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A new Pliocene terebratulid brachiopod from the Roe Calcarenite, Eucla Basin of southern Australia

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Abstract – The terebratulid brachiopod, *Neothyris rylandae* sp. nov., is described from the Pliocene Roe Calcarenite in the Eucla Basin of southern Australia. This is the earliest record of the genus from Australia, all previous records being of extant species. *Neothyris* is also recorded from the Miocene to Recent of New Zealand and Antarctica.

INTRODUCTION

The Roe Calcarenite is a thin, sandy limestone that forms the surface of the Roe Plains in the southern Eucla Basin. It comprises poorly bedded, medium to coarse grained porous shelly calcarenite (Lowry 1970: 121–124). It has a very rich fauna dominated by calcareous algae, foraminifers, molluscs (Ludbrook 1978, and Kendrick *et al.* 1991) and, to a lesser extent, echinoids (Foster and Philip, 1980, and McNamara 1996). The Roe Calcarenite covers most of the Roe Plains in the western Eucla Basin to a thickness of about 1.5 m. It is rarely exposed and is usually obscured under soil or sand. Natural sections are uncommon, but numerous borrow pits adjacent to the Eyre Highway have provided stratigraphical information not otherwise available. The type section is the entrance doline of Nurina Cave 10 km south of Madura Roadhouse. The thickest section appears to be at Eucla N°1 well where it is up to 7.5 m (Lowry 1970).

The terebratulid brachiopod, *Neothyris rylandae* sp. nov., described in this study represents the only brachiopod yet known from the Roe Calcarenite and was collected from borrow pits in the Hampton Repeater Tower area. The stratigraphy is illustrated in Figure 2.

The Roe Calcarenite unconformably overlies a wave-abraded surface of Abrakurrie Limestone in central and western sections of the plain. To the east it unconformably overlies the Wilson Bluff Limestone. In the western and coastal areas it is overlain by coastal dunes. At the foot of the Hampton Escarpment, the northern boundary, it is overlain by colluvium whilst elsewhere it is covered by clay soil with kankar nodules (Lowry 1970).

Ludbrook (1978) suggested an Early Pleistocene age for the unit. The presence in the Roe Calcarenite of a species of arcoid bivalve genus *Cucullaea*, which is not known from post-Pliocene sediments elsewhere in southern Australia casts doubt on Ludbrook's age estimate (Darragh 1985, Table 2). The most important correlative fossil in the Roe Calcarenite is the presence of species of a gastropod genus *Hartungia* which in New Zealand is essentially confined to the Pliocene (Beu and Maxwell 1990). This suggests a Pliocene age for the deposit (Kendrick *et al.* 1991).

The genus *Neothyris* has been regarded as a genus endemic to New Zealand and the Subantarctic islands off the southern and southeastern coast of the South Island (Neall 1972). It is "the most widely distributed subtidal brachiopod genus on the continental shelves surrounding New Zealand and the islands of the Campbell Plateau" (Chapman and Richardson 1981).

Bitner and Pisera (1984) describe a specimen from the Pliocene Polonez Cove Formation of King George Island of the South Shetland Islands of Antarctica as a *Neothyris.* As only a single specimen was available, the description lacks detail, as does the photograph supplied. Two species, *Neothyis* cf. *thomsoni* Allan, 1932 and an unnamed species of *Neothyris* are recorded by Biernat *et al.* (1985) from Middle to Late Miocene deposits of the Moby Dick Group of King George Island.

Neothyris is represented by five species and three subspecies in the fossil record from the Miocene to Early Pleistocene of New Zealand (Neall 1972). Three living species have been recognized. They are *N. dawsoni* Neall, 1972 and two subspecies (*N. lenticularis lenticularis* (Deschayes, 1839) and *N. l. compressa* Neall, 1972). However, Chapman and Richardson (1981) consider the latter taxa to be separate species. Living *Neothyris* have been observed as both free-lying (Richardson 1981) and attached (Grange *et al.* 1981).

All the material examined in this study is housed in the collection of the Western Australian Museum (WAM). Photographs were taken using a Nikon F 90 X camera with a macro lens and specimens coated with ammonium chloride.

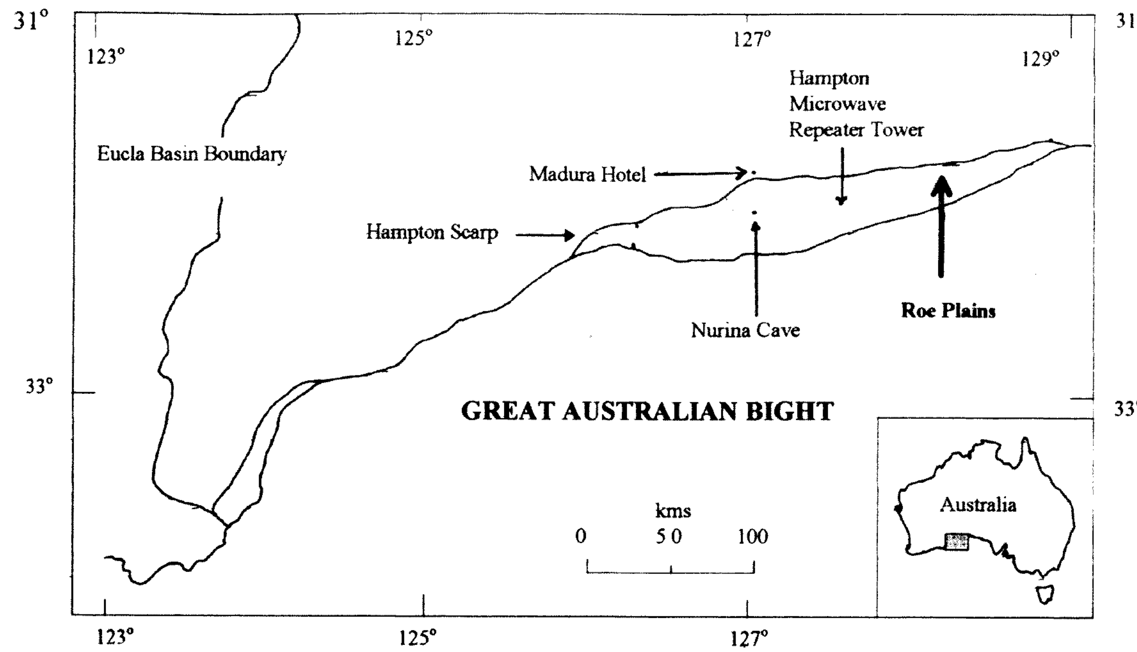

Figure 1 Locality map for the Roe Calcarenite and the Hampton Microwave Repeater tower.

SYSTEMATICS

Superfamily Terebratelloidea King, 1850

Family Terebratellidae King, 1850

Subfamily Terebratellinae King, 1850

Genus *Neothyris* Douville, 1879

Type Species
Terebratula lenticularis Deshayes, 1839.

Remarks
All recorded species of *Neothyris* to date have come from the South East Pacific Ocean, primarily around New Zealand and its associated islands. These include *N. anceps*, *N. novara*, *N. iheringi* and *N. obtusa* from the Miocene, *N thomsoni*, *N. campbellica* (*N. c. ovalis* and *N. c. campbellica*) and *N. obtusa* from the Pliocene and *N. campbellica elongata* from the Pleistocene. The living species are *N. dawsoni*, *N. lenticularis* and *N. compressa* (Neall 1972). Neall (1972) stated that the living species are found only in New Zealand and Subantarctic waters (Stewart Island, Pukaki Bank, Auckland Islands, Antipodes Islands, Campbell Island).

Thomson (1927) suggested that *Neothyris* "is merely a *Pachymagas* which has attained the magellaniform loop stage". MacKinnon (1987) questioned the existence of *Pachymagas* but gave no alternative name to replace it. Examination of the fossil and extant species of *Neothyris* led Neall (1972) to suggest an evolutionary trend toward a smaller foramen and a more incurved beak. In Recent species, the shell shape, cardinal process and degree of curvature of the beak of *Neothyris* appear to vary even within single populations and across a given species, according to the environment in which they are found (Neall 1972).

Neothyris rylandae sp. nov.
Figures 3 A–F and 4 A–C

Material Examined

Holotype
WAM 82.2368; Roe Plains, Madura district, Western Australia, Australia. Pit 1.5 km N of Hampton Microwave Repeater Tower. Basal 0.4 m carbonate sand.

Paratypes
Australia: Western Australia: WAM 69.382; Roe Plain, 25 miles east of Madura- south side of Eyre Highway. Bulldozed pit approx. 3 m deep.

WAM 75.178, WAM 76.2480; Roe Plain, Eucla Basin, Quarries beside road from Eyre Highway to Hampton Microwave Tower.

WAM 82.2367, 82.2369, 82.2370, 82.2372, 82.2373, 82.2378; Roe Plains, Madura district, Pit 0.5 km N of Hampton Microwave Repeater Tower. Basal 0.6 m carbonate sand.

WAM 85.2026, 82.2374, 82.2376, 82.2377, 82.2379 – 82.2388; Roe Plains, Madura district, Pit 1.5 km N of Hampton Microwave Repeater Tower: spoil heaps near base of tower.

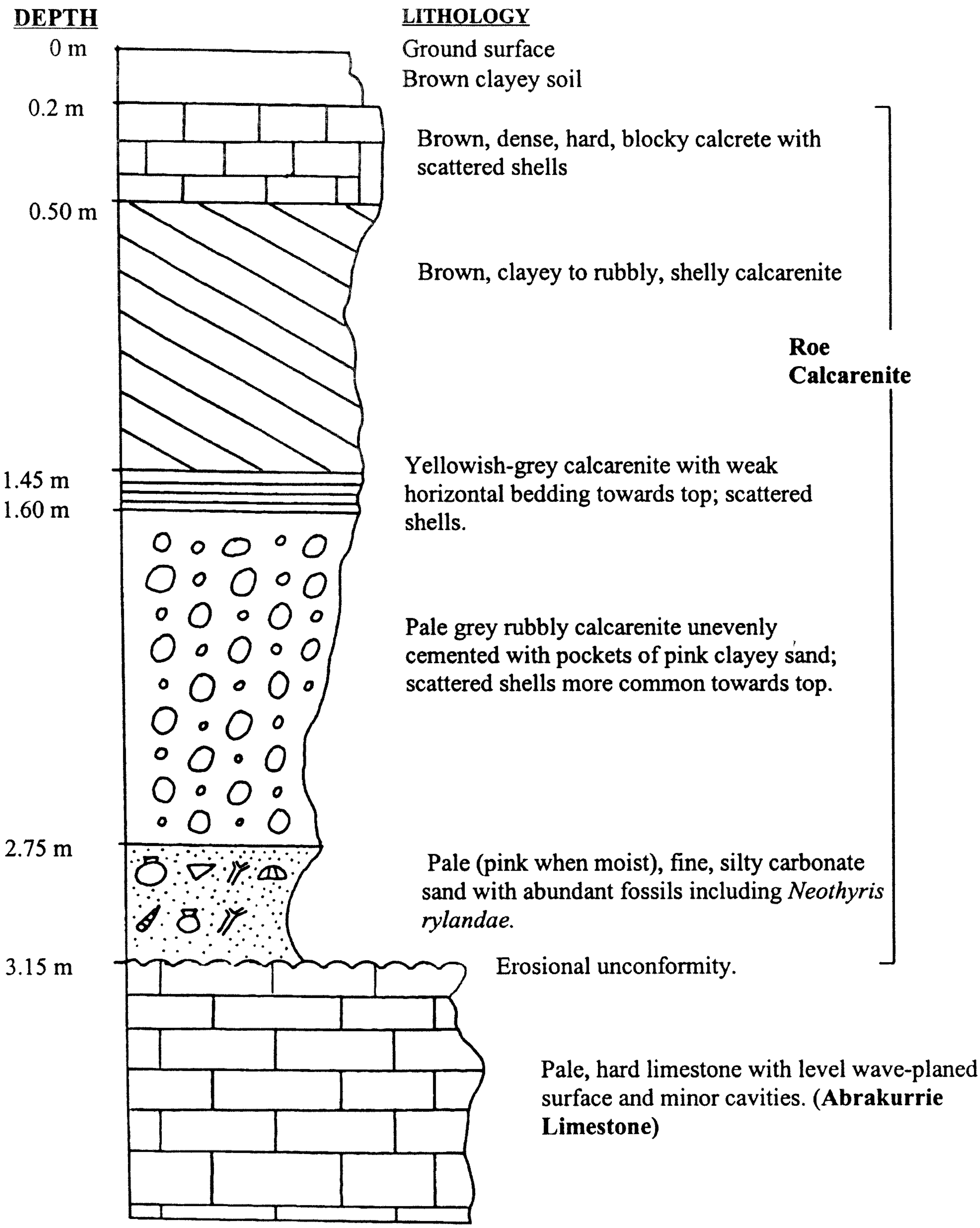

Figure 2 Section of the Roe Calcarenite at the type locality in pit 1.5 km north of Hampton Microwave Repeater Tower. (31°57'36"S 127°34'45"E). Courtesy G. W. Kendrick (personal communication).

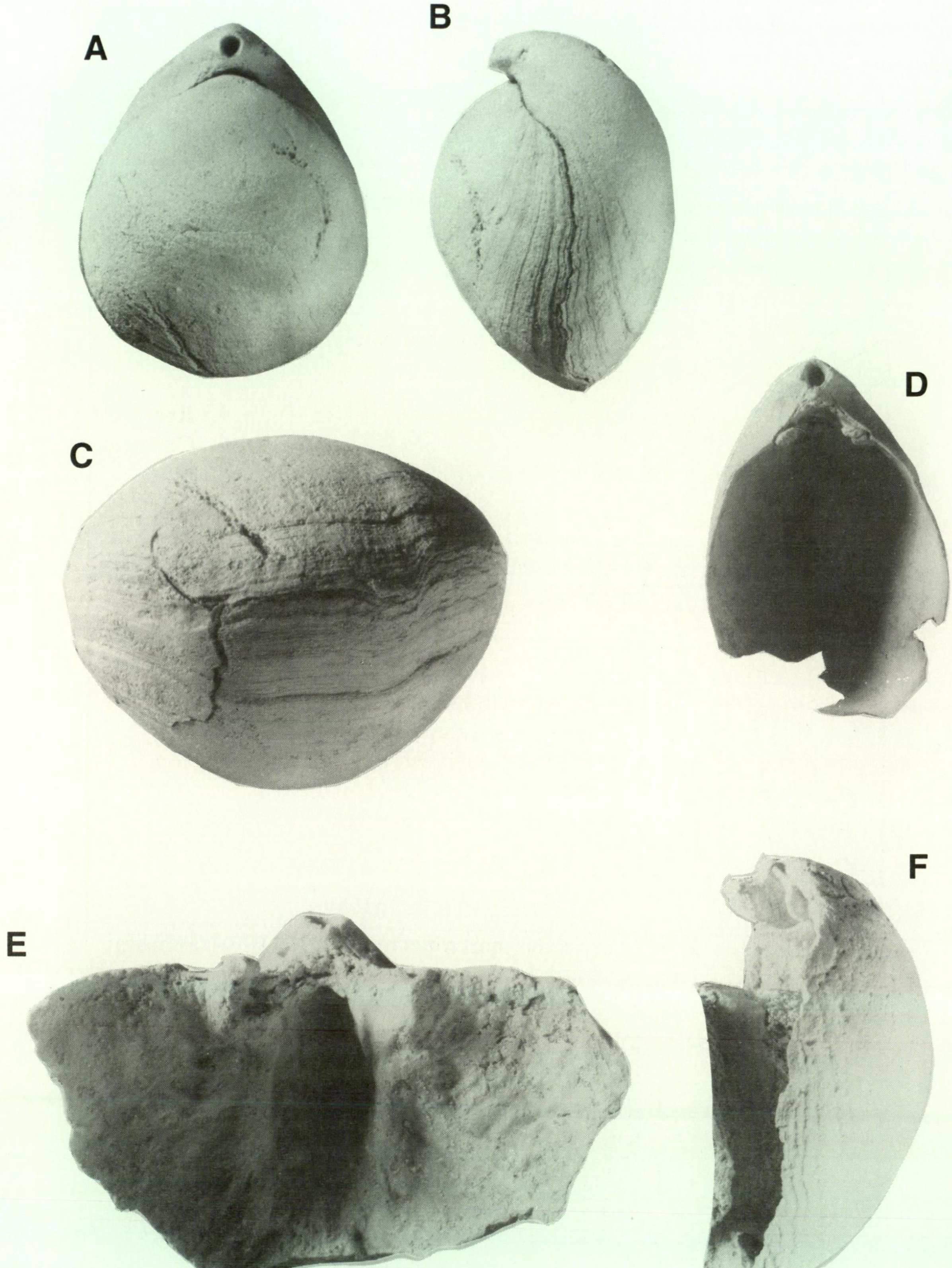

Figure 3 *Neothyris rylandae* A, WAM 82.2368, Holotype, dorsal valve exterior x 1; B, WAM 82.2368, Holotype, lateral margin x 1; C, WAM 82.2368, Holotype, anterior commissure x 1.5; D, WAM 82.2378a, Paratype, ventral valve interior x 1; E, WAM 82.2367b, Paratype, ventral valve interior x 2.5; F, WAM 82.2367a, lateral view of the brachial valve x 1.5.

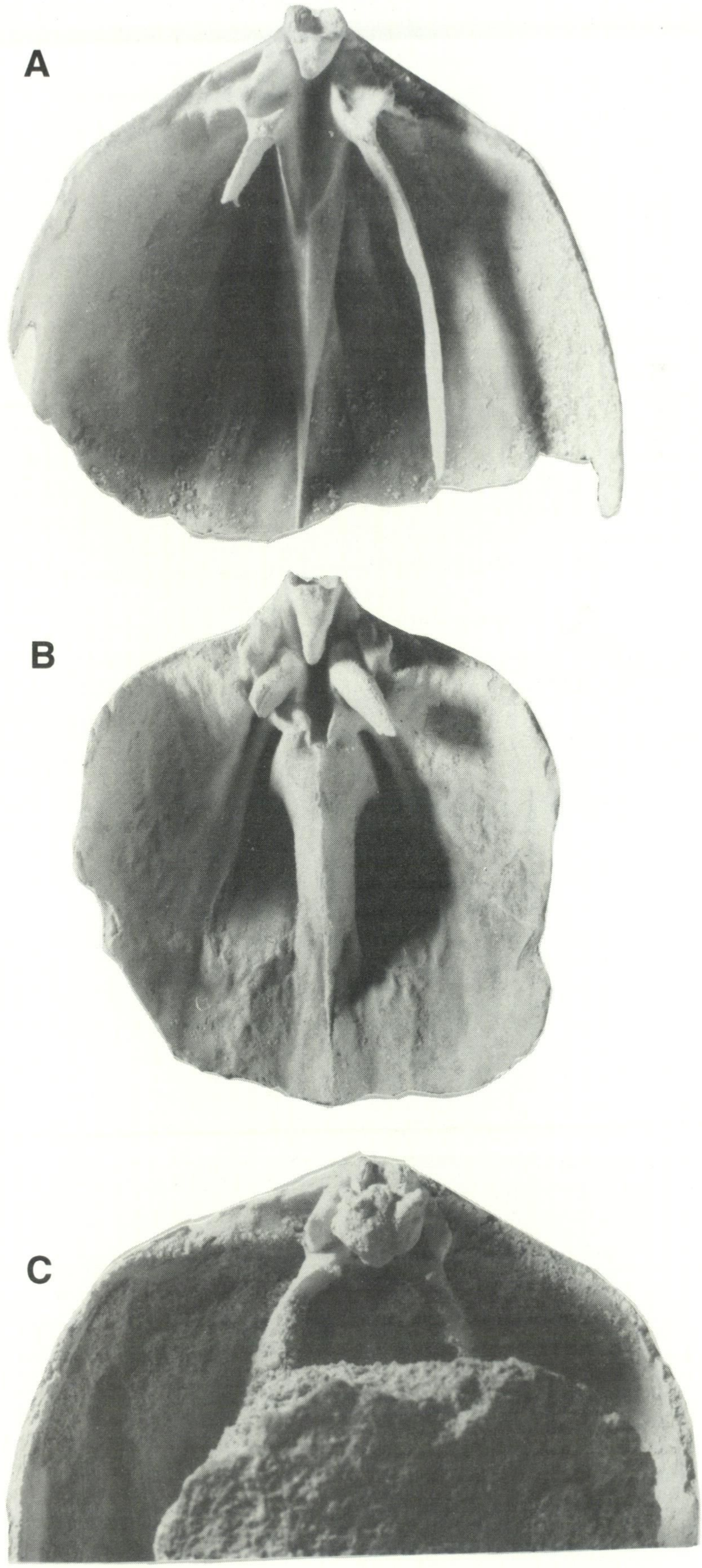

Figure 4 *Neothyris rylandae* A, WAM 82.2378b, Paratype, internal view of dorsal valve x 2.5; B, WAM 76.2480, Paratype, internal view of dorsal valve x 2; C, WAM 82.2367a, Paratype, internal view of dorsal valve x 2.

Description

External

Shell large (up to 65 mm in length), ovate to subpentagonal, biconvex, both valves approximately equal, greatest width just anterior to midlength, width 80% of length; lateral margins rounded, anterior margin bevelled; cardinal margin strongly curved, 60% of shell width; lateral commissure convex towards ventral valve, crenulate anterior to midlength; anterior commissure sulcate to incipiently intraplicate; ventral valve with keel developing posteriorly and widening until anterior commissure where it generates a fold.

Surface smooth, growth lines towards anterior commissure very prominent; punctae fine and regularly dense; beak suberect to erect, truncated, labiate; beak ridges wide, rounded meeting dorsal valve indistinctly anterior to cardinal margin; foramen round, large, 6% of shell length, mesothyridid; symphytium narrow, deeply concave, deltidal plates conjunct, without obvious median ridge.

Internal

Ventral valve. Pedicle collar short and thin; trench leading into pedicle area created by thickened posterior sides of valve; muscle scars a pair of furrows either side of pedicle neck, diverging and extending to midlength; hinge teeth strong, facing inward at a slight angle; grooved for reception of socket ridges; teeth wider than thick; hinge teeth bases swollen; no dental plates.

Dorsal valve. Sockets wide and deep; triangular with small roof posteriorly at apex; base anteriorly located; fulcral plate relatively thin; outer socket ridges sharp and slightly raised, extend slightly above hinge line, 12.5% shell length; inner socket ridges slightly raised; outer hinge plate joins inner socket ridge and crural bases to make V-shaped trough; inner hinge plates extend from crural bases to median septum, meeting medianly to create a hinge trough; crural bases thin, extending from posterior of shell to crura; crural process dart to talon shaped, vertical with slight anteriomedial curve producing a sharp point; median septum extends posterior of midlength; raised posteriorly, appearing to bifurcate where hinge trough meets it; base thickened posteriorly (crural bases and median septum swelling more pronounced with increase in size of valve); loop teleform (magellaniiform), extending greater than 75% shell length; descending band thin and wide; ascending loop very wide near transverse band which is wide, incurved and arched towards ventral valve; cardinal process protuberant, round with raised margins laterally and anteriorly, anterior extends vertically to cardinal margin, swollen and extending into shell over hinge trough, raising the cardinal process well above the cardinalia.

Intraspecific variation

In the smaller specimens (4–6 mm) the deltidal plates are disjunct and the beak suberect. From 11 mm – 43 mm the deltidal plates are conjunct, the beak is suberect but "moving" to the erect position and crenulations are non existent to incipient.

One specimen, WAM 82.2367, is similar in all features described above except for the following variations:

Ventral valve (Figure 3E): Foramen small (3.5% shell length). Pedicle collar thick. Hinge teeth upwardly curved.Considerable posterior shell thickening. Pedicle trench very narrow with near vertical sides formed by extended hinge teeth bases.

Dorsal valve (Figure 4C): Sockets deeper. Brachidium has wider bands to the loop. Cardinal process bilobed (cardinal wings; Neall 1972) and a flattened ridge extends from the cardinal margin. Two further "wings" are formed on either side which extend vertically down towards valve floor giving the impression of a "winged keel". The anterior vertical surface is convex, filling the area between the crural processes. The median septum is swollen below the hinge trough and the swollen area extends anteriorly, tapering as it does so.

WAM 76.2480 (Figure 4B), an incomplete dorsal valve also adds to the known variation of the species. No brachidium is present. The socket base is very swollen. The medium septum is swollen under the hinge trough. These two areas of swelling result in a deep, narrow trench forming between them, below the crural processes. The crural bases are also swollen. The cardinal process shows the beginnings of the "winged keel" forming.

Etymology

The species is named after Ms Valerie Anne Ryland, a former technical officer at the Western Australian Museum and undertook the preliminary work on all the specimens from the Roe Calcarenite.

Remarks

Neothyris rylandae has similarities to that of *Cudmorella*, especially in the interior of the dorsal valve. Allan (1939) suggests that there is an affinity between *Cudmorella* and *Neothyris* but differentiates them on the basis of *Cudmorella* having a permesothyridid foramen and a primitive cardinal process whilst *Neothyris* has a mesothyridid foramen and is less folded. *Neothyris rylandae* has a mesothyridid foramen and the folding is incipient.

The primary areas of morphological difference between *Neothyris* species are in the overall size, degree of convexity, cardinal margin, anterior commissure, foramen size relative to shell length, socket teeth and cardinal process. *Neothyris* *rylandae* is the only species with a labiate beak.

N. anceps Thomson, 1920 (Miocene) is a large shell (53 mm long) with a large foramen and a convex lateral margin similar to *N. rylandae,* which has a maximum length of 65 mm. The cardinal process is described as being "confined to the posterior part of the hinge trough" (Thomson 1920) whereas in *N. rylandae* the cardinal process is very large and takes up the majority of the "hinge trough". Richardson (1994) suggests that the "hinge trough" used in the description of *Neothyris* is in fact a consequence of differential thickening of inner hinge plates based on her work on juvenile specimens. Few details are available for *N. novara* Ihering (Miocene). Thomson (1920) describes it as being more than half as deep as long, having a straighter hinge line and a less convex lateral margin than *N. lenticularis N. rylandae* is as bulbous but has a more strongly curved hinge line and lateral margin than *N. lenticularis.*

N. iheringi Thomson, 1920 (Miocene) is medium sized (based on an illustration in Thomson (1920)), with a long beak and a small foramen. None of these features are comparable to those of *N. rylandae,* which is larger and has a larger foramen. The Pliocene *N. thomsoni* Allan, 1932 is similar to *N. rylandae* in that it is of similar size, strongly biconvex, having deep sockets, a wide "hinge trough" and a large crural process (Allan 1932). It differs from *N. rylandae* in having a smaller foramen and a rectimarginate anterior commissure.

The Pliocene *N. campbellica ovalis* (Hutton, 1886) differs from *N. rylandae* in that it has a rounded commissure, smaller sockets and a thin cardinal process. The size is moderate to large, as is the size of the foramen (Neall 1972). *N.c. campbellica* (Filhol, 1885) from the Pliocene is described by Neall (1972) as moderate to large in size, narrow and having a small foramen, all these features differing from *N. rylandae. N. c. elongata* Neall, 1972 (Nukumaruan-Pleistocene) is a flattened shell of medium size and with a medium-sized foramen (Neall, 1972).

The living *N. lenticularis* (Deshayes, 1839) is large, but in comparison to *N. rylandae* it would better be described as medium sized. The cardinal process has a small median boss whilst in *N. rylandae* it is very swollen.

The living *N. compressa* Neall, 1972 is medium-sized with a maximum length of 50 mm, having a compressed biconvex appearance (Chapman and Richardson 1981). *N. rylandae* is bulbous and much larger. *N. dawsoni* Neall, 1972 (Recent) is small with a tiny foramen (Chapman and Richardson 1981). According to Neall (1972), *N. obtusa* ranges from the Pliocene to the Recent. The species is described as having a small "hinge trough", small hinge teeth and a small to medium-sized cardinal process, making it quite different from *N. rylandae* with a swollen "hinge trough", large cardinal process and large hinge teeth.

N. rylandae has a large foramen and a suberect to erect beak. The cardinalia and posterior sections of the shell are much thickened (see above description). According to Richardson and Watson (1975) and Richardson (1981, 1984) this would suggest that the species is capable of, and adapted to, a free lying habit. The presence of the labiate suberect to erect beak, concave symphytium and mesothyrid foramen would indicate an inert pedicle (Richardson, 1981) *N. rylandae* is found in sandy calcarenite and this is consistent with the life habit as described above.

CONCLUSION

Present species of *Neothyris* are restricted to cool waters around southern Australia, Antarctica and New Zealand. The Roe Calcarenite species, *Neothyris rylandae*, appears to have inhabited relatively warmer waters during the Late Pliocene (Hodell and Warnke 1991). Why is a supposed endemic New Zealand genus which is believed to have evolved in New Zealand waters in the Middle Miocene (Neall 1972), found in the southern regions of Western Australia in the Late Pliocene? Two species of *Neothyris, N.* cf. *thomsoni* and another of uncertain species identity, are described from Early to Middle Miocene deposits of King George Island, South Shetland Islands, Antarctica (Biernat *et al.* 1985) as well as a single species of the genus of Pliocene age within the same group (Bitner and Pisera 1984). It is possible that these species, with *N. rylandae,* evolved from the same stock as the New Zealand *Neothyris* but that the ancestor was common to the mid-Tertiary of the Southern Ocean. Zinsmeister (1982, 1984) suggests that the high latitude region of the southern hemisphere acted as a centre of origin and dispersal for a broad spectrum of taxa. Precursors to modern deep and shallow water mid-latitude forms evolved and flourished in the high latitudes until conditions in lower latitudes favoured their dispersal. Bitner (1994) also suggests that the late Tertiary and Recent faunas of Australasia originated in Antarctic waters. Research on the brachiopods of the Late Paleocene deposits of northwest Western Australia (Craig, in preparation) suggests that a number of genera, common to southern Australia and New Zealand, evolved *insitu* along the southern Indo-Atlantic coastal region of Antarctica and Western Australia.

It is also possible that *Neothyris rylandae* evolved from New Zealand stock and moved east to west during a hiatus in the Leeuwin Current during the Late Pliocene (McGowran *et al.* 1997). This would not however explain the presence of the genus in Antartica during the Miocene. Until other species of this genus are located in Late Tertiary deposits in either Australia or Antarctica, the origin of the genus remains unclear.

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Measurements in millimetres: (VV = ventral valve, DV= dorsal valve)

Specimen	Features	Length	Width	Depth
WAM 69.382	conjoined valves, no interiors	65.0	43.8	37.9
WAM 76.2480	partial dorsal valve	40.1	37.1	–
WAM 82.2367	partial VV, DV intact and interior clear	65.1	48.8	46.3
WAM 82.2367	complete DV, partial VV	65.3	50.1	46.6
WAM 82.2368	conjoined valves , no interior available	63.8	50.9	42.5
WAM 82.2369	conjoined valves, no interiors	51.0	40.8	32.4
WAM 82.2370	conjoined valves, no interiors	52.2	39.8	33.3
WAM 82.2371	conjoined valves, no interiors	55.3	39.2	37.5
WAM 82.2372	partial VV and DV with interior observable	51.5	35.3	35.0
WAM 82.2373	partials but no interiors	21.6	16.6	10.6
WAM 82.2374	conjoined valves, no interiors	43.1	35.9	25.9
WAM 82.2375	conjoined valves, no interiors	56.6	43.3	35.3
WAM 82.2376	partial DV and VV, no interiors	37.7	34.1	21.6
WAM 82.2377	partials but no interiors	31.4	27.0	18.1
WAM 82.2378	nearly complete VV, partial DV and brachidium	55.3	36.9	36.1
WAM 82.2379	partial DV and VV with interiors	42.9	33.4	28.3
WAM 82.2380	partial DV and VV, some interior observable	44.6	40.4	32.6
WAM 82.2381	nearly conjoined valves	39.2	30.2	20.4
WAM 82.2382	partial DV and VV with interiors observable	29.7	24.5	15.1
WAM 82.2383	conjoined valves, no interiors	10.6	9.6	5.2
WAM 82.2384	conjoined valves, no interiors	8.3	6.3	4.5
WAM 82.2385	conjoined valves, no interiors	5.8	4.0	2.9
WAM 82.2386a	conjoined valves, no interiors	5.0	3.9	2.2
WAM 82.2386b	conjoined valves, no interiors	4.6	3.2	1.9
WAM 82.2387	conjoined valves, no interiors	4.1	3.3	1.6
WAM 82.2388	conjoined valves, no interiors	6.0	5.0	–
WAM 85.2026 a	conjoined valves, no interiors	60.1	41.1	36.8
WAM 85.2026 b	conjoined valves, no interiors	57.4	42.8	39.6
WAM 85.2026 c	conjoined valves, no interiors	51.9	38.2	32.8
WAM 85.2026 d	conjoined valves, no interiors	51.3	39.7	–