CR. 2997

FINAL REPORT

on

Relinquished Areas of Authority

to Prospect Nos. 354M - 375M

79 -

Undilla Basin Area

and

Whistler Creek Area

Northwest Queensland

by

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Sydney, N.S.W.

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INTRODUCTION

Authority to Prospect No. 354M was granted to Continental Oil Company of Australia Ltd., for a period of two years commencing 1st. July, 1966. The area originally comprised approximately 1023 square miles. Subsequently, this area was reduced to 500 square miles on 1st. July, 1967 as stipulated by the Authority to Prospect agreement.

On the 1st. January, 1967, Authority to Prospect 375M was granted covering approximately 468 square miles bordering 354M to the south. As stipulated by the Authority to Prospect agreement, 375M was reduced to less than 100 square miles on 1st. January, 1968.

Since exploration of both Authority to Prospect 354M and 375M would, of geographic necessity, be carried out simultaneously, approval was granted by the Mines Department, Queensland Government to combine the expenditure commitments for Authority to Prospect 354M and 375M. Ultimately both Authorities will be combined and treated as Authority to Prospect No. 601, parts 1, 2 and 3.

This report deals solely with areas herein relinquished within Authority to Prospect No. 354M, parts 1 and 2 (See Plate I). Authority to Prospect No. 375M, while treated together with 354M, has not been further reduced in area and therefore is not covered in this report.

Precise descriptions of both Authorities are contained in the original documents. The positions of corner points and boundaries of the Authorities to Prospect have been fixed by an authorised surveyor.

The areas relinquished are located in the Undilla Basin, Northwestern Queensland, i.e., in the "Undilla Homestead" area and in the Whistler Creek area (See Plate I and IV).

The major mining town of Mt. Isa (population 15,000) is the largest town in the region and is approximately 100 - 125 miles distant from the two areas relinquished. Both areas are from 180-225 miles south of the Gulf of Carpentaria.

The general vicinity is affected by flooding caused by unreliable monsoonal thunderstorms during the summer (or "Wet") months of December through March with occasional wet periods during the winter months (April - November) not uncommon. In the "Dry" Season accessibility varies from very poor to very good. The Barkly Highway is the only all-weather road in the region (See Plates I and IV). Unsealed roads vary from grader-improved roads to washed-out tracks. Four-wheel drive vehicles are a necessity for safety.

SUMMARY

During 1966, exploratory drilling was conducted over lithologicaly promising areas of 354M. Simultaneously and subsequently, numerous traverses have also been conducted to further support the exploratory drilling. The investigations covering the areas herein relinquished, i.e., the "Undilla Homestead" Area and the Whistle Creek Area, have been completed. Pre-drilling traverses in the "Undilla Homestead" Area and earlier drilling in the D-Tree Area to the east indicate and infer the presence of economically unimportant phosphatic limestone (Thorntonia Limestone) underlying thinly bedded, poorly developed and highly ferruginous and phosphatic shale-chert interbeds (Inca Creek-Beetle Creek Formations) at prohibitive depth in the "Undilla Homestead" Area.

In the Whistler Creek Area, a relatively more well developed, but incomplete and disturbed, phosphatic bed is recognised as having been derived from advanced erosion of the favourable Beetle Creek Formation on a basement high by later Inca Creek advancement. The phosphatic intervals encountered by exploratory drilling indicate that, although relatively better developed than in the "Undilla Homestead" Area, the phosphatic intervals have been

grossly disturbed by erosional processes and therefore have been intermixed with unwanted ferruginous and other impurities. On the basis of the drastically impure nature of the low-grade phosphatic material alone, not considering the prohibitive depth, the Whistler Creek area potential is deemed economically unimportant within the area relinquished.

The following report expands in some detail the above conclusions and their ramifications for the possible occurrence of a well developed phosphorite facies of potentially economic proportions in the region.

OPERATIONS

Field Operations

Although the general exploration philosophy was that of exploratory drilling rather than detailed field mapping, it soon became evident that because of the apparent complex facies relationships a certain amount of field mapping was necessary. To this end, a base map was prepared from available areal photographs and B.M.R. 4-mile geological mapping and subsequently modified by numerous traverses in both the "Undilla Homestead" and Whistler Creek Areas in addition to pertinent surrounding areas within Authority to Prospect Nos. 354M and 375M. The resulting map (Plate IV 1:86,000 Approx) clarified some of the facies relationships in selected areas but complicated relationships in others. In the "Undilla Homestead" Area the results from regional field mapping (i.e., unfavourable lithologies) combined with information gained from drilling in the D-Tree Area to the east considerably downgraded the potential of the "Undilla Homestead" Area and therefore no drilling could be justified.

In the Whistler Creek, however, field mapping indicated a very favourable lithology within the Inca Creek and Beetle Creek Formations. Exploratory drilling was justified.

Drilling Operations

General

As a result of favourable lithology encountered during the field mapping, the Whistler Creek Area was selected as one of the areas that merited drilling within Authority to Prospect Nos. 354M and 375M. Six (6) exploratory drill-sites were selected in the Whistler Creek Area to test the entire local section for its phosphate potential. Of the six (6) holes drilled, four (4) encountered an anomalous phosphate horizon. Three holes were later cored. The following is a summary of the drilling completed in the area:

Table 1

Whistler Creek Area

Exploratory Holes	Total Depth	Footage Cored	Recovery
Whistler No. 1	276'	Nil	Nil
"S"	238'	Nil	Nil
"T"	280'	14'4"	5'0"
"P"	263'	10'0"	1'0"
"Q"	215'	11'0"	2'6"
"R"	194'	Nil	Nil

Drilling was generally difficult with numerous intervals of lost circulation. Coring with conventional equipment proved almost impossible, with the chert-siltstone interbeds causing considerable problems of low recovery.

Sampling

Samples were taken at foot intervals. In several instances it was not possible to take foot samples because of loss in air circulation. Because of the severe and numerous cases of circulation loss, it is possible that the samples obtained, either dust samples or core samples, are only marginally representative and therefore were treated as such in all evaluations, being generally more pessimistic than optimistic. However, later experience has demonstrated that the large amounts of chert cavings and the partial loss of the fine and soft phosphatic dust (due to poor sample collection equipment) would almost certainly have a diluting effect on the P_2O_5 content. Also when rig weight is applied to the bit, contamination could result by the scraping effect of the drill pipe against the sides of the hole. As the phosphatic horizons are usually soft, the scraping effect may be most in those zones and the P_2O_5 content of the samples supposedly representing underlying sediments would thus be enhanced.

Low core recovery and reliability of section position also demanded a pessimistic view toward interpretation.

Logging and Testing

Logging of the cuttings were performed by geologists of Continental Oil Company of Australia Ltd. and consulting geologists of Mincil Services, directed by R. Grasso, Chief Consulting Geologist. Because of relatively fast drilling, the need to run "Shapiro" tests and other duties, the lithological logs are brief descriptions mostly compiled from a quick macro-inspection of the cuttings. (See Appendix II) Some of the more mineralogically interesting cuttings were later examined in detail by Continental staff and by A.M.D.E.L., Adelaide.

Field testing for phosphate was carried out by dropping one or two cuttings into a test tube containing ammonium-vanado-molybdate solution in nitric acid (Shapiro 1952). Samples showing a positive reaction (yellow colouration) were processed and analysed by the complete Shapiro method. Samples showing little or no reaction were recorded as containing 0 - 1% P_2O_5. Samples indicating greater than 2% P_2O_5 by the Shapiro method were sent to A.M.D.E.L., Adelaide for more accurate quantitative analysis. Correlation of field Shapiro results with those of A.M.D.E.L., Adelaide, is generally good, especially if the inaccuracies involved in taking a very small "grab" representative sample from the cuttings is considered.

Previous Investigations

The areas covered by Authority to Prospect Nos. 354M - 375M lie within the boundaries of the Camooweal and Mt. Isa four-mile geological map series, published by the Bureau of Mineral Resources.

Dr. A. A. Öpik has published numerous papers (1954, 1957, 1960) on the Cambrian geology and palaeontology of the area and his work forms the original basis for the subdivision of the Middle Cambrian adopted in the four-mile geological map series of the region. Dr. Whitehouse has also reported on the area. Recently other B.M.R. geologists, notably Dr. Frank deKeyser, among others, have further extended the knowledge of the Cambrian geology of north-central Australia.

REGIONAL GEOLOGY

The Undilla Basin, a marginal trough or deep of the larger Georgina Basin, developed during Middle Cambrian times, with some evidence emerging from phosphate exploration in the region of a late Lower Cambrian-very early Middle Cambrian date of original basal sedimentation over an irregular Precambrian erosional surface. Where a source for clastic deposition was available from Precambrian sediments, a basal sand was locally formed. Where not available, nondeposition predominated.

In the basin's present form, the Camooweal dolomite forms the western boundary, interfingering with many of the Middle Cambrian carbonates, non-clastics and clastics (pers. com. F. deKeyser). To the north, east and south, Proterozoic rocks outcrop to define the present Basin limits.

Numerous remnants of Middle Cambrian sediments, as outliers, indicate that contemporaneous deposition took place in the Undilla Basin and over at least part of a very irregular Precambrian surface to the east. Inter-connection between the Undilla Basin, the area east and south of Duchess and the Marqua-Huckitta area to the southwest is indicated by contempor-aneous deposition.

Mesozoic sediments were deposited on Middle Cambrian sediments and are now represented by lateritised mesas and dissected plateaux.

There were several periods of folding and granite emplacement during Middle Precambrian (Lower Proterozoic). The Gunpowder Creek Formation, the Paradise Creek Formation and the Mingera Beds, also of Lower Proterozoic in addition to the Pilpah Sandstone (Upper Proterozoic) were folded and faulted prior to the deposition of Cambrian sediments, with some evidence of tectonic disturbances or stress adjustments during early Middle Cambrian time (post Beetle Creek time - pre Inca Creek time). A major uplift has been reported for Middle or Upper Ordovician (Öpik, 1960) and has locally affected Cambrian sediments.

After the deposition of Mesozoic sediments, the area was reportedly again uplifted, to remain stable from that time to the present.

STRATIGRAPHY

Precambrian

Lower Proterozoic

A tightly folded complex of metamorphosed sediments and interbedded volcanics, intruded by granites and basic igneous rocks, comprise the Lower Proterozoic section.

Upper Proterozoic

Unconformably overlying the metamorphic basement is the Pilpah Sandstone, a moderately folded and faulted quartz sandstone with some conglomerate beds reported. This formation appears widespread but may be a relatively thin veneer overlying great thicknesses of Lower Proterozoic shales, siltstones, sands and minor carbonates.

Structurally, the Precambrian surface, over which the Cambrian seas transgressed, appears to have been one of the major controls regarding phosphorite deposition. The trough or shelf starting from the Undilla Basin proper south to Yelvertoft and south-east to Duchess appears to have been very irregular at the beginning of Cambrian time. The facies change from carbonate to deeper water shales and cherts probably was principally controlled by local basement (Precambrian) structure, thereby eliminating a simple strike zone of phosphorite deposition. Whenever water depths and other physio-chemical conditions of phosphorite deposition were met at least minor phosphorite was deposited; this is demonstrated by the very wide-spread occurrences of phosphorite, i.e., Duchess Area, Lady Annie Area, D-Tree Area, Yelvertoft area, Sherrin Creek and Lily Creek Areas, not considering those of the Northern Territory.

Also, the first period of phosphorite deposition (early Beetle Creek time) appears to have been interrupted at least once by a local structural uplift and probably more than once in other areas nearby. Multiple phosphorite intervals in other areas attest to sedimentation adjustments.

PALAEOZOIC

Cambrian

Camooweal dolomite

This formation is found in outcrop or subcrop over large areas to the west and southwest of the subject areas. Originally, it was thought to be Upper Proterozoic. Öpik (1957) thought it was older than Middle Cambrian and this concept was adopted in the B.M.R. four-mile series as upper Proterozoic or Lower Cambrian. Later work (Brown and Randal, 1962) indicated that the Camooweal dolomite interfingers with the Middle Cambrian section. Recently additional work (F. deKeyser, pers. com.) extends the age of the Camooweal dolomite from Upper Proterozoic to Upper Cambrian, interfingering with most Middle Cambrian carbonates and some clastics and non-clastics. Composed almost entirely of massive beds of dolomite with minor chert and limestone lenses, it is a maximum of 1,000 feet thick. Generally, its colour ranges from white to creamy brown. It is crystalline, dense, tough, very sparsely fossiliferous and contains pelletal zones. It was not found in the Morstone No. 1 well, nor in any of the known holes drilled through the

Middle Cambrian section to basement further to the east and south. A facies change from dolomite to limestone with chert bands, to siltstones with interbedded cherts and phosphorite locally, indicates deepening water to the east, south and southeast, i.e., into the Undilla Basin and southeast. The Camooweal dolomite is not known to appear in either the "Undilla Homestead" or Whistler Creek Areas and is therefore not dealt with in any detail in this report.

Yelvertoft sandstone (Beds)

A basal, partly phosphatic, partly arkosic, conglomeritic sand has been reported from a variety of locations within Authority to Prospect Nos. 354M and 375M, notably in the Sherrin Creek, Lily Creek, D-Tree Areas and very notably in the Engine Creek Area (See Plate I). The thickness varies from 5 to 30 feet, and in all cases known, overlie Precambrian sediments. It is a white to yellow to light grey, fine to coarse, cross-bedded sandstone with brown chert pebbles, laminations (?) and occasional Scolithus-like pipes or worm tubes. Öpik (1957) described the lithology as a basal conglomerate.

Although seemingly very restricted in occurrence, recent information reveals it to be a fairly consistent unit. Morstone No. 1 in the Undilla Basin proper encountered a thin sand below the Thorntonia Limestone (Stewart, 1963). Exploration in other sections of 354M and 375M indicates reasonable continuity. One area of particular importance is the Engine Creek Area (See Plate I and IV), where a well-developed basal sandstone in excess of 20 feet outcrops. It underlies the Beetle Creek Formation (Lower Middle Cambrian) and is underlain by the Pilpah sandstone (Upper Proterozoic). Previous B.M.R. four-mile mapping erroneously considered the sandstone in the Engine Creek Area to be the Split Rock sandstone (Upper Middle Cambrian).

Middle Cambrian

Thorntonia limestone

Outcropping strongly around the northern and north eastern margins of the Undilla Basin, this formation is the time equivalent of the Beetle Creek Formation and perhaps part of the "Yelvertoft Sandstone" (Beds). It is a thickly bedded massive dolomitic limestone with interbedded dolomite, limestone and chert. In places it is strongly and closely jointed on NW-SE Lines. The formation is often very fossiliferous and mildly phosphosphatic. Faunal groups of Xystridura and Redlichia are generally diagnostic (See PlateII). The maximum measured thickness is approximately 200 feet. The Thorntonia Limestone does not outcrop in the "Undilla Homestead" Area; it was also not found in any of the exploratory drilling in the Whistler Creek Area. It therefore will not be treated in any detail here, except to state that early in the exploration for phosphate (1965) the Thorntonia Limestone held considerable interest on strictly theoretical grounds which at that time was inconsistent with the accepted classical "up-welling" theories of phosphorite deposition.

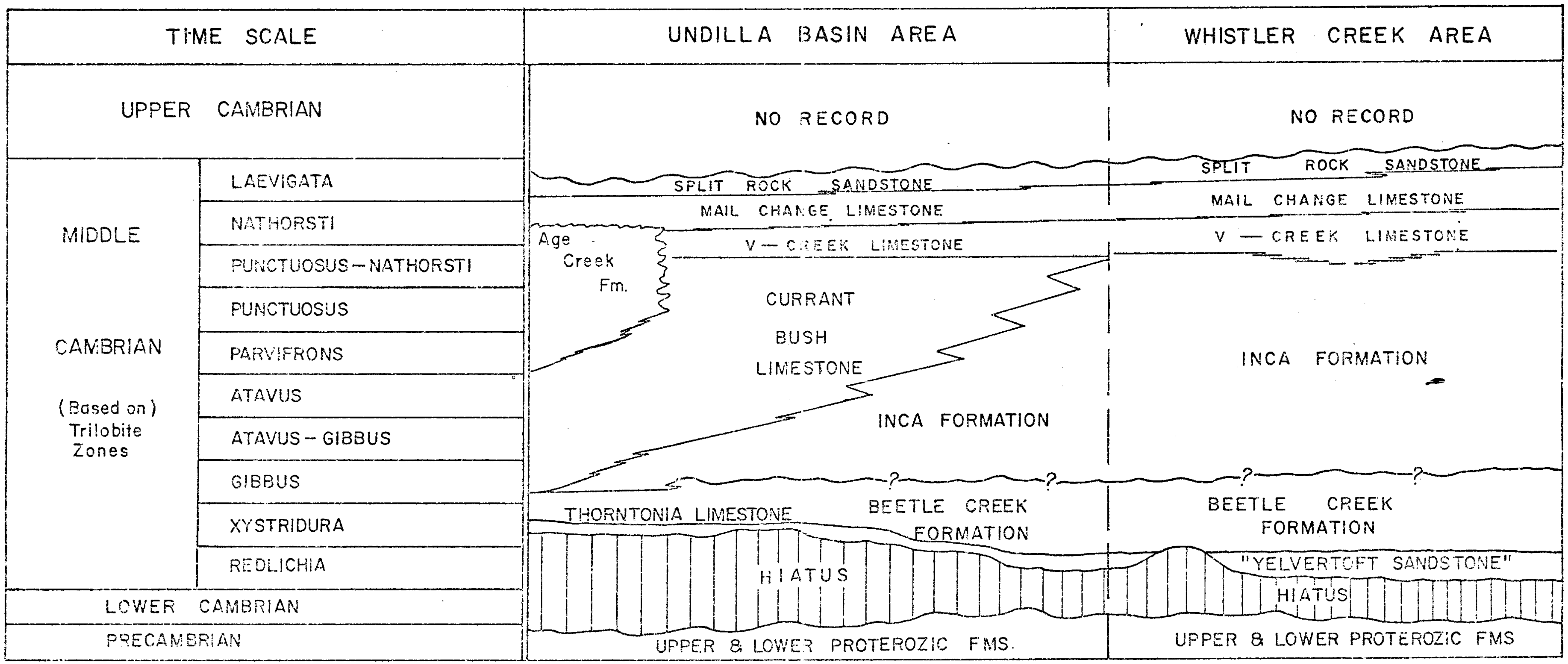
Beetle Creek Formation

The time equivalent of the Thorntonia Limestone, the Beetle Creek Formation demonstrates the facies change from carbonate to deeper water shales, cherts and siltstones. It is generally a light brown to light grey siltstone-shale with interbedded brown-black chert and some conglomerate intervals locally. The chert can usually be identified as belonging to the Beetle Creek Formation by its white spiculitic inclusions and wavy micro-bedding, in opposition to the overlying Inca Creek Formation's light grey to black and less abundant brown chert without small white inclusions and without noticeably wavy micro-bedding. Minor dolomitic Limestone is also reported locally within 354M - 375M. It is often very fossiliferous containing the diagnostic fauna Xystridura and in its lower sections the equally diagnostic Redlichia fauna (See Plate II).

PLATE II

CAMBRIAN CORRELATION CHART, UNDILLA BASIN, N.W. QUEENSLAND

MODIFIED AFTER A.A. ÖPIK, 1960



The Beetle Creek Formation was not encountered in outcrop in the "Undilla Homestead" Area. However, in the Whistler Creek Area, in addition to numerous other localities, within 354M - 375M, it was encountered during exploratory drilling and will be covered later in this report.

It was found to contain phosphorite and phosphatic siltstone with P_2O_5 content varying from less than 1% to over 30% locally in environments ranging from relatively thin erosional surfaces to relatively thick beds of phosphorite. In the Whistler Creek Area, the Beetle Creek Formation is generally a poorly developed and disturbed erosional interval.

Inca Creek Formation

This formation represents a facies change from the dominantly carbonate Currant Bush Limestone to dominantly siliceous shales, cherts and limestone lenses, some of which are bituminous. Thickness variations noted are 10 feet in the vicinity of Thorntonia Homestead to a quoted 500 feet east of the Whistlers Creek Area. It generally consists of light grey to bluish grey to yellow-brown, often waxy siltstone with light grey-black cherts without inclusions or micro-wavy bedding. It is often very fossiliferous with the faunal groups of Gibbus, Atavus, Parvifrons, and Punctuousus generally diagnostic and very reliable in field mapping regardless of the lithology, i.e., carbonates, shales and siltstones.

The Inca Creek Formation conformably overlies the Beetle Creek Formation in places but unconformably overlies it in local areas within 354M - 375M with minor erosional surfaces evident. The Whistler Creek Area is one such area where the Inca and Beetle Creek are unconformably related, perhaps on a very minor scale.

The Inca contains numerous phosphatic intervals of minor importance and appears to be crandalilitic at its base. This supports Russel (1967) and his preliminary evaluation of the Duchess phosphate occurrence and extends some of his stratigraphic relationships into the Undilla Basin Area.

Age Creek Formation

This formation is composed of coarsely current bedded calcarenites, dolomitic limestones and dolomite. It is thought to be contemporaneous with the Mail Change Limestone, the V-Creek Limestone, and probably the Camooweal Dolomite to the west.

It contains interbeds of calcareous sandstone and oolites and has been described as a slope deposit where slump structures are common. The Age Creek Formation was not found in outcrop in the "Undilla Homestead" Area or the Whistler Creek Area.

Currant Bush Limestone

The Currant Bush Limestone is probably contemporaneous with the lower Age Creek Formation and more certainly with the Inca Creek Formation. It is largely composed of bituminous, flaggy limestone often with marls, oolites and minor shales. This formation was found in outcrop over wide areas of the Undilla Homestead Area (See Plate IV). In the early stages of exploration (1965) it was thought to be the major carbonate in the Undilla Basin which had the classical petrologic and lithologic potential for phosphorite deposition in its facies related deeper water equivalent (Inca Creek). Although commonly phosphatic (less than 1% P_2O_5) throughout, early field traverses and more detailed work failed to support the potential of the Currant Bush limestone and its deeper water equivalent, with the minor exceptions of phosphatic and highly ferruginous erosional surfaces found within it and near the base of the Inca Creek Formation.

Known faunal groups are identical to those of the Inca Creek Formation.

V-Creek Limestone

This formation is a fossiliferous, impure, laminated limestone with interbedded calcilutites. Within the Undilla Basin, it is a wide spread formation and relatively easy to identify in outcrop on the basis of lithology and palaeontology (Faunal Group Punctuosus-Nathorsti) (See Plate IV). The measured thickness varies between 100 and 200 feet in outcrop to 325 feet in Morestone No. 1.

The V-Creek Limestone was found widespread in outcrop in the "Undilla Homestead" Area and the Whistler Creek Area. It holds relatively little interest with respect to phosphate potential and was therefore not examined in any great detail.

Mail Change Limestone

A generally two-coloured, thick bedded, fine grained limestone, it conformably overlies the V-Creek Limestone and also underlies the Split Rock Sandstone. It is confined to the Undilla Basin, is fossiliferous (Faunal Group: Nathorsti) and has not been found to exceed 20 feet in thickness. Morestone No. 1 encountered a 15' thickness. The Mail Change Limestone has been found in outcrop over wide areas in the Undilla Homestead Area and locally in the Whistler Creek Area (See Plate IV).

Split Rock Sandstone

The highest unit of the Middle Cambrian, it is described (Öpik, 1957) as having a rising contact with the V-Creek and Mail Change Limestone and consequently a three faunal group stratigraphic range (See Plate II). It is a fine grained, current bedded ferruginous quartz sandstone with interbedded ferruginous siltstone. The maximum measured thickness is 70 feet and has in places been heavily laterised. It has been confused with the "Yelvertoft Sandstone" (Beds) in the Engine Creek Area (See Plate IV).

JURASSIC

Scattered mesas of fresh water quartz sandstone and siltstones with plant fossils occur throughout the areas and were found not to exceed 20 feet in thickness (Öpik 1961). Most outcropping areas investigated were heavily laterised. These sediments were not examined in any detail.

CRETACEOUS

Undifferentiated Mesozoic sediments, i.e., conglomerate, sandstone and siltstone occur throughout the areas on elevated mesas. These sediments were also not examined in any detail.

AREA EXPLORATION RESULTS

"Undilla Homestead" Area

As a result of unfavourable lithology found during field mapping, no drilling in the area was done. An encouraging facies change from carbonate to siltstone encountered in the D-Tree Area (See Plate I) supported the above conclusions. The resultant map of the area is included in this report as Plate IV.

Whistler Creek Area

As previously mentioned six (6) exploratory holes were drilled in the Whistler Creek Area (See Plate I and IV). Of the six (6) drilled, four (4) encountered anomalous phosphate. The following is a general summary of the phosphate zones intersected.

Table 2

Summary Phosphate Encountered Whistler Creek Area

(Gross Zone ≥ 1.0% P_2O_5)

Exploratory Hole	Total Depth	Top of Zone	Zone Thickness	Zone (% P_2O_5)
Whistler Creek No. 1	276'	Absent	Nil	Nil
"S"	238'	212'	3'	5.0%
"T"	280'	241'	20'	7.0%
"P"	263'	168'	35'	9.0%
"Q"	215'	169'	26'	7.0%
"R"	194'	Absent	Nil	Nil

Summary: Exploratory Holes (See Plate I and IV for locations)

Whistler Creek No. 1

Located approximately 3.5 miles northeast of Hole "S", this hole was spudded in V-Creek Limestone to test the potential of the underlying Inca Creek Formation in the area. The exact contact of the V-Creek Limestone and Inca Creek Formation is in doubt but has been selected at an apparent erosional break expressed by a thin ferruginous siltstone with rounded fragments and pebbles at 95' (See Appendix I and II). Both the V-Creek and Inca Creek were phosphatic on a very minor scale. Neither Proterozoic nor Beetle Creek sediments were encountered but are believed to be within 250' below the T.D. of this hole. (See Plate III) Fossils were collected at 120' but preservation was poor. A very tentative Inca Creek age has been assigned to the assemblage. No significant phosphate was encountered in the section.

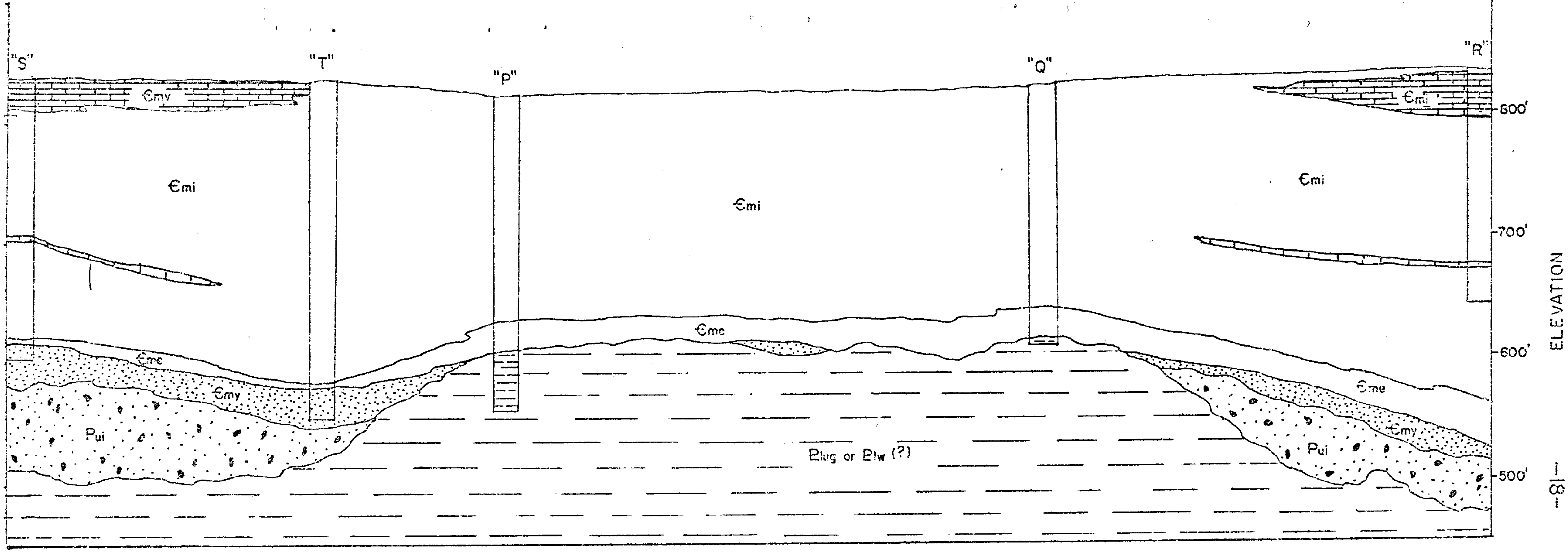
Exploratory Hole: "S"

Also spudded in V-Creek Limestone but approximately 230' topographically below Whistler Creek No. 1, Hole "S" encountered the Inca Creek Formation, the Beetle Creek Formation (?) and what appears to be the basal sandstone unit, the "Yelvertoft Sandstone" (Beds). The V-Creek Limestone -- Inca Creek Contact was chosen at the base of a grey-green to sl. pink limestone (which may be the Mail Change Limestone) but the contact may also be at the top of a limonitic, slightly calcareous and phosphatic siltstone. What appears to be poorly developed or grossly eroded Beetle Creek Formation, is a highly ferruginous highly phosphatic (ave. about 5.0% P_2O_5) erosional interval (surface?) which overlies a clayey sandstone with chert (Yelvertoft Sandstone"?). The Upper Proterozoic Pilpah Sandstone does not compare favourably with the sandstone encountered in this hole (therefore: "Yelvertoft Sandstone"?). See Appendix I and II for detailed lithologic descriptions.

Exploratory Hole: "T"

Located approximately 1.5 miles southeast of hole "S", this hole spudded in the Inca Creek Formation and encountered both the Beetle Creek Formation and "Yelvertoft Sandstone." As in hole "S", the Beetle Creek appears to be partly eroded and underlain by a basal sand which does not compare favourably with the Pilpah Sandstone.

Coring was attempted but with little success.



CAMBRIAN

- Єmv — V-Creek Limestone
- Єmi — Inca Creek Formation
- Єme — Beetle Creek Formation
- Єmy — "Yelvertoft Sandstone"(Beds)

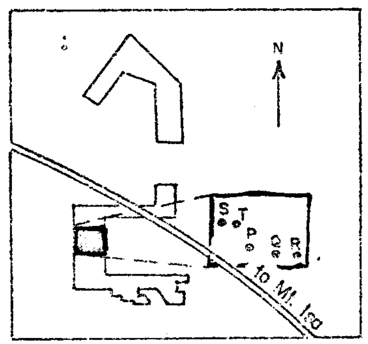
PRE-CAMBRIAN

- Pui — Pilpah Sandstone
- Blug — Gunpowder Creek Formation

and/or

- Blw — Mingera Beds

GENERALIZED INDEX MAP



(SEE PLATE IV FOR DETAILED LOCATIONS & SURFACE GEOL.)

PLATE III

CONTINENTAL OIL COMPANY OF AUSTRALIA, LTD.
MINERALS EXPLORATION DIVISION

DIAGRAMATIC FENCE

APPARENT LITHOLOGIC RELATIONSHIPS

AUTHORITY TO PROSPECT NO. 354M - 375M

SCALE: 1" = 4600' (Horizontal)
1" = 100' (Vertical)

Vertical exaggeration: 50x (approx.)

M. D. CAMPBELL

NOVEMBER, 1969

Table 3
Hole "T" Coring
(Physical)

Footage Cored	Cored Interval	Core Recovered	% Recovery (Approximately)	Information Value
241' -242'4"	1'4"	9"	50%	Fair
242'4"-244'2"	1'10"	1'	60%	Fair
244'2"-247'8"	3'6"	1'3"	40%	Poor
247'8"-249'2"	1'6"	9"	50%	Fair
249'2"-252'5"	3'3"	11"	30%	Poor
252'5"-255'4"	2'11"	4"	10%	Very Poor

The overall core recovered is at best of only marginal value with respect to analyses and detailed correlation or interpretation. Therefore only the overall characteristics of the intervals cored were considered in assessing the sediments' environment and implications of conclusions from later chemical analyses and petrological studies (See Appendix III for analysis, See Appendix I and II for detailed lithologic descriptions).

Exploratory Hole "P"

Approximately 1 mile south-southeast of Hole "T", Hole "P" also spudded in Inca Creek. The Beetle Creek Formation was encountered but a basal sand was not found below; Proterozoic shales were encountered. The Beetle Creek here appears to be more well-developed and less disturbed by erosion. It is immediately apparent that a basement high has had some effect on the deposition of the phosphate in this area. Although still highly ferruginous and partially indicative of an erosional surface, the numerous parameters for phosphorite deposition appear to be favourably combining. Decernable carbonate (i.e., fossiliferous limestone or dolomite) has still not developed which would considerably upgrade the potential of the Whistler Creek Area in general.

Coring was attempted again with little success.

Table 4

Hole "P" Coring

(Physical)

Total Cored	Cored Interval	Core Recovered	% Recovery (Approximately)	Information Value
185'-190'	5'	11"	20%	Poor
190'-195'	5'	9"	15%	Very Poor

See Appendix I and II for detailed lithology descriptions and Appendix III for analyses.

Exploratory Hole "Q"

Approximately 2.25 miles southeast of Hole "P", this hole was also spudded in the Inca Creek Formation. It encountered Beetle Creek and Proterozoic shales, "Yelvertoft Sandstone" is again missing. Of significance in this hole is a decernable spliting of the phosphatic intervals, an upper, i.e., basal Inca Creek, and a lower, i.e., Beetle Creek, with a ferruginous erosional zone between. Here, the Beetle Creek is noticeably becoming more well-developed lithologically in a south-eastwardly direction, but is still draping an erosion-prone basement high. The gross phosphatic content is considerably less than Hole P, indicating that erosional interference was still the major control for secondary highly ferruginous phosphorite deposition, although the lithologic features imply improved potential.

Table 5

Hole "Q" Coring

(Physical)

Footage Cored	Cored Interval	Core Recovered	% Recovery (Approximately)	Information Value
177' -181'4"	4'4"	1'	20%	Poor
181'4"-183'5"	2'1"	6"	30%	Poor
183'5"-188'	4'7"	6"	10%	Very Poor

See Appendix I and II for detailed lithologic descriptions.

Exploratory Hole "R"

Located approximately two miles due east of Hole "Q", this hole encountered only the Inca Creek Formation. The Beetle Creek would be expected within 100 feet below the T.D. of this hole. A limestone encountered in the upper section probably represents the first of Inca Creek carbonate deposition, but there is some evidence of the carbonate being of the V-Creek Limestone. A thin limestone bed at 165' is almost certainly that of Inca Creek.

No coring was done. See Appendix I and II for detailed lithologic descriptions.

SUMMARY: PHOSPHATE OCCURRENCE

The phosphate in all specimens examined is in the same form, wherever it occurs, it is cryptocrystalline and interstitial, and generally is in the matrix, although clay and carbonate are commonly associated. Pellets of phosphate do occur in some specimens, but are very rare and always form considerably less than 1% of the rock.

The fact that where the P_2O_5 content is small and free phosphate is seldom observable, a chemical association of the phosphate with an unusually complex carbonate is indicated. This is complicated by the fact that in the medium P_2O_5 content range (about 5-10% P_2O_5) occasionally free pellets were observed, generally in lower carbonate content rock.

The phosphate is undoubtedly some form of highly weathered primary phosphorite derived by erosional processes which introduced ferruginous material and later additional iron mineralisation (Janshin, 1967).

The carbonate found in the core specimens appears to be dolomite or siderite.

The clay in all specimens is of the same general type; it is colourless in thin section, and is not stained even though material around it may be. It has a low birefringence, but much of it is in oriented aggregates. It is also well crystalised. In most cases it occurs almost entirely as pellets, commonly elongated, but generally rounded, probably as a result of its softness and slight abrasions.

In summary, there is nothing to indicate that the cores examined in Core hole "T" are of true marine origin; the form of the clay, the unusual nature of the framework fragments, and the presence of a euhedral quartz grain would be more consistent with a near shore origin where erosion was highly to moderately active and continuous sediments were being deposited. Core Hole "P" on the other hand represents rocks that are more typical of some phosphatic sediments. They consist of chemically or biogenically precipitated phosphate and iron minerals (deKeyser, pers. com.). Some interaction however between nonclastic sedimentation and ferruginous clastic sediments is evident by the variable content of detrital quartz grains. Diagenesis is evident, particularly in one case, where pellets of geothite have formed the matrix. Generally, however, the iron hydroxide and phosphate minerals are of sub-micron size and are intimately associated. A shallow water origin for the higher-grade phosphorite areas nearby is supported by Bushinsky (1964) and deKeyser (pers. com.). The heretofore accepted "upwelling" theories (McKelvey, 1953, 1967, Sheldon, 1964 and Kazakov, 1937) do not appear to be particularly applicable to the Undilla phosphorite occurrences.

SUMMARY: PETROLOGIC STUDIES

The following remarks are a brief summary of more detailed studies carried out by staff of A.M.D.E.L., Adelaide and by geologists of Continental Oil Co. Aust. Ltd, Sydney.

Core Hole "T"

241'-246'8" (See Appendix I and III)

Upper Core Composite

This is a phosphatic rock in which dolomite grains 0.02 to 0.09 mm across form 30 to 40%. These do not appear to be detrital, and appear from their highly irregular outlines to be secondary. Ferruginous and opaque grains, smaller than the dolomite grains, form 5 to 7%.

The phosphate is almost cryptocrystalline, and forms a homogenous mass in which other minerals are scattered.

Lower Core Composite

This consists almost entirely of dolomite occurring in grains of the same type as above. Scattered fine quartz grains and fine clay pellets are also present, with a few ferruginous grains. The phosphate present appears to be in intimate association with the carbonate, and may be actually chemically associated, there is very little free phosphate pellets. (Lindholm, 1969)

246'8"-255'4" (See Appendix I and III)

Upper Core Composite

This is a clayey sandstone with a grain size of 0.05 to 0.25 mm. Secondary carbonate grains form about 30% and clay pellets about 30 to 35% of the rock. Opaque grains form 1 to 3%. One distinctive euhedral quartz grain was observed. The phosphate forms part of the matrix.

Lower Core Composite

This is a coarse sandstone or fine conglomerate with a grain size of 0.5 to 3 mm. The framework grains are rounded, and form about 50% of the rock. They consist mainly of clay, but some are chert and chalcedony, and rare grains are carbonate with radial and some concentric structure. The matrix is predominately carbonate, and has a grain size of about 0.05 mm. The clay in the framework is as above. What phosphate is present must be carbonate associated.

Core Hole "P"

185'-190' (See Appendix I and III)

Upper Core Composite

This rock is an arenaceous phosphorite. It consists essentially of clastic quartz grains in a matrix of submicron collophane and goethite. The quartz grains are sub-angular to sub-rounded and constitute about 30% of the rock. They vary from 0.05 to 0.38 mm. and average 0.12 mm.

The matrix is sub-micron. It consists of light to dark brown collophane and goethite intimately associated. Some opaque pellets (?) of goethite are also present. Microcrystalline quartz (chert) may also be present but is masked by the other matrix constituents.

Lower Core Composite

This is similar to the above but more clay is present. The goethite (?)-carbonate layers are present. Scattered rounded grains of quartz are present, but with the addition of possible chlorite. Some discrete phosphate is present, but it is fine grained, interstitial and apparently associated with the carbonate. A very small amount of phosphate pellets is scattered throughout the clay in irregular grains about 0.04 mm. across.

190 - 195 (See Appendix I and III)

Upper Core Composite

This rock is also an arenaceous phosphorite. Clastic quartz constitutes about 10% of the rock. The grains are angular to sub-angular and vary from 0.016 to 0.36 mm. (ave. 0.09mm).

The matrix consists of light brown, submicroscopic collophane and contains sub-rounded pellets of goethite averaging 0.32 mm. in diameter. The goethite pellets partially enclose clastic quartz grains and are considered here to be diagenic. They constitute about 10% of the rock.

Lower Core Composite

This rock is similar to the above. It is an arenaceous phosphorite. Clastic quartz grains constitute about 10% of the rock and vary from 0.016 to 0.38 mm in diameter averaging 0.09 mm. They are angular to sub-rounded. The matrix consists of light brown, sub-micron phosphorite. Irregular brown staining of goethite is present in patches. Some micro-crystalline quartz may be present in the matrix but was not observed optically.

Core Hole "Q"

177'-183'5"

Composite

This sample has the appearance of a sandstone in which most of the sand grains are actually clay pellets 0.02 to 0.1 mm. across. Finer ferruginous grains are scattered throughout and form about 5% of the rock. Quartz grains are rare. The clay in the pellets appears well-crystallised, and most are well oriented within the pellet. Carbonate grains are present but rare and widely scattered. Phosphate occurs in the matrix in association with some of the clay. Sand grain size pellets of phosphate occur but are very rare.

183'-188'

Composite

This sample is similar to the above, but some clay pellets 1 to 2 mm across are present. It is strewn with phosphatic blebs about 0.02 mm. across. Otherwise identical to the above.

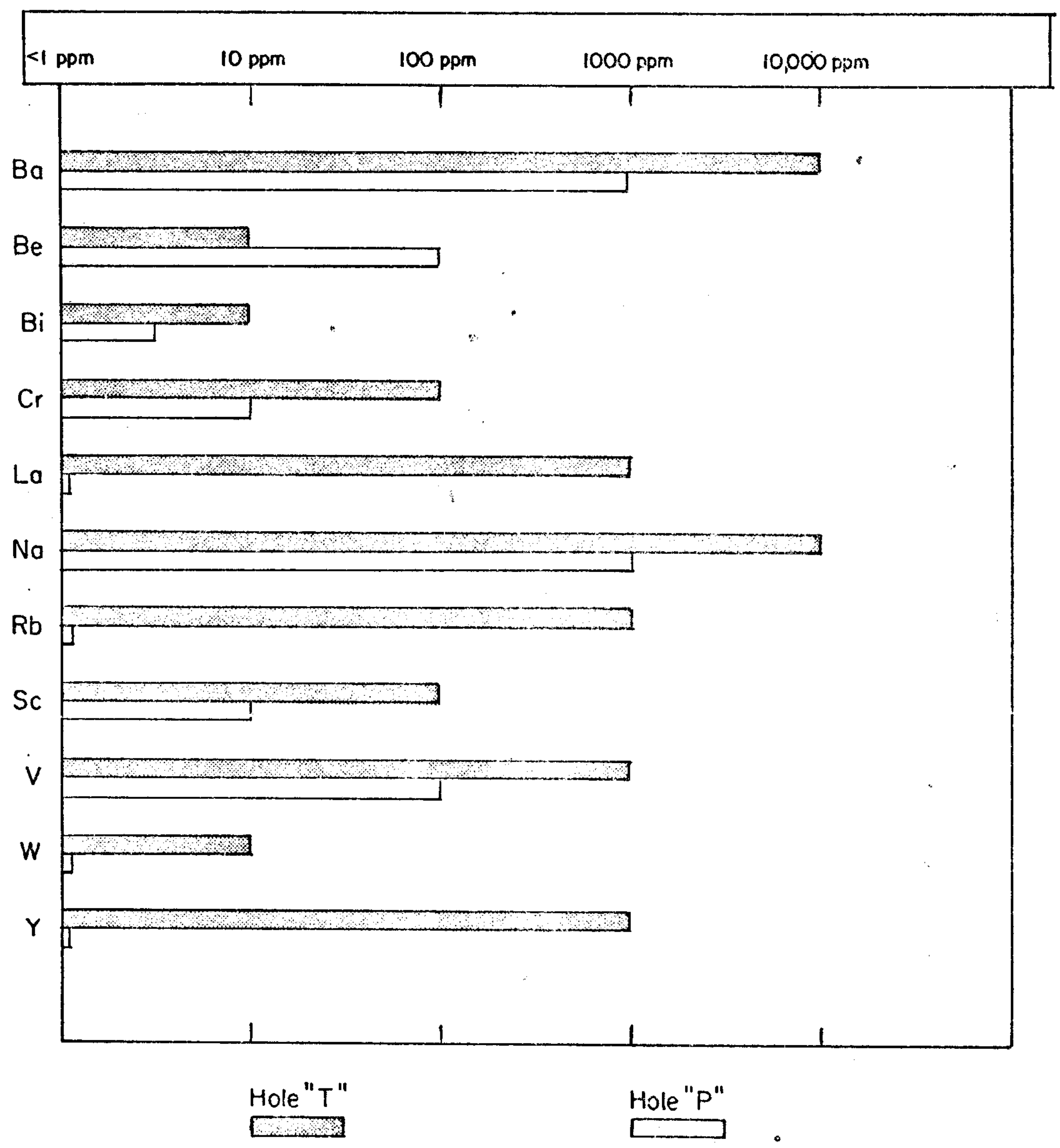
NOTES ON MINOR ELEMENT DISTRIBUTION

The distribution of some minor elements from Core Hole "T" and "P" indicates what appears to be a significant change in environment. Although Hole "P" contains more typical phosphorite-type sediments than Hole "T", a comparison of the minor element distribution indicates a significant increase of rare-earth metals in Hole "T" over Hole "P". The opposite would be expected, for "true" phosphorite is consistently higher in rare-earth metals than most marine shales and certainly higher than "normal" continental sediments (See Figure I). One explanation is: since Hole "T" sediments (within the cored intervals) have been considerably more influenced by terriginous sedimentation than Hole "P", perhaps Proterozoic shales have been the source for much of the Middle Cambrian sediments. This would support the view that the Pilpah Sandstone is far less widespread than indicated by the numerous Pilpah outcrops in the area, thereby

Figure 1

SIGNIFICANT ELEMENT DISTRIBUTION (Peak Range)

Total-Cored Intervals Hole "T" and Hole "P"



exposing to Pre-Middle Cambrian time erosion, the metasediments of Lower Proterozoic. This is partially supported in the Whistler Creek Area by exploratory drilling (See Plate III). If the conclusion is essentially correct, then potentially major copper, silver, lead, uranium, etc. mineralisation could be nearer the surface than presently assumed, especially if volcanism and structural unrest was active during Cambrian time, as is vaguely indicated by important sedimentation breaks after Lower Middle Cambrian deposition began.

CONCLUSIONS

The phosphate occurrence in the relinquished areas of the "Undilla Homestead" and Whistler Creek areas has either very little potential or is of no economic importance, respectively.

Although P_2O_5 values of 15% are not uncommon in the Whistler Creek Area, the ferruginous nature, in addition to other unwanted impurities, make the phosphate occurrence non-commercial.

The Beetle Creek Formation and/or the base of the Inca Creek Formation is poorly developed and generally non-typical of commercial phosphate deposits found elsewhere in the world and even non-typical of those phosphate deposits found elsewhere in the region.

Given a favourable basement configuration which may have controlled Middle Cambrian carbonate formation and apparently therefore phosphorite deposition, areas not too far distant eastward and south-eastward from the Whistler Creek Area have considerable potential for the occurrence of significant phosphorite deposits.

MAJOR REFERENCES

Brown, G. A., and Randal, M., 1962, Additional Notes on the Geology of the Camooweal 4-mile Sheet Area; B.M.R. Record 1962/49.

Bushinsky, G. I., 1964, On the Shallow Water Origin of Phosphorite Sediments; Developments in Sedimentology, Amsterdam, pp. 62-70.

Janshin, A. L., 1967, Classification of Phosphate Deposits in Their Context With the Weathering Process; Geochimiya, Academy of Science of the Soviet Union, vol. 176 (2), pp. 689-692 (In Russian).

Kazakov, A. V., 1937, The Phosphorite Facies and the Genesis of Phosphorites in Geological Investigations of Agricultural Ores, Trans. Sci. Inst. Fertilizers and Insect Fungicides, No. 142, pp. 95-113, (For 17th Int. Geol. Congress).

Lindholm, R. C., 1969, Detrital Dolomite in Onondaga Limestone (Middle Devonian) of New York: Its Implications to the "Dolomite Question"; A.A.P.G. Bull. vol. 53, no. 5 (May), pp. 1035-1042.

McKelvey, V. E., et alia, 1953, The Permian Phosphorite Deposits of the Western United States; 19th Int. Geol. Congress, Com. Rendus, Sec XI, fasc. XI, pp. 45-64.

McKelvey, V. E., 1967, Phosphate Deposits, U.S. Geol. Sur. Bull No. 1252-D.

Öpik, A. A., 1954, Cambrian Stratigraphy of the Camooweal Region (Progress Report), B.M.R. Aust. Rec. 1954/31.

Öpik, A. A., 1957, The Cambrian Geology of Queensland, B.M.R. Aust. Bull. 49.

Öpik, A. A., and Pritchard, P. W., 1960, Cambrian and Ordovician, The Geology of Queensland, Jour. Geol. Soc. Aust., vol. 7.

Öpik, A. A., et alia, 1961, Explanatory Notes on the Mt. Isa 4-mile Geological Sheet; B.M.R. Aust. Notes No. 20.

Russell, R. T., 1967, Discovery of Major Phosphate Deposits in North-west Queensland, Qld., Govt. Min. Journ., vol. 689 (786), pp. 153-157.

Shapiro, L., 1952 , Simple Field Method for Determination of phosphate in Phosphate Rocks, Am. Mineral., vol. 37, pp. 341-342.

Sheldon, R.P., 1964, Paleolatitudinal and Paleogeoraphic Distribution of Phosphorite; U.S.G.S. Prof. Paper 501-C, pp. 106-113.

Stewart, H. W. J., and Hoyling, N., 1963, Amalgamated Petroleum Exploration Pty. Ltd., Morstone No. 1, Authority to Prospect 79P, Queensland Well Completion Report.

REFERENCES OF INTEREST

d'Anglejan, B. F., 1967, Phosphate Genesis of Carbonate Sediments as a Mode of in situ Formation of Marine Phosphorites: Observations in a Core from the Eastern Pacific, Canadian Jour. Earth Sci., vol. 5, pp. 81-86.

Brown, G. A., 1962, The Petrology of the Carbonate Rocks of the Western Undilla Basin; B.M.R. Aust. Rec. 1962/43.

Bushinsky, G. I., 1963, Ancient Phosphorites of Asia and their Genesis, Academy of Science of the Soviet Union (In Russian).

Carter, E. K., and Öpik, A. A., 1963, Explanatory Notes on the Duchess 4-mile Geological Sheet: B.M.R. Aust., Explanatory Notes No. 23.

deKeyser, F., 1968, The Cambrian of the Burke River Outlier, B.M.R. Record 1968/67.

Kemezys, K. J., 1968, Cretaceous Phosphorites of the Darwin Region, B.M.R. Record 1968/52.

Milligan, E. N., 1963, The Bureau of Mineral Resources Georgina Basin Core Drilling Programme: B.M.R. Record 1963/86.

Nichols, R. A. H., 1966, Petrology of Some Carbonates in the Georgina Basin: B.M.R. Record 1966/145.

Pevear, D. R., 1966, The Estuarine Formation of United States Atlantic Coastal Plain Phosphorite, Econ. Geol. 61, 251-6.

Shepherd, S. R. L., 1945, Cambrian Oil Shale, Camooweal: Qld. Gov. Min. Jour.

Riley, J. R., 1968, Phosphorite Deposition (A.M.D.E.L. Report No. 593., B.M.R. Record 1968/92.