FORAMINIFERA AND PALAEOENVIRONMENT OF ELEVATED LATE PLEISTOCENE SANDS, WHITE ROCK POINT, SOUTHEASTERN TASMANIA

by Dale Lewis and Patrick G. Quilty

(with three text-figures, one plate, one table and one appendix)

Lewis, D. & Quilty, P.G. 2009 (11:xii): Foraminifera and palaeoenvironment of elevated Late Pleistocene sands, White Rock Point, southeastern Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 143(2): 95–100. https://doi.org/10.26749/rstpp.143.2.95

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A well-preserved foraminiferal fauna similar to that living in nearby Ralphs Bay in southeastern Tasmania is documented from raised shallow-water sediment of 130–119 Ka age (Late Pleistocene; Marine Isotope Stage 5e) at about 24 m above modern sea level on White Rock Point. Foraminifera and sediment characteristics indicate that deposition occurred in very shallow, highly oxygenated, high-energy marine conditions in an area of open circulation. There is very little infauna. The locality is the only known site for such a fauna from before human habitation of the Derwent Estuary region, and allows comparison with modern faunas.
Key Words: Pleistocene, Foraminifera, palaeoenvironment, Tasmania.

INTRODUCTION

Much has been written since the visit of Charles Darwin to Hobart in 1836 (Darwin 1891, Sutherland 1971, Banks 1971, Bowden & Colhoun 1984, Banks & Leaman 1999, M. Davies 2009) concerning possible "young" uplift or neotectonic activity of Tasmania. Darwin (1891) discussed briefly evidence in the form of raised shell beds in the vicinity of Hobart, and Banks (1971) and Banks & Leaman (1999) expanded on that comment, using Darwin's own diaries. Unfortunately, many of the localities Darwin visited are now altered or inaccessible because of development. Darwin referred to the then current belief by the "colonists" that most shell beds were the result of transport by Aborigines but his view was that "... the greater number [is due] to a small elevation of the land" (Darwin 1891 p. 158).

The question of rejuvenation of tectonically-controlled land level and its causes has become of recent interest with the need to differentiate evidence of land elevation change versus sea level change (Dickinson *et al.* 2002, Sandiford 2003, 2007, Sandiford *et al.* 2004). Tasmania has several recognised surfaces such as the Milford (c. 1 m above modern sea level) and Llanherne (4 m) surfaces of J.L. Davies (1951, 1961) who ascribed changes in level to variation in sea level. The Milford level was associated with a sea level highstand at 6–Ka. His papers did not refer to the higher level sediment studied here.

Unconsolidated sediment to 24 m above sea level (m.a.s.l.) occurs on White Rock Point (42°58'S, 147°24.3'E), on the peninsula immediately north of Opossum Bay, southeastern Tasmania (figs 1, 2). This is recorded as Mary Ann Bay sandstone on Leaman (1972). The sediment is not of middens, which do occur nearby, but undisturbed natural sediments, lying where deposited. This site, commonly referred to as Mary Ann Bay, is critical in the discussion of uplift because it appears to be the sole locality in the Tasmanian region which has yielded fossil-based information on elevation and age, thus allowing an estimate of rates of change of uplift. The sediments contain the only known "young" fauna from pre-human activity in the region.

The sediment has been dated by Murray-Wallace *et al.* (1990) and Murray-Wallace & Goede (1991, 1995) to the Last Interglacial Maximum, Marine Isotope Stage (MIS) 5e or 130–119 000 years, using amino acid racemisation and electron spin resonance techniques. These ages suggest deposition when sea level may have been a few metres above current (Hearty *et al.* 2007) but the true sea level difference depends on where, in the interval 130–119 Ka, the age of the sediment falls. This is unclear as yet. The subject of precise dating of, and sea level variation during, the Last Interglacial interval is contentious at present (Edwards *et al.* 1987, Szabo *et al.* 1994, Slowey *et al.* 1996, Muhs *et al.* 2002) and other dating techniques such as U/Th may be useful in placing this material in the context of climate change controlled by orbital forcing (the Milankovitch hypothesis).

The sediment is described in detail by Murray-Wallace *et al.* (1990). It consists of well-sorted quartz sand from more than one immediate source and contains grains, dominantly medium sand fraction, that vary from very well rounded to fresh, angular, commonly with some crystal faces indicating recent release from local high porosity Triassic sandstone. The sediment is cross-bedded and most molluscs are highly fragmented, suggesting deposition in shallow marine, high-energy conditions typical of small bays currently found around the peninsulas of South Arm and Tasman Peninsula (fig. 1). The sediments contain a diverse fauna of extant molluscs (Colhoun *et al.* 1982).

In addition to the molluscs, the sediments contain a significant foraminiferal fauna of species that are well-known in the vicinity (Harris 1969, Lewis 2006). They are well-preserved and thus allow comparison of conditions between pre- and post-human, occupation of the region, including geochemical signals in the calcium carbonate skeletons.

This paper documents the foraminiferal fauna, uses it to place limits on the palaeoenvironment at 130–119 Ka and establishes a foraminiferal baseline for southeastern Tasmanian Foraminifera from an environment that existed prior to disturbance by human activities.

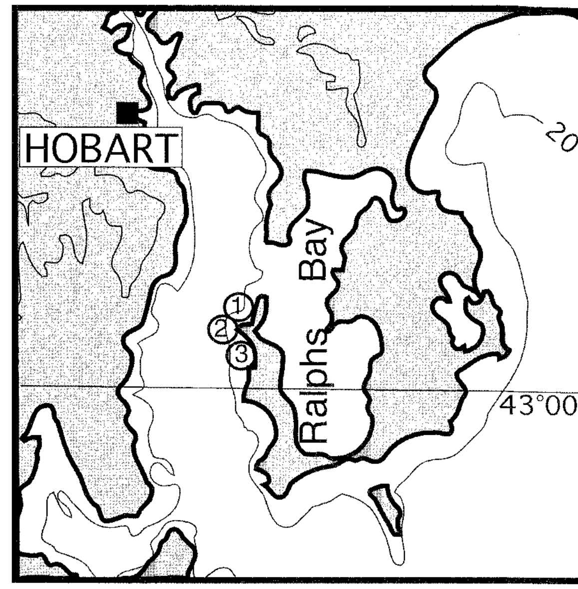

FIG. 2 — Detail of location of three specimens studied.

MATERIAL AND METHODS

Three samples (A, B and C) were collected from steep faces on the western side of the outcrop. As the sand is unconsolidated, processing consisted of simple washing of 3 x 20 g samples over nested sieves at 63, 125, 250 and 500 µm but only those resting on sieves coarser rhan 125 mm were examined. Washed residues were reduced in size by a sample splitter to yield statistically sound foraminiferal faunas; thus only 25% or 12.5% of the sample was picked to give the specimen count shown in table 1. Foraminifera were separated by standard methods, placed in cardboard slides and identified. The distribution of the Foraminifera is shown in table 1 and nomenclature followed is provided in appendix 1.

The material is well-preserved and there is no indication in rhe Foraminifera of damage through diagenesis although many specimens have minor abrasion or breakages consisrent with a high-energy environment; thus rhe final chamber wall of *Ammonia aoteana* (Finlay, 1940) commonly is broken but the rest of the test is well-preserved. While the robust environment is a likely cause, the broken final chamber could also be an arrefact of reproduction. There may also have been minor dissolution of test surfaces due to percolating meteoric waters but there is no evidence for significant dissolution in either molluscs or foraminiferal populations.

Species were identified using the studies by Yassini & Jones (1995), Hayward *et al.* (1999) and Lewis (2006). Once identified, a variety of standard techniques was used to categorise the fauna and to inrerpret the palaeoenvironment.

Samples studied and fossils illustrated are caralogued in the collection of the School of Earth Sciences, University of Tasmania, and the number following the initials UTGD is the accession number in that collection. Illustrated specimens (pl. 1) are in the range 128811–128822 and the hand specimens, washed residues and assemblage slides in 160918.

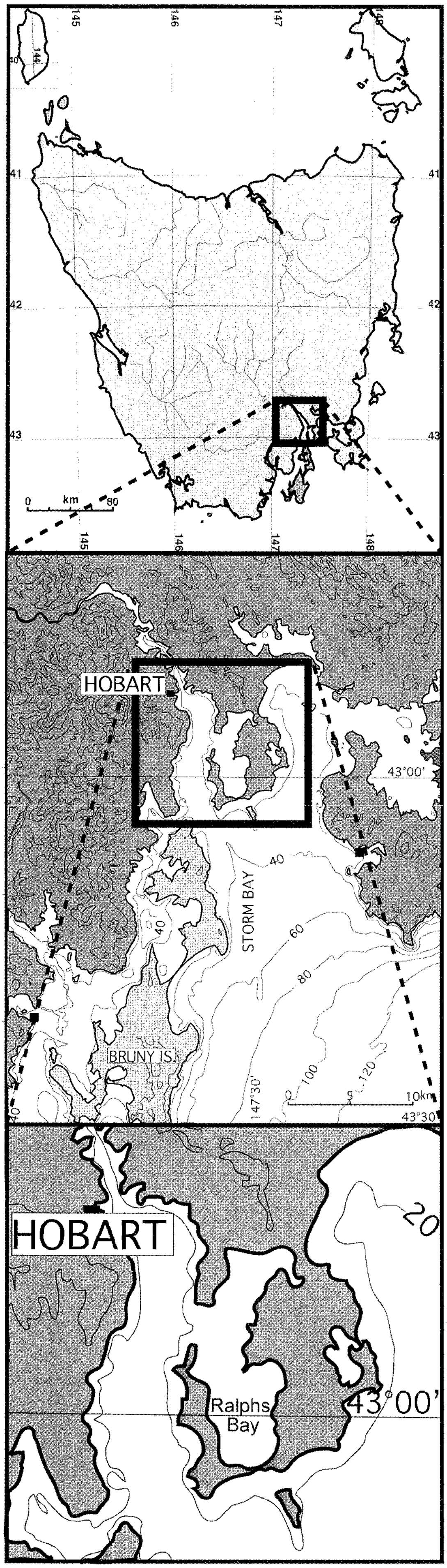

FIG. 1 — Locality map.

TABLE 1
Species recorded in subsets of three samples from the western side of the Mary Ann Bay outcrop

Species	Sample A	Sample B	Sample C
Benthic species			
Ammonia aoteana	87	76	37
Bulimina gibba	2		
Cibicides refulgens	16	8	1
Elphidium advenum advenum	6	8	5
E. advenum maorium		1	
E. crispum crispum	3		3
E. excavatum clavatum	5	2	
E. hawkesburiense	27	33	10
Nototrotalia clathrata	10	2	4
Parrellina verriculata		1	
Trifarina pacifica	1	1	
Uvigerina bassensis	1		
Planktonic species			
Globigerina bulloides			1
Total	157	132	61
Specimen count/20 gm	628	1056	488
Diversity	6	4	4
Dominance	55	58	61
Fisher a Index	3	3	2

FORAMINIFERAL FAUNA

The fauna is remarkably similar between samples. Diversity is low as expected in the palaeoenvironment envisaged. *Ammonia aoteana* is dominant (55–61%). The next most abundant species is *Elphidium hawkesburiense* (Albani, 1974) (16–25%). Other species make up lesser proportions of the samples. Sample A contains 2% infaunal species (*Uvigerina bassensis* Parr, 1950 and *Bulimina gibba* Fornasini, 1902), and samples A and B yielded a few infaunal *Trifarina pacifica* (Albani, 1974).

Miliolids and cassidulinid species are absent as are agglutinated forms showing that there is no evidence of reduced salinity or limited circulation.

Hayward *et al.* (1999) regarded *A. aoteana* as a subspecies of *A. parkinsoniana* (d'Orbigny, 1839) but we take it to be a valid species in its own right.

Dominance/diversity

Walton (1964) studied the distribution of several hundred samples from the Gulf of Mexico and plotted diversity and dominance. Dominance (the percentage of the fauna made up of the dominant species) for White Rock Point ranges from 55 to 60, and diversity (the number of species making up 95% of the fauna) is 4–6. The corresponding Fisher a Index (Fisher *et al.* 1943, Williams 1964, Quilty & Hosie 2006) is 2 to 3. Figure 3 shows the White Rock Point samples plotted on Walton's 0–10 fathom field, suggesting that species in the samples bear the same relationship to each other in the samples as they did in life. Thetefore, the faunas are neither mixed with those from any other source, and not have any species have removed from the parent sediment.

Faunal assemblage structure

There is a single occurrence of a planktonic foraminifer (*Globigerina bulloides* d'Orbigny, 1826). This is normal for sediments deposited close to a sandy beach in a shallow bay with open circulation. The ratio of infaunal/epifaunal species commonly is used as an index of nutrient supply (Corliss & Chen 1988, Murray 1991). In this case, there are very few infaunal species consistent with other evidence for a shallow-water, high-energy, highly oxygenated environment.

Comparison with nearby modern faunas

All species recovered are known locally and all are extant. Lewis (2006) has studied these species from the Pitt Water/Frederick Henry Bay area and has documented the environmental preferences of the species identified.

Deposition occurred in very shallow, high-energy, fully marine waters consistent with the evidence from the mollusc fauna discussed by Colhoun *et al.* (1982).

CONCLUSIONS

Marine sediments from about 24 m.a.s.l. at White Rock Point, southeastern Tasmania, have yielded a low diversity fotaminiferal fauna typical of those to be found in the region today in shallow water, high-energy environments only a few metres deep. There is no evidence of recycling and the fauna is *in situ* and suffering only minor abrasion as expected in that environment.

Age determination by amino-acid stratigraphy and electron spin resonance has provided control to show the sediments were deposited during MIS 5e (130–119 Ka). Sea level at the time was above modern but estimates of the amount vaty (2–4 m) and also depend on where in the interval the age lies. It would be worthwhile trying to limit the dates

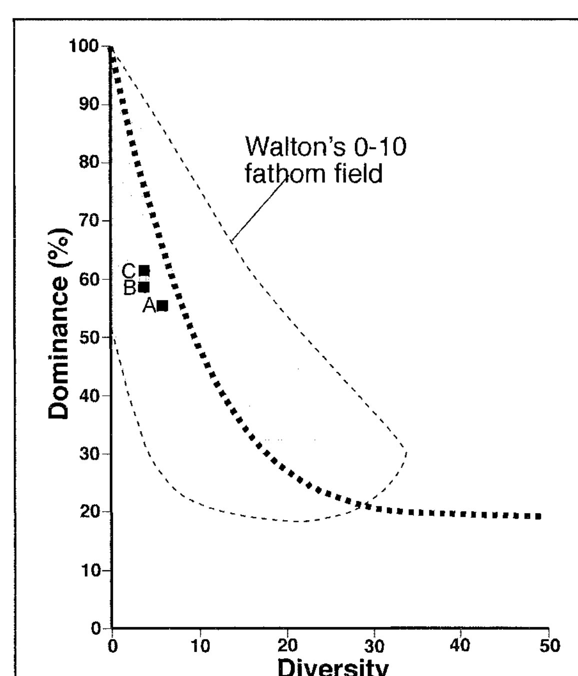

FIG. 3 — Dominance vs diversity and comparison with Walton's (1964) 0–10 fathom field for the Gulf of Mexico.

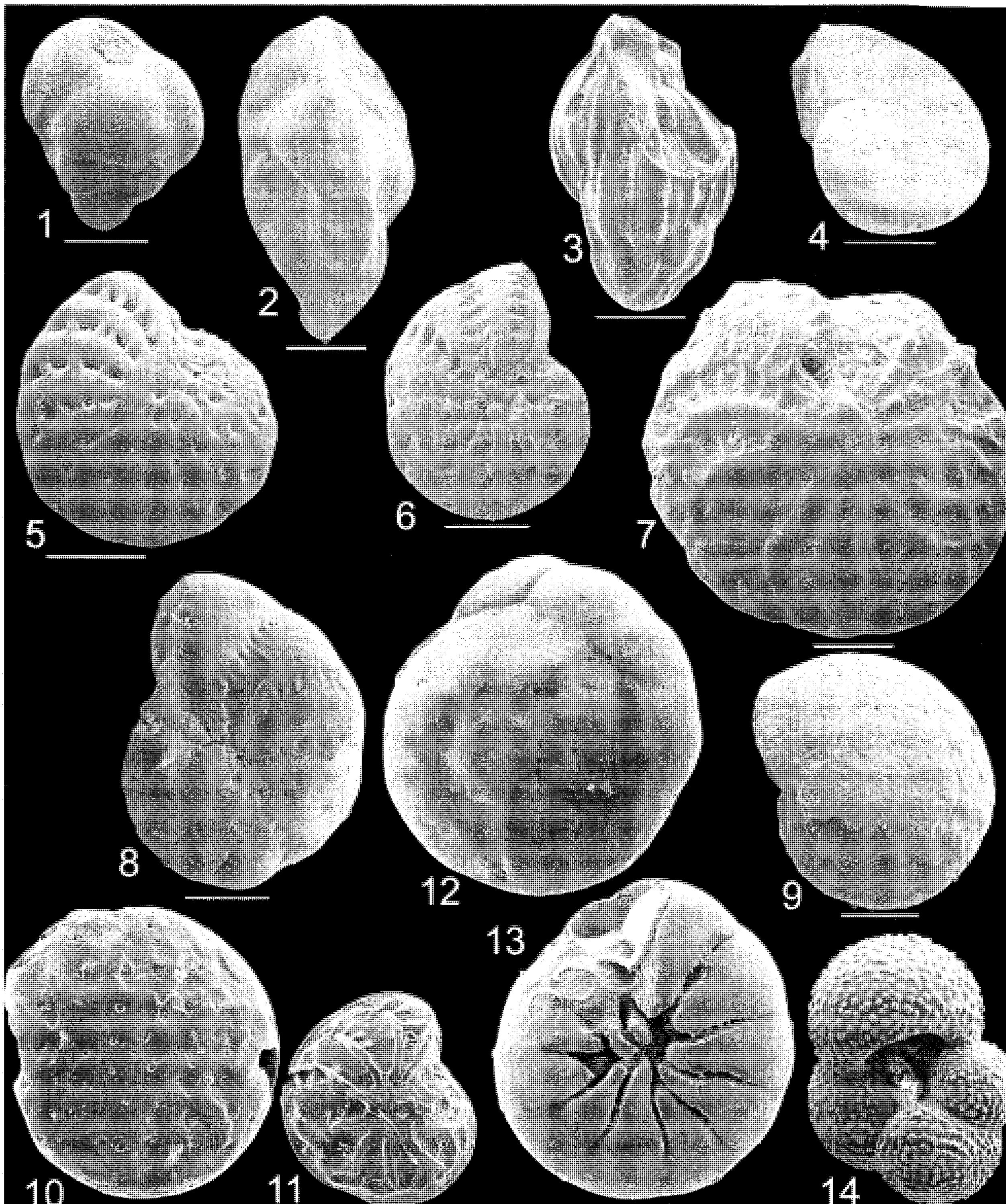

PLATE 1

Species identified from White Rock Point samples. Scale: 100 microns.

1. Bulimina gibba, *profile view, UTGD128811; 2.* Trifarina pacifica, *longitudinal profile, UTGD128812; 3.* Uvigerina bassensis, *longitudinal profile, UTGD128813; 4.* Cibicides refulgens *de Montfort, 1808, oblique ventral surface, UTGD128814; 5.* Elphidium advenum advenum*), lateral view, UTGD128815; 6.* Elphidium excavatum clavatum, *lateral view, UTGD128816; 7.* Elphidium crispum crispum *lateral view, UTGD128817; 8.* Elphidium advenum maorium, *lateral view, UTGD128818; 9.* Elphidium hawkesburiense*), lateral view, UTGD128819; 10, 11.* Notorotalia clathrata *dorsal and ventral views UTGD128820; 12, 13.*Ammonia aoteana *dorsal and ventral views, UTGD128821; 14.* Globigerina bulloides, *apertural view, UTGD128822.*

further using other techniques such as the U/Th method to allow more refined placement in the context of orbitally controlled climate change models.

The locality has been uplifted since deposition but estimates of the amount and rate of uplift rate depend on more refined age determination and of sea level at the time. The locality is the only site in Tasmania to provide information on faunas from before human habitation of the region. It would be very valuable if more such localities could be identified to further calibrate the uplift history.

ACKNOWLEDGEMENTS

We thank Prof. Eric Colhoun, University of Newcastle, New South Wales, for drawing our attention to the existence of the sediments and Dr Albert Goede, University of Tasmania, for advice and assistance in obtaining samples. SEM imaging was conducted at the Central Science Laboratory at the University of Tasmania and we say thank you to Dr K. Goemann for assistance. Dr W. Howard, ACE CRC, University of Tasmania, helped with discussions on sea level at the time of deposition of the sediments. We thank Drs S. Gallagher and D. Haig for constructive reviews.

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(accepted 6 October 2009)

APPENDIX 1
Nomenclature followed in specific identifications

The following is not a comprehensive synonymy but provides a reference to a more comprehensive discussion of species.

Ammonia aoteana (Finlay, 1940)
Streblus aoteana Finlay, 1940, p. 461.
Ammonia parkinsoniana f. *aoteanai*: Hayward *et al.* 2004, p. 162, pl. 16, figs 709.

Bulimina gibba Fornasini, 1902, p. 378, figs 32, 34.

Cibicides refulgens de Montfort, 1808, p. 123, p. 122, text-fig. 123.

Elphidium advenum advenum (Cushman, 1922)
Polystomella advena Cushman,1922, p. 56, pl. 9, figs 11, 12.
Elphidium advenum advenum: Hayward *et al.* 1997, p. 65, pl. 2, figs. 9–18.

Elphidium advenum maorium Hayward *et al.*, 1997, p. 69, pl. 1, fig. 7; pl. 4, figs 11–16; pl. 5, figs 1–5.

Elphidium crispum crispum (Linné, 1758)
Nautilus crispus Linné 1758, p. 709
Elphidium crispum crispum : Hayward *et al.* 1997, p. 74, pl. 7, figs 13–16; pl. 8, figs 1–9.

Elphidium excavatum clavatum Cushman, 1930
Elphidium incertum (Williamson) var. *clavatum* Cushman, 1930, p. 20, pl. 7, figs 10a, b.
Elphidium excavatum clavatum Cushman, 1930: Hayward *et al.* 1997, p. 76, pl. 8, figs 141–7; pl. 9, figs 1–8.

Elphidium hawkesburiense (Albani, 1974)
Cribrononion hawkesburiense Albani, 1974, p. 38, pl. 1, figs 12-14.
Elphidium hawesburiense: Hayward *et al.* 1997, p. 82, pl. 12, figs 1–4.

Notorotalia clathrata (Brady, 1881)
Rotalia clathrata Brady 1884, p. 709, pl. 107, figs 8, 9.
Notorotalia clathrata:Yassini & Jones 1995, p. 180, figs 159–161.

Parrellina verriculata (Brady, 1881)
Polystomella verriculata Brady, 1881, p. 66.
Polystomella verriculata: Brady 1884, p. 738, pl. 110, fig. 12.
Parrellina verriculata : Hayward *et al.* 1997, p. 97, pl. 19, figs 1–3.

Trifarina pacifica (Albani, 1974)
Trimosina pacifica Albani, 1974, p. 38, pl. 1, figs. 8,9.
Trimosina pacifica : Yassini & Jones, 1995, p. 154, fig. 62.
Trifarina pacific : Hayward *et al.* 1999, p. 134, pl. 9, figs. 25, 26.

Uvigerina bassensis Parr, 1950, p. 340, pl. 12, figs 19, 20.

Globigerina bulloides d'Orbigny, 1826 p. 277, list no. 1.
Globigerina bulloides d'Orbigny 1826: Banner & Blow, 1960, p. 3, pl. 1, figs. 1, 4.