High Paleoproterozoic seawater sulfate recorded in Earth's oldest known large evaporite basin

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Substantial accumulations of evaporite minerals in the rock record only occur after c. 1.2 Ga, allowing the interpretation that seawater sulfate did not rise to significant levels until the late Mesoproterozoic. Here we describe an exceptional archive of c. 2.0 Ga marine deposits that form an 830 m thick evaporite succession in the Paleoproterozoic Tulomozero Formation (TF) recovered in a core during drilling of the 3.5 km deep Onega Parametric Hole in the Onega Basin, Karelia, Russia. Carbonates occurring in the succession have $\delta^{13}C$ values mostly >10‰ consistent with accumulation during the Paleoproterozoic Lomagundi-Jatuli carbon isotope excursion. The evaporate succession begins with 100 m of halite, anhydrite, magnesite and K-, Mg- and Na-sulfate minerals with proportions similar to the precipitate that can be obtained from near complete evaporation of modern seawater. The halite dominated basal unit is followed by 500 m of anhydrite, magnesite and mudstone and then 230 m of interbedded dolostone, magnesite and mudstone all of which contain abundant Ca-sulfate pseudomorphs and other syn-sedimentary to early diagenetic evaporite fabrics showing displacive growth and compaction of laminae. Desiccation cracks developed in mudstones have in some intervals red hematitic coloration due to oxidation during subareal exposure. We interpret the succession as having formed in a barred, marine embayment bordered by sabkha-coastal plain settings. The mineralogical trends are consistent with the change in the evaporation rates with lower, halite-dominated unit corresponding to near complete evaporation under repeated marine inundations, followed up-section by lesser amounts of evaporation yielding first anhydrite and then dolomite dominated precipitates respectively. Accumulation of >800 m of sulfate-rich rocks at c. 2.0 Ga manifests a sizable and lasting seawater sulfate reservoir during the Paleoproterozoic.