Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7089

Geochemical evolution of Lake Lisan from interstitial soluble salts in cores of Dead Sea Deep Drilling Project and marginal outcrops

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Located on the transition between the climatic belts of the hyperarid Sahara Desert to the subtropical Mediterranean and being a terminal lake, the hypersaline Lake Lisan, the last glacial precursor of the Dead Sea, has been in the focus of extensive paleoclimate research during the past several decades. The sediments deposited from the lake comprise the Lisan Formation that consists mainly of sequences of laminated primary aragonite, silty detritus, and occasional gypsum.

Here, we report on the chemical compositions of interstitial soluble salts extracted from the Lisan sediments. The soluble salts crystallized in the pores of the Lisan sediments due to desiccation of trapped lake's brine, and thus they represent the composition of the lake's brines. The measured ions are Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Sr^{2+}, Cl^{-}, SO_4^{2-}, Br^{-}, NO_3^{-} and HCO_3^{-}. Samples were collected from the marginal terraces of the modern Dead Sea where the Lisan Formation is exposed and from sediments retrieved from cores drilled by the ICDP in the lake's deepest floor and at its shallow margin. Thus, the sampling provides information on the lake in the deep and shallow limnological environments.

Several ion ratios correlate well with the composition of pore-fluids extracted from the deep drilled core and represent the evolution of the lake's hypolimnion, e.g., the Na/Cl and Mg/Cl (in eq). The Na/Cl gradually increases from 0.3 at ~98 ka to ~ 0.7 at 12 ka and sharply drops to 0.3 during the Holocene. The Mg/Cl shows a mirror pattern (with max values of 0.5 and min of 0.2). These temporal changes reflect the deep lake's continuous freshening (the hypolimnion) that climaxed during the period of glaciation in the Northern Hemisphere and the lake's salinization during the warming period of the Holocene. The soluble salts extracted from the sediments of the high lake margins, representing the epilimnion, show large and frequent variations in the elemental ratios that reflect the effects of short-term climate incursions, such as the Heinrich events that were accompanied by regional aridity and lake level drops.