APPENDIX I

STROMATOLITES AND BIOGENIC ACTIVITY IN THE NABBERU BASIN

by Kathleen Grey

INTRODUCTION

A study of fossil material from the Nabberu Basin was undertaken in conjunction with the program of regional mapping at 1:250 000 scale. A diverse assemblage is present in the Earaheedy Group, and particular emphasis was placed on the biostratigraphic potential of the stromatolites. Microfossils were first reported from oncolites in the Frere Formation (Walter and others, 1976) and have since been found in several other formations (M. R. Walter, 1979, pers. comm.), they are not preserved in the stromatolites examined in this study, but a few filaments were observed in oncolites from near Camel Well.

PREVIOUS STUDIES

The earliest record of stromatolites in the Nabberu Basin was a description by Edgell (1964) of material collected by K. H. Morgan. Edgell identified the specimens as *Collenia undosa* Walcott. During regional mapping of the Officer Basin, stromatolites were collected from outlying outcrops of the Earaheedy Group and four new taxa were described by Preiss (1976b)—*Minjaria granulosa*, cf. *?Kulparia* f. indet., *Tungussia heterostroma*, and *Tarioufetia yilgarnia*.

Geologists of the Broken Hill Proprietary Co. Ltd (B.H.P.) began mapping parts of the Nabberu Basin in 1973, and in 1975 the Geological Survey began systematic regional mapping of the whole basin. During the course of these studies, approximately 20 new stromatolite localities were discovered. Brief descriptions of some of these localities have been published by Hall and Goode (1978), and others are shown on the relevant 1:250 000 geological sheets. Bunting (in this bulletin) gives a detailed description of the large, elongate domes present in the Kulele Limestone, and presents a palaeogeographical reconstruction based on the direction of elongation. A review of stratigraphic occurrences throughout the Western Australian Proterozoic, including those from the Nabberu Basin, has recently been published (Grey, 1981) and systematic studies of forms present in the Earaheedy Group have now been completed (Grey, 1984).

METHODS OF STUDY

Stromatolite samples, other than those described by Edgell (1964) and Preiss (1976b), were collected by J. A. Bunting and R. D. Gee of the G.S.W.A. during regional mapping of the Nabberu Basin between 1976 and 1979, W. D. M. Hall of B.H.P., or by the author in conjunction with M. R. Walter and S. M. Awramik in 1977. Methods of study, both field and laboratory, are basically those outlined by Walter (1972) and Preiss (1976a). The literature on stromatolitic carbonates is extensive, but comprehensive bibliographies have been published by Awramik and others (1976), and Awramik and others (1979).

COMPOSITION OF THE STROMATOLITE ASSEMBLAGE

In the Earaheedy Group, stromatolites are present in several formations. Small, complexly branching, bushy forms are common; larger branching forms occur at some localities, and domed and stratiform stromatolites are present at many horizons. The following forms have been recognized:

(a) *Carnegia wongawolensis* Grey 1984 (Figs 26 and 65C) is a common form in the Windidda Formation, and usually occurs as small, weathered-out nodules formed by complexly branched, irregular columns with a filmy microstructure.

(b) *Earaheedia kuleliensis* Grey 1984 (Figs 50 and 66D) is the only form described so far from the Kulele Limestone. Columns are broad and tend to be vertical, branching is usually parallel, and the form is characterized by a distinctive wavy lamination. The columns are grouped into domes which are frequently elongate. The interstitial material is usually composed of intraclasts and large oolites.

(c) *Ephyaltes* form indet. (Fig. 65B) is known from only one locality in the Earaheedy Group, from the Yelma Formation. It has not been possible to identify the taxon to form level because only one small sample is available. There are major differences between the Yelma specimen and conical stromatolites, which occur in the overlying

Scorpion Group, and also with *Conophyton garganicum australe* Walter which occurs in the Bangemall Group.

(d) *Externia yilgarnia* (Preiss) (Figs 8 and 66C) was originally reported to occur in the Frere Formation (Preiss, 1976b), but more recently the locality has been placed in the Yelma Formation (Bunting, in this bulletin). The form is characterized by a very distinctive, tufted microstructure, which differs considerably from the type form of the group *Tarioufetia*, to which it was assigned by Preiss (1976b), but closely resembles that of *Externia* Semikhatov 1978, (see Grey, 1984).

(e) The specimen described as cf. *?Kulparia* f. indet. Preiss is known from only one locality in the Windidda Formation, and because of the small size of the sample and poor preservation, could only be tentatively identified by Preiss (1976b). No additional material has been obtained. The taxon is characterized by straight, narrow columns with numerous peaks.

(f) *Murgurra nabberuensis* Grey 1984 (Fig. 64A) is a small, bushy form with very complex branching and a filmy microstructure. It occurs in the Yelma Formation.

(g) *Nabberubia toolooensis* Grey 1984 is a microcolumnar or nodular form in the Windidda Formation. It consists of numerous small wart-like projections which encrust other stromatolite forms.

(h) *Omachtenia teagiana* Grey 1984 (Fig. 65A) is a fairly large, branching form with a pseudocolumnar base, a banded microstructure, and short patches of wall formed by a single lamina. This form occurs at only one locality in the Yelma Formation, and may be present at a second, in the Frere Formation.

(i) *Pilbaria deverella* Grey 1984 (Fig. 64C) occurs at several localities in both the Yelma and the Frere Formations. It can be readily distinguished by the presence of very large niches and an irregularly streaky microstructure. It is usually present at the same localities as *Yelma digitata* and forms part of a cyclic sequence.

(j) *Windidda granulosa* (Preiss) Grey 1984 includes both *Minjaria granulosa* Preiss and *Tungussia heterostroma* Preiss, which are the upper and basal parts respectively of a single stromatolite with granular microstructure and multilaminate walls. Additional material has indicated that smooth-walled, parallel-branching columns arise from irregular, divergent branches, which occur at the base of the structure, and the new group *Windidda* Grey 1984 has been erected for stromatolites with this particular branching habit.

(k) *Yandilla meekatharrensis* Grey 1984 (Fig. 66A) occurs at a single locality in what is probably Yelma Formation. Columns are medium sized and have irregular margins, and microstructure is vermiform. Preservation is poor as a result of secondary alteration.

(l) *Yelma digitata* Grey 1984 (Fig. 64D) is a common form in the Yelma Formation, and is probably also present in the Frere Formation. It is a small, bushy form with long, narrow, parallel columns and a banded microstructure. It is commonly found in the upper part of a cyclic sequence which includes *Pilbaria deverella*.

STRATIGRAPHIC DISTRIBUTION

The stratigraphic distribution of stromatolites in the Earaheedy Group of the Earaheedy Sub-basin is summarized in Table 8.

YELMA FORMATION

Carbonate lenses in the dominantly clastic Yelma Formation have yielded seven taxa—*Ephyaltes* f. indet., *Omachtenia teagiana, Pilbaria deverella, Yandilla meekatharrensis, Murgurra nabberuensis, Externia yilgarnia* and *Yelma digitata*.

The northeast DUKETON locality with *Externia yilgarnia* has been described in detail by Preiss (1976b). The stromatolites are abundant in a carbonate band 3-5 m thick. Near Sweeney Creek, *Omachtenia teagiana* occurs in a partially silicified outcrop of grey limestone. One of the most interesting localities is near Sweetwaters Well, where stromatolites are abundant in a laminated, pale-grey dolomite. Five types have been recognized (Grey, 1984): *Murgurra nabberuensis, Pilbaria deverella, Yelma digitata,* and domed and stratiform stromatolites.

Preliminary work indicates that four of these types occur in a series of regressive cycles in which the most probable sequence is: domed stromatolites (Fig. 64B) overlain by *Pilbaria deverella, Yelma digitata* and, finally, stratiform stromatolites. More detailed studies are required to determine the precise relationships of the various components of the cycles.

TABLE 8. STRATIGRAPHIC RANGES OF STROMATOLITE TAXA IN THE EARAHEEDY GROUP.

STROMATOLITE TAXA	STRATIGRAPHIC DISTRIBUTION							
	Yelma Formation	Frere Formation	Windidda Formation	Wandiwarra Formation	Princess Ranges Quartzite	Wongawol Formation	Kulele Limestone	Mulgarra Formation
Earaheedia kuleliensis Grey 1984							▬	
Carnegia wongawolensis Grey 1984			▬					
Nabberubia toolooensis Grey 1984			▬					
Windidda granulosa (Preiss 1976)			▬					
cf. ? *Kulparia* Preiss 1976			▬					
Pilbaria deverella Grey 1984	▬	▬						
Yelma digitata Grey 1984	▬	▬						
Ephyaltes Grey 1984	▬							
Externia yilgarnia (Preiss 1976)	▬							
Murgurra nabberuensis Grey 1984	▬							
Omachtenia teagiana Grey 1984	▬							
Yandilla meekatharrensis Grey 1984	▬							

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Poorly preserved specimens of *Yelma digitata* occur at a locality near Combine Well, and *Pilbaria deverella* is probably present in a dark-grey limestone at a locality near Lake Gregory. Northwest of Edingunna Well, a dark-grey dolomite contains *Ephyaltes* f. indet. and ?*Yelma digitata*. A thick sequence of stromatolitic dolomite, probably in the Yelma Formation, outcrops approximately 5 km east of Phar Lap Well, as a component of the Kimberley Range Outlier, and contains *Yandilla meekatharrensis*.

FRERE FORMATION

The Frere Formation consists predominantly of ferruginous shale and granular iron-formation with minor chert and carbonate. Branching columnar stromatolites occur in the carbonate horizons but have not been reported from the cherts or iron-formation. The latter, however, contains stratiform stromatolites and oncolites. Walter and others (1976) reported abundant, well-preserved microfossils, some of which resemble modern iron-bacteria, from an oncolite-rich horizon near Camel Well. A few poorly preserved filaments (Fig. 67) were found during the present study.

Pilbaria deverella occurs in a pale-grey to white carbonate near Simpson Well, and specimens tentatively identified as *Yelma digitata* are known from south of Lake Carnegie.

WINDIDDA FORMATION

The Windidda Formation is grey-to-pink, laminated dolomite or limestone, interbedded with maroon or grey mudstone, and contains numerous stromatolites. Preiss (1976b) described *Windidda granulosa* (as *Minjaria granulosa* and *Tungussia heterostroma*) and cf. ?*Kulparia* f. indet. from Mount Elisabeth.

In the lower and middle part of the Windidda Formation, *Carnegia wongawolensis* is abundant and occurs as weathered-out nodules. It is particularly common from the gorge section near Tooloo Bluff, and in Wongawol Creek. *Nabberubia toolooensis* is a rare form, but is known from Mount Elisabeth and the gorge near Tooloo Bluff.

WONGAWOL FORMATION

Poorly preserved stromatolites occur in this formation (Bunting, in this bulletin).

KULELE LIMESTONE

Stromatolites are abundant in the Kulele Limestone, although the predominant type is a large, domed form which has not been named. Smaller domes are formed by the branching-columnar *Earaheedia kuleliensis*. This form is common near Thurraguddy Bore, and a detailed description of the locality is given by Bunting (in this bulletin). Unidentified stromatolites are also present at Mount Lancelot and Mount Hosken.

STROMATOLITE BIOSTRATIGRAPHY

The significance of the Earaheedy Group stromatolites to both Australian and world-wide Precambrian biostratigraphy has been discussed in some detail by Grey (1984). This study shows that a diverse assemblage, with restricted stratigraphic distribution, occurs in the Earaheedy Group (Table 8). The extent to which the distribution is controlled by major facies changes is uncertain. Nevertheless, the stromatolites provide a useful tool for the recognition of lithostratigraphic units within the basin.

Comparisons with other Australian and overseas assemblages have been made by Grey (1984) and show that the forms recognized in the Earaheedy Group have not been recorded from other parts of Australia. However, none of the stromatolite-bearing units are considered to be coeval with the sequence in the Earaheedy Sub-basin. Few studies of early and middle Proterozoic stromatolites from other parts of the world have been published, but the limited descriptions available suggest that similar forms may occur in other units of approximately the same age, particularly in Canada (Semikhatov, 1978).

ENVIRONMENT OF DEPOSITION

Stromatolites have frequently been used as environmental indicators in studies of sedimentation and basin analysis (for example, see papers by several authors in Ginsburg, 1975 and Walter, 1976). Direct comparisons between ancient and modern stromatolite environments must be approached with caution (Walter, 1977) because of the very specialized environments which support stromatolite growth today. In Proterozoic times, stromatolites were much more widespread and occupied a wider range of ecological niches. A major problem is the fact that complex, divergently branching columns have not been reported from recent environments, and there is some doubt about whether such forms represent subtidal or intertidal conditions. However, studies of the Malmani Dolomite (age 2 250 Ma) by Eriksson and others (1976) and of the Pethei Group (age 1 795-1 865 Ma) by Hoffman (1976) suggest that they are subtidal. Conical stromatolites almost certainly indicate a subaqueous environment Donaldson, 1976). The carbonate lenses in the Yelma and Frere Formations which contain *Ephyaltes*, and a variety of divergently branching stromatolites, probably formed as lagoonal phases in a predominantly clastic shelf environment. At Sweetwaters Well, *Pilbaria* and *Yelma* occur together in probable upward-shallowing sequences, with *Pilbaria* in lagoonal phases and *Yelma* in intertidal to supratidal phases.

Some of the stromatolites in the Windidda Formation appear similar to those occurring in recent freshwater algal-marshes (Monty and Hardie, 1976) but further work is necessary to confirm this. The domes and short columns which occur in the Kulele Limestone are indicative of an intertidal to shallow-subtidal regime.

STROMATOLITES AND MINERALIZATION

In recent years there has been increasing interest in the role of stromatolites, and associated microbial organisms, in the formation of stratabound ore deposits. A summary of associations recognized so far, and of the possible mechanisms involved, is given by Mendelsohn (1976) and Trudinger and Mendelsohn (1976). The trapping and binding function of a microbial mat may concentrate a mineral, which is present in the sediment supply, or some organisms may extract minerals from solution and precipitate them as sheaths. Furthermore, the decomposition of a thick microbial mat may provide a source of hydrogen sulphide. These mechanisms are the subject of much current investigation.

Detailed studies of the association between mineralization and biogenic activity have not been carried out in the Earaheedy Sub-basin, although several examples have been recognized which could form the basis of future studies. Of particular interest is the presence of bacteria in the Frere Formation (Walter and others, 1976). Some of these could have played an active role in the precipitation of iron-rich oncolites (Glaessner and Walter, 1981), and may even have controlled the deposition of much of the iron present in the formation. A second example is the association between stromatolites and galena near Sweetwaters Well, where the lead occurs in column interspaces and its distribution is apparently controlled by the higher porosity of the inter-columnar areas.

CONCLUSIONS

The diverse stromatolite assemblage present in the Earaheedy Group is significant for several reasons. Stromatolites and micro-organisms played a major role in the deposition of the various stratigraphic units, and possibly influenced mineralization in some parts of the sub-basin. The stromatolites provide useful lithostratigraphic markers, and are of significance for environmental interpretation.