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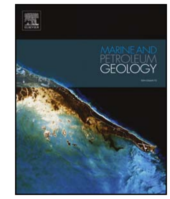

Research paper

Crustal configuration in the northern Levant basin based on seismic interpretation and numerical modeling

Lama Inati[a,b,c,d,*], Jean-Claude Lecomte[a], Hermann Zeyen[e], Fadi Henri Nader[a], Mathilde Adelinet[a], Muhsin Elie Rahhal[d], Alexandre Sursock[b]

[a] *IFP Energies Nouvelles, Geology Department, 1 and 4 Av. Bois Préau, 92852, Rueil Malmaison, France*
[b] *National Center for Geophysical Research, CNRSL, Bhannes- El, Metn, Lebanon*
[c] *Université Pierre et Marie Curie, 4 Place Jussieu, 75005, Paris, France*
[d] *Ecole Supérieure des Ingénieurs de Beyrouth, Université Saint Joseph, Mar Roukoz, Beirut, Lebanon*
[e] *Département des Sciences de la Terre, UMR 8148 GEOPS, Université Paris-Sud, CNRS, Université Paris-Saclay, France*

A B S T R A C T

The interpretation of five 2D PSTM seismic reflection sections (14 s TWT) covering the northern Levant Basin revealed a total of 10 horizons, among which, one is interpreted as an interface that may represent the Moho. The interpretation of seismic packages and their bounding surfaces as well as the seismic facies analysis were constrained by published 2D seismic interpretations of the northern Lebanese offshore. A total of nine seismic packages are identified in the basin with ages varying from the Mid Jurassic to the Quaternary. The filling of the basin is made up of thick Cenozoic and Mesozoic strata deposited above rifted Triassic – Early Jurassic interval. The sediments are deposited in deep water mixed-settings resulting from high-stand systems (various types of carbonate platforms) and low-stand systems (siliciclastic and carbonate deep-water turbidite complexes). Carbonate and siliciclastic systems are sealed by 1–1.5 km of evaporites, and underlie Plio-Quaternary hemi-pelagic and pelagic sediments intercalated by turbiditic sheets.

The time horizons were converted into depth using two methods; the first one is based on stacking velocities and the second one on velocities resulting from refraction data. 2D crustal modeling was achieved by integrating free-air gravity anomaly, geoid heights and topography data on the five interpreted PSTM seismic lines. The models representing five sections across the northern Levant Basin, show a progressively attenuated crystalline crust in an EW direction (away from the basin's eastern margin). The crystalline crust is best interpreted as a strongly thinned continental crust under the Levant Basin, represented by two distinct components, an upper and a lower continental crust. The Moho appears to be situated between 20 and 23 km in the central and southern Lebanese offshore. Estimated surface heatflow in the basin is around 40 mW/m^2, which is lower than reported values for the onshore and the margin. These differences in heatflow values between the offshore, the margin and the onshore have an important impact on hydrocarbon maturation and assessment of potential petroleum systems.

1. Introduction

The Levant Basin, located in the easternmost part of the Mediterranean region, has raised the interest of international oil companies after the recent discovery of more than 1.7 Tm^3 of natural gas in the region. The Eastern Mediterranean region has proven to be a world-class, frontier deepwater hydrocarbon province with numerous plays as highlighted by modern seismic data (e.g. Nader, 2011; Montadert et al., 2014; Hawie et al., 2013a) and new confirmed discoveries in under-explored areas (e.g. Zohr field, offshore Egypt). Despite numerous old and recent geophysical studies in this region (Woodside, 1977; Khair et al., 1997; Segev et al., 2006; Netzeband et al., 2006), the deep crustal configuration of the Levant Basin is still debated. While refraction studies (Netzeband et al., 2006) and geophysical modeling (Inati et al., 2016) (Fig. 1) advocate for an attenuated continental character of the southern Levant Basin crust, the northern part (offshore Lebanon and Cyprus), which is characterized by a lack of data and a complex geodynamic history, has not been well investigated yet. Surface temperatures and the thermal history of the region remain uncertain. Few wells were drilled onshore and in the southern part of the basin but the

* Corresponding author. IFP Energies Nouvelles, Geology Department, 1 and 4 Av. Bois Préau, 92852, Rueil Malmaison, France.
E-mail address: lamainati@hotmail.com (L. Inati).

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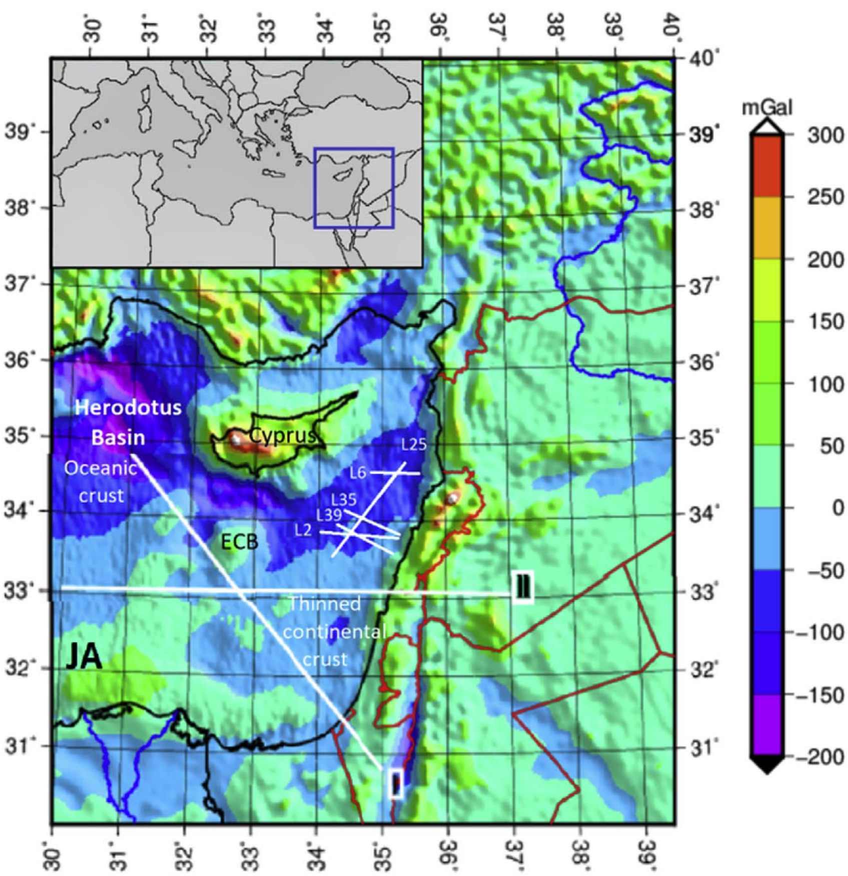

Fig. 1. Free-air gravity anomalies map (TOPEX database) showing the location of the thinned continental crust flooring the Levant Basin and the oceanic crust in the Herodotus Basin, resulting from 2D crustal modeling along profiles I and II (in black) (Modified from Inati et al., 2016). The profiles studied in this paper are represented in white (L2, L6, L25, L35, L39). JA = Jarrafa Anomaly, ECB = Eratosthenes Continental Block.

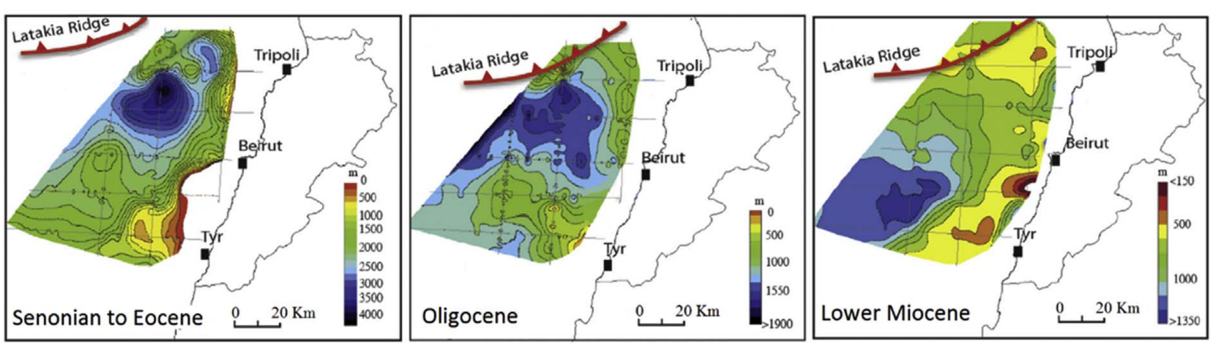

Fig. 2. Isopach maps (Senonian to Lower Miocene) showing the shift in depocenter location from the north (Senonian times) to the south (Lower Miocene times) in the northern part of the Levant Basin (modified from Hawie et al., 2013b).

thermal context of the northern part is yet unknown. Knowing these parameters would have important implications on thermogenic and biogenic petroleum systems in the study area.

Based on high-quality seismic reflection data and potential field geophysical data, we provide in this paper five interpreted crustal-scale profiles in the Lebanese offshore of the northern Levant Basin (covering the Lebanese Exclusive Economic Zone, EEZ). The seismic interpretation of five PSTM (pre-stack time migrated) long record length seismic reflection lines (14 s two way travel time (TWT)) is first presented. Then, crustal models are proposed based on numerical modeling integrating surface free-air gravity anomaly, geoid and topography, and constrained by the interpreted seismic lines. The heatflow can then be inferred, invoking the impacts on maturation of hydrocarbon and petroleum systems.

2. Geological setting

Geologic observations from around the eastern Mediterranean region (e.g. Sawaf et al., 2001; Gardosh et al., 2010; Yousef et al., 2010) suggest three major extensional episodes, during the Permian, Triassic and Early Jurassic. A shallow marine environment is thought to have occurred in the central basin during these early stages of the Levant Basin's formation (i.e., Paleozoic to Middle Jurassic), while fluvio-deltaic to shallow marine settings prevailed along the margin (Collin et al., 2010; Gardosh et al., 2010). After the rifting activity ceased, the initiation of a passive margin together with the deposition of marine carbonates and deepwater siliciclastics followed in the Late Jurassic (Cohen, 1976; Gardosh, 2002; Roberts and Peace, 2007). In the Early Cretaceous, a major emersion has led to the deposition of siliciclastic sediments along the Afro-Arabian Plate (Brew et al., 2001; Ziegler, 2001). In the Turonian, the collision of Afro-Arabia with Eurasia has created a foreland basin with an enhanced subsidence at the front of the

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