50th anniversary

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IAEG XII CONGRESS

Multidisciplinary methodology used to detect and evaluate the occurrence of methane during tunnel design and excavation: an example from Calabria (Southern Italy).

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UNIVERSITÀ DI ROMA

CERI CENTRO DI RICERCA
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DEI RISCHI GEOLOGICI

Introduction

The discovery of significant volumes of methane during the preliminary phases of tunnel design increases the risk of a potential explosion during or after the excavation work.

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Collaboration between ANAS and the CERI research institute "Sapienza" Rome University

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Identification of the geological conditions that can control and/or contribute to the genesis and migration of the gases.

New approach

- **Structural-Geological mapping**
- **Soil gas surveys along the road trace**
- **Determination of gas origin and migration pattern**
- **Development of a Monitoring Plan**

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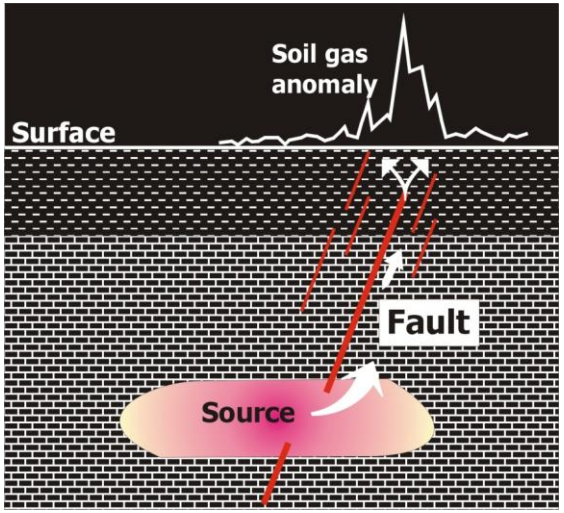
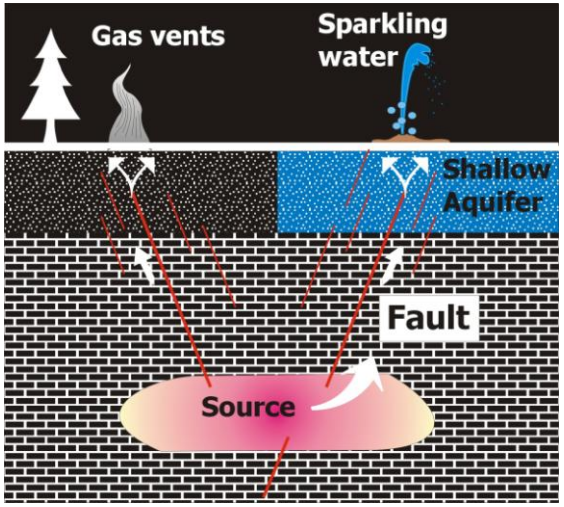
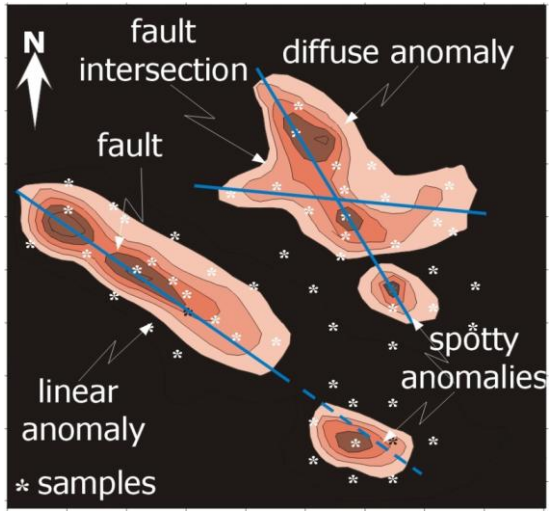
Gas migration: surface evidence





A deep source of gas rises up to the surface through areas of high permeability (faults). Surface evidence can be dry gas (gas vent) or, in presence of a shallow aquifer, sparkling water



Shallow soil gas surveys generate this kind of map highlighting these areas of high permeability thanks to the correlation between spotty anomalies

From Annunziatellis et al., 2008

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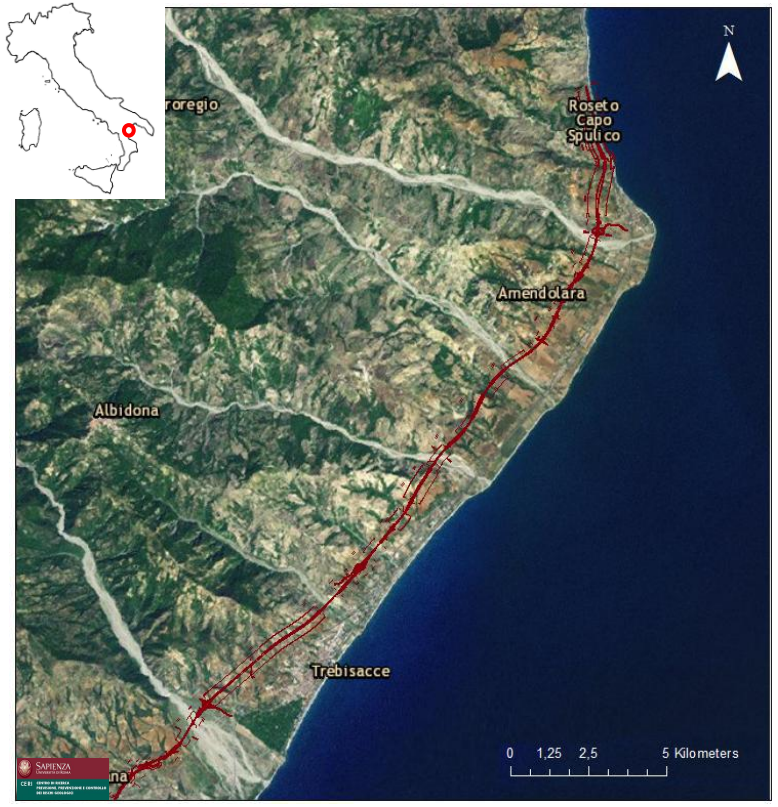
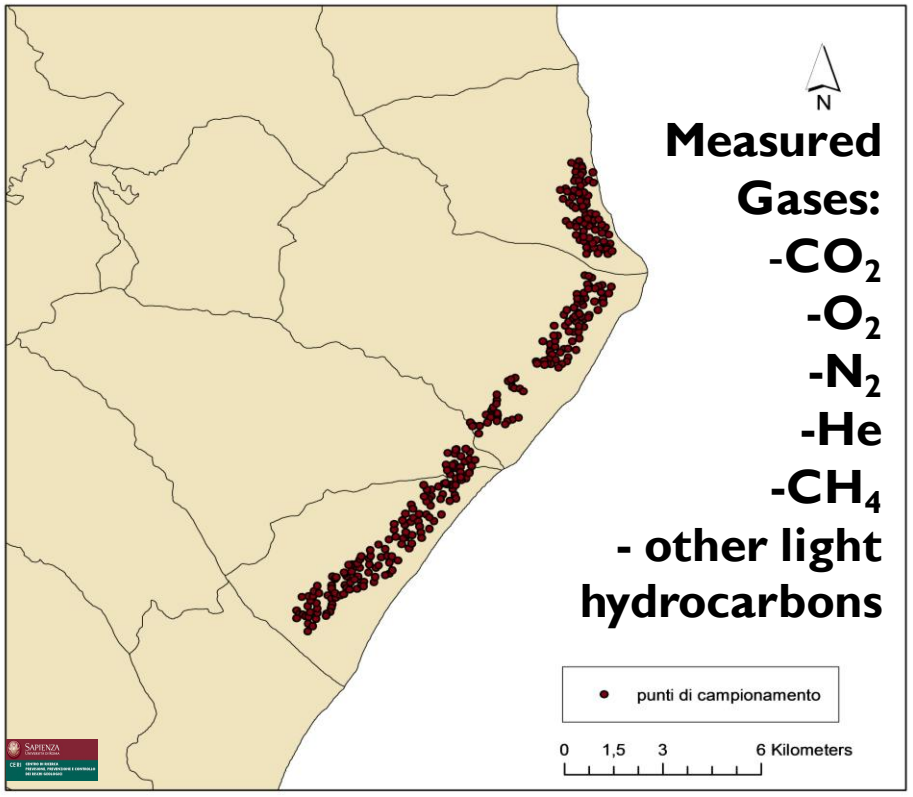
Sampling mode and methodology



Road trace: the studied area is between the villages of Trebisacce and Roseto Capo Spulico



422 shallow soil gas samples were collected along the road trace with a buffer of 1 km following the trace of the future road.

the integrated study of these different gas species allows a complete geochemical characterization

- Lombardi et al. - Multidisciplinary methodology used to detect and evaluate the occurrence of methane during tunnel design and excavation: an example from Calabria (southern Italy).

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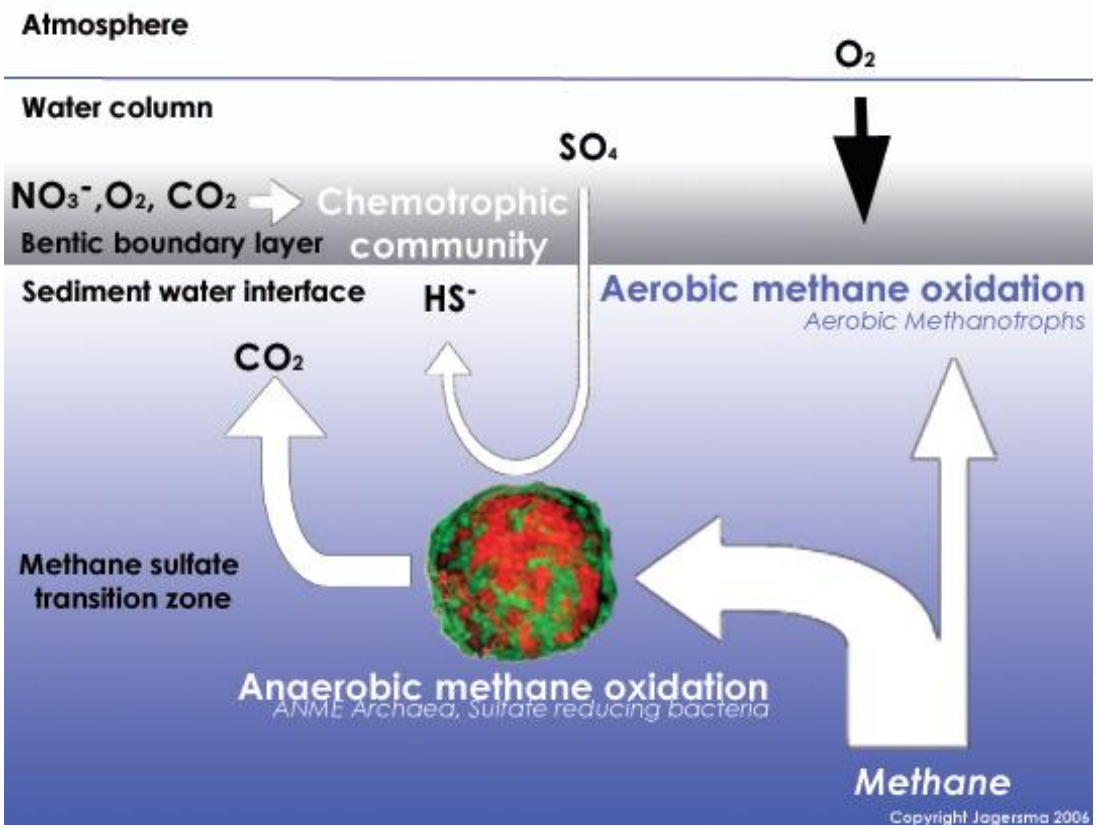
Ratio between gases: CO_2 and CH_4



Main source of CH_4 :

-Natural degassing of the Mantle

-Hydrocarbon reservoir

-Coal and peat deposits

-Biological origin and organic reaction near the Earth's surface

- Anthropogenic origin

CH_4 concentration in the Atmosphere averages 1.7 ppm. In subsoil, at 0.7 m depth, is normally 0.5 ppm, due to the presence of methanotrophic bacteria, that consume Methane and produce CO_2 as a waste product.

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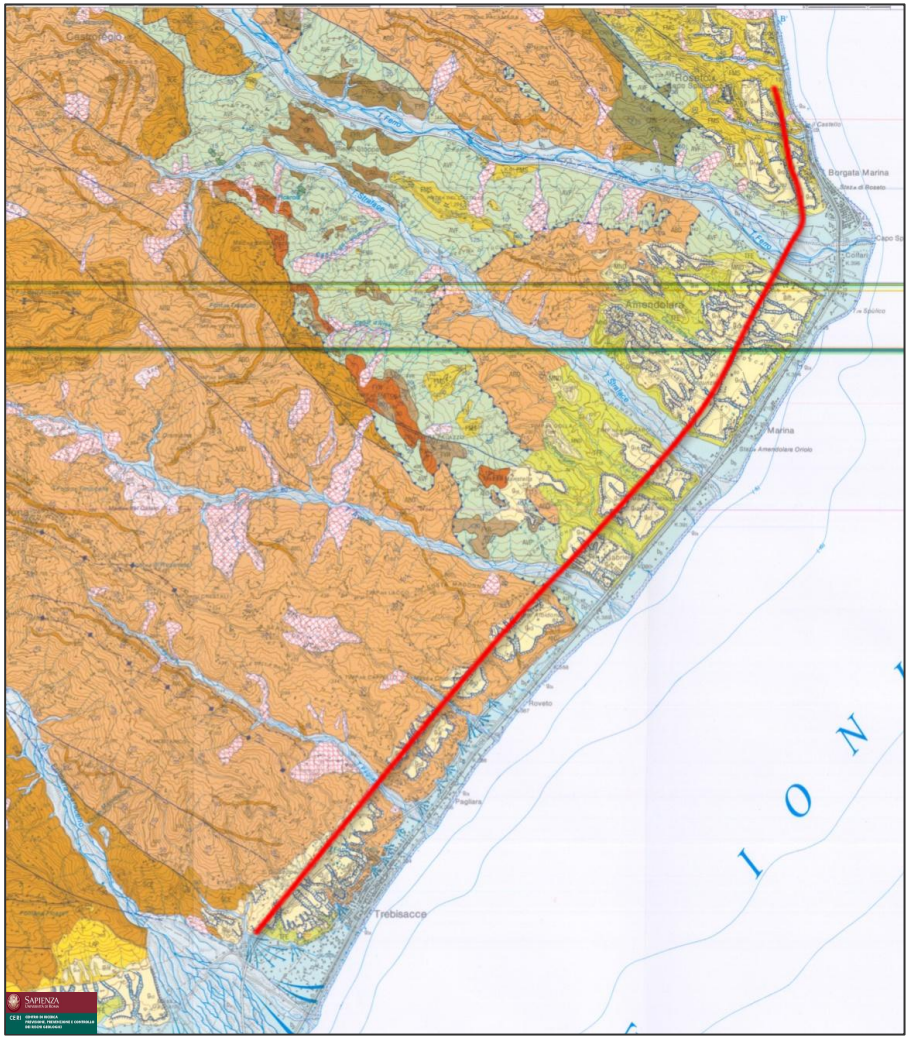
Geological setting



The stratigraphy in this area consists of:

a) the Albidona and Saraceno Formations, belonging to the Liguride and Sicilide units, consists of, respectively, marls, turbiditic sandstones and thick micro polygenic conglomerates, and of calcareous mudstones, grainstone and clays;
b) the Varicolori Clays Formation, which is tectonically placed on the previous units, consists of multicolored, over-consolidated clays containing olistoliths of lime-stone and interbedded with mudstone levels;
c) the Plio-Pleistocene marine sands and clays;
d) alluvial deposits
(Ogniben, 1969)

Scale 1:50.000 F°535 "Trebisacce" CARG Project
RED LINE= Schematic trace of the road SS 106 Jonica

Road: trace and tunnels

Roseto tunnel: 3573 m

Cielogreco tunnel : 710 m

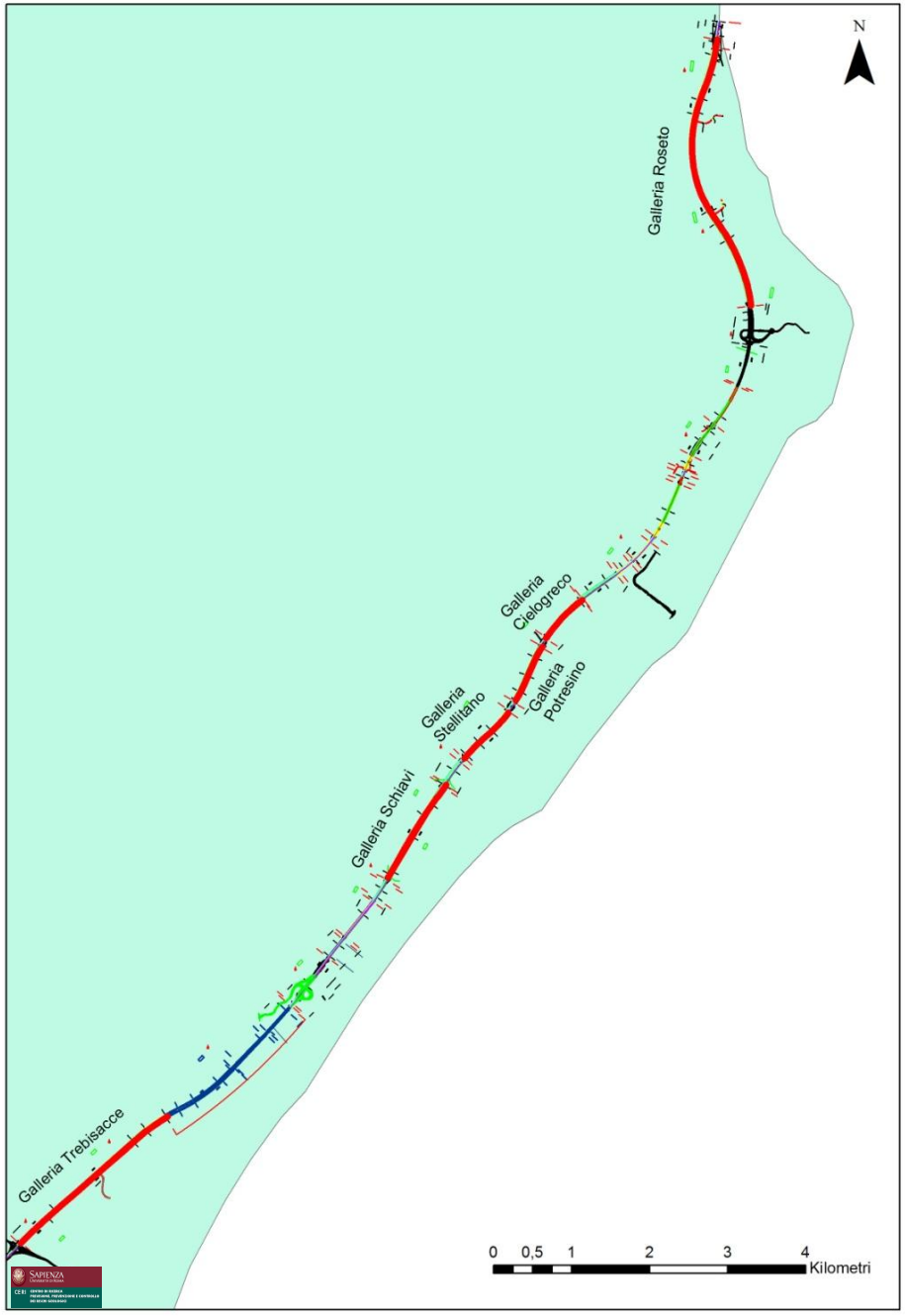
Potresino tunnel :657 m

Stellitano tunnel : 827 m

Schiavi tunnel : 1400 m

Trebisacce tunnel : 3500 m

The preliminary project included 6 tunnels, signed in red on the map. Trebisacce and Roseto tunnels were the 2 longer



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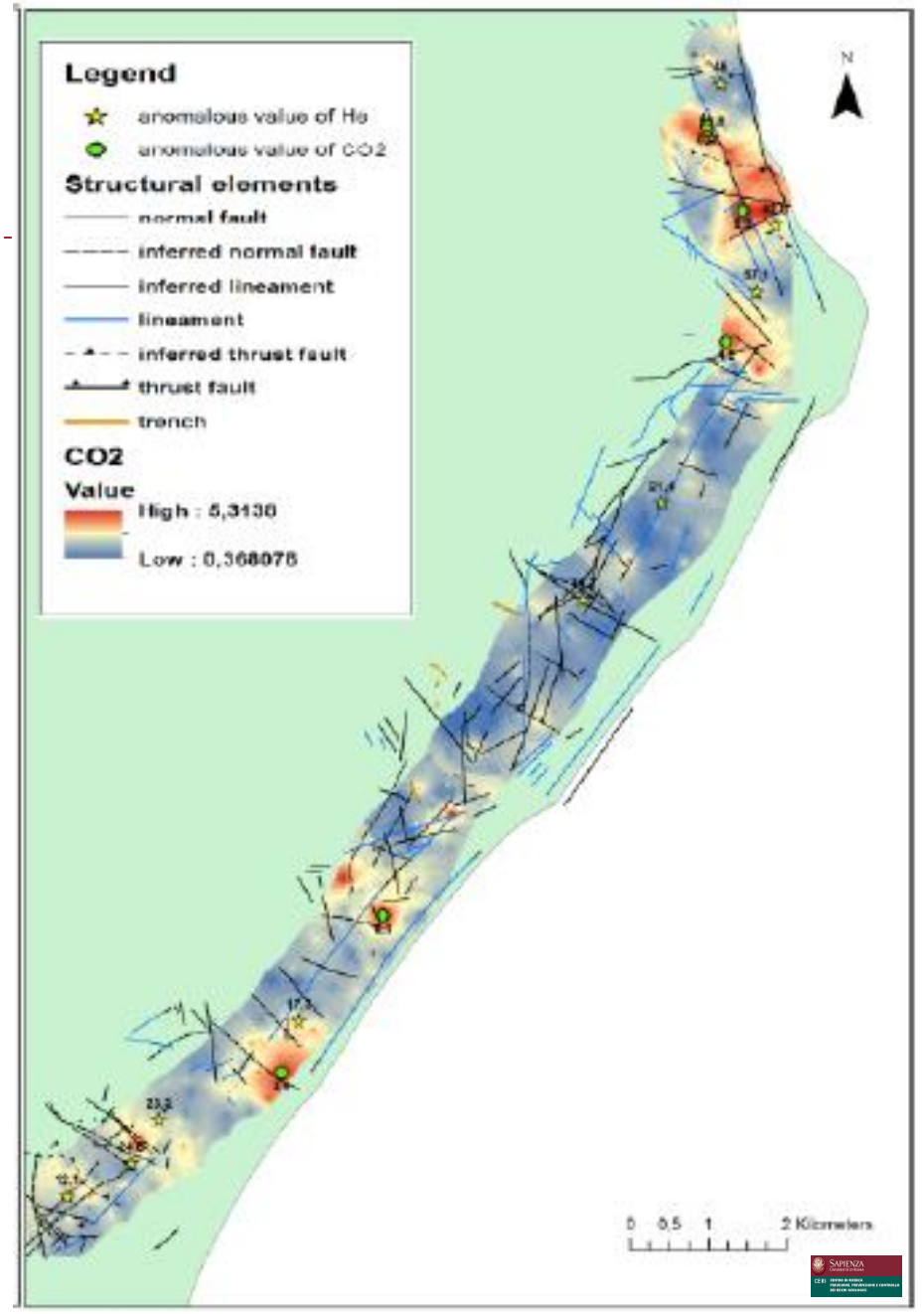
Soil gas CO_2

Shallow soil gas map of CO_2 concentration along the road trace. In red one can see the positive anomalous zones, prevalently on N and S zones, while in the middle zone have background values. Yellow stars indicate anomalous positive values of Helium, index of a deep origin of degassing.



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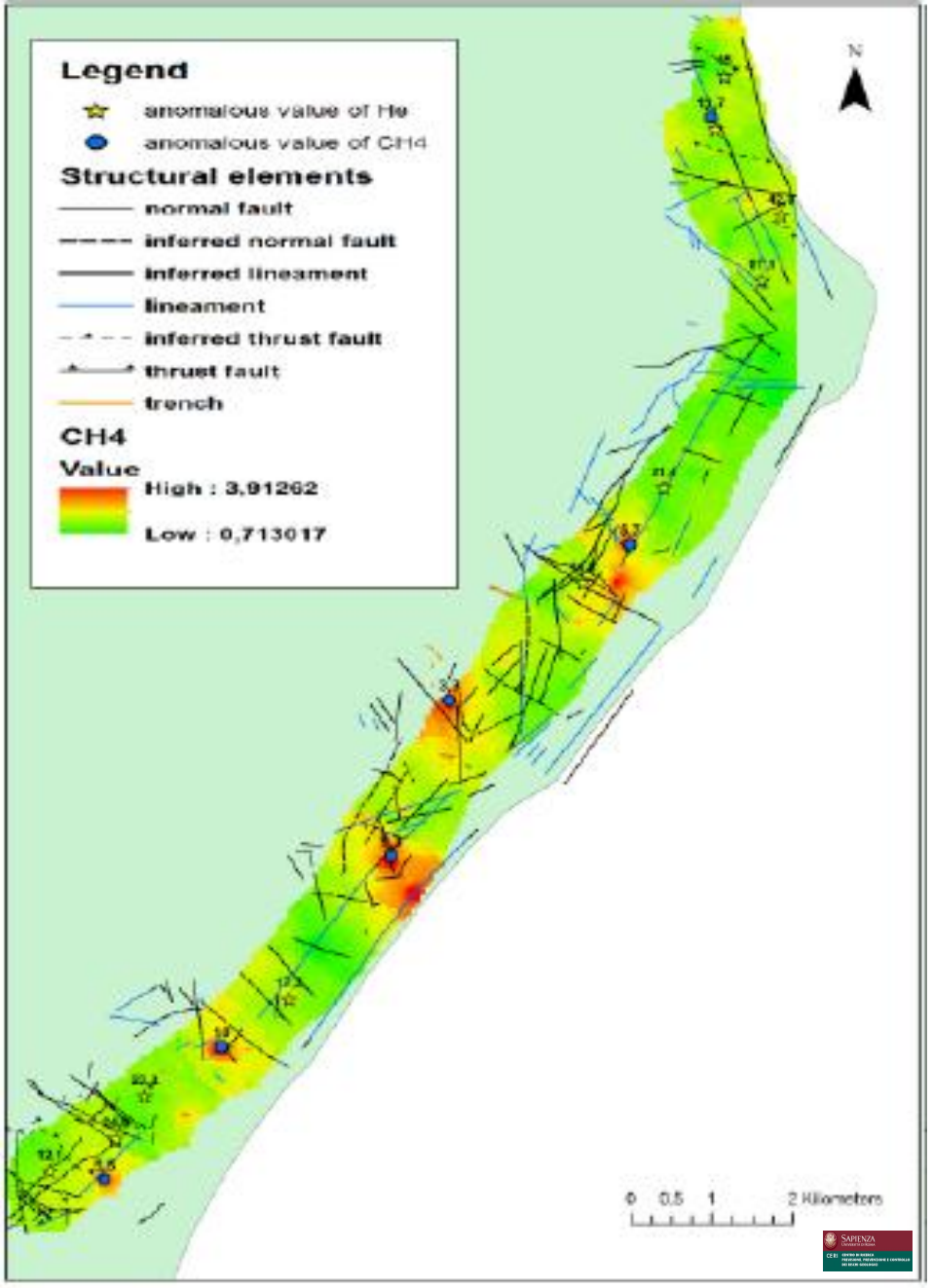
Soil gas CH_4

Shallow soil gas map of CH_4 concentration shows a more homogeneous distribution than CO_2 along the road trace, with maximum values in red one along the main rivers. Yellow stars indicate anomalous positive values of Helium, index of a deep origin of degassing.



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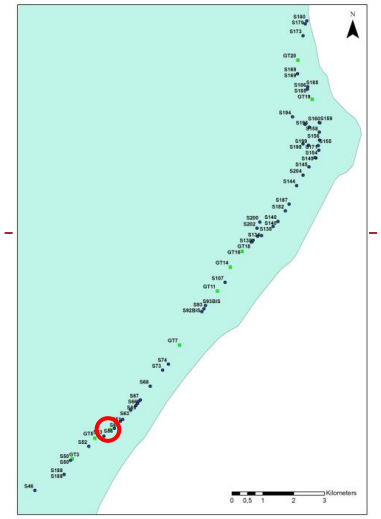
Borehole analyses

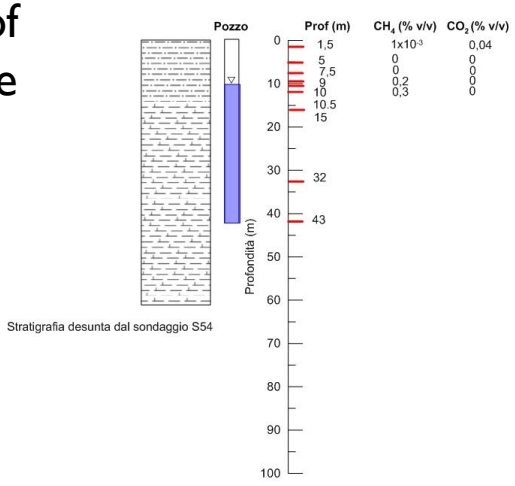
During drilling of GT6 well, there wasn't any evidence of CH_4. in the subsequent inspection, after sealing the borehole, we detect a significant concentration of CH_4, increasing along the time.



- 46 piezometers
- 9 down hole
- 17 inclinometer

For example: GT6

Sondaggio GT6
Coordinate 33 + 630944 - 4415652 Località Trebisacce
Altitudine 128 m slm

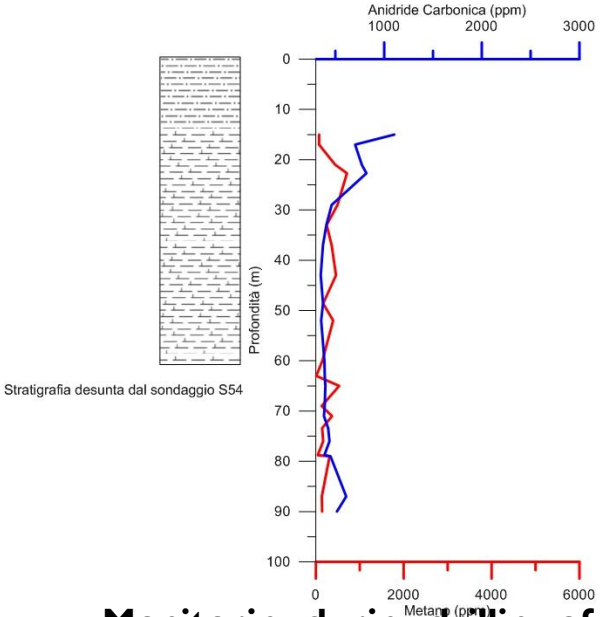


campioni acqua	
n°	Prof(m)
1	10,5
2	15
3	32
4	43

Ispezioni pozzi	CH4 (% v/v)	CO2 (% v/v)
18/06 h 15:55	19	0
20-06 h 09:00	21,5	0

Subsequent inspection and long term monitoring

Sondaggio GT6
Coordinate 33 + 630944 - 4415652 Località Trebisacce
Altitudine 128 m slm



Monitoring during drilling of the borehole

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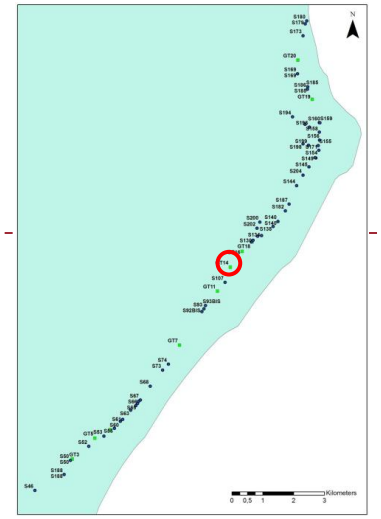
Borehole analyses

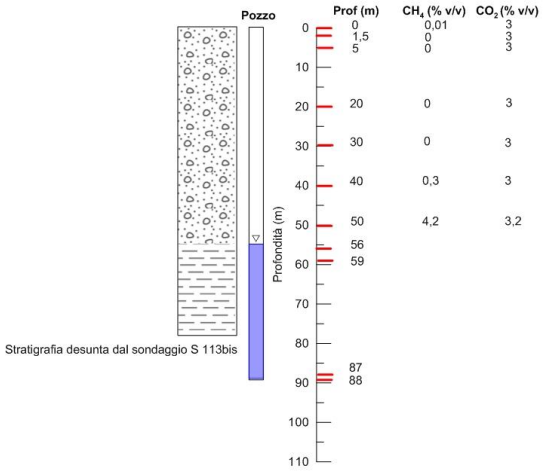
During drilling of GT14 well, as soon as it was perforated the Pliocenic clays, there was an increment in CH_4 concentration. In the subsequent inspection, after sealing the borehole, we didn't detect CH_4, proving that the system is not connected with a deep source.



- 46 piezometers
- 9 down hole
- 17 inclinometer

For example: GT14

Sondaggio GT14
Coordinate 33 + 634841- 4420929 Località Tarianni-Amendolara
Altitudine 128 m slm

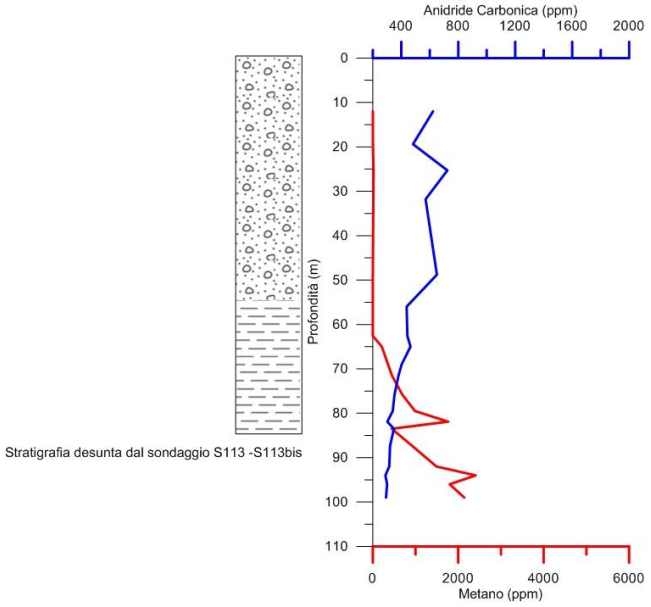


campioni acqua	
n°	Prof(m)
1	56
2	59
3	87
4	89

Ispezioni pozzi	CH4 (% v/v)	CO2 (% v/v)
19-06 h 8:35	0	0
20-06 h 10:10	0	0

Subsequent inspection and long term monitoring

Sondaggio GT14
Coordinate 33 + 634841- 4420929 Località Tarianni-Amendolara
Altitudine 128 m slm



Monitoring during drilling of the borehole

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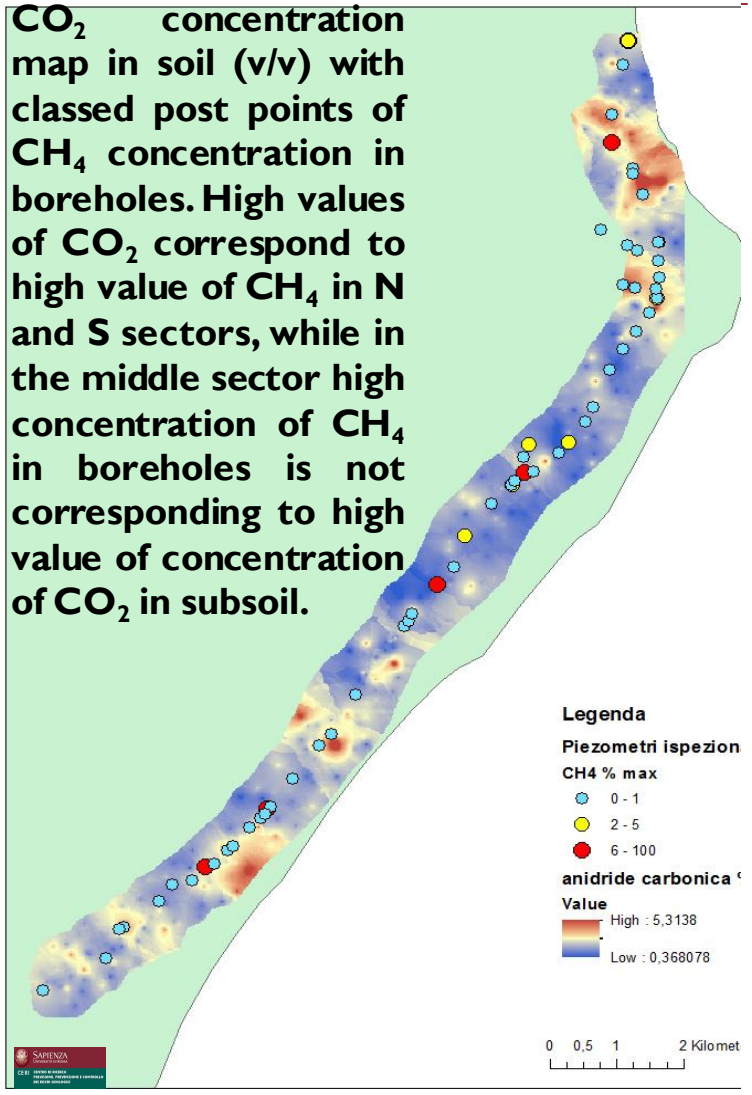
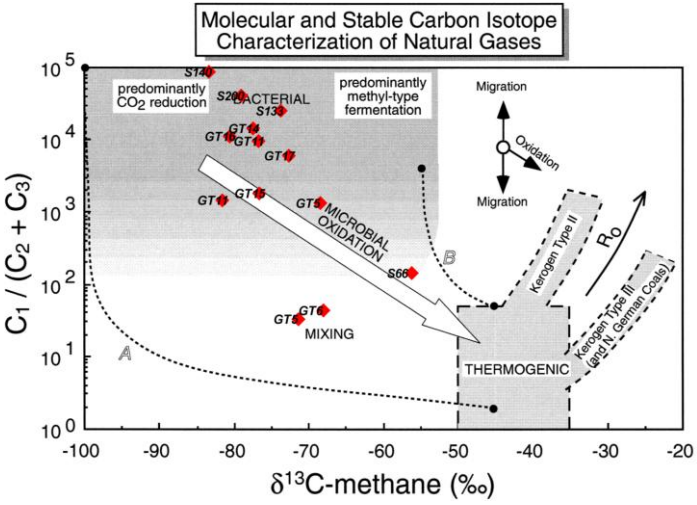
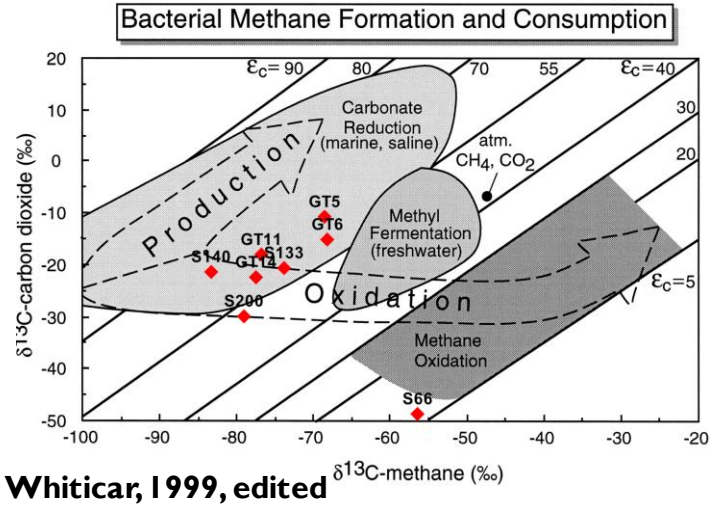
Soil gas – boreholes correlation

CO_2 concentration map in soil (v/v) with classed post points of CH_4 concentration in boreholes. High values of CO_2 correspond to high value of CH_4 in N and S sectors, while in the middle sector high concentration of CH_4 in boreholes is not corresponding to high value of concentration of CO_2 in subsoil.



Isotopes of $\delta^{13}C$ CO_2 and CH_4





Whiticar, 1999, edited

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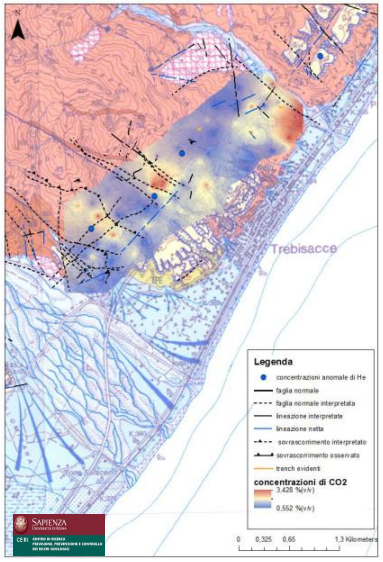
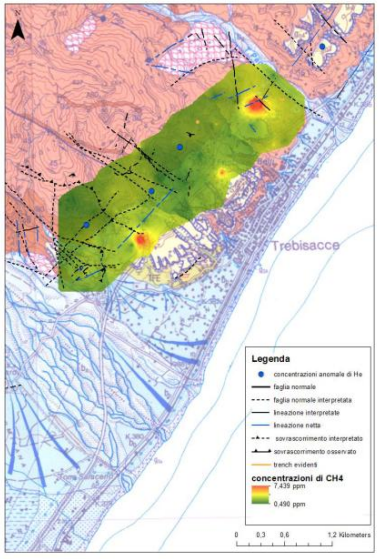
Migration model

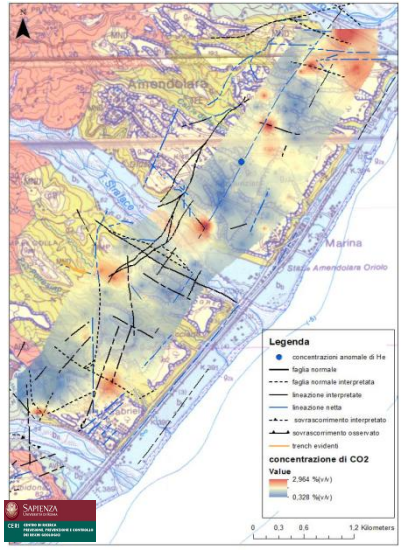
The different concentrations measured in the different geological settings suggest that the gas generation and migration is controlled by two main factors: structural control of faults and fractures and lithological and morphological control.

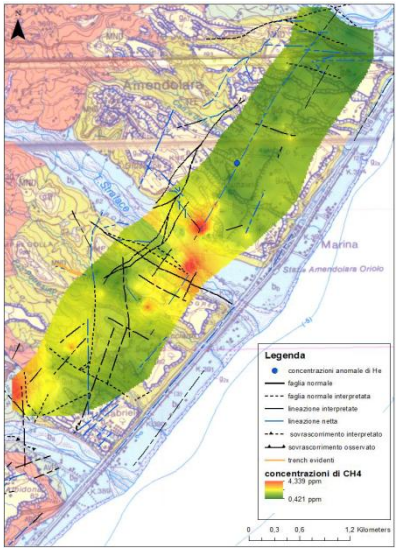
STRUCTURAL CONTROL
Trebisacce





LITHOLOGICAL AND MORPHOLOGICAL CONTROL
Amendolara





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Conclusion

This study has enabled us to create a migration model of gases in Ionian side of Calabria

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Combined analysis of structural and geochemical data has allowed us to distinguish zones where deep gas migration is controlled by faulting versus those zones where there is a superficial production of methane

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The building of these models is useful to find high risk zones during the design phases and in the planning the excavation activities in order to avoid these high risk zones to have the most detailed survey there.

Conclusion

It is highly recommended that near-surface surveys and monitoring be integrated into the initial phases of a project, as this information can give an important contribution to project planning and development.

.....THANK you!!!