Subsurface fluid flow dynamics in the Southern Levant Basin, SE Mediterranean and its implication on carbon capture and geological storage

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Abstract

The Levant Basin is indisputably a prolific hydrocarbon province having an estimated recoverable reserve discovered to date at more than 30 TCF of gas. During the geodynamic evolution of the Levant Basin, a multi-layered evaporitic sequence so-called the Messinian Evaporites (consisting of halite, anhydrite and clay) was deposited about 6 million years ago as a consequence of the Messinian Salinity Crisis that affected the entire Mediterranean realm. The Messinian evaporites serve as a sealing unit to the Oligocene-Miocene gas reservoirs. However, in the first part of this talk, I present evidence of fluids (methane, pore-water) bypassing this regional seal into the Pliocene-Quaternary overburden based on the analysis of a high-resolution depth-migrated three-dimensional seismic reflection dataset. These fluid flow elements are manifested as a suite of short-lived fluid flow pipe structures genetically and spatially compartmentalized in the study area as seepage and dissolution pipes. Importantly, the development of these pipe structures in the overburden have been inhibited by successive sedimentation and likewise by the emplacement of mass transport deposits during the Pliocene. In the second part of the talk I will show evidence for present-day seafloor gas expulsion in the Levant Basin along the Palmachim disturbance, a 20 km × 10 km gravitational collapse structure. Here, complex deformation manifested as a network of faults detaching onto the Messinian evaporites may have channeled fluids from the pre-Messinian reservoirs into the overburden where they are sequestered in channel-levee system and also in mass transport deposits. The fluids are subsequently either focused toward the seafloor for expulsion or migrating into the ridge-like structures which provide four-way closure and accommodation. In both scenarios, under an elevated pore pressure regime, hydrofracturing of the near-seafloor sediments results in the development of pockmarks from the expulsion of fluids and fluidized sediments along the seafloor. The fluid flow elements identified in this part of the Levant Basin may have significant implications for hydrocarbon exploration, CO_2 sequestration and nuclear waste disposal. Materials sequestered in potential pre-Messinian reservoirs or in deep saline aquifers may eventually bypass the evaporitic sealing unit via deformations (faults network) and likewise employ the pipe structures en route the seafloor for expulsion. The evaluation of these potential secondary migration pathways is a critical element for the success of carbon capture and geological storage projects in this region of the Mediterranean Sea.

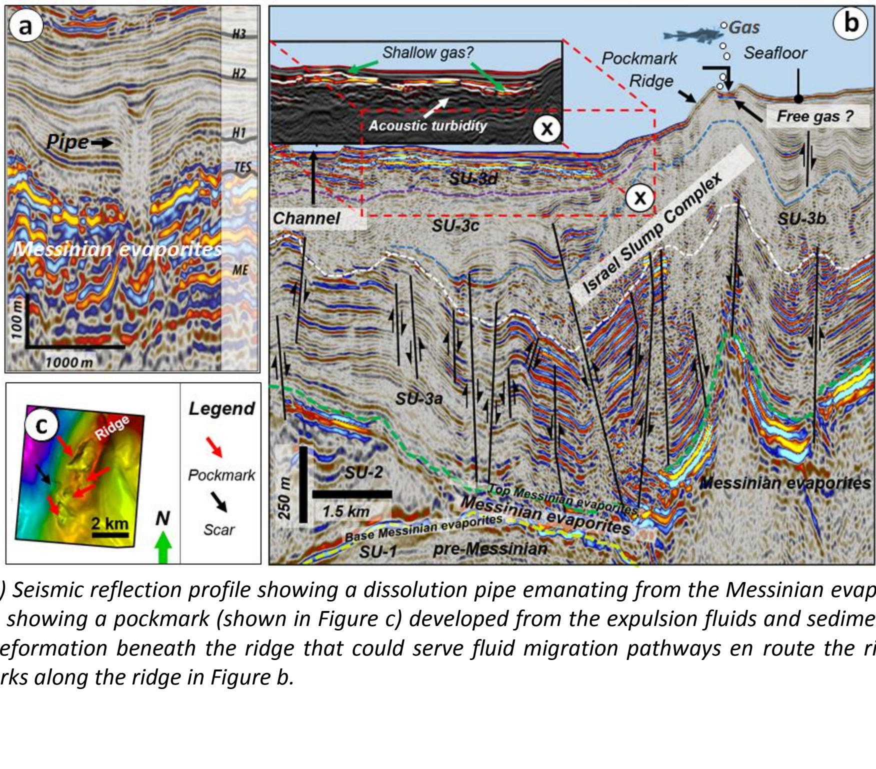

Figure Above: (a) Seismic reflection profile showing a dissolution pipe emanating from the Messinian evaporites (b) Seismic reflection profile showing a pockmark (shown in Figure c) developed from the expulsion fluids and sediment above a ridge. Also, note the deformation beneath the ridge that could serve fluid migration pathways en route the ridge. (c) Chain of seafloor pockmarks along the ridge in Figure b.