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Brine-freshwater interaction and redox conditions in Lake Lisan during MIS2

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The late Pleistocene Lake Lisan and the Holocene Dead Sea are hypersaline terminal lakes, whose limnological history (water sources, water column configuration, water composition, redox conditions) reflects millennial to decadal shifts in hydrological conditions in their large drainage area, which in turn responses to changes in the EM climate. The lakes fluctuated between low and high stand modes and layered and mixed configuration.

We established a high-resolution record of ^{87}Sr/^{86}Sr and ^{234}U/^{238}U ratios, δ^{34}S values and trace element abundances (e.g. Sr/Ca, U/Ca and Ce/Ce*) of authigenic aragonite and gypsum that precipitated from the upper layer of the lake and the mixed brine, respectively. While Sr/Ca- ^{87}Sr/^{86}Sr and U/Ca- ^{234}U/^{238}U appear to monitor the contribution of freshwater inputs to the surface layer and its interaction with the Ca-chloride brine, δ^{34}S and Ce/Ce* are robust recorders of redox conditions in the lower water layer. Enhanced bacterial sulfate reduction occurred in this layer during stable stratification and highest stand period (MIS2: 27-17 ka), lead to enrichment in δ^{34}S values (from ~ 20 to 30 ‰) and to continuous decrease in the U/Ca and Ce/Ce* ratios. In the upper water layer Sr/Ca ratio decreased due to inflow of freshwater. However, this decrease was buffered by an enhanced inflow of the saline springs, contributing high Sr/Ca and low U/Ca ratios. Sulfate accumulated in the upper water layer until gypsum began precipitating along with aragonite, thereby supplying sulfate to the lower water layer.

At the end of MIS2 the water column overturned, homogenizing the water column and precipitating relatively thick layers of gypsum. The high $\delta^{34}S_{SO4}$ values of Lake Lisan at the end of the Pleistocene was replaced in the Holocene Dead Sea by more depleted compositions (14.5‰), indicating that no long-term (thousands of years) stratification with bacterial sulfate reduction took place in the Dead Sea since its emergance.

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Uranium-series dating and diagenesis in deep sea corals

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U-series isotopes in biogenic carbonates provide an important tool in palaeoclimate research since the decay of U to Th is one of our few independent, absolute chronometers. Marine carbonates incorporate the (^{234}U/^{238}U) of the seawater in which they grow (denoted as d^{234}U and with a modern day value of 146). This value has been constant over the last several hundred thousand years and so if we use the U-Th age to calculate the d^{234}U at the time of formation it should be identical to the modern day. This information is used widely in surface corals as an indication as to whether the coral has remained a closed system. Deep-sea corals represent a directly datable archive from deep within the oceans. These corals grow, and are subsequently surrounded by seawater with a constant U isotopic ratio. We use both the U concentration and isotopic distribution in modern and fossil deep-sea corals to investigate the assumptions of closed-system behaviour in such an environment.

Induced fission of ^{235}U in coral sections provides unprecedented spatial resolution and sample maps of the U distribution. The concentration distribution is similar to the internal banding patterns observed within the coral. Modern corals discriminate sharply (over a factor of 4) against U incorporation during initial precipitation but the secondary aragonite has much higher concentrations. Fossil corals show a similar pattern but with a smaller difference between primary and secondary material. To investigate the mechanisms behind this change we made precise isotopic and concentration measurements (using multi-collector inductively coupled plasma mass spectrometry) on microsampled coral sections. Modern corals are shown to incorporate seawater d^{234}U, but fossil corals exhibit an elevated initial d^{234}U. This elevation (of up to 17 per mil) shows spatial variability and is most significant in regions of coral with low U concentration. These observations can be modelled as a combination of two processes: alpha-recoil mobilisation causing redistribution of ^{234}U (via ^{234}Th) and continual addition of U from seawater. These results are from deep sea corals, but they are equally applicable to surface corals which also exhibit variable initial U concentrations and often yield high initial d^{234}U.