Geophysical Research Abstracts
Vol. 16, EGU2014-15271-1, 2014
EGU General Assembly 2014

Long-term freshening of the Dead Sea brine during the last glacial revealed by porewater Cl- and δ18O in ICDP Dead Sea deep-drill

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The geological evolution of the unique Dead Sea Ca-chloride brine has been the focus of many research efforts for several decades. These studies relied on the information obtained from sedimentary exposures of the marginal terraces of the modern Dead Sea, mostly documenting the history of the surface lake brine during its high stands periods. The present study is the first attempt to establish the history of the deepest part of the lake by direct measurements of the chemical and isotopic composition of pore-fluids that were extracted from cores drilled during 2011 by ICDP in the deep basin of the Dead Sea at water depth of 300 m. The vertical profiles of chloride (Cl^-) and oxygen isotopes ($\delta^{18}O$) in pore brines reveal a substantial decrease in the salinity of the hyper-saline lake during the last glacial and particularly during MIS2 ($\sim$31-17 ka BP). The Cl^- concentration of the deep brine in the lake decreased gradually reaching a minimum of less than 2/3 of its present value while the $\delta^{18}O$ on the same time increased to maximum of $\sim$7‰ (3‰ higher than today). The low Cl^- indicates significant dilution of the bottom water mass (hypolimnion) of Lake Lisan (the last glacial predecessor of the modern Dead Sea) during its highest stand period. Beforehand, during the interglacial and later during the post-glacial and the Holocene the Cl^- concentrations and $\delta^{18}O$ values were similar to those of the modern Dead Sea. The slow dilution of the deep Ca-chloride brine was caused probably by continuous turbulent mixing of the hypolimnion with the less saline high $\delta^{18}O$ epilimnetic brine, across the epilimnion/hypolimnion interface (EHI). While the increase in $\delta^{18}O$ during the salinity decrease of Lake Lisan is a result of "normal" evaporation of the less saline epilimnetic brine, the post-glacial $\delta^{18}O$ decrease (contemporaneous with salinity increase) is attributed to the "backward" behavior of $\delta^{18}O$ during evaporation of high salinity brine. During the long freshening period the hypolimnion was enriched with dissolved sulfate supplied by the freshwater and transported by the turbulent mixing across the EHI until reaching gypsum saturation that commenced massive gypsum deposition at the end of this period, when full overturn took place.