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Gas hydrate stability in the Mediterranean Sea since the last glacial maximum: results from the HYDRAMED project

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The HYDRAMED project aims to assess the potential gas hydrate system in the Mediterranean Sea, over the timescales of glacial-interglacial change. Here we present results from the first part of the project, the modeling of the hydrate stability zone (HSZ) at present and for conditions approximating the last glacial maximum (uniformly lowered sea level and reduced bottom water temperatures).

The stability zone for methane hydrate in seawater is calculated using gridded parameters for pressure (water depth) and temperature (bottom water temperatures and geothermal gradients). Bottom water temperatures across the Mediterranean display little variance, so the extent and thickness of the HSZ depends primarily on the input geothermal gradients, for which we use an updated compilation of measurements (including over 1000 marine sites). The results show that the HSZ at present extends across most of the Mediterranean below depths of 1000-1250 m, but is only $>$150 m thick in the (geothermally cooler) east. However, the HSZ would have been thicker during the last glacial maximum (LGM), as the effects of reduced pressure (modeled sea level –125 m) were outweighed by lower bottom water temperatures (bwt). The disputed magnitude of the reduction in bwt is here modelled by uniform reductions of either –4˚C or -8˚C, the former resulting in a HSZ up to 50% thicker during the LGM, the latter up to 100% thicker. The glacial to interglacial transition is thus inferred to have resulted in a dramatic thinning of the HSZ, by up to half, as well as a deepening of its upper limit by up to 600 m along basin margins, with implications for the

deglacial release of methane from hydrate reservoirs and for slope stability.

A hypothesis that BSRs have not been seen in the Mediterranean because the base of the HSZ in many areas lies within the Messinian evaporitic succession was tested by comparing the calculated HSZ thicknesses to an isopach of the Plio-Quaternary succession. The results show that the base of the HSZ (at present and during the LGM) lies above the Messinian over the majority of the deep-water Mediterranean, save in two main zones in the east that follow the western and eastern Mediterranean Ridge. Correlation of areas where the HSZ is over 100 thick with potential sources of biogenic or thermogenic gas (Plio-Quaternary depocentres and/or areas of hydrocarbon seepage) allows the definition of three main areas of interest for present-day hydrate occurrence: the Rhone fan, the Ionian Sea (including the Calabrian Arc and the western Mediterranean Ridge) and the Levantine Sea (including the eastern Mediterranean Ridge - Anaximander Mountains and the Nile Fan). The HSZ results will next be used to guide re-examinations of seismic reflection data for potential BSRs on the Rhone fan, Calabrian Arc and Nile fan, as well as of DSDP/ODP drillsite data for geochemical indicators of hydrates in all of the above areas.

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