

## **Geological Field Trip 1 - Carbonate reservoir in the field**

### **Description**

This 4 days course in northwestern Sicily will provide the basics of carbonate reservoir characterization on the field, by means of spectacular exposures, visit to quarries, seismic scale outcrops. Main aims are to describe and illustrate the peculiar geological and petrophysical control factors occurring in carbonate reservoirs. The instructor will focus on the main sedimentological characteristics of different carbonate reservoir (pore diagenesis, facies, primary structures, paleontology, evolution and sequence stratigraphy) coupled with the role of fracturing (vertical and horizontal). Prediction criteria in fractures orientation will be explained, with limits and constrains. The course focuses on the seismic aspects of carbonate reservoir and the correlation with the outcrops. Role of permeability and anisotropy in fluids within the reservoir and relationship between boreholes and fractures will be cover using natural examples. A set of outcrops of shallow water carbonates affected by meso-and-macro volcano-dykes and atollo-type successions will show you some of the risks and critical factors occurring in reservoirs. At the end of this course you will able to describe carbonate reservoir at different scales, starting from the pore networks and rock textures, to the sedimentary bodies and stratigraphic-structural macro-architectures. A robust part on characterization of fractured reservoir with practical exercises is scheduled.

These outcrops provide therefore a natural laboratory to learn and experiment methods for characterizing and modelling properly carbonate reservoirs.

**Dates:** On Request/April-May or September-October

### **Meeting point:**

Palermo international airport

**Course Level:** Intermediate / advanced

**Duration:** 4 days

**Instructor:** Prof. Pietro Di Stefano and PhD Gabriele Lena

### **Designed for:**

This Course is suitable for geologists and geoscientist in general with some years of experience that want to broaden and deepen their knowledge on carbonate reservoir (properties and control factors on modeling). It assumes basic knowledge in geoscience. It's designed for reservoir engineers and explorationists wishing to improve their geological knowledge.

### **How we build your confidence**

Clear and impressive field stops allow a visualisation of the different facies typical of Carbonate reservoir.

Graphic material on site, correlation with seismic and well dataset will help you to understand the geological control factors typical of reservoir modeling

Practical exercises on geometries, fractures and heterogeneities of the reservoir will be conducted in quarries where a multiple exposure and variable geometries of cliffs permit a 3D visualization of critical surfaces.

### **The benefits from attending**

By the end of the course you will feel more confident in your understanding of geological key elements in characterization of carbonate reservoir. You will improve the capability to analyze and to assess properly the different control factors influencing a fractured reservoir, starting from petrophysical datasets and exporting to the large-scale reservoir.

### **Topics**

#### **Day 1**

- Introduction on the Carbonate Reservoirs in Sicily
- Geological and petrophysical characteristics
- Karst, fractures, jointing and anisotropy
- Homogeneous vs heterogeneous deposits
- Correlation with well dataset

#### **Day 2**

- Peritidal cycles and reef complex, characteristics, facies and geometries
- From outcrop to macro architectures of carbonate reservoir
- Domino style faulted reservoir
- Unconformities and sealing
- Rudistic limestone reservoir, porosity and connectivity

#### **Day 3**

- Tidal flats, effect of matrix
- Sedimentary dikes, large faulting, ramp-bounded reservoir
- Stepped margin, channels, breccias and auto-brecciated reservoir
- Channels and other discontinuity
- Correlation with seismic

#### **Day 4**

- Large vertical barrier/discontinuity, volcanic dykes
- Mixed deposits, petrophysical parameter
- Slope carbonates and calcareous turbidites
- Prediction criteria, risk and case study

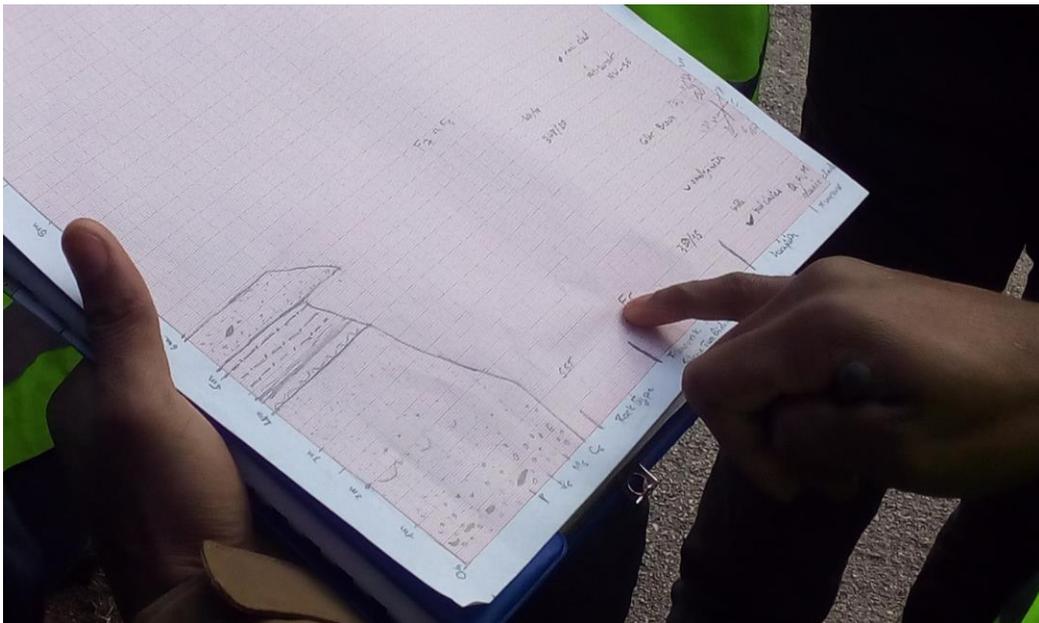
Daily Agenda				
Time	Day 1	Day 2	Day 3	Day 4
<b>Morning</b>	Introduction to the main geological settings of carbonate platform in Sicily. - San Vito Peninsula. Typical sedimentary features of peritidal limestones, porosity & permeability, lithological control factors, fractures and anisotropy. What's happen into the well? A field analogue.	Cozzo di Lupo: a geological transect along a reef complex. From fore reef to reef core and lagoon, characteristic, parameter, geological control factors affecting the platform. Practical exercises.  Monte Gallo: domino-style faulted reservoir, role on unconformities and sealing, vertical variation of porosity and permeability.	Maranfusa quarry: an open air laboratory on large fractures and Neptunian dykes affecting a Jurassic carbonate reservoir. Effects of hydraulic barrier. Vertical and horizontal connectivity. Tectonic history and fractures pattern. Effects of flexural stage and compressional stage on the carbonate reservoir.  Gola di Oni: seismic scale outcrop of a carbonate ridge, inverted structures and transpression. Ramp-dominated reservoir. Prediction criteria in the orientation of fractures using a 4D restoration.	Monte Balatelle: Carbonate reservoir affected by large volcanic dykes. Problems and characteristics. Sealing deposits.  Roccapalumba: atollo-type successions, shape and geometries. Mixed ramp deposits. Facies and unconformities. Permeability and porosity.
<b>Afternoon</b>	San Vito: homogeneous and heterogeneous deposits, spacing of fractures, jointing, scale effects. Exercises.	Monte Pellegrino: rudistic limestones reservoir. Type of porosity and characteristics. Connectivity. Effects of stratigraphic partition. Evolution of a carbonate platform.	Rocca Busambra: panoramic view of flower structure. Effect of channel and major faults. Stepped margin on reservoir. Close up view of the Trapanese succession. Auto-brecciated deposits. Fracture connectivity, impact of matrix and fractures pattern.	Sicani Mountains: slope carbonates and turbidites, lithological control factors. Risks and prediction criteria for exploration.  Discussion and final remarks.



Participants analyzing the peritidal cycles in San Vito Peninsula



The coral patch reef outcropping at Monte Sparagio



Stratigraphic logs and other practical activities will reinforce the field trip



Participants examining sedimentary dykes and fractures in Maranfusa quarry



The Jurassic hardground of Maranfusa quarry, a faulted shallow water carbonate overlies by deep water limestones.



View of the Jurassic-Cretaceous limestones of Monte Gallo

## **Geological Field Trip 2 - Structural Geology, stratigraphic architecture and trap styles of Sicily FTB**

### **A Multidisciplinary approach on the field**

#### **Description**

This 5 days field trip offers an intensive and robust multidisciplinary approach on techniques and analysis on the field (regional geology, geodynamics, structural geology, stratigraphy, facies analysis and petroleum geology). Set in the famous Sicily Island, one of the most interesting and complex fold & thrust belt worldwide, the course is designed to show to the participants typical geological control factors in different geodynamic and paleo environmental scenarios. The field trip is structured every day in the integrated analysis of stratigraphic and structural settings of one paleo domain, using existing dataset and comparing subsurface data and outcrops. 5 days for 5 different geological scenarios (carbonate platform, slope-to-basin, basin, terrigenous/evaporitic basin, foreland basin systems) in different tectonic stages (passive margin, failed rift, flexure, compression, thrust-top/satellite basin), every day the task is: to analyze the geosettings, to reconstruct the relationship and to predict the geometry of subsurface structures. Landscape and seismic-scale outcrops will help the participant in the correlation with tectonic model, geophysical data and analysis of structural styles. Once you arrived in Sicily, after a geology review and introduction on the regional settings, the field trip starts with the visit of various paleo domain, starting from the higher structural units towards the less deformed. Different pieces of information collected every day will allow you to put them together to draw a coherent geological picture, to produce a palinspastic restoration and to analyze the geodynamic scenario. We conclude with the prospect assessment and play analysis of some oilfields in Sicily, actually in production. Food, wine, monuments, impressive landscape and coastline of Sicily will accompany you along this trip.

**Course Level:** Intermediate to advanced

**Dates:** May or October

#### **Meeting point:**

Palermo International Airport

**Duration:** 5 days

**Instructor:** Gabriele Lena

#### **Designed for you, if you are...**

This Course is suitable for geologists, geophysicists, explorationists and geoscientists in general that want to broaden and deepen their knowledge on the field about the kinematic evolution of a FTB-foreland system, using a very multi-disciplinary approach. Continuous and well-exposed “seismic scale” outcrops will help you to understand the geometries of the geological bodies, using commercial and crustal seismic profiles, well and geophysical dataset.

## **How we build your confidence**

New insights in recognition and prediction of geometry of shallow-seated and deep-seated structures, ramp dominated units vs thrust sheet dominated unit.

Facies analysis and correlation between different paleo environmental scenarios, from meso-scale to seismic scale units.

Cross-correlations between outcropping and buried structures, using seismic profile and well-data applied to very impressive landscape.

Explanation of new data deriving from commercial and crustal profile providing new insights and prediction criteria on the relationships between a) an imbricated carbonate thrust system of the Northern chain, b) the huge Caltanissetta terrigenous trough consisting of emblicated thrusts system, and c) the flexure of the Iblean foreland crust below the FTB.

Different type of petroleum system and plays will be shown during this 5-days field trip

Exercises, line drawing, stratigraphic log, structural data plot and map and will be performed during the survey

## **The benefits from attending**

By the end of the course you will feel more confident in your understanding of:

- The geological setting of the Sicilian-Maghreb FTB: the Mesozoic paleo domains of the ancient African continental margin (basins and carbonate platforms) and their structural evolution;
- The relation between shallow-seated and deep-seated deformations in the Tertiary evolution of the thrust belt; the effects of the late transpressional tectonics;
- Large-scale inverted and transpressional structures and their potential for petroleum exploration
- Synorogenic Tertiary deposits: sedimentology and facies associations;
- Lateral facies changes, architecture and structural control of the sin-compressional Miocene basins in Northern Sicily;
- The Messinian evaporitic deposits: lithostratigraphy, sedimentation vs tectonic process and new insights;
- The potential geo-resources of the Caltanissetta Basin (late Messinian): bituminous euxinic shale, salt dome and methane mud volcanoes;
- The Pliocene foreland basins of the Gela plain and the oilfields in subsurface;
- The present-day structural setting of the Sicilian foreland, seismic data from the Sicilian offshore
- Reliable note, draw, plot and map during a field survey, and the importance of field techniques and analysis to decrease uncertainties;
- Unique opportunity to approach to different geological scenario in a single field trip.

## Topics

The course will cover the following areas of modern applications and perspectives of stratigraphy.

Day 1 - Introduction on the geological setting of the Sicily; the Mesozoic carbonate succession of the Panormide platform and facies relationships; interference between tectonic structures

Day 2 - Meso-Cenozoic slope-to-basin Imerese succession and its relationships with the overlying Oligo-Miocene Numidian Flysch foredeep

Day 3 - Mesozoic extensional tectonics, volcanism and sedimentation at the Triassic Jurassic boundary the Sicilian deep-water domain; comparison of outcrop and seismic profile; Neogene imbricate thrust system deposits.

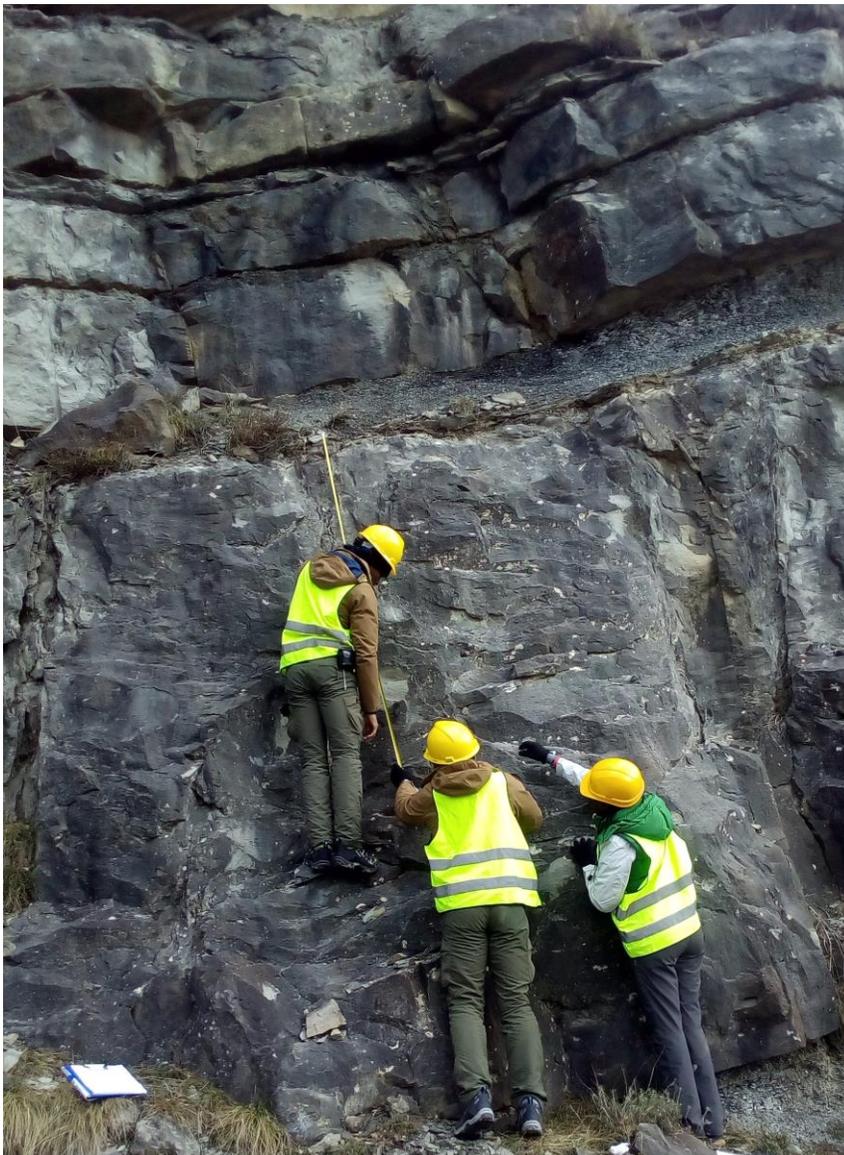
Day 4 - Georesources in the Messinian Evaporites; Miocene-Quaternary mixed ramp

Day 5 - The frontal part of the chain and the present foredeep: comparison with the subsurface setting will be imaged by seismic reflection profiles; the oil fields of Southern Sicily; the Iblean foreland and the forebulge with surface and sub-surface comparisons.

Daily Agenda					
Time	Day 1	Day 2	Day 3	Day 4	Day 5
<b>Main Topics</b>	<b>Carbonate units: stratigraphy, facies analysis and structural units (deep seated vs shallow seated def.)</b>	<b>Slope to Basin units (pelagic limestones and cherts): evolution from passive margin to compressional stages</b>	<b>Basinal units: facies, structural assemblage and the role of tectonic and volcanism during a failed rift stage.</b>	<b>Terrigenous and Evaporitic units: stratigraphy, facies and structural assemblage. Unconventional and seepages.</b>	<b>From the thrust front to the foreland. Depositional environment and petroleum potential. Exploration insights.</b>
<b>Morning</b>	Introduction on the geological setting of the Sicily; departure from Palermo. - Cozzo di	Collesano: main features of the Meso-Cenozoic slope-to-basin Imerese stratigraphic succession and its relationships with the overlying	- Montagnola quarry: correlation between the outcrops and seismic/well data. Restoration of superposition of structural units  - Pizzo Lupo quarry: Mesozoic extensional	- Caltanissetta terrigenous basin, introduction and characteristics.  - Santa Barbara village: the "Maccalube" mud volcanoes,	- Castelluccio hill: the Gela Nappe front along the Settefarine thrust and the Gela foredeep. Comparison with the subsurface setting will be

	<p>Lupo area: Mesozoic carbonate succession of the Panormide Carbonate platform: large and small scale stratigraphic analysis on reef complex. Prediction criteria using facies analysis on the field. Focus on the reef to back-reef lagoon facies relationships</p>	<p>Oligo-Miocene Numidian Flysch foredeep. How to recognize changes in geodynamic scenario (from passive margin to foreland basin stages).</p> <p>- Scillato: the internal deformation of the Imerese succession and panoramic overview of the Scillato wedge-top basin.</p>	<p>tectonics and volcanism and sedimentation at the Triassic Jurassic boundary, failed rift stages. Fractures pattern and critic parameters. Implication from the reservoir potential.</p> <p>- Monte Cammarata: a walk along the Triassic-Miocene carbonates succession of the Sicilian deep-water domain.</p>	<p>gas and oil seepages, analysis and possible interpretation.</p> <p>- Mt. Capodarso: Miocene-Quaternary section stacking pattern in a thrust-top basin setting. Orbital forcing and control on the deposition. Practical exercises.</p>	<p>imaged by seismic reflection profiles.</p> <p>- Settefarine: tectonic setting of the high angle Settefarine thrust.</p> <p>-Gela Oilfields: history, type of traps and style, play analysis and geological parameter affecting the origin of the play. Risks and prediction.</p>
<b>Afternoon</b>	<p>Kumeta ridge (Piana degli Albanesi): seismic scale field analysis to illustrate the interference between shallow- and deep-seated tectonic structures. Typical tectonic styles and</p>	<p>- Imera River gorge: from the foreland basin stage to the satellite basin stage. Geometry, facies and structures of the Scillato wedge top Basin succession will be observed in detail along the gorge.</p>	<p>- Monte Cammarata panoramic view: a comparison of the structural setting observed in outcrop and imaged in seismic profile.</p> <p>- Cozzo Monaco: panoramic view of the deformation style of Neogene imbricate thrust system deposits. Comparison with the deep structures. The role of</p>	<p>- Pietraperzia: panoramic view of seismic scale structures, folding and faulting. Prediction criteria. Stratigraphic and structural setting of Tripoli fm. and evaporites. Petroleum potential of unconventional</p>	<p>- Ragusa: the present-day foredeep and the Iblean foreland with surface and sub-surface comparisons. Relationship, comparison with the geological history, present day settings.</p> <p>- Ragusa Oilfield: history and type</p>

	structural assemblage in carbonatic units.  Dinner and overnight in Palermo	Synthesis respects the Wilson Cycle theory.  Dinner Overnight at Cammarata	the anisotropy.  Dinner and overnight in Caltanissetta	euxinic deposits. Recognition of cyclic successions and analysis on TOC. Limits and risks.  Dinner and overnight in Gela	of traps, risks and critic geological parameter. Exploration in foredeep/foreland systems.  Departure to Catania
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Participants examining a section of Numidian Flysch



Impressive Neptunian dykes, syndimentary faults and Hardground in ammonitic limestones



Panoramic view of the E-W trending flower structure of Kumeta anticline



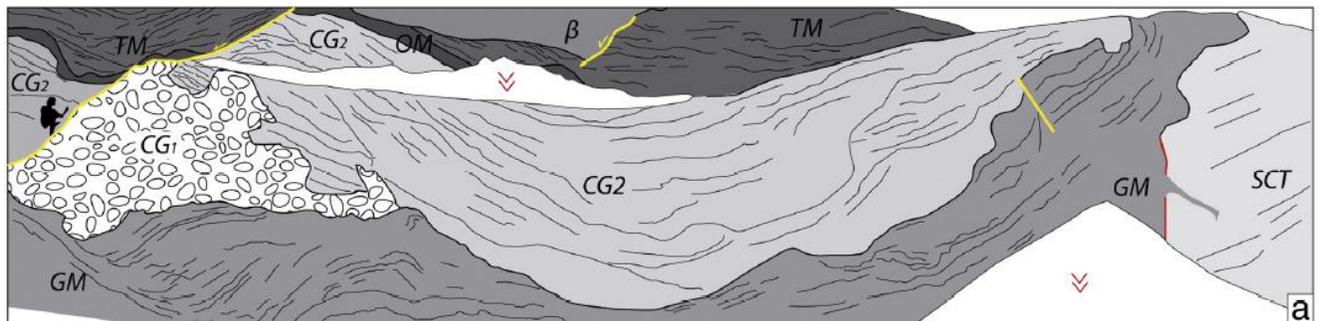
Asymmetric folds in Messinian Gypsum



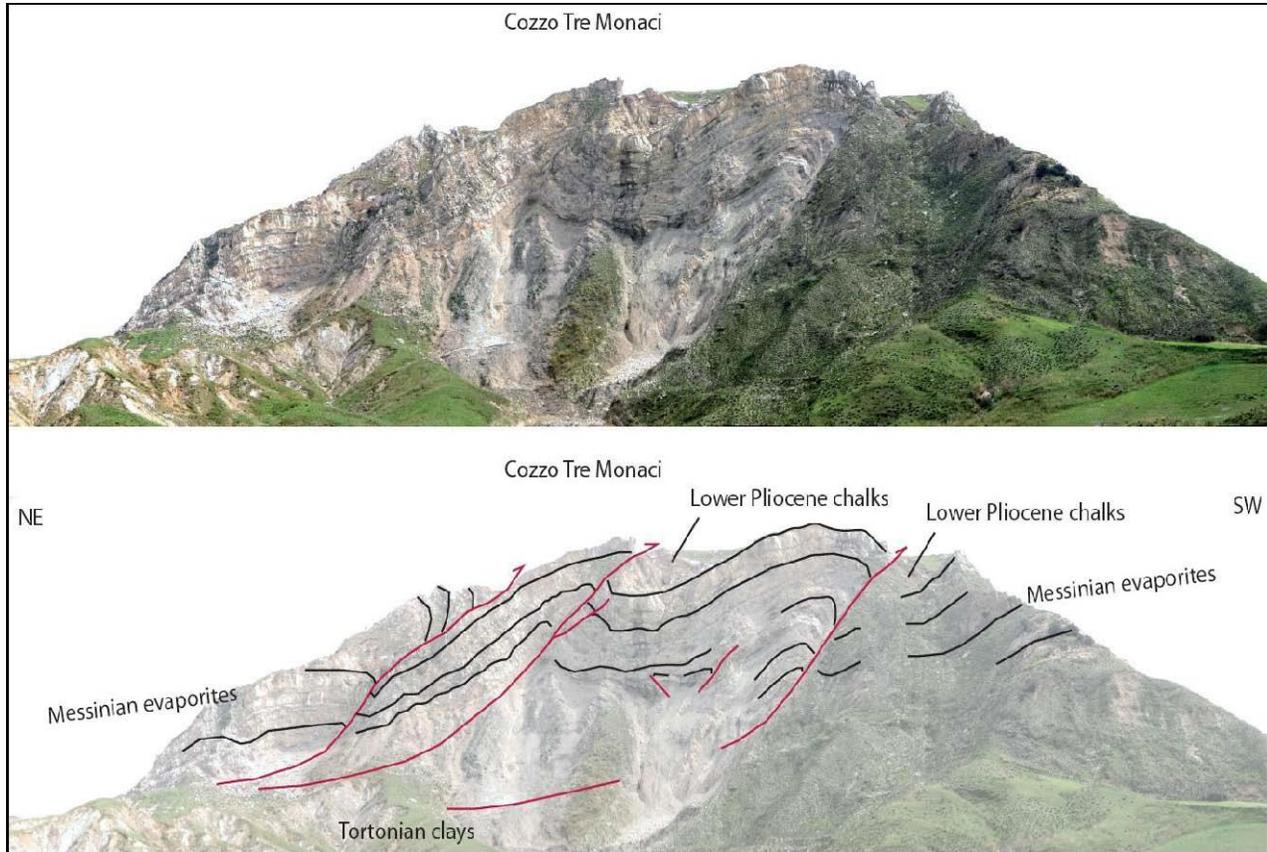
Horse-jack and derrick of Gela oilfields



Horse-jack in the Ragusa oilfield



Shallow-water carbonates resedimented in channel in the Sicilian Basin succession



Seismic-scale landscape showing the shallow seated deformation of Tertiary lithosomes



Sandstones organized in clinoforms, deposited in a quaternary mixed ramp environment