

4. EOCENE–OLIGOCENE PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF SITES 1126, 1130, 1132, AND 1134, ODP LEG 182, GREAT AUSTRALIAN BIGHT¹

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ABSTRACT

Planktonic foraminiferal results indicate that Paleogene sediments recovered at Sites 1126, 1130, 1132, and 1134 in the Great Australian Bight are of middle Eocene–late Oligocene age, in intervals equivalent to (sub)tropical Zones P12–P22. The southern temperate assemblage hosted several subtropical species in the middle–late Eocene and late Oligocene as immigrants probably transported by a warm-water system similar to the present-day Leeuwin Current. The four major hiatuses recognized or inferred fall (1) between Zones P12–13 and P15 in the middle Eocene, (2) within Zone P15, (3) between Zones P16 and P18 across the Eocene/Oligocene boundary, and (4) between Zones P19 and P20 and Subzone P21b in the mid-Oligocene. These unconformities represent region-wide events across the southern Australian margin, corresponding to global sequence boundaries Part-1 (39.1 Ma), Pr1 + Pr2 (37.1–36.0 Ma), Pr4/Ru1 (33.7 Ma), and Ru4/Ch1 (28.5 Ma), respectively. Unconformities at Site 1130 had a longer duration as lower Oligocene ooze with Zone P18–P19 species overlying a middle Eocene sandy limestone of Zone P12 age and the whole Oligocene were condensed to only half as thick as the coeval sediments from up- and downslope, indicating stronger erosion at this upper slope locality during the late Eocene. The biostratigraphic results confirm previous studies of the neritic record, reporting that carbonate deposition began in

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the middle Eocene probably as a response to global warming and marginal subsidence because of the accelerated seafloor spreading between Australia and Antarctica at ~43 Ma.

INTRODUCTION

During Ocean Drilling Program (ODP) Leg 182, Paleogene sediments were recovered at Sites 1126, 1128, 1130, 1132, and 1134 in water depths between 218 m (Site 1132) and 3875 m (Site 1128) from the western Great Australian Bight (Fig. F1). The siliciclastic sequence of pre-late Eocene age, at which most holes terminated, is poorly fossiliferous and could be fluvial to deltaic in origin. The overlying middle Eocene limestones grade upward to wackestones and calcareous oozes of younger ages (Feary, Hine, Malone, et al., 2000). Core recovery is low, <30% on average, as a result of cherts. Fossil assemblages of planktonic foraminifers and nannoplankton are moderately preserved, providing evidence for age determination and correlation.

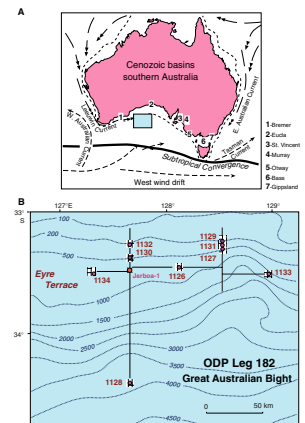
Early work on the Cenozoic biostratigraphy of the Great Australian Bight Basin and other basins along the southern Australian margin focused mostly on macrofossils. Glaessner (1951, 1953) pioneered the decisive shift to microfossils by describing three foraminiferal zones. Crespin (1956) and Ludbrook (1958a, 1958b, 1961) analyzed biofacies, including foraminifers, in samples from outcropping and drill hole sections in the onshore Eucla Basin north of the Great Australian Bight. McGowran and Lindsay (1969) reported planktonic foraminiferal assemblages of middle Eocene age, and McGowran et al. (1971) first attempted the correlation of local assemblages to tropical zonations. Based on sidewall cores, McGowran (1991) identified key events in the upper Eocene–lowermost Oligocene section from Jerboa-1 within the drilling area of Leg 182. These and subsequent studies distinguish a succession of planktonic foraminifer events for subdivision and correlation of the local neritic strata on which the temporal patterns of the stratigraphic record of southern Australia can be evaluated (McGowran, 1989; McGowran et al., 1992, 1997a).

We have examined all Paleogene core catchers from Sites 1126, 1130, 1132, and 1134 plus some additional samples from relevant core intervals. Our purpose is to document planktonic foraminiferal distribution in the middle Eocene–late Oligocene, to compare the assemblage composition between different settings, to identify hiatuses and their significance in the development of Cenozoic cool-water carbonate platform, and to extract biofacies information on environmental changes before and after the full opening of the Tasman Gateway, an event triggering circum-Antarctic deepwater circulation and global cooling in the latest Eocene–early Oligocene (Kennett, 1977; Kennett and Stott, 1990).

METHODS

A total of 141 samples from Sites 1126, 1130, 1132, and 1134 were used in this study. Core catcher samples were washed, dried, and examined on board and reexamined after the cruise. Thin sections of the Eocene limestone were made by N.P. James, collaborating a study on the first major transgression in the region. Material from the deepwater Site 1128 was not used because it has been distorted by dissolution.

F1. Map showing southern Australia, location of Cenozoic basins, Leg 182 sites, and Jerboa-1, p. 17.



Species identification was made by reference mainly to Blow (1979) and Bolli et al. (1985). Key species for biostratigraphy are discussed and illustrated. The timescale and zonal scheme of Berggren et al. (1995) were correlated with relevant datum levels of species found widely in southern Australia (Fig. F2). We used the calibrated first occurrence (FO) and last occurrence (LO) datums of many species given in Berggren et al. (1995) and updated by the Shipboard Scientific Parties of Leg 181 (Carter, McCave, Richter, Carter, et al., 1999; table T3 in Shipboard Scientific Party, 2000a) and Leg 182 (Feary, Hine, Malone, et al., 2000; table T3 in Shipboard Scientific Party, 2000b).

PLANKTONIC FORAMINIFERAL DATUMS AND ZONES

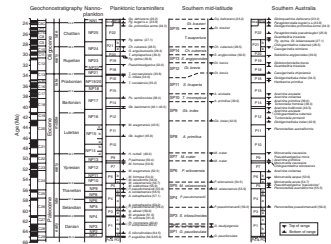
Figure F2 summarizes the integrated Paleogene geochronostratigraphy, emphasizing standard planktonic foraminiferal zones and datum levels from the (sub)tropics. The P-zonation of Berggren et al. (1995) has been correlated with the southern mid-latitude zones identified by Jenkins (1966, 1971, 1993) and important datum levels found in southern Australia (McGowran, 1986, 1991; McGowran et al., 1997a). Together with those used in defining the P-zones, many calculated datums provide the basic framework for the regional biostratigraphy. Local biozonations are not applied in this study for the same reason as stated in McGowran (1986; p. 250) that “it is easier to shuffle the inventory of biostratigraphic events than to redefine zones and subzones each time there is a new discovery, a correction, or a modest step forward in our understanding” (of the distribution of species). Apart from these datum levels, major components of the planktonic foraminiferal assemblages also provide evidence for changes in age and environment. Species associations help determine if datums are in situ or displaced. Biostratigraphic results from previous studies of neritic sediments are summarized below.

Eocene

The Paleocene–early Eocene marine record in southern Australia is sparse, and the Kings Park section near Perth and the coastal Pebble Point section to the southwest of Melbourne are the only two outcrops with good planktonic and benthic foraminifers of that age (McGowran, 1964, 1965). In contrast, middle–late Eocene carbonates rich in planktonic foraminifers are more widespread along the coast of southern Australia (Quilty, 1969, 1981; McGowran, 1979, 1990, 1991, 1992). The planktonic foraminiferal assemblages have these characteristics.

1. Prominent in the Eocene assemblage are *Globigerinatheka index*, *Acarinina primitiva*, *Acarinina bullbrooki*, *Acarinina collactea*, *Turborotalia* spp., *Subbotina linaperta*, and *Chiloguembelina cubensis*.
2. Most (sub)tropical species, especially those zonal markers listed in Fig. F2, are absent. *Morozovella* is rare and present mostly in Zone P10 or older intervals. *Hantkenina* is sporadic in Zones P15–lower P16.
3. The middle Eocene sediments can be subdivided on the following evidence. *Planorotalites australiformis* last appears within Zone P11. Assemblages with *A. bullbrooki*, *Acarinina densa*, and *G. index* indicate Zone P12. *A. primitiva* last appears within Zone

F2. Planktonic foraminifers, p. 18.



P14 equivalents, whereas the LOs of *A. collectea* and *A. aculeata* are in the middle Eocene part of Zone P15. The microperforate *Praetenuitella insolita* and related species are present in Zones P15–P16.

4. The late Eocene assemblage characterizes Zones upper P15–lower P16, mainly including *G. index*, *S. linaperta*, *S. angiporoides*, *Turborotalia increbescens*, *Turborotalia pseudoampliapertura*, *Catapsydrax* spp., and *Globorotaloides* spp. Zone P16 can be recognized only if *Turborotalia cunialensis* is present.
5. *Pseudohastingerina* spp. from the region appear to have their LO in the late Eocene, similar to their record elsewhere from southern mid to high latitudes (Jenkins and Srinivasan, 1986; Stott and Kennett, 1990; Nocchi et al., 1991).

Oligocene

The Oligocene planktonic foraminifers comprise chiefly cool-temperate species, and only during the late Oligocene did some subtropical forms occur. *Globorotaloides* and *Tenuitella* are most abundant, accompanied, respectively, by frequent *Chiloguembelina* in the early Oligocene and *Globigerina* in the late Oligocene.

1. Typical *Subbotina brevis* is present across the Eocene/Oligocene boundary. Zone P18 is difficult to recognize without *Pseudohastingerina micra*, but *S. brevis* can be used as a proxy because its LO datum falls close to the upper part of Zone P18 equivalents according to Jenkins (1985, 1993). *Guembelitria triseriata* is first present in the Zone P18 interval.
2. *Subbotina angiporoides* is common in the lower Oligocene up to the vicinity of the Zone P19/P20 boundary. It is accompanied in Zone P19 and replaced above Zone P19 by *Subbotina labiocrassata*, a species ranging into the upper Oligocene, close to the Zone P21/P22 boundary (Stott and Kennett, 1990; Huber, 1991; Berggren, 1992).
3. Typical *Paragloborotalia opima* is sporadic and restricted mainly to two intervals, Zone P19–P20 and Subzone P21b.
4. The southern Australian record of *C. cubensis* is consistent with Berggren et al. (1995), so its LO can be used to mark the Subzone P21a/P21b boundary and the upper/lower Oligocene boundary. Leckie et al. (1993), however, reported rare *C. cubensis* present throughout the upper Oligocene in tropical–subtropical sections (see comments in Berggren et al., 1995).
5. Four- and five-chambered *Globigerina* (*Globigerina ouachitaensis*, *Globigerina officinalis*, *G. praebulloides*, and *G. ciperoensis*) are common in the upper Oligocene. On the influx of *G. angulisuturalis*, Lindsay (1985) proposed a *G. angulisuturalis* Zone for sediments equivalent to Zone upper P21b–lower P22.
6. As well as *P. opima* and *G. angulisuturalis*, other warm-water species also invaded southern Australia during the late Oligocene–earliest Miocene. They include *Globoquadrina tripartita*, *Globoquadrina dehiscens* s.l., *Dentoglobigerina globulosa*, *Globigerinoides primordius*, and *Paragloborotalia kugleri*.
7. Sporadic *Turborotalia euapertura* range throughout the Oligocene, and its LO has been used for defining the Oligocene/Miocene boundary in high latitudes (Berggren, 1992). In the southern Australian–New Zealand region, *T. euapertura* often

ranges into the lowermost Miocene (Jenkins, 1985, 1993; Li and McGowran, 2000).

BIOSTRATIGRAPHY OF LEG 182 HOLES

Holes 1126B and 1126D

Planktonic foraminifers indicate that the Oligocene section at Site 1126 extends from 205.85 to 329.89 meters below seafloor (mbsf) between Samples 182-1126B-26X-CC, 15–18 cm, and 20R-CC, 20–22 cm, and the Eocene from 338.87 to 396.63 mbsf between Samples 21R-CC, 18–19 cm, and 27R-CC, 0–2 cm (Fig. F3).

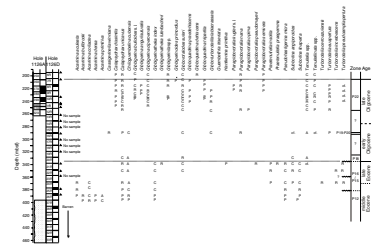
Typical late Oligocene assemblages are present between 205.85 and 254.82 mbsf in Holes 1126B and 1126D. Sample 182-1126B-26X-CC, 15–18 cm (205.85 mbsf), contains well-preserved specimens of, among others, *G. primodius*, *Globoquadrina praedeheiscens*, and *G. tripartita*. They are accompanied downcore to 254.82 mbsf (Sample 182-1126B-32X-CC, 26–28 cm) by *Globigerina ciperoensis* (rare), *G. angulisuturalis* (rare), *S. labiacrassata*, and *T. euapertura*, a typical Zone P21–P22 association. *P. opima*, a species confined to Zones P20–P21, is also present in this sample. Therefore, the Zone P21/P22 boundary falls in Core 182-1126B-31X at ~250 mbsf where there was no core recovery.

Between 254.82 and 329.89 mbsf, poor recovery hampers a proper dating of this interval, which is believed to encompass the upper/lower Oligocene boundary and Zones P19–P21 sediment. However, a fairly well preserved assemblage in Sample 182-1126D-16R-CC, 38–39 cm (290.98 mbsf), contains abundant *C. cubensis* and tenuitellids (including *Tenuitella munda* and *Tenuitellinata juvenilis*), frequent *Globorotaloides suteri*, *Catapsydrax unicavus*, and *Paragloborotalia nana*, as well as rare *T. euapertura* and *S. ex gr. angiporoides*. It indicates an early Oligocene age, probably within Zones P19–P20, in the absence of typically older or younger species.

Typical *S. angiporoides* dominates the coarser fraction of Sample 182-1126D-20R-CC, 20–22 cm (329.89 mbsf), whereas *C. cubensis*, *Tenuitella gemma*, and *T. munda* are abundant in the fine fraction. As the last two taxa are often present together in the lowermost Oligocene (Li et al., 1992), we assign this assemblage to Zone P18, even though the zonal marker *P. micra* is absent. It has become apparent that *P. micra* did not range through the Eocene/Oligocene boundary in either southern Australia (Lindsay, 1985; McGowran, 1991; Li et al., 2000) or sub-Antarctica (Jenkins and Srinivasan, 1986; Stott and Kennett, 1990; Nocchi et al., 1991).

An unconformity is inferred to be present at the Oligocene/Eocene boundary, as the underlying sediments in Sample 182-1126D-21R-CC, 18–19 cm (338.87 mbsf), contain *Globigerinatheka luterbacheri*, *G. index*, *P. insolita*, *S. linaperta*, and other middle–late Eocene species. Earlier studies indicated that *G. luterbacheri* as an immigrant from the subtropics is mainly confined to a short interval between Zones P15 and lower P16 in high southern latitudes (Nocchi et al., 1991) and so is *P. insolita* as a southern provincial dweller at a similar time period (Li et al., 1992). Zone P15 extends farther down to Sample 182-1126D-25R-CC, 15–17 cm (380.38 mbsf), in the presence of *Turborotalia cerroazulensis* s.l., *Acarinina aculeata*, and *A. collectea* but without *A. primitiva*. The upper/middle Eocene boundary is tentatively placed in Core 182-1126D-23R within Zone P15 (as per Berggren et al., 1995), approximating the LO of

F3. Distribution of planktonic foraminifers, Holes 1126A and 1126D, p. 19.



these small *Acarinina* species as suggested for the Australian–New Zealand region (Jenkins, 1996; McGowran et al., 1997a).

Zone P14 is probably missing from Hole 1126D, as an assemblage typical of Zones P12–13 characterized by *A. primitiva*, *A. bullbrooki*, and *A. cf. densa* was found in the lowermost two samples with planktonic foraminifers (Samples 182-1126D-26R-CC, 23–25 cm, and 27R-CC, 0–2 cm [390.38–396.63 mbsf]). An interval of Zone P12 or older in the middle Eocene is indicated by an association of these species with many long-ranging Eocene forms such as *C. cubensis*, *G. index*, *P. micra*, and *S. linaperta*. The underlying sand sequence contains no foraminifers; therefore, its age cannot be determined. An Eocene age is inferred on its ferruginous feature similar to those from onshore localities and by its position in the seismic Sequence 7 (Feary, Hine, Malone, et al., 2000).

Holes 1130A and 1130C

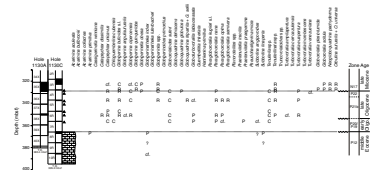
The stratigraphic succession at Site 1130 is truncated by large unconformities in the Miocene, Oligocene, and Eocene. An upper Miocene ooze unconformably overlies the Oligocene chalk/chert section, itself divided by unconformities and overlying the middle Eocene sandy limestone (Fig. F4). The ooze is present between 323.34 and 328.57 mbsf in Samples 182-1130C-3R-CC, 16–19 cm, and 35X-5, 87–92 cm (Li et al., this volume).

Immediately downcore at 328.89 mbsf (Sample 182-1130A-35X-CC, 27–30 cm) is a dark gray porcellanite containing poorly preserved planktonic foraminifers. The assemblage is dominated by small-sized species, including *Globigerina praebulloides*, *G. officinalis*, *G. ciperoensis*, *Globorotaloides* spp., and *Tenuitella* spp. Others are minor or rare, mainly *T. euapertura*, *T. venezuelana*, *P. nana*, *Globoquadrina cf. globulosa*, and *Globigerinita* spp. The assemblage indicates Zone P22 because *P. opima*, a Zone P21 species, is absent from this sample but is present in samples from below. The three core catcher samples between 337.73 and 351.37 mbsf (Samples 182-1130C-5R-CC, 3–4 cm; 6R-CC, 10 cm; and 182-1130A-38X-CC, 27–30 cm) all contain *P. opima*, plus other Oligocene species listed above, representing Subzone P21b.

The presence of lower Oligocene sediment is indicated by an assemblage with *C. cubensis* and *S. cf. angiporoides* in Sample 182-1130C-7R-CC, 6–8 cm (356.96 mbsf). Typical *P. opima* was not found in this sample, but specimens of *P. nana*–*P. opima* bioseries show transitional features between these two species, as illustrated by Bolli et al. (1985) as subspecies of *Globorotalia opima*. According to these authors, transitional forms between the small four-chambered *P. nana* and larger five-chambered *P. opima* are commonly present before and during the establishment of *P. opima* as a species in upper Zones P19–P21. Consequently, the assemblage from 356.96 mbsf is considered to represent Zone upper P19–P20 but not older because typical *S. angiporoides* (Zones P19 and older) is absent.

Thin sections from the underlying sandy limestone in Cores 182-1130C-8R through 10R show rare and poorly preserved neritic benthic species. Among the scattered planktonic specimens are *A. primitiva*, *G. index*, and *S. linaperta* (especially in Sample 182-1130C-8R-1, 99 cm), indicating Zone P12 or older in the middle Eocene.

F4. Distribution of planktonic foraminifers, Holes 1130A and 1130C, p. 20.



Hole 1132C

Hole 1132C was drilled at a water depth of 218.5 m with very low core recovery (6.1%). Planktonic foraminifers are rare and poorly preserved in core catcher samples from this shallow-water hole. Truncated by three unconformities, the Eocene–Oligocene sequence is present between 450.94 and 555.93 mbsf in Samples 182-1132C-24R-CC, 14–17 cm, through 35R-CC, 83–85 cm (Fig. F5). The upper Oligocene Zones P21b–P22 equivalent is indicated by an assemblage dominated by *C. unicavus*, *Globigerina praebulloides*, *G. ciproensis*, *Globorotaloides suteri*, and *Tenuitella* spp., with rare *S. labiacrassata*, *P. nana*, and *T. euapertura* found in Samples 182-1132C-24R-CC, 14–17 cm, through 27R-CC, 17–20 cm (478.17 mbsf). The absence of key species such as *P. opima* made separation of these zones impossible.

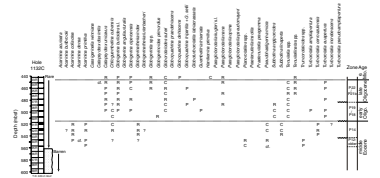
Farther downhole, Sample 182-1132C-28R-CC, 20–21 cm (487.9 mbsf), contains frequent *S. angiporoides* and *G. tripartita* but without *C. cubensis*. Such an association appears to be mainly associated with Zone P19 of the lower Oligocene (cf. Leckie et al., 1993) (Fig. F6). Together with those long-ranging species listed above, both *S. angiporoides* and *C. cubensis* were found in Samples 182-1132C-29R-CC, 24–26 cm (497.64 mbsf), and 30R-CC, 17–19 cm (507.27 mbsf), indicating Zones P18–P19. All this suggests that the mid-Oligocene Zones P20–P21a are missing and the existence of a hiatus of at least 1 m.y. between 28.5 and 30.3 Ma on the timescale of Berggren et al. (1995). The absence of such warm-water species as *T. ampliapertura* and *G. angulisuturalis* that characterize Zones P18–P19 cannot be a result of a cooler water regime because they are present farther east in the Gambier Basin where warm-water influence was much weaker (Li et al., 2000).

No specimens could be freely disaggregated from the sandy limestone in the lower part of Hole 1132C. In most thin sections of Samples 182-1132C-31R-1, 11 cm, through 35R-1, 80 cm, there are typical Eocene species *G. index*, *A. collactea*, and *A. primitiva*, as well as many small globigerinid forms, indicating Zones P14–lower P15 or older in the middle Eocene. Many specimens referable to *Planorotalites* cf., *P. australiformis*, and *Truncorotaloides* cf. *T. topilensis* were found from the base of the limestone in Samples 182-1132C-34R-2, 27 cm, to 35R-1, 80 cm, implying Zone lower P12 and older. These results point to the possibility that the entire upper Eocene (Zones upper P15–P17) is missing from Hole 1132C, and the upper middle Eocene is incomplete, as the Zone P12 assemblage similar to those in other holes has not been positively identified (Fig. F5).

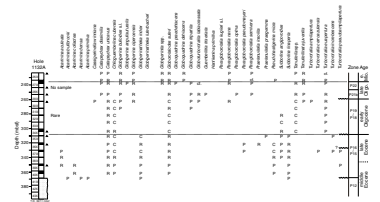
Hole 1134A

The Eocene–Oligocene planktonic foraminiferal succession in Hole 1134A is similar to that recorded in Holes 1126B and 1126D (see “Holes 1126B and 1126D,” p. 5) in both species composition and their stratigraphic distribution (Fig. F6). The Oligocene assemblage was found from 238.64 to 304.51 mbsf in Samples 182-1134A-27X-CC, 34–37 cm, through 34X-CC, 31–34 cm. Sample 182-1163C-27X-CC, 34–37 cm, consists of *Globigerina ciproensis*, *G. angulisuturalis*, *G. praedeheiscens*, and other long-ranging species but not *P. opima*, suggesting Zone P22. The presence of *P. opima* in Sample 182-1134A-29X-CC, 18–21 cm (253.08 mbsf), above the LO of *C. cubensis*, denotes Subzone P21b. The relationship between the upper and lower Oligocene sediments appears to be unconformable, as Sample 182-1134A-30X-CC, 22–25 cm, at 262.72

F5. Distribution of planktonic foraminifers, Hole 1132C, p. 21.



F6. Distribution of planktonic foraminifers, Hole 1134A, p. 22.



mbsf contains not only *C. cubensis* but also *Turborotalia ampliapertura*, a species present only in Zone P19 of the lower Oligocene and ranging down to upper Eocene Zone P16. This also accords with the absence of *G. angulituralis* and *P. opima*, two species characteristic of Zone P20 and younger assemblages. Therefore, Zone P20 and Subzone P21a of the upper lower Oligocene are likely missing, assuming they are not condensed into the nonrecovered Core 182-1134A-29X.

Zones P15–P16 planktonic foraminifers are present between 310.93 and 361.91 mbsf in Samples 182-1134A-35X-CC, 0–2 cm, to 40X-CC, 31–34 cm. Species including *G. index*, *P. micra*, *C. cubensis*, and *S. linaperta* are accompanied, in the upper part, by *T. increbescens*, *P. insolita*, and in the lower part, by *A. aculeata* and *A. collactea*. The LO of *A. collactea* in Sample 182-1134A-39X-CC, 31–34 cm (351.64 mbsf), marks the middle/upper Eocene boundary.

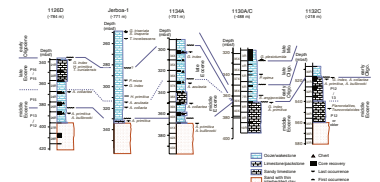
Foraminifers are rare in Sample 182-1134A-41X-CC, 20–22 cm (368.4 mbsf), from the underlying sandy limestone, and they are dominated by benthic forms. Zone P12 or older planktonic species such as *A. primitiva* and *A. bullbrooki* are present together with a few *G. index* and *G. linaperta*. The limestone is yellowish and poorly consolidated with abundant limonite and some kaolinite, suggesting probable weathering. The hiatus between the limestone and the overlying calcareous ooze of Zone P15–P16 in Hole 1134A, as at Hole 1126D, could have lasted at least for 2 m.y. No samples were available from the bottom of Hole 1134A, but the siliciclastic section is believed to be similar to Hole 1126D in containing no diagnostic foraminifers.

Correlation between Holes

Figure F7 summarizes the planktonic foraminiferal results for the Eocene–Oligocene sections studied. The following generalizations can be made.

1. Planktonic foraminiferal assemblages change from warm temperate with subtropical immigrants in the Eocene to cool temperate in the early Oligocene and warm temperate in the late Oligocene.
2. Biostratigraphy is better constrained in the middle–upper Eocene and upper Oligocene than in the lower Oligocene where fewer species datums were found. Stratigraphic packages are similar between sites, as are the ages of sediments.
3. The oldest planktonic foraminiferal assemblage, indicating lower Zone P12 or older, is present at 545–555 mbsf in Hole 1132C from a water depth of 218.5 m but not at sites from intermediate water depths. An early–middle Eocene depocenter is, therefore, inferred to have existed in what is now close to the shelf edge, although its altitudinal position could have been altered especially by the late Neogene basin inversion widely recorded in south Australia.
4. Carbonate deposition became widespread (over all sites studied) in P12 equivalents (Bartonian Stage, later middle Eocene). A hiatus of >1-m.y. duration may separate sediments of Zone P12 from Zones P14/P15 equivalents, and another is inferred within Zone P15 close to the middle/late Eocene boundary.
5. The Eocene–Oligocene sections at these four sites are all truncated by unconformities also at the Eocene/Oligocene boundary

F7. Biostratigraphic correlation between Leg 182 sites and Jerboa-1, p. 23.



and lower/upper Oligocene boundary, each with an estimated duration of at least 1 m.y.

6. The major unconformity separating the upper Miocene from upper Oligocene at Site 1130 indicates a long period of erosion or nondeposition during the early–middle Miocene. The thickness of Oligocene sediments at this site (~35 m) is also considerably less than those from upslope (~70 m at Site 1132) or downslope (~72 m at Site 1134 and ~130 m at Site 1126). Consequently, Site 1130 likely resides on a hinge zone that had been active since at least Eocene–Oligocene time.

REGIONAL CORRELATION AND DEPOSITIONAL ENVIRONMENTS

The drilling of Leg 182 confirms the stratigraphic record from neritic sediments that carbonate deposition in southern Australia began in the Eocene during a new phase of marginal subsidence stimulated by accelerated Australia–Antarctica separation (McGowran et al., 1997a). The unconformity-bounded “sequences” (allostratigraphic packages) of Eocene–Oligocene age can be correlated with regional transgressions using foraminiferal biostratigraphy. We attempt such a correlation in Figure F8.

Wilson Bluff Transgression

Although a comprehensive biostratigraphy of the Wilson Bluff Limestone from the Eucla Basin is still lacking, previous studies by Ludbrook (1961), McGowran and Lindsay (1969), Lowry (1970), and McGowran (1989) indicate that sands and marls at the base of the limestone contain Zone P12 planktonic foraminifers. Several species, *A. densa*, *S. frontosa*, and *A. primitiva*, are in common with the present material, and they do not extend above this stratigraphic package.

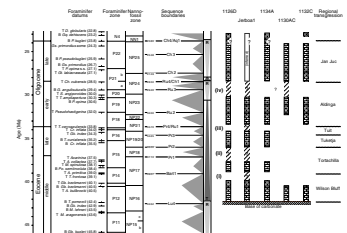
Tortachilla Transgression

Within the chronological constraints of the available fossils, there is a clear-cut hiatus preceding the second package, characterized by *A. aculeata* and *A. collectea* in the absence of the older species in adequate planktonic facies. Both biopackages are evident in Jerboa-1, but sampling was too coarse to address the hiatus itself.

Tuketja Transgression

The third Eocene allostratigraphic package is characterized by the association of *G. index*, *H. primitiva*, *P. insolita*, and *P. micra*. The *Hantkenina* warm ingression is within the uppermost Zone P15, constrained by the presence of the calcareous nannofossil *Isthmolithus restuvus*, defining the base of NP19/NP20 at 36 Ma (Fig. F8). Two of the sections are consistent with this; the Jerboa assemblage is certainly Tuketja but, again, the underlying hiatus is probable, not proven. Neritic sections in southern Australia seem to bury two sequence boundaries within this hiatus, for we have been unable to demonstrate a package defined by boundaries equivalent to global sequence boundaries Pr1 and Pr2, and the same applies to the present analysis, as seen in Figure F8.

F8. Eocene–Oligocene carbonates, p. 24.



Neritic sediments of the Tuketja Transgression include the upper Wilson Bluff Limestone (Eucla Basin), Blanche Point Formation (St. Vincent Basin), Narrawaturk Marl (western Otway Basin), and Castle Cove Limestone (eastern Otway Basin). Almost all of these rock units are truncated by unconformities at or close to the Eocene/Oligocene boundary (McGowran et al., 1997a). The subsequent Aldinga Transgression during the early Oligocene revived carbonate deposition in all basins.

Tuit Transgression and Eocene/Oligocene Boundary

McGowran et al. (1992) discussed, in detail, foraminiferal species datums and assemblage characteristics across the Eocene/Oligocene boundary in sections from the St. Vincent Basin. The Tuit has been subsequently identified to represent a sequence bounded by Pr3 and Pr4/Ru1 equivalents (McGowran and Li, 1997). However, it has not been recognized biostratigraphically, being characterized unsatisfactorily by *P. insolita* and *P. micra* and the absence of older (Eocene) and younger (Oligocene) species. Nor can it be seen in this study (Fig. F8), likely being subsumed in the boundary hiatus.

Aldinga Transgression

The lower Oligocene assemblage in the St. Vincent and Gambier Basins is characterized by *Cassigerinella chipolensis*, *Cassigerinella winniana*, *C. cubensis*, *S. angiporoides*, and *T. increbescens*, plus some *A. aculeata* that are probably reworked. Within available constraints, this carbonate-generating flooding occurred coevally at our sites. We have not made much progress in breaking out the three lower Oligocene (Rupelian) sequences as biofacies packages, but a beginning has been made (Li et al., 2000). The lower Oligocene chert-carbonate facies are not known from the Eucla Basin because of mid-Oligocene erosion (Lowry, 1970; Li et al., 1996) (Fig. F8). This mid-Oligocene unconformity has been observed in other southern Australian basins, including the Otway, Murray, and Gippsland Basins (McGowran et al. 1997a) (Fig. F5). In the Gambier Basin (or western Otway Basin), the mid-Oligocene section is either a shallow-water limestone or concealed by dolomitization (Li et al., 2000). At shallower localities of the Gambier, the Compton Conglomerate and similar facies unconformably overlie upper Eocene sediments (Ludbrook, 1961; White, 1996) (Fig. F4). Although dating the exact duration of the unconformity is difficult on few available marker species and datums in poorly preserved neritic assemblages, the indications are that the mid-Oligocene hiatus could have ~2-m.y. duration. This hiatus is represented by the Marshall Paraconformity in New Zealand, presumably related to a glacioeustatic fall and the inception of the Antarctic Circumpolar Current (Carter, 1985; Fulthorpe et al., 1996).

Jan Juc Transgression

There are three sequences in the upper Oligocene (Chattian), and they are clearly manifested in regional biofacies (Li et al., 1999). We do not make that subdivision here, but the Chattian package, as a whole, is seen above the mid-Oligocene hiatus. The assemblage in its lower part is characterized by *G. triseriata*, *G. labiacrassata*, and, in favorable facies, *P. opima* and *G. angulisuturalis*. Carbonates of late Oligocene age are

present more widely than the lower Oligocene sediments as limestones of the Ehrick–lower Mannum Formations accumulated in a more inland sea to the east of the Bight, the Murray Basin (Ludbrook, 1958a, 1961; Lindsay, 1985; Lukasik et al., 2000). The Eucla carbonate platform advanced again with the deposition of the Abrakurrie Limestone (Lowry, 1970; James and Bone, 1991; Li et al., 1996). Farther to the east, in Torquay, the Jan Juc Formation with its warm-water fossil assemblages typifies this regional event (McGowran et al., 1997b; Li et al., 1999) (Fig. F8).

It is noteworthy that the depocenter during the later Eocene was not in what is now the slope but the coastal area of the Bight where Wilson Bluff Limestone as thick as 300 m has been reported (Lowry, 1970, fig. 19). Carbonate production was probably stimulated by a warm nearly subtropical oceanic environment, enhanced by the first flow of a proto-Leeuwin Current from the northwest (Shafik, 1990; McGowran et al., 1997b) interacting with nutrient-rich southern waters on a subsiding continental margin (McGowran et al., 1997a). The subsequent global cooling in the latest Eocene and early Oligocene lowered sea level has been confirmed isotopically from other deep-sea localities and continental margins (Miller et al., 1991, 1998). The low sea level caused large-scale downcuttings and unconformities, such as those observed at Leg 182 sites. Sediment removal by underwater currents could have been also significant especially after the Tasman Gateway was fully open and the circumantarctic flow became intensified. Such erosional and nondepositional activities appear to be stronger in areas next to Site 1130 with a present water depth of ~500 m. The late Oligocene warming generated a warm-temperate environment in the region, supporting again a planktonic foraminiferal assemblage with subtropical immigrants.

A correlation of the Paleogene succession with global third-order sequences and boundaries reveals some matching patterns, especially in the four major unconformities falling close to four major sequence boundaries: Bart1, Pr1, Pr4/Ru1, and Ru4/Ch1 of Hardenbol et al. (1998) (Fig. F8).

SUMMARY AND CONCLUSIONS

1. Paleogene sediments recovered at Sites 1126, 1130, 1132, and 1134 in the Great Australian Bight contain middle Eocene to late Oligocene planktonic foraminifers correlated mainly to (sub)tropical Zones P12–P22. The biostratigraphic results confirm previous studies that widespread neritic carbonate deposition was initiated in the middle Eocene, probably responding to global warming and the accelerated separation between Australia and Antarctica at ~43 Ma.
2. The fossil foraminiferal fauna is typically southern temperate, with some warm-water species present in middle–late Eocene and late Oligocene time. The warm-water species were probably transported as immigrants by a warm-water system similar to the present-day Leeuwin Current during warming periods.
3. Four major hiatuses were identified: (1) between Zones P12–13 and lower P15 in the middle Eocene, (2) within Zone P15, (3) between Zones P16 and P18 across the Eocene/Oligocene boundary, and (4) between Zones P19–20 and Subzone P21b in the mid-Oligocene. At Site 1130, lower Oligocene ooze unconform-

ably overlies a middle Eocene Zone P12 sandy limestone and the whole Oligocene was condensed in a 35-m package that is only half as thick as the contemporary sediments from up- and down-slope, indicating stronger erosion and/or minimal deposition at this upper slope locality.

4. The dated unconformities represent regional events through the neritic realm in southern Australia, and they appear to be local manifestations of the global sequence boundaries close to 39.1, 37.1–36.0, 33.7, and 28.5 Ma, respectively. The estimated duration of each hiatus between 1 and 2 m.y. from the present mid and upper slope appeals to further studies of neritic sections in order to better understand the timing and amplitude of unconformities and their bearing on the evolutionary history of the southern Australian margin.

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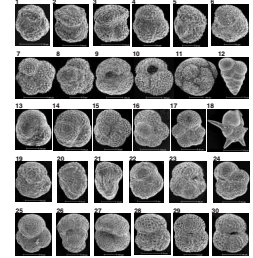
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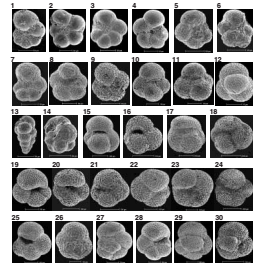
APPENDIX

- Acarinina aculeata* (Jenkins).
Acarinina bullbrookii (Bolli) (Pl. P1, figs. 5, 6; Pl. P3, figs. 10, 13).
Acarinina collectea (Finlay) (Pl. P1, figs. 7, 8).
Acarinina densa (Cushman) (Pl. P1, fig. 1).
Acarinina primitiva (Finlay) (Pl. P1, figs. 2, 3; Pl. P3, figs. 14, 15).
Acarinina spp. (Pl. P1, fig. 4; Pl. P4, figs. 13, 14).
Cassigerinella winniana (Howe) (Pl. P2, fig. 14).
Catapsydrax dissimilis Cushman and Bermudez (Pl. P2, figs. 29, 30).
Catapsydrax univavus Bolli, Loeblich, and Tappan (Pl. P1, figs. 13, 14).
Chiloguembelina cubensis (Palmer) (Pl. P1, fig. 12; Pl. P3, fig. 13).
Dentoglobigerina globularis (Bermudez) (Pl. P3, fig. 5).
Globigerina angulisurealis Bolli (Pl. P3, figs. 2, 3).
Globigerina bulloides d'Orbigny.
Globigerina ciperoensis Bolli (Pl. P3, fig. 1).
Globigerina officinalis Subbotina (Pl. P3, fig. 4).
Globigerina praebulloides Blow.
Globigerinatheka index (Finlay) s.l. (Pl. P1, figs. 9, 10; Pl. P3, fig. 9; Pl. P4, fig. 1).
Globigerinatheka luterbacheri Bolli (Pl. P1, fig. 11).
Globigerinita glutinata Parker.
Globigerinita naparimaensis Bronnimann (Pl. P2, fig. 12).
Globigerina primordius Blow.
Globoquadrina praedehiscens Blow and Banner (Pl. P3, fig. 8).
Globoquadrina pseudovenezuelana Blow and Banner (Pl. P2, figs. 17, 18).
Globoquadrina tripartita (Koch) (Pl. P3, fig. 7).
Globoquadrina venezuelana (Hedberg) (Pl. P3, fig. 6).
Globorotalodes suteri Bolli (Pl. P1, figs. 15, 16).
Globorotalodes sp. (Pl. P1, fig. 17).
Globoturborotalita brevis (Jenkins).
Globoturborotalita labiacrassata (Jenkins) (Pl. P2, fig. 16).
Guembelitra triseriata (Terquem) (Pl. P2, fig. 13).
Hantkenina alabamensis Cushman (Pl. P1, fig. 18).
Paragloborotalia kugleri (Bolli).
Paragloborotalia nana (Bolli) (Pl. P2, fig. 21).
Paragloborotalia optima (Bolli) (Pl. P2, figs. 22, 23).
Paragloborotalia pseudocontinua (Jenkins) (Pl. P2, figs. 26–28).
Paragloborotalia pseudomayeri (Bolli) (Pl. P1, fig. 24).
Paragloborotalia semivera (Hornibrook) (Pl. P2, figs. 24, 25).
Planorotalites cf. *australiformis* (Jenkins).
Praetenuitella insolita (Jenkins) (Pl. P2, figs. 2, 3).
Praetenuitella praegemma Li (Pl. P2, figs. 4–6).
Pseudohastigerina micra (Cole) (Pl. P2, fig. 1; Pl. P3, fig. 12).
Subbotina angiporoides (Hornibrook) (Pl. P1, fig. 29; Pl. P2, fig. 15).
Subbotina linaperta (Finlay) (Pl. P1, fig. 28; Pl. P3, fig. 11).
Subbotina minima (Jenkins) (Pl. P1, fig. 30).
Tenuitella gemma (Jenkins) (Pl. P2, fig. 7).
Tenuitella munda (Jenkins) (Pl. P2, fig. 10).
Tenuitella pseudoedita (Subbotina) (Pl. P2, fig. 9).
Tenuitellinata angustiumbilitata (Bolli) (Pl. P2, fig. 8).
Tenuitellinata juveniles (Bolli) (Pl. P2, fig. 11).
Turborotalia topilensis (Cushman).
Turborotalia ampliapertura (Bolli) (Pl. P2, fig. 19).
Turborotalia cerroazulensis (Cole) s.l. (Pl. P1, figs. 19–22).
Turborotalia euapertura (Jenkins) (Pl. P2, fig. 20).
Turborotalia increbescens (Bandy) (Pl. P1, figs. 25, 26).
Turborotalia pseudoampliapertura (Blow and Banner) (Pl. P1, fig. 27).
Turborotalia sp. (Pl. P1, fig. 23).

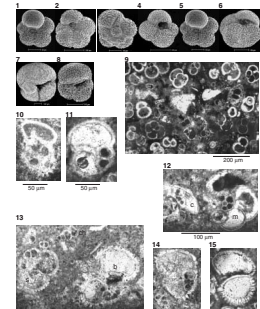
P1. Planktonic foraminifers, Holes 1126D and 1134A, p. 25.



P2. Planktonic foraminifers, Holes 1126D and 1134A, p. 26.



P3. Planktonic foraminifers, Holes 1134A and 1132C, p. 27.



P4. Planktonic foraminifers, Holes 1132C, p. 28.

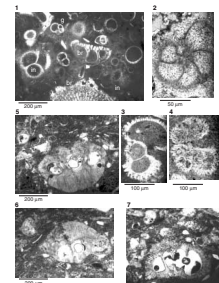


Figure F1. A. Map showing the modern circulation around southern Australia and the location of Cenozoic basins. B. Location of ODP Leg 182 sites and oil exploration drill hole Jerboa-1. Contours in meters.

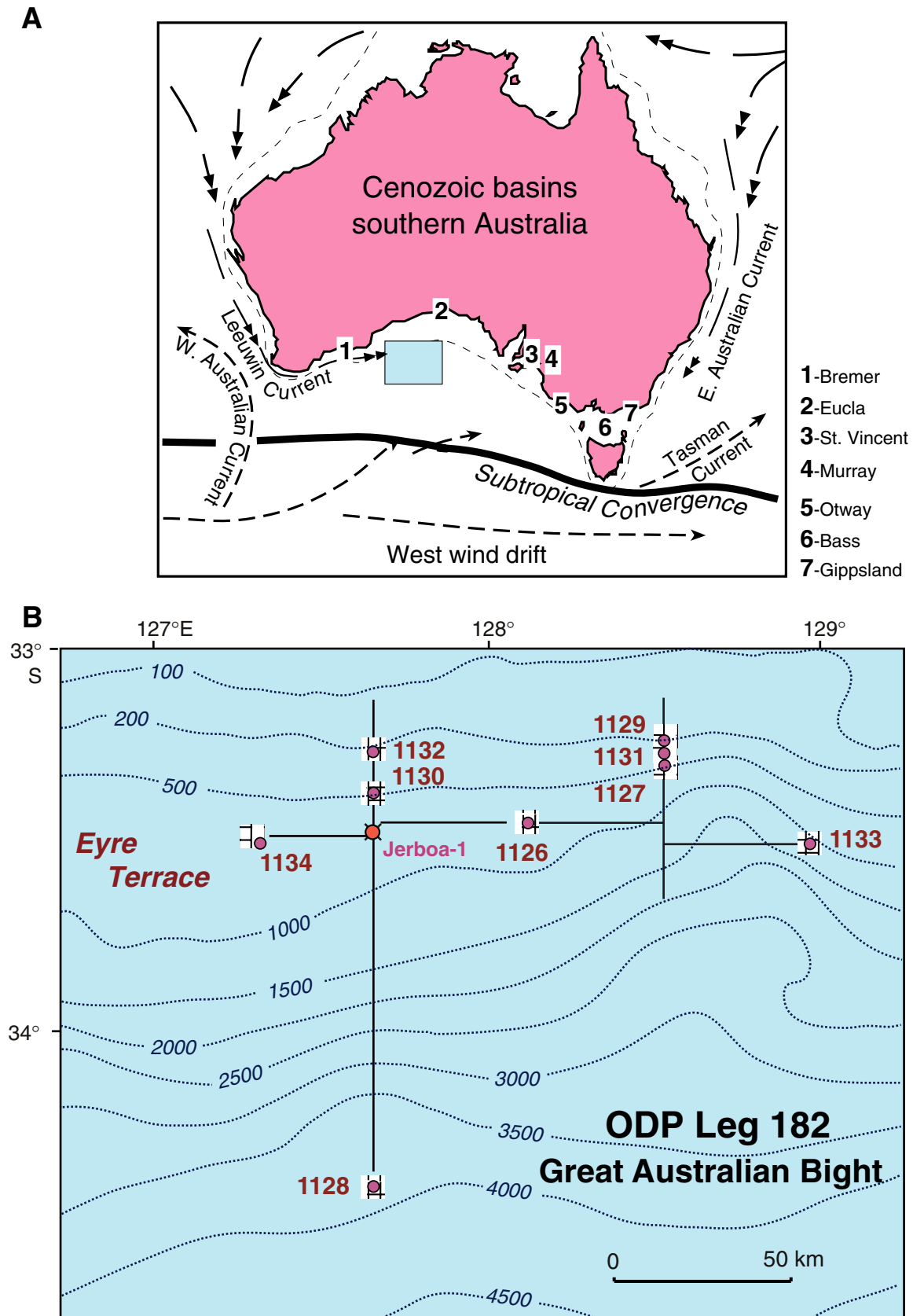


Figure F2. Paleogene geochronostratigraphy of Berggren et al. (1995) with P-zonation and datum levels of diagnostic planktonic foraminifers. The zonation of Jenkins (1966, 1971, 1993) is also shown, together with datum levels found in southern Australia (McGowran, 1989, 1991; McGowran et al., 1997a). Numbers are estimated ages in million years mainly by Berggren et al. (1995) (cf. Feary, Hine, Malone, et al., 2000, table T3).

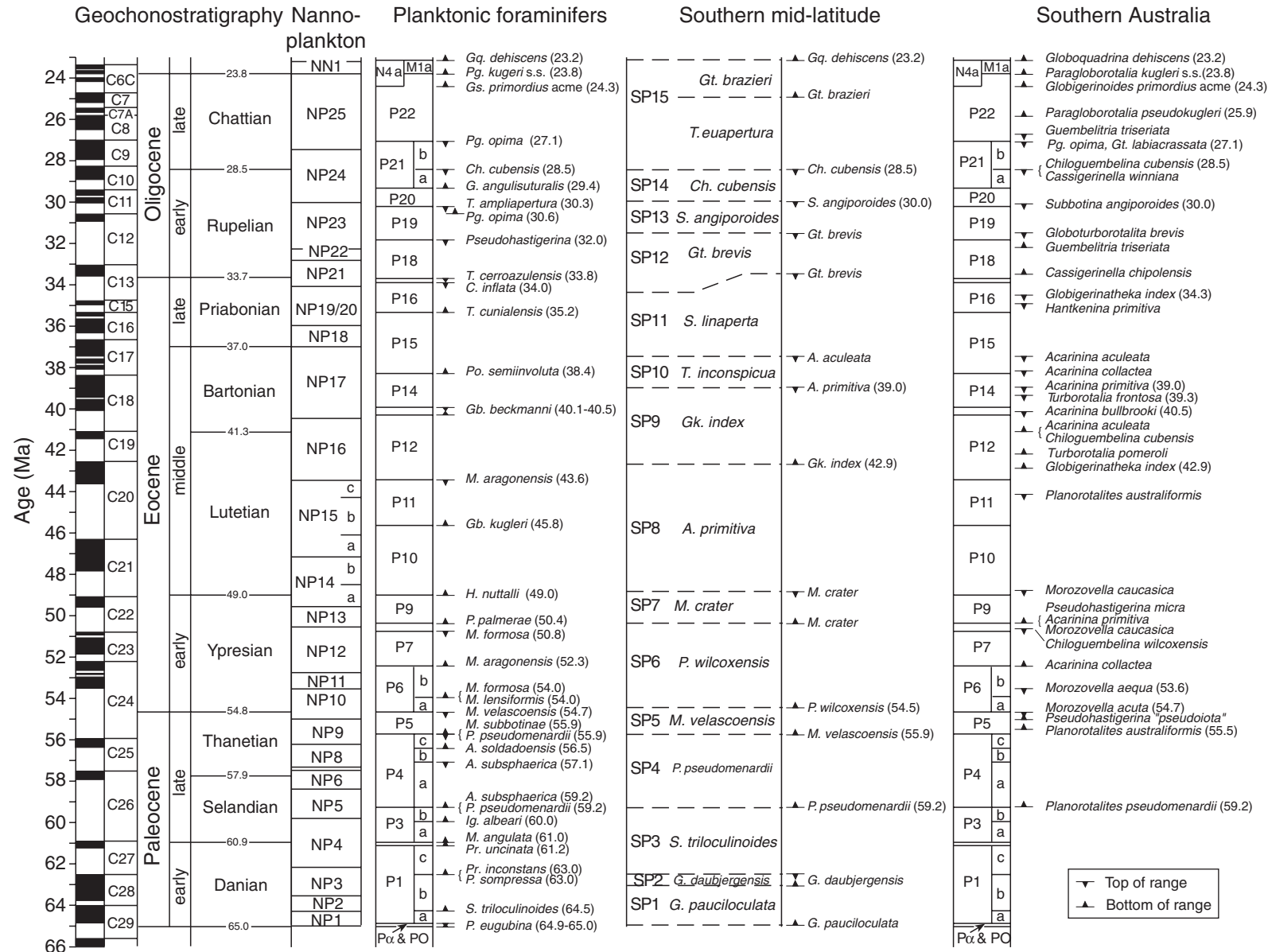
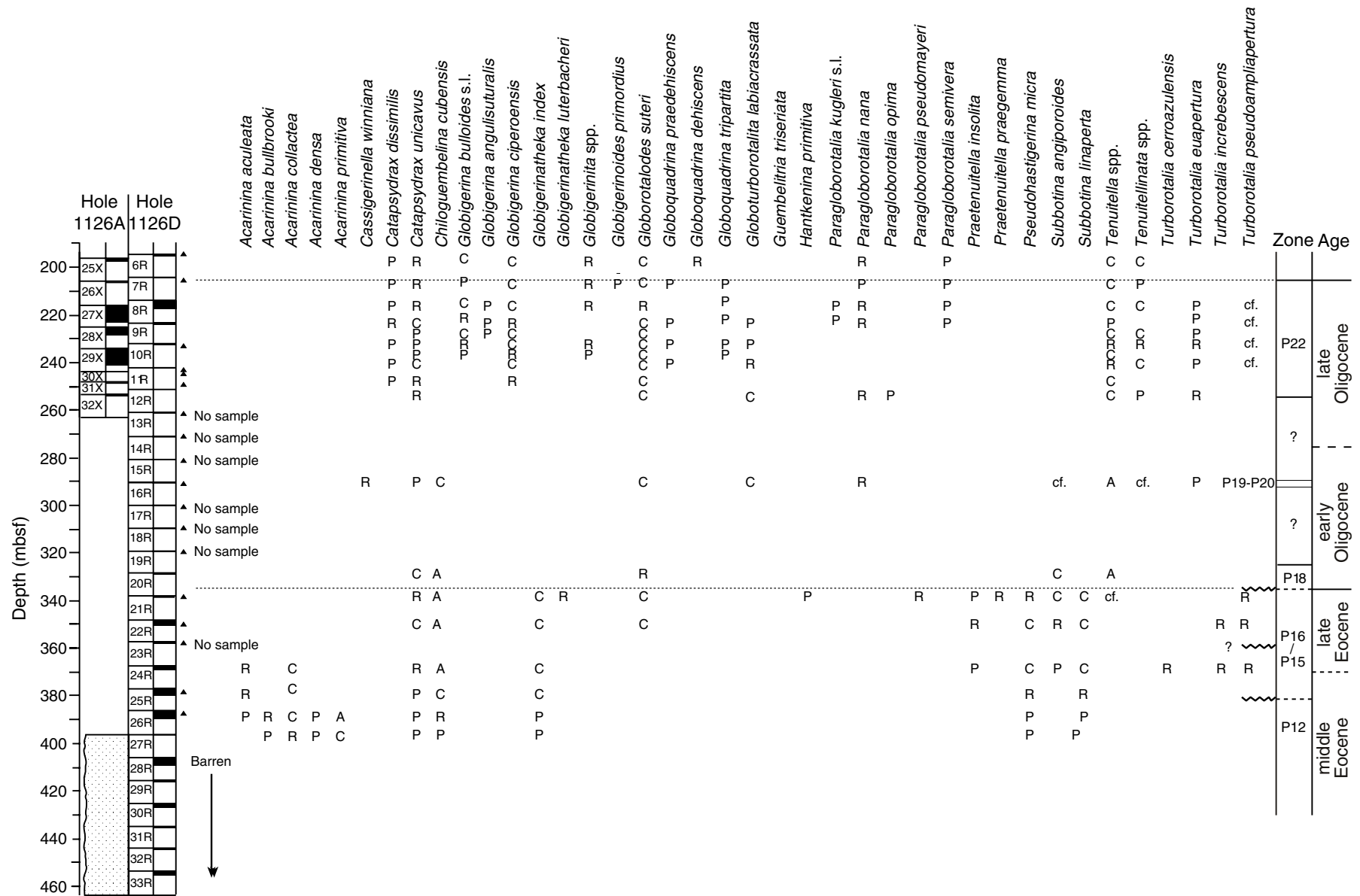


Figure F3. Distribution of planktonic foraminifers throughout the Eocene and Oligocene in Holes 1126A and 1126D based on 38 samples (including six thin sections). Foraminiferal relative abundance: present (P) = <1%, rare (R) = 1%–5%, common (C) = >5%–10%, abundant (A) = >10%–30%, and dominant (D) = >30%.



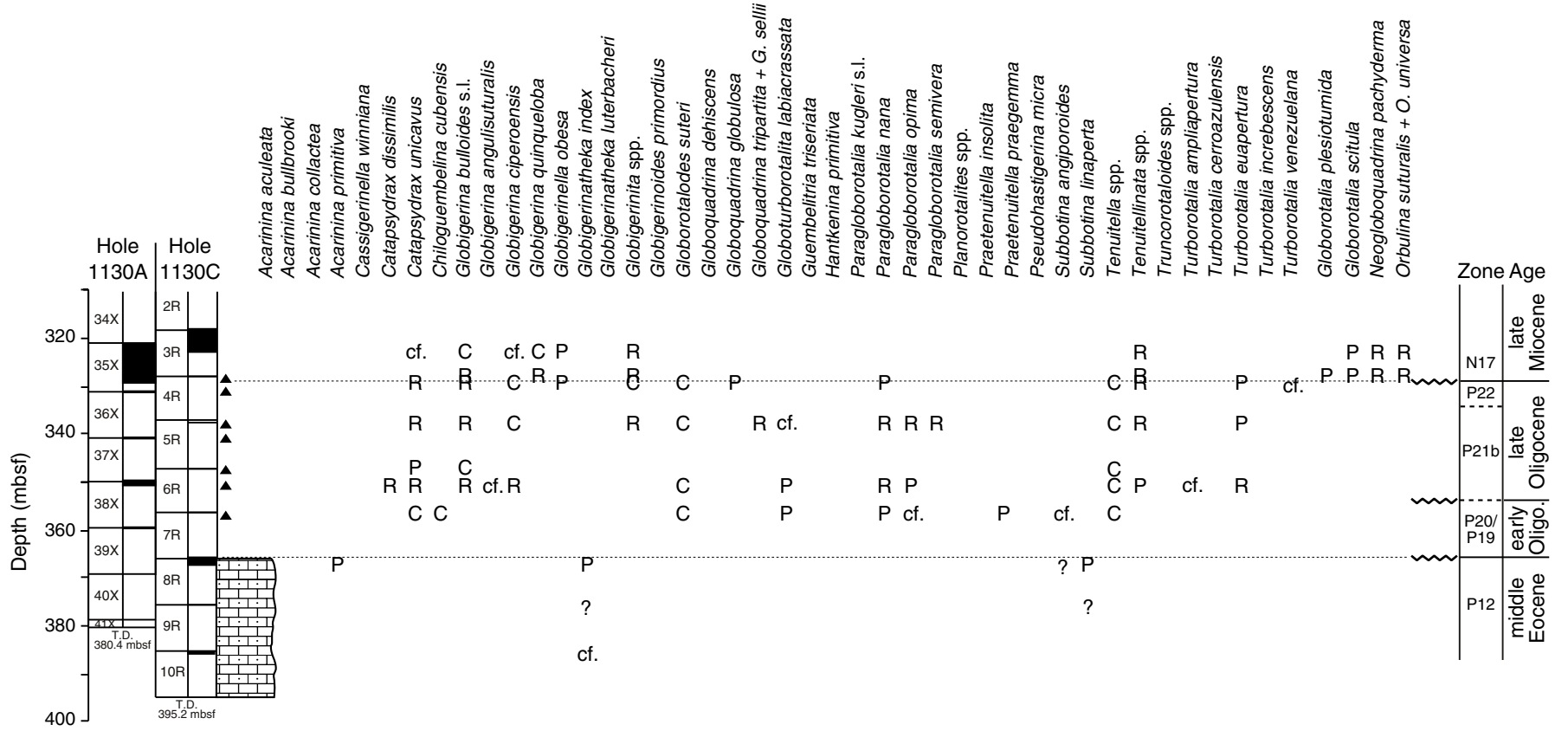


Figure F5. Distribution of planktonic foraminifers throughout the Eocene and Oligocene in Hole 1132C based on 47 samples (including 34 thin sections). Foraminiferal relative abundance: present (P) = <1%, rare (R) = 1%–5%, common (C) = >5%–10%, abundant (A) = >10%–30%, and dominant (D) = >30%. T.D. = total depth. Olig. = Oligocene.

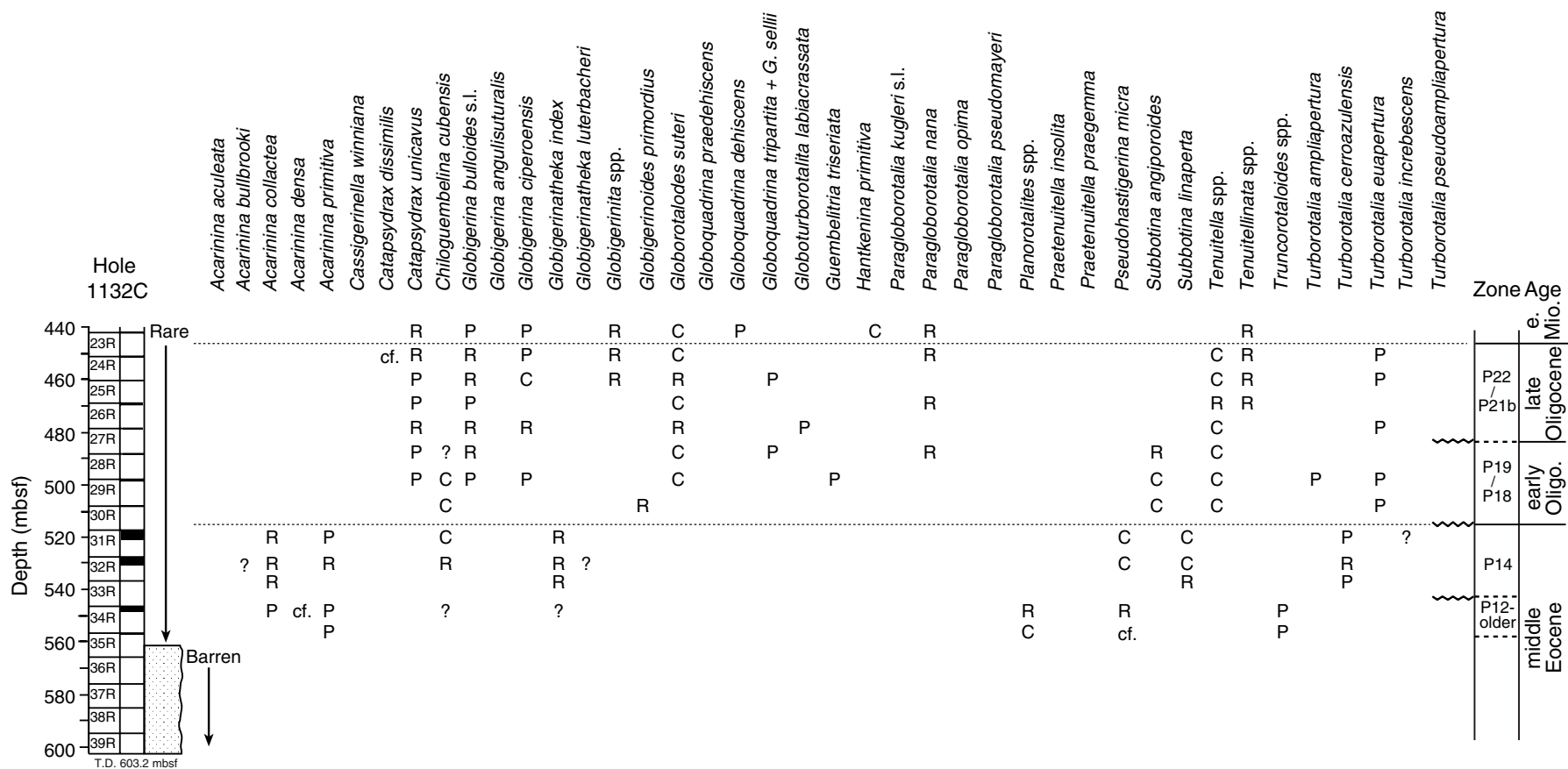


Figure F6. Distribution of planktonic foraminifers throughout the Eocene and Oligocene of Hole 1134A based on 24 samples (including eight thin sections). Foraminiferal relative abundance: present (P) = <1%, rare (R) = 1%–5%, common (C) = 5%–10%, abundant (A) = 10%–30%, and dominant (D) = >30%. T.D. = total depth. Olig. = Oligocene. Mio. = Miocene.

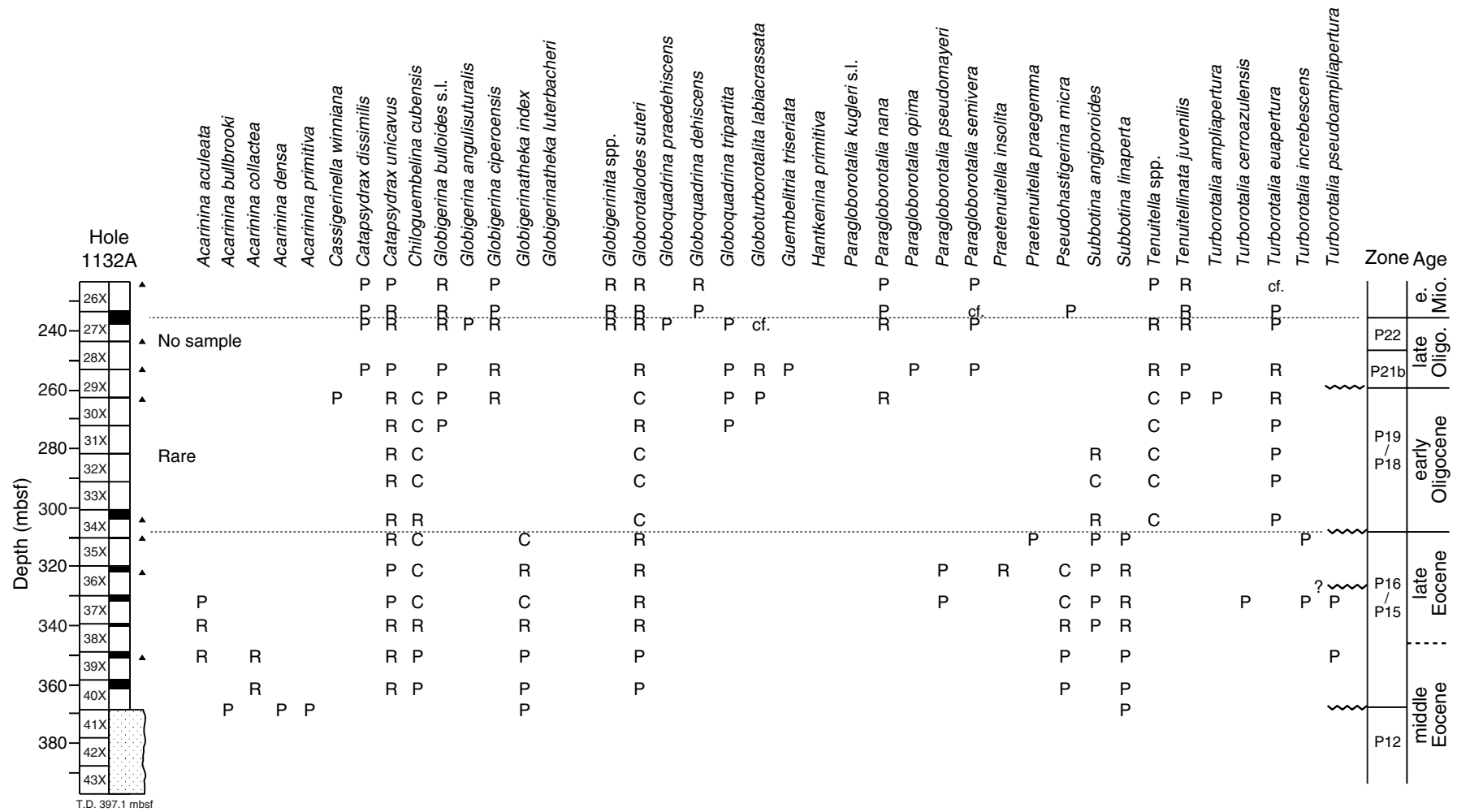


Figure F7. Biostratigraphic correlation between Leg 182 sites using foraminiferal data from this study and Jerboa-1 from McGowan (1991). Note the different age of sediments at shallow sites in Holes 1130A, 1130C, and 1132C. Oligo. = Oligocene. Mio. = Miocene.

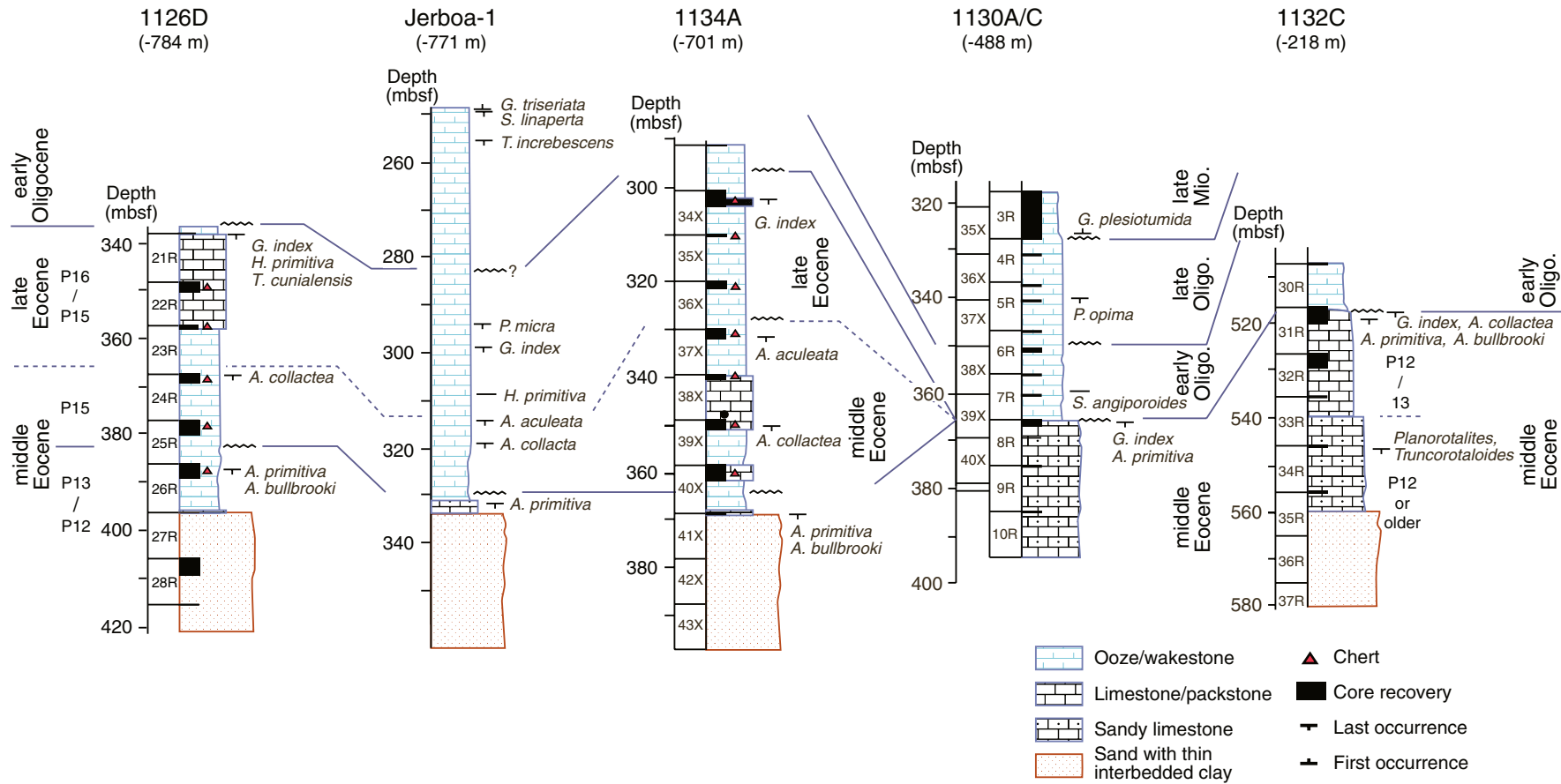


Figure F8. Stratigraphic positioning of the Eocene–Oligocene carbonates from the Great Australian Bight in global sequences and their boundaries (Haq et al., 1988; Hardenbol et al., 1998). Regional transgressions after McGowran (1979, 1986, 1989) and McGowran et al. (1997a). The four regional unconformities identified coincide, respectively, with major sequence boundaries Bart-1 (i), Pr1–Pr2 (ii), Pr4/Ru1 (iii), and R4/Ch1 (iv), each induced by a major drop in sea level. T = top, B = bottom.

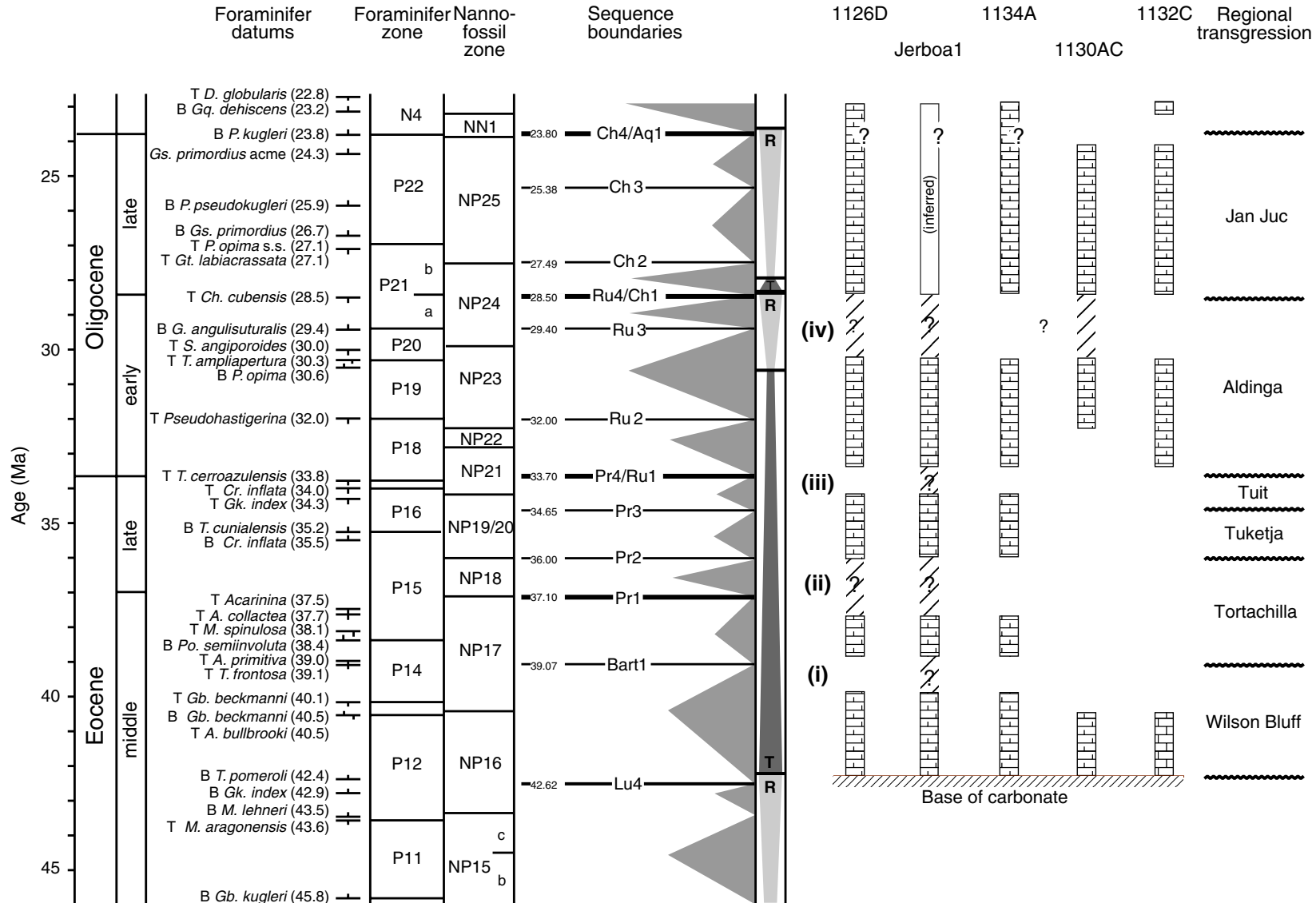


Plate P1. 1. *Acarinina* cf. *densa*; Sample 182-1126D-27R-CC, 0–2 cm. 2, 3. *Acarinina primitiva*; Sample 182-1126D-26R-CC, 23–25 cm. 4. *Acarinina* sp.; Sample 182-1126D-26R-CC, 23–25 cm. 5, 6. *Acarinina bullbrookii*; Sample 182-1126D-26R-CC, 23–25 cm. 7–8. *Acarinina collactea*; Sample 182-1126D-24R-CC, 30–33 cm. 9, 10. *Globigerinatheka index*; (9) Sample 182-1134A-37X-CC, 32–35 cm; (10) Sample 182-1134A-35X-CC, 0–2 cm. 11. *Globigerinatheka luterbacheri*; Sample 182-1126D-21R-CC, 18–19 cm. 12. *Chiloguembelina cubensis*; Sample 182-1134A-39X-CC, 31–34 cm. 13, 14. *Catapsydrax unicavus*; (13) Sample 182-1126D-27R-CC, 0–2 cm; (14) Sample 182-1126D-26R-CC, 23–25 cm. 15, 16. *Globorotaloides suteri*; (15) Sample 182-1134A-35X-CC, 0–2 cm; (16) Sample 182-1134A-36X-CC, 29–32 cm. 17. *Globorotaloides* sp.; Sample 182-1126D-22R-CC, 15–17 cm. 18. *Hantkenina alabamensis*; Sample 182-1126D-21R-CC, 18–19 cm. 19–22. *Turborotalia cerroazulensis* s.l.; (19, 20) Sample 182-1126D-24R-CC, 30–33 cm; (21, 22) Sample 182-1134A-39X-CC, 31–34 cm. 23. *Turborotalia* sp.; Sample 182-1134A-35X-CC, 0–2 cm. 24. *Paragloborotalia pseudomayeri*; Sample 182-1134A-37X-CC, 32–35 cm. 25, 26. *Turborotalia increbescens*; Sample 182-1126D-22R-CC, 15–17 cm. 27. *Turborotalia pseudoampliapertura*; Sample 182-1126D-24R-CC, 30–33 cm. 28. *Subbotina linaperta*; Sample 182-1126D-21R-CC, 18–19 cm. 29. *Subbotina angiporoides*; Sample 182-1126D-21R-CC, 18–19 cm. 30. *Subbotina minima*; Sample 182-1134A-36X-CC, 29–32 cm.

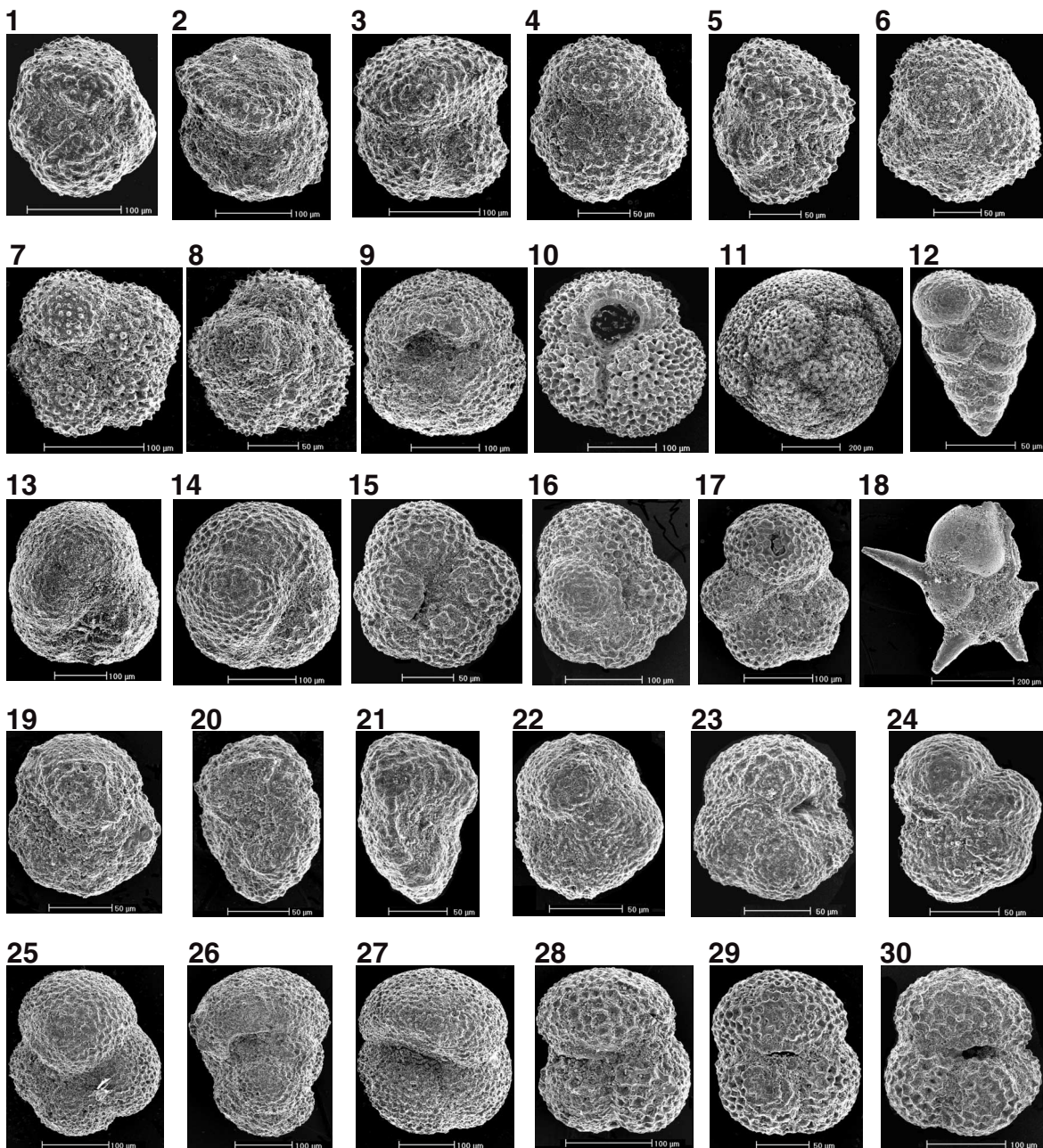


Plate P2. 1. *Pseudohastigerina micra*; Sample 182-1126D-24R-CC, 30–33 cm. 2, 3. *Praetenuitella insolita*; (2) Sample 182-1126D-21R-CC, 18–19 cm; (3) Sample 182-1134A-36X-CC, 29–32 cm. 4–6. *Paretenuitella praegemma*; (4) Sample 182-1126D-21R-CC, 18–19 cm; (5, 6) Sample 182-1134A-35X-CC, 0–2 cm. 7. *Tenuitella gemma*; Sample 182-1134A-32X-CC, 16–19 cm. 8. *Tenuitellinata angustiumbilitata*; Sample 182-1134A-32X-CC, 16–19 cm. 9. *Tenuitella* cf. *pseudoedita*; Sample 182-1134A-30X-CC, 22–25 cm. 10. *Tenuitella munda*–*Tenuitellinata juvenilis* transition; Sample 182-1134A-29X-CC, 18–21 cm. 11. *Tenuitellinata juvenilis*; Sample 182-1134A-29X-CC, 18–21 cm. 12. *Globigerinita naparimaensis*; Sample 182-1134A-27X-CC, 34–37 cm. 13. *Guembelitria triseriata*; Sample 182-1134A-29X-CC, 18–21 cm. 14. *Cassigerinella winniana*; Sample 182-1134A-30X-CC, 22–25 cm. 15. *Subbotina angiporoides*; Sample 182-1134A-32X-CC, 16–19 cm. 16. *Globoturbototalita labiacrassata*; Sample 182-1134A-30X-CC, 22–25 cm. 17, 18. *Globoquadrina pseudovenezuelana*; (17) Sample 182-1134A-32X-CC, 16–19 cm. (18) Sample 182-1134A-30X-CC, 22–25 cm. 19. *Turbototalia ampliapertura*; Sample 182-1134A-30X-CC, 22–25 cm. 20. *Turbototalia euapertura*; Sample 182-1134A-27X-CC, 34–37 cm. 21. *Paragloborotalia nana*; Sample 182-1134A-30X-CC, 22–25 cm. 22, 23. *Paragloborotalia opima*; Sample 182-1134A-29X-CC, 18–21 cm. 24, 25. *Paragloborotalia semivera*; (24) Sample 182-1134A-29X-CC, 18–21 cm; (25) Sample 182-1134A-27X-CC, 34–37 cm. 26–28. *Paragloborotalia pseudocontinua*; (26) Sample 182-1134A-30X-CC, 22–25 cm; (27, 28) Sample 182-1134A-27X-CC, 34–37 cm. 29, 30. *Catapsydrax dissimilis*; (29) Sample 182-1134A-27X-CC, 34–37 cm; (30) Sample 182-1134A-29X-CC, 18–21 cm.

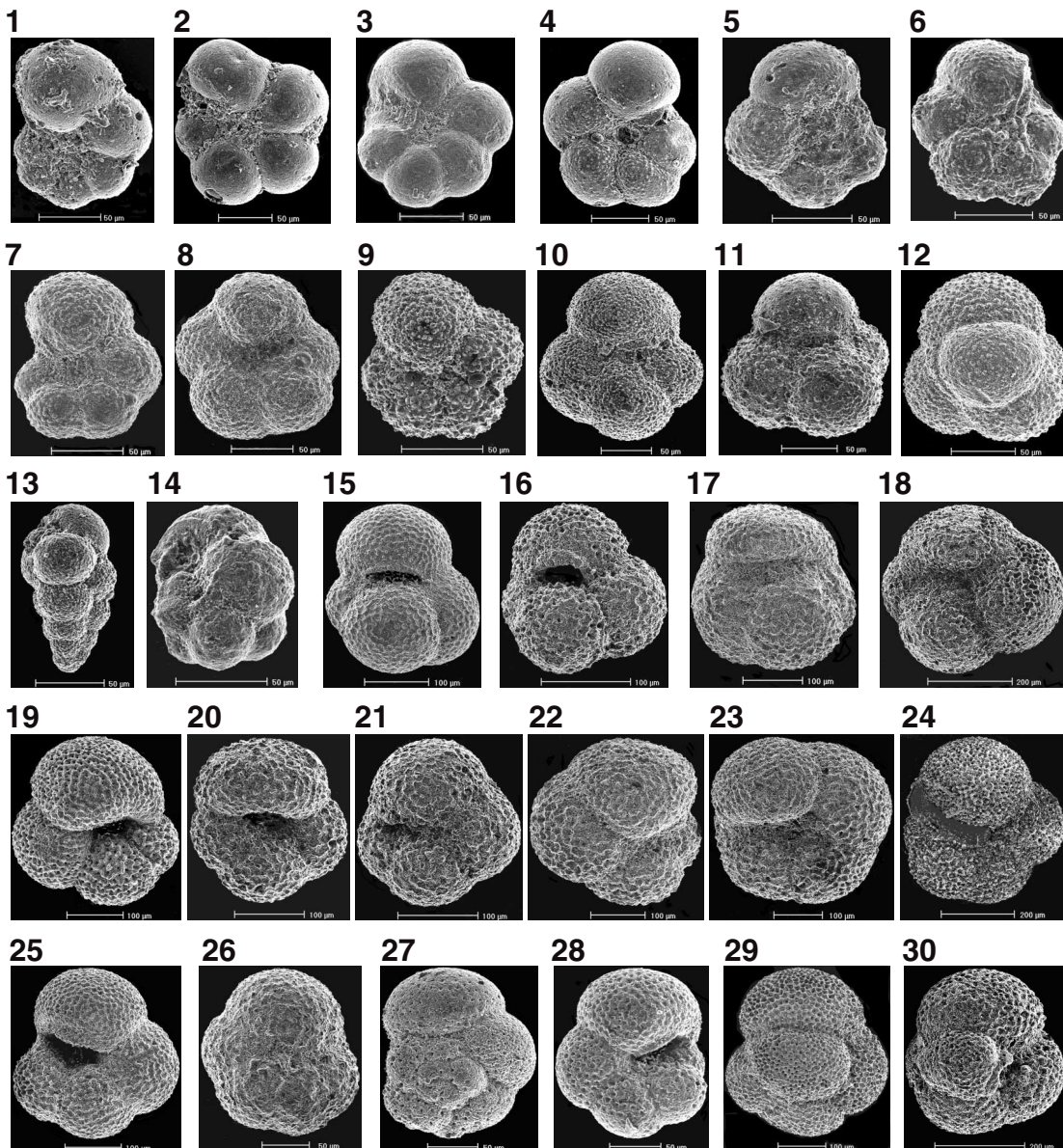


Plate P3. 1. *Globigerina ciperoensis*; Sample 182-1134A-29X-CC, 18–21 cm. 2, 3. *Globigerina angulisuturalis*; Sample 182-1134A-27X-CC, 34–37 cm. 4. *Globigerina officinalis*; Sample 182-1134A-27X-CC, 34–37 cm. 5. *Dentoglobigerina globularis*; Sample 182-1134A-27X-CC, 34–37 cm. 6. *Globoquadrina venezuelana*; Sample 182-1134A-27X-CC, 34–37 cm. 7. *Globoquadrina tripartita*; Sample 182-1134A-27X-CC, 34–37 cm. 8. *Globoquadrina praedeheiscens*; Sample 182-1134A-27X-CC, 34–37 cm. 9. Planktonic assemblage dominated by *Globigerinatheka index*; Sample 182-1132C-31R-1, 144 cm. 10. *Acarinina bullbrooki*; Sample 182-1132C-31R-1, 82 cm. 11. *Subbotina linaperta*; Sample 182-1132C-43R-2, 27 cm. 12. *Pseudohastigerina micra* (m) and a cibicidid form (c); Sample 182-1132C-43R-2, 27 cm. 13. *Acarinina bullbrooki* (b), *Chiloguembelina cubensis* (ch), and a subbotinid form (s); Sample 182-1132C-31R-1, 11 cm. 14. *Acarinina primitiva*; Sample 182-1132C-31R-1, 11 cm. 15. *Acarinina primitiva*; Sample 182-1132C-31R-1, 66 cm.

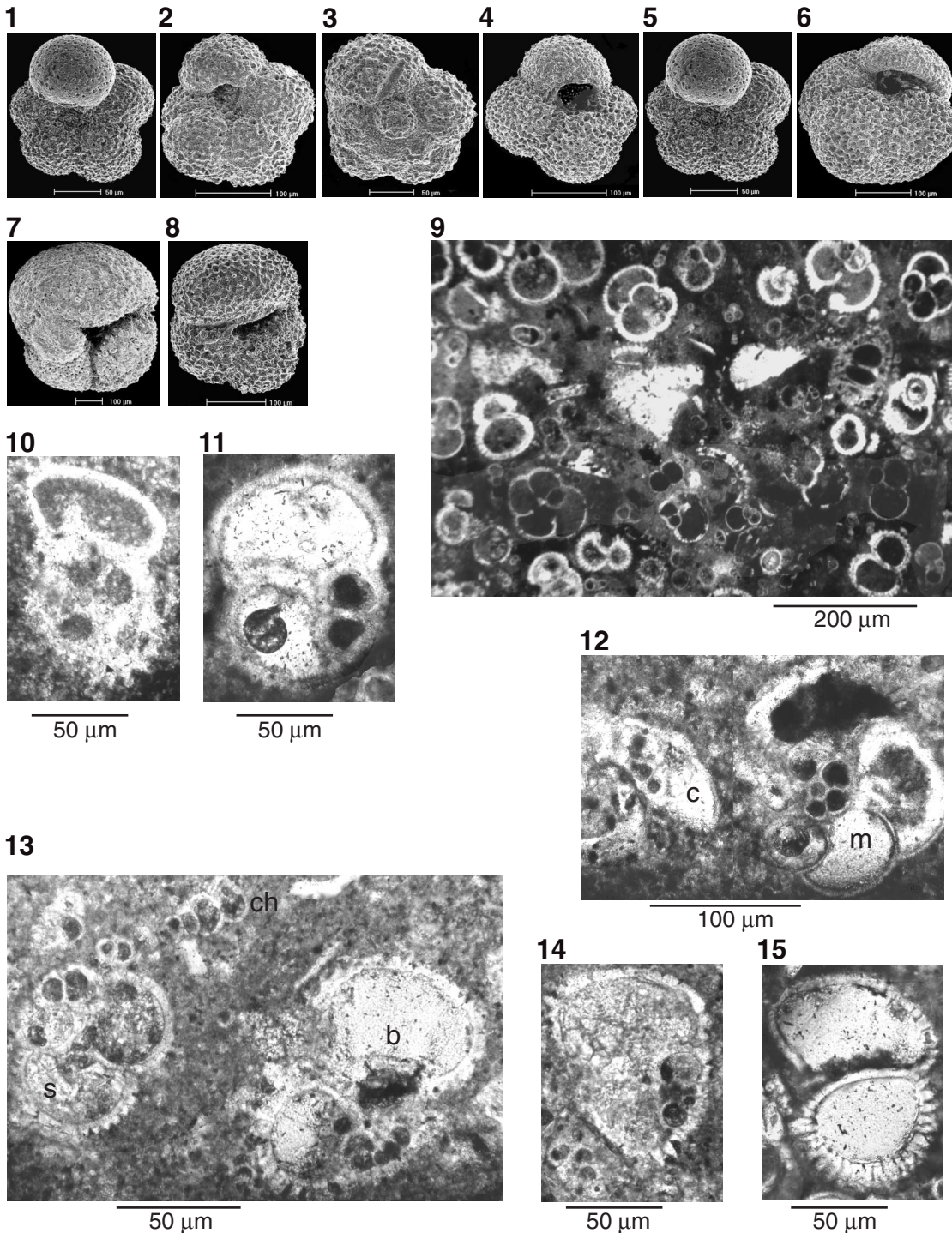
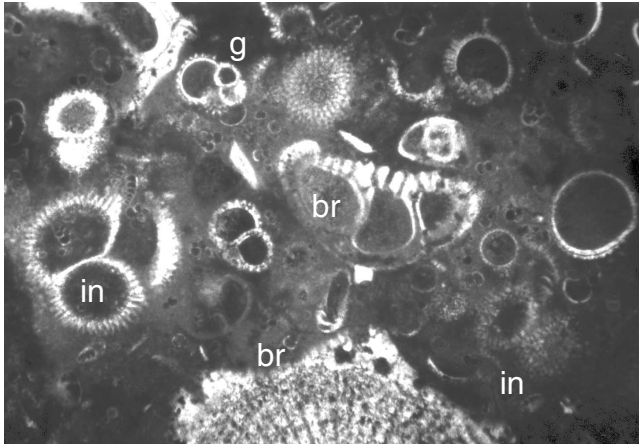


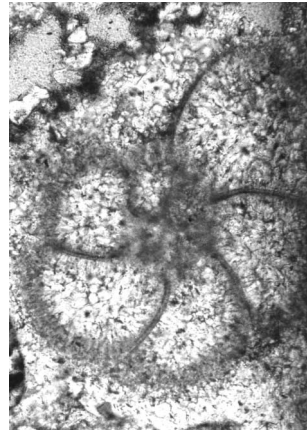
Plate P4. 1. *Globigerinatheka index* (in), small globigerinids (g), and bryozoans (br); Sample 182-1132C-31R-1, 44 cm. 2. A benthic nonionid form; Sample 182-1132C-35R-1, 80 cm. 3. *Acarinina* sp.; Sample 182-1132C-31R-1, 82 cm. 4. *Acarinina* sp.; Sample 182-1132C-31R-1, 82 cm. 5. A large benthic *Victoriella*?; Sample 182-1132C-32R-2, 78 cm. 6. Another large benthic *Victoriella*?; Sample 182-1132C-32R-2, 78 cm. 7. A large benthic *Maslinella adelaidensis*; Sample 182-1132C-43R-2, 27 cm.

1



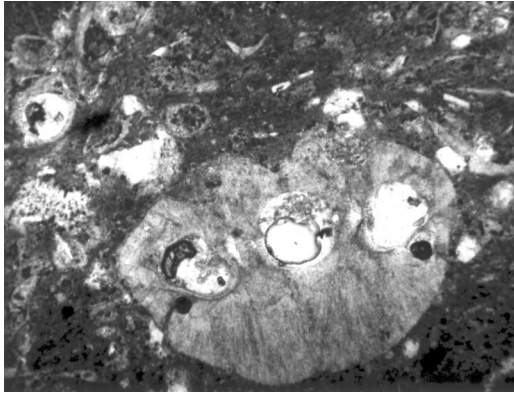
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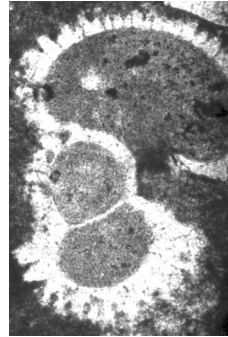
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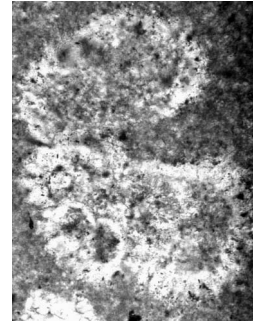
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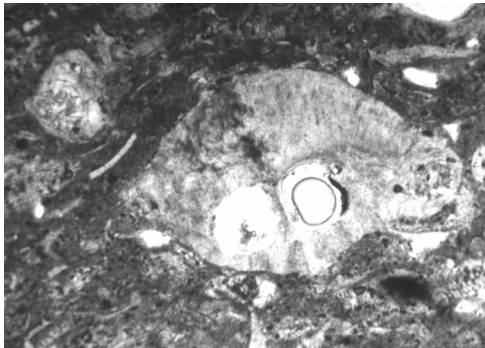
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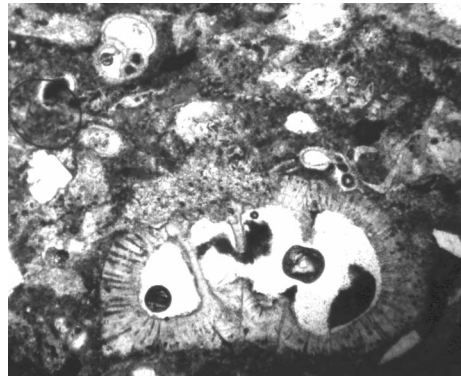
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