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Fault-controlled evaporite deformation in the Levant Basin, Eastern Mediterranean

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A multi-layered salt giant of averagely 1.5 km thickness was precipitated in the Levant Basin during the Messinian Salinity Crisis. Yet, deformation of this geologically young salt layer was mainly explained by basement inclination and differential sediment loading causing evaporites to either deform by gliding or spreading. Based on high-quality, depth-migrated seismic data we show for the first time how salt deformation was additionally influenced by a large system of sub-salt Miocene extensional faults, adding another mechanism to control the internal shape of the Messinian evaporites.

Where faults offset the base of the evaporites, we recognize a typical intra-salt deformation pattern: Intra-salt anticlinal folds frequently coincide with the footwall of sub-salt faults turning into synclinal structures towards the hanging wall. This deformation pattern is only evident within the lower stratigraphic units of the evaporites (ME-I to ME-III) and absent or heavily overprinted within the uppermost salt unit (ME-V). Furthermore, extensional faulting cannot be observed within the Pliocene-Quaternary overburden, indicating faulting activity to have ceased during Messinian times. Integrating these observations into a new conceptual model, we suggest Messinian extensional faulting to have caused the formation of syn-depositional monoclinal fault-propagation folds within the lower evaporite units. These folds may have now acted as nucleation points for accommodating subsequent Late Messinian tectonic shortening and thereby evolved into the presently observed complex intra-salt deformation pattern.

While syn-depositional fault-controlled evaporite deformation is evident in the northern part of the Levant Basin only, evaporites are increasingly influenced by Nile-derived differential sediment loading towards the south, causing evaporites to deform post-depositionally.

Locally, vertical zones of chaotic reflections extent from the sub-salt domain into depressions at the base of the evaporites and terminate into phase-reversed intra-salt bright spots. Such observations indicate fluids to locally migrate into the salt layer.