

Fracture distribution within a carbonate-hosted relay ramp: insights from the Tre Monti fault (Central Italy)

Mercuri, M.¹, Carminati, E.¹, Tartarello, M. C.¹, Brandano, M.¹, Mazzanti, P.^{1,2}, Brunetti, A.², McCaffrey, K. J. W.³, Collettini, C.¹



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4-8 May 2020



Factors controlling fracture distribution

Distance from the main fault

Damage zone

Fault core

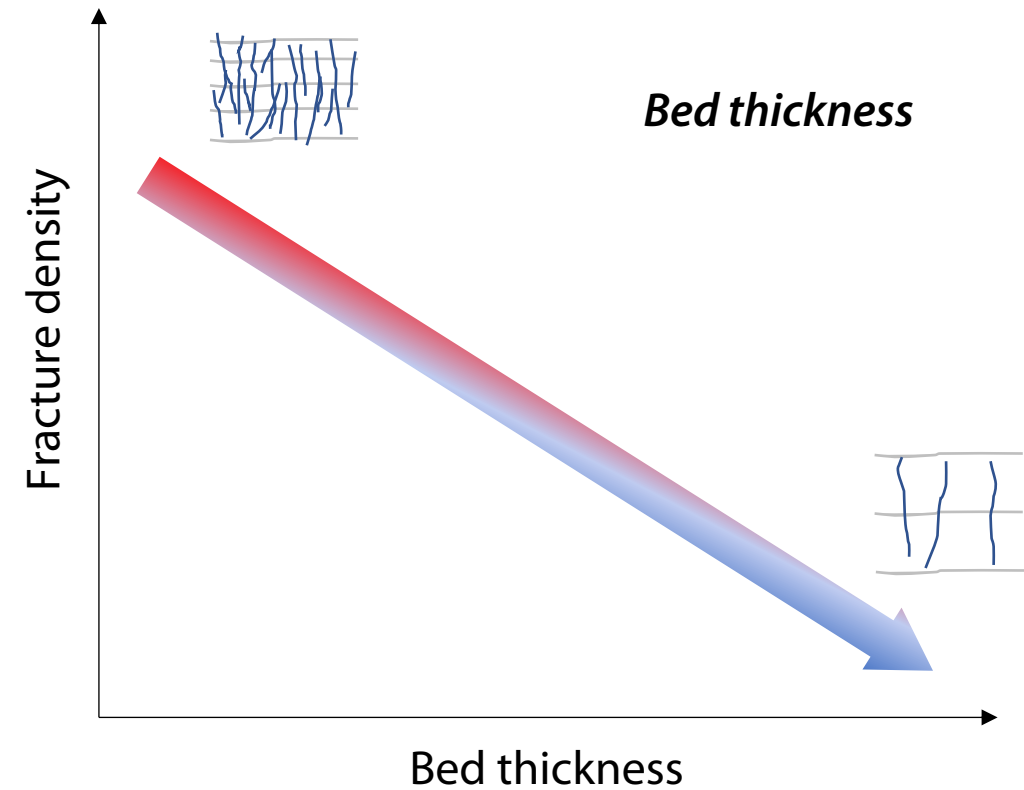
Subsidiary fault

fracture
density

permeability

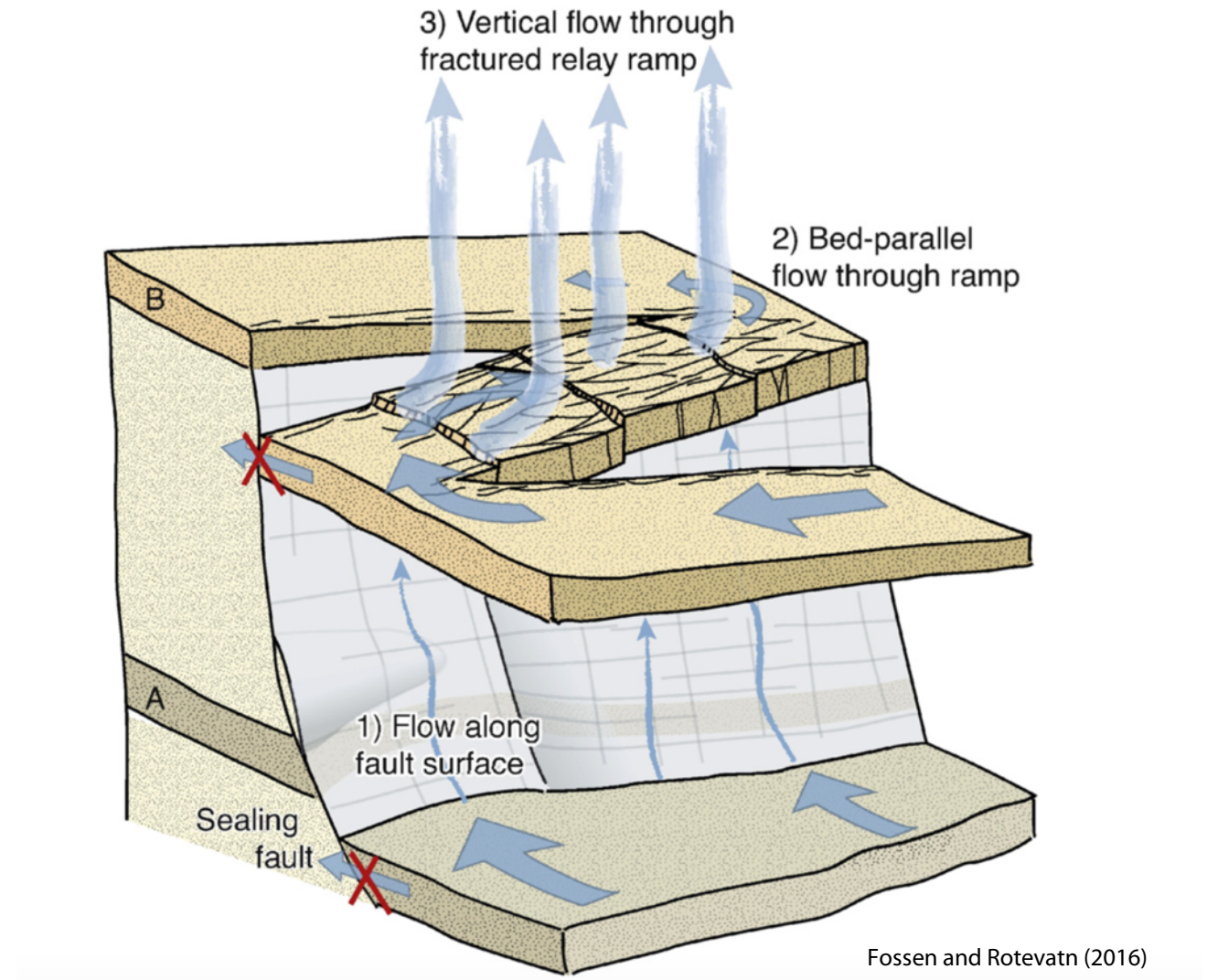
Faulkner et al. (2010)

Understanding factors controlling **fracture distribution** can help to better assess **fluid migration** within fault zones.



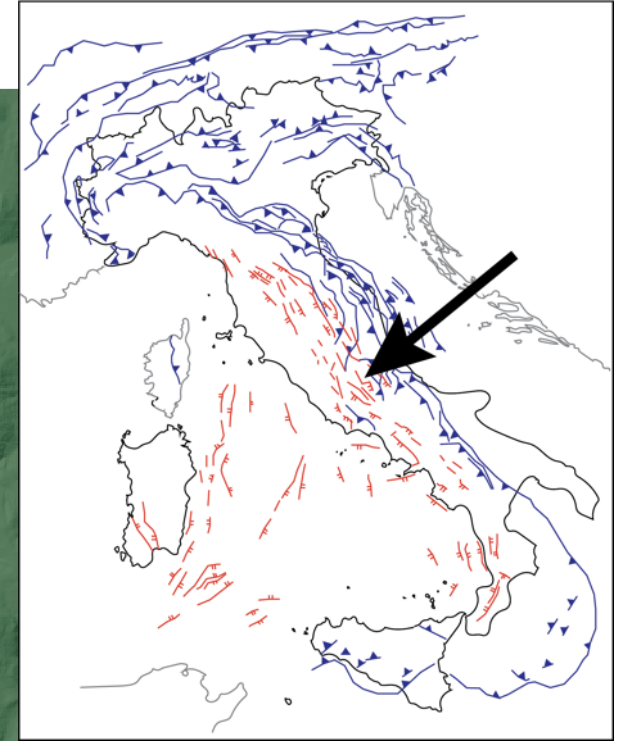
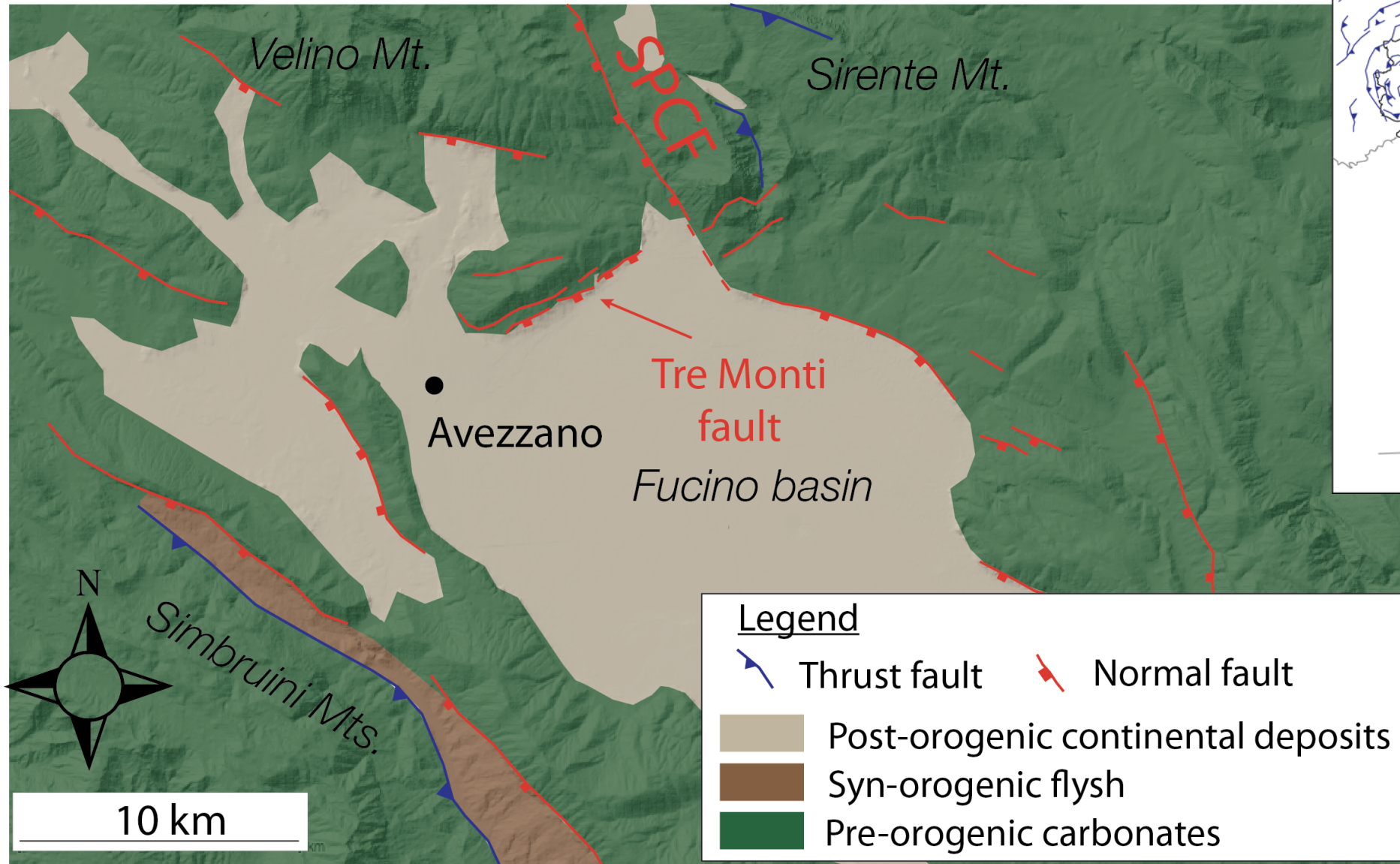
Relay ramps

Zones of interaction between fault segments (e.g., **relay ramps**) can be very important for fluid migration and/or intrapment



Tre Monti fault

The Tre Monti fault borders the Fucino basin to NW



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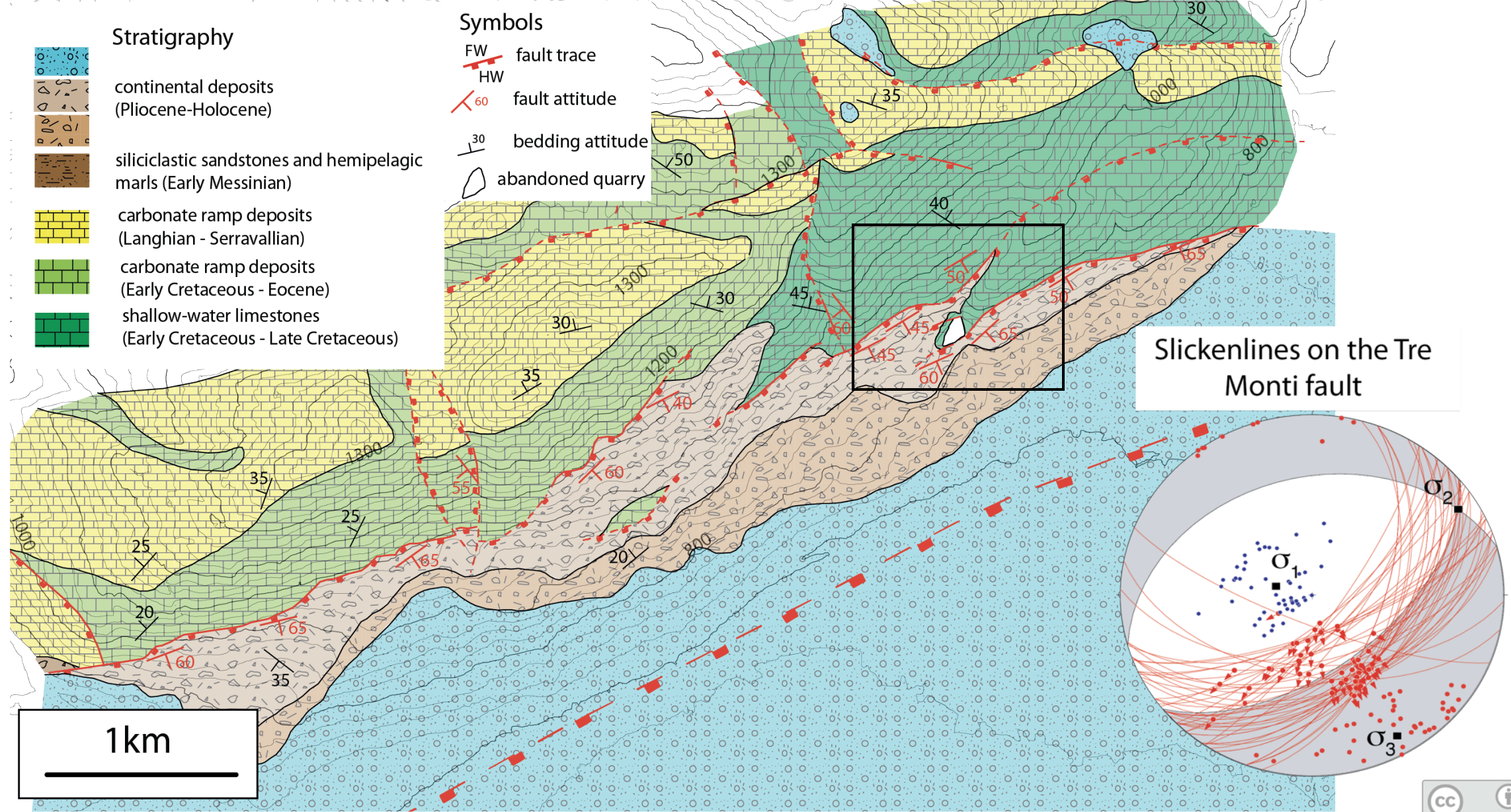
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Tre Monti fault

The slickenlines on the main fault scarps indicate dip-slip kinematics



Study outcrop



Stratigraphy

continental deposits
(Pliocene-Holocene)

siliciclastic sandstones and hemipelagic
marls (Early Messinian)

carbonate ramp deposits
(Langhian - Serravallian)

Symbols

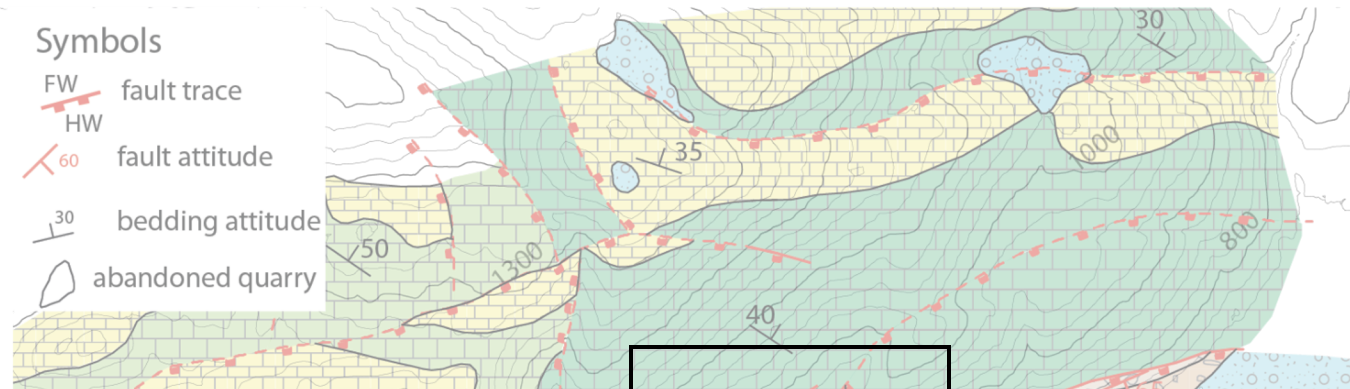
FW fault trace

HW

60 fault attitude

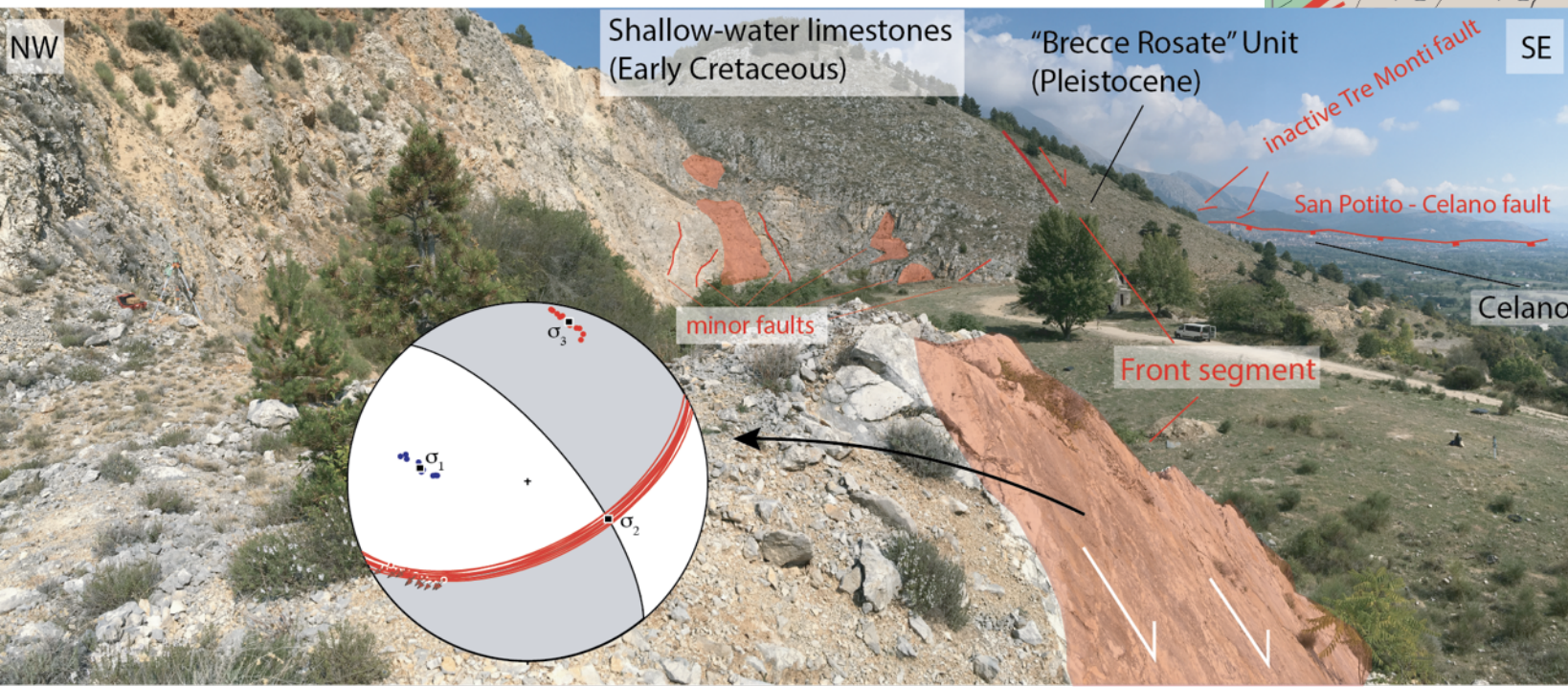
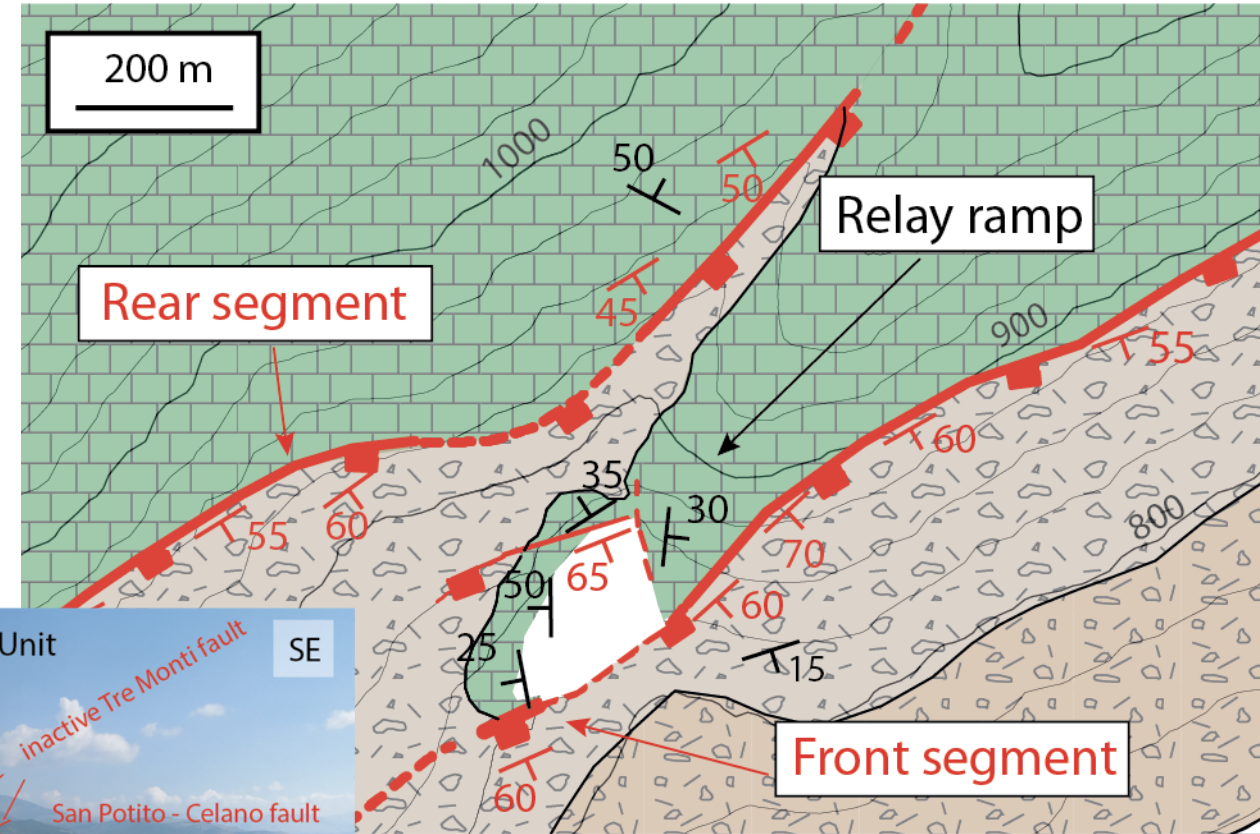
30 bedding attitude

abandoned quarry



Study outcrop

The study outcrop is located within **Lower Cretaceous peritidal limestones**



Peritidal facies

Supratidal facies:

grey to havana-brown poorly sorted grainstone with radial ooids and pisoids

Intertidal facies:

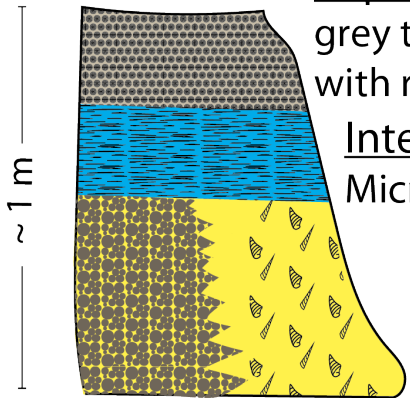
Microbial bindstones with birdseyes and fenestrae

Subtidal facies:

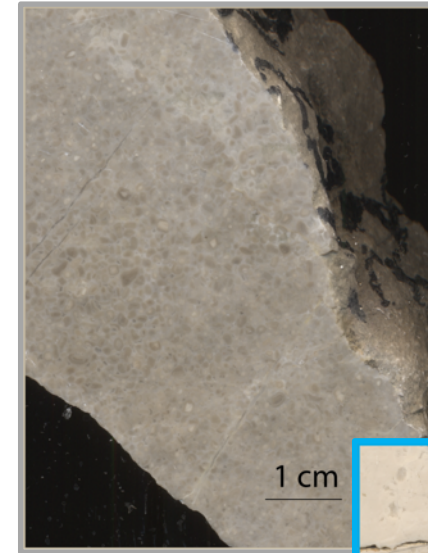
Peloidal packstones with oncoids

Rudstones with oncoids

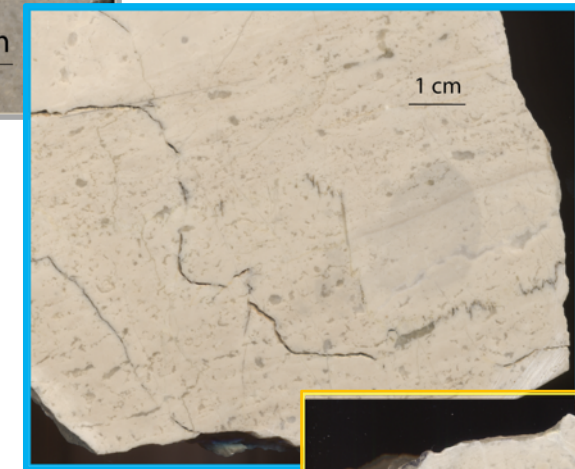
Floatstones with gastropods



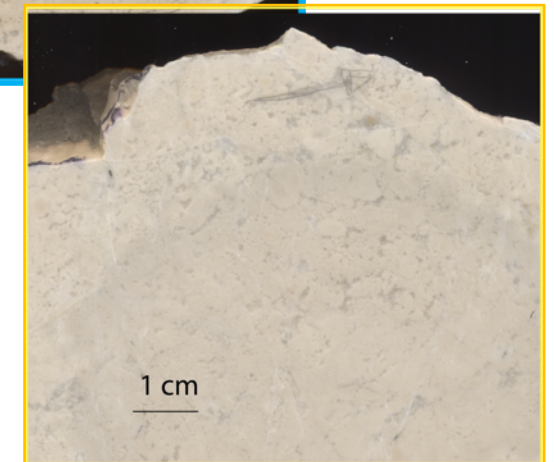
The study outcrop is located within **Lower Cretaceous peritidal limestones**



supratidal



intertidal



subtidal

1 cm

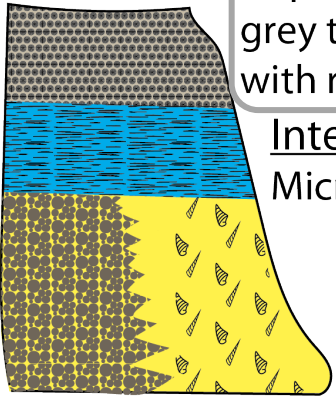
1 cm

1 cm

1 cm

Peritidal facies

~ 1 m



Supratidal facies:

grey to havana-brown poorly sorted grainstone with radial ooids and pisoids

Intertidal facies:

Microbial bindstones with birdseyes and fenestrae

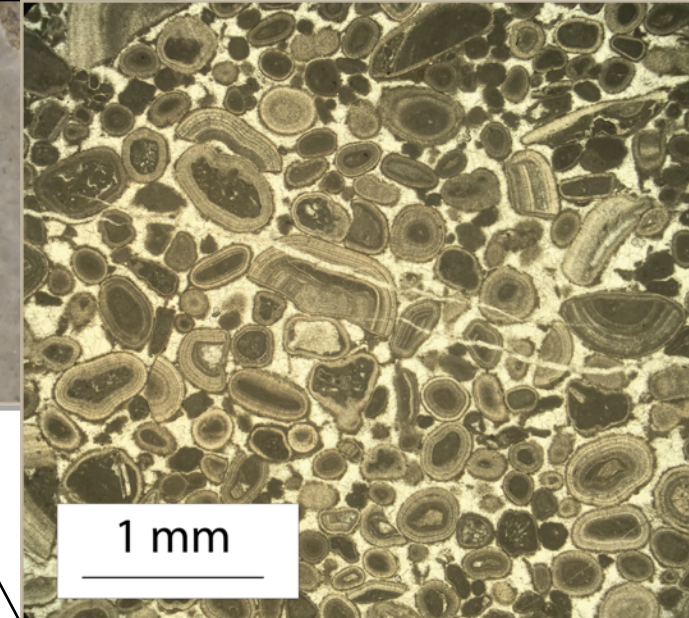
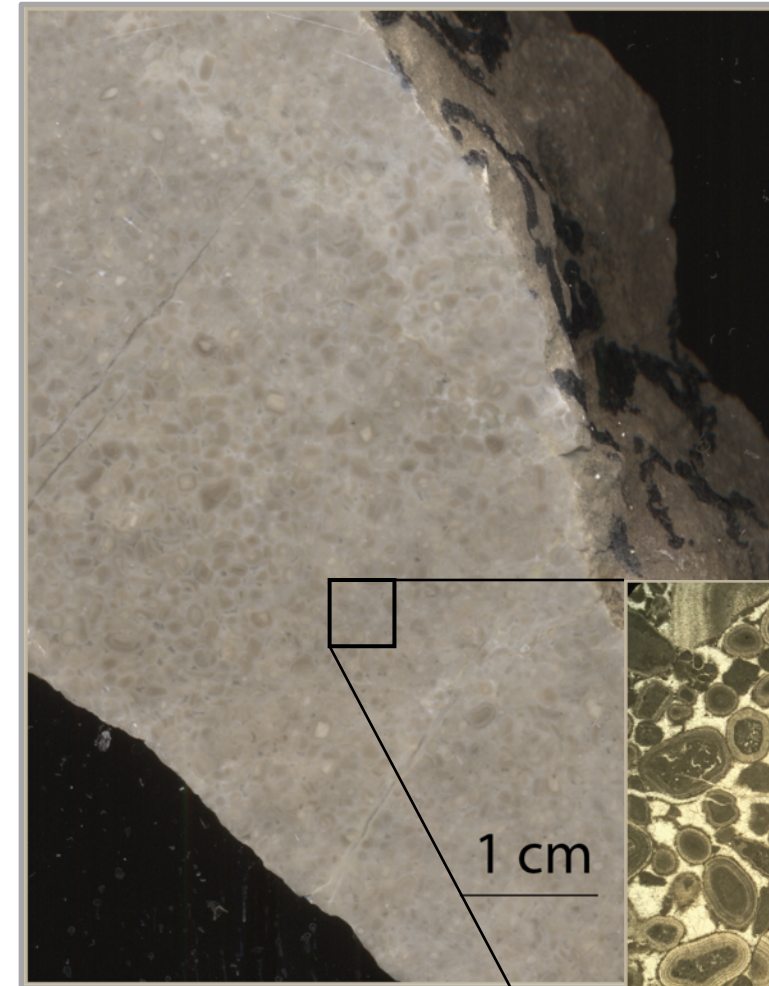
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Rudstones with oncoids

Floatstones with gastropods

The study outcrop is located within **Lower Cretaceous peritidal limestones**



Peritidal facies

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Intertidal facies:

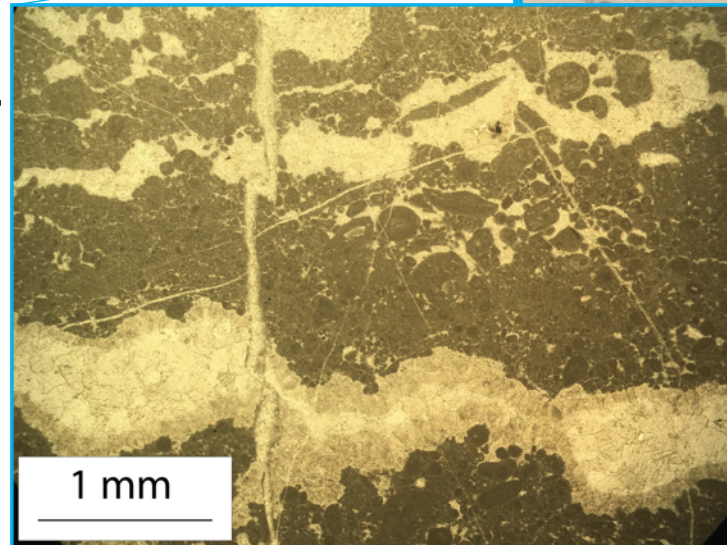
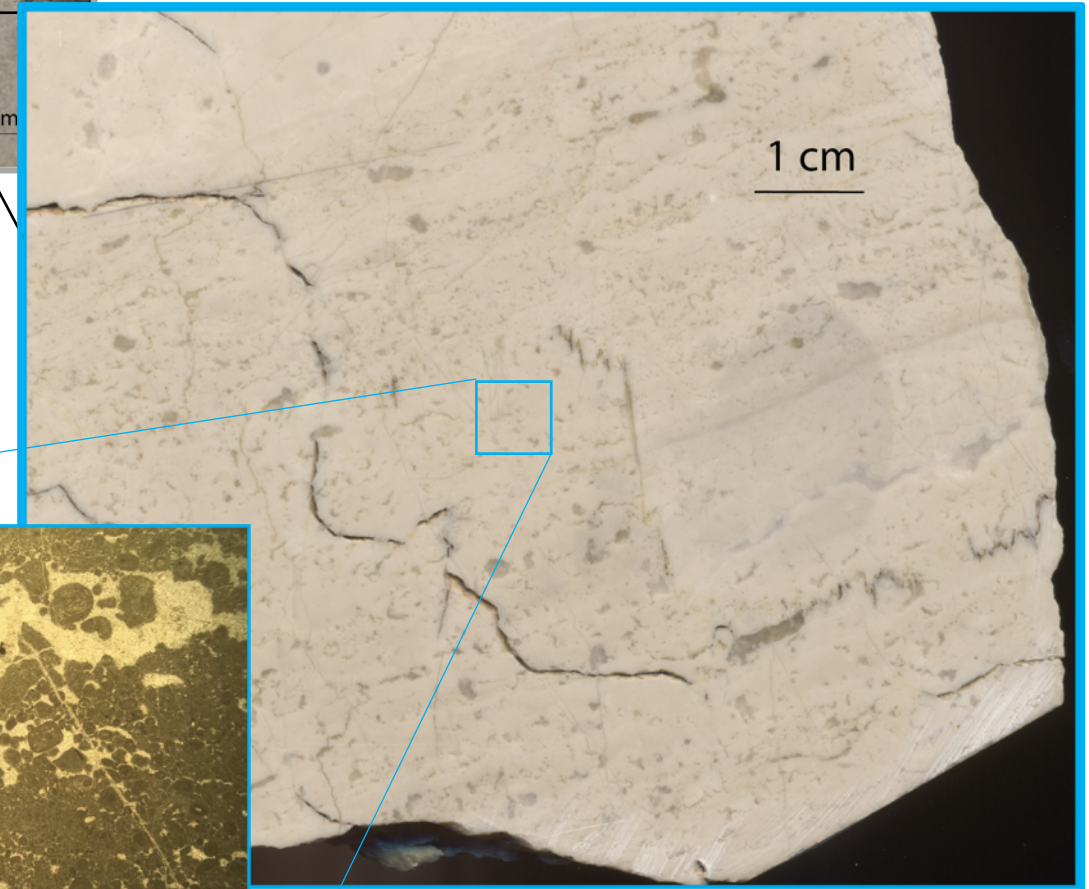
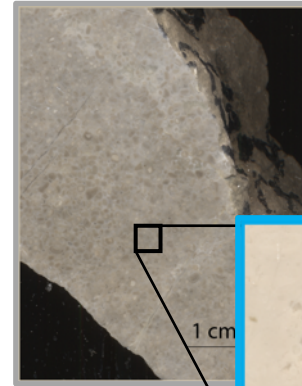
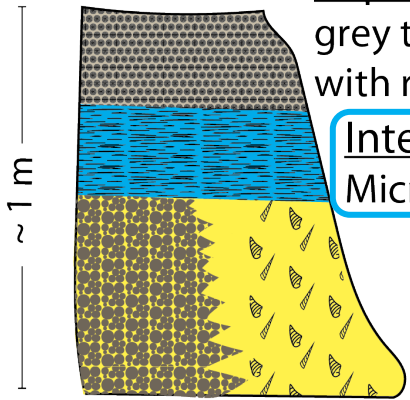
Microbial bindstones with birdseyes and fenestrae

Subtidal facies:

Peloidal packstones with oncoids

Rudstones with oncoids

Floatstones with gastropods



The study outcrop is located within **Lower Cretaceous peritidal limestones**

Peritidal facies

Supratidal facies:

grey to havana-brown poorly sorted grainstone with radial ooids and pisoids

Intertidal facies:

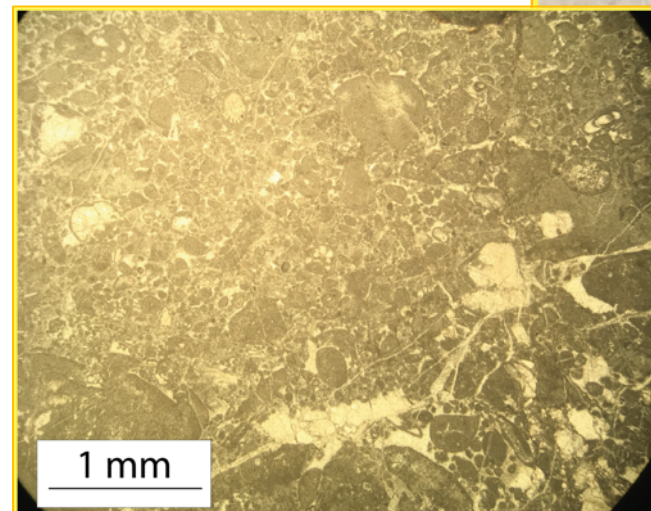
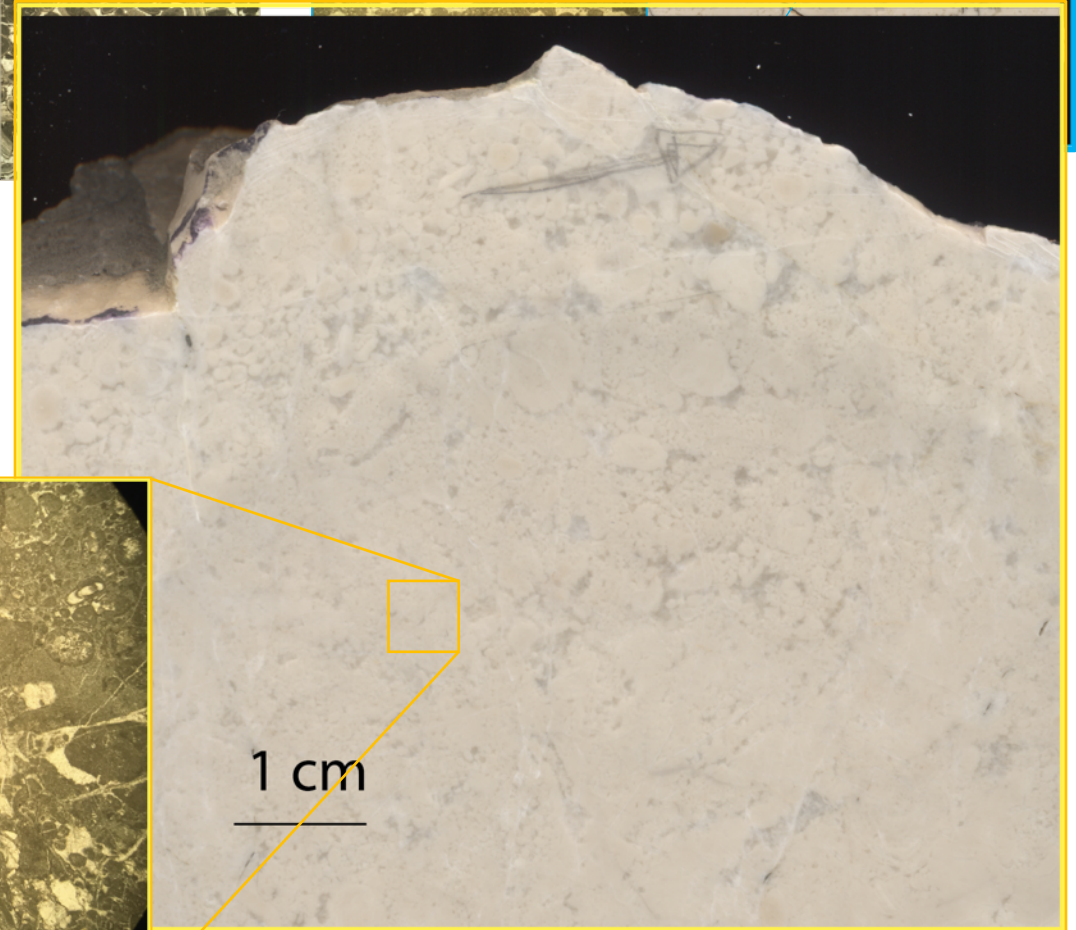
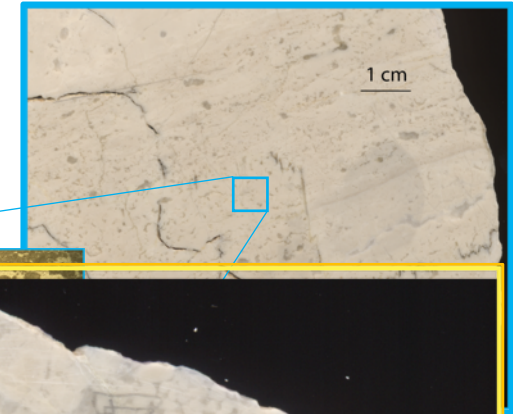
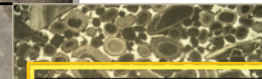
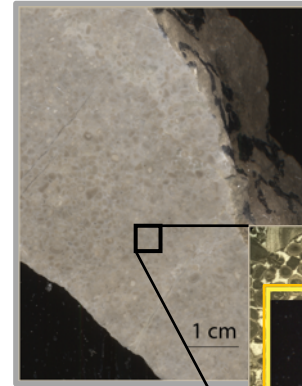
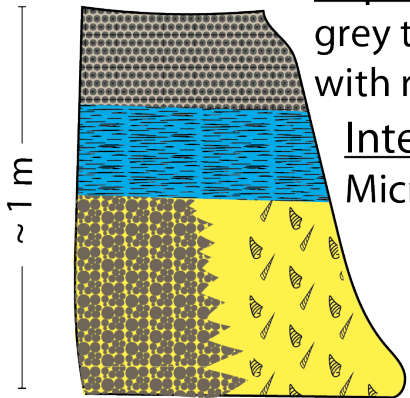
Microbial bindstones with birdseyes and fenestrae

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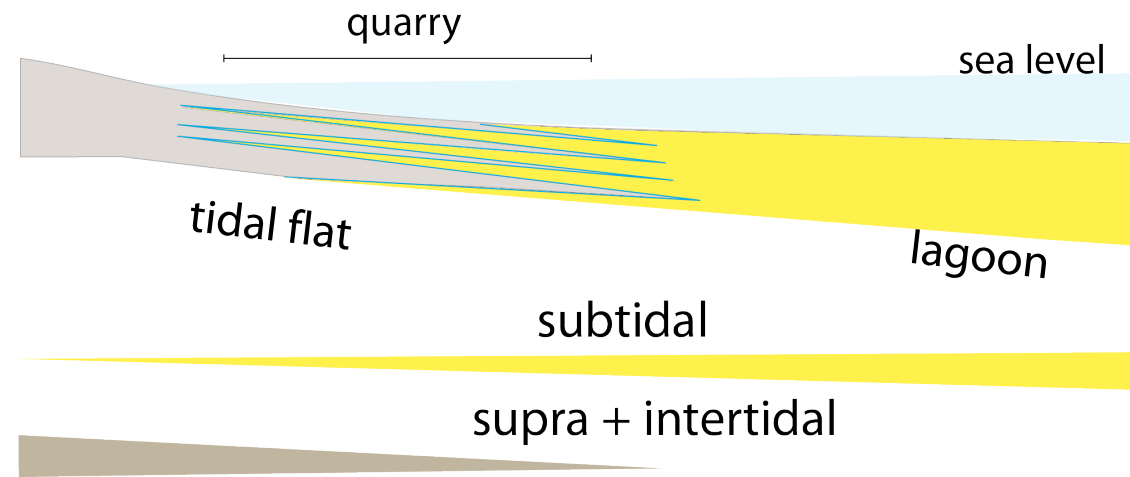
Floatstones with gastropods



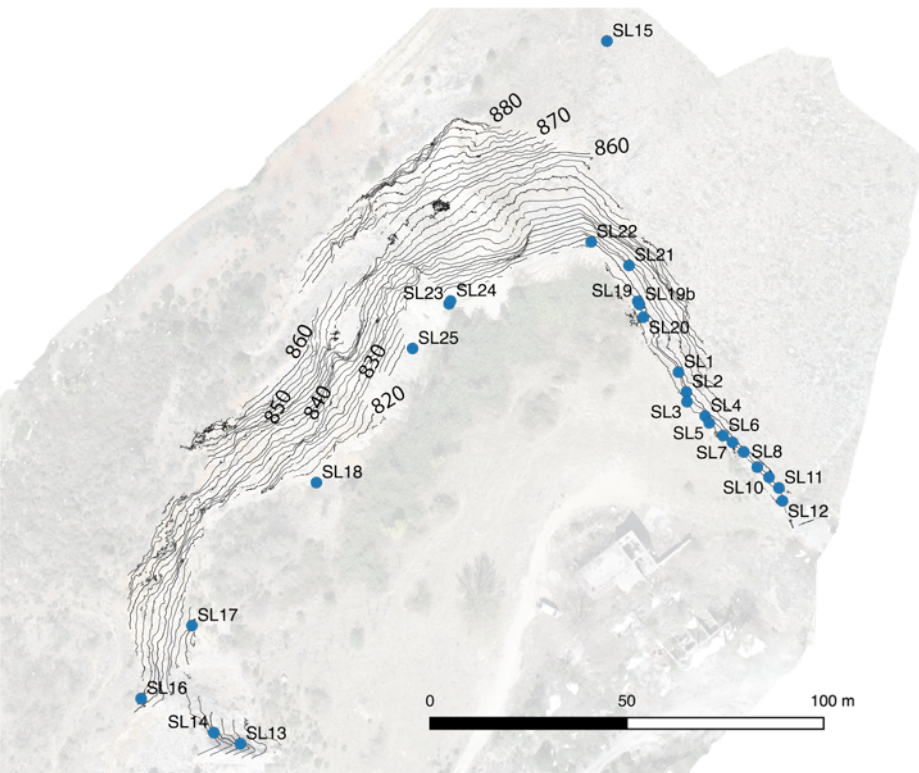
The study outcrop is located within **Lower Cretaceous peritidal limestones**

Peritidal facies

The study outcrop is located within **Lower Cretaceous peritidal limestones**

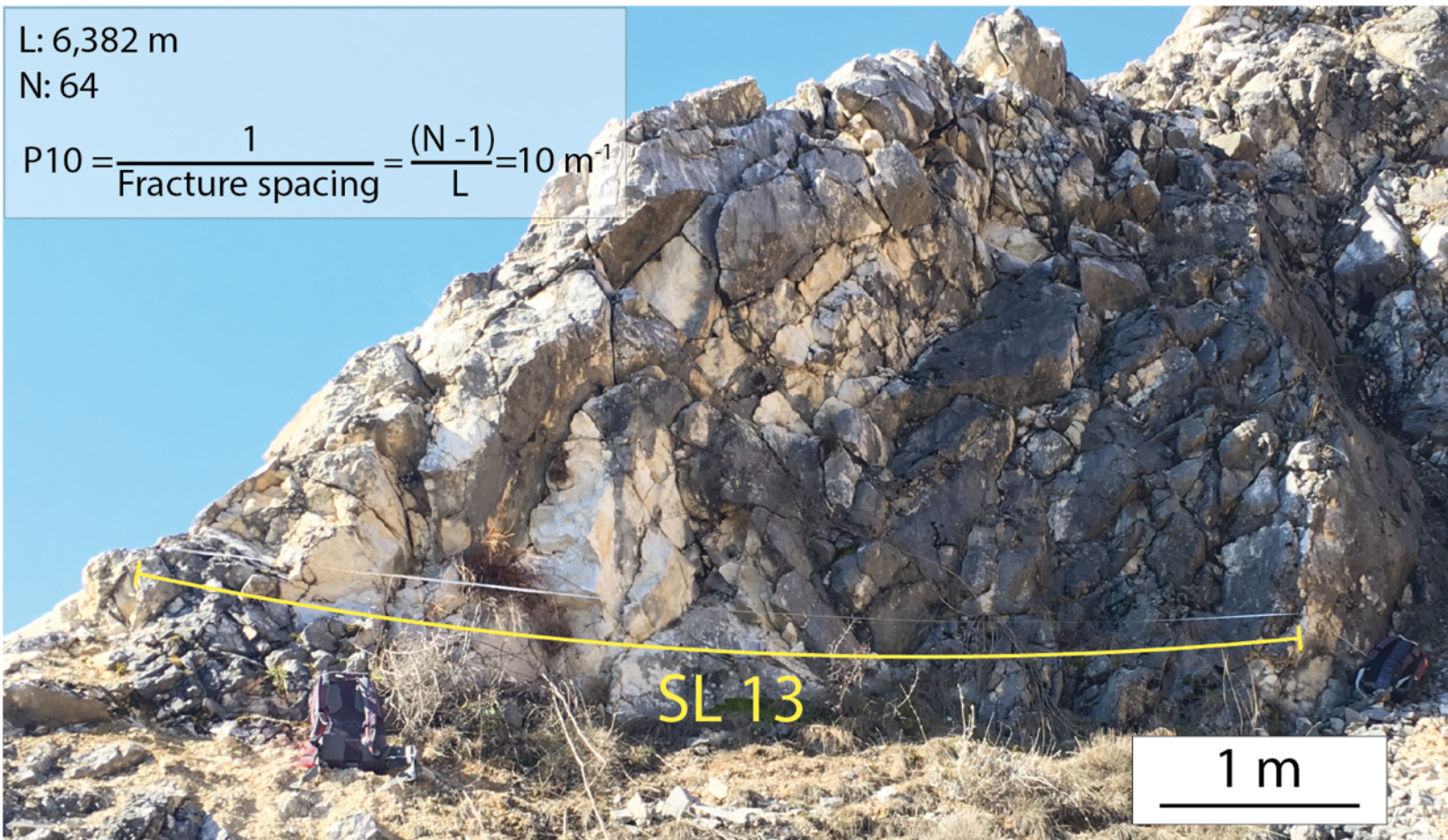


1) Scanlines



- Orientation
- Frequency
- Predominant peritidal facies

1800 fracture data collected along 26 scanlines



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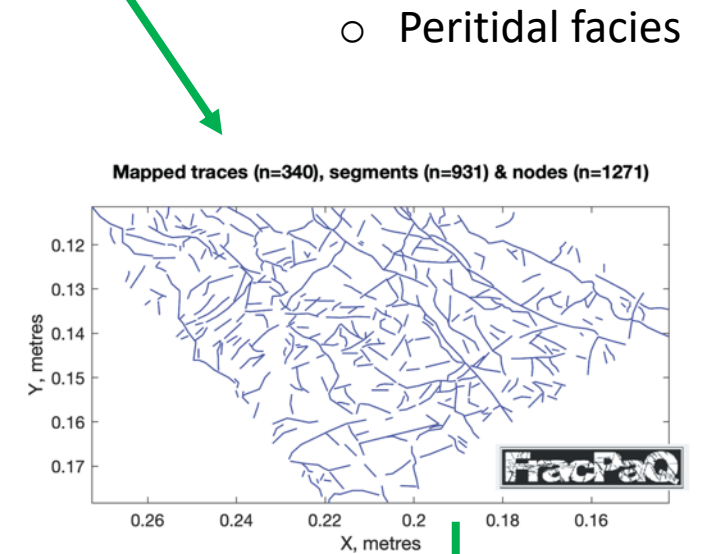
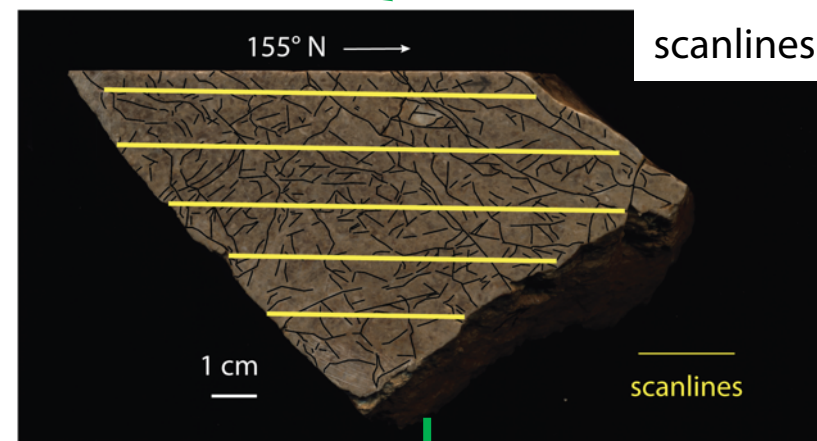
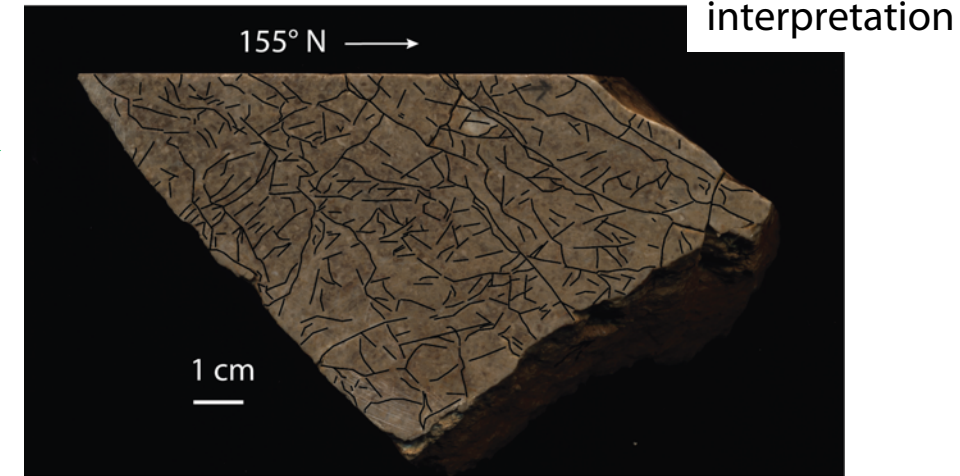
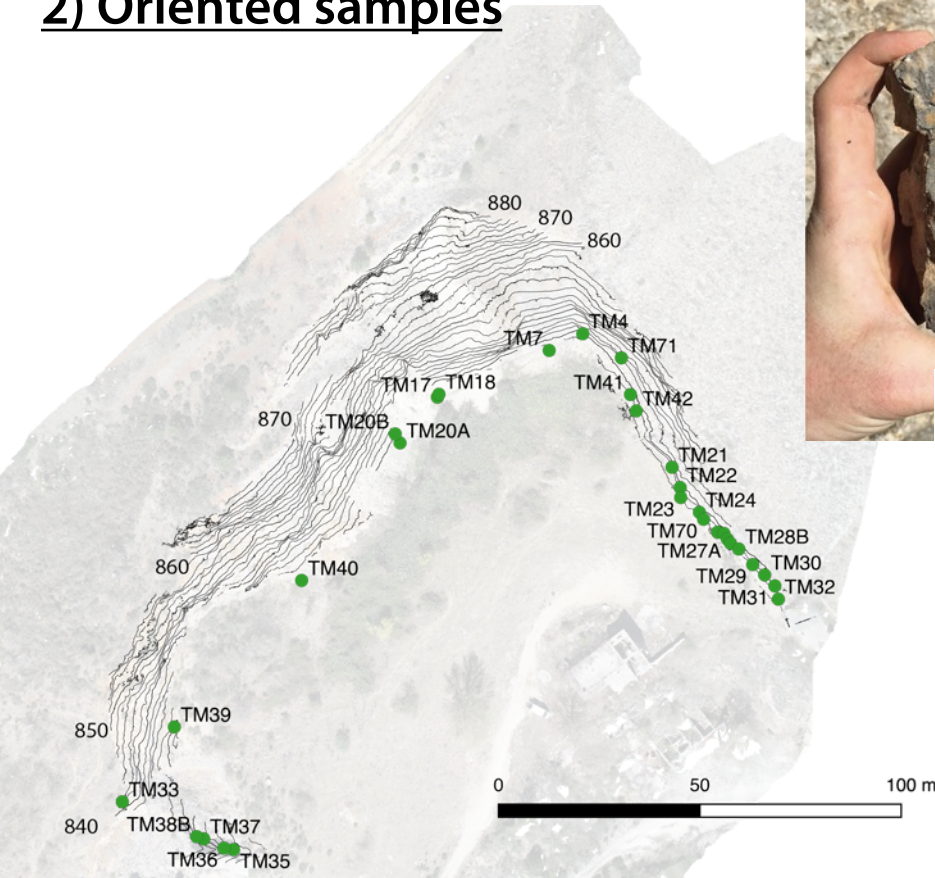
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2) Oriented samples



○ Linear fracture frequency (P10)

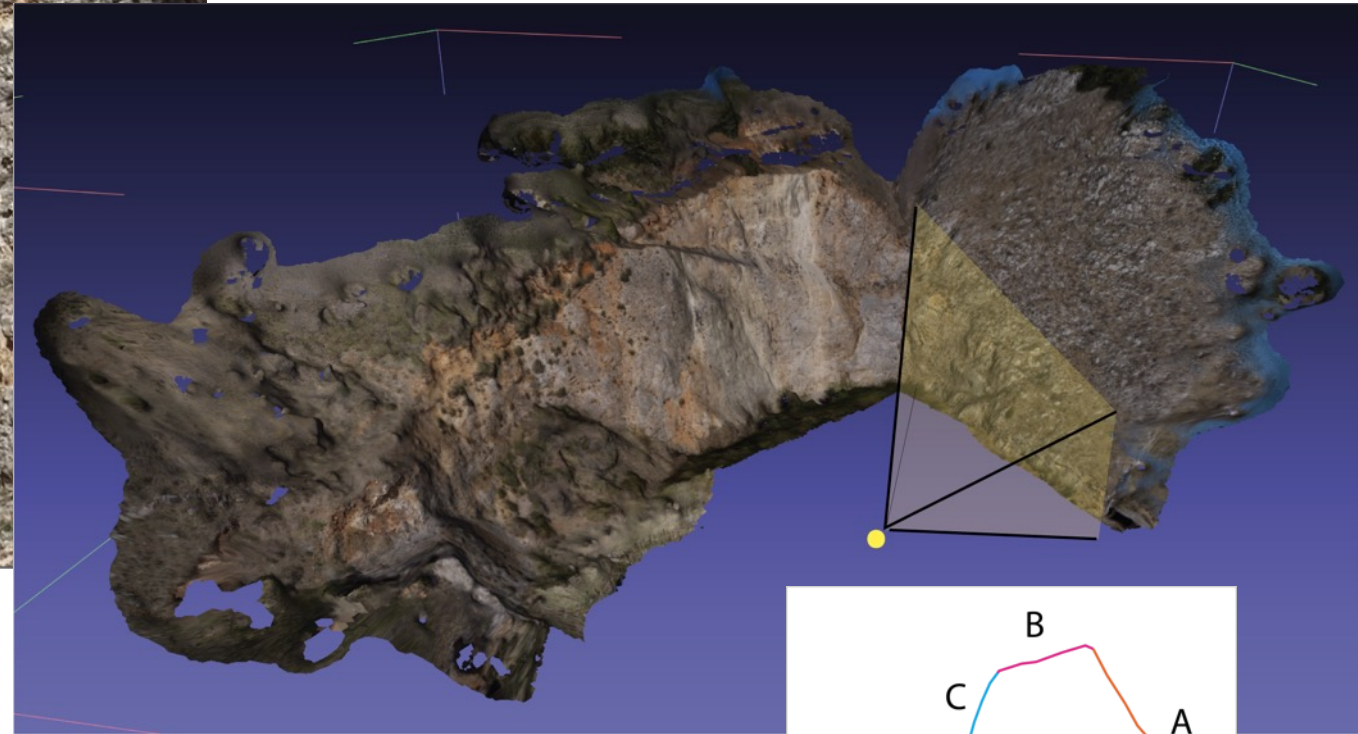
○ Areal fracture frequency (P20)

○ Fracture intensity

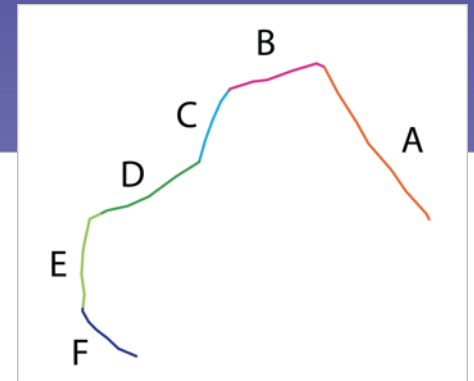
3) Virtual scan-areas



UAV-photogrammetry survey

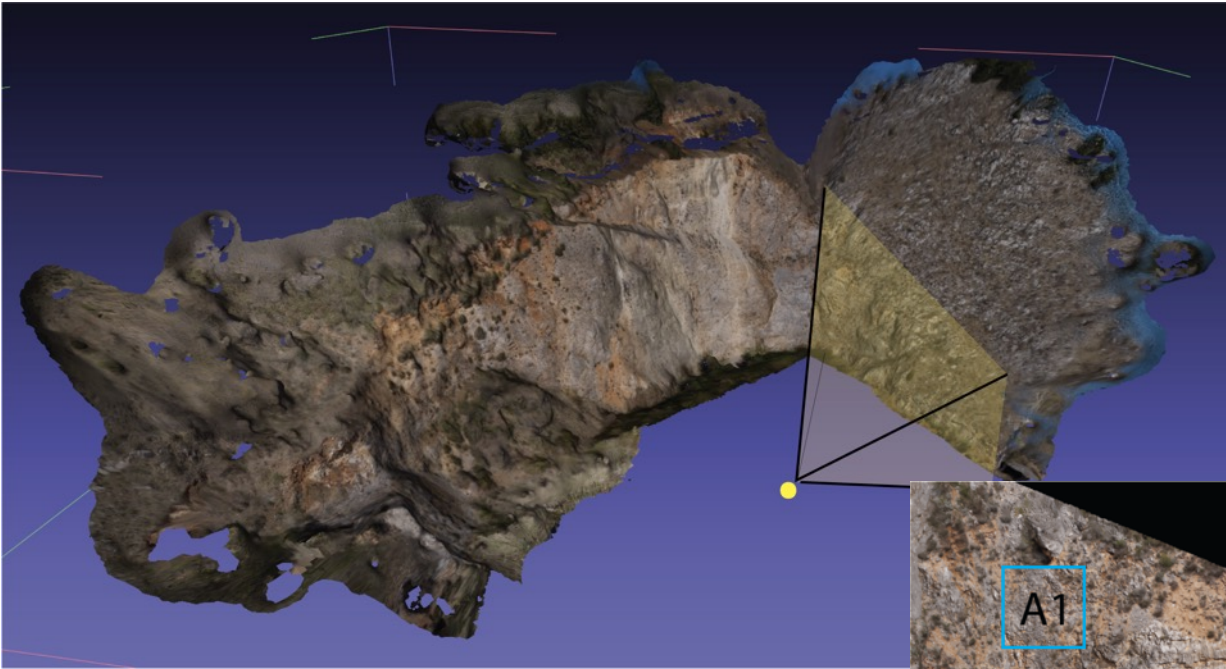


6 Ortho-mosaics

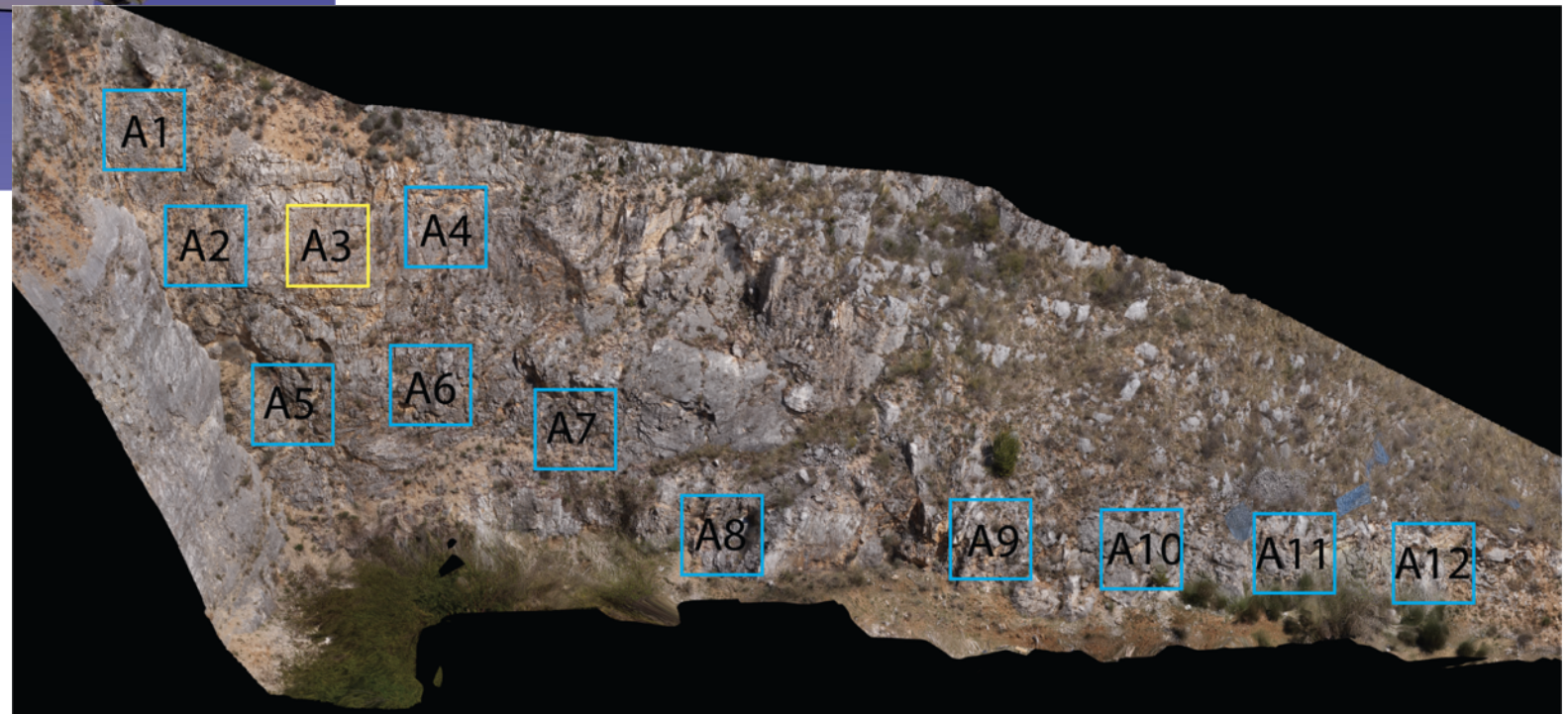
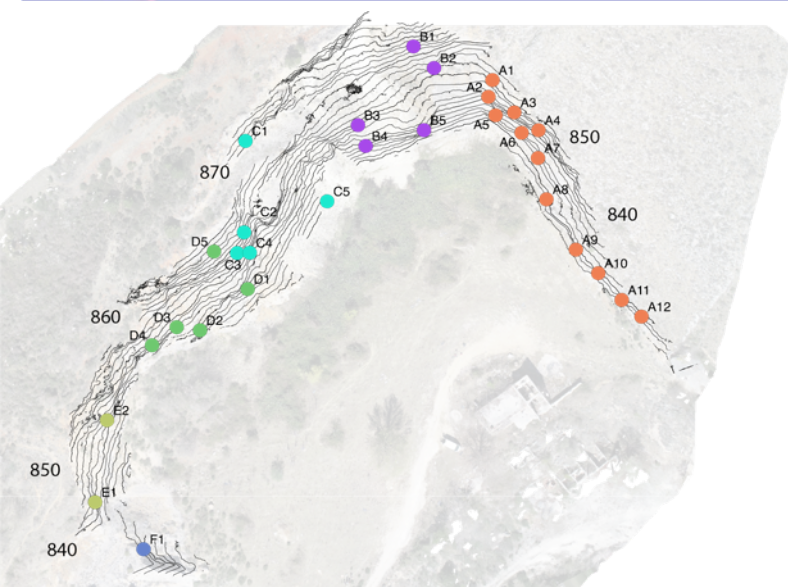




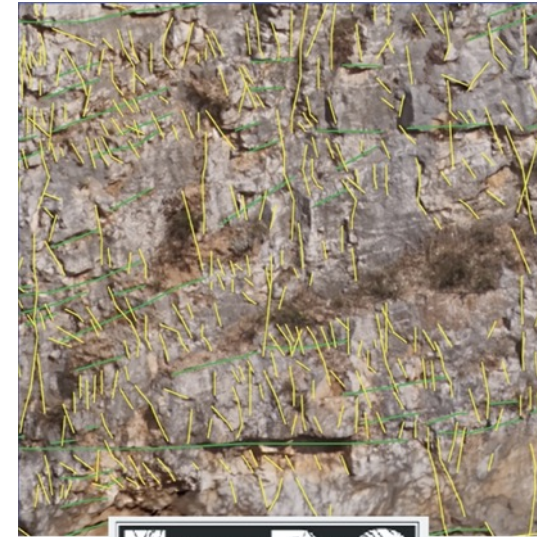
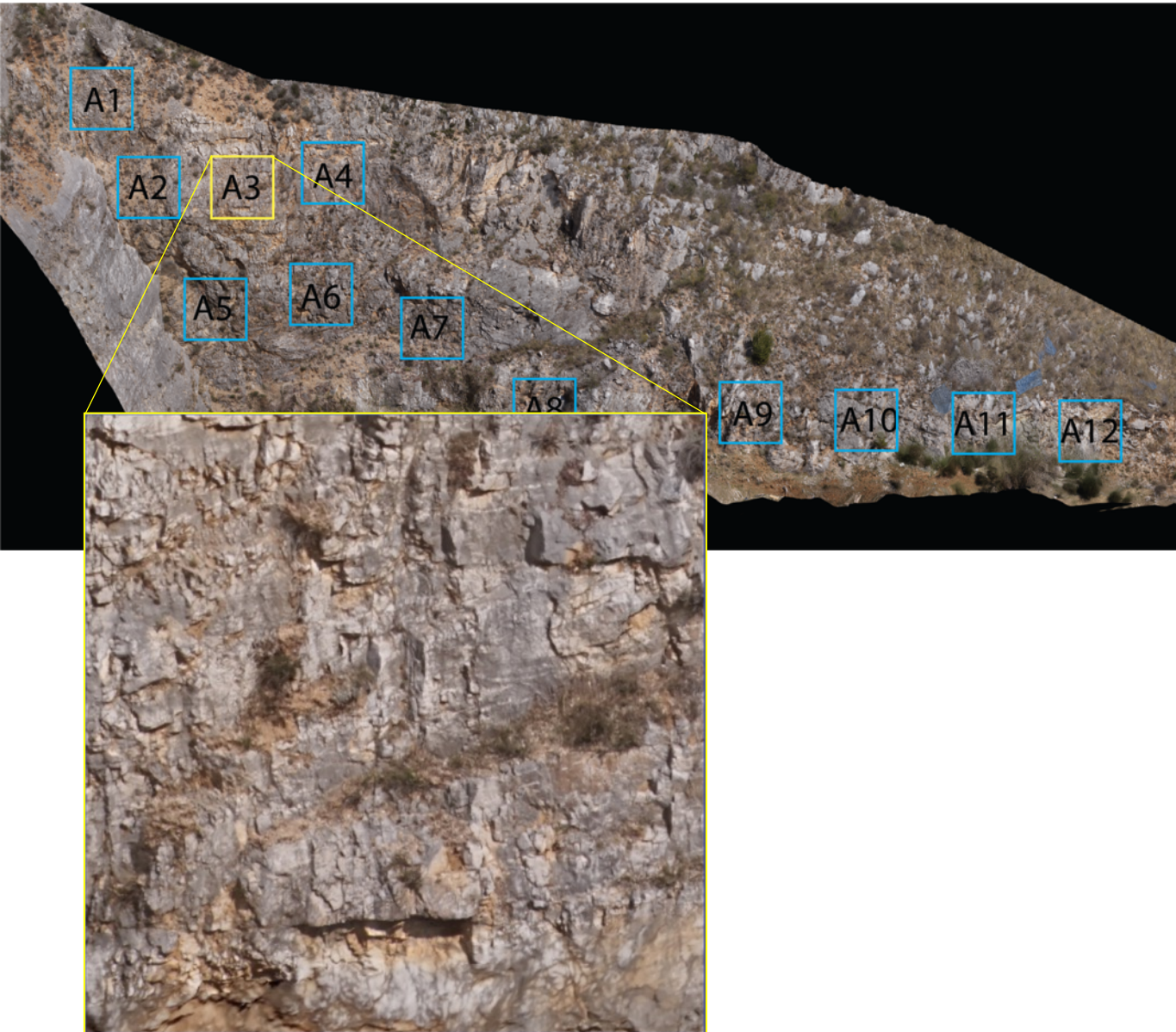
3) Virtual scan-areas



30 virtual scan-areas



3) Virtual scan-areas



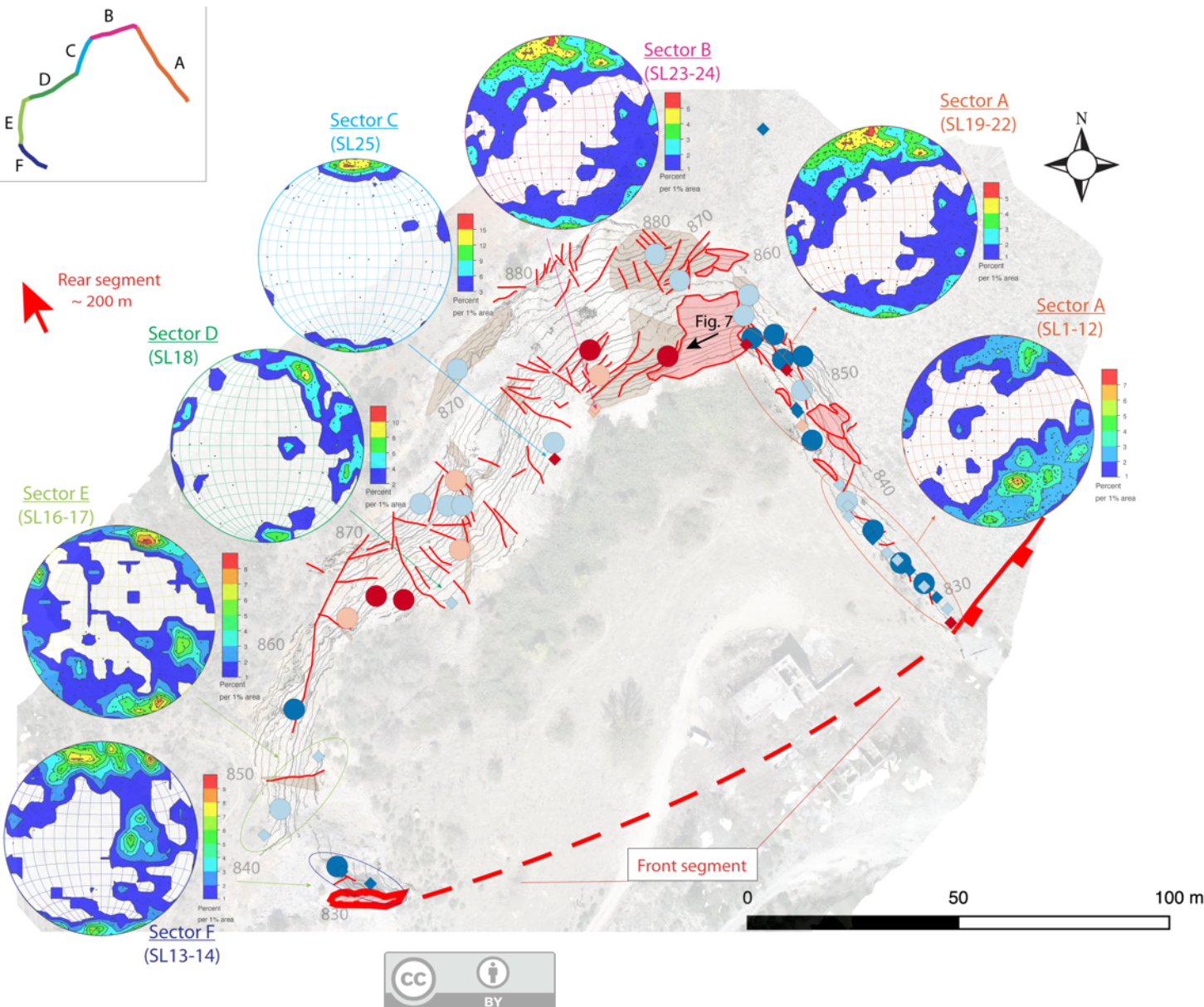
FracPaQ

Areal fracture frequency (P20)
Fracture intensity (P21)
Trace lengths

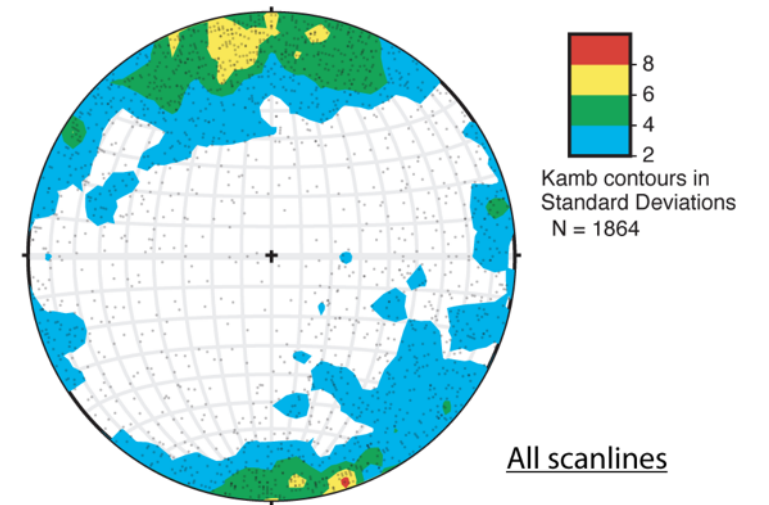


Supratidal facies
area

Fractures orientation and distribution



Fracture orientation is coherent with the fault kinematics

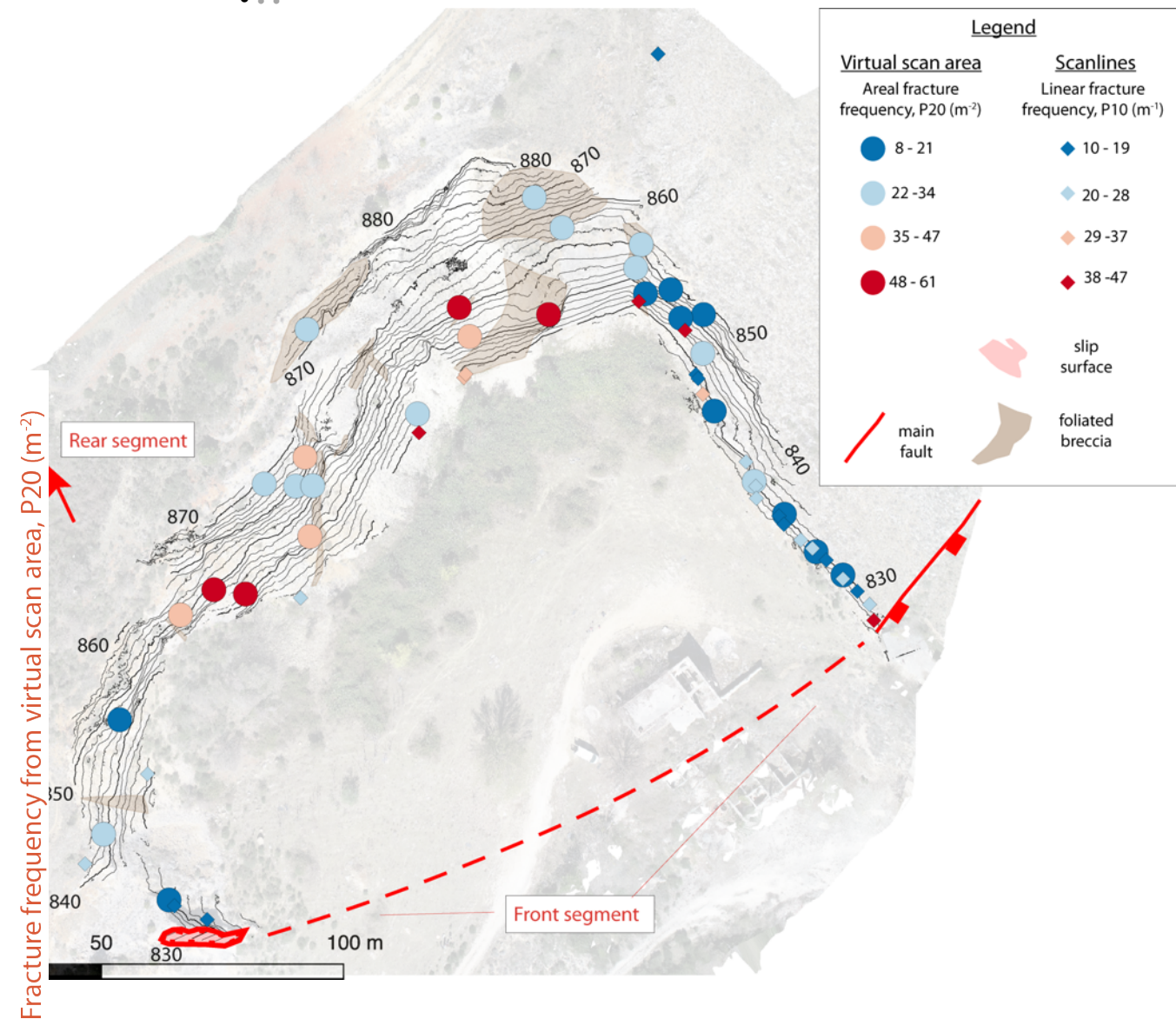
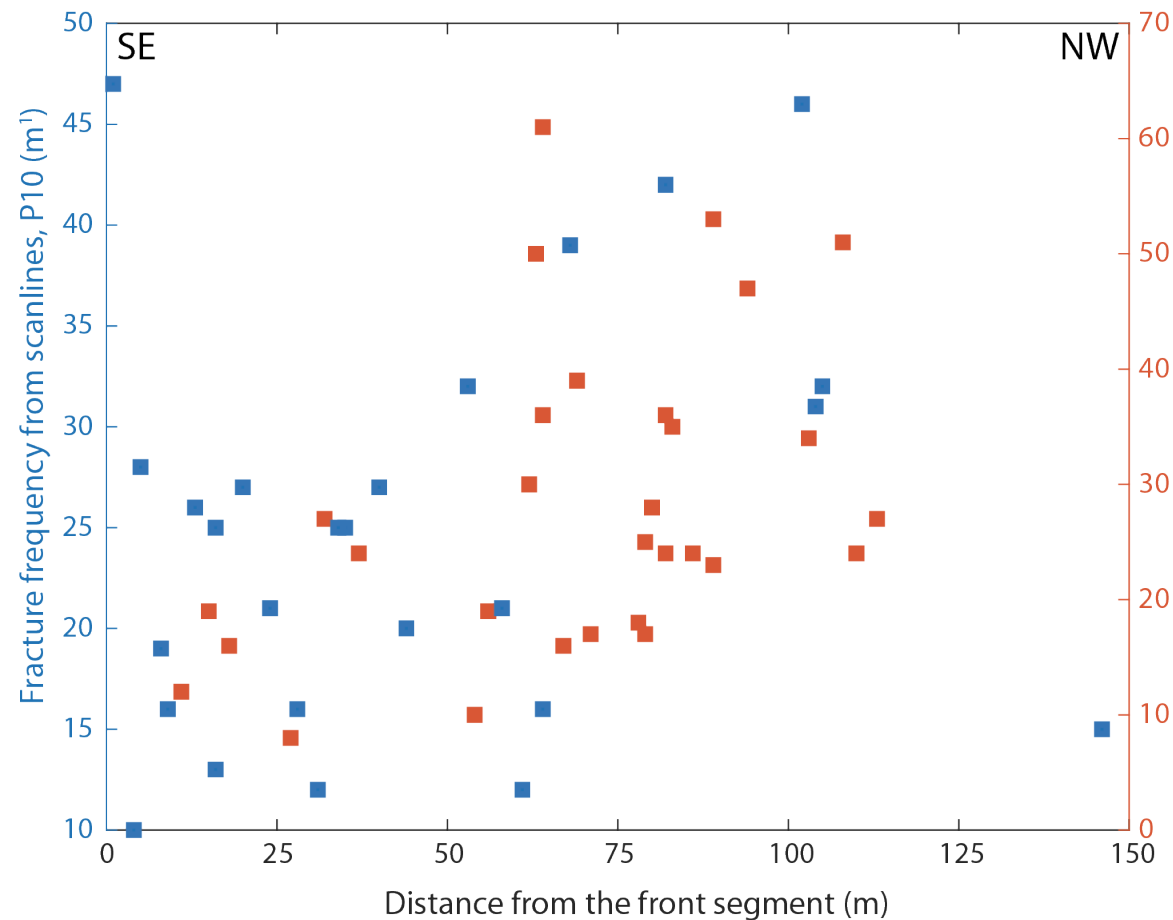


Legend

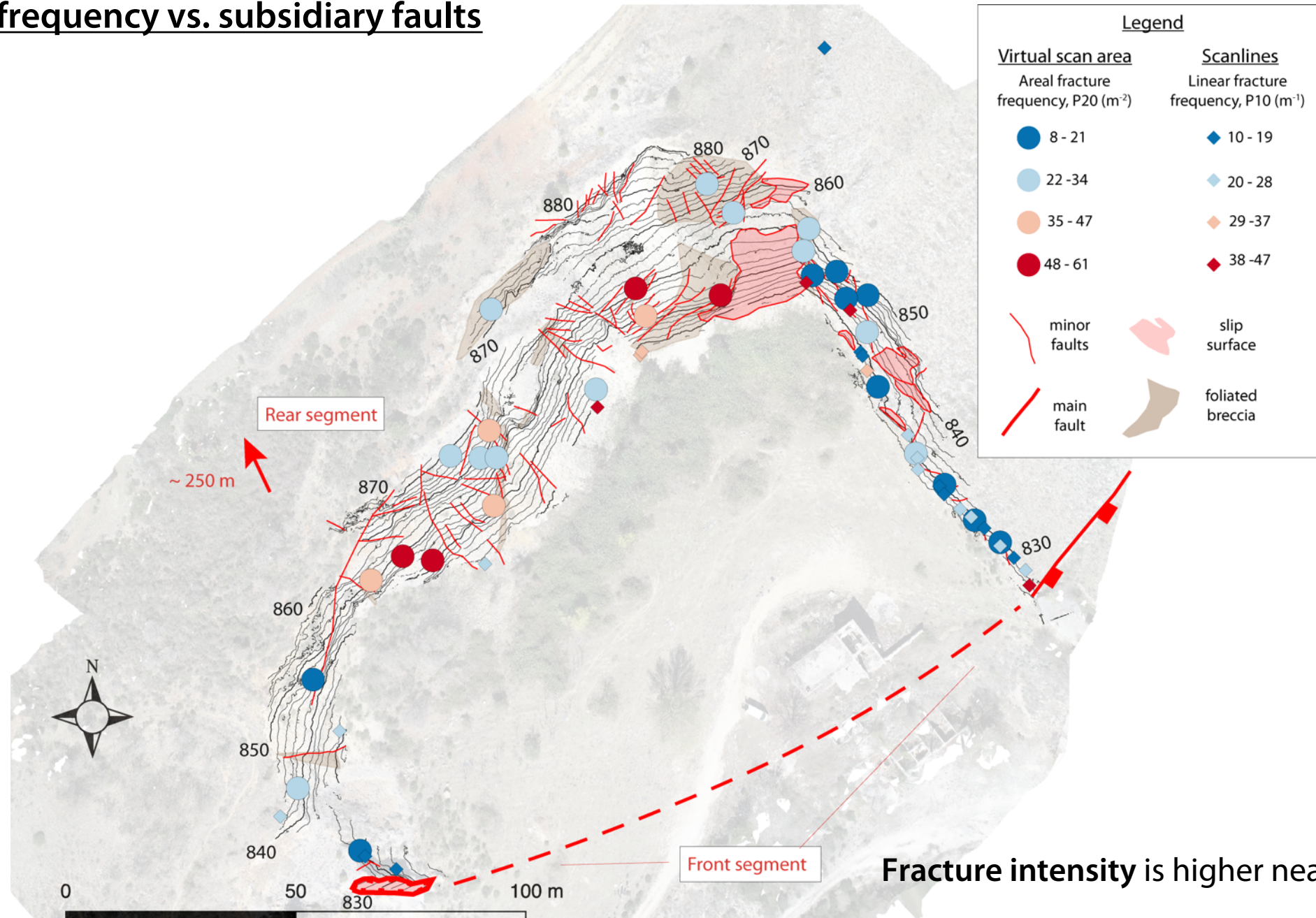
Virtual scan area	Scanlines			
Areal fracture frequency, P20 (m ⁻²)	Linear fracture frequency, P10 (m ⁻¹)		minor faults	slip surface
● 8 - 21	◆ 10 - 19			
● 22 - 34	◆ 20 - 28			
● 35 - 47	◆ 29 - 37			
● 48 - 61	◆ 38 - 47		main fault	foliated breccia

Fracture distribution

Fracture frequency increases with distance from the front segment of the relay ramp

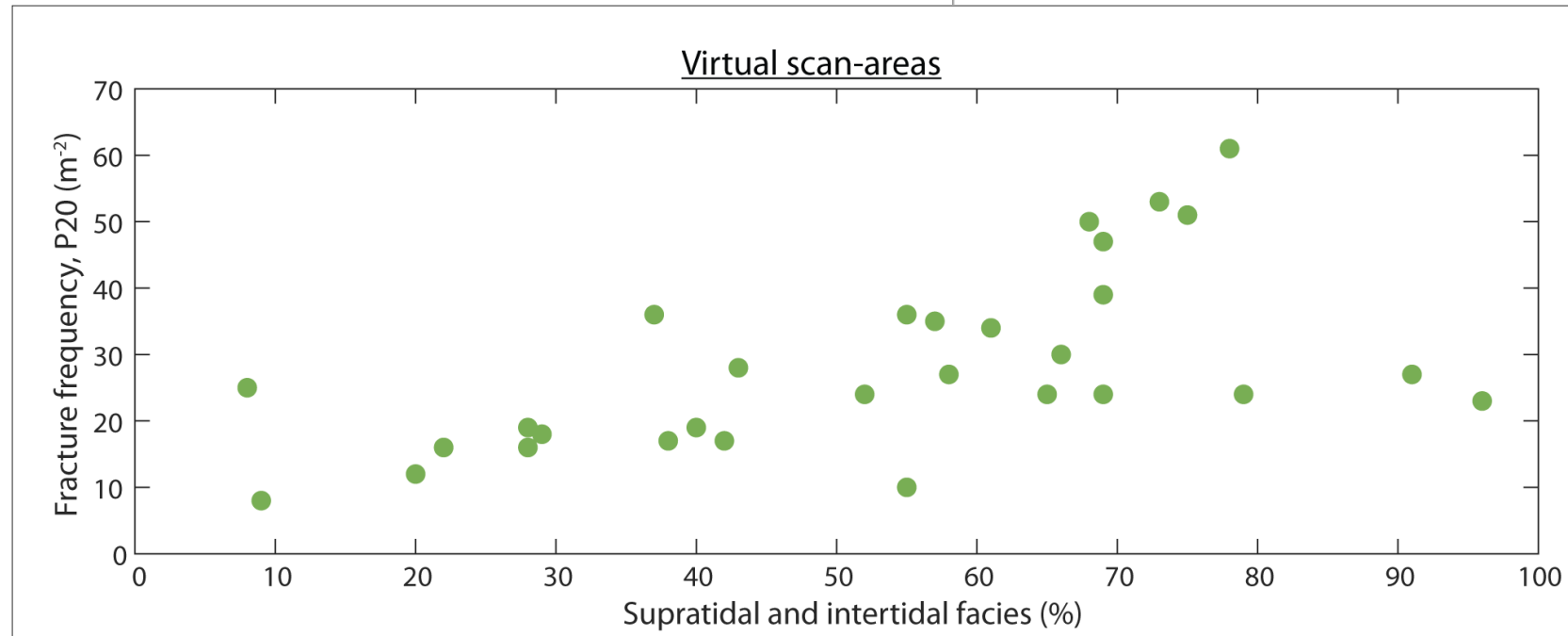
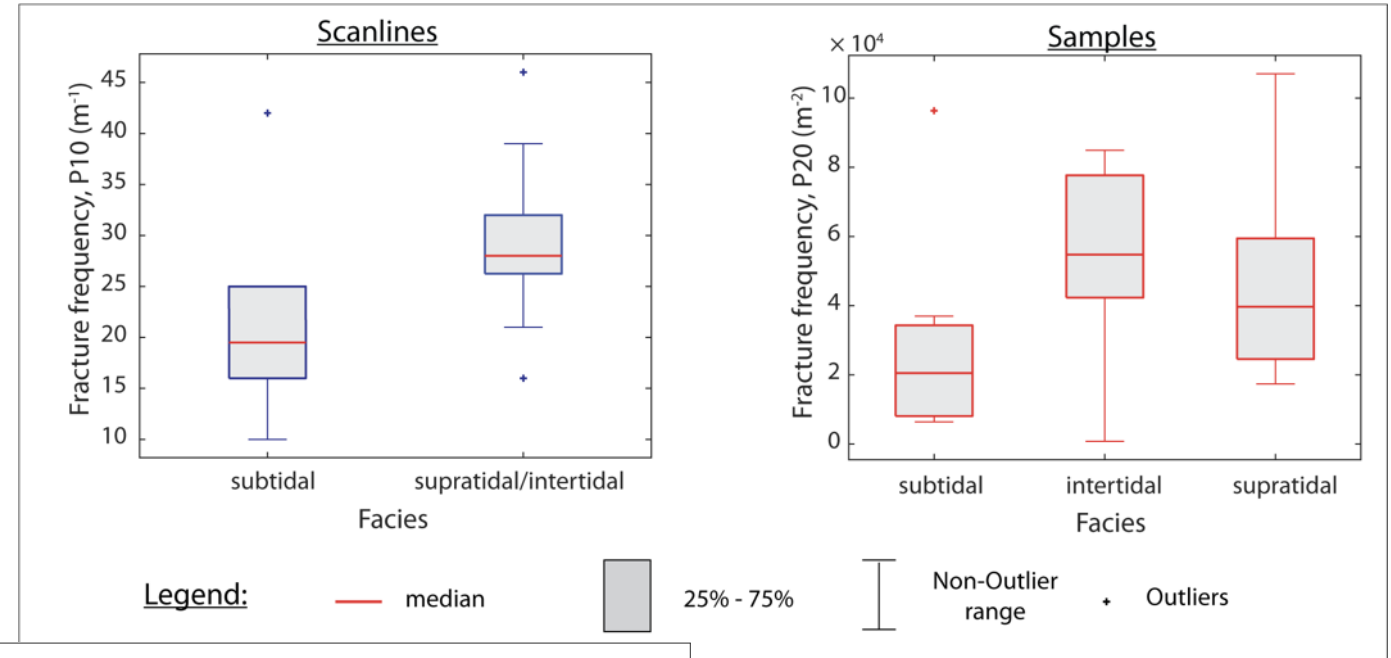


Fractures frequency vs. subsidiary faults

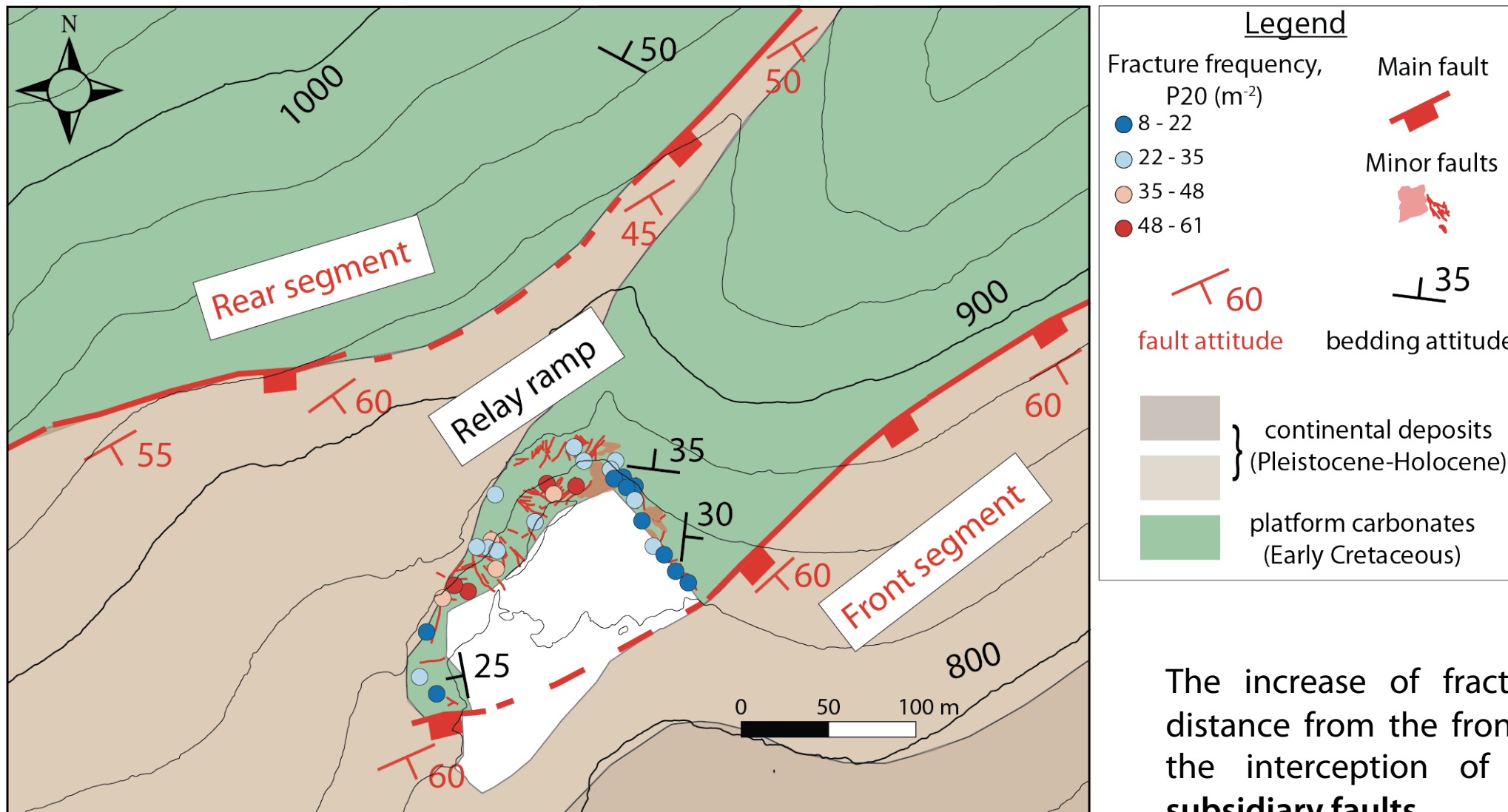


Fracture frequency vs. peritidal facies

Supratidal and intertidal facies
show **higher fracture frequency**
than subtidal facies

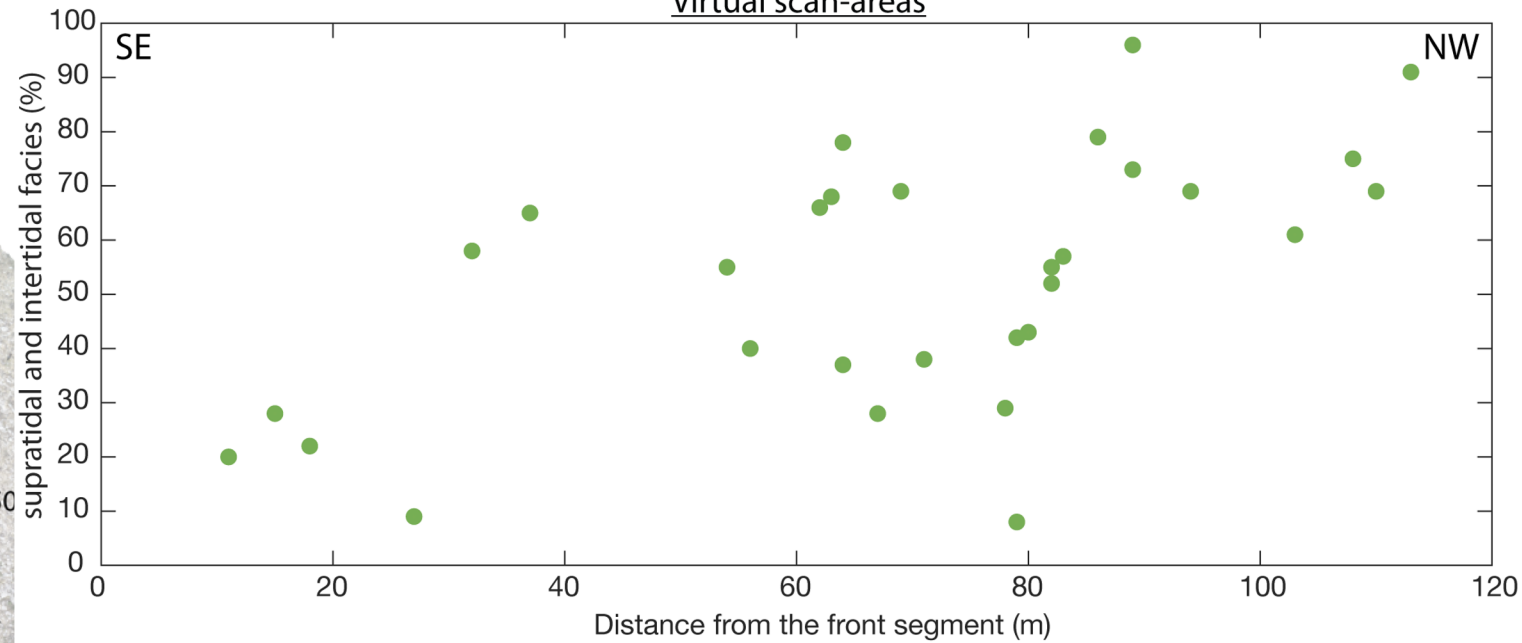
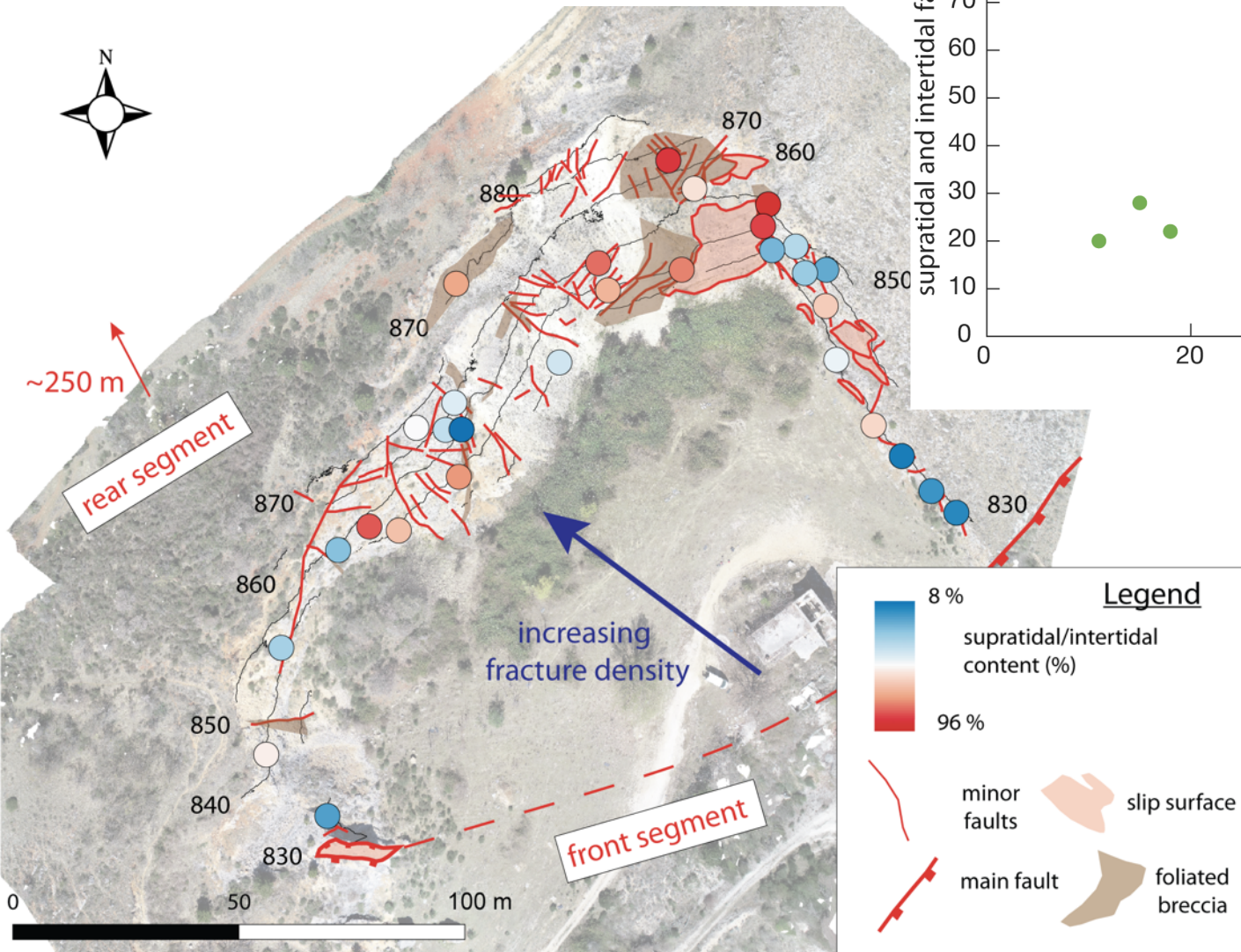


1) Structural control



The increase of fracture frequency with distance from the front segment is due to the interception of damage zones of subsidiary faults

2) Lithological control

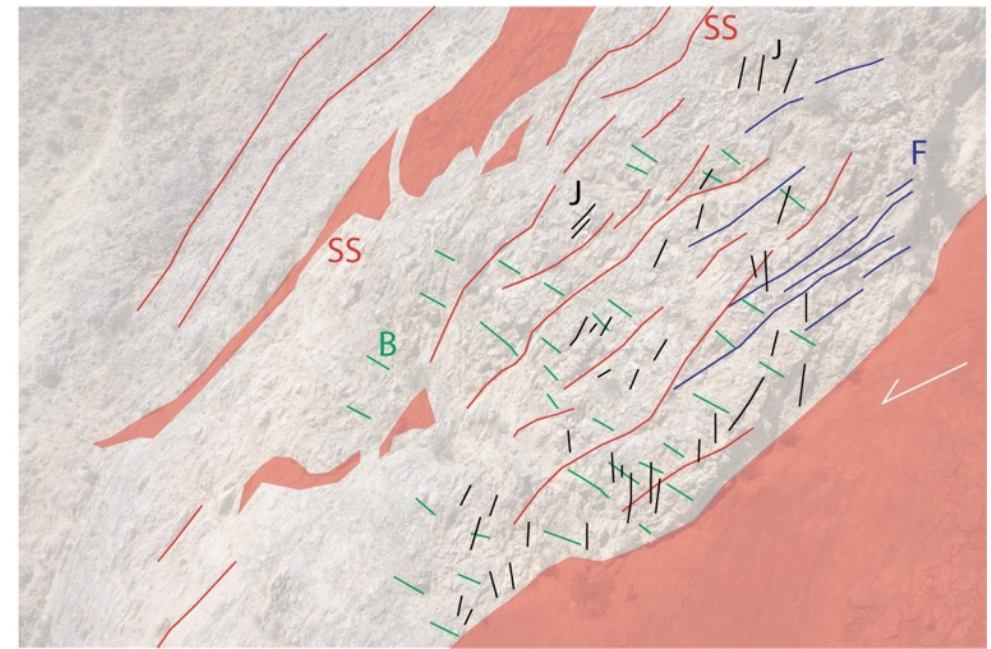
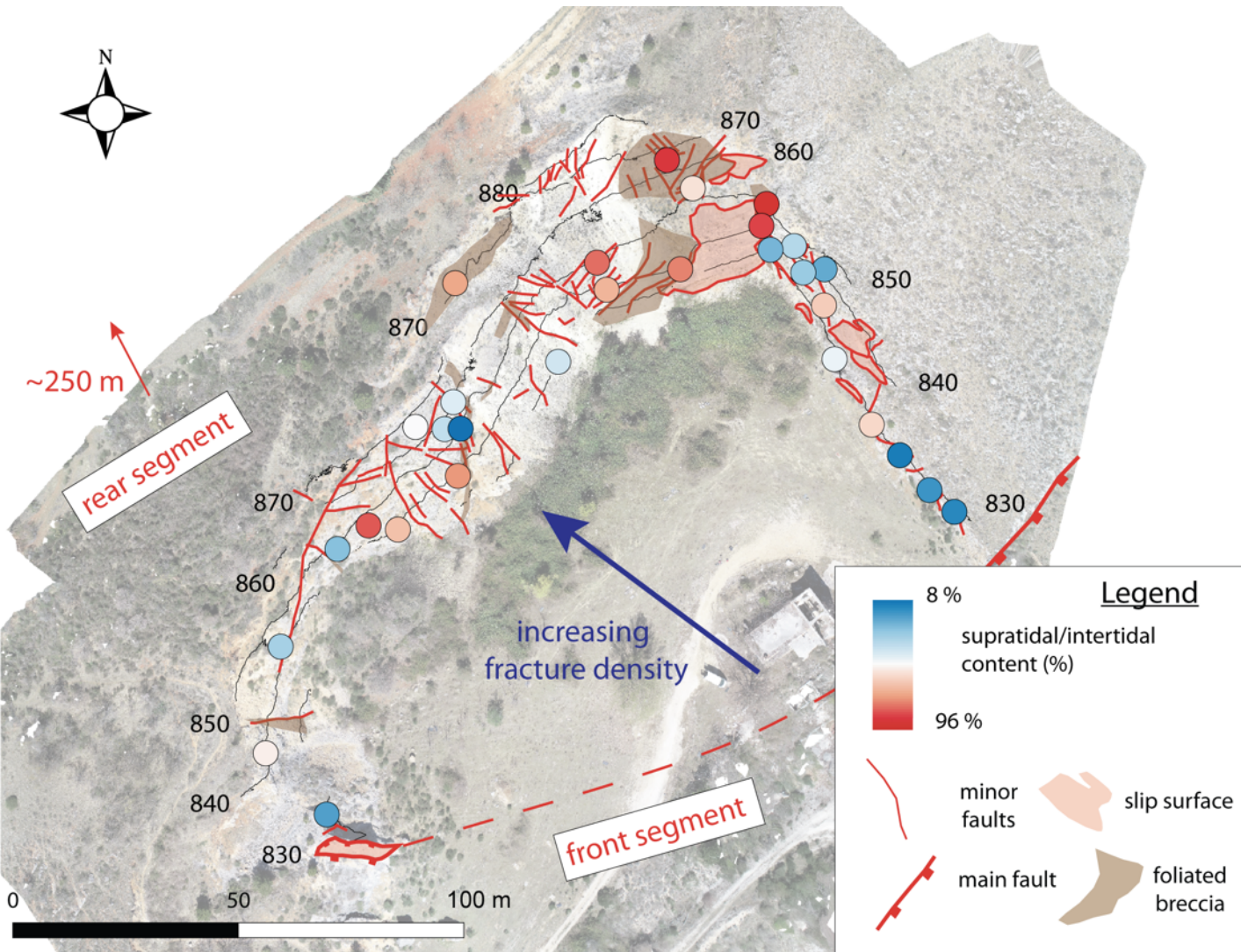


Analogously to fracture frequency, supratidal facies content increases with distance to the front segment of the relay ramp.

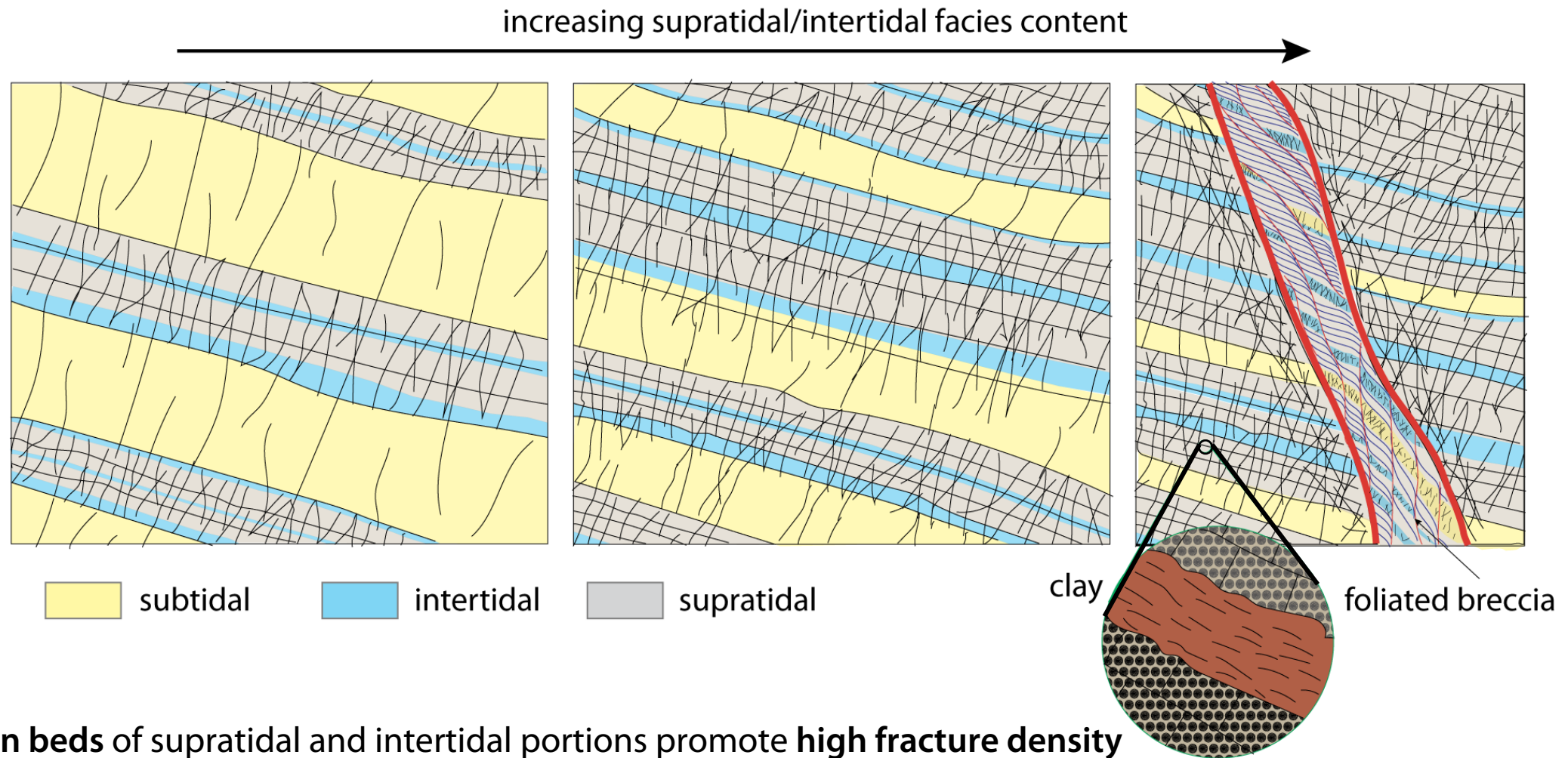
2) Lithological control



Presence of foliated breccias



2) Lithological control

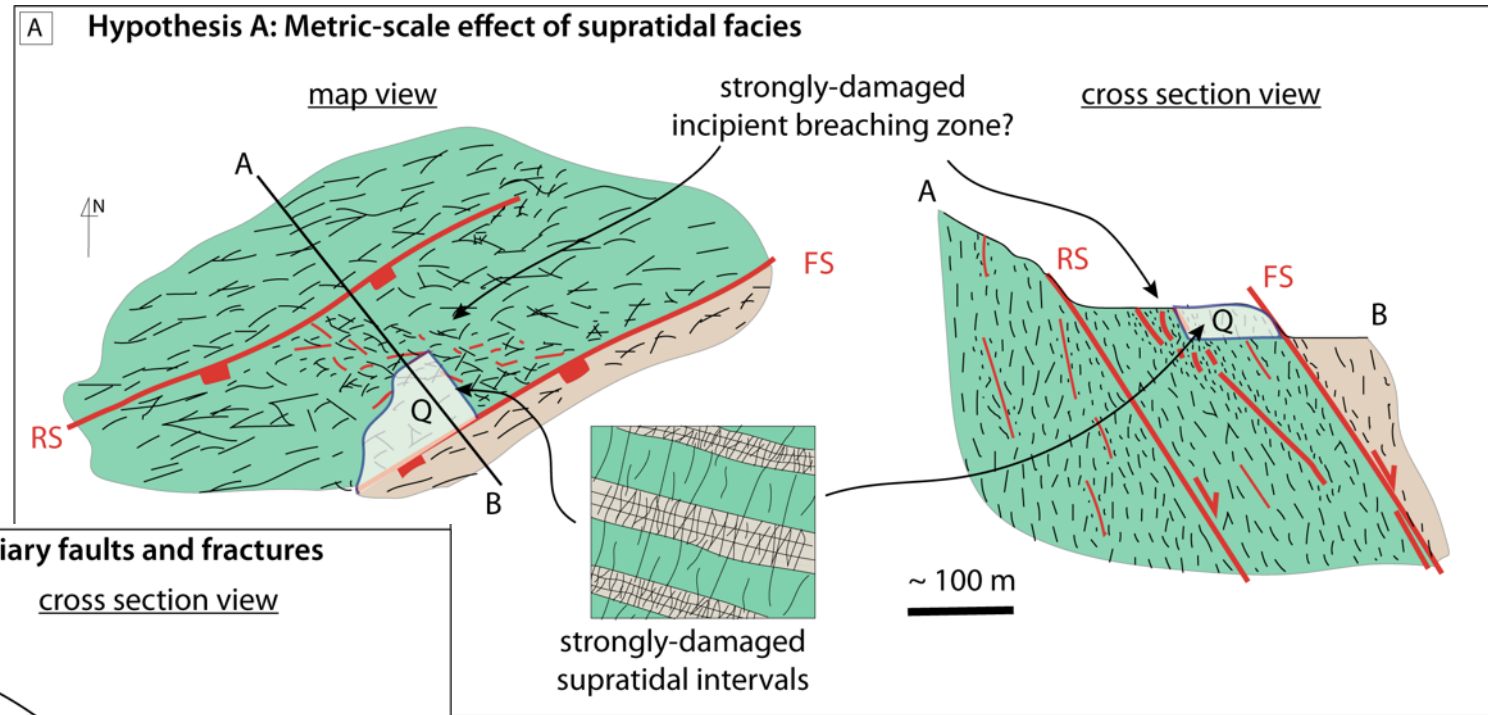


The **thin beds** of supratidal and intertidal portions promote **high fracture density**

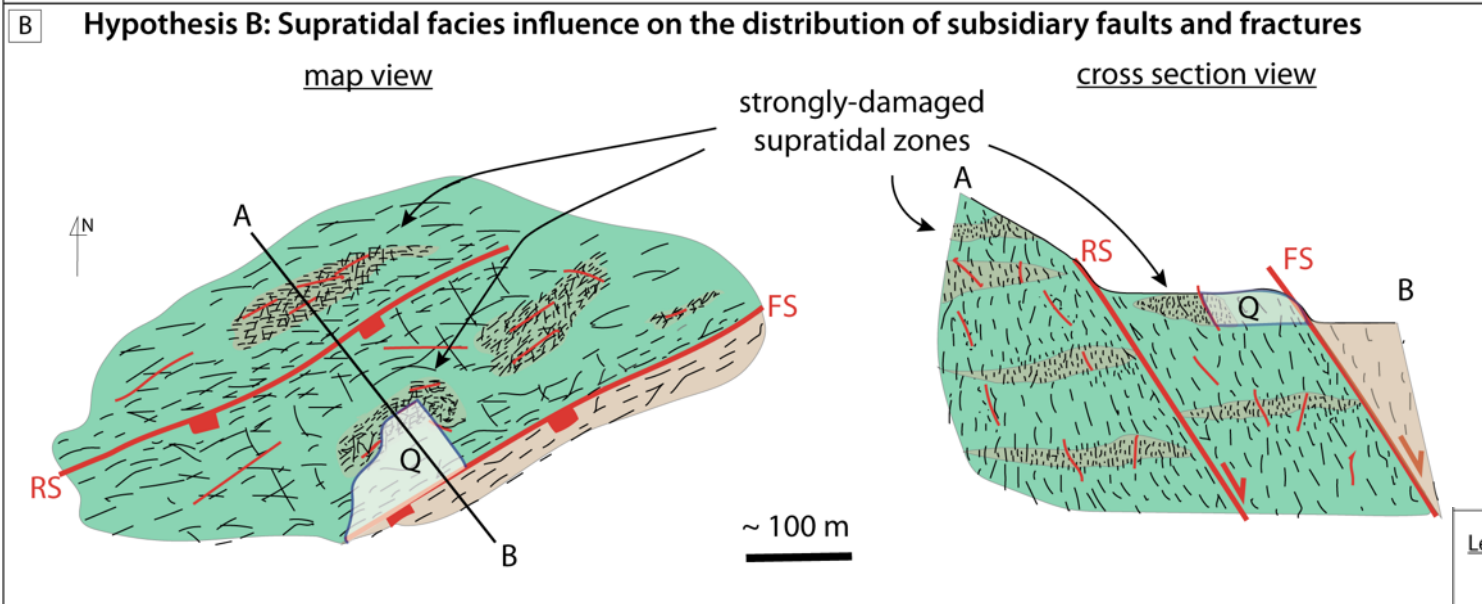
High fracture density and the presence of clay promote the **development of foliated breccia**

Structural vs. lithological control

Main controlling factor: structural setting



Main controlling factor: peritidal facies



Legend:

Main faults:
FS: front segment
RS: rear segment

Subsidiary
faults

Fractures

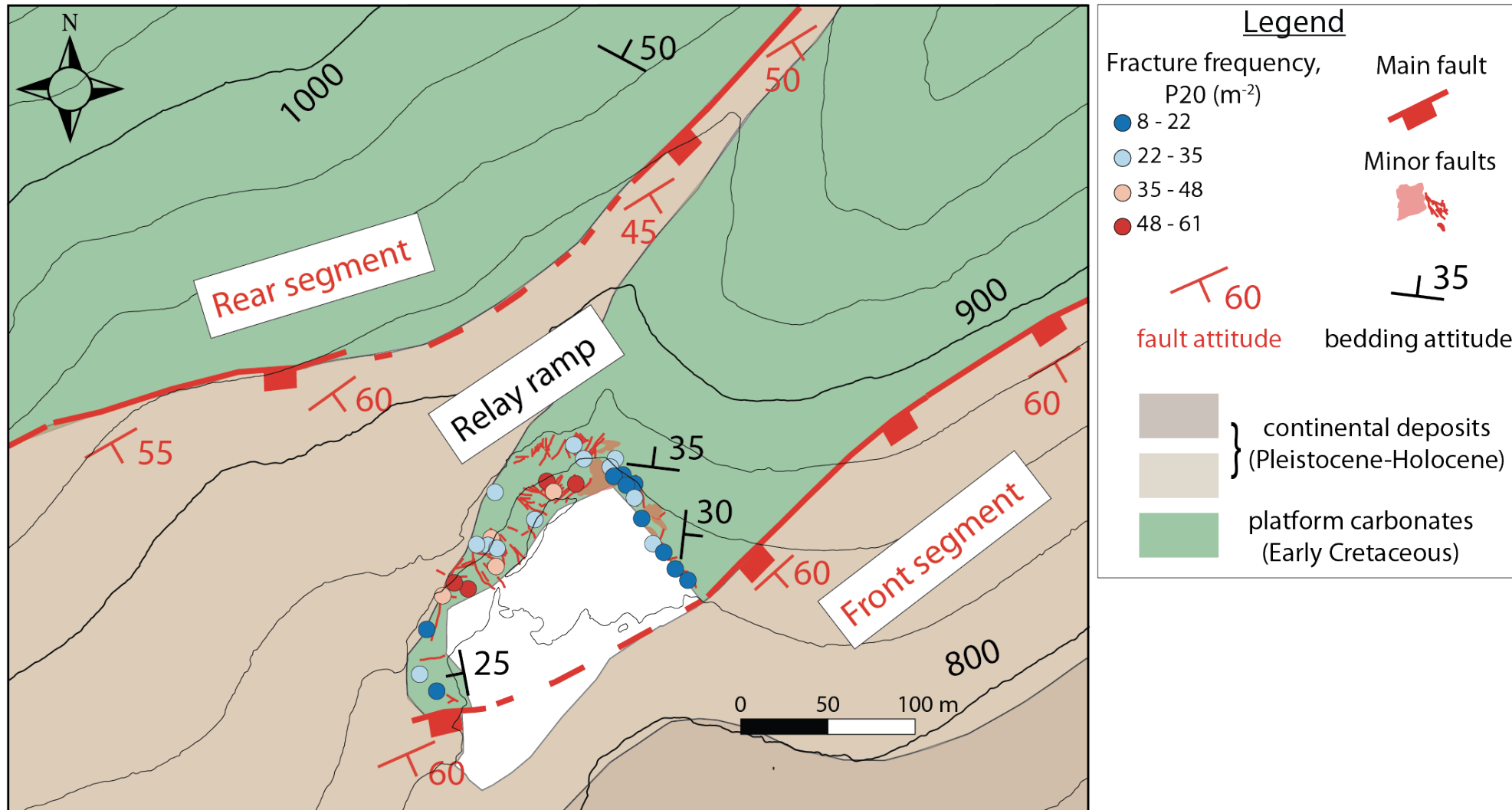
continental deposits
(Pliocene - Holocene)
Lower Cretaceous
limestones

A
B
cross section trace
Quarry

Conclusion

The prediction of fracture frequency distribution in relay ramps hosted by shallow water limestones necessitates a good control on

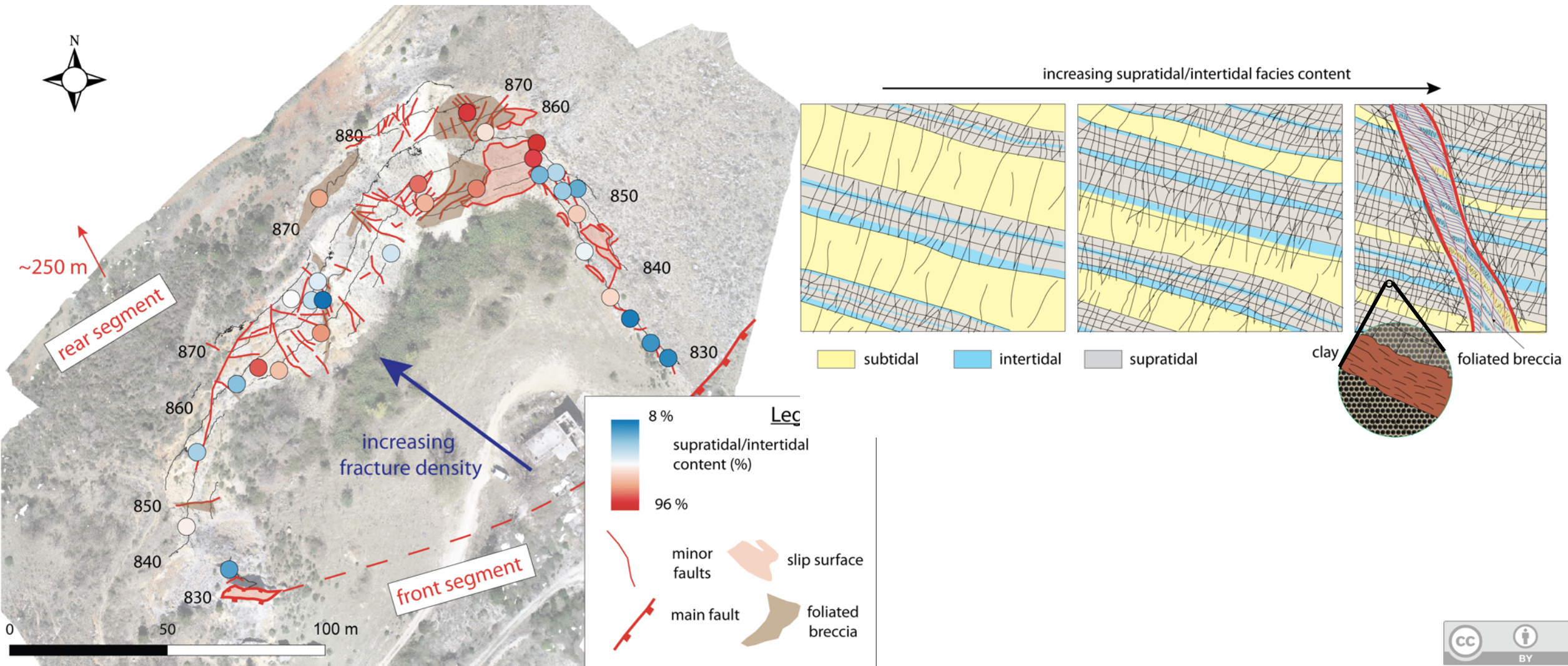
1) Structures



Conclusion

The prediction of fracture frequency distribution in relay ramps hosted by shallow water limestones necessitates a good control on:

2) Sedimentary facies distribution



Thank you!

Outcrop scale geometry and kinematics of a carbonate-hosted normal fault: The Tre Monti fault in Central Italy

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