First EAGE Workshop on Geophysical and Geological Challenges in the Hydrocarbon Provinces of the Eastern Mediterranean

6-7 December 2018 • St. Julian’s, Malta

www.eage.org
EM 05
Anatomy of the Mesozoic Tethyan Margins: The Eratosthenes Carbonate Platform

N. Papadimitriou\textsuperscript{1,2,3,4}, C. Gorini\textsuperscript{2,3}, A. Tassy\textsuperscript{3,4}; F. H Nader\textsuperscript{2,3}; R. Deschamps\textsuperscript{2,3}

1 Hellenic Hydrocarbon Resources Management S.A, Athens (Greece)

2 Georesources Department, Geosciences Division, IFP Energies Nouvelles (France)

3 ISTEP, UMR 7193, UPMC, F-75005 Paris (France)

4 CEREGE, Aix-Marseille Université (France)
OUTLINE

- Introduction

- Scientific Questions

- Geological Setting

- Data and Methods

- Tectonostratigraphy of the western part of the Levant Basin (The Eratosthenes Carbonate Platform)

- Conclusions and Future work
Introduction
What is a Carbonate Platform;

A body of carbonate strata deposited as a geomorphic feature adjacent to deeper-water strata and include reefs, lagoons, tidal flats, and flanking slopes

Types of carbonate platforms:
- Ramp
- Shelf Carbonate platforms
- Non-Rimmed carbonate platforms
- Epeiric Carbonate platforms
- Isolate carbonate platforms

Why it is important;
They host significant hydrocarbon resources

*Modified Pomar, 2001*
(a) Mountain belts due to continental collision

(b) Fold and thrust belts

(c) Accretionary complexes

(d) Intracontinental belts

(e) Back – Arc basins

(f) Tethyan ocean

Distribution of Isolate Carbonate Platforms in the Mediterranean (Giovanni Rusciadelli and Peter Shiner)
Hyper extended margin with thin continental crust (Inati et al., 2016)

Experience several tectonic processes:
- Rifting
- Passive margin development
- Convergence and ophiolite emplacement
  (e.g., Dewey et al., 1973; Garfunkel, 2004; Hall et al., 2005; Aksu et al., 2005; Le Pichon and Kreemer, 2010; Ghalayini et al., 2014).

Bounded:
- North: Collision zone
- East: Strike-slip (major plate boundary)
- West: Isolate Carbonate platform to the west
- South: Nile delta
Post-rift evolution of the Eratosthenes Carbonate Platforms (ECPs)

• The Impact of the post-rift differential subsidence between Eratosthenes Continental Block and the Levant Basin?

• The contribution of an Isolated Carbonate Platform to the infilling of the adjacent basin

• The impact of the collision between Eratosthenes Continental Block and Cyprus Arc.
Geological Setting
**EXTENSION PHASE**

**Late Triassic**
- Tethyan rifting
- Formation of Levant basin and Herodotus basin
- Eratosthenes Continental Block is detached from Afro-Arabian plate

**Middle Jurassic**
- Post rift subsidence
- Progressive development of a platform/slope/ basin morphology

*Vrielynck et al., 2014*
Late Cretaceous
Initial closing of Neo-Tethys
African plate moves northward with respect to Eurasian plate
Emplacement of ophiolites in the region

Vrielynck et al., 2014

Early Cretaceous
Marginal Uplift/ major boundary
Extension and/or Mantle plume
Oligocene to Miocene
Collision of African-Eurasian plates

Pliocene
Expulsion of Anatolia micro-plate towards the southwest
Compression leads to reverse and strike-slip structures

Vrielynck et al., 2014
• **Late Jurassic:** Wide carbonate platform attached to the Afro-Arabian Plate.

• **Early Cretaceous:** Terrigenous sediments originating from the inner continent.

• **Late Cretaceous (Turonian):** Drowning of the carbonate platforms.

• **Paleogene:** Deep marine setting during the Plaeocene.

• **Miocene:** Shallow marine conditions during the Miocene.

• **Messinian:** Demise of the Carbonate Factory

*Papadimitriou et al., 2018*
Data and methods
24 profiles of 2D (TWT) seismic

- 10 lines of conventional 2D data recorded in 2006-2008. Seismic grid 10 x 20 km.

- 14 lines of 2D data shot with the dual sensor GeoStreamer technology recorded in 2008. Seismic grid 20 x 20 km western domain and 5 x 5 km eastern domain.

- 3 ODP wells and Zohr
  (Emeis et al., 1996;a,b,c; Bertello 2016)

- Magnetic anomalies map
  (UGGS)
Two linear series of positive and negative series of magnetic anomalies:

**Domain 1:** Alternated high and low amplitude magnetic anomalies (Thin continental crust)

**Domain 2:** Constant low amplitude magnetic anomalies (Oceanic crust)

**North:** Along the Cyprus Arc, high amplitude magnetic anomalies

**South:** Positive anomalies in a NW-SE direction; interpreted as transfer zones controlling the hinge line of Levant and Egyptian platforms

*Makris 1983; Norton 1991; Gardosh 2006; Hawie et al., 2013; Montadert et al., 2014; Tassy et al., 2015*
**ODP wells:**
- **site 966:** 360 m deep recovering Pliocene to Eocene sediments;
- **site 965:** 250 m deep Pliocene to Miocene;
- **site 967:** 600 m deep; Pliocene to Early Cretaceous sediments

**Zhor:** 2654 m; hit 630 m biogenic gas column in a carbonate sequence of Cretaceous to Miocene in age

*Flecker et al., 1998*

*Bertello, 2016*
Tectonostratigraphy of the western part of the Levant Basin (offshore)
SEISMIC INTERPRETATION

Pull up?
## AGE MODEL AND SEISMIC STRATIGRAPHY ANALYSIS (Basin Domain)

<table>
<thead>
<tr>
<th>Seismic Packages</th>
<th>Age</th>
<th>Events</th>
<th>Lower Bounding surface</th>
<th>Upper Bounding surface</th>
<th>Reflection configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP 8</td>
<td>Pliocene</td>
<td></td>
<td>Irregular surface/truncation</td>
<td>Irregular surface/truncation</td>
<td>Parallel to subparallel configuration</td>
</tr>
<tr>
<td>SP 7</td>
<td>Messinian</td>
<td>MSC</td>
<td>Irregular surface/truncation</td>
<td>Irregular surface/truncation</td>
<td>Reflection free configuration (transparent)</td>
</tr>
<tr>
<td>SP 6</td>
<td>Late Miocene</td>
<td></td>
<td>Onlaps Onlaps on the margin</td>
<td>Irregular surface/truncation</td>
<td>Parallel to subparallel reflection and minor chaotic reflections</td>
</tr>
<tr>
<td>SP 5</td>
<td>Early Miocene</td>
<td></td>
<td>Conformable Onlaps on the margin</td>
<td>minor truncation</td>
<td>Subparallel configurations with some high amplitude condensed intervals</td>
</tr>
<tr>
<td>SP 4</td>
<td>Oligocene</td>
<td></td>
<td>Irregular surface/truncation</td>
<td>Conformable</td>
<td>Parallel to subparallel configurations/ Progradational sigmoid configuration with minor chaotic intercalations</td>
</tr>
<tr>
<td>SP 3</td>
<td>Late Cretaceous-Eocene</td>
<td>CONVERGENCE PHASE COLLISION (siliciclastic influx)</td>
<td>Onlap surface</td>
<td>Irregular surface/truncation</td>
<td>Parallel to subparallel reflections intercalated with some chaotic configuration</td>
</tr>
<tr>
<td>SP 2</td>
<td>Cretaceous</td>
<td></td>
<td>Baslap</td>
<td>Conformable</td>
<td>High amplitude parallel to subparallel configuration with some mounded intervals</td>
</tr>
<tr>
<td>SP 1</td>
<td>Late Jurassic</td>
<td></td>
<td>-Onlaps</td>
<td>Baslap</td>
<td>Parallel to subparallel reflections with some minor chaotic intervals</td>
</tr>
</tbody>
</table>

*Hawie et al., 2013*
AGE MODEL AND SEISMIC STRATIGRAPHY ANALYSIS (Platform Domain)

Tassy et al., 2015

ER1=Mid Jurassic

Mid Jurassic

Tassy et al., 2015
ELSP1-2: LATE JURASSIC?

Legend
Fa 11=carbonate platform (outer shelf)
Fa 12=Inner carbonate platform (lagoonal)
Fa 12'=Volcanoclastics
Fa 13=Pinnacle reefs
Fa 14=Shelf edge progradation
ESP3: EARLY CRETACEOUS

Depth map of top ESP3 Seismic unit.

Bertello, 2016
ESP4: CRETACEOUS

Depth map of top ESP4 seismic unit.

Conceptual model: (OMAN) Droste, 2010

Bertello et al., 2016
ESP5- Late Cretaceous/ Paleogene convergence of AfroArabia- Eurasia
Legend
Fa 11 = carbonate platform (outer shelf)
Fa 12 = Inner carbonate platform (lagoonal)
Fa 12' = Volcanoclastics
Fa 13 = Pinnacle reefs
Fa 14 = (shelf edge progradation)

Robertson, 1998
Miocene Carbonate Platform
Collision of Africa - Eurasia
Miocene/ Messinian Collision of Africa - Eurasia
Different thickness and range

**Onshore Cyprus:**
Deep marine sediments
Related to the initiation of the Pafos Thrust

**Offshore:**
Not confirmed nature but their geometrical position shows that are detached from Eratosthenes carbonate platform

MTCs are the witnesses a major geodynamic events (Climax of the collision)
Conclusions
• Successive Carbonate platforms:

(A) Late Jurassic (B) Early Cretaceous, (C) Late Cretaceous;

• The position of basement-high (ICPs) is controlled by structures inherited from the rifting.

• Studies on Tethyan carbonate platforms point out the fundamental differences between platform facies and basinal facies.

• Tectonism is related with the initiation and the drowning of carbonate platform (including both compressional and extensional tectonics).

• The distance of the paleo-relief from the continent has a fundamental role in the evolution of a carbonate platform.
Integration with other projects
Thank You / Questions