Chasing hydrocarbon reserves in Carbonate Buildups: Examples from the Eastern Mediterranean

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N. Papadimitriou
K. Oikonomopoulos
G. Makrodimitras
What is a Carbonate Platform?

A body of shallow carbonate strata deposited as a geomorphic feature adjacent to deeper-water strata and include different facies (reefs, lagoons, tidal flat deposits).

Why it is important;
They host significant hydrocarbon resources

Examples of good reservoirs:
• The Carboniferous of North America (360-299 Ma)
• The Permian of the United States (298-250 Ma)
• The Mesozoic in the Mediterranean (200-65 Ma)
• Tertiary Southeast Asia and Brazil. (24-5 Ma)
Geophysical studies

- Seismic Interpretation
- Well data
- Magnetic anomalies map (UGGS)
- Gravity map
Study Area

(a) Mountain belts due to continental Collison
(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, 2018)
Geological Setting

Late Permian-Triassic-Jurassic
Tethyan rifting
Opening of Neo-Tethys ocean

Examples:

North:
• ICPs developed on the Adriatic microcontinent (Apulian, Adriatic-Gavrovo-Tripolitza)
• Menderes platform
• Taurus platforms

South:
• Eratosthenes Carbonate Platform
• Levant and Egyptian Margin

(after Vrielynck et al., 2014)
Examples from Eastern Mediterranean

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; Aksu et al., 2005; Le Pichon and Kreemer, 2010).

**Bounded:**
- North: Collision zone
- East: Strike-slip (major plate boundary)
- West: Isolate Carbonate platform to the west
- South: Nile delta

(Gardosh et al., 2010)
Seismic interpretation
Eratosthenes Carbonate Platform
# Seismic Interpretation

<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>
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<tr>
<td>SP 8</td>
<td>Pliocene</td>
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<td>Irregular surface/truncation</td>
<td>Irregular surface/truncation</td>
<td>Parallel to subparallel configuration</td>
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<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</td>
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<td>SP 6</td>
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<td>Conformable</td>
<td>minor truncation</td>
<td>Subparallel configurations with high amplitude condensed intervals</td>
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<td>Oligocene</td>
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<td>Parallel to subparallel configurations/ Progradational sigmoid configuration with minor chaotic intercalations</td>
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<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>
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<tr>
<td>SP 2</td>
<td>Cretaceous</td>
<td></td>
<td>Baselap</td>
<td>Conformable</td>
<td>High amplitude parallel to subparallel configuration with some mounded intervals</td>
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<tr>
<td>SP 1</td>
<td>Late Jurassic</td>
<td></td>
<td>-Onlaps</td>
<td>Baselap</td>
<td>Parallel to subparallel reflections with some minor chaotic intervals</td>
</tr>
</tbody>
</table>

(Hawie et al., 2013)
Seismic Interpretation

ER1-Mid Jurassic

Mid Jurassic

Tassy et al., 2015
Tethyan Carbonate Platforms (Apulia)

- Similarly during the Mesozoic, the Apulian platform was isolated and could be a good analogue.
- Deep-water gravity flow carbonates of Late Cretaceous outcropping in the Gargano Peninsula and the Maiella Mountain are analogous with Eratosthenes gravity driven deposits.
Hellenic Arc (Offshore Crete)

Hellenic Arc
Fold belt

**CM:** Cretan margin
**BS:** Backstop
**MR:** Accretionary prism

Bounded
North: Crete
South: African plate
East: Herodotus Basin
West: Hellenic trench

*Makris et al., 2013*
Shallow carbonates correspond to the Gavrovo-Tripolis Zone outcropping onshore along the southern coastline of Crete

(after Papanikolaou et al., 2010)
Hellenic Arc (Offshore Crete)

NW Carbonate Built up
Neogene (Flysh Sediments)
Messinian Evaporites
Mesozoic Carbonates
Basement?
20 km

www.greekhydrocarbons.gr
Conclusions

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

• Studies on Eratosthenes and Apulia 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.

Understanding the regional geology is great tool for HC exploration!
Thank you for your attention!
**ESP1-2: LATE JURASSIC?**

Depth map of top ESP1-2 seismic unit.
Hellenic Arc (Offshore Crete)

- Carbonate Built up
- Neogene (Flysh Sediments)
- Mesozoic Carbonates
- Salt Diapir
- Messinian Evaporites
- Tilted blocks
ESP3: EARLY CRETACEOUS

Depth map of top ESP3 Seismic unit.
ESP4: CRETACEOUS

Bertello et al., 2016
ESP6 - Miocene

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
Offshore Western Greece: The current study

North of KTF

Abyssal plain-escarpment (Calabrian)

Apulian platform (A)

Mesozoic carbonates

Basement?

Hellenides FTB (i.e. Ionian z.)

? FTB extension
Top Cretaceous-Paleocene carbonates corresponds to the top of undifferentiated, i.e. pelagic versus shallow-water carbonates belonging to the Hellenides Thrust and Fold Belt.

The top undifferentiated carbonates is most often represented by the base Neogene Flysch but these carbonates could also be directly onlapped by Messinian or Pliocene sediments.

The distinction between shallow-water versus pelagic carbonates is made on the base of regional knowledge and seismic facies comparison with the North Ionian Offshore. Then shallow-water carbonates are mostly characterized by a massive transparent facies showing little internal stratification as on seismic line 3014 across the Chryssi-Koufonissi block between the Ptolemy and Pliny troughs and on previous figures showing seismic. Knowing that only future drilling will enable further distinction, carbonates that does not look like shallow-water carbonates are by default attributed to the Pindos series in the continental margin.