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Geometrical Bounds on the Atlantic - Mediterranean connection during the Messinian Salinity Crisis

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A modelling study that uses strait dynamic theory in order to give geometrical limits on the Atlantic - Mediterranean gateway(s) that existed during the build up to the Messinian Salinity Crisis (MSC).

6% of the World Ocean's salt (mainly gypsum and halite) was deposited in the Mediterranean Sea about 6Ma ago: The Messinian Salinity Crisis. This extreme event is still evident today in the form of an up to 2km thick salt layer in the sediment under the Mediterranean Sea. Together with the evaporation across the basin, the geometry of the Atlantic - Mediterranean connection must have triggered this drastic increase of Mediterranean salinity (gypsum saturation is reached at about $130g/kg$ and halite saturation at about $350g/kg$, compared to the Atlantic salinity of about $35g/kg$). Today's Atlantic - Mediterranean water connection is the Strait of Gibraltar. Scientists are in great debate where the connection was in the build up and during the MSC. Potential candidates for the ancient corridor(s) during that time are proposed to be seaways through the south of Spain, the north of Morocco or as an early Strait of Gibraltar.

Here a modelling study is presented that considers water exchange between a salt reservoir (the Atlantic) and an high saline enclosed basin (the Mediterranean). From this starting point it is possible to set limits on the possible gateway geometries for this extreme event. The theoretical basis lies in strait dynamics for idealised gateway geometries, which allow for 2-layer exchange flow, as it is known from gateways like the Bosporus or the Strait of Gibraltar.

Our calculations predict that the in- and outflux through the Messinian gateway(s) must have been of the order of 5% or less than the water exchange at Gibraltar today in order to sustain gypsum or halite saturation in the basin. Before, this extreme restriction was thought to be mainly due to a strong reduction in the water depth of the gateway. Now, we demonstrate that not only shallow gateways will restrict the exchange flux enough, but also narrow or long corridors can lead to the same effect. Using these model results as a framework, it will move the interpretation of MSC related observations a step forward.

Key Words: Messinian Salinity Crisis, Strait/Fluid Dynamics, Modelling, Strait of Gibraltar, Mediterranean Sea