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Reconstructing Mediterranean-Atlantic exchange: Can Nd isotopes tell us about the Messinian Salinity Crisis?

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Throughout the Late Miocene, the Betic-Rif region underwent progressive tectonic restriction, leading to the closure of the Betic and Rifian Corridors (present-day southern Spain and northern Morocco, respectively), and the opening of the Gibraltar Straits. During this period, the exchange of water between the Mediterranean Sea and the Atlantic Ocean varied considerably, which is thought to have contributed to the Messinian Salinity Crisis (5.96 Ma to 5.33 Ma).

Evidence of these changes in Mediterranean-Atlantic exchange can be found in faunal distributions, which suggest that at times, all Atlantic inflow may have been channelled through the Rifian Corridor while Mediterranean Outflow Water (MOW) flowed out of the Mediterranean through the Betic Corridor (Benson et al. 1991). At others, two-way flow through one or both gateways is envisaged (e.g. Flecker and Ellam, 2006; Benson et al. 1991). Periodic shut-down of MOW may also have occurred (e.g. Alhammoud et al., 2010; Roveri et al., 2008; Krijgsman and Meijer, 2008).

We use Neodymium isotopes (expressed in terms of εNd) as a water-mass tracer to reconstruct the bottom water flow patterns through the Rifian corridor. Atlantic and Mediterranean waters have sufficiently distinct εNd values to be distinguishable from each other. Thus, we have analysed the Nd isotope ratio preserved in fish-teeth and benthic foraminifera from the Zobzit, Oued Akresh, Ain el Beida, Loulja-A and Loulja-B astronomically tuned sections to show where and when water flowed from the Atlantic to the Mediterranean, and where and when water flowed from the Mediterranean to the Atlantic. Initially, we analysed 35 samples (each containing approximately 400-800 foraminifera or one fish tooth) covering the time period 7.6 Ma to 5.0 Ma, which we used to build a new chronology of Mediterranean-Atlantic exchange. This reconstruction provides important insights into the underlying causes of the Messinian Salinity Crisis and challenges some of the preconceived hypotheses for changes in the exchange during this period.