CIRCULAR STRUCTURES IN A LATE PRECAMBRIAN SANDSTONE: FOSSIL MEDUSOIDS OR EVIDENCE OF FLUIDIZATION?

by P. S. PLUMMER*

Summary

PLUMMER, P. S. (1980) Circular structures in a Late Precambrian sandstone: Fossil medusoids or evidence of fluidization. *Trans. R. Soc. S. Aust.* **104** (1), 13-16, 29 February, 1980.

Small circular structures have been found preserved on the basal surface of a Late Precambrian sandstone within the Moorillah Formation in the Flinders Ranges, South Australia. Although their mode of preservation and general appearance suggest a biogenic origin, it is believed that a non-biogenic process involving gas migration and sediment fluidization was responsible for their formation.

Introduction

Recently found within the central Flinders Ranges of South Australia was a float sample[1] of ripple cross-laminated fine sandstone on the basal surface of which are preserved a number of small, roughly circular structures of problematic origin. The sample was collected about 10 km southeast of Wilpena Chalet (lat. 31°36'S, long. 138°40'E) near the contact between the Moorillah Formation and the underlying Mooloolоo Formation of the Late Precambrian Brachina Subgroup (Plummer 1978). Its lithology is typical of the lower portion of the Moorillah Formation and, although the sample is from float, it is considered to have come from this horizon.

A possible biogenic origin for these structures is suggested if their mode of preservation (i.e. on the basal surface of a sandstone lying directly above a clay layer) is compared with that of the many soft-bodied animal fossils found within the Late Precambrian Ediacara assemblage (see Wade 1968). This, along with their overall circular shape and concentric rings marking their perimeters, suggests a resemblance to small medusoid fossils. If this were so, they would form perhaps the oldest fossil coelenterate occurrence known, lying 2500 m below the level of the Ediacara assemblage, and well beneath the presently known oldest occurrence in the Bonney Sandstone (formerly the "Red Pound") of the Pound Subgroup where small medusoids are found in association with sinuous tracks (Wade 1970).

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[1] Sample in Department of Geology, University of Adelaide: cat. No. 469/EPB110.

Description

The basal surface of the sample measures 16 x 11 cm and shows several roughly circular structures which range 6–20 mm in diameter with relief up to 2 mm (Fig. 1a). The centres of these structures are generally shallowly domed (Fig. 1b), although some are flat, or display a central depression (Fig. 1c). Poorly defined step-like concentric rings are present toward the edges of some of the structures (see Fig. 1b), whilst surrounding them is the suggestion of a flat skirting rim up to 8 mm wide. Shaly material is patchily preserved on this basal surface of the sample, indicating that the ripple cross-laminated sand formed casts of these structures which were developed in, or present on an underlying clay bed.

Interpretation

These structures are comparable to the fossil medusoids classed as *Protolyella* Torell 1870, which includes the taxon *Medusina* Sprigg 1949. *Protolyella* is represented by circular bodies up to 5 cm diameter, comprising a smooth central area and an outer annular zone, separated by an annular furrow (Moore 1956; Glaessner & Wade 1966). Although the central area of these fossils can show faint concentric markings, the outer annular zone usually displays numerous radial grooves not present on the structures described herein.

Other widely distributed circular organic structures of Late Precambrian age are the planktonic remains known as *Chuaria* Walcott 1899. These fossils, however, are usually preserved as black, discoidal compressions, commonly carbonaceous, and having a maximum diameter of 5 mm (Hofmann 1977). As such, the structures described here are too large and of the wrong style of preservation to be *Chuaria*.

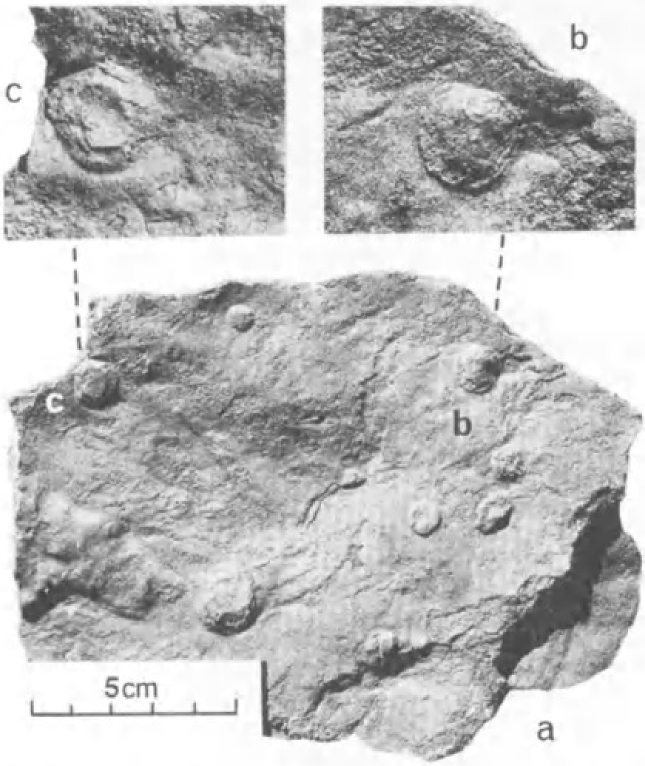

Fig. 1. Circular structures. (a) casts on basal surface of sample; (b) shallowly domed centre; (c) central depression.

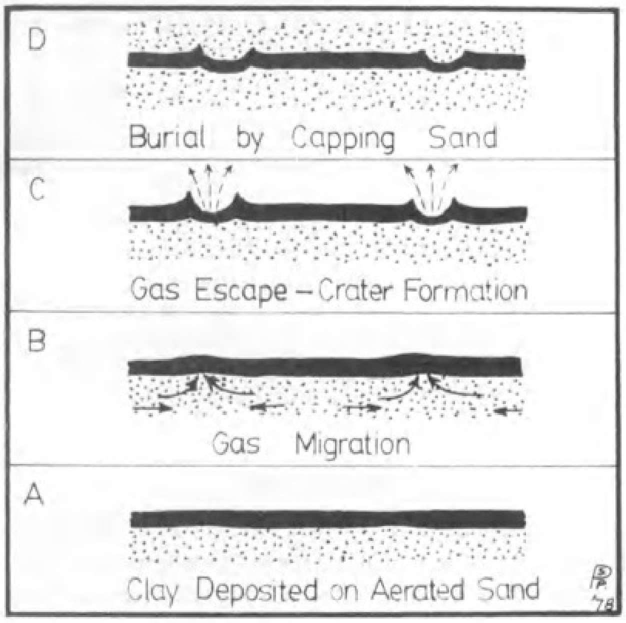

Fig. 2. Schematic diagram of crater formation by 'cold' fluidization process.

Maxson (1940) and Cloud (1960) have interpreted structures comparable to those under discussion in terms of gas escape and fluidization phenomena. Such phenomena are well known to igneous geologists (e.g. Reynolds 1954; Holmes 1965), but their influence upon sedimentation has been little discussed. Mills (1969), however, gives an excellent account of structures formed experimentally by 'cold' fluidization which closely resemble the structures discussed herein. Although his experiments were concerned with the origin of craters on the lunar surface, the phenomenon of 'cold' fluidization is equally applicable to much smaller scale structures.

The process of 'cold' fluidization involves the migration to the surface of gas trapped within a stationary bed. In a cohesive sediment, such as a clay, gas migration can cause the bed to expand and display the flow properties of a liquid. Often the gas flow finds preferred channels of escape and, if the flow is great enough, bubbles may form in the channels. On reaching the surface the bubbles either burst, or dissipate gently (depending on the degree of bed cohesion) causing the bed to then contract and subside. Ring slumping and faulting often accompanies the subsidence, and the net result is the production of circular, crater-like structures.

Such a process could have operated to produce the structures found on the sample described here. Sedimentologic analysis has indicated that the Moorillah Formation was deposited dominantly within an intertidal environment (Plummer 1978). During a period of low tide, gas or air trapped within sandy sediment could have migrated upward through a capping clay layer (possibly deposited during the slack-water stage of the previous high tide) to burst and form small craters on the surface. Gas escape phenomena are known to occur on present-day intertidal flats (Reineck & Singh 1975, Fig. 61), and the burial of such craters by a layer of sand during the following incoming tide could then preserve them as casts on its basal surface (Fig. 2). Such gas produced structures have been called 'evasion marks' by Cloud (1960), who differentiated them from 'contact marks' produced by single, or numerous gas bubbles blown across the sediment surface; raindrop impressions (Lyell 1851, Shrock 1948); and other 'pit-and-mound' structures produced by compaction-induced dewatering (Kindle 1916, Schofield & Keen 1929), or current flow stress (Karcz *et al.* 1974).

Other organic structures?

Also reported from the Moorillah Formation are other structures which were initially believed to be of organic origin. The solitary trace-like marking *Bunyerichnus dalgarnoi* Glaessner 1969 was described as the track of an animal possibly "related to primitive mollusca without mineralized shells" (Glaessner 1969, p. 379). However, Jenkins (1975, p. 19) regarded it "a unique and accidental set of markings made by a tethered implement being moved by a current" (e.g. possibly ribbon-like algae such as are known from rocks of similar age in the U.S.S.R.). A close resemblance is also noted between this marking and certain lineations produced by vorticity along lines of wind flow (Whitney 1978, Fig. 4B). Also, abundant cylindrical to conical structures occur in this formation that resemble either certain fossil burrows or other problematic Precambrian sack-shaped fossil organisms such as *Namalia* Germs 1968, the 'Erniettomorpha' of Pflug (1972) and *Baikalina* Sokolov 1972. These structures, however, are pot-casts produced by the helical scouring action of water currents (Jenkins *et al.* in prep.).

Conclusion

Of the two possible origins presented to explain the structures discussed herein (*viz.* the fossilization of small medusoids, or gas escape and 'cold' fluidization phenomena) the latter, non-biogenic origin is favoured. Similarly, other circular structures found in deposits of Precambrian age that have previously been described as problematica or organic remains (e.g. Bassler 1941, Alf 1959, Shepherd & Thatcher 1959, Johnson & Fox 1968) should be reviewed in terms of formation by fluidization phenomena, or other inorganic processes (as suggested by Cloud 1960, 1973).

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References

ALF, R. M. (1959) Possible fossils from the Early Proterozoic Bass Formation, Grand Canyon, Arizona. *Plateau* **31**, 60-63.

BASSLER, R. S. (1941) A supposed jellyfish from pre-Cambrian of the Grand Canyon. *Proc. U.S. Nat. Mus.* **89**, 519-522.

CLOUD, P. E., Jr. (1960) Gas as a sedimentary and diagenetic agent. *Am. J. Sci.* **258A**, 35-45.

—— (1973) Pseudofossils: A plea for caution. *Geology* **1**, 123-127.

GERMS, G. J. C. (1968) Discovery of a new fossil in the Nama System, South-West Africa. *Nature* **219**, 53-54.

GLAESSNER, M. F. (1969) Trace fossils from the Precambrian and basal Cambrian. *Lethaia* **2**, 369-393.

GLAESSNER, M. F. & WADE, M. (1966) The Late Precambrian fossils from Ediacara, South Australia. *Palaeont.* **9**, 599-628.

HOFMANN, H. J. (1977) The problematic fossil *Chuaria* from the Late Precambrian Uinta Mountain Group, Utah. *Prec. Res.* **4**, 1-11.

HOLMES, A. (1965) "Principles of Physical Geology." (Nelson: London).

JENKINS, R. J. F. (1975) The diversification of early metazoans. *Abstr. 1st Aust. geol. Conv., geol. Soc. Aust.*, 19-20.

JENKINS, R. J. F., PLUMMER, P. S. & MORIARTY, K. C. (in prep.) A South Australian find of abundant Late Precambrian pseudofossils remarkably resembling true fossils of comparable age.

JOHNSON, H. & FOX, S. K., Jr. (1968) *Dipleurozoa* from Lower Silurian of North America. *Science* **162**, 119-120.

KARCZ, I., ENOS, P. & LANGILLE, G. (1974) Structures generated in fluid stressing of freshly deposited clays resembling ichnofossils. *Geology* **2**, 289-290.

KINDLE, E. M. (1916) Small pit and mound structures developed during sedimentation. *Geol. Mag.* **3**, 541-547.

LYELL, C. (1851) On fossil rain-marks of the Recent, Triassic and Carboniferous periods. *Quart. J. geol. Soc. London* **7**, 238-247.

MAXSON, J. H. (1940) Gas pits in non-marine sediments. *J. sediment. Pet.* **10**, 142-145.

MILLS, A. A. (1969) Fluidization phenomenon and possible implications for the origin of lunar craters. *Nature* **224**, 863-866.

MOORE, R. C., (Ed.), (1956) "Treatise on Invertebrate Paleontology. Part F, Coelenterata." (Geol. Soc. Am: Kansas.)

PFLUG, H. D. (1972) Zur Fauna de Nama-Schichten in Südwest-Africa III. Erniettomorpha, Bau und Systematik. *Palaeontographica* **A139**, 134-170.

PLUMMER, P. S. (1978) The stratigraphy of the lower Wilpena Group (Late Precambrian), Flinders Ranges, South Australia. *Trans. R. Soc. S. Aust* **102**, 25-38.

REINECK, H.-E. & SINGH, I. B. (1975) "Depositional Sedimentary Environments." (Springer-Verlag: New York).

REYNOLDS, D. L. (1954) Fluidization as a geological process, and its bearing on the problem of intrusive granites. *Am. J. Sci.* **252**, 577-613.

SCHOFIELD, R. K. & KEEN, B. A. (1929) Rigidity in weak clay suspensions. *Nature* **123**, 492-493.

SHEPHERD, R. G. & THATCHER, D. (1959) The geology of the Quorn military sheet. *Rep. Invest. geol. Surv. S. Aust.* (13).

SHROCK, R. R. (1948) "Sequence in Layered Rocks." (MacGraw-Hill: New York).

SOKOLOV, B. S. (1972) Vendskiy etap v istorii zimli (Vendian Stage in the history of the Earth). *Mezhd. geol. kongr., Dokl. sov. geol. Probl.* **7**, 114-123.

SPRIGG, R. C. (1949). Early Cambrian 'jellyfishes' of Ediacara, South Australia, and Mount John, Kimberley District, Western Australia. *Trans. R. Soc. S. Aust.* **73**, 72-99.

TORELL, O. (1870) Petrifacta suecana formationis cambricaea. *Lunds Univ. Arsskrift 1869, pt. 2*, (8), 1-14.

WADE, M. (1968) Preservation of soft-bodied animals in Precambrian sandstones at Ediacara, South Australia. *Lethaia* **1**, 238-267.

—— (1970) The stratigraphic distribution of the Ediacara Fauna in Australia. *Trans. R. Soc. S. Aust.* **94**, 87-104.

WALCOTT, C. D. (1899) Pre-Cambrian fossiliferous formations. *Bull. geol. Soc. Am.* **10**, 199-244.

WHITNEY, M. I. (1978) The role of vorticity in developing lineation by wind erosion. *Bull. geol. Soc. Am.* **89**, 1-18.