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RECORD 1975/17

NEW PRECAMBRIAN FOSSILS FROM THE ARUMBERA SANDSTONE, NORTHERN TERRITORY, AUSTRALIA

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ABSTRACT

Large fossil structures occurring commonly on certain bedding planes in the Arumbera Sandstone southwest of Alice Springs are described as Arumberia banksi gen. et sp. nov. and interpreted as remains of cup-shaped animals, probably of coelenterate grade, resembling two genera described from the Nama Group of South-West Africa and one from near Lake Baikal, Siberia.

Introduction

In the course of geological mapping in the Amadeus Basin west of Alice Springs, in October 1966, Mr J. Banks found on an outcrop of Arumbera Sandstone near Laura Creek a loose block, nearly in situ, which was covered with peculiar grooves radiating from several centres (Pl. 1, fig. 1). The structures appeared to be of organic origin. During a visit to the Geology Department of the University of Adelaide he showed photographs to M.F. Glaessner and Mary Wade, who were unable to identify these fossils. The fossiliferous rock, which had been brought to the office of the Magellan Petroleum Company in Alice Springs, was later presented by the Company to the Department, but after examination the fossils remained unidentified. Unfortunately the specimen was lost during subsequent rearrangements of collections and laboratories. After the appearance of a monograph on the Erniettomorpha from the Nama Group of Southwest Africa (Pflug 1972 b) and examination of this material together with Professor Pflug in Giessen, M.F. Glaessner came to the conclusion that the fossil found by J. Banks might be related in some way to the Erniettomorpha. After detailed information on the original locality had been obtained from Mr Banks M.R. Walter agreed to visit it in 1973, to collect further specimens, and to participate in their study. Morphological analysis by M.R. Walter of the 24 new specimens has allowed the original form of the organism to be reconstructed and has resulted in a more precise assessment of its relationships.

Acknowledgments

The authors wish to thank Mr J. Banks, Pinellas Park, Florida, USA, for bringing these fossils to their notice and for supplying information; the Magellan Petroleum Co. for giving access to an unpublished geological report by J. Banks; Professor H.D. Pflug for demonstrating his collections; and Dr G.J.B. Germs in Windhoek and Professor B.S. Sokolov in Novosibirsk for information and reprints of papers. M.R. Walter publishes with the permission of the Acting Director of the Bureau of Mineral Resources, Geology and Geophysics.

Occurrence

The fossils are known from three localities; two are 14 km SW of Alice Springs, due south of Temple Bar homestead; the third is 22 km WSW of Alice Springs, on the eastern side of the gap made by Laura Creek, south of Valley Dam (Alice Springs 1:250 000 Geological Series map sheet). This is the locality first reported by J. Banks.

South of Valley Dam and at the stratigraphically higher of the other two localities the fossils are very abundant. Near Valley Dam they are found on many bedding planes over a stratigraphic interval of about 1 m, in beds that outcrop along strike for only 10 m or so. At the other two localities they are not in situ, but could not have moved far. They almost completely cover the bedding planes on which they occur. They are on the surfaces of 5-20 cm thick beds of well cemented fine-grained feldspathic and micaceous quartz sandstone. In one specimen which was sectioned the fossils occur on the sole of the upper of two sandstone beds that are separated by a 1 mm thick lamina of siltstone. Bedding surfaces consist of irregular, rounded mounds and hollows (Pls 1-3). The fossils are frequently centred in hollows on the upper surfaces of the beds (or the corresponding mounds on lower surfaces). On some bedding planes there are streaming lineations, current crescents (Conybeare & Crook, 1968) and small flute moulds (Pl. 2, Fig. 1; Pl. 3, Fig. 3), usually orientated parallel to the fossils. In one specimen the

fossils are superimposed on symmetrical rectilinear ripple marks and are overlain by a thin sandstone bed with abundant shale clasts.

Twenty-four specimens have been collected, many with numerous fossils. The orientation of 13 of these samples was determined in the field. Eleven have fossils on the lower surfaces (soles) of beds, where they show as sharply incised grooves ("concave hyporeliefs" in the terminology which is in use for trace fossil orientation). Two have fossils on upper surfaces, where they are narrow ridges ("convex epireliefs"). Three of the other 11 specimens appear to be convex epireliefs.

Stratigraphy and age

The Arumbera Sandstone (as presently defined), which reaches a maximum thickness of 1200 m, is about 550 m thick in the Laura Creek area. Its lower part has been considered to be of Precambrian age since 1959, when D.J. Taylor discovered in it one specimen of "Rangea" cf. longa Glaessner & Wade, a component of the Ediacara fauna of the Adelaide Geosyncline (Glaessner & Wade, 1966; Glaessner, 1969, fig.9A). Trace fossils in the upper Arumbera were recognized as Cambrian by J. Gilbert-Tomlinson (in Wells et al., 1967, 1970) and described as including distinctive Early Cambrian forms by Glaessner (1969). Subsequently, Daily (1972) proposed a three fold subdivision of the Arumbera Sandstone (fig. 1) on the basis of lithology and a sequence of trace and body fossils. He believes that a disconformity separates units 1 and II. Units II and III contain trace fossils considered to be of Early Cambrian age (Rusophycus, Diplichnites, Phycodes pedum and Didymaulichnus in II, Plagiogmus in III); these units are soon to be named as formations by Daily. Unit I, the Arumbera Sandstone s. str., contains components of the Ediacara fauna and also Hallidaya brueri Wade, a member of the Mount Skinner fauna (Wade, 1969). Results of the radiometric dating of the Pertatataka Formation and its correlatives are described by Walter (1972, p. 38-39): the Olympic Member (upper tillite) of the formation may be about 670 m.y. old.

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The fossils here described occur at the Valley Dam locality, 85 m below the green siltstone at the base of Daily's unit II and approximately 230 m above the base of the Arumbera Sandstone. According to Wade (pers. comm. to Walter, 1974) this is the level at which H. brueri occurs. At the other two localities the fossils are 26 m and about 125 m below the base of unit II. Thus they are considered to be latest Precambrian.

Taxonomy.

Although these fossils cannot be reliably assigned to any major taxonomic unit, they are distinctive and locally abundant, and not without relations to known Precambrian fossils from other continents. Consequently, they are named and formally described to facilitate future recognition and reference to them.

Arumberia gen. nov.

Type species: A. banksi sp. nov.

Characteristics: As for the species.

Name: The fossils are from the Arumbera Sandstone.

Arumberia banksi sp. nov.

Plates 1-3, Text-Figure 2

Name: In honour of J. Banks, who first found this fossil.

Holotype: CPC 14948. The fossils are deposited in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Geology and Geophysics, Canberra, and are numbered CPC 14948 to 14958.

Diagnosis: Hollow compressible ribbed bodies, originally of flexible tissues, of conical to cylindrical shape, attached by a blunt apex. Ribs flat, 0.3 - 7.0 mm wide, divided by shallow grooves 0.05 - 0.7 mm wide. The ribs bifurcate in places and may consist of finer ribbing. Distal margin indistinct. No traces of inner walls or septa.

Description: On the lower surfaces of sandstone slabs the fossils are represented by long, narrow, subparallel, straight to gently curved grooves. The grooves are shallow and about 0.05 - 0.7 mm wide. Maximum frequencies seem to occur in the lower and upper thirds of this range. Between the

grooves are flat to gently convex ribs. They are 0.3 - 7.0 mm wide, with apparently two frequency maxima, one in each half of this range. Although the overall arrangement of grooves on small areas of bedding planes is sub-parellel, the study of larger specimens shows that they converge towards small apical areas that are mound-like on lower surfaces of beds (Pls 1, 2). As the protruding areas were directed downward in the sense of the stratification, the grooves must have radiated from hollows in the underlying sediment. In some examples where the mounds are less well defined, the grooves converge towards an indistinct line rather than a small area (Pl. 1, fig. 2: Pl. 2, fig. 3) and in some instances they arise from a finely reticulated or wrinkled area (Pl. 2, fig. 3). There are large areas of almost parallel ribbing, apparently down the flanks of elongate mounds, and distinct divergence to more than 90° occurs near the apex, occasionally with hook-like bends (Pl. 1, fig. 1) resulting from the radial arrangement of grooves near the apex. It is often difficult to distinguish the margins of adjacent complete individuals (i.e. those radiating from individual centres) and to find clearly marked distal margins. There are 8 examples of probable distal margins, of which 7 are known, or appear to be, convex epireliefs and the eighth is a concave hyporelief (3 examples are shown on Pl. 3, figs 4, 5, 6). No specimen shows the whole of the distal margin. The ribs intersect the margin at about 90°. The greatest observed length of individuals (measured parallel to the grooves) is 20 cm; the greatest width is 16 cm. The smallest individual is about 5 cm long, with a width of 3 cm. On most slabs, or at least on most individual sand laminae, there is a distinct, preferred, overall direction of grooving. In some places a splitting of ribs (or insertion of grooves) is clearly seen (Pl. 3, fig. 2). A transverse sculpture crossing the ribs is seen only rarely and faintly; it is possibly due to composite moulding of specimens lying in different directions on adjacent sand laminae. The transverse sculpture faintly visible in Plate 3, Figure 5 may have resulted from contraction of the organism after burial. There are no other

body fossils on these bedding planes, and the only possible trace fossil is a single, short worm trail (Pl. 3, fig. 5).

Preservation: The fossils occur preferentially on lower surfaces, as do the fossils in the Pound Quartzite at Ediacara, for a similar reason. Bedding planes correspond to minor phases of depositon of finer-grained sediment. The soft-bodied organisms were preserved on this silty substratum when the next sand wave passed over and eventually covered them. The parallelism of the ribbing indicates the direction of the sand-laden current which knocked the cups down, partly filling them near their margins and finally flattening them under the weight of newly deposited sand. The less abundant epireliefs of these fossils on upper bedding planes are the counterpart moulds of the hyporeliefs on the succeeding lower bedding planes (see Glaessner & Wade 1966; Wade 1968).

Interpretation: The ribbing and grooving is interpreted as biogenic and it is considered that it could not have been caused by mechanical forces. We are dealing with individual structures with ribs diverging from an apex which was directed downward, in the sense of stratification. The ribs and grooves are sharply defined, have distinct width ranges, and at some distance from thr apex they are almost parallel, with sharp changes of direction observable between adjacent structures. There are several examples in which the ribs radiate in all directions from the apex (but never equally in all directions). All this is quite unlike any known or imaginable mechanical bedding plane lineations or drag or prod marks. It is due to the deposition on the bedding planes of organic remains of more or less definite shape. Water movement, however, has affected them during their deposition and its effect must be considered in any attempted reconstruction. The observed features can be explained by reconstructing organisms in the shape of cups or inverted cones, each with a blunt apex, attached in large numbers to the surface of the sediment (fig. 2). The sides of the cups converged more or less rapidly to almost parallel. They must have been flexible and compressible and seem to

have been folded over in some places without fracturing. They may have thinned out near their distal margins to near the limit of preservability. As a result the geometry of the distal margin is incompletely known; it is impossible to assert unquestionably that it was circular and entire. However, its most probable shape was subcircular and approximately at right angles to the axis. If the symmetry had not been radial, there would be some indication of it in the character of the ribs. Hence the bodies most likely had the form of a cup, the function of which is difficult to understand, in the absence of any indication of porosity of the walls. The associated sedimentary structures indicate that the organisms lived in an environment with intermittent very energetic water movement and intermittent but probably rapid sand deposition, most likely a shallow subtidal marine environment. It was a more energetic environment than that postulated for the main fossil beds at Ediacara by Goldring & Curnow (1967).

Systematic position

There are three known genera of fossils, all of Late Precambrian age, which resemble the Arumbera specimens.

Namalia Germs, 1968 (type species N. villiersiensis Germs) comes from the Upper Clastic Member, Kuibis Formation, lower part of the Nama Group, South-West Africa (Buchholzbrunn, about 200 km east of the coast at Luderitz, and Vrede, about 50 km northwest of the first locality). About five specimens have been figured but "in many cases this fossil was discovered in colonies of up to thirty individuals. Generally, the individuals lie perpendicular to the bedding plane in the rock, but some are oblique to that plane, and in a few cases they lie in the bedding plane". The fossil is conical to cylindrical, apparently with a blunt apex. It has 27-40 longitudinal ridges on its surface which are about 3 mm wide. The length of the fossil is 5.2 - 9 cm and its greatest diameter is 1.5 - 7 cm. Germs believes that there is an inner wall with septa perpendicular to the walls but the illustrations of these features are unconvincing, as are those of a "possible articulation".

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In at least one specimen figured as Namalia the outer ribs are shown to consist of smaller ridges but the identification of this specimen is questionable.

Nasepia Germs, 1972 (type species N. altae Germs) was described from the Nasep Quartzite Member of the Schwarzrand Formation which overlies its Basal Quartzite Member. (The Schwarzrand Formation follows above the Schwarzkalk Limestone Member which rests on the Upper Clastic Member of the Kuibis Formation, the basal part of the Nama Group). The locality is Arimas, about 60km west of the Fish River Canyon in southwest Africa. "The fossil consists of leaf-like bodies with thin ribs, mostly in one direction and usually then subparallel to the long axis". The ribs vary from 0.1 - 1.0 mm in width and one "measured petaloid" (apparently unfigured) is 10.5 cm across (Germs 1973). The author considers that Nasepia consists "of a bundle of spindle-shaped bodies" but the reason for this description is not apparent from the illustrations. He observes that Namalia (described as conical) strongly resembles an individual petaloid of Nasepia (described as leaf-like) and that he "also found intermediate forms of Pteridinium and Ernietta, and fossil-fragments resembling Nasepia".

Baikalina sessilis Sokolov, 1972 is from the River Malyi Anai, Ayankan Formation, the equivalent of the Irkutsk "Horizon" of the Upper Yudomian of the area near Lake Baikal in Siberia. A stratigraphic column showing the position of this find was published by Khomentovsky (1974, fig.2). The Ayankan Formation is there dated at 607 m.y. and placed at the top of the Precambrian. The only description of this new genus and species is given in the legend to plate 3 figure 1 of Sokolov (1972; see also Sokolov 1973) and states (translated): "Internal mould of an organism with bag-shaped body, narrowed at the base, apparently benthonic: the outer cover of the organism elastic, organic, weakly wrinkled. Measurements 20-22 x 30 mm, width of the wrinkles about 1 mm". Although objections have been raised and there are ambiguities in it, this brief description must be considered as validating the name of the fossil to which it refers. It seems likely that plate 3 figure 2,

described as Pteridinium and representing a concave external mould from the same locality, is actually a second specimen of Baikalina sessilis.

These three monotypic genera are insufficiently known and inadequately described. It would be confusing to apply arbitrarily one of these three generic names to the fossils from the Arumbera Sandstone. However, further discoveries may provide evidence of generic identity, or favour a wider generic concept in this group. At the present state of knowledge, or ignorance, certain differences between the previously described and the new fossils are apparent. The new form grows to a larger size than Namalia, with twice as many ribs or more. There is no evidence of inner walls, septa or "articulation", but these characters are not well documented in Namalia and the first two cannot be expected to be visible in our material, which consists of hyporelief casts of external surfaces. This leaves the cylindro-conical shape and the external grooving as common character , and the significant difference in size and in number of ribs as distinguishing features.

Nasepia is distinguished by the clearly marked margin of the petaloids in several specimens (Germs 1973, fig. 2A and D), the different character of the ribs and the lack of definition of the apex in all specimens that have beenillustrated. The shape of the bodies appears therefore as leaf - rather than bag-like, but admittedly only more or less leaf-shaped surface impressions are preserved in the new fossils, with the adapical (proximal) side turned under in the shape of a blunt cone. The original distal (peripheral) margin may have differed from that of Nasepia in preservability rather than in its geometrical shape.

Baikalina is also smaller than the new fossil, but resembles it in its bag-like shape, with ribs of a similar size converging to a narrowed base. As only two incomplete and very inadequately described specimens are known, it would not be helpful or appropriate to assign the abundant new material to this genus.

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The recent discoveries of three apparently similar kinds of fossils of approximately equal age in widely distant regions indicates the significance of this group of fossil organisms, but does not clarify its systematic position. Germs (1972) has formally placed Nasepia and Namalia, together with Rangea Gürich, Pteridinium Gürich, and Ernietta Pflug, in the "Group Petalonamae". The evidence of such a grouping of rather diverse organisms has to be examined together with the question of their relations to other taxa, since we have reasons to believe that Nasepia, Namalia and Baikalina are related to the Arumbera fossils. However, in the present context it is neither necessary nor possible to carry out a searching and detailed evaluation of the far-reaching claims made by Pflug in his numerous contributions to the interpretation of this group. The term "Group" was apparently used by Germs in preference to Phylum because of some doubt about its status. The name appears first in the form "Petalonamidae", without definition (Pflug 1970a, p.258). In the same year (Pflug 1970b, pp.201-2) it takes the form "Petalonamae", still remaining undefined except for a reference to the feather-like surface structures and to the inclusion of Rangea and Pteridinium. In the following year (Pflug 1971, p. 1341) it emerges that Rangea, Pteridinium and Arborea are included in this taxon which subsequently is placed under the heading "Phylum" and given a diagnosis (Pflug 1972 a; 1972b, pp.136, 155, 158, 166). The diagnosis characterizes the Phylum as extinct animals whose bodies consist of several identical leaf-like parts (petaloids) forming fan-like structures. They are said to be linked (towards the base) according to a combined dichotomous-sympodial mode, and (laterally) by smooth zones of fibrillar tissue. Pflug does not admit the existence of single leaf-shaped Pteridinium individuals, but he admits, apparently, Charnia Ford (see Pflug 1970b, p. 288) and, certainly, Arborea Glaessner & Wade as members of the same group. As they do not show linked petaloids, this conflicts with his diagnosis. What remains then is the "feather-like" ribbing of the surface of a soft body. How greatly this varies within one subdivision of the

"petalonamae", the "Class Erniettomorpha", can be seen in Pflug's (1972b) numerous photographs. They show that the dividing line corresponding to that between the ribs on the two flanks of the petaloid of Pteridinium can be either clearly developed as in the typical Ernietta, or confined to an apical region (Pflug 1972b, pl. 39, fig.2) from which the ribs radiate outward. As Germs has rightly assumed, the absence of this (typically zig-zag) line does not necessarily exclude his new genera from classification together with genera included by Pflug in his "Petalonamae". It does distinguish the three genera discussed above and Arumberia from typical Erniettomorpha. Incidentally, the formdescribed as Erniograndis Pflug (1972b. pl. 38) shows a structure resembling the "articulation" observed by Germs in one of his specimens of Namalia.

What are the "Petalonamae"? They appear to represent a major taxon of soft-bodied organisms with a basically leaf-like but often complexly folded or composite structure. The visible surfaces are often grooved and ribbed in parallel, divergent or branching patterns. Where body cavities are preserved, they do not appear to be of great complexity than in some living coelenterates. The basic morphological character of the coelenterate organism, the polyp itself, cannot be demonstrated in the fossils here considered. The formal application of the name "Petalonamae" is avoided by Pflug (1974) in favour of the informal term "Petalo-organisms". In view of the confusion in diagnoses and the overloading of the term with speculative implications, which gives it the character of a hypothetical concept rather than a taxon, its application to a systematic grouping containing the fossils here described together with others is not recommended.

Pflug has laboriously and often ingeniously reconstructed these organisms and speculated on them. His views cannot be discussed here at length but to avoid misunderstandings we must make it quite clear that we cannot accept some of his basic assumptions, which are the basis of his judgment that the "Petalo-organisms" represent a peculiar branch of

precambrian evolution, filling an intermediate position between the kingdoms of plant and animals" (Pflug 1973, p. 167; see also Pflug 1974). We do not accept any of the homologies between Petalostroma and Pteridinium implied in fig.5 (1973, p. 165) of his paper and do not believe that conclusions drawn from the supposed microscopic structures of the former can effect the systematic position of the latter genus and others. We consider the form variants of the "Class Erniettomorpha" as illustrated (Pflug 1972b, fig. 6, p. 147) to be entirely due to deformation during fossilization, a factor which must be carefully considered in the taxonomy of fossil soft-bodied organisms.

Some fossils placed by Pflug in the group "Petalonamae" ("Rangea" grandis and "R". longa Glaessner & Wade - now placed in a new genus Glaessnerina by Germs, 1973 - Pteridinium Gurich, Arborea Glaessner & Wade, and Charnia Ford) have been considered as Pennatulacea. "Further study of Glaessnerina and Charnia may perhaps make it advisable to place them in the same genus" (Germs 1973, p.5). There are resemblances with the still incompletely described and unnamed fossils from the Conception Group of the Avalon Peninsula, Newfoundland (Misra 1969). Glaessner (unpublished observations, 1968) considered some of them as possibly related to colonial hydrozoans. The morphology of some of these fossils and of Rangea schneiderhoehni Gurich suggests the existence of polyps on secondary branches of their preserved structures. Others, like Pteridinium, the Erniettomorpha, Arumberia, Namalia, Nasepia and Baikalina have - apart from uncertain traces - only a primary ribbing without any suggestion of the placement of possible polyps. All authors who have studied these fossils have recognized a general similarity of all these soft-bodied, frond-, leaf- or bag-shaped organisms. However, at the present state of our knowledge their formal grouping in a higher taxon is unwarranted. There is no evidence for considering them as plants or as sponges, nor are there any reasons for assuming that their level of organization was higher than that of the coelenterates. It is suggested that they may be classified provisionally as Coelenterata of uncertain systematic position.

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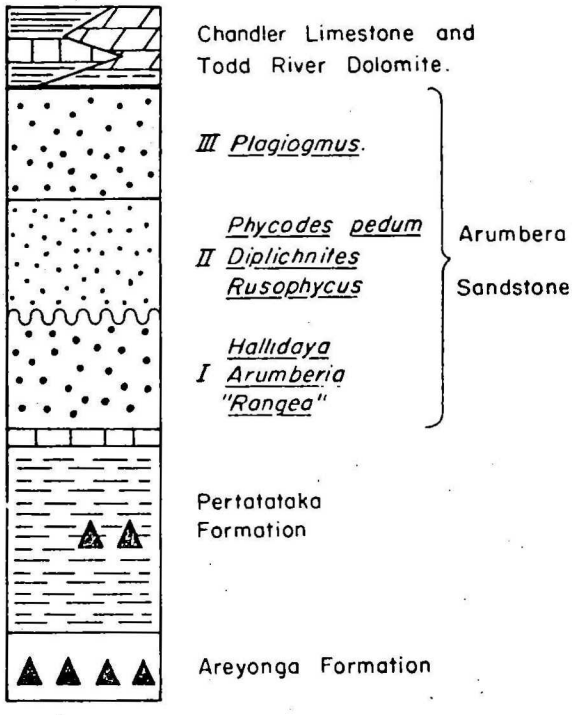

Figure 1. Generalized stratigraphic column, not to scale, for the Arumbera Sandstone and contiguous units in the northeastern Amadeus Basin (modified from Wells et al., 1967 and Daily, 1972). The triangles represent tillites.

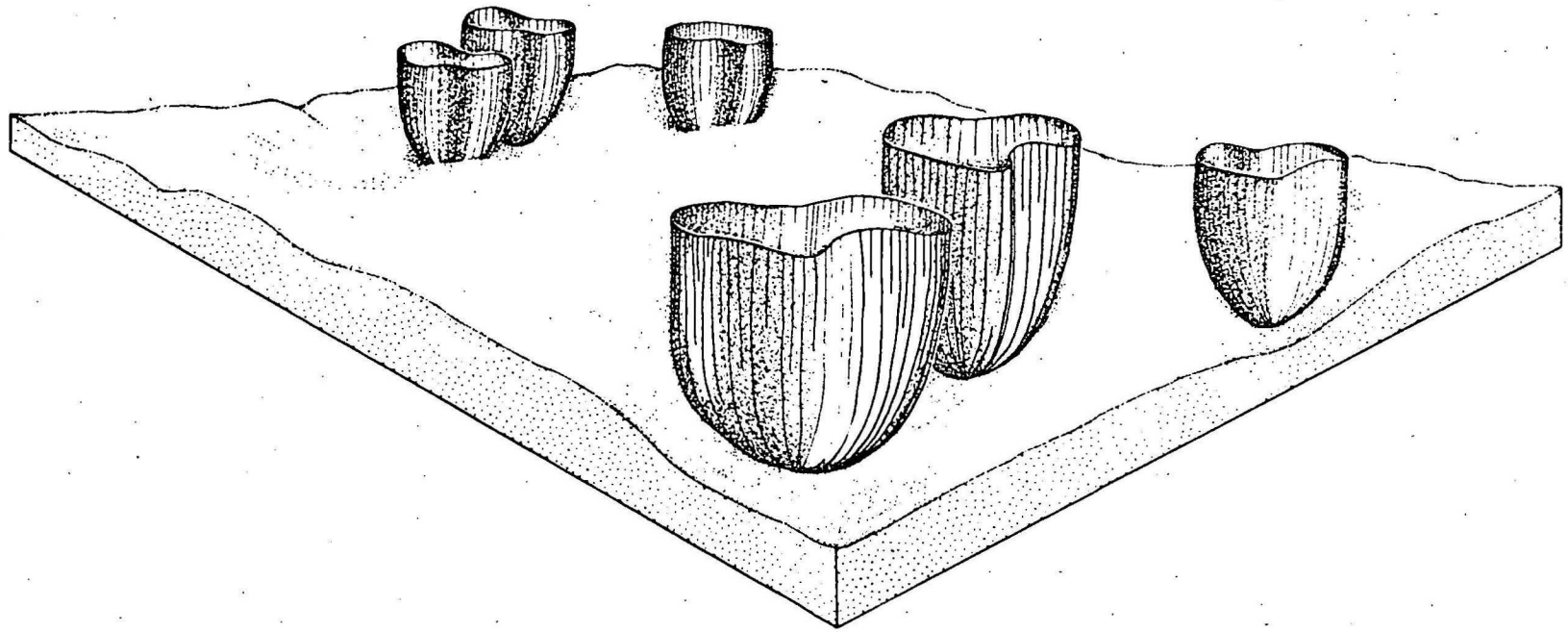

Figure 2. Diagrammatic reconstruction of the appearance during life of Arumberia banksi. Each cup is 5-20cm high. Only selected longitudinal ribs are shown.

Plate and Figure Captions

Plate 1. Arumberia banksi, Arumbera Sandstone; lower bedding surfaces.

Fig. 1. Specimen photographed in the field by J. Banks.

The positions of the apices of two fossils are indicated by radially arranged grooves (arrows point to these apices). The specimen has a maxium width of about 40 cm.

Fig. 2. It is not clear how many individuals are represented on this specimen.

Fig. 3. This specimen shows several bedding planes and more than three individuals (a, b, c). Individual "a" is the holotype. CPC 14948, x 1/3.

Editor and reviewers please note: arrows and letters have now been added to the original of this plate.

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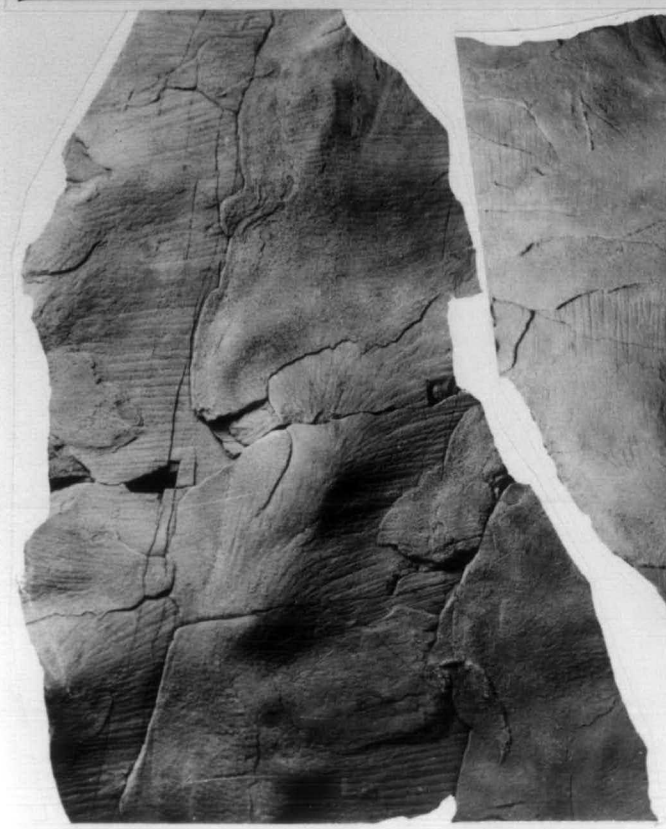

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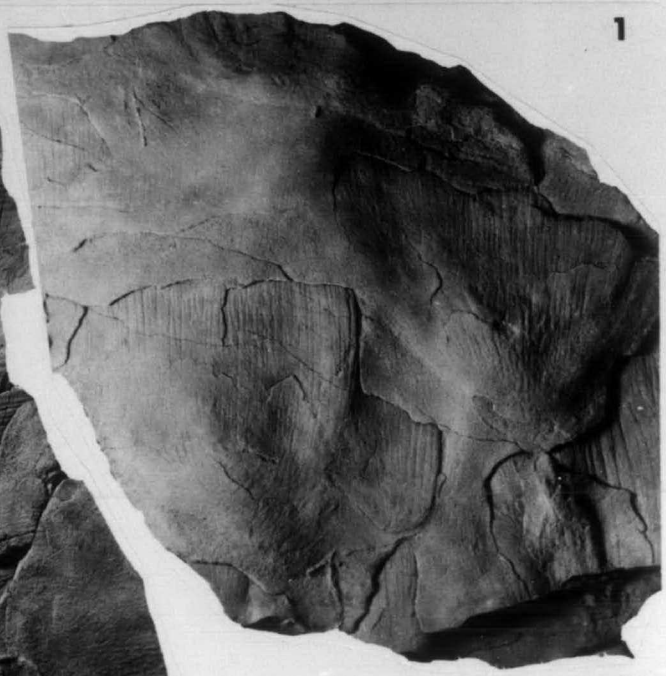

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Plate 2. Arumberia banksi, Arumbera Sandstone; lower bedding surfaces.

Fig. 1. Large specimen showing various directions of ribs because of folding of the individual prior to burial. CPC 14955, x ¼.

Fig. 2. The pattern of overlap of contiguous individuals visible on this lower bedding plane shows that the organisms are preserved as casts of impressions in the underlying silt layer. CPC 14949, x ½.

Fig. 3. The reticulate pattern of grooves near the lower part of the figure resulted from the near-vertical collapse of the organism; the pattern of converging grooves in the centre of the figure is a cast of a fold in the side of an organism. CPC 14952, x 1/3.

Fig. 4. Numerous small individuals on a probable lower bedding surface. CPC 14950, x ½.

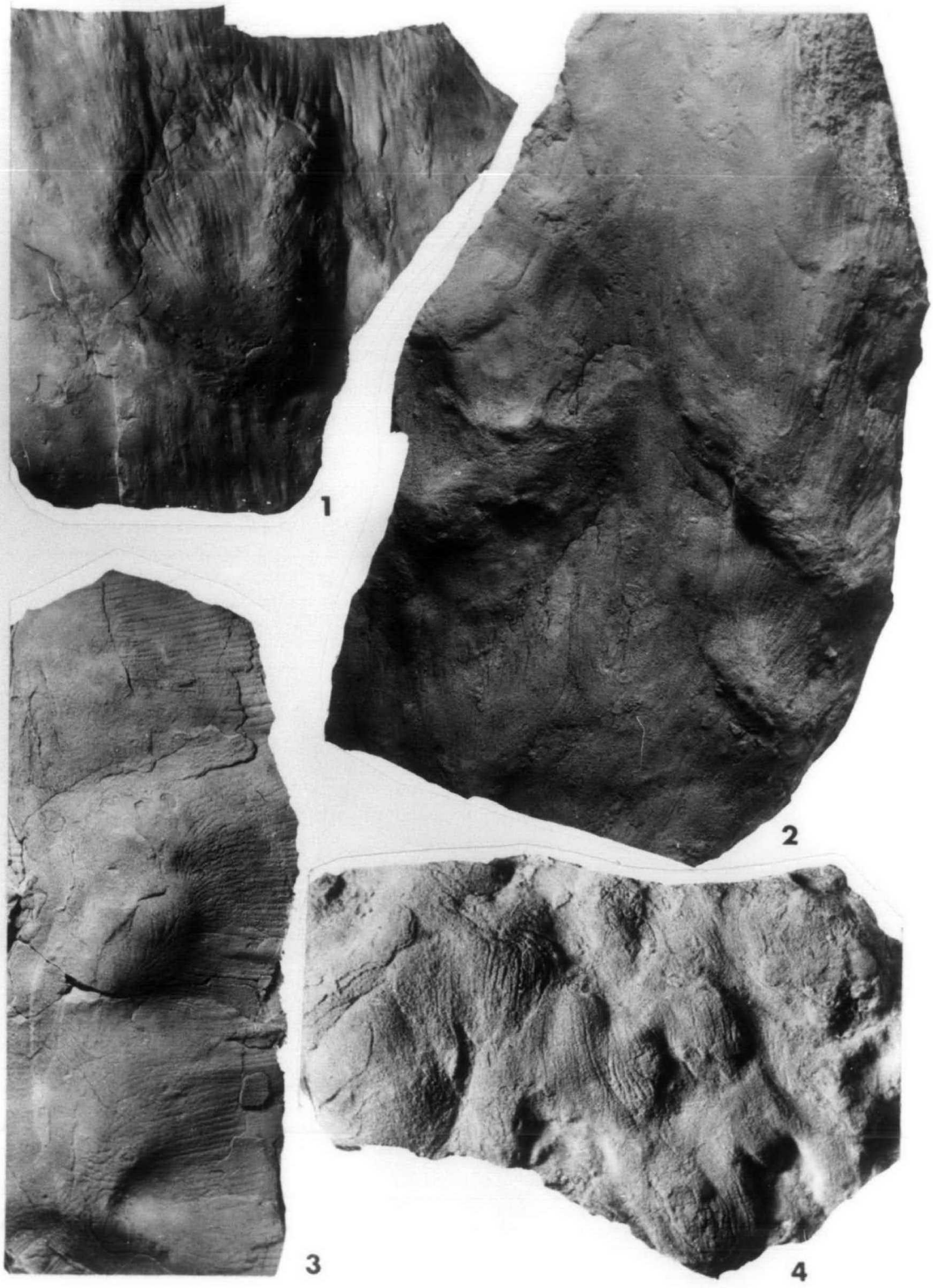
1
2
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Plate 3. *Arumberia banksi*. Arumbera Sandstone

Figs 1, 2. CPC 14956; fig. 1, x 3, lower surface of bed; fig. 2, rubber mould of part of the area visible in fig. 1, x ½ showing the convergence and serial insertion of grooves.

Fig. 3. Aligned fossils and flute moulds; lower surface of bed. CPC 14954, x ¼.

Fig. 4–6. Distal margins; fig. 4, rubber mould of lower bedding surface, CPC 14957, x ½; fig. 5, upper bedding surface, CPC 14953, x ½ (the ribs directed downwards in this figure are intersected by transverse folds parallel to the distal margin, and by a short worm trail); fig. 6, rubber mould of probable upper bedding surface, CPC 14958, x ½.