

The Buried Fold-and-Thrust Belt in Sicily: Perspectives for Future Exploration*

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Abstract

The study region is a part of the Sicilian-Maghrebian Fold and Thrust Belt (FTB), a segment of the Alpine collisional belt, recently described as a result of both post-collisional convergence between Africa and Europe and roll-back of the subduction hinge of the Ionian lithosphere.

The region (extending in central Sicily from the Madonie Mountains. to the eastern corner of the Iblean-Pelagian foreland through the impressive NE-SW trending Tertiary clastic and evaporitic range of the Caltanissetta trough) is located in an area where the main thrust system disappears beneath a wedge of deformed Neogene deposits.

Earlier studies have neglected the importance of the potential target for hydrocarbon opportunities as well the occurrence of carbonate platform rock bodies at a depth and their tectonic relationships with the deepwater carbonate thrust systems.

Due to the poorly known structural and stratigraphic characters of the study area some questions arise:

- Is there a thrust pile structurally comparable with the western and eastern Sicily tectonic wedge?
- Are there carbonate platform units involved in the belt and what is their depth?
- Is the clastic and evaporitic Neogene tectonic wedge filling the Caltanissetta trough so thin to be crossed by oil research boreholes?

Stratigraphy and mesostructural analyses, accomplished in the last years, in the frame of the Field Mapping CARG Project, provide new data able to constrain the geological cross-sections.

The latter are further calibrated by a deep crustal seismic profile (SI.RI.PRO. Project, scientific leader R. Catalano) recently acquired across Sicily, together with refraction seismic, gravimetry and magnetotelluric data. It has strongly improved the knowledge of the deep crustal characters beneath the central Sicily.

The recognized deep geometries and the presumed Moho location represent a strong control of the surface geological setting.

The results obtained illustrate the foreland forming a steep regional monocline underlying a thickened carbonate thrust wedge to the north and the Gela Nappe to the south, allowing a correlation between outcropping and buried carbonate units, and evidencing the structural relationships between shallow and deep water carbonate units. The reconstruction of the pattern and timing of deformation will be able to propose a kinematic model useful for exploration strategies.

References

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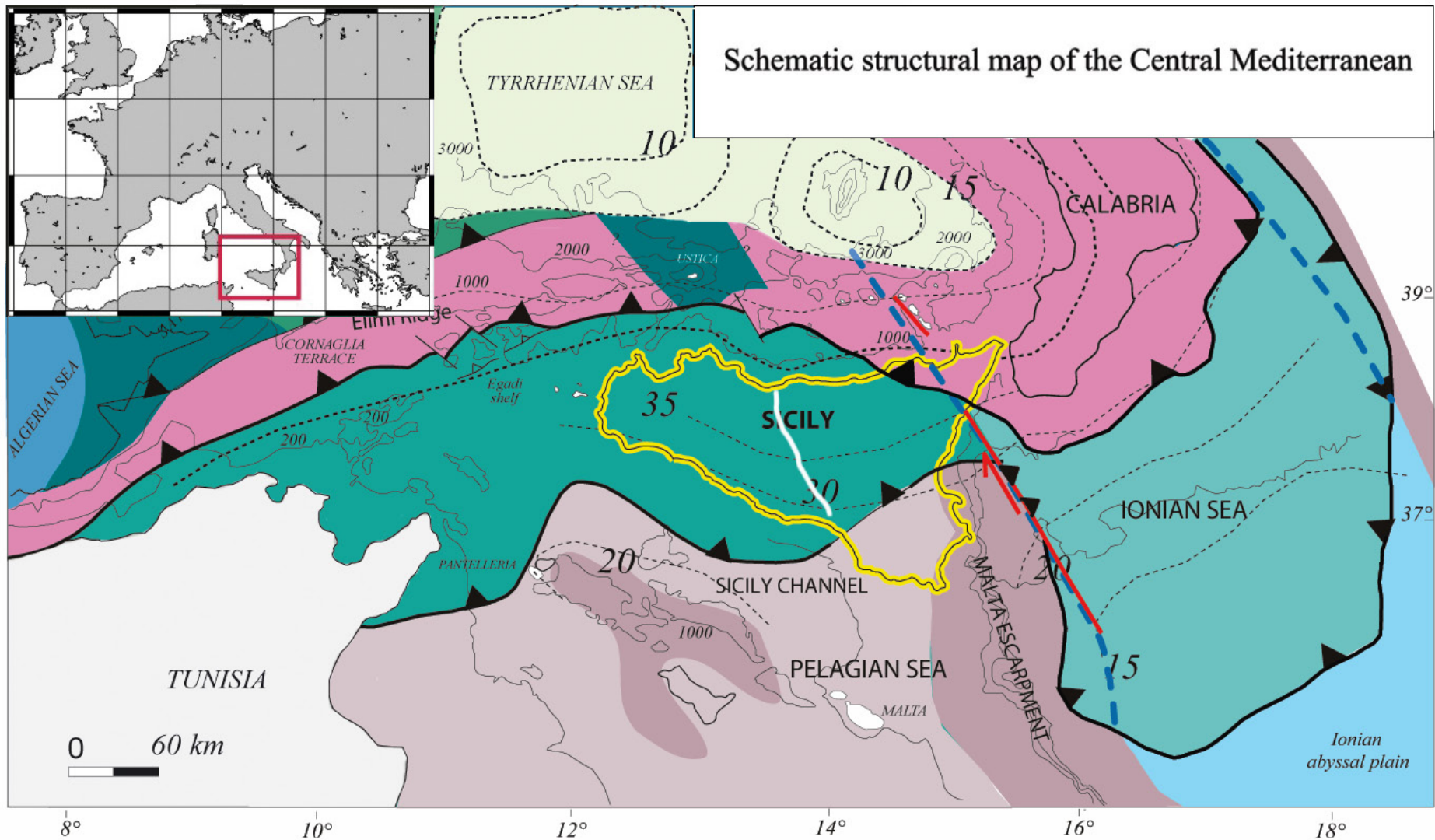
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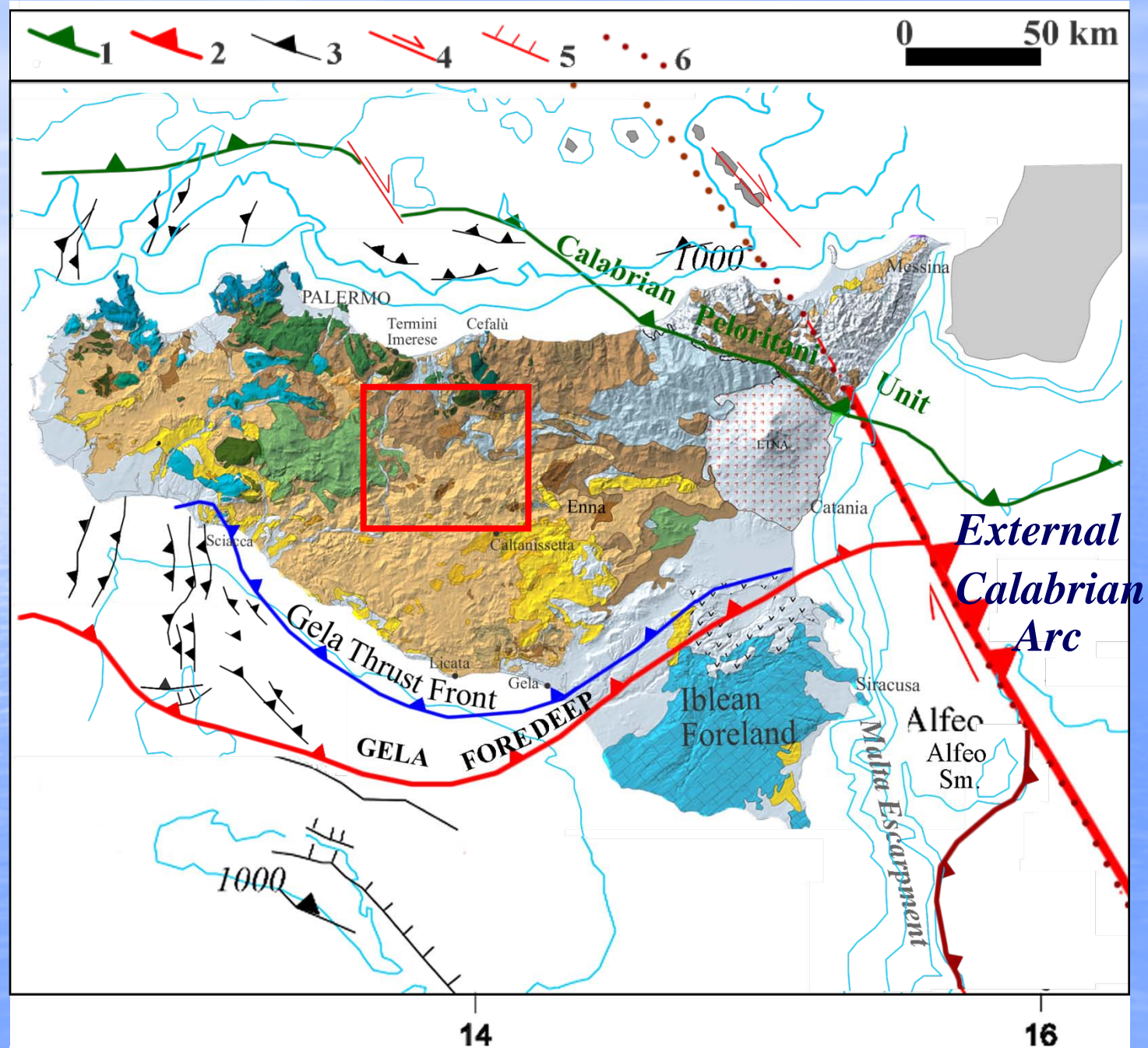
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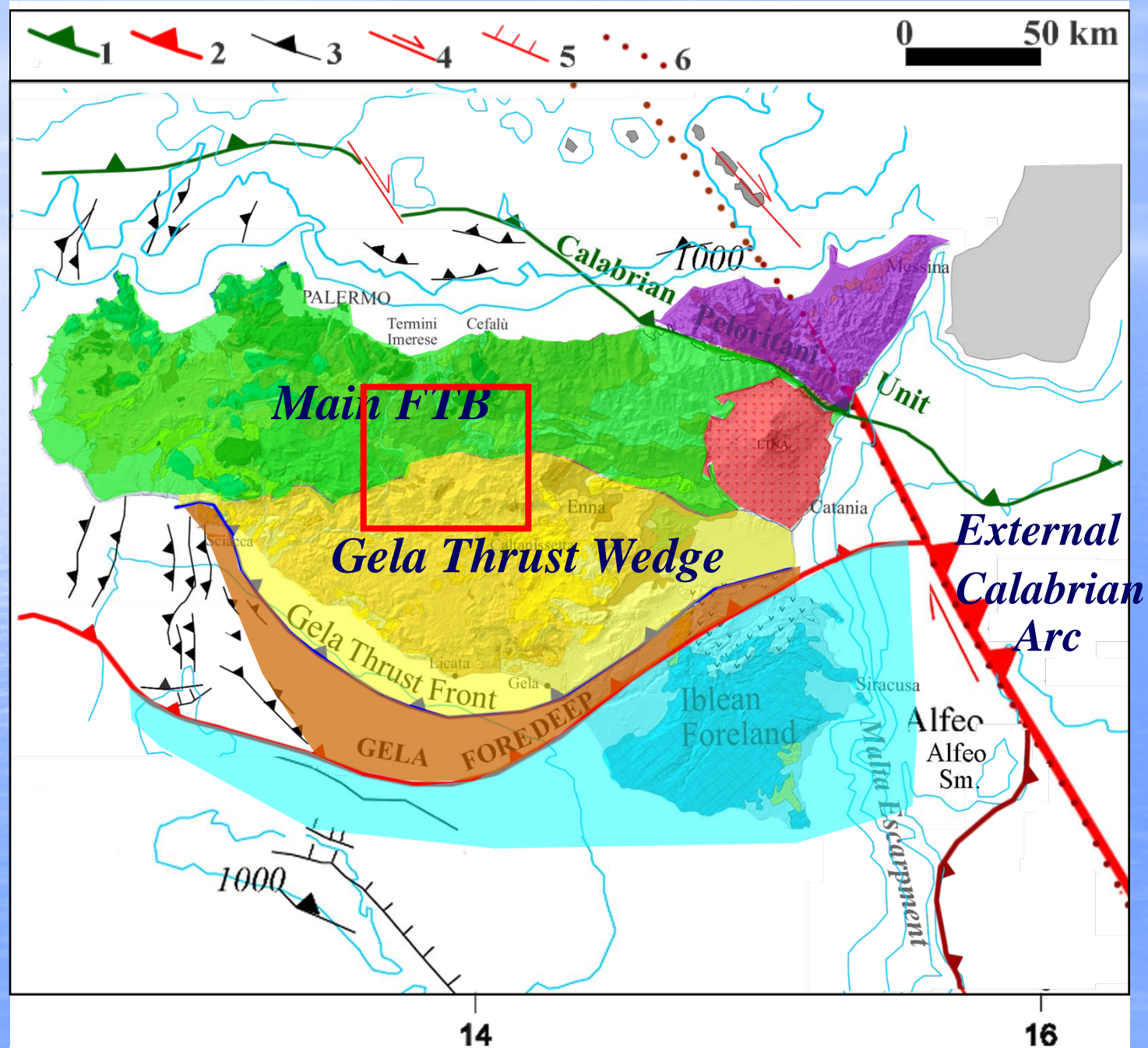
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The study area-regional framework



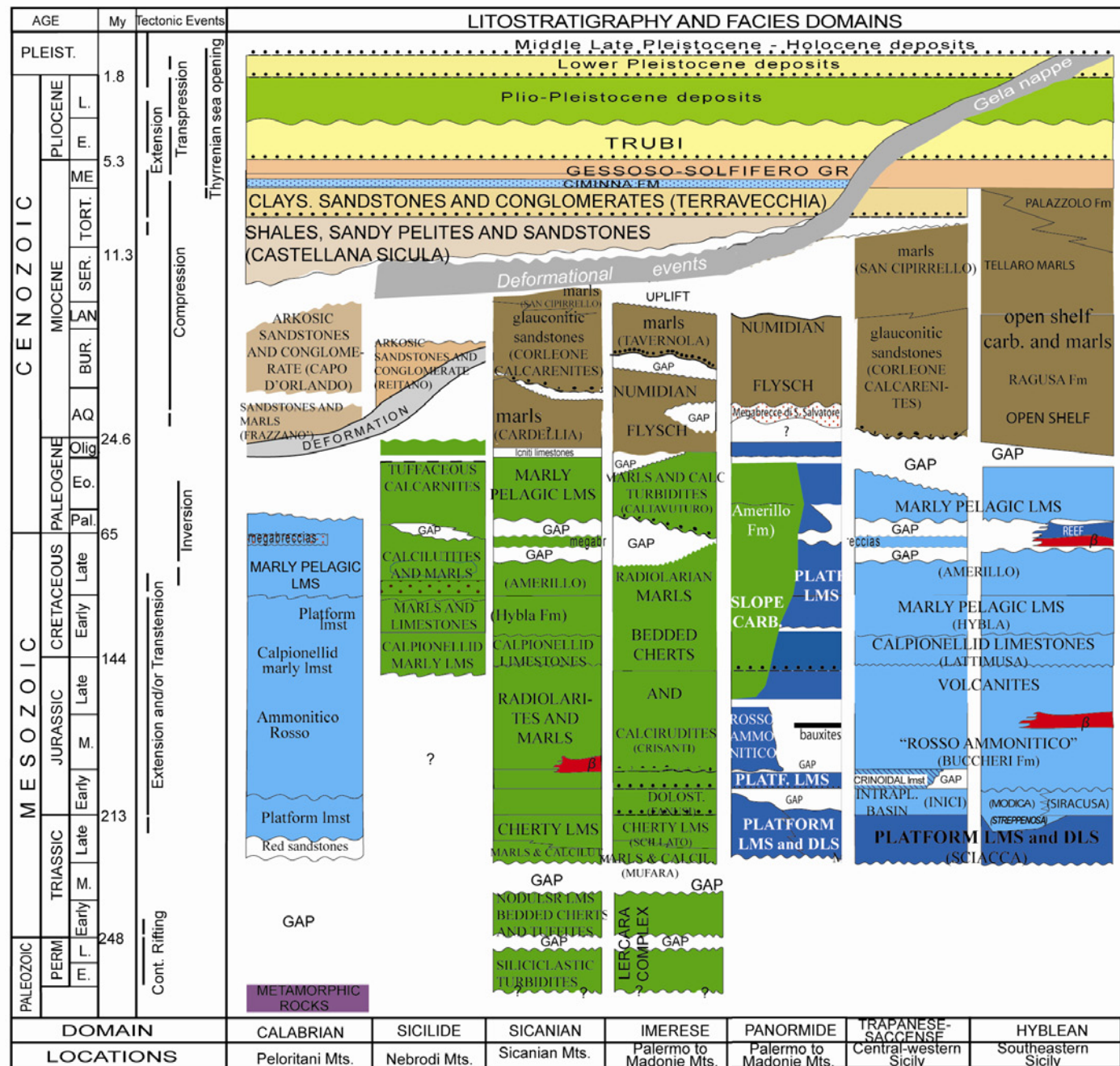
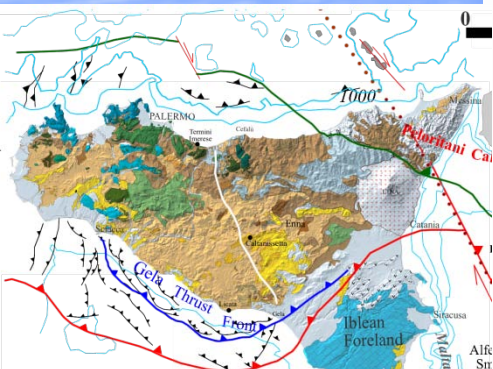
The study area-regional framework



Imerese and Sicanian units are the Meso-Cenozoic deep water domains,

the Trapanese-Saccense units represent the Meso-Cenozoic carbonate platform domains,

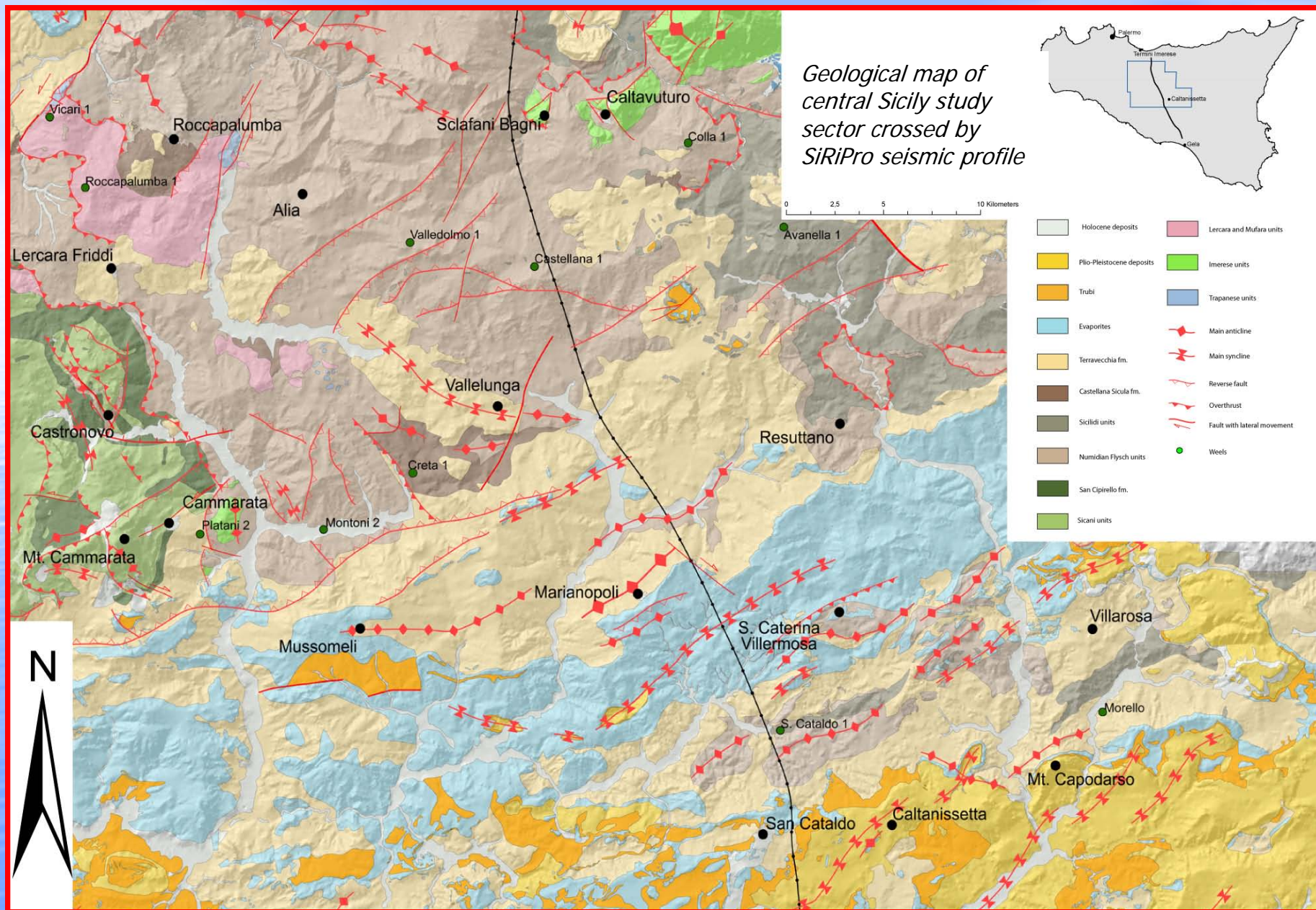
as well the **Iblean unit** that is the foreland of the chain.

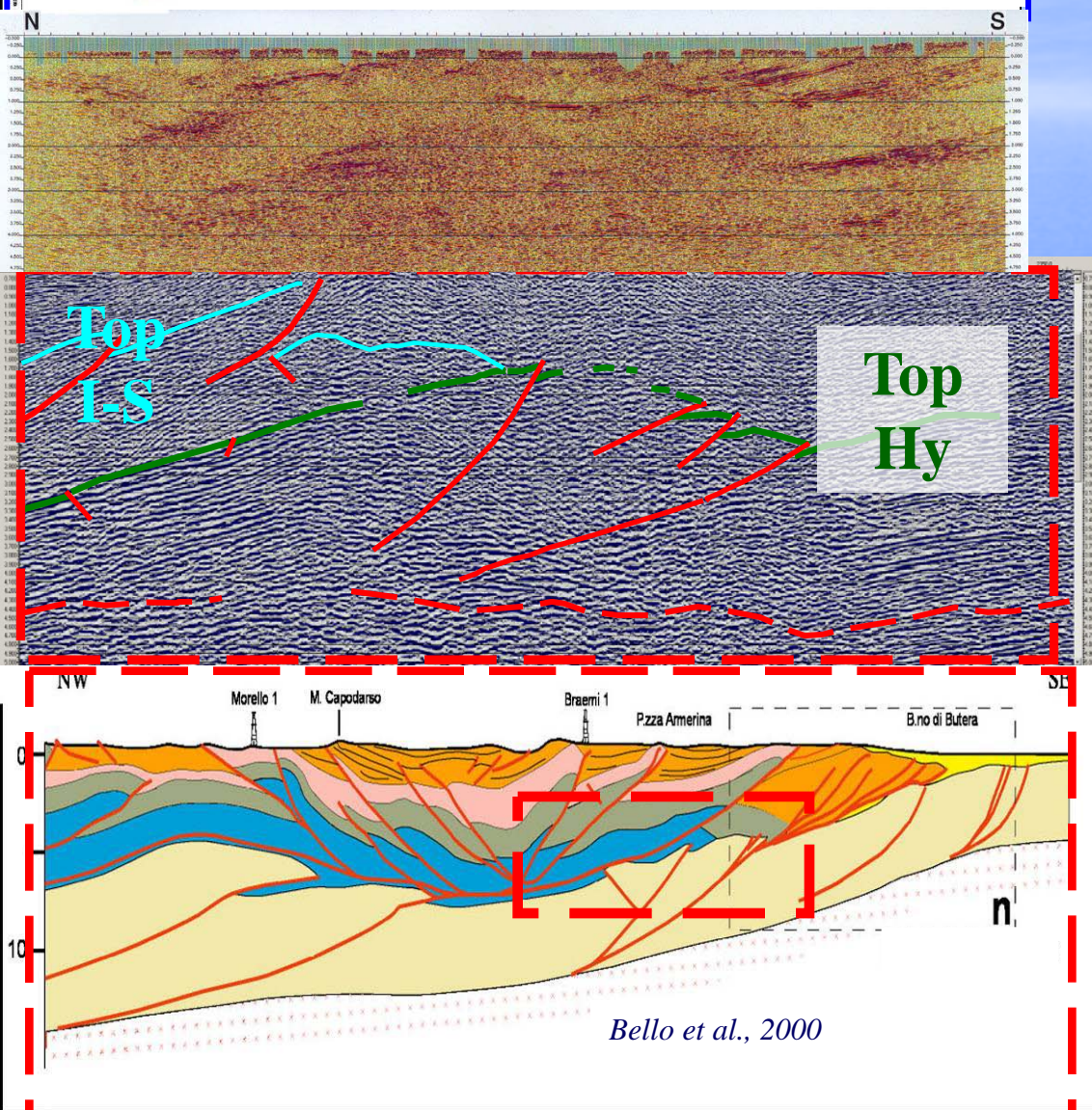


European Tethyan

African

The study area concerns a sector located in **central Sicily** between the **Madonie** and **Caltanissetta** through. It covers the **eastern Sicanian Mountains**





Previous papers have described the chain in Central-Western Sicily (Catalano et al., 1998, 2000) and Eastern Sicily (Bello et al., 2000) as formed from the bottom, by a stack of **mesocenozoic carbonate platform ramp anticlines, deep water carbonate thrust sheets and clastic-evaporitic nappe wedge, lying above a believed not involved northward-dipping crystalline basement.**



Due to the poorly known structural and stratigraphic characters of the study area some questions arise:

Is there a thrust pile structurally comparable to the western and eastern Sicily carbonate tectonic wedges?

Are there carbonate platform units involved in the chain and what is their depth?

- Are these units a local extension of the Pelagian-Iblean carbonate northward plunging foreland or a more internal carbonate platform thrust sheets?

- Is the clastic and evaporitic Neogene sedimentary wedge covering the Caltanissetta through enough thin to be crossed by oil research boreholes?

Materials and methods

To know more about the area, we performed:

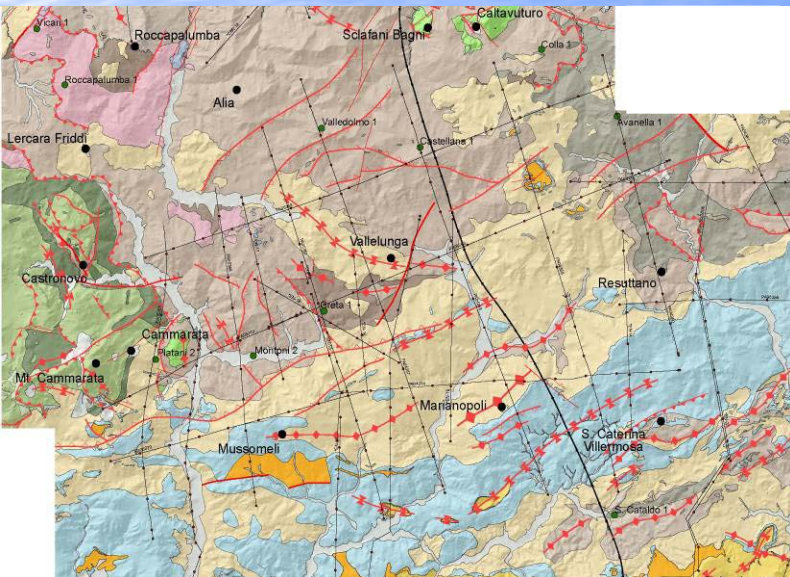
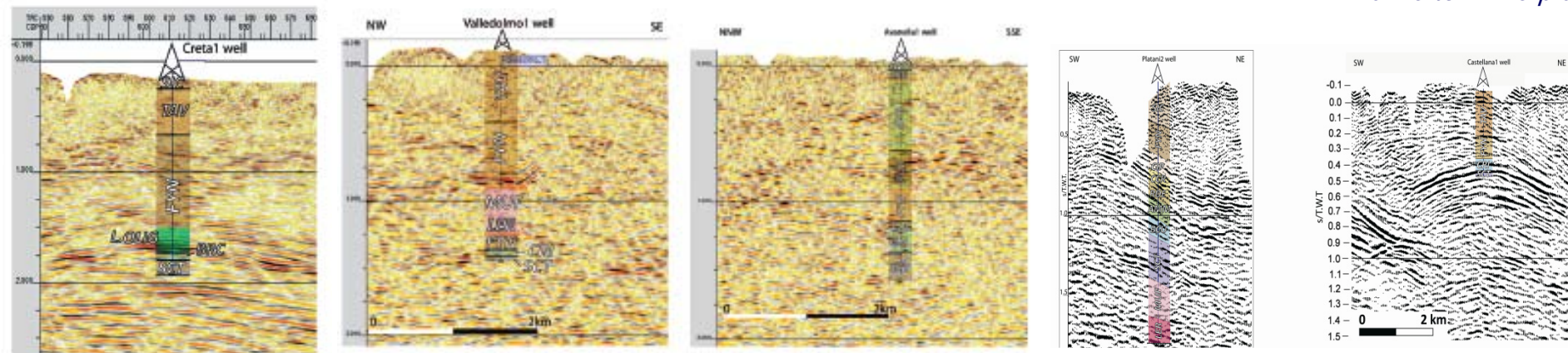
- Detailed stratigraphy and field investigation
- Structural analysis
- Seismostratigraphic analysis of a dense grid of seismic reflection profiles
- Borehole calibration

V



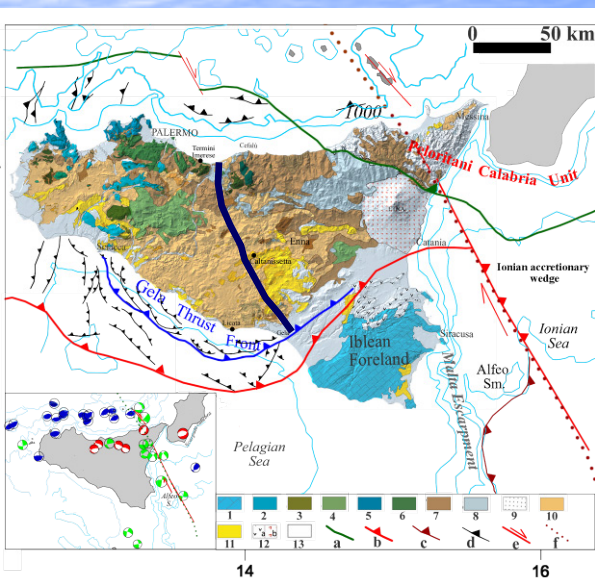
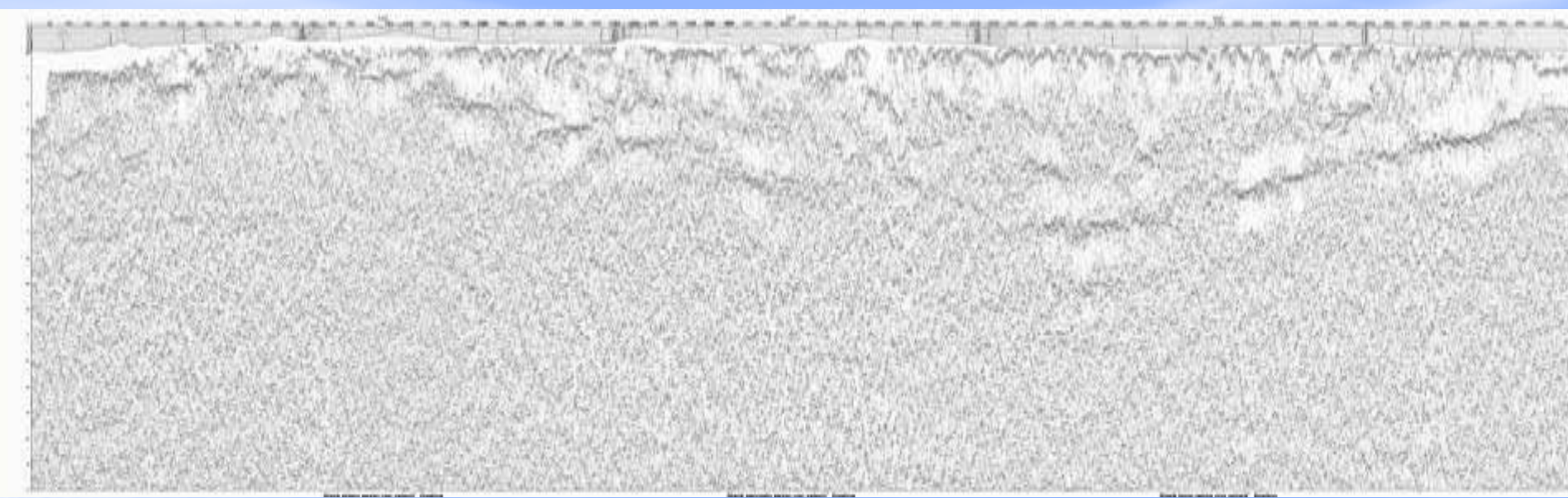
The boreholes main stratigraphic horizons have calibrated important seismic reflectors

Thanks to ENI S.p.a.



The new stratigraphy and the mesostructural analyses accomplished in the last years support with field data the joint interpretation of the confidential seismic lines acquired by ENI S.p.A. (Catalano et al., 2008, 2010)

These results are now calibrated by a crustal profile (SIRIPRO Project, leader R. Catalano) recently acquired across Sicily from the Tyrrhenian coast to the Sicily Channel

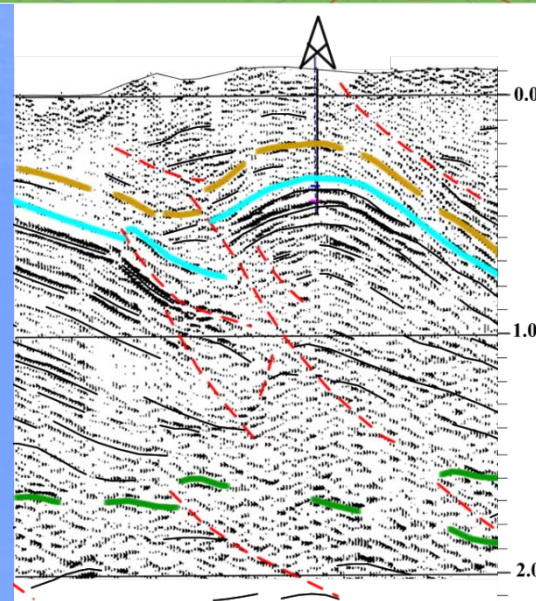
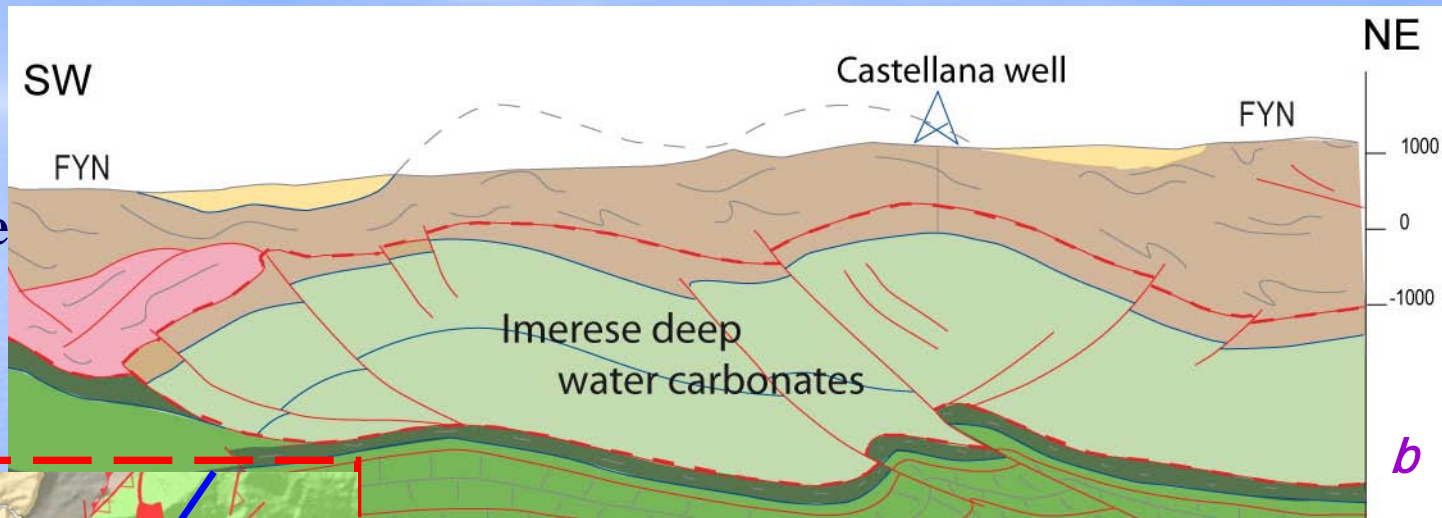


Main aim:

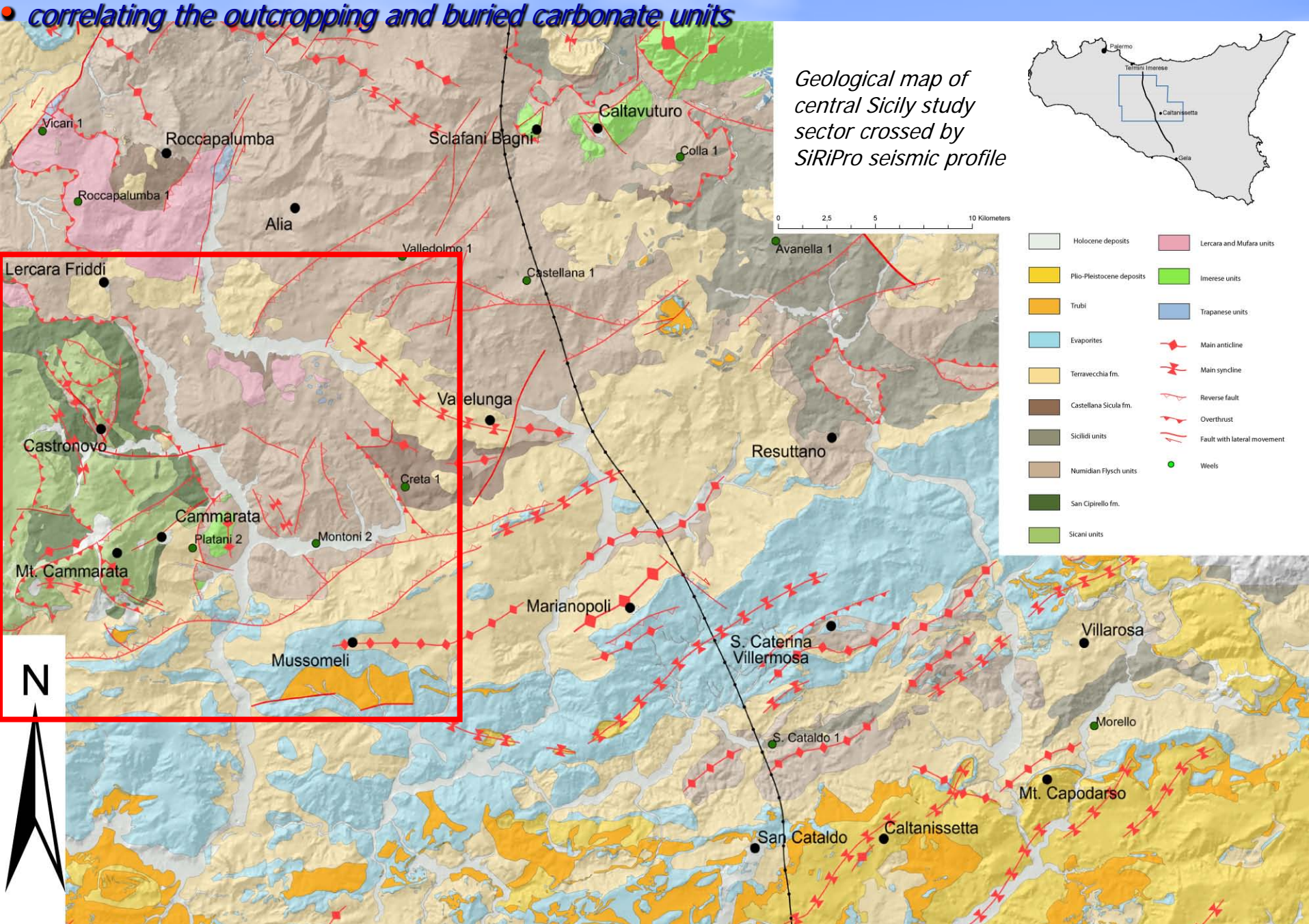
To define the structural setting of the buried FTB in central Sicily we proceeded:

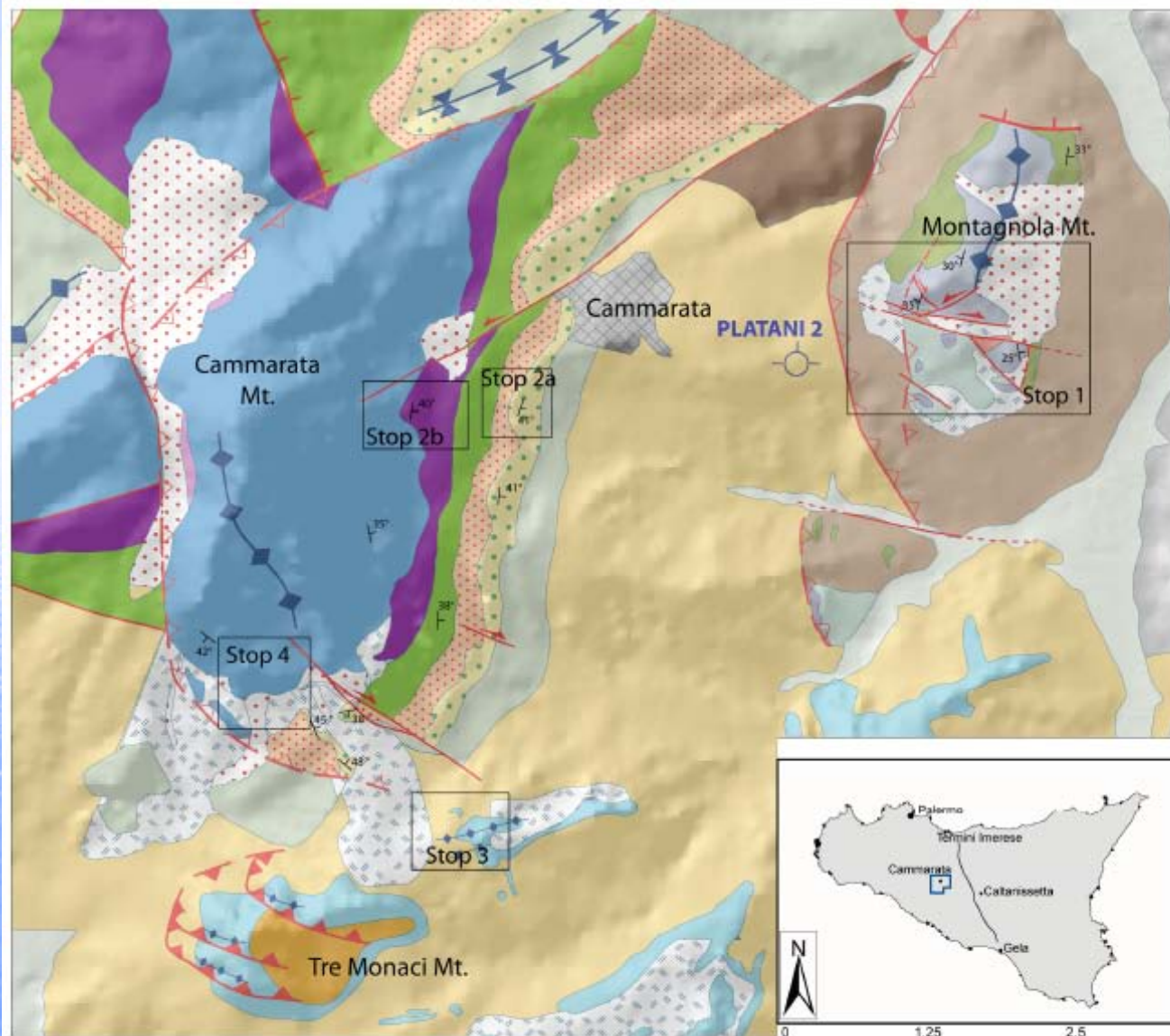
- correlating the outcropping and buried carbonate units
- showing the structural relationships between shallow and deep water carbonate units
- reconstructing pattern and timing of deformation
- proposing a kinematic model useful for exploration strategies.

- Two main sections crossing the western Madonie Mts and the Valledolmo area show as the outcropping and buried thrust sheets correlate in **facies stratigraphy (Imerese), thrust geometry and same south-westward vergency**
-
- The diagram is a geological cross-section. At the top left, the letters 'SW' are written. Below them, the letters 'FYN' are written. The section shows several layers of rock. A yellow layer is at the top. Below it is a brown layer. Below the brown layer is a green layer. A red layer is shown as a thrust sheet, dipping to the right (south-east). The red layer is labeled with 'I' at its base. The diagram illustrates the relationship between different geological units and their orientation.



● correlating the outcropping and buried carbonate units

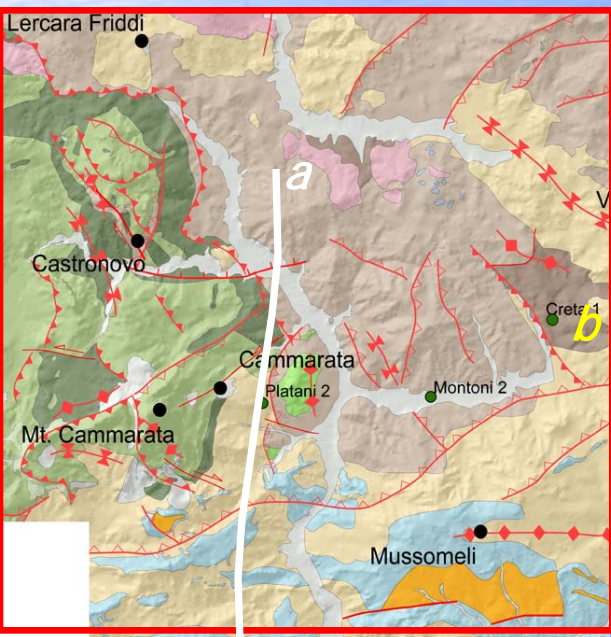
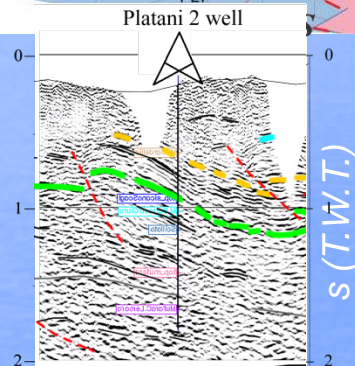
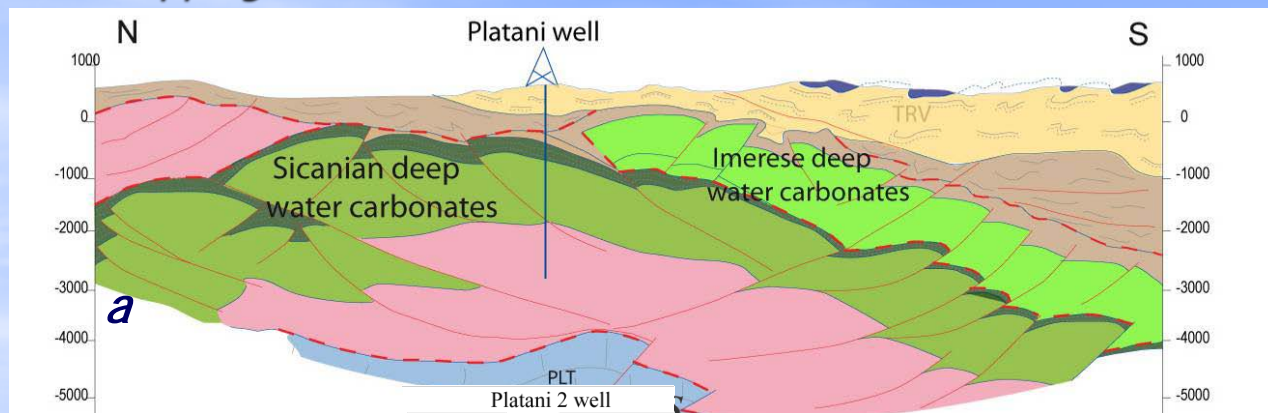




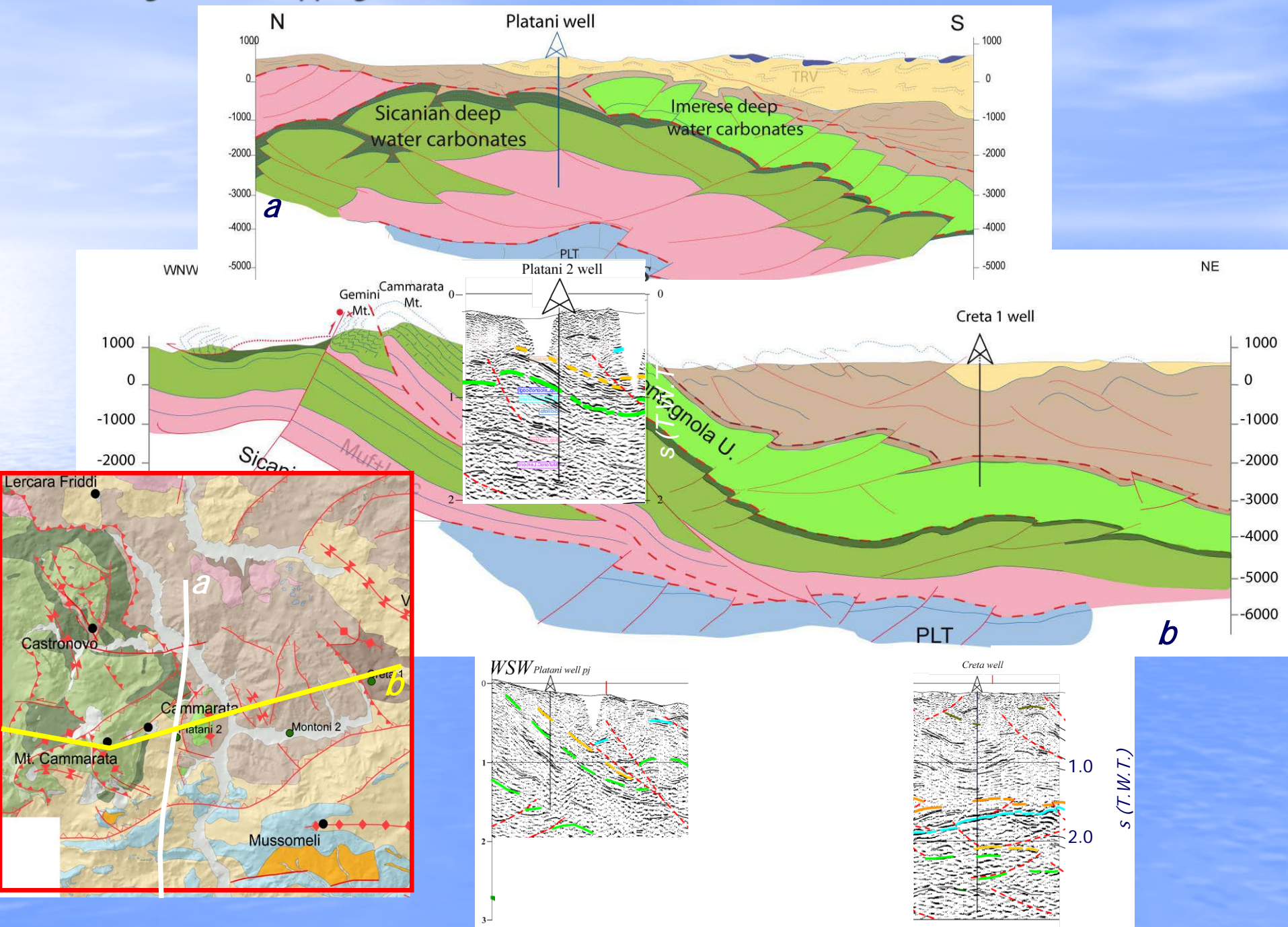
- Olocen deposits
- Trubi fm.
- Evaporites
- Terravecchia fm.
- Castellana Sicula fm.
- Imerese Units**
 - Numidian flysch
 - Caltavuturo fm.
 - Rudistid breccias member
 - Marly spongolithic member
 - Ellipsactinia breccias member
 - Radiolarian member
- Sicanian Units**
 - San Cipirello marls
 - Corleone calcarenites
 - Cardellia marls
 - Amerillo fm.
 - Hybla, Lattimusa and Barracù fms.
 - Scillato fm.
 - Scillato fm.
- Main anticline
- Main syncline
- Reverse fault
- Overthrust
- Fault with lateral movement

5 Kilometers

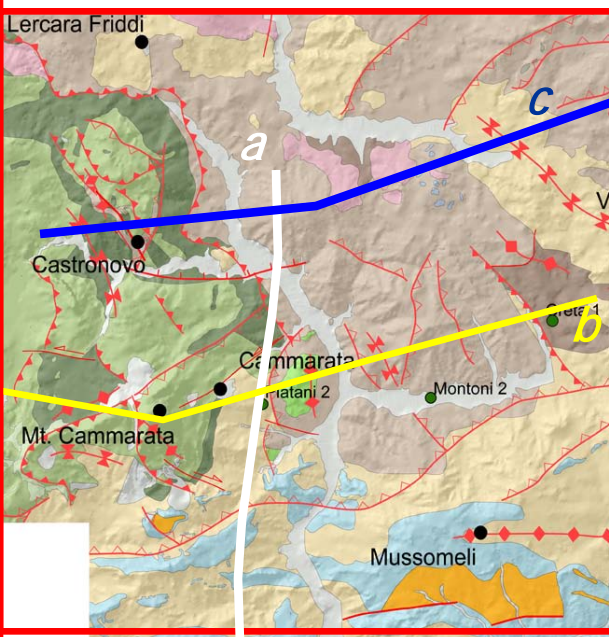
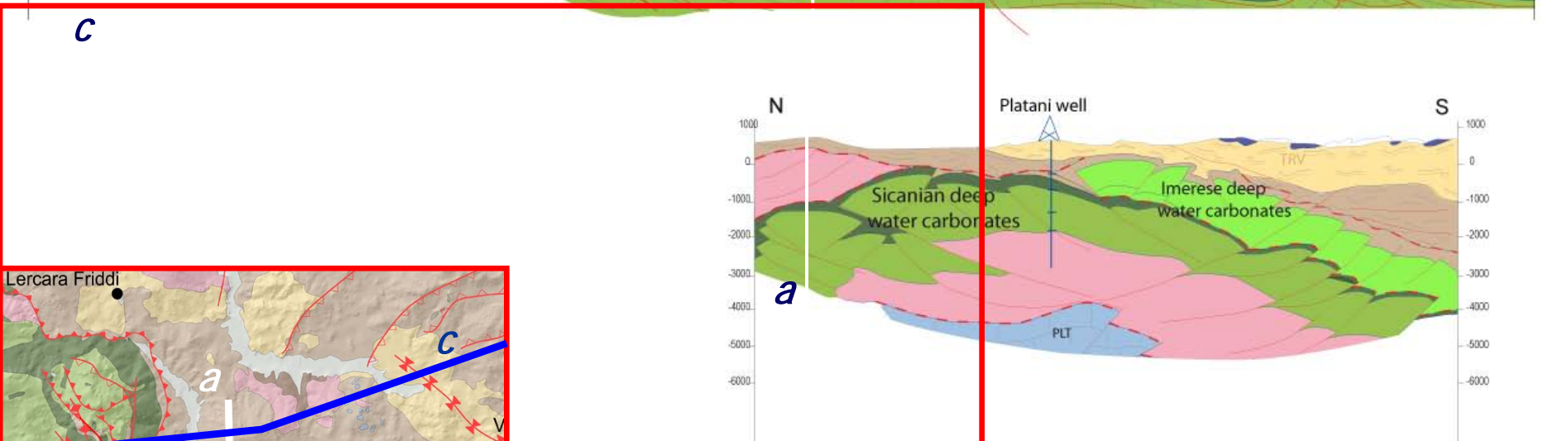
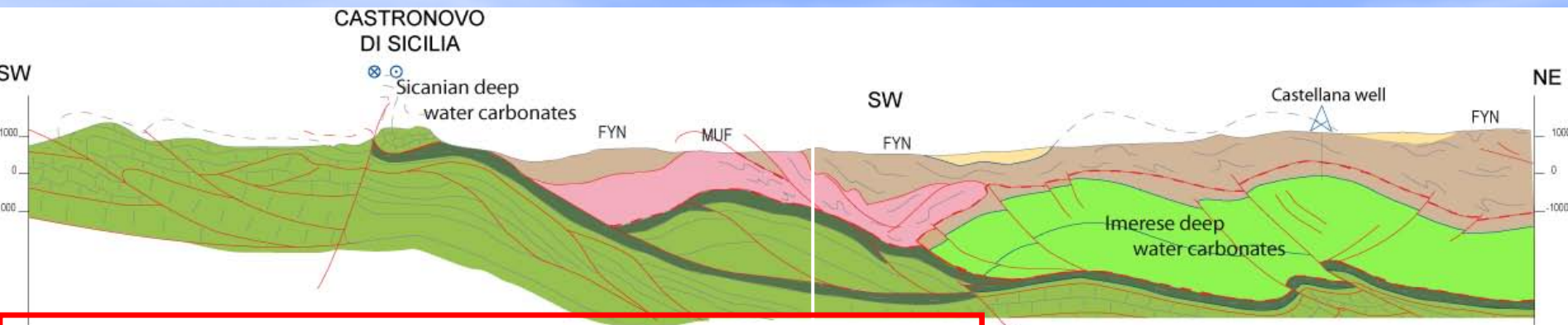
● correlating the outcropping and buried carbonate units



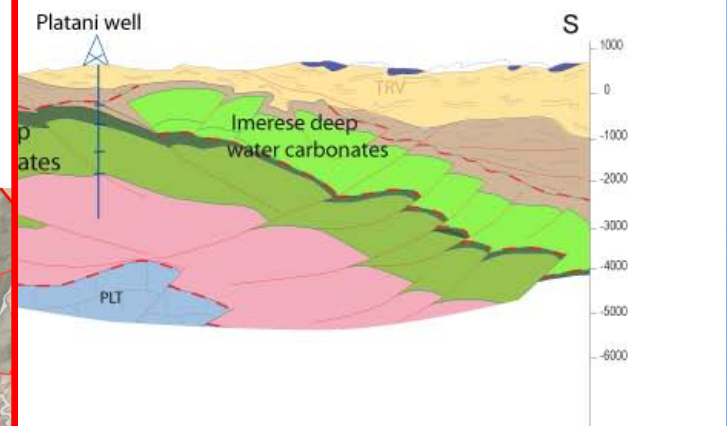
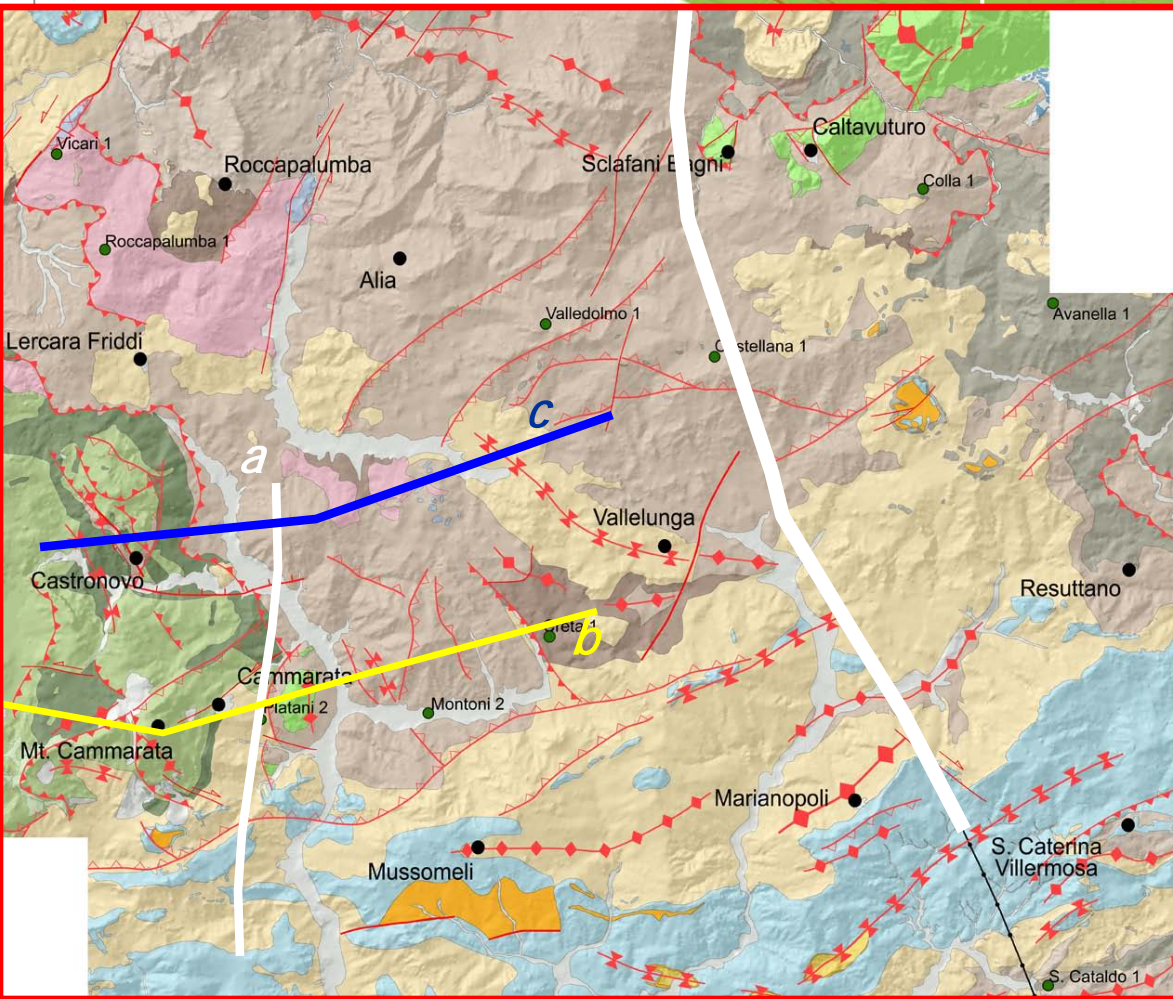
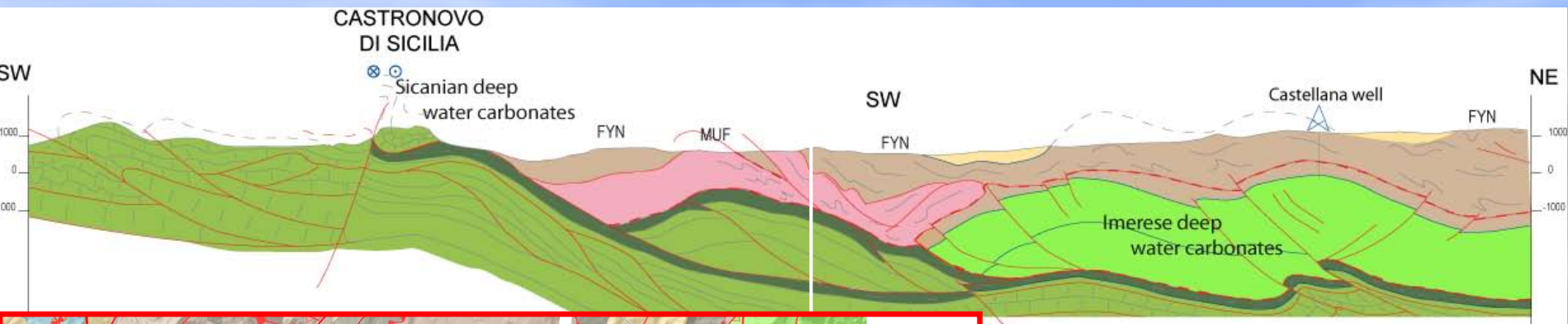
● correlating the outcropping and buried carbonate units



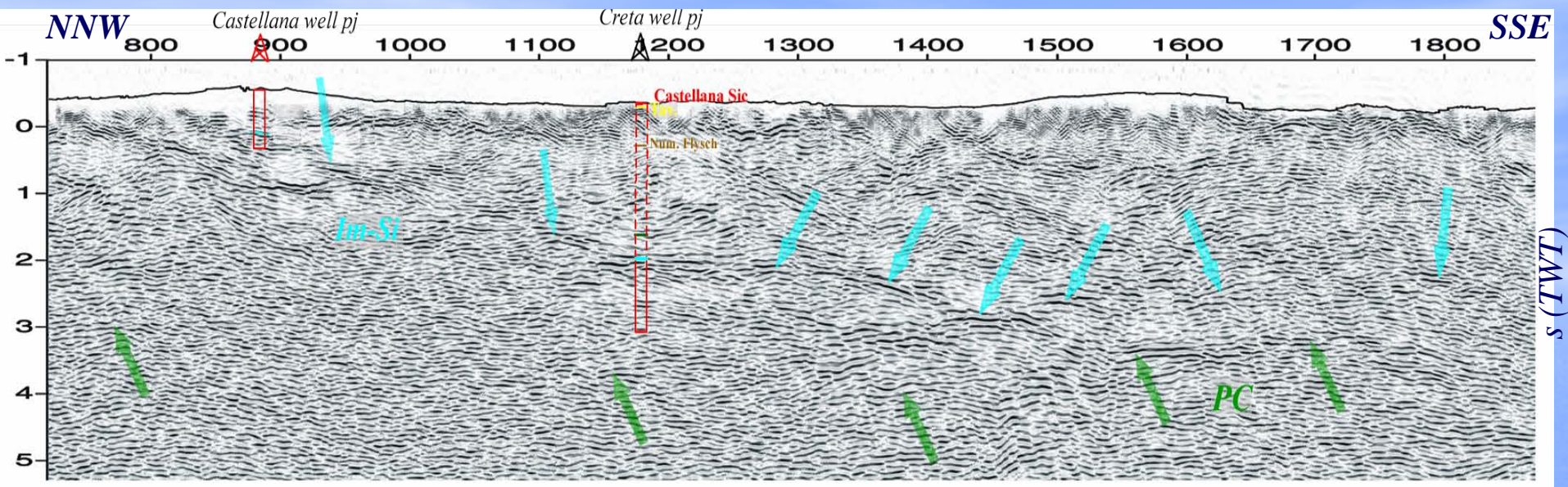
● *correlating the outcropping and buried carbonate units*



● **correlating the outcropping and buried carbonate units**



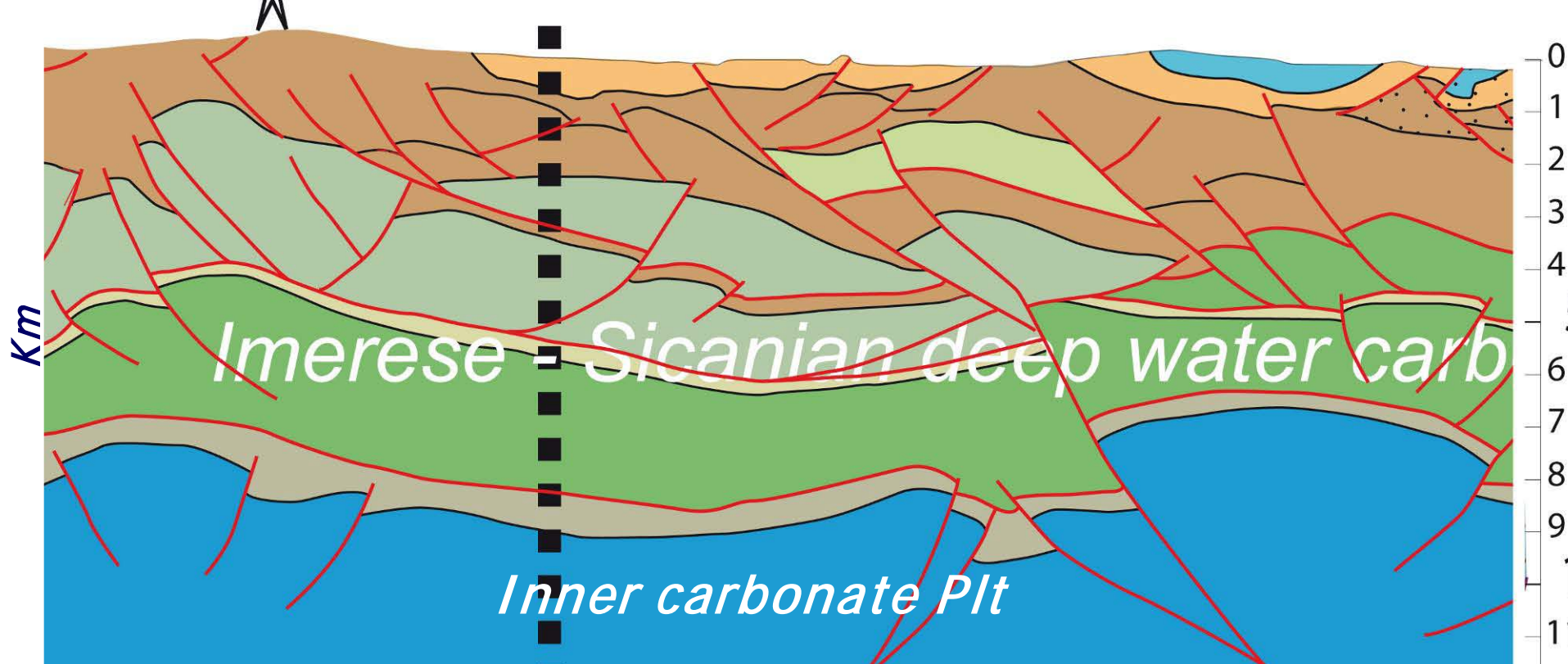
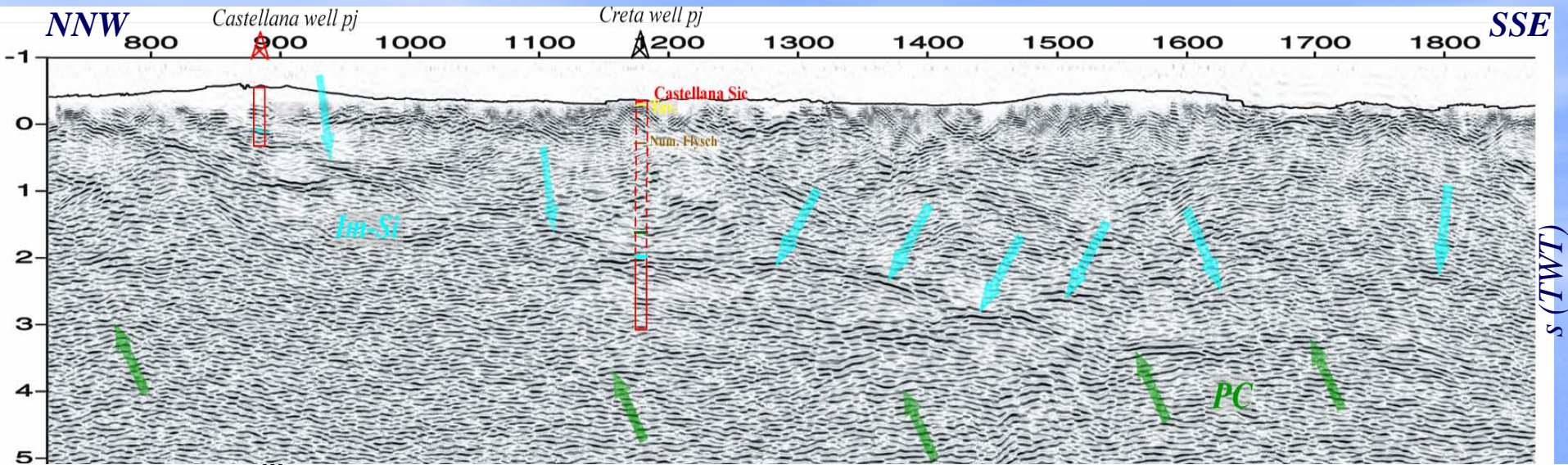
- showing the structural relationships between shallow and deep water carbonate units



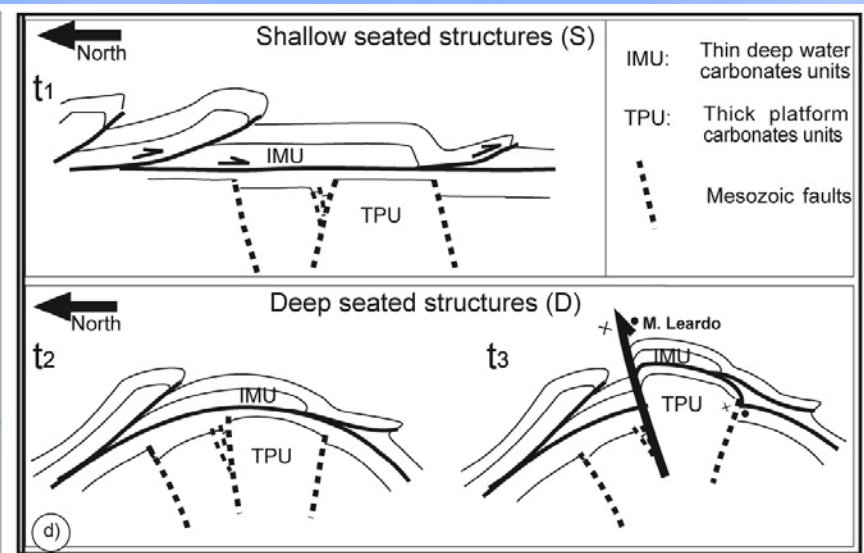
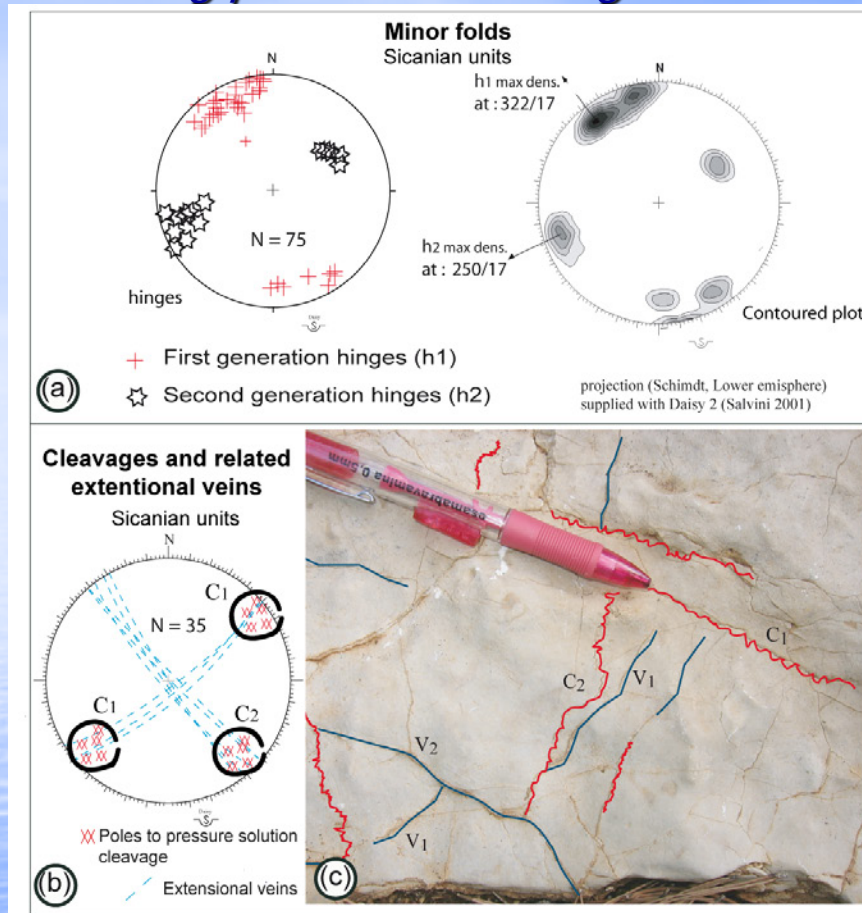
Carbonate platform is characterized by mainly low frequency, high amplitude group of reflectors (green arrow). Its top is located at 3 to 4 s (T.W.T.)

Deep water carbonates are high frequency, high to medium amplitude group of reflectors, 0.5 to 1 s/TWT thick (light blue arrow), bounded by continuous reflectors that represent the top of the Cretaceous beds and the bottom of the upper Triassic strata Imerese and Sicanian units, after boreholes calibration.

• showing the structural relationships between shallow and deep water carbonate units



reconstructing pattern and timing of deformation



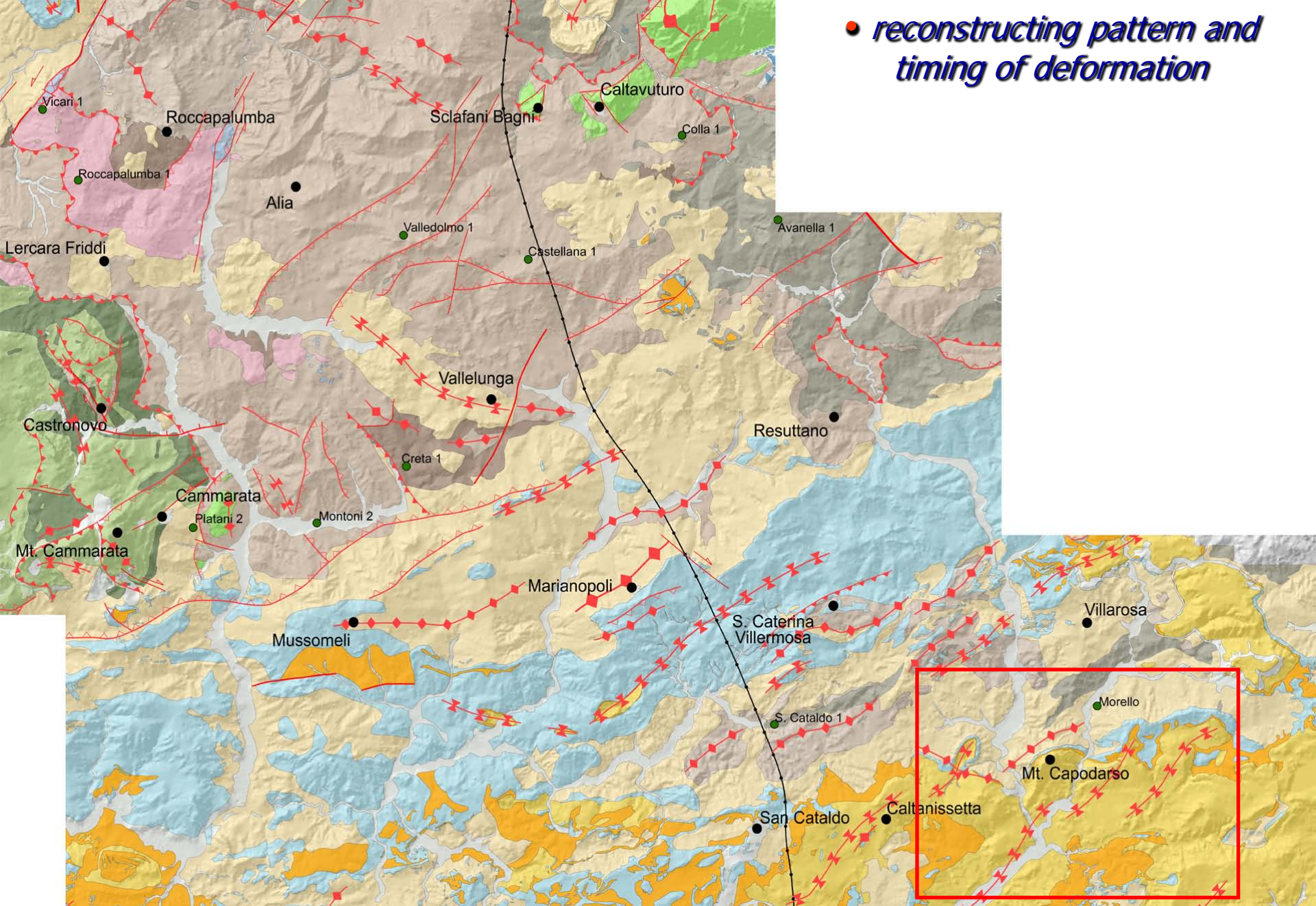
two main tectonic events are envisaged; shallow-seated and deep-seated thrusts occurred during the Miocene-Quaternary time interval that deformed the sedimentary cover of the former continental margin.

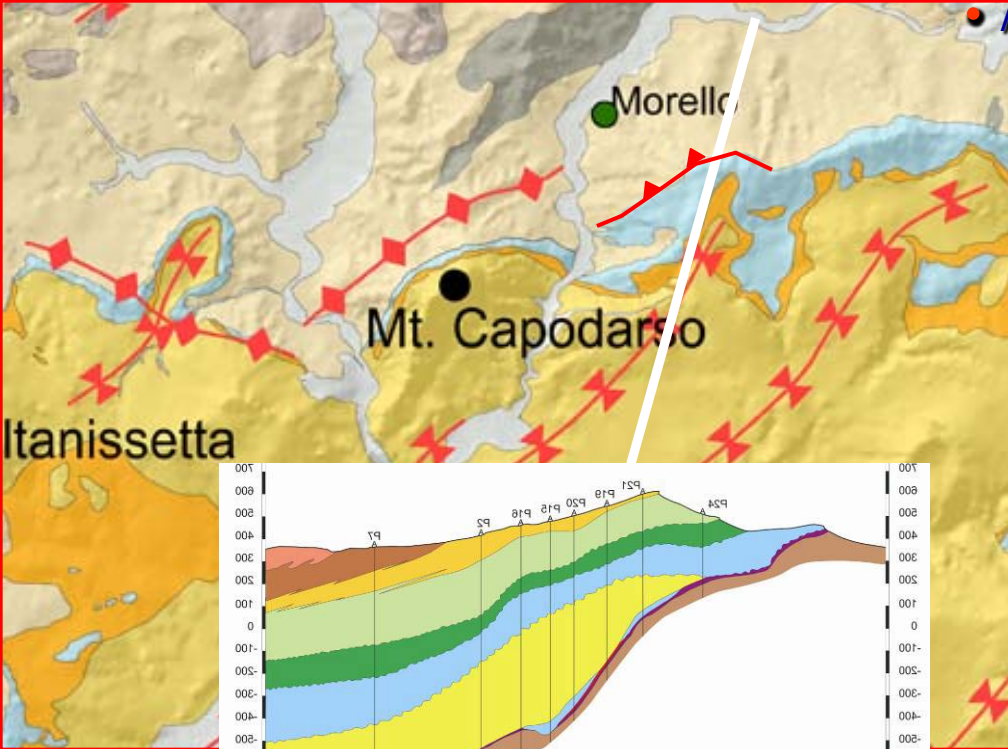
Meso-structural data highlights **two main NW-SE and NE-SW trending folds and cross-cutting relations** pointing out the **implaced shallow-seated and deep-seated units have respectively SW- and E-vergency**

An earlier phase of thrusting involved the Sicilide, the Numidian flysch and the deep-sea Imerese-Sicanian units (Middle-Upper Miocene).

Following their emplacement, the deep seated thrust reactivation detached and deformed the buried carbonate platform; it implied re-imbrication and shortening into the overlying deep water carbonate units as well in the highest tertiary levels

● *reconstructing pattern and timing of deformation*





reconstructing pattern and timing of deformation

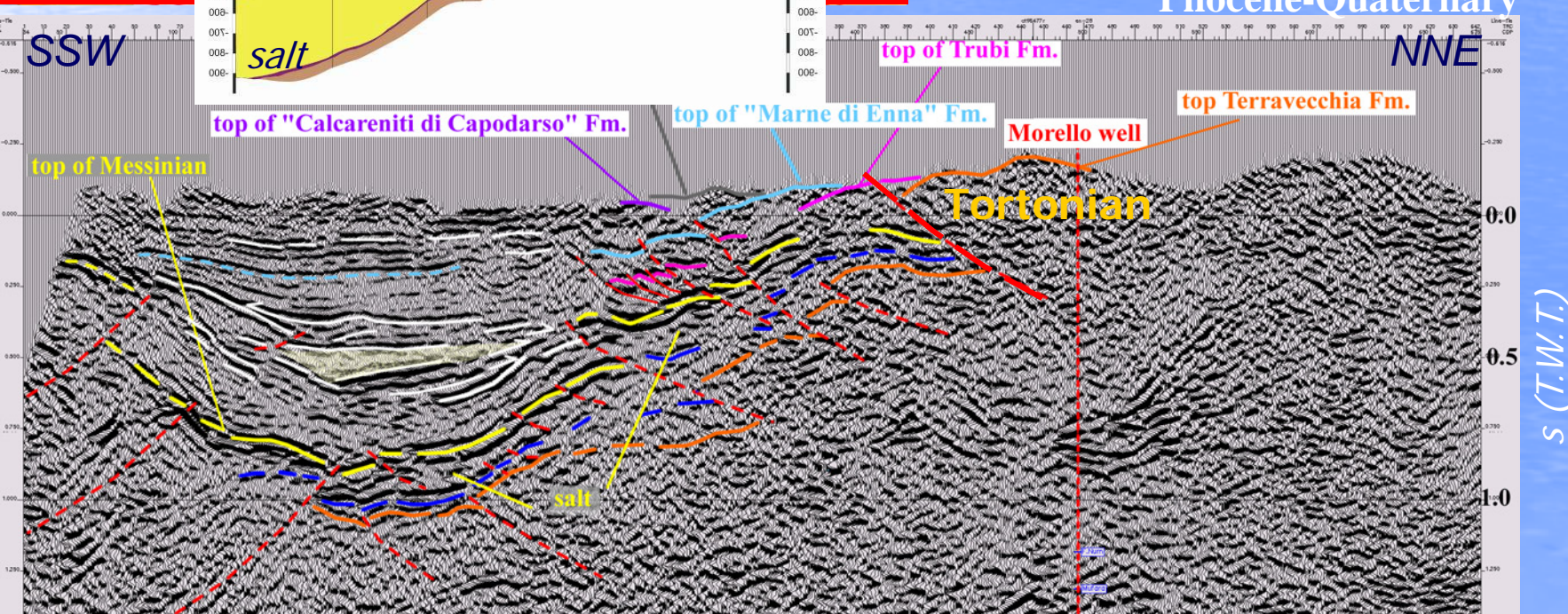
The progressive activation of deep seated thrusts and back-thrusts occurred since the Pliocene, developing structural depressions enclosed between growing structural highs (Morello well).

SW-wards migration of the depocentre implying syntectonic sedimentation due to

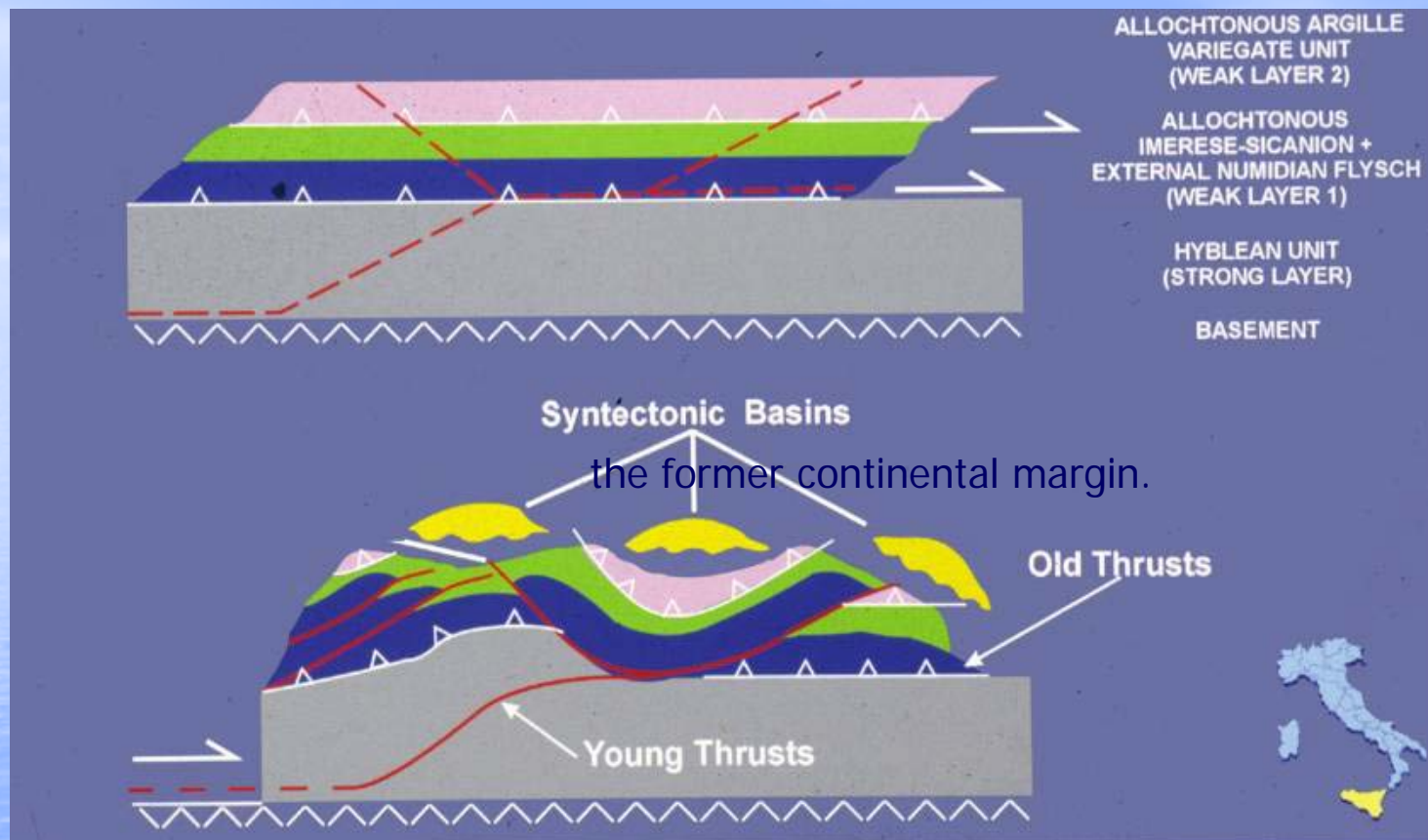
a) tectonic uplift of the underlying thrust sheets

b) sedimentary supply and subsidence

Timing of deformation involving the underlying already stacked units is Pliocene-Quaternary



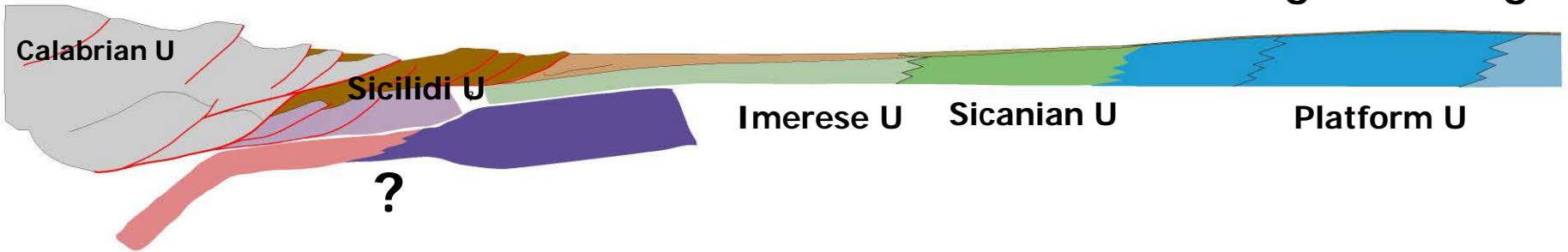
- *reconstructing pattern and timing of deformation*



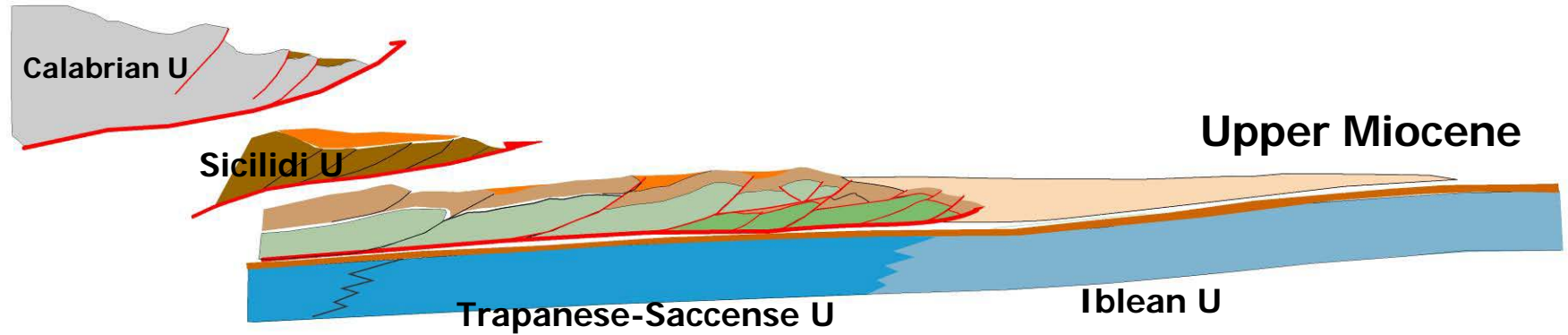
The formation of the basins is due to the development of the deep-seated thrusts (in our case carbonate platform units) with foreland- and hinterland-verging structures.

proposing a kinematic model useful for exploration strategies

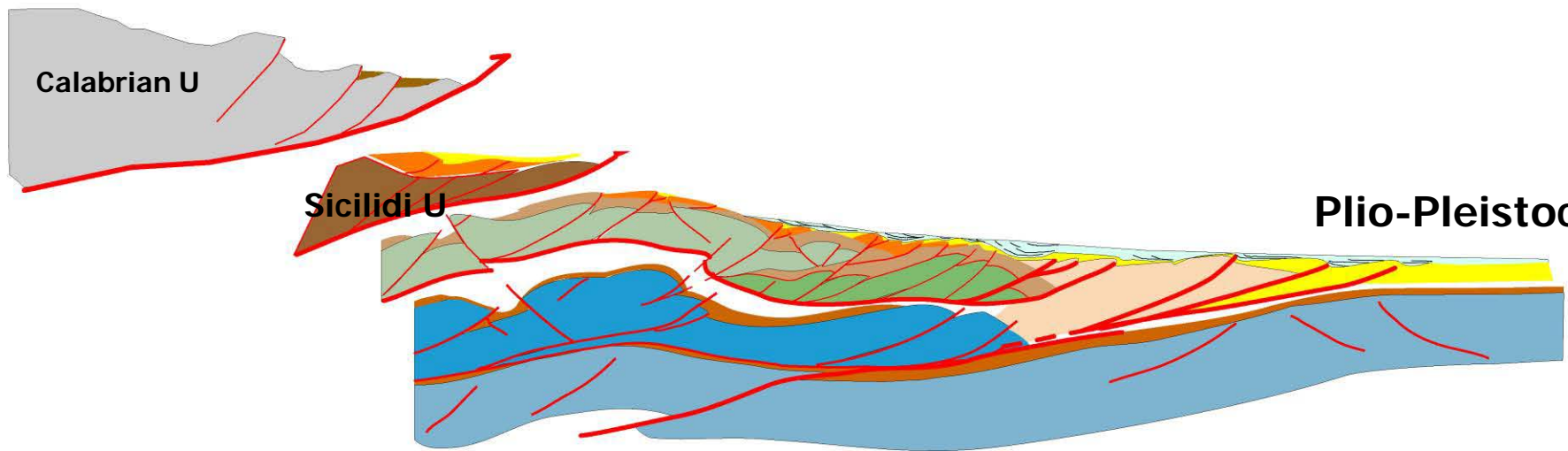
Burdigalian-Langhian



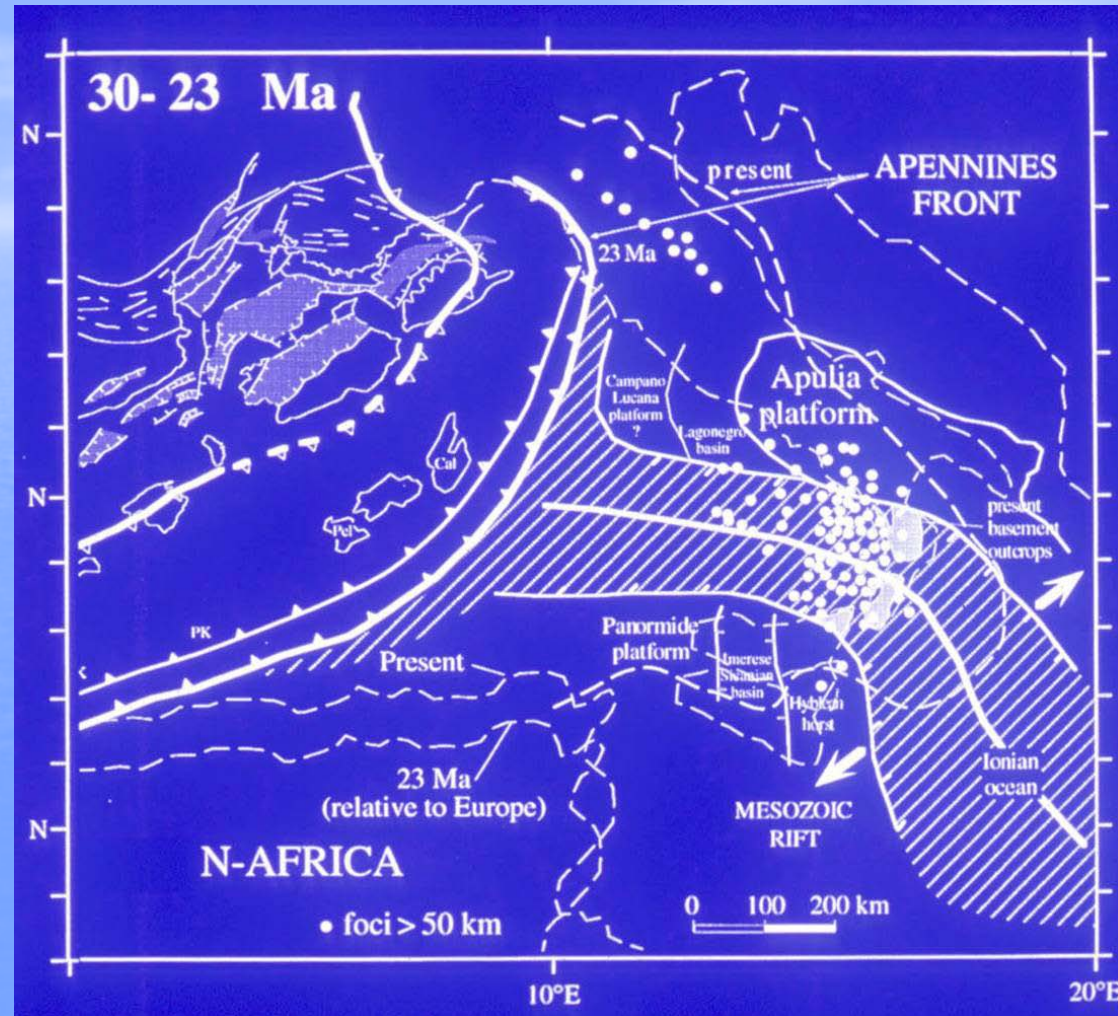
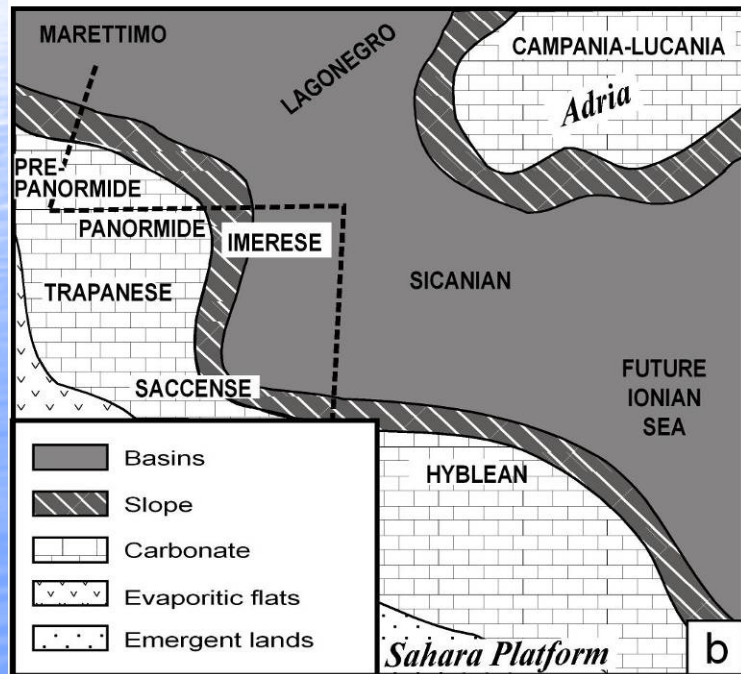
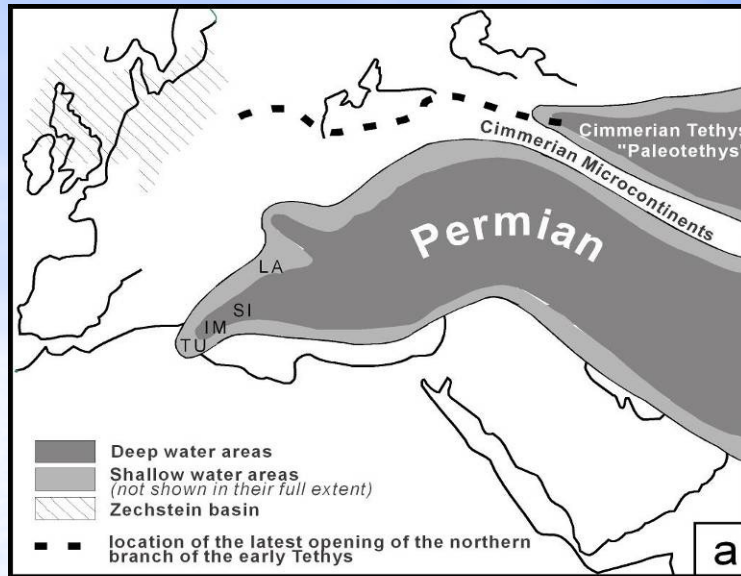
Upper Miocene



Plio-Pleistocene



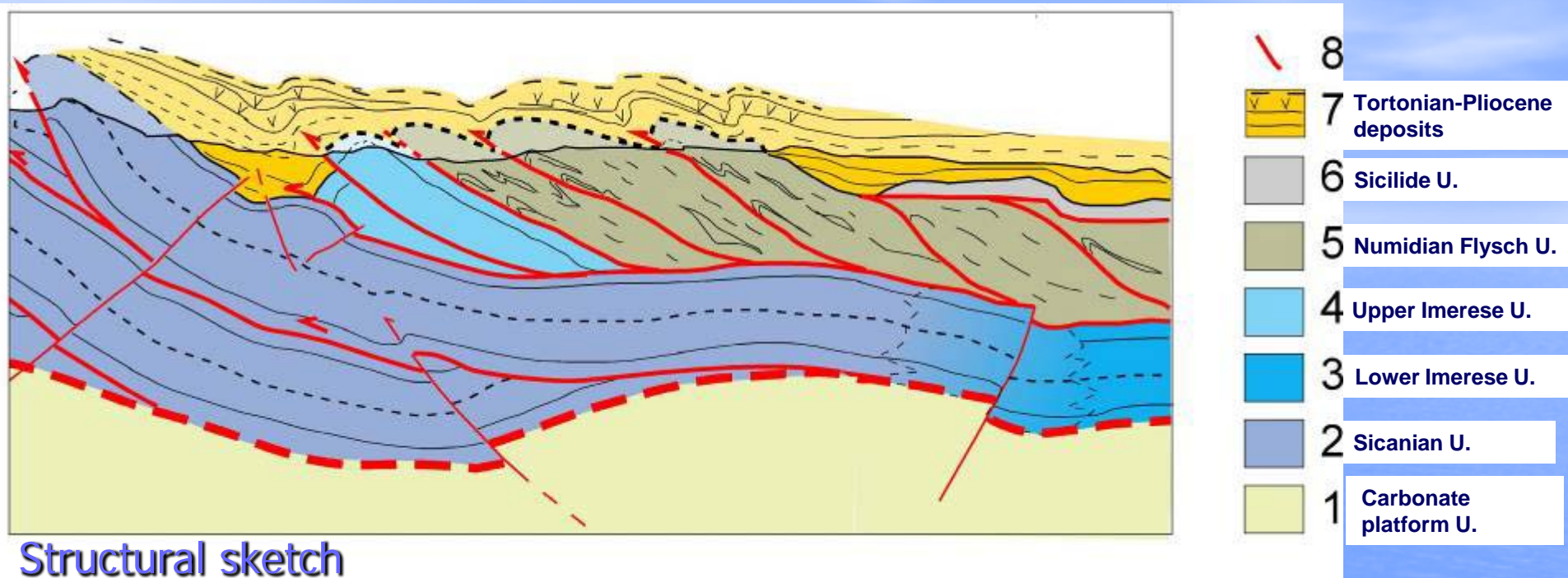
- proposing a kinematic model useful for exploration strategies.



Answers to the previous questions

- The main results reveal the occurrence in central Sicily of a tectonic wedge comparable with the eastern and western structures
- The carbonate platform units occur beneath a pile of deep-water carbonate thrust sheets at depth between four and seven km.
- The deep-seated carbonate platform units appear detached from platform Domains (Trapanese-Saccense) internal to the Iblean platform. The latter appears to extend beneath, slightly deformed and thinning towards the Tyrrhenian Sea
- The clastic, evaporitic and carbonatic Neogene to Quaternary tectonic wedge ,occurring in the area, reaches thickness that may be locally crossed by wells

- proposing a kinematic model useful for exploration strategies.



A thick thrust pile of deep water carbonates (Imerese and Sicanian) units rests on carbonate platform imbricates (Trapanese units), resulting from latest Miocene-Quaternary deformation

Tertiary terrigenous units and Pleistocene syntectonic basins overlie the carbonate thrust stack

The occurrence of a deep seated carbonate platform body, forming local structural highs, could be a new potential target for hydrocarbon opportunities in central Sicily