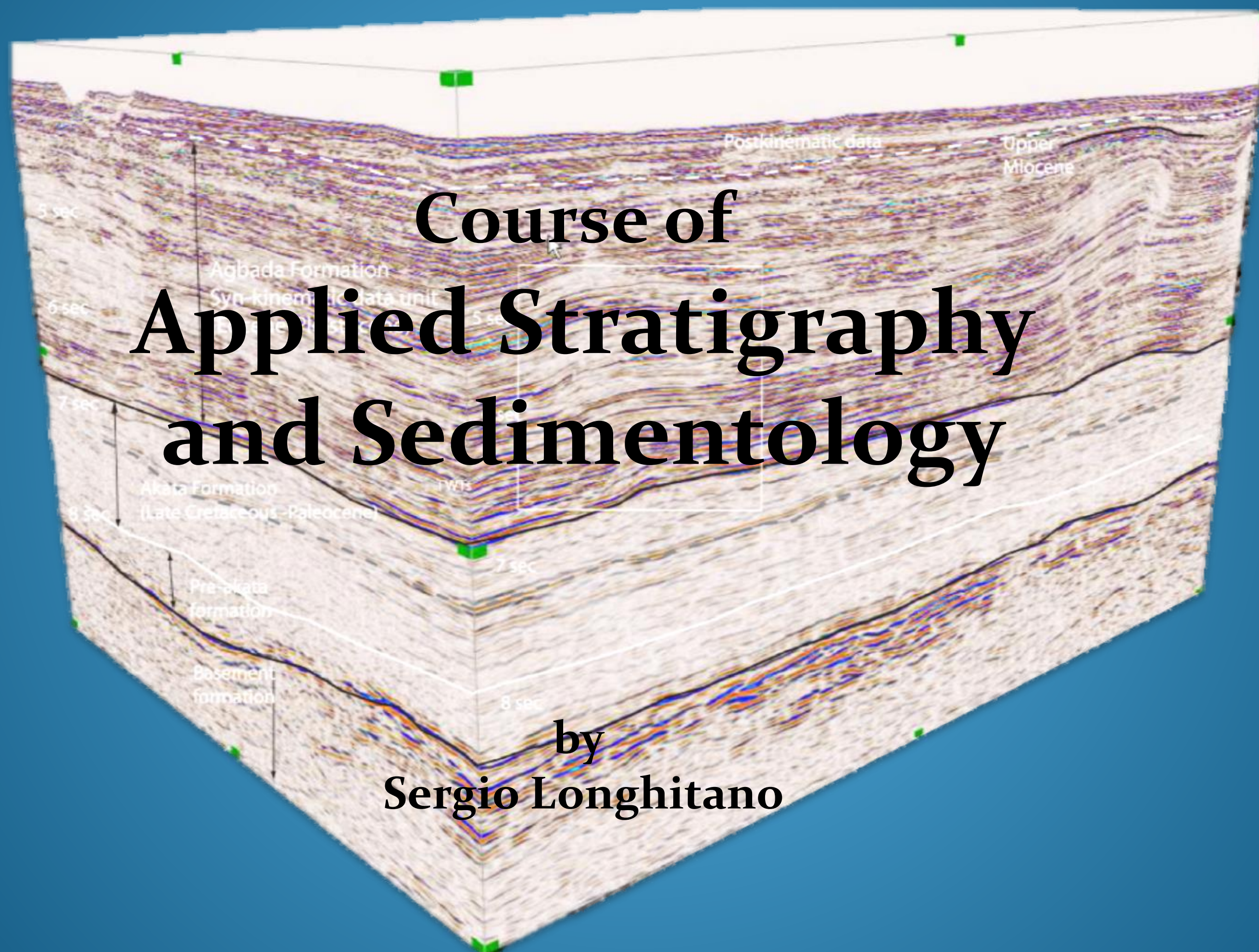
MsC in

Geosciences and Georesources



Course of

Applied Stratigraphy and Sedimentology

by

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University of Basilicata

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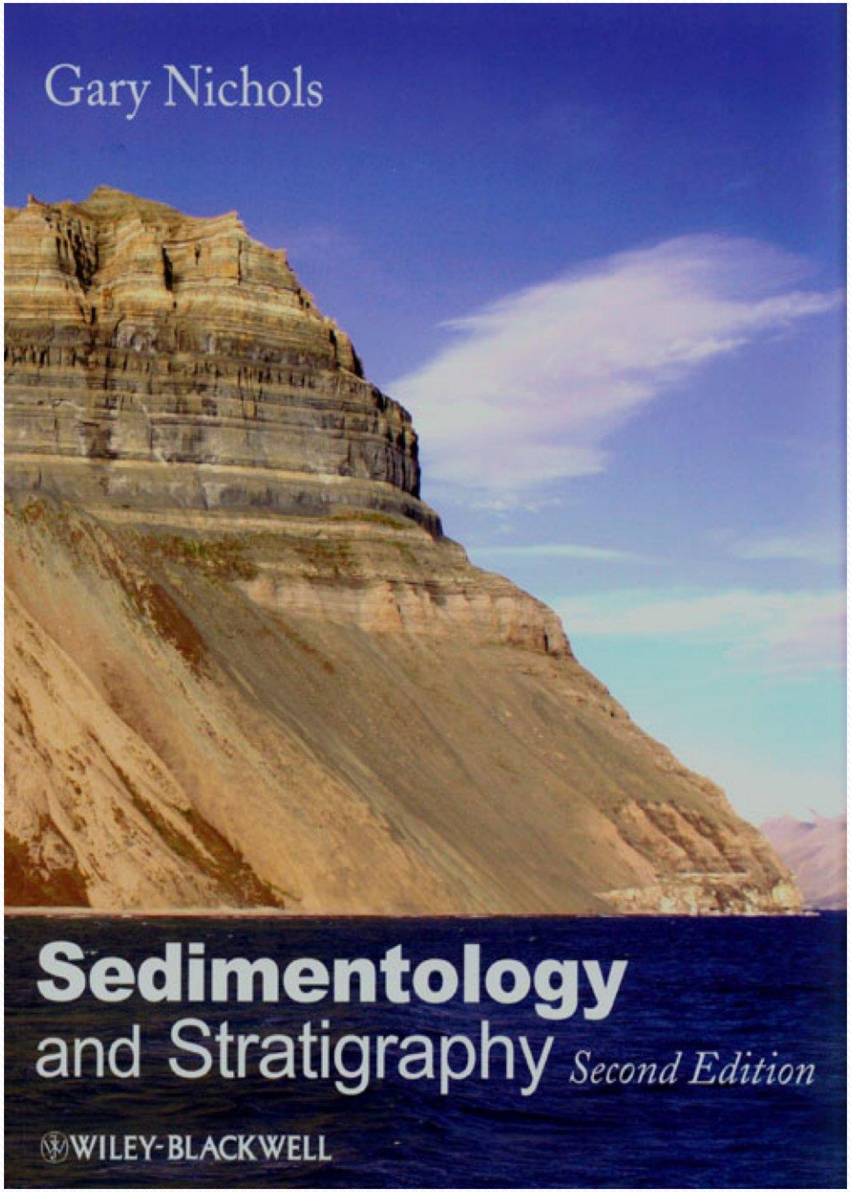
CONTENTS

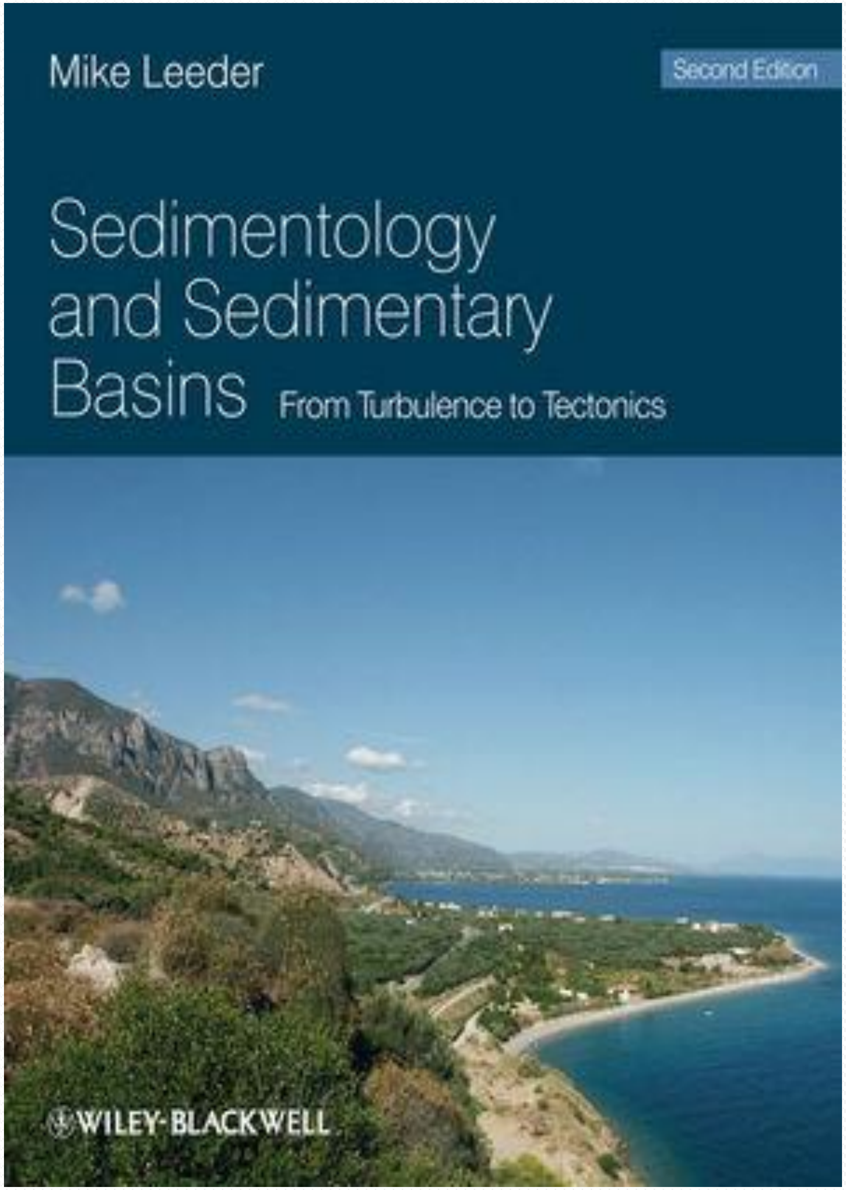
The course aims to treat major aspects and essential elements on modern applications and perspectives of Stratigraphy and Sedimentology as tools to identify, use and defend the main Georesources. It focuses on traditional and innovative techniques and how these can be utilized in the reconstruction of the geological history of sedimentary basins and in solving manifold geological problems of identification of the best Georesources. Each lecture reviews the historical background; includes a synopsis of study principles and methodology, and discusses recent developments and significant applications. These lectures are followed by selected case histories that demonstrate the applications and efficacy of Stratigraphy and Sedimentology and related techniques applied to the study of the Georesources.

LEARNING OUTCOMES

Review of the basic and advanced principles of Stratigraphy and fundamental concepts on the identification of the Sedimentary Rocks and their importance on the detection, exploitation and protection of the Georesources ; knowledge of the main environments composing the most common depositional systems; knowledge of sedimentary processes; methodological practice on some of the main techniques of acquirement, analysis and interpretation of stratigraphic and sedimentological data, from both the field and subsoil.

SUGGESTED READINGS





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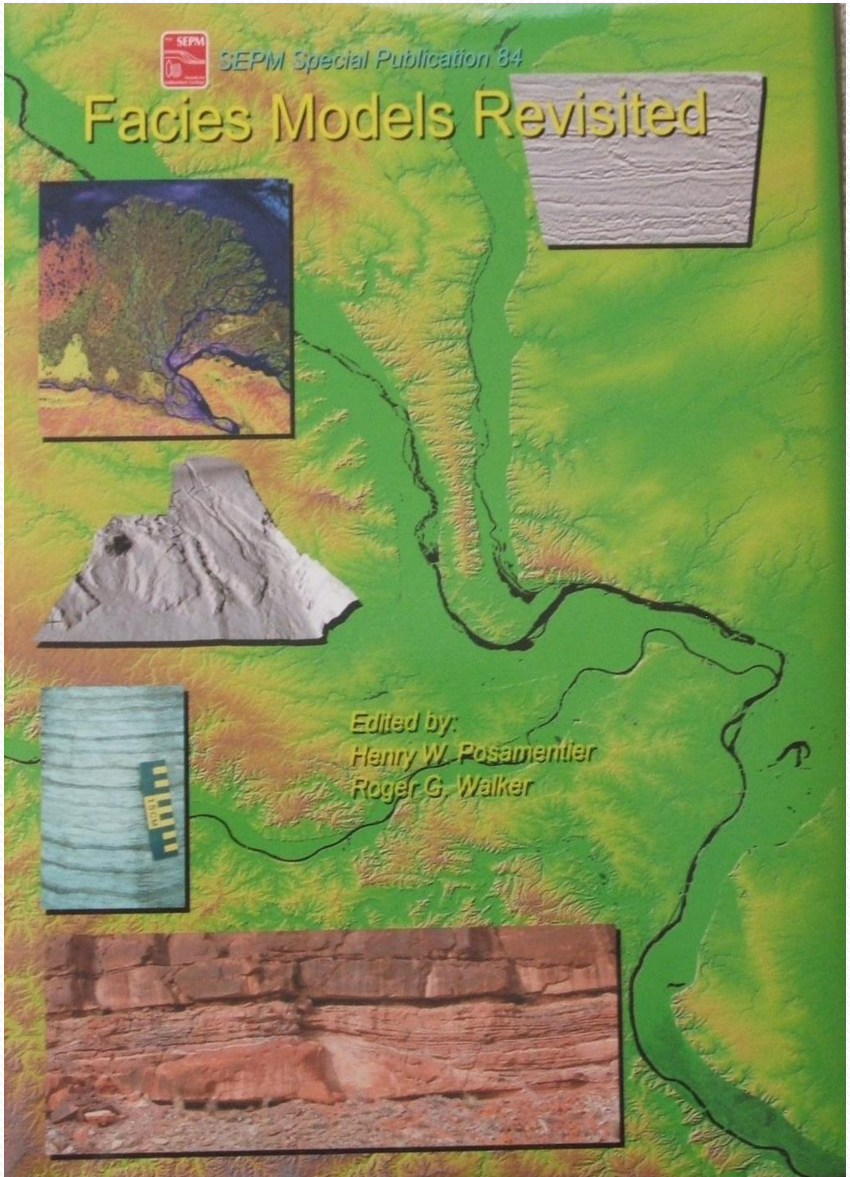

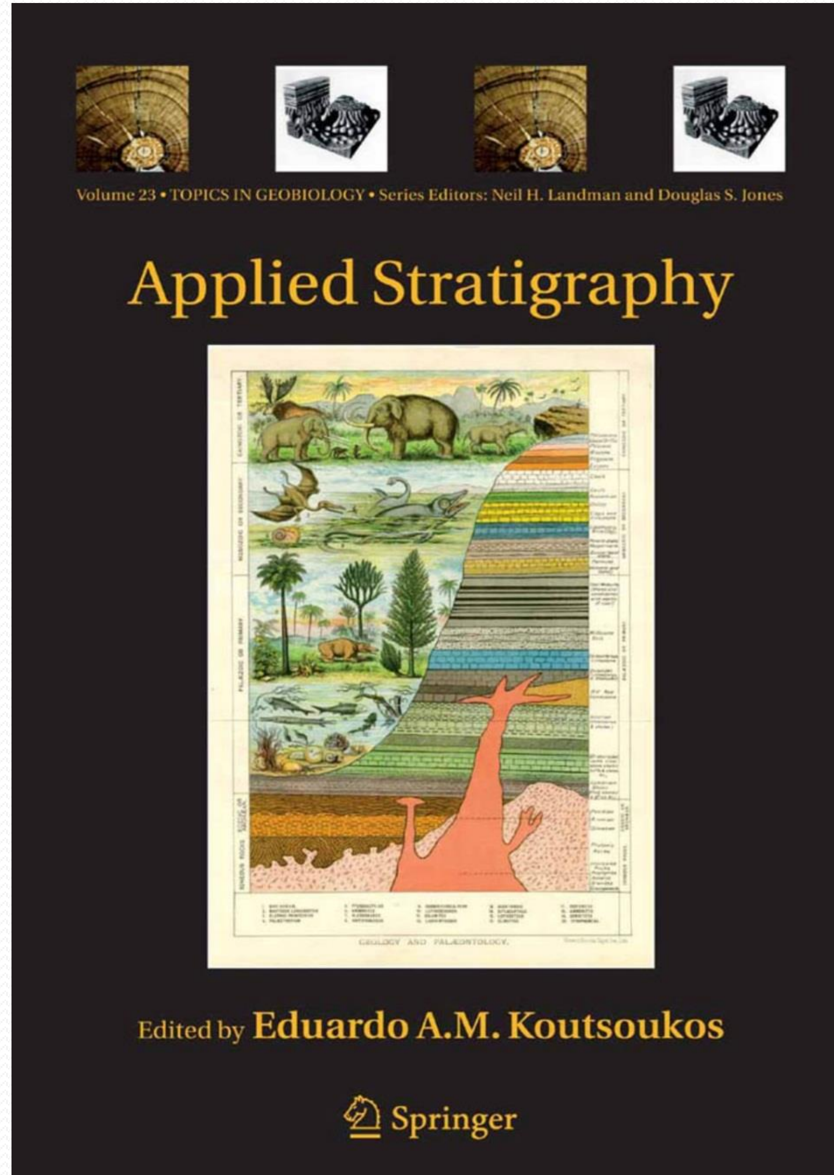

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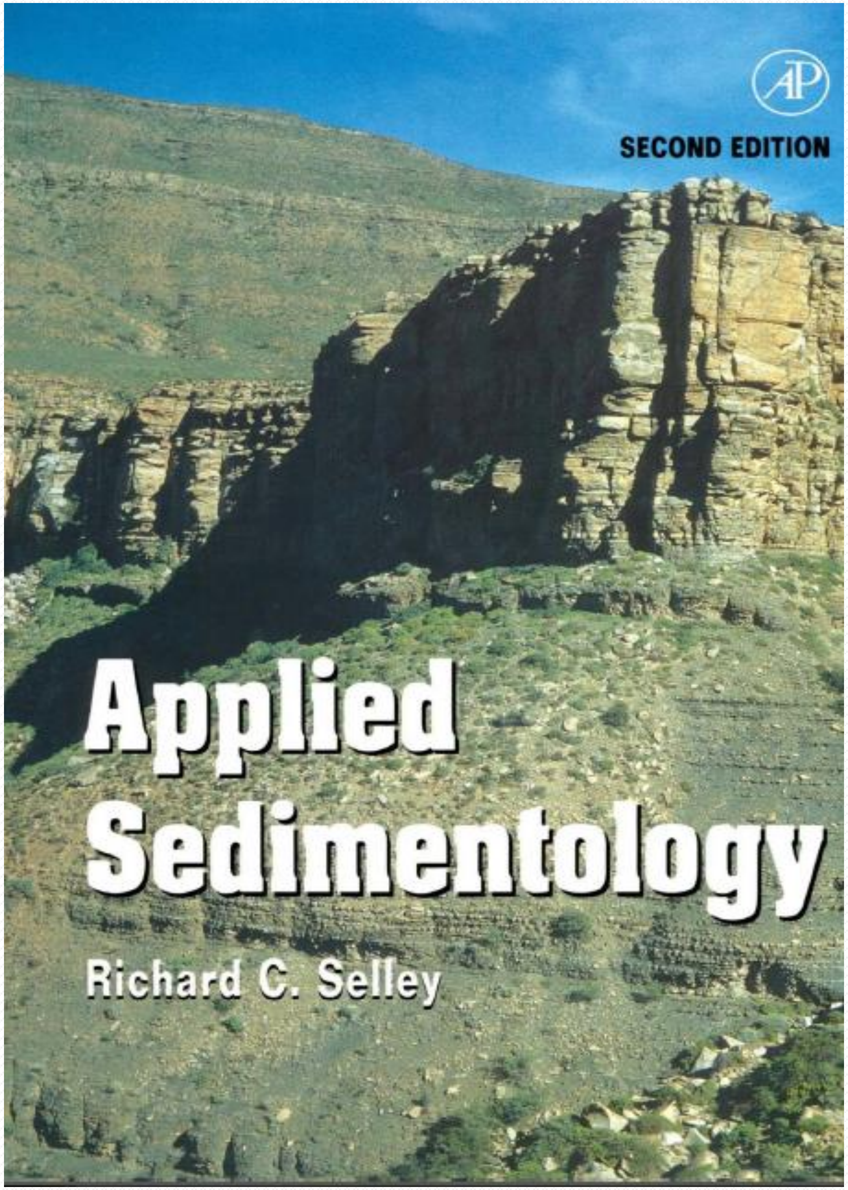
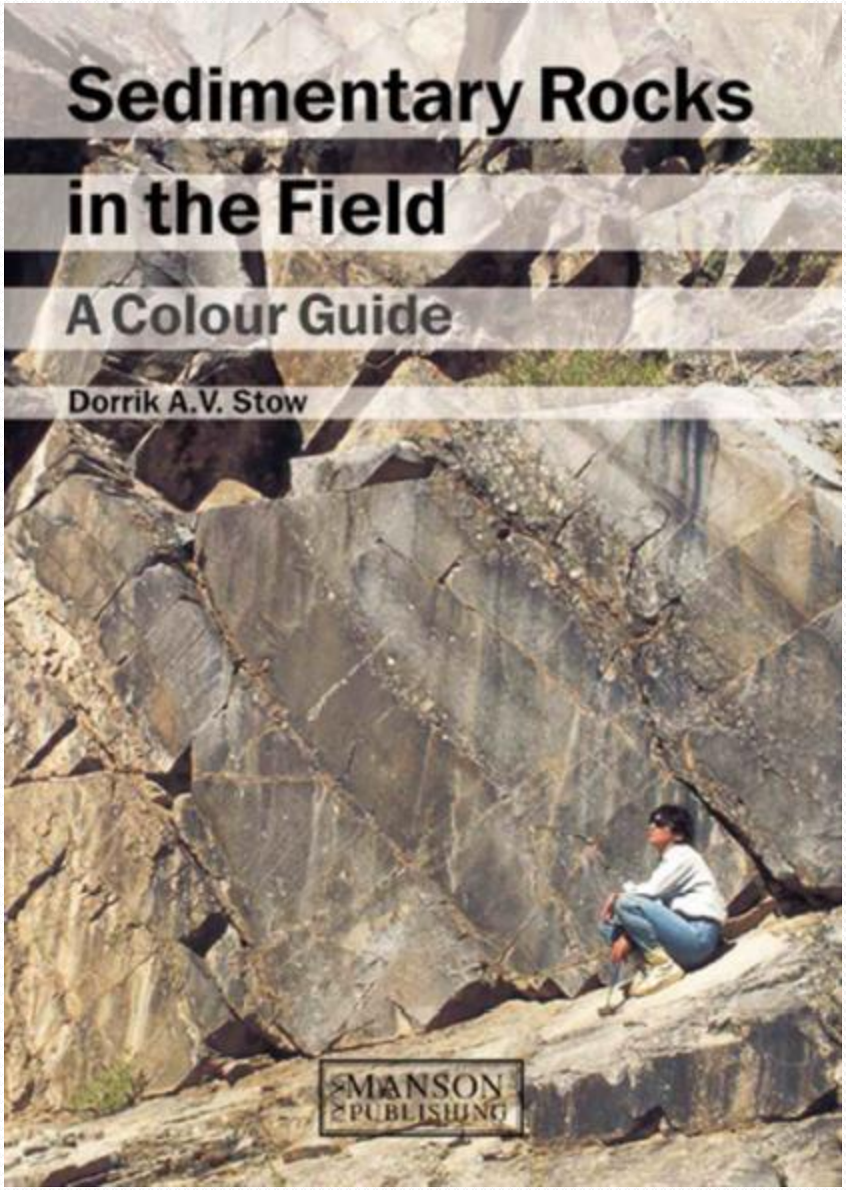




PROGRAM of the COURSE

1. Introduction to the course

1a. *Main features of sedimentary deposits and rocks and of stratigraphic successions.* ***1b****. The importance of the Stratigraphy and Sedimentology in the processes and techniques of identification and protection of Georesources.*

2. Stratigraphy

2a. *Stratigraphic successions and their importance for the Georsources;* ***2b.*** *Stratigraphic surfaces;* ***2c.*** *Complete, reduced and condensed successions;* ***2d.*** *Main stratigraphic units;* ***2e.*** *Stratigraphic correlations;* ***2f.*** *Sedimentary basins;* ***2g.*** *Basin analysis.*

3. Sedimentology

3a. *Origin of sediments;* ***3b.*** *Clastic and non-clastic sediments;* ***3c.*** *Main erosional, transport and sedimentation processes;* ***3d.*** *Main sedimentary processes (selective, mass, etc …).* ***3e.*** *Facies, facies associations, depositional environments, depositional systems.* ***3f****. Sedimentary Georesources.*

4. Techniques of stratigraphic analysis

4a. *Basin Analysis;* ***4b.*** *Sequence stratigraphy;* ***4c.*** *Stratigraphic correlations;* ***4d****. Analysis and interpretation of seismic lines.* ***4e****. Importance in the identification of sealed Georesources.*

5. Techniques of sedimentological analysis

5a. *Facies analysis applied on exposed and well-core rocks and sediments;* ***5b.*** *Grain-size analysis;* ***5c.*** *Other types of sedimentological investigations and their relevance for the Georesources.*

6. Examples and study cases

6a. *Regional and semi-regional-scale stratigraphic correlations to identify economically-relevant successions;* ***6b.*** *Facies analysis on Quaternary continental deposits (alluvial fan, fluvial) and idrostratigraphic implications;* ***6c****. Stratigraphic outcrop analogues for reservoir characterisation studies;* ***6d****. Sedimentological analysis applied to littoral studies.*

Course of

Applied Stratigraphy and Sedimentology

1. Introduction to the course

1a. *Main features of sedimentary deposits and rocks and of stratigraphic successions.*

1b*. The importance of the Stratigraphy and Sedimentology in the processes and techniques of identification and protection of Georesources.*

«The entire mass of stratified deposits in the Earth's crust is at once the monument and measure of the denudation which has taken place».

Charles Lyell (1838)

The Rocks Display's (from Wilson, in Read, 1944), illustrating that the sedimentary cycle is a small part of the whole crustal cycle of the dynamic earth. Individual sedimentary grains of stable minerals, principally quartz, may be recycled several times before being destroyed by metamorphism.

1a. *Main features of sedimentary deposits and rocks and of stratigraphic successions.*

Sedimentary rocks represent ca. the 35-40% of the deposits ont eh Earth surface.
Their nature is a valuable source of information in the field of geological application.

SEDIMENTARY DEPOSIT (or 'TERRA' in *Italian, geo-engineering term*)**:**
Mineral (unorganic) material, forming non-consolidated accumulation of clasts

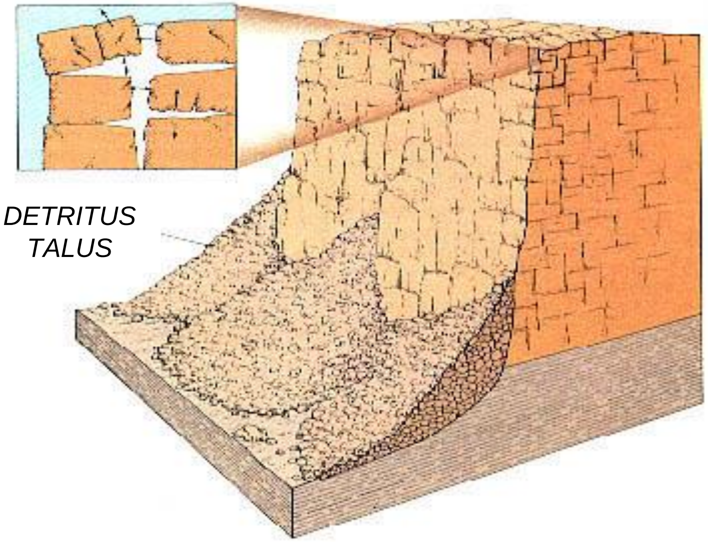
SEDIMENTARY ROCK:
Mineral (unorganic) material, forming consolidated accumulation of clasts

SEDIMENTARY DEPOSIT or 'TERRA' (*Italian*)**:** Mineral (unorganic) material, forming non-consolidated accumulation of clasts

SEDIMENTARY DEPOSIT or 'TERRA' (*Italian*)**:** Mineral (unorganic) material, forming non-consolidated accummulation of clasts

SEDIMENTARY ROCK: Mineral (unorganic) material, forming consolidated accumulation of clasts

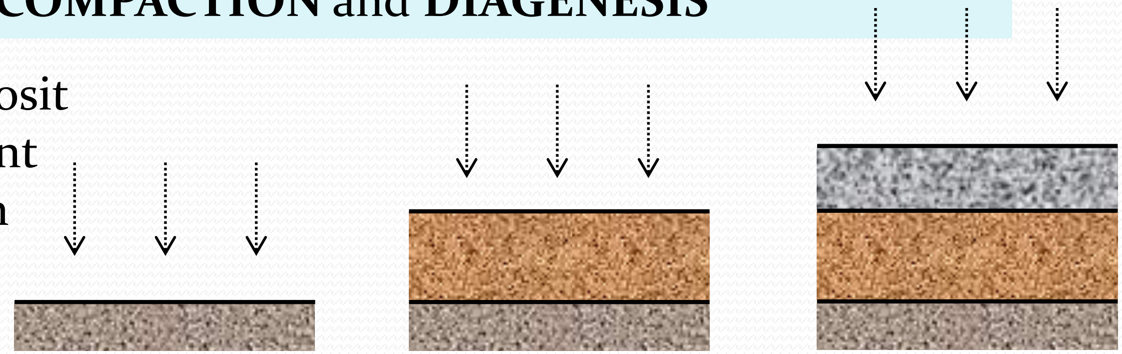
Often, sedimentary rock and sediments occur adjacently and they can, thus, be genetically linked each other



Sediments change into rocks as consequence of a combined process of **BURIAL**, **COMPACTION** and **DIAGENESIS**

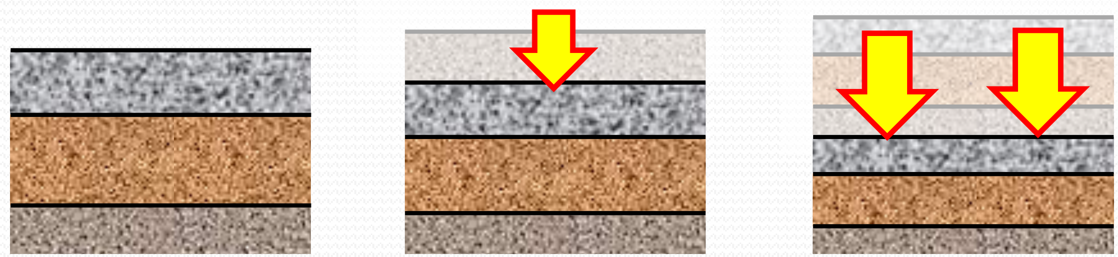
1

The **burial** of a sedimentary deposit occurs because even new sediment accumulates over the previous, in absence of relevant processes of erosion



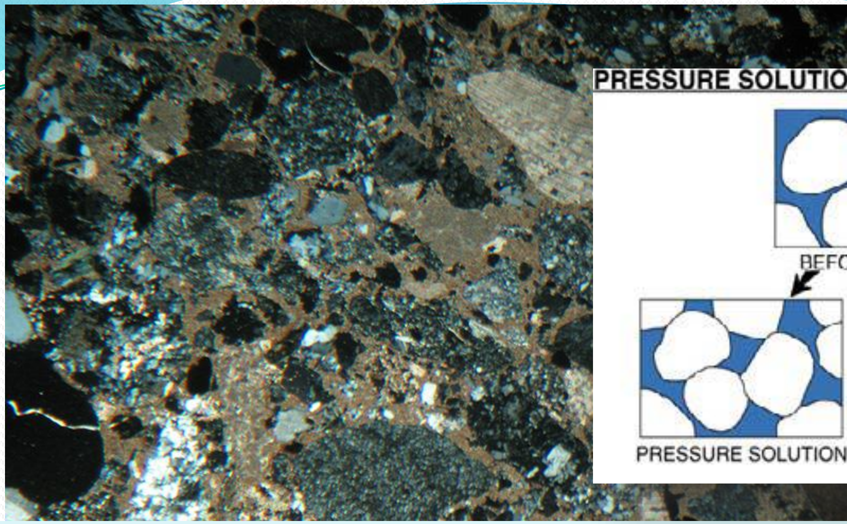
2

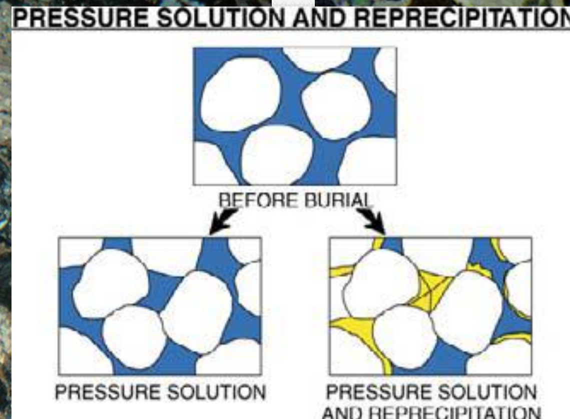
The **Compaction** occurs because of the pressure exerted from the *lithostatic weight* due to the overlying sediment. A compaction causes the decreasing of *porosity*, influencing the internal circulation of fluids and provoking possible fragmentation among clasts.

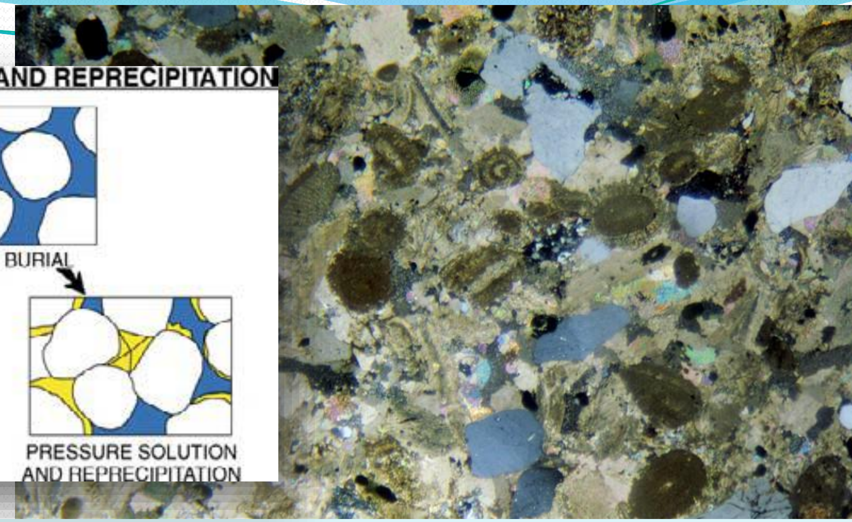


3

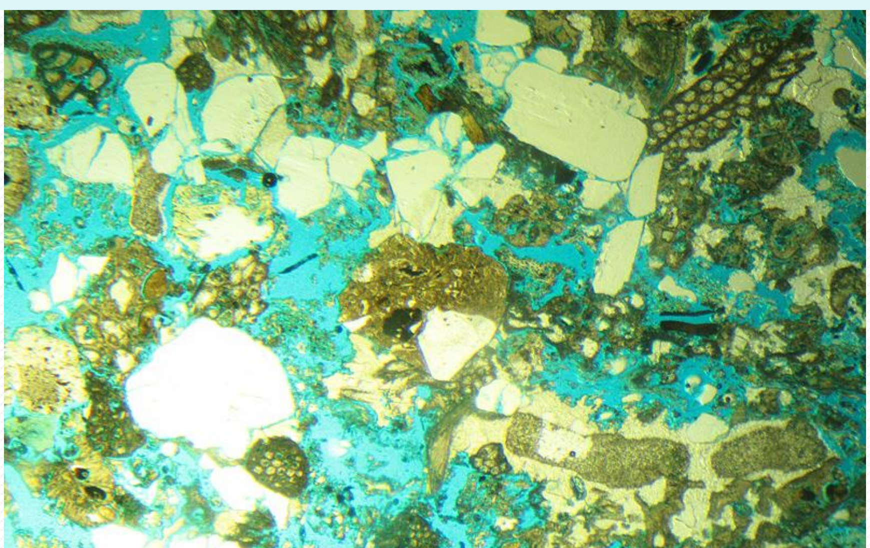
The **Diagenesis** is the process of transformation (*lithification*) of sediment from unconsolidated to lithified rock, through the sum of physical and chemical changes, which occur after the phases of burial and compaction.

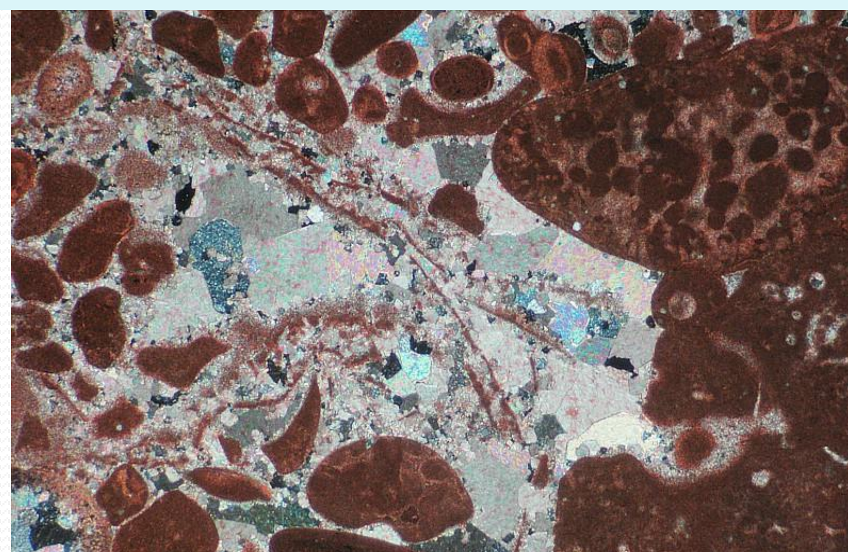


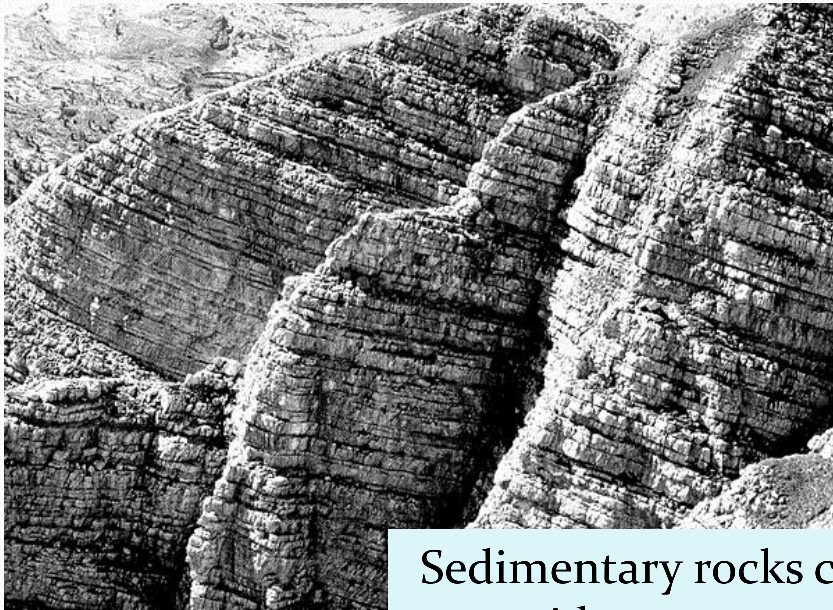


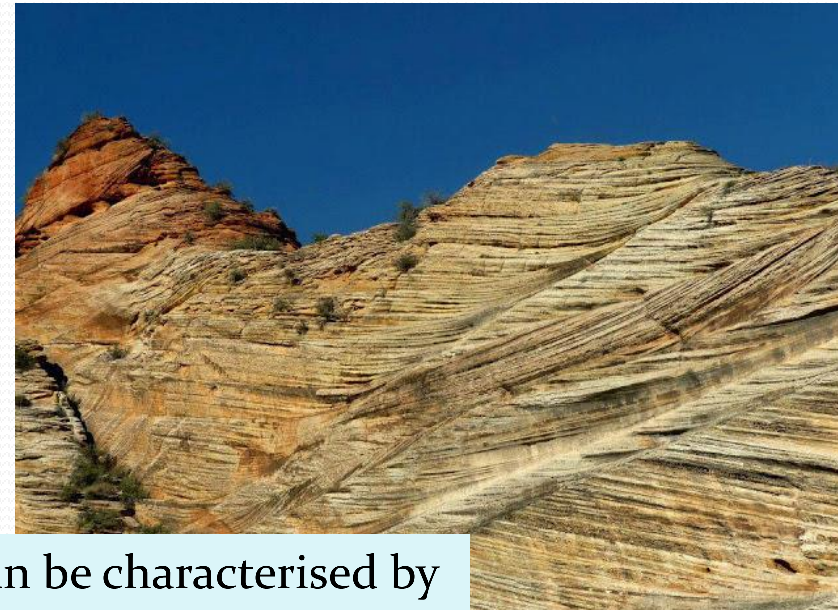


After the transformation of a sediment into a rock, before or during the process of **diagenesis**, the sedimentary rocks can be subject to relevant changes of their primary features, because of the **burial** and the consequent **compaction**, specially concerning their POROSITY and PERMEABILITY

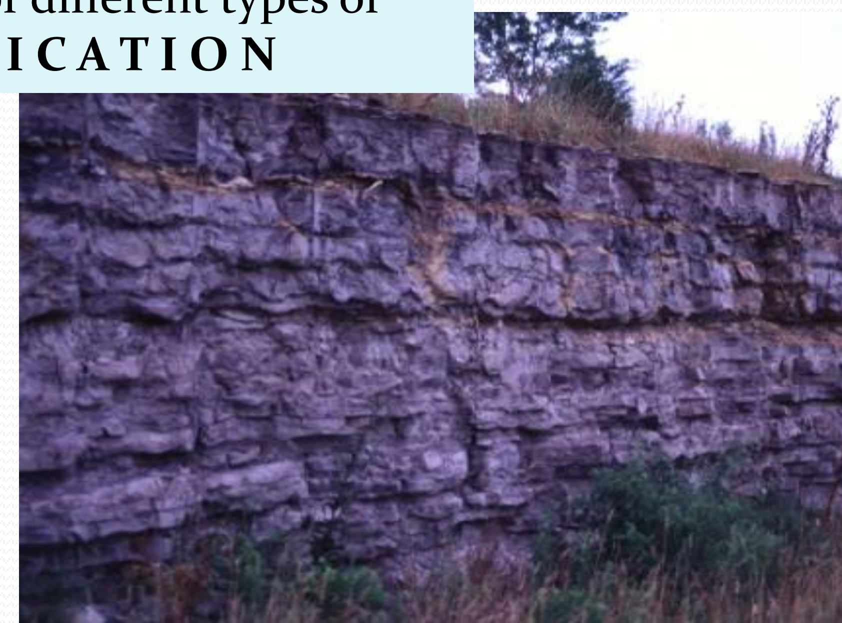


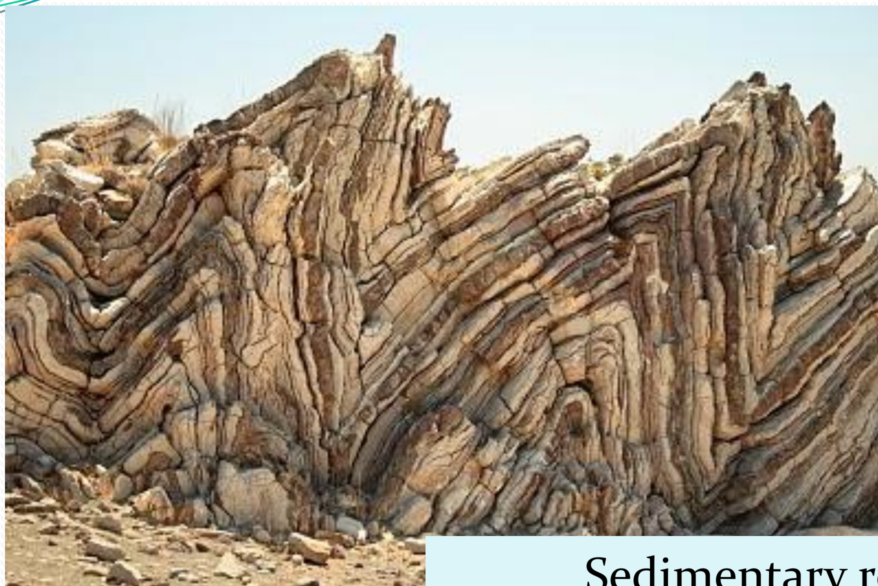






Sedimentary rocks can be characterised by a wide spectrum of different types of **STRATIFICATION**





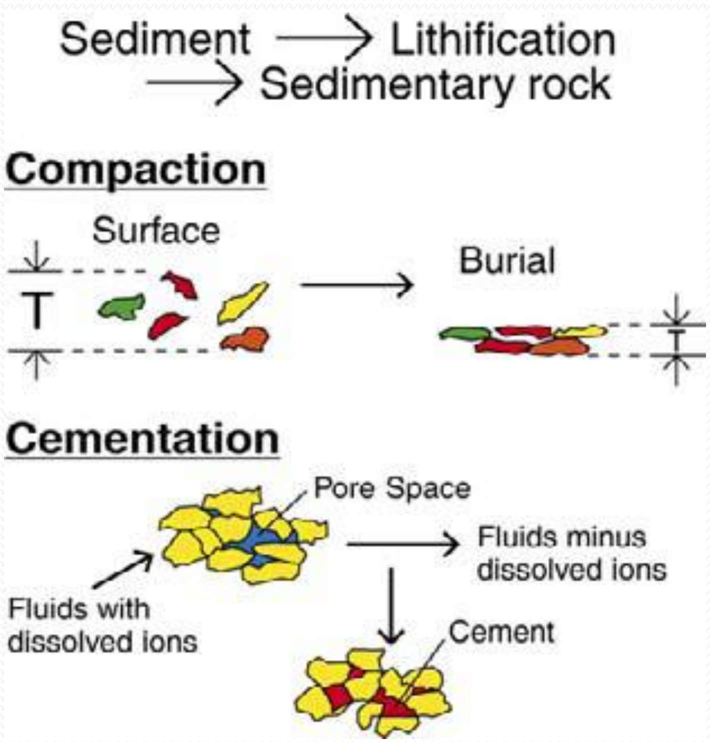
Sedimentary rocks can also be
DEFORMED and/or FAULTED

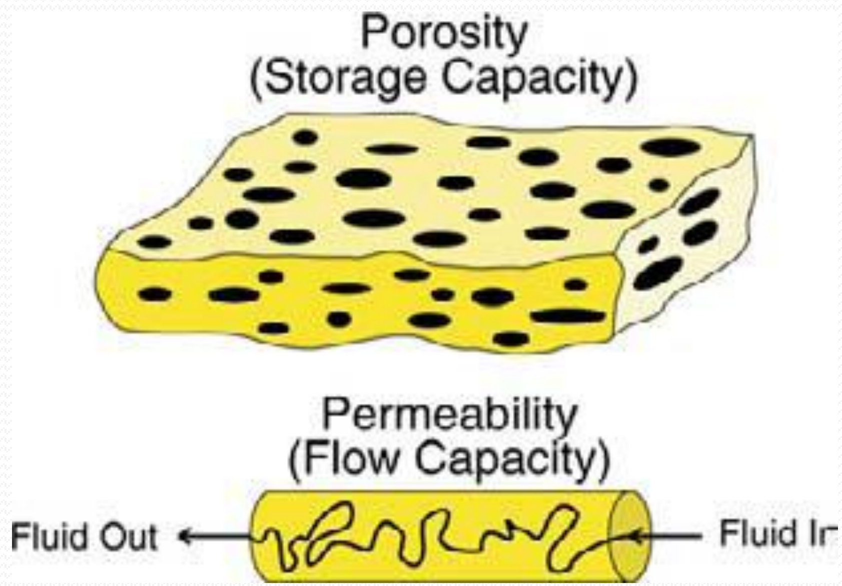
Sedimentary rocks subjcted to very low metamorphism can also exhibit **S C H I S T O S I T Y**

POROSITY & PERMEABILITY

The two properties that control the **storage potential** (*potenziale di immagazzinamento*) **of fluid and gas** at microscopic scale in a sedimentary rock are the POROSITY and PERMEABILITY.
Togehter, these two features are often considered as fundamental in reservoir characterisation studies.

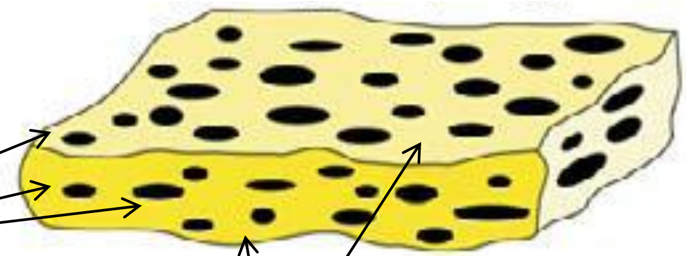
The quality of a reservoir of a sedimentay rock depends upon the **texture of a rock** and the **primary sediment composition**.
The primary texture can often be modified after the burial, compaction and deformation.





POROSITY & PERMEABILITY

The **POROSITY** represents the percentage fo the total volume of pores (space potentially filling by fluids or gas) included within a rock (measurable in %).

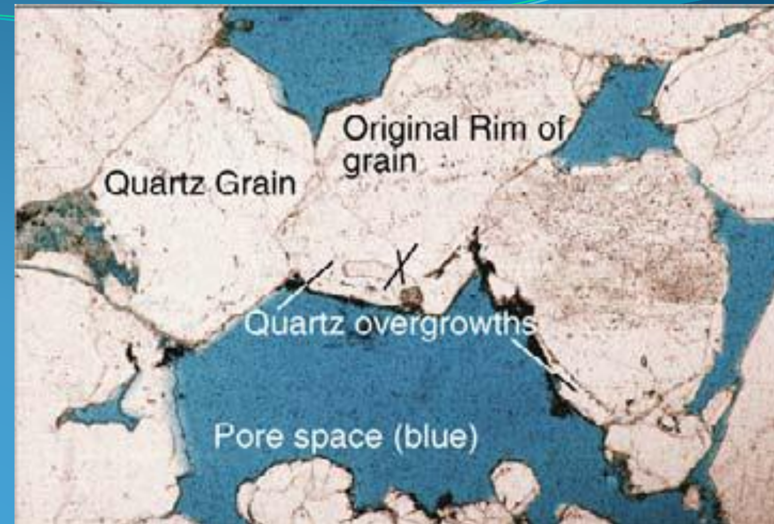


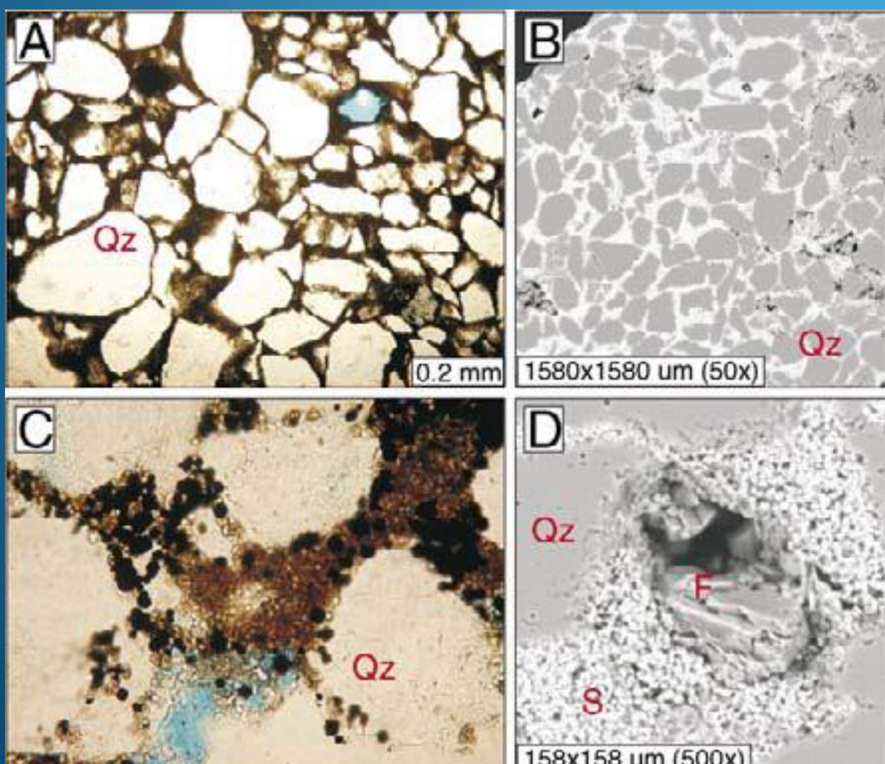
The **PERMEABILITY** represents the capacity of a rock to be passed through by a fluid (it is, thus, a velocity and it is measured in *milliDarcy - mD*).

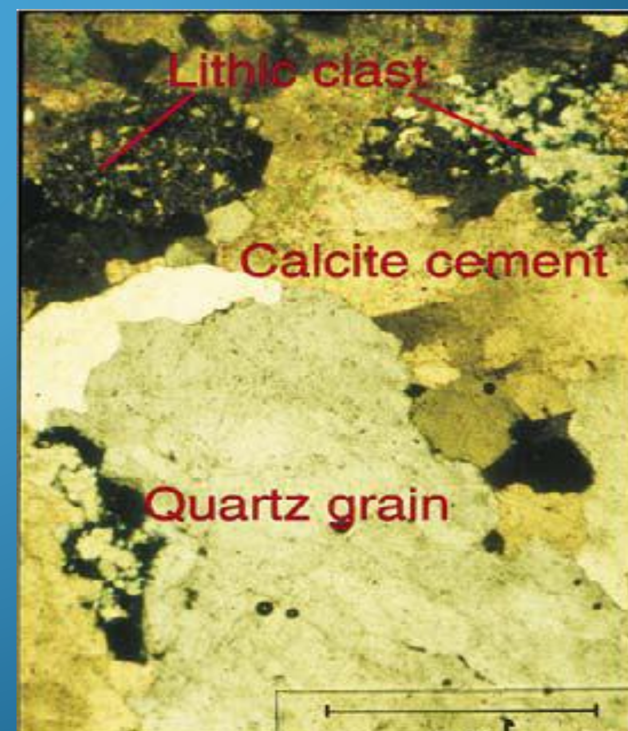
Hypothetic pathway of a flux passing through the pores of a sedimentary rock

Note: a rock has a good **porosity** if it is characterised by a high percentage of pores; it implies a high storage capacity of fluids or gas.
However, if none of these pores are interconnected each other, fluids or gas cannot propagate and, consequently, a rock has a scarce **permeability**. Contrarily, a better permeability derives from well-interconnected pores.


Quartz overgrowth
Clay mineral grains

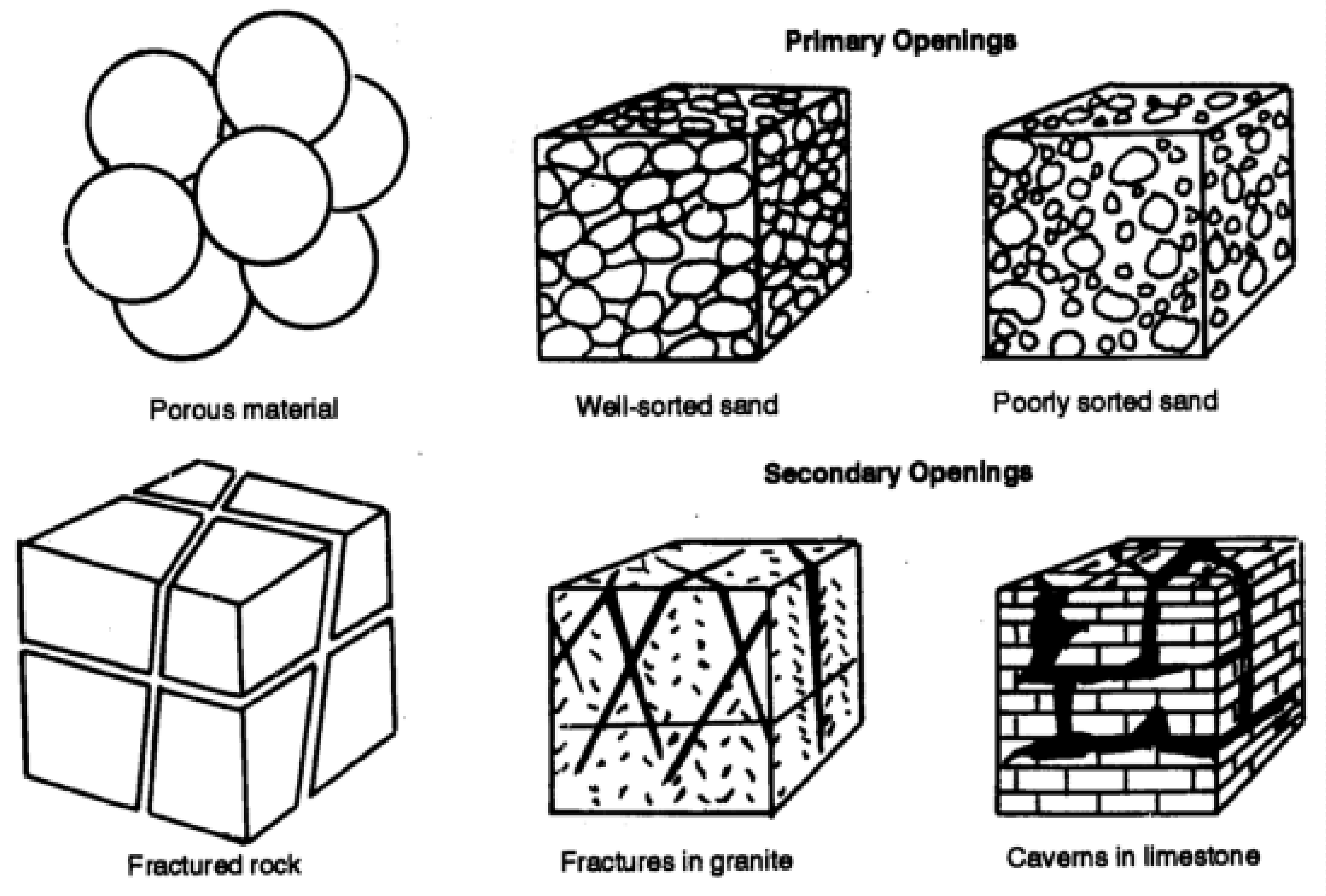

Original Rim of grain
Quartz Grain
Quartz overgrowths
Pore space (blue)


A
Qz
0.2 mm
B
Qz
1580x1580 um (50x)
C
Qz
D
Qz
F
S
158x158 um (500x)


Lithic clast
Calcite cement
Quartz grain

POROSITY in sedimentary rocks can be of dual origin:

1. **Primary Porosity** and
2. **Secondary Porosity**



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Charles Lyell (1838)

GEORESOURCES

Natural asset (at solid, liquid or gas state) deriving from geological processes and of economic/social relevance. Such resources must be protected and preserved from an unexcessive exploitation and consequent depletion.

MINERAL RESOURCES
- Precious metals
- Coals
- Gems

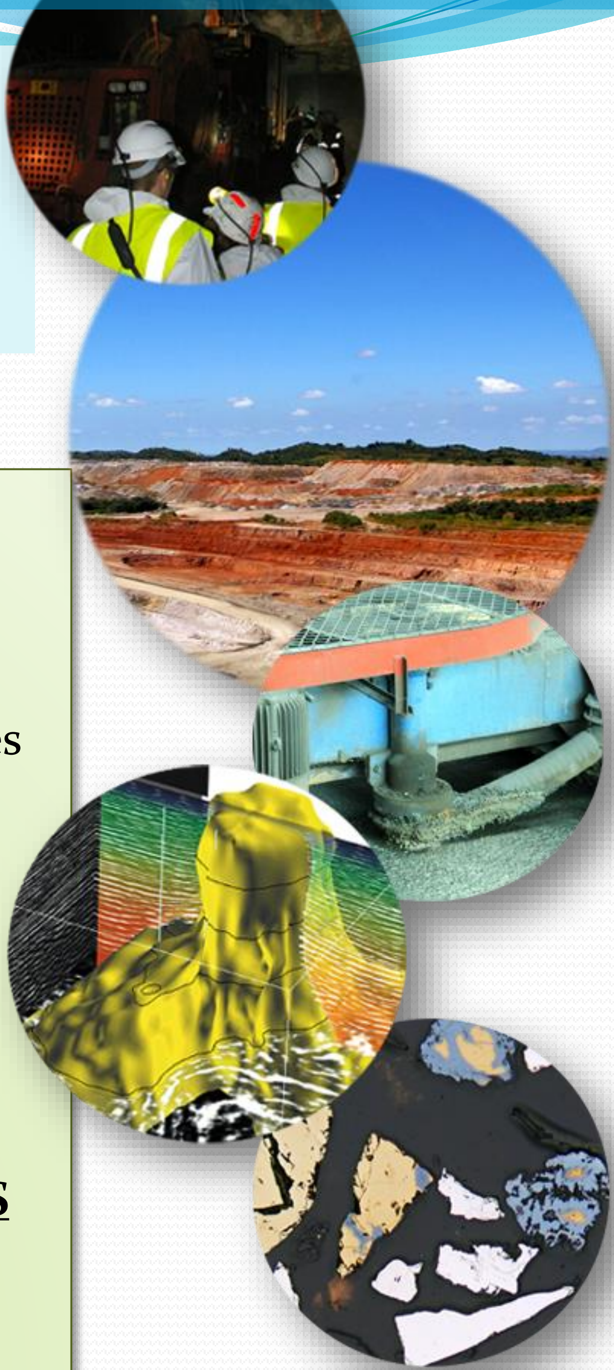
HYDROCARBONS
- Oil
- Natural gas

WATERS
- Juvenile
- Connate
- Acquifers
- Natural lakes

SEDIMENTARY RESOURCES
- Lapideous materials used as coating or covering
- sand for industrial uses
- Littoral sands
- Gems

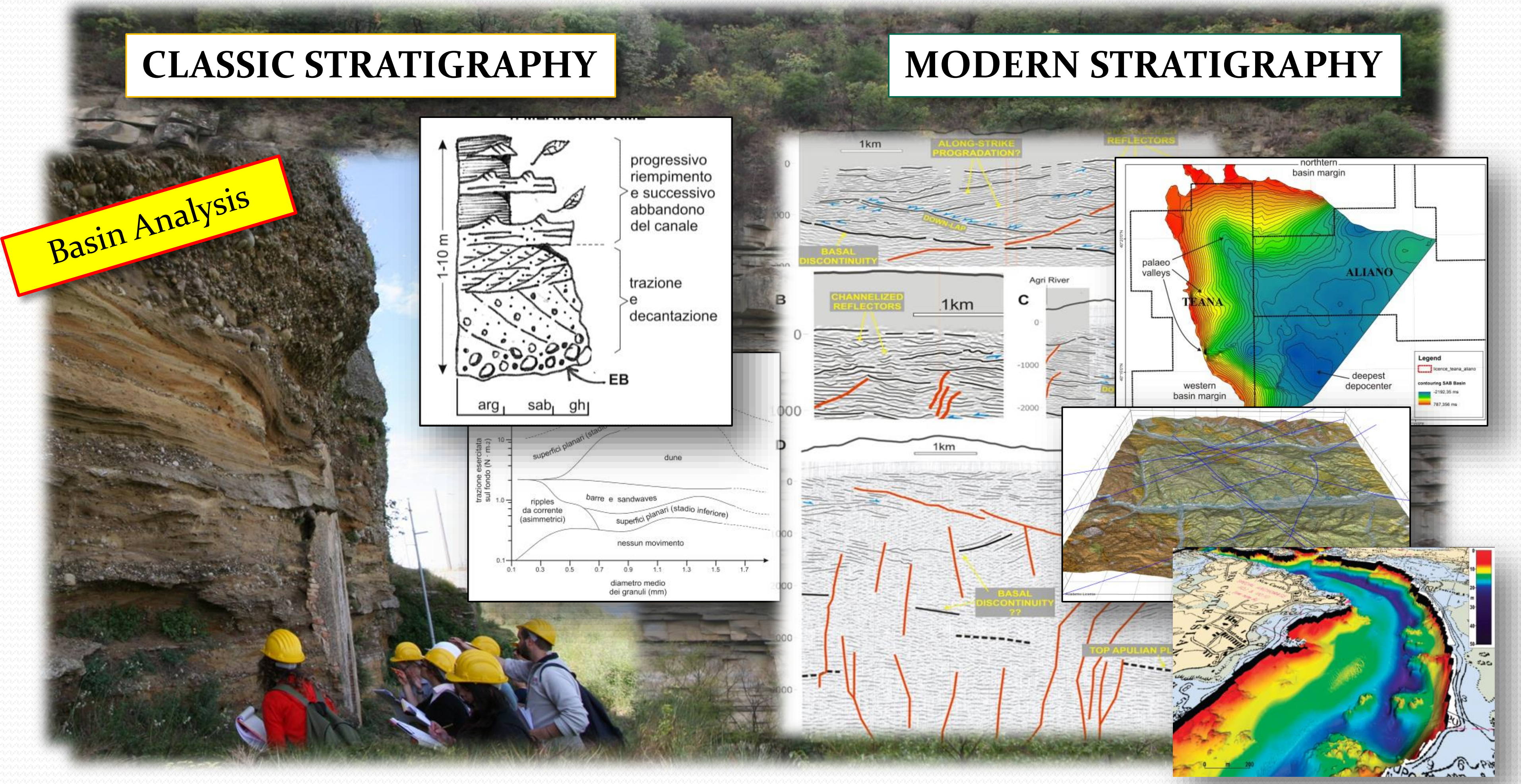
BIOGENIC RESOURCES
- Fossils
- Footprints

TOURISTIC GEORESOURCES
- Geosites
- 'Open-sky' museums



STRATIGRAPHY

It includes the observation, description and interpretation of the sedimentary successions. This approach is applicable either on rocks exposed on the Earth surface (outcropping) and/or rocks preserved in the Earth subsurface.

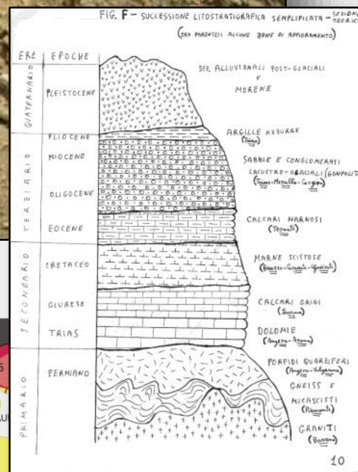


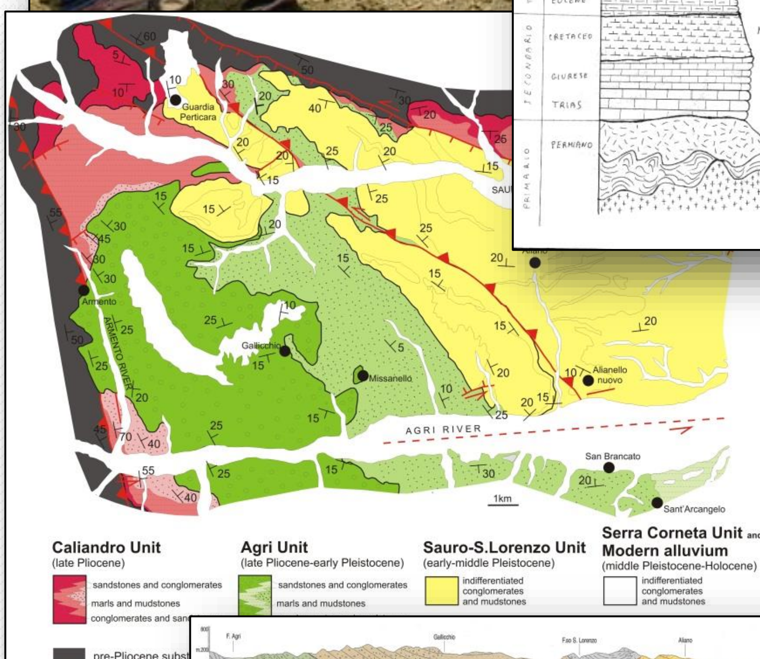
CLASSIC STRATIGRAPHY

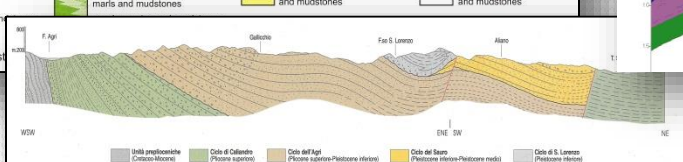
It deals on the identification of the features of two physical elements:

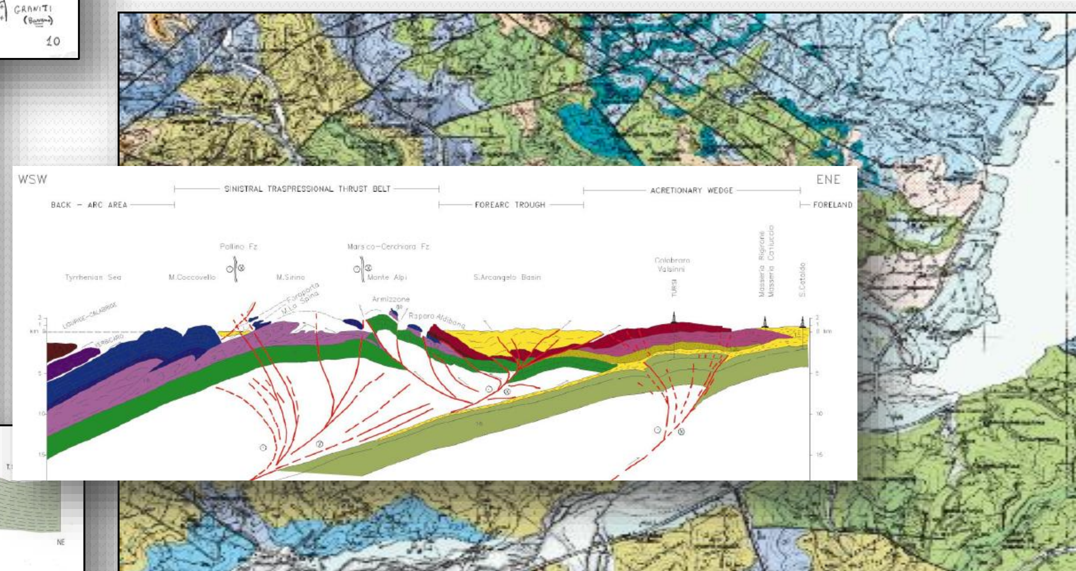
- *stratigraphic surfaces*;
- *stratigraphic successions*.

Surfaces and successions can be represented in cross-sectional or in-plant view, at the following scales:
strata (m), outcop (dam), succession (hm), basina (km), seismic, semi-regional and regional (10s-100s km).





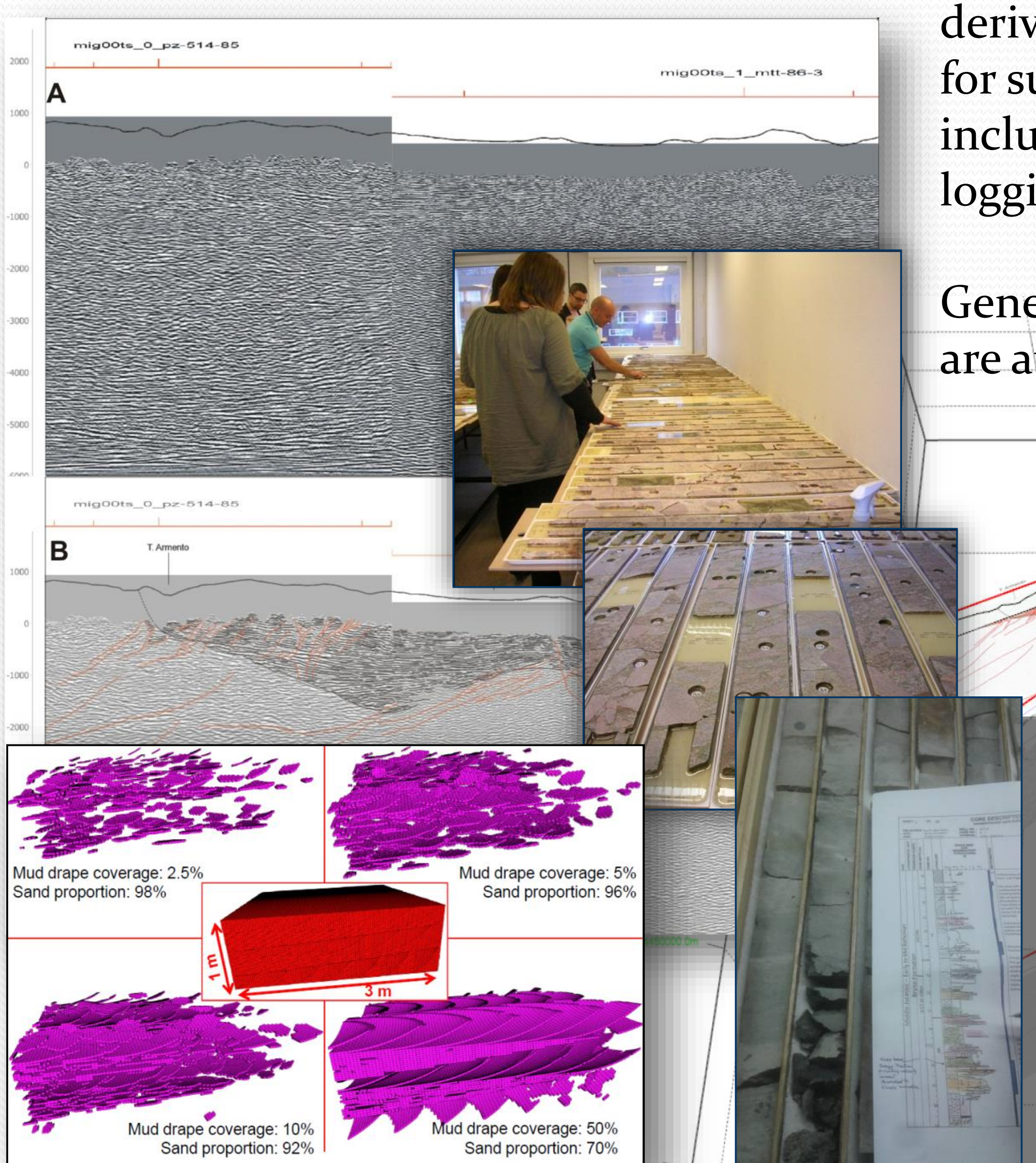


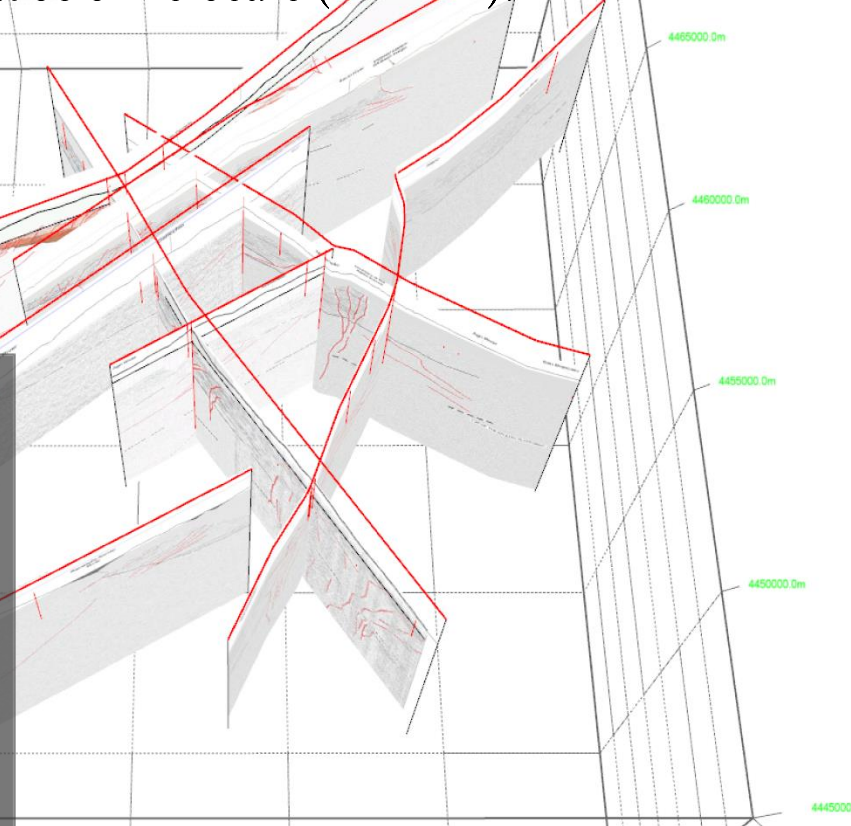


MODERN STRATIGRAPHY

It deals on the interpretation of the results deriving from advanced survey techniques for surface and subsurface investigations, including: bi- e tri-dimensional seismic, logging, modelling and reconstruction.

Generally, the various scales of interpretation are at seismic-scale (hm-km).

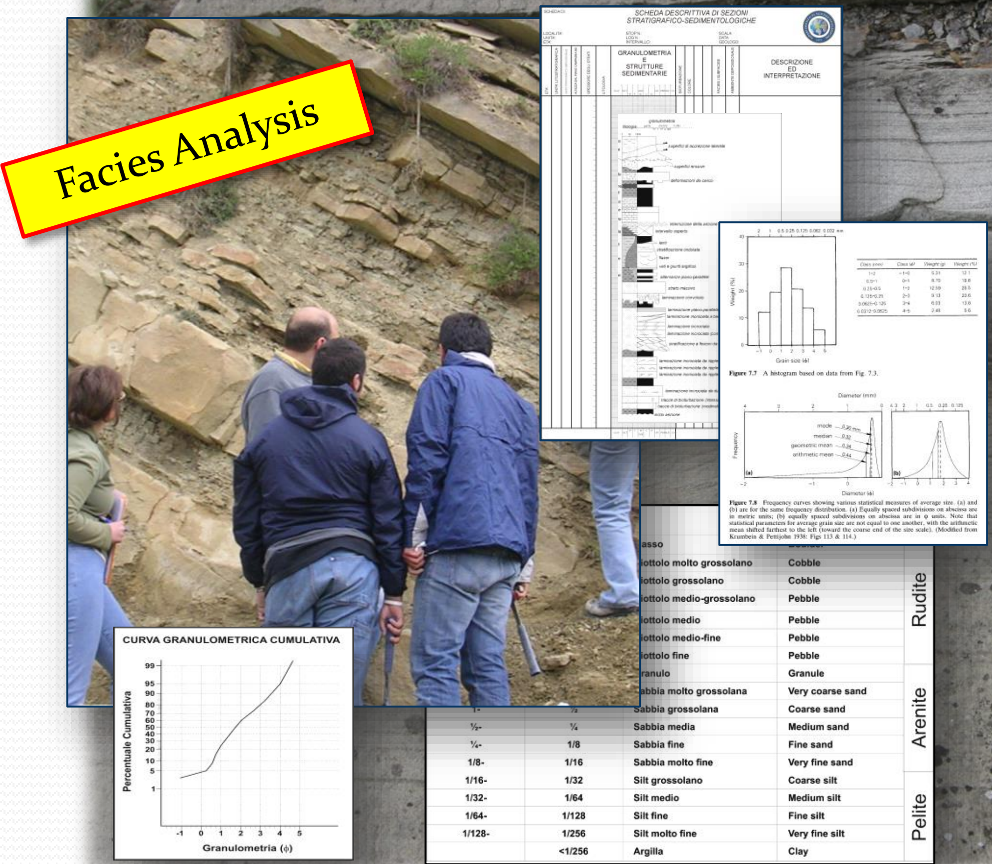




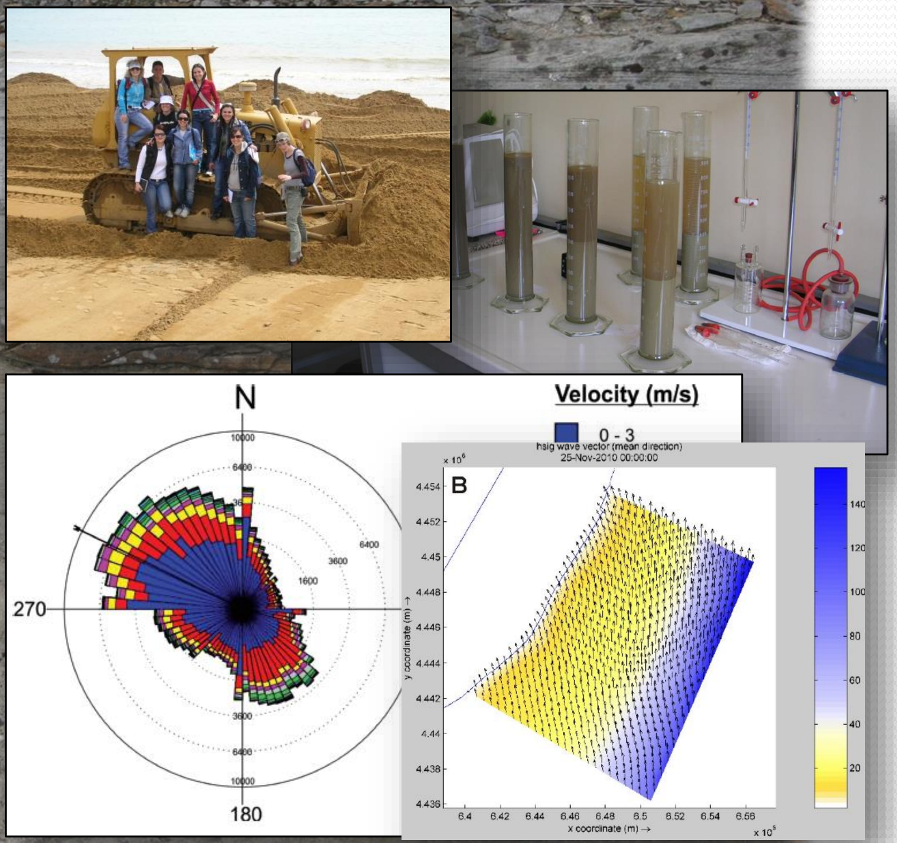
SEDIMENTOLOGY

It includes the observation, description and interpretation of the sedimentary rocks and deposits (facies), in order to understand their genetic processes, the depositional environments and the depositional systems, boh from surface and subsurface data.

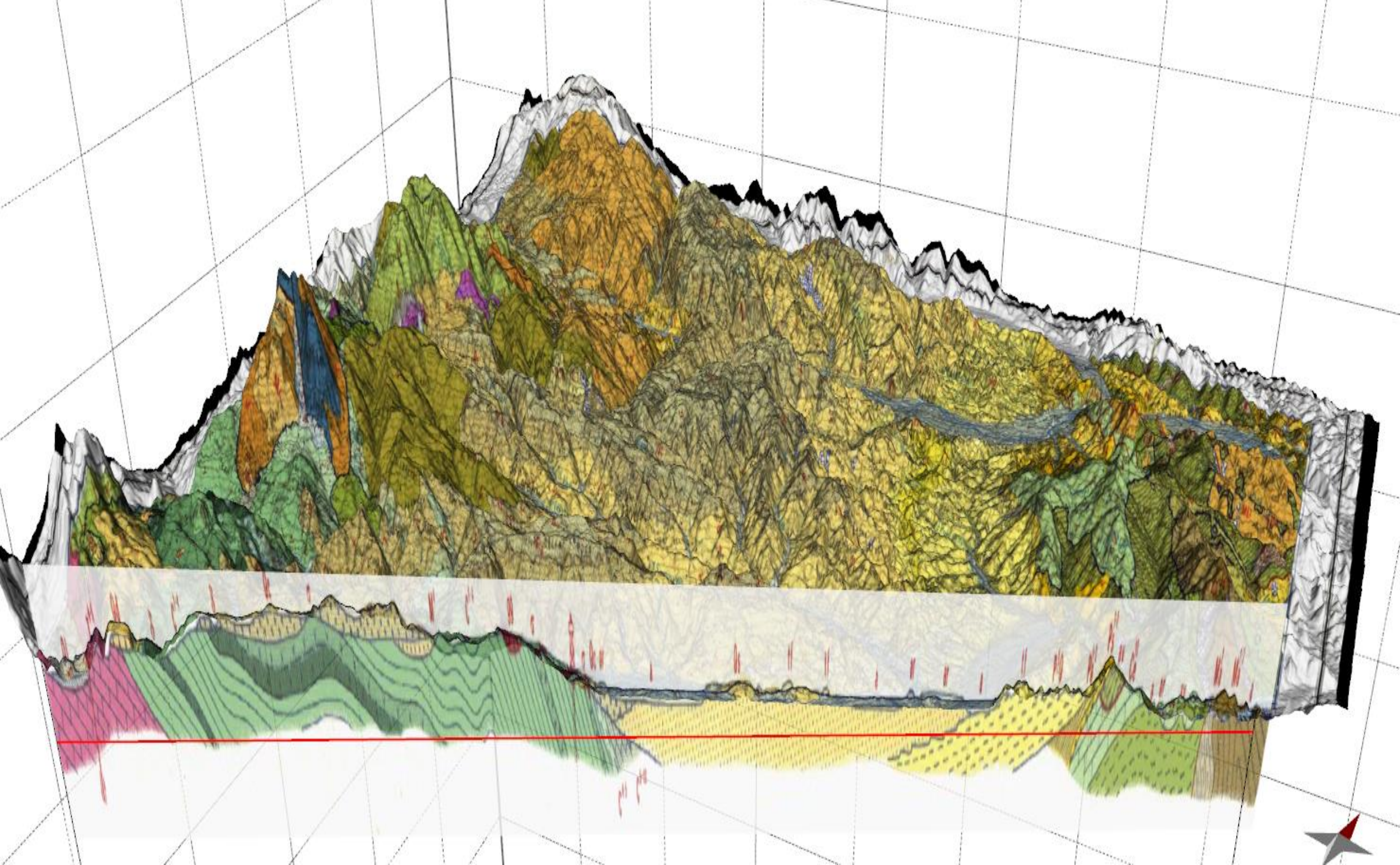
CLASSIC SEDIMENTOLOGY



MODERN SEDIMENTOLOGY



Exemple of software elaboration (Move®) of seismo-stratigraphic data and reconstruction of the base of the sedimentary basins (case study: *the Sant'Arcangelo Basin –Total-UniBas Project 2014*)



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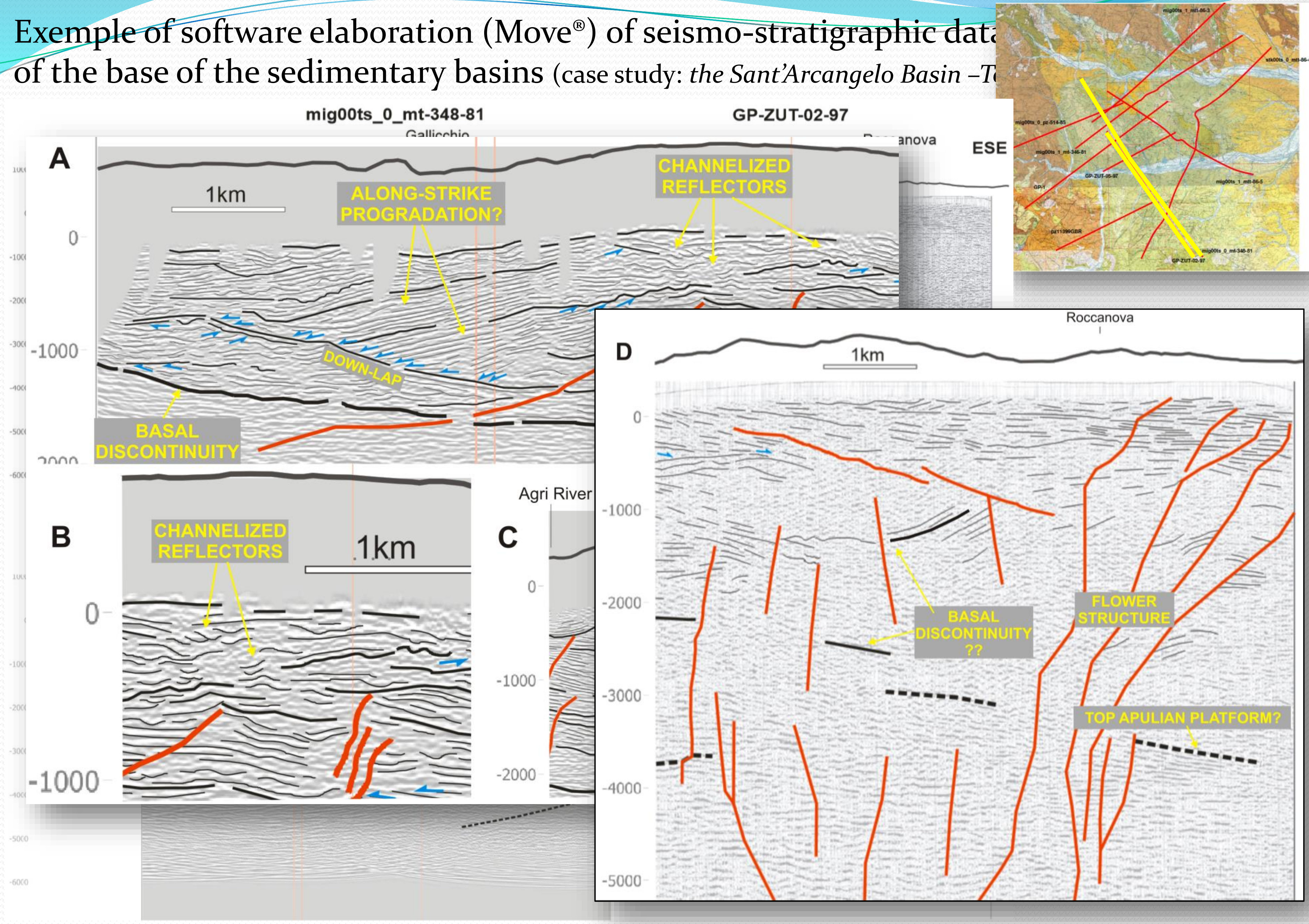

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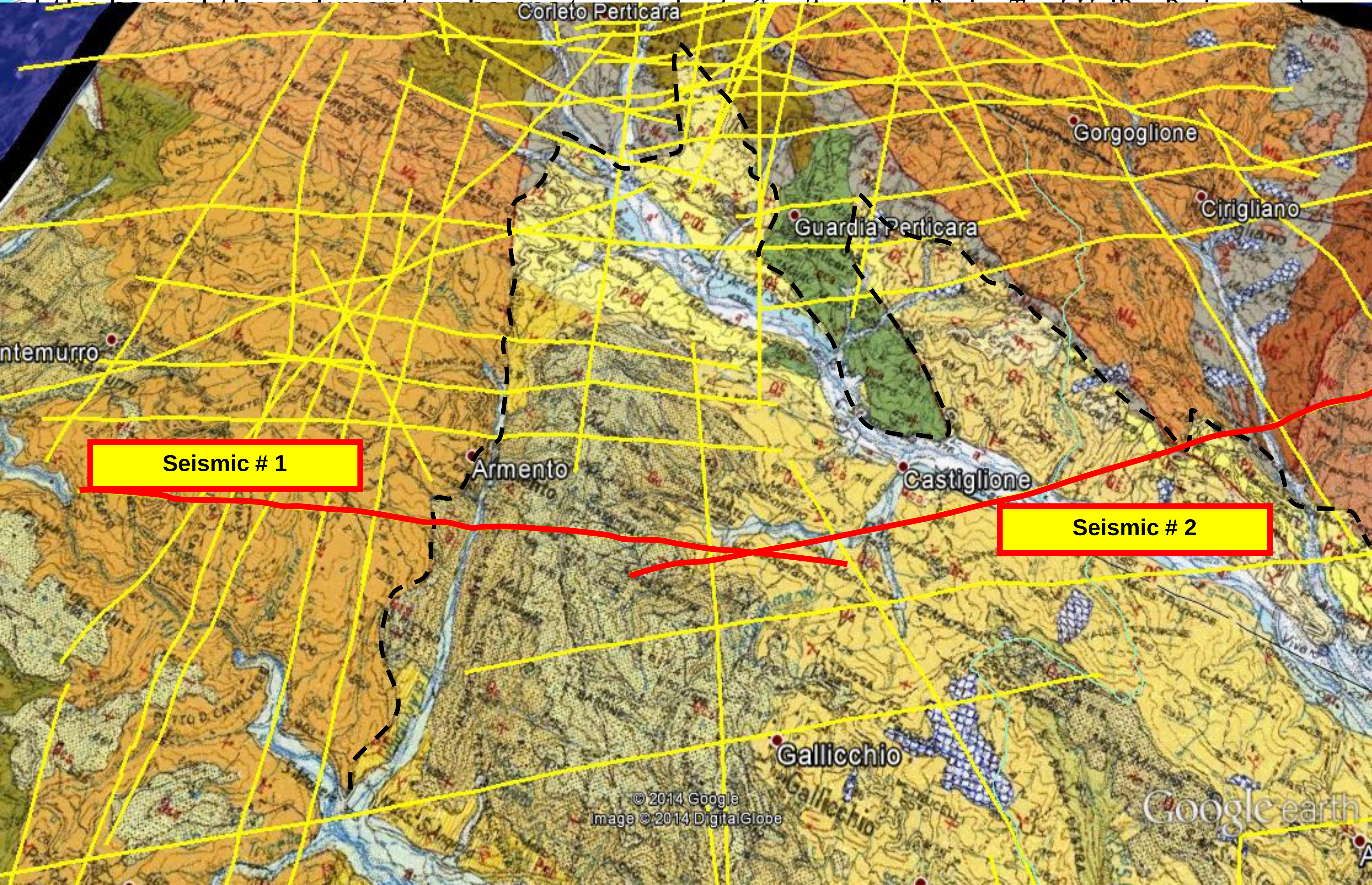

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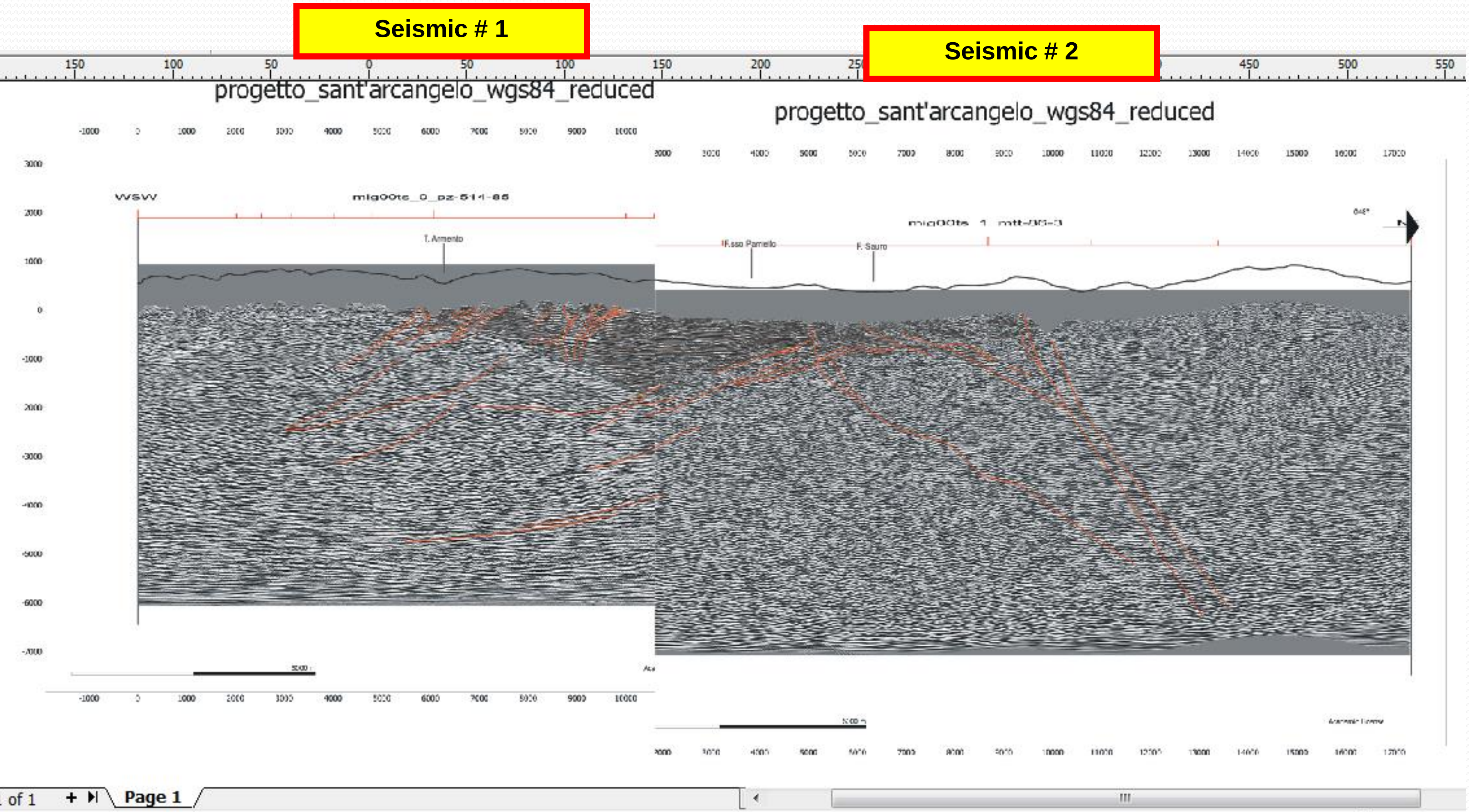

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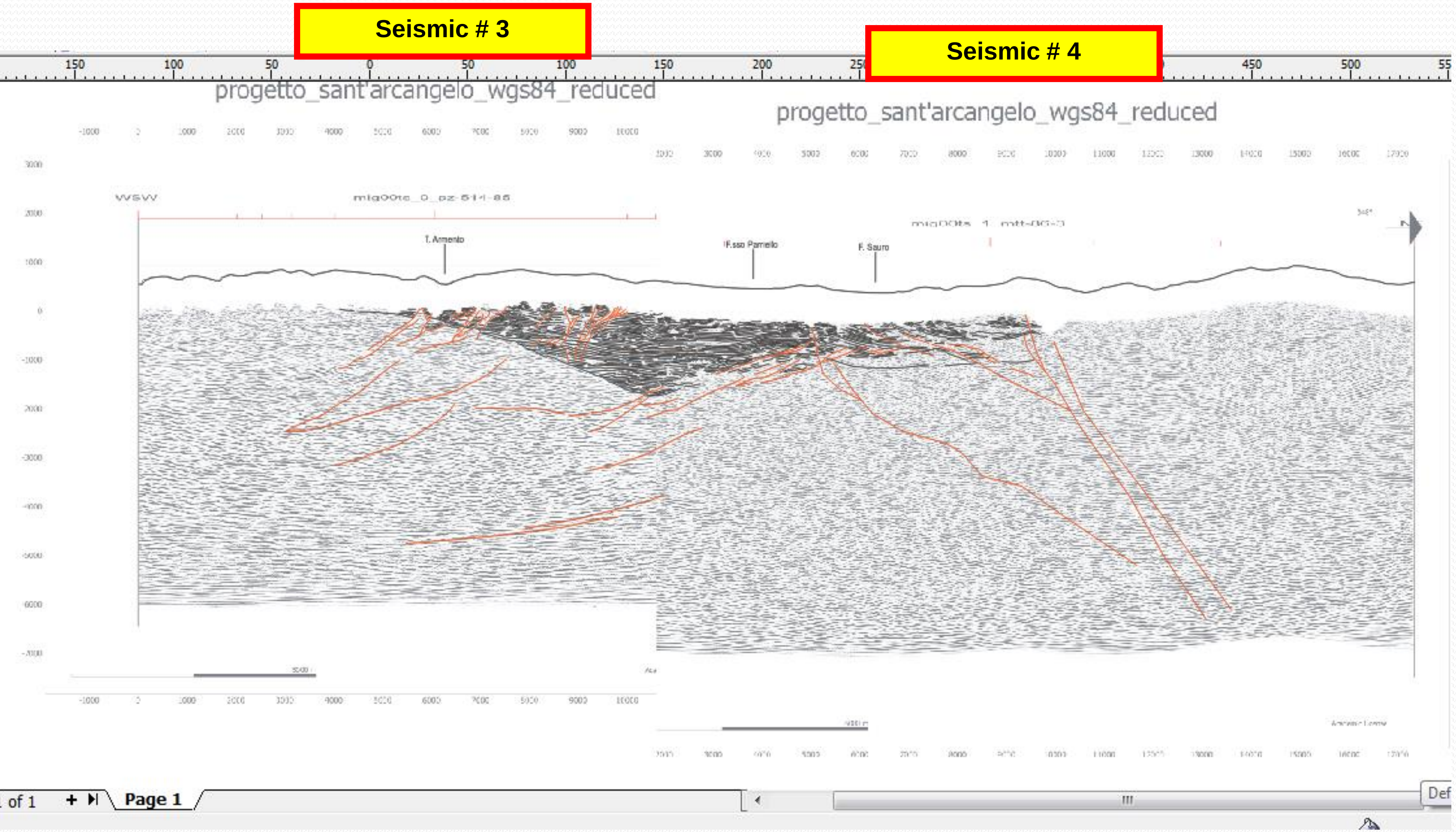

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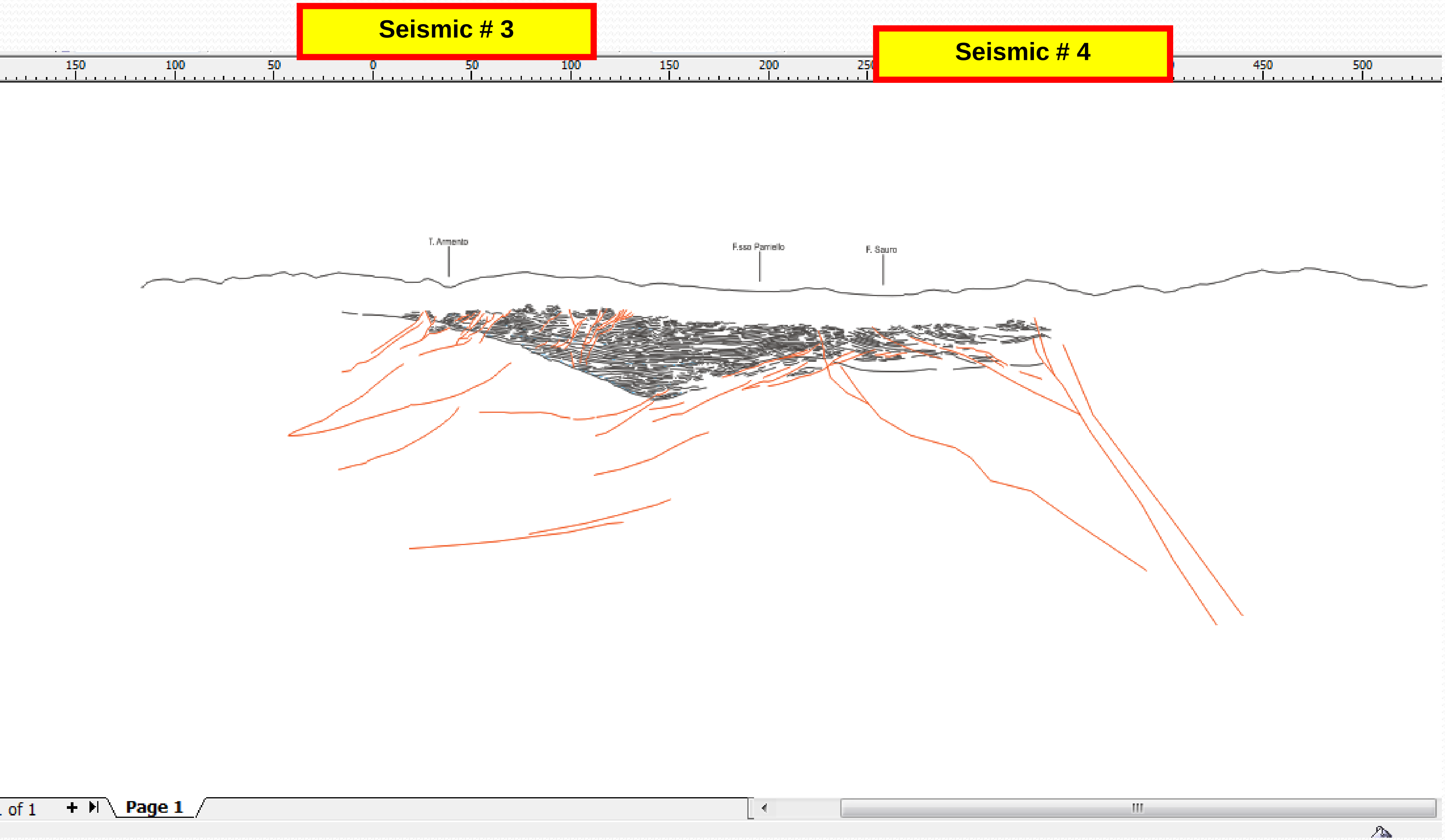
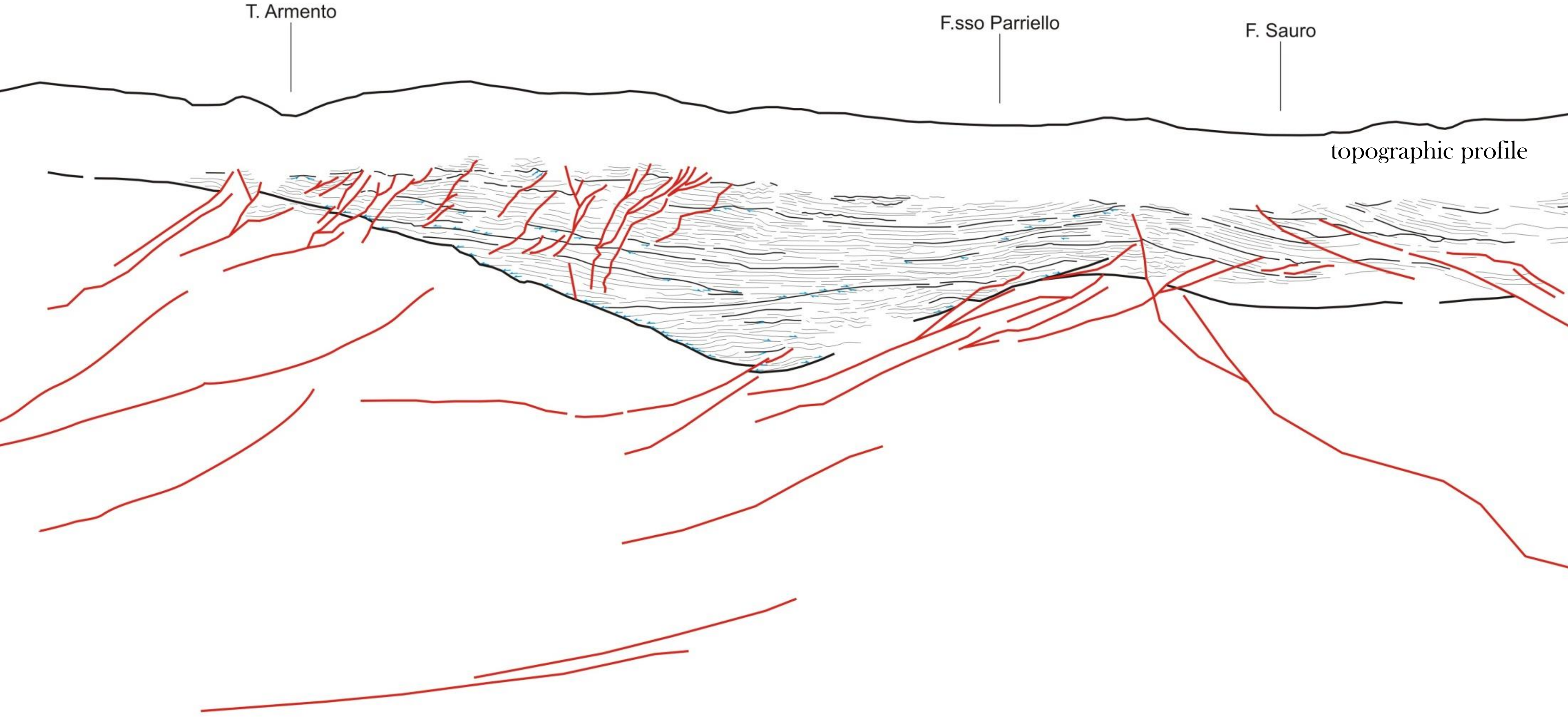


Exemple of software elaboration (Move®) of seismo-stratigraphic data and reconstruction of the base of the sedimentary basins (case study: *the Sant'Arcangelo Basin –Total-UniBas Project 2014*)

Five main seismic units, separated by important discontinuity surfaces



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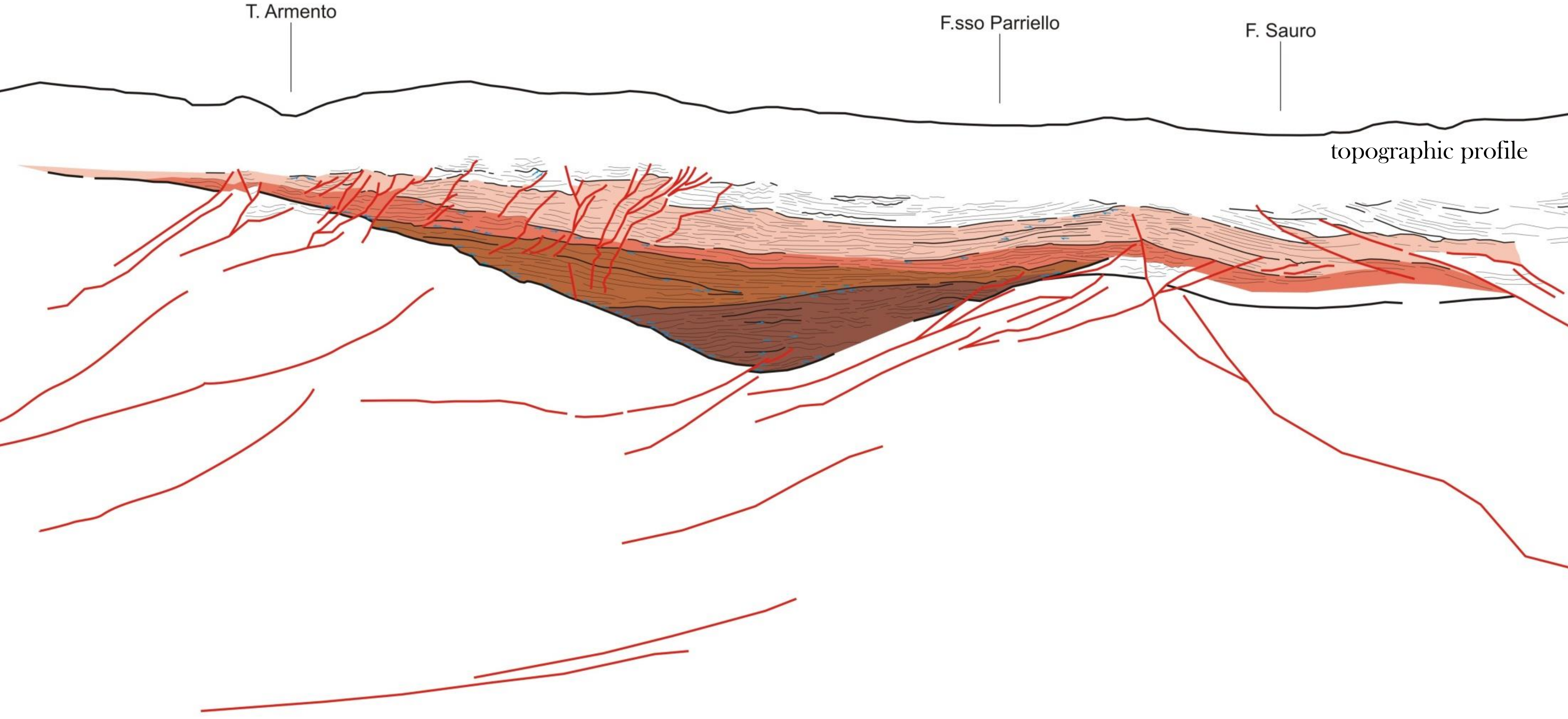

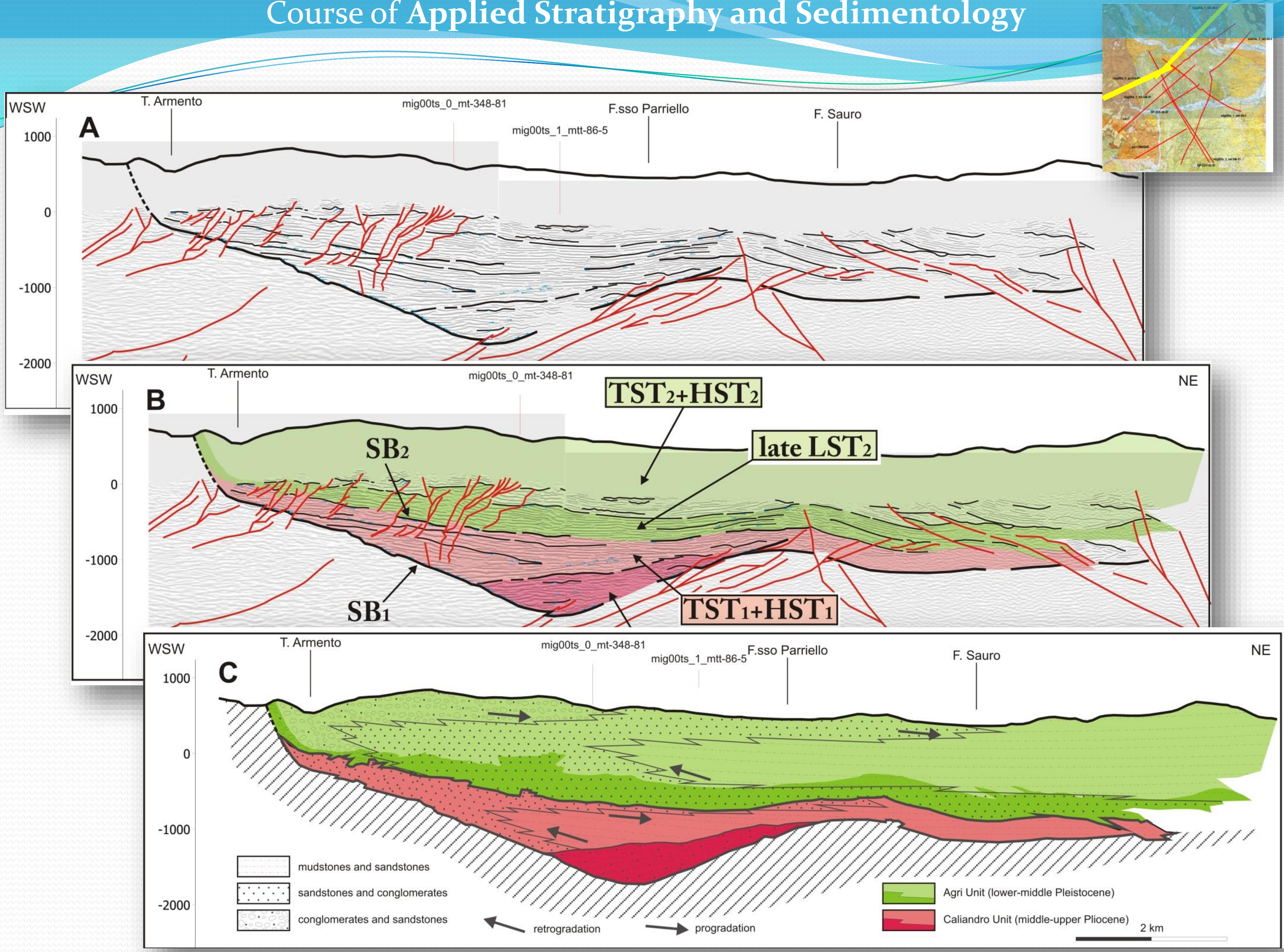
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F.sso Parriello
F. Sauro
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TST2+HST2
late LST2
SB2
SB1
TST1+HST1
WSW
NE
C
1000
0
-1000
-2000
T. Armento
mig00ts_0_mt-348-81
mig00ts_1_mtt-86-5
F.sso Parriello
F. Sauro
mudstones and sandstones
sandstones and conglomerates
conglomerates and sandstones
retrogradation
progradation
Agri Unit (lower-middle Pleistocene)
Caliandro Unit (middle-upper Pliocene)
2 km

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