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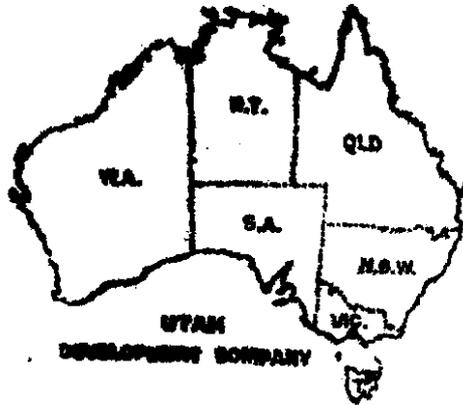
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Report on Q31
RESULTS OF PHOSPHATE TESTING
in the
DEN RANGE, N. E. TASMANIA.

No. 155.

August, 1968.

(3)



by
Peter Rix,
Senior Geologist.

Melbourne,
Australia.

Report No. 155.

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SUMMARY

Phosphate exploration in both Permian and Lower Paleozoic rocks of Tasmania carried out under the direction of Mr. M. Banks, the Company consultant, defined the Lower Paleozoic Mathinna Beds of northern Tasmania as the rocks with the greatest phosphate potential.

In the Mathinna Beds of the Den Range, secondary wavellite on joint and cleavage faces in the slates was found to occur in a narrow zone parallel to the strike. The wavellite zone is exposed intermittently over a length of about $2\frac{1}{2}$ miles and is 15 - 20 feet wide on the surface.

Costeaming of the wavellite zone and adjacent slates revealed that the wavellite continues in depth and is restricted to massive beds of silty slate in which jointing is well developed. Chemical testing of about 230 samples from about 1,000 feet of stratigraphic section exposed in the costeams did not reveal any primary phosphate in the sediments. However, a decomposed igneous rock exposed in one costean was found to contain 1.5% P_2O_5 present as apatite.

It is concluded that this rock, a probable lamphrophyre of Devonian age is the likely source of the secondary wavellite in the Den Range. This type of occurrence has no economic potential and it is recommended that we do not renew Exploration Licence 2/67.

INTRODUCTION

Background

Company phosphate investigations were re-opened in late 1966 after three years of inactivity due to an unfavourable Government policy on phosphate. The program was under the direction of Mr. O. N. Warin who had selected the Lower Paleozoic rocks of eastern Australia as a potential phosphogenic province.

It was considered that Coastal Queensland and Tasmania had the greatest potential within the Lower Paleozoic belt, and phosphate investigations were carried out in both areas. The Queensland phosphate search is documented in U. D. C. Report Number 148 by P. Rix, which also includes a background study of the geology of phosphorite and its application to phosphate search in Australia.

Concurrently with the Queensland work and programme of mapping, sampling and section measuring was carried out in Tasmania by postgraduate students of the University of Tasmania, under the direction of Mr. M. R. Banks, Reader in Geology at the University of Tasmania, consulting for the Company. The results of this work are summarised below.

Consulting Work

The consulting work in Tasmania is documented in three consultant's reports :

- | | |
|-----------|---|
| C. R. 575 | Reconnaissance Search for Phosphate - Tasmania, by M. R. Banks. |
| C. R. 581 | Reconnaissance Search for Phosphate in West Tasmania, by M. R. Banks. |
| C. R. 584 | Phosphate Search in the Den Range, Back Creek Area, North East Tasmania by M. R. Banks and E. A. Smith. |

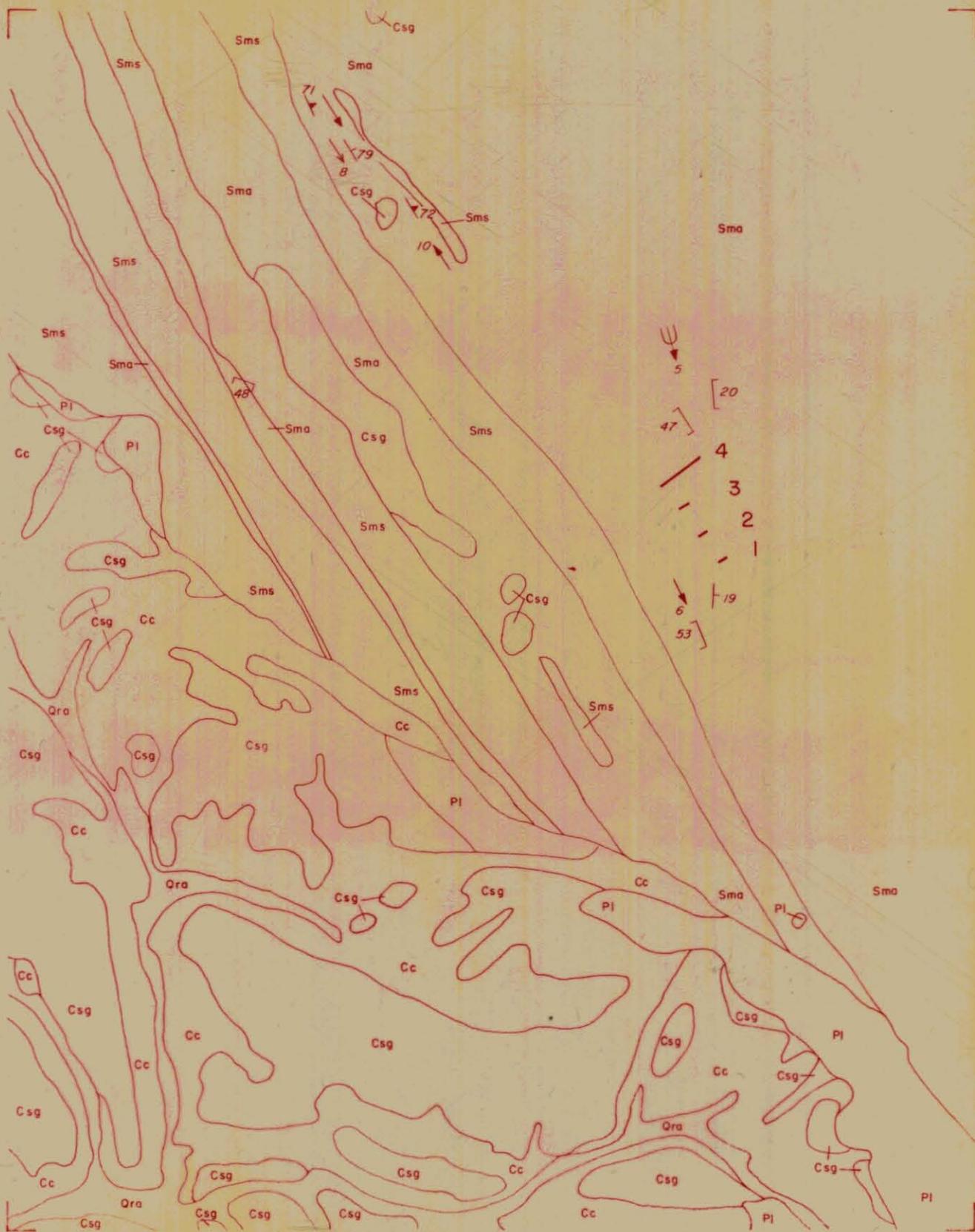
The first two reports record the results of reconnaissance mapping, sampling and section measuring in both Permian and Lower Paleozoic rocks. From this work, the Den Range of north-east Tasmania (Fig 1) emerged as the most attractive area. Here secondary phosphate mineralisation with apparent stratigraphic control occurs in the slate of the Lower Paleozoic Mathinna Beds. Further work was concentrated in this area and systematic mapping and sampling was done. U. D. C. Report Number 154 is a detailed record of this phase of the investigations; it includes a thorough study of possible structural and stratigraphic interpretation and their relevance to the search for primary phosphate mineralisation in the Den Range.

The secondary phosphate mineral, wavellite, occurs in joints and in fault breccias in the slates, and is confined to a narrow zone that parallels the strike of the beds. The wavellite zone is exposed intermittently over a length of about $2\frac{1}{2}$ miles and is 15 - 20 feet wide on the surface; using an assumed grade of 1% wavellite, it is estimated that the zone contains about 50 tons of redistributed P_2O_5 per vertical foot.

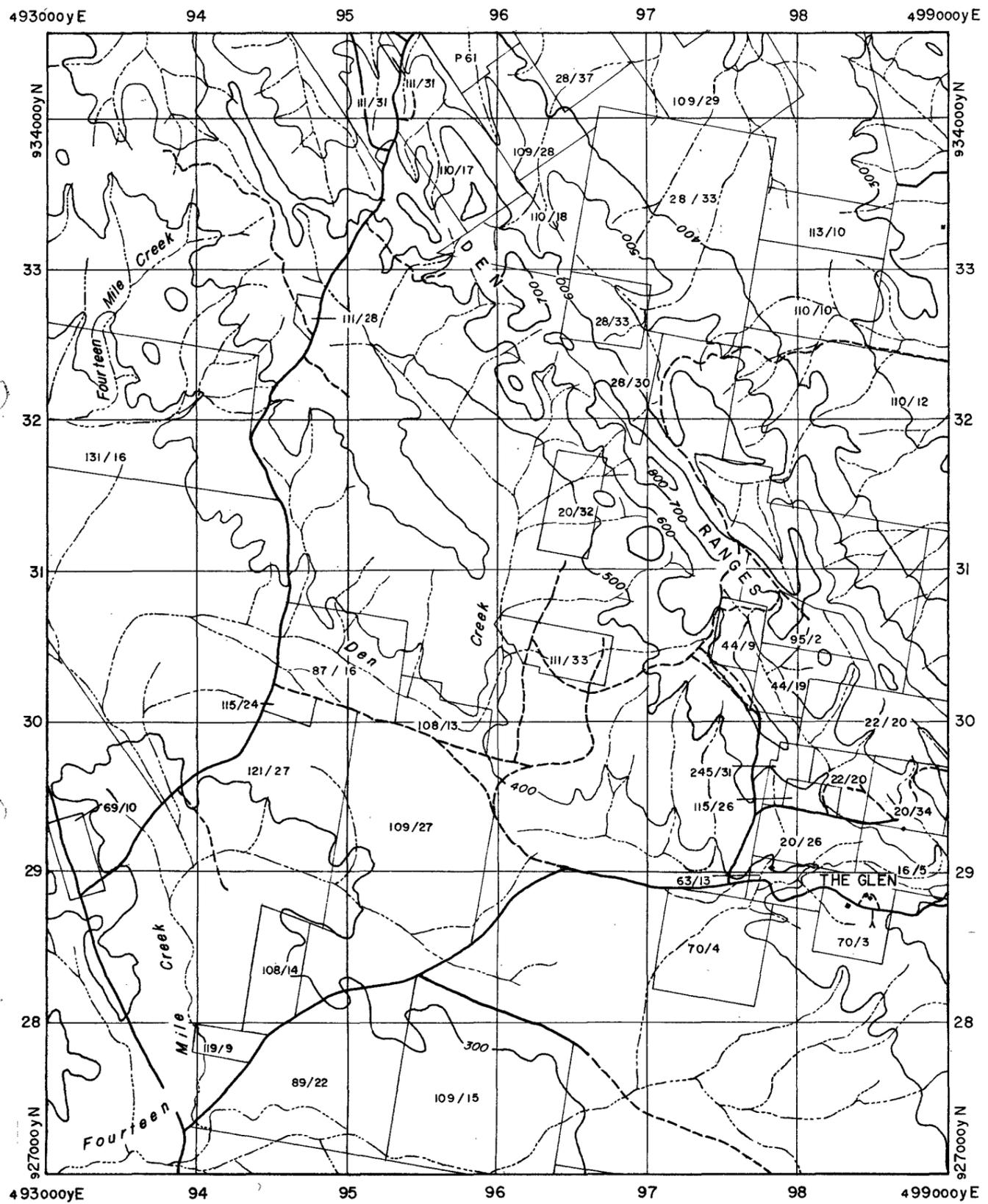
Rock exposure is extremely poor in this area and no definite conclusion was reached as to the origin of the wavellite or the possible location of primary phosphate mineralisation. Alternative hypotheses were proposed for the source of the wavellite:

- (1) The primary phosphate lies below the Den Range and the wavellite occupies a crush zone along the crest of an antiform in the cleavage.
- (2) The primary phosphate source was topographically above the Den Range within the arenite-lutite association of the Mathinna Beds but has subsequently been eroded.
- (3) The primary phosphate was of distinctly younger age (e. g. Permian) and was again topographically above the Den Range in rocks which have since been eroded. In this hypothesis the secondary phosphate would have been leached down later, probably in the Tertiary.

Recommendations for sub-surface testing of the sequence were made. These were : horizontal drilling from the flank of the Range to test



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TOPOGRAPHIC LEGEND

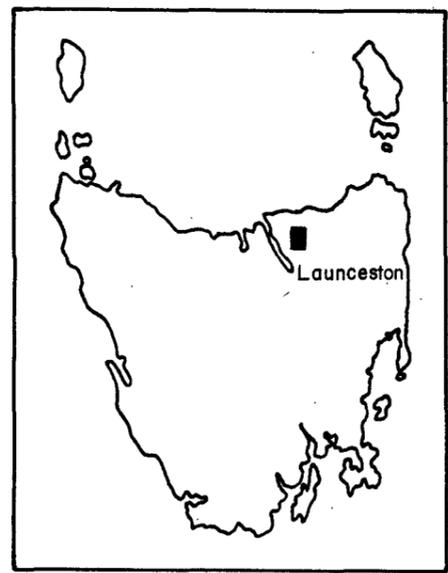
- Sealed Roads
- Tracks
- Land holding boundaries and reference number
- Building
- Stream
- Contour

GEOLOGICAL LEGEND

- Geological boundary - approximate
- Dip and strike of bedding
- Plunge of minor antiform
- Strike and dip of cleavage
- Strike and dip of strain slip cleavage
- Plunge of lineation
- Costean

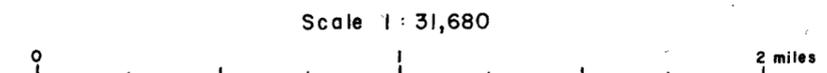
QUATERNARY	Qra	Alluvial deposits
CAINOZOIC	Cc	Silt and clay with occasional pebbles
	Csg	Round and angular gravel, mainly vein quartz
LOWER PERMIAN	Pl	Conglomerate and pebbly mudstone and sandstone
SILURIAN	Sms	Siltstone and sandstone
	Sma	Slate and phyllite

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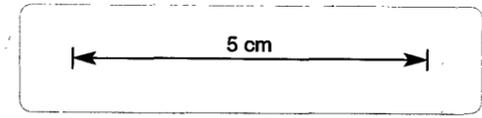


LOCALITY DIAGRAM OF AREA COVERED BY THIS REPORT

LOCALITY MAP
DEN RANGE
N.E. TASMANIA



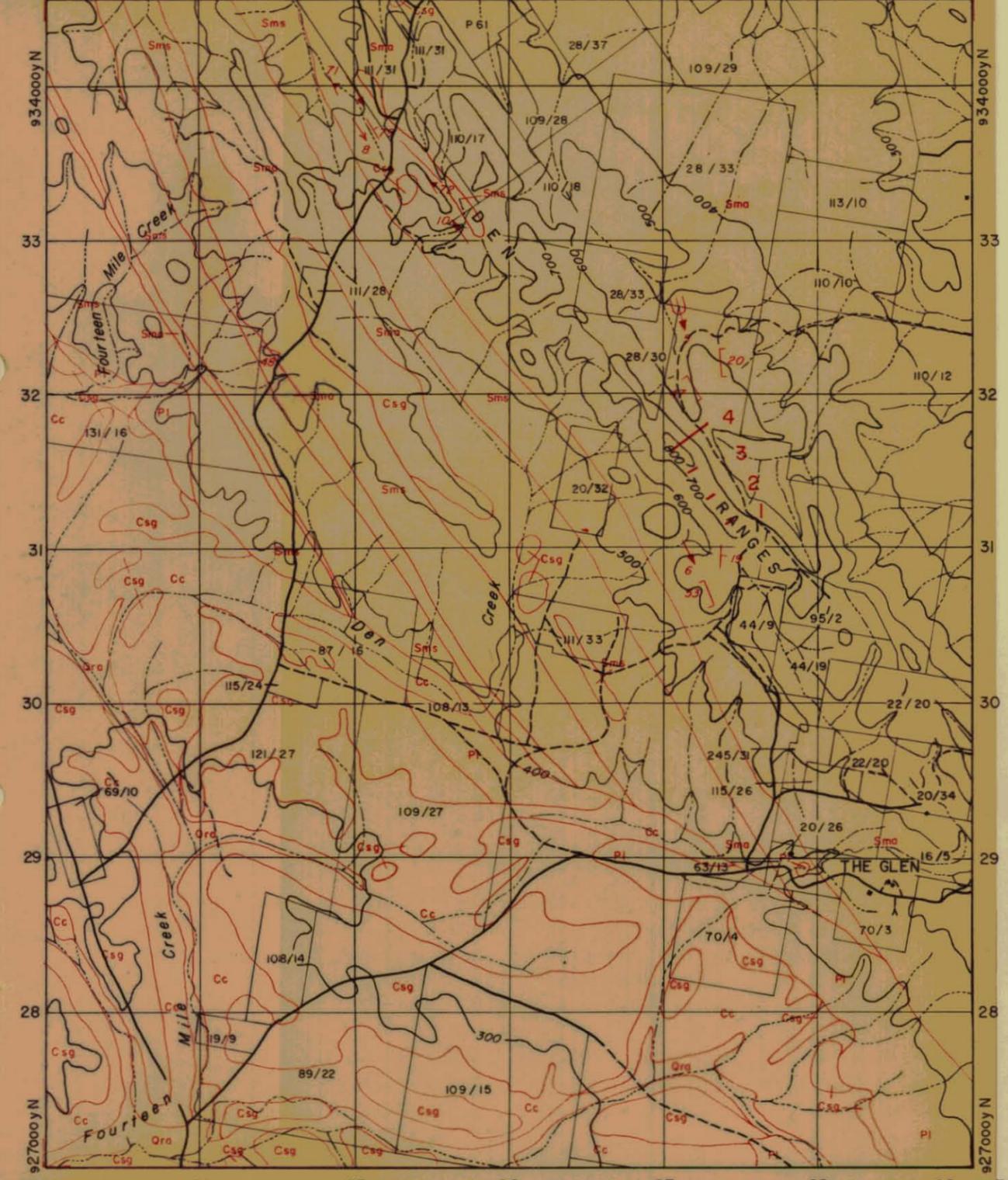
Scale 1 : 31,680



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Figure 1
Report No 155
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August, 1968

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493000yE 94 95 96 97 98 499000yE

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TOPOGRAPHIC LEGEND

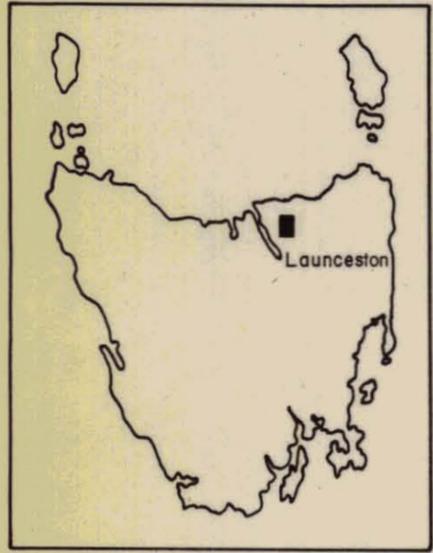
- Sealed Roads
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GEOLOGICAL LEGEND

- Geological boundary - approximate
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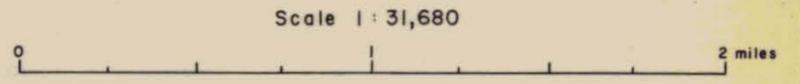
QUATERNARY	Qra	Alluvial deposits
CAINOZOIC	Cc	Silt and clay with occasional pebbles
	Csg	Round and angular gravel, mainly vein quartz
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SILURIAN	Sms	Siltstone and sandstone
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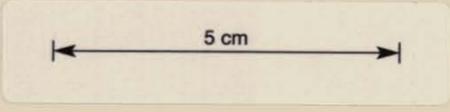


LOCALITY DIAGRAM OF AREA COVERED BY THIS REPORT

LOCALITY MAP
DEN RANGE
N.E. TASMANIA



Contour Interval 100 feet



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Figure I
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hypothesis (1), costeaning to test hypothesis (2), and field examination of remnants of the former Permian cover to test hypothesis (3).

In the event, it was considered that such inconclusive results did not justify drilling. Consequently, costeaning was chosen as the means of testing both the wavellite zone and the adjacent strata for primary phosphate. Hypothesis (3) was discounted after field examination of nearby Permian rocks.

COSTEANS

Location and Access (Fig 1)

The costeans are located in the Den Range, 20 miles north of Launceston. They are reached by way of the East Tamar Highway (sealed) for 16 miles to Mt. Direction; the old Georgetown road (sealed) for 4 miles to The Glen turn-off; a gravel road for $2\frac{1}{2}$ miles to The Glen, and a rough forest track for $1\frac{1}{2}$ miles to the costean sites. The costeans are situated on Crown Land (Fig 1).

Dimensions

Four costeans were cut with a D6-size bulldozer; three (Nos. 1-3) are 100 - 150 feet long, 12 feet wide and have a maximum depth of 8 feet, and one (No. 4) is 1,000 feet long, 12 feet wide and has a maximum depth of 15 feet. All four costeans cut the wavellite zone that runs along the top of the Den Range, and No. 4 continues down the north east flank of the Range to expose adjacent strata (Fig 1).

Lithologies

The predominant rock type in the costeans is carbonaceous slate; the main variation within the slate sequence is the alternation of regularly-cleaved massive silty slate with highly carbonaceous fine grained slate showing distorted cleavage (Figs. II and III). Original sandy lenses (now quartz-mica phyllite) are rare in the Den Range sequence, which is part of the lutite association of the Mathinna Beds. The sandy lenses that do exist often contain much iron oxide and have a cellular texture; evidence from less weathered rocks in this area has indicated that the features result from oxidation of pyrite in the lenses.

FIG II :

TS 10479 x 42 crossed nicols.
Wavellite (white) in small shear
planes which cross the schistosity at
a low angle. Quartz and altered mica
(grey). Pyrite has been replaced by
goethite (black).

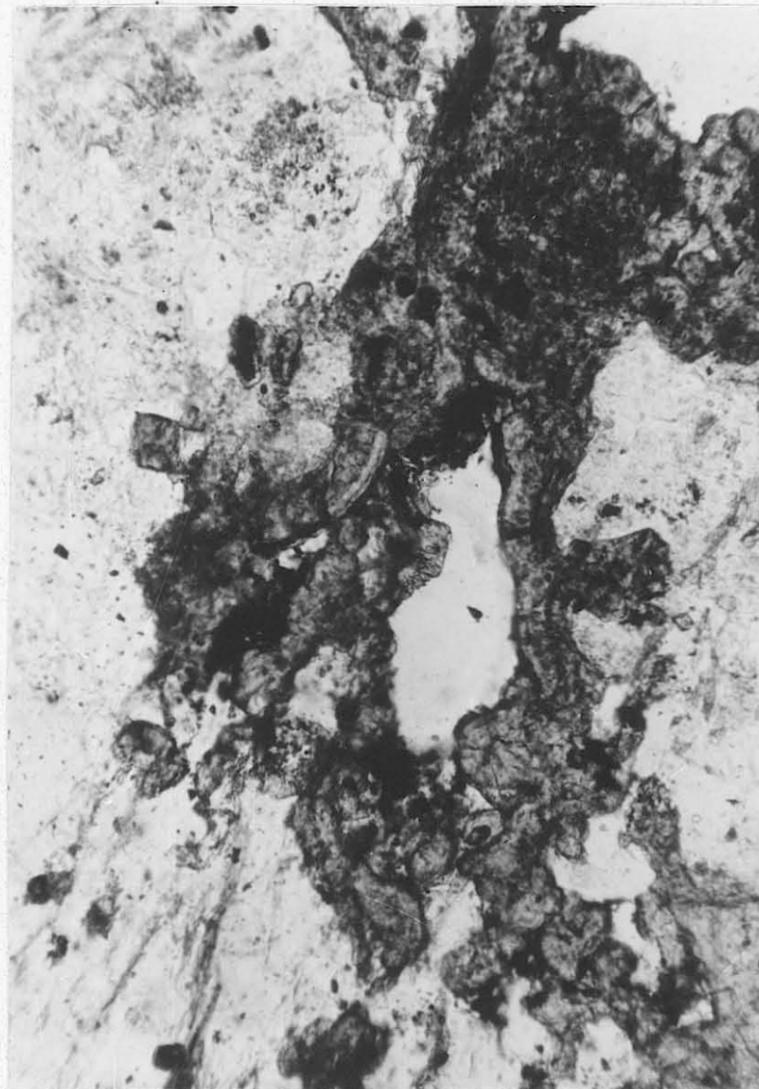


FIG III :

TS 10479 x 125 crossed nicols.
Radiating crystals of wavellite
intergrown with quartz. Some
mica has been replaced by
wavellite.

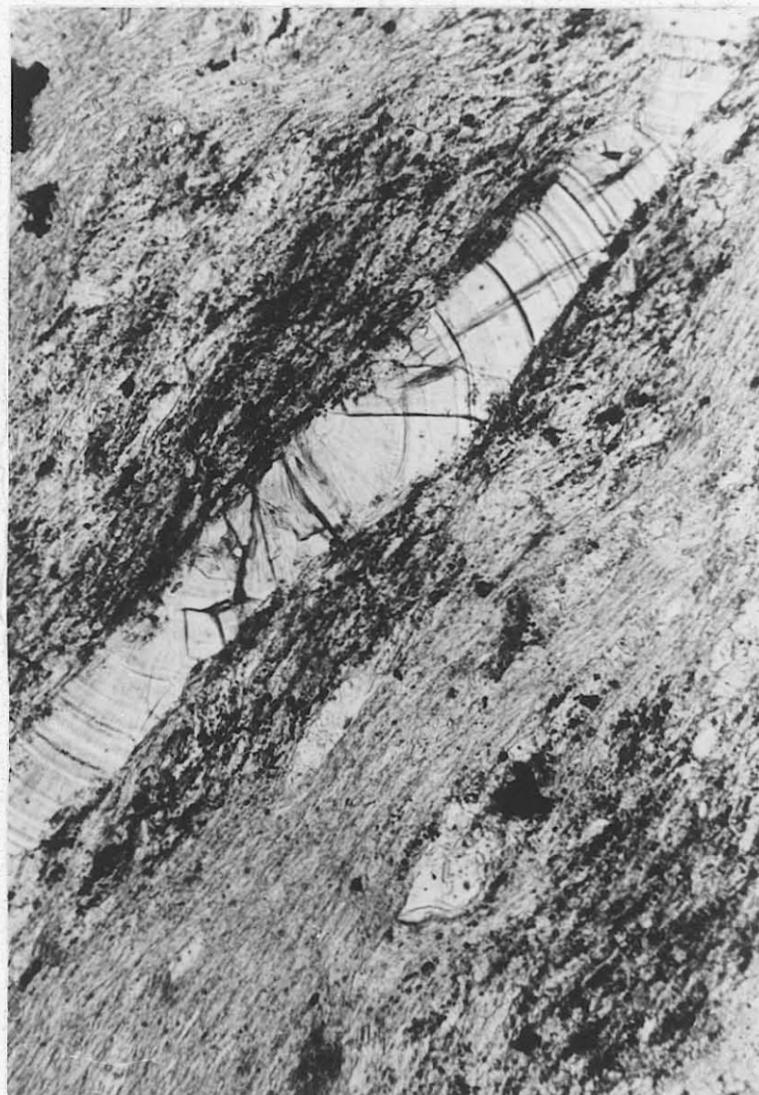


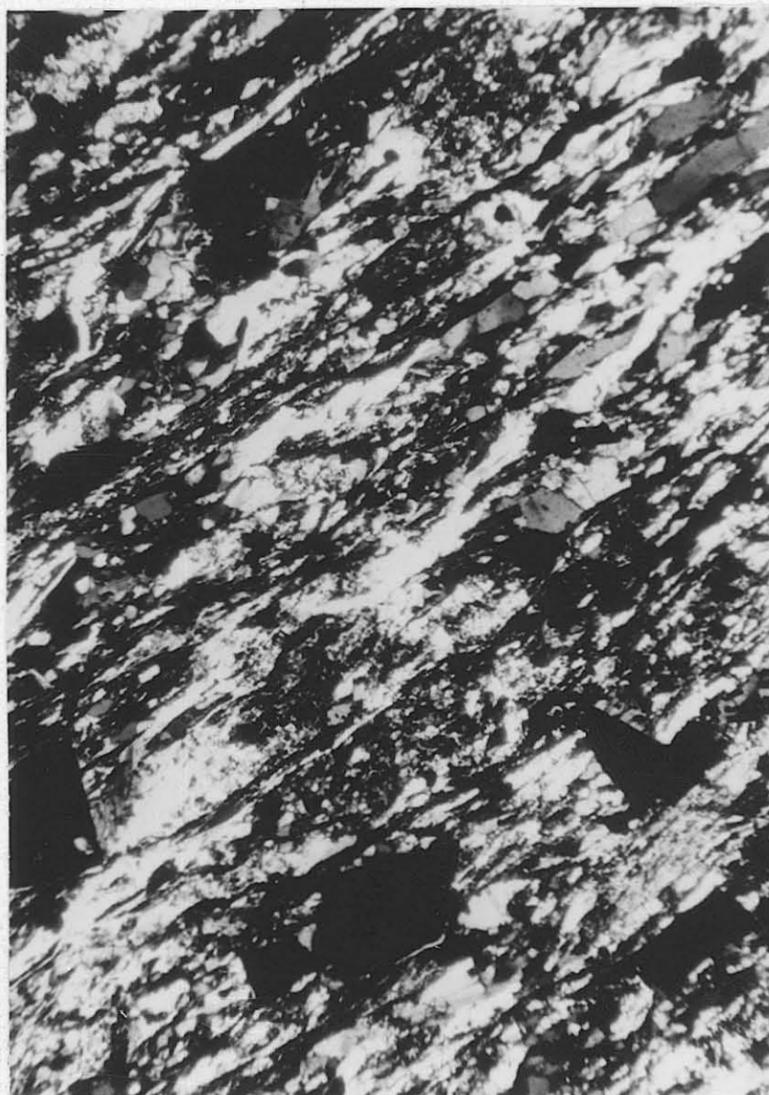
FIG IV :

TS 10481 x 125. PPL. A vein containing wavellite (centre) is parallel to the schistosity.



FIG V :

TS 10478 x 125 PPL.
Colloform layers and spherulites
to a phosphate mineral structurally
related to millicite but containing
some iron.



Structure

The exposures in the costeans show the structure of the Den Range to be an anticline, and the attitude of the slaty cleavage (~~Figs II and III~~) ^{Plates 1 & 2} suggests that it is probably overturned. The work of Messrs. Banks and Smith indicates that the Den Range structure may be part of a broad anticlinorium involving the Mathinna Beds.

The structure in Costean 4 on the north-east side of the range has been discussed in some detail and interpreted by Mr. Banks in consultant's report C. R. 584. Essentially there are three structural elements: bedding, ~~slaty cleavage~~ and a later strain-slip cleavage. Bedding is rarely seen but compositional banding enabled a few determinations to be made; on the south-west side of the range the dip is 60° south-west (~~Figs. II and III~~) and on the north-east side it appears ^{Plates 1 & 2} to be steep to the north-east. The slaty cleavage is the prominent structural element, and its prevailing attitude is about 30° south west (~~Figs. II and III~~). However, in Costean 4 the slaty cleavage is seen to be folded, and the formation of these F2 folds was accompanied by a strain-slip cleavage. The second generation folds are markedly asymmetrical, within one vertical or near vertical limb; their wavelength is some tens of feet. Minor north-east to south-west cross fractures occur in the Den Range.

The structural observations have shown that the structure of the Den Range is sufficiently complex to make the tracing of any phosphorite bed a very difficult task.

Secondary phosphate mineralisation:

Wavellite (aluminium phosphate) occurs ^{Plates 1 & 2} on joints and cleavage faces in the slates exposed in the costeans (~~Figs. II and III~~). It is restricted to the massive silty slate beds along the top of the Range, the reason being that these much-jointed, relatively competent beds would have formed a favourable environment for the deposition of wavellite from phosphate-bearing fluids. The wavellite mineralisation is present to a depth of at least eight feet; this tends to indicate that the original source is below the Den Range.

Wavellite also occurs in the cross fractures where it forms the matrix of the "wavellite breccia" which crops out in a number of places on the Den Range. The strike of the fractures parallels the costeans with the

result that the wavellite breccias are not well seen. However, a wavellite-bearing siliceous breccia zone, striking northwest/southeast, does occur in Costean 2.

Probably the most interesting occurrence of wavellite is in the sandstone lenses. Small spherules of wavellite occur in these lenses and give the rock a texture not unlike that of some phosphorites. Mr. Banks carried out a detailed petrological study on samples from some of these lenses (See Report C. R. 584) and concluded that wavellite may have replaced quartz in some of them. He requested that we get a second opinion of these rocks, and a number of his rocks and slides were sent to the Australian Mineral Development Laboratories for assay and petrographic description. These results are included in this Report as an Appendix I.

Sampling Results

All the costeans were mapped and chip sampled. A 5 ft. sampling interval was chosen because at this spacing it is unlikely that any economic phosphorite would be missed. The sample sites for costeans 1 and 4 are shown on ~~Figures II and III~~ respectively; the other costeans were similarly sampled. ^{Plates 142}

230 samples were tested for both calcium phosphate (apatite) and aluminium phosphate (wavellite) by the semi-quantitative method described by Shapiro (1952).

All the results were negative, indicating the absence of economic phosphorite beds in the Den Range. However, the source of the wavellite was still unexplained; consequently, sampling of sandstone lenses (commonly 6 - 9 inches thick) and channel sampling near lithological boundaries in the slates was carried out. At the same time, additional trenching in the igneous rock in Costean 4 yielded fresher specimens for testing.

Chemical testing of the additional samples revealed that the sediments are non-phosphatic however, positive reactions for apatite were obtained on the fresher samples of the igneous rock. The decomposed parts of the intrusive (now mottled clays) reacted for wavellite but not for apatite, and the reaction weakened towards the contact. Thus the apatite was decomposed and wavellite was formed by reaction between the phosphate radical and clay minerals.

The igneous rock is considered to be a lamprophyre of probable Devonian age; it assayed 1.5% P_2O_5 and is the likely source of the secondary wavellite in the Den Range. The size, configuration and number of these intrusives in the Den Range area are not known.

CONCLUSIONS

1. There is no evidence of the presence of primary sedimentary phosphate in the Lower Paleozoic Mathinna Beds of the Den Range.
2. The most likely source of the secondary wavellite is the igneous rock exposed in costean 4. This rock contains 1.5% P_2O_5 , present as apatite.
3. The igneous rock is probably a lamprophyre dyke of Devonian age; other such intrusives may underlie the Den Range. They have no potential for economic deposits of apatite.

RECOMMENDATIONS

Further phosphate exploration is not warranted in the Den Range area, and it is recommended that we do not renew Exploration Licence 2/67.

REFERENCES

BANKS, M. R. 1967 : Reconnaissance search for phosphate in Tasmania. U. D. C. Consultant's Report No. C. R. 575

BANKS, M. R. 1968 : Reconnaissance search for phosphate in West Tasmania. U. D. C. Consultant's Report No. C. R. 581.

BANKS, M. R. and SMITH E. A. 1968 : Phosphate search in the Den Range - Back Creek area, north-east Tasmania. U. D. C. Consultant's Report No. C. R. 584.

RIX, P 1968 : Phosphate investigations in Lower Paleozoic rocks of the Tasman Geosyncline in Eastern Queensland. U. D. C. Report No. 148.

SHAPIRO, L 1952 : Simple field method for determination of phosphate in phosphate rocks.

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APPENDIX ISECONDARY PHOSPHATE MINERALS IN
SCHIST AND WEATHERED ROCKSample : 10477 Igneous rock from Costean 4; assay 1.5% P₂O₅

Rock Name :

Decomposed rock, probably originally igneous.

Hand Specimen :

Pale yellowish green decomposed rock with encrustations stained by iron oxide on joint surfaces. This rock and the encrustation both give a positive reaction for phosphate.

Thin Section :

A visual estimate of the constituents gives the following :

	<u>%</u>
Chlorite	50-60
Quartz	10-20
Clay	20-30
Rutile & Sphene	2-3

The rock is now composed predominantly of secondary alteration products - chlorite and clay with patches of very fine grained rutile and sphene. Quartz grains (0.1-0.2mm) are scattered through the rock and line some cavities.

Relict textures indicate that it formerly contained 20-30% of a prismatic mineral which occurred as randomly orientated crystals up to 1.5mm long. A few show typical amphibole form in cross section. This mineral was uniformly distributed throughout the rock and has been replaced mainly by chlorite with a little fine grained sphene. Interstices between former prismatic crystals contain quartz, chlorite and clay.

A few small (0.1mm) cavities are lined with a brown stained isotropic mineral with a moderately high R. I. which is probably an impure secondary phosphate mineral.

X-ray investigation - Rock -

The results indicate mainly quartz and chlorite. Apatite type minerals are not reported and there is no evidence of any other phosphate minerals suggesting that only small amounts are present.

Encrustation - Kaolin and quartz only are detected.

History :

Decomposed weathered rock which may originally have been a basic igneous rock. Minor secondary phosphate is present but no definite mineral has been identified in the rock, or in the material encrusting joint surfaces, although both give positive results when tested for phosphate.

Sample: 10478 Wavellite-bearing sandstone; assay 5.1% P_2O_5

Rock Name :

Weathered quartz-mica schist with secondary wavellite.

Hand Specimen :

A medium-grained, pale coloured rock with weak schistosity.

Thin Section :

A visual estimate of the constituents gives the following :

	<u>%</u>
Quartz	70-80
Altered mica (illite)	10-15
Wavellite	1 -3
Millicite type	10-15
Geothite	trace
Tourmaline	trace
Zircon	trace
Clay	minor

The rock contains large (0.2-0.5mm) quartz grains scattered through a mosaic of fine-grained to almost microcrystalline quartz with patches and thin layers of very fine grained, partly weathered mica (illite).

Wavellite occurs as small (0.2-0.4mm) patches of radiating fibrous to prismatic crystals intergrown with the quartz mosaic. Tourmaline and zircon grains are rare - zircon is rounded, some tourmaline has secondary overgrowth. Cavities from which a cubic mineral, probably pyrite, has been leached have been filled or lined with a pale brown, fibrous phosphate mineral which commonly occurs as colloform layers and small spherulites.

Refractive index varies from slightly below 1.687 to approximately 1.695. Birefringence is moderately low. Some thin colloform layers have slightly different refractive indices suggesting some variation in composition.

X-ray investigation indicates the presence of about 10-15% of a phosphate mineral structurally related to millisite (Na, K) $\text{CaCl}_6(\text{PO}_4)_4(\text{OH})_9 \cdot 3\text{H}_2\text{O}$. This is almost certainly the brown mineral referred to above, but the colour and refractive indices do not agree with those of millicite (RI of millicite is reported to be 1.584 - 1.602).

The brown colour and higher refractive index of the mineral in this specimen suggests the presence of some iron.

History :

Metamorphic rock derived from an argillaceous sandstone or siltstone. There is no discernible evidence of primary phosphate. The wavellite could have replaced quartz. A secondary phosphate mineral structurally related to millicite but containing some iron has been deposited in cavities from which pyrite has been leached.

Sample: 10479 Wavellite-bearing sandy rock; assay 12.9% P_2O_5

Rock name :

Weathered quartz - mica schist with wavellite.

Hand Specimen:

Medium-grained, pale grey rock with weak schistosity.
Wavellite encrusts joint surfaces.

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APPENDIX I

Page 4.

Thin Section : (Figs. 1 and 2)

A visual estimate of the constituents gives the following :

	<u>%</u>
Quartz	40-50
Wavellite	20-30
Goethite after pyrite	3-5
Weathered mica	10-15
Jarosite	trace

Wavellite occurs as elongated aggregates (up to 0.2mm) of radiating crystals intergrown with a mosaic of quartz grains, and in places it fills spaces between thin layers of weathered mica. Some wavellite has replaced mica retaining numerous minute inclusions which indicate former texture and cleavage of the mica. Some wavellite may have replaced quartz (or a former feldspar which was intergrown with the quartz). The evidence for this is inconclusive and it is a suggestion only.

Most of the wavellite occurs along small shear planes which intersect the schistosity at a low angle. (Fig. 1). Euhedral crystals of former pyrite (?) up to 0.3mm have been replaced by goethite, and very rare cavities from which pyrite has been leached are lined with jarosite.

History :

A metamorphic rock probably derived from siltstone or impure sandstone. Secondary wavellite has been deposited along shear planes, some has replaced mica and some may have replaced quartz. Primary phosphate minerals were not observed but the grade of metamorphism is such that evidence of these would almost certainly have been obliterated.

Sample : 10480 Wavellite-bearing sandy rock; assay 3.6% P_2O_5

Rock Name :

Weathered carbonaceous and pyritic quartz-mica schist with secondary wavellite

Hand Specimen :

Weathered and partly leached grey schist with abundant pyrite in an unoxidized portion. Spherulitic aggregates of wavellite fill a small vein.

Thin Section :

a visual estimate of the constituents gives the following :

	%
Quartz	60-70
Weathered mica	20-30
Wavellite	10-15
Carbonaceous material	2-5
Former pyrite	5-10
Zircon	rare
Tourmaline	rare
Leucoxene	1-2
Goethite	2-3

Similar to T. S. No. 10478 but with carbonaceous material in some layers. There are also scattered aggregates of fine-grained sphene or "leucoxene".

Zircon and tourmaline occur along some layers.

Some of the wavellite occurs in lenticular patches and is associated with fine-grained carbonaceous material.

Coarser grained wavellite occurs in places where fine layering has been partly disrupted, and also along a cross cutting vein.

History :

Metamorphic rock formed from carbonaceous siltstone/shale or sandstone/shale, probably containing syngenetic sulphide. There is no definite evidence of primary phosphate but this would almost certainly have been obliterated during recrystallisation.

Sample : 10481 Wavellite-bearing lens; assay 5.5% P_2O_5

Rock name :

Weathered and leached pyritic and carbonaceous mica schist.

Hand Specimen :

Dark grey schist weathering to pale grey with leached patches stained by iron oxide.

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APPENDIX I

Page 6.

Thin Section :

a visual estimate of the constituents gives the following :

	<u>%</u>
Quartz	10-20
Weathered mica	40-50
Chlorite	30-40
Leucoxene	3- 5
Carbonaceous material	3- 5
Wavellite	3 - 5
Tourmaline	trace
Goethite	trace

The rock differs from specimens 10478 to 10480 in that it contains less quartz and much more mica and chlorite with slightly more leucoxene.

The schistosity is crenulated or has developed in two directions, probably indicating two phases of tectonic stress. Wavellite occurs in a narrow vein parallel to one direction of schistosity (Fig.III) and also in a few small (0.2mm) lenticular patches in the rock.

There are traces of pale brown, fibrous mineral occurring as colloform layers lining cavities. This is similar to the mineral present in section No. 10478.

History :

A metamorphic rock probably derived from shale. Secondary wavellite occurs mainly in veins. Some may have replaced mica.

Note :

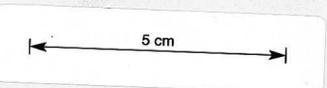
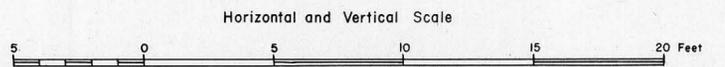
X-ray investigation indicates that specimens 10478, 10479 and 10481 contain an unknown mineral which structurally is similar to innelite - a new mineral reported by Kravchenko et al. (American Mineralogist, 47 (1962) pp805-806) to be a silicate containing Ba, K, Ca, Na, Ti with Na_2SO_4 . No mineral of this description was detected in the thin sections.

(Later letter from AMDL stated that unknown mineral was positively identified as VARISCITE).

UTAH DEVELOPMENT COMPANY
(Mineral Development & Geology)

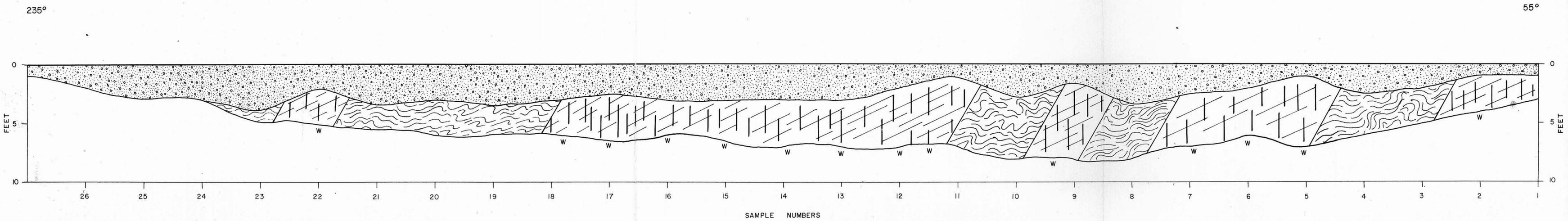
SECTION
NORTH WALL OF COSTEAN I
DEN RANGE
N.E. TASMANIA

Plate I



022

Report No. 155
P. Rix
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LEGEND

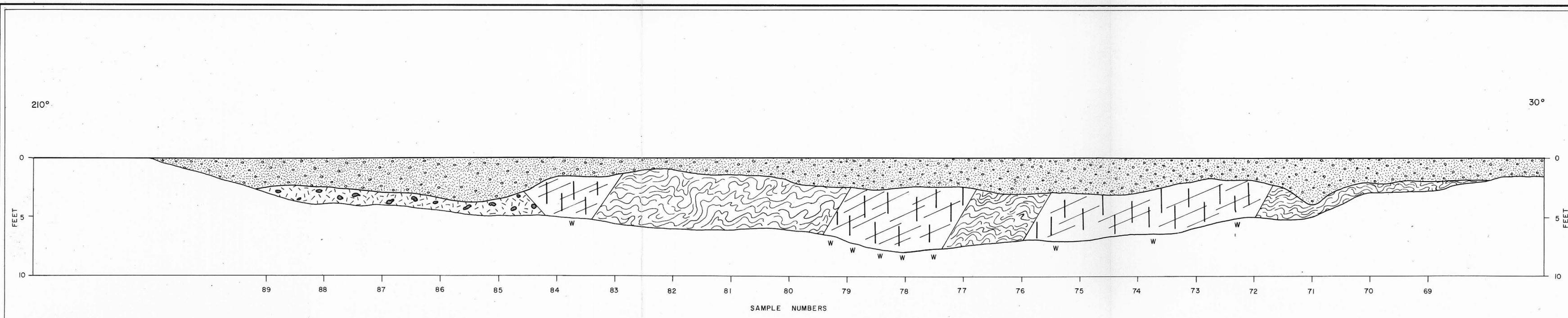
- Soil and eluvial gravel.
- Slaty cleavage in silty slates.
- Hard carbonaceous silty slate - jointed and regularly cleaved.
- Distorted cleavage in weathered carbonaceous slates.
- Soft highly carbonaceous slate with distorted cleavage caused by bleaching and expansion during weathering.
- Wavellite on cleavage and joint faces.
- Vertical joints, two sets at 240° and 180°.

UTAH DEVELOPMENT COMPANY
(Mineral Development & Geology)

SECTION

NORTH WALL OF COSTEAN 4
(South West end)
DEN RANGE
N.E. TASMANIA

Plate 2



LEGEND

- Soil and eluvial gravel.
- Hard carbonaceous silty slate - jointed and regularly cleaved.
- Soft highly carbonaceous slate with distorted cleavage caused by bleaching and expansion during weathering.
- Mottled clays with sporadic cores of weathered apatite-bearing basic igneous rock (lamprophyre) (grade 1-5% P₂O₅)
- Slaty cleavage in silty slates.
- Distorted cleavage in weathered carbonaceous slates.
- Wavelite on cleavage and joint faces
- Vertical joints, two sets at 240° and 180°

