DEPARTMENT OF MINES
SOUTH AUSTRALIA

PHOSPHATE DEPOSITS

Section 281, Hd. Myponga

- Heatherdale Pastoral Pty. Ltd. M.C. 4965 -

(Cresco Fertilizers Ltd. - Authority to Enter)

by

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APPENDIX - Scintillometer Survey

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Rept. Bk. No. 65/62
G.S. No. 3801
D.M. No. 844/67

29th September, 1967

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ABSTRACT

Comparatively high grade phosphate rock is present at the Myponga deposit, discovered in 1921. A total of 887 tons was produced by the Broken Hill Pty. Ltd. in 1941-1942.

The phosphate occurs in the upper beds of the lower Cambrian Mt. Terrible Formation.

A drilling programme is recommended to determine the extent of the deposit, and to prove reserves and grade of ore. A scintillometer survey has shown some measure of correlation with phosphatic beds and therefore gamma ray logging of boreholes is proposed as a possible guide to future exploration.

INTRODUCTION

Topographical and geological surveys of the property were carried out in order to advise Cresco Fertilizers Ltd. on the investigation of the phosphate deposits, discovered in 1921. R.A. Callen also mapped the regional geology of the district as a guide to the interpretation of the local stratigraphy and structure. B.J. Taylor made a scintillometer survey to help determine whether this method can be used in prospecting for phosphatic beds.

A considerable amount of exploration and sampling of the deposit was undertaken by Broken Hill Pty. Ltd. between 1940

and 1943, in their search for phosphate rock required in the production of high-phosphorus pig iron, and a total of 887 tons was extracted.

Further investigations and sampling were carried out by Geosurveys of Australia Pty. Ltd. in July, 1966, on behalf of Mr. T.P. Leppinus, Chairman of Directors of Heatherdale Pastoral Pty. Ltd.

TITLE

The land and mineral rights are owned by Heatherdale Pastoral Pty. Ltd. The company registered M.C. 4965 of 20 acres on 27th April, 1966, covering the same area as M.C. 2854 originally pegged by the Broken Hill Pty. Ltd. and relinquished by them in 1951. Right of entry for exploration was granted to Cresco Fertilizers Ltd. on 15th June, 1967.

LOCATION AND ACCESS

The property is about 37 miles by road south of Adelaide and two miles northwest of Myponga. It may be reached by turning westwards off the main road along the road to Myponga Reservoir for one mile. A track to the phosphate quarry $\frac{3}{4}$ mile long leads off through two gates on the right hand side of the road. The track is winding and fairly steep, and in wet weather, is suitable only for vehicles with four wheel-drive.

Phosphate produced by B.H.P. in 1941-1942 was taken out by truck to Rapid Bay for shipment. When Jack (1921) examined the property shortly after the discovery of phosphate, there was no access road and he envisaged the construction of an aerial ropeway to the coast (about $1\frac{1}{4}$ miles away in a direct line).

GEOGRAPHY

The district is hilly and deeply dissected by numerous creeks which flow only during the wetter winter months. Climate is Mediterranean type with a total average annual rainfall of 29.33 ins. (Myponga township), most of which falls between April and September. Weathering is deep and outcrops are poor, except in the more resistant beds. The hills have a cover of coarse grasses, dotted with eucalypts and are used for grazing sheep and cattle. The lower slopes are blanketed by grass-covered downwash which has been deeply gullied. There have been recent landslips, especially on the eastern side of Black Hill.

HISTORY OF MINING AND EXPLORATION

Phosphate rock was discovered by the Sinclair brothers in 1921. (Jack, 1921) Jack suggested a systematic prospecting programme to decide if there was sufficient material to justify the construction of an access road, but little work appears to have been done at this time. Before World War II, development of South Australian phosphate deposits generally was inhibited because of the abundant cheap, high grade phosphate rock imported from Nauru, Ocean and Christmas islands. However, with the outbreak of war in 1939, interest was once more focussed upon local deposits. The Broken Hill Pty. Ltd. required a source of phosphate rock for the production of high-phosphorus pig iron used in castings, and investigations of the Myponga deposit started in late 1940. The property was explored by means of three shafts and numerous costeans, trenches and pits. A quarry was opened up, exposing about 10 to 12ft. of phosphate rock. According to Christian (1941), prospecting had proved about 5,000 tons of good grade phosphate rock, with prospects

of a further 5,000 tons. In 1941-1942, a total of 887 tons was produced, being taken out in trucks to Rapid Bay, on the coast about 22 miles by road southwest of the deposit, and was shipped to Whyalla. Operations were suspended in April, 1943, because of the boggy conditions, the shortage of suitable labour and because the demand had been temporarily satisfied. The lease was finally abandoned in 1951.

M.C. 4965 covering the same area was pegged by Heatherdale Pastoral Pty. Ltd. in 1966 and a brief examination was made by Geosurveys of Australia Pty. Ltd. in July of that year. Wilson and Connard (1966) concluded that further exploration was warranted and recommended at least one shallow drill-hole to guide an exploration programme.

Access rights for exploration purposes were granted by Heatherdale Pastoral Pty. Ltd. to Cresco Fertilizers Ltd. on 15th June, 1967, and the investigations described in this report were made in response to a request by the latter company.

REGIONAL GEOLOGY

The following table summarises the geology of the district:

Recent	7. Soil and downwash; landslips 6. Stream alluvium 5. Older alluvium
Permian	4. Glacial sand and boulder clay (Unconformity)
Lower Cambrian	3. Wangkonda Limestone 2. Mt. Terrible Formation.(-with Phosphatic beds.)
Proterozoic: (Adelaide System)	1. Marinoan

The extent of these various units (except the Permian) is displayed in Plan Nos. 67-596 and L67-86.

Stratigraphy

1. Marinoan Series

The uppermost beds of the Adelaide System are represented by phyllites and bands of hard, white compact quartzite.

Lower Cambrian 2. Mt. Terrible Formation (Daily, 1963)

Coarse cross-bedded arkose passes up into coarse, leached, calcareous sandstone, with thin interbedded siltstones having a pitted appearance along bedding planes. Bedding is irregular and appears to have been reworked by worms and other organisms. This sequence, totalling about 40ft., is overlain by about 200ft. of yellow-weathered dark grey siltstone, becoming pitted and cavernous along the bedding in the upper parts, due to the weathering out of clay or limestone nodules. Worm activity has given rise to a spotted appearance. The upper part of the Mt. Terrible Formation, the fossiliferous "Hyolithes" sandstone of Abele and McGowran (1959), is about 45ft. thick, consisting of leached cavernous calcareous sandstone and siltstone, with the cavities (2"-6" long) elongated parallel to bedding, and locally showing bedding disrupted or disturbed by worm burrows and castings.

R.A. Callen found traces of phosphate at the top of the Mt. Terrible Formation, just below the Wangkonda Limestone, during an investigation of the Sellick Hill area, northeast of the Myponga deposit. Phosphate in the Myponga quarry described in this report may be in a similar stratigraphical position.

3. Wangkonda Limestone (Abele and McGowran, 1959)

Massive pale grey to dark blue limestone, with a lenticular band of calcareous sandstone up to about 150ft. thick,

about 180ft. above the base of the formation. The whole sequence has a total thickness of 400ft.

Structure

During the lower Palaeozoic orogeny, the beds were folded into a complex synclinal structure overturned to the northwest, with its axis trending northeasterly and plunging gently in this direction. Thus the Cambrian beds form an ~~in~~ out lier, surrounded by bands of Proterozoic quartzite and phyllite. The southwestern portion of the syncline, near the quarry, has probably been uplifted, resulting in the removal by erosion of the limestone (See Plan 67-596). The southern margin of the syncline has been sheared, causing crumpling and repetition of the beds on this side of the structure. To the northeast, there has been drag-folding against the Black Hill Fault; however, the structure is obscured here by overlying Permian sands.

LOCAL GEOLOGY

Outcrops are poor and weathered, and it is difficult to correlate the beds of the Mt. Terrible Formation west of the inferred fault with the main outcrops east of it, where the succession from the Mt. Terrible Formation to the Wangkonda Limestone can be recognised. The upper part of the Mt. Terrible Formation west of the fault consists of a thick sequence (probably increased by folding) of soft yellow and white shales, siltstones and sandstones which have been deeply weathered. The sequence is thus somewhat different to that encountered elsewhere in the district. The phosphate quarry is sited on the northwestern limb of the synclinal structure and near its southwestern closure. The Wangkonda Limestone does not outcrop and

has apparently been removed by erosion, so that much of the obscured ground south of the quarry may be occupied by the Mt. Terrible Formation. If the phosphate bed in the quarry is persistent, it might then be present at no great depth farther south below the blanket of downwash and talus higher up the slope.

The phosphate rock in the quarry consists of hard yellow-stained pale cream and brown pods and irregular masses in a matrix of soft pale purple and white siltstone which has been highly weathered (Appendix II; Specimen P.340/67). The rock commonly has a roughly mammillated appearance with a coating of yellowish-brown limonite (Specimen P.338/67). When broken open, a thin white coating is usually visible round the phosphate. The phosphatic bed overlies soft yellow-stained sandy shale and siltstone (Specimen P.341/67); it is overlain by soft brown, cream, buff and yellowish siltstones and sandy shales (Specimens P.329-P.337; P.339/67), with some coarse sandy and gritty beds.

Older alluvium is represented by remnants of alluvial terraces largely removed by streams which have cut down as much as 12ft. below them. The terraces consist of yellowish- and reddish-brown sandy or gritty clays with bands of coarse gravel. Fragments of phosphate rock resembling that now exposed in the quarry were observed in a band of gravel 4ft. below surface, in the south bank of the creek about 100yds. downstream from the fence (See Plan 67-596).

When the deposit was first discovered, black soils were recorded in the vicinity of the quarry. Similar black soil was noted downstream towards the northeastern boundary of the lease, and also near the northeastern margin of the area shown on Plan 67-596, where the scintillometer survey showed increased radioactivity above background (See Plan 67-594,

Line "G").

Deep reddish-brown soil ("terra rossa") has formed above the weathered limestone, probably due to the concentration of insoluble iron-rich residues from the eroded limestone. Patches of ferruginous sandstone or siltstone shown on the geological Plans may have been formed by a similar accumulation from limestone which has been stripped off the Mt. Terrible Formation, possibly in Tertiary or Recent times; however the possibility cannot be discounted that some ferruginisation might be connected with fault zones.

Recent alluvium consists chiefly of boulders and pebbles of Marinoan quartzite and quartz; sandstone and siltstone from the Mt. Terrible Formation; and also Wangkonda Limestone downstream. Scattered fragments of phosphate rock occur in the bed of the main creek.

ECONOMIC GEOLOGY

Mineralogy of Phosphate Rock

(See Appendix II; Specimen P.338/67; TS.19609)

Examination by AMDEL of a specimen from the quarry has shown that fine-grained collophane (hydrated calcium phosphate) is the dominant phosphatic mineral, accompanied by apatite (calcium phosphate) which has filled fracture planes and cavities. There has been intraformational brecciation of the bed and fragments of lithified phosphorite are surrounded by a groundmass of similar material.

Origin of the Phosphate Rock

According to the petrologist, the phosphate rock in the quarry was probably deposited in a shallow-water marine environment in which unconsolidated beds were disturbed and

brecciated, presumably by changing wave or current action.

If the phosphate-bearing beds exposed in costeans or trenches north of the creek are also bedded phosphates, then there are a number of favourable horizons within the Mt. Terrible Formation, stratigraphically below the deposit in the quarry. In a later chapter, drilling has been recommended which will help to resolve this problem. However, the possibility cannot be overlooked that phosphatic beds at or near surface in this locality may have been formed by weathering processes and by subsequent concentration in, or by replacement of, favourable beds.

Workings and Sampling

The workings shown on Plans 67-596 and L67-86 were excavated by the Broken Hill Pty. Ltd. between 1940 and 1943. Three shafts were sunk, and the quarry was opened up to exploit the phosphatic bed intersected in No. 1 and No. 2 shafts. Numerous costeans, trenches and shallow pits were cut.

No. 1 Shaft

A vertical shaft 28ft. deep, with a crosscut for 32ft. south and a northern crosscut 16ft. long. The phosphate-bearing formation is apparently about 30ft. thick, though phosphate is erratically distributed throughout this thickness. Sampling by B.H.P. indicated sections ranging from 8.7% to 27.7% P_2O_5 (See Section on Plan L67-86). During the present survey, a channel sample 4ft.10in. long was taken down the face of the south crosscut. The sample assayed only 1.1% P_2O_5 so that the end of the crosscut is above the phosphate bed and there would be no point in extending the workings in this direction, unless

proposed drilling were to show phosphate in stratigraphically higher beds.

No. 2 Shaft

This shaft was sunk vertically to a depth of 32ft. with a south crosscut 50ft. long and a north crosscut 14ft. long. The phosphate bed was about 20ft. thick, reputed to contain up to 36.7% P_2O_5. Much of this material was later removed when the quarry was opened up, and the shaft no longer exists.

Quarry

B.H.P. started mining operations from the quarry about 1941. Phosphate rock exposed in the face was blasted and removed in side tipping trucks with a capacity of 1 cu. yd. which were hauled on a 2ft. gauge line by a petrol-driven winch. A total of 887 tons of high-grade phosphate rock was produced in 1941-1942.

The excavation is about 160ft. long, with a maximum height of face from the floor to the upper bench of about 33ft. The upper bench is cut about 7ft. below the northern end of the ridge. Phosphate rock is exposed in the lower part of the face (See Plan L67-86). Samples taken by Geosurveys of Australia Pty. Ltd. southwest of No. 1 shaft assayed between 22.6% and 29.8% P_2O_5.

The bed appears to dip southwards at about 30° so that the amount of overburden will increase, as the ground also rises in this direction.

No. 3 Shaft

This shaft is now overgrown. Material assaying 33% P_2O_5 is recorded at 5ft. (old B.H.P. plan) which may be the total depth.

Costeans, trenches and pits

Most were cut on the steep slope northwest of the main creek, and are now overgrown or infilled, with few outcrops. Much sampling was done by B.H.P. and also by Geosurveys, as shown on Plan L67-86. The figures appear to indicate several irregular belts containing significant phosphate, separated by zones which are non-phosphatic or of low-grade, or by ground which has not been tested. Drilling of this part of the property is desirable.

There are several shallow overgrown trenches on the ridge over a fence northeast of the eastern boundary of M.C. 4965 which were probably excavated in the search for phosphate rock. The beds here are weathered fine limonitic siltstones and sandstones, with worm b rrows, assigned to the Mt. Terrible Formation.

Analyses

Sampling by B.H.P. and Geosurveys indicated values of P_2O_5 up to 34.1%, though such high grade material may be erratically distributed within the phosphatic formation. However, acid soluble alumina (Al_2O_3) and ferric oxide (Fe_2O_3) appear to be fairly high, as shown in a number of recorded assays below:-

	P_2O_5(%)	Equivalent Tricalcium phosphate $Ca_3(PO_4)_2$ (%)	Al_2O_3(%)	Fe_2O_3(%)	Total Al_2O_3 and Fe_2O_3 (%)
B.H.P.	31.83	69.5	5.44	3.00	8.44
	25.42	55.5	8.39	5.30	13.69
	21.53	47.0	8.61	3.60	12.21
	23.82	52.0	8.79	3.00	11.79
Geosurveys	13.60	29.7	3.85	6.70	10.50
	10.00	21.8	7.10	3.60	10.70
	10.00	21.8	8.70	4.15	12.85
	28.70	62.7	2.75	4.60	7.35
Christian (1941)	(30.91)	67.5	-	-	5.78

It is not known whether the high R_2O_3 content is merely a surface effect due to weathering and oxidation. Diamond drilling would provide information on the amounts of ferric oxide and alumina present in depth.

Production of Phosphate Rock

	Tons
1941	214
1942	673
Total	887

Reserves

Christian (1941) reported that, at the quarry site, prospecting had proved about 5,000 tons of phosphate rock of good grade with prospects of a further 5,000 tons, of which quantity 887 tons was subsequently extracted. These appear to

be reasonable figures, though no reliable calculation can be made at present owing to the lack of openings, or drill holes behind the face. Proposed drill holes Nos. 1, 2 and 3 would provide additional information for an estimate to be made.

Johns (1962, p. 28) calculated that about 500 tons has been cleared of overburden and exposed in the face.

Other boreholes recommended will allow an appraisal of surface work required to prove reserves elsewhere on the lease.

Scintillometer Survey

Radiometric traverses made by B.J. Taylor (See Appendix I) showed that zones of increased radioactivity appear to follow phosphatic beds and he proposes that, if drilling is carried out, the holes should be surveyed with a gamma ray probe.

Readings taken up the northern face of No. 1 Shaft were variable but were higher where phosphate rock was observed. A sample collected at a depth of 2ft. where a higher reading was obtained gave a positive reaction for phosphate, though phosphate was not visible in the hand specimen (See Dwg. No. S6011).

The radiometric profile down the quarry face showed a fair correlation with the phosphatic bed exposed in the lower part of the face.

CONCLUSIONS

.... Phosphate rock occurs in the lower Cambrian Mt. Terrible Formation close to the contact with the overlying Wangkonda Limestone. The host rocks have been folded into a complex southwesterly trending syncline plunging towards the northeast. West of the fault, the southwestern end of the structure has been uplifted and the Wangkonda Lime-

stone appears to have been entirely removed by erosion, though it is possible that weathered remnants might be preserved below superficial deposits on the ridge south of the quarry. Therefore the phosphatic beds in the upper part of the Mt. Terrible Formation might be present at no great depth in this part of the structure.

.... While the phosphate is apparently confined to particular beds in the Mt. Terrible Formation, it may be erratically distributed within those beds. In the quarry, the higher grade material consists of irregular masses, lenses and pods of yellow-stained pale cream and brown, roughly mammilated phosphate rock. There may be a white bloom or coating round the edges, prominent when the rock is broken

.... Sampling by B.H.P. and Geosurveys has indicated scattered exposures of high grade phosphate over a total distance of about 600ft. from southwest to northeast. Outcrops are poor and there is a deep cover of overburden over much of the lease. It is considered that further testing should be carried out and that shallow diamond core drilling would be the best method at this stage in order to determine grade a d available reserves of phosphate rock. Drilling would also provide important information on the amounts of ferric oxide and alumina present in depth.

.... The present floor of the quarry is near the intersection of three creeks and is near creek level, so that further extraction of phosphate rock below creek level might be hampered by water during the winter months.

RECOMMENDATIONS

.... A diamond drilling progr mme is proposed to test the deposits in depth, designed to allow an appraisal of the

extent and grade of phosphate rock available on the property. Core would provide the maximum of information and accuracy of assays. Good recovery of friable rock should be ensured by the largest possible core (preferably NX) and by the use of a double tube core barrel, in which core being cut is separated from the water flush by an inner barrel.

A series of 10 holes totalling about 950ft. is suggested as a preliminary step, listed below in order of priority. In addition, two alternative sites are shown, should Nos. 4, 5 and 10 fail to locate the phosphate-bearing beds. Drilling should be carried out in Stages; if poor results are obtained from boreholes at the quarry site (Stage 1), the remainder of the programme should be re-assessed.

STAGE 1 (Quarry site)

Hole No.	Inclination	Bearing (Magnetic)	Proposed length	Purpose
1	Vertical	-	90ft.	To intersect the phosphatic formation back of the face in the quarry.
2	Vertical	-	110 ~~100~~ft.	———"———, and also below its position in the south cross-cut in No. 1 Shaft.
3	40°	340°	100ft.	To test below a costean north of creek, in which 28% P_2O_5 recorded by B.H.P.

STAGE 2

Hole No.	Inclination	Bearing (Magnetic)	Proposed length	Purpose
4	50°	335°	120ft.	To explore probable eastern extension along strike of main phosphatic bed in quarry.
4A	50°	335°	80ft.	If phosphate bed not intersected in No.4, may indicate that strike swings southwards. This hole would check.
5	Vertical		80ft.	Site would depend on data gained from No.4 (or No. 4A).
5A	50°	335°	70ft.	To be drilled if phosphate bed not intersected in No.5.
6	50°	335°	90ft.	To test below No.3 shaft, and below costean in which assays of up to 28.7% P_2O_5 have been recorded.
7	40°	335°	100ft.	To test below phosphatic beds in a costean.
8	40°	335°	80ft.	To test below No. 3 shaft and costean at a shallower depth than No. 6.
9	40°	335°	80ft.	To test below phosphatic beds assaying up to 24% P_2O_5.
10	40°	330°	100ft.	To explore for western extension of phosphatic band in quarry. Site may be influenced by results from No. 1.

It is considered that these holes would provide valuable information on phosphate-bearing ground over a strike length of about 700ft., to depths of about 100ft.

Results would point to the necessity or otherwise of further drilling in the northeastern portion of the lease in

order to trace the phosphatic beds; and also southwest and southeast of the quarry round the structure.

.... If extensive phosphatic formations were indicated, consideration should be given to the proving of reserves by a grid pattern of shallow vertical boreholes and by planned trenching.

.... A scintillometer survey by B.J. Taylor has shown that there might be a connection between phosphate content and increased radioactivity over background radiation. Gamma-ray logging of the boreholes should be carried out in order to attempt a correlation of P_2O_5 assay results with gamma ray activity.

.... Scintillometer surveys and sampling should be extended to the northeast.

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APPENDIX I

In mid July a scintillometer survey of the Myponga phosphate lease was carried out. This was to determine whether these phosphates contain small amounts of uranium, and if so, whether extensions of the known deposits can be detected.

Four traverses were made across the lease area and one to the north of the lease. Readings were taken every 20' except in areas of high gradient where the distance was reduced. Initially three scintillometers were used on one line to compare the relative sensitivities and "noise" variatons of the three instruments. It was found that all were of equal value, and therefore only one was used for the rest of the survey. Radiometric readings were taken every 2' up the quarry face and shaft side, to determine whether there were bands containing readable increased radioactivity.

Profiles of radioactivity in micro-Röntgens / Hour are shown on Dwg. No. 67-594, and a possible correlation of radioactive "highs" are shown on a map of the area (Plan no. 67-596). The intensities of the radiometric "highs" are not much greater than the background count (10-11 µR/HR), but the highs tend to follow the general trends of the beds containing phosphate. There seems to be no relation between relative amounts of phosphate and intensity of radioactivity, but areas containing known high percentages of phosphate invariably exhibited above normal radioactivity. The Profile of the line to the northeast of the lease shows a broad high (approx. 240' wide), but at present no samples from this area have been taken.

This method could be used to delineate possible extensions to the known deposit, provided that the soil cover is less than 1' thick, as this amount of cover will attenuate the intensity of the radioactivity by 90%. If drilling is started in this area, it may be of some interest to log the holes using a gamma ray probe, as this log should delineate the positions of the phosphate in the hole.

B.J. TAYLOR
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APPENDIX II

PETROLOGICAL AND MINERAGRAPHIC REPORTS

Australian Mineral Development Laboratories

Report MP.266-68 25.8.1967

Sample P329/67: M1: TS19600

Rock Name:

Sandy shale.

Hand Specimen:

Quartz grains up to 1mm. in diameter occur in a buff-coloured friable fine-grained matrix.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	50
Matrix	50
Biotite	acc

This is a medium- to coarse-grained, poorly sorted rock composed of rounded detrital grains which have moderate to high sphericity. These are set in matrix of clays and micas and very fine silica. Recrystallization under stress has occurred and bands of schistose matrix traverse the rock. The quartz grains have diffuse grain boundaries. Grains of quartzite are also present.

Sample P330/67: M2: TS19601

Rock Name:

Shale.

Hand Specimen:

A very fine-grained, friable, pale grey rock with thin irregularly defined bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	45
Matrix	55

Silt-sized grains of quartz are enclosed in a recrystallized matrix of clays and micas. The minute matrix flakes have a very prominant parallel orientation. Ferruginous material is distributed through the rock.

Sample P331/67: M3: TS19602

Rock Name:

Sandy shale.

Hand Specimen:

A fine-grained, grey-white, very friable rock with poorly defined bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	40
Matrix	60
Tourmaline, zircon	acc

This rock is similar to P329/67, but the quartz grains are better sorted, with an average diameter of 0.15mm. (fine sand sized). The grains are angular to sub-angular. Recrystallized matrix flakes have a parallel alignment.

Sample P332/67: M4: TS19603

Rock Name:

Sandy Shale.

Hand Specimen:

Sparse quartz grains up to 2mm. in diameter are set in a very friable, cream coloured, fine-grained matrix. Thin bedding planes are poorly defined.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	40
Matrix	60
Tourmaline, zircon	acc

This is a poorly sorted rock in which rounded grains of quartz, up to 2mm. in diameter, but having an average grain size of 0.15mm. are set in a recrystallized matrix of clays and micas. These small matrix flakes have a poorly developed parallel alignment. This rock is basically similar to P329/6 , 331/67.

Sample P333/67: M5: TS19604

Rock Name:

Sandy shale.

Hand Specimen:

A very fine-grained, pale yellow, thinly bedded, friable rock, This is crossed by a discordant band of ferruginous material.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	30
Matrix	55
Goethite	15

Angular to sub-angular quartz grains with an average diameter of 0.1mm. (fine sand) are set in a ferruginous matrix of recrystallized clays, micas. There is a poorly developed parallel alignment of sericite flakes.

Banding in the rock is wavy and is due to some layers having a higher proportion of ferruginous material than others. A band composed of goethite, with rare detrital quartz grains scattered through it, crosses the rock.

Sample P334/67: M6: TS19605

Rock Name:

Sandy shale.

Hand Specimen:

A very fine-grained, friable, thinly bedded, cream-yellow coloured rock. Rare rounded quartz granules are present.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	40
Matrix	59
Tourmaline, zircon, opaques	1
?Barite	acc

Fine sand-sized (median diameter 0.1mm.) angular to very angular detrital quartz grains are set in a silt-sized matrix of recrystallized clays, micas and quartz. Occasional large, rounded, grains of quartz and quartzite, up to 1.5mm. in diameter occur in the rock, and the bedding, as defined by a strong parallel alignment of the matrix flakes, is disrupted about them. Clusters of small granules of ?barite are scattered through the rock, and are probably secondary in origin.

Sample P335/67: M7: TS19606

Rock Name:

Siltstone.

Hand Specimen:

A very fine-grained, cream-yellow coloured, friable rock.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	50
Matrix	50
Muscovite, tourmaline, zircon	acc

Fine sand-sized detrital grains (median diameter 0.08mm.) of quartz are set in a silt-sized matrix of micaceous clays and quartz. The clastic grains are angular and moderately well sorted. Graded bedding in which silt and clay-sized layers alternate with those containing fine sand-sized particles is well developed, and a cross bed is also present. Finely disseminated ferruginous material occurs in the matrix giving it a red-brown colour.

Sample P336/67: M8: TS19607

Rock Name:

Siltstone.

Hand Specimen:

A very fine-grained, pale yellow, friable, massive rock.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	30
Matrix	70

Silt-sized (0.03 median diameter), angular grains of detrital quartz are set in a ferruginous silt- and clay-sized matrix of recrystallized micas, quartz and clays. The matrix flakes have a parallel alignment, and bedding is apparent. A small fault transects the bedding, and displaces the layers by 0.3mm.

Sample P337: M9: TS19608

Rock Name:

Siltstone.

Hand Specimen:

A very fine-grained, pale yellow, massive, friable rock.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	20
Matrix	80
Muscovite, tourmaline	acc

Silt-sized (median diameter 0.03mm.), angular, detrital grains of quartz are set in a ferruginous matrix of silt- and clay-sized flakes of mica, quartz and clay. The rock represents an intraformational breccia, as although the lithologies of the fragments are almost identical, the bedding directions as indicated by the alignment of the matrix flakes are at variance. The lithic fragments are up to 5mm. in length and surrounded by a matrix of similar composition.

Sample P338/67: M10: TS19609

Rock Name:

Phosphate rock.

Hand Specimen:

A pale yellow rock, composed of coarse, rounded, lithic fragments in various tones of yellow. All components are fine-grained.

Thin Section:

Collophane is the dominant mineral in this phosphatic rock. It has been chemically precipitated from water, and forms an almost isotropic groundmass. In this groundmass are angular silt-sized quartz grains, which are the sub-dominant components, together with accessory illite, and a trace of kaolin. There has been intraformational brecciation of the bed, and large, rounded fragments have been surrounded by similar material. Rare, angular fragments of shale are also present. Bedding in the rock is seen by a decrease in the proportion of fragments to matrix. Small fractures and cavities have been lined by apatite, which shows numerous growth rings.

Special Features:

This is the only rock in the sequence in which phosphate minerals have been found.

Sample P339/67: M11: TS19610

Rock Name: (Just above the phosphate layer)

Siltstone.

Hand Specimen:

A very fine-grained, pale yellow, friable rock. Appears massive, but has faintly defined, very thin bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	15
Matrix	85
Opaques	acc
Muscovite	acc

Silt-sized (median diameter 0.03mm.), angular, detrital quartz grains are randomly distributed through a ferruginous silt- and clay-sized matrix of recrystallized clays, micas and quartz. The brown ferruginous material serves to outline the bedding, which is highly irregular. Patches of finely disseminated opaque material up to 1mm. in diameter enclose some quartz grains.

Sample P340/67: M12: TS19611

Rock Name: (In the phosphate layer)

Siltstone.

Hand Specimen:

A very fine-grained, friable, slightly mottled, cream coloured rock, with thin, indistinct bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	49
Matrix	50
Feldspar	1

Silt-sized, angular, detrital grains of quartz (median diameter 0.03mm.) are set in a matrix of recrystallized clay minerals. The matrix differs from previous rocks in that ferruginous material is generally absent. There is a parallel alignment of the matrix mineral flakes and bedding due to slight segregation of quartz, and clay minerals is apparent. The bedding is wavy and contorted to a limited extent.

Sample P341/67: M13: TS19612

Rock Name:

Siltstone.

Hand Specimen:

A very fine-grained, friable, cream-white coloured rock, with thin, poorly defined bedding.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	20
Matrix	58
Feldspar	20
Carbonate	1

Fine sand-sized, angular, detrital quartz grains with a median diameter of 0.07mm. are set in a non-ferruginous matrix of recrystallized clay minerals and quartz. Clastic grains of both microcline and plagioclase are present, together with small clots (up to 0.15mm. diameter) of micritic carbonate. There is an alignment of matrix flakes, and weakly defined graded bedding. Illite is the dominant clay mineral, and kaolin is accessory.

Sample P342/67: M14: TS19613

Rock Name:

Siltstone:

Hand Specimen.

A very fine-grained, pale yellow, apparently massive rock.

Thin Section:

A visual estimate of the constituents gives the following:

	%
Quartz	30
Feldspar	10
Clay mineral	60

A ferruginous clay-mineral matrix encloses very fine sand sized, angular, detrital grains of quartz and microcline. Bedding is highly contorted, and intraformation brecciation has occurred to some extent.

DISCUSSION

This is a sequence of sandy shales and siltstones. The predominant clay mineral is illite, which favours a marine basin of deposition.

Below the phosphatic horizon, the beds contain an appreciable amount of feldspar. There has also been intraformational brecciation or disturbance of the bedding in P337-340 and P342.

Above the phosphatic layer, quartz appears to be the only significant clastic detritus, and generally there is a coarsening in its grain size towards the top of the sequence, together with an increase in the degree of recrystallization of the matrix.

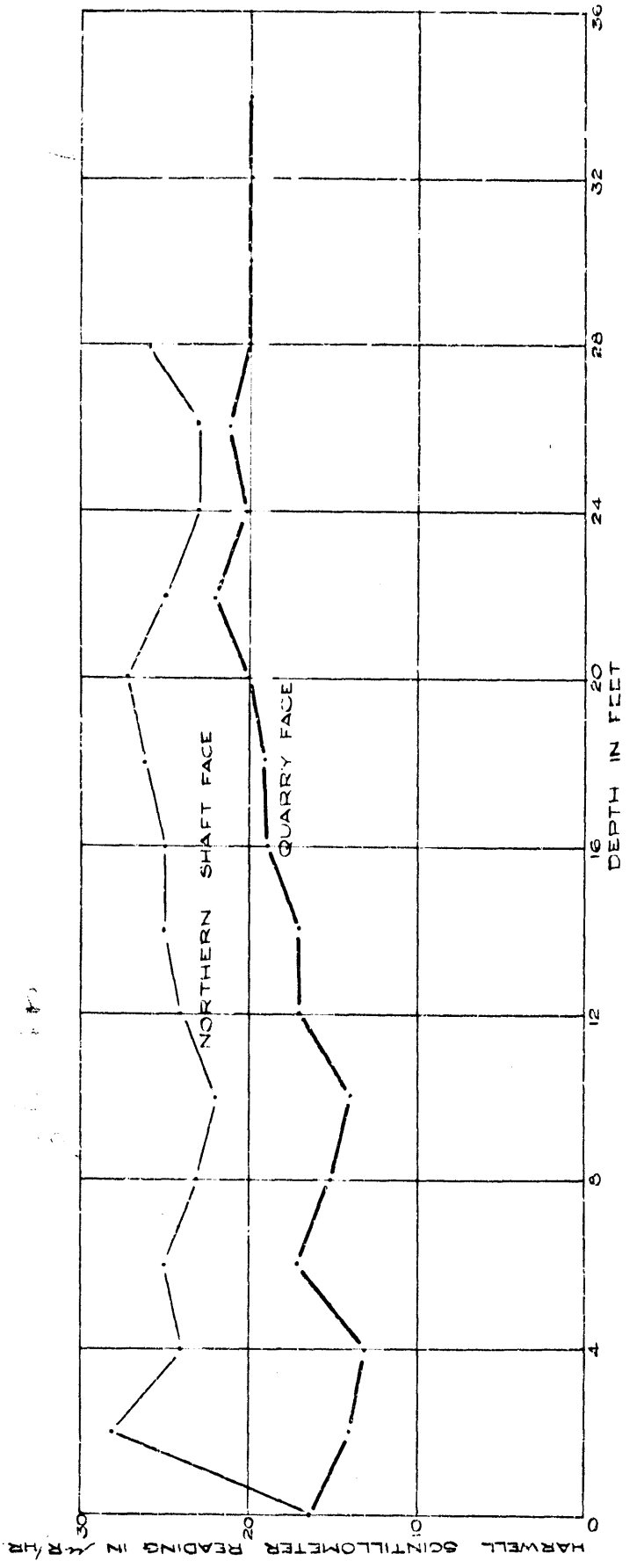
It is suggested therefore that this is a marine sedimentary phosphorite, and its association with land-derived sediments is indicative of a near shore environment. The phosphorite is bedded to a certain extent, and contains subangular to sub-rounded lithic fragments of the same material.

This indicates intraformation brecciation and limited abrasion either during or after precipitation from the sea water when the bed was still mobile.

X-ray Diffraction by: N.A. Trueman

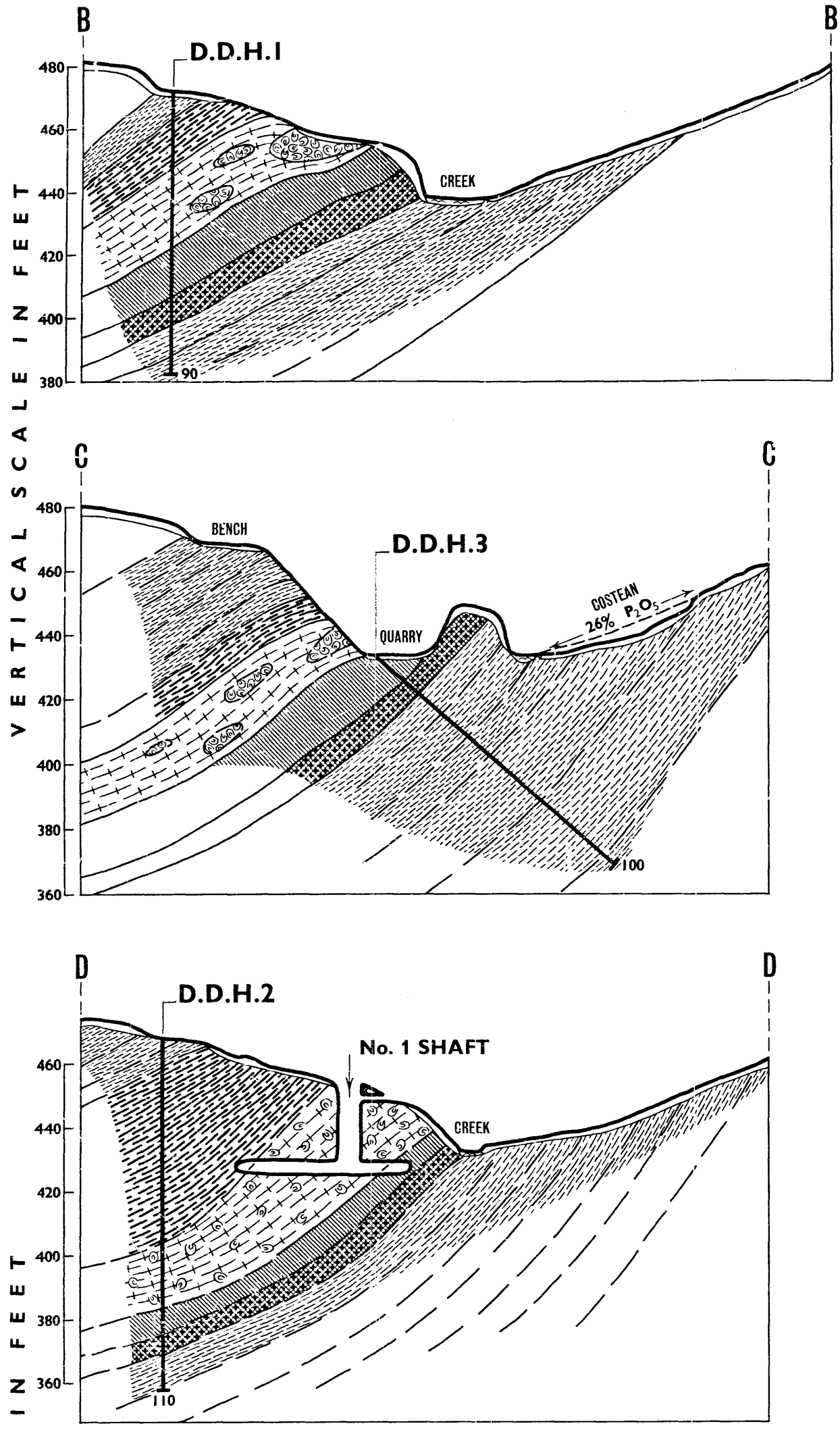
Investigation and Report by: G. Williams

Officer-in-Charge, Mineralogy Section: H.W.Fander



DEPARTMENT OF MINES — SOUTH AUSTRALIA

	Drn. BT	PHOSPATE DEPOSIT, SEC. 281, HD. MYPONGA, PROFILES OF RADIOACTIVITY WITH DEPTH.	SCALE: As shown
	Tcd.		S6011 Hc 4
	Ckd. L.V.W.		
	Exd.		DATE: 21-8-67



LEGEND

RECENT

Soil

Creek alluvium

LOWER CAMBRIAN

WANGKONDA LIMESTONE

Dark to light blue-grey to grey massive limestone

Grey siltstone with numerous worm burrows infilled with yellow and white siltstone

MT. TERRIBLE FORMATION

Yellow-brown to white shale or shaly siltstone

Well laminated to massive micaceous yellow-brown siltstone and sandstone interbedded with white shale with worm burrows

Grey to greenish-yellow micaceous laminated siltstone, bedding disrupted by worm activity

Goethite-limonite with remnant sandstone and shale

White micaceous siltstone

Pale purple silty shales with lenses and pods of yellow and white cavernous phosphate rock

Brown, well laminated silty shale

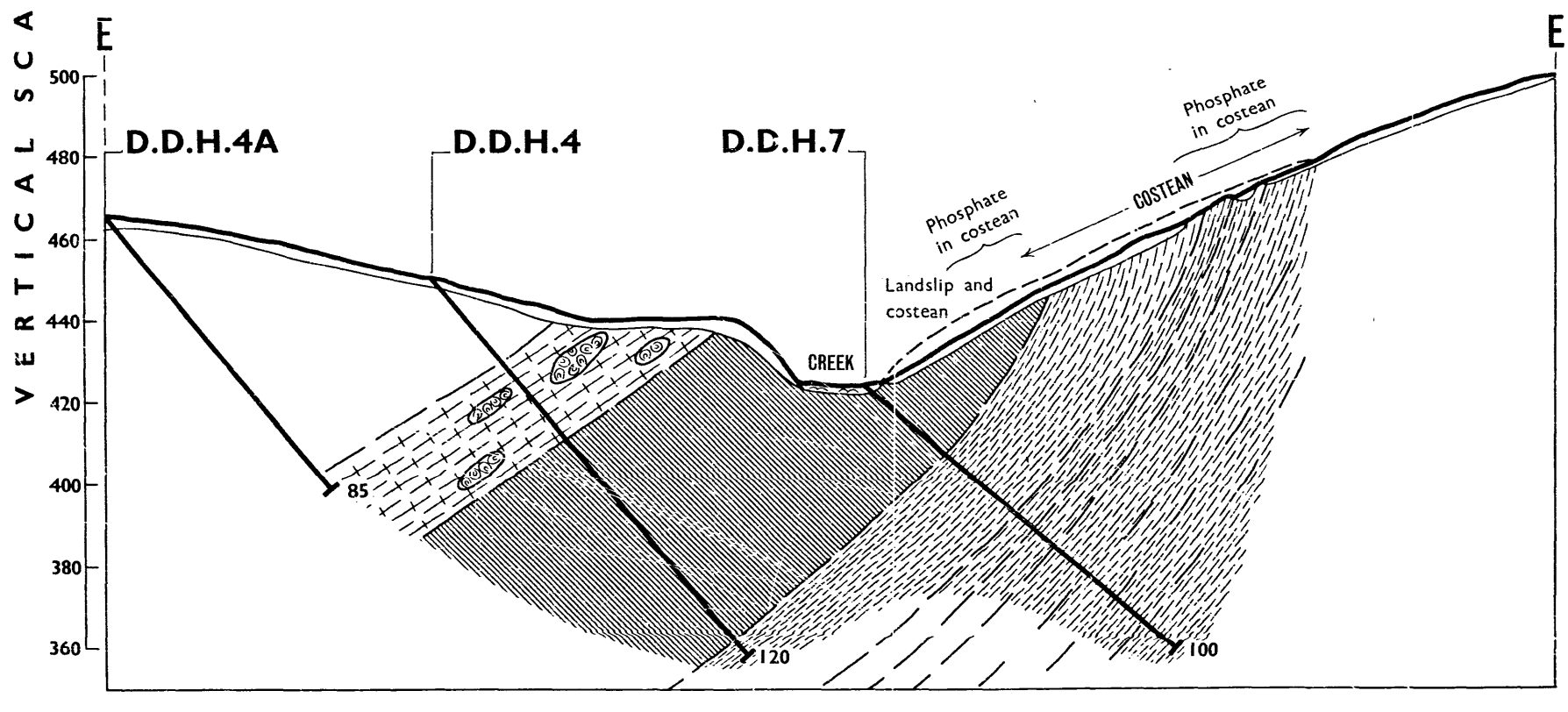
Yellow shale with many grit particles and discontinuous bedding (worm activity), numerous white lenses parallel to cleavage

Coarse grained white sandstone

Purple shale

Yellow shale with discontinuous white lenses

Pink to white coarse grained sandstone with worm burrows



SCALE

FEET 50 0 50 100 150 FEET

67-598

A. H. Blissett Assistant Senior Geologist R. A. Callen Geologist

S.A. Department of Mines

SCALE

FEET 50 0 50 100 150 FEET

VERTICAL SCALE IN FEET

F — F

D.D.H.5A

D.D.H.5

D.D.H.6

D.D.H.8

D.D.H.9

Ferruginous Sandstone

D ? U

TRACK

Soil

cover

TRACK

- Yellow gritty shales and siltstones, white siltstones, sandstones and brown shale.

CREEK

Soil

cover

COLLAPSED SHAFT No. 3

COSTEAN

26·7 24·4

•28·7

•1·05

1·35 0·45 6·0 9·9 19·5 16·1 24·4

•9·1

70

80

80

80

90

Probable position of phosphate horizon

A — A

For Legend See Fig. 4

Spot tests gave negligible results in this section (Mines Dept.)

Soil

cover

Variegated shales and siltstones

Probable white sandstone with worm casts and burrows

•0·40 •22·6 •29·3 •1·8

•26·0 •0·45

28·0

MYPONGA PHOSPHATE QUARRY

DUMP

CREEK

Soil

cover

•0·30 •0·30 •0·20

QUARRY

Mainly Sandstone

Interbedded shales

VERTICAL SCALE

No.1 SHAFT

(Section looking East)

27·7 27·2 24·5 21·7 9·4 10·0 14·2 24·0 15·0 8·9 15·8 12·8 2·7

No.2 SHAFT

(Section looking East)

From selected material not representative

26·9 25·0 28·6 9·6 22·9 36·7 34·0 36·7 35·7 35·5

REFERENCE

⊢------⊣---- % P_2O_5 (Projected on to section)

⊢——⊣---- % P_2O_5 (On section)

67-597

A. H. Blissett Assistant Senior Geologist R. A. Callen Geologist

S.A. Department of Mines

N

SCALE

FEET 100 0 100 200 300 400 500 600 700 800 FEET

FOR ENLARGEMENT SEE FIG. 1

M.C.4965

200N 240N 560N 640N

LINE B LINE C LINE D LINE E LINE G

FAULT

CONCEALED

No.1 No.2 No.4 No.4A No.5 No.5A No.6 No.7 No.8 No.9

No.10 (40°) 100' Brg. 330°(Mag.)

160S 320S 520S

Existing borehole (cased)

LEGEND

RECENT

Cover of Soil and Alluvium

LOWER CAMBRIAN

Sandstone and siltstone Worm burrows

Pale grey to dark blue-grey dense limestone

Micaceous sandstone, siltstone, shale Worm burrows and disturbed bedding

EAST FAULT WEST

MT. TERRIBLE WANGKONDA FORMATION LIMESTONE

Phosphatic beds

Ferruginous sandstone and siltstone

Limestone boulders

Strike and dip of bedding 45

Strike and dip of cleavage 85

Strike and dip of joints 75

Outcrop boundary

Scintillometer traverses

Possible correlation of radioactive anomalies

Diamond Drill Hole (proposed)

Costean, trench, pit

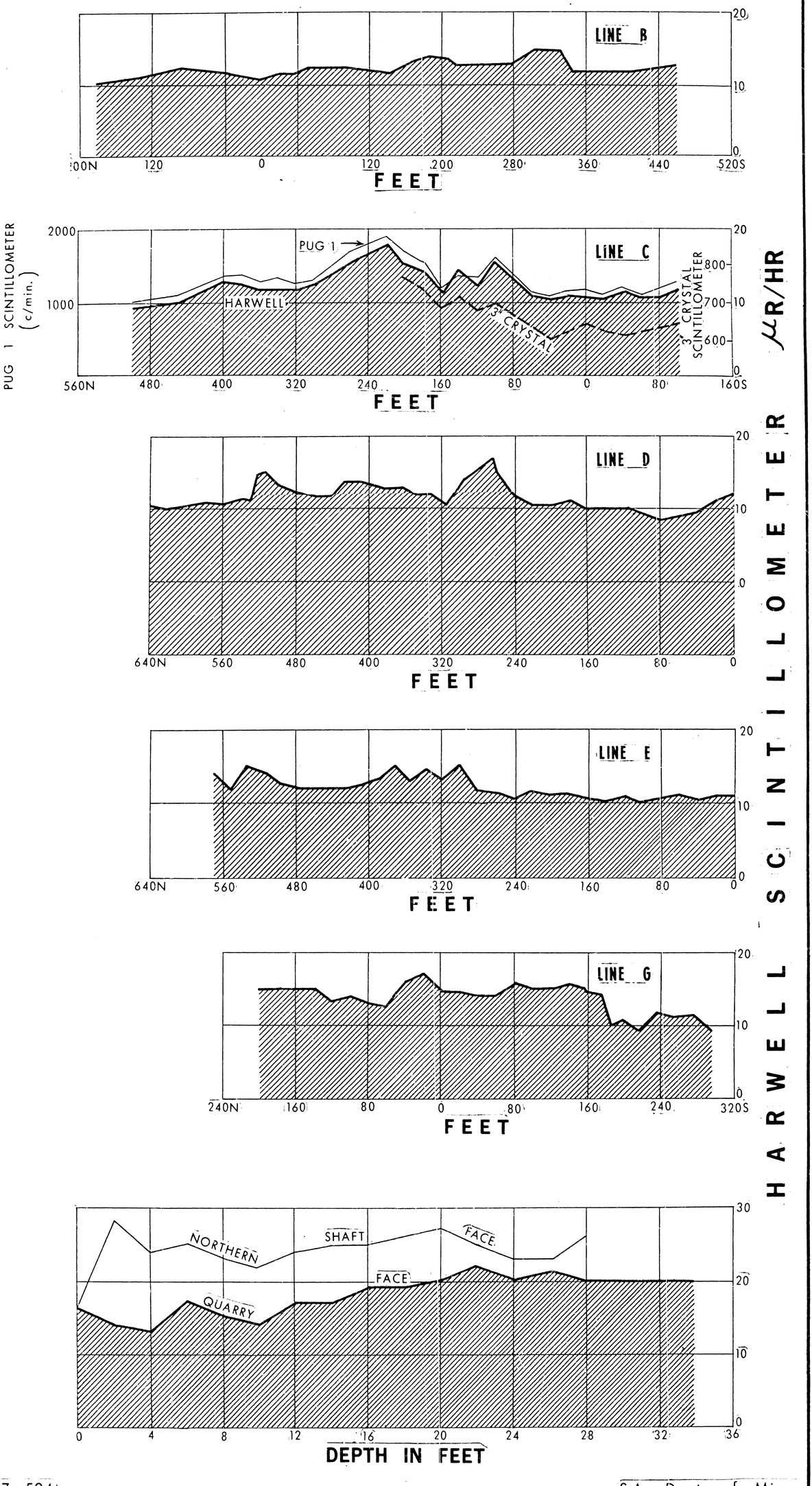
Bank or quarry face

Contours at 20ft. intervals (arbitrary datum) 620 600

67—596

A.H. Blissett Assistant Senior Geologist R. Callen Geologist

S.A. Dept. of Mines



67—594

S.A. Dept. of Mines

GRAPHS SHOWING PROFILES OF RADIOACTIVITY

PHOSPHATE DEPOSIT SEC. 218 HD. MYPONGA

R.127

FIGURE

Dark grey siltstone and white shale with worm burrows

Dark brown to black soil with ferruginised sandstone boulders

Light brown soil with scree bands

Dark brown soil

BOULDERS

LIMESTONE

Nº 9 (40°) 80Ft

Nº3 SHAFT Collapsed

Nº8 (40°) 80 Ft

Nº6 (50°) 90 Ft

Nº7 (40°) 100 Ft

Nº5 (Vertical) 80 ft

Nº5A (50°) 70 Ft

Nº4 (50°) 120 Ft

Nº4A (50°) 80 Ft

Black to dark brown soil

Dark brown soil with ferruginised sandstone boulders

FAULT ?

CONCEALED ?

SCALE

FEET 20 10 0 20 40 60 80 100 FEET

SCALE IN METRES

SCALE IN FEET

Nº 2 SHAFT
Section looking East
(From B.H.P. plan)

From selected material not representative

Nº1 SHAFT
Section looking East
(From B.H.P. plan)

F1

LEGEND

RECENT
- Soil
- Creek alluvium

WANGKONDA LIMESTONE
- Dark to light blue-grey to grey massive limestone
- Grey siltstone with numerous worm burrows infilled with yellow and white siltstone

LOWER CAMBRIAN

MT TERRIBLE FORMATION
- Yellow-brown to white shale or shaly siltstone
- Well laminated to massive micaceous yellow-brown siltstone and sandstone interbedded with white shale with worm burrows
- Grey to greenish yellow micaceous laminated siltstone bedding disrupted by worm activity
- Goethite-limonite with remnant sandstone and shale
- White micaceous siltstone
- Pale purple silty shales with lenses and beds of yellow and white cavernous phosphatic rock
- Brown well laminated silty shale
- Yellow shale with many grit particles and discontinuous bedding (worm activity) numerous white lenses parallel to cleavage
- Coarse grained white sandstone
- Purple shale
- Yellow shale with discontinuous white lenses
- Pink to white coarse grained sandstone with worm burrows

ASSAY RESULTS (in $\%P_2O_5$)
- Geosurveys, 1966 (From 1"=100' plans)
- Petrological sample
- B.H.P. 1941 (From 1"=20' plans) Accuracy = 10%
- Phosphate sample intervals
- Strike and dip of bedding
- Strike and dip of cleavage
- Boundary of outcrop
- Boundary of small scattered outcrops
- Geological Section
- Diamond Drill Hole (proposed)
- Costean, trench, pit
- Contour (20ft intervals)
- Creek bank or quarry (showing top and bottom of slope
- Shafts
- Probable location of old shaft
- Drive
- Level outline
- Survey station
- Measuring peg
- Fence

For Geological Map and Scintillometer Traverses see plan 67-596
For Geological Sections see plans 67-597 & 67-598

DEPARTMENT OF MINES — SOUTH AUSTRALIA

MYPONGA PHOSPHATE DEPOSIT
BLACK HILL — SEC. 281 HD. MYPONGA
WORKINGS AND DETAILED GEOLOGY

NON-METALLIC MINERALS SECTION		Drn RAC	SCALE: 1in = 20ft
		Tcd R.H	67-596
Director of Mines		Lrd	DATE: 2-10-67

F2

T N M N

Dark grey siltstone and white shale with worm burrows

Dark brown to soil with ferrug sandstone bou

Greenish-yellow to grey sandstone

Greenish-yellow to grey siltstone

Light brown soil with scree bands

White micaceous siltstone

Black soil

Light brown clayey soil with scree bands

Black to dark brown soil

Brecciated shale

Variegated shale-siltstone sequence

CAUSEWAY

FAULT ?

CONCEALED ?

N°1 SHAFT Depth 32 ft

N°2 SHAFT

N°3 SHAFT Collapsed

N° 9 (40°) 80 Ft.

N°8 (40°) 80 ft.

N°6 (50°) 90 ft

N°5 (Vertical) 80 ft

N°5A (50°) 70 ft.

N°7 (40°) 100 ft

N°4 (50°) 120 ft

N°4A (50°) 80 ft.

N° 3 (40°) 100 ft

N°2 110 ft.

N°1 90 ft

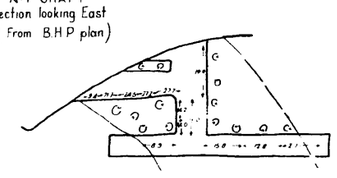
A △ 481'

B △ 481'

C △ 446.5'

FEET 20 10

N°1 SHAFT
Section looking East
(From B.H.P plan)



N° 2 S
Section l
(From B