

The Neoproterozoic Emergence and Environmental Consequences of Biomineralized Sponge-Grade Animals

Kaufman, Alan J.¹, Lindsay-Kaufman, Amelia², Lojcono-Evans, Bernard², Schiffbauer, James D.³, Selly, Tara³, Bykova, Natalia³, Manzuk, Ryan⁴, Maloof, Adam⁴, and Grazhdankin, Dmitriy V.⁵

¹University of Maryland, Geology Department and Earth System Science Interdisciplinary Center

²University of Maryland, Geology Department

³University of Missouri, Department of Geosciences

⁴Princeton University, Department of Geosciences

⁵Trofimuk Institute of Petroleum Geology and Geophysics, Russian Academy of Sciences, Novosibirsk

While molecular clock studies suggest a Tonian-Cryogenian (~800–635 Ma) emergence of the Porifera, convincing fossil evidence of sponges is seen only as far back as ~530 Ma. The >100 Ma lacuna for sponges represents a critical missing piece of the Neoproterozoic puzzle. Assembling an evolutionary framework requires that Poriferan antiquity be understood in terms of sponge form and function, and the emergence of suspension-feeding amid profound environmental and climatic change. Here we report newly discovered biomineralized fossils of sponge-grade animals in Neoproterozoic carbonates of Siberia, Australia, and Brazil. Using a wide range of petrographic, eProbe, μ XRF, μ CT, and serial grinding techniques, the sponge-grade fossils are shown to be remarkably preserved in three dimensions, displaying broad morphological characters associated with early experiments in biomineralization such as siliceous spicules and external carbonate shells. Reconstructions of their bauplan reveal forms evolutionarily equipped for a suspension-feeding lifestyle, well-prepared for pumping seawater through their bodies. As ecosystem engineers that clarified the water column and allowed for greater depths of photosynthetic activity, the emergence (and dominance) of sponge-grade animals in shallow marine carbonate reefs had the potential to drive environmental change that is arguably recorded during extremes in the Neoproterozoic carbon cycle. With their global distribution, these animals would link the planktic and benthic realms for the first time in Earth history and represent a sink for the photosynthetically derived organic matter that impacted the oxidation state of the oceans and atmosphere. Notably, most of these fossils are archived in carbonates preserving global expressions of profoundly negative $\delta^{13}\text{C}$ perturbations. These include the Ediacaran Period Shuram Excursion, which foreshadowed the widespread appearance of the Ediacara biota, and the terminal Cryogenian Period Trezona Anomaly, which immediately preceded the Marinoan snowball Earth.