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Legacy DSDP and ODP data suggest a paradigm shift in methane hydrate stability in the Mediterranean Basin

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The global reservoir of submarine gas hydrates is favored by the cold temperature of oceanic bottom water and the generally low geothermal gradients along passive continental margins. The continental margins of the land-locked Mediterranean basin are a remarkable exception for the lack of evidence of extensive presence of gas hydrates. Using public data of the physics and chemistry of the subsurface available from 44 Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) wells as lithologic logs, downhole temperature measurements, and pore water salinity values, and observed physical characteristics of bottom waters, we model the theoretical methane hydrate stability zone (MHSZ) below the seafloor and in the water column.

We find important positive pore water salinity anomalies in the subsurface indicating the pervasive presence of concentrated brines up to saturation concentration of halite and gypsum (> 300 ‰). The resulting sub-bottom MHSZ is thinner by up to 90-95% with respect to its thickness calculated assuming constant salinity with depth equal to bottom waters salinity. In the Eastern Mediterranean deep basins the thickness of the subsurface MHSZ is largest (up to ~ 350 m) and the anomaly induced by subsurface brines is highest (~ -300 m), while in the Alboran, Western Mediterranean, Tyrrhenian, Sicily Channel, Adriatic and Aegean basins the MHSZ, where present, thins to less than 100 m with mostly negligible anomaly induced by the presence of subsurface brines.

Modelling results suggest that subsurface brines can produce dramatic reductions of the thickness of the MHSZ only where the geothermal gradient is low (Eastern Mediterranean). We have modelled the same brine-induced limiting effect on the thickness of the MHSZ in synthetic cases of high and low heat flow to simulate Western and Eastern Mediterranean subsurface thermo-haline conditions. The salinity effect is attenuated by the thermal effect in the Western Mediterranean that produces the most relevant thinning of the MHSZ.

The distribution of the MHSZ resulting from the modelling coincides well with the distribution of the Late Miocene salt deposits which limit further the possibility of formation of gas hydrates acting as low permeability seal to the up-ward migration of hydrocarbon gases.

This modelling exercise provides a robust explanation for the lack of evidence of widespread gas hydrates on Mediterranean continental margins, with the exception of areas of local methane upward advection such as mud volcanoes, and it outlines a number of local hydrate-limiting factors that make this basin unfavorable to gas hydrate occurrence.