REPT.BK.NO. 76/6

# FORAMINIFERAL BIOSTRATIGRAPHY OF DEPT. MINES BOREHOLE STR-2, KEITH AREA

J.M. LINDSAY

Department of Mines
South Australia ——

BIOSTRAT.REPT.NO. 3/76

DEPARTMENT OF MINES
SOUTH AUSTRALIA

# FORAMINIFERAL BIOSTRATIGRAPHY OF DEPT. MINES BOREHOLE STR-2, KEITH AREA

by

J.M. LINDSAY

Palaeontology Section
BIOSTRATIGRAPHY DIVISION

27th January, 1976

Rept.Bk.No. 76/6
G.S. No. 5684
D.M. No. 236/69
Biostrat.Rept.No. 3/76

| CONTENTS | PAGE |
|---|---|

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No. 76/6
G.S. No. 5684
D.M. No. 236/69
Biostrat.Rept.No. 3/76

# FORAMINIFERAL BIOSTRATIGRAPHY OF DEPT. MINES BOREHOLE STR-2, KEITH AREA

## ABSTRACT

STR-2, on the Padthaway Ridge, near Monster Mount, Keith district, penetrated a Cainozoic sequence approximately 88 m thick resting on bedrock of weathered quartz-feldspar porphyry. ?Coomandook Formation (8-28 m, ?Early Pleistocene) is distinguished from ?Loxton Sands (28-42 m, Early Pliocene, with *Crespinella umbonifera* and significant planktonic species). Ettrick Formation (42-73 m, Oligocene) and Buccleuch Beds (73-?88 m, Late Eocene) underlie the mid-Tertiary unconformity. Comparisons are made with the sequence to bedrock in a bore 14.5 km to the north-northwest, previously studied and now revised.

Keywords: Foraminifera-benthonic, foraminifera-planktonic, Tertiary, Pleistocene, Pliocene, Oligocene, Eocene, biostratigraphy, Coomandook Formation, Loxton Sands, Ettrick Formation, Buccleuch Beds, Padthaway Ridge.

## INTRODUCTION

Dept. Mines observation borehole STR-2 is located at Lat.36°13'50.3"S, Long. 140°15'48.6"E, 15 km southwest of Keith, 7 km southwest of Monster Mount, and 1 km southwest of Gum Waterhole on 1:100 000 Sheet Keith 6925-1, and NARACOORTE 1:250 000 Sheet. The hole is 15 m northeast of borehole STR-1, on a road reserve adjacent section 418, hundred of Stirling, County Buckingham. Structurally, the area is on the southern part of the Padthaway Ridge. Borehole STR-2 was drilled with cable-tool rig between 29th Jan. and 19th Feb., 1974, to a total depth of 96.50 m. Permit number was A.505. In addition to cable-tool sludge samples taken generally every 2 m, five open-tube cores, five "bit samples", and one "casing shoe sample" provided

more or less *in situ* material from various depths. O.J. Bowering, Hydrogeology Section, provided a preliminary log. This was supplemented by the usual lithological and micropalaeontological examination of washed residues under binocular microscope, and also by comparing the driller's log which is recorded below in the "Descriptions of Samples".

The nearest borehole on which biostratigraphic work had been done previously was H.M. Densley bore 4, section 61, hundred of Laffer, County Cardwell, 14.5 km to the north-northwest (Lindsay, 1968). This bore was used in the cross-section A-A' compiled by Rochow (1969) for NARACOORTE. Some comparisons are made between a revision of this bore sequence and that in STR-2.

Due to facies variations on and around the Padthaway Ridge, and the distance from type sections, there are some difficulties in interpreting the stratigraphic succession in terms of previously named units, and the subdivision of STR-2 is therefore somewhat tentative at present. It is anticipated that studies in progress by the writer, of recent stratigraphic drilling by the Bureau of Mineral Resources towards Bordertown, Willalooka and Naracoorte, will help to elucidate these problems.

STRATIGRAPHIC SUMMARY

| Unit | Depth (metres) | Thickness (metres) |
|---|---|---|
| Quaternary units (undifferentiated) | 0-8 | 8 |
| ?Coomandook Formation (?Early Pleistocene) | 8-28 | 20 |
| ?Loxton Sands (Early Pliocene) | 28-42 | 14 |
| Ettrick Formation (Oligocene) | 42-73 | 31 |
| Buccleuch Beds (Late Eocene) | 73-?88 | ?15 |
| Bedrock (probably early Palaeozoic) | ?88-96.5(T.D.) | 8.5+ |

## STRATIGRAPHIC UNITS ENCOUNTERED

### Quaternary units (undifferentiated)

These comprise a) thin surficial sand, mapped as Molineaux Sand on NARACOORTE 1:250 000 Geological Sheet (Rochow, 1969);

b) clay, silt, sand, and rubbly calcareous sandstone to sandy limestone probably calcreted in part. Some of the latter, as pale grey quartz-bearing fine-grained limestone with only occasional fossil remains, is comparable with interdunal "Padthaway Formation". This grades down to the underlying ?Coomandook Formation with increasing marine influence below 8 m. Bridgewater Formation (aeolianite) appears to be not present in this sequence, although it is mapped in a nearby "range".

### ?Coomandook Formation

### (?Early Pleistocene)

This interval comprises 17 m of calcarenitic and calcareous sandstone, underlain by 3 m of calcarenitic silt, sand and clay, all in marine rather than aeolianite facies. Foraminifera are first encountered downhole at a depth of 8 m (i.e. where the top of this unit is put). They increase in abundance and diversity downwards through the unit, but *Ammonia beccarii* (Linné) and *Elphidium* spp. predominate throughout, suggesting marginal-marine lagoonal to bay environments. The foraminifera present do not date the unit with more precision than "late Cainozoic". The presence of a few charophyte oogonia in the upper part supports a marginal situation, and the sparse glauconite suggests some marine influence.

In H.M. Densley bore 4, Sect. 61, Hd. Laffer, 14.5 km to the north-northwest, ?Coomandook Formation is now interpreted to extend down only to 35.1 m, i.e. to a comparable depth to that in STR-2. In both cases a silty to clayey bed marks the base of the unit.

Coomandook Formation as proposed by Firman (1967, 1973) was dated "Lower Pleistocene in the South Australian sequence", and its distribution was described as "southwest of a line Coomandook to Naracoorte on the Padthaway Archipelago." The primary sub-surface type section is in K.J. and C.R. Barney bore 1, Sect. 38 (plotted "B"), Hd. Peake (83 km north-northwest of STR-2) between the depths of 4.27 and 35.05 m. The formation was identified subsurface, with some doubt, over a wide area of NARACOORTE by Rochow (1969), including the vicinity of borehole STR-2. However, as discussed below, the lower part of this interval in STR-2 is older and distinct (?Loxton Sands, Early Pliocene).

Studies are continuing on the stratigraphy of Plio-Pleistocene marine sands and sandstones in the southeast of South Australia, and in western Victoria (cf. Whalers Bluff Formation and its Werrikoo Member). Pending the outcome of this work, Coomandook Formation is tentatively identified in STR-2 as shown.

?Loxton Sands

(Early Pliocene)

Shelly, quartzose, more or less marine calcarenites between 28 and 42 m may be distinguished from the unit described above, and are tentatively identified as Loxton Sands. Their age by foraminifera appears to be Pliocene, and probably Early Pliocene, implying a distinct time-break to the overlying unit. They are ferruginous below 34 m (brown staining and impregnation; ferruginous grains). The unit, at least in part, is silty and finely micaceous.

Between 28 and 34 m there is an appreciable content of planktonic foraminifera in the microfauna, suggesting more access to marine influence than above or below. *Globigerina foliata* Bolli is common; and *Globorotalia (Turborotalia)* sp. aff. *G. (T.) puncticulata* (Deshayes), though scarce, is

consistently present. According to Blow (1969), the former species ranges up into the Early Pliocene, and *G. (T.) puncticulata* ranges from Early Pliocene to the Recent. This indicates an Early Pliocene age for the unit.

Kennett (1970), Barbieri (1971), and Collen and Vella (1973) have also recently discussed the taxonomy and biostratigraphy of *G. (T.) puncticulata*, and its distinction from *G. (T.) crassaformis* (Galloway and Wissler) and *G. (T.) inflata* (d'Orb.). Collen and Vella (op. cit.) recorded *G. (T.) puncticulata* only from the Opoitian Stage (Early Pliocene) of New Zealand.

An Early Pliocene age is supported by the presence of the benthonic foraminifer *Crespinella umbonifera* (Howchin and Parr) certainly between 34 and 38 m, and with probable fragments at 30-32 m, and at 38-40 m. The known range of *C. umbonifera* is Middle Miocene to Early Pliocene, the youngest occurrence in the Murray Basin being recorded from the Loxton Sands (Ludbrook, 1961, Table 10, p.87) which are dated Early Pliocene (Ludbrook 1963, 1973). There is no Middle Miocene unit known in the vicinity of STR-2 from which the quite well-preserved specimens of *C. umbonifera* could have been reworked. Furthermore, the specimens mostly occur between 34 and 38 m depth, not in the basal 4 m of this unit where reworked mid-Tertiary (Oligocene) material becomes evident.

In H.M. Densley bore 4, Sect. 61, Hd. Laffer, *C. umbonifera* occurs between 35.1 and 39.6 m, i.e. at very similar depths to those in STR-2. The specimens in the Densley bore were regarded as possibly reworked from Miocene beds by Lindsay (1968), but the same arguments apply as outlined above for STR-2. The specimens are now thought to be more likely indigenous, and indicative of Early Pliocene age. A pronounced lithological change also occurs in the Densley bore at 35.1 m where the basal clay bed of Coomandook Formation overlies a shelly sand with *C. umbonifera*. Loxton Sands are therefore now tentatively recognised also in the Densley bore between 35.1 and ?43.3 m. As in STR-2, mid-Tertiary (Oligocene) material, seemingly reworked, occurs in increasing abundance towards the base of this interval, but below

the zone of *C. umbonifera*.

Another benthonic foraminifer which supports an Early Pliocene age for the interval 28-42 m in STR-2 is *Fabularia howchini* Schlumberger (occurring at 34-40 m), described from, and hitherto confined to the Early Pliocene of Western Victoria (Schlumberger, 1891; Parr, 1939).

The distinctive bivalve mollusc *Nuculana (Scaeoleda) woodsi* (Tate) occurs between 30 and 42 m. It has not been recorded from above the (Late Pliocene) Dry Creek Sands in South Australia (Ludbrook 1955, 1963). In Western Victoria it is recorded as ranging up to the Early Pliocene Kalimnan Stage and is distinct from the Werrikooian *N. (S.) killara* Singleton (see Singleton, 1941).

## Ettrick Formation

## (Oligocene)

This formation is represented by fossiliferous grey-brown silty fine-grained quartz sand and sandy silt with impoverished but marine microfaunas suggesting middle to early Oligocene age. Tube cores were taken at 42 and at 64 m. The presence of the planktonic foraminifer *Globigerina (Subbotina) angiporoides* Hornibrook indicates an age not younger than middle Oligocene, Zone P.19/20 of Blow (1970). *G. (S.) linaperta* Finlay is not present, but a few small forms aff. *linaperta* at the base of the interval suggest proximity to the Eocene, as does the preponderance of *Chiloguembelina cubensis* (Palmer) over *Guembelitria stavensis* Bandy.

The sandy nature of this Ettrick Formation, compared with the more usual glauconitic marl to limestone (Ludbrook, 1961) and the depleted microfauna, are no doubt due to more nearshore and restricted-marine deposition in the Padthaway Archipelago.

The unconformity between ?Loxton Sands and Ettrick Formation in the Densley bore, 14.5 km to the north-northwest, is at about 43 m, i.e. at much the same depth as in STR-2. The lithology of the Ettrick Formation

in the Densley bore is more typical, and the microfauna more distinctive, but the thickness is much less than in STR-2 (2.4 m as compared with 31 m).

## Buccleuch Beds

## (Late Eocene)

At 73 m there is a pronounced coarsening of grain-size to fossiliferous gravelly calcarenite/calcirudite, quartzose, with abundant bryozoal fragments and a significant change in microfauna. This is recognised as the top of Buccleuch Beds, which are taken to continue until weathered bedrock is encountered at about 88 m. The lithology is mostly comparable with Buccleuch "B" of Ludbrook (1961).

The planktonic foraminifer *Globigerapsis index* (Finlay) and the benthonic *Maslinella chapmani* Glaessner and Wade, both occur at 73-74 m and indicate Eocene age, as does Genus aff. *Bolivinella* sp. (of Ludbrook, 1961) at 75 m. *Globorotalia (T.) gemma* Jenkins and *Globigerina* sp. aff. *G. gortanii* Borsetti, also at the latter depth, would restrict this to Late Eocene (Blow, 1969). *Bulimina* sp. aff. *B. pupoides* d'Orbigny, which occurs at 87 m, is elsewhere in the Murray Basin characteristically present in Buccleuch clays.

Buccleuch "A" and "C" units of Ludbrook (1961) cannot be identified in this bore. Similarly, separation into Buccleuch "A", "B", and "C" was not attempted in the Densley bore 4, 14.5 km to the north-northwest, where the thickness of Buccleuch Beds is 30 m, i.e. twice the thickness in STR-2.

The basal few metres of the Tertiary succession in STR-2, at least from 84 m downwards, have a reduced microfauna and comprise poorly sorted fine to gravelly (angular to subrounded) quartz sand and silt, carbonaceous and somewhat pyritic. These are not the "carbonaceous silts and fine sands generally well-sorted", of typical Renmark Beds (Harris, 1966). The lithology may be transitional to Knight Formation, but this typically has "coarse to very coarse well rounded quartz sand, often conglomeratic"

(Harris, 1966), and the gravelly sand at this level of STR-2 is not well rounded. The interval is here included in Buccleuch Beds. In the Densley bore 4, 12.5 m of ?Renmark Beds were distinguished between Buccleuch Beds and weathered bedrock (Lindsay, 1968), but the sideritic aggregates and pellets common in this interval of the Densley bore, do not occur in STR-2.

The total thickness of Ettrick + Buccleuch + ?Renmark Beds in the Densley bore (44.5 m) is almost the same as the total thickness of Ettrick + Buccleuch Beds in STR-2 (46 m).

## Bedrock

(probably early Palaeozoic)

Weathered quartz-feldspar porphyry (with abundant grey-brown smoky quartz) was entered by at least 94.5 m, and probably by 88 m. Calcarenitic material below this is considered to be probably caved. Feldspar (white to salmon-pink) increases in abundance below 94.5 m. Green patches in the porphyry may be due to epidote and/or chlorite.

Quartz porphyry crops out at Monster Mount, 7 km to the northeast (e.g. Rochow, 1971). Of the quartz phenocrysts in a nearby porphyritic rhyolite "some are euhedral and some are corroded, but most are fairly rounded" (Rochow, 1971, Appendix 17-1, p.330), and this could explain some rounding of the smoky quartz grains in what appears to be weathered bedrock in STR-2.

In H.M. Densley bore 4, 14.5 km to the north-northwest of STR-2, weathered bedrock was encountered at about 88 m, i.e. at virtually the same depth as in STR-2. However, the bedrock lithology in the Densley bore is sericitic schist, not an igneous rock.

DESCRIPTIONS OF SAMPLES

| Depth (metres) | Description |
|---|---|
| 0-1.50 | Driller : 'sand'. |
| (sludge) | Quartz sand, fine to medium-grained, sub-angular to sub-rounded, mostly water-polished; pale yellow-brown; no foraminifera; a (reworked)bryozoal fragment. |
| 1.50-2.00 | Driller " 'brown clay'. |
| (sludge) | Silt, calcareous, yellow-brown; sand, quartzose, fine to coarse-grained, with calcareous grains, pale yellow-brown; calcareous sandstone and sandy limestone, quartzose, fine to very coarse-grained, as occasional fragments or pebbles up to 7 mm diam., yellow to white; no fossils seen. |
| 2.00-8.00 | Driller : 'limy clay and stone'. |
| (sludges) | Clay, calcareous, sandy (quartzose, fine-grained), with limy fragments; sand, calcareous sandstone, sandy limestone, quartzose, fine-grained, the fragments of sandstone and limestone seem to be in part calcreted; no foraminifera; occasional small, high-spired gastropods. |
| 8.00-10.00 | Driller : 'limy clay and stone'. |
| (sludge) | Calcareous sand, sandstone, and minor sandy limestone, quartzose, part seems to be calcreted; off-white, pale grey, mottled brown; together with calcareous |

clay, as above. *Foraminifera, present for the first time, and mostly recrystallized, include *Ammonia beccarii* (C), *Elphidium* sp. aff.*E. advenum* (Cushman) (F), *Cibicides refulgens* Montfort (V), and *Lagena* sp. (V). Other fossils comprise fragments and moulds of small gastropods (R); ostracode valves (F); and charophyte oogonia (V).

10.00-12.00 (sludge) — Driller : 'grey sand, sandstone and shells'. Calcareous sand and sandstone, quartzose; mottled yellow, orange-brown, and white; fine to medium-grained; with common fragments and moulds of small bivalve and gastropod molluscs; foraminifera are mostly *Ammonia beccarii* (C) and *Elphidium* spp. (C), and their preservation is quite good. Other fossils include ostracode valves (R) and charophyte oogonia (V).

12.00-18.00 (sludges) — Driller : 'grey sand, sandstone and shells'. Calcarenitic quartz sand and calcareous sandstone, fine to medium-grained; minor finely broken shell; white to yellow-brown; occasional glauconite grains; foraminifera abundant and more diverse than above, with

---

* Relative abundance of foraminiferal species in a standard sample is indicated thus:

V (Very rare, 1-2 specimens recovered)
R (Rare, 3-5)
F (Frequent, 6-10)
C (Common, 11-25)
A (Abundant, 25+)

*Ammonia beccarii* (A), *Elphidium* spp. (A), and species of *Bolivina, Cibicidoides, Patellina, Lenticulina, Uvigerina,* and miliolids. Bryozoal fragments (R), ostracode valves (F), and charophyte oogonia (V) are also present.

18.00-25.00 (sludges) — Driller : 'brown sand and sandstone'. Calcarenitic quartz sand and calcareous sandstone, fine to medium-grained, pale brown, finely micaceous, silty; occasional glauconite grains; microfauna similar to above, dominated by *Ammonia beccarii* and *Elphidium* spp.

25.00-26.00 (sludge) — Driller : 'dark grey sandy clay'. Sandy silt and sand, minor cementation to calcareous sandstone; quartzose (very fine to medium-grained); grey finely speckled brown; calcarenitic, finely micaceous; occasional glauconite grains; foraminifera abundant, dominated by *Ammonia beccarii* (A), *Elphidium* spp. (A), with *Cibicides refulgens* (V), and species of *Bolivina, Angulogerina, Fissurina,* and miliolids (C). Two small specimens of *Globigerina* sp. are the first planktonic foraminifera noted.

26.00-28.00 (sludge) — Driller : 'light grey sandy clay'. Clay, silt, and sand; minor cementation to calcareous claystone and sandstone; quartzose, calcarenitic; most of the washed residue is fine to medium-grained

calcarenitic quartz sand; shelly, with common small gastropod and bivalve molluscs; pale grey to yellow-brown; micaceous; ostracode valves are common; foraminifera are again dominated by *Ammonia beccarii* (A), *Elphidium* spp. (A), and miliolids (C); *Discorbis* sp. aff. *D. mira* Cushman (R) is present.

28.00-30.00 (sludge)

Driller : 'blue clay, sand, and sandstone'.

Quartzose calcarenite, shelly, part-cemented, brownish-grey; part dark grey pyritic clay; slightly glauconitic; micaceous; abundant and diverse foraminifera, many well-preserved, some pyrite-filled or encrusted; benthonic forms include *Ammonia beccarii* (A), *Elphidium* sp. aff. *E. crispum* (Linné) (F), *Marginopora vertebralis* Blainville (V, fragments), *Notorotalia clathrata* (Brady) (R), *Discorbinella biconcava* (Jones and Parker) (F), *Cibicides refulgens* (V), *Discorbis* sp. aff. *D. mira* (R), *Cibicidoides pseudoungerianus* (Cushman) (V), *Peneroplis* sp. (V), *Bolivinella folia* (Parker and Jones) (V); planktonic forms present include *Globigerina foliata* (C), *Globorotalia (Turborotalia)* sp. aff. *G (T.) punticulata* (V) and *Globigerinoides* sp. aff. *G. ruber* (d'Orb.) (V).

30.00-32.00 (sludge)

Driller : 'bluish sand and shells'.

Quartzose calcarenite and calcarenitic quartz sand, with minor calcareous cementation to sandstone;

quartz sand mostly fine-grained; silty, finely micaceous; partly pyritic; slightly glauconitic; brownish-grey; shelly,with bivalve molluscs including *Nuculana (Scaeoleda) woodsi* (Tate), gastropods, barnacle plates; bryozoal and echinoid fragments; foraminifera are still dominated by *Ammonia beccarii* (A), then *Elphidium* spp., *Notorotalia clathrata* and *Discorbis* sp. aff. *D. mira*, with first appearances of benthonic forms *Triloculina trigonula* (Lamarck) (R), *Elphidium crassatum* Cushman (V), and a possible fragment of *Crespinella umbonifera*. Planktonic forms include *Globigerina foliata* (A), *G. angustiumbilicata* Bolli (F), *Globorotalia (T.)* sp. aff. *G. (T.) punticulata* (V), *Globigerinita uvula* (Ehrenberg) (= *Globigerina bradyi* Wiesner) (V), and *Globigerinoides* sp. aff. *G. ruber* (R).

32.00-34.00 (sludge)

Driller : as above.

Similar to above, with frequent *Nuculana (S.) woodsi*, and the continuing association of *Globigerina foliata* (F) and *G. (T.)* aff. *punticulata* (V).

34.00-36.00 (sludge)

Driller : 'blue clay sand stone and shells'.

Shelly calcarenite, quartzose (fine to very coarse-grained), ferruginous (brown impregnation and staining, ferruginous grains) glauconitic (± oxidized grains); frequent to common bryozoal, mollusc, and echinoid fragments, and barnacle plates. *Crespinella umbonifera* is definitely present, but rare; miliolids predominate, with

*Fabularia howchini* Schlumberger (F), *Triloculina tricarinata* d'Orb. (R), and *T. striatotrigonula* Parker and Jones (V) making their first appearance; *Valvulineria kalimnensis* Parr (F) appears. Planktonic foraminifera were not observed.

36.00-38.00 (sludge)

Driller : 'greenish clay sand stone and shells'. Shelly calcarenite, brown and white, ferruginous, quartzose (poorly sorted, very fine-grained to very coarse-grained) silty, pebbly, slightly glauconitic (more or less oxidized), part-cemented; bryozoal and mollusc fragments common, echinoid and barnacle remains frequent; rare ostracodes, brachiopod and crustacean fragments. Planktonic foraminifera are infrequent and not diagnostic; benthonics include *Crespinella umbonifera* (V), *Fabularia howchini* (V), *Ammonia beccarii* (A), *Discorbis* sp. aff. *D. mira* (C), *Peneroplis pertusus* (Forskal)(R) and *Notorotalia clathrata* (F). *Siphonaperta ammophila* (Parr) (R) appears.

38.00-40.00 (sludge)

Driller : 'greenish clay sand stone and shells'. Quartzose calcarenite, shelly, poorly-sorted, ferruginous, glauconitic, pebbly (ferruginous grains, quartz), greenish brown and white; many more or less worn fossil fragments (mostly bryozoa) are present, associated with ferruginous and glauconitic matter - these seem to be reworked from a mid-Tertiary source, as do similarly preserved specimens of foraminifera *Dorothia* sp. and *Textularia* sp. However the bulk of foraminifera are similar to above; *Crespinella*

*umbonifera* is still present (one fragment only); *Siphonaperta ammophila* (C) *Quinqueloculina* (C), *Ammonia beccarii* (A), and *Discorbis* sp. aff. *D. mira* (C) predominate; planktonic forms (probably reworked) include *Globigerina praebulloides* s.l. (R), *G. angustiumbilicata* (V), and *G.* sp. aff. *G. officinalis* Subbotina (V).

40.00-42.00 (sludge)

Driller : as above.

As above; part-cemented, fragments of ferruginous sandstone; pyritic in part; occasional coral and bone fragments; frequent *Nuculana (Scaeoleda) woodsi*, and continuing late Cainozoic foraminifera as above; a considerable proportion of more or less ferruginous mid-Tertiary material (?reworked), including foraminifera *Chiloguembelina cubensis* (V), *Porosorotalia crassimura* (Carter) (V), *Gyroidinoides* sp. aff. *G. zelandica* (Finlay) (V), *Eponides* sp. (V), *Dorothia* sp. (F), *Textularia* sp. (F).

42.00-42.40 (tube core)

Driller : 'fine silty sand, blowing'.

Quartz sand, very fine to medium-grained, silty and clayey; grey-brown; calcarenitic, finely shelly; glauconitic (more or less oxidized), and ferruginous-stained; some mild cementation; micromicaceous; common bryozoa, rare coral and brachiopod fragments; foraminifera abundant: planktonic forms include *Chiloguembelina cubensis* (C), *Globigerina (Subbotina) angiporoides* (C); benthonics include *Karreria pseudoconvexa* (Parr) (C), *Gyroidinoides* sp. aff. *G. zelandica* (R), *Porosorotalia crassimura* (R), *Bolivinopsis cubensis* (Cushman and Bermudez) (R), *Spirillina mediocabra* Carter (R), *Dimorphina janjukensis* Crespin (V).

44.00-46.00 , Driller : as above.

50.00-52.00 (sludges) Quartz sand, mostly fine-grained, calcarenitic, slightly glauconitic, grey speckled brown; a *Guembelitria stavensis* (planktonic foraminifer) at 44-46 m; *in situ* foraminifera infrequent, but considerable mixture with caved late Cainozoic forms (*Ammonia, Elphidium, Peneroplis, Marginopora* etc.).

56.00-58.00 (sludge) Driller : 'silty sand with a little brown clay'. Similar to above, mostly fine-grained quartz sand, slightly shelly, calcarenitic, glauconitic and pyritic; very poor microfauna, with *Cibicidoides pseudoungerianus* (R).

64.00-64.40 (tube core) Driller : 'sandy brown clay'. Quartz sand, fine-grained, silty, slightly carbonaceous, glauconitic, pyritic, micaceous, calcarenitic (frequent foraminifera, bryozoal, echinoid, mollusc fragments); poor microfauna.

68.00-70.00 (sludge) Driller : 'fine silty sand'. Quartz sand, fine-grained, silty, grey, pyritic (fillings, encrustations e.g. bryozoa), slightly glauconitic (more or less oxidized), micromicaceous; bryozoal fragments common, foraminifera sparse and non-diagnostic.

72.00-73.00 (sludge) Driller : 'sandy brown clay'. Silt, sandy and clayey, grey-brown, quartzose (mostly fine-grained sand), slightly carbonaceous, glauconitic, pyritic (occasional pyrite/quartz aggregates), calcarenitic. Planktonic foraminifera include *Chiloguembelina cubensis* (A) (but not

*Guembelitria stavensis), Globorotalia (T.) gemma* (R), *Globigerina (S.) angiporoides* (small, R), *G. (S.)* aff. *linaperta* (small, R), *Globigerina officinalis* (A), *G. praebulloides* s.l. (A).

73.00-74.00 (sludge)

Driller : 'fossils coral fragments and sand'.

Shelly calcarenite/calcirudite, quartzose (very fine to very coarse-grained sand), gravelly; pale brown; slightly glauconitic and pyritic; abundant bryozoal and mollusc fragments; less common echinoid, brachiopod and coral fragments, and fish otoliths. Planktonic foraminifera include top *Globigerapsis index* (V), and other species as above; benthonics include top *Carpentaria* sp. aff. *C. globiformis* Chapman (C), *Maslinella chapmani* (V). *Sherbornina atkinsoni* Chapman (F), *Eponides lornensis* Finlay (F), *Spirillina decorata* Brady (V), *Cibicides vortex* Dorreen (R), and *Astrononion* sp. aff. *A. centroplax* Carter (V).

74.00-76.00 (sludge)

Driller : as above.

Quartzose calcarenite/calcirudite, bryozoal,quartz is poorly sorted (fine to very coarse-grained, and gravelly), pale brownish-grey, slightly pyritic; planktonic foraminifera include top *Pseudohastigerina* sp. (V); benthonics include top *Lenticulina* sp. aff. *L. gyroscalpra* (Stache) (V).

75.00-75.40 (tube core)

Driller : as above.

Quartzose calcarenite, bryozoal; slightly silty amd clayey; pale brownish-grey; quartz is poorly sorted (very fine to very coarse-grained sand); occasional glauconite grains and fillings.

Planktonic foraminifera include top *Globigerina* sp. aff. *G. gortanii* (V); and *Globorotalia (T.) gemma* (V) is still present. The varied benthonic microfauna includes an unornamented *Hofkerina* sp. (V); also *Carpentaria rotaliformis* Chapman and Crespin (V), *Bolivina pontis* Finlay (V), and Genus aff. *Bolivinella* sp. (V).

At 84.00 m (bit sample)

Driller : 'black clay and sand' (83-84 m).

Sandy silt/clay, quartzose (very fine to very coarse-grained), pyritic (minor cementation to pyritic quartz sandstone), dark grey-brown; common bryozoal fragments; a small and non-diagnostic fauna of benthonic foraminifera.

At 87.00 m (bit sample)

Driller : 'weathered basement?'

Silt and quartz sand, part clayey; medium to dark grey; pyritic and glauconitic; carbonaceous (abundant woody fragments, some pyritized); quartzose (very fine to very coarse-grained, and gravel to 4 mm, ± angular); some calcarenitic material, mostly bryozoal (unknown amount caved); poor foraminiferal microfaunas; top *Bulimina* sp. aff. *B. pupoides* (V).

At 87.40 m (sample out of casing shoe)

Driller : as above.

As above, with much smoky-quartz sand (very fine to very coarse-grained; angular to sub-rounded, more or less pitted, commonly with adherent white "silty" matrix); only rare benthonic foraminifera *(Cibicidoides, Gyroidinoides, Karreria, Angulogerina, Quinqueloculina)*; abundant carbonaceous (woody) fragments.

| | |
|---|---|
| At 89.00 m | Driller : as above. |
| (bit sample) | The washed sample contains abundant sand-sized fragments of white/pale grey very fine-grained rock which is non-calcareous. This pale-coloured matrix contains much sand-sized smoky-quartz (very fine to very coarse-grained, angular to occasionally sub-rounded, mostly pitted), which also occurs loose, with adherent white matrix; occasional pyrite aggregates have the same matrix adhering. Benthonic foraminifera are present, but could be caved. |
| At 92.00 m | Driller : as above. |
| (bit sample) | As above. |
| 94.5-96.0 m | Driller : as above ("hard from 94.5 m"). The washed sample consists mostly of sand-and gravel-sized (to 5 mm) fragments of weathered porphyry, comparable with above, the matrix being very fine-grained, white/pale grey, and phenocrysts (in matrix, and loose) being mostly smoky-quartz (grey-brown) with less abundant feldspar (mostly white). Some green patches may be epidote and/or chlorite. The quartz continues to be angular to occasionally sub-rounded, and mostly pitted. Calcarenitic fossil fragments and foraminifera present are interpreted as being caved. |
| 96.0-96.5 (T.D.) | Driller : as above; hard. |
| (sludge) | As above; weathered quartz-feldspar porphyry, with more common feldspar (white to salmon-pink) and green epidote and/or chlorite. Frequent (caved) fossil fragments. |

27th January, 1976
JML:IA

J.M. Lindsay

J.M. LINDSAY
Palaeontology Section
BIOSTRATIGRAPHY DIVISION

REFERENCES

Barbieri, F., 1971. Comments on some Pliocene stages and on the taxonomy of a few species of *Globorotalia*. *Ateneo parmense, Acta Naturalia*, 7(1): 3-24.

Blow, W.H., 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In:* P. Brönnimann and H.H. Renz (Editors), *Proceedings of the first International Conference on Planktonic Microfossils*, Geneva, 1967. E.J. Brill, Leiden, Vol. I: 199-422.

Blow, W.H., 1970. Validity of biostratigraphic correlations based on the Globigerinacea. *Micropaleontology*, 16(3): 257-268.

Collen, J.D. and Vella, P., 1973. Pliocene planktonic foraminifera, southern North Island, New Zealand. *J. Foram. Research*, 3(1): 13-29.

Firman, J.B., 1967. Late Cainozoic stratigraphic units in South Australia. *Quart. Geol. Notes, Geol. Surv. S. Aust.*, 22: 4-8.

Firman, J.B., 1973. Regional stratigraphy of surficial deposits in the Murray Basin and Gambier Embayment. *Rept. Invest. Geol. Surv. S. Aust.*, 39: 68 pp.

Harris, W.K., 1966. New and redefined names in South Australian Lower Tertiary stratigraphy. *Quart. Geol. Notes, Geol. Surv. S. Aust.*, 20: 1-3.

Kennett, J.P., 1970. Pleistocene paleoclimates and foraminiferal biostratigraphy in subantarctic deep-sea cores. *Deep Sea Res.*, 17: 125-140.

Lindsay, J.M., 1968. Groundwater supplies at Keith and its surroundings. Progress Report No. 6: micropalaeontological examination of bores, Hds. Stirling and Laffer. Dept. Mines unpublished report 66/47. Pal. Rept. 2/68.

Ludbrook, N.H., 1955. The molluscan fauna of the Pliocene strata underlying the Adelaide Plains. Part II - Pelecypoda. *Trans. R. Soc. S. Aust.*, 78:18-87.

Ludbrook, N.H., 1961. Stratigraphy of the Murray Basin in South Australia. *Bull. Geol. Surv. S. Aust.*, 36: 96 pp, pls. I-VIII.

Ludbrook, N.H., 1963. Correlation of the Tertiary rocks of South Australia. *Trans. R. Soc. S. Aust.*, 87: 5-15.

Ludbrook, N.H., 1973. Distribution and stratigraphic utility of Cenozoic molluscan faunas in South Australia. *Tohoku Univ., Sci. Rep., 2nd ser. (Geol.), Special Vol. 6 (Hatai Memorial Volume)* : 241-261, pls. 24-28.

Parr, W.J., 1939. Foraminifera of the Pliocene of Southeastern Australia. *Min. geol. J.*, 1(4): 65-71.

Rochow, K.A., 1969. NARACOORTE map sheet, Geological Atlas of South Australia, 1:250 000 series, *Geol. Surv. S. Aust.*

Rochow, K.A., 1971. The Padthaway Ridge, Ch. 17 *in:* H. Wopfner and J.G. Douglas (Editors), *The Otway Basin of Southeastern Australia.* Special Bull., Geol. Survs. S. Aust., Vict., pp. 325-337.

Schlumberger, M.C., 1891. Description of a new species of *Fabularia.* *Trans. R. Soc. S. Aust.*, 14: 346-354, pl. 13, figs. 5-8.

Singleton, F.A., 1941. Studies in Australian Tertiary Mollusca, Part II. *Proc. R. Soc. Vict.*, 53(N.S.): 423-429.