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The origin of Messinian canyons in the Mediterranean: the role of brine-related dense shelf water cascading currents

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Recent studies on modern deep-sea environments have documented the role of submarine processes, such as turbidity currents, fluvial flood-related hyperpycnal flows and dense shelf water cascading (DSWC), in the genesis and evolution of canyons and gullies. These processes are largely independent from sea-level fluctuations and significant erosion has been shown to occur even at present-day sea-level highstand conditions.
The study of ancient deep-marine environments and processes may take great advantage from the knowledge produced during the last decade in this field of research. The study of some exceptional events of the past is an exciting issue for a common effort of specialists from different disciplines (geomorphology, geology, physical oceanography) in the understanding of modern and ancient deep seascape. An example is provided by the genesis of the widespread Messinian erosional surface (MES) and the associated gullies and canyons, which have been recognized through seismic data along the Mediterranean shelves and slopes. These features are commonly related to subaerial fluvial processes that imply a 1500 m drawdown and the desiccation of the Mediterranean Sea during what has been called the "Messinian salinity crisis" (MSC). Such an interpretation is one of the main arguments for the shallow-water deep-basin model (Hsü et al., 1973), which is the current paradigm for the MSC. However, no unquestionable evidence for subaerial deposits associated with the MES has been ever documented.
We suggest that fully submarine erosional processes played a significant role in shaping the Mediterranean slopes also during the MSC; thus, no desiccation is needed to explain canyon formation and/or rejuvenation.
We want to stress here the importance of the processes, driven by evaporative fluxes in shallow areas, that lead to the formation of seasonal high-density contrasts and cause the development of cascading along the continental slopes (Shapiro et al., 2003). These processes are active today in the Mediterranean margins where they produce large-scale erosional features within canyons (Canals et al., 2006; Palanques et al., 2012).
On the basis of modelling of cascading events that recently occurred in the Gulf of Lions, we performed numerical simulations of Messinian brine-related cascading currents at different water density contrasts.
Our results show that the activation of downslope flow of hypersaline dense waters may well account for both significant slope erosion and progressive salinity rise leading to the accumulation of deep-seated supersaturated brines. These findings support a "deep-water deep-basin" model thus implying that the evaporite deposition occurred in a non-desiccated basin with strongly reduced connections with the global ocean.

References

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