Would Integrated Stratigraphic Geomodels Resolve The Challenges of Frontier Hydrocarbon Provinces? The Case of the Levant Basin*

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A New Hydrocarbon Province

Today, the Levant Basin – located in the East Mediterranean region (Figure 1) – represents a new Frontier Gas Province. Offshore discoveries in this basin (e.g., Mari-B, Tamar, Dalit, Leviathan, Tanin, Karish, and Cyprus-A) have confirmed the presence of gas accumulations in subsalt lower Miocene sandstones (exceeding 38Tcf of recoverable reserves). The East Mediterranean region remains, nevertheless, burdened with a complex geodynamic, tectono-stratigraphic history and high exploration costs (deep offshore drilling, sub-salt reservoirs).

Frontier hydrocarbon basins are commonly associated with risky and rather expensive exploration. A very limited number of wells generally exist and seismic data constitute the key information that is available for evaluating the basins' architecture and sedimentary-filling history (and subsequently its prospectivity). Here robust geological concepts and uncertainty analyses become crucial tools for sound economic assessment.

The origin of the Levant Basin (as a part of the Neo-Tethys) has been ascribed to the Permo-Triassic fragmentation of Pangea. Sedimentary filling therein was influenced by several tectonic events, including the closure of the Neo-Tethys, pulsating compressive folding (previously called "Syrian Arc Deformation"), and strike-slip faults associated with the separation of the African and Arabian Plates. Impacts of such tectonic history on the distribution of sedimentary facies (source-, reservoir-, and sealing rocks) remain difficult to comprehend, and need appropriate numerical modeling before successful drilling. New seismic data confirm that the southern part of the Levant Basin (offshore Sinai, Israel) is significantly different from the northern part (offshore Lebanon, Cyprus). Indeed, the latter could be associated with a western extension of the southern Palmyride zone, denoting thicker Upper Cretaceous – Cenozoic rock successions, and thicker underlying crustal segment invoking thin-skinned tectonics. Three distinct domains across the northern Levantine basin/ margin (Lebanon) have been illustrated in Nader (2011): deep basin offshore, margin offshore, and margin onshore. The latter domain is correlated with the inland Palmyride Trough (see Figure 2). Such domains align with recent results of seismic interpretation and basin modeling provided by a series of academic projects (MSc and PhD theses; Hawie et al., 2013; Bou Daher et al., 2014; Ghalayini et al., 2014).

New ideas have emerged from recent studies regarding source-to-sink approach for filling the basin with relatively thick sedimentary packages, in-depth structural investigation of the mechanisms and timing of observed faults and folds, and geochemical analyses of outcropping source rocks (Hawie et al, 2013; Ghalayini et al., 2014; Bou Daher et al., 2014; and references therein). Integrating all such information in one geomodel will provide a powerful tool to test geological concepts and to de-risk the continuing exploration of such a frontier province.

Towards an Integrated Stratigraphic Geomodel

An emerging frontier hydrocarbon province, with risky offshore subsalt exploration and production, presents numerous challenges. One of which, may be seen by far as the most important, concerns the lack of available data – especially in distal parts of the basin (offshore). Classically, the lack of data is met with adequate regional studies and comprehensive synthesis (Figure 3), taking into account the scarce available information, which is then extended to unknown areas through extrapolation. This is based on the state-of-the-art concepts of geology and basin analysis. In frontier offshore basins, reflection seismic data (2D and 3D) among other geophysical techniques are often being used extensively. Yet even with relatively robust geologic concepts and reasonable seismic-stratigraphic correlations, the lack of data prohibits crucial validations to limit uncertainties.

Various types of modeling have been therefore used in order to test a broad range of hypotheses. For instance, Gvirtzman et al. (2014) make use of IFPEN's Dionisos software package in order to constrain the major sediment sources responsible for filling the southern part of the Levant Basin (Figure 3). Other types of numerical modeling at the basin-scale attempt to understand the distribution of organic matter, to apply structural restoration, or to infer about the evolution of basinal fluids. Analog modeling (sand-box experiments) have also been used in order to constrain boundary conditions for the effects of tectonics on the basin architecture and geometries (Figure 3).

An integrated stratigraphic geomodel includes the application of the above-mentioned approaches and tools (Figure 3). Hence, workflows are designed to make use of the regional synthesis of a frontier basin in order to construct a forward stratigraphic model. Then such model is used, aiming to achieve best-fit simulations associated with tests with other tools (e.g., sand-box experiments). Integrating a stratigraphic model with a petroleum system basin model will be the final stage, whereby the produced geomodel scenarios could be used in optimal conditions to better understand the investigated frontier hydrocarbon basin.

Pacts-Basins R&D Approach

Today, the academic and industrial realms are faced with the needs to further upgrade research and development tools and workflows. Numerical modeling software packages are being continuously improved, and new requirements keep on emerging. Under the PACTS-Basins Research Program, IFPEN proposes to develop a methodology for evaluating source-rock maturity in frontier hydrocarbon basins with complex geodynamic tectono-sedimentary history, based on integrated stratigraphic basin geomodeling. The Levant Basin is believed to be an excellent application for the proposed approach.

In addition to the workflow presented above, this proposed research program will include uncertainty numerical modeling. Such tool will be used to constrain uncertainties where validation and calibration are lacking (namely, in frontier hydrocarbon provinces). Uncertainty analysis may be considered as an adequate way to value the integrated geomodels in underdrilled frontier basins, paving the way for a less risky exploration.

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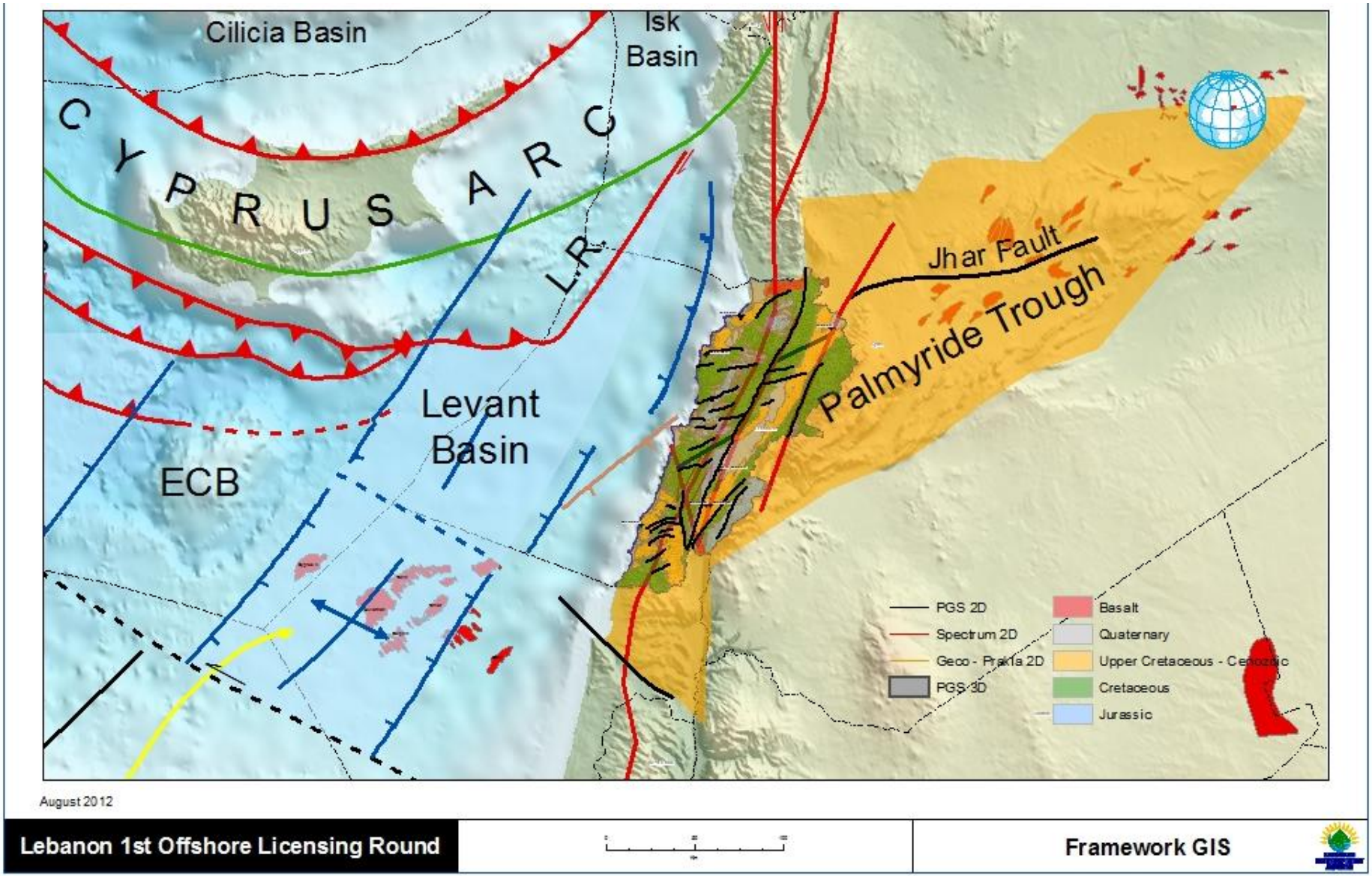

Figure 1. Schematic structural map of the Levant Basin showing the major discoveries offshore Israel and Cyprus and the onshore fields in Syria (in the Palmyride Trough). The map is after Montadert et al. (2010) and taken from the Lebanese First Offshore Licensing Round Framework GIS Package (website accesses January 19, 2015) (http://www.lpa.gov.lb).

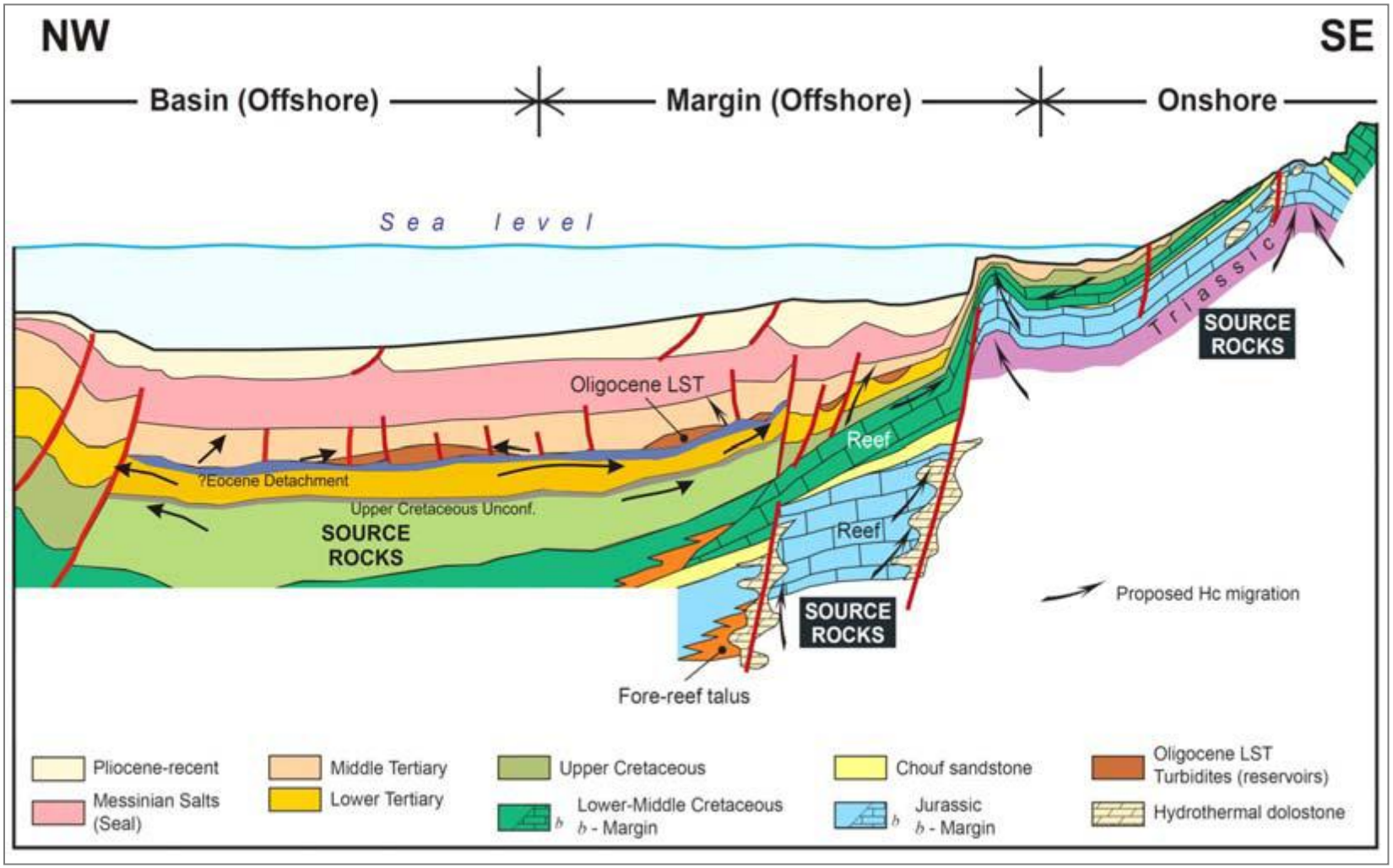

Figure 2. Schematic petroleum system model for Lebanon (northern Levant Basin), with possible plays offshore, in the continental margin and onshore (Nader, 2011).

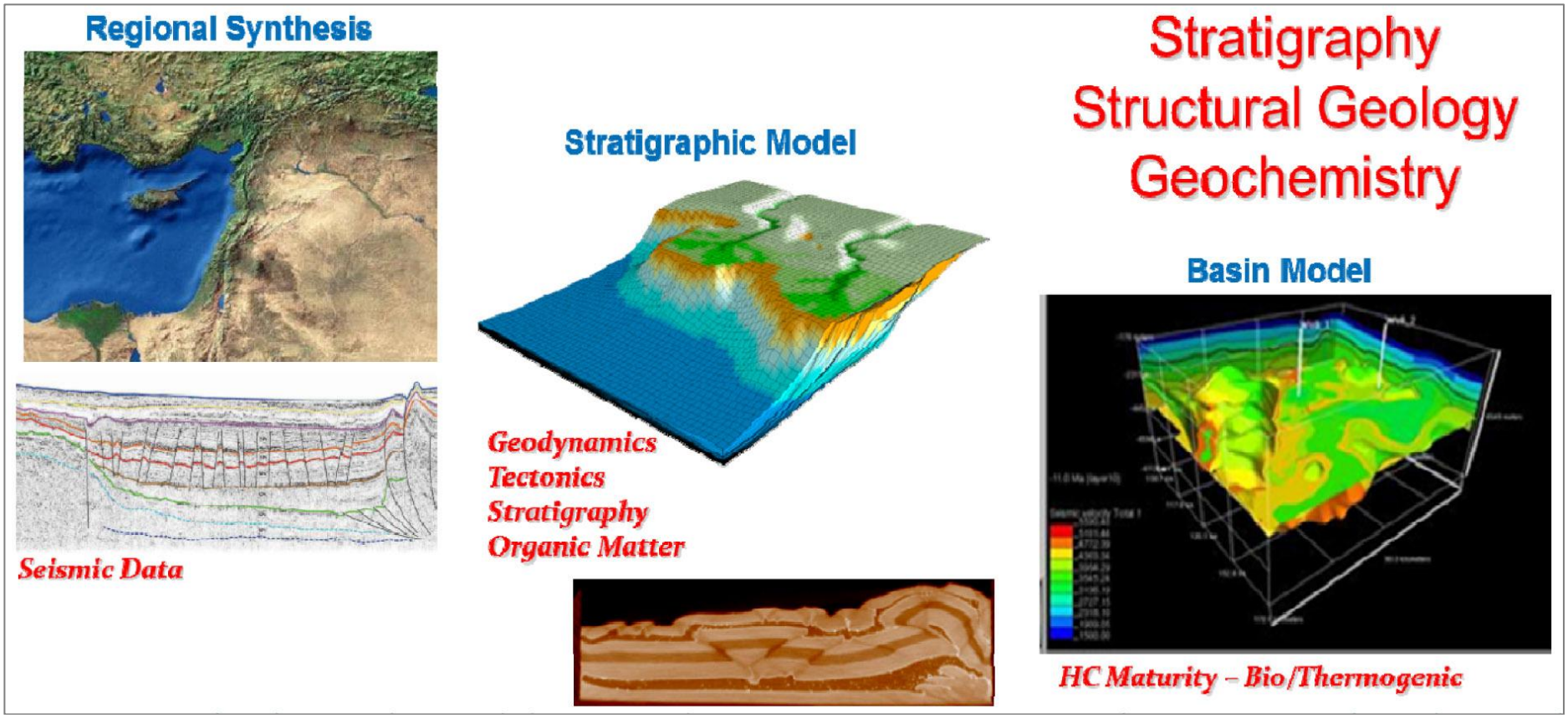

Figure 3. Regional geologic synthesis (including seismic data interpretations; e.g., Hawie et al., 2013), stratigraphic and structural modeling (e.g., Gvirtzman et al., 2014), and petroleum systems basin modeling--tools often used to test scenarios and limit exploration uncertainties.