DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO.82/36
OLIGO-MIOCENE TRANSGRESSIVE
MANNUM FORMATION NEAR MANNUM,
MURRAY BASIN

GEOLOGICAL SURVEY

by

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BIOSTRATIGRAPHY SECTION

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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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OLIGO-MIOCENE TRANSGRESSIVE MANNUM FORMATION NEAR MANNUM, MURRAY BASIN.

(Client: Dr. P.A. Jell, National Museum of Victoria)

ABSTRACT

Analyses of key benthonic and planktonic foraminifera from this thin transgressive deposit, and of boundary criteria, indicate a date close to the Janjukian/Longfordian Australian Stage boundary, and close to the international Oligocene/Miocene boundary. The deposit corresponds to the basal part of the nearby type section of Mannum Foramtion, and its age matches the transgressive peak of global sea-level Cycle TO2.2 of Vail _et al_.

INTRODUCTION

Arising from his study of southern Australian Tertiary crinoids, a request was received recently from Dr P.A. Jell, Curator of Invertebrate Fossils at the National Museum of Victoria, to date as precisely as possible by foraminifera a sample of the thin bed of crinoid-rich Mannum Formation which transgresses on to a granite inlier 4 km northeast of Mannum. This quarry exposure was described more than 20 years ago (Ludbrook, 1961, pp. 45-46) so it is timely to review the foraminiferal evidence and date in the light of current knowledge. It is important also to date accurately this and other transgressive events because some are known to be associated with the formation of economically significant resources such as coal deposits; and all need to be tested against recently proposed cycles of global eustatic sea-level change in order to correlate local sequences with regional patterns.

SAMPLE LOCATION

ADELAIDE 1:250 000 Sheet (SI 54-9),
Mannum 1:100 000 Sheet (6728-II),
Mannum 1:63 360 Sheet,
Lat. $34^0 53.7'$S, Long. $139^0 21.3'$E,
County Russell, Hundred Younghusband, Section 156.

MATERIAL EXAMINED

1. Sample collected recently and supplied by Dr. P.A. Jell, comprising SADME Biostratigraphy Section sample F13/82, from crest of hill at the quarry; rubbly fines from within 2 m above granite/Mannum Formation contact.
2. Sample F250/72 collected by J.M. Lindsay in January 1972, comprising rubbly fines from Mannum Formation about 1 m above the granite contact in the southern part of the quarry.
3. The microfaunal slide picked by Dr. N.H. Ludbrook from sample F249/53 (Ludbrook, 1961, p. 46) which was collected from the same quarry exposure.

DESCRIPTIONS OF SAMPLES

Sample F13/82: Rubbly sandy limestone (grading to calcareous sandstone) and much silty clayey loose calcarenite; overall brown colour; quartzose, ferruginous, glauconitic (more or less oxidised); fossiliferous, with echinoid, crinoid, bryozoal, and molluscan fragments, plus abundant foraminifera. The planktonic/benthonic foraminiferal ratio is very low. Benthonic forms include:

Amphistegina sp. (common)

Sherbornina atkinsoni Chapman (c.)

Sherbornina cuneimarginata Wade (very rare)

Crespinella parri Quilty (rare)

Parrellina crespinae (Cushman) (r.)

Bolivinopsis cubensis (Cushman and Bermudez) (v.r.)

Astrononion centroplax Carter (v.r.)

Textularia vertebralis Cushman (v.r.)

Gyroidinoides cf. allani (Finlay) (v.r.)

Pararotalia verriculata (Howchin and Parr (v.r.).

Planktonic foraminifera, which are small and rare, include:

Globigerina officinalis Subbotina (r.)

Globigerina bulloides d'Orbigny group (r.)

Globigerina cf. ouachitaensis Howe and Wallace (v.r.)

Globigerina angustiumbilicata Bolli (v.r.)

? Globoquadrina sp. (v.r.)

Turborotalia cf. pseudokugleri Blow (v.r.)

Cassigerinella chipolensis (Cushman and Ponton) (r.)

Sample F250/72: Loose, brown, ferruginous, silty and clayey quartzose calcarenite with minor cemented limestone (to calcareous sandstone); glauconitic (more or less oxidised); fossiliferous, with echinoid, crinoid, bryozoal, and molluscan fragments, plus common foraminifera. The planktonic/benthonic foraminiferal ratio is even lower than in F13/82. Benthonic forms include:

Amphistegina sp. (abundant)

Crespinella parri Quilty (frequent)

Pararotalia verriculata (Howchin and Parr) (r.)

Sherbornina atkinsoni Chapman (r.)

Textularia vertebralis Cushman (v.r.)

Sigmomorphina haeusleri (Parr and Collins) (v.r.)

Astrononion centroplax Carter (v.r.).

Planktonic foraminifera, small and rare, include:

Globigerina officinalis Subbotina (r.)

'*Globigerina*' *woodi connecta* (Jenkins) (v.r.).

Sample F249/53: The following more significant foraminifera (all but one, benthonic) are represented on the microfaunal slide picked by Dr N.H. Ludbrook:

Sherbornina atkinsoni Chapman (f.)

Sherbornina cuneimarginata Wade (v.r.)

Amphistegina sp. (f.)

Crespinella parri Quilty (v.r.)

Pararotalia verriculata (Howchin and Parr) (v.r.)

Parrellina crespinae (Cushman) (v.r.)

Planolinderina plana (Heron-Allen and Earland) (v.r.)

Sigmomorphina haeusleri (Parr and Collins) (v.r.), and

a solitary planktonic form:

Globigerina officinalis Subbotina (v.r.).

DISCUSSION

This remnant of Mannum Formation is so thin (only a metre or two thick), and the lithologies and microfaunas of the samples display so many similarities, that the foraminifera may be considered together as one microfauna for the purpose of dating the deposit and the transgression which led to its formation.

Benthonic foraminifera (Fig. 1a)

The presence, as here, of even a solitary specimen of *Bolivinopsis cubensis* is significant, since in southern Australia the species indicates Janjukian Stage or older. In the Janjukian stratotype at Torquay, Victoria, *B. cubensis* (earlier recorded as

B. crespinae Parr) is present consistently in the lower and middle parts of the section, but does not range above the Jan Juc Formation (Raggatt and Crespin, 1955). From the examination of available comparative material it is not even certain that the species continues to the very top of the Janjukian stratotype at Bird Rock. Similarly in the Murray and Otway Basins of South Australia, B. cubensis often does not range as high as characteristic Janjukian foraminifera such as Massilina torquayensis (Chapman) or Victoriella conoidea (Rutten) - see for example, Ludbrook (1961), Lindsay and Bonnett (1973), McGowran (1973); and it does not range up to the top of the type section of Ettrick Formation (Ludbrook, 1961, p. 32, table IV).

Gyroidinoides cf. allani, of the G. zelandica (Finlay) lineage (Finlay, 1939; Hornibrook, 1961) is restricted to strata of Janjukian and older age at some localities in the Murray Basin (e.g. Lindsay and Bonnett, 1973), but in other localities the form seemingly ranges up higher. Re-examination of the material suggests that this same form was recorded by Ludbrook (1961), variously and in part, as Gyroidina sp. A (tables 2,4), G. soldanii d'Orbigny (table III), G. novozelandica Finlay (table I), and G. cf. novozelandica (pl. 2, figs 10-12), the latter two names being typographical errors for G. zelandica Finlay. Typical specimens of the South Australian form from the Oligocene of the Murray Basin were shown by the writer to Dr. N. de B. Hornibrook at the N.Z. Geological Survey in 1976. He considered that these specimens represented G. allani rather than G. zelandica. In the subsurface type section of Ettrick Formation, 27 km southeast of the Mannum granite quarry, G. cf. allani ranges up very rarely and sporadically into the overlying Mannum Formation (Ludbrook, 1961, table IV); but at the Mannum pumping station the type section of Mannum Formation lacks this species (Ludbrook, 1961, table VI). In the coastal section at Torquay, Victoria, the species is known to range up to the top of the Janjukian type section, but is not recorded from above that level. Carter (1964, table 2) similarly did not find '*Gyroidina zelandica*' above the Janjukian Lakes Entrance Formation in Gippsland. Thus the presence of *G.* cf. *allani* in sample F13/82 suggests that the sample is more likely Janjukian and pre-Longfordian, but not conclusively so.

Planolinderina plana (= *Planorbulinella plana*) was not found in Janjukian, pre-Longfordian, strata by Ludbrook (1961) or Carter (1964). However more recently Cooper (1979, fig. 29) recorded an isolated first appearance in Janjukian strata, within the range of *Victoriella*, in the eastern St Vincent Basin. This was in a sludge sample, not core, so the possibility of downhole caving must be taken into account. Thus the single specimen of *P.plana* in sample F249/53 from the Mannum granite quarry most likely indicates a post-Janjukian age.

Crespinella parri, *Astrononion centroplax*, *Pararotalia verriculata*, and *Parrellina crespinae* are now known to occur in both Janjukian and post-Janjukian strata in South Australia.

The prominence of *Amphistegina* in the samples from the Mannum granite quarry, taken in stratigraphic context, indicates a level within the late Janjukian - early Longfordian 'lower *Amphistegina* peak' (Lindsay and Bonnett, 1973).

Neither Ludbrook (1961), Carter (1964), Wade (1964), nor Lindsay (1969) recorded *Sherbornina cuneimarginata* below the Longfordian Stage. However in the eastern St Vincent Basin, Cooper (1979, fig. 29) has found the species in core from immediately beneath the thin local range-zone of *Victoriella*, hence within the Janjukian. Thus S. cuneimarginata can be regarded no longer as exclusively Longfordian, at least in South Australia. S. atkinsoni, which predominates in the samples from the Mannum granite quarry, ranges up from pre-Janjukian strata into the earlier part of the Longfordian.

In upward succession, Sigmomorphina haeusleri is replaced by S. subregularis in the Longfordian of the eastern St Vincent Basin, and presumably also the Murray Basin. The species present in samples F249/53, F250/72, is S. haeusleri rather than S. subregularis, and so could indicate either Longfordian or pre-Longfordian age.

The notable absence of Operculina victoriensis Chapman and Parr from all three samples in otherwise suitable facies, indicates a stratigraphic level below that of the local initial appearance of the species. In the type section of Mannum Formation nearby, the first appearance was reported to occur about 2 m below the top of the lower member of the formation (Ludbrook, 1961, p. 44). This first appearance was regarded by Carter (1964) as an early event in the Longfordian Stage.

Textularia vertebralis occurs abundantly in a thin zone at the base of the type section of Mannum Formation (Ludbrook, 1961, p.44). The presence of the species in the samples from the Mannum granite quarry, even though not in large numbers, suggests a local correlation with the basal part of stratotype Mannum Formation. Many of the occurrences of T. vertebralis elsewhere in South Australia are associated with the late Janjukian - early Longfordian warm episode and its 'lower Amphistegina peak'.

In summary then, most of the benthonic foraminifera recovered from the three samples and discussed above are known to occur in both the Janjukian and Longfordian. The exceptions are

Bolivinopsis cubensis, which does not range higher than Janjukian in southern Australia so far as is known, and perhaps *Planolinderina plana*, which occurs only very doubtfully beneath the Longfordian. Hence in terms of stadial nomenclature the best fit for the samples is in the vicinity of top Janjukian/base Longfordian. This is consistent with other indicators such as the 'lower *Amphistegina* peak', and the absence of *Operculina*. The deposit also gives the best microfaunal match with the basal part of the nearby type section of Mannum Formation, not the uppermost part as suggested by Ludbrook (1961, p. 45).

The Oligocene/Miocene and Janjukian/Longfordian boundaries (Fig. 1b).

Much progress has been made towards dating the Janjukian/Longfordian boundary in international terms since Ludbrook (1961, p. 86) wrote that 'the Oligocene-Miocene boundary cannot be established so long as it remains unresolved eslewhere in the world'. Van Couvering (1978) reaffirmed that the beginning of the Miocene Epoch, and thus the Oligocene-Miocene boundary, is now embodied by international agreement in the base of the exposed Aquitanian Stage stratotype (at normal water level) in the bank of the Saucats River at Moulin de Bernachon, southwest France. This follows decisions taken by the Committee on Mediterranean Neogene Stratigraphy at meetings held in 1958, 1959, and 1964; and is essentially as recommended by the Tertiary Era Sub-Committee of the Geological Society of London (George *et al.*, 1969, pp. 157-158). Shafik and Chaproniere (1978) strangely ignore this agreement, and instead discuss the unfortunate further recommendation of the Neogene Committee at Bologna, 1967, that the *Globigerinoides* first appearance datum should form 'an easily recognisable isochron for the inter-regional correlation of the base of the lecto-stratotype Aquitanian and, thus, the base of the Miocene' (Blow, 1969, p. 224). This recommendation has not been ratified, and is now generally regarded as inappropriate in view of the early or variable appearance of Globigerinoides reported, for example, by Belford (1974), Lamb and Stainforth (1976), Shafik and Chaproniere (1978).

In terms of correlatable foraminiferal zones, the base of the restricted Aquitanian stratotype and hence of the Miocene is now regarded as 'middle or upper Zone N.4' (Van Couvering and Berggren, 1977) or 'somewhere in the middle of Zone N.4' (Van Couvering, 1978). In terms of calcareous nannoplankton this is 'lower or middle Zone NN.1' (Van Couvering and Berggren, 1977) or 'approximately coeval with the NP.25/NN.1 ...... Zone boundary' (Van Couvering, 1978). Siesser (1979) has recognised the NP.25/NN.1 nannofossil zonal boundary about 2.5 m below the top of the stratotype Janjukian Stage at Bird Rock, Torquay, the remainder of the Janjukian above this being Zone NN.1, and the base of the overlying Puebla Formation (Longfordian) being in Zone NN.2. Within the limits of resolution presently possible by means of calcareous nannoplankton, and noting the call by Shafik and Chaproniere (1978) for 'a buffer zone representing the Oligocene-Miocene transition', the Janjukian/Longfordian boundary appears to be very close to the international Oligocene-Miocene boundary.

Planktonic foraminifera

Of the planktonic foraminifera found in the three samples from near Mannum, the occurrence together of Turborotalia cf. pseudokugleri and Globigerina woodi connecta suggests an age also close to the Oligo-Miocene boundary. T. pseudokugleri does not range above mid Zone N.4 (Blow, 1969), i.e. approximately the Oligo-Miocene boundary. The two small specimens from sample F13/82 are morphologically close to T. pseudokugleri and suggest an age no younger than this. The first appearance of Globigerina woodi connecta in New Zealand is in the upper Waitakian Stage. This datum was regarded as latest Oligocene by Hornibrook and Edwards (1971) and by Jenkins (1974). Van Couvering and Berggren (1977) put the datum virtually at the Oligo-Miocene boundary, within the boundary zone of uncertainty.

Globigerinoides is notably absent, although in all, 20 specimens of Globigerina were picked from the 3 samples. This might suggest an Oligocene age, prior to the Globigerinoides primordius First Appearance Datum ('Globigerinoides datum'); however planktonic abundance is low (less than 30 specimens, in all, recovered), the specimens are small, and the absence of Globigerinoides could be only a result of unfavourable facies.

The other planktonic foraminifera as listed do not discriminate between Oligocene and Miocene. Globigerina ouachitaensis is recorded mostly from the Palaeogene, but Jenkins (1966) found it in the lower part of stratotype Aquitanian. G. officinalis is likewise recorded mostly from the Palaeogene, but Blow and Banner (1962) found 'closely similar forms in the lower Aquitanian of Escornebeou, southwest France'; and long ranges, well up into the Miocene, have been recognised in South Australia (Ludbrook and Lindsay, 1969; Lindsay, 1969).

Global sea-level cycles

This thin deposit of Janjukian/Longfordian and Oligocene/Miocene age thus corresponds to the transgressive peak of Cycle T02.2, at the Oligo-Miocene boundary (Vail et al., 1977; Vail and Hardenbol, 1979; Loutit and Kennett, 1981). Correlation of similar transgressive deposits in the Murray Basin is continuing (Lindsay and Williams, 1977; Lindsay, in prep.).

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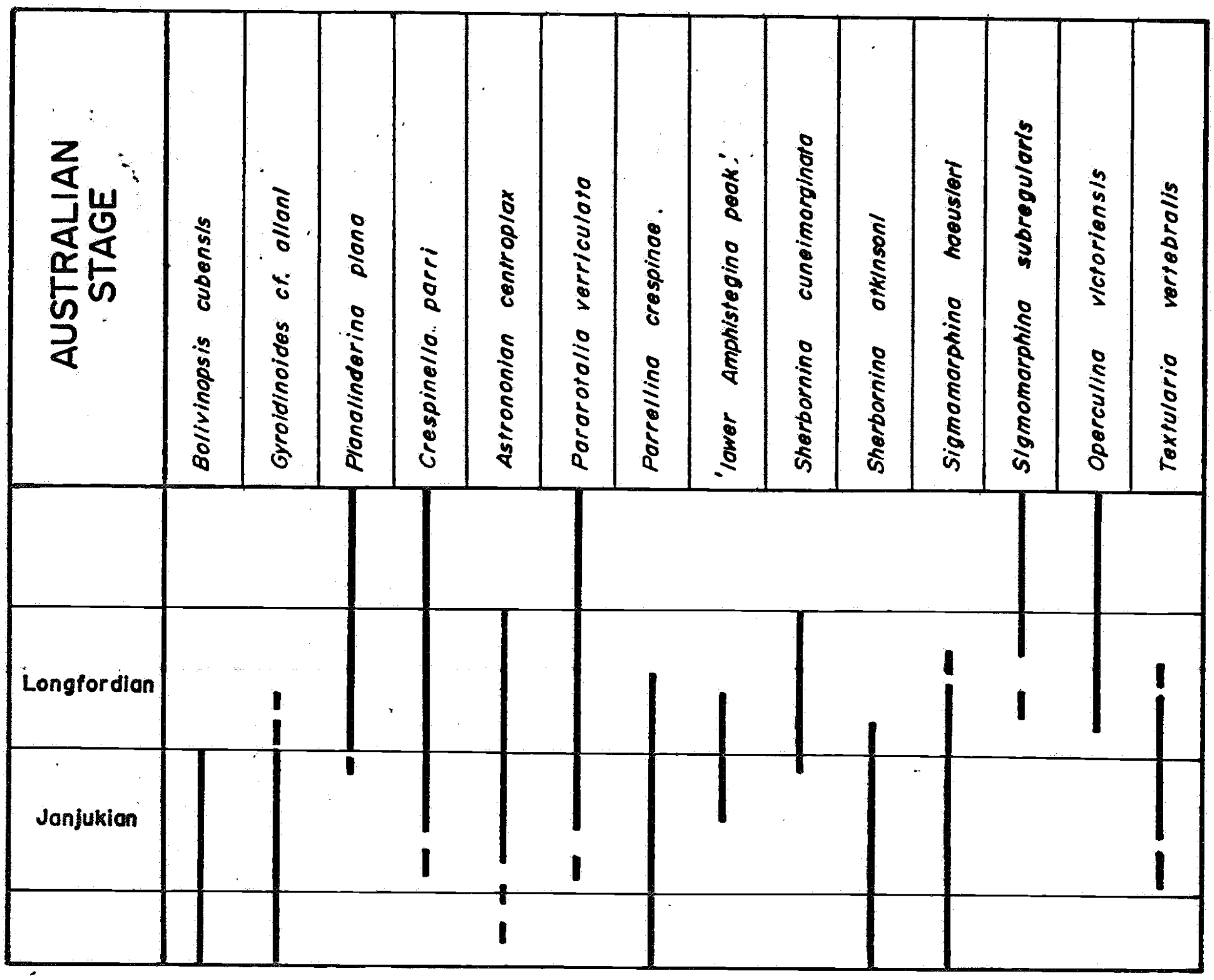

a) Ranges of some benthonic foraminifera in relation to Janjukian and Longfordian Stages in South Australia.

EPOCH	European Stage Stratotypes	Planktonic foraminiferal zone	Calcareous nannoplankton zone	Australian Stage
Lower MIOCENE	Burdigalian	N. 5	NN. 2	LONGFORDIAN
	Aquitanian		NN. 1	
		N. 4		?
Upper OLIGOCENE	Chattian	N. 3 (P. 22)	NP. 25	JANJUKIAN

b) The Oligocene / Miocene boundary in relation to various stage and microfossil zone boundaries. (in part after Van Couvering and Berggren, 1977)

Figs. I a,b

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

OLIGOCENE / MIOCENE AND JANJUKIAN / LONGFORDIAN BOUNDARIES
BIOSTRATIGRAPHY

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