Geophysical Research Abstracts
Vol. 17, EGU2015-2336, 2015
EGU General Assembly 2015

Nanoscale petrographic and geochemical insights on the origin of Paleoproterozoic stromatolitic phosphorites from Aravalli, India

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Stromatolites occur throughout the rock record starting at ca. 3.5 Ga, but their abundance and morphological and mineralogical diversity significantly expanded during the Paleoproterozoic Great Oxygenation Event. In particular, columnar-branching and multifurcate stromatolites composed of jasper or apatite begin to occur in post-Lomagundi-Jatuli successions around 1.9 Ga and suggest the emergence of novel types of biomineralization at that time. The microscopic and nanoscopic petrology of organic matter in stromatolitic phosphorites might provide insights into the suite of diagenetic processes of these types of stromatolites and/or into the role of specific microorganisms in these communities. Here, we report on the occurrence of nanoscopic disseminated organic matter in Paleoproterozoic stromatolitic phosphorite from Rajasthan, India. Microscopic spheroidal grains of apatite occur in both microbial mats in stromatolite columns and in the chert core of microscopic apatite rosettes. Organic petrography by Raman imaging demonstrates syngeneity of the organic matter. Our observations point to a microfossil origin for the microscopic spheroids of organo-apatite, which are cemented to calcite micro-spar by later diagenetic dolomite. Apatite rosettes also likely have a diagenetic origin. Total organic carbon of these stromatolitic phosphorite columns is between 0.05 and 3.0 wt% and has a large range of d13C values with an average of -18.5permil (1sigma = 4.5permil). Whole rock d15N values are between -1.2 to +2.7permil. Nitrogen and carbon isotope compositions suggest that high phosphate abundance caused these cyanobacteria to bloom, thereby enhancing fixing nitrogen to sustain community growth. Synchronous early diagenetic formation of calcite micro-spar, resulted in the growth of centimeter size columns from the seafloor and occasionally branching or multifurcate stromatolites. Finally, our findings suggest that these stromatolites accreted pelagic cyanobacterial clumps adhering to microbial mats lithified by biomineralized calcite micro-spar and cyanobacterial apatite in the stromatolites columns.