

EARLY MIOCENE SILICIFIED LIMESTONE FROM TEMMA, NORTHWESTERN TASMANIA: FURTHER EVIDENCE OF SUBSTANTIAL POST-EARLY MIOCENE UPLIFT OR TILTING OF TASMANIA

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(with two text-figures, two plates and one table)

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Silicified shallow-water Early Miocene (Longfordian) marine limestone occurs in altitudes to over 160 m, 12 km east of Temma in northwestern Tasmania, the highest elevation known to date for rocks of this age and environment of deposition. Age and environmental data are provided by Foraminifera, calcareous algae and poorly preserved macrofauna. Mode of silicification of Foraminifera varies systematically between suborders – miliolids and agglutinated species as internal moulds, nodosariids, rotaliids and cibicides as volume-for-volume replacements. Foraminifera are benthic only. Miliolids dominate but preservation is too poor to allow statistically valid analysis. The locality provides only the second occurrence of *Tenisonina tasmaniae* Quilty, and, for the first time, it occurs with *Sherbornina atkinsoni* Chapman.

Key Words: Miocene, Foraminifera, Tasmania, marine, Temma, uplift.

INTRODUCTION

Australia is currently tectonically active and Tasmania perhaps more than other regions is rising quite rapidly (Sandiford 2007, 2009). There is thus interest in detecting evidence of the distribution of sedimentary rocks of various ages to place limits on amounts of uplift and rate and timing of such uplift. Early Miocene marine sedimentary rocks that are well-dated and which contain internal evidence about their relation to past sea level are common across northern (Fossil Bluff, Wynyard, Cape Grim, Temma, Granville Harbour, Musselroe Bay – Quilty 1972, Quilty & Telfer 1994) and southern (offshore southeastern – Quilty & Telfer 1994) Tasmania (fig. 1). All are approximately coeval. Those in northwestern Tasmania are now generally within 30 metres above sea level (m.a.s.l.), that at Musselroe Bay is 25 m below m.a.s.l. and that in southeastern Tasmania is 810 m below m.a.s.l. Boulders of Mid-Late Miocene marine sedimentary rocks are known on the beach at Ocean Beach, Strahan (Quilty & Telfer 1994), indicating that equivalent sections occur offshore in shallow water. All these data indicate that there has been significant tilting or faulting of Tasmania to change original relationships. Quilty & Telfer (1994) commented that other samples from a variety of depths and farther offshore also showed signs of having accumulated in shallower water than that in which they now reside.

Many of these sections have yielded significant foraminiferal faunas which have provided many new species and genera (Chapman 1922, Quilty 1974, 1977, 1980, 1982).

This paper records the biota (principally Foraminifera) and lithology and age of sedimentary rocks from a previously unstudied site in northwestern Tasmania on the Temma map sheet (fig. 2; table 1) near coordinates 315000mE543600mN (Seymour & Reed 2003) and elevation 140–160 m.a.s.l., considerably higher than previous sedimentary sections. The rocks are now mainly spongolite that are the silicified remnants of sponge spicule rich carbonate sediment. The section is overlain by a basalt flow which accounts for the

locally higher topography and may have helped preserve the section from erosion.

The spongolite has been used by Indigenous Tasmanians for a long time as a source of ideal material for artefacts, and Painter (1992) reviewed this role and the question of distribution and trading paths. The location seems to be the only source of such spongolite in the region and the material was carried or traded for a distance of up to 50 km

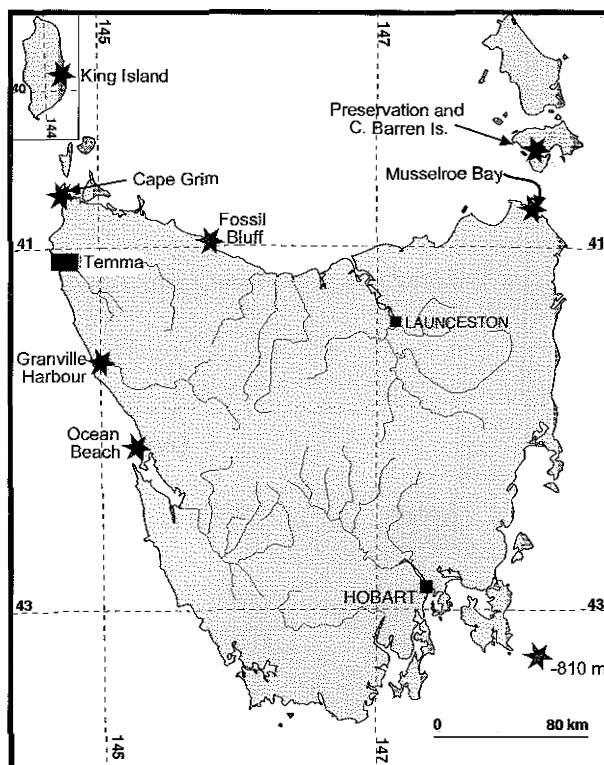
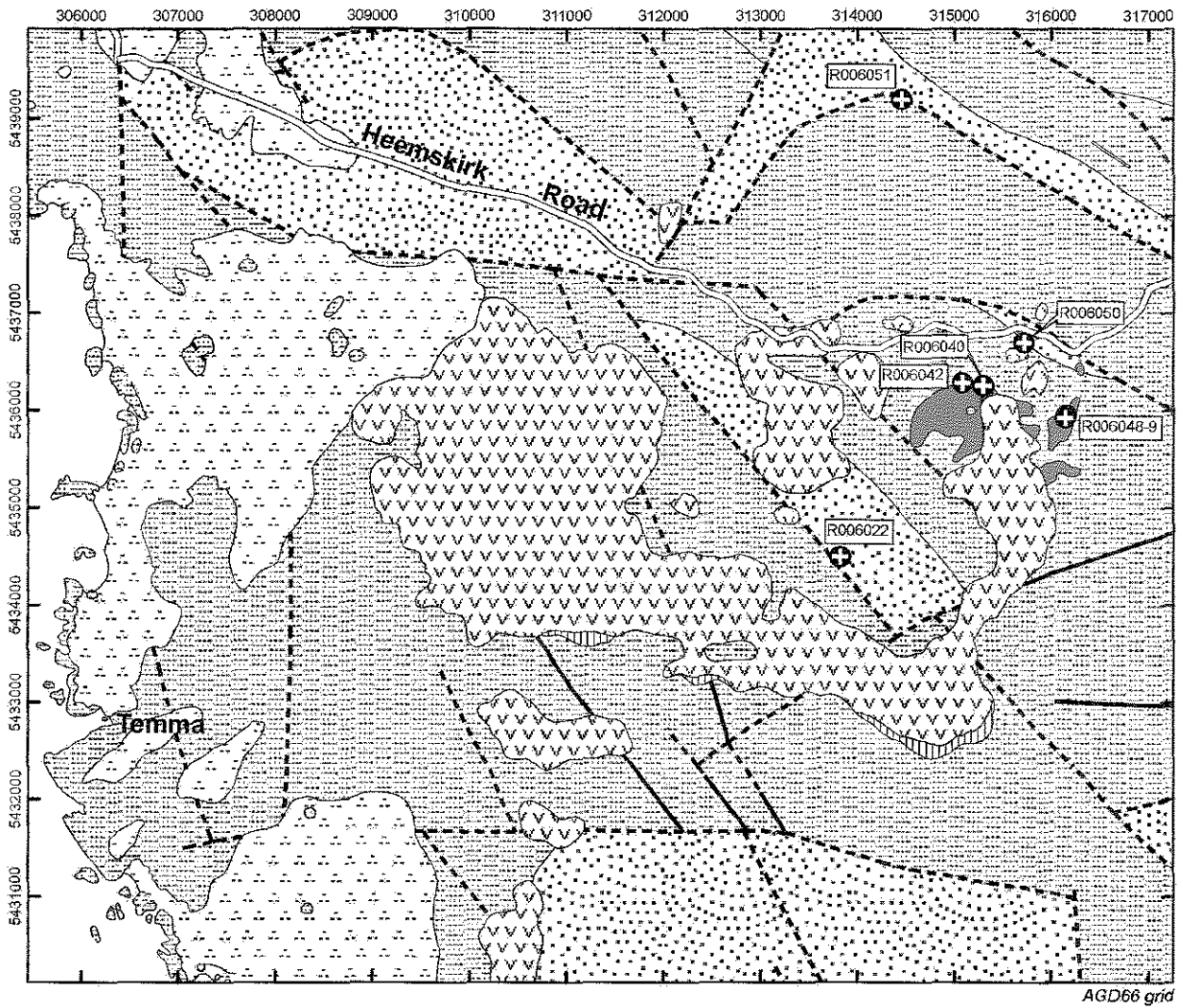


FIG. 1 — Localities in Tasmania that have yielded Early Miocene marine sedimentary rocks. Localities marked by star.



AGD66 grid

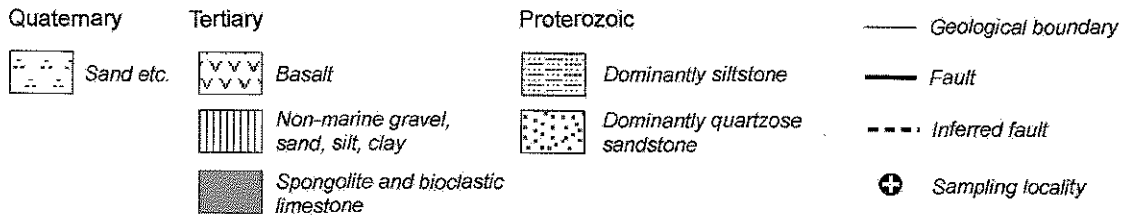


FIG. 2. — Simplified geology of Temma region showing sample site. (After Seymour & Reed 2003).

TABLE 1
Location of individual sample studied

Sample	Field No.	Easting	Northing	Type
R006022	TE117	313823	5434487	Outcrop, Rebecca Ck
R006040	TE437	315300	5436250	Float
R006042	TE507	315085	5436280	Float
R006048	TE572	316150	5435950	Float
R006049	TE573	316140	5435920	Float
R006050	TE663	315721	5436698	Float
R006051	TE692	314454	5439196	Float

from the site. The locality is now designated an “Informal Reserve managed by Forestry Tasmania”.

GEOLOGICAL SETTING

The Miocene section overlies a Mesoproterozoic basement of shale, siltstone, sandstone and conglomerate with a strong northwest structural grain and is overlain by a ridge of basalt. The Miocene outcrops consist of three separate mapped areas but float specimens are widespread attesting to a much wider original extent. The major, eastern occurrence appears on Seymour & Reed (2003) as four patches in contact with basalt. It covers approximately one square kilometre and a considerable part is overlain by the basalt, indicating that the four units are contiguous under the basalt and that there may be considerably more material farther to the west below the basalt. This outcrop extends from below 120 m.a.s.l. at its western extent to slightly above 140 m.a.s.l. at its eastern end. The other two patches lie to the east, one between 140 and 160 m.a.s.l. and the other, smallest patch, above 160 m.a.s.l.

The basalt, recorded by Sutherland & Corbett (1967) as Temma Basalt, is the dismembered remnant of a more widespread subaerial flow of which age and source are unknown. Sutherland & Corbett (1967) suggested that a considerable time had elapsed between deposition and erosion of the Miocene rocks, and the eruption of the basalt. They also mentioned the existence of the Miocene sedimentary rocks in pebbles on the beach at Temma and suggested either a Balcombian age for the material studied here by comparison with Victorian sections, or Batesfordian as at Marrawah.

Tertiary marine sediments were recorded from a very small outcrop of silicified biocalcarene near Granville Harbour by Quilty (1972) at approximately “350 feet” (say, 105 m.a.s.l.). Preservation in that material was such that individual silicified Foraminifera could be recovered and identified well. They included index species for southeastern Australian, benthic-based zonal schemes in use at the time. The source of the silica is unknown.

MATERIAL AND METHODS

Sample treatment varied according to lithology and preservation. Most samples are highly silicified and lithified and were studied in thin section or in one case, a disaggregated sample. Preservation varies dramatically from sample to sample, some yielding workable faunas, others none at all. Preservation is such that, while many species are identifiable and age and palaeoenvironment able to be determined, the detailed structure of the faunas (dominance, diversity, miliolid percentage etc) is indeterminate.

Selected individual specimens were imaged under scanning electron microscope (SEM) at the Central Science Laboratory, University of Tasmania, and those in thin section, under petrological microscope at the School of Earth Sciences, University of Tasmania. The silicification has made coating of specimens for SEM work less successful than normal carbonate specimens, and some specimens were apt to charge and to need re-coating or imaging at lower voltage.

Identifications follow Quilty (1974, 1977, 1980, 1982) and Li & McGowran (2000) and appendix 1 refers to the species nomenclature employed.

Rock samples and thin sections are held by Mineral Resources Tasmania and the number (e.g., MRT R006022) is the accession number in its collection. Illustrated species are held in the School of Earth Sciences, University of Tasmania, and the number following the abbreviation UTGD is the accession number in that collection. All grid coordinates quoted herein are AGD66 AMG Zone 55.

SAMPLE DETAILS

Sample MRT R006022 – sample and thin section

The small hand specimen is solid, pale, milky chert, barren of any evidence of fossils. In thin section, the rock is a highly uniform chert with few thin, straight quartz veins. A few bodies may be the remains of sponge spicules but preservation is very poor and basically all original texture has been destroyed.

Sample MRT R006040 – sample and thin section

The hand specimen is pale, mottled but massive chert. Thin section shows clearly that this is a “chertified” biocalcarene. Microfossil material is abundant but as wispy profiles, rarely even identifiable to a group of organisms. Much of the biogenic material is in the form of roughly parallel straight elongate shapes that were once sponge spicules; a few have the internal tube preserved very poorly. Some shapes represent bryozoans and one is a cibicidid foraminifer. There is one curved shape that was a bivalve. The original sediment was sponge-rich with a significant calcareous fossil component. While no age diagnostic forms are present, the palaeoenvironment was shallow and fully marine.

Sample MRT R006042 – sample and thin section

The specimen is pale, highly variegated chert with clear stratification. In thin section, fossils are obvious and there is a differentiation of bands that are purely sponge spicules, (including terrasters) and others that were sponge-rich carbonate sand. The latter contain evidence of calcareous algae, bryozoans, echinoid spines and some Foraminifera that may be cibicidids, but preservation is too poor to allow any more definitive statement. While no age diagnostic forms are present, the palaeoenvironment of deposition was shallow, within the photic zone and fully marine.

Sample MRT R006048 – sample and three thin sections

The rock is dominantly of brown chert with a white horizon on one side of the specimen. It is a high purity spongolite coloured brown due to Fe oxide staining in small vuggy patches. Very few elements are identifiable as cibicidid foraminifer (one likely to be *Cibicides vortex* Dorreen, 1948) or echinoid spines. Sponge spicules are notable in being large with large central hollows.

Sample MRT R006049 – sample and two thin sections

The specimen is pale, highly porous silicified biocalcarenite. It appears friable but is not so in reality. It is completely silicified but fossils are obvious, diverse and some are identifiable. It was initially a biocalcarenite that has been completely silicified. Calcareous algae, bryozoans, echinoid spines, gastropods, bivalves and serpulids are identifiable in general terms. Foraminifera include *Sherbornina* (probably *atkinsoni* Chapman, 1922 due to its thin wall; seen in both equatorial and vertical section) and *Tenisonina* as well as probable *Carpenteria*, *Parredicta* (*Valvulineria kalimnensis* of Quilty 1972), agglutinated species, miliolids, cibicidids, globocassidulinids and minor sponge spicules.

A seemingly friable sample was broken down and sieved at 125–250 μ , 250–500 μ and >500 μ . All residues are clean, white, silica-rich and carbonate-free. Much of the rock is in the form of internal moulds of various biogenic material but differs from grade to grade. Specimen numbers recorded below are from this sample. In addition, two thin sections provided additional sections through many species (see pls 1, 2).

>500 μ

Entirely biogenic with sponge spicule-rich fragments, small gastropods very abundant, bivalve fragments, echinoid spines and very few identifiable Foraminifera.

250–500 μ

The material is as for the 250–500 μ fraction but with a higher proportion of identifiable material with some very well-preserved, entirely replaced silicified Foraminifera. A high proportion of the foraminiferal fauna consists of silica internal moulds of miliolids such as *Quinqueloculina* and *Miliolinella*. A few fragments consist of several parallel sponge spicules.

125–250 μ

Internal moulds are not uncommon and include Foraminifera, gastropods and a few sponge spicules but by far the highest proportion is in the form of isolated chamber lumen internal moulds. A few Foraminifera have suffered replacement silicification. There are also very rare rounded quartz grains that attest to a detrital component.

The fauna consists of (numbers of specimens in parentheses):

Anomalinooides macraglabra (Finlay, 1940) (4)
A. sp. indet. (1)
Calcarina verriculata (Howchin & Parr, 1938) (6)
Cassidulinoides sp. (1)
Cibicides perforatus (Karrer, 1864) (35)
C. vortex Dorreen, 1948 (9)
Cribrorotalia ornatissima (Karrer, 1864) (4)
Fissurina globosa Bornemann, 1855 (2)
Globocassidulina subglobosa (Brady, 1881) (2)
Guttulina problema d'Orbigny, 1826 (2)
 Internal moulds of *Quinqueloculina/Miliolinella* (220)
Melonis obesa (Carter, 1964) (2)
Oolina globosa (Montagu, 1803) (1)
Pyrgo cf. vespertilio (Schlumberger, 1891) (1)
Pyrulina gutta d'Orbigny, 1826 (1)
Sherbornina atkinsoni Chapman, 1922 (1)
Sigmoilina obesa Heron-Allen & Earland, 1932 (1)
S. sp. (1)
Tenisonina tasmaniae Quilty, 1980 (3)
 Textulariid internal moulds

There were also a few fragments identifiable only as of Foraminifera.

Sample MRT R006050 – sample and thin section

Massive white chert with “traces”. Pure spongolite but with scattered quartz grains that may be relict detrital grains. Seems identical with one of the thin sections of MRT R006048.

Sample MRT R006051 – sample and two thin sections

Sample of white chert that appears to be a silicified sandstone (but is not).

Thin section shows it to be a silicified biocalcarenite with wispy and unidentifiable traces of bryozoans, gastropods, and a few Foraminifera. Sponge spicules very dominant.

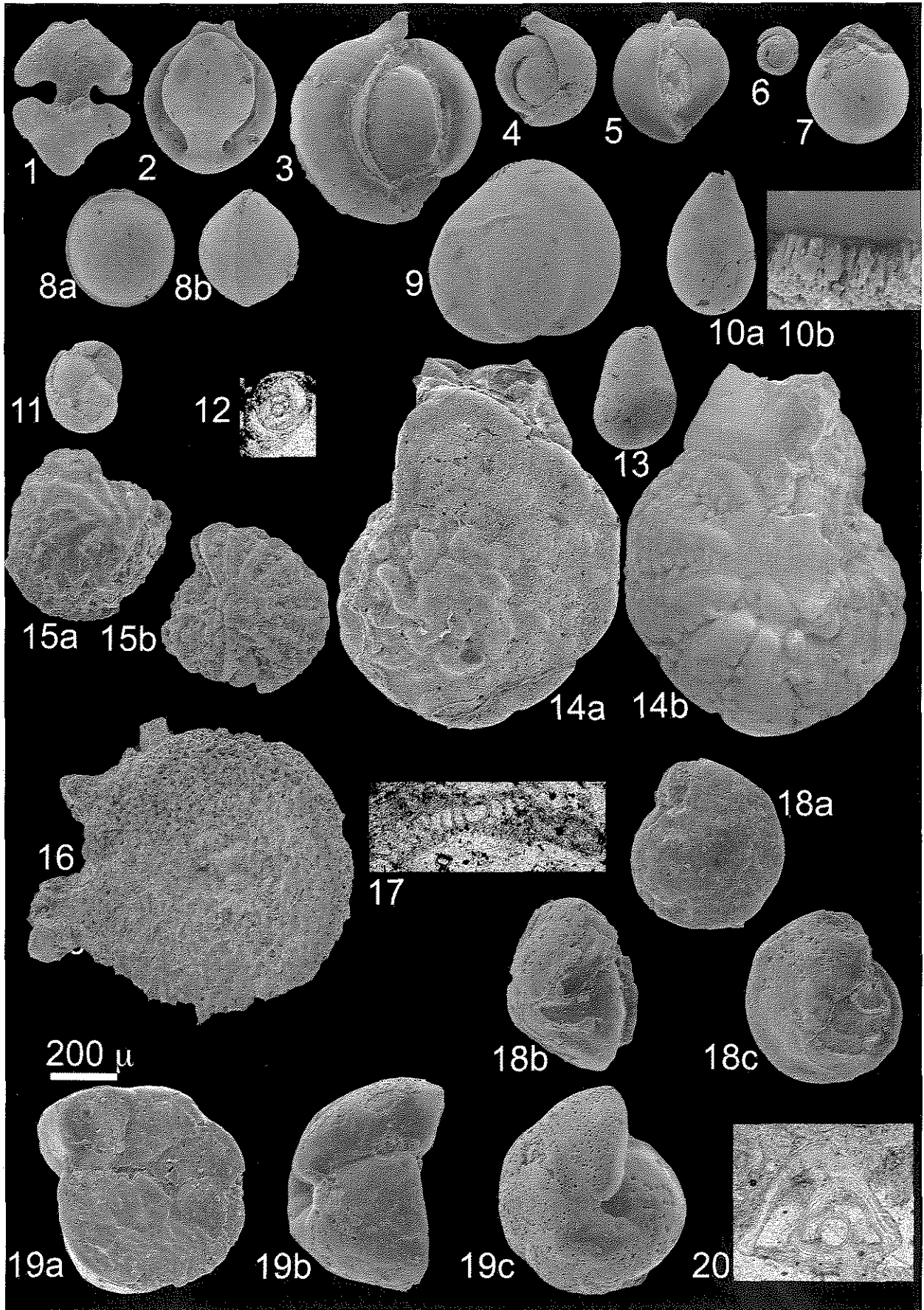
DISCUSSION

Age of the fauna

The fauna contains very few species that are age-diagnostic and planktonic species are absent, but *Sherbornina atkinsoni*,

PLATE 1 (opposite)

Miocene Foraminifera from Temma. Scale bar = 200 microns except for fig. 10b. 1. Internal mould of textulariid species, UTGD128828. 2. Internal mould *Pyrgo cf. vespertilio* (Schlumberger), UTGD128829. 3, 4. *Quinqueloculina/Miliolinella*, internal moulds UTGD128830. 5. *Sigmoilina obesa* Heron-Allen & Earland, internal mould, UTGD128831. 6. Internal mould *Sigmoilina sp.*, UTGD128832. 7. *Oolina globosa* (Montagu), UTGD128833. 8a, b. *Fissurina globosa* Bornemann, ventral and profile views respectively, UTGD128834. 9. *Guttulina problema* d'Orbigny, UTGD128835. 10a, b. *Pyrulina gutta* (d'Orbigny), UTGD128836. 10b illustrates preservation of wall structure in opaline silica. 11. *Globocassidulina subglobosa* (Brady), UTGD128837. 12. *G. subglobosa* (Brady), thin section MRT R006049A. 13. *Cassidulinoides sp.*, UTGD128838. 14a, b. *Calcarina verriculata* (Howchin & Parr), dorsal and ventral aspects respectively, UTGD128839. 15a, b. *Cribrorotalia ornatissima* (Karrer), dorsal and ventral aspects respectively, UTGD128840. 16. *Sherbornina atkinsoni* Chapman, specimen preserved as opaline replacement, UTGD128841. 17. *S. atkinsoni* vertical section, MRT R006049A. 18a-c. *Cibicides perforatus* (Karrer), dorsal, lateral and ventral aspects respectively, UTGD128842. 19a-c. *Cibicides vortex* Dorreen, dorsal, lateral and ventral aspects respectively, UTGD128843. 20. *C. vortex*, vertical section, MRT R006049.



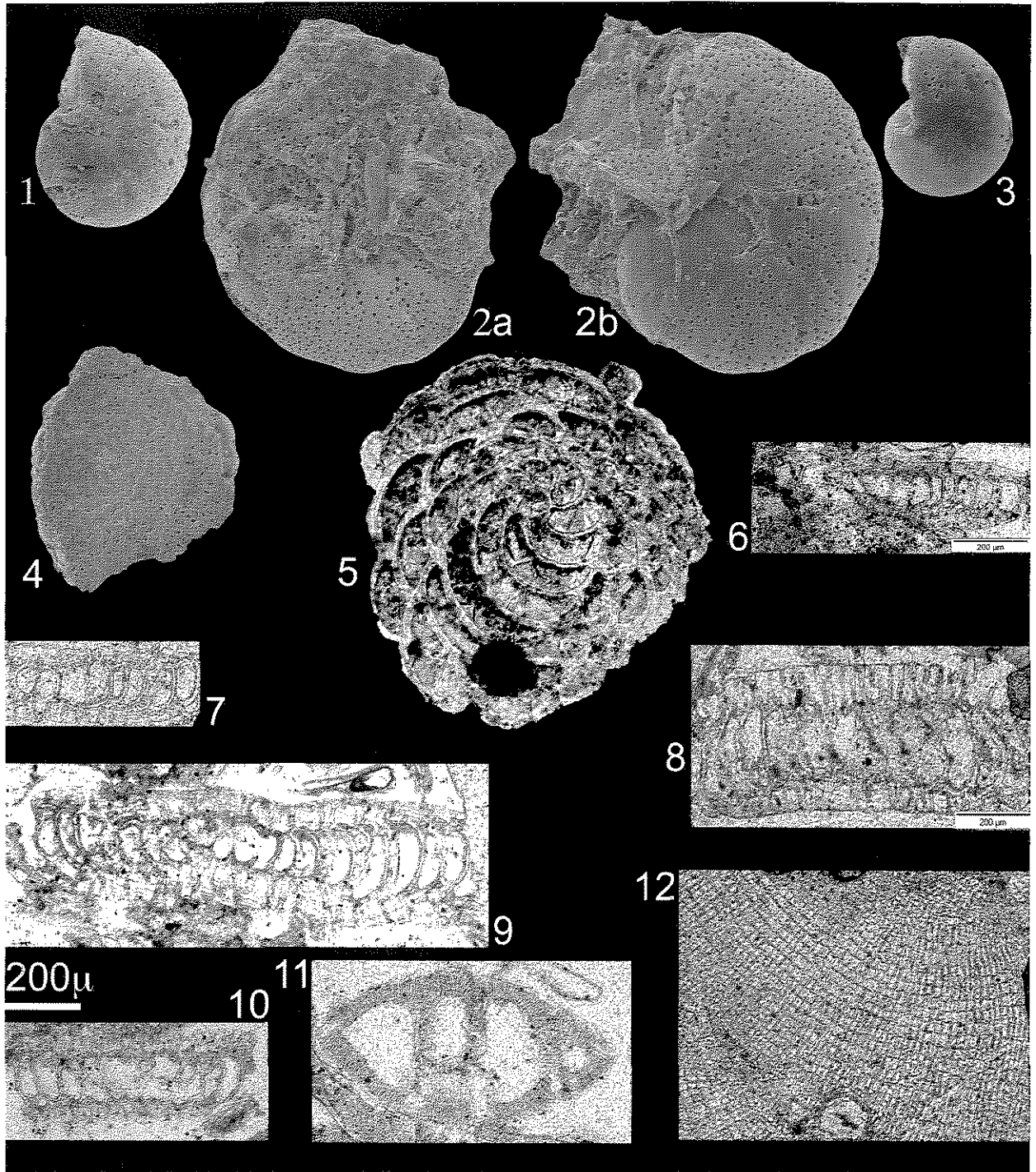


PLATE 2

Miocene foraminifera from Temma. Scale bar = 200 microns. 1. *Melonis obesa* Carter, lateral aspect, UTGD128844. 2a, b. *Anomalinooides* sp. ventral and dorsal aspects respectively, UTGD128845. 3. *Anomalinooides macraglabra* (Finlay), lateral aspect, UTGD128846. 4-10. *Tenisonina tasmaniae* Quilty. 4. Fragment of silicified specimen, UTGD128847. 5. Equatorial section through silicified specimen, UTGD128848. 6-10. Vertical and oblique sections, MRT R006049A 11. *Crespinnella* sp., vertical thin section, MRT R006049A. 12. Silicified calcareous algae, MRT R006049B.

Parredicta kalimnensis, *Cibicides perforatus* and *C. vortex* are well-known in Tasmanian rocks shown to be Longfordian (Early Miocene) by Quilty (1972). Other species such as *Calcarina verriculata* are consistent with this assignment. *Cribrorotalia ornatissima* is known only from the Miocene in New Zealand (Hornibrook *et al.* 1989). Most other species are long-ranging. This locality is only the second to yield *Tenisonina tasmaniae* originally described from nearby Cape Grim (Quilty 1980) which also lacked planktonic species. At Cape Grim, that absence is a primary feature but whether due to original absence or destruction by silicification is not clear in the Temma instance. It seems highly likely then that the section forms part of those deposited during a widespread marine incursion around Tasmania at the time.

Environment of deposition

It has proven impossible to conduct any form of statistical analysis of the faunas because the samples have been altered so much from the original; however, some contain calcareous algal remains and the Foraminifera and diversity of molluscs are strongly indicative of very shallow-water (<20 m), fully marine conditions. Quinqueloculine miliolids dominate the fauna which contains several forms that indicate normal marine salinity and not an estuarine environment; conversely, no estuarine indices are present. There is no evidence of any significant infaunal element suggesting a low nutrient input. No planktonic foraminiferal species were seen and this is in common with the Early Miocene section at Cape Grim. There are no indications of sub-tropical or tropical elements adding to the similarity with coeval rocks at Cape Grim some 65 km to the northwest. The abundance of sponge remains suggests accumulation in a sponge thicket.

The locality is now approximately 12 km inland and this gives an indication of the minimum extent that the marine embayment must have reached. Equivalent-age sedimentary rocks are at sea level at Temma (Quilty 1972) and thus this region has been raised some 150 m since deposition.

Silicification

All samples examined have suffered extensively from silicification, probably due almost entirely to remobilisation of opaline silica from abundant sponge spicules, although some contribution from weathering of basaltic minerals cannot be ruled out. Silicification of Foraminifera varies dramatically and the result depends on the original wall structure; some preserve poorly or not at all and others are excellent. No agglutinated forms were recovered as such but isolated internal moulds of biserial textulariid forms are common and are visible in thin section; they are neither identifiable nor provide information of the proportion of the original fauna made up of these forms. Miliolids are the dominant Foraminifera identifiable as such, and a few are specifically identifiable, some probably identifiable confidently to genus, but all are internal moulds. In the 250–500 μ size range, entire specimens are represented by coherent internal moulds but no test material replaced by silica has survived; however, filling of the chamber lumina must have taken place before the walls were removed. In the 125–250 μ fraction, the proportion of coherent miliolid internal moulds is much less and other species also are less represented. Nodosariid forms are occasionally excellently preserved and readily identifiable. For cibicidid species, *Tenisonina tasmaniae* and *Sherbornina atkinsoni*, the original calcium carbonate (calcite) wall has

been replaced and thus the original form of the specimen has been preserved allowing specific identity to be determined with confidence. It is unclear what proportion of the original species of the fauna is not represented at all.

Other

Several species identifiable in thin section (for example *Parredicta kalimnensis* (Parr, 1939)) have not been recovered from the disaggregated specimen.

This is only the second locality to yield *Tenisonina tasmaniae* Quilty, 1980 and further reinforces the link between this section and that at Cape Grim, the type locality of *T. tasmaniae*. Here, *T. tasmaniae* occurs with *Sherbornina atkinsoni*, the first place for which this is true. In other ways, the section contrasts markedly with coeval marine sedimentary rocks (except that at Granville Harbour) because of the intense silicification, a result of a high sponge spicule content.

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APPENDIX 1

Species nomenclature employed

- Anomalinoides macraglabra* (Finlay, 1940) = *Anomalina macraglabra* Finlay, 1940, 460, pl. 66, figs 141–143.
- A. sp. indet.*
- Calcarina verriculata* (Howchin & Parr, 1938) = *Rotalia verriculata* Howchin & Parr, 1938, 310, pl. 19, figs 8, 9, 11, 15.
- Cassidulinoides sp.* *Remarks.* An unusual, fully silicified, very highly coarsely perforate species represented by a single specimen. It is unlike any described species.
- Cibicides perforatus* (Karrer, 1865) = *Rotalia perforata* Karrer, 1865, 81, pl. 16, fig. 13 = *Cibicidoides perforatus* (Karrer).- Li & McGowran 2000, 117.
- C. vortex* Dorreen, 1948, 299, pl. 41, figs 5a-c.
- Crespinella sp.* Seen only in thin section and this specifically unidentifiable as the number of chambers per whorl cannot be determined.
- Cribrorotalia onatissima* (Karrer) = *Amphistegina ornatissima* Karrer, 1864 = *Cribrorotalia ornatissima* (Karrer). - Hornibrook, 1971, 20, pl. 3 figs 47–49, text-fig. 3. *Remarks.* This appears to be the first record of this Miocene species from Australia.
- Fissurina globosa* Bornemann, 1855, 317, pl. 12, fig. 4.
- Globocassidulina subglobosa* (Brady, 1881) = *Cassidulina subglobosa* Brady 1881, 60; Brady 1884, 430, pl. 54, fig. 17.
- Guttulina problema* d'Orbigny, 1826, 266.
- Internal moulds of *Quinqueloculina/Miliolinella*. *Remarks.* Abundant but identifiable only to one of the quinqueloculine genera.
- Melonis obesa* (Carter, 1964) = *Astrononion obesum* Carter 1964, 112, pl. 10, figs 205, 206. = *Melonis obesum* (Carter).- Li & McGowran 2000, 121, figs 42 U,V.
- Oolina globosa* (Montagu, 1803) = *Vermiculium globosa* Montagu, 1803, 523. *Remarks.* Preserved as a fully silicified test and thus identifiable.
- Pyrgo globula* (Bornemann).- Cushman, 1932, p. 65, pl. 15, figs. 6–8 = *Biloculina globulus* Bornemann, 1855, 349, pl. 19, fig. 3.
- Pyrgo cf. vespertilio* (Schlumberger, 1891) = cf. *Biloculina vespertilio* Schlumberger, 1891, 561, pl. 10, figs 74–76. *Remarks.* Species not identifiable with confidence as it occurs only as an internal mould.
- Pyrulina gutta* (d'Orbigny, 1826) = *Polymorphina (Pyruline) gutta* d'Orbigny, 1826, 267. *Remarks.* Identifiable specifically as it occurs as a completely silicified specimen.
- Sherbornina atkinsoni* Chapman, 1922, 501, pl. 32, figs 1-5.
- Sigmoilina obesa* Heron-Allen & Earland, 1932, 320, pl. 7, figs 1–4. *Remarks.* Identifiable even though preserved only as internal moulds.
- Sigmoilina sp.* *Remarks.* Identifiable only to generic level.
- Tenisonina tasmaniae* Quilty, 1980, 305, figs 7, 8.