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Temporal changes in Miocene Mediterranean gateways due to the flexural response to the Messinian Salinity Crisis

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One of the most spectacular examples of the interaction of climate and tectonics is the Messinian Salinity Crisis (MSC, 5.97-5.33 Ma) in the Mediterranean, possibly one of the largest evaporitic events in geological history. Progressive closure of the gateways between the Mediterranean Sea and the Atlantic Ocean is thought to have been responsible for the MSC. Initially, during the progressive closure of the marine gateways salinity in the Mediterranean rose and a sequence of extremely thick evaporite units (Primary Lower Evaporites and halite, up to $\sim$2 km thick) was deposited throughout the Mediterranean (5.97 – 5.55 Ma). Subsequently, the Mediterranean Sea became disconnected from the Atlantic Ocean resulting in a dramatic sea level drop estimated between 800 m and 1.5 km ($\sim$5.6 Ma).

The lithosphere adepts to changes in loads on the surface by flexural adjustment of the Earth's surface. During the MSC, the deposition of the evaporites and changes in the water column load have had a significant impact on the bathymetry/topography of the Mediterranean and, hence, the gateways with the Atlantic and Paratethys. Until now, flexural movement during the MSC has been studied mainly in two dimensional cross sections and, more recently, as a series of steady states in a three dimensional elastic model. However, the temporal evolution of the gateways during the MSC, while important for understanding the potential cause of the MSC, is still largely unexplored.

Here we use an elastic model (TISC) coupled with a simple hydrology model to calculate the temporal and spatial response of the solid Earth to an increasing salinity (seawater density) of the Mediterranean Sea, deposition of evaporites, and a drop in local sea level. Our results focus on the flexure-induced depth variations of the gateway areas between the Mediterranean and Atlantic Ocean and between the Mediterranean and Paratethys Sea during the MSC. Furthermore, we quantify how progressive loading and unloading alters the stresses and slopes around the deep basins, leading to slope instability and mass transport towards the basin.