

COPY 3

A. K. Skwarko

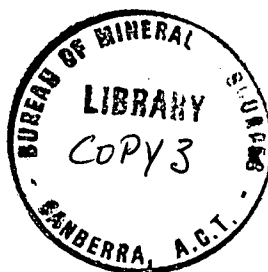
COMMONWEALTH OF AUSTRALIA.

(3)

DEPARTMENT OF NATIONAL DEVELOPMENT.
BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

RECORDS.

1961/153



PROGRESS REPORT ON THE FIELD ACTIVITIES IN THE NORTHERN TERRITORY
DURING 1961 FIELD SEASON

By

S. K. Skwarko

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 It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

PROGRESS REPORT ON THE FIELD ACTIVITIES IN THE NORTHERN TERRITORY
DURING 1961 FIELD SEASON

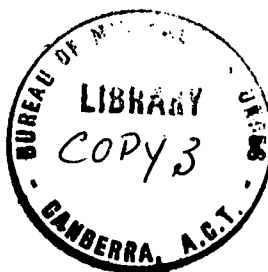
by

S.K. Skwarko

RECORDS 1961/153

CONTENTS

	<u>Page</u>
SUMMARY	1
INTRODUCTION	2
DARWIN 4-MILE SHEET	3
PINE CREEK 4-MILE SHEET	5
MT. EVELYN 4-MILE SHEET	6
FERGUSSON RIVER 4-MILE SHEET	7
KATHERINE 4-MILE SHEET	10
URAPUNGA 4-MILE SHEET	14
ROPER RIVER 4-MILE SHEET	16
BAUHINIA DOWNS 4-MILE SHEET	17
MT. YOUNG 4-MILE SHEET	20
TANUMBIRINI 4-MILE SHEET	20
HODGSON DOWNS 4-MILE SHEET	21
WALLHALLOW 4-MILE SHEET	21
CALVERT HILLS 4-MILE SHEET	22
MT. DRUMMOND 4-MILE SHEET	23
MELVILLE ISLAND 4-MILE SHEET	23
PRELIMINARY NOTES ON THE HISTORY OF SEDIMENTATION OF THE CRETACEOUS STRATA OF THE NORTHERN TERRITORY	24
1. NEOCOMIAN	24
2. ALBIAN MARINE	26
3. THE INLAND MESOZOIC BASIN	28
ACKNOWLEDGEMENTS	29
REFERENCES	30
APPENDIX - LIST OF FOSSILIFEROUS LOCALITIES	31



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 It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

SUMMARY

Mesozoic sediments of the Northern Territory, which were examined during the 1960 and 1961 field seasons, can be subdivided into three main groups, the subdivision being based primarily on the age and environment of deposition of the sediments concerned.

For 20 miles along the coast on either side of Darwin, sandstones and claystones of very limited thickness crop out. These, in places, contain rich marine macro- and micro-faunas, both indicative of Lower Cretaceous age, while the closer dating on macrofossils suggests Upper Albian age. Inland extension of the marine Darwin strata can possibly be traced about 70 miles south-east of Darwin, where a richly siliceous fine-grained rock with ammonite fragments is overlain by an unfossiliferous sandstone-claystone sequence. It is not known whether these barren upper beds belong to the Darwin sequence or are an extension of the inland basin beds of the south.

In the past, radiolaria of the type similar to those found at Darwin were observed as far to the south and south-east as Buldiva and Cresswell Downs in hard siliceous cappings overlying plant-bearing beds. These radiolarian sediments were correlated by past workers with beds at Darwin.

In the future it may be possible to show that the area of Upper Albian marine sedimentation extends east into Arnhem Land and south-west into the Port Keats area. Marine Cretaceous sedimentation at Bathurst and Melville Islands commenced probably in about Aptian times and continued into Lower Turonian. Exceptional conditions of sedimentation in this area and farther to the west allowed the accumulation of greater thickness of sediment than on the mainland.

A second area of sedimentation extends in an uneven belt from near the eastern shores of Bonaparte Gulf in the north-west to the Queensland border in the south-east. The thickness ranges from 80 to 120 feet and consists of a basal saccharoidal sandstone layer containing plant remains to the exclusion of other fossil groups, overlain by alternating claystone and sandstone layers. Some of these claystones contain marine arenaceous foraminifera which have been quite recently described from the Lower Wilgunyah Formation in south-west Queensland. This Formation has been dated on independent evidence as probably of Aptian age, but in the Northern Territory the age of these long-ranging forams is not known. Thus, although the age of the inland beds is not yet known, it may be Upper Jurassic or Lower Cretaceous, and it is thought that this area of deposition was an inland basin in which shallow-water lacustrine sedimentation was periodically interrupted by deeper-water marine transgressions.

A third area of sedimentation adjoins the inland basin on the north and north-east and extends as a broad belt around the southern and western coast of the Gulf of Carpentaria. Its extension to the north and to the east has not been traced. Lithology consists of conglomerate, sandstone, claystone and a few calcarenite outcrops. The environment was deltaic or

estaurine. Rich marine molluscan assemblages are preserved in marine marginal deposits, whereas plant remains are found in the closely associated non-marine, partly brackish and partly river-borne sediments. Plant-bearing sediments were also found alternating vertically with the strata containing marine shell assemblages. The richest marine fossils were collected in the Mt. Young 4-mile Sheet area, and have a definite Lower Neocomian aspect. Elements of this fauna were found scattered in rocks extending from Mt. Evelyn 4-mile Sheet area in the north-west to Mt. Drummond 4-mile Sheet area in the south-east.

If the age of the sediments in this area of sedimentation is indeed Neocomian, then the beginning of the Cretaceous deposition in the Northern Territory followed the well-established pattern of the Indo-Pacific region. In India, South and East Africa, as well as in eastern Queensland (e.g. Stanwell) and northern Western Australia (e.g. Dampier Peninsula) Cretaceous sedimentation was initiated with alternating phases of marine and non-marine environments.

INTRODUCTION

During the 1960 field season the writer spent about two months on a preliminary survey of the Mesozoic strata of the Northern Territory. Numerous collections of fossils, both marine and plant, were made at widespread localities. Some observations on stratigraphy and on depositional environment were also made. (Skwarko, 1961).

A more systematic approach was attempted during the four months of the 1961 field season. In the field, emphasis was placed on determination of environmental conditions of deposition as well as on exhaustive fossil collecting. An attempt was made to trace boundaries between different areas of sedimentation, but this was not always successful because of similarity of marine and non-marine lithologies, frequent paucity of fossils, complete removal of Mesozoic strata in critical areas, and finally, lack of sections which would show the stratigraphical relationship of individual areas of sedimentation. It is hoped that the age of fossils collected will help to solve some of the problems encountered in the field.

The area covered is a large one, and falls into the following 4-mile Sheets : Darwin, Pine Creek, Mount Evelyn, Fergusson^{River}, Katherine, Urapunga, Roper River, Mount Young, Tanumbirini, Bauhinia Downs, Wallhallow, and Calvert Hills. Some work was also done on a portion of the Melville Island 4-mile Sheet. Unfortunately, it was not possible to do exhaustive research on all of the areas cited. Some of the 4-mile Sheet areas south of the Gulf of Carpentaria were barely touched, and much is still to be done before all the problems are solved.

In the present report, individual areas are considered in turn, and it is found practicable to commence description of Mesozoic beds of each 4-mile Sheet area with a brief summary of field observations as well as work done in the past. This is followed by actual field notes arranged under headings

of individual 1-mile Sheets. All deductions regarding environmental conditions and age of sediments are left till the end.

Many areas of the Northern Territory have not yet been investigated, and much remains yet to be learnt of the depositional history of the Mesozoic strata of the Northern Territory. No attempt has been made to list faunal determinations. Some, as yet, are not available, and it is thought advisable to withhold results of palaeontological examination until its completion.

DARWIN 4-MILE SHEET

For summary of this area see Chapter on "Albian Marine" (p.26).

Cape Hotham 1-mile Sheet :

The coastline between Cape Hotham and Gunn Point was examined at several points where the following sequences were observed:

Cape Hotham : 12' Claystone showing ferruginous and mottled zones of the lateritic profile.

4' Porous, iron-stained quartz sandstone with quartz pebbles.

Escape Cliff : 21' Claystone as above.

3' Beach boulders of coarse, porous sandstone.

Point Stephens: 15' Claystone as above.
Sandstone beach boulders.

Clyde Point : 3' Very strongly lateritized claystone.

There is no definite lithological evidence to suggest Mesozoic age. No macrofossils were found, but samples for microfossil analysis were collected and await examination. * Nowhere was the base of sections observed.

Gunn Point: About 6 miles south of Gunn Point a wave-cut cliff of iron-stained and leached claystone and sandstone some 20 yards from the beach is underlain by soft, plastic when wet, blue-grey clay with some sandstone. A prominent outcrop of this clay just above the beach was examined and sampled (T.T.15) during the 1960 field season when it yielded a small collection of gastropods, pelecypods, crustacean remains and some very questionable ammonite remains. No definite dating for both micro- and macro-fossils was possible at the time, but there was some evidence for mid-Tertiary or younger age. During the recent visit sediments of similar lithology were found to crop out along the beach close to the low-water mark, some 200-300 yards north from T.T.15, and 10-12 feet stratigraphically below it. At this horizon ammonites are common and well preserved and the strata are definitely of Cretaceous age.

* These microsamples were found to be barren of fossils.

It is possible that H.Y.L. Brown's original collection from "Shoal Bay, between Pright and Tree Points" was obtained from the vicinity of locality T.T.15. Brown's fossils were dated by Whitehouse (1926) as Upper Albian. There are specimens in the Bureau of Mineral Resources collections from "Gunn Point", presumably collected by Woolnough, which show similar pyritic preservation. These may have also been collected at the T.T.15 site. Etheridge (1907) correlated Brown's collection from this area with another from Charles Point.

Darwin 1-mile Sheet:

At Charles Point, the fossiliferous beds are not exposed in the cliff section beneath the lighthouse, but occur lower down below the low-water mark. During sea storms, iron impregnated pelecypods and ammonites are washed up on to the beach. There is no lithological evidence for a Mesozoic age of the Charles Point cliff section, and the strata exposed in it may well be of later age (see Cape Hotham, etc.). Intermittently along the shore to the east of Charles Point, however, yellow claystone with belemnite impressions crops out in wave-cut cliffs. This clay can be correlated with some of the Mesozoic clays exposed in the cliffs at Darwin.

Darwin City: Several sections of Mesozoic strata were examined during the 1960 field season in wave-cut cliffs in the city of Darwin. The flat-lying Mesozoic sediments are separated from the steeply-dipping Proterozoic beds by an impersistent layer of varying thickness of quartz boulders and pebbles, both rounded and angular, which were derived from quartz lenses in the Proterozoic sediments.

The lower of the two layers which make up the sequence at Darwin is a brown, porous, sandy bed up to 15 feet thick. The overlaying claystone is hard and usually yellow in colour, although it can be mottled, as at Myilly Point, or pallid, as at the Cathedral Quarry. Belemnites are quite common in the claystone layer as external casts, which occur scattered throughout the bed, or concentrated into prominent bands within it. These bands are laterally impersistent and have no known correlative value. Ammonites and pelecypods have been found in the past in the claystone layer, but are very rare. The greatest measured thickness of the claystone is 18 feet.

Koolpinyah 1-mile Sheet:

The only Mesozoic outcrop is quite small and consists of yellow claystone boulders similar in appearance to claystone outcropping in the Darwin coastal sections. No fossils were found.

Submarine Tertiary (?Pleistocene) strata are present at Tree Point, and extend perhaps as much as 3 miles north of the Point. These beds are very rich in crustacean remains which are well preserved in numerous cobbles of iron-stained sandstone thrown up on the beach by the waves.

Southport 1-mile Sheet:

Outcrops are of very limited extent and consist of yellow claystone with belemnite casts as well as rare pelecypod remains.

Humpty Doo 1-mile Sheet:

Remnants of Mesozoic cover are confined to very strongly lateritized residual cappings of small areal extent.

Mary River and Mount Bundey 1-mile Sheets:

Mesozoic beds on these two 1-mile Sheets were not examined.

No outcrops of Mesozoic strata are known from Point Stuart, Woolner, Tumbling Waters, and Marrakai 1-mile Sheets.

PINE CREEK 4-MILE SHEET

As in the Darwin area, the Mesozoic cover of the Pine Creek 4-mile Sheet was largely stripped off, and its remnants appear as mesa-forming outcrops in the middle and south-east portions of the Sheet.

The beds in the south-east corner of the 4-mile Sheet, i.e. those making up the Mullaman Tableland and surrounding mesas, contain plant remains and are regarded as a continuation of the plant-bearing bed or beds of Fergusson River 4-mile Sheet and the south-west portion of the Katherine 4-mile Sheet. They consist of fossiliferous sandstone and overlying claystone of total thickness not exceeding 30 feet. In the past Darwin-type radiolaria were reported from these claystones. In the middle of the Sheet the thickness may be locally as great as 60 feet, but the beds are apparently barren, though still showing similar lithological sequence. Here, however, in places, the lower sandstone layer is underlain by hard, silicified, fine-grained rock which contains very rare ammonite remains. It is possible that ammonites occur also in the sandstone layer.

Burnside and Tipperary 1-mile Sheets:

The majority of sections examined here have a similar lithological sequence, in which a layer of quartz sandstone not exceeding 15 feet is overlain by up to 14 feet of claystone. The sandstone is white saccharoidal quartz sandstone, with a hard and silicified outer layer but friable inside; alternatively it may be red friable quartz sandstone. Grain-size varies between medium and coarse. The claystone is usually yellow and hard and shows structures which may represent very poorly preserved plant remains; on the other hand these may be solution perforations.

On the New Daly River Road, about 4 miles from the Stuart Highway (T.T.41), exposed sections differ

somewhat from the above. The greatest thickness measured is at least 70 feet and consists of:

30-36' Fine to medium-grained yellow and brown claystone.

25' White, saccharoidal quartz sandstone.

(?)20' Hard, silicified, nodular claystone, in places strongly lateritized, with rare ammonite remains.

Burrundie and Tabletop 1-mile Sheets:

These were examined during the 1960 field season. Mesozoic strata consist of:

10-12' White, hard, silicified claystone, with medium-sized quartz grains at the bottom.

12-16' Mottled sandstone with lenses of quartz grains of coarser size. Plant fragments at the bottom.

Douglas 1-mile Sheet:

Mesozoic outcrops are limited to remnant heaps of boulders of saccharoidal quartz sandstone overlying Cambrian limestone.

There are no Mesozoic strata on Mount Tolmer, Batchelor, Ban Ban, Mount Hayward and Daly River 1-mile Sheets. Wool Wonga and Reynolds River areas each have a single small outcrop of Mesozoic sediments, both difficult of access. These were not examined.

MT. EVELYN 4-MILE SHEET

Comparatively large areas of Mesozoic strata crop out on the eastern periphery of this 4-mile^{Sheet} area. These, unfortunately, were found to be quite inaccessible by land from the west and were, consequently, not examined.

In the rest of the Sheet Mesozoic beds are virtually confined to a large, if somewhat disjointed, plateau covered by Goodparla North, Goodparla South, Ranford Hill, Mount Evelyn and Mount Stow 1-mile Sheets. This plateau extends onto the Katherine 4-mile Sheet to the south. The sediments making up this large outcrop were examined at the following points: in the vicinity of the Coronet Hill Mine; to the south and south-east of El Sherana; at points where the new Moline-El Sherana Road crosses the Mesozoic beds on the Goodparla South Sheet; and in the north-western extremity of the plateau.

The surface of the plateau is almost everywhere covered with loose residual sand.

The greatest thickness of sediment examined was in a cliff, several miles long to the east of the Coronet Hill Mine, where at least 150 feet of Mesozoic sediments are exposed- the base is not seen. The succession is

the familiar sandstone-claystone sequence, here severely lateritized at the top. There are marine pelecypoda in the middle portion of the sandstone layer, and questionable plant remains close to the top of the claystone bed. The section is as follows:

- 10-12' Strongly lateritized claystone
- 35-40' Claystone, lateritized at the top, showing very gradual grain-size gradation towards the top. ?Plant bearing.
- 80-90' Yellow-red, medium grained, friable sandstone. Rare, large, rounded quartz cobbles at the visible base. Marine mollusca in the middle.*

Sections examined in the stream cuttings in the "inner" portions of the plateau are not as revealing, but are similar in lithology and, it is thought, contain successions similar to those described above. Towards the western and north-western margins of the plateau, however, there is a marked change in lithology and thickness. The claystone layer disappears altogether with the rapid diminishing of thickness, whereas the sandstones coarsen rapidly, passing into quartz conglomerates within a comparatively short distance. These conglomerates usually have well rounded pebbles and cobbles of surrounding Proterozoic rocks but are poorly sorted. These are marine near-shore conglomerates marking the westerly and north-westerly limit of the marine Mesozoic sedimentation in the area. The eastern and southern limits of sedimentation are probably outside the Mount Evelyn 4-mile Sheet area.

RIVER FERGUSON/4-MILE SHEET

The Mesozoic strata of this 4-mile Sheet are of considerable areal extent and can possibly be traced from the middle of the Pine Creek 4-mile Sheet south-east to Calvert Hills 4-mile Sheet area. They are relatively thick. Individual sections exceed 100 feet, but the occurrence of Mesozoic beds at different altitudes within short distances of each other suggests original thickness well in excess of that figure. On the other hand there is also evidence for infilling of original topographical irregularities. There is an obvious lack of marker beds, and without them it is very difficult to arrive at an accurate figure for the overall thickness of Mesozoic strata. The sequence consists of alternating layers of differing thicknesses of sandstone and claystone which are silicified to various degrees. Extreme lateritization occurred throughout this area, but subsequently the ferruginous zone has been removed by erosion from most of the outcrops, except in the south and south-western portion of the Sheet area.

* Plant remains were also observed at the base of the section not far from the spot where this section was measured. (Pers.comm.P.Dunn)

At several outcrops the lower sandstone layer have been found to contain plant remains. In the past, radiolaria of the type found at Darwin were reported from claystone which overlies the plant-bearing sandstone. This has led the previous workers to believe a marine transgression extended across the north part of the Territory into Queensland. The underlying plant-bearing sandstones were regarded as being deposited under non-marine, lacustrine conditions.

Muldiva Creek 1-mile Sheet:

Plant remains were collected at Buldiva as early as 1937. They were dated as Upper Jurassic by Walkom (in Hossfeld 1937) and Brunnenschweiler (in Traves, 1955). Noakes and Crespin (1952) favoured Lower Cretaceous age. Sections exposed in the vicinity of Buldiva show the following lithological succession:

- 18' Strongly ferruginized sandy claystone with some poorly preserved plant remains.
- 30' Yellow and white leached claystone. Secondary "rainbow" staining in concentric fashion.
- 35' Red and friable quartz sandstone. Cross-bedded, partly silicified, of uniform grain size, but with an admixture of coarser grains. Rare wood fragments.

The passage from sandstone to claystone is abrupt and the sandstone is purplish in colour close to its upper contact.

Obolloo and Lewin Springs 1-mile Sheet:

Outcrops are poor and good sections are lacking. Mapped Mesozoic consists of residual heaps of sandstone boulders overlying Cambrian strata, or of scattered claystone boulders overlying flat surfaces of residual Mesozoic sand.

Wingate North 1-mile Sheet:

The originally continuous Sheet of Mesozoic strata is strongly dissected by streams. The two sections given below are representative of a number examined:

- 1. 40' Reddish or dark brown, richly silicified porous quartz sandstone, with some plant remains (fragment of Taeniopteris)
- 20' Mottled claystone.
- 21' Loose, even-grained quartz sandstone. Wood fragments and angular pebbles and boulders common.
- 2. 44' Red, friable quartz sandstone. Straight, vertical, narrow and long cavities abundant (?Worm borings)
- 27' Interbedded yellow and purple-red claystone.

Hungry Knob 1-mile Sheet:

Well exposed sections in the Mesozoic strata occur in the middle and western portion of this 1-mile^{Sheet} area. A generalized lithological sequence for the area is as follows:

- 45' Dark brown, strongly ferruginised medium-grained sandstone. Abundant but indefinite markings and perforations (?plant remains)
- 20' Mottled claystone.
- 40' Red, friable, coarse-grained sandstone. Cross-bedded and ripple-marked, very coarse in places.

These strata are lacking in definite plant remains, but at one locality in the southeastern extremity of the Sheet well-preserved plants were collected (T.T.54):

- 6' Coarse, yellow-brown sandstone
- 4' Yellow claystone with numerous (?) worm tracks.
- 5' Yellow-red, medium-grained sandstone.
- 15' Not exposed.
- 20' White saccharoidal quartz sandstone with white claystone. Abundant plant remains at the bottom. Base of section not exposed.

Florina 1-mile Sheet:

Sequences consist of alternating layers of sandstone with claystone. The sandstone is white saccharoidal quartz sandstone or more frequently its weathered counterpart. Cross-bedding is common; ferruginization is not severe.

Wingate South 1-mile Sheet:

Mesozoic beds cover a large portion of this Sheet. Several sections examined in the north-western portion of this 1-mile Sheet show the following succession:

- 25' Hard, partly silicified, mottled sandstone. With or without (?)plant remains.
- 35'-40' Mottled micaceous claystone.

In the south, the cliffs overlooking the Fitzmaurice River are strongly lateritized to considerable depth.

Dorisvale, Mount Borwolla and Mount Freda 1-mile Sheets:

Stream channels have dissected the once continuous sheet of Mesozoic strata which covered this area, and only more or less scattered remnants remain. No fossils were found here. The lithological succession is generally similar and consists of alternating claystone and sandstone layers of limited thickness. Lateritic profile is strongly developed throughout these 1-mile Sheets. A representative section is as follows:

- 5' Very strongly lateritized rock. Original composition obscured.
- 20' Dark brown or red cross-bedded sandstone.
- 40' Mottled claystone.

Mount Bowman and Limestone Creek 1-mile Sheets:

Mesozoic strata occur as scattered remnants of a once continuous sheet of considerable thickness. A typical section is as follows:

- 10' White and yellow, mottled claystone. (?) Plant remains.
- 8' Massive and jointed, light and porous, yellow sandstone of uniform grain size.
- 35' Claystone, mottled at the top, greyish, hard, micaceous and uniform towards the bottom. Jointed on a small scale both horizontally and vertically
- 55' Massive, hard, medium-grained quartz sandstone.

KATHERINE 4-MILE SHEET

Mesozoic beds cover a large portion of the Katherine 4-mile area. Outcrops of the western and southwestern portion of the Sheet consist of a sandstone layer overlain by one or two layers of claystone. Greatest thickness measured is about 100 feet, but this is exceptional. The sandstone contains plant remains and is thought to be an extension of similar plant-bearing basal sandstones in the Fergusson 4-mile Sheet and in the southern portion of the Pine Creek 4-mile Sheet; in the future it may be possible to trace it to the south-east as far as the Queensland border.

In the past Darwin-type radiolaria were reported from the overlying claystone, especially those that were richly silicified, but recently collected samples have yielded a rich assemblage of arenaceous foraminifera similar to an assemblage from Lower Wilgunyah Formation of Mount Whelan 4-mile Sheet, south-west Queensland. (pers. comm. Dr. Crespin).

Outcrops of Mesozoic strata on the remaining portion of the Katherine 4-mile Sheet have yielded in places rich collections of marine macrofossils almost to the complete exclusion of plant remains. Lithologies in this area are not unlike those in the south-west portion of the Sheet, but differences in the fossil content suggest different environment of deposition. It is thought that the division-line between the different environments extends roughly parallel to the Stuart Highway, on its eastern side, and at varying distances from it. Because of lack of outcrops, frequent lack of fossiliferous outcrops, and similarity of lithologies, only approximate boundaries of sedimentation can be traced at this stage of investigation.

Mount Todd and Mount Harvey 1-mile Sheets:

Mesozoic strata occur in the eastern portion of the Mount Todd and in the western portion of the Mount Harvey 1-mile areas. Because of their inaccessability the strata were not investigated, but they are thought to represent a continuation of beds examined on the Mount Evelyn 4-mile Sheet. Beds in the south-eastern corner of the Mount Harvey 1-mile Sheet constitute a portion of a larger sheet of marine beds and in this area consist of a laterite capping about 15 feet thick.

Diljin Hill 1-mile Sheet:

Most of the surface area of this Sheet is covered by Mesozoic beds, but outcrops are poor and strongly lateritized. No fossils were found here. In the eastern extremity of the Sheet lateritization is less severe, and at one point about 25 feet of yellow-white claystone crops out. This claystone is unusual in being jointed and in having numerous coarse sandgrains. A few boulders of red friable sandstone appear at the base of the scree. The surface of the outcrops consists of loose residual sand and soil, or of occasional lateritic capping.

Katherine 1-mile Sheet:

The total thickness of Mesozoic beds is of the order of 100 feet. A good representative section 12 miles west of Katherine township has 20 feet of sandstone, 15 feet of yellow claystone and about 40 feet of purple-grey claystone. The basal sandstone is white saccharoidal quartz sandstone of uniform grain-size, but with an occasional admixture of quartz grains of larger size. In surface outcrop the sandstone may appear as grey, semi-rounded boulders or alternatively as strongly lateritized brown or reddish-brown masses. The only fossils found in sandstone occur east of Katherine and consist of rare and indistinct plant remains. The complete thickness of yellow claystone was observed only at the above locality where it passes into the overlying purplish clays. No macrofossils were found in either of the two claystones but microfauna is prolific and consists of marine arenaceous forams.

All other outcrops examined show limited thickness of basal sandstone with or without a few feet of overlying claystone.

Katherine River 1-mile Sheet:

Mesozoic strata cover most of this 1-mile Sheet area as a stream-dissected plateau whose scarps provide good sections, while the flat surface of the plateau is masked by residual sand and laterite or laterite alone.

At locality T.T.49, Yeuralba, about 30 feet of Mesozoic sediments are exposed. The base consists of about 5 feet of conglomerate made up of unsorted, rounded pebbles and cobbles of locally distributed Proterozoic strata, set in a clay-sandstone matrix. This is overlain by about 10 feet of white saccharoidal quartz sandstone which is richly fossiliferous, the assemblage

consisting of a few corals, belemnites and brachiopods, and of numerous genera and species of pelecypods, most of which have already been collected from Urapunga and Mount Young 4-mile Sheet areas. The fossils are not particularly well preserved and are difficult to extract from the rock matrix. Other fossil localities at Yeuralba were found during the 1960 field season (e.g. T.T.13) and illustrate very rapid variations, both lithological and faunal, within short distances.

No fossils were found at several other outcrops examined elsewhere on this one-mile Sheet but the sections are lithologically similar to that described for Yeuralba.

Black Cap 1-mile Sheet:

Fossiliferous localities (T.T.9-11, T.T.19) were found during the 1960 field season in the extensive Mesozoic beds. The lithological sequences are as follows:

- | | | |
|--------|-----|---|
| T.T.9 | 20' | Claystone with an irregular admixture of quartz grains. |
| | 30' | White saccharoidal quartz sandstone, or red-brown ferruginous sandstone with rounded pebbles at the top. Pelecypods, belemnites, roots, algae and corals occur here. |
| T.T.10 | 6' | Yellow claystone, silicified at the top. |
| | 50' | Red-brown ferruginous friable sandstone with pelecypods, belemnites and worm trails. Of uniform grain-size, but with 3" band of rounded pebbles, and other pebbles disseminated throughout the thickness. |
| T.T.11 | 6' | Yellow claystone. |
| | 9' | Very poorly sorted, cross-bedded river conglomerate. |

Sediments which contain marine fossils and which are of marine origin contain plant remains associated with river-borne conglomerate of very limited lateral extent.

Manbulloo 1-mile Sheet:

In this area a thin veneer of sandy claystone, usually strongly lateritized, overlies white, cross-bedded saccharoidal quartz sandstone, which is in many places altered to red, friable sandstone. The greatest observed thickness of the sandstone is 17 feet. Plant remains are common in the sandstone, but are poor and generically indeterminable.

Maranboy 1-mile Sheet:

Mesozoic cover is extensive, but in most places is obscured by loose residual sand, soil, or boulders of laterite. All scarps to the south and west of Maranboy

tinfield are of low relief and at best show but a few feet of sandstone or its overlying claystone. No fossils were found.

Outcrops in the north-eastern corner of the Sheet provide better sections. A typical sequence consists of up to 18 feet of mottled or yellow claystone, which in some places contains indefinite worm borings, underlain by up to 20 feet of impure red or yellow-red sandstone. The sandstone is often hard and contains abundant but questionable kelp remains.

Waterhouse 1-mile Sheet:

Sporadic belts of Mesozoic strata extend in the northern and eastern portions of this 1-mile Sheet. They were examined during the 1960 field season, when four fossiliferous localities (T.T.14,16,17,18.) were examined.

At T.T.14 and T.T.17 only heaps of boulders of iron-impregnated sandstone are visible. Some fragments of ammonites were found.

The section at T.T.16 is as follows:

- 6' Yellow claystone with pelecypods.
- 10' Iron-impregnated sandstone with worm borings at the top and pebbles of quartz at the base. An ammonite fragment was found at this horizon.
(Collector: R. Bryan)

At T.T.18, 30 feet of poorly sorted coarse sandstone with plant remains at the top overlies 2 feet of white, fine-grained claystone. This locality is one of very few which show coarser grained beds overlying finer grained ones.

King River 1-mile Sheet:

60-80 feet of sandstone was measured in some outcrops, and over 35 feet of claystone in others. The sandstone is the common saccharoidal quartz sandstone and does not contain fossils. The claystone is mottled, hard, weathered and jointed, also without fossils. No altitude readings are available, and in the absence of marker beds it is not possible to relate the individual outcrops.

Stirling 1-mile Sheet:

Scarps of Mesozoic strata are low and outcrops are generally unrevealing. Soil, residual sand, and laterite boulders mask the underlying beds.

Mataranka 1-mile Sheet:

Mesozoic beds in this area are confined to a solitary hill overlooking Waterhouse River. The section exposed consists of:

- 3' Hard, brown, compact quartz sandstone
- 10' White or yellow, soft or hard claystone
- (?)8' Red, friable sandstone.

URAPUNGA 4-MILE SHEET

Most of the original strata which are thought to have blanketed the whole of this 4-mile Sheet has been removed by erosion, and at present only a few scattered remnants remain. These are mainly concentrated in the north-west corner of the Sheet as flat-topped and flat-lying outcrops, but they also occur scattered singly or in groups of mesas over the whole of the Sheet ~~area~~. Throughout the area the sequence is generally similar and consists of a sandstone layer overlain by a claystone layer. The sandstone is usually uniform in grain-size with only a few instances of graded bedding. Thin lenses of conglomerate also occur but cannot be traced laterally. Haphazard admixture of coarser, angular and rounded grains and pebbles is common. The claystone layer is of more limited thickness than the sandstone and is rarely fossiliferous, except for indefinite worm borings which are relatively common. Marine fossil assemblages found in different portions of the 4-mile Sheet are closely similar to those in the Katherine 4-mile (e.g. T.T.49) and Mount Young 4-mile (esp. T.T.35) Sheets, and it is thought that sedimentation throughout this area and farther to the south, extending into the Mount Drummond 4-mile Sheet, was contemporaneous.

Canopy Rock 1-mile Sheet:

This 1-mile Sheet ^{area} was visited in the 1960 field season when fossils were collected at three localities, T.T.5, 7, and 8. Individual lithological successions and fossil content were as follows:

- T.T.5 6' Silicified, ironstained claystone showing gradual transition into sandstone below.
- 12' Strongly weathered sandstone of uniform grain size with usual admixture of larger angular grains and pebbles which occur singly or in bands.
- 2' Comparatively fresh sandstone with poorly preserved pelecypods, brachiopods and sponges. Slabs of underlying Proterozoic rocks included in the bottom of the sandstone sequence.
- T.T.7 4' White claystone with (?) sponges.
- 21' Unfossiliferous white sandstone.
- T.T.8 3' Weathered white or yellow claystone with an admixture of coarser quartz grains.
- 4' Hard, silicified blue-grey claystone with erect plant remains.
- 12' Alternating thick bands of sandstone with

thin bands of conglomerate. Sandstone with pelecypods, corals, brachiopods and belemnites. Conglomerate of rounded and sub-rounded pebbles. Slabs of Upper Proterozoic strata included in the base of the sandstone layer.

Mount Throsby 1-mile Sheet:

Mesozoic strata of this 1-mile Sheet were examined during the 1960 field season when a single fossiliferous locality, T.T.6, was visited. The collection is particularly rich in molluscan genera and species, and the lithological succession is as follows:

- 4' Mottled or whitish claystone
- 15' Unfossiliferous white sandstone
- 6' Hard, red, fossiliferous sandstone

Snowden Peak and Benda Bluff 1-mile Sheet:

It was not possible to examine the few and scattered outcrops of Mesozoic strata.

Flying Fox Creek 1-mile Sheet:

Scattered remnants of Mesozoic beds occur over the whole 1-mile area, but access to many of them is very difficult. Those examined were apparently unfossiliferous. They consisted at most of 15 feet of hard red sandstone overlain by 14 feet of yellow claystone.

Mount Turner 1-mile Sheet:

Mesozoic beds here are confined to the north-west corner of the 1-mile Sheet and form a part of a larger area of strata already examined at more accessible points on the Canopy Rock and Flying Fox 1-mile Sheets.

Maiwok Creek and Mount Patterson 1-mile Sheets:

On the Maiwok Creek 1-mile Sheet, Mesozoic strata occur in two groups of outcrops. The first is centred about the Sentinel Hill and at the most consists of 20 feet of sandstone overlain by 30 feet of claystone (e.g. T.T.47). No fossils were found in the claystone, but the sandstone layer contains in places very numerous worm borings (including Rhizocorallum) and a few specimens of Trigonia. The section exposed at Sentinel Hill itself is unusual in that the 3 feet of sandstone and 12 feet of claystone exposed there both contain unsorted and subrounded slate boulders.

The second group of outcrops forms a belt extending to the east and west of Die Jumb Peak. Here the greatest thickness measured is 40 feet and consists of 20 feet of sandstone overlain by 20 feet of claystone. Both layers are usually devoid of fossils, but at T.T.48 a belemnite and a gastropod (similar to one found in the Bauhinia Downs 4-mile) were found in the sandstone layer. The eastern edge of this belt of outcrops extends on to Mount Patterson 1-mile Sheet.

Mt. Chapman 1-mile Sheet:

No Mesozoic strata occur on this 1-mile Sheet area.

Urapunga 1-mile Sheet:

Outcrops of Mesozoic strata are confined to a group of mesas which occupy a small area in the south-east corner of the Sheet. These were examined at three points, two of which proved fossiliferous and were numbered T.T.45 and T.T.46. At T.T.46 a thickness of 65 feet is exposed and consists of 25 feet of white, hard claystone with some bryozoan and belemnite fragments. This claystone passes down transitionally into 30 feet of yellow and red (mottled) sandstone which contains abundant bryozoans and some pelecypods. About 10 feet of hard, red, ferruginous sandstone with belemnites underlies the sandstone.

At locality T.T.45 several feet of basal sandstone are preserved as basal boulders. These are strongly ferruginised, and contain many large pelecypods which are possibly correlable with pelecypod faunas from T.T.6 and from Yeuralba, as well as with the fossils from Mount Young area.

Roper Valley and Mount Eclipse 1-mile Sheets:

No Mesozoic strata occur here.

ROPER RIVER 4-MILE SHEET

There are six small outcrops known, of Mesozoic strata, on the Roper River 4-mile Sheet. Although most of them were visited and were found to contain some fossils, collections were made from only two of them, T.T.42 (on the Roper River 1-mile Sheet) and T.T.43 (on the Phelp River 1-mile Sheet), they represent the most prolific occurrences of Mesozoic fossils in this 4-mile Sheet area.

The lithologies are similar to those examined in other parts of the Territory and consist of iron-stained, quartzitic sandstones and kaolinic claystones as well as laterites, residual sands and conglomerates. Thicknesses of strata are everywhere limited, while sequences are variable, consisting at some localities almost entirely of claystone (e.g. T.T.42, where 24 feet of claystone is underlain by a foot of conglomerate) and at others sandstone.

The majority of fossils contained in these sediments are confined to the upper portion of the sequence. They consist of belemnites and echinoid spines as well as species of pelecypods. Many fossils are flattened suggesting removal of a thickness of strata.

Field identifications suggest contemporaneity of deposition of Roper River sediments and Mesozoic deposits

of Katherine, Bauhinia Downs, Mount Young, Urapunga
4-mile Sheets.

BAUHINIA DOWNS 4-MILE SHEET

Scattered remnants of Mesozoic cover occur in most parts of this 4-mile Sheet, although there is a concentration of outcrops in its western portion. Here, however, large areas of presumably Mesozoic strata are masked by later deposits.

Bauhinia Downs 4-mile area has a complex pattern of sediments containing assemblages of fossils usually associated with basically different environments of deposition. There are claystones and cross-bedded and ripple-marked sandstones which contain rich marine fossil faunas. Similar or somewhat different sandstones and claystones in adjoining areas commonly contain numerous plant remains. Some of these are directly associated with roughly cross-bedded, very poorly sorted, round pebble and cobble conglomerates which are restricted in their lateral developments and which at one time may have been deposited by rivers. Other, more numerous, plant-bearing beds are surrounded by conglomerate-free even-grained sandstones of considerable lateral extent. It is suspected that these were laid down in a still-water, non-marine environment. In some places these different kinds of deposits are found to grade laterally into each other, showing close association of different environments at the same time. In addition, both marine and non-marine deposits occur at different elevations. In some areas this is caused by original relief in the surface on which Mesozoic sediments were laid down, but in others it implies successive incursions and withdrawals of sea with the passage of time.

Only a relatively small percentage of all Mesozoic outcrops was visited and data obtained are not sufficient to allow plotting of boundaries between sediments deposited in different environments.

Bauhinia Downs 1-mile Sheet:

Fossils were collected at three localities during the 1960 field season, T.T.31, T.T.32 and T.T.33. Lithological sequences are as follows:

- T.T.31 6' Plant-bearing, impure claystone.
- 30' Cross-bedded and ripple-marked medium-grained, saccharoidal quartz sandstone, with alternating layers with plant and marine fossils.
- T.T.32 15' White saccharoidal quartz sandstone with plants.
- T.T.33 15' Yellow, hard and massive claystone with marine fossils.

Yalco Creek 1-mile Sheet:

Only one collection of fossils, T.T.23, consisting of well preserved plant remains was obtained. The outcrop consists of residual boulders of fine-grained silicified sandstone. Collector K.A. Plumb.

Borrooloola 1-mile Sheet:

The thickest Mesozoic sequence examined at any one spot is located on Run 3 Ph.5205 Pt. 3. The unfossiliferous lithological sequence is as follows:

- 30' Hard, yellow claystone.
- 2' Banded purple and yellow claystone; individual bands 8" thick.
- 20' Cross-bedded red and white medium-grained sandstone.

Fossils were collected from four localities (T.T.21,25,26 and 27).as follows:

- T.T.21 15' Massive, hard, yellow and white silicified claystone with quartz pebbles distributed irregularly throughout. Fossils, flattened by vertical compression, consist of pelecypods, belemnites and wood fragments and are confined to the lower portion.

One section, examined between T.T.21 and T.T.22 shows the following succession:

- 2-6' Massive, yellow-white claystone.
- 6" Round pebble conglomerate with rare and poorly preserved belemnite and bivalve casts. (not collected).
- 16' Massive red-brown sandstone, even-grained except for quartz pebbles which increase in numbers towards the top.

- T.T.25 20' Red and white (mottled) claystone
- 3' White claystone with marine fossils.
 - 6" Round pebble and cobble conglomerate with slabs of underlying Proterozoic rock at the base. Pelecypods, gastropods and belemnites occur here.
- T.T.26 10' Dark grey and brown sandstone with poorly preserved plant impressions.

About $1\frac{1}{4}$ miles north of the above outcrop occur round cobble conglomerate beds which are suspected to have been deposited by a river. It is thought that plant remains at T.T.26 were brought in by the river which deposited the conglomerate along its channel.

Balbirini 1-mile Sheet:

Fossil plants were found at one locality, T.T.34, during the 1960 field season. The sequence exposed consists of:

- 5-10' Massive and white medium-grained, friable quartz sandstone with plants.
- 30-40' Massive white and grey porcellanite and chert.
Collector: K.A. Plumb.

Batten Creek 1-mile Sheet:

Some Mesozoic strata were examined during the 1960 field season, when fossils were found at two localities, T.T.22 and T.T.28. Lithological sequences at these two outcrops are as follows:

- T.T.22 15' Claystone similar to that at T.T.21, but with bands of belemnite casts. Gastropods, wood fragments, and flattened pelecypods also occur here. Top 1' of claystone soft and weathered.
- T.T.28 8' Pebble conglomerate with subangular to subrounded grains; contains casts of belemnites and pelecypods.
- 7' Claystone with an admixture of quartz sand.
- 1' Angular, loosely cemented sandstone fragments
- 4-5' Alternating layers of sandstone and chert.
- (?)20' Greyish to white hard sandstone.(?Mesozoic)

O.T. Downs 1-mile Sheet:

Mesozoic strata were examined at four points on this Sheet, and at one spot, T.T.29, fossils were found. Sections examined are as follows:

- Three Knobs: 10' Yellow claystone
- 15' Coarse, poorly sorted sandstone with worm borings at the top. Contains scattered pebbles up to $1\frac{1}{2}$ " across
- T.T.29 20-25' Creamy, strongly leached claystone with worm tubes (?).
- ?15' Red sandstone.
- Favenc Range 50' Mottled zone and pallid zone claystone
- ?20' Heavy, iron-impregnated sandstone (Mesozoic?)

Run.II Ph.5413 Pt.I: 10' Mottled zone claystone
 20' Cream and rosy pallid zone
 claystone

Mallapunyah 1-mile Sheet:

Only one collection, T.T.24, consisting of plant remains, is available from this 1-mile Sheet. The rock consists of hard, silicified, off-white sandstone.

MOUNT YOUNG 4-MILE SHEET

Although Mesozoic strata are very widespread on the Mount Young 4-mile Sheet it was possible to examine only four sections in detail. All are fossiliferous and bear the following numbers, T.T.35, T.T.55-57. Sequences exposed at these outcrops are as follows:

T.T.35: 30'-40' Mottled, sandy claystone with a rich marine fauna

20- 30' White, saccharoidal quartz sandstone with plant remains. (Collected originally by A.G.L. Paine.)

T.T.55: 35' White, hard, saccharoidal quartz sandstone, Rounded or angular, coloured sandstone pebbles in the top 20'. Small-shell fauna for the next 10', with a 6" band of belemnites and large Trigonias close to the bottom. Bottom 3' contains no fossils; it is stained yellow or pink and has rounded pebbles scattered through it. (Collected originally by K. Plumb.)

About 200 yards away from this outcrop fossils disappear altogether and are replaced by a conglomerate whose cobbles and pebbles are derived from the surrounding Proterozoic strata. The position of this conglomerate, which is deposited against an old "high" formed by the Yiyintyi Range, the type of pebbles which are well sorted but angular, and the close association of a rich marine fauna suggest this to be a near-shore marine conglomerate.

T.T.56: 24' Hard, creamy or yellow-red sandstone with pelecypods.

40' Sandstone, red and friable at the top, hard and white beneath.

T.T.57: 23' Red and friable sandstone with a remnant hard layer at the top. Marine bivalve fauna.

TANUMBINI 4-MILE SHEET

Only three fossiliferous localities were examined in the Tanumbirini 4-mile Sheet, these were T.T.36, T.T.37 and T.T.38. At T.T.36, clean, white

quartz sandstone contains plant remains, T.T.37 consists of red, impure sandstone with worm tubes. T.T.38 has 5-10 feet of buff-coloured, fine-grained quartz sandstone, also with worm tubes. Specimens from all three localities were collected by A.G.L. Paine.

HODGSON DOWNS 4-MILE SHEET

Here the Mesozoic beds were examined at only one locality. At T.T.58 the lithological sequence is as follows:

- 30' Hard, mottled claystone with a laterite capping.
- 8' Hard, dark brown, iron impregnated sandstone with rare belemnites.
- 3' Calcarenite, brown when fresh, greenish when weathered.
- 9' Sandstone as above, but with belemnites more common.

Both localities were originally visited by A.G.L. Paine.

WALLHALLOW 4-MILE SHEET

Mesozoic beds are very extensive, forming part of the Barkly Tableland plateau. Outcrops, however, are scarce. Unfortunately, it was possible to visit only those outcrops which are exposed in the vicinity of the Malapunyah - Cresswell Downs road. A section on the eastern side of the road, about 1 mile north of the gate, 6 miles south of the Top Springs Waterhole, is as follows :

- 23' Alternating sandstone-claystone layers, individual beds less than 7' thick.
Sandstone hard, red, cross-bedded.
Claystone yellow, hard, strongly jointed, showing conchoidal fractures.
- 57' Claystone, hard and yellow at the top, softer and comparatively fresh and blue-grey towards the bottom. Base not visible.
Micro-fossil examination showed the presence of arenaceous forams in abundance.

At this locality no macrofossils were found, but field geologists (K.A. Plumb and J.M. Rhodes) reported the presence of poorly preserved plant remains in the sandstone beds to the east of this locality. These plants were not collected and it is not known whether the two sets of sandstone are from the same horizon.

Sections examined at the northern edge of the Tableland suggest that the overall thickness of the Mesozoic strata in this area is well in excess of 100 feet.

CALVERT HILLS 4-MILE SHEET

Large sheets of Mesozoic strata crop out in the north-western, southern and south-eastern portions of this area. Only the more accessible outcrops, i.e. those in the vicinity of Seigals Creek Homestead and along Seigals Creek - Calvert Hills Road were examined.

Major portion of sediments examined consist of plant-bearing quartz sandstone overlain by apparently barren claystone. The sandstone is thought to be an extension of the plant-bearing sandstone of the Fergusson 4-mile Sheet. Some beds containing a limited marine fauna crop out about 12 miles east of Seigals Creek Homestead. Their lateral extension is not known.

Plant-bearing sediments.

These extend from at least 20 miles south to at least 22 miles north of the Seigals Creek Homestead, and stretch no less than 20 miles across. The beds occur as a partly stream-dissected plateau, and as low-level infillings of lows in the pre-Mesozoic surface. Sections exposed are as follows:

1. $\frac{1}{2}$ miles south-west from Seigals Creek Homestead (T.T.59):
 - 14' Sandy red and yellow claystone (?worm tracks)
 - 4' White, pink and yellow claystone
 - 33' (?50') Red, friable, sandstone and white, saccharoidal, cross-bedded quartz sandstone. Plant-bearing.
2. 2 miles east of Tin Hole:
 - 30' Interbedded claystone and sandstone, possibly plant-bearing; strongly lateritized.
3. Headwaters of Settlement Creek:
 - 32' Ferruginised, mottled claystone
 - 42' Medium-grained, friable, red and pink sandstone with rare plant remains
 - 55' White, saccharoidal, quartz sandstone with poorly preserved plant remains.

Area of marine deposition:

1. Elongate mesa 9 miles east of Seigals Creek Homestead.
 - 10' Claystone with thin sand lenses. ?Worm borings.
 - 10' Coarse, badly sorted, ferruginised sandstone with size of grains decreasing towards the top.
 - 11' Alternating layers of uniformly grainsized claystone and pebbly claystone.

2. 22 miles north-east from Seigals Creek Homestead:
20' Hard, red, medium-grained sandstone.
3. 12 miles south-east from Seigals Creek Homestead
(T.T.60):

Near-shore facies with very irregular lithology undergoing very rapid lateral variation. Round fossiliferous cobble conglomerate near the shore at the base of the sequence. This is overlain by long thin lenses of clay and thicker beds of coarse sandstone. Lithologies are more stable farther away from the shore and consist of about 6 feet of claystone with sandy lenses overlain by 15 feet of very coarse sandstone or grit.

MOUNT DRUMMOND 4-MILE SHEET

Mesozoic strata of this area was not examined by the writer. In 1959 H.G. Roberts collected a small pelecypod assemblage (T.T.52) which in spite of poor preservation has some diagnostic forms which appear similar to recently found better-preserved (?) Neocoenian assemblages of the Mount Young 4-mile Sheet.

MELVILLE ISLAND 4-MILE SHEET

The purpose of the Bathurst Island visit was to recollect fossil faunas known to occur there and to make further stratigraphical observations. Unfortunately, the proposed length of stay had to be limited to one week, which resulted in the mission being only partly successful.

In 1954 B. Daly, University of South Australia, made geological observations on Bathurst Island, and his detailed and exhaustive notes on stratigraphy, lithology, and palaeontology (field identifications only) of the Cretaceous beds found there are available in an unpublished report at the Bureau of Mineral Resources Library, Canberra. Numerous fossils collected by Daly were sent to England where they are undergoing detailed examination.

"Report on reconnaissance survey of Bathurst Island" by A.M. George, R. Hare, and Associates (Oil Development), of 16th December, 1960, is lodged on a Bureau of Mineral Resources File 106/N.T/5Pt.2, and contains a comprehensive summary of field observations on Cretaceous and post-Cretaceous sediments of this island.

As a result of the writer's short visit the following additional notes are available:

I. The Tertiary cover, which masks the Cretaceous beds over most of the island and which is regarded as fresh-water or continental type, is at least in part of marine origin, and may still be forming at the present time. Two fossils found in a well-indurated quartz sandstone outcropping at sea-level on the western shore of the island are a well-preserved mollusc Spondylus, of a present day species, and an Exogyra, also a present day form. The

Spondylus still retains its natural colour.

2. A single lump of iron-impregnated rock carrying several poorly preserved shell impressions was collected two years ago from the beach on Clift Island, a small island off the western coast of Bathurst Island, and was regarded as possible evidence for a local occurrence of Permian rocks. No further fossils were found by the writer in close proximity to Clift Island, which, however was not visited, and nothing was seen to suggest presence of beds older than Cretaceous.

3. At present it is not possible to correlate the Bathurst Island beds with the Mesozoic beds at Darwin. The 30 mile long section exposed in cliffs along the southern shore of the island is mostly of Lower Cenomanian age. There is evidence for local presence of Lower Turonian beds, and local upfaulting has upthrown some Albian strata. Only the Albian sediments may, in time, be correlable with the Darwin beds, which, at least in part are of Upper Albian age. Lithologies in the two areas are only generally similar, and results of detailed examination of fossils is not yet available.

Fossil collecting on Bathurst Island was limited to the southern coast, in particular, to a stretch between Marialampi Point (about 9 miles south-west of the Bathurst Island Mission) and Mirindow Point, where localities T.T.50 and 51 were established.

PRELIMINARY NOTES ON THE HISTORY OF SEDIMENTATION OF THE CRETACEOUS STRATA OF THE NORTHERN TERRITORY.

1. NEOCOMIAN

Sedimentation in the Northern Territory during the Mesozoic commenced at about the beginning of the Cretaceous - probably at the beginning of the Neocomian - in the Valanginian times. The part of the Territory in which Neocomian sediments occur extends as a belt of uneven width along the southern and southwestern margins of the Gulf of Carpentaria. Near the Northern Territory - Queensland border this belt is probably less than 50 miles across, but there is some evidence for Neocomian strata in the western portion of the Drummond 4-mile Sheet, about 150 miles from the present day coastline. This belt widens to over 200 miles west of the mouth of the Roper River and probably extends under the Gulf of Carpentaria where it is covered by younger sediments; its eastern and north-western extremities are as yet not known.

The surface of the land upon which Neocomian sediments were deposited was low-lying, and flat in many places, but by no means devoid of relief. In the low-lying areas deltaic or estuarine conditions prevailed for at least some of the time, to be replaced from time to time by definite marine conditions possibly brought about by transgression of the sea. Small surface irregularities

in the Mesozoic surface were dwarfed by low mountain ranges of the older, resistant rock, remnants of the preceding cycle of erosion. These overlooked the marshy depressions, only to be isolated as islands and promontories, and the lower ones completely submerged, during the transgression of the sea over land and over areas of non-marine sedimentation.

The low deltaic areas must have received a large volume of sediment, much of it quartz sand, from the south - probably from the eroded Proterozoic sandstones, Cambrian sandy limestones, and volcanics of various ages and the accumulation of only very limited thickness of sediment is probably due to very slow overall sinking of the ocean bottom. As the sedimentation proceeded, some changes must have taken place in the drainage pattern, and the provenance of the rivers, which brought in much of the sand, as well as some round pebble and cobble conglomerates, changed from time to time, with the resultant periodical deposition of claystone. But at all stages of the early Cretaceous deposition in the Northern Territory some of the old areas of high relief remained above the water level, supplying coarser detritus to the areas of sedimentation. This detritus consisted of angular or sub-rounded pebble and cobble conglomerates which were deposited against the old highs as near-shore conglomerates; more important, it consisted of individual angular and sub-angular pebbles and cobbles of variable abundance, but associated characteristically and ubiquitously with the marine and the non-marine sediments which otherwise were uniformly grained.

Plant remains, brought in by the rivers, were incorporated in both the marine and the non-marine sediments, in the latter, almost to the complete exclusion of other fossil types. This lack of the preserved endemic forms of life (e.g. burrowing worms, etc.) in non-marine sediments may be regarded as evidence for brackish or near-brackish conditions. There is no good evidence for fresh-water lakes. Plant remains were also found directly associated with unquestionably marine sediments. It is unfortunate that the distribution of plant remains is not uniform, for this leaves large volumes of sediment devoid/and apparently barren of any remnants of life, and the environment in which these barren beds were laid down can only be guessed at. In the Neocomian mudflats, plant roots and stems are found preserved in position of growth, but these are not common.

At some outcrops of Neocomian strata, plant-bearing saccharoidal sandstones are overlain by sands and clays with a rich marine molluscan fauna, while in others the reverse is true. At least one section shows successively alternating horizons with plants and marine fossils. It seems clear, therefore, that marine and non-marine conditions succeeded each other, both laterally and in time. Rise and fall of the sea-level with the resultant changes in the river grade may have accounted in part for some changes in the grain-size of the sediments, but changes due to this cause must have been minor, as is suggested by the friable and easily eroded character of the Proterozoic quartz sandstones, whose individual grains would be but little affected by transport as the distance from the source to the place of deposition increased. Presence of similar fossil assemblages and of identical conglomerates in both claystones and

sandstones in a single sequence is regarded as further evidence suggesting that abrupt change of grain-size from coarse to fine is, at least in those cases, independent of the depth of water. Vertical gradation of the grain-size from coarse to fine at the top of sequence observed in some sandstones may, however, be the result of steady lowering of the bottom.

The frequently observed cross-bedding and the less common ripple-marking, which are confined to the sandstones, as well as the presence of marine shallow-water faunas, suggests shallow water environment. In spite of periodical partial emergences, some overall sinking must have been taking place during the deposition, allowing accumulation of a limited thickness of sediment. The thickest sections examined hardly exceed 120 feet, but fossils collected close to the gulf coast, i.e. presumably in the area of greatest accumulation at present above the sea level, are found to be strongly compressed by the weight of the overburden, now removed. This applies to shells collected from the top layers of the present-day sections. This does not, however, necessarily imply removal of any great thickness of strata.

There is some evidence that the marine transgression which preceded deposition of claystone with the Wilgunyah-type arenaceous foraminifera over the inland non-marine arenites extended over at least some Neocamian beds.

2. ALBIAN MARINE

Albian marine sedimentation took place in the extreme northern portion of the Northern Territory. At this stage of the investigation the full extent of this transgression, which occurred in the Upper Albian and probably proceeded from the north, cannot be traced satisfactorily but beds which contain macrofossils of this age have been found on Bathurst Island, at Darwin, in coastal outcrops on each side of Darwin, and possibly in an inland outcrop 70 miles south-south-east of Darwin. There are relatively large exposures of Mesozoic strata extending along the northern coast of Arnhem Land which have not so far been investigated, but which may possibly be of Albian age. Finally, past records indicate the possibility of Albian beds outcropping on the eastern shores of the Bonaparte Gulf. It is likely, therefore, that the least potentially tracable area of Albian sedimentation is about 450 miles long and 150 miles across. The encroachment of sea on to the land must have been rapid, and there is nothing to suggest that the Upper Albian transgression took longer than a portion of the duration of a single stage.

Previous reports of Darwin-type radiolaria from inland outcrops in the vicinity of Buldiva and along the Northern Territory portion of the Barkly Tableland (Cresswell Downs, etc.) have led previous workers to postulate an Upper Albian transgression across the northern portion of the Territory into Queensland. Unfortunately, recent attempts to substantiate this view have not met with success.

Mesozoic sediments in the immediate vicinity of Darwin are of limited thickness and their outcrops are confined to coastal areas and cliff sections. They consist of a near-horizontal lateritized and silicified sandstone-claystone sequence, which for a long time has been regarded as of Cretaceous age. These beds overlies Proterozoic strata with an angular unconformity and are separated from them by a laterally impersistent layer of quartz boulders and pebbles originally derived from quartz lenses in the Proterozoic beds. Fossil content in the Cretaceous beds at Darwin is confined to rare pelecypods, very rare ammonites, radiolaria, and very numerous external casts of belemnites.

South of Gunn Point, which is about 20 miles north-east of Darwin, a leached cliff section, apparently unfossiliferous, is underlain by soft blue-grey clay with some sand lenses which has yielded, both recently and in the past, pelecypods, gastropods, ammonites, and crustaceans. Etheridge (1907) dated this assemblage as Lower Cretaceous and correlated the horizon in which it occurs with another richly fossiliferous bed at Charles Point. Whitehouse (1926, p.279) dated the Charles Point assemblage as Upper Albian. The preservation of fossils in the two assemblages is not the same, and while at Gunn Point the parent bed is visible at the surface (though its contact with the overlying cliff section is obscured, and its base has never been seen), the source bed at Charles Point is submarine.

If Etheridge's correlation and Whitehouse's dating of Charles Point and Gunn Point horizon are correct, then the horizontal or near horizontal disposition of the beds at Darwin suggests the presence of two distinct horizons. Following similar reasoning, Noakes and Crespin (1952, p.103) suggested that "...the beds containing the larger fossils at Point Charles, Gunn Point, Darwin, are of Upper Aptian or Lower Albian and the radiolarian beds of Upper Albian age." This conclusion, however, questions Whitehouse's dating of the Charles Point beds, and presupposes the presence at Darwin of a distinct Radiolaria horizon overlying a lower horizon with belemnites: this has never been demonstrated.

Wave-cut cliff sections north-east of Darwin exposed at Cape Hotham, Escape Cliff, Point Stephens, Clyde Point, as well as at Charles Point, contain no macrofossils. Twelve miles south of Gunn Point, however, at Tree Point, there is evidence for a submarine fossiliferous bed not older than Pleistocene. In the absence of any other fossil evidence (e.g. microfossils) in the above-cited coastal sections, this may possibly provide evidence for late Tertiary age of the sediments exposed there. At Bathurst and Melville Islands, Middle Cretaceous sediments are overlain by Tertiary deposits which, although regarded in the past as of fresh-water origin, are known to be at least in part marine, and of very young age.

The Neocomian beds around the Gulf of Carpentaria discussed already do not seem to be related geographically or palaeontologically to the Upper Albian beds around Darwin. At this stage there is nothing to discount the probability that these two regions were anything but two unconnected areas of sedimentation, the deposition of which was brought about by local marginal downsinking of the

Australian continent at two distinct points.

Although there is no evidence for the initiation of marine sedimentation in the Darwin area before Albian times there is ample evidence for its continuation beyond the Upper Albian. Most of the coastal sections exposed along the southern shores of the Bathurst and Melville Islands are of Cenomanian age, and there is some evidence of Lower Turonian. In this off-coastal area, however, conditions of deposition differed from those on the mainland in the more accelerated downsinking of the accumulating material, and perhaps in a greater volume of sediment available. This allowed a greater thickness of material to accumulate, especially to the west of, and in the western portion of Bathurst Island. Recent drillings on this Island have penetrated over 1000 feet of Cenomanian strata without reaching the basement rock.

3. THE INLAND MESOZOIC BASIN

A third area of Mesozoic sedimentation in the northern portion of the Northern Territory extends as a belt of irregular width from the vicinity of the eastern shore of the Bonaparte Gulf in the north-west to the Queensland border in the south-east. Sediments of this belt have been examined recently in parts of the following 4-mile Sheets: Pine Creek, Fergusson^{River}, Katherine, Hodgson Downs, Tanumbirini, Bauhinia Downs, Wallhallow, and Calvert Hills. Much work is still to be done in these areas as well as in others, which have not been so far at all investigated.

Differences in elevation of the beds, lack of marker horizons, frequent lack of fossils and fossil horizons, numerous original variations in lithology from place to place and in time, and finally, changes in lithology brought about by prolonged leaching, lateritization and erosion - all have contributed towards the difficulty of interpreting the history of sedimentation in this area of deposition. However even at this stage some generalizations are justified.

Sedimentation in the inland area seems to have commenced with deposition of quartz sand. Complete lack of marine fossils both large and small, coupled with the presence of plant remains over large areas of sandstone outcrops, implies a non-marine environment - possibly a lake without a sea connection. The presence or absence of this sandstone at any particular locality, and its thickness, is at least in part dependent on the elevation of the basement rock above the sea-level about the time of deposition. Over 55 feet of saccharoidal sandstone was laid down in some areas, none in others.

After sand clay was deposited. At one outcrop, close to Katherine, 55 feet of clay was measured, its top an erosion surface. This outcrop yielded a well preserved assemblage of arenaceous ~~Foram~~inifera of unknown age.

In the vicinity of Buldiva, plant-bearing sandstone is overlain by about 20 feet of claystone which here is barren of fossils, but which is in turn overlain by plant-bearing sandy claystone. In the past, radiolaria similar to the type occurring in the coastal sections at Darwin were reported from siliceous, fine-grained rock overlying the upper plant-bearing sandy bed. If the claystone which overlies the lower sandstone bed at Buldiva can be correlated with the foraminifera-bearing claystone in the vicinity of Katherine, then we have possible evidence for two marine transgressions which interrupted two periods of non-marine sedimentation. Too little is known at this stage to warrant any definite conclusion.

The assemblage of arenaceous foraminifera from the vicinity of Katherine is very similar to another from south-west Queensland (Mt. Whelan 4-mile Sheet) where it occurs in the Lower Wilgunyah Formation, which is probably of Aptian age. The arenaceous forams, however, are long-ranging species and their distribution in time is not clearly known and, whereas in Queensland an independent control has been exercised with the aid of associated fossil groups, this is not possible at this stage in the Northern Territory. Foraminifera similar to those near Katherine have also been obtained from fine-grained strata in other parts of the Territory (i.e. from the Wallhallow 4-mile Sheet), where the underlying beds are also plant-bearing sandstones, and from the Mt. Evelyn 4-mile Sheet, where the underlying beds contain Neocomian marine strata.

In the middle of the Pine Creek 4-mile Sheet, some fragments of ammonites were found in fine-grained, siliceous rock underlying a sandstone-claystone sequence not unlike the sandstone-claystone sequences of the inland basin, but apparently devoid of fossils in this outcrop. It is thought that the fossiliferous bed is an inland extension of the Darwin marine **strata**, but it is not possible to say whether the upper portion of the sequence also belongs to the Darwin marine beds, or whether it is a continuation of the beds of the inland basin of sedimentation. If the latter is true, then the inland sandstones and the overlying claystones cannot be older than Upper Albian.

At present no definite conclusion is possible about the age of the sediments in the inland basin.

ACKNOWLEDGEMENTS

I wish to thank especially C. Prichard, H.G. Roberts, A.G.L. Paine, K.A. Plumb and J.M. Rhodes for assistance in facilitating the examination of Mesozoic strata, collecting fossils and ensuring their safe arrival at Canberra. Many discussions with these field geologists, and also with P.R. Dunn, helped towards obtaining a clearer picture of the history of deposition of Mesozoic sediments, especially in those parts of the Northern Territory not visited by the writer.

I also wish to thank J.N. Casey and J.M. Dickins for constructive criticism of this Record.

REFERENCES

- BRUNNSCHWEILER, R.O., 1955 - In D.M.Traves, Appendix C:
"Report on Mesozoic plants from the
Mullaman Group in the vicinity of
Willeroo, Northern Territory."
Bur.Min.Resour.Aust.Bull. 27.
- DALY, B., 1954 - Geological Observations on Melville
and Bathurst Island. Dept.Geol.
Univ.of S.A.
- ETHERIDGE, R. Jun., 1907 - "Official contributions to the
Palaeontology of South Australia".
S.Aust.Parl.Papers 54 (Suppl. to
55, 1906), 15-21.
- NOAKES, L.C.; CRESPIAN, I., 1952 - In L.C.Noakes, A.A.Öpik and
I.Crespin; "Bonaparte Gulf Basin,
North Western Australia." 19th
Cong.Geol.Internat.Symposium Ser.
Gondwana, 91-106.
- SKWARKO, S.K., 1961 - "Progress Report on Field Activities
in the Northern Territory during
the 1960 Field Season". Bur.Min.
Resour.Aust.Rec. 1961/11 (Unpubl.)
- WALKOM, A.B., 1937 - In P.S.Hossfeld: "The Tin Deposits
in the Buldiva-Collia Area, Daly
River District." Aerial, Geological
& Geophysical Survey of Northern
Australia.Rept. 18.
- WHITEHOUSE, F.W., 1926 - "The correlation of the marine
Cretaceous deposits of Australia."
Rept.Aust.Assoc.Adv.Sci. 18,
275-280.

APPENDIXLIST OF LOCALITIES IN MESOZOIC STRATA FROM WHICH FOSSILS
WERE COLLECTED DURING THE 1961 FIELD SEASONMT. EVELYN 4-MILE SHEET:Ranford Hill 1-mile Sheet

- T.T.40: About 5 miles south-east of Coronet Hill Mine;
2 miles due east of the southern tip of the Little
Mary Waterhole
Fossils: Pelecypods, plants, wood fragments.
Age: Lower Cretaceous (Neocomian)

PINE CREEK 4-MILE SHEET:Burnside 1-mile Sheet

- T.T.41: On the new Daly River Road, about 5 miles from the
Stuart Highway.
Fossils: Ammonites
Age: Upper Albian (Lower Cretaceous)

ROPER RIVER 4-MILE SHEET:Port Roper 1-mile Sheet

- T.T.42: 4 miles south-east of Murrenjerro Waterhole
Fossils: Pelecypods, belemnites.
Age: Neocomian (Lower Cretaceous)

Phelp River 1-mile Sheet

- T.T.43: About 20 miles north-north-west of Wommurri Waterhole
Fossils: Pelecypods, gastropods, belemnites
Age: Neocomian (Lower Cretaceous)

Sheet 5/64 1-mile

- T.T.44: About 9 miles north-west of Wommurri Waterhole.
Fossils: Pelecypods and belemnites
Age: Neocomian (Lower Cretaceous)

URAPUNGA 4-MILE SHEET:Urapunga 1-mile Sheet

- T.T.45: About 2 miles north of the Roper Valley road, about
18 miles east of the Roper River Mission.
Fossils: Pelecypods, corals, belemnites
Age: Neocomian (Lower Cretaceous)
- T.T.46: About $14\frac{1}{2}$ miles east of the Roper River Mission.
Fossils: Pelecypods, belemnites, bryozoans
Age: Neocomian (Lower Cretaceous)

Maiwok Creek 1-mile Sheet

T.T.47: 2.3 miles, 10° west of north from Sentinel Hill.

Fossils: Worm tubes and pelecypods
Age: Neocomian (Lower Cretaceous)

T.T.48: About 6½ miles north-west from Die Jumb Peak

Fossils: Belemnites and gastropods
Age: Neocomian (Lower Cretaceous)

KATHERINE 4-MILE SHEET:Katherine River 1-mile Sheet

T.T.49: 1.2 miles north off the edge of the plateau, in cliffs facing Katherine River across main Yeuralba Mine Road.

Fossils: Pelecypods and belemnites
Age: Neocomian (Lower Cretaceous)

MELVILLE ISLAND 4-MILE SHEETBuchanan 1-mile Sheet

T.T.50: Southern coast of Bathurst Island. In cliff between Marialampi Point and Pouplimadourie Creek

Fossils: Ammonites and pelecypods
Age: Cenomanian (Upper Cretaceous)

T.T.51: Southern coast of Bathurst Island, Cliff between Pouplimadourie Creek and Mirindow Point.

Fossils: Ammonites and pelecypods
Age: Cenomanian (Upper Cretaceous)

MOUNT DRUMMOND 4-MILE SHEETWaterfall Creek 1-mile Sheet

T.T.52: 12 miles north-west to west-north-west of the Mitchibo Waterhole, in the headwaters of Fishhole Creek, Pt.1 Photo 5233 Run 9

Fossils: Pelecypods
Age: Neocomian (Lower Cretaceous)

RIVER

FERGUSSON 4-MILE SHEETHungry Knob 1-mile Sheet

T.T.54: About 9 miles south-west from Daly River crossing, on road to Dorisvale Homestead.

Fossils: Plant remains.
Age: ?Lower Cretaceous.

MOUNT YOUNG 4-MILE SHEETD/53/15/84 1-mile Sheet

T.T.55: On both sides of a creek, on the western edge of Yiyintyi Range; 20 miles north-north-east of Rosey Creek. Run 7 Ph.5191 Pt.8.

Fossils: Pelecypods, belemnites, plant remains.
Age: Neocomian (Lower Cretaceous)

D/53/15/97 1-mile Sheet

- T.T.56: Tawala pocket, 16 miles from Rosey Creek, bearing
195° Run.15 Ph.5023 Pt.22
Fossils: Pelecypods and brachiopods
Age: Neocomian (Lower Cretaceous)
- T.T.57: 11 miles at 188° from Rosey Creek, Run 13 Ph.5177
Pt. 2
Fossils: Pelecypods
Age: Neocomian (Lower Cretaceous)

HODGSON DOWNS: 4-MILE SHEETCox River 1-mile Sheet

- T.T.58: 20 miles north-west of Tanumbirini Station. Run 15
Ph.5141 Pt.1
Fossils: Belemnites
Age: Neocomian (Lower Cretaceous)

CALVERT HILLS 4-MILE SHEETSeigals Creek 1-mile Sheet

- T.T.59: About $\frac{1}{2}$ mile south-west from Seigals Creek Homestead,
in cliffs on the west bank of Agnes Creek. Run 10
Ph.5013 Pt.1.
Fossils: Plant remains; single pelecypod
Age: Lower Cretaceous?
- T.T.60: About 12 miles just south of east from Seigals
Creek Homestead. Run II Ph.5093 Pt.2
Fossils: Pelecypods
Age: ?Aptian (Lower Cretaceous)
- Wollogorang 1-mile Sheet
- T.T.61: North side of Calvert Hills-Wollogorang road, about
30 miles east from Calvert Hills Homestead. Run 3
Ph.5113 Pt. 3
Fossils: Plant remains
Age: ?Lower Cretaceous

