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Erosion, tectonics, and climate in the Miocene Mediterranean: a mechanistic approach to the Messinian Salinity Crisis

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There is an agreement that the interplay between global sea level changes and the tectonic uplift of the connecting corridors in the Gibraltar Arc were the main control on the Messinian Salinity Crisis (MSC). But there is no full consensus, for example, on whether a kilometric drawdown ever took place, or when during the MSC would it have happened, or whether it may have occurred in multiple occasions intercalated by an equal number of floods refilling the Mediterranean. Two of the reasons behind these uncertainties are the absence of drillings that cross the entire evaporitic sequence in the deep basins and the lack of direct correlation between marginal and deep stratigraphy. I will focus on a third reason: the shortage for quantitative, process-based, mechanistic models that aim to account for the vast amount of multidisciplinary observations available on the MSC.
In this presentation I will combine published results from a simple forward numerical model based on 1D mathematical approaches to water-flow and erosion on a seaway applied to the initiation and the end of the MSC. The applied erodabilities are constrained from published continental landscape evolution models. Salt precipitation in the isolated side of the seaway is computed as a function of the salt concentration imposed by varying rates of evaporation, precipitation and seaway uplift. The results show that the erosion exerted on the seaway by the Atlantic inflowing water allows a long-term connection of a few tens of meters by reaching a dynamic equilibrium with tectonic uplift, even if the global sea level fluctuates with larger amplitude. The predicted uplift rates required to block the inflow of Atlantic water are consistent with the present altitude of uplifted marine sediments and with geodynamic models of a proposed lithospheric slab detachment under the Gibraltar Arc. A minor increase in tectonic uplift rate or a large, rapid ocean level drop of a few tens of meters can lead to the full disconnection and the emergence of the seaway, upon which the Mediterranean drops to an equilibrium level of 1.1-2.5 km by evaporation. This is consistent with the restored depth of Messinian erosion surfaces (the M reflector) visible in seismic imaging in areas as the Rhone and the Ebro deltas.
Finally, the same model is used to estimate the water discharge and the duration of the flood that refilled the Mediterranean at the end of the MSC, assuming that this is mainly controlled by the feedback between water inflow and erosion across the Gibraltar Strait. The results suggest a very rapid flooding that could explain the 200-800-m deep erosion trough documented in the Alborán Sea.
These results show that combining the existing data in simple mechanical and hydraulic models can shed light on standing open questions about the Messinian Salinity Crisis, and link it quantitative links with independent phenomena.