Extra-large and morphologically unique microfossils of the 2.52 Ga Gamohaan Formation, South Africa

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Abstract

The microorganisms that evolved during the Archean era had extraordinary impacts on this planet. If not for them, Earth would not have developed the oxygen-rich atmosphere needed to support the evolution of multicellular organisms. However, our direct observations of life from that time come from only fifteen known fossiliferous Archean rock formations, and the exploration of these formations is not complete. As a result, study of these formations can yield new insights into the communities of microfossils that lived in the Archean era and previously unobserved microfossil morphologies. Here we present spheroid microfossils, as well as unusually large microfossils with clublike morphologies not previously observed in Archean microorganisms. These microfossils were three-dimensionally preserved in black chert from the Gamohaan Formation, Griqualand West Basin, Kaapvaal Craton, South Africa. These microfossils were discovered in a small, domal stromatolite that formed in a shallow marine setting on a carbonate shelf system at 2.52 billion years ago (Sumner and Bowring, 1996), just one to two hundred million years before the Great Oxidation Event.

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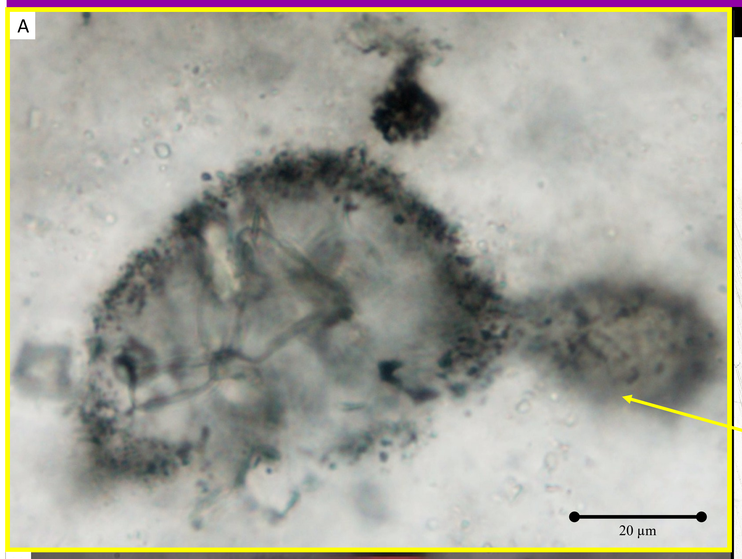


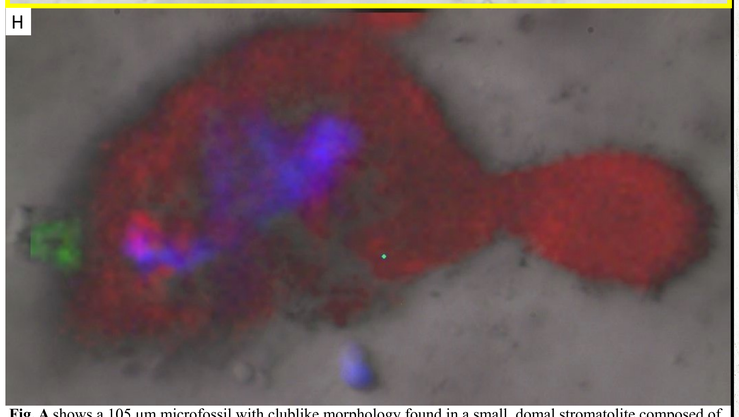
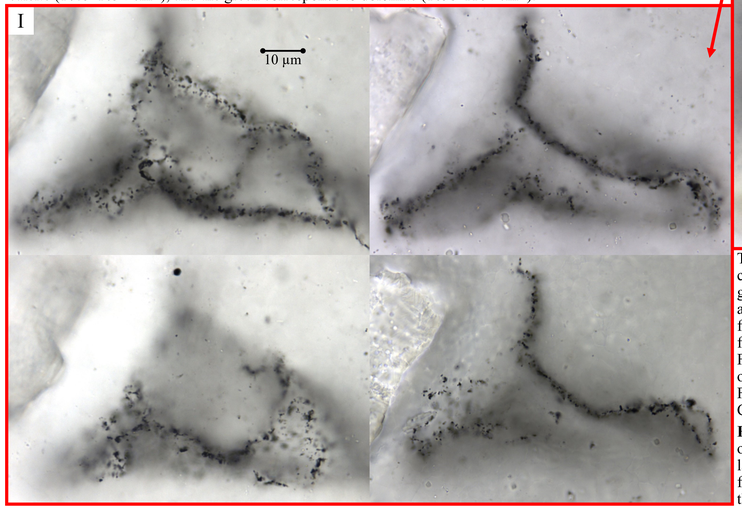
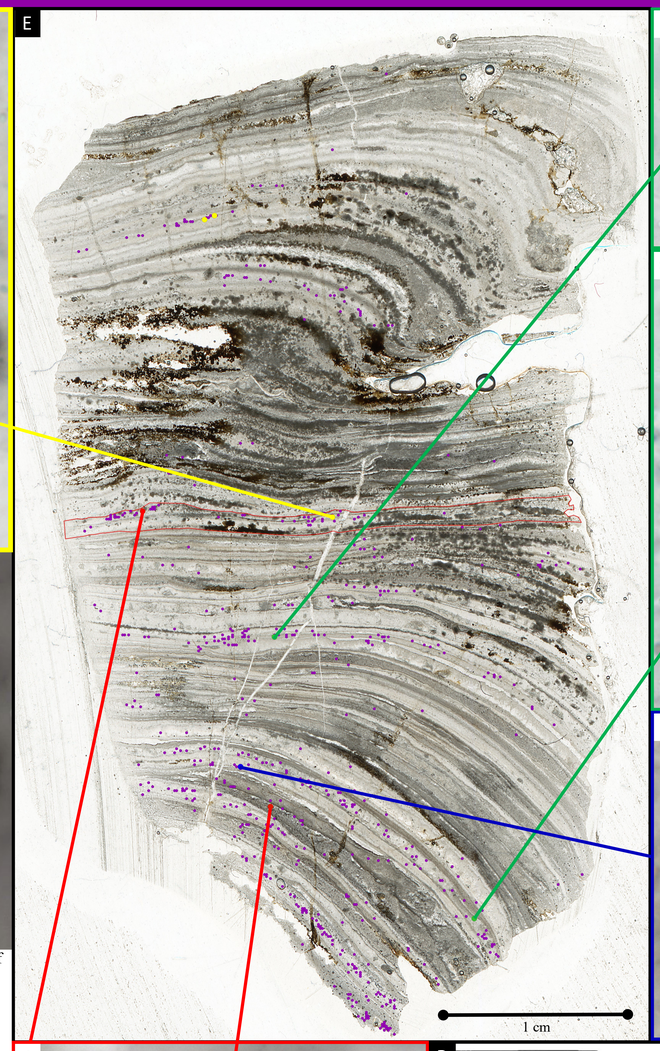


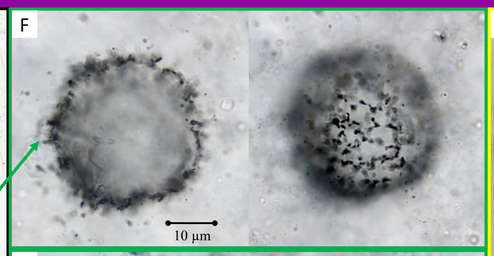
Fig. A shows a 105 µm microfossil with clublike morphology found in a small, domal stromatolite composed of black chert that was collected from a nearshore facies of the Kuruman Kopp locality of the Gamohaan Formation (Transvaal Supergroup, South Africa). Its location and geological context are illustrated in **Figs. B** (Sumner, 1997)**, C and D**.

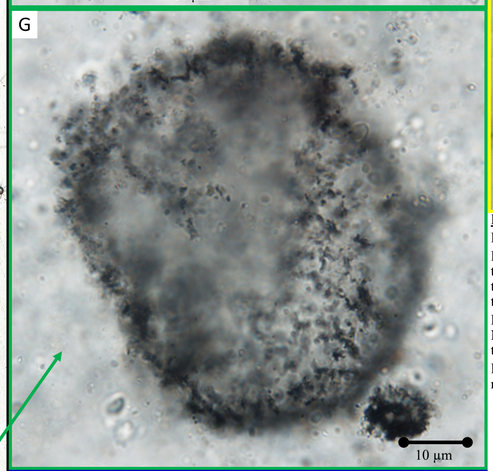
Fig. E is a micromap that shows the locations of the 569 microfossils observed within a thin section prepared from the stromatolite (e.g., Fig. C). The location of the microfossil in Fig. A is indicated by a yellow dot and arrow. Two yellow dots near the top of Fig. E show the location of two additional microfossils that display a clublike morphology. **Fig. K** shows a 112 µm clublike microfossil that was observed in a second thin section prepared from the same stromatolite as that of Fig. E. Most of the observed microfossils are spheroids, such as those in **Figs. F and G**, with diameters from 4 to 200 µm.

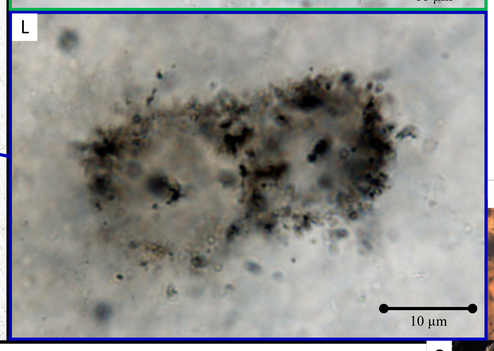
Fig. H is a Raman map overlain on a photomicrograph of the same microfossil in Fig. A. The red of the Raman map corresponds to kerogen (fossil organic matter; wavenumber range 1565-1640 cm^{-1}), the blue corresponds to calcite (1079-1094 cm^{-1}), and the green corresponds to dolomite (1093-1104 cm^{-1}).

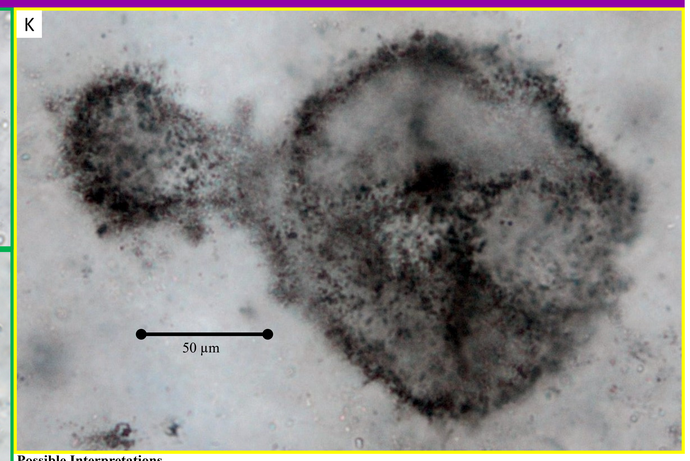












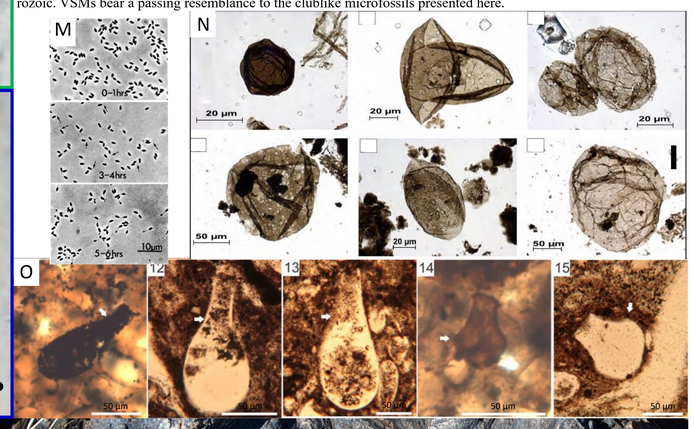
Possible Interpretations

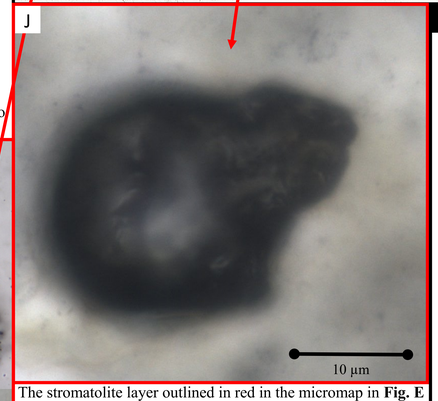
Fig. L shows spheroid microfossils that may be exhibiting binary fission.

Fig. M (Whittenbury and Dow, 1977) shows the morphological changes exhibited by *Rhodomicrobium* cells during their vegetative cell cycle. *Rhodomicrobium* is a genus of bacteria that includes species that can carry out the photo-trophic oxidation of ferrous iron. The clublike morphology seen in some stages of its cell cycle strongly resembles the clublike microfossils presented here, though on a much different scale.

Fig. N (Baludikay et. al, 2016) shows several organic walled microfossils from the Meso- to Neoproterozoic Mbuji-Mayi Supergroup (Democratic Republic of Congo), which were interpreted as leiosphere acritarchs. These resemble the spheroid microfossils in **Figs. F and G**.

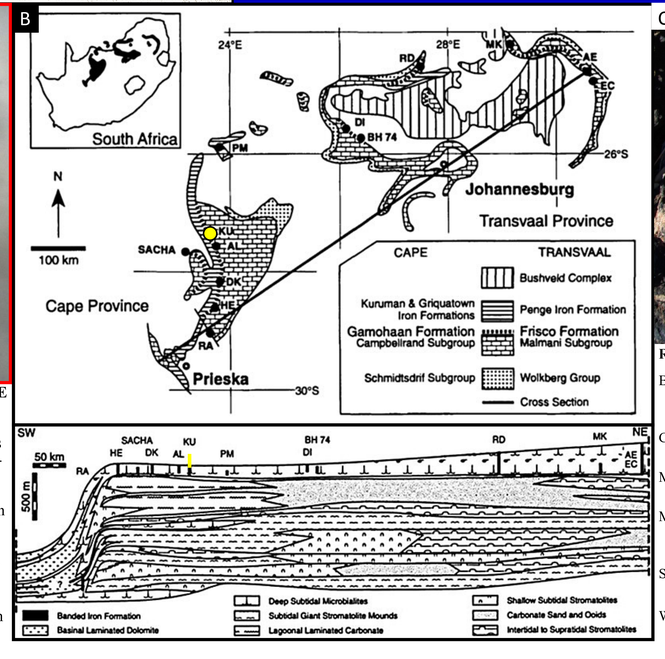
Fig O. (Morais et al. 2019) shows several vase-shaped microfossils (VSM), protists that flourished in the Neoproterozoic. VSMs bear a passing resemblance to the clublike microfossils presented here.

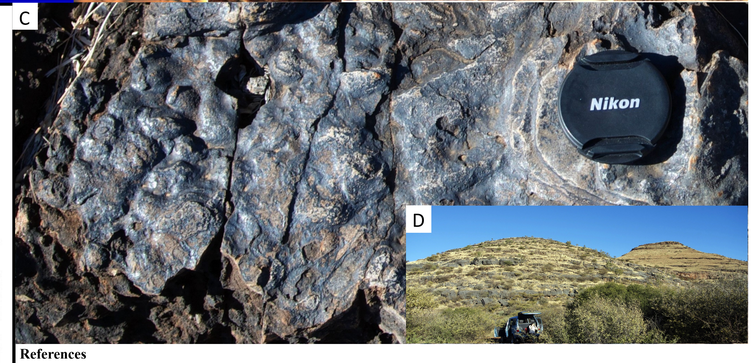




The stromatolite layer outlined in red in the micromap in **Fig. E** contains 52 microfossils, which have an average taphonomic grade of 2.14 based on a scale developed by Manning-Berg et al., (2019), where 1 = poor, 2 = fair and 3 = good. **Fig. I** shows four images of a microfossil that is similar in size to the microfossil in **Fig. A**, taken at different depths. The microfossil in Fig. A scores a taphonomic grade of fair because it exhibits original morphological characteristics, unlike the microfossil in Fig. I, which has been distorted by taphonomic processes (cf. Czaja et al., 2016) and scores a taphonomic grade of poor.

Fig. J shows a possible gas bubble or void within a chert layer of the thin section. Comparison with fig. A reveals that the large, clublike microfossil exhibits a texture characteristic of fossilized organic cell walls that is unmistakably different from that of a gas bubble.





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