Understanding the Evolution of Sedimentary Basins as Rock-Fluid Systems Through Integrated Geological Modeling: The Case of the Levant Basin (East-Mediterranean Region)

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Abstract

Sedimentary basins host a large range of geo-resources that are a necessity for societal development towards sustainability. In the last decades, the Eastern Mediterranean region witnessed exceptional developments in terms of oil and gas exploration, demonstrated by major discoveries and the opening of new frontiers and acreages. The industrial advances happened together with an impressive set of scientific achievements in various fields. Hence, a huge wealth of data, viable concepts and expertise have been made available for this region and analogues worldwide. More than 70TCF of gas have been discovered so far in the Levant Basin within only a few producing and upraised fields (e.g. Tamar, Leviathan, Aphrodite, Zohr, Calypso, Glaucus). All these discoveries are reported to relate to biogenic gas sourced in Oligo-Miocene clastics, while some new findings (e.g. Karish field) may suggest the viability of thermogenic petroleum systems. Crucial questions pertaining to the quantitative understanding of basin evolution dynamics (e.g. architecture, source-to-sink, geomechanics and fluids), and, in particular, to the precise estimation of the biogenic gas accumulations across the basin, and to infer about other potential thermogenic hydrocarbon occurrences are still un-answered. An integrated workflow for modeling sedimentary basins was designed to include geodynamics and crustal modeling, source to sink stratigraphic simulations, thermal and burial evolutions (fluid flow and accumulations), and uncertainty analysis. The constructed numerical models cover around 200,000 sq. km, with horizontal cells grid resolution of 5 sq. km and a vertical resolution of less than 50m. The following steps were achieved: i) characterization and integration of geological, geophysical and geochemical data (leading to the geological conceptual models); ii) crustal modeling (architecture and evolution of the crust underlying the Levant Basin and its margins); iii) sedimentary facies modeling using numerical forward stratigraphic approaches (testing multi-scenario GDE maps, play fairways); iv) Seismic-data based structural characterization and modeling; and iv) burial/thermal and petroleum systems modeling - with a new, specific approach for simulating biogenic gas generation, expulsion and accumulation; and v) Uncertainty analyses and modeling aiming to examine the modeling constraining parameters and de-risking exploration. This contribution will illustrate, first, how the above mentioned (un-answered) questions were addressed, demonstrating that an integrated approach can provide a reliable tool for de-risking exploration in typical frontier provinces such as the Levant Basin. Then, the lessons learnt through this process with respect to the sedimentary basins as comprehensive rock-fluid systems will be presented.