PLATE CONSISTS OF WASH
DRAWINGS HELD BY THE
AUTHOR.

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MICROFOSSILS FROM PLEISTOCENE TO RECENT DEPOSITS, LAKE EYRE, SOUTH AUSTRALIA

BY

N. H. Ludbrook

1. Summary

Samples from sands, clays and limestones on the southern eastern corner of Lake Eyre were found to contain remains of fresh or brackish water microscopic plants and animals which inhabit inland and coastal lagoons, together with species of brackish water foraminifera. Deposition probably took place during Pleistocene high sea levels.

2. Introduction

Samples from two shallow boreholes sunk with a post hole digger on the south eastern corner of Lake Eyre and from a thick shell bed 136 feet above the present level of the lake were submitted for routine micropalaeontological examination by Mr. D. King, Geologist, South Australian Department of Mines, who was a member of the party led by Mr. Warren Bonython to Lake Eyre North 400 miles north of Adelaide in May, 1953. The object of the expedition was to investigate further the geography and geology of the lake and the occurrence of native sulphur observed on the lake shore in December, 1951, after the flooding in 1949-1950.

Bore No. 1 situated on the flat between dunes, reduced level of surface 110.75ft. passed through the following strata:

0'0" to 0'6"	Yellow-brown, very fine slightly clayey quartz sand with grit. Residue after washing consists of sub-angular quartz grains usually etched and pitted on the surface, some large grains of opaline silica and an occasional oolite of calcite.
0'6" to 2'4"	Fine yellow-brown quartz sand, similar to that at the surface.
2'4" to 4'6"	Yellow-brown fine clayey sand, washed residue of sub-angular quartz grains with a little oolitic calcite.
4'6" to 6'6"	Yellow-brown fine clayey sand, washed residue of subangular quartz grains of varying size with well-rounded grains of cryptocrystalline silica.

6'6" to 7'9"	Pale yellow-brown coarse to gritty sand with some gypsum; washed residue mainly of quartz grains of varying size and some gypsum fragments.
7'9" to 10'3"	Brown clay with fine and crystalline gypsum and quartz grit; washed residue of quartz grains of varying size with both seed and crystalline gypsum.
10'3" to 12'10"	Fine gypseous sand and clay; washed residue of large subrounded quartz grains much etched on the surface.
12'10" to 16'4"	Light brown sandy clay; washed residue of coarse quartz grains, many of them rather flat and of even size, and some gypsum crystals.
16'4" to 18'8"	Banded vari-coloured plastic clay; washed residue similar to the previous.
18'8" to 21'4"	Fine gravel with white limestone fragments; the coarse fraction of the washed residue consists of large quartz grains finely etched on the surface, and fragments of porcellanite and limestone.
21'4" to 22'0"	Black clay; the finer fraction (passing through 20 mesh) of the washed residue consists of subangular quartz grains with some limestone fragments. Also present are a number of platy grains of saponite with laminar intergrowths of finely divided pyrite.
22'0" to 22'5"	Hard white dolomitic limestone with a gastropod mould. Such friable material as could be washed free of clay yielded white limestone fragments, subangular quartz grains some of them flat, and plates of pyrite crystals.

Bore No. 4. Situated ½ mile southeast of Prescott Point at the north of Sulphur Peninsula, passed through:-

0' to 2'3"	Pale brown clayey sand; washed residue of medium fairly evensized subangular quartz grains with some limestone fragments.
2'3" to 3'6"	Grey sandy clay; washed residue of fine angular and subangular quartz grains, some so little worn as to still retain their crystalline form.
3'6" to 12'0"	Brown clay; washed residue of angular quartz grains, some very fresh, and an occasional grain of pyrite.

12'0" to 16'10" Blue very sticky clay; washed residue of medium sized subangular quartz grains and calcite fragments, with authigenic pyrite some of which is intergrown with saponite.

16'10" to 17'0" Hard white limestone, the friable portion of which was washed, leaving a residue of medium sized subangular quartz grains, white calcite fragments and a pale green mineral of the beidellite-nontronite series, held together by calcite.

Without exception the samples were fossiliferous, almost all having oogonia of Chara and relatively fewer heavily calcified valves of ostracoda and tests of "Rotalia" beccarii. The distribution of the organisms is shown in the distribution table p. . The sands and sandy clays in Borehole 1 from the surface to 16'4" apparently represent the most favourable environment for their development; it issuggested that these represent a period of increasing salinity in the lake.

Two other samples were examined for identifiable microfossils with negative results:

1. Grey clay interstatified with limestone from Position R, point at a small island with samd spit.

Very little residue remained after washing, and this consisted mainly of flat, worn grains of calcite with some angular quartz grains.

2. Dense white clayey limestone taken from 3'6" to 4'6" in a bore at Locality C.

The only organic remains are horny tubes of unidentified origin.

The most interesting sample was taken at position M from the upper shell bed consisting almost entirely of shells of Coxiella gilesi (Angas). The unconsolidated matrix was found to contain numerous valves of two speciesof ostracoda and thin-shelled well-preserved tests of a form of "Rotalia" beccarii, together with a small numberofoogonia of Chara. One broken fragment of the pelecypod Corbiculina, not specifically identifiable, was found, and some indeterminate fish vertibrae.

3. Environment

Regional investigations have not yet reached the stage where it is possible to determine whether conditions of sedimentation were lacustrine

or estuarine. Since my preliminary note (Ludbrook, 1953) was published Dr. R. W. Fairbridge has suggested to me that the microfaunal assemblage is one which would naturally inhabit an extensive gulf or estuary reaching Lake Eyre via Lake Torrens from the head of Spencer's Gulf during the high sea level phases of the Pleistocene. While this is certainly feasible, freshwater lake deposits now represented by indurated oolitic ostracode limestones, similar to the dolomitic limestone in which the borings ceased, have been found in widely separated localities in the west of South Australia. Whether the lacustrine environment persisted at Lake Eyre, increasing salinity providing a favourable milieu for brackish water organisms which had been introduced by birds, or whether freshwater lakes were transformed during part of the Pleistocene into the estuary suggested by Dr. Fairbridge can be determined only by observations made on a regional scale.

4. Acknowledgements

I am indebted to the Petrology Section, Department of Mines, for identification of the saponite and beidellite-nontronite minerals. to Dr. H.B.S. Womersley for placing specimens of Characeae belonging to the Botany Department, University of Adelaide, at my disposal, to Mr. B.C. Cotton for allowing me to examine mollusca in the South Australian Museum, and to Dr. Rhodes Fairbridge for drawing my attention to the possible conditions of deposition.

5. Fauna

FORAMINIFERA

FAMILY NONIONIDAE

GENUS ELPHIDIUM Montfort, 1808.

Type species Nautilus macellus Fichtel & Moll.

(?) Elphidium advenum (Cushman) (pl. fig. 9).

For early synonymy see Cushman, 1939, U.S.G.S. Prof. Paper 191 p.60; Bermudez, 1949, Cush. Lab. Foram. Res. Spec. Pub. 25, p.167.

Elphidium advenum (Cushman), 1944, Cushman Lab. Foram. Res. Spec. Pub. 12 p.26 pl.3 Fig. 36.

Elphidium advenum (Cushman) Howchin & Parr, 1938. Trans. Roy. Soc. S. Aust. 62, (2), p.299.

Elphidium advenum Cushman. Parr, 1943, Mal. Soc. S. Aust. Pub. 3, p.20, 1950, Journ. Roy. Soc. W. Aust. 34, p.72.

Material. One worn specimen, sample F173/53 Bore 1 0'0" - 0'6".

The calcified condition of the single specimen renders identification very doubtful. Its occurrence only in the surface sample of Bore No. 1 suggests that the species may have been introduced by birds and had no continuous existence in the area. On the other hand, it is recorded as occurring frequently in the late Pleistocene "Arca" horizon of Peppermint Grove. (Parr, 1950).

Howchin (1901, p.9) postulated dispersal by birds of the two species of Elphidium, which he discovered in the silt of Yorketown Lagoon.

GENUS NONION Montfort, 1808

Type species Nautilus incrassatus Fichtel & Moll.

(?) Nonion scapha (Fichtel & Moll) (pl. fig. 10).

For synonymy see Cushman, 1939, U.S.G.S. Prof. Paper 191 p.20.
Nonion Scapha Fichtel & Moll. Parr, 1943. Md. Soc.S. Aust. Pub. 2, p.20.
Nonion Scaphum (Fichtel & Moll). Cushman, 1946, Cush. Lab.
Foram. Res. Spec. Pub. 17, p.14.

One specimen, sample F177/53.

Bore 1. 6'6" - 7'9".

As the test is coated with thin calcite and the aperture obscured, identification of this species is tentative only.

Anomalinidae

GENUS CIBICIDES Montfort, 1808

Type species Cibicides refulgens Montfort.

Cibicides refulgens Montfort (pl. figs. 11, 12).

For early synonymy see Cushman 1931. U.S. Nat. Mus. Bull. 104, pt.8 p. 116, Cibicides refulgens Montfort, Cushman & Todd, 1945, Cush. Lab. Fort. Res. Spec. Pub. 15 p.70. Cushman & Gray 1946, ed. Spec. Pub. 19, p,45 pl.8, figs. 15-17, Cushman & Todd, 1947, ed. Spec. Pub. 21, p.23 pl.4, fig. 7. Chapman & Parr, 1935. Journ. Roy. Soc. S. Aust. 21, p.3, Crespin, 1943, Min. Res. Sur. Bull. 9 (Pal. Ser. 4) p.78 (mimeographed). Parr, 1950, Journ. Roy. Soc. W. Aust. 34, p.71.

Material. One speciman Sample F.

Borehole 4, 3'6" - 12'0".

The specimen recovered is small and well preserved and typical of the species. Although its occurrence also suggests fortuitous introduction, it was recorded as common in the late Pleistocene "Arca" horizon, Peppermint Grove.

FAMILY ROTALIIDAE

GENUS ROTALIA Lamarck, 1804.

Type species Rotalia trochidiformis Lamarck.

Rotalia beccarii Linne cf. var. tepida Cushman (pl. figs.13, R 14, 15).

Rotalia beccarii (Linne) var. tepida Cushman, 1926, Carnegie Inst. Washington. Pub. 344, p.79, pl.1. D.K. Palmer, 1945, Bull. Amer. Pal. 29, (115) p.60 (fide Bermudez); Bermudez, 1949, Cush. Lab. Foram. Res. Spec. Pub. 25 p.234.

Streblus beccarii (Linne) var. cf. tepida (Cushman). Parr, 1950 Journ. Roy. Soc. W. Aust. 34, p.22.

Material: Calcified specimens, as many as 49 in one sample from almost all but 5 samples from Boreholes 1 and 4; numerous (over 100) well preserved specimens from matrix of upper (Coxiella) shell bed.

The occurrence of this species in almost every sample including the sulphur bed suggests that its introduction has not been completely fortuitous. Two possibilities present themselves: the first, that widespread estuarine conditions during the late Pleistocene enabled the species to spread towards Lake Eyre from the head of Spencer's Gulf, the second, that the variety has been introduced by birds or by winds into sha shallow saline lakes in the late Pleistocene, and finding a favourable habitat rapidly established itself.

All specimens show abundant evidence of environmental influence. As compared with marine examples of the species, the tests are small and variable in shape. Those recovered from the clays of Borehole 1 and Borehole 4 are all heavily calcified. Very few showed the umbilical plug generally characteristic of the species.

All the Lake Eyre specimens appear, so far as one can determine in the absence of authentic topotypes for comparison, to be close to the variety tepida described by Cushman (1926, p.79) from shallow and stagnant water at Porto Rico. It has been recorded and illustrated by Bermudez (1949, p.234 pl. 15 figs. 49-51) associated with a shallow

water molluscan fauna from the Upper Miocene of Las Salinas Formation Dombnican Republic and by Parr from the "ARCA" horizon, Peppermint Grove.

The two specimens figured show the degree of variation presented by the Lake Eyre specimens. One (pl., fig.15) is typical of the calcified tests obtained from the clays of the bores. The other (pl. figs. 13, 14) is a somewhat extreme example of the form which occurs numerously in the Coxiella bed. It is characterized by its small fairly thin test, only slightly limbate sutures and absence of umbilical plug. The astral lobe, if developed at all, is frequently broken and not preserved.

MOLLUSCA.

CLASS PELECYPODA

SUPERFAMILY SPHAEREACEA

FAMILY CORBICULIDAE

GENUS CORBICULINA Dall, 1903.

Corbiculina Dall, 1903, Proc. Biol. Soc. Washington 16, p.6.

Type of species(monotypy) Corbicula angasi Prime

Corbiculina sp. indet

Material: one broken specimen, sample F172/53.

A fragment only of the hinge portion of a juvenile shell was collected from the upper shell bed. In view of extreme intraspecific variation in this genus, it is impossible to decide whether it is the Recent species Corbicula desolata (Tate) or not.

CLASS GASTROPODA

SUPERFAMILY RISSOACEA

FAMILY ASSIMINEIDAE

GENUS COXIELLA Smith, 1894/

Coxiella Smith, 1894. Proc. Malac. Soc. 1, p.98.

(Blanfordia Cox, 1868, Mon. Aust. Land Shells, p,94 non Menke).

(Coxielladda Iredale & Whitley, 1938, S. Aust. Nat., 18, (3), p.66).

(Blandfordia Tate 1894, Trans. Roy. Soc. S. Aust. 18, p.196

lapsus calami for Blanfordia),

Type species (monotypy) Truncatella striatula Menke.

Coxiella gilesi (Angas) (PL.1 fig.1).

Paludinella gilesi Angas. 1877. Proc. Zool. Soc. March. p.169 pl. 26 fig. 2.

Paludinella gilesii Angas. Tate & Brazier, 1882. Proc. Linn. Soc. N.S.W. 6, p564.

Blandfordia stirlingi Tate, 1894, Trans. Roy. Soc. S. Aust. 18, p. 196.

Coxiellada gilesi Angas. Cotton, 1942. Trans. Roy. Soc. S. Aust. 66, (2), p.129.

Coxiellada gilesi Iredale & Whitley, 1938, S. Aust. Nat. 18, (3), p.66.

Descriptions: Shell thin, globose - turbinate, perforate, with a rather low spire, apparently orange or flesh-coloured but almost always bleached white.

Apex subacute, flattened at the origin, protoconch of 1½ flatly convex almost smooth turns constricted at the suture, followed by 4½ roundly convex whorls fairly rapidly increasing in size, arcuate in profile, sculptured with fine somewhat irregular transverse growth strial. Sutures impressed, strongly marked. Body whorl large, about three-quarters total height of shell. Umbilicus narrow, generally almost concealed by the expansion of the aperture over the columella.

Aperture subovate, roundly angulate posteriorly and rounded anteriorly, peristome entire, everted over the columella, parietal Callus thin and frequently broken.

Dimensions of figured specimen. Height 5.3, width 4, height of body whorl 4, height of aperture 3.7, width of aperture 2 mm.

Type Locality. Lake Eyre.

Holotype: British Museum.

Material: Innumerable specimens, upper shell bed, Lake Eyre North.

Distributions: Lake Eyre, Lake Callabonna.

Observations: There is no evidence that this shell has survived desiccation of the area. Although both Angas, who described the Lake Eyre species, and Tate, who described its Lake Callabonna counterpart, found one specimen retaining the original colour, all the specimens seen by the writer have been bleached white.

The species is closely related morphologically and in apparent habitat to Coxiella confusa (Smith) found sometimes in enormous numbers in submarginal lagoons and salt lakes in the southern part of the State

The genus is euryhaline, with a very wide range of salinity tolerance covering from freshwater to waters more saline than the sea, its preference apparently being for the latter.

Iredale and Whitley (1938, p.66) introduced without diagnosis the name Coxielladda for Paludina (sic) gilesi Angas. On morphological grounds it is impossible to select diagnostic generic characters to justify the genus. Intraspecific variation in Coxiella is considerable particularly in the height of the spire, and to give this the status of generic diagnosis (Cotton 1942, p.129) can hardly be supported. Neanic specimens of Coxiella confusa bear a very close resemblance to adults of Coxiella gilesi.

The species described by Tate (1894 p.196) as Blandfordia stirlingi is almost certainly conspecific with the present species, although only a statistical analysis of the very numerous examples from the two areas can establish the fact. Tate (1.c.p.195) noted the relationship between the southern Coxiella confusa (=Blanfordia striatula Tate non Menke). Increasingly saline conditions in the Lake Eyre doubtless provided a favourable milieu for the development of innumerable Coxiellas. In this environment Pontocypris attenuata could also survive and "Rotalia" beccarii although inadequately nourished, maintain a foothold.

The affinities of the genus Coxiella are ill-defined. Wenz (1938, p.582) places it in the Tomichiinae, subfamily of the Truncatellidae to which appears to the writer to be not closely related. It is here placed in the Assimineidae; it seems to be close to Paludinella in which gilesi was originally placed by Angas.

OSTRACODA

FAMILY CYPRIDAE

GENUS CYPRIS Muller

Type species Cypris pubera Muller

(?) Cypris sp. (pl. figs. 7, 8).

Description: Carapace viewed laterally, broadly reniform, greatest height in the middle, equal to more than half the length. Anterior extremity gently arcuate proterior extremity flatly rounded; dorsal margin arched, highest in front of the middle ventral margin sinuated in the middle valves unequal, right slightly larger than left and overlapping it in part of the middle of the dorsal margin.

Surface when well preserved sculptures with a fine reticulate pattern. Adductor muscle scars four in the middle of the shell, frequently visible from the outside.

Dimensions: Length 0.6 mm.

0.36 mm.

Width 0.36 mm.

Observations: Although it is generally obscured by a coating of calcite which may be very thick, the reticulate sculpture readily characterizes the species which I have not so far been able to identify.

GENUS PONTOCYPRIS G. O. Sars, 1866.

Type species Pontocypris trigonella G. O. Sars.

Pontocypris attenuata G. S. Brady. Pl.1, figs. 5, 6.

Pontocypris attenuata Brady, 1868, Ann. Mag. Nat. Hist. ser. 4, 2, p.179, pl.4, figs. 11-14: Brady, 1880, Chall. Rep. Zool., 1, (3), p.38, pl.15, figs. 1a-d; Brady, 1890, Trans. Roy. Soc. Edin., 35, p.491, pl.1, figs. 3, 4; Chapman, 1902, Journ. Linn. Soc. Lond., 28, p.419; Chapman, 1910, id., 30, p.427; Chapman, 1919, Austr. Abstract, Exped., Ser. C. 5, (7), p.17; Chapman, 1941, Trans. Roy. Soc. S. Aust., 65, (2), p.194, pl.9, fig. 8.

Material: 45 single valves.

Observations: This is a shallow water Indo-Pacific and Australian species which has been recorded twice by Chapman from deep water, first at 1,215 fathoms at Funafuti and secondly from 505 fathoms of South Eastern Australia. With the exception of one specimen from 16'4" to 18'8" in Borehole No.1, all the present examples were found either in the matrix of the upper shell bed or in the clay beneath the shell bed. This would indicate that the species was of late sporadic introduction and survived only in saline water.

No undamaged pair of valves was obtained. Many of the single valves, both adult and juvenile, one of which is figured (pl. , fig.6) still retained the conspicuous posterior spine which Brady (1890, p.491) and Chapman (1941, p.194) have noted. One specimen bears an additional small anterior spine. Either the spines are an inconstant feature, or they are easily broken from the carapace and not preserved.

6. Flora

1. Oogonia of Characese.

Nearly all samples contain oogonia of Chara probably belonging to more than one species. These could not be identified as belonging to any described species living in South Australia. Three shapes illustrated (pl. figs. 2, 3, 4) may possibly represent three species.

2. Leaves.

From the matrix of the Coxiella shell bed some small, elongate, rather thick leaves possibly of Chenopodiaceous plants were recovered. These had probably been blown in by the wind and deposited with the shell.

7. Distribution:

The distribution of the microfossils and the number of specimens recovered from washing about 200 gms. of each sample are shown in the distribution table.

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9. Explanation of Plate.

Figure 1. Coxiella gilesi (Angas) X 10; protoconch X 37.

Figure 2. Chara sp.1, oogonium X 35.

Figure 3. Chara sp.2, (?), oogonium X 35.

Figure 4. Chara sp.3 (?), oogonium X 40.

Figure 5. Pontocypris attenuata Brady, adult left valve without spines X 65.

Figure 6. Pontocypris attenuata Brady, juvenile left valve with anterior and posterior spines X 65.

Figure 7. Cypris sp., both valves, lateral view, X 80.

Figure 8. Cypris sp., left valve X 85.

Figure 9. (?) Elphidium advenum (Cushman) X 110.

Figure 10. (?) Nonion scapha (Fichtel & Moll) X 85.

Figure 11. Cibicides refulgens Montfort, apertural view X 180.

Figure 12. Cibicides refulgens Montfort, dorsal view X 180.

Figure 13. Rotalia beccarii (Linné) var. tepida Cushman, extreme FORM, DORSAL VIEW, X 80.

Figure 14. Rotalia beccarii (Linné) var. tepida Cushman, extreme Form, ventral view, X 80.

Figure 15. Rotalia beccarii (Linné) var. tepida Cushman, calcified specimen, typical of Lake Eyre sediments, X 80.

Locality of borehole	Upper Shell Bed	Borehole Below Shellbed	Borehole 1					
Depth			0'0"-0'6"	0'6"-2'4"	2'4"-4'6"	4'6"-6'6"	6'6"-7'9"	7'9"-10'3"	10'3"-12'10"
Sample No.	172/53	172A/53	F173/53	F174/53	F175/53	F176/53	F177/53	F178/53	F179/53
Coxiella gilesi	innum-erable	-	-	-	-	-	-	-	-
Corbiculina sp.	1	-	-	-	-	-	-	-	-
Rotalia beccarii	110	-	-	-	1	24	37	27	27
Cibicides refulgens	-	-	-	-	-	-	-	-	-
(?) Elphidium advenum	-	-	1	-	-	-	-	-	-
(?) Nonion scapha	-	-	-	-	-	-	1	-	-
Cypris sp. both valves	31	3	1	-	1	4	15	7	18
single valves	6	12	-	-	8	11	32	29	88
Pontocypris sp. both valves	-	1	-	-	-	-	-	-	-
single valves	100+	1	-	-	-	-	-	-	-
Chara sp. 1.	23	-	-	-	15	127	212	129	101
Chara sp. 2. (?)	1	-	-	-	-	-	-	2	-
Chara sp. 3 (?)	3	-	-	-	6	35	41	15	55

TABLE.

					Borehole 4.				
12'10"-16'4"	16'4"-18'8"	18'8"-21'4"	21'4"-22'0"	22'0"-22'5"	0'½"-2'3"	2'3"-3'6"	3'6"-12'0"	12'0"-16'10"	16'10"-17'
F180/53	F181/53	F182/53	F183/53	F184/53	F185/53	F186/53	F187/53	F188/53	F189/53
-	-	-	-	-	-	-	-	-	?1 =
-	-	-	-	-	-	-	-	-	-
49	1	2	1	-	-	12	-	1	-
-	-	-	-	-	-	-	1	-	-
=	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
4	4	1	-	1	-	4	1	-	-
55	9	21	4	-	2	12	-	1	-
-	-	-	-	-	-	-	-	-	-
-	1	-	-	-	-	-	-	-	-
80	25	80	13	7	10	90	3	-	-
8	3	-	-	-	-	-	-	-	-
39	12	25	-	-	3	15	-	-	-