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Messinian Salinity Crisis and basin fluid flow

Claudia Bertoni and Joe Cartwright

Shell Geoscience Laboratory, Department of Earth Sciences, University of Oxford, United Kingdom
(claudiab@earth.ox.ac.uk)

Syn- and post-depositional movement of fluids through sediments is one of the least understood aspects in the evolution of a basin. The conventional hydrostratigraphic view on marine sedimentary basins assumes that compactional and meteoric groundwater fluid circulation drives fluid movement and defines its timing. However, in the past few years, several examples of instantaneous and catastrophic release of fluids have been observed even through low-permeability sediments. A particularly complex case-study involves the presence of giant salt bodies in the depocentres of marine basins. Evaporites dramatically change the hydrostratigraphy and fluid-dynamics of the basin, and influence the P/T regimes, e.g. through changes in the geothermal gradient and in the compaction of underlying sediments.

Our paper reviews the impact of the Messinian Salinity Crisis (MSC) and evaporites on fluid flow in the Mediterranean sub-basins. The analysis of geological and geophysical sub-surface data provides examples from this basin, and the comparison with analogues in other well-known evaporitic provinces. During the MSC, massive sea-level changes occurred in a relatively limited time interval, and affected the balance of fluid dynamics, e.g. with sudden release or unusual trapping of fluids.

Fluid expulsion events are here analysed and classified in relation to the long and short-term effects of the MSC. Our main aim is to build a framework for the correct identification of the fluid flow-related events, and their genetic mechanisms. On basin margins, where evaporites are thin or absent, the sea-level changes associated with the MSC force a rapid basinward shift of the mixing zone of meteoric/gravity flow and saline/compactional flow, 100s-km away from its pre-MSC position. This phenomenon changes the geometry of converging flows, creates hydraulic traps for fluids, and triggers specific diagenetic reactions in pre-MSC deep marine sediments. In basin-centre settings, unloading and re-loading of water associated to the sea-level changes leads to the sudden release of focused fluids, enhancing pockmark formation, evaporite dissolution, gas-hydrate dissociation and methane venting.

After the MSC, and in the long-term basin evolution, the aquitard effect of the thick evaporites also created favourable condition for the development of overpressures in the pre-MSC sediments. However, the traditional view of saline giants as impermeable barriers to fluid flow has been challenged in recent years, by the documented evidence of fluid migration pathways through thick evaporites. Ultimately, these events can lead not only to fluid, but also to sediment remobilisation. The review here presented has applications as a tool for identifying, quantifying and understanding controls and timing of fluid dynamics in marine basins hosting extensive evaporitic series.