 | 2.45 | 2.02 | 0.58 | 0.43 | 0.19 | 5.48 | 0.19 | 0.43 | 40.40 | 11.11 | |
| | SP131/1H | 30.39 | 4.59 | 1.41 | 0.35 | 0.72 | | 2.12 | 8.48 | | 0.35 | 0.35 | 0.35 | 0.72 | 0.72 | 39.93 | 9.54 | |
| | SP131/1J | 36.87 | 1.47 | 1.18 | 0.59 | | 1.18 | 3.54 | 2.06 | | | 0.29 | | 0.29 | | 46.90 | 5.60 | |
| | SP131/1K | 21.70 | 5.53 | 1.21 | 1.04 | | 1.38 | 2.94 | 1.21 | | | 0.69 | | | | 58.03 | 6.39 | |
| | SP131/1L | 16.58 | 3.18 | 1.06 | 0.66 | 0.13 | 0.26 | 4.11 | 1.33 | | | | 0.66 | 0.13 | | 52.25 | 19.63 | |
| ALDEBARAN SANDSTONE | SP112/1A | 9.85 | 9.85 | 1.85 | * | | | + | 12.92 | ‡ | | 2.77 | | | 2.15 | 47.69 | 12.92 | |
| | SP112/1B | 32.89 | 1.97 | | * | | | + | 1.97 | ‡ | | | 1.32 | | 3.29 | 55.26 | 3.29 | |
| | SP112/1D | 17.28 | 3.66 | 2.84 | * | | | + | 5.28 | ‡ | | 2.03 | | | 3.05 | 57.93 | 7.93 | |
| | SP112/1E | 15.96 | 5.32 | 0.53 | * | | | + | 0.53 | ‡ | | 0.53 | | | 0.53 | 54.25 | 22.34 | |
| | SP112/1F | 17.18 | 11.45 | 1.91 | * | | | + | 6.11 | ‡ | | 1.53 | | | 2.67 | 46.18 | 12.98 | |
| | SP112/1G | 13.66 | 5.46 | 0.96 | * | | 0.55 | + | 3.41 | ‡ | | | | | 1.64 | 45.76 | 24.59 | |
| | SP112/1H | 32.18 | 9.95 | 3.62 | * | | | + | 5.79 | ‡ | | 0.90 | 0.36 | | 1.27 | 42.13 | 3.80 | |
| | SP112/1J | 24.14 | 11.49 | 5.29 | * | | | + | 5.52 | ‡ | | | | | 0.46 | 48.28 | 4.83 | |
| | SP112/1L | 20.15 | 12.42 | 3.17 | * | | 0.25 | + | 3.42 | ‡ | | 1.14 | | | 5.20 | 48.16 | 6.08 | |
| | SP112/1M | 17.10 | 11.84 | 3.95 | * | | | + | 5.00 | ‡ | | 2.10 | | | 1.32 | 50.00 | 8.68 | |
| CATHERINE SANDSTONE | SP134/1A | 42.08 | 8.80 | 2.93 | * | | | | 5.28 | ‡ | | | | | 0.29 | 36.66 | 3.96 | |
| | SP134/1B | 16.51 | 9.12 | 3.14 | * | | | | 1.10 | ‡ | | 2.36 | | | 1.73 | 47.96 | 19.18 | |
| | SP134/1D | 34.90 | 8.18 | 3.71 | * | | | | 2.40 | ‡ | | 1.53 | | | 0.87 | 43.62 | 4.80 | |
| | SP134/1F | 12.02 | 15.02 | 1.72 | * | 0.43 | | | 4.72 | ‡ | | 0.86 | | | 2.15 | 53.65 | 7.30 | 2.15 |
| | SP134/1G | 20.93 | 27.91 | 2.79 | * | | | | 9.30 | ‡ | | | | | 0.46 | 34.42 | 4.19 | |
| | SP129/1B | 26.80 | 9.87 | 2.31 | 0.73 | 0.12 | | 3.90 | 3.53 | ‡ | | 0.61 | 0.12 | 2.68 | 0.61 | 40.68 | 8.28 | |
| | SP129/1C | 39.08 | 3.43 | 3.23 | 0.49 | 0.10 | | 2.15 | 2.45 | ‡ | | 0.98 | 0.02 | | 0.50 | 39.18 | 8.72 | |
| | SP129/1D | 22.87 | 8.12 | 2.37 | 0.62 | 0.25 | | 1.25 | 1.25 | ‡ | | 1.37 | 0.25 | 0.25 | 1.37 | 45.00 | 15.00 | |
| | SP129/1E | 37.80 | 2.73 | 2.09 | 0.36 | | | 0.91 | 2.64 | ‡ | | 0.46 | | 0.01 | 0.29 | 51.73 | 1.00 | |
| | SP129/1F | 28.70 | 6.69 | 0.77 | 0.64 | | | 0.64 | 0.77 | ‡ | | 0.64 | | | 0.39 | 58.30 | 2.44 | |
| | SP129/1G | 24.11 | 5.93 | 1.19 | | | | 0.99 | 2.17 | ‡ | | 0.79 | | | 0.40 | 48.02 | 16.40 | |
| | SP129/1H | 22.15 | 5.45 | 1.94 | 0.23 | | | | 0.73 | ‡ | | 0.73 | 0.12 | | 0.73 | 46.37 | 21.79 | |
| | SP129/1J | 31.24 | 6.11 | 1.40 | 0.35 | | | 0.70 | 2.80 | ‡ | | | | | 0.87 | 54.10 | 2.44 | |
| COLINLEA SANDSTONE | SP118/B | 16.49 | 14.01 | 0.70 | 0.88 | | | 0.53 | 2.65 | | | 0.53 | | | 1.23 | 55.26 | 8.25 | |
| | SP124/1 | 25.67 | 7.89 | 1.33 | 0.55 | | 0.22 | 0.55 | 1.33 | 0.11 | | 0.78 | | | 0.44 | 55.55 | 5.55 | 0.21 |
| | SP124/2A | 31.17 | 9.07 | 1.94 | 1.48 | | 0.46 | 0.65 | 2.22 | | | 0.27 | | 0.09 | 1.29 | 46.90 | 4.35 | |
| | SP124/2B | 12.82 | 3.35 | 1.58 | 0.28 | 0.10 | | 0.49 | 0.98 | | | 0.19 | | | 1.08 | 57.20 | 22.19 | |
| | SP124/3 | 11.82 | 7.23 | 1.15 | 0.33 | 0.49 | | | 1.97 | 0.66 | | | | | 1.31 | 63.55 | 9.85 | |
| | SP124/4A | 14.23 | 3.33 | 1.28 | 0.13 | | | | 5.26 | | | 0.26 | | | 0.52 | 50.00 | 25.00 | |
| | SP125/1A | 26.71 | 7.70 | 0.86 | 1.57 | 0.14 | 0.57 | | 8.84 | | | 0.29 | | | 1.57 | 43.51 | 8.27 | |
| | SP125/1B | 29.40 | 6.26 | 1.93 | 0.72 | 0.24 | | | 0.96 | | 0.96 | 0.72 | | | 2.41 | 48.43 | 7.95 | |
| | SP125/1C | 34.68 | 7.38 | 2.91 | 0.45 | | 1.34 | 0.90 | 2.80 | 0.56 | | 0.11 | | | 2.12 | 43.96 | 2.80 | |
| | SP126/1B | 20.83 | 0.76 | | 1.14 | | 3.79 | | 2.28 | | | | | 3.79 | | 61.74 | 4.17 | |

* Monazite rare - included with tourmaline.
\+ Hornblende rare - included with biotite.
ǂ Included with opaques - rare.
‡ Chlorite very rare or absent - where present, included with biotite.
Muscovite is also exceedingly rare and some grains may be included in "Others".

Sphene is very rare; some sphene may have been recorded as zircon because of its close resemblance when rounded to brown zircon.