Relationship between gas-bearing (?) sediments and biogenic mounds in the Kalloni Gulf, Lesvos Island, Greece

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RELATIONSHIP BETWEEN GAS-BEARING SEDIMENTS (?) AND BIOGENIC MOUNDS IN THE KALLONI GULF, LESVOS ISL.

(Innomar Student project 2013)

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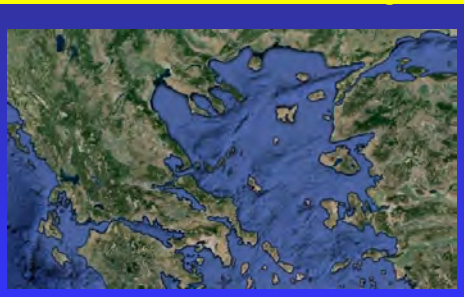
Location of the study area



Simplified geologic map of Lesvos

Faults in Lesvos

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Introduction

- **The Kalloni Gulf is a large (20 km long) and shallow (<20 m deep) semi-enclosed embayment, at the western side of Lesvos island in the NE Aegean Sea that communicates with the open sea through a narrow strait.**
- **Previous sparse single-beam bathymetric studies have shown the presence of randomly distributed mounds, up to 4.0 m in height relatively to the surrounding seabed.**
- **Seabed sampling has revealed that the mounds consist mainly of molluscs of various sizes and they correlate well with some of the most productive scallop fishing locations in the gulf.**

***The purpose of this study is*:**

- **to detect the surficial distribution of the mounds at the central part of Kalloni Gulf,**
- **to investigate their morphology and shallow subbottom structure**
- **to discuss parameters that may affect/control their formation.**

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Methods

A 2-D seismic reflection survey in conjunction with a side scan sonar mapping was carried out on May 2013 using Innomar's SES-2000 light plus SBP and SSS. The sonar was side-mounted onto the Dept of Marine Sciences R/V "Amfitriti". Data acquisition was implemented by the SESWIN software, whereas for post-processing the ISE software was used.

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Methods

Parametric Innomar system: Primary frequency of 100 kHz and secondary frequency of 5 - 15 kHz (6kHz)

- **SSS: 600, 410 and 250 kHz (410 and 250 kHz)**
- **SBP penetration: ~20.0 m at the central part of the gulf**
- **Main line spacing: 80 m almost parallel to the major axis of the gulf (SSS mosaic) + cross lines**
- **Positioning: Hemisphere Differential GPS**
- **Survey speed: ~4 knots**
- **Heave compensator to reduce vertical movements**
- **Sound velocity (calculated from 2 CTD measurements): 1524 ms^{-1}**

Ground-truthing

- **Scuba diving at two sites**
- **Few video camera and grab drops at selected locations**

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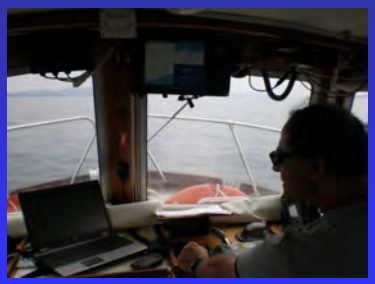
Methods

Navigation of R/V Amfitriti



Innomar top-side unit

Innomar parametric system and Hemisphere DGPS

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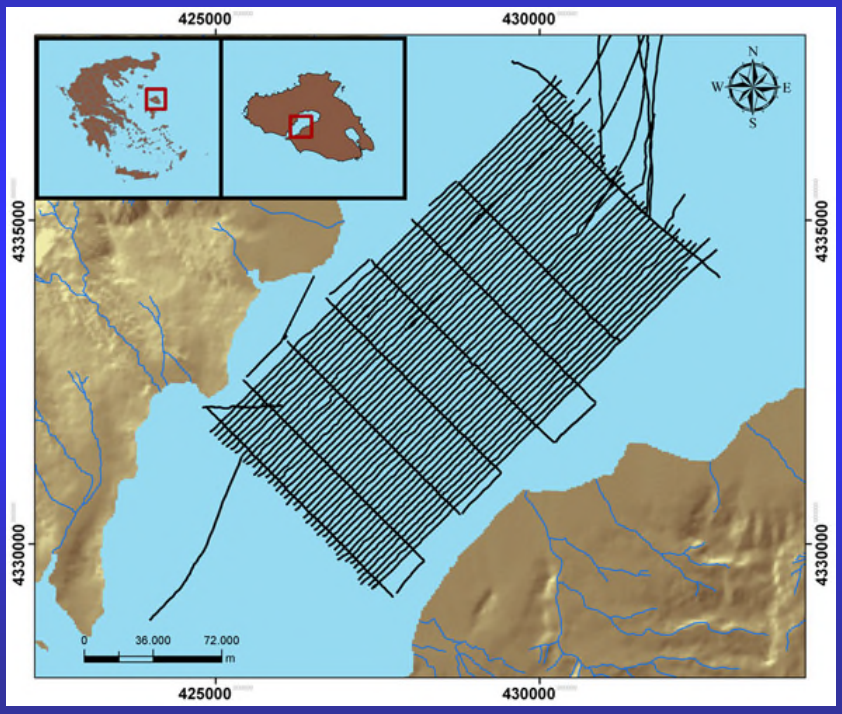
Methods

Main navigation lines



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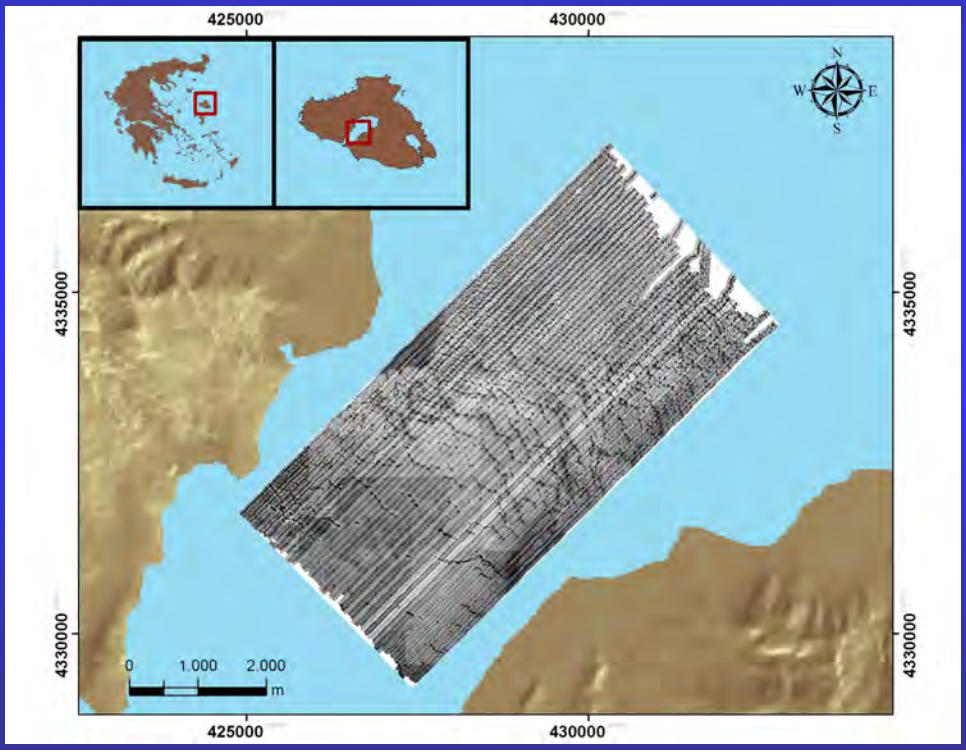
Results

Morphology: from bathymetric sections and reflectivity patterns in the side scan sonar mosaic



Download: www.innomar.com/seabed-acoustics-2013.php

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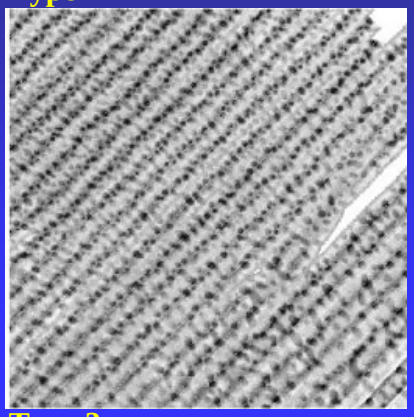
Results

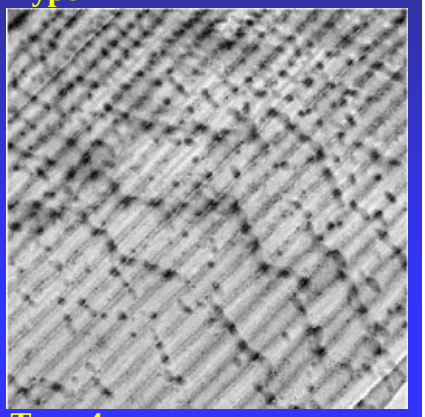
Acoustic reflectivity (backscatter) types

Type 1: 11.15 km²
Type 2: 10.3 km²
Type 3: 4.8 km²
Type 4: 0.9 km²

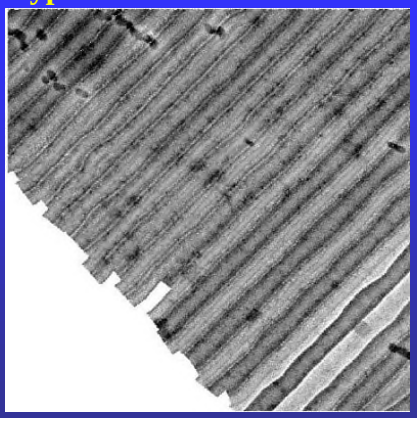
Type 1



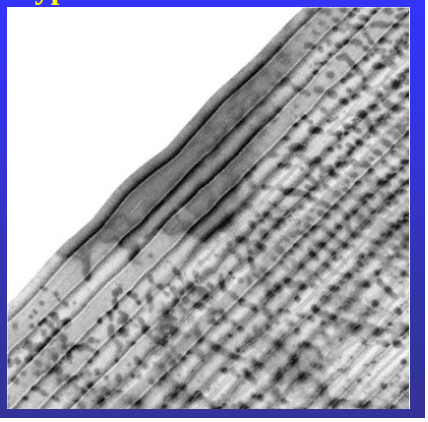
Type 2



Type 3



Type 4



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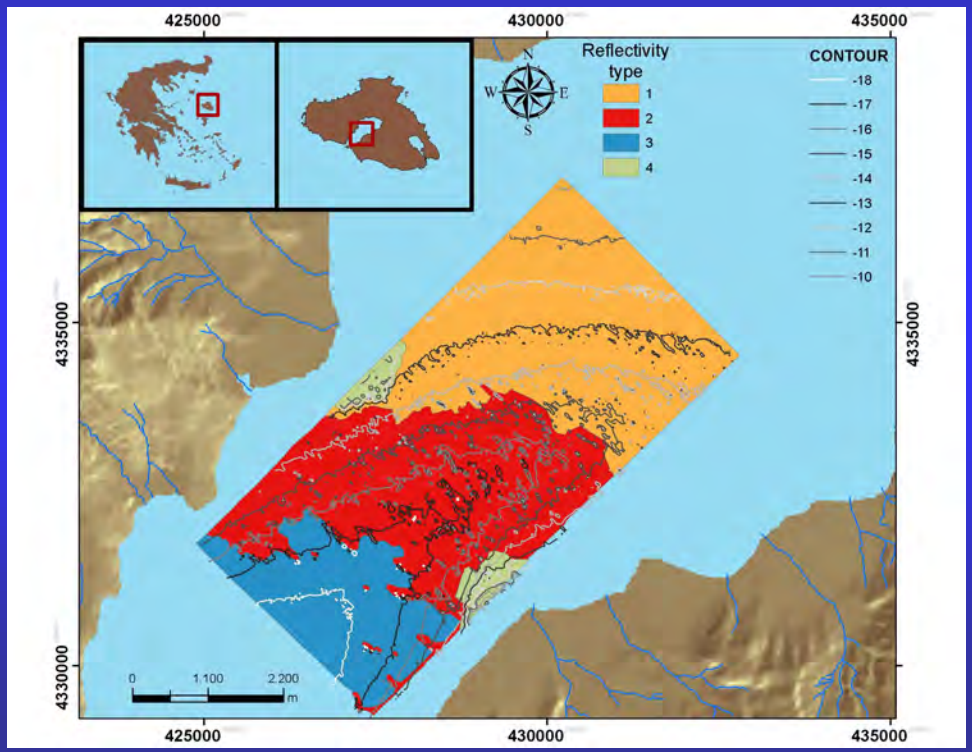
Results

Acoustic reflectivity (backscatter) map and bathymetry of the studied area



Download: www.innomar.com/seabed-acoustics-2013.php

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Results

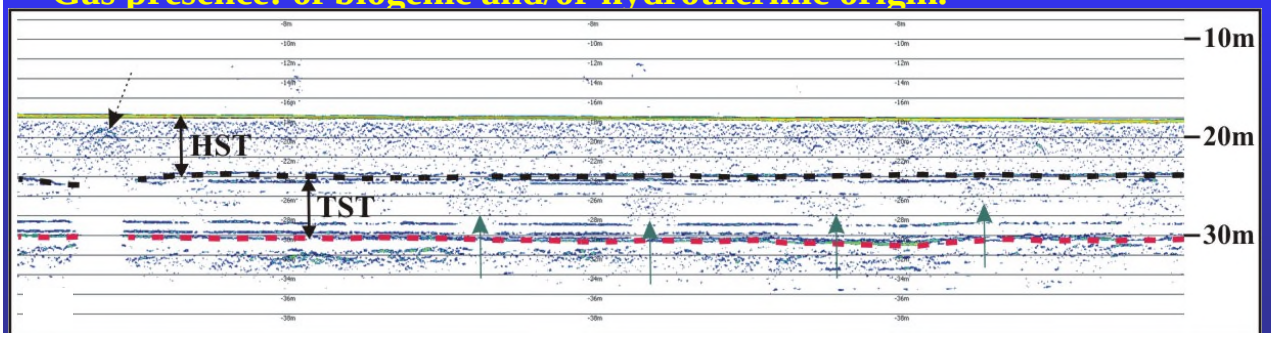
Shallow geology

Two main seismic sequences: upper (separated into two sub-units) and lower. They indicate a surficial almost homogeneous fine-grained layer (~7-12 m thick) with few coarser or denser internal layers that is underlain by a highly reflective layer of compacted materials.

The boundary between the two seismic sequences is a distinct basal unconformity corresponding to Wurm Glaciation.

The sub-units boundary (of the upper seismic sequence) probably correspond to the Holocene highstand and transgressive system tracts (HST and TST).

Gas presence: of biogenic and/or hydrothermic origin.



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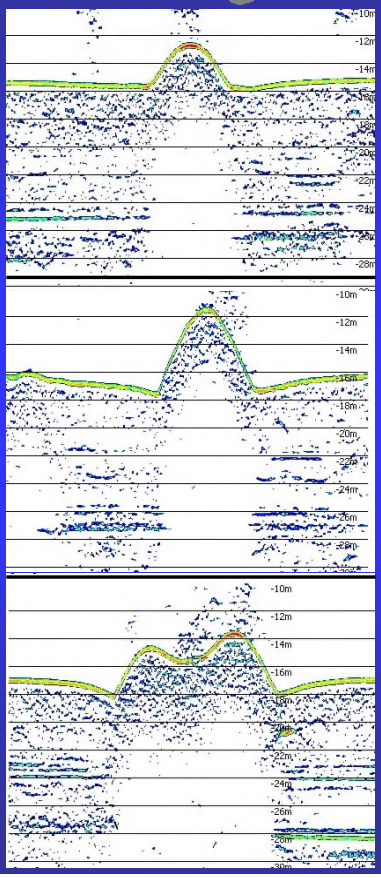
Results

Shallow geology

The observed mounds:

- **form symmetrical and/or asymmetrical structures, and locally composite structures,**
- **often are followed by small and shallow depressions (0.5-1.5 m) immediately next to their base,**
- **have slopes: 4.5º - 16.7º,**
- **present intense bottom-echo at the top of the mounds (masking of the underlying reflectors).**



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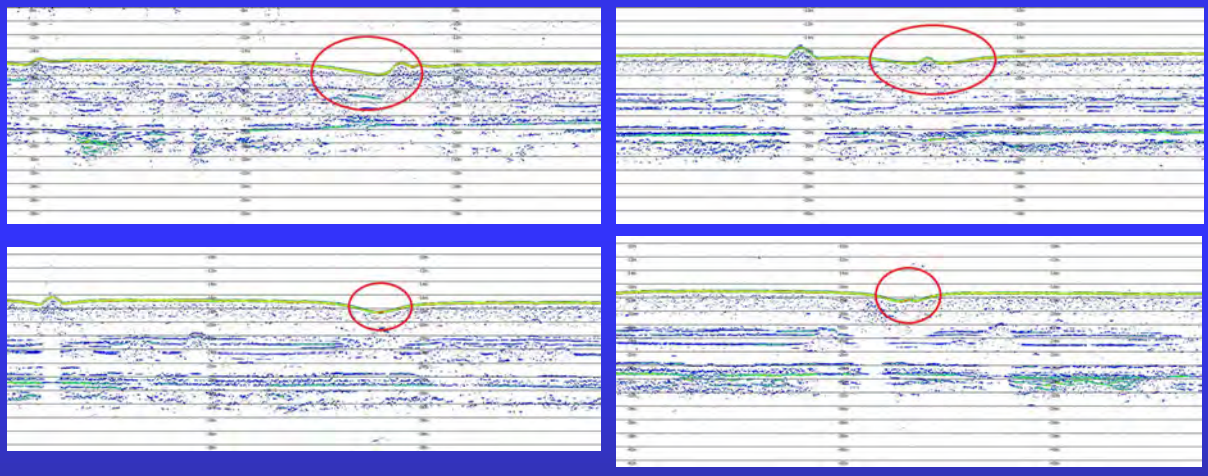
Results

Few depressions (up to 1.5 m deep) were also observed, some of them hosting very small mounded formations.



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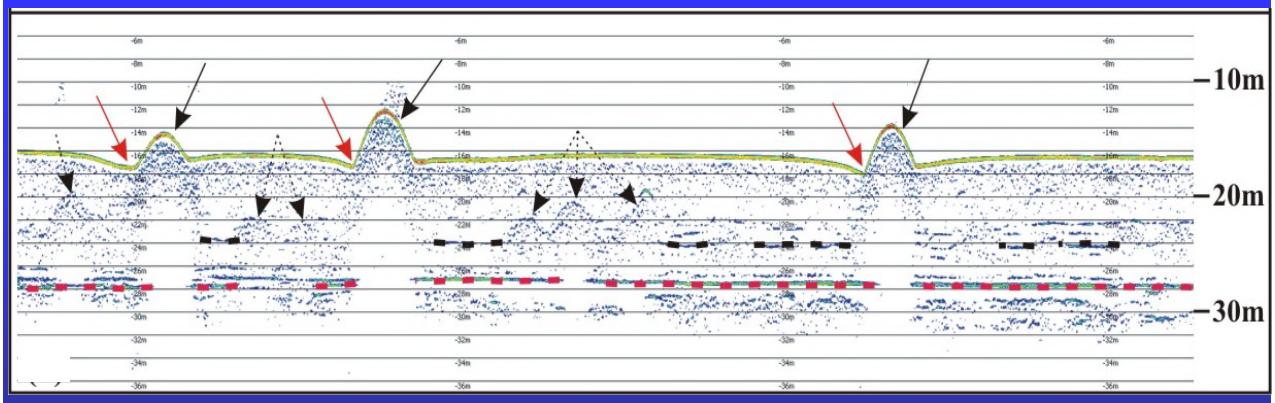
Results

Shallow geology

One of the most interesting features is the presence of buried mounds, most of them developed in the boundary between the TST and the HST (misinterpretation in the older poor quality analogue SBP profiles: acoustic anomalies related to gas-charged sediments, due to their somewhat similar acoustic appearance).



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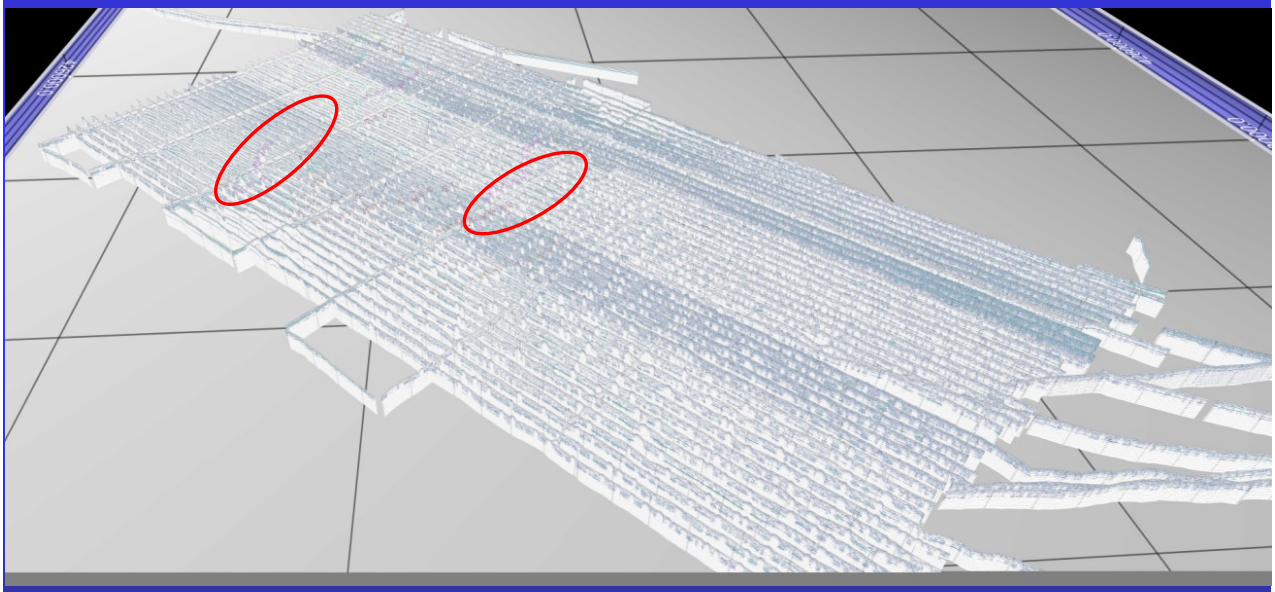
Results

Fledermaus 3-D analysis and interpretation



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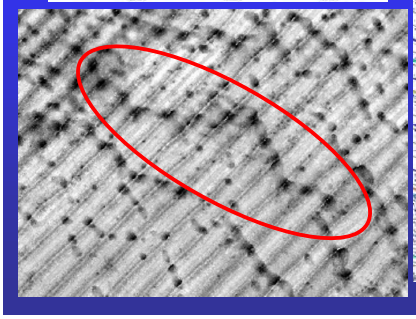
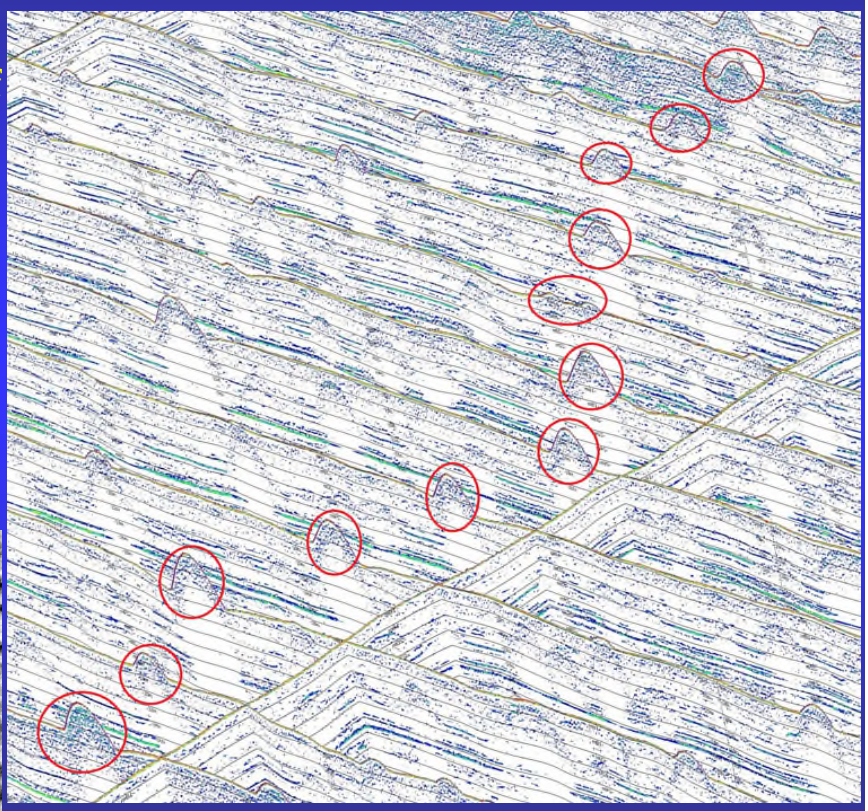
Results

Fledermaus image of a curved elongated mound of varying relief.





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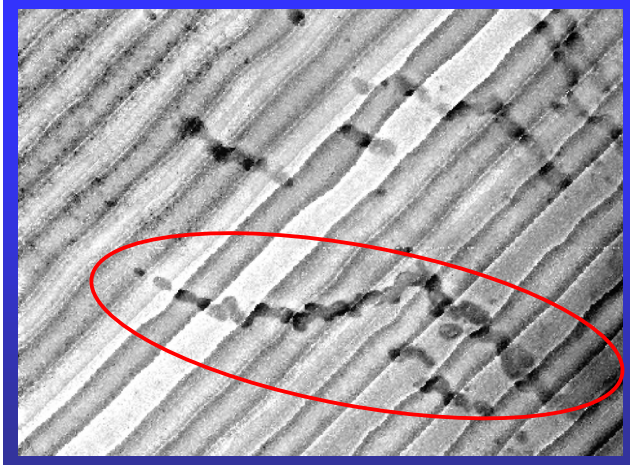
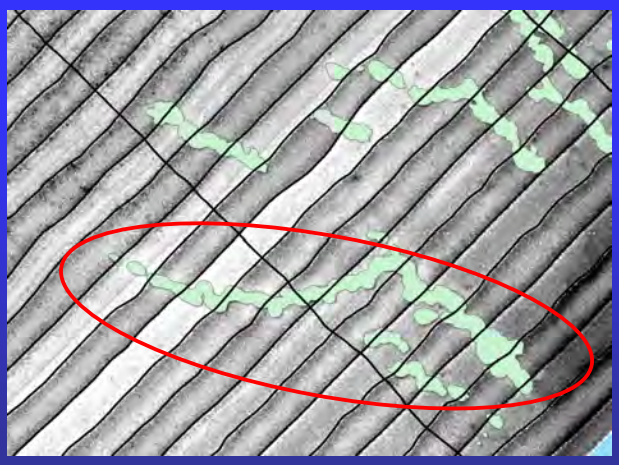
Results

SSS mosaic showing an elongated curved mound





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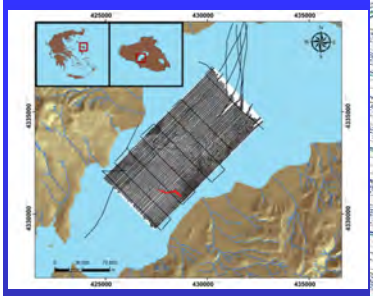
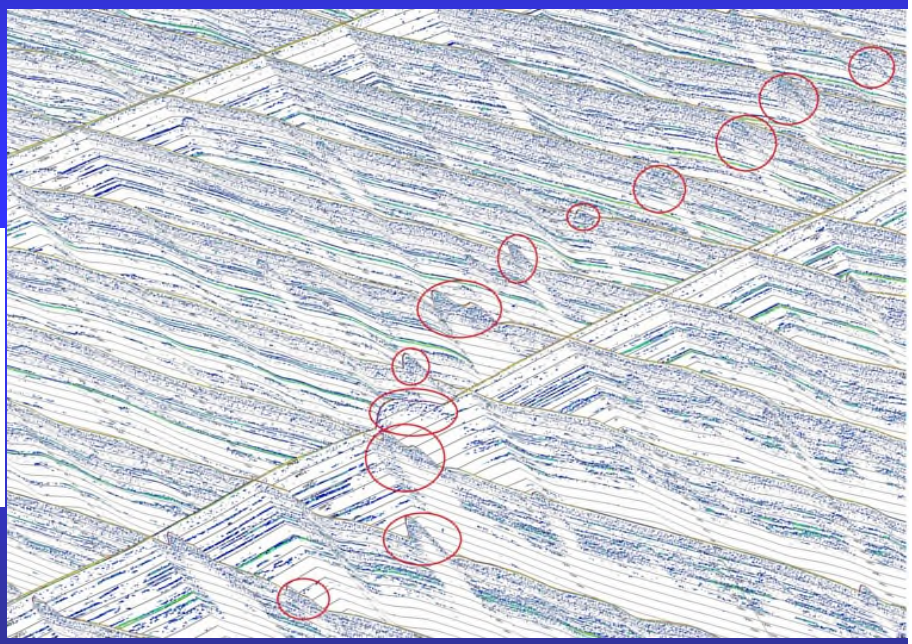
Results

Fledermaus image showing an elongated curved mound and its buried continuation towards the west.





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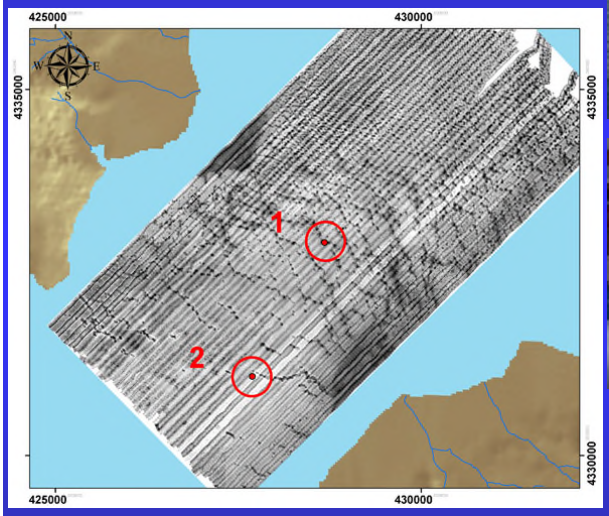
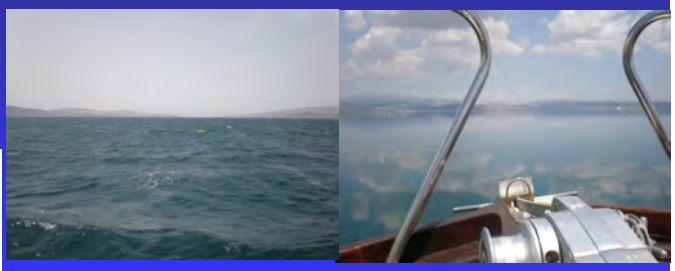
Results

Ground-truthing

Scuba and video camera diving





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Results

Ground-truthing

Scuba and video camera diving verified that the mounds consist of assemblages of mollusks (mainly), sponges, crustaceans, askidians, echinoderms, polychaetes and cnidaria of various sizes, together with fine-grained sediments.

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Results

Ground-truthing

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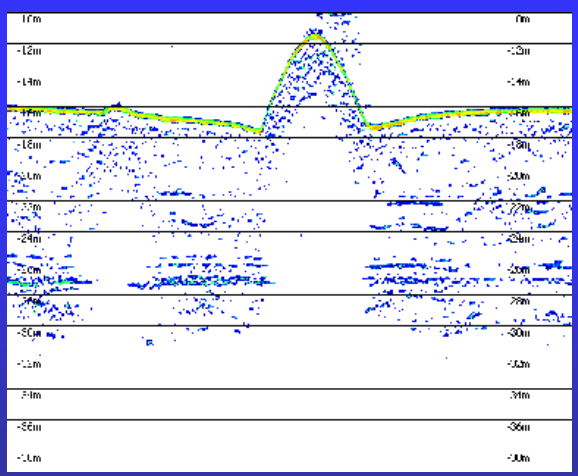
Results

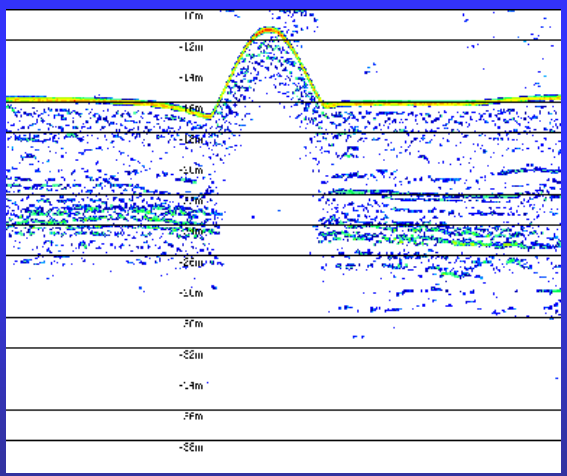
Ground-truthing – hole at 1st dive

A very interesting finding at the crest of each of the two highest mounds which were detected, was the presence of two holes, 30cm in max diameter (depth not measured).

Mound 6.0 m in height - 1st dive



Mound 5.6 m in height – 2nd dive



Results

Ground-truthing – hole at 1st dive

Results

Ground-truthing – hole at 2nd dive

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Discussion - Conclusions

- **This study detected the mounded morphology of the benthic assemblages, their spatial distribution over the seabed and their peculiar morphology at the central part of the Kalloni gulf. The SSS mosaic give signs that the mounds may also be present towards the SW, closer to both gulf sides.**
- **The dense SBP parametric grid demonstrates special mound morphological aspects (height, local composite morphology, neighboring depressions) but most importantly distinguishes similar buried structures that were initially interpreted to be gas-charged sediments in an older pure quality SBP record.**

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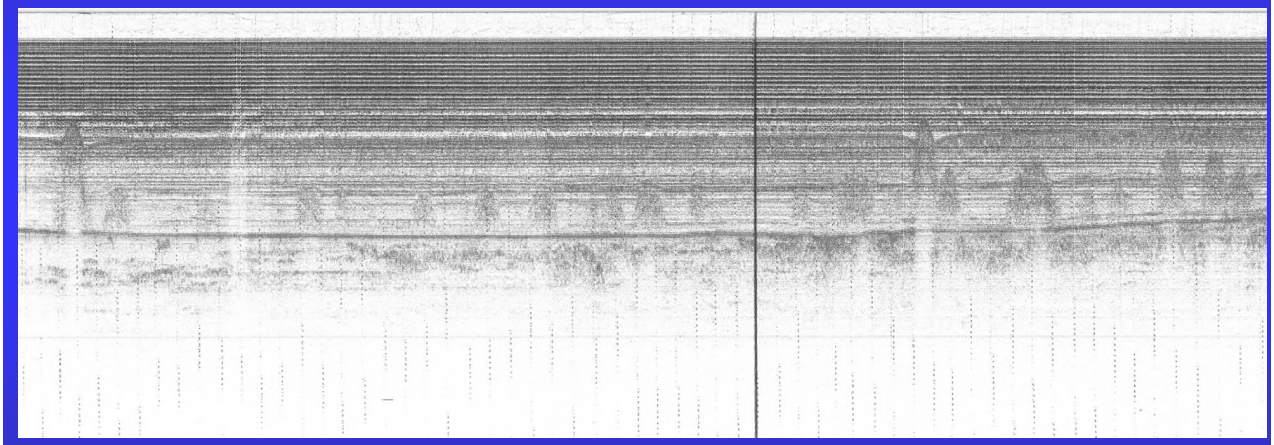
Discussion - Conclusions

An old analogue 3.5 kHz SBP line



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Discussion - Conclusions

- **Indications of gassy sediments occur mainly under and along the (i) Holocene-Pleistocene and (ii) Holocene TST-HST unconformities.**
- **Most of the buried mounds build up along the TST-HST boundary.**
- **Scuba and camera diving revealed (a) the abundance of the highly reflective benthic assemblages over the mounds and (b) the presence of one hole close to the highest point at two mounds, not ascribed to benthic activity.**
- **The Kalloni biogenic mounds constitute unique morphological features, not observed elsewhere according to the bibliography. Abundant biogenic activity and build up of molluscs has been documented elsewhere to be related to slow gas leakage mainly within or next to pockmark fields.**

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Discussion - Conclusions

- **The depressions next to some of the mounds cannot be due to the hydrodynamic activity (muddy sediment consistency) and thus they could possibly suggest initially formed shallow craters, where benthic life preferentially started to colonize and build up. Fluid seepage might have contributed to the re-suspension of sediments and nutrients, which have a positive effect on the local ecosystems and mainly to the filter-feeding molluscs.**
- **The observed holes at the top of the two mounds may represent older vents along which fluid escape took place but they are now seem to be inactive and highly colonized.**
- **The tectonic regime (earthquake epicenters are distributed along the gulf axis) may have also contributed to slow fluid leakage, however no fault lines were detected.**

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Discussion - Conclusions

- The buried mound position suggest that they have probably started to grow during the Late Holocene (~5500BP), when a small and steady-rate of sea level rise occurred.
- The buried and recent mound formation may have been influenced by late Holocene fluctuations of the physical environmental conditions (shallow water, light conditions, low sedimentation rates etc) as well as by fluid escape.
- The mode of development of these unique mounds cannot be solved only with the findings of this research. Core samples and dating, multi-beam morphology (morphometrics), ROV or diver divings, benthic/ecological surveys and CTD and fluid measurements are considered essential in order to shed light to the mound formation.

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Acknowledgments

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!!! thank you for your attention !!!