THE WESTERN AUSTRALIAN
NATURALIST

Vol. 22 30th May 2000 No. 4

NEW RECORDS OF JURASSIC MOLLUSCS FROM THE CADDA FORMATION AT ENANTY HILL, IRWIN RIVER DISTRICT, WESTERN AUSTRALIA

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ABSTRACT

Fourteen species of Mollusca (12 Bivalvia, two Cephalopoda) have been collected from the Cadda Formation at Enanty Hill, Irwin River district, northern Perth Basin, increasing from 11 to 18 the number of species recorded from this source. New bivalve records are: juvenile gryphaeid oyster; Lucinidae undetermined species; cf. *Astarte cliftoni* Moore; two species of undetermined Heterodonta. New cephalopods are the ammonite *Pseudotoites* sp. and an unidentified belemnite. The assemblage compares closely with that of the Middle Jurassic (Bajocian) Newmarracarra Limestone of the Geraldton hinterland.

INTRODUCTION

The Cadda Formation is a sequence of diverse lithologies – sandstone, siltstone, shale and limestone - which forms limited, sporadic outcrops in the northern Perth Basin between the Hill River area and south to about the latitude of Dandaragan. There, it lies in conformable contact with the Cockleshell Gully Formation (below) and Yarragadee Formation (above) according to Playford *et al.* (1976: 144-147 and maps). Fossil evidence indicates that the Cadda Formation is, in part at least, equivalent in age to the Middle Jurassic (Bajocian) Newmarracarra Limestone of the Geraldton hinterland, of which it appears to be a southerly, more restricted and shallow water facies equivalent.

A small, isolated surface deposit correlated with the Cadda Formation is located on the southwestern slope of Enanty Hill, about 3 km NNE of the

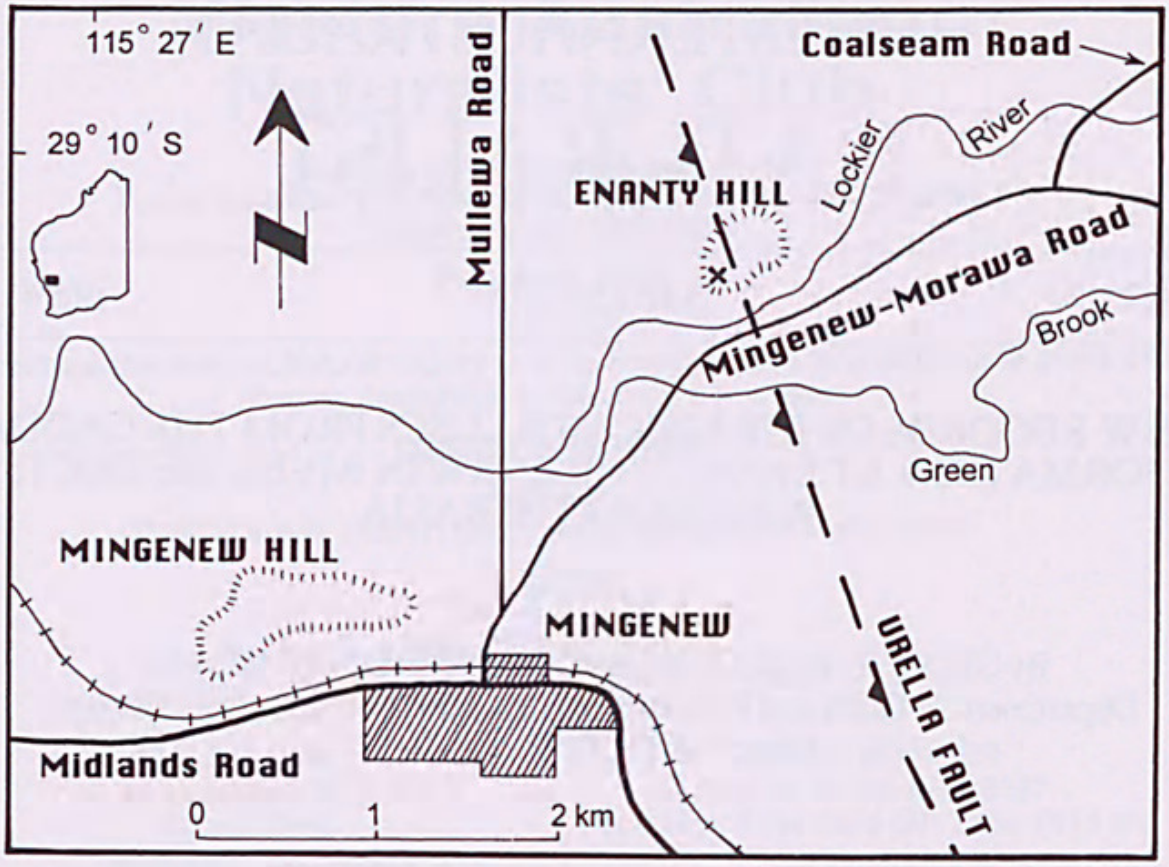

Figure 1. Environs of Mingenew, W.A. Fossil site at X.

town of Mingenew (lat. 29°10'S, long. 115°27'E; Figure 1), from where fossils were first recorded by Coleman and Skwarko (1967). This exposure, located in a disused road-gravel pit, lies ca 120 km N from the nearest known outcrops of the Cadda Formation in the Hill River area and about 50 km ESE from the nearest occurrence of the Newmarracarra Limestone at Mt Hill. Drilling at Enanty Hill shows the Cadda Formation there to be at least 19.8 m. thick, overlying Triassic Kockatea Shale.

Enanty Hill lies within a zone of complex faulting associated with the major NNW-trending Urella Fault (Playford *et al.* 1976, p. 236). Downthrow is to the west with Permian sedimentary rocks confined to the eastern side of the fault and Mesozoic (Triassic to Cretaceous) deposits exclusively to the west. Evidently faulting has preserved the Cadda Formation remnant at Enanty Hill, all other surface evidence of coeval sedimentation in the district having been removed by erosion.

The greater part of Enanty Hill is formed of Permian rocks of the Mingenew Formation. Mingenew Spring and other major springs in the district lie within the Urella Fault system, which allows groundwater to come to the surface.

At the Enanty Hill gravel pit, the Cadda Formation occurs as discrete pebble to cobble-sized pieces of ferruginous reddish-brown to purple-brown fine to very coarse-grained, lateritised sandstone, sometimes gritty or conglomeratic. Fossils are sparse, occurring as internal or external moulds of mollusc shells, principally single

valves of Bivalvia, with rare cephalopods and small indeterminable gastropods. Small pieces of fossil wood are not uncommon. No bedded sequence is visible on the surface, where material appears to be a mantle of accumulated weathering residue overlying coherent strata (Coleman and Skwarko, 1967).

Fossils collected in May 1999 by members of the Western Australian Naturalists' Club include new records for both locality and formation and have been added to the research collections of the Western Australian Museum (WAM).

All specimen numbers cited below are from the Museum's catalogues of fossil invertebrates and plants.

NOTES ON THE FOSSIL ASSEMBLAGE

Bivalves

Family CUCULLAEIDAE.

Of the four specimens of *Cucullaea* sp. from Enanty Hill figured by Coleman and Skwarko (1967), two (figs 16, 19, 20) have the elongate form, i.e., length exceeding height, of the common, rather variable *C. semistriata* Moore and may represent that species. One specimen (fig. 15), a juvenile, is proportioned more like the relatively uncommon *C. inflata* Moore (height generally exceeding length) but has a reticulate umbonal sculpture, as is seen on well-preserved *C. semistritata* (e.g. 91.914).

Two internal moulds (WAM 99.365) of single valves are of mature size, closely resembling others attributable to *C. inflata* Moore and are identified accordingly. Neither is complete but length to height ratios and umbonal inflation agree well with Moore's criteria for the species (Moore, 1870: 250, pl. 14, figs 1, 2).

Type localities for *Cucullaea inflata* Moore and *C. semistriata* Moore are "Greenough district", Newmarracarra Limestone. Both species have been well figured by Skwarko (1974: pls 21, 22). Moore (1870), *inter alia*, recognised four species of *Cucullaea* in the Newmarracarra Limestone but the most recent revision of these by Skwarko (1974) acknowledged three, a conclusion with which we concur.

Family LIMIDAE.

Incomplete external moulds (99.367, 99.375) bearing sculpture identical with that of *Pseudolimea duplicata* (J. de C. Sowerby) supplement those reported by Coleman and Skwarko (1967). Radial ribs are strong, with V-shaped interspaces, the base of each being occupied by a thin radial riblet.

P. duplicata is a widespread Middle Jurassic species, which is not uncommon in the Newmarracarra Limestone. Skwarko (1974, p. 88) noted that the Western Australian specimens, in their smaller size and reduced rib-count, are closer to Indian examples from Cutch, compared with those from Europe.

Family GRYPHAEIDAE.

Several internal moulds of juvenile oyster shells are present on the external mould of a right valve of a small *Camptonectes greenoughi* Skwarko (99.368, see below and Figure 2A). Limestones of the Cadda Formation in the Hill River district "are usually coquinas of small oyster shells" (Playford *et al.*, 1976: 144) and concentrations of similar material also occur in the Newmarracarra Limestone. The identity of these small oysters

requires further study but provisionally they may be regarded as probable juveniles of the common gryphaeid *Amphidonte tholiformis* (Etheridge). The type locality for *A. tholiformis* Etheridge is "Tibradden Station, Greenough River district", Newmarracarra Limestone.

Family OXYTOMIDAE.

Two representatives of this extinct family of pectinoid clams are known from Enanty Hill. Coleman and Skwarko (1967) record the mould of a small left valve consistent with *Oxytoma decemcostata* Whitehouse and the species is also reported from the Hill River area by Playford *et al.* (1976). The type locality is the Bringo railway cutting, Newmarracarra Limestone.

Incomplete external moulds of *Meleagrinella sinuata* (Teichert) in the present material (99.359, 99.365) supplement those reported by Coleman and Skwarko (1967). These are readily recognised by the narrow, spaced, radial ribs of alternating strengths on the left valve. *M. sinuata* is common in the Newmarracarra Limestone and occurs in the Cadda Formation, Hill River district (Playford *et al.* 1976); the type locality is the Bringo railway cutting, Newmarracarra Limestone.

O. decemcostata and *M. sinuata* are both strongly inequivalve species. Most collection specimens are the larger, costate and strongly inflated left valves; the smaller, flattened and faintly sculptured right valves are less often collected.

Family PECTINIDAE.

As *Chlamys*? sp. nov. aff. *C. splendens* (Dollfuss, 1863), a small pectinid was recorded from Enanty Hill by Coleman and Skwarko (1967 p. 206, pl. 25, figs 9, 13, 17) and subsequently described as *Chlamys enantyi* by Skwarko (1974, p. 83, 84, pl. 26, figs 1, 6, 12). This uncommon species is otherwise known only from fragmentary specimens from the Newmarracarra Limestone. The type locality is "Waggrakine via Geraldton. One mile south of road to Nanson on W side of hills", i.e., Moresby Range.

A second small pectinid from Enanty Hill was reported by Coleman and Skwarko (1967) as *Camptonectes* sp. nov. aff. *C. lens* (Sowerby, 1821) and subsequently described as *C. greenoughi* Skwarko, 1974. An external mould, 99.368 (Fig. 2A), represents this species in the present material. As noted above, it bears moulds of juvenile oyster shells, probably *Amphidonte tholiformis* (Etheridge).

C. greenoughi is only occasionally collected in the Newmarracarra Limestone; the type locality is "Approximately one mile [1.6 km] NW of Mt Fairfax, via Geraldton, W face of hills", i.e., Moresby Range. It is distinguished from other pectinids in the assemblage by its thin shell and very fine divaricate sculpture. It is not significantly related to the large *"Camptonectes" waggrakinensis* Skwarko, which, lacking any kind of radial-divaricate sculpture, is better located in the genus *Mclearnia* Crickmay, 1930.

Fine, divaricate sculpture also distinguishes *C. greenoughi* from *"Pecten" greenoughiensis* Moore, 1870, a rare species from "Greenough district", unrevised since its original, limited description.

Family TRIGONIIDAE.

Trigonia moorei Lycett in Moore, the common and characteristic fossil of the Newmarracarra Limestone (and associated formations of the Champion Bay Group), is well represented in all

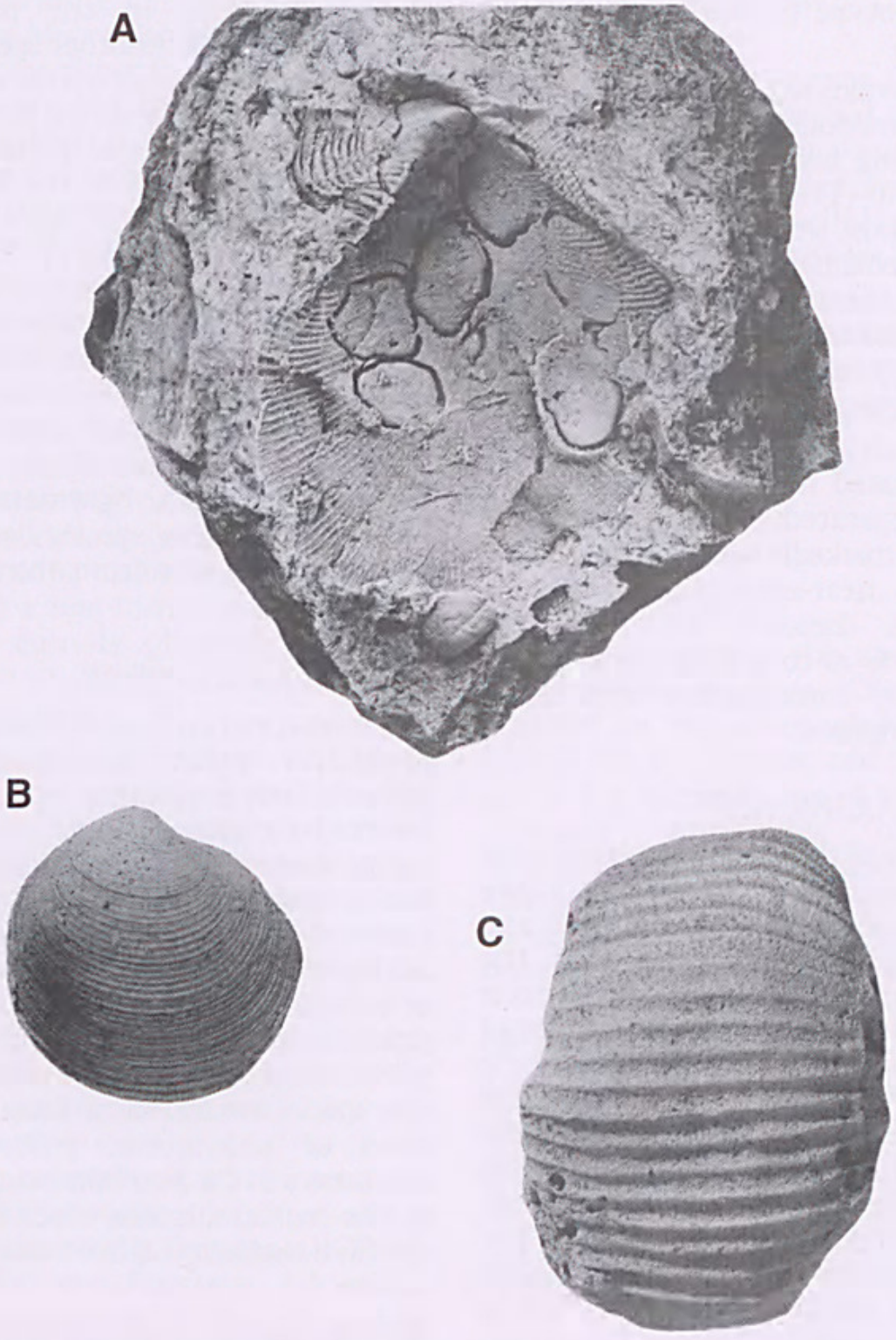

Figure 2. Molluscs from the Cadda Formation, Enanty Hill. A WAM 99.368. *Camptonectes greenoughi* Skwarko. Natural mould of right valve exterior with moulds of attached juvenile oysters, x 2. B WAM 99.370. Lucinidae, genus unidentified. Latex cast of right valve exterior, x 1.8. C WAM 99.374. *Pseudotoites* sp. Latex cast of venter, x 1.8. All whitened.

collections from Enanty Hill and elsewhere in the Cadda Formation (Coleman and Skwarko, 1967; Playford *et al.* 1976). The type locality, omitted from the original description (Moore, 1870), is "Greenough River district, W.A.", Newmarracarra Limestone, according to the label accompanying

the holotype (Skwarko, 1974 pl. 33 caption).

The trigoniids were a dominant, diverse and cosmopolitan family of shallow-burrowing bivalves throughout the Mesozoic (Triassic to Cretaceous). Their robust, strongly sculptured shells, with elaborate, interlocking hinge teeth, enabled them to flourish in energised, coarse-grained substrates of inner shelf environments (Stanley, 1977).

All WAM specimens (99.361, 99.369) of *Trigonia moorei* from Enanty Hill are disassociated single valves, that have been separated *post-mortem*. These contrast markedly with the thin-shelled, fragile, near-edentulous *Gresslya sanfordii* (below), which occurs frequently as conjoined, paired valves, in likely consequence of a deep-burrowing habit.

Family LUCINIDAE.

A species of this family has been listed, as "*Lucina* sp.", by various authors (see Playford, 1959; Playford *et al.*, 1976 and references) in the fauna of the Newmarracarra Limestone but has never been considered further and at present remains somewhat enigmatic. Some possible examples of this rare species have been collected recently from the Newmarracarra Limestone and now also from Enanty Hill (99.370, Figure 2B). The latter does not closely resemble any of the genera of Jurassic Lucinidae in Chavan (1969) and identification is deferred until the hinge and other internal characters are known.

Family ASTARTIDAE.

One confirmed and one probable species of this family are present in the Cadda Formation at Enanty Hill. The small *Astarte apicalis* Moore was recorded by Coleman and Skwarko (1967) and is also represented in the present collection (99.375). Another specimen (99.372), a fragmentary external mould, retains sculpture quite similar to that of *Astarte cliftoni* Moore, a species now included provisionally in the Enanty Hill assemblage. Both *A. apicalis* and *A. cliftoni* are common in the Newmarracarra Limestone, the former also present in the Kojarena Sandstone and the latter in the Colalura Sandstone (Playford *et al.*, 1976). Type localities (Moore, 1870: 249-250) are "Greenough district" and "Greenough river" respectively, both Newmarracarra Limestone. Neither species has been recorded elsewhere from the Cadda Formation.

Family CERATOMYIDAE.

The most common fossil at Enanty Hill is the thin-shelled *Gresslya sanfordii* (Moore), found as either external or internal moulds of single or paired valves (Coleman and Skwarko, 1967). Even fragmentary impressions of external surfaces (93.362, 99.371) are readily recognisable from the presence of very fine, close, radial micro-striation, crossing the low, irregular growth ridges. More conjoined valves of this species are found at Enanty Hill than of any other, probably a consequence of a deep-burrowing habit in fine-grained substrate, which favours the close association of both valves *post-mortem*.

The type locality of this species was not stated by Moore (1870, p. 253) but the label accompanying his figured specimen (pl. 13, fig. 9) reads "Shark Bay, W.A.", according to Skwarko (1974, caption to pl. 32). This erroneous locality evidently arose from confusion accompanying specimens collected by M.W. Clifton and sent to W.A. Sanford in England prior to 1862.

In providing Clifton's material to Charles Moore, Sanford opined that it had come either from "Shark's Bay" or "Champion Bay", more likely the former (Moore, 1870, p. 228-229). The species is unknown from the Shark Bay district but is common in the Newmarracarra Limestone. Both of Skwarko's figured specimens are from problematical sources and the type locality for the species remains undesignated.

Unidentified bivalves. Fossil wood (99.378) showing on the freshly broken cross-section two narrow, infilled, tubular borings, parallel to the sides of the wood, may be attributable to a wood-boring marine bivalve, though at present a non-marine origin for these seems equally plausible. No shell remains are visible and interpretation is conjectural.

Moore (1870, p. 255, pl. 12, fig. 11) described a presumed wood-boring bivalve, *Teredo australis* Moore from "Western Australia", without more specific locality data. He evidently had two specimens, both of which were figured by Skwarko (1974, p. 99, pl. 34, fig. 20, pl. 36, fig. 1) and reclassified as *Martesia (Particoma) australis* (Moore), family Pholadidae. The locality of the former specimen, designated by Skwarko as "holotype" is not given. That of the latter, a colony attached to a remnant of fossil wood in a block of richly fossiliferous shelly limestone, is "Shark Bay, Western Australia" (Skwarko, 1974, caption to pl. 36, fig. 1). This specimen may be regarded as the paralectotype. According to Moore (1870, p. 230), it is associated with "as many as thirty species" of typical Newmarracarra Limestone fauna, unknown from the Shark Bay area. Evidently Moore's specimens of "*Teredo*" *australis* were among those with spurious locality data obtained from W.A. Sanford ex M.W. Clifton, as discussed above.

This species is unknown from all subsequent collections and is clearly most rare. In view of the prevalence of fossil wood in the Cadda Formation at Enanty Hill, the possibility of its discovery there should be kept in mind.

Three small incomplete external moulds (99.363, 99.364, 99.377) representing two species of bivalve, probably Heterodonta, remain unidentified.

Cephalopods

Ammonoidea

Family SONNINIIDAE

Three specimens of the ammonite *Newmarracarroceras clarkei* (Crick) were reported (as *Fontannesia clarkei*) from Enanty Hill by Coleman and Skwarko (1967). The species is one of the more common ammonites of the Newmarracarra Limestone and Enanty Hill provides the only other known occurrence. This and related taxa have been revised recently by Hall (1989).

Family OTOITIDAE

A specimen (99.374) of a species of *Pseudotoites* (Fig. 2C) from Enanty Hill provides the first record from there of this genus, previously known from the Cadda Formation of the Hill River district and from the Newmarracarra Limestone.

Coleoidea

Belemnite, unidentified. The mould of part of a belemnite guard (99.373), showing the posterior part of the phragmocone, provides the first record of this group from Enanty Hill. It remains generically and specifically unidentified.

Fossil wood. Small pieces of fossil wood,

Table 1. Molluscan fossils recorded from the Cadda Formation of Enanty Hill. Sources: I Coleman & Skwarko, 1967; II WAM collection, 1999.

	Species	I	II
1.	*Cucullaea inflata* Moore	?	+
2.	*Cucullaea* sp. cf. *C. semistriata* Moore	+	
3.	*Pseudolimea* sp. cf. *P. duplicata* (J. Sowerby)	+	+
4.	Ostreoidean, juvenile cf. *Amphidonte tholiformis* (Etheridge)		+
5.	*Oxytoma decemcostata* Whitehouse	+	
6.	*Meleagrinella sinuata* (Teichert)	+	+
7.	*Camptonectes greenoughi* Skwarko	+	+
8.	"*Chlamys*" *enantyi* Skwarko	+	
9.	*Trigonia moorei* Lycett in Moore	+	+
10.	Lucinid, genus undetermined		+
11.	*Astarte apicalis* Moore	+	+
12.	cf. *Astarte cliftoni* Moore		+
13.	*Gresslya sanfordii* (Moore)	+	+
14.	Bivalve, genus undetermined, species A		+
15.	Bivalve, genus undetermined, species B		+
16.	*Newmarracarroceras clarkei* (Crick)	+	
17.	*Pseudotoites* sp.		+
18.	Belemnite, genus and species undetermined		+

variously preserved, are not uncommon at Enanty Hill, at times associated directly with marine fossils and a possible leaf (99.369, P.99.57). From this, it would appear that the site was in proximity to a river that discharged terrestrial flood debris into the adjacent inshore sandy shallows.

CONCLUSION

As presently known, the fauna of the Cadda Formation is a subset of that of the Newmarracarra Limestone, the former entirely, the latter substantially molluscan in character, in which Bivalvia predominate. The lesser faunal diversity of the Cadda Formation reflects its relative paucity of outcrop, rarity of fossils and the limited attention which they have received. It appears that the Cadda Formation represents a faunistically deficient gulf environment, essentially enclosed by land on three sides and with a marine connection to the north, allowing only restricted oceanic exchange/circulation and more significant fluviatile discharge, compared with the more fully marine depositional environment of the Newmarracarra Limestone.

Because the Champion Bay Group (which includes the Newmarracarra Limestone) and Cadda Formation are the only known marine Middle Jurassic deposits in surface outcrop in Australia, their Mollusca have been studied extensively since 1870, as reviewed by Skwarko (1974). The more common species of Bivalvia are now known reasonably well but there remain many uncommon to rare species of which little or nothing is known. The small gastropod and scaphopod fauna remains

essentially unknown. The Western Australian Museum is currently enlarging its research collection of Jurassic molluscs in order to better understand the composition of the fauna and its biogeographical significance.

ACKNOWLEDGEMENTS

We have to thank Mr and Mrs C. Gillam of "Irwin Park", Irwin for access to Enanty Hill and consent for the removal of fossil material. We are greatly obliged to members of the W.A. Naturalists' Club for their generous contributions to collection. Mrs A. Nevin typed the manuscript.

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