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The curious case of Lake Van dolomite: Centennial-scale climate variability forcing dolomite formation under more humid conditions?

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Due to difficulties in precipitating dolomite in laboratory experiments simulating Earth's surface conditions, the key factors controlling its occurrence in the geological record remain speculative and debated. Modern dolomite-forming environments are often limited to evaporitic settings such as lagoons and sabkhas. Beside microbial mediation, high temperatures and Mg^{2+} concentrations in solution are factors considered important in aiding dolomite formation. Accordingly, episodic occurrence of dolomite in lacustrine successions is commonly uncritically associated with enhanced evaporation, low lake levels and a higher Mg/Ca ratio. This was also the case for the presence of dolomite within deep sediments of alkaline Lake Van (Turkey) (1-4).

A systematic study of Lake Van carbonates in a sedimentary profile covering the last ca. 250 kyr by means of XRD, SEM and stable isotope ($\delta^{18}O$ and $\delta^{13}C$) mass spectrometry revealed cyclic occurrence of dolomite-rich intervals (20 – 85 % relative carbonate content). Comparison with published data (ICDP PALEOVAN) suggests that these intervals coincide with periods of high lake level and increased humidity related to suborbital climate variability (Dansgaard-Oeschger cycles). Before, investigating the relationship between dolomite nucleation and environmental factors, we first considered the origin of Lake Van´s dolomite. SEM imaging documents large dolomite crystals interwoven with clay minerals and individual crystals with different crystallographic orientations grown together, indicating space-limited growth within the sediment. According to recent climatic reconstructions for the here studied interval, the water depth of the coring site – today at 350 m – unlikely fell below 200 m. Dolomite formation in the sediment below a thick water column at constantly low temperatures is also supported by its heavy $\delta^{18}O$ signature.

Furthermore, high dolomite concentrations do not always correlate to high amounts of organics within the sediment, and show no correlation with variations in alkalinity, pH, Mg/Ca ratio, or salinity. While lake level fluctuations affect these factors, we show that none of these directly control the formation or cyclicity of dolomite. We propose that dolomite precipitation in Lake Van (with or without a precursor phase) is a product of a microbially influenced process triggered by ecological stress resulting from episodic re-ventilation of the water-sediment interface. Independently from the validity of this hypothesis, our results call for a re-evaluation of the paleoenvironmental conditions often invoked for early diagenetic dolomite-rich intervals within ancient sedimentary sequences (e.g., periods of enhanced aridity and evaporation) and for additional caution when interpreting time series of sub-recent lacustrine carbonates.

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