Seismic character as a tool to identify geotectonic zones in the frontier area offshore south of Crete, Greece
What is a frontier area?

- It is an area where the exploration activities have not been carried out or an area with short-term exploration.

Why offshore south of Crete IS a frontier area?

- Debatable and controversial complex geological processes
- Only limited geological knowledge from onshore can be applied to offshore Crete
- Very underexplored area
- Lack of wells
- Sparse seismic grid
- Deep water

But it all comes down to...

The most critical question:
Is there is an active petroleum system?
Study area and available data

- Bathymetric maps/data
- Legacy seismic data (approx. 650 km, 1980s)
- PGS-2012 seismic data (PSTM, PSDM)
- 3 Ocean Drilling Project wells (ODP 969, 970, 971)
- Published literature
Offshore Crete – Approach

Mapping geotectonic zones

Seismic character comparison (Western Greece)

Differentiate seismic pattern

Backstop Crete

Messinian Gulf

HHRM S.A. workflow 2018

Bathymetry
Projection of faults on seismic

ODPs
Check for horizons

Basic
Tectonic Elements & Seismic interpretation

Velocities

Differentiate seismic pattern

Literature overview
What happens offshore south of Crete?
Onshore Crete – Tectonic nappe pile

**Lower Metamorphic set of nappes**

- **HP-LT metamorphism of Oligo-Miocene age**
  - 25-20 Ma (Seide et al., 1982)

**Uppermost Non-Metamorphic set of nappes**

- **Pindos/Arvi:** deep marine environment deposits Triassic-Paleocene
- **Gavrovo-Tripolitza:** Neritic carbonate platform series U. Triassic-M. Eocene & L. Eocene-Oligocene flysch

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Surface exposure/outcropping

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Modified after Papanikolau and Vassilakis 2008

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Klein et al. 2012

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Gavrovo-Tripolitza: Neritic carbonate platform series U. Triassic-M. Eocene & L. Eocene-Oligocene flysch

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Triassic-Paleocene

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Triassic-Paleocene
Offshore Crete – ODP

SITE 970

SITE 969

SITE 971

ODP 969

Depth (m)

2150

2200

2250

2300

2350

2400

969A

969B

969C

969D

969E

969F

MES

Methane sourced gas

Mud debris-flow deposits

Matrix-supported clast-rich debris-flow deposits/breccia/conglomerate

Nannofossil ooze and/or sapropels

Mouselleike or calcarceous silty clays

Hemipelagic sediments

PGS 2012, line 3015 PSDM

www.greekhydrocarbons.gr
Geotectonic units of Greece
Offshore Crete – Cretan Margin

<table>
<thead>
<tr>
<th>South of Crete geological units</th>
<th>Cretan Margin (CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>West (Gavdos high)</td>
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<tr>
<td><strong>Pleistocene sequence</strong></td>
<td></td>
</tr>
<tr>
<td>Amplitude</td>
<td>High</td>
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<tr>
<td>Frequency</td>
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<tr>
<td>Continuity/Configuration</td>
<td>Continuous</td>
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<tr>
<td><strong>Messinian-Pliocene sequence</strong></td>
<td></td>
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<tr>
<td><strong>Carbonate sequence</strong></td>
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<td>Amplitude</td>
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![West Cretan Margin](image1)

![East Cretan Margin](image2)
Offshore Crete – Cretan Margin

Messinian Gulf (South Peloponnese)

Shallow marine carbonate deposits

East Cretan Margin

West offshore Peloponnese (Pre-Apulia)

GAVROVO

HHRM S.A. model 2018

Eocene-Oligocene

Eocene

Paleocene

Upper Cretaceous

Lower Cretaceous

Klein et al. 2012

HHRM S.A. model 2018

Offshore Crete – Cretan Margin

East Cretan Margin

Deepwater deposits

Messinian Gulf (South Peloponnese)

Typical deep-water column

Klein et al. 2012

HHRM S.A. model 2018
Offshore Crete – Backstop

<table>
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<tbody>
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- **Backstop (offshore South of Crete)**

- Significantly more rigid than the sedimentary sequence lying trenchward of it.
- Lithification may create the mechanical boundary against which the younger sediments are accreted.
- It partitions subduction material, either directing it to the MR (Back thrusting) or diverting it deeper into the subduction zone (Under thrusting).
- **BS controls the shape or MR. BS geometry affects subduction processes**
Offshore Crete – Backstop

Messinian Gulf (South Peloponnese)

Backstop (offshore South of Crete)

Shallow marine carbonate deposits

GAVROVO

- Eocene-Oligocene
- Eocene
- Paleocene
- Upper Cretaceous
- Lower Cretaceous

HHRM S.A. model 2018
Offshore Crete – Mediterranean Ridge

- Formed at the leading edge of convergent plate boundary by skimming-off sediments and rocks from the lower plate.
- Stack of sediments in vertical piles and shortens them horizontally.
- Large and fast deformation of MR results in disrupted and mixed rocks.
  - Lack of continuous bedding
  - Fragments of rocks of all sizes
  - Matrix supported with deformed matrix
  - Exotic clasts (other environment) or native (reworked)
Offshore Crete – Syn-tectonic sediments

East Cretan Margin

Syn-tectonic Basin fill

Turbidite deposits (distal slope/basin plain)

An olistolith of limestone with lower embedded in lithified dolomitic sands (upper)

Clast-supported water-flow deposits

Seidel. 2003

An olistolith of limestone with lower embedded in lithified dolomitic sands (upper)

Seidel. 2003

Turbidite deposits (distal slope/basin plain)

Seidel. 2003

Seidel. 2003

Clast-supported water-flow deposits

Seidel. 2003

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Seidel. 2003
Offshore Crete
Offshore Crete
Offshore Crete

Offshore Crete
Offshore Crete

Eocene-Cretaceous carbonate platform before tectonism

Similarities with other Mediterranean Isolate Carbonate Platforms

Thin continental crust near Crete (platform). Similar age platforms offshore Libya
Conclusions

- Crete is a **frontier area** and underexplored area.

- For the exploration of such an area, we have used and **intergrade all the available data** (bathymetric, seismic, velocity, ODP).

- Offshore Crete area reflects the **geological complexity** of onshore Crete (South Aegean Tectonic window).

- Bathymetry & seismics → main tectonic elements (faults, thrusts) and subdivision of study area (CM, BS, MR, PT, PL and STR)

- Investigate their **seismic pattern**.

- **Similarities** of seismic pattern offshore Crete with those offshore Western Greece.

- **Mapping** of basic non-metamorphic geological units.

- **Inferred petroleum prospectivity** is speculative:
  (SR - Syntectonic basins and mud-rich deep-water deposits, R - Platform domain, S - Plio-Pleistocene sediments & Evaporites)

**Suggestions:**

- **Dense seismic network** to map in detail geotectonic zones and platform facies (slope, margin etc.).

- **Deeper seismic data** to have a better understanding of the deep structural setting.

- Further investigation on the **scenario of HC migration from SR to R** (onlapping Syntectonic basin fill → Platform facies)
Thank you!
Ευχαριστώ!