COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

RECORDS.

1955/40

CRETACEOUS FORMATIONS, MURCHISON HOUSE AREA, WESTERN AUSTRALIA.

by

M. A. Condon & S. D. Henderson

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CONTENTS

SUMMARY

Sediments of the Lower Murchison River area previously described as Cretaceous have been found to include sandstone older than Mesozoic. Sandstones, radiolarian shale, greensand, chalk and marl of Cretaceous age are described, new formation names are proposed, and a correlation with other Western Australian areas is given.

INTRODUCTION

The area described in this report is the extreme south-western part of the Carnarvon Basin. The main exposures of Cretaceous sediments are on the northern side of the Murchison River valley between its mouth at Gantheaume Bay and Mt. Curious. Additional outcrops are seen at the Weerinoogudda Dams nine miles to the north of Mt. Curious, and at Meanarra Hill on the south side of the river near its mouth.

Access to the area is by the station track from Ajana (close to the North West Coastal Highway from Geraldton to Carnarvon) to Murchison House Homestead.

This investigation was carried out by the Carnarvon Geological Party consisting of S.D. Henderson, D.J. Belford and T. Quinlan, as part of the Bureau of Mineral Resources' regional survey of the Carnarvon Basin which is mainly concerned with assessing the possibility of oil occurrences in this region. M.A. Condon personally supervised the earlier stages of the mapping and measured the type sections.

The mapping was done with the aid of overlapping aerial photographs with slotted templet control.

PREVIOUS WORK

The first geologist known to have worked in this area was A. Gibb Maitland who in 1901 traversed the telegraph line from Northampton to Carnarvon and described sandstones, grits and their derivatives near Mt. Curious, but did not mention the chalk scarps near the abandoned airstrip where the line crosses Cretaceous formations.

R.A. Hobson (1936) reports that in 1932 F.G. Forman noted the occurrence of Permo-Carboniferous sediments overlain by Cretaceous sediments between the Lower Murchison River and the coast, the whole dipping westwards at 1° to 2°.

Later in 1932 E.S. Simpson visited the most southerly exposure of the main Cretaceous sediments near Alinga Point (White Cliffs), and also Thirindine Point. He stated that a capping of chalk overlay glauconitic sands and shales from which fossils were obtained. These were recognised as being Cretaceous forms by L. Glauert. Underlying these beds was reddish sandstone the age of which was given as Jurassic(?). A description of phosphatic nodules, phosphatised wood, barites and glauconite from the Cretaceous beds was given.

F.G. Forman in 1937 described a section of Upper and Lower Cretaceous near Mt. Curious with a list of fossils obtained.

In March 1943 F.G. Forman with C. Teichert of the University of Western Australia and J.C. Dulfer of the British Phosphate Commission visited exposures in the vicinity of the abandoned airstrip north of Buhu Well. A Senonian fauna was observed in the chalk which overlay glauconitic sands and shales, siliceous shales, and cross-bedded sandstones. Localities near the Weerinoogudda Dams were also visited.

In August 1944 Teichert revisited the area with E. de C. Clarke of the Western Australian University and they continued the survey southwards to Alinga Point and across the Murchison River

to Meanarra Hill. The result of their work was published in 1948. They proposed the name Murchison House Series for the sedimentary succession examined, with further subdivision, in descending order, into the Second Gully Shale, Toolonga Chalk, Alinga Beds, Thirindine Shale, Butte Sandstone, and Tumblagooda Sandstone (pp. 24-25). They stated (p.41) that the whole sequence is conformable and that there are no major breaks in the sedimentation process.

The paper by Clarke and Teichert is so detailed that the present paper may seem redundant. Several major errors of observation and interpretation were immediately obvious, especially the relationship between the Tumblagooda Sandstone and the overlying formations, and the thickness measurements of the formations. For these reasons what was intended to be an inspection for information had to be turned into a check survey to revise Clarke and Teichert's work.

Some brachiopods from the Toolonga Chalk were described by G.F. Elliot in 1952.

Rhodes W. Fairbridge in his "Australian Stratigraphy" (1953) amended the name "Butte Sandstone" to "Tutula Sandstone" and referred this formation together with the Tumblagooda Sandstone to the Permian. He proposed the name Murchison House Group for the remaining Cretaceous sediments, also emending the name "Alinga Beds" of Clarke and Teichert to "Alinga Greensand".

TABLE 1. COMPARISON OF STRATIGRAPHIC NOMENCLATURE

Clarke & Teichert 1948			Fairbridge 1953 (invalid)			Condon & Henderson 1955		
CRETACEOUS	Second Gully Shale	MURCHISON HOUSE SERIES	CRETACEOUS	Second Gully Shale	"MURCHISON HOUSE GROUP"	CRETACEOUS	Second Gully Calcilutite	MURCHISON HOUSE GROUP
CRETACEOUS	Toolonga Chalk		CRETACEOUS	Toolonga Chalk		CRETACEOUS	Toolonga Chalk-Calcarenite	
CRETACEOUS	Alinga Beds		CRETACEOUS	"Alinga Greensand"		CRETACEOUS	Alinga Formation Woomana Shale	
CRETACEOUS	Thirindine Shale		CRETACEOUS	Thirindine Shale		CRETACEOUS	Thirindine Formation Yandilla Greensand	
CRETACEOUS	Butte Sandstone		PERMIAN	"Tutula Sandstone"		CRETACEOUS	Birdrong Formation	
CRETACEOUS	Tumblagooda Sandstone		PERMIAN	Tumblagooda Sandstone		PRE-CRET.	Tumblagooda Sandstone	

PHYSIOGRAPHY

To the northwest of the Murchison River from its mouth to Mt. Curious is a plateau bounded on the west by steep cliffs against the Indian Ocean and on the southeast by broken scarps along the river valley. The elevation of the plateau is 370 feet near Nungajay Spring rising slowly to the north and reaching over 800

feet 40 miles north of the river mouth. The surface also rises to the northeast reaching 600 feet at the scarps behind the Weerinoogudda Dams. The plateau is capped with travertine and some laterite with only a light covering of sand in the south. To the north of the area the sand thickens and sandridges are developed.

South of the Murchison River, Meanarra Hill, a flat topped mesa with gently sloping sides below the travertine capping, rises to over 500 feet. The denseness of the vegetation makes access to the exposures on the southwest of the hill difficult.

The valley of the river is in the form of a gorge cut through the Cretaceous rocks and underlying sandstone. The river is lined with white gum trees. The sandstone is deeply dissected by stream erosion along joint planes and where it is concealed by sand or alluvium from the overlying formations heavy tree growth makes travelling extremely difficult.

STRATIGRAPHY

In the Lower Murchison River area Cretaceous formations rest unconformably on sandstone of Pre-Permian age.

Plate 2 shows sections measured at various points indicated on the map, Plate 1. Table 2 shows the relationship of the formations and also their correlation with the Gin Gin-Dandaragan and Giralia Cretaceous rocks.

The map (Plate 1) delineates the boundary of the duricrust plateau and the top of the Cretaceous rocks exposed along the scarps. The contact between the Yandilla Greensand and Butte Sandstone, and the unconformity between the Butte and Tumblagooda Sandstones are also shown. As the Thirindine Radiolarite usually stands out as a terrace with a steep side, the underlying Yandilla Greensand and its contact with the Butte Sandstone is usually well exposed and can readily be mapped. The exposure of Butte Sandstone in contact with Tumblagooda Sandstone is seen to the east of the Toolonga Hills and is best developed above Natts Flat. In other places the Butte Sandstone has disintegrated and the contact is taken as the highest point at which fragments of Tumblagooda Sandstone are found.

TUMBLAGOODA SANDSTONE

This formation was named by Clarke and Teichert (p 26) after Tumblagooda Hill, two miles north of the mouth of the river and between the estuary and the coast. The formation occurs widely outside the area described but will be discussed here only insofar as it has bearing on its unconformable relationship with the overlying Cretaceous beds.

The outcrop of the Tumblagooda Sandstone is striking in its appearance. It is a reddish medium-grained to coarse-grained quartz sandstone, massive and cross-bedded and strongly dissected by joints with an average bearing of 120° to 130°. Between Tutula Well and Brackens Dam the highest beds of the formation exposed are less coarse and more flaggy. The colour here is red laminated with white. To the north of Tutula Well there is 150 feet of the flaggy sandstone, 50 feet between Thirindine and Toolonga Points, and near Brackens Dam the flaggy sandstone is not present. Jointing is not well developed in this part of the formation. The average dip of the Tumblagooda Sandstone is 2° to the northwest. The overlying sediments are nearly horizontal, the dip of the Yandilla Greensand as measured by barometric traverse being $\frac{1}{3}$° to the north of west. This discordance of dips, the pinching out of the flaggy sandstone, the strong jointing in the Tumblagooda Sandstone compared with the absence of jointing in the Cretaceous, and the induration of the Tumblagooda Sandstone compared with the looseness of the overlying sediments establish the presence of an unconformity.

Apart from worm burrows and invertebrate trails, no fossils were found in the Tumblagooda Sandstone. The only indication of its age is given by its being unconformably covered by Permian (Sakmarian) Lyons Group sediments east of Ajana. This confirms that it is much older than Cretaceous.

BUTTE SANDSTONE

The Butte Sandstone was named by Clarke and Teichert after the conical hill or butte in Second Gully where it has its maximum outcrop thickness: Fairbridge (1953 VII/15) emended the name to Tutula Sandstone as the butte has no geographical name and Tutula Well is the nearest named point. As Tutula Well is in an area of well-exposed Tumblagooda Sandstone it is felt that the emended name should be discarded. An approach has been made to the Western Australian Lands and Survey Department to have the hill formally named "Butte Hill" and it is proposed to retain the original name if this is agreed to.

At Butte Hill the section of the Butte Sandstone is poorly exposed. The section giving best exposures is in the gully running north from Toolonga Point (at Lat. 27°33'43" Long. 114°15'06") and this is therefore taken as the type section of the formation. The sequence there, in descending order, is as follows:-

Yandilla Greensand conformably overlying

1 foot of SANDSTONE, medium hard, coarse-grained and very coarse-grained with fossil wood fragments and calcareous lenses (Sample MR27).

11 feet of SAND, loose white medium grained, with coarse and very coarse grains, all grains round to subround; gypseous at top;

25 feet of SAND, friable red brown medium grained with coarse and very coarse grains; all grains subround to round;

40 feet not exposed; light yellow brown sand soil on gully side;

5 feet of SAND, loose yellow-brown medium-grained with hard limonitic nodules and few coarse grains

13 feet not exposed; light yellow-brown sand soil in gully side;

2 feet of SILTY SANDSTONE, semi-friable, variegated medium grained with very coarse (4 mm) and coarse (2 mm) grains and few small pebbles of quartz; (Sample MR31) unconformably overlying indurated white and red medium grained to coarse grained thin-bedded cross-laminated sandstone of the Tumblagooda Sandstone.

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97 feet - type thickness of Butte Sandstone.

Good exposures of part of the formation are found from Alinga Point to the abandoned emergency airstrip near Mt. Curious; at Meanarra Hill and the Weerinoogudda Dams residual sands derived from the sandstone can be identified.

Normally the sandstone is incoherent and is composed of subrounded to rounded grains of quartz which are commonly coated with limonite producing a brown sandstone. Near the top of the formation white bands occur with unstained quartz grains and very fine gypsum prisms. The sandstone is normally medium-grained but the higher beds are fine grained and the basal sandstone very coarse grained with small quartz pebbles up to ½ inch in diameter.

Poorly sorted beds are common throughout the formation the grainsize varying from very fine to very coarse.

Because of the loose nature of the formation no continuous section but only the total thickness between the top of the Tumblagooda Sandstone and Yandilla Greensand can be measured. The maximum thickness is in the south, (125 feet at Butte Hill). At Toolonga Point (type section) it is 97 feet and at the abandoned airstrip the thickness is 98 feet increasing westwards to 115 feet at Pillarawa. The section cannot be measured at Meanarra Hill nor at the Weerinoogudda Dams.

Phosphatised wood with numerous tubes filled with phosphatic material is common near the top of the formation especially from Alinga Point to the Toolonga Hills. It is less common near Pillarawa but fragments are found northeast of the abandoned airstrip. The wood is similar to that of the Mesozoic conifer Cedroxylon which occurs at Dandaragan (Simpson, 1934) and the tubes are probably caused by woodborers such as Teredo. Simpson determined that the phosphate was apatite, which constitutes 73% of the petrified wood.

Siliceous Butte Sandstone is found in the vicinity of Pillarawa (Clarke and Teichert, p.34). It varies in thickness from 1 foot to 3 feet and is from 7 feet to 15 feet below the top of the formation. It is medium grained and contains open burrows 3 to 4 mm. in diameter, probably caused by worms. Pelecypods have been found in these beds (personal communication, D. Johnstone, West Australian Petroleum Ltd.).

The Butte Sandstone is a typical transgressive clean sand. Although it contains few plant remains and even few shelly fossils it is almost certainly marine.

YANDILLA GREENSAND.

This name is proposed for the sediments forming the "transition zone" between the Butte Sandstone and Thirindine Shale described by Clarke and Teichert (p.35).

The name is taken from Yandilla Creek which runs from the Jannawa and Pillarawa Hills to Bettie Crossing of the Murchison River.

The type section of the Yandilla Greensand is in a gully running north from Pillarawa Hill into Yandilla Creek (at Lat. 27°28'32" Long. 114°16'28"E). There the sequence in descending order is as follows:-

Thirindine Radiolarite (interbedded thin soft grey and moderately hard white radiolarite) conformable overlies:

1 foot of GREENSAND, friable dark-green medium grained (Sample MR47);

3 feet of GLAUCONITIC MARL, friable dark green; conformably overlying Butte Sandstone (loose pale brown medium grained to coarse grained quartz sand).

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4 feet - type thickness of Yandilla Greensand.

It outcrops from Alinga Point to the old airstrip, and between these localities the formation is well exposed in many places. At Meanarra and Weerinoogudda the Yandilla Greensand is not exposed.

The lithology is usually a tough greensand composed of glauconite, silt, and rounded medium-grained and some coarse-

grained quartz grains. Mudballs and disseminated gypsum are often present. In some places it is a glauconitic marl.

The thickness is everywhere between 3 feet and 4 feet although only 2 feet are exposed at Alinga Point, because of slumping of the overlying strata.

No megafossils have been found but D.J. Belford records the presence of radiolaria.

THIRINDINE RADIOLARITE

The Thirindine Shale and Alinga Beds of Clarke and Teichert (pp. 35-37) in fact consist of three different lithological units with gradational contacts between. The names Thirindine and Alinga are retained for the lowermost and uppermost formations respectively. As the lowermost formation consists not of shale but of radiolarite (comminuted and complete tests of radiolaria with other minor constituents) it is renamed Thirindine Radiolarite.

The Thirindine Radiolarite is the formation of thin bedded to laminated medium hard and soft radiolarite conformable between the Yandilla Greensand below and the Woonana Shale above.

Thirindine Point is a pronounced feature of the scarp 3 miles north of Murchison House Homestead.

The type section is in the gully running north from Toolonga Point, where the sequence, in descending order is:-

Base of Woonana Shale (2 feet of soft laminated radiolarian shale) conformable overlying

28 feet of light grey medium hard and friable thin bedded and laminated radiolarite with ?fish scales and mollusc impressions (Samples MR34 and 35);

4 feet of interbedded thin medium-hard light grey radiolarite and laminated grey siltstone with belemnite guard moulds;

1 foot of friable light grey glauconitic radiolarite (Sample MR33); Conformably overlying silty greensand (Yandilla Greensand).

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33 feet - type thickness of Thirindine Radiolarite.

As it is more resistant than the beds above and below it, the Thirindine Radiolarite produces a distinct terrace on the Cretaceous scarp face and consequently good sections are exposed throughout the area between Second Gully and the abandoned airfield. At Alinga Point and Meanarra Hill fragments only were found in the surrounding sand and scree. In the vicinity of Weerinoogudda there are extensive outcrops of the radiolarite but sections cannot be measured.

The lithology is a hard, light grey, siliceous fine-grained radiolarite; radiolarian tests can be recognised in hand specimen. Thin layers of softer radiolarite produce lamination in beds one foot thick. Some samples are slightly calcareous, but this is not common. Fine-grained dark olive glauconite is disseminated through the formation. The weathered outcrop is usually white but at Thirindine Point and east of the abandoned airstrip there are red coloured exposures.

The maximum thickness of 35 feet is exposed southwest of the abandoned airstrip, 30 feet at Pillarawa, 33 feet at Toolonga Point and 23 feet at Thirindine Point. North of the old airfield the thickness exposed is 13 feet to 15 feet but the top is

concealed by slumped sediments. No outcrop is seen at Alinga Point but fragments can be recognised. At Meanarra Hill the thickness is at least 9 feet.

Besides radiolaria, remains of belemnite guards are common, especially in the Toolonga Hills section. Fragments of molluscs and fish scales (?) are found. What is possibly a saurian vertebra was found 1 mile south of Toolonga Point by D.J. Belford. Crushed organic remains at present unidentified also occur there.

The Thirindine Radiolarite is not a deep sea deposit but an organic sediment accumulated under neritic conditions where there was an absence of terrigenous material. This probably indicates an adjoining continental area of extremely low relief, supplying abundant silica in solution.

WOONANA SHALE

The Woonana Shale is the formation of radiolarian bentonitic shale conformable between the Thirindine Radiolarite below and the Alinga Greensand above.

The name of this formation is taken from Woonana Gully which is 1 mile to the north of Toolonga Point.

The type section is in a gully on the west side of Toolonga Point, one of the few places where the whole formation is well exposed in situ. There the sequence, in descending order, is:-

Soft grey radiolarian bentonitic shale (Sample MR39) 16 feet.

Finely interbedded medium-hard light grey thin bedded bentonitic radiolarite and laminated soft grey radiolarian bentonitic shale (Samples MR37 and 38) 24 feet.

Soft light grey radiolarina bentonitic shale (Sample MR36) 4 feet.

Type thickness of Woonana Shale - 42 feet.

Because of the soft shale the formation is often badly eroded and slumped, and in consequence cannot be examined or measured everywhere. At Meanarra Hill a section 10 feet in thickness is largely obscured by sand. Fragments possibly occur between Second Gully and Toolonga Point. At Pillarawa there are no exposures but scree derived from the formation occurs on the slopes. Limited outcrops are seen eastwards towards the abandoned airstrip, but no definite exposures may be seen at Weerinoogudda.

North of Thirindine Point the formation is predominantly interbedded clayey radiolarite and radiolarian shale, of which 33 feet are exposed but the top is concealed by slumped sediments. To the north of Pillarawa the section cannot exceed 35 feet but is probably at least 25 feet: it is a glauconitic and bentonitic radiolarian siltstone.

No megafossils are found in the formation but radiolaria are abundant.

Despite its fine grain-size the Woonana Shale is regarded as being not a deep sea deposit but a neritic deposit derived from a deeply weathered continental source of low relief supplying abundant clay, and silica in solution but practically no coarse clastic sediments. The bentonite, commonly derived from pyroclastic material, is probably developed from terrestrial clays.

ALINGA GREENSAND

The name Alinga Beds of Clarke and Teichert was emended to Alinga Greensand by Fairbridge (X/5) because of the predominance of glauconite. Although Fairbridge's revision was not valid as it was not based on re-examination of the sequence in the field and as only the upper part of the Alinga Beds is strongly glauconitic,

the name is appropriate for that upper part and is therefore used in that sense.

The Aldinga Greensand is the formation of glauconite with clay, silt and sand resting conformably on the Woonana Shale with a gradational contact and overlain, probably disconformably, by the Toolonga Chalk. The formation takes its name from Alinga Point which is 6 miles north of the mouth of the river and 1½ miles from the coast.

The type section, in the gully running north from Toolonga Point, in descending order consists of:-

Friable light cream calcarenite (Toolonga Calcarenite) overlying, probably disconformably,

13 feet of friable dark greenish brown glauconitic marl (Sample MR42);

5 feet of friable light green sandy fine-grained greensand;

15 feet of friable dark green clayey fine-grained greensand (Samples MR40 and 41); Conformably overlying radiolarian bentonitic Woonana Shale.

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33 feet - Type thickness of Alinga Greensand.

The Alinga Greensand is found from Meanarra Hill to the Weerinoogudda Dams. The soft nature of this formation results in few exposures of fresh rock but weathering produces a characteristic scree. Slumping is extremely common. Only at Toolonga Point do the strata appear to be entirely in situ, although even here there is a thin cover of scree.

The Alinga Greensand consists mainly of glauconite with clay, silt, and quartz grains. In consequence the colour is dark green. Gypsum crystals up to 3 inches are found at Alinga Point and the Toolonga Hills, while fine gypsum prisms are found in most outcrops. One mile south from Toolonga Point there is a small exposure of black glauconitic shale within the greensand. It is also seen at Weerinoogudda under greensand. This is the only change in lithology observed.

The greatest thickness of 35 feet to 39 feet is in the Toolonga Hills. A similar thickness is probably present near Thirindine Point but here the exposures are largely concealed by scree from the overlying beds. At Alinga Point only the top 27 feet can be measured. This is underlain by 32 feet of scree which conceals the base of the Alinga Greensand and also the Woonana Shale and Thirindine Radiolarite. At least 20 feet occur in the Pillarawa area but because of slumping the full section is not seen. At Weerinoogudda and Meanarra Hill the limited exposures cannot be measured.

The only fossils found are belemnite guards which occur everywhere in the area, and shark teeth found only south of Toolonga Point. Belemnites are abundant throughout the formation. At Pillarawa and Weerinoogudda they are small, about 1 inch long, but at Alinga Point where they are especially abundant they exceed 2 inches.

The Alinga Greensand indicates a stillstand which brought the deposition of the fine-grained Murchison Group to a close. A period of non-deposition between the Alinga Greensand and the Toolonga Calcarenite is indicated by the sharp change in lithology and by the nodule bed at the lease of the Toolonga.

MURCHISON GROUP

It is proposed to use the name "Murchison Group" for the

sequence comprising the Yandilla Greensand, Thirindine Radiolarite, Woonana Shale, and Alinga Greensand which have lithological similarities and differ significantly from the formations above and below.

TOOLONGA CALCARENITE

This formation takes its name from the Toolonga Hills where it is well exposed. The name has been changed from Toolonga Chalk of Clarke and Teichert to Calcarenite to distinguish it from the overlying formation which is a chalky calcilutite.

The Toolonga Calcarenite outcrops in scarps throughout the area, and except at Weerinoogudda it is prominent in all the scarps. It is also seen in the sea cliffs near Nungajay Spring but the exposures are limited.

The type section on the west side of Toolonga Point consists from top to bottom of:-

Friable cream calcilutite (Second Gully Calcilutite) conformably overlying

17 feet of moderately friable pale cream fine-grained calcarenite with Inoceramus fragments, foraminifera and small molluscs; few phosphatic nodules near bottom; (Samples MR43 and 44); Overlying, probably disconformably, friable dark greenish brown glauconitic marl of Alinga Greensand.

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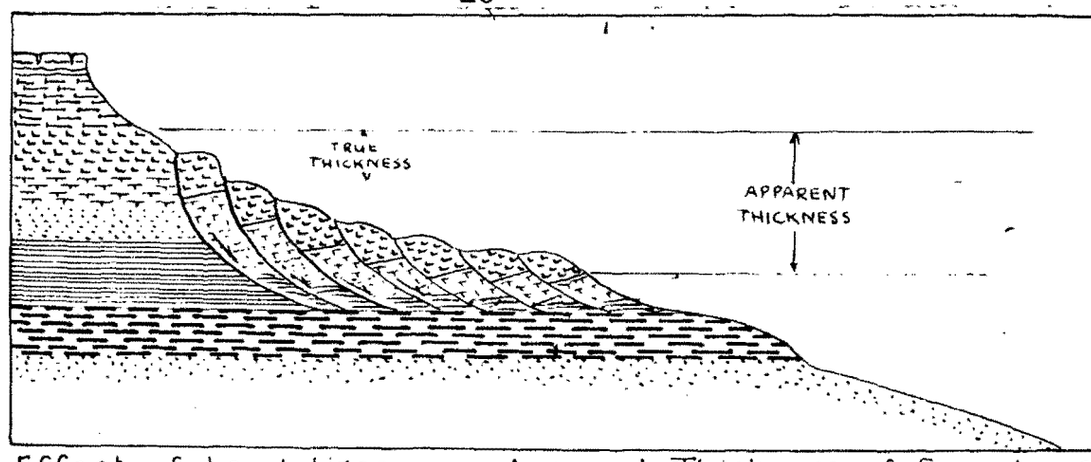
17 feet - type thickness of Toolonga Calcarenite.

The Toolonga Calcarenite consists of a white to pale cream fine-grained calcarenite with light greenish-brown chert or phosphatic nodules which frequently exceed 1 foot in length. Glauconite is rarely found disseminated through the formation. Cylindrical phosphate nodules about 1 inch in diameter and 6 inches long are common at the base at Pillarawa while nodules up to 6 inches in diameter are abundant at Alinga Point. The centre of these nodules is often chalk which is encased in phosphatic material given by Simpson as 78% apatite.

Huge blocks are often slumped down the scarps because of landslides caused by the weakness of the Woonana Shale. A distinct terrace produced by this slumping is most prominent on the western side of Second Gully and is also seen in the Toolonga Hills and Pillarawa scarps.

When "in situ" the upper and lower limits of the formation are well delineated. The thickness is 17 feet at Toolonga Point, 25 feet at Pillarawa, and 5 feet at Meanarra Hill; 25 feet is exposed at Alinga Point but the top is concealed by slumping. A few scattered outcrops are seen at Weerinoogudda.

Clarke and Teichert state (p.39) that the "Toolonga Chalk", which by lithological description is the same unit as here named Toolonga Calcarenite, ranges in outcrop thickness from 35 feet at Toolonga through 70 feet at Meanara to 120 feet north of Pillarawa. All of these "thicknesses" are incorrect - they probably represent the vertical distance between the lowest exposure of slumped calcarenite and the top of the calcarenite in place thus:-



Effect of Landslides on Apparent Thickness of Formations

Because of the recognition of the common occurrence of slump topography, very great care was taken, in measuring formation thicknesses, to ensure that the formation was in place. Sections were measured only where this was certain. In the whole area only one complete section from the top of Tumblagooda Sandstone to the Second Gully Calcilutite was seen. This section, in the gully running north from the west side of Toolonga Point was for this reason taken as the type section of almost all of the formations.

The formation is very fossiliferous. Fragments of large Inoceramus are particularly abundant. Ostrea and Gryphea are also common while Cidaris spines and Crinoid plates are frequently found.

The megafossils in the following list were found in the formation or the wash derived from it. The determinations by S.D. Henderson are tentative:-

Vermes:- Serpula sp., Spiorbis sp., Spirulaea spp.

Brachiopoda:- Inopinatarcula acanthodes (Etheridge)
Bouchardiella cretacea (~~Eth~~)
Terebratulids.

Bryozoa:- Fenestrate bryozoan.

Echinoderma:- Marsupites spp., Cidaris sp.,
Irregular echinid (1 specimen)

Mollusca:- Ostrea, Gryphea (Pycnodonta),
Spondylus(?), Inoceramus.
Oyster borer ? gastropod.
Belemnite guard (1 specimen)

Arthropoda:- Scalpellum (?).

The Toolonga Calcarenite correlates in lithology with the Gin Gin Chalk and with the Korojon Calcarenite of the Giralia Anticline. There is a difference in fauna which may represent a difference in age or merely a difference in facies perhaps related to latitude. At Gin Gin and Murchison House similar faunas of macrofossils and microfossils are found. Marsupites, Uintacrinus and Bolivinoides strigillata have not been recorded from Giralia. This may indicate that the deposition of the Korojon Calcarenite started later than the Toolonga Calcarenite or Gin Gin "Chalk".

SECOND GULLY CALCILUTITE

This was the uppermost formation described by Clarke and Teichert (pp. 39-41). They called it the Second Gully Shale after Second Gully where it outcrops below the duricrust.

It is a pale cream calcilutite (90% acid soluble) with pockets of slightly glauconitic sand and marl. Poorly developed lamination is sometimes seen giving a "shaley" appearance. The name Second Gully Calcilutite is here proposed as the formation

name as the term shale is misleading.

As the type locality, Second Gully, has no section showing the relationship with the Toolonga Calcarenite, a type section was selected in the scarp west of Wookia Rockhole where the sequence is as follows:

Soft green glauconitic marl (Wookia Marl) conformably overlying

15 feet of Soft pale cream slightly glauconitic calcilutite (88.5% acid soluble); (Sample MR45); Conformably overlying firm fine-grained calcarenite (Toolonga Calcarenite).

There are outcrops at Meanarra Hill, Alinga Point, the Toolonga Hills, and in the vicinity of Pillarawa, and near Nungajay Spring. Isolated outcrops of calcilutite at Weerinoogudda are possibly referrable to this formation. The top has been eroded and so the maximum thickness originally deposited is not known. There are 25 feet at Meanarra, at least 50 feet at Alinga Point, 10 feet to 15 feet in the Toolonga Hills, and 45 feet southwest of Pillarawa decreasing eastwards to 10 feet at the large breakaway and absent at the abandoned airstrip.

Small fragments of Inoceramus, Cidaris spines, and oysters are found. In the duricrust capping north of Pillarawa altered corals (?) are found.

The Second Gully Calcilutite correlates with the upper part of the Gin Gin Chalk and with the Korojon Calcarenite of the Giralia Anticline.

WOOKIA MARL

One mile south of Toolonga Point a lens of greenish glauconitic marl with sandy pockets, and having a maximum thickness of 5 feet occurs above the Second Gully Calcilutite and below the travertine.

Although it was seen in outcrop only at this one place it is of different lithology and age from the underlying Second Gully Calcilutite and is therefore given the formation name Wookia Marl. The name is derived from Wookia Rock hole on the Murchison River 1½ miles east of the type section which is near the top of the east-facing scarp at Lat. 27° 34¼' S., Long. 114° 14¾' E. There, five feet of friable green glauconitic marl with foraminifera conformably overlies the Second Gully Calcilutite. Its upper surface grades up into travertine.

Belford (1955) considers this, the youngest Cretaceous formation exained, to be of Maestrichtian age. At Alinga Point the highest fragments of calcilutite are found 42 feet below the duricrust. Most of the scarp here is covered with boulders of duricrust and a soft clay which may be derived from the Wookia Marl.

The Wookia Marl may be of about the same age as the Miria Marl of the Giralia area but contains no ammonites or other large fossils.

POST CRETACEOUS GEOLOGY

(a) COASTAL LIMESTONE

The sea cliffs to the west of the area are composed of "Coastal Limestone", a massively crossbedded formation of medium-grained to coarse grained shell fragments and quartz grains. North of the mouth of the Murchison River the "Limestone" cliffs reach over 120 feet and rest against a scree-covered Cretaceous

scarp, the top of which is 370 feet at Nungajay Spring. The height of the Coastal Limestone increases northwards until it reaches the top of the scarp. At the "conspicuous hill" which is 890 feet above the sea, the sea cliffs are 816 feet high, and are entirely of Coastal Limestone, the top of which is travertined.

(b) DURICRUST

The plateau above the scarps is covered by a duricrust varying from 10 feet to a maximum of 25 feet measured near Pillarawa. It is mainly a travertine but at Weerinoogudda and Gee-Gie laterite also occurs.

(c) SAND

The duricrust is covered by red and white medium-grained sands. The covering is very thin and is frequently absent in the southeast along the scarps but thickens northwards where a few sandridges are developed.

AGE AND CORRELATION

The age of the different formations indicated by micropalaeontological evidence is given by Belford (1955).

No evidence as to the age of the Tumblagooda Sandstone is found in the area described but its relationships east of Ajana indicate that it is Permian or older.

The Butte Sandstone and the formations of the Murchison Group all appear to be conformable. The Cedroxylon of the Butte Sandstone and belemnites and Shark teeth of the Alinga Greensand are Mesozoic forms. A Cretaceous age is inferred as the break between the overlying Santonian beds does not appear to be great. The age of Muderong Shale (see below) is Upper Albian to Cenomanian (Edgell 1952).

The presence of the crinoid Marsupites proves the Toolonga Calcarenite to be Santonian (U.Cret.).

The Second Gully Calcilutite is conformable on the Toolonga Calcarenite and must be Upper Cretaceous.

The Wookia marl south of Toolonga Point is considered to be Maestrichtian by Belford. The contact of this marl with the Second Gully Calcilutite is quite sharp and may be a disconformity.

The presence of phosphatic nodules at the base of the Toolonga Chalk suggests a depositional break, i.e. a diastem. (Stephenson 1929).

The correlation given in Table 2 is based on the Santonian age of the Gin Gin Chalk, the Toolonga Calcarenite, and the Korojon Calcarenite.

The Butte Sandstone and Birdrong Formation are both essentially friable medium grained quartz sandstone and both have petrified wood as the main fossils.

There is no lithological resemblance between the Yandilla Greensand and the Muderong Shale.

The Thirindine and Windalia Radiolarites are very similar.

The Woonana Shale and Gearle Siltstone are both radiolarian and bentonitic.

The Alinga Greensand is comparable with the Molecap (Lower) Greensand of Dandaragan but appears to be absent further north.

CORRELATION OF WESTERN AUSTRALIAN CRETACEOUS.

TABLE 2.

	Gingin-Dandaragan	Lower Murchison River		North of Gascoyne River	
TERTIARY	Poison Hill (Upper) Greensand			CARDABIA GROUP	Boongerooda Greensand
					Disconformity
CRETACEOUS		Wookia Marl			Miria Marl
		Disconformity			Disconformity
	Gingin Chalk	(Second Gully Calcilutite) (Toolonga Calcarenite)			Korojon Calcarenite
	Phosphatic bone bed	Phosphatic nodules			Disconformity
	Molecap (Lower) Greensand	MURCHISON GROUP	Alinga Greensand	WINNING GROUP	Gearle Siltstone
			Woonana Shale		
			Thirindine Radiolarite		Windalia Radiolarite
			Yandilla Greensand		Muderong Shale
		Butte Sandstone			Birdrong Formation
	Unconformity	Unconformity			Unconformity
PRE-CRETACEOUS	Sandstones and shales with Jurassic plants	Tumblagooda Sandstone			Permian Sediments

The Toolonga Calcarenite plus Second Gully Calcilutite correlates with the Gin Gin Chalk and the Korojon Calcarenite. The apparent absence of Uintacrinus from the Lower Murchison area and of Marsupites from the Korojon Calcarenite may indicate that the start of deposition of the Chalk was later in the north than in the south.

The Wookia Marl possibly of Maestrichtian age may be correlated with Miria Marl which is Maestrichtian, although no megafossils have been found in the former.

Teichert (1946) suggested that the Poison Hill (Upper) Greensand corresponds to the Boongerooda Greensand of the Tertiary of the Carnarvon Basin, but no corresponding formation is known in the Lower Murchison Area.

REGIONAL CONVERGENCE

The total thickness of the formation above the Butte Sandstone varies regularly. Isopachs trend about 20° east of north (roughly parallel to the main line of the scarp from Thirindine to Weerinoogudda). A convergence of about 25 feet per mile towards East south east is indicated.

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PLATE 1

GEOLOGICAL MAP
MURCHISON HOUSE AREA

To Accompany Records 1955/40

SCALE - miles

0 1 2 3 4 5 6

LEGEND

Qra	Alluvium
Qrs	Sand
Qrt	Travertine
Qpc	"Coastal Limestone"
Tlat	Laterite
K	Cretaceous
Klb	Butte Sandstone
?Ot	Tumblagooda Sandstone

20 21 22 23

160 000 yd N

159 000

158 000

157 000

156 000 yd. N

190 000 yd E.

Qrs Qrt Qra Qpc Tlat K Klb ?Ot

GEE GEE OUTCAMP

Weernoogudda Well

Weernoogudda Creek

Weewarra Hill

Abandoned Airstrip

Mt. Curious

Bungabandi Ck

Pillarana H.

Brackens Pt

Bethe Crossing

Mt. Yduadda

Woonana G.

Toolonga Pt

Wookia Rockhole

Nunajay Sp

Obutte Hill

Himmaine Pt

Alinga Point

Yalthoo

Bully Pool

Tumblagooda Hill

Meanarra Hill

"MURCHISON HOUSE"

To Ajana

OCEAN

INDIAN

GANTHEAUME BAY

LOCALITY MAP

WESTERN AUSTRALIA

Carnarvon

Ajana

Geraldton

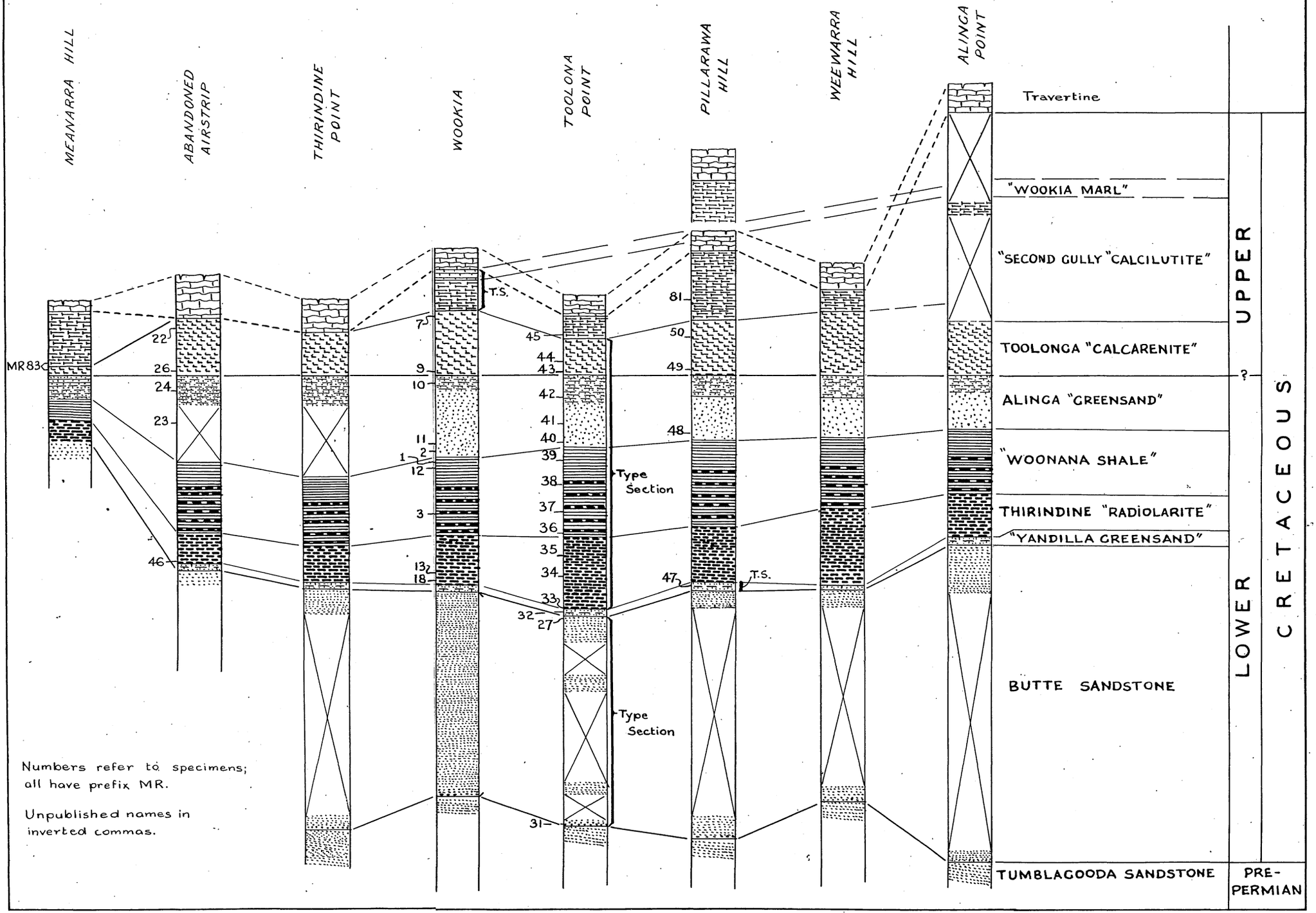
PERTH

PLATE 2

MURCHISON HOUSE AREA
STRATIGRAPHICAL COLUMNS

SCALE - feet

40 0 40 80 120 160



Numbers refer to specimens; all have prefix MR.

Unpublished names in inverted commas.