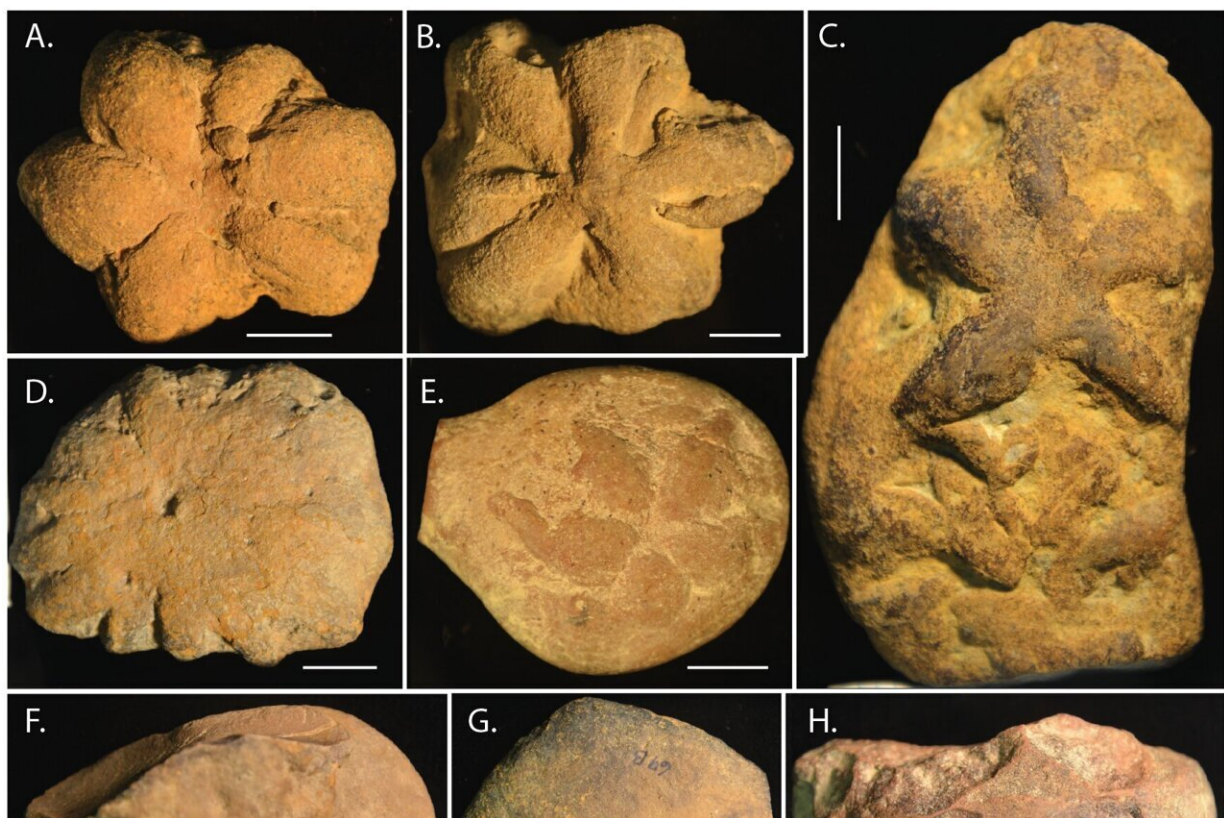


Is the middle Cambrian *Brooksella* a hexactinellid sponge, trace fossil or pseudofossil?

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Brooksella shapes are variable: typical *Brooksella* have approximately six lobes (A, B); twinned *Brooksella* can also occur (C); others can have multiple indistinct lobes (D) or lobes that are completely embedded in a concretion (E). Concretions (F–K) also vary in shape, but are mostly round to oblong and many have fossils fragments or whole trilobites embedded in them. Scale bars = one cm.

Brooksella figured: (A) UGA 1; (B) UGA WSL2.AL2; (C) UGA WSL2.AL16;

(D) UGA WSL2.AL4; (E) UGA LSV1.AL2; concretions figured: (F) UGA 40; (G) UGA 69; (H) UGA 25; (I) UGA 73; (J) UGA 136; (K) UGA 22. Credit: *PeerJ* (2023). DOI: 10.7717/peerj.14796/fig-5

More than 100 years ago, Charles Doolittle Walcott from the Smithsonian Institution was asked to examine strange star-shaped fossils with lobes hailing from the ~ 514-million-year-old Conasauga Formation in Alabama. Walcott described these odd fossils as jellyfish that likely floated in the middle Cambrian seas of what is now the southeastern United States. Little did he know that the Cambrian fossil he named would cause more than 100 years of controversy.

The controversy hinged on the interpretation of what *Brooksella* really was: Was it truly a jellyfish that would be important for middle Cambrian marine ecosystems, a time when animals were originating and diversifying for the first time on Earth? Or was *Brooksella* just preserved gas bubbles? Or maybe it was a type of bulbous algae? Or a glass sponge made of opaline silica?

Or, as hypothesized, perhaps *Brooksella* was not a fossil at all.

Using shape and chemical analyses combined with high-resolution 3D imaging, we evaluated whether *Brooksella* was a fossil, like a sponge, a trace fossil, representing the burrows of worm-like animals, or not a fossil. We found that *Brooksella* lacked characteristics of glass sponges, specifically, the opaline-fused spicules that compose the body. Nor did it grow as a sponge would be expected to over its lifetime. Importantly, in the field, its purported excurrent canal (osculum) was always oriented down in the sediment, which would make it very hard—if not impossible—to filter water for food.

We also did not find any indication that worms made the iconic star-shaped lobes. We then compared the composition and internal structure of *Brooksella* to silica concretions from the same middle Cambrian rock beds. We did not find any difference between *Brooksella* and the concretions, other than *Brooksella* had lobes and the concretions did not. We thus concluded that *Brooksella* was not part of early sponge diversification in middle Cambrian seas, but rather, was an unusual type of silica concretion. Concretions can be all kinds of shapes to the point some look like they were organically formed.

The significance of our finding is two-fold: First, there are numerous enigmatic Cambrian fossils that need to be scrutinized to determine if they are really fossils to help paleontologists refine biodiversity estimates for the Cambrian when most of Earth's major animal groups originated. Second, this is not the first time that unusual fossils and rocks from the Cambrian have puzzled scientists, and our findings highlight the necessity of close scrutiny of early fossil materials, especially using newer, powerful analytical techniques like micro-CT in combination with classic lab and field approaches.



Sunset at Weiss Lake where *Brooksella alternata* were collected. Credit: Morrison R. Nolan

Morrison Nolan, Department of Geosciences, Virginia Tech, says, "*Brooksella alternata* interests me because so many scientists have worked on identifying it and have come to very different conclusions. It really illustrates how difficult it can be to distinguish one type of life from another, and even life from non-life, which is especially challenging for early materials in the [geologic record](#)."

"Amateur paleontological/geological groups like the Georgia Mineral Society helped me learn about *Brooksella* and other interesting

geological features around me. Such groups do a great job of teaching the public about the geologic past and bringing people to the field to see and learn about these features."

Sally Walker, Professor of Paleontology at the University of Georgia in Athens, Georgia, U.S., says, "Brooksella intrigued me because, unlike most fossils, it had a 3D shape like a star-shaped puffed pastry that is unusual for soft-squishy animals like a sponge. A sponge usually gets flattened like roadkill during the fossilization process—especially a fossil more than 500 million years old.

"Also puzzling was the fact that no one inspected Brooksella where it lived and its orientation; if they did, they would find that most lobes were oriented downward, which does not make sense for a sponge to be eating mud. Lastly, the puzzle of Brooksella continues: What are the physical, chemical and perhaps [biological processes](#) that actually formed these strange Brooksella concretions? That is for a future paleontologist to solve.

James Schiffbauer, Associate Professor of Geological Sciences, University of Missouri, says, "While the applications for microCT have been nearly endless in the materials sciences and engineering fields, its capacities for elucidating the fossil record are really just beginning to be explored. This project is an excellent example of the types of fossil mysteries we can solve with applications of microCT. When we can scrutinize the internal construction of Brooksella with reference to its many past interpretations, it becomes increasingly apparent that none of them really match."

More information: Morrison R. Nolan et al, Is the middle Cambrian Brooksella a hexactinellid sponge, trace fossil or pseudofossil?, *PeerJ* (2023). [DOI: 10.7717/peerj.14796](https://doi.org/10.7717/peerj.14796)

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