Sedimentological review of depositional environments in the External Hellenides isopic zones, Ionian Sea and Western Greece margin.

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Hellenic Hydrocarbon Resources Management S.A.
Current status in Greece

- Prinos concession*
- Katakolo*
- Ioannina
- Aitolakarnania

- Patraikos Gulf (west)*
- Arta-Preveza*
- NW Peloponnese*
- Block 2
- Block 10*
- Ionian
- West of Crete
- SW of Crete
  - Block 1*
  - Sea of Thrace

- Block 2*
- West of Crete*
- SW of Crete*
- Ioannina*
- Aitolakarnania*
- Ionian*

- West of Crete
- SW of Crete

* Operator waiting list

Open Acreage Studies

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Aim of the study

- To generate for each of the Segments in Western Greece the Facies Associations (FAs) and their Depositional Packages (DPs).

- Highlight any differences among Segments, especially between Segment A (North) and B (South), which were divided by KTF.

- Distinguish differentiations in basin-fill per Isopic Zone per Segment.

- Highlight FA’s which potentially may have better reservoir quality properties.
Geological setting and well data

SEGMENT A
- East Ericoussa-1
  - TD: 2392m
- Yanadhes-1
  - TD: 3951m
- Parga-1
  - TD: 3653m

SEGMENT B
- South Kefallinia-1
  - TD: 2203m
- Agios Kirikos-1
  - TD: 1327m
- Peristeri-1
  - TD: 1520m
- Sosti-1
  - TD: 3949m
- Paxi Galos-1X
  - TD: 5500m
Available data and limitations

Available data:

• 8 wells
• Legacy seismic lines & 2012 PGS lines to project well data.
• Limited LAS files.
• Log data (GR, Sonic, Drilling porosity, resistivity, calcimetry).
• Lithology column from cuttings.
• Biostratigraphic data.
• Very basic core descriptions.

Limitations:

• Lack of LAS files for most of the well data
• Lack of basic log data e.g. NPHI-RHOZ for most of the wells.
• The description of carbonate rocks did not follow the Dunham’s (1962) classification scheme
• Lack of vital sedimentological information such as: bioturbation index, sedimentary structures, types of skeletal and non-skeletal allochems, types of cements, clay content (kaolinite, illite or smectite), types of porosity (1P, 2P, OP, BX, V, MO, μP, F) a.o.
Descriptive framework and approach

Lithotypes/Lithofacies
- Core samples & core description
- Thin-section descriptions

Depositional Packages
- P6.1
- P3.1

Facies Associations
- P6.1
- P3.1

Depositional System
- Logs & seismic data

Seismic data / Modeling decisions

Basin Fill

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From Lithotypes/Lithofacies to Facies Associations

Evaluation of any available log data:

- GR
- Resistivity
- Neutron
- Density
- SP
- Calcimetry
- Porosity
- TOC

Example from Sosti-1 Pleistocene deposits
East Ericoussa-1

Pliocene-Pleistocene Oligocene-Miocene Jurassic-Lower Cretaceous Triassic

Upper Cretaceous-Eocene Jurassic-Lower Cretaceous Triassic

OTZ

L/TF?

B

OTZ

L/TF?

B

DS 19.30%

LSF.d 20.85%

IS 85.78%

B 75.35%

OTZ 25.45%

L/TF? 46.11%

B 53.89%

OTZ 46.11%

L/TF? 100.00%
Parga-1

Pliocene-Pleistocene
Early Miocene
Middle Miocene
Late Miocene
FLv 6.76%
B/L 41.52%
LFS.p 6.29%
OTZ 6.01%
OS 26.86%
B 100.00%
LS 3.34%
IS 18.27%
SL 21.29%
B 57.18%
CH 2.84%
LS 25.85%
LSf 2.48%
IS 68.83%
Sosti-1

AAPG GTW Exploration and development of Siliclastics and Carbonate Reservoirs in Eastern Mediterranean.
26-27 February 2019 | Tel Aviv – Israel.
Peristeri-1

- Upper Triassic: 5.77%
- Pleistocene: 75.38%
- Pliocene-Pleistocene: 8.69%
- Oligocene: 10.15%
- DS: 32.76%
- B/L: 18.58%
- FLv: 20.69%
- SW: 23.18%
- LFS.d: 2.45%
- DS: 100%
- L: 25.86%
- TF: 59.71%
- SB?: 6.90%
- E: 100.00%
### Facies Associations in studied area 1/2

<table>
<thead>
<tr>
<th>Depositional system</th>
<th>Facies Associations</th>
<th>Facies Associations code</th>
<th>Lithology</th>
<th>Well log characteristic</th>
<th>Log curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodplain channel</td>
<td>FL.ch</td>
<td>Sandstone with minor mudstone interbeds, Rare ligate traces.</td>
<td>Moderate to low amplitude due to sandstone presence. Abrupt high spikes due to common mudstone beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodplain valley</td>
<td>FL.v</td>
<td>Dominant mudstone with rare sandstone beds, and linite traces.</td>
<td>High to very high amplitude (60-150 GAPI). Profile range among wells from funnel to irregular bloody shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swamp</td>
<td>SW</td>
<td>Mudstone domination with presence of sandstone layers. Lignite has commonly observed.</td>
<td>High amplitudes due to mudstone. Sandstone and lignite contribute to typical irregular shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bay/Lagoon</td>
<td>B/L</td>
<td>Mudstone with silstone interbeds.</td>
<td>Very high amplitude (80-100 GAPI) with serrated shape due to mudstone</td>
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<td></td>
</tr>
<tr>
<td>Delta Plain</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prodelta</td>
<td>PD</td>
<td>Mudstone domination with rare sandstone, marl or limestone beds. Rare lignite might be present.</td>
<td>High amplitude (50-60 GAPI) with serrated shape due to mudstone. Rare higher/lower peaks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Shoreface</td>
<td>UFS</td>
<td>Sandstone with minor to absent mudstone or silstone layers. Rare calcareites.</td>
<td>Low amplitude (30-40 GAPI) due to sandstone domination, rarely serrated shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Shoreface proximal</td>
<td>LPS.p</td>
<td>Dominant sandstone with mudstone or silstone interbeds.</td>
<td>Typically low amplitude (40 GAPI) for sandstones and higher amplitude for mudstone layers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Shoreface distal</td>
<td>LPS.d</td>
<td>Dominant mudstone, silstone or marl with sandstone interbeds.</td>
<td>High amplitude (40-60 GAPI) due to mudstone domination, and &quot;U&quot; shaped profile for sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshore Transition Zone</td>
<td>OTZ</td>
<td>Mustone or marl sedimentation. Rare silstone beds.</td>
<td>Typically high values (50-55 GAPI) with homogenous profile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debris Sheets</td>
<td>DS</td>
<td>Matrix-supported or clast-supported conglomerates or disrupted sandstone with minor silstone beds.</td>
<td>Moderate to low amplitude with &quot;U&quot; shape. When silstone is present, higher amplitudes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Facies Associations in studied area 2/2

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<th>Lithology</th>
<th>Well log characteristic</th>
<th>Log curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deepwater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sedim/Offshore</td>
<td>B/OS</td>
<td>Low to very low (0-20 GAP), homogenous to serrated amplitude.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Channel-fill</td>
<td>CH</td>
<td>Moderately (20-50 GAP), blocky &quot;U&quot; shaped to locally upward-dipping responses.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lobe sandsheet</td>
<td>LS</td>
<td>Clear sandstone responses with blocky to serrated profile (40-50 GAP).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lobe sandsheet fringe</td>
<td>LSF</td>
<td>Moderate upward-dipping responses (30-50 GAP), or appear as &quot;U&quot; shape among higher amplitude.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inter-lobe mudrock sheets</td>
<td>IS</td>
<td>High (50-80 GAP) homogenous to serrated trendless amplitude.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carbonate platform/ramp</td>
<td>CGD</td>
<td>Limestone and limestone mixed with mudstone deposits.</td>
<td>Low (5-10 GAP), &quot;U&quot; shape amplitude, easily distinguished among higher amplitude.</td>
</tr>
<tr>
<td></td>
<td>Evaporites</td>
<td>E</td>
<td>Moderate to low amplitude with box shape. Profile might be homogeneously low when E becomes thick.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sabkha</td>
<td>SR</td>
<td>Irregular shape range of &quot;U&quot; shape locally (due to evaporite precipitation) to serrated (dolomitic).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lagoon</td>
<td>L</td>
<td>Irregular to serrated shape with moderate to low amplitude. Rare spikes due to dolomitic masslet.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tidal Flats</td>
<td>TF</td>
<td>Very low amplitude (5-15 GAP) with minor spikes above 20 GAP.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slope</td>
<td>SI</td>
<td>Moderate to low amplitude (20-30 GAP) with spikes up to 40 GAP. Serrated shape.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Base of slope</td>
<td>BS</td>
<td>Very low amplitude (3-15 GAP) with minor spikes above 15 GAP.</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions – Differentiations between Segments A & B

Segment A

- Jurassic
- Cretaceous-Eocene
- Oligocene-Miocene
- Pliocene-Pleistocene

Segment B

- Jurassic
- Cretaceous-Eocene
- Oligocene-Miocene
- Pliocene-Pleistocene

Both Segments exhibit shallow marine & coastal facies. However, KTZ activation juxtapose deeper facies of Segment B westwards, compared to A. Variations might be due to bigger coverage for the North Segment and well position (East Ionian). However, shallower facies shows relatively shallowing of Ionian domain to the North compared to the South during Oligocene-Miocene.

Major difference in depth might be due to rifting and paleogeography (development of new platforms in the area).

Due to different isopic domains (Ionian-deep Vs Pre Apulian-shallow)
Lateral continuation from Seg. A to Seg. B

Variations might be due to bigger coverage for the North Segment and well position (East Ionian). However, shallower facies shows relatively shallowing of Ionian domain to the North compared to the South during Oligocene-Miocene.

Due to different isopic domains (Ionian-deep Vs Pre Apulian-shallow)
Lateral continuation from Seg. A to Seg. B
Conclusions

- Facies observed in Segments A and B will be present in western areas of Ionian Sea.

- Variable reasons for differentiations in FAs base on well data:
  i. Rifting and paleogeography
  ii. Relatively shallowing
  iii. KTZ juxtapose of FAs
  iv. Different domains (isopic)
  v. Coverage issue

- Carbonate deposits from studied wells confirmed the model:
  i. Inner ramp → Pre-Apulian Zone (L, L/TF, E, E/SB in PG-1X, SK-1)
  ii. Middle to Outer ramp → External and Middle Ionian Zone (Sl and BS in S-1)
Thank you!