Rock-physical properties of a fault zone in a porous-fractured carbonate reservoir:

Micro-geophysical in-situ and laboratory studies of a fault in the LSBB.

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Context of the Research:

- Currently, the fault zone properties are studied:
  - (i) at the laboratory scale on centimeter samples
  - (ii) at the reservoir scale through seismic imaging methods.

Lack of decameter scale studies

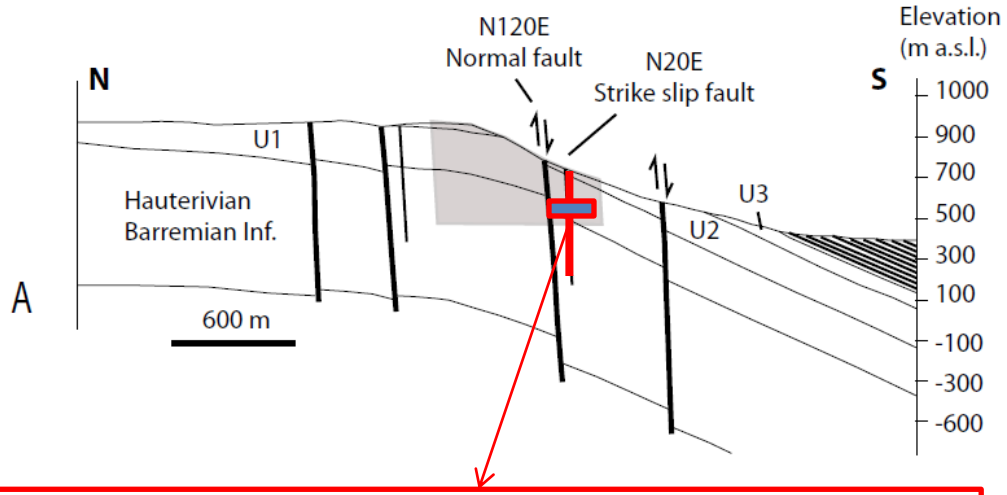
that consider both matrix and fracture deformations

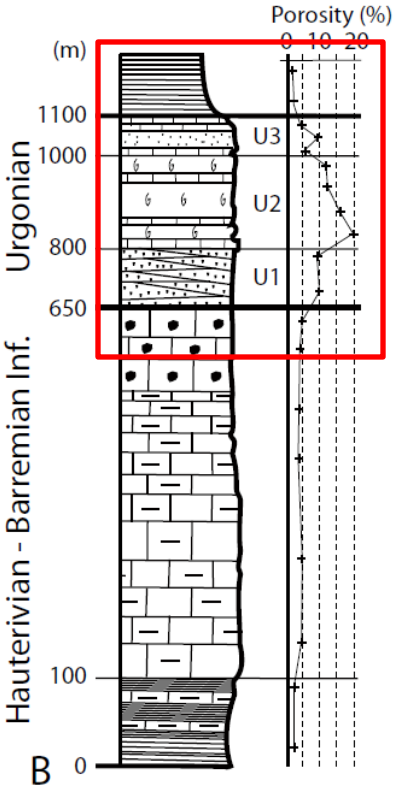
- Fault zone modern properties mainly result from:
  - (1) Sedimentary rock type properties
  - (2) Multi-Phase diagenetic history of the rock

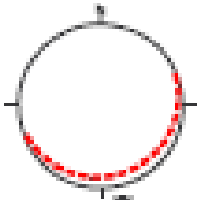
Coupling between (1) and (2) ⟺ ***fault moderm properties***

Geological context:

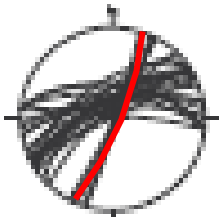
- Strike-slip N20 fault
- Length = 500m
- Thickness =30m



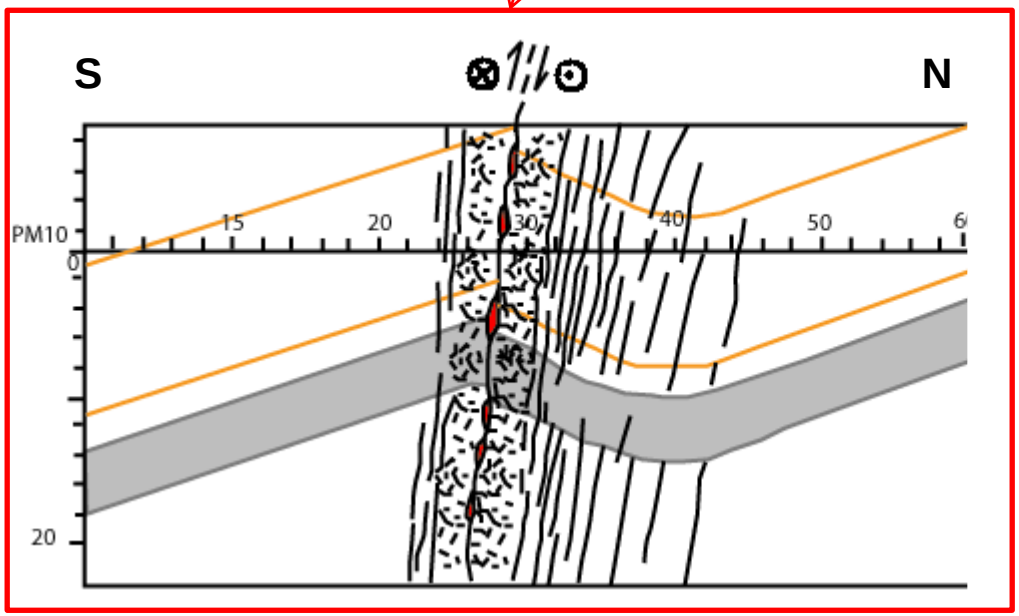


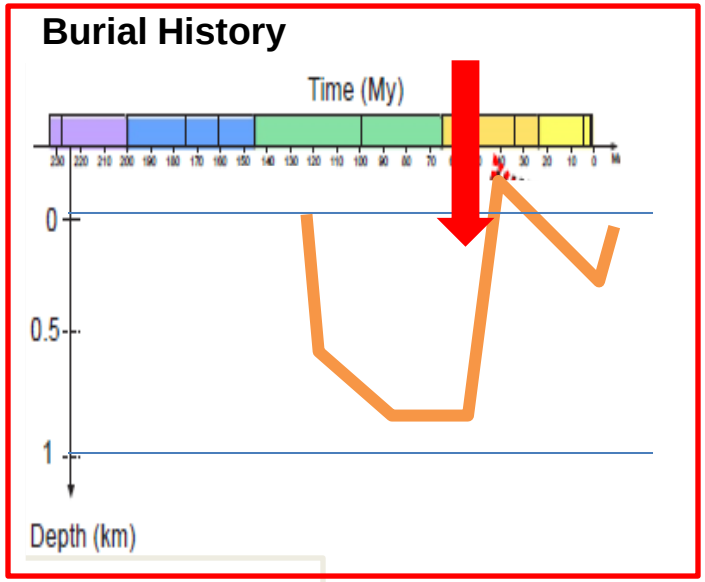


Bedding planes



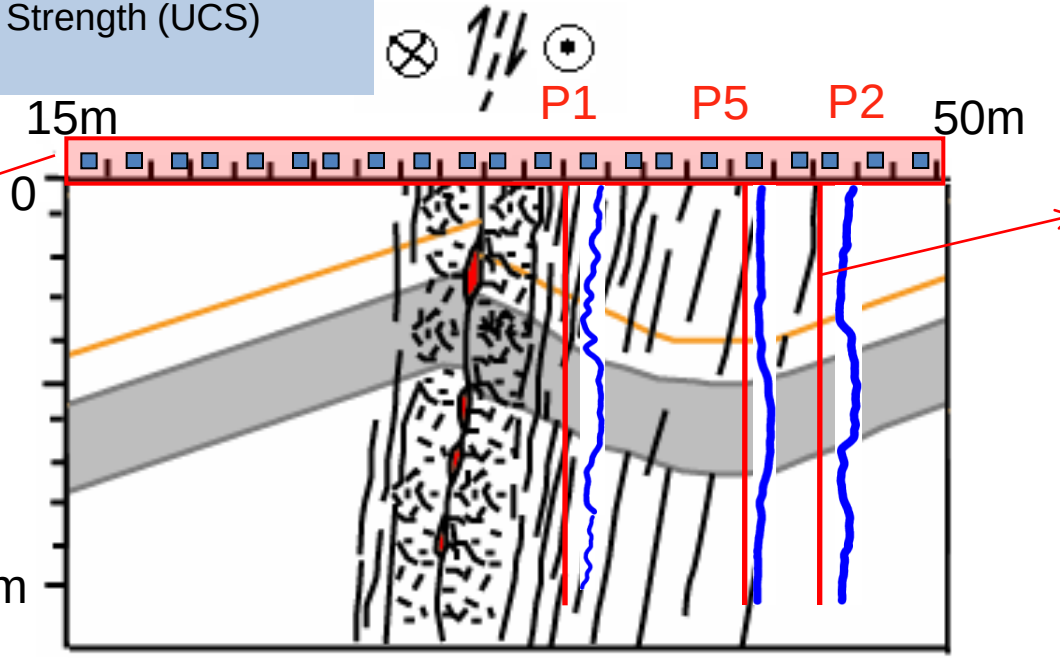
Fault/fractures



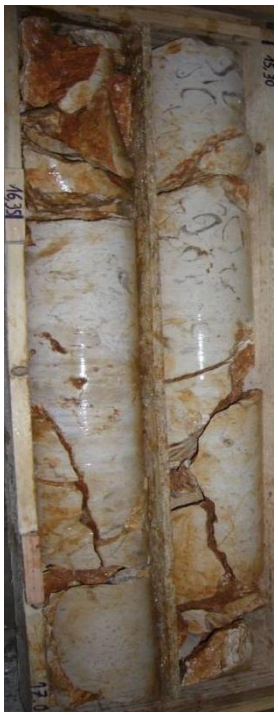


In Situ and Laboratory Micro-geophysical and Geo-mechanical investigation methods

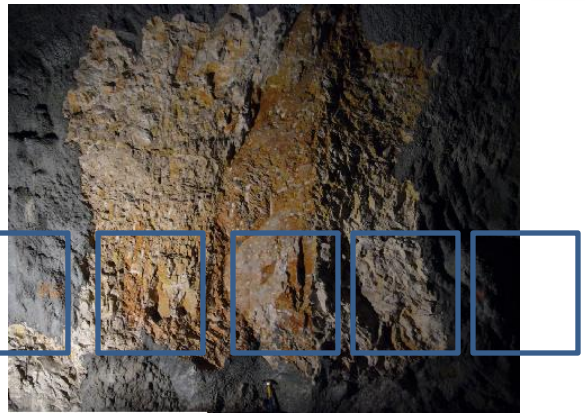
Gallery wall:
- Geology (fracturation, sedimentary facies)
- Acoustic Velocity (Vp)
- Uniaxial Compressive Strength (UCS)
- Thin sections



0.14m



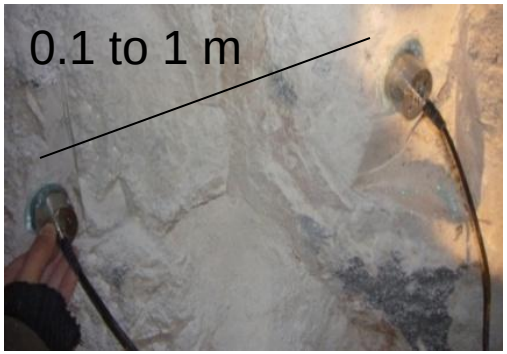
2 m



Borehole logging :
- Geology (fracturtion, sedimentary facies)
- Vp
- UCS
- Clay content
- Resistivity
- Density
- Water content

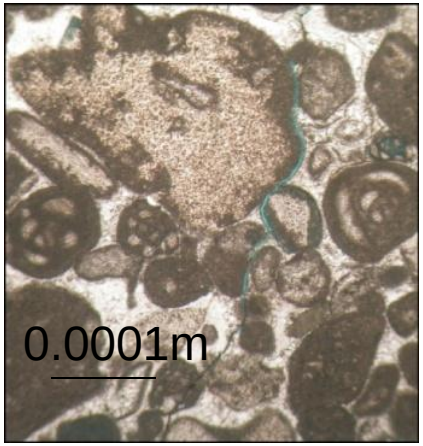
Micro-geophysical and Geo-mechanical investigation methods

Acoustic sounding

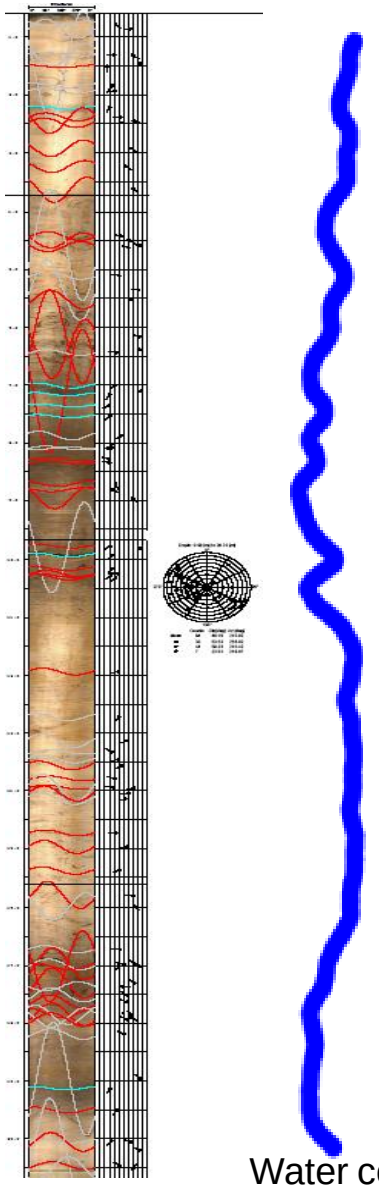


UCS

Thin section



Borehole logging



Water content

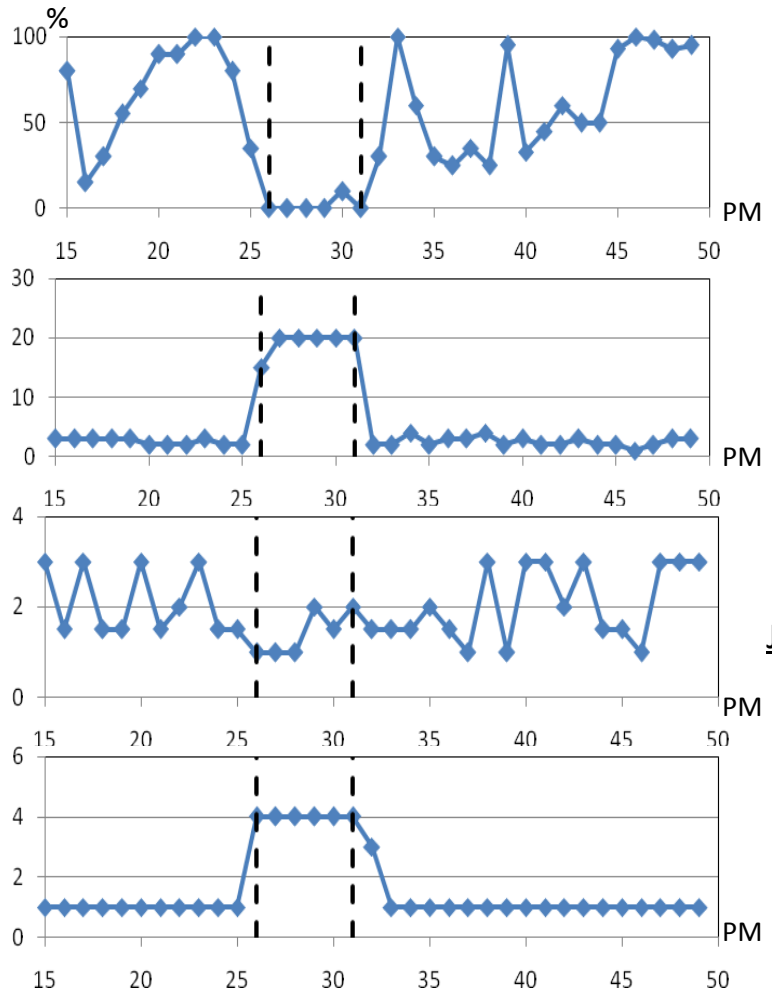
- Macroscopic Characterization of the Fault Damage Zone

- Acoustic Velocities Variations (V_P)

- Rock Initial Porosity Alteration

- Statistical Multivariate Analysis
  - Discrimination of initial sedimentary factors and fault diagenetic factors

Characterization of fractures (Gallery wall)

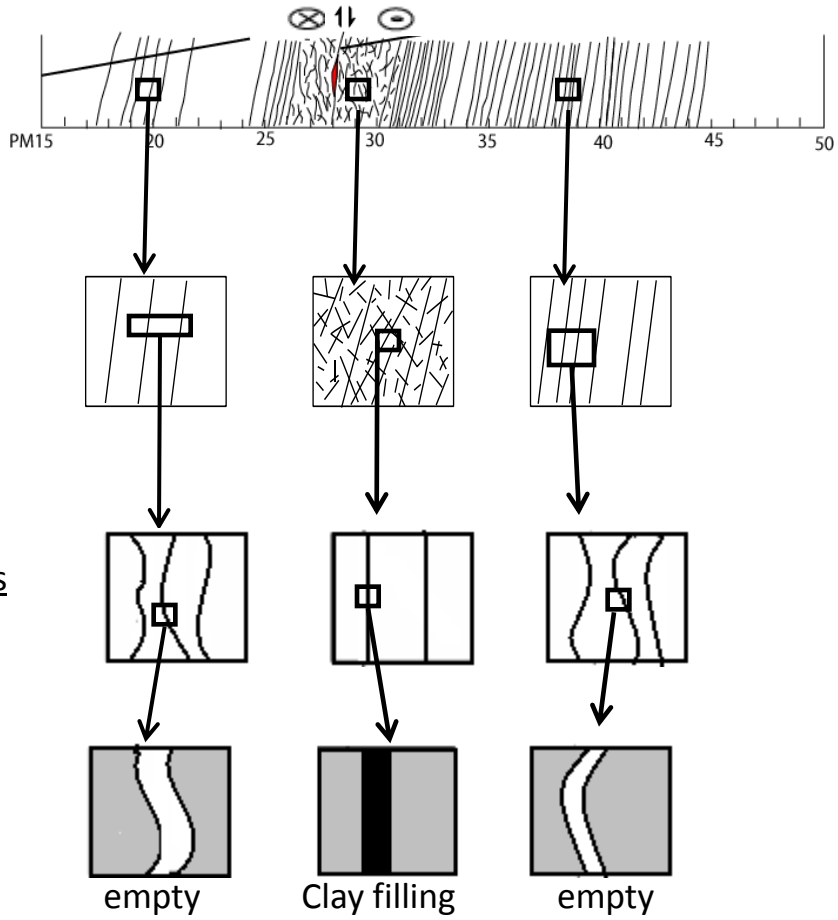


Fracturation degree (RQD)

Joint set (Jn)

Joint roughness (JRC)

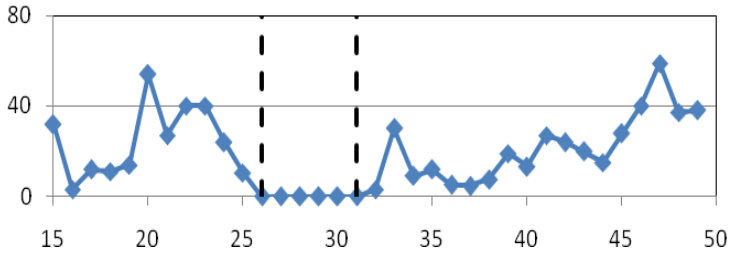
Joint filling (Ja)



Rock Quality imaging around the fault zone : Fracturation is different depending on the rock type

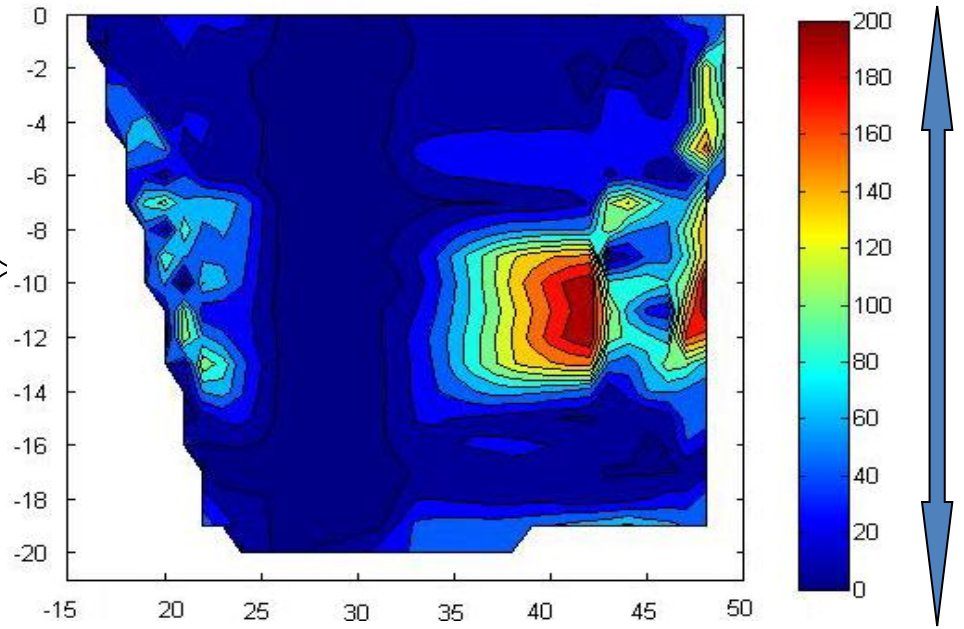
(Barton, 2002)

$$Q = \frac{RQD}{Jn} \times \frac{JRC}{Ja} \times \frac{Jw}{SRF}$$



Variation of Q along the outcrop

Fault influence



Rock type

Sedimentary facies influence

- Macroscopic Characterization of the Fault Damage Zone

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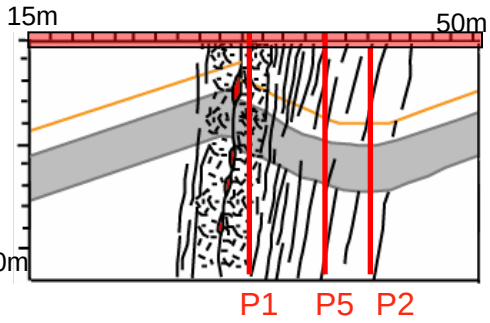
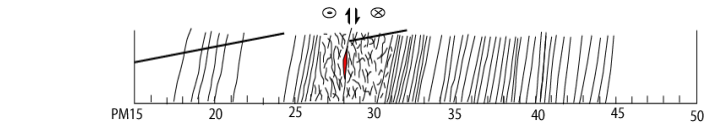
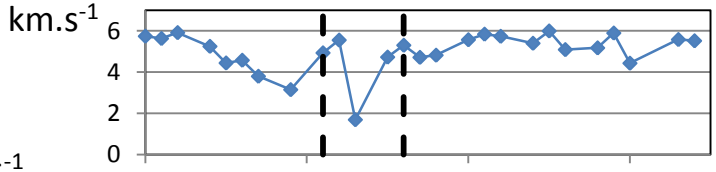
Acoustic P-Waves Velocities Variations:

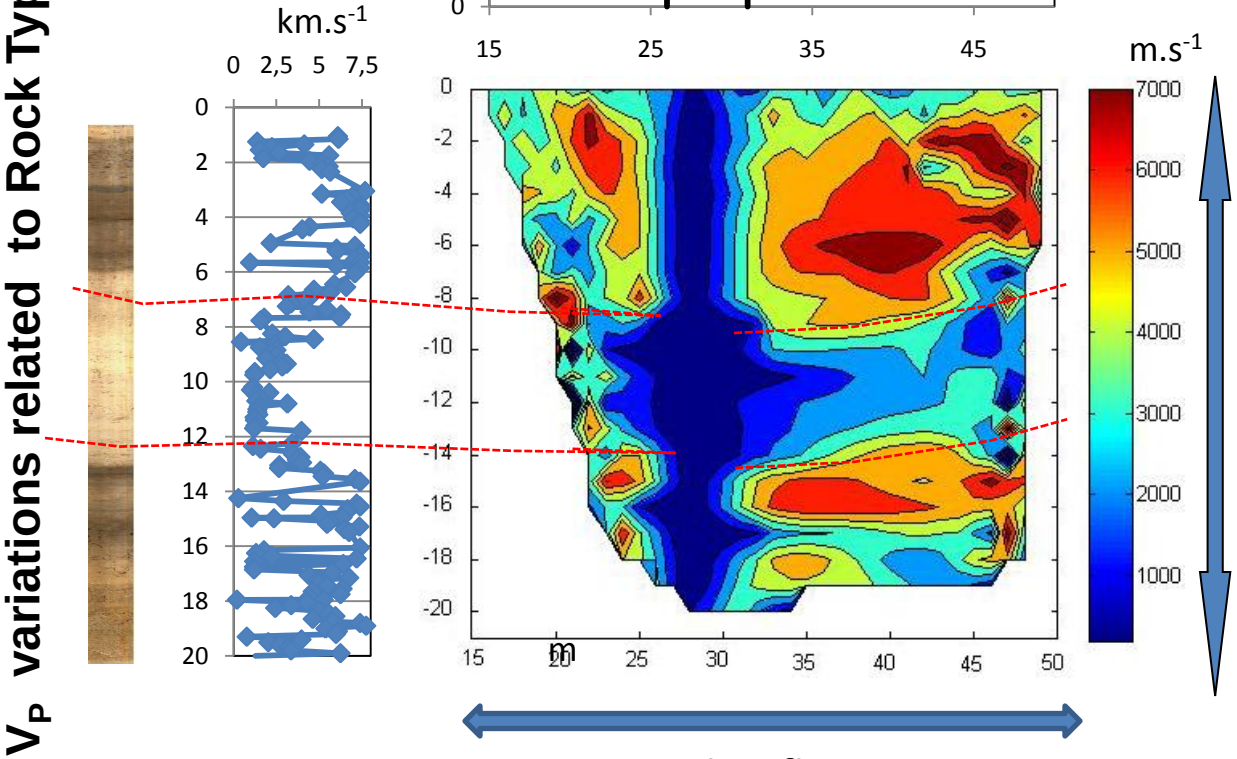
- Strong stratigraphic contrast
- Fault effect depends on rock type



V_P variations related to the fault







Rock Type

Sedimentary facies influence

- Macroscopic Characterization of the Fault Damage Zone
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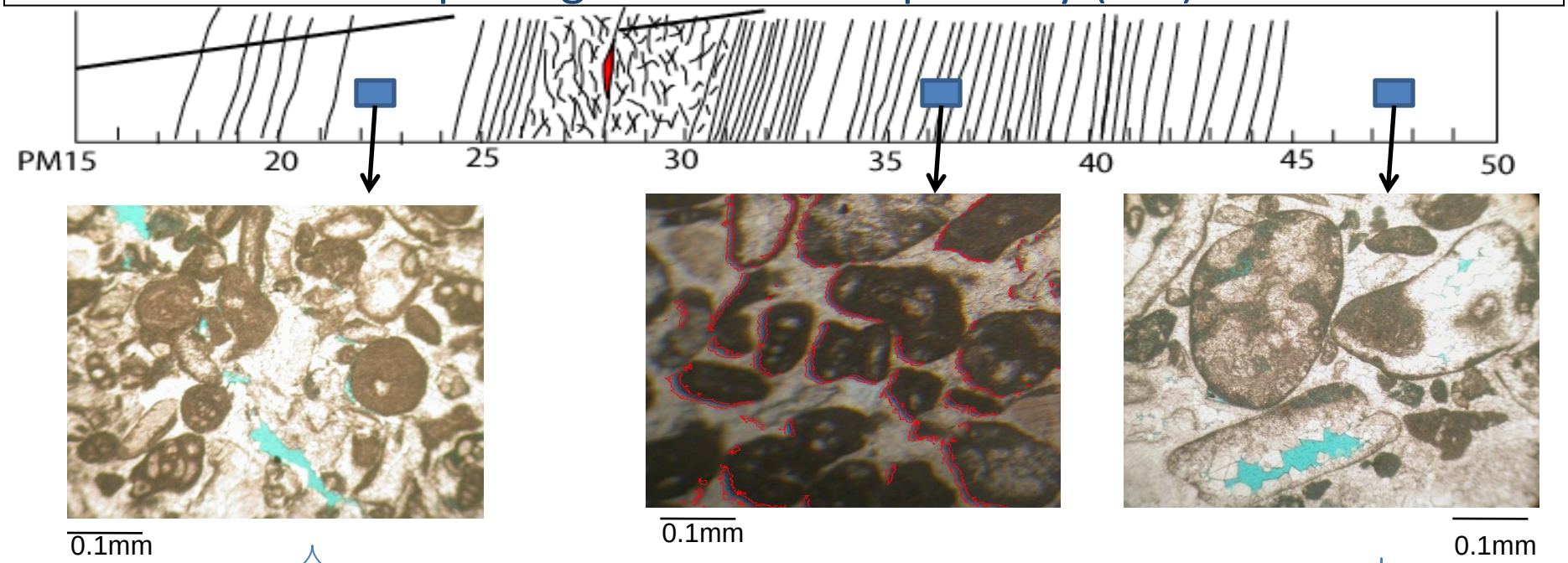
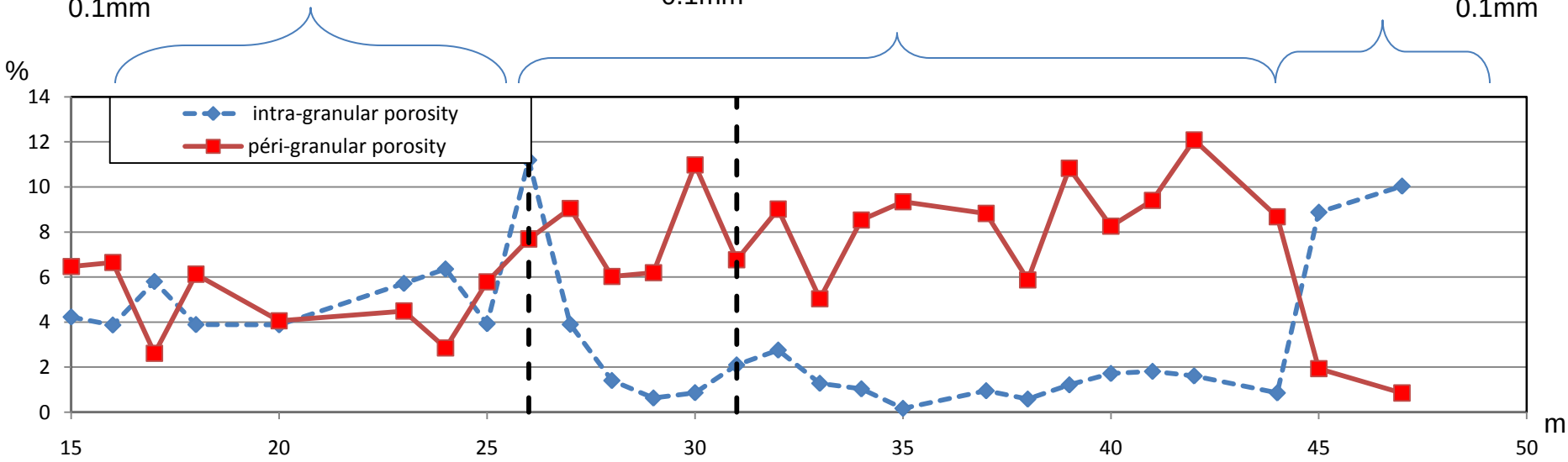
Initial Porosity alteration by the fault

- Closing of Intra-Granular Porosity (blue)
- Opening Peri-Granular porosity (red)





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- Acoustic Velocities Variations (V_P)
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Attributes Considered in the Principal Component Analysis

JOINTS

- RQD
- ROUGHNESS
- FILLING
- TYPE : (1) bedding planes, (2) fractures, (3) faults
- Rock Type : (1) mudstone, (2) wackstone, (3) Packstone, (4) Grainstone

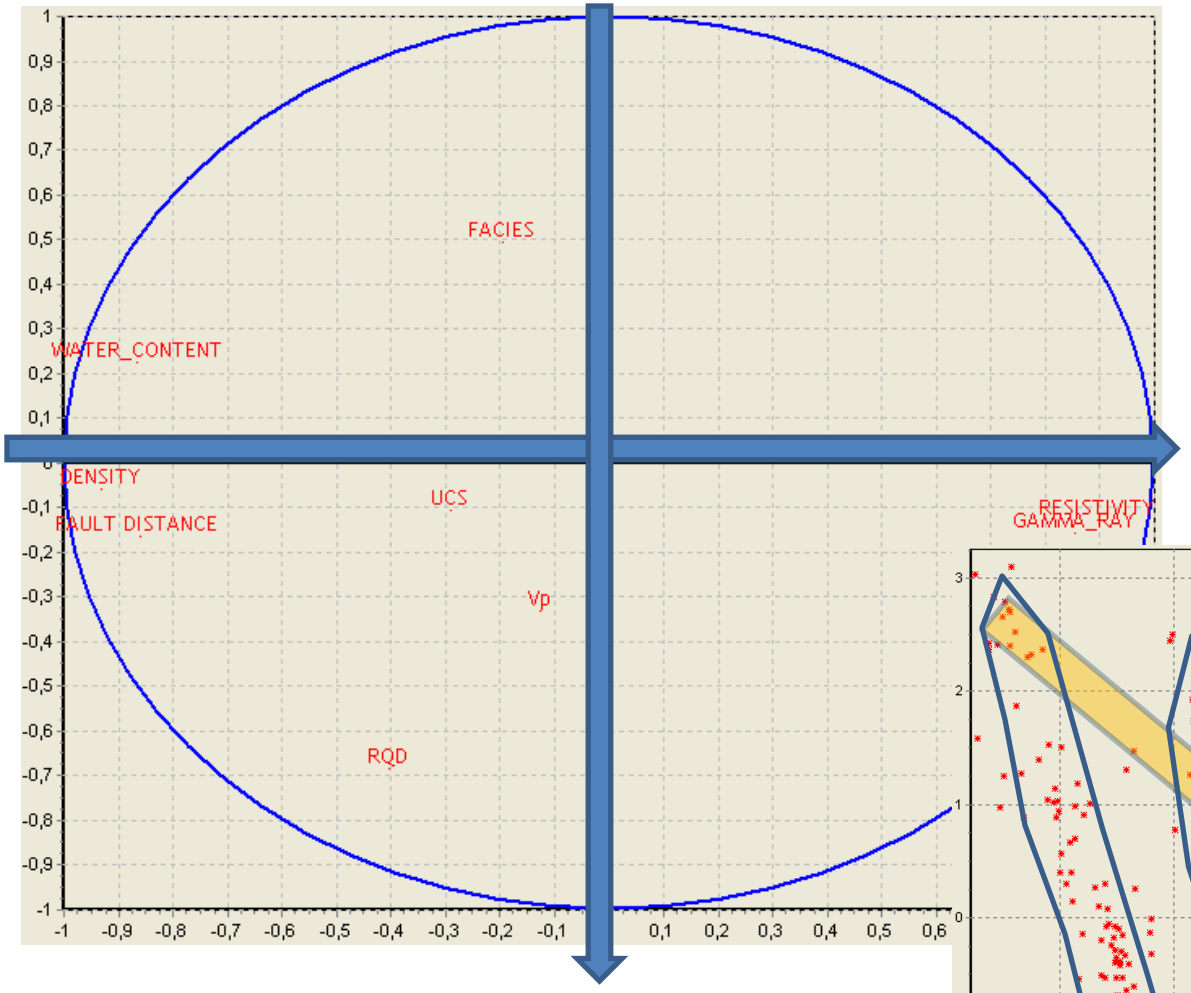
LOCALISATION

- DISTANCE TO THE FAULT

ROCK PHYSICS

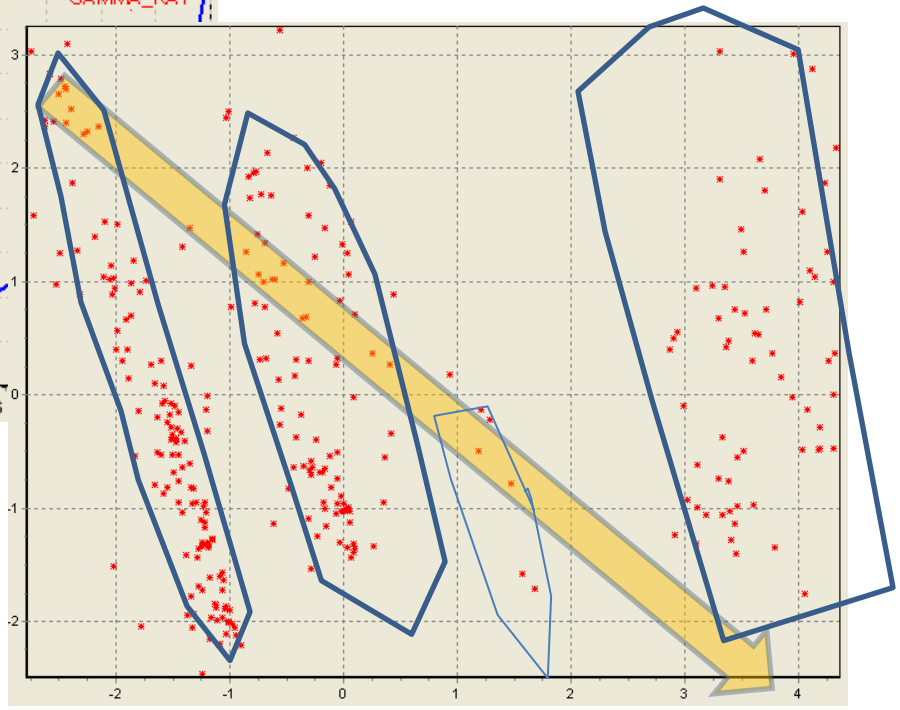
- Vp (p-Wave velocity)
- UCS (Uniaxial Compressive Strength)
- JCS (Joint Compressive Strength)
- Resistivity
- Clay content
- Water content
- Density

Matrix and pore's content ?



Axis 1: 47%

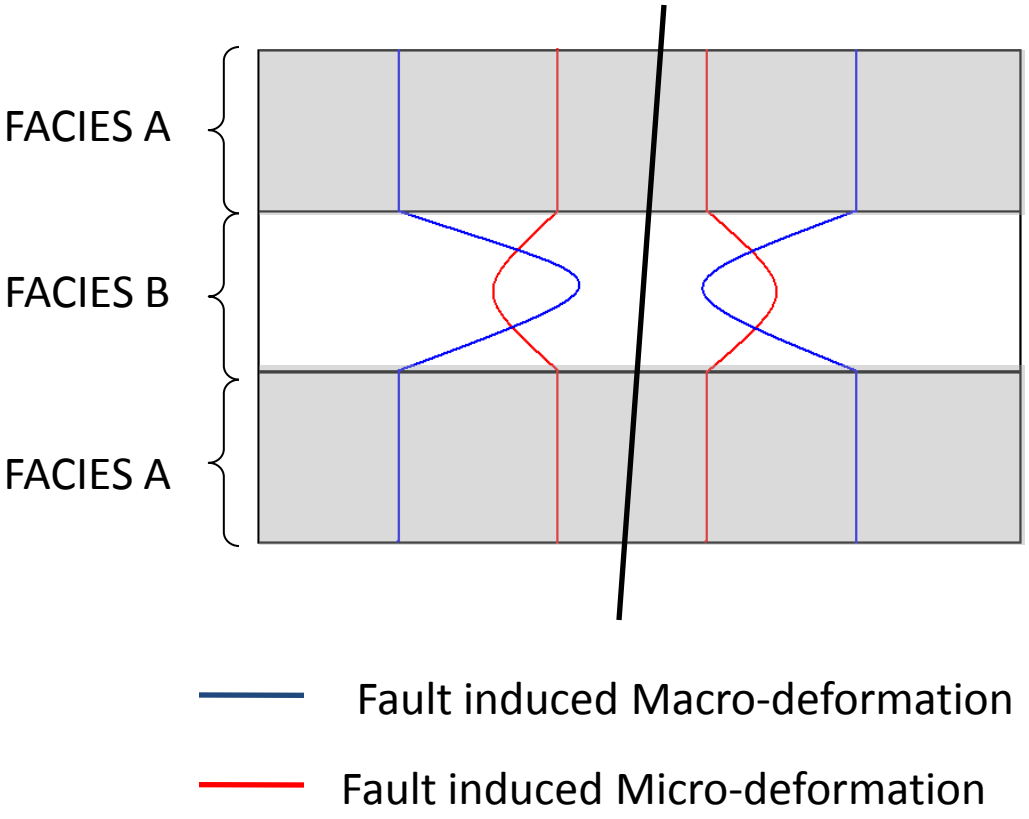
Fault influence



Axis 2: 20%

Sedimentary facies influence

CONCLUSION


FACIES A
FACIES B
FACIES A
Fault induced Macro-deformation
Fault induced Micro-deformation