

**The LEVANT OFFSHORE BASIN and its PETROLEUM PERSPECTIVES:
 PETROLEUM PROSPECTS of LEBANON**

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Introduction

In the last couple of years, important discoveries of natural gas were reported from offshore Israel (Tamar and Dalit wells; total proved reserves of 273 Bcf according to Noble Energy - www.nobleenergyinc.com). Such events led some petroleum companies to re-evaluate the prospects of the eastern Mediterranean region. This contribution revisits the subject of petroleum prospects of Lebanon. Data presented and discussed here, are based on excellent previous studies that benefited from lessons learnt during the actual onshore exploration work (e.g. Renouard, 1955; Beydoun, 1977 and 1981) and more recent studies involving regional correlation and diagenesis (Nader and Swennen, 2004). To these, the discussions on the recent offshore seismic surveys and their results (Roberts and Peace, 2007; Per Helge Semb, *pers. comm.*, 2008) are added in order to update the working petroleum model earlier proposed by Nader and Swennen (2004). The tectono-sedimentary history and related occurrence of interesting structures and diagenetic features were placed within the framework of the broader geological province of the Levant.

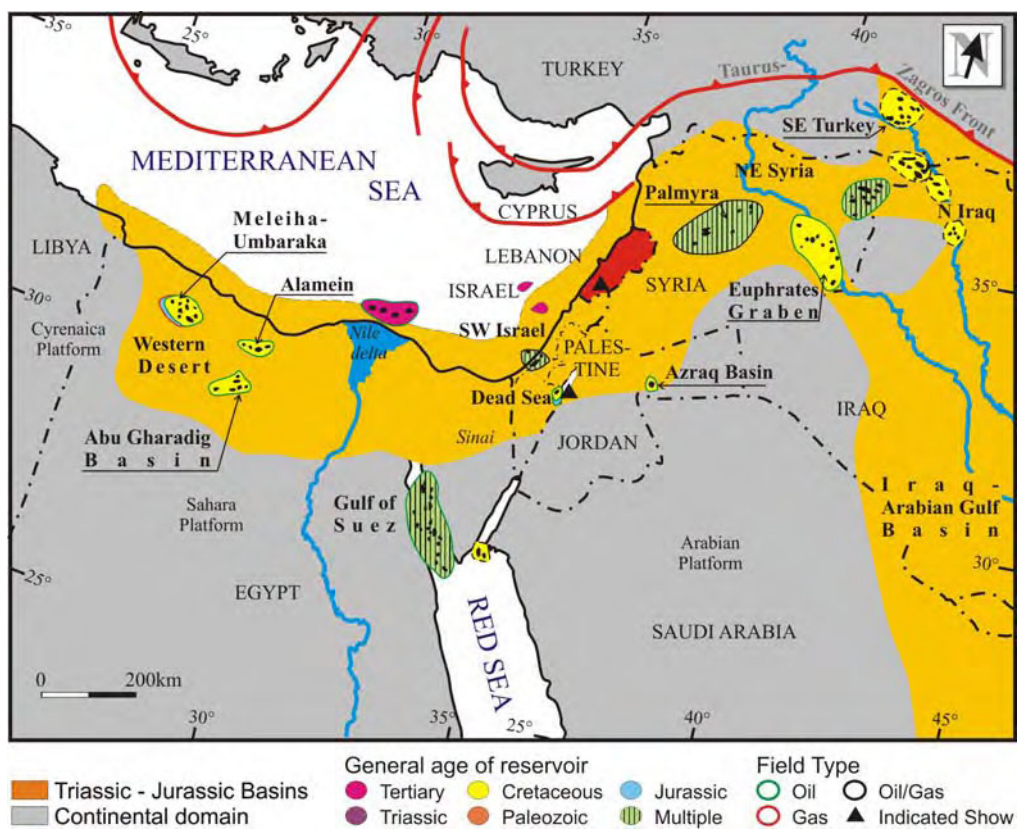


Fig. 1. Simplified map showing the Eastern Mediterranean region and the extent of Triassic-Jurassic basins with the major known oil fields (modified and updated from May, 1991).

A quick overlook on the distribution of major oil and gas fields in the Eastern Mediterranean region highlights certain consistencies with respect to major source rocks (Fig. 1; May, 1991). With the exception of the Nile Delta and the Gulf of Suez, the main stratigraphic units hosting source rocks are Triassic, Jurassic, and Upper Cretaceous. Recent studies have confirmed that the Chekka Formation (Senonian, Late Cretaceous), which consists of organic-rich mudstone and is well exposed in southern Lebanon (Hasbaya), includes two types of asphalt: the first one is related to in situ maturation of organic matter in the rock matrix, and the second type is fracture-related, and attributed to another deeper source. Renouard (1955) and Beydoun (1977) had also discussed the same rock units and the latter even proposed probable Devonian/Silurian sources for the Hasbaya asphalts.

The presented conceptual petroleum model incorporates both offshore and onshore potential prospects. Offshore prospects will be highlighted through the discussion of seismic profiles (after Roberts and Peace, 2007; and new PGS 3D seismic sections; courtesy of Per Helge Semb, 2008). Here, the focus will be chiefly dedicated to the Miocene rock units, underlying the Messinian salts. Insights into the prospectivity of Triassic potential reservoir units in onshore central-northern Lebanon are presented, where the “Qartaba” structure has been investigated.

Hydrocarbon shows

Based on recent seismic and satellite seep studies more than 200 seep features were identified offshore Lebanon; some of which were associated with clear migration pathways through deep-seated faults on seismic sections (Roberts and Peace, 2007). This clearly shows that indications for Lebanese hydrocarbon prospects are not lacking.

The most important hydrocarbon surface indication in Lebanon is present in the region of Hasbaya (Fig. 2). There, asphalt has been exploited since the pre-Christian times. It is found in Senonian rocks (the Chekka Formation), usually filling fractures. Renouard (1955) suggested that these asphalts are the shows of an active migration whose origin is deep, based on the nature of the hydrocarbon and that of the surrounding rocks. Viscous asphalt was encountered at the top of the Chekka Formation in the Yohmor-1 well (Fig. 2). Caves and old mining pits partially filled with recent (flowing) asphalt and tar are found in the vicinities of the Hasbaya, Sohmor and Yohmor villages. Gas was also found deeper in the Senonian strata, causing a blow out estimated to be in the order of 50m³/day during drilling and testing works. The composition of the gas was approximately 85% methane and 15% heavier fractions. Gas shows were also found in the nearby Paleocene limestones intruded by Sohmor-1 (Beydoun, 1977). Some asphalts have also been located in a fault zone in Cenomanian rocks along Ouadi Challita (Metrit village; Fig. 2). These asphalts are found in marco-vugs together with quartz cement in dolostones. Common oil traces occur in the Jurassic limestone and dolostone rocks of northern Lebanon. These are diffuse impregnations (soluble in chloroform), usually structurally controlled (occurring along faults, fractures; unpublished report – Renouard, 1967).

Bitumen/coal shows are found in the Chekka area: commonly small (10s of cm long), isolated in the clay and generally surrounded by diffusion rings. In the El Qaa borehole (northern Bekaa), small amounts of bitumen were encountered at 1585m below surface (in Cenomanian strata). In the Terbol-1 borehole (northern Lebanon), the Cenomanian rocks are characterized by bitumen (covering the whole rock-unit), the Aptian strata include one bitumen show, and some Late Jurassic (Kimmeridgian) rocks include up to 10% of solid hydrocarbons (at 2170 and 2572m below ground level; Ukla, 1970).

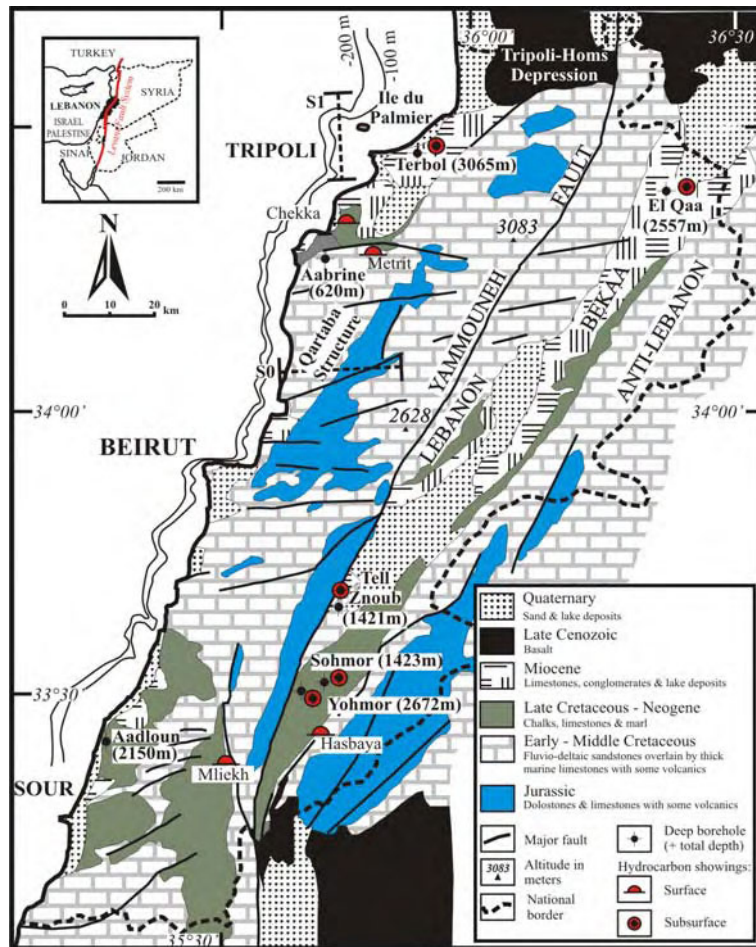


Fig. 2. Simplified geological map of Lebanon showing the locations of the seven exploration wells and reported hydrocarbon shows (Dubertret, 1955; Ukla, 1970, Beydoun, 1977).

Conclusion

A conceptual schematic model is presented and aims to offer the basis for future, serious investigations and exploration drilling in Lebanon. The model describes two major types of plays (offshore/onshore):

Offshore plays may consist of local reef platform structures of Miocene age, sandstone and turbidites (Cretaceous and Cenozoic). Such plays are sealed with the overlying Messinian salts. The timing of hydrocarbon migration should be constrained. If it can be demonstrated that the sealing occurred before migration, a “layered cake” stratigraphic pattern scenario may be met. Triassic, Jurassic, Cretaceous and Miocene strata reservoirs will be isolated by the evaporites, volcanics, clays and marls, as well as the Messinian salts, which acts as a heat conductor and may save the underlying source rocks from over-cooking.

The Qartaba Structure, situated in northern Mount Lebanon may constitute the best onshore play for Triassic (or pre-Jurassic) prospects. The structure has a length that may reach 75km and a width ranging between 10 and 25km. It also provides optimal locations for exploration wells reaching the Carboniferous. The Ile du Palmier Structure, situated offshore Tripoli (northern Lebanon), where the continental shelf is the widest along the Lebanese coastline, may target the various formations classically known to produce and accumulate hydrocarbon.

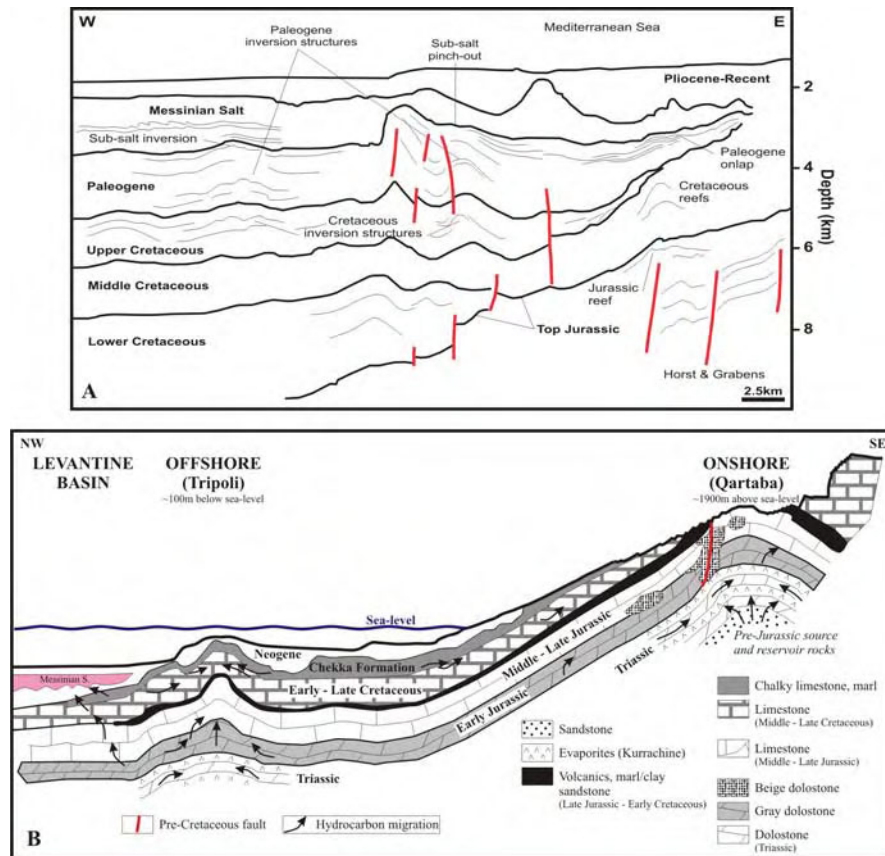


Fig. 3. A) Interpreted seismic line offshore Lebanon presenting some of the major types of offshore plays (from Roberts and Peace, 2007). B) Proposed petroleum system model for Lebanon (Nader and Swennen, 2004).

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