

# Supporting Information

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## SI Text

### Geological Setting

The Doushantuo Formation in the Weng'an phosphorite mining area, Guizhou Province, South China (Fig. S1A), crops out in a pattern controlled by a north/northeast-south/southwest-trending Baiyan–Gaoping anticline (Fig. S1B). The Doushantuo sequence here represents a typical shallow water facies succession of the southwestern margin of the Yangtze block during the Ediacaran period (1). A generalized stratigraphic column of the Doushantuo Formation in this area is displayed in Fig. S1C. The entire formation is composed of six members, including the cap dolomite, the lower phosphorite, the middle dolomite, the upper phosphorite, the phosphoritic dolomite members, and banded phosphorite member. A *ca.* 40-cm-thick Fe–Mn-rich mudstone unit separates the Doushantuo Formation from the underlying Nantuo tillite (deposit of the global Marinoan glaciation, Snowball Earth). The lower part of the Doushantuo Formation consists of *ca.* 20 m of thickly bedded dolomite interstratified with shale in the middle part. This unit is considered to be a cap carbonate. However, unlike the typical cap carbonate in the Yangtze Gorges area (1, 2), it is much thicker, and no characteristic sheet cracks or giant tepee-like cross-bedding could be observed. The cap dolomite is overlain by the lower phosphorite member, with siltstone and thin intercalated phosphorite layers in the lower part and laminated siliceous phosphorite in the upper part. A dolomite member is developed in the middle of the Doushantuo Formation, overlying the lower phosphorite member. The thickness of this member varies in the Weng'an mining area because the top boundary of the member is a karstic and erosive surface. Above the karstic surface, there is a *ca.* 2.5-m-thick black phosphorite, which constitutes the lower part of the upper phosphorite member. The upper part of this member is oolitic dolomitic phosphorite. Well-preserved embryos, acritarchs, and multicellular algae have been discovered in this interval. The unit overlying the upper phosphorite member is a 4-m-thick, thinly bedded dolomite, interbedded with thin layers of micritic phosphorite. The top of the Doushantuo Formation is characterized by 3- to 5-m-thick banded phosphorite. The Doushantuo Formation is overlain by the Dengying Formation, and the boundary between the two formations is gradational.

All of the rock samples for this study are gray oolitic dolomite phosphorite from the lower part of the upper phosphorite member (Fig. S1).

### Systematic Paleontology

**Phylum.** The phylum is Porifera.

**Genus.** The genus is *Eocyathispongia* gen. nov.

**Etymology.** The generic name is a compound of “dawn” (Greek *eo-*) and “cup-shaped” (Greek *cyathifer*), combined with an indication of its biological taxonomy.

**Diagnosis.** The fossil specimen is a small, solitary sessile sponge (about 1.2 mm in width and depth, 1.1 mm high; Fig. 1) that is soft-bodied and cup-shaped, with a holdfast-like base. It lacks an overt anterior/posterior or dorsal/ventral axis but has a clear basal/apical polarity, terminating in a major funnel-like opening at the end facing up. The animal consisted of three independent tubular chambers, emergent from the common base. The largest chamber gives rise to an outflow funnel, which is  $\sim 300$   $\mu\text{m}$  in diameter at its exit, but each of the other two chambers also resolves into apical, osculum-like openings. The largest chamber is curved and bulbous, whereas the other two emerge more directly up from the common base of the specimen. The whole specimen is covered by flattened cells (8–12  $\mu\text{m}$  in diameter, not uniform in shape or orientation), except for an area covered by a lawn of very closely packed, protruding, short, hollow tubes (some are  $>10$   $\mu\text{m}$  tall, and they are typically 5–8  $\mu\text{m}$  in diameter). The holdfast-like base is solid, consisting of an outer layer and an inner layer. There are no basement membrane-like structures between the two layers. Inside the funnel, the inner surface is lined with an array of spaced pits, arranged non-randomly in rows, pairs, and sometimes rosettes. The pits are about 8–10  $\mu\text{m}$  in diameter.

**Type of Species.** The species type is *Eocyathispongia qiania* gen. et sp. nov. (Fig. 1).

**Etymology.** The specific name refers to the abbreviation of Guizhou Province, China.

**Holotype.** The holotype number is NIGPAS161760.

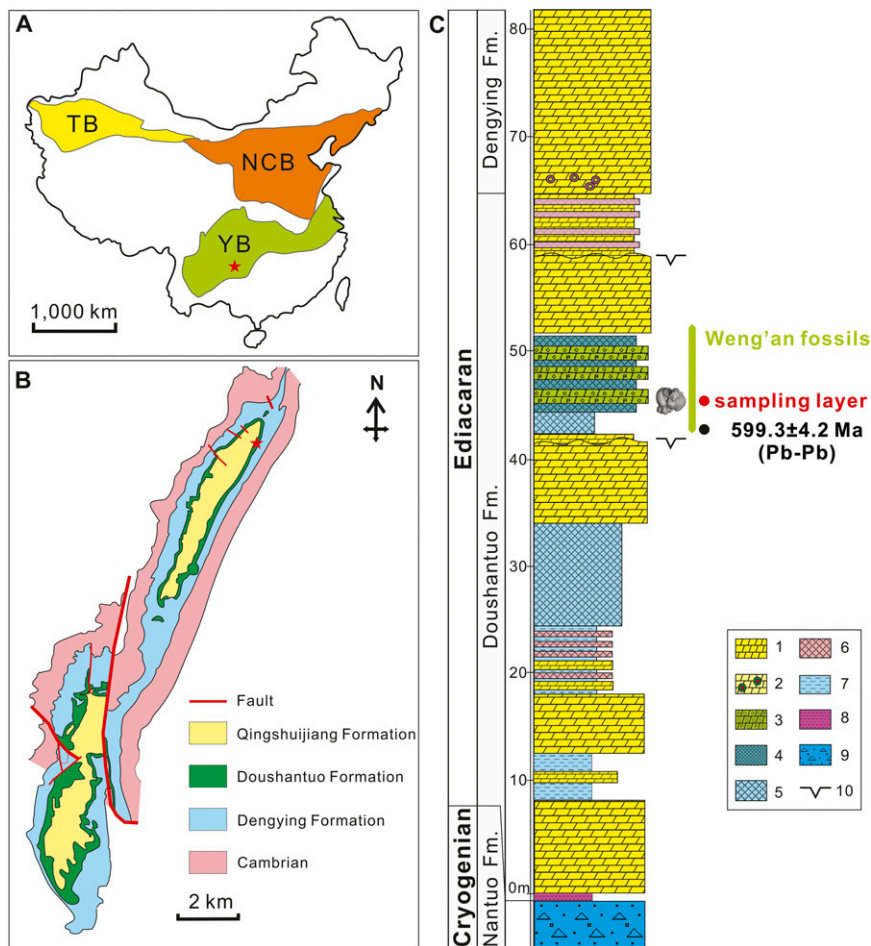
**Material.** The single specimen is housed at the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.

**Diagnosis.** The diagnosis is the same as the generic diagnosis.

**Locality and Stratigraphy.** The specimen was discovered at the Badoushan phosphorite mining quarry, Weng'an County, Central Guizhou. It was taken from the lower part of the gray oolitic dolomitic phosphorite layer of the upper phosphorite member, Doushantuo Formation.

1. Zhu M, Zhang J, Yang A (2007) Integrated Ediacaran (Sinian) chronostratigraphy of South China. *Palaeogeogr Palaeoclimatol Palaeoecol* 254(1–2):7–61.

2. Zhu M, et al. (2013) Carbon isotope chemostratigraphy and sedimentary facies evolution of the Ediacaran Doushantuo Formation in western Hubei, South China. *Pre-cambrian Res* 225:7–28.



**Fig. S1.** Locality and geology maps and stratigraphic column. (A) Relationships between the Yangtze Block (YB), North China Block (NCB), and Tarim Block (TB). A red star marks the locality of the Weng'an phosphorite mining area. (B) Geological setting of the Weng'an area; the outcrop is marked by a red star. (C) Ediacaran stratigraphic column of the Beidoushan section in the Weng'an area showing the fossil horizon. The radiometric Pb-Pb age of  $599.3 \pm 4.2$  Ma data are from refs. 1 and 2. The Doushantuo sequence in the area crops out in a pattern controlled by a north/northeast-south/southwest-trending Baiyan-Gaoping anticline (as shown in B), representing a typical shallow water facies succession of the southwestern margin of the Yangtze block during the Ediacaran period. Data from ref. 3. The entire Doushantuo sequence (as shown in C) is composed of five members, and the Doushantuo microfossils are from the upper phosphorite member, which comprises two different lithological facies: the lower black siliceous phosphorites and the upper gray oolitic, phosphatized dolostone. The fossil specimen for this study was collected from the upper gray lithological facies, in which all of the microfossils are phosphatized and well preserved in the form of phosphate oolites, cemented together by carbonate. 1, dolomite; 2, oncolite dolomite; 3, phosphorous dolomite; 4, dolomitic phosphorite; 5, black phosphorite; 6, siliceous phosphorite; 7, shale; 8, Fe-Mn-rich mudstone; 9, tillite; 10, erosion surface. Fm., formation.

- Barfod GH, et al. (2002) New Lu-Hf and Pb-Pb age constraints on the earliest animal fossils. *Earth Planet Sci Lett* 201(1):203–212.
- Liu P, et al. (2014) High-resolution biostratigraphic and chemostratigraphic data from the Chenjiayuanzi section of the Doushantuo Formation in the Yangtze Gorges area, South China: Implication for subdivision and global correlation of the Ediacaran System. *Precambrian Res* 249:199–214.
- Zhu M, Zhang J, Yang A (2007) Integrated Ediacaran (Sinian) chronostratigraphy of South China. *Palaeogeogr Palaeoclimatol Palaeoecol* 254(1-2):7–61.

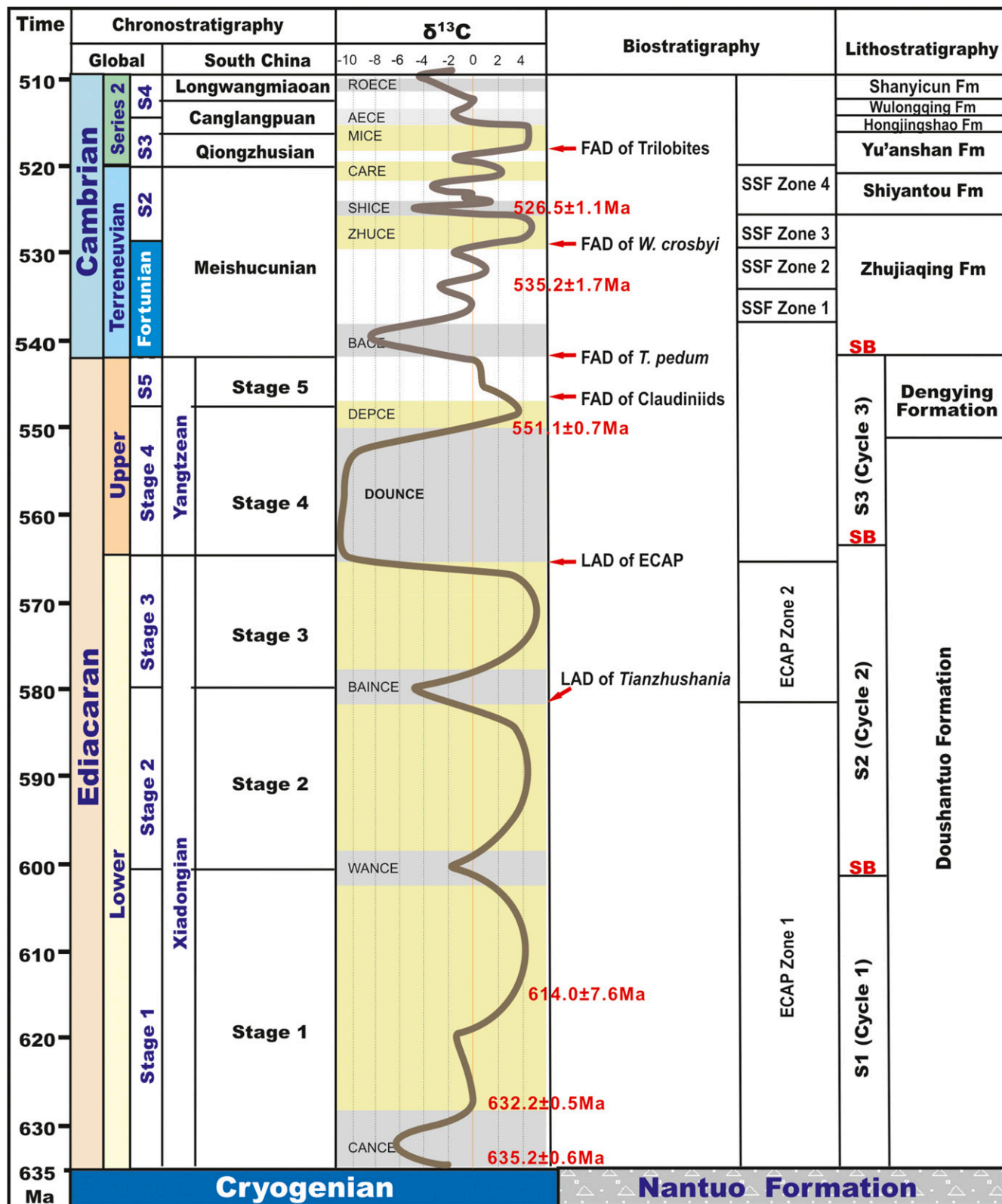
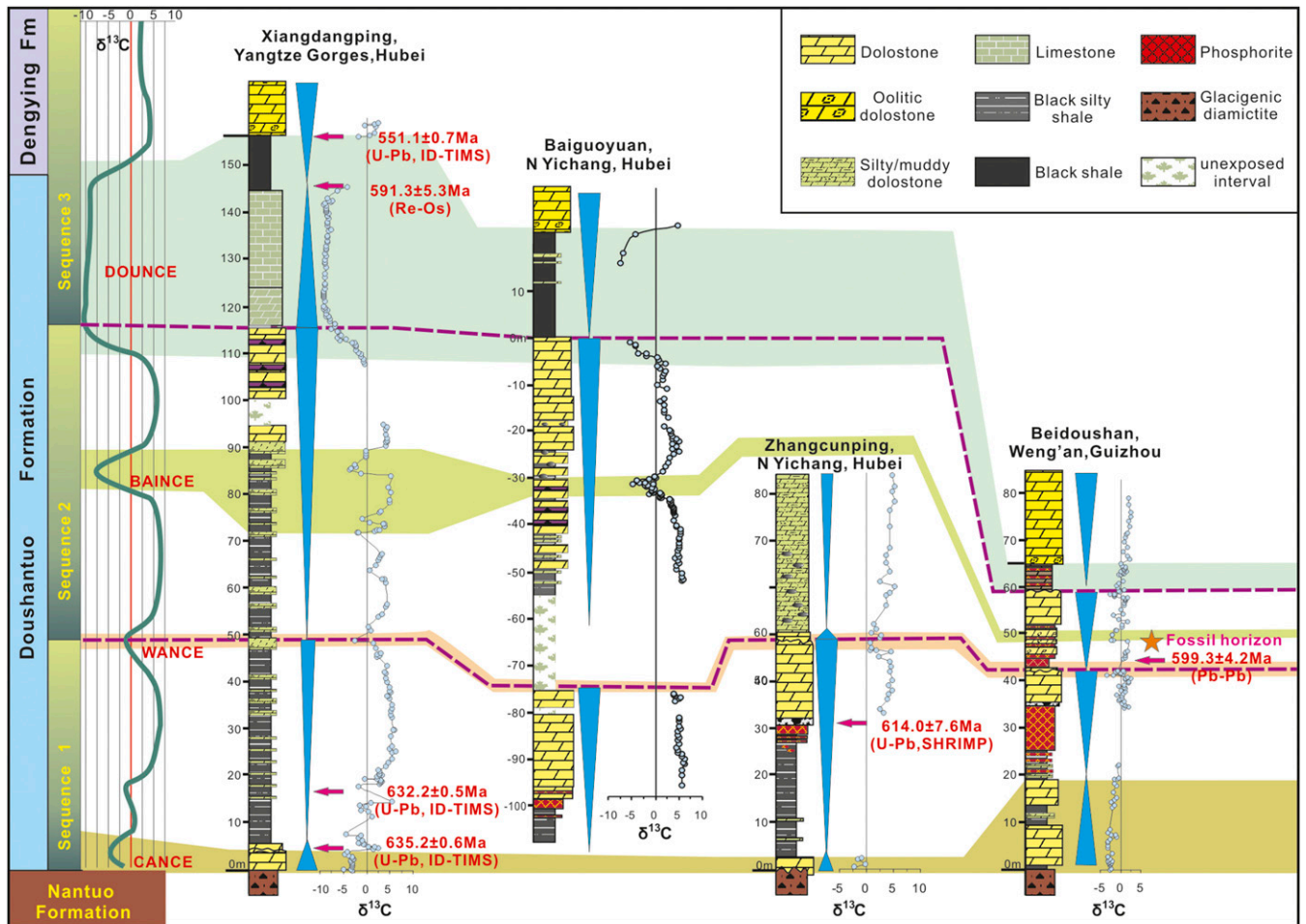


Fig. S2. Integrated Ediacaran stratigraphic framework of South China. Data from refs. 1–3. Radiometric age data from refs. 4–7. ECAP, Ediacaran complex acanthomorphic palynoflora; FAD, first appearance datum; LAD, last appearance datum; SB, sequence boundary; SSF, small shelly fossils.

- Zhu M, Zhang J, Yang A (2007) Integrated Ediacaran (Sinian) chronostratigraphy of South China. *Palaeogeogr Palaeoclimatol Palaeoecol* 254(1-2):7–61.
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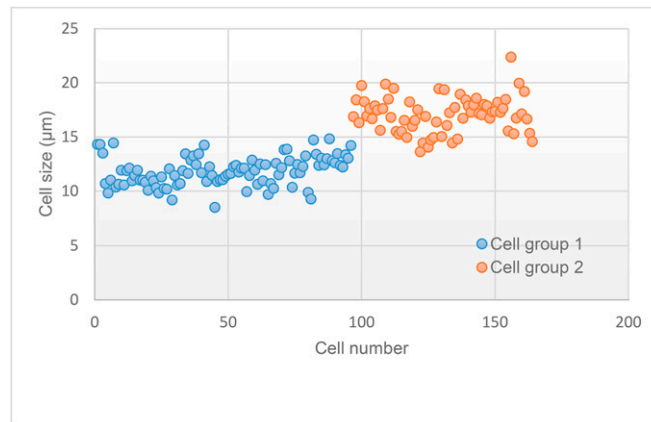
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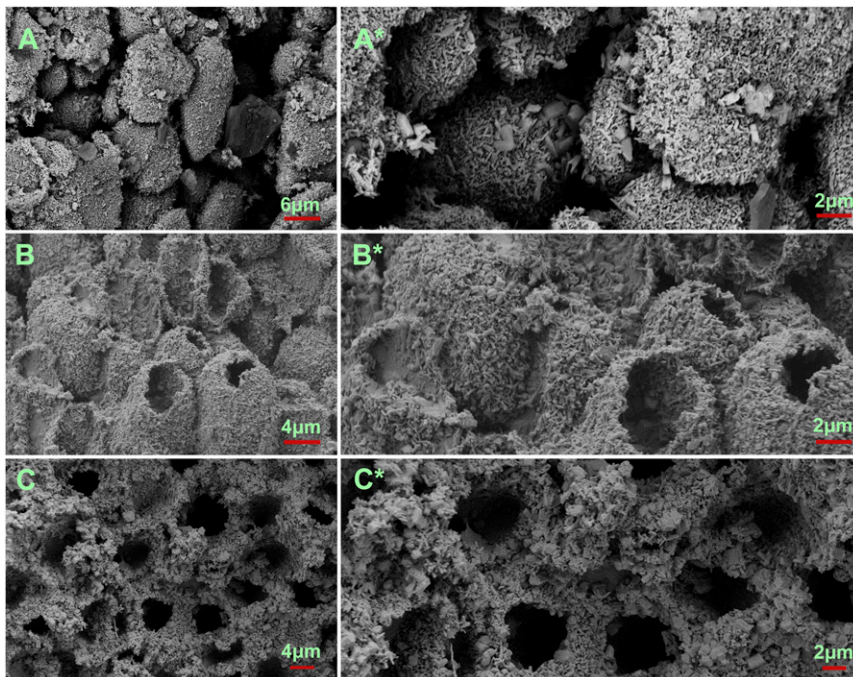
**Fig. S3.** Sequence and carbon isotope chemostratigraphic correlations of the Ediacaran Doushantuo successions between the Beidoushan section and other representative sections in the Yichang area (western Hubei). Data from refs. 1 and 2. Radiometric age data from refs. 3–6. ID-TIMS, isotope dilution-thermal ionization mass spectrometry; SHRIMP, sensitive high-resolution ion microprobe.

- Zhu M, Zhang J, Yang A (2007) Integrated Ediacaran (Sinian) chronostratigraphy of South China. *Palaeogeogr Palaeoclimatol Palaeoecol* 254(1-2):7–61.
- Zhu M, et al. (2013) Carbon isotope chemostratigraphy and sedimentary facies evolution of the Ediacaran Doushantuo Formation in western Hubei, South China. *Precambrian Res* 225:7–28.
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- Zhu B, et al. (2013) Re-Os geochronology of black shales from the Neoproterozoic Doushantuo Formation, Yangtze platform, South China. *Precambrian Res* 225:67–76.





**Fig. 54.** Measurements of cell size on the surface of the specimen, showing the constancy of cell size of the two different groups. Cell group 1 comprises round cells, and cell group 2 comprises oval cells. The size of the oval cells is the length of their long axis.



**Fig. 55.** Phosphatic impregnation of cells. All of the pictures are SEM images. The external covering cells on the surface (A), the small papillae-like hollow tubes (B), and the cell-like structure on the inner surface of the large funnel (C) are shown. (A\*–C\*) Higher magnification SEM views of areas from A–C, respectively. Note the apparently random orientation of these tiny phosphatic crystals.