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Evidence of a connection between the Atlantic and Mediterranean during the Messinian Salinity Crisis from Pb and Nd isotopes

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Prior to the opening of the Gibraltar Strait at 5.33 Ma, the Betic (southern Spain) and Rifian (northern Morocco) marine palaeocorridors linked the Mediterranean to the Atlantic. Although the central regions of these corridors have been heavily eroded due to uplift, evidence published to date indicates that both closed before the onset of the Messinian Salinity Crisis (MSC; 5.97 to 5.33 Ma [1, 2]). However, pre-MSC corridor closure presents a paradox, as the volume of halite deposited within the Mediterranean basin requires several times the volume of seawater contained in the basin itself. In this regard, radiogenic isotopes such as Sr, Pb, and Nd can provide key information about the timing of exchange through the Betic and Rifian palaeogateways. Due to the resolvable isotopic difference in Nd isotope signatures of outgoing Mediterranean and incoming Atlantic water masses, demonstrated both for the present day as well as the past environment, this isotope system can be used to identify exchange between these two water bodies. Although less well constrained to date, the Pb isotope system can be used in a similar manner due to its short residence time in seawater and interbasin variability.

A high resolution Pb isotope record extracted using laser ablation from ferromanganese crust 3514-6 (recovered from the Lion Seamount, NE Atlantic, water depth 690-940 m) indicates a relatively constant Pb isotope signature before, during and after the MSC period. The previously published [3] Nd isotope record of crust 3514-6 corroborates that the crust was deposited in a current distinct from NE Atlantic Deep water or Antarctic Intermediate Water, the principal currents in the region of the Lion Seamount. The combined Pb and Nd isotope evolution suggests that Mediterranean Outflow Water (MOW) was continuously advected into the NE Atlantic during and after the MSC. Furthermore, preliminary Nd isotope records from Late Miocene sediments collected in the Sorbas Basin, Spain, suggest that Atlantic inflow through the Spanish palaeocorridor into the Mediterranean persisted for longer than this corridor is thought to have existed.

Our new isotope records thus suggest an alternative scenario. The corridors may have closed later than current estimates, and/or another connection to the Atlantic through the Gibraltar region persisted. These records are consistent with existing Sr isotope records from within the Mediterranean suggesting intermittent Atlantic inflow during the first stage of evaporite deposition [4]. They are also consistent with recently published Nd isotope records suggesting the persistence of Mediterranean outflow into the Atlantic during the MSC [5].

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