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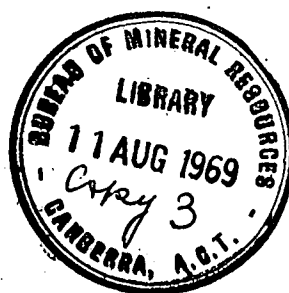
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PROGRESS REPORT

RUM JUNGLE PHOSPHATE SURVEY 1962/63

by

P.W. Pritchard, J. Barrie, W. Jauncey, and A.G. Fricker



The information contained in this report has been obtained by the Department of National Development, as part of the policy of the Commonwealth Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

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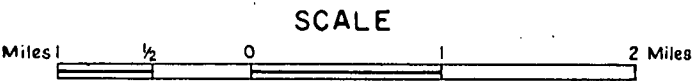
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(iii)

Plate 1	E63	Geology and topography		
2	E82	"	"	"
3	E83	"	"	"
4	E93	"	"	"
5	E82	Surface radiometric contours		
6	E83	"	"	"
7	E93	"	"	"
8	Geolsec Special			

Fig. 1

PHOSPHATE ROCK OCCURRENCES
RUM JUNGLE AREA, N.T.
(Base map after Malone and others 1960)



REFERENCE

* Known occurrences of phosphate rock

QUATERNARY

Qa Alluvium

UPPER PROTEROZOIC

Puo Depot Creek Sandstone

LOWER PROTEROZOIC

Pln Noltenius Formation

Pld Golden Dyke Formation

Plo Coomalie Dolomite

Pler Crater Formation

Pel Celia Dolomite

Ple Beestons Formation

Eg Rum Jungle and Waterhouse Granites

--- Geological boundary, position approximate

20 Strike and dip of strata

--- Established fault, position approximate

--- Established fault, concealed

■ H.S. Homestead

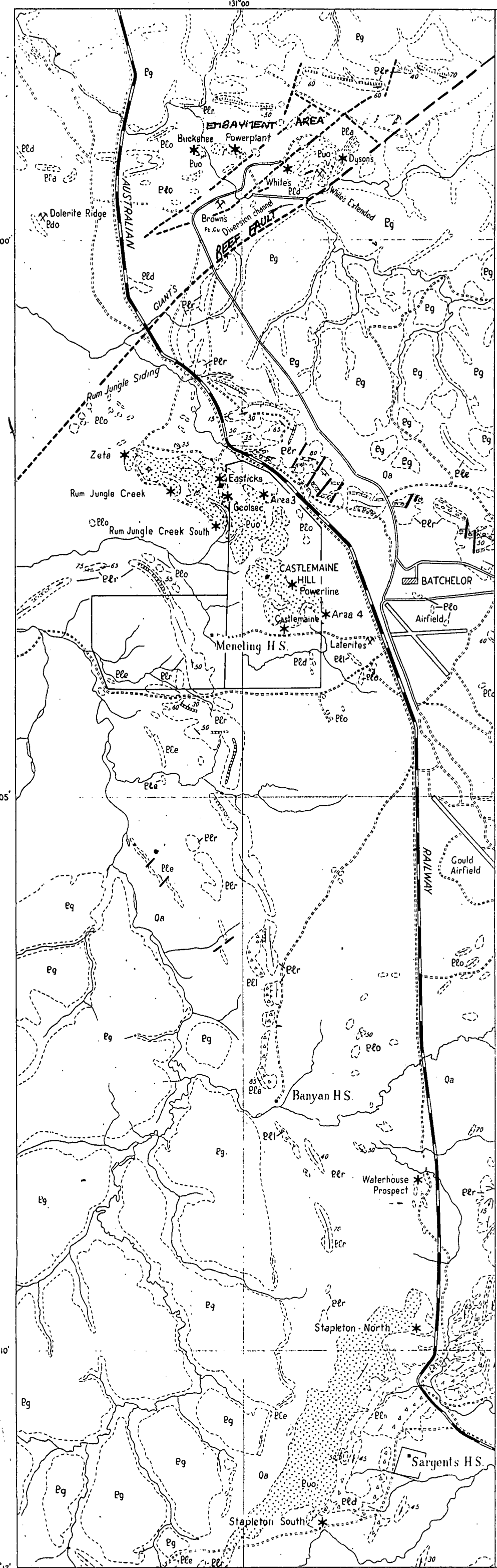
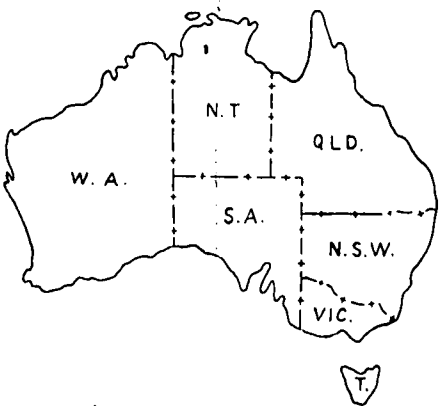
— Railway

== Highway

==== Vehicle track

— Fence

✕ Mine or prospect



PROGRESS REPORT

RUM JUNGLE PHOSPHATE SURVEY 1962/63

by

P.W. Pritchard, J. Barrie, W. Jauncey, and A.G. Fricker.

SUMMARY

Phosphate deposits were recognised in the Rum Jungle Region in 1961. ~~sixteen~~ ^{nine} occurrences are now known, ^{nine} in the Castlemaine Hill area, four in the Embayment area, two in the Stapleton area, and the Waterhouse No.2 uranium prospect, 6 miles south of Batchelor. The principal phosphate mineral is fluorapatite in hematitic mudstone, siltstone, and quartz breccia. Similar deposits have been found in the South Alligator Valley and phosphate rock crops out at Sleisbeck on the Katherine River. Phosphate rock in shears in granite has been reported from the uranium prospects in the Edith River area and from Copperfield Creek.

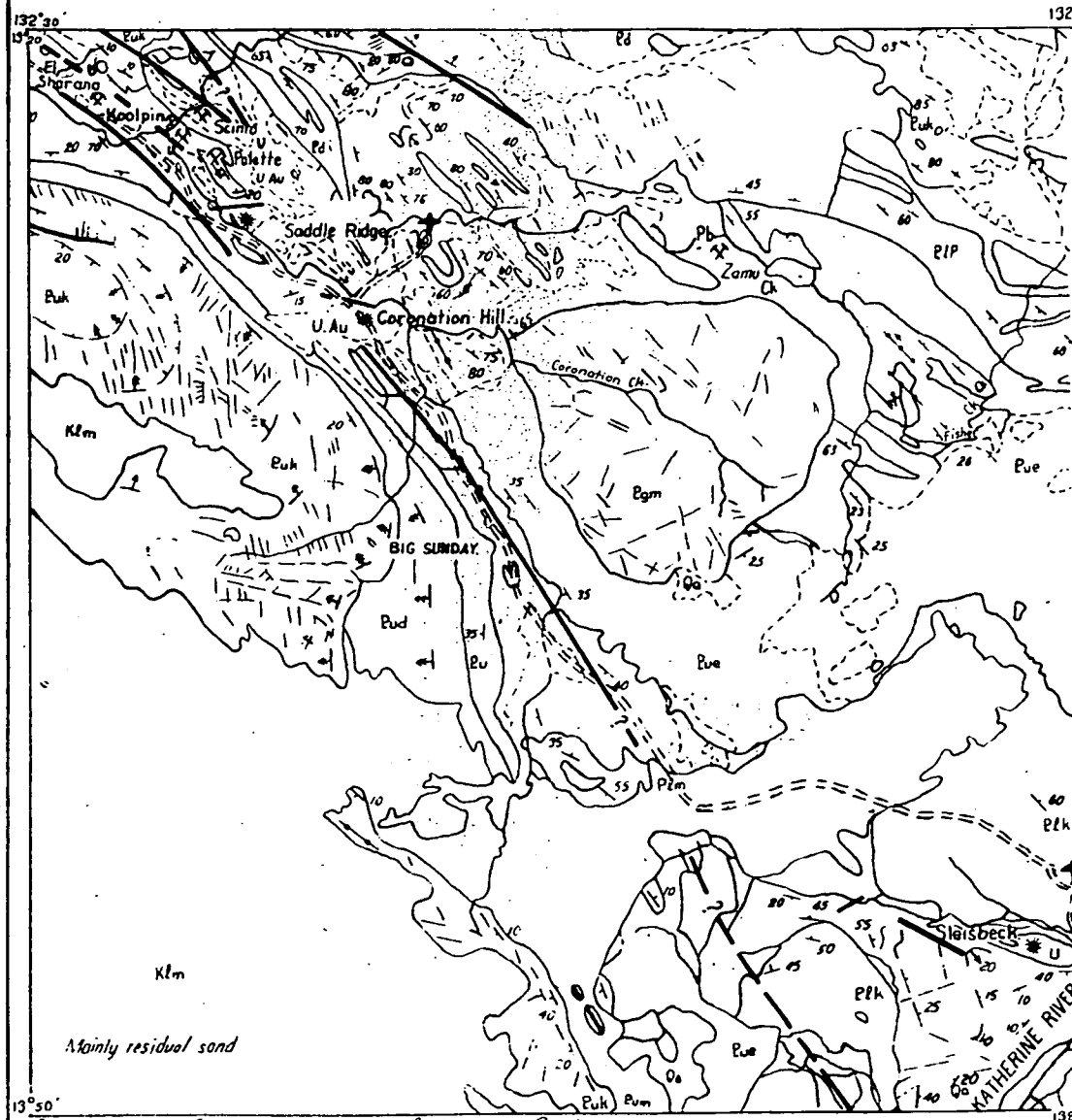
The phosphate deposits are considered to be supergene enrichments of fluorapatite in an ancient regolith formed on the Coomalie Dolomite. At Castlemaine Hill the dolomite occupies the core of a syncline of Lower Proterozoic metamorphosed sediments between the Rum Jungle and Waterhouse granitic complexes. The Embayment area is a continuation of this syncline displaced by the Giant's Reef Fault.

In 1962 and 1963 the Geolsec prospect on Castlemaine Hill was diamond drilled and shown to contain over 1,000,000 tons of material containing from 5 to 37 percent P_2O_5 . An auger drilling programme around the edges of Castlemaine Hill, and west of White's Mine in the Embayment area extended the known limits of some of the deposits but did not reveal any new ones.

The Rum Jungle phosphate deposits would need to be beneficiated before they could be used as raw material for superphosphate manufacture. The high content of finely disseminated iron makes beneficiation by present methods impracticable; at the moment the only obvious use of the material is a low cost ground rock phosphate fertiliser.

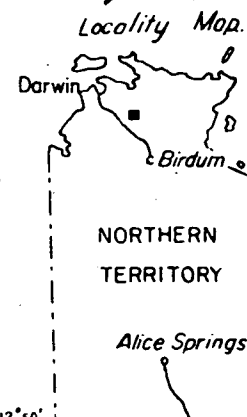
SOUTH ALLIGATOR VALLEY - SLEISBECK PHOSPHATE LOCALITIES

FIG. 2



- Reference**
- Qa Alluvium soil cover
 - Euk Kombolgie Formation
 - Eud Plum Tree Creek Volcanic Member
 - Eue Edith River Volcanics
 - Egm Malone Creek Granite
 - Edi Zamu Complex
 - PIP Fisher Creek Siltstone
 - Elm Masson Formation

- Established Geological boundary - position accurate
- - - Established Geological boundary position approximate
- ↘ 20° Inclined strike and dip
- ⊥ Vertical strike and dip
- ⊕ Horizontal strike and dip
- Trend line showing prevailing direction of dip
- - - Trend lines and photo interpretation
- ↗ Angle of dip 15° } or photo interpretation
- ↘ Angle of dip 15°-45° }
- Established fault, position accurate
- ? - Probable fault
- Quartz filled fault or fracture
- ||||| Main pattern, in photo interpretation
- - - Vehicle track
- ◆ Landing ground
- ✱ Mine or prospect
- Au Gold
- Pb Lead
- U Uranium
- ☼ Phosphate



Scale



INTRODUCTION

Rum Jungle Area (Fig.1)

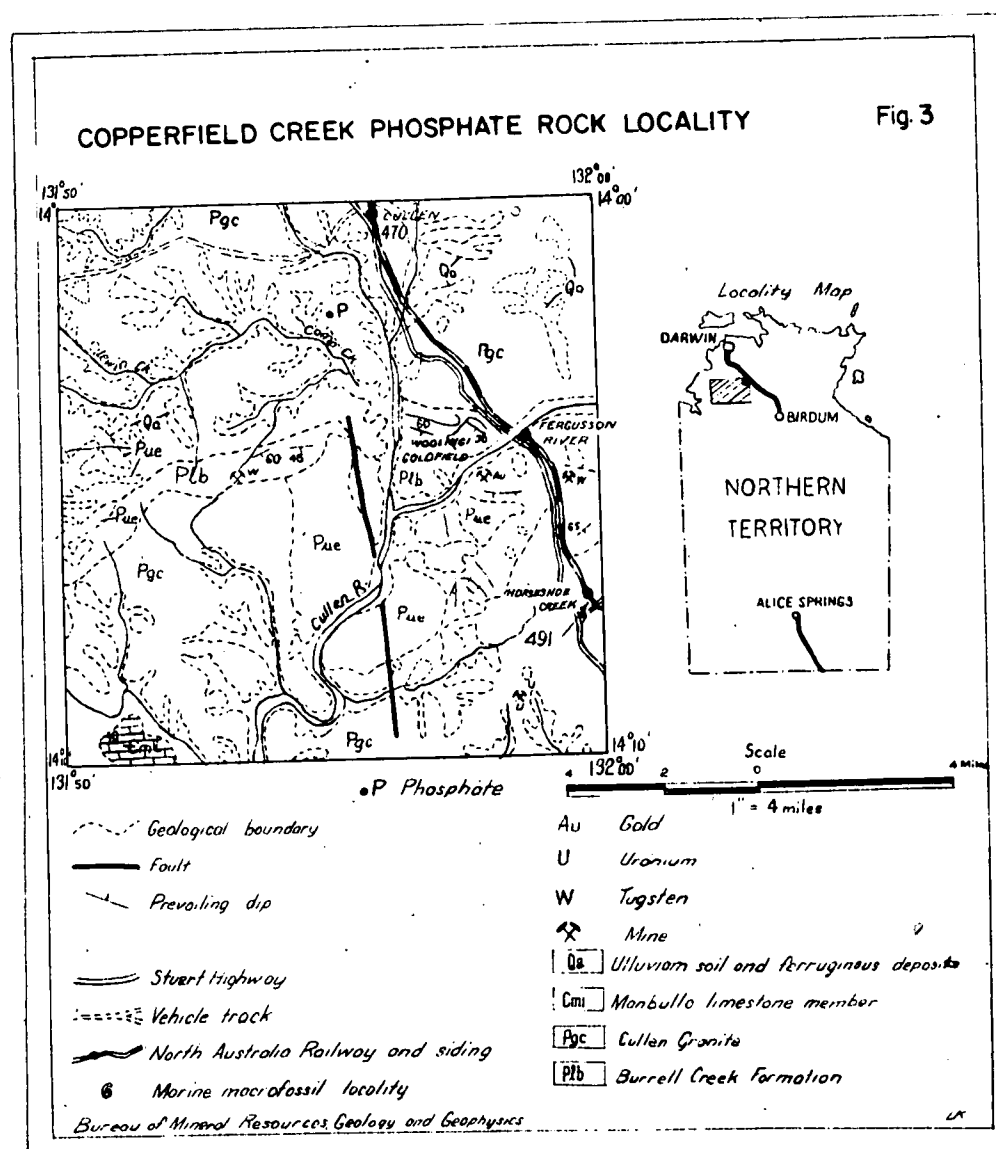
Phosphate rock occurs in the Rum Jungle area of the Northern Territory of Australia at sixteen localities. Its presence was recognised in 1961 when specimens of lilac siltstone from the Geolsec radiometric anomaly were sent to the Bureau of Mineral Resources, Geology and Geophysics (B.M.R.) laboratory in Canberra by B.P. Ruxton for spectrographic analysis and found to consist mainly of apatite (Ruxton 1963). B.P. Ruxton and J. Shields found outcrops of similar material at Easticks, Area 3, Area 4, Rum Jungle Creek South, Rum Jungle Creek, Buckshee and Dysons and showed that it is present in diamond drill core from Waterhouse No.2 uranium prospect. Later in the same year W. Patterson of Enterprise Exploration Pty. Ltd. found phosphate rock at Stapleton North and Stapleton South.

South Alligator Valley and Sleisbeck (Fig.2)

Similar phosphate rock occurs at Coronation Hill and Saddle Ridge in the South Alligator valley and at Sleisbeck on the Katherine River (Walpole, 1961, 1962).

Copperfield Creek and Edith River Uranium Prospect (Fig.3)

In 1962, J. Ericson, of Darwin, reported outcrops of phosphate rock near Copperfield Creek and apatite has been found in diamond drill core from the Edith River Uranium Prospect (Bryan, 1962). Other uranium prospects in this area contain small amounts of phosphate rock (D.E. Gardner pers.comm.).



REVIEW OF OPERATIONS

The 1962/63 Survey

The 1962/63 survey involved mapping the Castlemaine Hill area and the Buckshee and Powerplant prospects in the Embayment area (Fig.1); auger drilling and costeaning prospective areas around the edges of Castlemaine Hill; auger drilling the Buckshee prospect; diamond drilling the Geolsec prospect; and testing selected core from Territory Enterprises (Pty.) Ltd. (T.E.P.) diamond drilling. The phosphate localities at Sleisbeck (Fig.2) and near Copperfield Creek (Fig.3) were briefly examined.

Geological Maps

The results of geological mapping and information from previous B.M.R. and T.E.P. work have been recorded on a series of maps based on the T.E.P. Mine Grid. This series consists of 1:1200 field sheets each representing an area 3000 x 2000 feet and 1:4800 compilation sheets each representing an area 12,000 feet by 8000 feet (Plates 1 - 7). Blocks of one hundred 1:4800 sheets have been given letter symbols (e.g.E.) the individual 1:4800 sheets are numbered (e.g. E83) and the sixteen 1:1200 sheets making up each 1:4800 sheet are given an additional number (e.g. E83-6). Block E has its bottom left hand corner located at 00E x 00N on the T.E.P. Mine Grid.

Surveying

The B.M.R. geophysicists' grid was used during the field work on Castlemaine Hill and a new grid was pegged out for the survey of the Buckshee and Powerplant prospects.

Local grids around Castlemaine Hill have been located by theodolite traverses to Lands and Survey Department bench marks along the fence shown on survey plan A138 and along a survey line extending 13 miles south-west from Manton Dam. The extension of the geophysicists' grid from Castlemaine Hill towards Area 55 has been controlled by T.E.P. theodolite traverse from the '6-mile' peg on the Manton Dam Line to the beacon at Area 55. The local grid over the Buckshee and Powerplant prospects has been related to T.E.P. survey pegs near the Finnis River Bridge on the road from Batchelor to the treatment plant.

Table 1.

* HUNDRED OF GOYDER TRIGONOMETRICAL STATIONS** Mine Grid coordinates (feet)

<u>Station</u>	<u>Easting</u>	<u>Northing</u>
Spike,	28 460.06 E	25 720.78 N
Giants Reef	43 572.39 E	36 778.87 N
Mt. Wimpey	31 647.52 E	28 373.79 N
Stratton	40 259.60 E	17 621.79 N
Red Ochre	27 107.51 E	13 124.94 N
Flynn	31 708.84 E	15 997.33 N
R.J.C.S.	29 175.65 E	9 627.95 N
Castlemaine	32 436.72 E	7 251.60 N
Mt. Burton	14 245.21 E	35 154.11 N
Mt. Fitch	13 109.33 E	40 475.45 N
Area 55		
Area 65 A	51 406.53 E	5 739.71 S
Area 65 B	50 658.21 E	7 872.26 S
Area 65	51 568.12 E	10 816.12 S

* Survey for T.E.P. by Department of Lands and Surveys, Darwin, October, 1961.

** Coordinates of local Mine Grid for Station 'U' have been accepted for the conversion from the coordinate of the Transverse Mercator Zone 4 Australian Series. Mine Grid North is two (2) minutes west of true north.

<u>Mine Grid Coordinates</u> feet			<u>Zone 4 Coordinates</u> yards	
<u>Station</u>	<u>Easting</u>	<u>Northing</u>	<u>Easting</u>	<u>Northing</u>
U	33 735.46	31 378.12	401463.55	3345282.71

Assaying

Samples from drill holes or costeans were assayed for phosphate in a field laboratory and in the B.M.R. Canberra laboratories. Check analyses were made by the Australian Mineral Development Laboratories (AMDL) in Adelaide. Two orders of chemical assay were used in the field laboratory, a semi-quantitative method (50 to 70 samples/man/day) and quantitative gravimetric and volumetric methods (8 and 6 samples/man/day respectively).

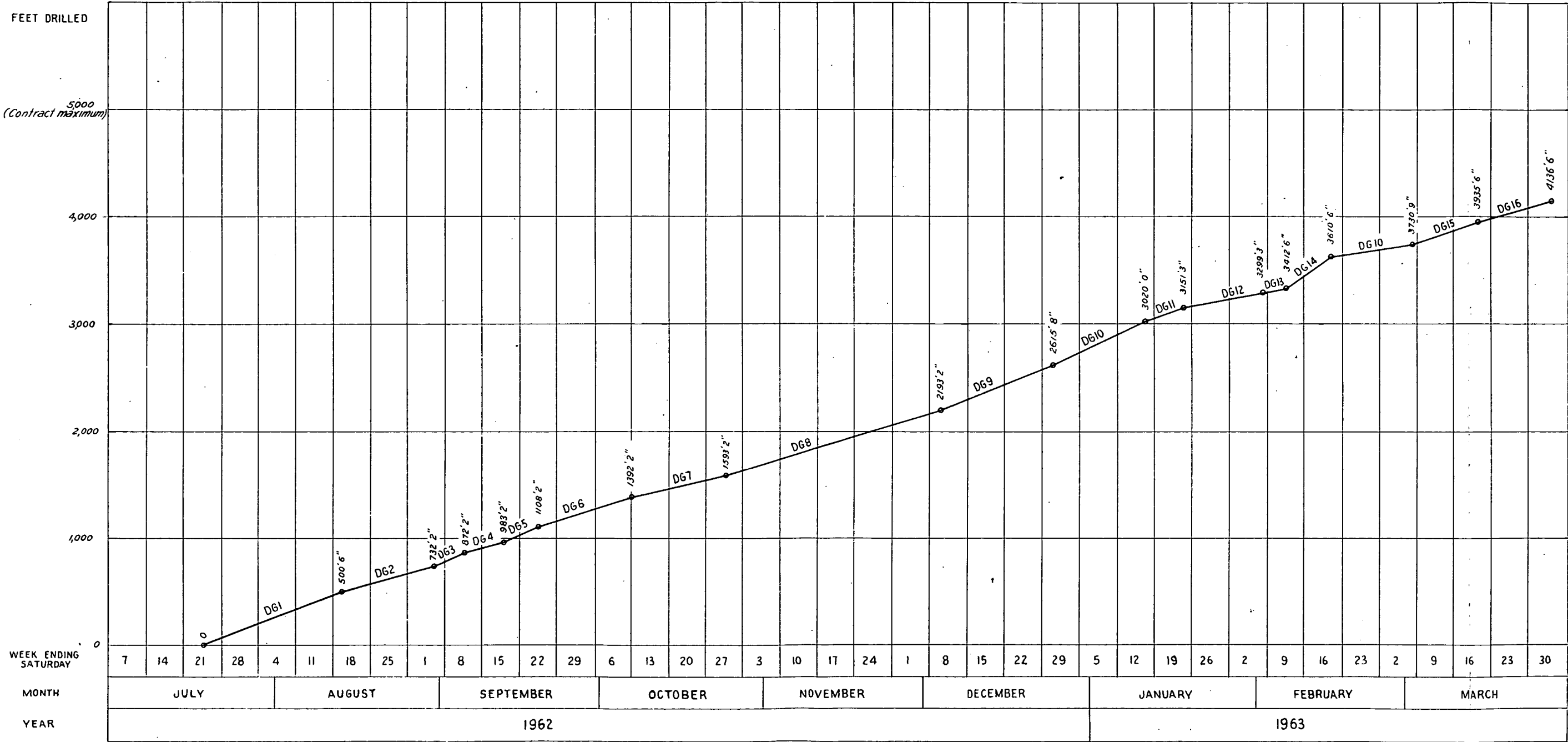
The semiquantitative method was used to select from the large number of samples received each day those samples with sufficient P₂O₅ content (normally greater than 10 percent P₂O₅) to warrant quantitative analysis.

Both quantitative methods used were based on the precipitation of ammonium phosphomolybdate. The gravimetric method is quicker than the volumetric method, is more accurate (± 4 percent as opposed to ± 6 percent), and requires less equipment and reagent preparation.

Diamond Drilling

The diamond drilling contract is summarised in Fig.4.

Each hole was radiometrically logged by geophysicists from the Darwin Uranium Group.



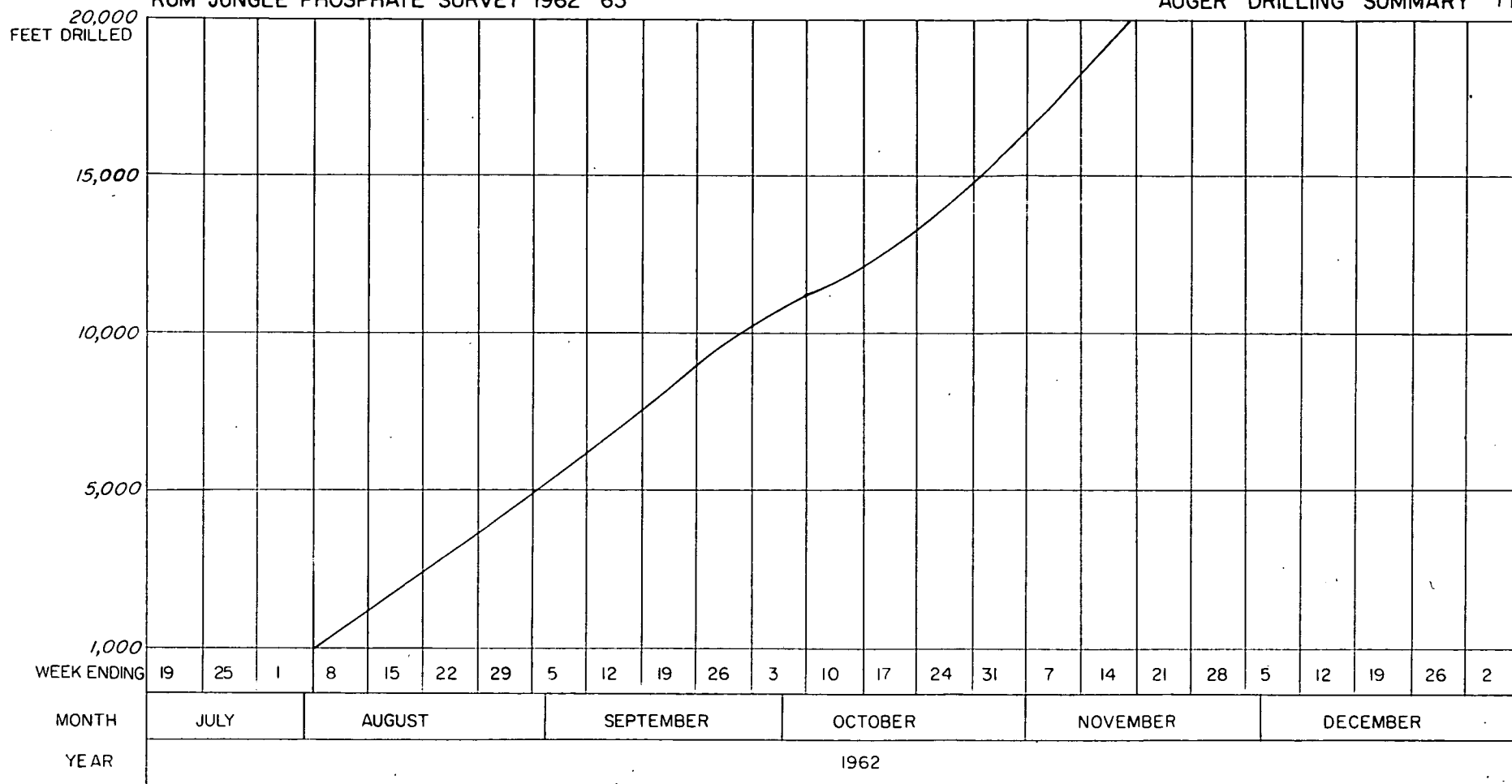
CONTRACTOR: *Atlantic Drillers*
TYPE OF RIG : *Mindrill F20*
CORE SIZE : *BM, some NX*
DRILLER : *F. Kelly*
LOCATION : *Slopes of Castlemaine Hill*
ACCESS : *Good. Bulldozed tracks*

PRICE PER FOOT DRILLED : £1 : 8 : 6
CORE RECOVERY BONUS PER FOOT : 80 - 85%, £1 : 15 : 6
86 - 90%, £2 : 4 : 0
91 - 96%, £2 : 8 : 0
96 - 100% £2 : 12 : 0

TOTAL COST : £16,867 : 19 : 5
TOTAL FOOTAGE DRILLED : 4,136'6"
AVERAGE COST PER FOOT : £4 : 1 : 7

RUM JUNGLE PHOSPHATE SURVEY 1962-63

AUGER DRILLING SUMMARY Fig 5



CONTRACTOR : *Monier Earth Drilling Pty. Ltd*
 TYPE OF RIG : *Gemco Auger Drill*
 HOLE SIZE : *4 inches*
 DRILLER : *J. Close*
 LOCATION : *Slopes of Castlemaine Hill*
 ACCESS : *Good*

PRICE PER FOOT DRILLED :
 0 - 8,000 FEET : *6/3^d*
 8,000 - 20,000 FEET : *3/9^d*

TOTAL COST : *£6409.6 11*
 TOTAL FOOTAGE DRILLED : *20,662 ft.*
 FOOTAGE PAID FOR : *19,996 ft.*
 AVERAGE COST PER FOOT : *6/5^d*
 NO OF HOLES DRILLED : *835*
 AVERAGE DEPTH OF HOLE : *25 ft.*

All core was split, crushed and assayed for phosphate. The bulk of this material is stored in Darwin, a small amount is stored in Canberra. Composite logs of the diamond drill holes are reproduced in Appendix 1.

Auger Drilling

The auger drilling contract is summarised in Fig.5.

Radiometric logging of the auger drill holes was done by members of the party. Samples were tested at the drill site for phosphate and the phosphatic ones were crushed and assayed. A complete set of samples is stored in Darwin and a set of 'bottom hole' samples has been given to the B.M.R. laboratory in Canberra for spectrographic analysis to supplement the 1961 and 1962 geochemical surveys. Composite logs for each hole are held in the party files.

Bulldozer Operations

Bulldozers were used for costeaning, and preparation of drill sites and access tracks. Table 2 summarizes the use of hired bulldozers. Channel samples of some of the costeans are stored by the Senior Geologist, Darwin.

Table 2

SUMMARY OF BULLDOZER HIRE

<u>Owner</u>	<u>Bulldozer</u>	<u>Cost per hour</u>	<u>Hours worked</u>	<u>Work done</u>	<u>Cost</u>
T.E.P.	Caterpillar D7	£6	33	Costeans 1,2,& 3.	£198
W.Childs Ltd.	International (equivalent to Caterpillar D6)	£5.10.0	157	Costeans 4 to 12.	£863.10.0

REVIEW OF GEOPHYSICAL INFORMATION

B.M.R. geophysicists have made airborne and ground, radiometric and electromagnetic surveys in the Rum Jungle region, and a seismic survey at the Geolsec prospect.

Radiometric Surveys (Douglas, 1962)

Radiometric anomalies are associated with the exposures of phosphate rock. Dysons, Whites, Zeta, Rum Jungle Creek, Castlemaine, Geolsec and Easticks were known as radiometric anomalies before phosphate rock was recognised at each of them.

Electromagnetic Surveys (Douglas, 1962)

In the Castlemaine Hill area electromagnetic surveys have indicated a conducting zone around the western, southern and south-eastern margin of the hill. Apart from outlining a conducting body which may be a structural marker these results do not have a direct application to the search for phosphate rock.

Seismic Survey

The results of a seismic survey at the Geolsec prospect by T. Andrews in 1963 are being processed. Preliminary indications are that a high velocity layer of about 13,000 feet/second at 30 feet below the surface masked the reflections from underlying layers.

GEOLOGY

Regional Geology

The regional geology of the Rum Jungle area is described by Malone (1958, 1962), Malone and others (1960).

Stratigraphy

They recognised four major stratigraphic elements; the Rum Jungle and Waterhouse granitic complexes (basement); the overlying metamorphosed Lower Proterozoic sediments; the relatively flat lying Upper Proterozoic sediments; and the Tertiary to Recent sediments and soils. The stratigraphy is summarised in Fig.6.

Fig 6

GENERALISED STRATIGRAPHIC COLUMN - RUM JUNGLE
(Based on Malone 1958 and 1962)

PHOSPHATE SURVEY 1962-63

AGE.	ROCK UNIT.		SCHEMATIC SECTION	ROCK TYPE IN THE RUM JUNGLE AREA.
RECENT.			~ Discontinuity ~	Alluvium, colluvium, red brown soils, red earths.
			~ Discontinuity ~	Sand, sometimes ferruginous and kaolinitic, often well rounded and poorly sorted.
TERTIARY.			~ Discontinuity ~	Ferricrete, mainly pisolitic.
UPPER PROTEROZOIC.	Tolmer Group	Depot Creek Sandstone.	~ Unconformity ~	Hematitic quartz breccia, hematitic conglomerate, siltstone & mudstone, quartz sandstone.
		Rum Jungle & Waterhouse Granite.	~ Unconformity ~	Granite and adamellite.
LOWER PROTEROZOIC.	Finnis River Group	Noltenius Formation.		Quartz greywacke siltstone, greywacke, quartz greywacke.
		Burrell Creek Formation.		Siltstone, greywacke siltstone, greywacke, quartz greywacke.
	Goodparla Group	Golden Dyke Formation.	~ Overlap ~	Quartz siltstone, carbonaceous siltstone, marl, dolomite, chert, pyritic in places.
		Acacia Gap Tongue.		Quartz greywacke, quartz sandstone, siltstone, carbonaceous siltstone pyritic in places.
	Batchelor Group	Coomalie Dolomite.		Dolomite, carbonaceous dolomite and siltstone.
		Grater Formation.		Quartz greywacke, greywacke, arkose conglomerate, pyrite and carbonaceous siltstone.
		Celia Dolomite.		Algal dolomite.
		Berston's Formation.		Arkose greywacke siltstone, conglomerate, arkose conglomerate.
ARCHEAN.			~ Unconformity ~	Granitic gneiss, schist.

LA

Structure

The major structural elements of the area are the Rum Jungle and Waterhouse domes with the basement rocks exposed in their centres and the Lower Proterozoic metamorphics folded around them. Faulting is common in the area but the most striking fault is the Giants Reef Fault (a dextral wrench fault) which disrupts Upper Proterozoic and older rocks. The distribution of these elements can be seen on the Rum Jungle Special map B.M.R. (1960).

Geology of the Prospect Areas

The results of mapping at 1:1200 scale in the prospect areas are shown on plates 1 to 4. Outcrop in these areas is very poor, most of the rock visible is rubble and the geological boundaries shown in the plates are usually rubble boundaries.

At each prospect the phosphate rock is associated with hematitic quartz breccia, mudstone, siltstone and sandstone referred to by T.E.P. as the mudstone sequence and mapped by Malone and others (1960) as part of the Upper Proterozoic Depot Creek Sandstone. These rocks, which will be called the breccia-mudstone sequence, are now considered to be remnants of a regolith developed over the Coomalie Dolomite. The age of this regolith is not known. It is older than the Giants Reef Fault.

In the South Alligator Valley similar breccia, siltstone and phosphate rock occur at the bottom of the Upper Proterozoic sequence.

Castlemaine Hill

The regional geological map (B.M.R. 1960) shows that Castlemaine Hill lies in a syncline of Lower Proterozoic rocks between the Rum Jungle and Waterhouse granite complexes.

It is probable that the Coomalie Dolomite, immediately underlying the breccia mudstone sequence, is in the core of the syncline and overlies the schist containing the Rum Jungle Creek South uranium orebody. Lineations mapped at the 'Batchelor Laterites' indicate that the syncline plunges north-west. This conclusion is further supported by the shape of the conducting zone outlined by the electromagnetic surveys.

A well defined arcuate photo lineation on the western edge of Castlemaine Hill is coincident with a change of topographic relief and the boundary between the Coomalie Dolomite, with its overlying regolith, and the schist west of the hill. This lineation parallels one of the schistosity directions in the schist containing the Rum Jungle Creek South uranium orebody. Evidence that it is a shear zone, on which there has been movement after the formation of the breccia mudstone sequence, is given in D355 where a shatter zone at 600 feet contains fragments of the hematitic quartz breccia together with fragments of schist and dolomite.

Another arcuate photo lineation roughly parallel to the one just described can be discerned on the eastern side of Castlemaine Hill. This too may be a shear zone.

Other photo lineations roughly parallel to the Giants Reef cross the Castlemaine Hill area and at least some of these are probably faults.

Scattered masses of boulders of pink, medium grained, thin to medium-bedded and massive silicified quartz sandstone occur on Castlemaine Hill. These may be remnants of the Depot Creek Sandstone.

In a railway cutting between Batchelor and the southern end of Castlemaine Hill a sequence of pebbly kaolinitic quartz sandstone and black siltstone appears to rest unconformably on the older Lower Palaeozoic rocks. Sediments similar to these have not been recognized elsewhere in the area but around the edges of Castlemaine Hill quartz sand, in places at least forty feet thick, may be related to these sediments. This sand is usually well-rounded but poorly sorted; much of it is kaolinitic and ferruginous.

Small patches of pisolitic ferruginous breccia and ferruginous sandstone occur around the edges of Castlemaine Hill. These are probably remnants of a Tertiary or Recent land surface.

The Embayment Area

The geology of the Embayment Area is a continuation of the geology of Castlemaine Hill area displaced by the Giants Reef Fault. The Coomalie Dolomite overlain by remnants of the breccia-mudstone sequence, is exposed on the northern flank of the faulted continuation of the synclinal structure present in the Castlemaine Hill area. This syncline appears to open out westwards towards Brown's and Area 55.

Lithologies in the Deposits

Phosphate Rock

The highest grade phosphate rock (containing up to 37% P_2O_5) is a mudstone or siltstone containing fluorapatite with hematite and minor calcite, chlorite, mica, sericite and quartz. The apatite grains are in two size groups; the hematite ranges in grain size from 0.0001 to 0.027 mm and is disseminated throughout the rock (Table 3).

TABLE 3

* GRAINSIZES AND MODAL ANALYSES

<u>Sample Number</u>	<u>Coarse-grained apatite</u>		<u>Fine-grained apatite</u>		<u>Hematite</u>	
	<u>Grainsize</u>	<u>Modal</u>	<u>Grainsize</u>	<u>Modal</u>	<u>Grainsize</u>	<u>Modal</u>
	(mm)	% analysis	(mm)	% analysis	(mm)	% analysis
10792	0.13	5	0.018-0.045	34	0.0001-0.027	20
12824	0.02-0.1	67	0.004-0.012	25	0.0005-0.007	3
12825	-	-	0.036-0.12	38	0.0005-0.013	17

* Information from W. Morgan (Appendix 4).

Much of the lower grade phosphate rock is hematitic quartz breccia containing up to 25% P_2O_5 . The phosphate is present as fluorapatite in the hematitic mudstone and siltstone matrix. None of the breccia with quartz sand grains in the matrix, or of the ferruginous quartz sandstone contain more than a trace of phosphate.

X-ray diffraction analyses to two clay samples (32'6" to 33' and 96'6" to 97' in diamond drill hole DG13) (Goadby 1963) showed that the clay mineral present is kaolinite. Investigations by the Australian Mineral Development Laboratories of material from the surface of the Geolsec prospect show that although most of the phosphate is present as fluorapatite a variety of phosphate minerals occur - millisite ($Na_2O \cdot 2CaO$).

$6\text{Al}_2\text{O}_3 \cdot 4\text{P}_2\text{O}_5 \cdot 15\text{H}_2\text{O}$); a member of the variscite ($\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$) - strengite ($\text{FePO}_4 \cdot 2\text{H}_2\text{O}$) series; and wavellite ($\text{Al}_3(\text{OH})_3(\text{PO}_4)_2 \cdot 5\text{H}_2\text{O}$). These are associated with quartz, kaolinite, sericite or illite, hematite and (?) goethite.

Traces of beryllium are present in the apatite rock.

Table 4

*BERYLLIUM CONTENT OF PHOSPHATE ROCK

<u>Sample locality</u>	<u>Number of samples</u>	<u>Beryllium content</u> ppm.
Easticks	2	10
Geolsec	6	13
Area 3	1	8
Area 4	2	10

* Supplied by D.A. Haldane.

Hematitic quartz breccia

The hematitic quartz breccia is a distinctive rock type. Angular fragments of quartz are set in and embayed by a matrix of mudstone, siltstone and quartz sandstone containing finely disseminated hematite. The quartz grains in the sandstone were originally well rounded but these too are pitted and embayed, and are coated with hematite. In drill core the quartz fragments are glassy but when weathered most have a sugary texture and appear to be devitrified. Most of the quartz fragments are less than a foot across and the fabric of most of the breccia is chaotic, but in a few places the arrangement of the quartz fragments suggests bedding or a metamorphic banding. Similar banding outlined by quartz is visible in the dolomite exposed north-west of the Zeta prospect.

PHOSPHATE ROCK PROSPECTS

The localities of the sixteen phosphate prospects are shown on Fig.1.

Geolsec (Plates 3,6,8).

The Geolsec prospect, on the eastern side of Castlemaine Hill, is the largest exposure of phosphate rock in the Rum Jungle area. It was first known as a radiometric anomaly and was tested for uranium by T.E.P. with diamond drill holes D550, D555 and D559. During the 1962 - 1963 survey the B.M.R. drilled fourteen diamond drill holes (DG1 - DG14 - Appendix 1) to test for phosphate.

The dominant lithology is hematitic quartz breccia, in which angular and embayed fragments of sugary or glassy quartz are set in a matrix of hematitic siltstone. Minor bands of quartzite and hematitic mudstone have also been intersected. The sequence is fractured and contains many thin quartz veins; dark green chlorite and polished hematite are common on slickenside surfaces.

The breccia mudstone sequence is underlain by coarsely crystalline limestone belonging to the Lower Proterozoic Coomalie Dolomite. In places the limestone is brecciated and partly silicified, grading upwards into hematitic quartz breccia. The principal phosphate mineral present is fluorapatite.

The prospect is a lens shaped body plunging to the south-east, thinning and becoming poorer in grade towards Area 3 and Eastick's. The boundaries of the deposit are defined by grade within the gradual transition from barren rock at the upper and lower edges of the body to higher grade rock in the centre. DG14 and DG12 lie outside the north and north-eastern edge of the deposit and DG13, DG5, D559 and DG11 penetrated thin sections of low grade phosphate rock. On the southern side DG7 lies outside the deposit; a strong air photo lineation passing between DG7 and DG6 and trending north-east through Eastick's prospect, is probably a fault marking the south-western edge of the deposit. The deposit has not been delineated to the south-east. Phosphate rock, containing more than 5 percent P_2O_5 , was intersected in DG10 between 404 and 470 feet. The best intersection of phosphate rock is in DG9 (Appendix 1).

Between DG2 and DG9, and between DG12 and DG9 the contact of the breccia mudstone sequence with the limestone deepens by about 220 feet. This deepening continues very gradually towards DG10. The sudden deepening of the limestone as described may be a 'solution' surface or due to faulting. The depth of the limestone is not known south of DG1: DG8 reached a total depth of 600 feet without intersecting limestone.

Early in 1963 more than 1,000,000 tons of phosphate rock, varying in grade from 5 to 37 percent P_2O_5 and averaging more than 10 percent, had been indicated in the Geolsec prospect.

Easticks (Plates 3,6).

The Eastick's prospect, 1200 feet north-west of the Geolsec prospect, is also a radiometric prospect tested by T.E.P. with diamond drill holes, D560, D553 and D564.

In 1961 and 1962 the area was auger drilled on a 100 foot grid to delineate the prospect below the soil and rubble cover. Its known boundaries were extended some 300 feet east of the outcrops and the drilling indicates a possible 4000 tons of phosphatic material per vertical foot and thicknesses of up to 120 feet (D564). The grade of the material is generally lower than that in the Geolsec prospect.

Area 3 (Plates 3,6.)

The Area 3 prospect is 1200 feet north-east of the Geolsec prospect. Two small outcrops of phosphate rock are known near 40E.25N. Auger drilling in 1962 on a 100 and in places a 50 foot grid showed the presence of phosphatic material over a distance of 1600 feet along the edge of Castlemaine Hill towards the northern end of the Geolsec prospect.

Powerline (Plates 3,6).

The Powerline prospect is a small outcrop of phosphatic breccia no more than ten feet across on the south-eastern side of Castlemaine Hill. Auger drilling around this prospect in 1962 did not reveal any extension.

Area 4 (Plates 4,7).

The Area 4 prospect on the south-eastern edge of Castlemaine Hill was auger drilled in 1961 and 1962. Limited extensions of the deposit were found east of the hill.

Batchelor Laterites (Plates 4,7).

The "Batchelor Laterites" is a radiometric anomaly associated with hematitic mudstone, hematitic siltstone and a small amount of hematitic quartz breccia south east of Castlemaine Hill. It has been diamond and churn drilled by T.E.P. and was auger drilled by the B.M.R. in 1961 and 1962. Although a few auger holes drilled in 1962 contained traces of phosphate, no phosphate deposit has been found in this area.

Castlemaine (Plates 4,7).

The Castlemaine prospect west of Batchelor Laterites on the southern end of Castlemaine Hill has been known for several years as a radiometric and geochemical anomaly. The prospect has been diamond and churn drilled by T.E.P. and was auger drilled in 1961.

Phosphate rock crops out near 106E, 15N and T.E.P. diamond drill holes D520, D526, D527 and D530 intersected phosphatic breccia and mudstone. The best intersection was D530 which penetrated material containing 14 to 20% P_2O_5 between 20 and 63 feet and 8 to 17% P_2O_5 between 125 and 212 feet. The bulk of the drilling was in the schists south of the prospective breccia-mudstone sequence.

Rum Jungle Creek to Rum Jungle Creek South (Plates 3,6.)

This area is on the western side of Castlemaine Hill. It has been extensively diamond and churn drilled and costeamed by T.E.P. and was auger drilled by the B.M.R. in 1961 and 1962.

Phosphate rock and phosphatic hematitic quartz breccia is exposed along the 11N line between 10E and 18E and was intersected in diamond drill holes D520, D299, and D522, churn drill hole C320 and auger drill holes giving a possible strike length of 4000 feet. Auger drilling in 1962 along the edge of the hill encountered only traces of phosphate in chloritic and carbonaceous schist.

Zeta (Plates 2,5.)

The Zeta prospect is a radiometric anomaly on the northern end of Castlemaine Hill tested for uranium by T.E.P. with costeams and one diamond drill hole (D363). Phosphate rock crops out and is exposed in one of the costeams. D363 passed through material containing 6 - 25% P_2O_5 between 10 and 46 feet.

Buckshee (Plate 1)

The Buckshee prospect, the second largest exposure of phosphate rock known in the Rum Jungle area, is located in the "Embayment Area" west of the Finnis River.

Auger drilling in 1962 showed no extensions of phosphate rock outside the low rise on which it is exposed. Dolomite was encountered south of this rise and the breccia mudstone sequence thins in this direction. From the present evidence this deposit contains about 5000 tons of phosphate rock per vertical foot and the auger drilling indicates depths of the order of 50 feet giving a possible tonnage of more than 250,000 tons of phosphatic material in this deposit.

Powerplant (Plate 1)

Two exposures of phosphate rock were found in the area referred to as the Powerplant anomaly, west of White's Mine. This is an electromagnetic anomaly drilled and costeamed by T.E.P. in the early stages of their activities at Rum Jungle.

White's and Dyson's

Phosphate rock crops out about 150 feet south-west of Dyson's Open Cut. Four T.E.P. diamond drill holes (D115, D122, D130, D317) which penetrated the breccia-mudstone sequence were tested and each passed through phosphatic material. D122, at the north-eastern end of Dyson's Open Cut, penetrated material containing 14-24% P_2O_5 between 51 and 73 feet, and D317 on the eastern edge of White's Open cut penetrated material containing 15 to 28% P_2O_5 between 268 and 297 feet and 8 to 23% P_2O_5 between 352 and 401 feet.

Stapleton North and Stapleton South

In 1961 W. Patterson of Enterprise Exploration Pty. [Ltd.] found two deposits of apatite rock in the Stapleton area; their location is shown in Fig. 1. These deposits have yet to be tested and examined.

Waterhouse No. 2 Uranium Prospect

Selected samples of drill core from this prospect contained from 8 to 17 percent P_2O_5 (Ruxton 1961).

UTILISATION OF THE RUM JUNGLE PHOSPHATE ROCK

Australia's main demand for phosphate rock is as a raw material for the production of superphosphate fertiliser or as ground phosphate rock fertiliser.

Beneficiation

The low average grade of the Rum Jungle phosphate rock and its high iron content means that it will have to be beneficiated before it could be used for superphosphate manufacture. The small tonnages at present indicated in the area, the unlikelihood of the Rum Jungle material being able to compete in the southern States with low cost phosphate rock from Nauru, Ocean and Christmas Islands, and the lack of a market in the Northern Territory indicate that extensive beneficiation tests are not economically warranted at this stage. The proving of large tonnages of phosphate rock and the development of agriculture in the Northern Territory may alter this situation.

Use as ground rock fertiliser

At this state of investigations the only likely use of the Rum Jungle material is as ground rock phosphate fertiliser. It is estimated that the material could be mined and finely ground for about £2 per ton. The Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O.) has tested the effect of the application of ground Rum Jungle phosphate rock on plant growth (Appendix 5).

Table 5 is an abstract of these results.

The tests compared the short term responses of grain sorghum plants, grown in pots of Tippera clay loam (a neutral phosphorus - deficient soil from Katherine, N.T.) under greenhouse conditions, to ground Rum Jungle rock (ground finer than 2 mm but coarser than flour), Christmas Island phosphate rock dust (ground finer than flour), and superphosphate.

Two samples of different types of Rum Jungle phosphate rock were used. Both samples are from costean 1 at Geolsec, sample 1 being high grade phosphate rock from 459 to 462.5 feet, and sample 2 grab sample of the low grade phosphatic clay between 260 and 350 feet.

The following conclusions can be drawn from these results:

1. The weight of dried plant material obtained from each pot treated with ground Rum Jungle phosphate rock was approximately double that from the standard, but was only half of that obtained from the optimum application of superphosphate.
2. Significant variation between the weights of dry plant material was obtained at the end of the tests from each of the types of fertiliser used.
3. Very little variation between the weights of dry plant material was obtained at the end of the tests using varying amounts of Rum Jungle 1 or of Rum Jungle 2 fertilizer. In contrast, excluding the abnormally depressed yields from the 8 and 16 cwt/acre applications of superphosphate, significant increase in the weight of dry plant material was obtained from the application of increasing amounts of Christmas Island rock or of superphosphate.
4. The availability of phosphorus in the phosphatic clays represented by sample Rum Jungle No.2 is slightly greater than that of Christmas Island phosphate rock and less than a third of that of superphosphate, but this may be related to the fineness of grinding. The availability of phosphorus from the high grade apatite rock represented by sample Rum Jungle No.1 is apparently only half that of sample Rum Jungle No.2.

This suggests that the Rum Jungle phosphate rock could be used as a ground rock fertilizer. C.S.I.R.O. have agreed to carry out field tests (which will take five years) to examine its usefulness as a fertilizer and to test the residual long term benefits usually derived from ground rock fertilizers and any toxic effects that the high iron, high fluorine Rum Jungle material may have.

TABLE 5.

RESULTS OF POT TESTS BY C.S.I.R.O.

Fertilizer Sample	Phosphate content (%P)	Amount of Fertilizer Applied (*cwt/acre)	Dry weight of Plant Material Recovered (gms/pot)	Weight of Phosphorus Recovered (gms/pot)	Percentage of Phosphate in Plant Material (%P)	Percentage Recovery of Phosphate Available (%P)
Rum Jungle No.1.	15.2 (34.8% P ₂ O ₅)	1	4.08	0.00238	0.058	-
		4	4.40	0.00218	0.050	1.44
		8	4.70	0.00240	0.051	-
		16	5.24	0.00284	0.054	-
Rum Jungle No.2.	5.8 (13.3% P ₂ O ₅)	1	3.80	0.00170	0.045	-
		4	4.23	0.00186	0.044	2.90
		8	4.56	0.00234	0.051	-
		16	4.86	0.00248	0.051	-
Christmas Island	15.6 (35.7% P ₂ O ₅)	1	5.25	0.00266	0.051	-
		4	6.38	0.00334	0.052	2.57
		8	7.13	0.00390	0.055	-
		16	8.09	0.00460	0.057	-
Superphosate	10.5	1	6.22	0.00252	0.040	-
		4	7.36	0.00735	0.100	9.82
		8	** (3.55	0.00597	0.168	-
		16	(5.70	0.01032	0.181	-
Control	0	-	2.00	0.00079	0.040	-

* 0.159 grams of fertilizer per pot is equivalent to 1 cwt per acre.

** These depressed yields of plant material may be due to an excessive concentration of soluble phosphorus in small pots.

CONCLUSION

The sixteen phosphate occurrences in the Rum Jungle area are associated with an ancient regolith overlying Lower Proterozoic Coomalie Dolomite.

Only one prospect, Geolsec, has been specifically tested for phosphate by diamond drilling. This has indicated resources of more than 1,000,000 tons of material ranging from 5 to 37 percent P_2O_5 . Prospects on which only auger drilling has been done cannot be considered to have been tested because the auger drill was not capable of penetrating the harder material which may contain the bulk of any phosphate rock present. It is likely that some of these prospects (e.g. Rum Jungle Creek to Rum Jungle Creek South) are larger than Geolsec.

Additional geological work is needed to test each of the deposits and to test the breccia mudstone sequence for concealed deposits.

The deposits will be amenable to open cut mining.

The Rum Jungle phosphate deposits probably can be used as relatively cheap ground rock fertilizer.

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The figures in the right hand column of these logs are the results of radiometric logging. The values are in milli-roentgens per hour.

APPENDIX 1

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT: PHOSPHATE SURVEY - 1962

REMARKS

Top of stand pipe 378.8 feet

HOLE No. D-Q1

CO-ORDINATES 25.5E 11N

R.L. GROUND 377.4

LOCATION E93-6 BMR GRID

ANGLE FROM HORIZONTAL 60°

DIRECTION 22½°

DESCRIPTION OF CORE	R.L. CASINO	DEPTH SIZE OF CORE	LOG	LIFT CORE RE COVERY %	% _{log} S ₂	REMARKS	% _{log} Q
Lilac red breccia. Fragments of angular and embayed quartz and ferruginous siltstone up to 2" across in a matrix of poorly sorted very fine to coarse grained quartz sand with ferruginous coatings, ferruginous silt and ferruginous clay.		0-10' NX casing		83	1		
Lilac red poorly sorted medium-grained ferruginous quartz sandstone with subangular to subrounded quartz grains.		10-12' BMLC		60	10'		
Lilac red breccia. Fragments of angular and embayed quartz and lilac-red siltstone in a matrix of ferruginous very fine-grained angular quartz sand, ferruginous quartz silt and ferruginous clay. In places the core contains medium to coarse grained rounded quartz grains. In a few places the quartz fragments enclose hematite.		12-20' BMLC		90	20'		
		20-30' BMLC		100	4%		0.6%
		30-32' BMLC		100	30'		12.2%
		32-35' BMLC		100	35' 3"		11.9%
		35-40' BMLC		100	18%		9.7%
		40-48' BMLC		95	40'		14.5%
Shattered material with minor pink clay.		48-50' BMLC		100	20%		10.1%
		50-58' BMLC		88	50'		18.5%
		58-60' BMLC		100	10%		10.6%
		60-66' BMLC		96	60'		8.8%
		66-70' BMLC		100	14%		15.4%
		70-75' BMLC		100	18%		9%
		75-80' BMLC		100	75'		5.9%
		80-82' BMLC		100	6%		9.5%
Lilac-red and pink clay and quartz silt with scattered angular and embayed quartz fragments.		82-90' BMLC		100	20%		30.6%
		90-95' BMLC		100	36' 6"		31.0%
Lilac-red breccia similar to that between 12' and 82'.		95-100' BMLC		100	21%		18.9%
		100-100' BMLC		100	9%		

DRILL NO. TYPE MINDRILL F20	EXPLANATION CASING IN HOLE DURING DRILLING	HEAD OFFICE LOGGED BY P.W. PRITCHARD
DRILLER F.A. KELLY COMMENCED 18-7-62 COMPLETED 16-8-62	REFERENCES Radiometric log by J. Ashley and M. Ciszek 15-8-62, 16-8-62	DRAWN BY CHECKED BY
		SHEET 1 OF 1 DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT. PHOSPHATE SURVEY - 1962

REMARKS.

Top of stand pipe 378.8'

HOLE NO. D-G1

CO-ORDINATES 25.5E 11N

R.L. GROUND 377.4'

LOCATION EB3-6 BMR GRID

ANGLE FROM HORIZONTAL 60°

DIRECTION 272°

DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT CORE RE COVERY %	% _{log} sq"	REMARKS	% _{log} sq"
		100'			6%		101.6"
				100	105		4.7%
					22%		108.4"
Pink porous very fine-grained quartz sandstone with subangular grains. Rare rounded grains to 1mm diameter.		108'					001
		108.7"		95	110		010
		112.9'			28%		010
Lilac-red and pink, porous, silt and clay.				100	115		011
					27%		015
		120'			119.8'		013
Lilac-red breccia similar to that between 12' and 82'. Breccia fragments up to 2" in diameter.				100	120		018
				94	125		015
					18%		020
				98	130		014
		130'			2%		008
				94	135		007
				100	140		005
					7%		004
		140'			6%		004
Lilac-red medium-grained ferruginous quartz sandstone of subrounded grains in a hematite matrix. Minor angular quartz fragments up to 1/2" across.				100	145		006
					3%		006
		150'			149'		006
				100	155		004
					3%		004
6" of brecciated pink quartz siltstone at the base.		160'			t		003
Lilac-red breccia similar to that between 12' and 82'.				100	160		003
					24%		004
				100	165		004
				100	170		003
		170'			23%		002
Lilac-red ferruginous clay and quartz silt with minor angular quartz fragments up to 1" across.				98	175		003
					15%		004
				100	180		004
					27%		002
		180'			181		003
				100	185		011
					23%		008
Bedding		185.2'			7%		009
				100	190		010
Lilac-red breccia similar to that between 12' and 82' with bands of lilac-red ferruginous silt and sand.					12%		012
				100	195		012
					12%		011
		190'					010
				100			009
							005
							006
							005
							005
							006
							006
							007
							007
							007
							008
							004
							004
							004
							004
							004
							004
							005
							005

DRILL NO. TYPE MINDRILL F2R

CASING IN HOLE DURING DRILLING

EXPLANATION

HEAD OFFICE

LOGGED BY P.W. PRITCHARD

DRAWN BY

CHECKED BY

SHEET 2 OF 5

DRAWING NO.

DRILLER F.A. KELLY
COMMENCED 18-7-62
COMPLETED 16-8-62REFERENCES
Sq" - semi-quantitative analyses on spot samples 15" apart

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PHOSPHATE SURVEY - 1962

HOLE NO. D-G1

CO-ORDINATES 25 SE 11N

REMARKS

Top of stand pipe 378.8'

LOCATION EB3-6 BMR GRID

R.L. GROUND 377.4'

ANGLE FROM HORIZONTAL 60

DIRECTION 224

DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT CORE RE COVERY %	% _{LOS} S ₂	REMARKS	% _{LOS} Q
		200'		100	5%		5.8%
					208'		004
				100	6%		004
					210'		004
		210'		100	13%		004
					215'		004
				100	25%		004
		220'			225'		004
				100	11%		004
					225'		004
		230'		100	20%		004
				75			004
				100	12%		004
					235'7"		004
Dolomite breccia. Angular and embayed fragments of white crystalline dolomite in a lilac-red ferruginous siltstone and mudstone matrix.		235'7"		96	4%		004
				100	4%		004
				96	221'3"		004
				100	9%		004
					245'		004
		250'		98	8%		004
					255'		004
				100	5%		004
				100	5%		004
		260'		100			004
Dolomite breccia similar to that between 235'7" and 260'10" but with minor amounts of matrix. Core lengths of dolomite up to 5'.		260'10"		100	<1%		004
					265'		004
				100	<1%		004
					265'6"		004
		270'		100	<1%		004
					275'		004
				100	<1%		004
		280'			285'		004
				100	<1%		004
					285'		004
		290'		100	<1%		004
					290'		004
				100	t		004
					295'		004
		300'		100	t		004

DRILL NO.
TYPE MINDRILL-F2D

CASING IN HOLE DURING DRILLING

EXPLANATION

HEAD OFFICE

DRILLER F.A. KELLY
COMMENCED 18-7-62
COMPLETED 16-8-62

REFERENCES

LOGGED BY P.W. PRITCHARD

DRAWN BY

CHECKED BY

SHEET 3 OF 5

DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PHOSPHATE SURVEY - 1962

HOLE NO. D-G1

CO-ORDINATES 25 5 E 11 N

REMARKS

Top of stand pipe 378.8'

R.L. GROUND

377.4'

LOCATION E83-6 BMR GRID

ANGLE FROM HORIZONTAL 60°

DIRECTION 222°

DESCRIPTION OF CORE	R.L. CASINO	DEPTH SIZE OF CORE	LOG	LIFT CORE RE COVER %	% Loss sq'	REMARKS	ASSAYS
		BMIC			t		004
				100	308'		003
					t		0045
				100	310'		0045
					t		0045
				100	315'		004
					t		004
				100	320'		004
					t		003
				100	325'		003
					t		003
				100	330'		003
					t		003
				100	335'		003
					t		003
				100	340'		003
					t		003
				100	345'		003
					t		003
				100	350'		003
					t		003
				100	355'		003
					t		003
				100	360'		003
					t		003
				100	365'		003
					t		003
				100	370'		003
					t		003
				100	375'		003
					t		003
				100	380'		003
					t		003
				100	385'		003
					t		003
				100	390'		003
					t		003
				100	395'		003
					t		003
				100	400'		003
					t		003
				100	405'		003
					t		003
				100	410'		003
					t		003
				100	415'		003
					t		003
				100	420'		003
					t		003
				100	425'		003
					t		003
				100	430'		003
					t		003
				100	435'		003
					t		003
				100	440'		003
					t		003
				100	445'		003
					t		003
				100	450'		003
					t		003
				100	455'		003
					t		003
				100	460'		003
					t		003
				100	465'		003
					t		003
				100	470'		003
					t		003
				100	475'		003
					t		003
				100	480'		003
					t		003
				100	485'		003
					t		003
				100	490'		003
					t		003
				100	495'		003
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				100	500'		003
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				100	505'		003
					t		003
				100	510'		003
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				100	515'		003
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				100	520'		003
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				100	525'		003
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				100	530'		003
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				100	535'		003
					t		003
				100	540'		003
					t		003
				100	545'		003
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				100	550'		003
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				100	555'		003
					t		003
				100	560'		003
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				100	565'		003
					t		003
				100	570'		003
					t		003
				100	575'		003
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				100	580'		003
					t		003
				100	585'		003
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				100	590'		003
					t		003
				100	595'		003
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				100	600'		003
					t		003
				100	605'		003
					t		003
				100	610'		003
					t		003
				100	615'		003
					t		003
				100	620'		003
					t		003
				100	625'		003
					t		003
				100	630'		003
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				100	635'		003
					t		003
				100	640'		003
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				100	645'		003
					t		003
				100	650'		003
					t		003
				100	655'		003
					t		003
				100	660'		003
					t		003
				100	665'		003
					t		003
				100	670'		003
					t		003
				100	675'		003
					t		003
				100	680'		003
					t		003
				100	685'		003
					t		003
				100	690'		003
					t		003
				100	695'		003
					t		003
				100	700'		003
					t		003
				100	705'		003
					t		003
				100	710'		003
					t		003
				100	715'		003
					t		003
				100	720'		003
					t		003
				100	725'		003
					t		003
				100	730'		003
					t		003
				100	735'		003
					t		003
				100	740'		003
					t		003
				100	745'		003
					t		003
				100	750'		003
					t		003
				100	755'		003
					t		003
				100	760'		003
					t		003
				100	765'		003
					t		003
				100	770'		003
					t		003
				100	775'		003
					t		003
				100	780'		003
					t		003
				100	785'		003
					t		003
				100	790'		003
					t		003
				100	795'		003
					t		003
				100	800'		003
					t		003
				100	805'		003
					t		003
				100	810'		003
					t		003
				100	815'		003
					t		003
				100	820'		003
					t		003
				100	825'		003
					t		003
				100	830'		003
					t		003
				100	835'		003
					t		003
				100	840'		003
					t		003
				100	845'		003
					t		003
				100	850'		003
					t		003
				100	855'		003
					t		003
				100	860'		003
					t		003
				100	865'		003
					t		003
				100	870'		003
					t		003
				100	875'		003
					t		003
				100	880'		003
					t		003
				100	885'		003
					t		003
				100	890'		003
					t		003
				100	895'		003
					t		003
				100	900'		003
					t		003
				100	905'		003
					t		003
				100	910'		003
					t		003
				100	915'		003
					t		003
				100	920'		003
					t		003
				100	925'		003
					t		003
				100	930'		003
					t		003
				100	935'		003

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL... 90°

Green chlorite on small shears ↗ 95'6"
↘ 96'
↘ 99'

GD 130

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PHOSPHATE SURVEY - 1962

REMARKS

Top of strand Age 349.8'

HOLE No. PG 2

CO-ORDINATES 25.5E 11N

R.L. GROUND 349.4'

LOCATION E83-6 B.M.R. GRID

ANGLE FROM HORIZONTAL 90°

DIRECTION

DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT CORE RE- COVERY %	%H ₂ O _s Sa	REMARKS	%H ₂ O _g Q
					17%		9.2% 101.10"
					104'10"		0.05
					15%		0.08
					110'		0.11
					24%		0.12
					115'		0.15
					35%		0.21
					120'		0.31
					32%		0.34
					124'7"		0.31
					5%		0.32
					126'10"		0.40
					16%		0.45
					128'9"		0.40
					16%		0.45
					133'		0.45
					15%		0.45
					137'4"		0.45
					18%		0.45
					26%		0.45
					9%		0.45
					151'5"		0.45
					26%		0.45
					18%		0.45
					22%		0.45
					17%		0.45
					19%		0.45
					14%		0.45
					2%		0.45
					4%		0.45
					3%		0.45
					1%		0.45
					200'		0.45

DRILL NO.	EXPLANATION	HEAD OFFICE
TYPE MINDRILL F20	CASING IN HOLE DURING DRILLING	LOGGED BY P.W. Pritchard
DRILLER F.A. KELLY	REFERENCES	DRAWN BY
COMMENCED 17-8-62		CHECKED BY
COMPLETED 30-8-62		SHEET 1 OF 2
		DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT B CORE	% <i>log</i>	REMARKS	ASSAYS
	CASING	ST. OF CORE		RE COVERY %	<i>SA</i>		

TD 231' 8"

GD130

GEOLOGICAL LOG OF DRILL HOLE

PROJECT. PHOSPHATE SURVEY - 1962

HOLE NO. DC 3

CO-ORDINATES 25 SE 13N

REMARKS

Top of stand pipe 323.9'

LOCATION EB3-6 BMR GRID

R.L. GROUND

ANGLE FROM HORIZONTAL 90°

DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT CORE RE COVERY %	SAMPLES	REMARKS	% P ₂ O ₅	
	CASING SIZE OF CORE	SIZE OF CORE					Se	a
Rubble. Lilac red quartz hematite breccia, brown very fine grained quartz sand. Lilac and white phosphatic siltstone.				25				.014 .011 .009 10' .010 5' .012 .013 .014 7.6 .017 .021 .031 .045 10' .045 .035 .027 .047 .040 .050 2.4 .050 .047 .045 .042 15' .045 .047 .045 .050 .055 .055 .050 .050 8.4 .050 .050 20' .055 .050 .045 .050 .060 .055 .055 .065 4.4 .065 .070 25' .065 .060 .045 .055 .055 .040 .037 .034 18.0 .031 .024 30' .019 .016 .013 12.0 .011 .013 35' .013 .014 .016 .021 7.7 .024 .032 .032 .027 41' .021 .024 .021 .015 27.2 .015 .010 4.5' .009 .009 14.8 .008 .009 50' .007 .006 5.5' .008 .009 55' .010 .011 3.9 .014 .013 60' .014 .016 3.0 4.8 66.6 69' 3.6 2.8 74' 2.5 79' 2.6 82' 2.2 84.5' 2.7 86.9' 2.6 90' 2.6 92.5' 1.9 2.8 97' 5.9
		10'						
		20'						
		30'						
		40'	a a a	80				
Lilac hematitic clay and porous siltstone with bands of brown clay and cream clay. The porous siltstone is vuggy apatite rock and contains stringers of and disseminated hematite. It is marked a in the graphic log.	41'	8' BMLC		80				
		10'		90				
		20'		96				
		30'	a a a	96				
		40'		90				
		50'		92				
	62.3"	60'		90				
Pale green and cream clay with scattered fine quartz grains and mica flakes.	69'	8'		90				
		10'		83				
Lilac red hematitic micaceous siltstone with green stringers of chloritic clay. Brecciated in places.		20'		83				
		30'		88				
		40'		100				
		50'		88				
		60'		90				
As above with bands of green chloritic siltstone.	84.5'	8'		90				
Lilac red hematitic micaceous siltstone with stringers of green clay. Friable from 88'	86.9'	8'		92				
		10'		92				
		20'		85				
		30'		88				
As above with yellow-brown bands and fragments of greasy, lilac	97'	8'		82				

DRILL NO.
TYPE MINDRILL F20

CASING IN HOLE DURING DRILLING

EXPLANATION

HEAD OFFICE

LOGGED BY

P.W. PRITCHARD

DRAWN BY

CHECKED BY

SHEET

OF 2

DRAWING NO.

DRILLER FA KELLY
COMMENCED 31-8-62
COMPLETED 4-9-62REFERENCES
Radiometric log. F. Maranzano 1368A/41 Probe DH24 Scale 2%
6/9/62 Surface reading .013.

GEOLOGICAL LOG OF DRILL HOLE

REMARKS.

R.L. GROUND

ANGLE FROM HORIZONTAL

DIRECTION

DRILL NO. _____ TYPE <u>MINDRILL F20</u>		EXPLANATION CASING IN HOLE DURING DRILLING <u>H</u>	HEAD OFFICE LOGGED BY <u>P.W. PRITCHARD</u> DRAWN BY _____ CHECKED BY _____	
DRILLER <u>F.A. KELLY</u> COMMENCED <u>5-9-62</u> COMPLETED <u>12-9-62</u>		REFERENCES <u>Radiometric log. F. Mangano 1368A/64 Probe DH24 Scale 2%</u> <u>12/9/62</u>		
		SHEET <u>1</u> OF <u>2</u> DRAWING NO. _____		

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT: PHOSPHATE SURVEY - 1962		REMARKS: Too of stand pipe 313.11"							
HOLE No. DC 5		CO-ORDINATES 23.5E 15N		R.L. GROUND					
LOCATION EBS-6 BMR GRID		ANGLE FROM HORIZONTAL 90°		DIRECTION -					
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	% 20s		
	CASING	SIZE OF CORE							
One foot of 1/8" quartz fragments and lilac, brown and white clay fragments. 17'9" Red very fine to fine-grained well rounded quartz sand. 21'4" Lilac-red clay with stringers of brown, yellow and white clay with occasional black blotches. Some of the clay is in granules 1/8" in diameter. 31' As above with fragments of hematite and hematitic quartzite breccia. 33' Clay similar to that between 21'4" and 31' 54'4" As above with sooty chocolate brown clay. 63'4" Lilac-red silt. 69'6" Pink clay. 72'6" Lilac-red clay with brown and yellow clay stringers. 77' Lilac red silt and clay with yellow clay stringers. 88'6" As above with very fine grained quartz sand. 97'- Cavings of quartz pebbles with nugs. 97'-	10'		17				4.1%	005 006 005 006 006 006 005 006 005 006 006 007 005 006 007 005 006 005 005 006 004 005 005 006 007 006 006 007 006 006	
		20'	96				21.4"		
			96				4.1%		
			92				29'		
		30'	100				7.8%		
			100				31'		
			83				5.7%		
			100				36'		
			96				7.0%		
		40'	83				4.1'		
			100				7.8% 42.9"		
			100				6.2% 44"		
			86				10.9%		
			94				4.9'		
		50'	83				11.9% 52'		
			97				7.8% 64.4"		
			98						
		60'	98				3.2%		
			100				65.4"		
			92				8.2%		
			100				69.6"		
		70'	100						
			95				4.4%		
			94				77'		
		98							
		98				4.8%			
	80'	100				87'			
		87							
		96				4.2%			
	90'	100				97'			
		91				6.7%			
		95				100'			

DRILL NO.	EXPLANATION	HEAD OFFICE
TYPE MINDRILL F20	CASING IN HOLE DURING DRILLING	LOGGED BY P.W. PATCHARD
DRILLER F.A. KELLY	REFERENCES	DRAWN BY
COMMENCED 13-9-62	Radio-metric log F. Maranzano. Ratometer 1368A/64 Scale value 2% Probe 3H 10. 20/9/62.	CHECKED BY
COMPLETED 19-9-62		SHEET 1 OF 2
		DRAWING NO

GEOLOGICAL LOG OF DRILL HOLE

PROJECT **PHOSPHATE SURVEY - 1962**

REMARKS

*Top of stand. elev. 313.3'*HOLE No. **DC5**CO-ORDINATES **23.5E 15N**

R.L. GROUND

LOCATION **E83-6 B.M.R. GRID**ANGLE FROM HORIZONTAL **90°**DIRECTION **-**

DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT CORE RE COVERY %	SAMPLES	REMARKS	ASSAYS
CAVITY. 100'-125'		100'	CAVITY.	100			
T.D. 125'		120'					
		30'					

DRILL NO.	EXPLANATION	HEAD OFFICE
TYPE MINDRILL F20	CASING IN HOLE DURING DRILLING H	LOGGED BY P.W. PRITCHARD
DRILLER F.A. KELLY	REFERENCES	DRAWN BY
COMMENCED 13.9.62		CHECKED BY
COMPLETED 19.9.62		SHEET 2 OF 2
		DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT PHOSPHATE SURVEY - 1962			REMARKS <i>Top of stand pipe 377.3'</i>						
HOLE No. DG6		CO-ORDINATES 25.5E 10N			R.L. GROUND				
LOCATION E83-6 BMR GRID		ANGLE FROM HORIZONTAL 90°			DIRECTION				
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	%P.O.S	ASSAYS	
	CASING	SIZE OF CORE							
Lilac red breccia.				80				.006	
Lilac-red fine to medium grained quartz sand.							2.2	.006	
		56'					6.3'	.007	
Breccia fragments up to 1/2" across derived from disintegration of lilac-red hematitic quartzite breccia.							3.7	.006	
		10'						.006	
								.007	
								.006	
								.006	
		16'					16'	.005	
								.005	
Solid core. Qtz fragments up to 1" across (mostly 1/2") in a lilac-red siltstone matrix. Fractures coated with pink clay at 40' to core axis. Scattered blebs of specular hematite.							9.4	.004	
		20'		97			20'	.004	
							12.8	.004	
							25'	.005	
				100				.005	
							16.5	.005	
		30'					30'	.006	
				98			18.3	.007	
		33 1/2"					33 1/2"	.006	
Pink and lilac-red porous siltstone with stringers of green chlorite. (? Fault zone).							28.7	.007	
				98			28 1/2"	.008	
		40'					24.6	.008	
				88				.007	
							44'	.006	
		44'						.005	
Breccia. Quartz fragments up to 1" across in lilac-red siltstone matrix. Chlorite filled shears from 45'-47' and 49 1/2'-51'.				96			14.2'	.004	
		50'					40'	.004	
				90				.005	
							14.3	.005	
				96			54'	.008	
		57 1/2"					16.7	.007	
							57 1/2"	.005	
Fine-grained breccia. Quartz fragments to 1/2" across to 59 1/2" and up to 3/8" across 59 1/2" - 60 1/2". Small quartz veins at 45'.		60'		87			2.5	.004	
							60 1/2"	.004	
							18.7	.005	
Lilac and pink siltstone with scattered quartz fragments and chlorite stringers. May be fault or joint.				100			65 1/2"	.004	
		69 1/2"					14.2	.004	
				100			69 1/2"	.005	
Breccia. Angular elongate quartz fragments up to 1" long in lilac-red siltstone matrix.		70'					27.6	.009	
				100			7 1/2"	.006	
							19.3	.007	
		75 1/2"					75 1/2"	.008	
Pink and lilac red siltstone and siltstone breccia. Chlorite stringers. Porous in places (pitted).		80'		100			27.7	.010	
							80 1/2"	.009	
							22.7	.008	
								.007	
				100			25.8"	.006	
		88 1/2"					28.7	.005	
							88 1/2"	.004	
Breccia with sandstone matrix and interbands. Fine to coarse-grained breccia of angular and embayed white quartz fragments in a lilac-red quartz sandstone matrix with hematitic cement.		90'		98			0.6	.003	
							93 1/2"	.002	
				100				.002	
							0.2	.003	
		100'						.003	

DRILL NO. TYPE MINDRILL F20		EXPLANATION CASING IN HOLE DURING DRILLING H		HEAD OFFICE LOGGED BY P.W. RITCHARD	
DRILLER F.A. KELLY COMMENCED 21.9.62 COMPLETED 6.10.62		REFERENCES Radiometric log 9-10-62 by G. Cole.		DRAWN BY CHECKED BY SHEET 1 OF 3 DRAWING NO	

GEOLOGICAL LOG OF DRILL HOLE

LOCATION EB3-6 B.M.R. GRID

ANGLE FROM HORIZONTAL . . . 90

DIRECTION

DRILL NO. TYPE <u>MINDRILL F20</u>		EXPLANATION CASING IN HOLE DURING DRILLING <u>H</u>	HEAD OFFICE LOGGED BY <u>P.W. PRITCHARD</u> DRAWN BY CHECKED BY SHEET <u>2</u> OF <u>3</u> DRAWING NO.	
DRILLER <u>F.A. KELLY</u> COMMENCED <u>21.9.62</u> COMPLETED <u>6.10.62</u>		REFERENCES		

GEOLOGICAL LOG OF DRILL HOLE

PROJECT PHOSPHATE SURVEY - 1962

HOLE No. **DC-6**

CO-ORDINATES 25.5E 10N

REMARKS

Top of stand pipe 377.3'

R.L. GROUND

LOCATION E83-4 B.M.R GRID

ANGLE FROM HORIZONTAL . . . 90

DIRECTION

LOCATION	DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT CORE RE COVERY %	SAMPLES	REMARKS	%ZnO ₅ Q	ASSAYS
		CASINO	SIZE OF CORE						
			8MLC		100			<0.2	003
					100			205'9"	003
			20'		100				003
					100				003
			220'		100				003
					100				003
	Shearing. 216'6" 217'4"		220'		100				003
					100				003
			230'		100				003
	Vertical shearing with chlorite on the shear planes. 227'2" 233'8"				100				003
					100				003
			240'		100				003
	?Flow banding. Green white streaks of siltstone. Quartz 243' - 243'10" with shear plane. 239' 243'4"				100				003
					93				003
			250'	DX	100				003
				BMLC	42				003
					80				003
			260'		100				003
					93				003
			270'		100				003
	Lilac red hematitic siltstone with quartz fragments, green and white siltstone stringers and minor hematite patches. 271' 278'9"				100				003
					96				003
	Breccia. Quartz fragments in lilac-red hematitic siltstone matrix. 275'				95				003
	T.D. 284'				83				003
			290'						003
			300'						003

DRILL NO. TYPE <u>MINDRILL F 20</u>	CASING IN HOLE DURING DRILLING	EXPLANATION	HEAD OFFICE
DRILLER <u>F. A. KELLY</u> COMMENCED <u>21.9.62</u> COMPLETED <u>6.10.62</u>		REFERENCES	LOGGED BY <u>P. W. RITCHARD</u> DRAWN BY CHECKED BY SHEET <u>3</u> OF <u>3</u> DRAWING NO

GEOLOGICAL LOG OF DRILL HOLE

HOLE No. D.G. 7

REMARKS

Top of stand pipe 399.1

HOLE No. *DG 7* CO
LOCATION *E83-10. B.M.R. GRID*

CO-ORDINATES 25.5 E 8 N

R.L. GROUND

ANGLE FROM HORIZONTAL 90°

DIRECTION

DRILL NO.	EXPLANATION	HEAD OFFICE
TYPE <i>MINDALL F20</i>	CASING IN HOLE DURING DRILLING. <i>H</i>	<i>A. J. Pritchard</i> LOGGED BY <i>W. J. Jansky</i>
DRILLER <i>F. KELLY</i>	REFERENCES	DRAWN BY
COMMENCED		CHECKED BY
COMPLETED <i>23-10-62</i>		SHEET <i>1</i> OF <i>2</i>
		DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT: <i>PHOSPHATE SURVEY 1962</i>			REMARKS: <i>Top of stand pipe 999.1'</i>						
HOLE NO: <i>DG 7</i>		CO-ORDINATES: <i>25 5 E 8 N</i>			R.L. GROUND				
LOCATION: <i>E 83-10 B.M.R. GRID</i>			ANGLE FROM HORIZONTAL: <i>90°</i>		DIRECTION				
DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	% P ₂ O ₅		
matrix. Less shattered and slickensided. Quartz breccia fragments sub-angular and embayed; on freshly broken surfaces has sub-vitreous lustre. Scattered bands of hematitic mudstone. Quartz is fractured, with rare, minor faulting. Core becomes less broken from 110'4" Mainly Quartz Hematite fraction is commonly earthy and amorphous. Dark green? chlorite common on slickensides. Red/brown matrix is generally hematitic and siliceous with patches of earthy hematite. Quartzite fragments decrease in size and number. Quartzite and hematite irregularly banded at 177'6". Core good. Minor green? chlorite on slickensides and, rarely, as fragments in breccia.		101'						101'	
			106'						< 0.4%
			110'						111'
			116'						
			118'						
			120'						
			122'						
			127'						
			130'						
			132'						
			135'						135'
			140'						< 0.1%
			145'						145'
			150'						
		155'							
		158'							
		160'							
		163'							
		168'							
		170'							
		173'							
		178'							
		183'							
		188'							
		193'						< 0.1%	
		196'						195'	
		200'							
		201'							

DRILL NO. TYPE: <i>MINDRILL F20</i>	EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i>	HEAD OFFICE LOGGED BY <i>R.W. Pritchard</i> DRAWN BY <i>W. Jannay</i> CHECKED BY SHEET <i>2</i> OF <i>2</i> DRAWING NO.
DRILLER <i>F.A. KELLY</i> COMMENCED COMPLETED <i>23-10-62</i>	REFERENCES	

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

TRACE P₂O₅.

F.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962*

REMARKS

*Top of stand pipe 398.5'*HOLE No. *D.S. 8*CO-ORDINATES *AS-SE 6 N*

R.L. GROUND

LOCATION *E 81-10 B.M. GRID*ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L. CASINO	DEPTH SIZE OF CORE	LOG	LIFT & CORE RE COVERY %	SAMPLES	REMARKS	S/O	ASSAYS
				100				001
				100				002
				100				003
				100				004
				100				005
				100				006
				100				007
				100				008
				100				009
				100				010
				100				011
				100				012
				100				013
				100				014
				100				015
				100				016
				100				017
				100				018
				100				019
				100				020
				100				021
				100				022
				100				023
				100				024
				100				025
				100				026
				100				027
				100				028
				100				029
				100				030
				100				031
				100				032
				100				033
				100				034
				100				035
				100				036
				100				037
				100				038
				100				039
				100				040
				100				041
				100				042
				100				043
				100				044
				100				045
				100				046
				100				047
				100				048
				100				049
				100				050
				100				051
				100				052
				100				053
				100				054
				100				055
				100				056
				100				057
				100				058
				100				059
				100				060
				100				061
				100				062
				100				063
				100				064
				100				065
				100				066
				100				067
				100				068
				100				069
				100				070
				100				071
				100				072
				100				073
				100				074
				100				075
				100				076
				100				077
				100				078
				100				079
				100				080
				100				081
				100				082
				100				083
				100				084
				100				085
				100				086
				100				087
				100				088
				100				089
				100				090
				100				091
				100				092
				100				093
				100				094
				100				095
				100				096
				100				097
				100				098
				100				099
				100				100

TRACE P205

DRILL NO.
TYPE *Handdrill F.20*

CASING IN HOLE DURING DRILLING

EXPLANATION
*Logged - 0-145' P.W. Pritchard.
145-600' W. Saucy.*

HEAD OFFICE

LOGGED BY

P.W. Pritchard

DRAWN BY

N.J. W. Saucy

CHECKED BY

SHEET *2* OF *6*

DRAWING NO.

DRILLER *F.A. Kelly*
COMMENCED *25-10-62*
COMPLETED *3-12-62*

REFERENCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		CO-ORDINATES <i>25° 5' E 6 N</i>		REMARKS <i>Tan of stand pipe 398.5'</i>		R.L. GROUND		ANGLE FROM HORIZONTAL <i>Vertical</i> DIRECTION	
HOLE NO. <i>D.G. 8</i>		LOCATION <i>E 83-10 B.H.R. GRID</i>							
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE NO. & COVER %	SAMPLES	REMARKS	S/Q	ASSAYS	
	CASING	SIZE OF CORE							
<i>Hematitic quartz breccia. Glassy and sugary quartz; hematitic silt matrix, generally silicified. Fractured, slickensides with chlorite and red/brown hematite. Scattered bands of earthy, clayey hematite.</i>		203'		203'				005	
				100				005	
				204'				006	
				100				005	
				208'				003	
				100				001	
				209'				002	
				99				004	
				214'				006	
				100				006	
<i>Hematitic quartz breccia. Quartz is minor fraction, fragments generally < 1/2". Bands of large quartzite fragments. Hematitic silt matrix. Slickensides with chlorite and red/brown, polished hematite. All fragments embayed.</i>		210'		210'				006	
				218'				006	
				100				006	
				221'				006	
				100				007	
				227'				006	
				100				004	
				227'				004	
				233'				006	
				100				005	
<i>Quartz Fraction increases slightly. Bands of small fragments < 1/4". Patches of ? weathered, much- fractured breccia and hematite.</i>		220'		233'				005	
				100				007	
				238'				007	
				100				005	
				242'				004	
				100				003	
				246'				005	
				100				005	
				249'				004	
				100				003	
<i>Mainly red/brown hematitic sand; some silt, very minor bands of breccia. Quartz where present is glassy. Minor drusy cavities with quartz. Slickensides with chlorite and hematite. Core good, little fracturing.</i>		240'		249'				004	
				254'				004	
				100				004	
				259'				003	
				100				006	
				261'				005	
				100				005	
				267'				005	
				100				004	
				271'				004	
<i>As above, lilac in colour.</i>		250'		271'				004	
				274'				003	
				100				003	
				280'				005	
				100				004	
				285'				004	
				100				007	
				290'				004	
				294'				003	
				296'				003	
DRILL NO. TYPE <i>Hand Drill F-20</i>		EXPLANATION				HEAD OFFICE			
CASING IN HOLE DURING DRILLING		REFERENCES				LOGGED BY <i>H. Tauney</i>			
DRAWN BY <i>W.T.</i>						CHECKED BY			
DRILLER <i>F.A. Kelly</i>						SHEET <i>3</i> OF <i>6</i>			
COMMENCED <i>25-10-62</i>						DRAWING NO.			
COMPLETED <i>3-12-62</i>									

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962*HOLE No. *D.G. 8*CO-ORDINATES *25 5 E 6N*

REMARKS

*Top of stand pipe 398.5'*LOCATION *E 83-10 B.M. GRID*

R.L. GROUND

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RE COVERY %	SAMPLES	REMARKS	S/Q.	ASSAYS
	CASING	SIZE OF CORE						
<i>Siliceous hematitic quartz breccia. Bands of hematitic quartzite with very fine quartz breccia fragments.</i> <i>Core very broken, patches of much-fractured, clayey breccia. Slickensides with chlorite.</i> <i>Core less broken below 315'.</i>		300'6"		301'6"			300'6"	003
				100				003
				306'6"			305'	002
				100				004
				311'			310'	004
				100				003
				315'			315'	005
				100				006
				319'6"			320'	006
				99				004
				325'6"			325'	003
				100				002
				331'			330'	002
				100				004
				336'6"			335'	003
<i>Hematitic silt. Bands of hematitic quartzite with scattered breccia fragments. Scattered large quartz fragments with crystalline hematite in pitted surface. Quartz is sheared. Slickensides with chlorite.</i>		340'6"		347'6"			346'8"	006
				100			350'	005
				352'6"				006
				94			355'	004
				356'6"				006
				97			360'	004
				362'				006
				100			365'	005
				367'6"				006
				100			370'	006
<i>Hematitic quartz breccia; quartz fragments angular - rounded - embayed, sheared and pitted with crystalline hematite.</i> <i>Hematitic silt matrix; in places hematitic quartzite. Slickensides with chlorite.</i> <i>Mainly hematitic silt, scattered quartz breccia, 1</i>				373'			375'	007
				100				006
				376'			375'	007
				100				008
				378'6"			378'6"	006
				381'6"			380'9"	007
				100				007
				386'6"			385'	006
				100			390'	005
				391'9"			395'	007
				100				005
				396'6"				
				100			400'	

TRACE P.O.s

DRILL NO.
TYPE *MINDRILL F-20*

CASING IN HOLE DURING DRILLING

EXPLANATION

HEAD OFFICE

LOGGED BY *H. Jauncey*DRAWN BY *H. J.*

CHECKED BY

SHEET *4* OF *6*

DRAWING NO.

DRILLER *F. A. KELLY*
COMMENCED *25-10-62*
COMPLETED *3-12-62*

REFERENCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		CO-ORDINATES <i>25.5 E 6N.</i>		REMARKS <i>Top of stand pipe 998.5'</i>		R.L. GROUND		ANGLE FROM HORIZONTAL <i>Vertical</i> DIRECTION	
HOLE No. <i>DG 8</i>		LOCATION <i>E 83-10 B.M.R. GRID</i>							
DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	S/O	ASSAYS	
Core broken; matrix dark red/brown. Minor clay bands; increasing hematitic quartzite below ~ 4426'.	407'	100	407' 6"	100			405'	TRACE LOGS	
	410'	100	412'	100		412'			
	420'	100	427' 6"	100		417'			
	422'	100	427'	100		422'			
	430'	100	432'	100		432'			
	436'	100	437'	100		437'			
	440'	98	442'	100		442'			
	444'	100	447'	100		447'			
	450'	100	451' 8"	100		452'			
	Core less broken.	457'	100	457'	100		457'		
460'		100	462'	100		462'			
462'		100	467'	100		467'			
470'		100	472'	100		472'			
477' 3"		100	477' 3"	100		477' 3"			
480'		100	482'	100		482'			
484' 7"		98	487'	100		487'			
489'		100	492'	100		492'			
496' 4"		100	497'	100		497'			
497'		97							
Increasing amount quartz, angular and embayed and sheared. No pitting with hematite in this section. Matrix is hematitic silt. Core fractured with minor chlorite on fracture planes.									
Lilac quartzite. Quartz grains elongate on fracture planes, with chlorite. Quartzite is massive, minor faulting. Very minor brecciation in restricted bands.									
Hematitic quartzite breccia, high % quartz. Bands of quartzite lilac - red/brown. Hematitic matrix is silty and sandy.									

DRILL NO. <i>Hindcrill F-20</i> TYPE <i>Hindcrill F-20</i>		EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i>		HEAD OFFICE LOGGED BY <i>W. J. Jancay</i> DRAWN BY <i>W. J.</i> CHECKED BY <i></i>	
DRILLER <i>F. A. Kelly</i> COMMENCED <i>25-10-62</i> COMPLETED <i>3-12-62</i>		REFERENCES <i></i>		SHEET <i>5</i> OF <i>6</i> DRAWING NO. <i></i>	

GEOLOGICAL LOG OF DRILL HOLE

LOCATION E 83-10 BMR GRID

REMARKS

Top of stand pipe 398.5'

R.L. GROUND

ANGLE FROM HORIZONTAL *Vertical.* DIRECTION

TRACE 205

DRILL NO. _____ TYPE <i>Mudrill F-20</i>		EXPLANATION CASING IN HOLE DURING DRILLING	HEAD OFFICE LOGGED BY <i>W. Tainey</i> DRAWN BY <i>W.T.</i> CHECKED BY _____ SHEET <i>6</i> OF <i>6</i> DRAWING NO. _____
DRILLER <i>F. A. Kelly</i> COMMENCED <i>25-10-62</i> COMPLETED <i>3-12-62</i>		REFERENCES	

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962* REMARKS *Top of stand pipe 958.5'*
 HOLE No. *D.G. 9* CO-ORDINATES *27.5E 13N* R.L. GROUND
 LOCATION *E 83-6 (B.M.R. GRID)* ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	P.O.S. Q.	ASSAYS Q
	CASING	SIZE OF CORE						
Light brown sandy silt with sub-rounded fragments of quartzite. Coarse grit, with angular fragments of white quartz and purple, red/brown hematitic quartzite.		10'		60.			Trace	
Light purple hematitic quartzite breccia. White sugary quartz fragments, angular, embayed, aligned in places. Matrix of purple hematitic silt and quartzite. Much weathered 24'3"-26' matrix clay core very broken. A 1' band of light gray quartzite at bottom.	19'10"	20'		100			Trace 19'10"	
				100			Trace 22'	
				100			Trace 24'3"	
				100			Trace 26'	
				100			Trace 29'	
				100			Trace 33'6"	
				100			1% 35'	
Dark chocolate brown clayey silt with high percentage medium-coarse angular quartz sand.	33'6"			91			1%	
White/gray-red/brown, medium-coarse, rounded quartzite, sheared, veined with quartz, hematitic in patches. Scattered embayed fragments of glassy quartz. Patches and bands of hematitic quartz breccia, commonly with elongate fragments. Matrix in breccia fractions is hematitic silt.	40'	40'		100			Trace 40'	
				100			Trace 45'	
				100			Trace 50'	
				100			Trace 55'	
				100			Trace 57'	
				100			Trace 62'	
				100			3%	
Purple hematitic quartz breccia. Angular and embayed quartz. Hematitic silt matrix. Partly weathered; core broken.	57'	60'		100			67'	
				100			4% 69'2"	
Quartz breccia. Embayed fragments of glassy quartz. Matrix siliceous, ferruginous, dark grey and claret colour. Light pink-lilac red siliceous material intimately crystallised with and outlying quartz and matrix. Also light-dark green mineral ? chlorite	69'2"	70'		100			Trace 74'	
Quartz fragments decrease. Matrix commonly fine-grained, red/brown hematitic silt and claystone. Red/pink siliceous material as above, plus light-dark green ? chlorite. Core very broken, with shearing and slickensides. From 93', the core shows signs of severe weathering in patches, being crumbly and clayey. Quartz fragments vary up to 1"	77'3"	80'		100			13% 77'3"	7.3%
				100			8% 80'	10.7%
				100			12% 85'	7.5%
				100			4% 90'	5.5%
				100			9% 93'	6.8%
				100			8% 98'	8.2%
		100'		100				

DRILL NO. TYPE <i>MINDRILL F-20</i>	EXPLANATION CASING IN HOLE DURING DRILLING	HEAD OFFICE
DRILLER <i>F.A. KELLY</i>	REFERENCES <i>Radiometric log - F. Maranzana (B.M.R.) 24-12-62.</i>	LOGGED BY <i>W. Fauncey</i>
COMMENCED <i>5-12-62</i>	<i>Chemical Assays - W. Fraser.</i>	DRAWN BY <i>G.M. & M.J.</i>
COMPLETED <i>23-12-62</i>		CHECKED BY <i>W.J.</i>
		SHEET <i>1</i> OF <i>5</i>
		DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962*HOLE NO. *D.G. 9*CO-ORDINATES *27.5 E 13 N*

REMARKS

*Top of stand pipe 958.5'*LOCATION *ESJ 6 (B.M.A. GRID)*

R.L. GROUND

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT CORE RE COVERY %	SAMPLES	REMARKS	P205		ASSAYS
	CASING	SIZE OF CORE					S-Q		
				100			7%	9.4%	
				100			10%	8.3%	
				100			13%	13.7%	
				100			9%	11.4%	
				100			23%	81%	
				100			16%	14.8%	
				100			24%	25.2%	
				100			22%	19.6%	
				100			13%	16.8%	
				100			12%	12.1%	
				100			73.5%	84.8%	
				96			12%	24.8%	
				96			Trace	9.7%	
				100			Trace		
				100			Trace		
				100			1%		
				97			4%		
				96			19%	13.0%	
				100			6%	5.1%	
				100			32%	26.8%	
				100			30%	18.8%	
				100			>35%	26.8%	
				98			>35%	32.4%	
							>35%	33.4%	

DRILL NO.	EXPLANATION	HEAD OFFICE
TYPE <i>MINDRILL F-20</i>	CASING IN HOLE DURING DRILLING <i>H</i>	LOGGED BY <i>W. J. Fauncey</i>
DRILLER <i>F. A. KELLY</i>	REFERENCES	DRAWN BY <i>G. H. S. W. J.</i>
COMMENCED <i>5-12-62</i>	<i>Radiometric Log - F. Haranzana (B.M.A.) 24-12-62</i>	CHECKED BY <i>W. J.</i>
COMPLETED <i>23-12-62</i>	<i>Chemical Assays - W. Fraser</i>	SHEET <i>2</i> OF <i>5</i>
		DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		CO-ORDINATES <i>27 52 13N</i>		REMARKS <i>Top of stand pipe 958.5'</i>		R.L. GROUND		ANGLE FROM HORIZONTAL <i>Vertical</i> DIRECTION	
HOLE No. <i>D.G. 9</i>		LOCATION <i>E 83-6 (C.B.M.R. GRID)</i>							
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT TO CORE RE COVERY %	SAMPLES	REMARKS	ASSAYS		
	CASING	SIZE OF CORE					P ₂ O ₅ S. Q.		
					100		73.5%	37.6%	
					100		205		
					100		73.5%	36.4%	
		210'			100		210'		
					100		34%	32.6%	
		215'			100		215'		
					99		35%	32%	
		220'			100		220'		
					100		12%	8.8%	
		225'			100		225'		
<i>Hematitic quartz breccia. Quartz sheared, angular and embayed. Matrix hematitic silt. Soft and crumbly in parts, with light green ? chlorite on fractures and slickensides.</i>		227' 9"			96		5%	5.5%	
		230'			100		227' 9"		
					100		1%	2.5%	
		232'			100		232'		
					100		6%	6.7%	
		237' 11"			100		237' 11"		
		240'			100		4%	3.4%	
					100		240'		
					100		4%	4.9%	
		245'			100		245'		
<i>Light-dark red/brown, soft, hematitic, "claystone." Heavy. Slickensides, with chloritic material in small patches, scattered bands and on fracture. Scattered patches of hematitic quartzite breccia. Scattered fragments of black, non-calcareous siltstone. (265' - 270' mainly hematitic quartz breccia)</i>		250'			100		3%	4.9%	
					100		250'		
					100		13%	9.2%	
		255'			100		255'		
					100		8%	6.5%	
	260'				100		260'		
					100		2%	15.2%	
	265'				100		265'		
					100		18%	4.3%	
	270'				100		270'		
					100		32%	22.7%	
		275'			100		275'		
					100		73.5%	29.2%	
		280'			100		280'		
					100		6%	4.7%	
	285'				100		285'		
					100		3%	5.4%	
	290'				100		290'		
					100		3%	4.4%	
	293' 3"				100		293' 3"		
					100		1%		
		300'			100		295'		
					100		1%		
					100		300'		

DRILL NO. TYPE <i>HINDRILL F-20</i> DRILLER <i>F. A. KELLY</i> COMMENCED <i>5-12-62</i> COMPLETED <i>23-12-62</i>		EXPLANATION CASING IN HOLE DURING DRILLING ☒		HEAD OFFICE LOGGED BY <i>W. Tannery</i> DRAWN BY <i>G. H. & W. J.</i> CHECKED BY <i>W. J.</i> SHEET <i>3</i> OF <i>5</i> DRAWING NO.	
REFERENCES <i>Radiometric log - F. Haranzana (C.B.M.R.) 24-12-63</i> <i>Chemical Assays - W. Fraser</i>					

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962*HOLE No. *D.G. 9*CO-ORDINATES *27.5E 13N*

REMARKS

*Top of stand pipe 358.5'*LOCATION *E83.6 (B.M.R. GRID)*

R.L. GROUND

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L. CASINO	DEPTH SIZE OF CORE	LOG	LIFT B CORE RE COVERY %	SAMPLES	REMARKS	<i>1205</i> <i>S.Q.</i>	ASSAYS
<i>Hematitic quartz breccia. High percentage quartz, with bands of quartz and scattered small fragments, angular, embayed and sub-rounded. Matrix hematitic silt, in places sandy. Quartz is strained, in places there is minor faulting. Very common thin bands (1') of chloritic material. Light to dark green, as chlorite on slickenside, as chloritic clay, and in veins in the breccia. Scattered patches of soft clay. Phosphatic reaction with molybdate.</i>				100			1%	
				100			Trace	
		310'		100			Trace	
				100			Trace	
		320'		100			Trace	
				100			1%	
		330'		100			Trace	
				100			Trace	
		340'		100			Trace	
				100			Trace	
<i>Soft, light-dark red/brown, hematitic claystone (very soft and clayey in parts). Minor chlorite, quartz. Fractured, with polished hematite on slickensides. Hematitic quartz breccia (mainly quartz) 359'-360'9"</i>	351'			100			Trace	
				100			Trace	
		360'		100			1%	
				98			Trace	
	363'6"			100			Trace	
	364'2"			100			Trace	
	365'6"			100			Trace	
		370'		100			Trace	
				100			1%	
		380'		100			1%	
<i>Hematitic quartzite breccia, quartz fragments and bands of quartz. Quartz is angular and embayed. Matrix hematitic claystone and siltstone. Distribution varies from nearly all quartz to nearly all matrix (396'3" to 397'3" crystalline limestone with minor hematitic claystone matrix) (400' to 401'9" Much weathered hematitic chlorite ? schist)</i>				100			Trace	
				100			Trace	
		390'		100			Trace	
				100			Trace	
				100			Trace	
				100			Trace	
				100			Trace	
				100			Trace	
				100			Trace	
		400'		100			Trace	

DRILL NO. TYPE <i>MINDRILL F-20</i>	EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i>	HEAD OFFICE LOGGED BY <i>W. Jancey</i>
DRILLER <i>F. A. KELLY</i>	REFERENCES <i>Radiometric Log - F. Maranzana (B.M.R.) 24-12-62</i>	DRAWN BY <i>G. N. S. W. J.</i>
COMMENCED <i>5-12-62</i>	<i>Chemical Assays - W. Fraser</i>	CHECKED BY <i>W. J.</i>
COMPLETED <i>23-12-62</i>		SHEET <i>4</i> OF <i>5</i>
		DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962* REMARKS *Top of stand pipe 358.5'*
 HOLE No. *DS-9* CO-ORDINATES *21° 5' E 13° N* R.L. GROUND
 LOCATION *ES-6 (B.H.R. GRID)* ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	ASSAYS
	CASING	SIZE OF CORE					
Core much weathered below 401' 9". Hematitic and chloritic claystone. Broken, slickensides, scattered bands of broken quartz.		400'		100			3% 401' 9"
							2% 405'
				100			1% 410'
		410'		100			1% 414' 8"
				100			Trace 419'
Coarsely crystalline red? dolomitic limestone breccia; very minor matrix, of hematitic silt and clay. Fractured, some slickensides.		420'		100			<1% 421' 6"
T.D. 422' 6"		430'					

DRILL NO. <i>HINDRILL F-20</i>	EXPLANATION	HEAD OFFICE
TYPE <i>HINDRILL F-20</i>	CASING IN HOLE DURING DRILLING <i>H</i>	LOGGED BY <i>H. J. Fauncy</i>
DRILLER <i>F.A. KELLY</i>	REFERENCES	DRAWN BY <i>G.H. & W.J.</i>
COMMENCED <i>5-12-62</i>	<i>Radiometric Log - F. Maranzana (B.H.R.) 24-12-62</i>	CHECKED BY <i>H. J.</i>
COMPLETED <i>27-12-62</i>	<i>Chemical Assays - W. Fraser</i>	SHEET <i>5</i> OF <i>5</i>
		DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT: <i>Phosphate Survey 1962</i>	REMARKS: <i>Top of stand pipe 414.8'</i>								
HOLE NO: <i>DG 10</i>	CO-ORDINATES: <i>29 5 E 11 N</i>				R.L. GROUND: <i>414.8'</i>				
LOCATION: <i>L 8 J - 6 (B.H.R. GRID)</i>					ANGLE FROM HORIZONTAL: <i>Vertical</i> DIRECTION: _____				
DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	AOS S.Q.	ASSAYS Q	
<i>Red/brown, ferruginous, silty sand. Fine grained, angular. Fragments of hematitic quartzite and quartz.</i> <i>At ~ 13', grit of angular quartz and hematitic quartz.</i>		NX		63					
		10					13'		
		15					15'		
		20					20'		
		25					25'		
		30					30'		
		35					35'		
		40					40'		
		45					45'		
		50					50'		
<i>Silicified hematitic quartz breccia.</i>				80					
		10							
		20							
		30							
		40							
		50							
		60							
		70							
		80							
		90							
<i>Hematitic quartz and quartzite breccia, highly silicified. Bands of pink and red/brown, partly leached sandstone. Medium grained, scattered quartz fragments. Rare fractures at N70°.</i> <i>Core very broken in patches, with silt and sand.</i> <i>No sandstone below 30'.</i>		8X		100					
		10			100				
		20			100				
		30			100				
		40			100				
		50			100				
		60			100				
		70			100				
		80			100				
		90			100				
<i>Mainly red/brown - lilac quartzite with scattered fragments of quartz. Very hard, silicified.</i>		70 1/4°		100					
		10			100				
		20			100				
		30			100				
		40			100				
		50			100				
		60			100				
		70			100				
		80			100				
		90			100				
<i>Light red/brown, hematitic quartz breccia. Generally highly quartzose and silicified, but in patches weathered and crumbly. Core generally fractured.</i>		77 7/8°		100					
		10			100				
		20			100				
		30			100				
		40			100				
		50			100				
		60			100				
		70			100				
		80			100				
		90			100				
							TRACE AOS		

DRILL NO. _____ TYPE: <i>MINDRILL F. 20</i>	EXPLANATION CASING IN HOLE DURING DRILLING: <i>H</i>	HEAD OFFICE LOGGED BY: <i>W. J. Jannay</i> DRAWN BY: <i>W. J.</i> CHECKED BY: _____
DRILLER: <i>F. A. KELLY</i> COMMENCED: <i>27-12-62</i> COMPLETED: <i>10-1-63</i>	REFERENCES <i>Radiometric log - F. Maranzano (B.M.R.) 11-1-63.</i> <i>Chemical Assays - W. Fraser.</i>	SHEET: <i>1</i> OF <i>6</i> DRAWING NO. _____

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		CO-ORDINATES <i>29° 5' E 11 N</i>		REMARKS <i>Top of stand pipe 414.8'</i>		R.L. GROUND <i>414.8'</i>			
HOLE NO. <i>D.G. 10</i>		LOCATION <i>E 81-6 (B.M.R. GRID)</i>		ANGLE FROM HORIZONTAL <i>Vertical</i>		DIRECTION			
DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	P205 J.Q.	ASSAYS	
<i>Very broken; small % quartz. Generally red/brown hematitic siltstone with white, yellow and pale green clay mottling and on fractures.</i>		100					105'		
		110					110'		
		114' 4"					114' 4"		
		120					120'		
		123'					123'		
							125'		
							130'		
							135'		
							140'		
							145'		
<i>Quartz sheared near 160'.</i>		150					150'		
							155'		
							160'		
		163' 7"		97			163' 7"		
				100			167'		
		170		100			172'		
				98			177'		
		180		100			180'		
				100			185'		
		190		100			190'		
<i>Hematitic quartz breccia. Quartz fragments very variable in size, angular and embayed, and sheared. In scattered patches matrix is hematitic, red/brown sand and pink ferruginous quartzite; elsewhere it is red/brown hematitic siltstone. Slickensides with hematite and dark green chlorite. At ~203', light orange quartzite and light green chlorite (sample). Bands of hematitic quartzite. Core very broken in places.</i>				100			195'		
		200		100			200'		

TRACE P205

DRILL NO. <i>F.A. KELLY</i> TYPE <i>MINDRILL F.20</i>		EXPLANATION <i>CASING IN HOLE DURING DRILLING</i>		HEAD OFFICE LOGGED BY <i>W. J. Tannery</i> DRAWN BY <i>W. J.</i> CHECKED BY SHEET <i>2</i> OF <i>10</i> DRAWING NO.	
DRILLER <i>F.A. KELLY</i> COMMENCED <i>27-12-62</i> COMPLETED <i>10-1-63</i>		REFERENCES <i>Radiometric log - F. Maranzano (B.M.R.) 11-1-63.</i> <i>Chemical Assays - W. Fraser.</i>			

GEOLOGICAL LOG OF DRILL HOLE

LOCATION E83-6 (B.M.R. GRID)

CO-ORDINATES 29.5 E 11 N.

REMARKS

Top of stand proc 414.8' $\frac{1}{2}$

R.L. GROUND 414.8

ANGLE FROM HORIZONTAL *Vertical*

DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT CORE RE COVER %	SAMPLES	REMARKS	F.S.	ASSAYS
	CASING	SIZE OF CORE						
Chlorite becomes more common with depth.				100				
----- 204'6"				100				
Very chloritic. /	206							
----- 209'		210		100				
Transition. Patches and bands of hematitic quartz breccia, bands of light red/brown quartzite, fractured, with hematite and chlorite.	209'			100				
----- 218'3"				100				
Silicified light red/brown quartzite. Much fractured in places; chlorite on fracture surfaces.	218'3"	220		100				
----- 227'7"				100				
Small bands and patches of hematitic quartz breccia. Fractures and shears nearly to core.	227'7"	230		100				
----- 241'3"		240		100				
Hematitic quartz breccia. Very broken in places. Chlorite on slickensides and fractures. Silicified in places.	241'3"			100				
----- 249'8"		250		100				
High % quartz; sheared, in places with specular hematite. Light red/brown quartzite with scattered patches and bands of H.Q.B.	249'8"			100				
----- 257'4"				100				
Matrix hematitic silt. Crystalline quartz is common. Scattered bands of quartzite. Chlorite with sericite flakes.	257'4"	260		100				
----- 263'				100				
----- 267'		270		100				
----- 272'				100				
----- 277'		280		100				
----- 282'				100				
----- 287'				100				
Very soft hematitic sandy silt. /	286'8"			100				
----- 286'				100				
----- 290'6"		290		100				
Breccia. In places very crumbly; high % red/brown hematitic siltstone matrix with chlorite on slickensides. Fragments of white grey crystalline limestone. Fragments on quartz	290'6"			100				
----- 294'10"		300		100				
----- 299'10"								

DRILL NO. TYPE MIN. DRILL F. 20

DRILLER F. A. KELLY

COMMENCED 27-12-62

COMPLETED 10-1-63

EXPLANATION

CASING IN HOLE DURING DRILLING

REFERENCES

Radiometric log - F. Haranzano (C.B.H.R.) 11-1-63.

Chemical Assays - W. Fraser.

HEAD OFFICE

LOGGED BY W. J. Tancey

DRAWN BY W. J.

CHECKED BY

SHEET 3 OF 4

DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

REMARKS

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DRILL NO.	EXPLANATION	HEAD OFFICE	
TYPE <i>MINDRILL F20</i>	CASING IN HOLE DURING DRILLING <i>H</i>	LOGGED BY <i>N. J. Tannay</i>	
DRILLER <i>F.A. KELLY</i>	REFERENCES	DRAWN BY <i>N.J.</i>	
COMMENCED <i>27-12-62</i>	<i>Radiometric log - F. Maranzano (B.M.R.) 11-1-63.</i>	CHECKED BY	
COMPLETED <i>10-1-63</i>	<i>Chemical Assays - W. Fraser.</i>	SHEET <i>4</i> OF <i>6</i>	
		DRAWING NO.	

GEOLOGICAL LOG OF DRILL HOLE

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT S CORE RE COVERY %	SAMPLES	REMARKS	P205 S. Q.	ASSAYS Q
	CASINO	SIZE OF CORE						

Bottom blocked, sand and mud.

GD130

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		CO-ORDINATES <i>29° 5' E 11° N</i>		REMARKS <i>Top of stand pipe 414.8'</i>		R.L. GROUND <i>414.8'</i>		DIRECTION <i>(color)</i>	
HOLE No. <i>DS. 10.</i>		LOCATION <i>E 87-6 (B.M.R. GRID)</i>		ANGLE FROM HORIZONTAL <i>Vertical</i>					
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	P ₂ O ₅		ASSAYS
	CASING	SIZE OF CORE					S.Q.	Q	
<i>Scattered fragments of white/grey, fine-grained limestone.</i>				100			<1%	3.1%	
				100			1%	2.4%	
		510		100			1%	3.1%	
				100			<1%	3.1%	
				100			Trace	3.1%	
		520		100			Trace	1.0%	
<i>Partly silicified limestone. White, pink. Fine grained. Irregular pods of glassy r.d. quartz and veins of calcite.</i>	521.5'	521.5'		100					
		530							

DRILL NO. <i>MINDRILL F-20</i> TYPE <i>MINDRILL F-20</i>		EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i>		HEAD OFFICE LOGGED BY <i>W. J. Janssen</i> DRAWN BY <i>W. J.</i> CHECKED BY <i></i>	
DRILLER <i>F.A. KELLY</i> COMMENCED <i>15-2-63</i> COMPLETED <i>1-3-63</i>		REFERENCES		SHEET <i>6</i> OF <i>6</i> DRAWING NO.	

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>	REMARKS <i>Top of stand pipe 335'</i>								
HOLE No. <i>DS 11</i>	CO-ORDINATES <i>23 5 E 13 N</i>				R.L. GROUND				
LOCATION <i>E 83-6 (B.H.R. GRID)</i>					ANGLE FROM HORIZONTAL <i>Vertical</i> DIRECTION				
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	ASSAYS		
	CASING	SIZE OF CORE					A.O.S.	Q	
<i>Red/brown, hematitic clayey silt.</i>							5%	5.6%	
		10'		18				5%	
<i>Grit; angular quartz grit and fragments of hematitic quartzite.</i>				69			4%	7.6%	
		19'6"						4%	
<i>Fragments of hematitic quartz breccia. 22'-24' - hematitic clay</i>		20'		97			9%	7.6%	
		25'						9%	
<i>Much-weathered hematitic silt and clay; red/brown, soft and wet; bands of light brown limonitic clay. Scattered fragments and bands of hematitic quartz breccia, with core sandy in places.</i>				100			3%	6.5%	
		30'		100			1%	2.7%	
				100			1%	2.7%	
		40'		100			2%	3.2%	
				100			5%	9.8%	
<i>Very black staining. Not heavy; not more radioactive than elsewhere.</i>		46'6"		100			5%	8.0%	
		48'6"		100				6.5%	
		50'		100			6%	6.6%	
				100			6%	5.0%	
		60'		100			6%	7.7%	
				100			4%	10.0%	
		70'		100			5%	5%	
				100			5%	9.2%	
		80'		100			7%	9.1%	
				100			6%	5%	
		90'		100			5%	10.0%	
				100			5%	5%	
				100			4%	9.8%	
				100			3%	7.2%	
		100'		100					

DRILL NO. <i>MINDRILL F-20</i> TYPE <i>MINDRILL F-20</i>	EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i>	HEAD OFFICE LOGGED BY <i>W. J. Tauney</i> DRAWN BY <i>W. J.</i> CHECKED BY
DRILLER <i>F. A. Kelly</i> COMMENCED <i>14-1-63</i> COMPLETED <i>17-1-63</i>	REFERENCES <i>Radiometric Log - F. Maranzana 17-1-63.</i> <i>Chemical Assays - W. Fraser.</i>	SHEET <i>1</i> OF <i>2</i> DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

[illegible]

DRILL NO TYPE <i>MINDRILL P20</i>	EXPLANATION CASING IN HOLE DURING DRILLING	HEAD OFFICE
DRILLER <i>F. A. KELLY</i>	REFERENCES <i>Radiometric Log - F. Maranzana 11-1-63</i> <i>Chemical Assays - W. Fraser</i>	LOGGED BY <i>W. J. Jaucy</i> DRAWN BY <i>W. J.</i> CHECKED BY _____ SHEET <i>2</i> OF <i>2</i> DRAWING NO _____

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Rum Jungle Phosphate Survey 1962</i>	CO-ORDINATES <i>29° 5' E 15° N</i>			REMARKS <i>Top of stand pipe 369.2'</i>			R.L. GROUND <i>369.6 feet</i>		DIRECTION <i>Vertical</i>
HOLE NO. <i>DG 12</i>									
LOCATION <i>E 83-6 (B.H.R. GRID)</i>									
ANGLE FROM HORIZONTAL									
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	P205 S.Q.	ASSAYS	
	CASING	SIZE OF CORE							
<i>At top - hematitic silt with fragments of quartzite. Grades to hematitic silt with medium grained quartz sand.</i>		10		65					
<i>Very broken core. Mainly hematitic quartzite breccia. Angular and embayed fragments of white, sugary quartzite, and hematitic silt matrix. Leached along fractures. Patches of sandstone and pink, weathered siltstone.</i>		20		100			20'		
				88			25'		
				100			30'		
				100			35'		
				100			40'		
				100			45'		
				100			45'		
				100			50'		
				94			55'		
				100			60'		
<i>As for 20'-43'</i> <i>Brown, wet, ferruginous clayey and silty quartz sand. Med.-coarse grained angular-sub-rounded sand; silt matrix varies in amount. Scattered fragments of hematitic quartz breccia, very broken. Very slightly calcareous in spots - probably scattered grains of carbonate.</i>		43		100					
				100					
				100					
				100					
				100					
				100					
				100					
				100					
				93					
				100					
<i>As for 20'-43'</i> <i>Hematitic quartz breccia. Quartz fragments angular and embayed. Matrix hematitic silt.</i>		72'6"		100			72'6"		
				100			74'7"		
				84					
				100			80'		
				100			85'		
				100			90'		
				100			95'		
				100					
				100					
				100					

Radiometric Values 0.005 throughout
 TRACE P205

DRILL NO. TYPE <i>Handdrill F-20</i> DRILLER <i>F. Kelly</i> COMMENCED <i>18-1-63</i> COMPLETED <i>1-2-63</i>	EXPLANATION CASING IN HOLE DURING DRILLING <i>H</i> REFERENCES <i>Radiometric log - F. Maranzana (B.H.R.) 1-2-63. GD4H.</i> <i>Chemical Assays - W. K. Fraser.</i>	HEAD OFFICE LOGGED BY <i>W. Tauney</i> DRAWN BY <i>W. J.</i> CHECKED BY SHEET <i>1</i> OF <i>2</i> DRAWING NO.
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GEOLOGICAL LOG OF DRILL HOLE

PROJECT *Phosphate Survey 1962* REMARKS *Top of stand pipe 869.8'*
 HOLE No. *DG 12* CO-ORDINATES *29.5 E 15 N* R.L. GROUND *869.6*
 LOCATION *E83-6 (B.M.R. GRID)* ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L. CASING	DEPTH SIZE OF CORE	LOG	LIFT & CORE RE COVERY %	SAMPLES	REMARKS	P.O.S. S.G.	ASSAYS
<i>Brown, unsorted fine - medium grained, rounded, silty quartz sand.</i>	100.6'			100			100.6'	
				100			105'	
				100			110'	
				100			115'	
				100			120'	
				100				
				100				
				100				
				100				
				100				
<i>Hematitic quartz breccia fragments grading to hematitic mudstone and chloritic mudstone.</i>	126.9'			100			126.9'	
<i>Limestone. Dark red/brown, crystalline, ? dolomite marble, with minor chlorite.</i>	132.9'			100			132.9'	
				100			137'	
				100			142'	
				100				
				100				
T.D.	147.7'			100			147.7'	
		150'						

TRACE P2O5

869.8'

869.6'

869.4'

869.2'

869.0'

868.8'

868.6'

868.4'

868.2'

868.0'

867.8'

867.6'

867.4'

867.2'

867.0'

866.8'

866.6'

DRILL NO. <i>Hindrill F. 20</i>	EXPLANATION	HEAD OFFICE
TYPE <i>Hindrill F. 20</i>	CASING IN HOLE DURING DRILLING	LOGGED BY <i>W. J. Jamney</i>
DRILLER <i>F. A. Kelly</i>	REFERENCES	DRAWN BY <i>W. J.</i>
COMMENCED <i>18-1-63</i>	<i>Radiometric log - F. Maranzana (B.M.R.) 1-2-63. G 24H.</i>	CHECKED BY
COMPLETED <i>1-2-63</i>	<i>Chemical Assays - W. K. Fraser</i>	SHEET <i>2</i> OF <i>2</i>
		DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>	REMARKS <i>Top of stand pipe 321.7'</i>								
MOLE NO. <i>D.G. 13</i>	CO-ORDINATES <i>27.5 E 17N</i>				R.L. GROUND <i>321.7</i>				
LOCATION <i>E83-6 (B.H.R. GRID)</i>					ANGLE FROM HORIZONTAL <i>Vertical</i> DIRECTION				
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	P ₂ O ₅ S.Q.	ASSAYS Q.	
<i>Wet, red brown hematitic, sericitic quartz silt and sand; becomes silty sand below 20'. Phosphatic, slightly calcareous.</i>									
		10					7%	8.4%	
								7%	
		50					9%	10.4%	
								9%	
		20							
		100					9%	11.2%	
								9%	
		25							
<i>Sandstone: med. grained quartz with hematite and sericite. Some glassy quartz, rounded fragments.</i>									
		30					7%	10.3%	
								7%	
		100							
		30					11%	10.3%	
								11%	
		100							
		35							
<i>1' band of quartzite and sheared glassy quartz with minor hematite. Hematitic quartz breccia with v. minor quartz. Matrix is hematitic silt.</i>									
		40					9%	10.3%	
								9%	
		100							
		40					9%	12.2%	
								12.2%	
		100							
		45					6%	10.2%	
<i>Weathered hematitic silt with sericite, white/yellow talc patches, some staurolites. In places (a' in log) partly siliceous hematitic silt with cavities - angular, probably weathered out breccia fragments. Phosphatic, slightly calcareous, particularly at 66'. Rounded pebbles at 65.6".</i>									
		50					7%	10.2%	
								10.2%	
		100							
		50					4%	5.8%	
								4%	
		100							
<i>Weathered, red/pink crystalline limestone. Minor banded hematitic and chloritic clay.</i>									
		60					11%	3.6%	
								11%	
		100							
		60					4%	12.4%	
								12.4%	
		100							
<i>Wet, dark brown calcareous sand. Rounded, unsorted quartz; scattered grains limestone. Minor clay and limestone.</i>									
		70					3%	4.1%	
								4.1%	
		100							
		70					5%	6.8%	
								6.8%	
		100							
<i>Mottled lilac, white, purple, brown, wet, sticky, weathered clay. Calcareous in patches.</i>									
		80					2%	6.8%	
								6.8%	
		100							
		80					5%	8.0%	
								8.0%	
		100							
<i>Much weathered dark red crystalline limestone.</i>									
		90					6%	8.0%	
								8.0%	
		100							
		90					2%	2.6%	
								2.6%	
		100							
<i>Wet, sticky, weathered clay. Calcareous in patches.</i>									
		100					1%	2.3%	
								2.3%	
		100							
		100					10%	14.4%	
								14.4%	
		100							

DRILL NO. *1-2-63*

TYPE *MINI DRILL 1" 20'*

DRILLER *ATLANTIC DRILLERS*

COMMENCED *2-2-63*

COMPLETED *6-2-63*

EXPLANATION

CASING IN HOLE DURING DRILLING *[mark]*

REFERENCES

Radiometric Log - F. Haranzana (B.H.R.) 6-2-63.

Chemical Assays - W. K. Fraser.

HEAD OFFICE

LOGGED BY *W. J. Janczy*

DRAWN BY *W. J.*

CHECKED BY

SHEET *1* OF *2*

DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>Phosphate Survey 1962</i>		HOLE No. <i>D.G. 12</i>		CO-ORDINATES <i>27° 54' 17" N</i>		REMARKS <i>Top of stand pipe 321.7'</i>		R.L. GROUND <i>321.7'</i>	
LOCATION <i>E 83-6 (B.H.A. GRID)</i>		ANGLE FROM HORIZONTAL <i>Vertical</i>		DIRECTION					
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	ROs	ASSAYS	
	CASING	SIZE OF CORE					S.Q.	Q	
<i>Red and white coarsely crystalline limestone; minor patches of chlorite</i>		<i>102'6"</i>					<i>130%</i>	<i>Less than 1.0%</i>	
					<i>99</i>		<i>Trace 107</i>	<i>Less than 1.0%</i>	
			<i>110</i>		<i>100</i>		<i>Trace 113'</i>	<i>Less than 1.0%</i>	
		<i>113'5"</i>				<i>TD 115' 8"</i>			
		<i>120</i>							
		<i>130</i>							

DRILL NO. TYPE <i>Mindrill F-20</i>	CASING IN HOLE DURING DRILLING	EXPLANATION	HEAD OFFICE	
DRILLER <i>Atlantic Drillers</i>		REFERENCES	LOGGED BY <i>W. J. Jamney</i>	
COMMENCED <i>2-2-63</i>		<i>Radiometric Log - F. Maranzana (B.H.A.) 6-2-63.</i>	DRAWN BY <i>W. J.</i>	
COMPLETED <i>6-2-63</i>		<i>Chemical Assays - W.K. Fraser</i>	CHECKED BY	
			SHEET <i>2</i> OF <i>2</i>	
			DRAWING NO.	

GEOLOGICAL LOG OF DRILL HOLE

LOCATION

R.L.GROUND

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

Red/brown, hematitic silt;
scattered angular fragments of
quartz, generally $< \frac{1}{4}$ ", rarely
larger. (Weathered hematitic
quartz breccia).

DRAWN BY	W. J.
CHECKED BY	
SHEET 1	OF 2
DRAWING NO.	

GEOLOGICAL LOG OF DRILL HOLE

R.L. GROUND
ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DRILL NO. TYPE <i>MMDRILL F-20</i>	EXPLANATION CASING IN HOLE DURING DRILLING	HEAD OFFICE
DRILLER <i>ATLANTIC DRILLERS</i>	REFERENCES <i>Radiometric Log - F. Harenzana (B.M.R) 14-2-63.</i> <i>Chemical Assays - W. Fraser.</i>	LOGGED BY <i>W. Taunsey</i> DRAWN BY <i>N.J.</i> CHECKED BY _____
COMMENCED <i>7-2-63</i>		SHEET <i>2</i> OF <i>2</i>
COMPLETED <i>14-2-63</i>		DRAWING NO _____

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

GEOLOGICAL LOG OF DRILL HOLE

PROJECT *PHOSPHATE SURVEY 1962*

REMARKS

*Top of stand sec. 343.7*HOLE No. *DG 15*CO-ORDINATES *25 5 E 00*R.L. GROUND *343.7*LOCATION *EB3-10 (B.M.R. GRID)*ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	ASSAYS
	CASING	SIZE OF CORE					
<i>Soft weathered fine grained and ferruginous silt. Scattered fragments (<1") quartz. Very rare scattered calcareous spot reaction with acid.</i>		NX					
		10'					
		20'					20'
<i>Light red/grey silicified quartzite fragments. Quartz veins of quartz sheared broken core. Weathered.</i>		23' 9"					23' 9"
		30'					30'
<i>Weathered silty ferruginous medium coarse angular sub-rounded quartz sand with grains of quartzite. Very rare spot calcareous reaction.</i>		30'					35'
<i>Silt fraction increases with depth.</i>		40'					40'
		45'					45'
		49' 6"					49' 6"
<i>Light purple Quartzite and broken fragments of quartz.</i>		51' 5"					51' 5"
<i>At 60' 2" glassy quartz.</i>		55'					55'
		60'					60'
		62'					62'
<i>Fragments of pink silicified weathered quartzite and quartz; some ferruginous clay mottled red and grey.</i>		65' 5"					65' 5"
		70'					70'
		75'					75'
		77' 6"					77' 6"
<i>Pink and white weathered crystalline limestone. Partly brecciated with minor hematitic mudstone matrix.</i>		82' 3"					82' 3"
		85'					85'
<i>Soft weathered hematitic red/brown chloritic (minor) siltstone and mudstone with scattered fragments of pink/white weathered crystalline limestone. Minor specular hematite.</i>		90'					90'
		93' 7"					93' 7"
<i>Pink white weathered crystalline limestone fractured and broken core.</i>		97' 6"					97' 6"
<i>Hematitic siltstone. Soft crumbly quartz breccia fragments weathered in situ.</i>							

Trace
P₂O₅DRILL NO.
TYPE *Blvd. Drill - F. 20*

CASING IN HOLE DURING DRILLING

EXPLANATION

HEAD OFFICE

DRILLER *F. Kelly*
COMMENCED *1-3-63*
COMPLETED *15-3-63*REFERENCES
Radiometric log - F. Moranzano
*Chemical Assays - W. Fraser - semi-quantitative*LOGGED BY *W. Jouncey*DRAWN BY *L. Kruger*

CHECKED BY

SHEET *1* OF *2*

DRAWING NO.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>PHOSPHATE SURVEY 1962</i>		CO-ORDINATES <i>25°E 00</i>		REMARKS <i>Top of stand pipe 343.7'</i>		R.L. GROUND <i>343.7</i>		ANGLE FROM HORIZONTAL <i>Vertical</i>	
HOLE No. <i>DG 15</i>		LOCATION <i>E83-10 (B.M.R. GRID)</i>				DIRECTION			
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT & CORE RECOVERY %	SAMPLES	REMARKS	ASSAYS		
	CASING	SIZE OF CORE							
<i>Partly calcaceous with fragments of breccia of 103'6" - 111'6"</i>		103'6"					101'	↑ Trace PQs ↓	
		110					106'		
<i>Medium grained light red / brown quartzite. Fractures and shears nearly 1/cor. Slickensides with chlorite & yellow / brown P.Talc? sericite. Silicified. Scattered patches hematitic quartz breccia</i>		111'6"					111'6"		
		115'					115'		
		120					120'		
		BMLC					125'		
		130					130'		
<i>Hematitic quartz breccia. Angular, sub-rounded embayed fragments of quartz, glassy & sheared; matrix hematitic siltstone. Scattered hematitic quartzite. Rare chlorite, some slickensides, core broken. Some of quartz fragments embayed and pitted with specular hematite. Minor fragments.</i>		BX					133'8" (<i>Bigger core</i>)		
		135'7"					135'7"		
		140					140'		
		145					145'		
		150					150'		
<i>Minor bands of quartzite.</i>		155'					155'		
		160					160'		
		165'					165'		
		170					170'		
		175'					175'		
		180					180'		
		185'					185'		
		190					190'		
		195'					195'		
		200					200'		
T.D. 204'9"		200							
DRILL NO.	EXPLANATION	HEAD OFFICE							
TYPE <i>Min. Drill F-20</i>	CASING IN HOLE DURING DRILLING ☒	LOGGED BY <i>W. Jouncey</i>							
DRILLER <i>F. Kelly</i>	REFERENCES	DRAWN BY <i>L. Kruger</i>							
COMMENCED <i>1-3-63</i>	<i>Radiometric log - F. Moranzano</i>	CHECKED BY							
COMPLETED <i>15-3-63</i>	<i>Chemical Assays - W. Fraser - semi quantitative</i>	SHEET <i>2</i> OF <i>2</i>							
		DRAWING NO.							

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS									
GEOLOGICAL LOG OF DRILL HOLE									
PROJECT <i>PHOSPHATE SURVEY 1962</i>			REMARKS <i>Top of stn 1 m. 326.9</i>						
HOLE No. <i>DG 16</i>		CO-ORDINATES <i>25 5 E 6 S</i>			R.L. GROUND <i>326.9</i>				
LOCATION <i>E83-10 (B.M.R. GRID)</i>			ANGLE FROM HORIZONTAL <i>VERTICAL</i> DIRECTION						
DESCRIPTION OF CORE	R.L.	DEPTH	LOG	LIFT B. CORE RE COVERY %	SAMPLES	REMARKS	ASSAYS		
<i>Mainly sand, coarse grain angular quartz and hematitic quartz sand low % silt.</i> <i>Bands of silicified hematitic breccia breccia. Angular embayed glossy quartz (parts are sugary). Notable bands shown & in log.</i> <i>Matrix of breccia hematitic silt and sand.</i>		NX	▲▲▲▲▲ ▲▲▲▲▲ ▲▲▲▲▲ ▲▲▲▲▲						
		10							
		20	BIM	▲▲▲▲▲ ▲▲▲▲▲					
				▲▲▲▲▲					
		30		▲▲▲▲▲ ▲▲▲▲▲					
		40		▲▲▲▲▲ ▲▲▲▲▲					
		50							
		60							
		66' 3"							
	<i>Hematitic quartz breccia high % quartz fragments (glossy) with siliceous hematitic matrix. Veins of quartz. Quartz fragments angular embayed.</i>		70						
<i>Wet sludge of silty fine-grained hematitic sand with fragments (1") quartz. Scattered bands of hematitic quartz breccia.</i>		78' 6"							
<i>Broken core of hematitic quartz breccia</i>		86' 4"							
		89' 6"							
<i>Mainly red/brown hematitic quartzite; minor breccia fragments</i>		94' 5"							
<i>Hematitic quartz breccia high % quartz, Silicified Quartz veins.</i>		97' 4"							
		100							

15'
20'
22'
24'
25'
29'
31'
35'
41'
42' 6"
45'
50'
55'
60'
65'
66' 3"
70'
75'
78' 6"
82'
86' 4"
89' 6"
94' 5"
97' 4"
100'

Trace
P₂O₅

DRILL NO.

TYPE *Min. Drill. F-20*

DRILLER *F. Kelly*

COMMENCED *15-3-63*

COMPLETED *27-3-63*

EXPLANATION

CASING IN HOLE DURING DRILLING *H*

REFERENCES

Radiometric log G. Cole

Assays - some - quantitative - W. Fraser

HEAD OFFICE

LOGGED BY *W. Jarmey*

DRAWN BY *L. Kruger*

CHECKED BY

SHEET *1* OF *2*

DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

ANGLE FROM HORIZONTAL *Vertical* DIRECTION

DRILL NO.	EXPLANATION	HEAD OFFICE	
TYPE <i>Min. Drill-F-20</i>	CASING IN HOLE DURING DRILLING	LOGGED BY	<i>W. Jouncey</i>
		DRAWN BY	<i>L. Kruger</i>
		CHECKED BY	
DRILLER <i>F. Kelly</i>	REFERENCES	SHEET <i>2</i>	OF <i>2</i>
COMMENCED <i>12-3-63</i>	<i>Radiometric log G. Cole</i>	DRAWING NO.	
COMPLETED <i>27-3-63</i>	<i>Assays semi-quantitative - W. Fraser</i>		

APPENDIX 2.

Field Chemical Laboratory Report

by

A.G. Fricker

A field chemical laboratory was used throughout the field season to provide assays of samples as they were collected. Several rapid semi-quantitative field tests for phosphate and a biogeochemical prospecting method were examined.

FIELD AND LABORATORY PROCEDURES

SAMPLING

Most of the samples assayed were split diamond drill core, auger drill cuttings and channel samples from costeans. A few grab samples were assayed.

Auger Cuttings

A representative part of the cuttings from every two foot interval of each auger drill hole was set aside and samples consisting of representative and equal amounts of cuttings for a two foot interval were taken for analysis. Sampling intervals were determined by change (usually coincident) of either lithology or of colour. Transitions between lithologies and colours were sampled separately. The usual maximum sampling interval was ten feet, a few samples of twelve feet were taken.

Diamond drill core

All core from the B.M.R. diamond drilling was split and half was crushed for analysis. Selected T.E.P. drill core was spot tested for phosphate with field reagent and the phosphatic sections were split and half was crushed for analysis. The maximum sample interval was five feet with smaller intervals where there were changes in lithology.

Costean channel samples

Channel samples were obtained from the floor of the costeans dug for the B.M.R. The maximum sample interval was ten feet with smaller intervals where there were changes in lithology.

SAMPLE PREPARATION

All samples were partly dried and broken to small fragments in jaw and roller crushers. They were then split to an eighth or a sixteenth depending upon original size. The small fraction was oven-dried and pulverised to approximately -200 mesh, when it was thoroughly mixed and bagged ready for analysis.

ANALYTICAL METHODS

Qualitative spot test

A solution of ammonium molybdate in nitric acid (nitric-molybdate reagent) gives a canary yellow precipitate of ammonium phospho-molybdate when applied to rock and soil containing acid soluble phosphate (Vogel 1954). The test is sensitive, detecting 0.1% P_2O_5 under favourable conditions, and is essentially qualitative.²⁵ The intensity and speed of formation of the precipitate can indicate the amount of phosphate present but is not reliable. The test itself is heat sensitive; on a cold morning phosphate rock may not give a positive reaction immediately or develop an intense precipitate. Slight warming of the rock and reagent on cold mornings, aids precipitation, but overheating (i.e. above 50°C) is to be avoided.

Semi-quantitative

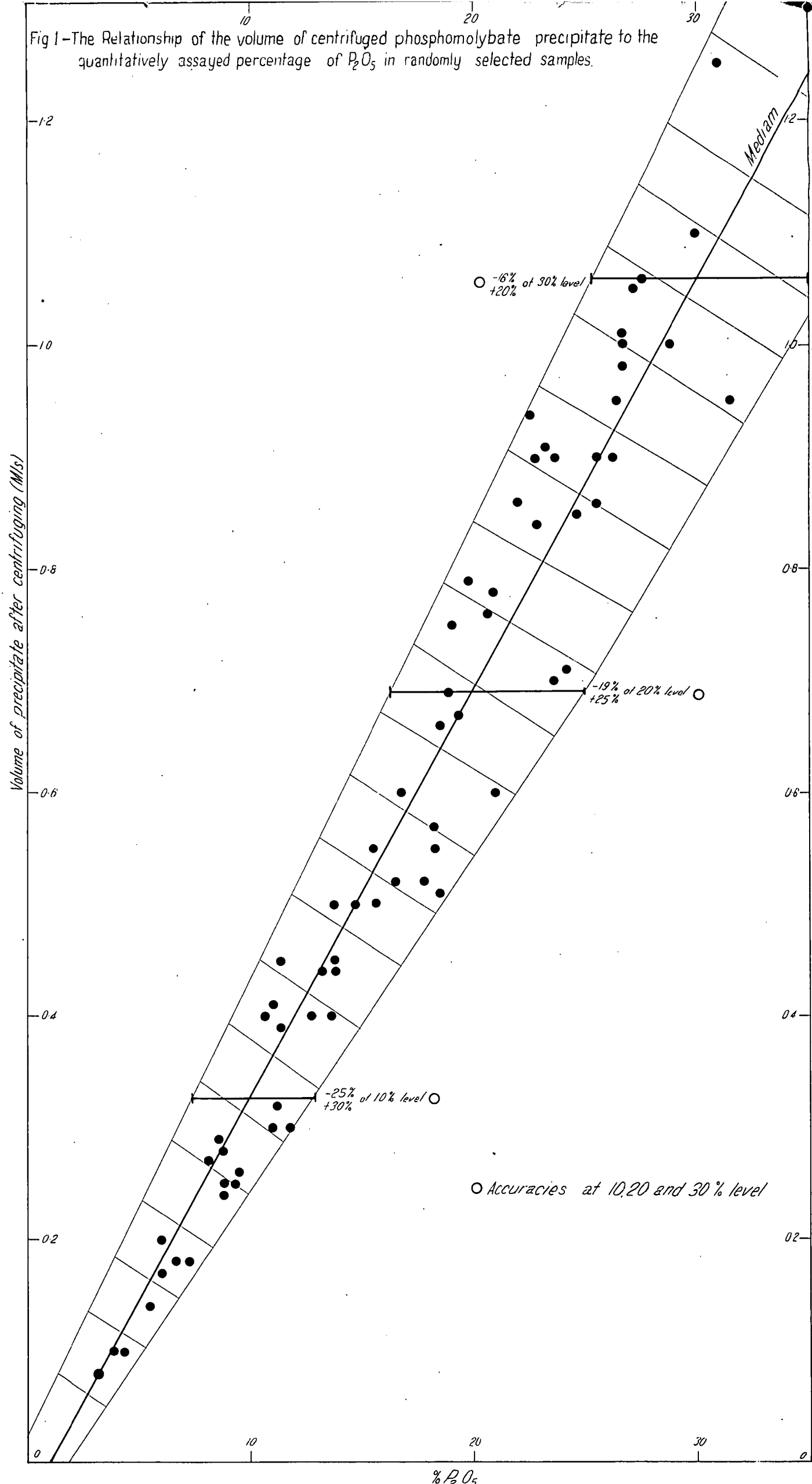
A rapid indication of the phosphate content of rocks and soils can be made by forming ammonium phosphomolybdate and estimating the volume of the bulky precipitate (Mabie & Hess 1960). Beevers (see appendix 3) has developed a method on these lines and the essentials of his technique were followed during the field season. They are to digest the sample in nitric acid, decant the resulting solution precipitate the ammonium molybdate, centrifuge the precipitate in a graduated tube and measure its volume.

The method used in the field differs from that of Beevers in that:

1. The sample was ground to minus 200 mesh.
2. Digestion was for a minimum of 15 minutes at simmering temperature.
3. After digestion the acid phosphate solution was filtered (for drill core samples) or decanted (for auger samples) into an assembled centrifuge tube and funnel and 50 mls. of the molybdate reagent was added and thoroughly mixed.
4. The molybdate reagent was prepared by dissolving 60 gms. of finely crushed ammonium molybdate in a solution of 10 mls. of concentrated ammonia solution and 300 mls. of water. When the molybdate had dissolved, 130 gms. of solid ammonium nitrate were added and the solution was made up to 1 litre, and allowed to stand overnight.

Although the precipitate from 0.2 gm. sample would theoretically occupy a volume of no greater than 0.05 ml. in practice it was found that, particularly with auger samples, a bulky flocculent material tended to develop after the addition of the molybdate reagent to the solution decanted from the acid digestion. This flocculent was mainly derived from clay and ferruginous matter and quite commonly occupied a large volume in the bottom of the centrifuge tube. However, its presence was easily discernible by eye because the ammonium phosphomolybdate precipitate usually formed a layer above the flocculent material. A correction was easily made but was only applicable in samples quite low (less than 5% P_2O_5) in phosphate.

Fig 1 - The Relationship of the volume of centrifuged phosphomolybdate precipitate to the quantitatively assayed percentage of P_2O_5 in randomly selected samples.



The method has accuracies of - 16 and +20% at the 30% P_2O_5 level, -19 and +25% at the 20% level, and -25 and +30% at the 10% level (see fig. 1). The output of the method is 50 to 70 samples per man day from the weighing stage.

Quantitative

Generally phosphorus is determined colourimetrically as the blue phosphovanadomolybdate using an absorptiometer to measure colour intensities (which are proportional to the concentration of phosphate present). The method is extremely sensitive and most often applied to determining trace amounts. For field conditions the instrumental measure of light intensities becomes impracticable and thus classical precipitation methods must be used to determine the phosphate content of potential ore grade samples. On the macro scale phosphorus may be precipitated as the magnesium ammonium phosphate, but this method involves a second precipitation to remove impurities carried down by the first precipitate. Alternatively a simple precipitation as ammonium phosphomolybdate carries fewer impurities but its composition varies with the conditions of precipitation. To ensure a definite and invariable composition of the precipitate, conditions must be strictly controlled. In the presence of nitric acid (to prevent co-precipitation of molybdic acid), ammonium phosphomolybdate of definite composition is precipitated from boiling solutions. (Kassner, Crammer, and Ozier, 1948).

Alkalimetric

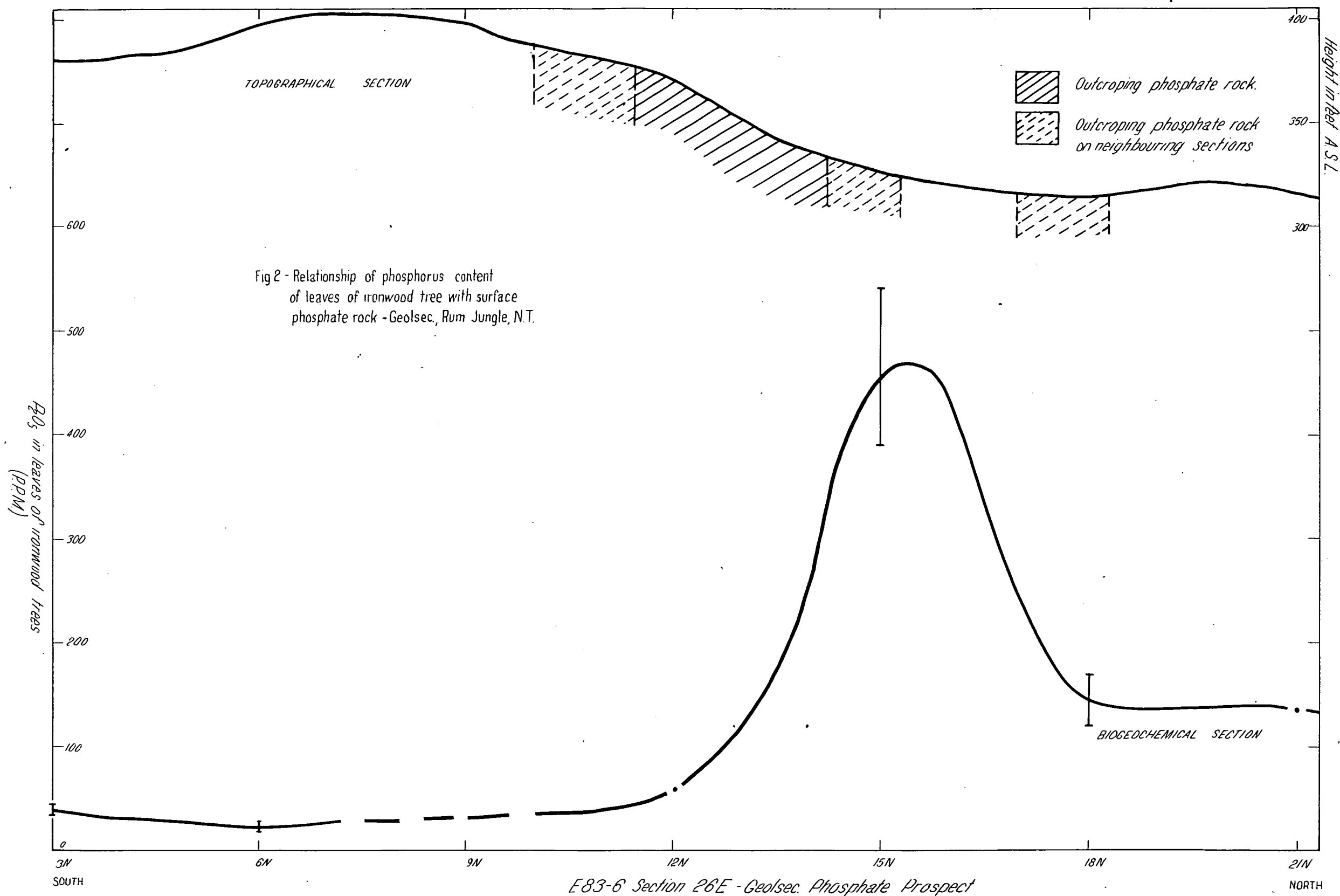
Essentially, the method of Kassner (1948) was followed, but varied in that:-

1. 1 gm. of sample was digested with 30 ml. of nitric acid. (The mixture was warmed before leaving overnight and digested at a simmering temperature for four hours in the morning).
2. The residue from the digestion was discarded. (Any phosphate in the residue would not be available to superphosphate manufacture).
3. The Aliquot for the precipitation was neutralised with ammonia solution before the addition of the citromolybdate solution.

The method used was calibrated against standard potassium dihydrogen phosphate, but good reproducibility was not obtained. The end point of the titration was difficult to estimate and in practice the method was less efficient and accurate than the gravimetric method described hereunder. Six samples per man day from the weighed stage was the output of the method.

Gravimetric

The phosphorus was precipitated as in the alkalimetric modification of Kassner's method (1948), and collected on a weighed sintered glass crucible (porosity 4) similar to the procedure suggested by Piper (1947, pp.293 and 151). The precipitate was washed six times with 2% ammonium nitrate



(acid to litmus), twice with ice-cold water, and thrice with acetone, aspirated for 30 sec. evacuated in a dessicator and weighed after 30 min.

On calibration an experimental 0.03475 was obtained as the fraction of P_2O_5 in the precipitate (for the ideal composition $(NH_4)_3P_6O_{12} \cdot 12MoO_3$, the P_2O_5 fraction is 0.03783). The method is accurate to $\pm 4\%$, $3\pm 2\%$ and $5\pm 1.3\%$ at the 10%, 20% and 30% P_2O_5 levels. (see fig. 2). Eight samples per man day is the output by this method.

Comments on quantitative procedure

In several instances early in the season quantitative determinations were found to be much lower than the semi-quantitative percentage initially read from Beever's chart. Repeated determinations under the same conditions generally confirmed the lower quantitative figure within reasonable tolerance, but occasionally a discrepant value was obtained. The extraction of phosphate from the sample became suspect and an examination of the residue after the digestion showed the continued presence of phosphorus. Redigestions of the residue using an extra 10 mls of acid and/or a more severe and longer time of digestion did not remove all the phosphate. Samples at this stage had been crushed to minus 80 mesh and too large a particle size was suspected to prevent all the phosphate from entering solution. Samples were then ground to minus 200 mesh but it was still found that some phosphate (but less than for the samples ground to minus 80 mesh size) remained in the residue.

The same problem did not appear to occur in semi-quantitative determinations which were made using 0.1 gm. of sample and 10 ml. of acid. This gives an acid to sample ratio of 100:1, whereas the ratio for the quantitative method was 30:1. The apparently greater extraction using the larger acid sample ratio led to quantitative determinations using the same acid to sample ratios giving more accurate results. The extractability of phosphate is thus a function of particle size and acid to sample ratio. Quantitative determinations using 0.1 gm. samples digested in 100 ml. of acid were reproducible within tolerable limits, and the residue was free of phosphate. However the assumption that 0.1 gm. is representative of a large sample is undesirable.

AVENUES INVESTIGATED

BIOGEOCHEMICAL

Although apatite and apatitic rock are recognisable in hand specimen, phosphatic quartz-hematite breccia was difficult to distinguish from the non-phosphatic breccia. A means of indirectly identifying the presence of phosphorus, e.g. a geobotanical indicator was desirable for both current and future work.

Some plants take from soils rich in phosphorus only that amount of phosphorus necessary for healthy growth, whereas legumes concentrate it in their extremities. The ironwood tree, a legume, is common and widespread around Rum Jungle and was chosen as a standard. Fresh healthy leaves were sampled at similar positions from trees of similar heights.

From south to north on line 26E (see plate 3, Sheet E83) at Geolsec the high, non-phosphatic ground gives way to lower, phosphatic ground and then to yet lower ground, phosphatic through hill-wash. The P_2O_5 content of ironwood leaves from this line were estimated by visual colourimetry. Two estimations were made on each test solution and the results are illustrated graphically (fig. 2). The topography apparently displaces the biogeochemical reflection of the phosphate rock. Hill wash presumably is responsible for the displacement and the significantly high phosphorus content of the leaves of trees on the flat which probably does not overlie phosphate rock.

RAPID SEMI-QUANTITATIVE FIELD METHODS

The molybdate spot test for phosphate is too sensitive to select potentially economic phosphate rock from low grade phosphate rock. A rapid semi-quantitative field method became desirable to reduce or eliminate unnecessary handling, crushing and analyses of samples.

Chromographic

Following a suggestion by J. Barrie a chromographic method was developed where a molybdate impregnated filter paper was treated with a small volume of a solution suspected to contain phosphorus. The area covered by and the intensity of the yellow phosphomolybdate precipitate developed is approximately proportional to the P_2O_5 content.

Reagents and equipment

a. Molybdate impregnated filter papers. - Filter papers (preferably Whatman's No.41) are thoroughly impregnated with a neutral molybdate solution prepared as in Beever's semi-quantitative method, and hung to dry in a well shaded position.

b. Concentrated nitric acid.

c. Standard phosphate solution (0.3834g KH_2PO_4 /100 ml contains 2 mg. P_2O_5 ml.).

d. Scoop measure, test tubes and rack, 1 ml. graduated pipette, wash bottle and water.

Procedure

Measure a scoopful (approx. 0.1g) of the powdered sample into a 10 ml. graduated test tube, add 1 ml. of conc. nitric acid and shake well for 30 secs., and then add 1 ml. of water and shake periodically over 5 mins. (the generated heat aids digestion of the phosphate). Top up to 10 ml. with water, shake well and allow to settle (at least 15 mins.). Measure a 0.1 ml. aliquot onto a well shaded molybdate impregnated paper, keeping the paper in the horizontal plane and slightly rotating the jet of the pipette over the centre of the paper. When fully and evenly soaked allow to dry in full shade, and compare against a range of standard papers.

Standard Filter Papers

Pipette 0, 1, 2, 3, 4, 5 mls. of the standard phosphate solution (2mg. P_2O_5 /ml) into separate 10 ml. graduated test tubes, add 1 ml. of concentrated nitric acid, top up to 10 ml. with water, mix well and proceed as before. The intensity of and the area covered by the phosphomolybdate precipitate developed is equivalent to 0, 2, 4, 6, 8, 10% P_2O_5 on the 0.1 g test scale. Once dry the colours are quite stable and may be used for several days provided they are kept in a box when not in use.

The choice of filter paper is not important. No. 41 papers are of open texture and rapidly allow the 0.1 ml. aliquot to spread evenly with the development of an even colour. Less absorbent papers are satisfactory but the colour tends to be blotchy. The size and intensity of the colour are paper dependent and it is imperative that standard comparisons are on similar paper.

The impregnated papers are light sensitive and turn blue on exposure to the sun. The whole operation is advisedly performed in full shade, particularly when the aliquot is added to the paper.

The method was originally developed to differentiate in the 0 to 10% P_2O_5 range, but as there is little difference between the intensities of the 8 and 10% papers, no differentiation above 8% was made. The range of the method could possibly be shifted by using another sample volume. The measurement of the sample by volume, rather than by weight, and especially the rapid, warm, acid digestion are the sources of greatest error.

The value of the method is illustrated in the application to drill cores DG1 and DG2. Spot samples were obtained at 15" intervals using an electric drill and masonry bit and four samples were combined to make a composite sample for a 5' interval. Both centrifugal and chromagraphic analyses were made on each 5' sample and the results are recorded on the logs. Very few phosphatic samples escaped detection by the chromagraphic method. The allocation of a percentage by this method may be ambitious in view of the unknown extraction of phosphate, but at least low, medium and high divisions can be made.

RAPID QUANTITATIVE LABORATORY METHOD

The accuracy of the semi-quantitative centrifuge method decreases with decreasing phosphate concentration. At 5% P_2O_5 the accuracy is $\pm$ 40% of 5%. The study of phosphate in the soil and weathered rock profile to detect phosphate may be akin to the study of trace metals viz. Cu, Zn, Pb, etc. In the latter case anomalous areas are provided by a mere hundred or so p.p.m. whereas in the former case a fraction of a percent may be anomalous. A rapid quantitative survey of low order phosphate in soils and weathering profile may reveal phosphatic areas. The gravimetric quantitative method is too labourious for rapid work, and could in itself be replaced by a rapid and equally accurate analytical method. Colourimetric methods in phosphorus determinations although rapid, are dependent on instrumental colour intensity measurement. However the possibilities of visual estimation of colour intensity were investigated.

The method of Fogg and Wilkinson (1958) has been adapted to suit field conditions and mass handling as follows:

Procedure

0.1g. of sample is fumed in a 10 ml. graduated test tube for 30 minutes with 1 ml. of concentrated sulphuric acid, cooled and diluted to 10 ml. with water, well shaken and allowed to settle. An aliquot is taken into a 100 ml. beaker, about 10 ml. of water added and the solution neutralised with ammonia. 2 ml. of sulphuric-molybdate reagent and about 0.05 g. of ascorbic acid are added. The solution is quickly brought to the boil and after 15 sec. removed to cool. The solution is then washed into a 25 ml. stoppered cylinder and made up to the mark, and the blue intensity compared against standards of 0, 50, 100, 150, 200, 250 ug. P_2O_5 .

Table 1.

CENTRIFUGAL AND COLOURIMETRIC DETERMINATIONS OF P_2O_5

Sample	% P_2O_5				
	Centrifugal Method	Colourimetric Method			
A1004 26-36	5	2	1.7	1.75	
54-56	7	3	2.7	2.75	
56-58	5	2	2.3	2.25	
A1003 0-2	<1	3	2.7	2.5	
2-8	1	1.4	1.8	1.9	
8-10	3	0.7	0.7	0.7	
10-16	trace	0.3	0.4	0.45	
34-42	trace	0.6	0.7	0.7	
A1002 2-8	1	0.5	0.6	0.5	
8-10	<1	0.2	0.2	0.3	

The method with refinement is obviously quite reproducible and would probably be very satisfactory as a quantitative method for determining low order and trace phosphate. More work would be needed to confirm its suitability, the manipulations in dilution may detract from its simplicity.

RECOMMENDATIONS

1. The molybdate reagent as a qualitative field test be retained.
 2. That the application of the "hydrochloric acid test" to the Rum Jungle phosphate rock be studied. (see Gardner 1944, p.16).
 3. That a semiquantitative method is necessary to eliminate unimportant samples if a large volume of samples are handled, unless a rapid quantitative method replaces the gravimetric method.
 4. That semi-quantitative field method for the determination of P_2O_5 of L. Shapiro (1952, p.341-342) be examined as suitable to replace Beever's centrifuge method.
 5. That Fogg and Wilkinson's (1958) or Mabie and Hess' (1960) method for the quantitative determination of P_2O_5 replace the gravimetric method.
 6. That only semi-quantitative work is done in the field and all quantitative work be done in Canberra or at AMDL.
 7. That "extractability" of apatite be studied.
 8. The "suitability" of nitric acid as digestant be studied.
 9. That rapid quantitative studies of P_2O_5 content of surface soils be made to assist in siting drill holes.
 10. That geochemical and geobotanical work continue.
 11. That the chromatographic method be applied in the field to cut out unnecessary handling of samples.
-

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APPENDIX 3.

PRELIMINARY REPORT ON A FIELD METHOD FOR THE RAPID DETERMINATION OF THE P_2O_5 CONTENT OF A PHOSPHATIC ROCK.

by

J.R. Beevers

I. The Analytical Technique

Introduction

To further the expeditious, but approximate and preliminary, assessment of the grade of phosphate deposits, and to serve as a ready guide during prospecting, a rapid technique for the estimation of phosphate has been tested in the laboratory. A single phosphate estimation, assuming that the sample is ready for weighing, takes about 30 minutes.

The method recommended here is the age-old one of precipitation of the ortho-phosphate as ammonium phosphomolybdate from acid solution using ammonium molybdate as the precipitating reagent, but with a difference, in that the volume of the resultant precipitate is determined as distinct from any gravimetric or volumetric procedure on it. Although the method is simple in its application and is not claimed to give any more than a fair approximation to the true P_2O_5 content of the rock under analysis, it must be emphasised at the outset that cursory methods of analysis will serve only to give erroneous results. For this reason the likely pitfalls into which one may fall, if not forewarned are here listed, and unless these precautions are observed the final results will be unreliable.

- (a) Use 0.1 gm. of sample or, if this is not practicable, as near 0.1 gm. as possible, but know the exact weight. Correction of the volume of the resultant precipitate for this weight discrepancy will give the true P_2O_5 content.
- (b) Use only the ammonium molybdate/ammonium nitrate reagent recommended, otherwise precipitation of the phosphomolybdate crystals will be incomplete.
- (c) Use only 10 ml. of concentrated nitric acid per 0.1 gm. sample. Smaller or greater volumes of acid affect the final volume of the precipitate.
- (d) Work always at a temperature of 45-50°C. for both the rock solution and the molybdate reagent. Above this temperature precipitation of molybdic oxide may take place.
- (e) Always add the reagent to the solution of the rock under test. Addition of the rock solution to the molybdate sometimes causes the co-precipitation of white molybdic acid.
- (f) Allow the precipitate and solutions to stand in the tube and funnel for 10 minutes only, and centrifuge for 5 minutes at 1100 r.p.m..
- (g) Very occasionally the supernatant liquid fails to clear in the allotted ten minutes settling period. Should this happen it is recommended that the particular test be discontinued and a fresh one carried out.
- (h) It is found in the laboratory that periodically, for as yet no determined reason, a low result is given by this method for the P_2O_5 content. With this in mind it is recommended that whenever possible, and if time allows, a duplicate sample shall

be analysed. If the two values obtained seriously disagree, then a third analysis should determine the correct one.

Method

0.1 gm. of the suspected phosphatic rock, ground preferably to pass 72 B.S.S., is put into a 150 ml. beaker, and to it is added 10 ml. of concentrated nitric acid. On heating to slightly below boiling point, any phosphate will dissolve; the volume of the solution is now brought up to 50 ml. using distilled water, or, if this is not available, water suitable for drinking will do; a blank test on this should, of course, be carried out. The temperature of the solution is then raised to 45° - 50°C in readiness for the precipitation.

50 ml. of the ammonium molybdate/ammonium nitrate reagent, also at a temperature of 45°-50°C, and also contained in a small beaker, is then poured into the sample solution, the whole stirred for two seconds, and immediately transferred into a previously assembled piece of apparatus consisting of a graduated centrifuge tube and attached funnel. The reaction beaker is washed out into the funnel using 5-10 ml. water from a small plastic wash bottle. Any precipitate adhering to the beaker and not removed by the washing is insignificant, and is therefore ignored. It is generally necessary, to use a long, thin, stirring rod to dispel the air-lock which develops in the centrifuge tube.

The whole assembly is then allowed to stand for 10 minutes with no further attention or agitation. After this period, the supernatant liquid in the funnel, which, incidentally, should be clear at this stage except for traces of the precipitate adhering to the glass and floating on the liquid surface, is decanted off, using the lip provided on the funnel, and discarded. This adherent precipitate in the funnel is very small compared with the bulk of the precipitate in the tube, and can therefore be ignored. When the liquid surface is just below the top of the centrifuge tube the funnel is detached and the tube and contents centrifuged for five minutes at a speed of 1100 r.p.m.. The tube is removed from the centrifuge and, using the graduations on the lower portion, the volume of the precipitate is determined.

Using this figure with reference to the attached graph the percentage of P_2O_5 in the rock sample may be ascertained. As the hand centrifuge recommended for field work is fitted with a carrier for four tubes it is advised that four analyses be carried out simultaneously.

Any precipitate adhering to the sides of the centrifuge tube, funnel, and beaker can generally be easily removed by brushing; however, it may occasionally be necessary to use a dilute ammonia solution to thoroughly clean the apparatus.

Preparation of the Precipitating Reagent.

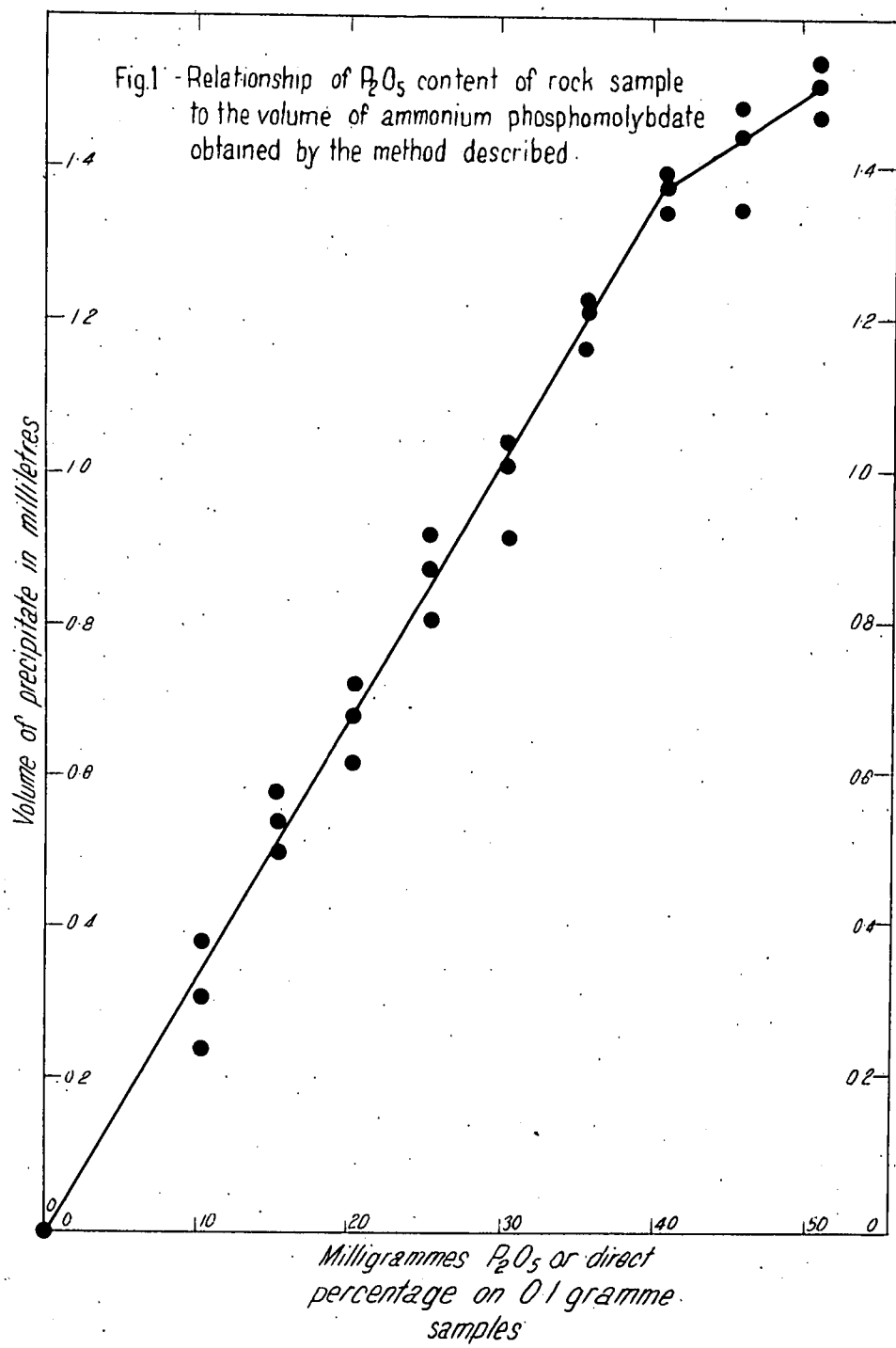
60 gm. of the crystalline ammonium molybdate are dissolved in 300 ml. water using gentle heat if necessary, but always with stirring. When completely dissolved, 140 gm. of solid ammonium nitrate are added to this solution, and the whole made up to 1 litre in a stoppered bottle. Shake well, if the solution is milky at this stage it is allowed to stand overnight, when the clean supernatant liquid may be decanted off for use next morning.

TABLE 1.
EXPERIMENTAL DATA

*Known P_2O_5 content mgms.	Volume of ammonium phosphomolybdate		Maximum deviation from the mean %
	ml.	Mean ml.	
10.0	0.24, 0.25, 0.32, 0.34, 0.38, 0.32, 0.28, 0.32	0.31	+ 22.6
15.0	0.50, 0.57, 0.53, 0.58, 0.57, 0.53, 0.30, 0.52	0.54	+ 5.6 - 7.4
20.0	0.72, 0.69, 0.68, 0.70, 0.69, 0.62, 0.69, 0.64	0.68	+ 6 - 8.8
25.0	0.81, 0.87, 0.85, 0.88 0.82, 0.92, 0.92, 0.90	0.87	+ 5.7 - 7
30.0	1.01, 1.03, 1.03, 1.04 0.92, 0.96, 1.03, 1.03	1.01	+ 3 - 9
35.0	1.22, 1.23, 1.17, 1.23, 1.18, 1.20, 1.22, 1.20	1.21	+ 1.7 - 3.3
40.0	1.38, 1.38, 1.36, 1.39, 1.36, 1.34, 1.37, 1.39	1.37	+ 1.5 - 2.2
45.0	1.42, 1.42, 1.40, 1.41, 1.35, 1.42, 1.43, 1.37, 1.45, 1.48, 1.44, 1.45	1.42	+ 4.2 - 5
50.0	1.52, 1.52, 1.54, 1.53 1.47, 1.49, 1.48, 1.52	1.51	+ 2 - 2.7

* Osina samples of 100 mgm of phosphatic rock

(The theoretical percentage of P_2O_5 in
 $Ca_3(PO_4)_2$ is 45.8)



APPENDIX 4.

PETROGRAPHIC EXAMINATION OF RUM JUNGLE APATITE ROCK

by

W.R. Morgan

Herewith are the results of a detailed petrographic examination of four samples of apatite rock collected in the Rum Jungle area, N.T. The specimens examined are:-

- R.10792 - D.D.H., 555, at 92 feet.
- R.12824 - D.D.H., D.G.1, at 119 feet, 4 inches.
- R.12825 - D.D.H., D.G. 1, at 31 feet, 5 inches.
- R.12826 - D.D.H., D.G.1, at 86 feet, 6 inches.

Generalized descriptions of R.12824 to R.12826 can be found in my earlier report (file 64NT/1, 29th November, 1962). Specimen R.10792 consists mostly of a mosaic of fine apatite crystals together with granules and flakes of hematite; the hematite is enclosed within apatite crystals, and is not interstitial. Small areas of heavily ferruginized argillaceous material are surrounded by the fine apatite. The rock is cut by very irregular veins that are filled with calcite, subordinate chlorite, and small amounts of coarse apatite and opaque iron oxide. In these veins, the opaque iron minerals form crystals discrete from the coarse apatite.

The table shows the grain-sizes and modal analyses of the specimens. The modal analyses should be regarded as inaccurate for two main reasons. Firstly, because of the extremely fine-grained nature of the rocks: the grain-sizes are smaller than the thickness of the rock slice (0.03mm.). Secondly, the effect of the hematite; much of it is too fine-grained to be seen properly during point-counting, resulting in an under-estimation of the amount present. However, what can be seen and counted during modal analysis will be over-estimated because of the "Holmes Effect" (Chayes, 1956). Taking these two effects of hematite into account, it is hard to judge whether the ultimate results are over-estimates or under-estimates.

Other minerals are:- R.10792: calcite, chlorite, subordinate quartz; R.12824: quartz, ferruginous argillaceous material, and some sericite; R.12825: ferruginous slate, silty slate, siltstone, and quartzite; R.12826: quartz and mica.

In all specimens, hematite is enclosed within apatite crystals, and not interstitial to them; this statement applies particularly to the finer-grained apatite, although some hematite is enclosed in the coarser apatite.

Specimen R.12824 is the one most free of hematite. The total amount of apatite present is reduced to 62% if the vugs (represented by holes in the slide) are taken into account. Some of the vugs are filled by quartz, and may be more completely filled in other parts of the rock at this horizon.

Reference

Chayes, F., 1956: The Holmes Effect and the Lower Limit of Modal Analysis. Miner. Mag., 31, 276-281.

TABLE

	Grain Sizes and B.S. Sieve Apertures					Modal Analyses (Percentages)				
	Apatite				Hematite		Apatite		Hematite	Others
	Coarse		Fine		grain-size	B.S. Aperture	Coarse	Fine		
	grain-size	B.S. Aperture	grain-size	B.S. Aperture						
R.10792	0.13 mm.	100	0.018 to 0.045 mm.	<300	0.0001 to 0.027 mm.	<300	5	34	20	41
R.12824	0.02 to 0.1 mm.	300 to 150	0.004 to 0.012 mm.	<300	0.0005 to 0.007 mm.	<300	67	25	3	4
R.12825	-	-	0.12 to 0.036	<300	0.0005 to 0.013 mm.	<300	-	38	17	45
R.12826	0.06 to 0.3 mm.	300 to 45	0.012	<300	0.005 to 0.018 mm.	<300	37	31	20	12

APPENDIX 5.

Report on Pot tests with samples of Rum Jungle phosphate rock.

by

M.J.T. Norman *

Samples of two types of phosphate-rich rock from the Rum Jungle area were received from the Bureau of Mineral Resources for assay. The samples were:

1. Rum Jungle No. 1. - Pale red colour
2. Rum Jungle No. 2. - Ochre colour.

Methods

The assay method adopted was to compare the responses of grain sorghum plants grown in Tippera clay loam (a phosphorus-deficient soil from Katherine, N.T.) to the two phosphates and to Christmas Island rock phosphate dust and superphosphate at 4 levels of fertilizer. The 17 treatments were:

Rum Jungle No.1	}	x	(1 cwt/ac (equivalent)
Rum Jungle No.2			(4 cwt/ac
Christmas Island Rock			(8 cwt/ac
Superphosphate			(16 cwt/ac
Control			No phosphate

(With 3 replicates)

Fertilizers were milled to a fine powder and mixed with Tippera clay loam soil. Five-inch enamel pots were filled and each planted with 12 seeds of "Hegari" grain sorghum on October 26, 1962. The pots were placed in the greenhouse and watered 2 - 3 times a day. On December 12, all plants were harvested. The tops were cut off at ground level and the roots washed free of soil. Tops and roots were dried separately at 85°C for 24 hours and weighed. The dried samples were milled and analysed for total phosphorus.

* C.S.I.R.O Division of Land Research and Regional Survey.

Samples of the fertilizer were also analysed for total phosphorus.

Results

At the high levels of superphosphate (8 and 16 cwt/ac), sorghum yields were markedly depressed. This may have been due to an excessive concentration of soluble phosphorus in the small pots, leading to undesirable osmotic effects. The results were therefore analysed in two ways to exclude this anomaly:

1. All fertilizers at the 1 and 4 cwt/ac level
2. All levels of fertilizer, Rum Jungle and Christmas Island treatments only.

Dry matter yields are shown in Table 1. There were no significant interactions between fertilizer type and level, and the standard errors and significance levels shown in the table for the main effects of fertilizer are the only ones that need be considered.

At the 1 and 4 cwt/ac level, superphosphate clearly outyielded Christmas Island, which in turn outyielded the Rum Jungle samples. There were no significant differences between the two Rum Jungle samples. These comparisons applied to tops, roots and total plant yield. The yield at 16 cwt/ac of both Rum Jungle samples was approximately the same as that from 1 cwt/ac Christmas Island and less than that from 1 cwt/ac superphosphate.

Phosphorus content is shown in Table 2. Phosphorus content of plants receiving Rum Jungle 1 averaged approximately the same as that of plants receiving Christmas Island rock. Rum Jungle 2 showed a lower phosphorus content of tops. With Rum Jungle 1, there was no increase in phosphorus content of plants as the level of fertilizer was raised; with Rum Jungle 2 and Christmas Island a slight increase; and with superphosphate a very marked increase in phosphorus content.

Phosphorus yield is shown in Table 3. Significant interactions were recorded in the analysis of all fertilizers at the 1 and 4 cwt/ac level, due to the high uptake of phosphorus from super at the 4 cwt/ac level in comparison with other fertilizers. In the analyses of all levels of fertilizer excluding super there were no significant interactions.

Phosphorus yield of plants receiving Christmas Island rock was significantly higher than that of plants receiving Rum Jungle 1 and 2. The phosphorus yield of plants receiving Rum Jungle No.1 was slightly higher than that of plants receiving Rum Jungle No.2; this difference was barely significant for total phosphorus yield and not significant for roots or tops considered separately. The average total phosphorus yield of plants receiving 16 cwt/ac Rum Jungle 1 and 2 was the same as that of plants receiving 1 cwt/ac Christmas Island rock.

The total phosphorus content of the fertilizers was:

Rum Jungle 1	-	15.2%
Rum Jungle 2	-	5.8%
Christmas Island	-	15.6%
Superphosphate	-	10.5%

159 mgm of fertilizer was mixed in each pot for each equivalent 1 cwt/ac of fertilizer. Percentage recovery of the total phosphorus mixed in each pot, at the 4 cwt/ac level, was therefore :

Rum Jungle 1	-	1.44%
Rum Jungle 2	-	2.90%
Christmas Island	-	2.57%
Superphosphate	-	9.82%

Thus, compared with Christmas Island rock phosphate, Rum Jungle 1 had a similar total P content but gave a substantially lower recovery by plants; Rum Jungle 2 had a low total P content but gave a recovery of the same order as Christmas Island rock. Percentage recovery from superphosphate was higher than that from all other materials.

Conclusion

All the results, dry matter yield, phosphorus content, phosphorus yield and phosphorus recovery, support the conclusions that the amount of phosphorus in the Rum Jungle samples immediately available to plants was low. Whether the rock is suitable as a base for the manufacture of superphosphate is a matter for industrial chemists and economists to decide, but from this test it would seem that unless the material shows a compensating long-term residual effect of a very high order it is not suitable for direct use as a phosphate fertilizer.

Table 1. Dry matter yield of plants

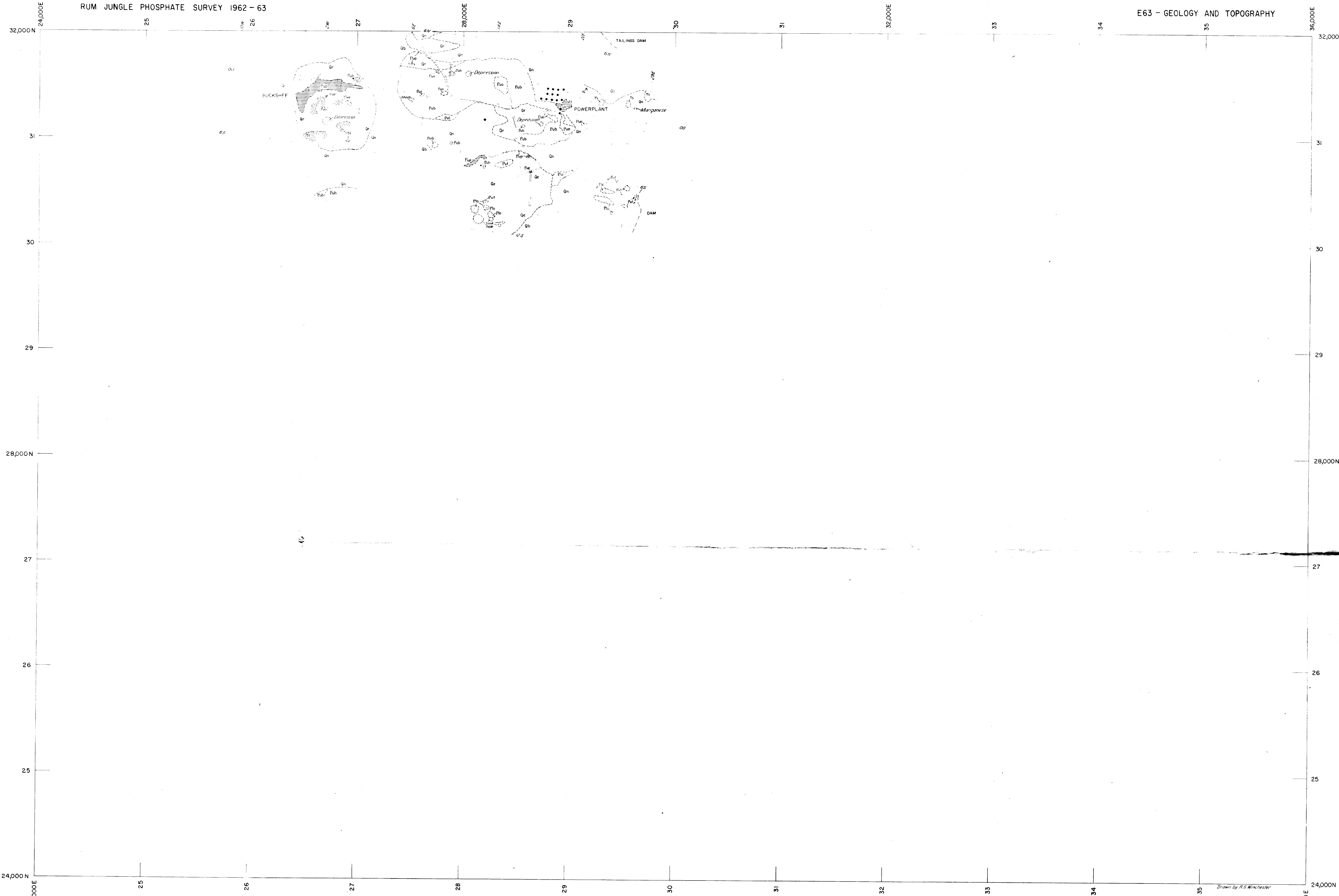
Plant Attribute	Equivalent Fertilizer Level	Rum Jungle Sample 1	Rum Jungle Sample 2	Christmas Island Dust	Super-phosphate
Dry weight of tops	1 cwt/ac	1.94	1.99	2.58	3.21
	4 cwt/ac	2.10	2.18	3.36	3.77
	8 cwt/ac	2.38	2.11	4.00	1.74
	16 cwt/ac	2.35	2.28	4.43	2.93
			$\pm 0.11^{***}$		
(gm/pot)	Mean of all levels	2.19	2.14	3.59	-
	Mean of 1 & 4 cwt/ac	2.02	2.08	2.97	3.49
			$\pm 0.14^{***}$		
Control yield with no fertilizer 1.12					
Dry weight of roots	1 cwt/ac	2.14	1.81	2.67	3.01
	4 cwt/ac	2.30	2.05	3.02	3.59
	8 cwt/ac	2.32	2.45	3.13	1.81
	16 cwt/ac	2.89	2.58	3.66	2.77
			$\pm 0.13^{***}$		
(gm/pot)	Mean of all levels	2.41	2.22	3.12	-
	Mean of 1 & 4 cwt/ac	2.22	1.93	2.84	3.30
			$\pm 0.23^{**}$		
Control yield with no fertilizer 0.88					
Total dry weight	1 cwt/ac	4.08	3.80	5.25	6.22
	4 cwt/ac	4.40	4.23	6.38	7.36
	8 cwt/ac	4.70	4.56	7.13	3.55
	16 cwt/ac	5.24	4.86	8.09	5.70
			$\pm 0.21^{***}$		
(gm/pot)	Mean of all levels	4.60	4.36	6.71	-
	Mean of 1 & 4 cwt/ac	4.24	4.01	5.81	6.79
			$\pm 0.20^{***}$		
Control yield with no fertilizer 2.00					

Table 2. Phosphorus content of plants
(Weighted Means)

Plant Attribute	Equivalent Fertilizer Level	Rum Jungle Sample 1	Rum Jungle Sample 2	Christmas Island Dust	Super-phosphate
Phosphorus Content of tops (% P)	1 cwt/ac	0.072	0.049	0.066	0.044
	4 cwt/ac	0.063	0.047	0.064	0.123
	8 cwt/ac	0.061	0.062	0.064	0.238
	16 cwt/ac	0.071	0.064	0.062	0.221
	Mean of all levels	0.067	0.056	0.064	-
	Mean of 1 & 4 cwt/ac	0.067	0.048	0.065	0.087
Control P content with no fertilizer 0.036					
Phosphorus Content of roots (% P)	1 cwt/ac	0.046	0.040	0.036	0.036
	4 cwt/ac	0.037	0.040	0.039	0.075
	8 cwt/ac	0.040	0.042	0.042	0.101
	16 cwt/ac	0.041	0.040	0.050	0.138
	Mean of all levels	0.041	0.040	0.043	-
	Mean of 1 & 4 cwt/ac	0.041	0.040	0.038	0.058
Control P content with no fertilizer 0.044					
Phosphorus Content of whole plant (% P)	1 cwt/ac	0.058	0.045	0.051	0.040
	Mean 4 cwt/ac	0.050	0.044	0.052	0.100
	8 cwt/ac	0.051	0.051	0.055	0.168
	16 cwt/ac	0.054	0.051	0.057	0.181
	Mean of all levels	0.053	0.048	0.054	-
	Mean of 1 & 4 cwt/ac	0.054	0.044	0.052	0.073
Control P content with no fertilizer 0.040					

Table 3. Phosphorus yield from plants

Plant Attribute	Equivalent Fertilizer Level	Rum Jungle Sample 1	Rum Jungle Sample 2	Christmas Island Dust	Super-phosphate
Phosphorus yield of tops	1 cwt/ac	1.39	0.98	1.70	1.43
	4 cwt/ac	1.33	1.03	2.15	4.65
	8 cwt/ac	1.46	1.30	2.58	4.14
	16 cwt/ac	1.66	1.46	2.75	6.49
			$\pm 0.29^*$		
(mgm/pot)	Mean of all levels	1.46	1.19	2.30	-
	Mean of 1 & 4 cwt/ac	1.36	1.00	1.92	3.04
			$\pm 0.22^{**}$		
Control P yield with no fertilizer 0.40					
Phosphorus yield of roots	1 cwt/ac	0.99	0.72	0.96	1.09
	4 cwt/ac	0.85	0.83	1.19	2.70
	8 cwt/ac	0.94	1.04	1.32	1.83
	16 cwt/ac	1.18	1.02	1.85	3.83
			$\pm 0.06^{**}$		
(mgm/pot)	Mean of all levels	0.99	0.90	1.33	-
	Mean of 1 & 4 cwt/ac	0.92	0.78	1.08	1.90
			$\pm 0.13^{***}$		
Control P yield with no fertilizer 0.39					
Total phosphorus yield of plants	1 cwt/ac	2.38	1.70	2.66	2.52
	4 cwt/ac	2.18	1.86	3.34	7.35
	8 cwt/ac	2.40	2.34	3.90	5.97
	16 cwt/ac	2.84	2.48	4.60	10.32
			$\pm 0.12^{***}$		
(mgm/pot)	Mean of all levels	2.45	2.09	3.63	-
	Mean of 1 & 4 cwt/ac	2.28	1.78	3.00	4.94
			$\pm 0.21^{***}$		
Control P yield with no fertilizer 0.79					



LOCATION DIAGRAM

REFERENCE

Qa	Alluvium, undifferentiated	Tr	Ferruginous breccia, mostly pisolitic	Qub	Hematitic quartzite breccia	Qul	Limonitic siltstone and sandstone	Qlu	Dolomite marble
Qr	Rubble, undifferentiated	Ts	Ferruginous sandstone	Qup	Phosphate rock				
Qb	Black and grey soil			Quh	Iron oxide, mainly hematite				
Qn	Red-brown earth			Quo	Quartzite, pink, medium bedded				
Qe	Red earth			Qus	Sandstone and conglomerate				
Qs	Sand								

Legend

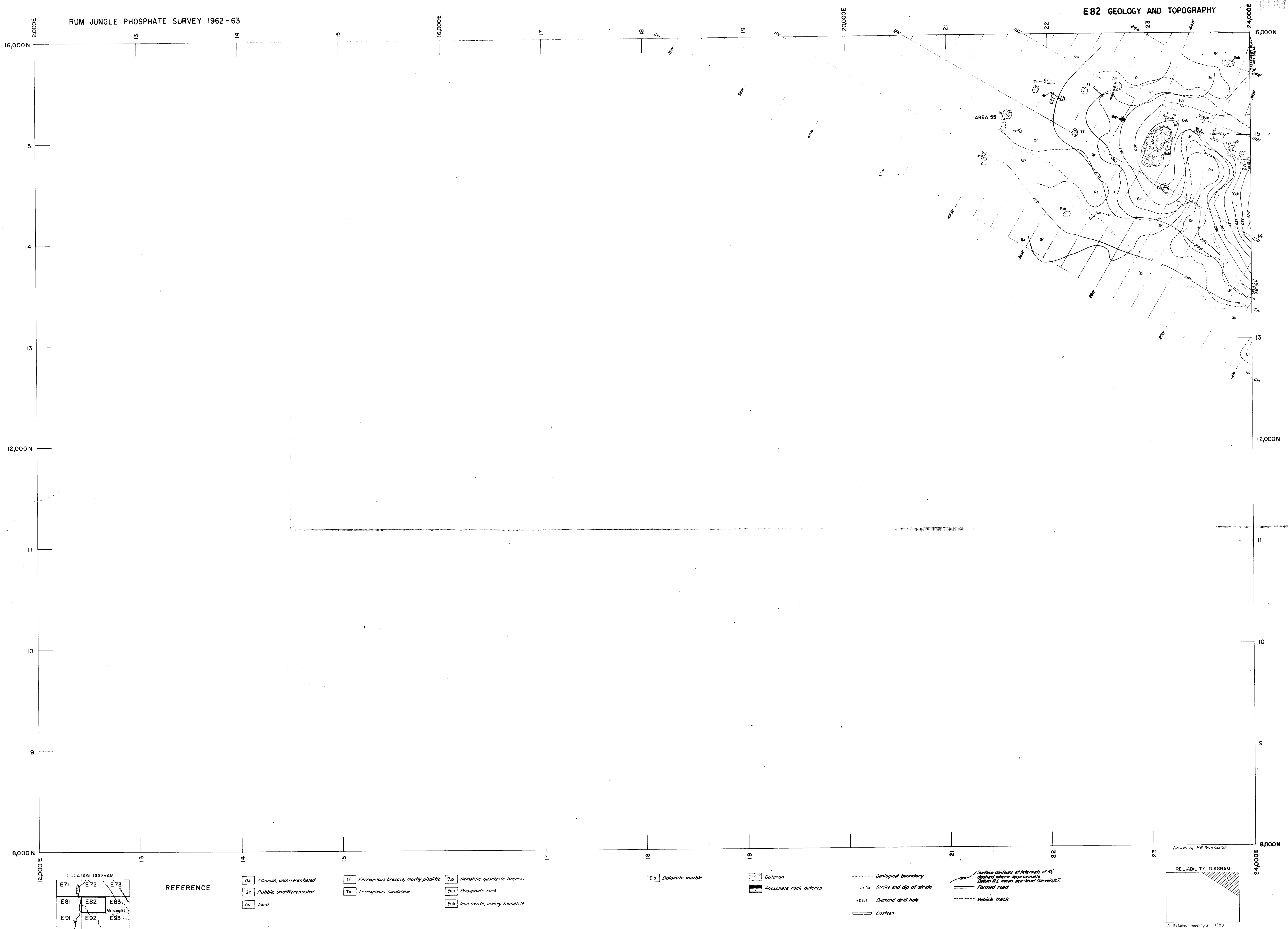
	Outcrop		Geological boundary		Vehicle track
	Phosphate rock outcrop		Strike and dip of strata		Diamond drill hole
			Churn drill hole		Coastline

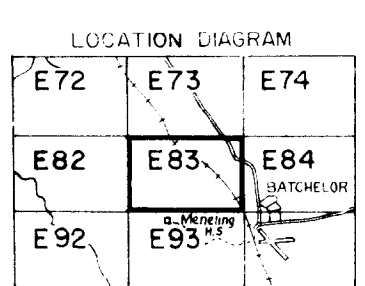
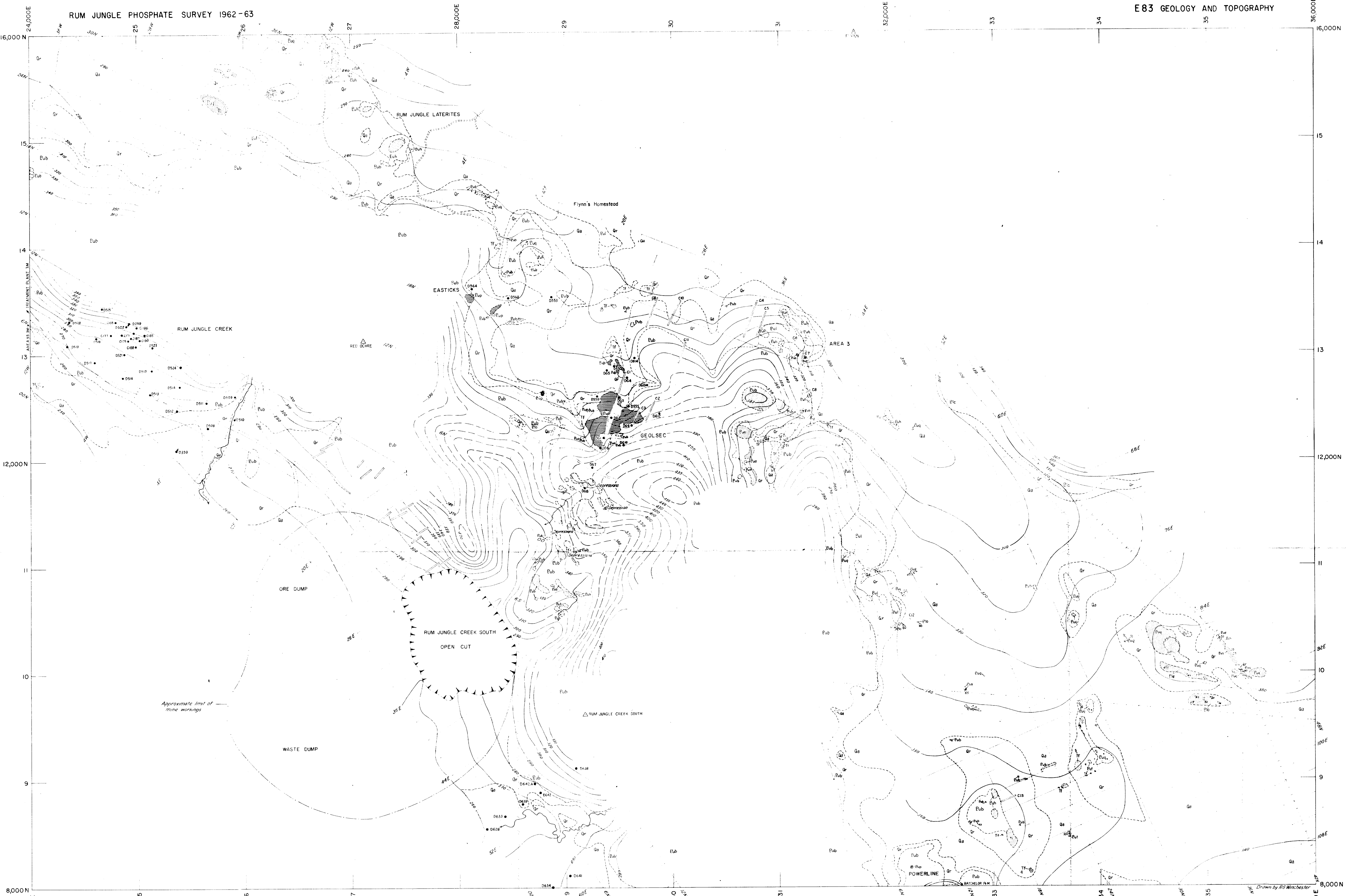
RELIABILITY DIAGRAM

SCALE

MAJOR GRID: T.E.P. mine grid, bearing 359°58'00"

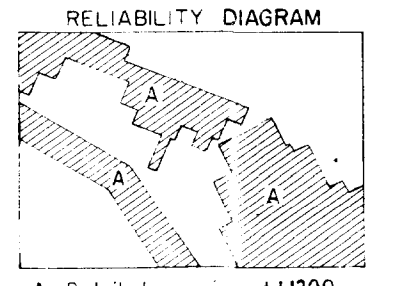
MINOR GRID: B.M.R. geophysical grid, 1960-62



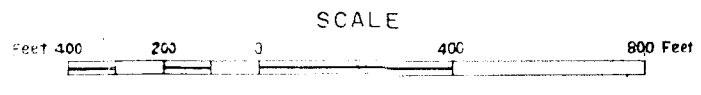


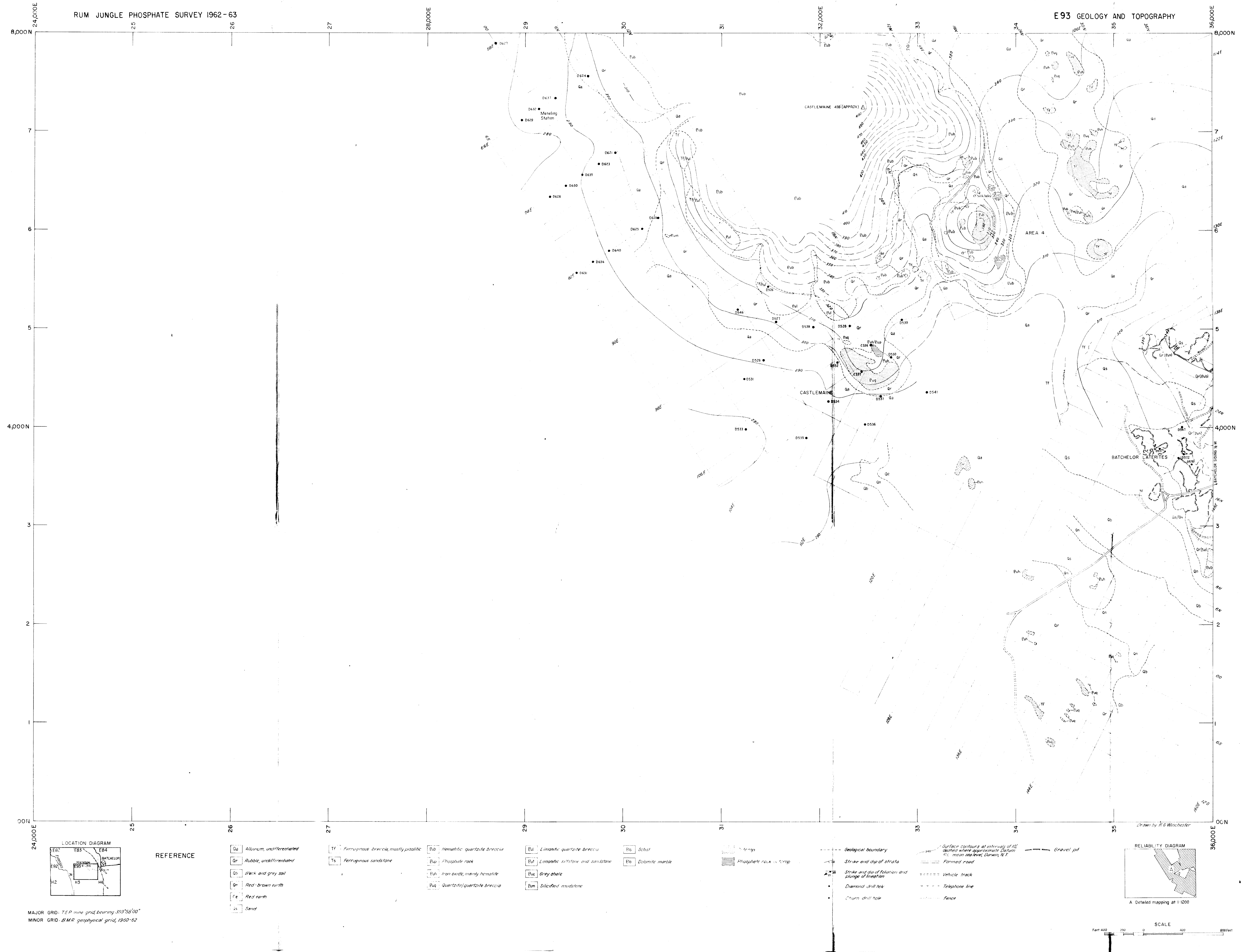
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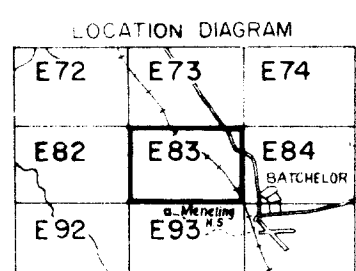
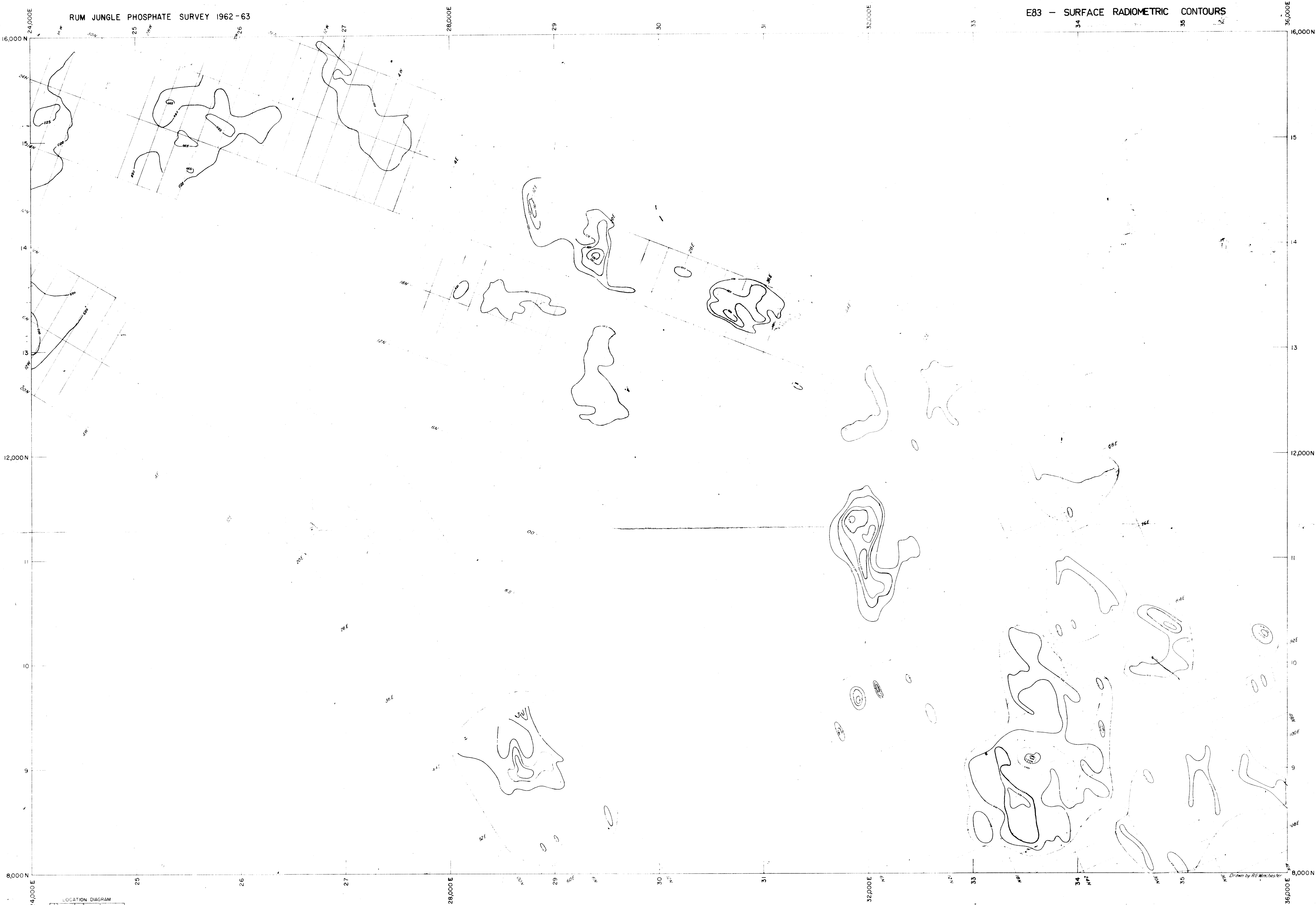
- | | | | | | | | |
|-------------------------------|---|-----------------------------------|--------------------------------------|----------------------|------------------------|-------------------------------|--|
| Qa Alluvium, undifferentiated | TF Ferruginous breccia, mostly pisolite | Pu Quartzite, pink, medium bedded | PuL Luminous quartzite breccia | Pls Schist | Outcrop | Geological boundary | Surface contours at intervals of 10', dashed where appropriate. Datum, M.L. mean sea level, Darwin, N.T. |
| Qr Rubble, undifferentiated | | Pus Sandstone and conglomerate | PuL Luminous siltstone and sandstone | Ple Calcareous slate | Phosphate rock outcrop | 45 S' - N' and dip of strata | Formed road |
| | | Pub Hematite quartzite breccia | Pue Grey shale | Ple Dolomite marble | | Diamond drill hole (D62, D55) | Vehicle track |
| | | Pup Phosphate rock | | Ple Grits | | C4 Cast iron | Railway line |
| | | Puh Iron oxide, mainly hematite | | | | | Telephone line |
| | | Pug Quartzite/quartzite breccia | | | | | Power line |
| | | | | | | | Fence |



MAJOR GRID: TEP mine grid, bearing 359°50'00"
MINOR GRID: BMR geophysical grid, 1960-62



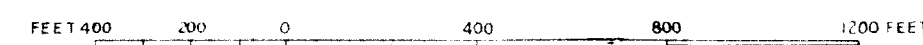




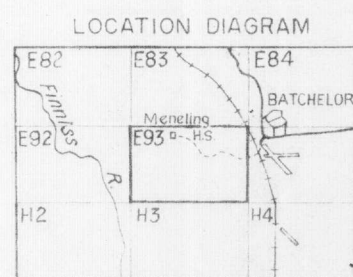
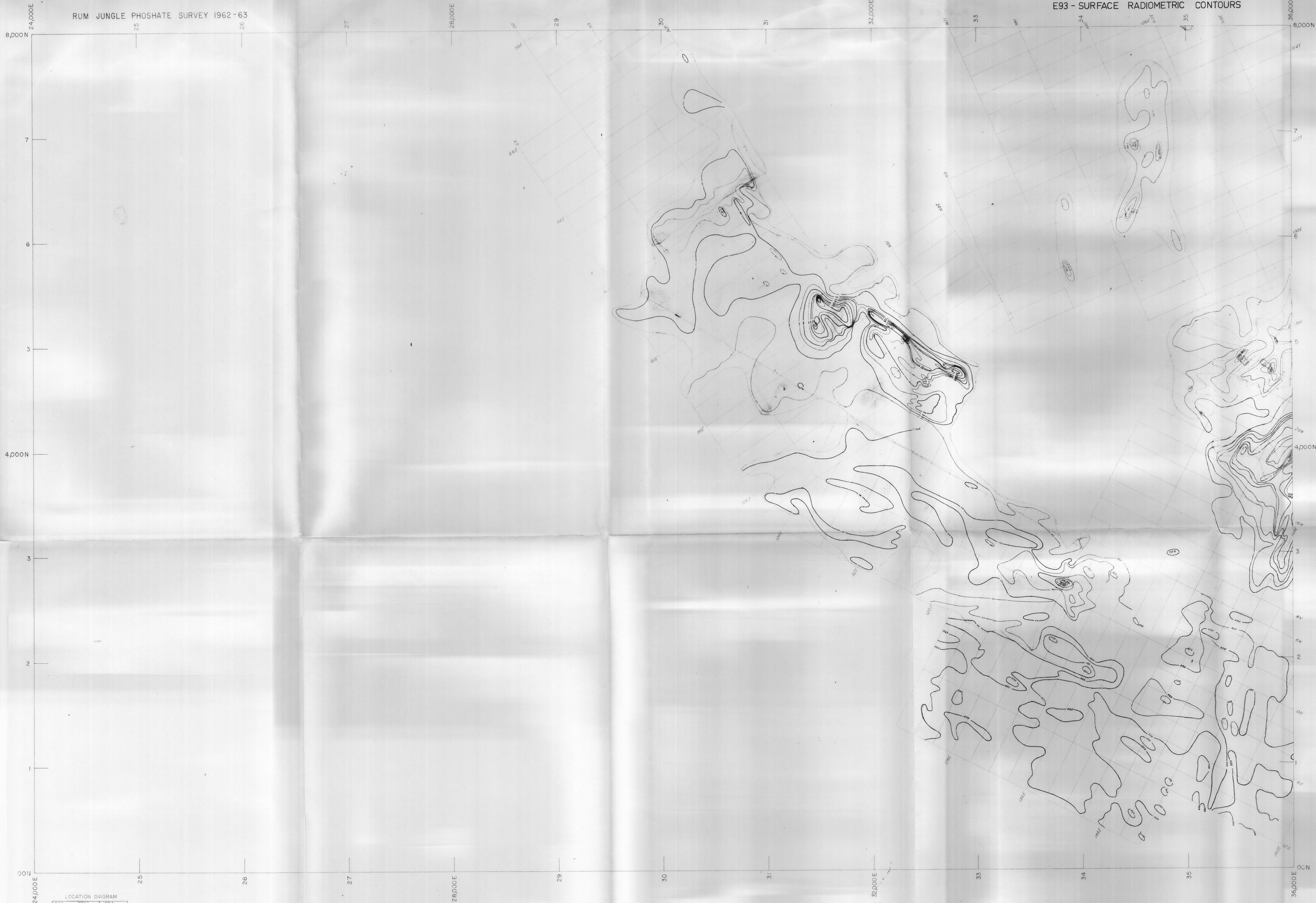
MAJOR GRID TEP mine grid, bearing 359°58'00"

MINOR GRID BMR geophysical grid 1960-62

SCALE



Drawn by R. G. Winchester



— Radiometric contours in mR/hr

MAJOR GRID: TEP mine grid, bearing 359°58'00"

MINOR GRID: BMR geophysical grid, 1960-62

SCALE

0 100 200 300 400 500 600 700 800 900 1000 FEET

