and area of occupancy (AOO: 16 km^2) were calculated based on a cell width of 2 km (ref. 10). The species has been provisionally assessed here as 'Endangered', following the guidelines of IUCN[11]. Landslides are frequent in the Anjaw district of Arunachal Pradesh. Developmental activities such as broadening of roads, construction of schools, new settlements and markets, and jhum cultivation are some of the major threats to this species in Arunachal Pradesh.

1. http://www.plantsoftheworldonline.org (accessed on 30 December 2021).
2. Bhattacharyya, U. C. and Goel, A. K., *Phytotaxonomy*, 2014, **14**, 1–22.
3. Sinha, B. K. and Datta, S., *Nelumbo*, 2016, **58**, 1–43.
4. Jack, W., *Trans. Linn. Soc. London*, 1823, **14**, 42.
5. Clarke, C. B., In *Monographiae Phanerogamarum* (eds de Candolle, A. L. P. P. and de Candolle, A. C. P.), G. Masson, Paris, 1883, vol. 5(1), pp. 1–303.
6. Clarke, C. B., In *The Flora of British India* (ed. Hooker, J. D.), L. Reeve & Co., London, UK, 1884, vol. 4, pp. 336–375.
7. Gledhill, D., *The Names of Plants*, Cambridge University Press, Cambridge, UK, 2002, 3rd edn, pp. 1–326.
8. Dunn, S. T., *Bull. Misc. Inform. Kew*, 1920, **1920**(4), 135.
9. Hu, J., Xiong, Y.-N., Li, L., Liu, Q. and Wen, F., *Phytotaxa*, 2020, **450**, 109–114.
10. Bachman, S., Moat, J., Hill, A., de la Torre, J. and Scott, B., *ZooKeys*, 2011, **150**, 117–126.
11. http://www.iucnredlist.org/documents/RedListGuidelines.pdf.2019 (accessed on 30 December 2021).

ACKNOWLEDGEMENTS. We thank Dr A. A. Mao, Director, Botanical Survey of India, Kolkata, for providing the necessary facilities and encouragement, and Dr V. K. Rawat, Head of Office (ARUN) and Dr M. U. Sharief, Head of Office (MH), for help and support; Dr J. S. Jalal, Scientist, BSI, Kolkata for help in estimation of EOO and AOO. We also thank the Principal Chief Conservator of Forests, Arunachal Pradesh, for collection permits; Mr Khulai Chaitom and Mr Jabralum Chaitom for accommodation, and Mr Isang Chowsong and Mr Sunil Soniyal for help with plant collection.

Received 10 March 2022; accepted 16 March 2022

KRISHNA CHOWLU[1]
GOPAL KRISHNA[2,*]
W. ARISDASON[3]

[1]*Botanical Survey of India, Arunachal Pradesh Regional Centre, Itanagar 791 111, India*
[2]*Botanical Survey of India, CGO Complex, 3rd MSO Building, DF Block, Sector 1, Salt Lake City, Kolkata 700 064, India*
[3]*Botanical Survey of India, Southern Regional Centre, TNAU Campus, Lawley Road, Coimbatore 641 003, India*
**For correspondence.*
e-mail: gopal_bsi@yahoo.co.in

Possible Ediacaran discs from the Paniam Quartzite, Kurnool Group, South India

The Ediacaran Period (635–541 Ma) reveals the appearance of varied life forms, both in animal and plant communities, some of which continued in the Phanerozoic, while a few others disappeared as failed experiments of nature[1–3]. During this period, the Earth experienced significant changes in the lithosphere, biosphere, atmosphere and hydrosphere. Life forms suddenly became big and complex after the Marinoan (~635 Ma) and Gaskiers (~579 Ma) glaciations in the Ediacaran Period[4]. The megascopic Ediacaran fauna that appeared around 570 Ma, with a remarkable diversity around 560–550 Ma, is the first record of morphologically complex life[5–7]. As of now, Ediacaran fossil assemblages have been reported from more than 30 localities worldwide[8]. The distinctive soft-bodied organisms are an important indicator of the evolutionary history of the Proterozoic. Disc-shaped fossils are the most common elements of the Ediacaran biosphere. They were first described by Billings[9] from Canada and are considered as an important component of Ediacaran metazoans, which evolved during the terminal Ediacaran Period. The impressions of Ediacaran discs are found best preserved on the bedding surfaces of siliciclastic sandstone and shale[2,10]. These discs are generally considered to be of Cnidarians affinity and many to be the holdfast of the soft-bodied metazoans.

Similar discs were reported from the different Ediacaran successions of the Indian subcontinent: Krol Formation, Nainital Syncline, Lesser Himalaya[11,12], the Jodhpur Group, Marwar Supergroup[13–17], Maihar Sandstone and Bundi Hill Sandstone of the Vindhyan Supergroup[18–20]. This note discusses the possible Ediacaran discs from the Kurnool Group of peninsular India. Discoid fossils from the Kurnool Group are morphologically well compared with the established forms of the Ediacaran biota.

The Kurnool Group is the youngest group of the Cuddapah Supergroup in South India. It is invariably deposited over different parts of the Cuddapah Supergroup and is exposed in the Kundair Valley in the west and the Palnad area in the northeast (Figure 1)[21]. It has been subdivided into six formations in stratigraphic order. These are: Banganpalle Quartzite, Narji Limestone, Owk Shale, Paniam Quartzite, Koilkuntla

Table 1. Generalized lithostratigraphy of the Kurnool Group, Cuddapah Basin, South India (after Nagaraja Rao *et al.*[21])

Geological unit	Formation	Thickness of the unit (m)
Kurnool Group	Nandyal Shale	50–100
	Koilkuntla Limestone	15–50
	Paniam Quartzite	10–35
	Owk Shale	10–15
	Narji Limestone	100–200
	Banganpalle Formation	10–50
----------	Unconformity ----------	
Cuddapah: Srisailam Quartzite		

Limestone and Nandyal Shale, together attaining a thickness of about 450 m (Table 1)[21]. The age of the Kurnool Group is poorly constrained due to the absence of suitable dating material and rocks for direct radiometric dates. The lowermost unit of the Kurnool Group, i.e. the Banganpalle Quartzite is diamond-bearing, the source of which is considered the Vajrakarur kimberlite dated as 1140 Ma (ref. 22). Thus, the Kurnool Group is considered younger than 1140 Ma; however, the minimum and maximum age for shales of the Kurnool Group is proposed as 500 Ma (K/Ar) and 980 Ma (Rb/Sr) respectively[23]. A limestone xenolith found in the Siddanpalle kimberlite was studied, considering that the limestone was part of the Kurnool Group. Therefore, the age of the Kurnool Group was suggested to be Late Mesoproterozoic (>1090 Ma)[24]. The upper age limit of the Kurnool Group was reported to be >1.1 Ga (ref. 25). Palaeobiological data from the Kurnool Group are meagre and consist of macerated material[26–31]. Gururaja *et al.*[27] recommended that the Pc–C boundary lies within the Kurnool Group. Here we report possible Ediacaran discs from the Paniam Quartzite of the Kurnool Group of the Cuddapah Supergroup. They are preserved as epirelief and hyporelief on the Paniam Quartzite. The remnants of Ediacaran affinity are assigned to ?*Aspidella terranovica*, ?*Nimbia dniesteri*, ?*Charnia* sp. The presence of Ediacaran discs is of significance in understanding the megascopic life, multicellularity and evolution of high-grade body organization in the early biosphere. Documented specimens are deposited in the Birbal Sahni Institute of Palaeosciences (BSIP) museum bearing the numbers BSIP-41836 to BSIP-41839, BSIP-42002 to BSIP-42006 with statement no. 1538.

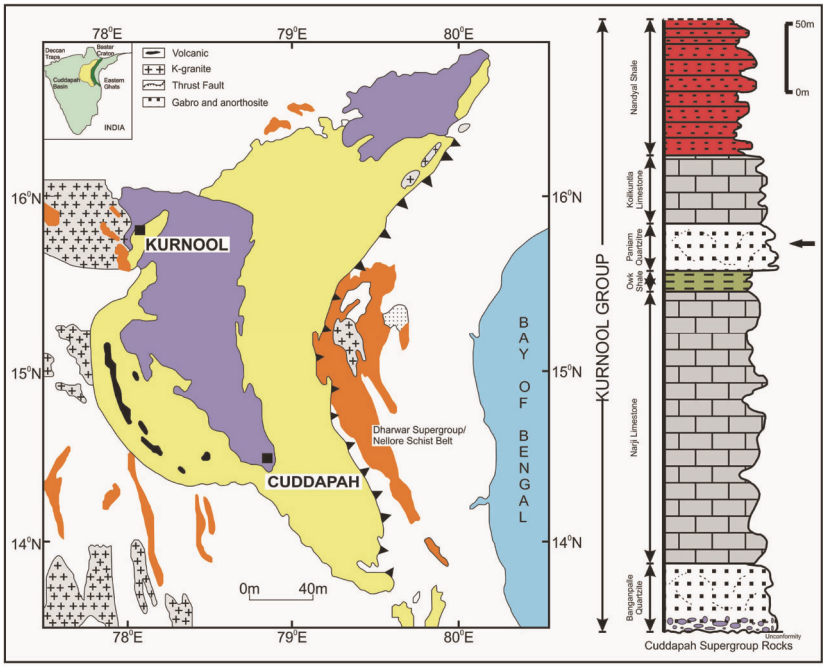

Figure 1. Generalized geological map (after Mishra[36]) and lithostratigraphic succession of the Kurnool Basin, South India (after Nagaraja Rao *et al.*[21]). (Inset) Location of the Cuddapah Basin in India.

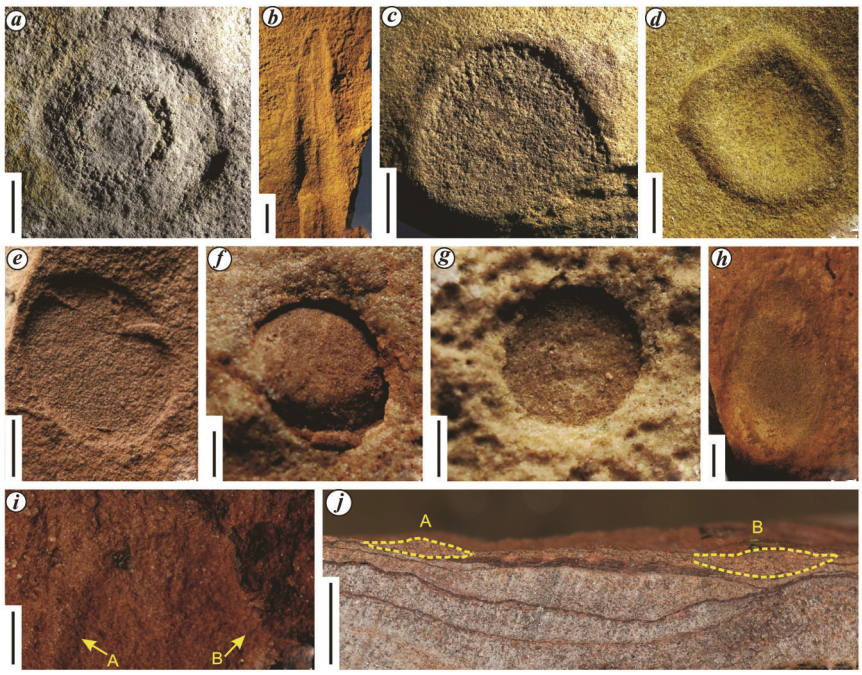

Figure 2. ***a***, ?*Aspidella terranovica*, BSIP specimen no. 41836. ***b***, ?*Charnia* sp.? BSIP specimen no. 41837. ***c***, ***d***, ***i***, ***j***, ?*Nimbia dniesteri*: (***c***) BSIP specimen no. 41838; (***d***) BSIP specimen no. 41839; (***i***, ***j***) BSIP specimen no. 42006; (***j***) BSIP specimen no. 42006. ***e–h***, Discoidal structures: (***e***) BSIP specimen no. 42002; (***f***) BSIP specimen no. 42003; (***g***) BSIP specimen no. 42004; (***h***) BSIP specimen no. 42005. (Scale bar: ***a–c***, ***c***, ***e***, ***h*** = 10 mm and for ***d***, ***f***, ***g***, ***i***, ***j*** = 5 mm.)

?*Aspidella terranovica* Billings 1872.

Description: One complete specimen. Rounded form with wide marginal area, sharp outer ring, having 30 mm of diameter, with a central boss of 15 mm diameter, the disc is smooth with a radial groove (Figure 2 *a*).

?*Charnia* sp.

Description: One incomplete specimen closely resembling ?*Charnia* (Figure 2 *b*). The specimen is ovate having an elongated body that narrows towards the tip; 65 mm in length and 14 mm in width, with a straight central furrow. Head shield *U*-shaped. Although similar to *Charnia*, there are no primary branching units, making it difficult to be convincingly established as *Charnia*.

?*Nimbia dniesteri* Fedonkin, 1980 (ref. 32).

Description: Three specimens. Small discoidal organism with flat and smooth central

part and protruding margin <1 mm, rim of 2 mm thickness, which is circular to slightly elliptical in shape (Figure 2 *c*). The diameter of the specimen is 32 mm. The smaller specimen is simple discoid-shaped having a smooth inner surface with a gentle groove, with a raised outer rim of 13 mm diameter (Figure 2 *d*, *i* and *j*).

The discs reported above reveal the presence of possible Ediacaran fossil assemblage in the southern part of peninsular India and indirectly indicate the age of the fossil-bearing horizon. Although there are uncertainties regarding the exact age of the possible discoid fossils reported from the Paniam Quartzite (Figure 2 *e*–*h*), the presence of most of the fossil *Aspidella* in the terminal Ediacaran[33,34] helps constraint the age of the Paniam Quartzite to Ediacaran. Previous reports on the presence of worm burrow in the underlying Narji Limestone and *Obruchevella*, *Chuaria*, *Tawuia* and *Leiospherids* in Owk Shale, and the presence of trace fossils in the Paniam Quartzite also corroborate the Ediacaran age for the Paniam Quartzite[28–31,35]. A further collection of specimens is required to strengthen the biostratigraphy of this region. The age of the Kurnool Group, therefore, should be Neoproterozoic and may be bracketed in the Ediacaran Period.

1. Vickers-Rich, P. and Komarower, P. (eds), *Geol. Soc. London Spec. Publ.*, 2007, **286**, 456.
2. Fedonkin, M. A., Gehling, J. G., Grey, K., Narbonne, G. M. and Vickers-Rich, P., *The Rise of Animals: Evolution and Diversification of the Kingdom Animalia*, The Johns Hopkins University Press, Baltimore, USA, 2007, p. 326.
3. Narbonne, G. M., *Annu. Rev. Earth Planet. Sci.*, 2005, **33**, 421–442.
4. Muscente, A. D., Boag, T. H., Bykova, N. and Schiffbauer, J. D., *Earth.-Sci. Rev.*, 2018, **177**, 248–264.
5. Knoll, A. H. and Carroll, S. B., *Science*, 1999, **284**, 2129–2137.
6. Knoll, A. H., Walter, M. R., Narbonne, G. M. and Christie-Blick, N., *Science*, 2004, **305**, 621–622.
7. Martin, M. W., Grazhdankin, D. V., Bowring, S. A., Evans, D. A. D., Fedonkin, M. A. and Kirschvink, J. L., *Science*, 2000, **288**, 841–845.
8. Narbonne, G. M., Xiao, S., Shields, G. A. and Gehling, J. G., *The Geologic Time Scale*, Elsevier, 2012, **1**, 413–435.
9. Billings, E., *Can. Nat*., 1872, **6**, 478.
10. Laflamme, M., Darroch, S. A. F., Tweedt, S. M., Peterson, K. J. and Erwin, D. H., *Gondwana Res*., 2013, **23**, 558–573.
11. Mathur, V. K. and Shanker, R., *J. Geol. Soc. India*, 1990, **36**, 74–78.
12. Shanker, R., Bhattacharya, D. D., Pandey, A. C. and Mathur, V. K., *J. Geol. Soc. India*, 2004, **63**(6), 649–654.
13. Raghav, K. S., De, C. and Jain, R. L., *Indian Min*., 2005, **59**(1–2), 23–30.
14. Kumar, S. and Pandey, S. K., *J. Palaeontol. Soc. India*, 2009, **54**(2), 171–178.
15. Srivastava, P., In Gordon Research Conference in Geobiology, California, USA, 2011.
16. Srivastava, P., *Int. J. Geol.*, 2012, **3**, 1120–1126.
17. Srivastava, P., *Geosci. Front*., 2014, **5**(2), 183–191.
18. De, C., *J. Asian Earth Sci*., 2006, **27**, 660–683.
19. Srivastava, P., In Proceedings of the Diamond Jubilee International Conference, Birbal Sahni Institute of Palaeosciences, Lucknow, 2006, pp. 187–188.
20. Srivastava, P., *Geol. Soc. London Spec. Publ*., 2012, **365**, 247–262.
21. Nagaraja Rao, B. K., Rajurkar, S. T., Ramalingaswamy, G. and Ravindra Babu, B., *Mem. Geol. Soc. India*, 1987, **6**, 33–86.
22. Crawford, A. R. and Compston, W., *J. Geol. Soc. Aust.*, 1973, **19**(4), 453–464.
23. Raman, P. K. and Murty, V. N., *Geology of Andhra Pradesh*, Geological Society of India, 1997, p. 235.
24. Dongre, A., Chalapathi Rao, N. V. and Kamde, G., *J. Geol.*, 2008, **116**(2), 184–191.
25. Chalapathi Rao, N. V., Anand, M., Dongre, A. and Osborne, I., *Int. J. Earth Sci*., 2010, **99**(8), 1791–1804.
26. King, W., *Geol. Surv. India Mem*., 1872, **8**, 346.
27. Gururaja, M. N., Ashok Kumar, P., Rao, C. V. and Chauhan, R. H., *Geol. Surv. India*, *Spec. Publ*., 2000, **55**, 155–162.
28. Sharma, M. and Shukla, M., *Curr. Sci*., 1999, **76**(9), 1247–1251.
29. Sharma, M., *Mem. Geol. Soc. India*, 2008, **74**, 119–131.
30. Sharma, M. and Shukla, Y., *J. Earth Syst. Sci.*, 2012, **121**(3), 755–768.
31. Sharma, M. and Shukla, Y., *J. Palaeontol. Soc. India*, 2016, **61**(2), 175–187.
32. Fedonkin, M. A., *Paleontol. J.*, 1980, **2**, 7–15.
33. Xiao, S. and Laflamme, M., *Trends. Ecol. Evol*., 2009, **24**, 31–40.
34. Gehling, J. G., Narbonne, G. M. and Anderson, M. M., *Palaeontology*, 2000, **43**(3), 427–456.
35. Kumar, A., Anantaram, P., Patil, R. S., Guruaja, M. N. and Das Shram, D. C., *Rec. Geol. Surv. India*, 1993, **126**(5), 296.
36. Mishra, D. C., *J. Geol. Soc. India*, 2011, **77**, 17–25.

ACKNOWLEDGEMENTS. We thank our colleagues V. K. Singh, S. K. Pandey, Yogmaya Shukla and Shamim Ahmad for help during this work. Financial support received under DST-RFBR (grant no. INT/RUS/RFBR/P-278) is acknowledged. We also thank the Director, BSIP, Lucknow, for providing the necessary facilities and permission to publish this paper (BSIP/RDCC/77/2019-20).

Received 17 March 2020; re-revised accepted 15 March 2022

YOGESH KUMAR[1,2]
MUKUND SHARMA[1,*]
SHREERUP GOSWAMI[2,3]

[1]*Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow 226 007, India*
[2]*Department of Earth Sciences, Sambalpur University, Jyoti Vihar, Burla, Sambalpur 768 019, India*
[3]*Present address: Department of Geology, Utkal University, Vani Vihar, Bhubaneswar 751 004, India*
**For correspondence.*
e-mail: mukund_sharma@bsip.res.in