Widespread tetraradial symmetry among early fossil sponges

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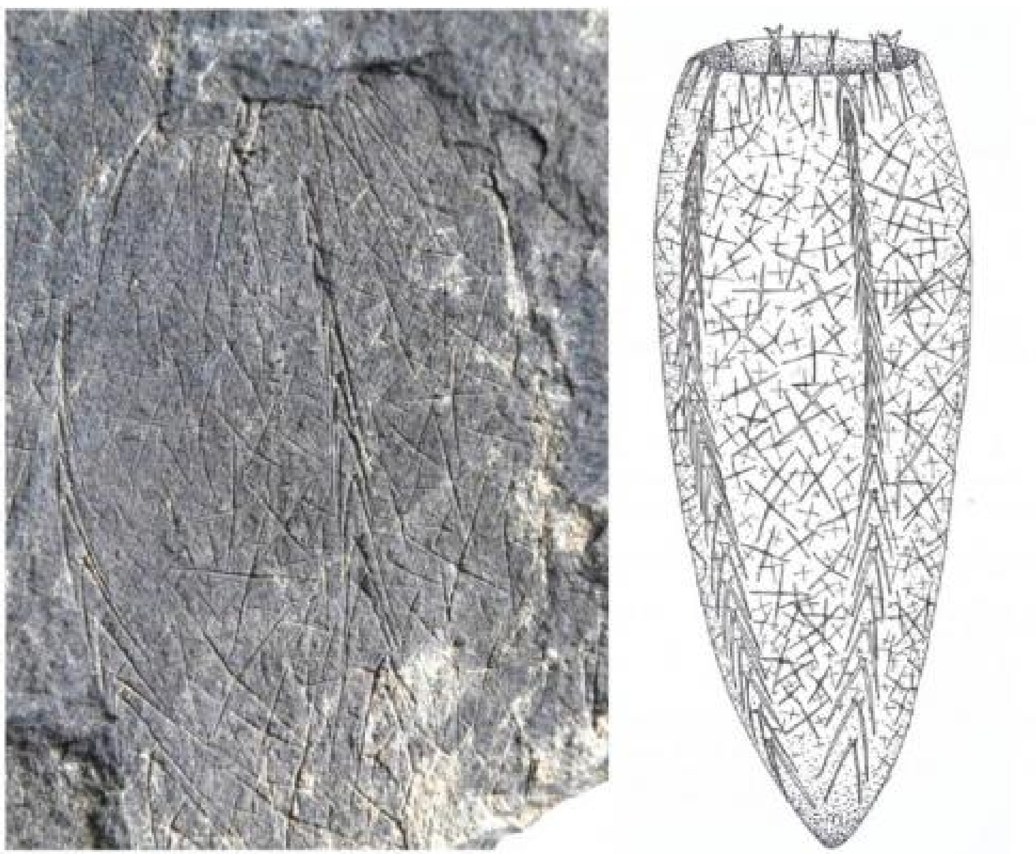

This is part of one of the new specimens of *Metaxyspongia* with tetraradial symmetry, and reconstruction of the whole animal. The fossil is 9 mm wide, with the delicate skeleton flattened onto the plane of the rock. Most of the skeleton is composed of cross-shaped spicules, except for the columns of modified spicules that define the symmetry of the sponge. Credit: Science China Press

Sponges are usually considered to be the oldest living animals, having evolved before all other groups. The simplicity of their body structure and tissue organization has for many years made them candidates for the ancestral group of animals, and they have long been regarded as our best illustration of what the earliest animals would have looked like. This has been supported by genetic analyses, which suggest that sponges branched from other animals a very long time ago, deep in the Precambrian. Until recently, most zoologists believed that sponges were little more advanced than a colonial protist, with tissues and organs never fully developed. However, in recent years there has been an increasing appreciation of the complexity of their genetics and biochemistry, and this has cast doubt on the impression of simplicity. Now, new evidence from the fossil record confirms that early sponges were in some ways more complex than their living descendents.

The fossil record of early sponges is patchy. Although they have a mineral skeleton made of minute silica (opal) and/or calcite spicules, in most sponges this is a very delicate structure that is normally destroyed before being fossilized. However, there are occasional sites with exceptionally-preserved fossils around the world, and these often include sponges. Most of these resemble the living deep-sea group called hexactinellids, but this is now known to be a superficial similarity, and the fossils include a range of very primitive sponge groups that evolved before the appearance of the living classes. These 'stem-group' fossils are vital in revealing what early sponges were like, and how they differed from living species.

Most of the early sponge fossils show definite shapes. Usually these are globose or vase-shaped, with a single circular opening at the top. The irregular compound growth form of most living species evolved later, and is not a primitive feature. Some early sponges have an angular outline, usually eight-sided. This is well known among palaeontologists, but has not previously been regarded as significant because the examples are scattered, and any similarity has been presumed to be coincidental. Also, it has been assumed that these prismatic outlines do not represent true symmetry, but are merely shapes evolved in response to their environments. Remarkable new sponge fossils from the early Cambrian (around 520 million years old) Hetang Biota of Anhui, South China, have now been found by Dr. Joseph BOTTING and colleagues from the Nanjing Institute of Palaeontology, China, and show that there is more to these outlines than has been thought. These fossils, which are classified in the genus Metaxyspongia, had a roughly circular outline but a symmetrical skeleton with four columns of large spicules running up the full height of the sponge. Several similar sponges have also been recovered in the assemblage, and this group is also related to Takkakawia from Canada's famous Burgess Shale deposit. In Takkakawia, the four columns each divide very low down to give eight-fold symmetry, but in the Chinese fossils, there are only four columns throughout.

Isolated sponges with tetraradial symmetry might be fortuitous or environmentally controlled, but there are now examples known from several different groups of early sponges, and no consistent examples of any other symmetry. The consistency of the structural symmetry within Metaxyspongia and its relatives implies that this is a real, genetically-controlled aspect of their biology. The early growth stages of other fossil sponges also reveal the same symmetry, where there is no obvious symmetry in the adults. There is even a trace of this symmetry known in living calcareous sponges, in which the larvae at one stage show a tetraradial arrangement of cells. This range of examples suggest that it is a deep-rooted aspect of sponge biology.

Symmetry is not visible in living sponges, but this may be because they have evolved to be more irregular, with compound, often encrusting growth that is adapted to fit the environments in which they live. Even if their bodies are organized on a tetraradial blueprint, they no longer have the structured organization that allows us to see it, and the genetics dictating their symmetry may even have been degraded or lost. In the early fossils, though, this symmetry was widespread and obvious.

If sponges originally had tetraradial symmetry, then it they were too highly organized to have evolved directly from colonial protists. The symmetry also suggests a direct relationship with one of the other early animal groups, the cnidarians (which include corals and jellyfish). These are the only other animal group to include tetraradial body-plans, and the possibility that there is some shared symmetry between sponges and cnidarians must be considered. Most importantly, this unexpected complexity of early sponges means that we no longer have a good idea of what the last common ancestor of animals looked like – but it seems it may not have looked anything like a sponge.

More information: Botting, J P, Yuan X and Lin J P. Tetraradial symmetry in early poriferans. CHIN SCI BULL, 2014 vol 59(7): 639-644.
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