

REDESCRIPTION OF TYPE SPECIMENS OF *GLOBOROTALIA CHAPMANI* PARR FROM THE UPPER PALEOCENE, WESTERN AUSTRALIA

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ABSTRACT

Environmental scanning electron microscopy of the type specimens of *Globorotalia chapmani* Parr confirms that the holotype has 11 chambers, with four fully exposed on the involute umbilical side; a marginal imperforate band at least on early chambers in the final whorl; and depressed sutures between all chambers. The periphery of the final chamber is more broadly rounded than in most topotypic specimens of the species. The aperture is an extraumbilical arch highest toward the periphery, bordered above by a prominent lip, but partially obscured by extraneous material. Topotypes have four to five chambers exposed on the umbilical side, consistent marginal imperforate bands, consistent broad apertural lips, consistent microporations, and variable fine granulate ornament scattered on the test surface.

The type stratigraphic level of *G. chapmani* in the lower part of the Kings Park Shale contains a foraminiferal assemblage dominated by benthonic rotaliid foraminifera and interpreted to reflect a mid-neritic (50–100 m water depth) depositional environment. Few planktonic species occur in the type assemblage; these include *Acarinina aquiensis* (Loeblich and Tappan), *Subbotina* spp., and very rare *Morozovella convexa* (*Subbotina*) which together suggest a late Paleocene age (probably zone P4).

INTRODUCTION

Although he considered the fauna to be of Late Eocene age, Parr's (1938) documentation of foraminifera from the Kings Park Shale in the Perth Basin of Western Australia (Fig. 1) represented the first systematic description of Paleocene species from the Australian region. Among the 15 new species and two new varieties named by Parr was a planktonic form, *Globorotalia chapmani*, now recognized widely in the Paleocene as an important stratigraphic index species (McGowran, 1964, 1968; Stainforth, Lamb, Luterbacher, Beard, and Jeffords, 1975; Berggren, 1977; Toumarkine and Luterbacher, 1985; Banner, 1989). To support his description of *G. chapmani*, Parr (1938, Pl. 3, Figs. 8–9) illustrated the holotype and a topotype by line drawings. Although McGowran (1964, p. 85, 86, Pl. 1, Fig. 9) carefully redescribed aspects of the test morphology and reillustrated (in line drawing) Parr's topotype specimen, and figured additional material from the Kings Park Shale (McGowran, 1964, Pl. 1, Figs. 1–8, line drawings; McGowran, 1968, Pl. 4, Figs. 15, 16, thin-section photo-

graphs), confusion still exists as to the taxonomic affinity and detailed morphology of the species (e.g. Blow, 1979; Toumarkine and Luterbacher, 1985, p. 108).

Recent advances in "environmental" scanning electron microscopy allows secondary-electron images to be made of uncoated specimens on original slide mounts. The specimens are undamaged in this procedure and are not subjected to carbon or metallic coating. High-resolution photographs now can be made of valuable foraminiferal type material without disfigurement of specimens. The purpose of this paper is to (1) present secondary-electron images of the holotype and Parr's topotype of *G. chapmani*, obtained through Environmental SEM analysis; (2) illustrate newly recovered topotypic specimens; and (3) comment on the taxonomic significance of these images.

MATERIAL AND METHODS

The type slide is housed in the Museum collections of the Department of Geology, University of Western Australia under acquisition number UWA18897. It contains two specimens: the holotype figured in umbilical and peripheral view by Parr (1938, Pl. 3, Figs. 9a,b) and a topotype (figured in spiral view in Parr's Pl. 3, Fig. 8). The type specimens come from Kings Park Bore 1, 755 ft, in the lower part of the Kings Park Shale. The type level has been dated as late Paleocene (McGowran, 1964; zone P4 according to McGowran, 1991).

The specimens were not removed from the type slide during our SEM analysis. Preparation involved gentle cleaning of the surface of each test using a fine sable-hair brush saturated in distilled water. The specimens were repositioned on the type slide in the desired orientation for imaging from a viewpoint looking directly down onto the slide.

The specimens were examined in an ELECTROSCAN model E-3 ESEM (environmental scanning electron microscope) using an accelerating voltage of 30 kV, working distance of around 9.4 mm and a chamber gas pressure (in this case air) of 4.1 torr. The images obtained are an intensity modulated display of the ionization of the chamber gas by emergent secondary and/or backscattered electrons from the specimen as it is scanned by the primary electron beam. The negative component of the gas ionisation is selectively used for imaging, the positive component cancels any surface charge on the specimen. Principles of the ESEM were reviewed in detail by Danilatos (1991).

A comparison between conventional SEM and ESEM images is presented in Plate 1 (ESEM; type specimens) and Plate 2 (conventional SEM; additional topotypes). No major differences in image type are apparent, as would be expected, and both sets of photographs exhibit the edge highlighting and 3-D information typical of secondary electron images (Goldstein and Yakowitz, 1975). The ESEM images appear 'softer' and this reflects a lower degree of edge

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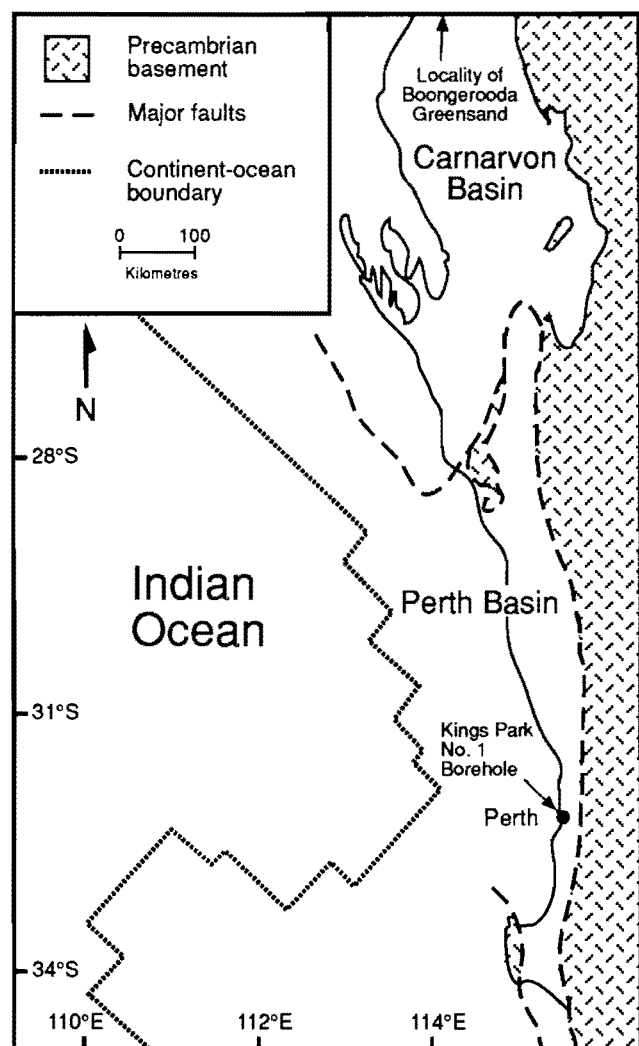


FIGURE 1. Location of Kings Park Bore 1, type locality of *Globorotalia chapmani* Parr.

enhancement due to the absence of a high SE-yielding surface coating (usually gold), but this is not considered to compromise interpretation of the images.

The Environmental SEM imaging was undertaken by B. J. Griffin, and morphological and taxonomic inferences from these images were made by D. W. Haig. Additional topotypic material was provided by B. Ujetz who reassessed the fauna at the type level in the Kings Park I borehole.

TYPE SPECIMEN MORPHOLOGY

The holotype is an infilled specimen with a partially damaged test. The final chamber is extensively fractured on the spiral side with much of the wall material removed (Pl. 1, Fig. 3). Part of the spiral wall of the fourth-last chamber also is missing. Most of the periphery of the test is complete, and the test outline and the nature of sutures between chambers are clear.

The holotype consists of 11 chambers; the last four of which are visible from the umbilical side (as shown in Parr's type figure). The chambers increase rapidly in size; the final chamber is slightly higher than wide. The initial

spire is flat; the final chamber diverges slightly towards the umbilical side. Chamber surfaces on the spiral side are gently convex with sutures depressed even between early chambers. In peripheral view (Pl. 1, Fig. 2), the margin seems more broadly rounded than illustrated by Parr, and is more rounded than the peripheries of most topotypic specimens (e.g. Pl. 2, Figs. 2, 7, 10, 13, 16, 19, 22). The "imperforate marginal band" identified by McGowran (1964) as characteristic of the species is evident in our images of the holotype (Pl. 1, Fig. 2), at least on earlier chambers of the final whorl. Elsewhere the test is very finely and evenly perforate. The perforations appear to be similar to the "microperforations" described by Banner (1989, p. 177) for *Globanomalina ovalis* Haque. Most of the test surface seems devoid of ornament; a few scattered fine granules are present on the surface of the penultimate chamber (Pl. 1, Fig. 3).

Apertural details are somewhat obscure on the holotype. A conspicuous apertural lip was shown in Parr's type figure of the holotype. According to Blow (1979, p. 1059), Dr. F. T. Banner examined the holotype and recognized a "strongly developed apertural plate-like structure," and because of this Blow suggested that *G. chapmani* may be a *Valvulineria*. Our images show that the aperture is infilled and the umbilicus partially covered by extraneous material. A prominent lip appears to be present above a moderately high-arched aperture which is confined to the umbilical side in an extraumbilical position highest toward the periphery. The lip does not extend onto the spiral side as suggested in Parr's figure.

Parr (1938, Pl. 3, Fig. 8) chose the topotype to illustrate the morphology of the spiral side of the test, probably because the spiral wall is better preserved than in the holotype. Our SEM images show that the characters displayed on the spiral side of the topotype are similar to those of the holotype, although more fine granules are evident on the test surface, particularly on the third-last and penultimate chambers (Pl. 1, Fig. 6). In peripheral view, the margin of the final chamber is more angulate than in the holotype, although some post-burial distortion and breakage has occurred. A marginal imperforate band seems to be present, but the preservation of the test in the peripheral region is poor. The umbilicus of the topotype and its apertural details are obscured by extraneous grains cemented to the test.

DISCUSSION

Based on re-examination of the type material and other specimens from the Kings Park Shale, McGowran (1964) characterised *G. chapmani* by (a) an imperforate marginal band that is not thickened as a keel; (b) chambers in peripheral view with an equally biconvex arrowhead shape; and (c) sutures distinctly depressed on both sides. These features are apparent in our SEM images of the holotype. Parr (1938) noted that "not more than five" chambers form the final whorl, and McGowran's (1964) figures of additional specimens also show a similar complement of chambers. Among specimens from the Kings Park Shale, variability was noted by McGowran in the equatorial outline (due to variable increase in chamber size), convexity of the spiral side (although initial whorls are usually depressed

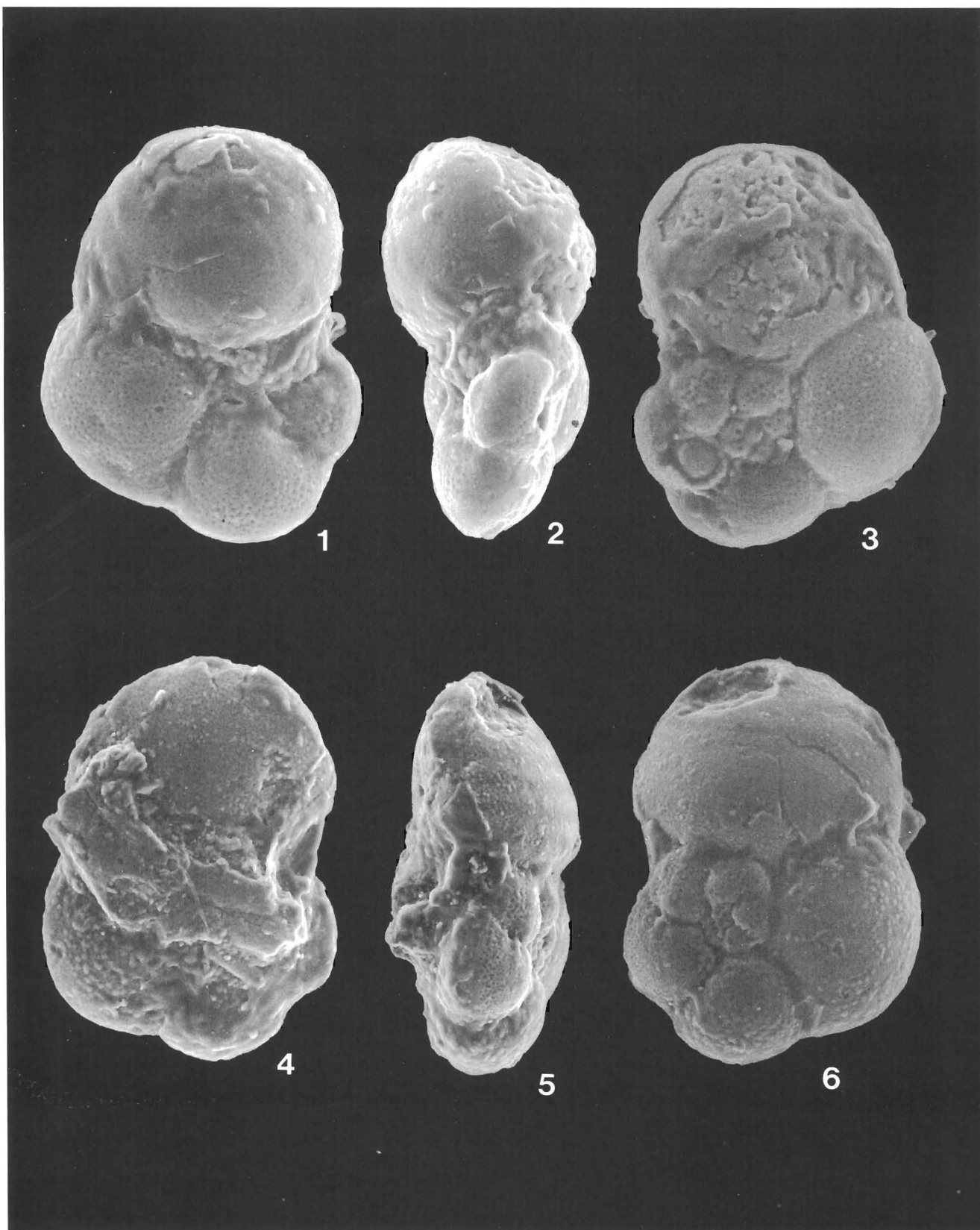


PLATE 1

Secondary electron images (ESEM). *Globorotalia chapmani* Parr. 1–3, UWA18897a, holotype from Kings Park 1, 755 ft; 1, umbilical view, $\times 205$; 2, peripheral view, $\times 210$; 3, spiral view, $\times 215$. 4–6, UWA18897b, topotype figured by Parr (1938), from Kings Park 1, 755 ft; 4, umbilical view, $\times 155$; 5, peripheral view, $\times 150$; 6, spiral view, $\times 155$.

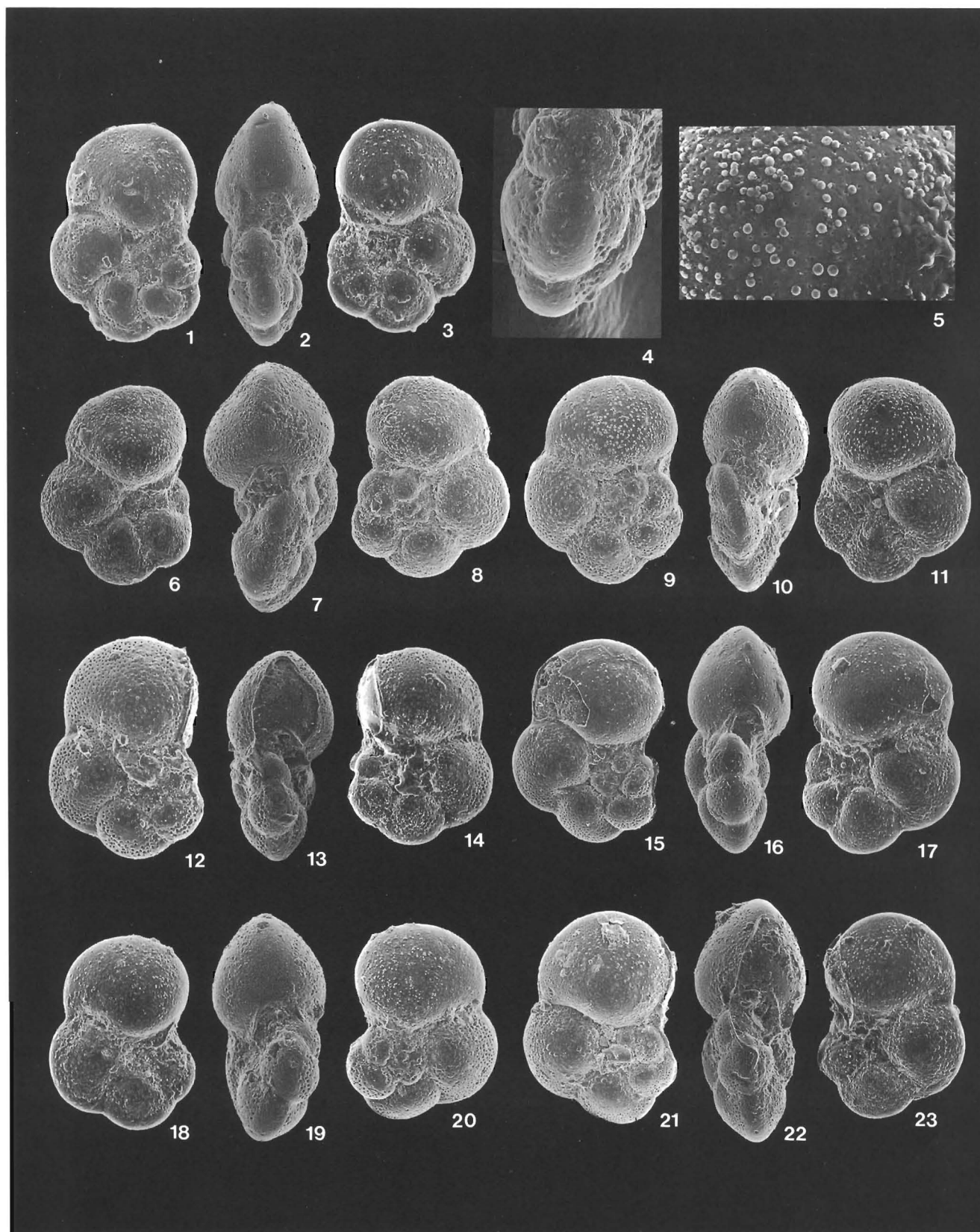


PLATE 2

Secondary electron images (conventional SEM). *Globorotalia chapmani* Parr; topotypes from Kings Park Bore 1, 755 ft. **1–4** UWA115708; 1, spiral view, $\times 135$; 2, peripheral view, $\times 140$; 3, umbilical view, $\times 135$; 4, detail of periphery, $\times 280$. **5, 9–11**, UWA115709; 5, detail of granulate ornament, $\times 470$; 9, spiral view, $\times 105$; 10, peripheral view, $\times 120$; 11, umbilical view, $\times 105$. **6–8** UWA115710; 6, umbilical view, $\times 95$; 7, peripheral view, $\times 120$; 8, spiral view, $\times 95$. **12–14**, UWA115711; 12, spiral view, $\times 150$; 13, peripheral view, $\times 140$; 14, umbilical view, $\times 125$. **15–17** UWA115712; 15, spiral view, $\times 115$; 16, peripheral view, $\times 135$; 17, umbilical view, $\times 120$. **18–20**, UWA115713; 18, umbilical view, $\times 120$; 19, peripheral view, $\times 150$; 20, spiral view, $\times 135$. **21–23**, UWA115714; 21, spiral view, $\times 105$; 22, peripheral view, $\times 120$; 23, umbilical view, $\times 100$.

below the outer whorl), and inflation and sharpness of the periphery.

The foraminiferal assemblage recovered by Parr from the type locality of *G. chapmani* is housed in the UWA Geology Museum collection on slide UWA55142 (grid compartments A12 to D14). The assemblage consists mostly of benthonic specimens, including the diverse species tabulated by Parr (1938, p. 72, 73). The few planktonic foraminifera in the type collection include three specimens in compartment C17 that can be attributed to *G. chapmani* and two similar types located in compartment D2 among specimens of *Cibicides pseudoconvexus* Parr. Some small and poorly preserved *Acarinina* and *Subbotina* also are present on Parr's slide.

One of us (B.U.) has reprocessed material from the type level in Kings Park Bore 1, and made a systematic assessment of the contained fauna. Planktonic specimens comprise 34% of the total foraminiferal assemblage found in the >150 µm sediment fraction, and are mostly small forms we identify as *Acarinina aquiensis* (Loeblich and Tappan). Specimens we regard as conspecific with *Globorotalia chapmani* comprise about 3% of the foraminiferal assemblage. Other planktonic species include small *Subbotina* spp. (7%) and very rare *Morozovella convexa* (Subbotina). The benthonic assemblage is dominated by *Cibicides umbonifer* Parr (15% of the total foraminiferal assemblage), *Cibicides pseudoconvexus* Parr (10%), *Anomalinoides perthensis* (Parr) (5%), and *Gyroidinoides* cf. *octocamerata* (Cushman and Hanna) (5%).

Our newly recovered topotypic population of *G. chapmani* includes 25 dextral tests and 18 sinistral individuals. On Plate 2, we illustrate some of the better preserved topotypes in the collection using conventional scanning electron micrographs. All specimens have 4–5 chambers exposed in the final whorl on the involute umbilical side, depressed sutures between chambers, and umbiliculi of varying width. Most of the specimens have sharper and more equilateral peripheral margins than on the holotype, and all appear to possess an imperforate band on the periphery. Fine granulate ornament, barely discernible under reflected light, is commonly scattered on chamber surfaces. Individual granules average about 3 µm in width.

The planktonic assemblage suggests a late Paleocene age for the type level in the Kings Park 1 Bore, and although we have located the zonal index species *Planorotalites pseudomenardii* only at a higher level (413–545 ft) within the borehole, the types of *Globorotalia chapmani* probably come from zone P4 (following the definition of Berggren and Miller, 1988).

From the general composition of the foraminiferal assemblage at the type locality, and from the geological setting of the Kings Park Shale, we conclude that the fauna inhabited normal-marine waters at mid-neritic depths (perhaps 50–100 m) in an incised submarine valley on the continental shelf. According to Veevers, Powell, and Roots (1991), the paleolatitude of this site lay close to 65°S, presumably in a cool climatic belt (as suggested by nannofossil assemblages from the Kings Park Shale, according to Shafik, 1978).

The specimen figured by Berggren, Olsson and Reyment (1967, text-fig. 1) was mislabelled as a topotype. It comes from the Boongerooda Greensand in Toothawarra Creek in

the Giralia Range, about 1300 km north of the Kings Park Shale type locality (and from the Carnarvon Basin, rather than from the Perth Basin). The Boongerooda specimen, also from zone P4, displays the chamber arrangement and test shape characteristic of the type specimens.

In recent literature, a consensus has formed that *Globorotalia ehrenbergi* Bolli and *Globorotalia troelseni* Loeblich and Tappan are subjective junior synonyms of *G. chapmani* (e.g. McGowran, 1968; Stainforth et al., 1975; Toumarkine and Luterbacher, 1985; Banner, 1989). Generic assignments for *G. chapmani* have included *Planorotalites* (e.g. by McGowran, 1968; Berggren, 1977; Toumarkine and Luterbacher, 1985); *Globorotalia* (*Tuborotalia*) by Blow (1979); and *Globanomalina* (e.g. by Banner, 1989). Banner (1989, p. 178) placed *G. chapmani* in the "*Globanomalina*" lineage with *Globigerina compressa* Plummer as its immediate ancestor, and *Globanomalina ovalis* Haque as its immediate descendent. He also derived *Globorotalia pseudomenardii* Bolli from *G. chapmani*. In chamber shape and arrangement typical *G. chapmani* seems very similar to specimens of *G. compressa* from the Midway Formation of Texas illustrated in electron micrographs by Stainforth et al. (1975, p. 179), but differs in possessing an imperforate peripheral band rather than an evenly perforate periphery. Typical *G. chapmani* differs from paratypic *G. ovalis* illustrated in electron micrographs by Banner (1989, Pls. 1, 2) by the more broadly rounded and evenly perforate periphery of the latter species. The imperforate peripheral band of typical *G. chapmani* may be a precursor to the keel of *Globorotalia pseudomenardii* but transitional specimens between these taxa have not been observed among the sparse planktonic faunas of the Kings Park Shale.

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REFERENCES

- BANNER, F. T., 1989, The nature of *Globanomalina* Haque: Journal of Foraminiferal Research, v. 19, 171–179.
- BERGGREN, W. A., 1977, Atlas of Palaeogene planktonic foraminifera, some species of the genera, *Subbotina*, *Planorotalites*, *Morozovella*, *Acarinina* and *Truncorotaloides*, in Ramsay, A. T. S. (ed.), Oceanic micropaleontology: Academic Press, London, p. 205–300.
- BERGGREN, W. A., and MILLER, K. G., 1988, Paleogene tropical planktonic foraminiferal biostratigraphy and magnetobiochronology: Micropaleontology, v. 34, p. 362–380.
- BERGGREN, W. A., OLSSON, R. K., and REYMENT, R. S., 1967, Origin and development of the foraminiferal genus *Pseudohastigerina* Banner and Blow, 1959: Micropaleontology, v. 13, p. 265–288.
- BLOW, W. H., 1979, The Cainozoic Globigerinida: E. J. Brill, Leiden, 1413 p.
- DANILATOS, G. D., 1991, Review and outline of environmental SEM at present: Journal of Microscopy, v. 162, p. 391–402.
- GOLDSTEIN, J. I., and YAKOWITZ, H. (Eds.), 1975, Practical scanning electron microscopy. Plenum Press, New York.
- McGOWRAN, B., 1964, Foraminiferal evidence for the Paleocene age of the King's Park Shale (Perth Basin, Western Australia): Journal of the Royal Society of Western Australia, v. 47, p. 81–86.
- , 1968, Reclassification of early Tertiary *Globorotalia*: Micropaleontology, v. 14, p. 179–198.
- , 1991, Maastrichtian and early Cainozoic, southern Australia:

- planktonic foraminiferal biostratigraphy, *in* Williams, M. A. J., De Deckker, P., and Kershaw, A. P. (eds.), *The Cainozoic in Australia: a re-appraisal of the evidence*: Geological Society of Australia Special Publication, v. 18, p. 79–98.
- PARR, W. J., 1938, Upper Eocene foraminifera from deep borings in King's Park, Perth, Western Australia: *Journal of the Royal Society of Western Australia*, v. 24, p. 69–101.
- SHAFIK, S., 1978, Paleocene and Eocene nannofossils from the Kings Park Formation, Perth Basin, Western Australia: Australian Bureau of Mineral Resources, Geology and Geophysics, Bulletin, v. 192, p. 165–172.
- STAINFORTH, R. M., LAMB, J. L., LUTERBACHER, H., BEARD, J. H., and JEFFORDS, R. M., 1975, Cenozoic planktonic foraminiferal zonation and characteristics of index forms: The University of Kansas, Paleontological Contributions, v. 62, 425 p.
- TOUMARKINE, M., and LUTERBACHER, H., 1985, Paleocene and Eocene planktic foraminifera, *in* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K. (eds.), *Plankton stratigraphy*: Cambridge University Press, Cambridge, p. 87–154.
- VEEVERS, J., POWELL, C. McA., and ROOTS, S. R., 1991, Review of seafloor spreading around Australia. 1. Synthesis of the patterns of spreading: *Australian Journal of Earth Sciences*, v. 38, p. 373–389.

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