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The elastic age: rise and fall of Precambrian biomat communities

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During the billions of years before large vendobionts, plants and metazoans appeared, aquatic biotopes probably carried about the same biomass as in later times – but it consisted of microscopic bacteria. This had two effects: (1) they made our planet habitable by gradually oxygenating its hydro- and atmosphere, (2) their sticky secretions made loose sand behave as an elastic sheet. The second effect resulted in unusual sedimentary structures, which are only found in the Precambrian or in anoxic environments of later periods and have often been misinterpreted. For example, shrinkage cracks in a surficial tough biomat may resemble sinusoidal trace fossils (the pseudofossil Manchuriophycus), three-dimensional lenticular cracks in the underlying "biopudding" that were filled from below with even more liquid "biosoup" have been interpreted to be pseudomorphs of gypsum desert roses. To understand the properties of biomats, we numerically simulate the development of Manchuriophycus. We show that a simple shrinking process within wave ripple troughs can produce sinusoidal pseudofossil-like instabilities when shrinkage cells are larger than the troughs. Manchuriophycus develops only when the shrinking material has the physical properties of biomats, a sticky sand with a very high strength and elasticity. The results of our model, together with the predominant occurrence of this structure in Precambrian sediments evidence the exceptional and profoundly different material properties of water-rich biomat sediments within this Precambrian "elastic age". The dramatic change in the physical material properties of biomats over the Precambrian – Cambrian time interval indicates fundamental changes within the microbial community structure and the biogeochemical processes leading to biomat formation.