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The role of dust in aragonite deposition at the Dead Sea and Lake Lisan

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The Dead Sea contains one of the longest archives in Middle East for climate reconstruction and its lacustrine sequences were used to study the natural climate variability of the Levant and its role on a variety of issues from hominid migration out of Africa to predictions for future aridification and loss of water resources. The Dead Sea is a deep, Ca-chloride hyper-saline terminal lake that accumulated a relatively continuous sequence of detrital and chemical sediments. Large portions of the sequences consist of alternating couplets of detritus and chemical aragonite. Previous studies showed the detrital laminae are composed of regional dust inputs and local run-off erosion products brought by flash floods from the catchment area. The aragonite laminae deposition is inorganic and results from the interaction between freshwater run-off and the Dead Sea hyper-saline brine. Although mass balance calculations attributed the chemical sources of CO_3 and Ca to the HCO_3 input with fresh water and Dead Sea brine, it is still unclear what is the trigger and timing of a chemical precipitation event that creates a lamina.
The present study uses a new approach based on theoretical calculations involving known physical and chemical parameters of the lake. Our main conclusion is that dust has a major role in the chemical precipitation of aragonite. We demonstrate that aragonite crystals nucleate on micro-particles with critical radius of 0.1 μm in the supersaturated surface mixed layer of the lake. Homogeneous nucleation of randomly colliding diffusing $CaCO_3$ molecules is an unrealistically long process. Small super-critical aragonite crystals grow by adjoining the diffusing $CaCO_3$ however for larger clusters diffusion is irrelevant as these grow by collecting molecules during their gravitational fall. The crystal growth is rapid at the scale of an hour, and the final size of clusters, which can reach $\sim$300 μm depends on their travel path in the surface layer. The clusters will sink for a few hours before reaching the lake floor and accumulate in a discrete lamina. The main conclusion is that aragonite deposition in the Dead Sea is not solely controlled by the input of freshwater. This elucidates on the occurrence of aragonite laminae during the last glacial period and in the last 3000 yr BP when dust fluxes to the Dead Sea drainage basin were relatively high.