Comparison of normal fault slip to long-term landscape building : Insights from morphometry analysis and geochronological data on Magnola-Velino fault system (Apennines, Italy)

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Context and objectives

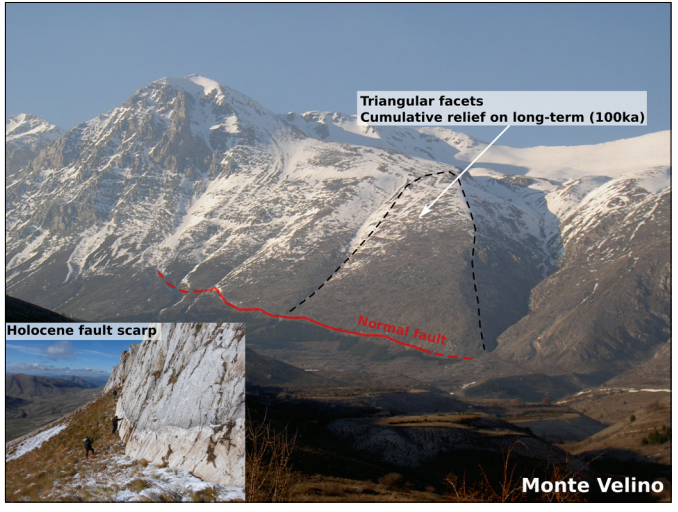
What markers can be used to constrain the long-term fault activity ?

Markers from :

- fluvial / marine terraces
- glacial moraines
- landslides

→ Usually a temporal record over a few 10s ka

versus



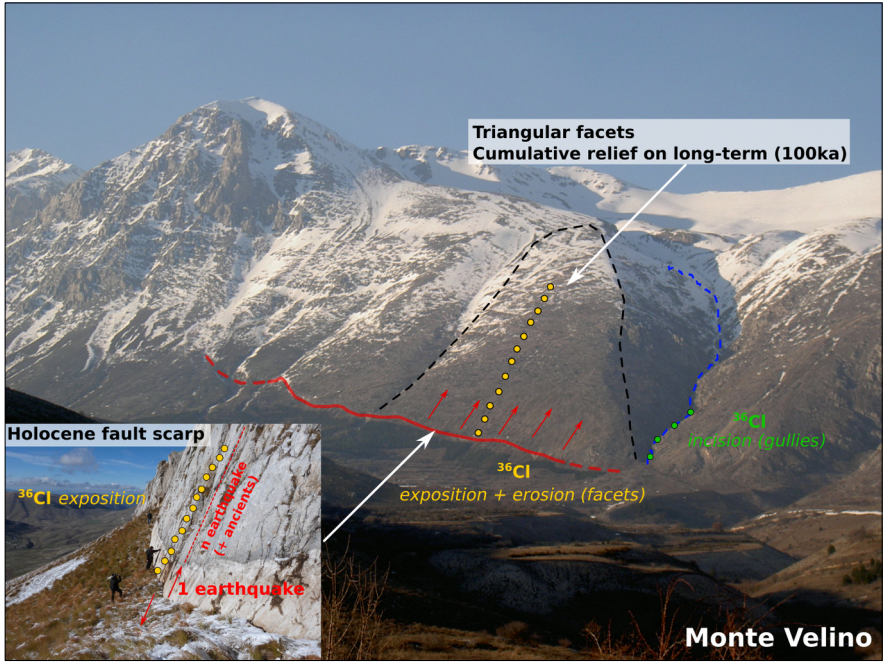
Normal faults facets

- Temporal record : **several 100s ka**
- potential markers of tectonic activity
- recording quantitative informations

→ **Let's study them !**

Context and objectives

Study the links between normal fault slip rate, facets building and gullies denudation rates on the Magnola-Velino normal fault system



Fault scarp
- fault dip
- slip rates

- [36Cl] CRN along the facets profiles
- Slip-rate modelisation

LINKS ?

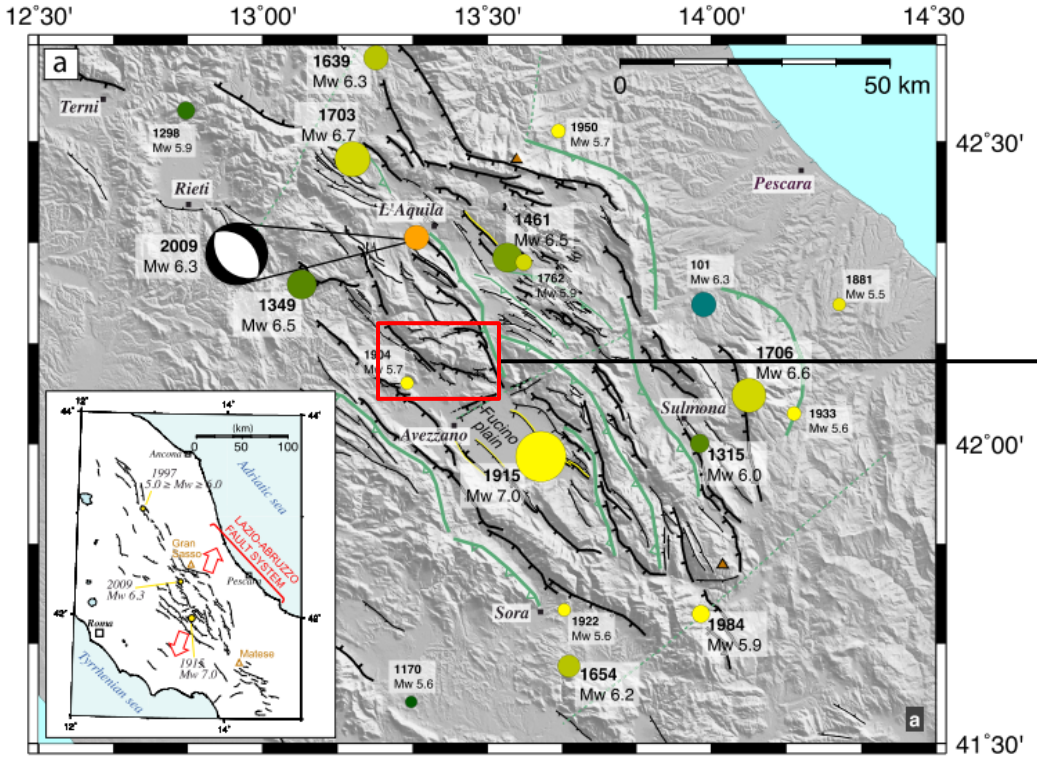
- [36Cl] CRN on gullies
- High resolution DTM
- Morphometric param.

Facet
- slope/relief
- erosion rates

Gully
- incision rates
- Channel steepness

Study area

The Central Apennines and the Magnola-Velino fault system



The Apennines

- NW-SE moutain range in Italy
- Many destructive earthquakes (present, historical and paleo) from normal faults

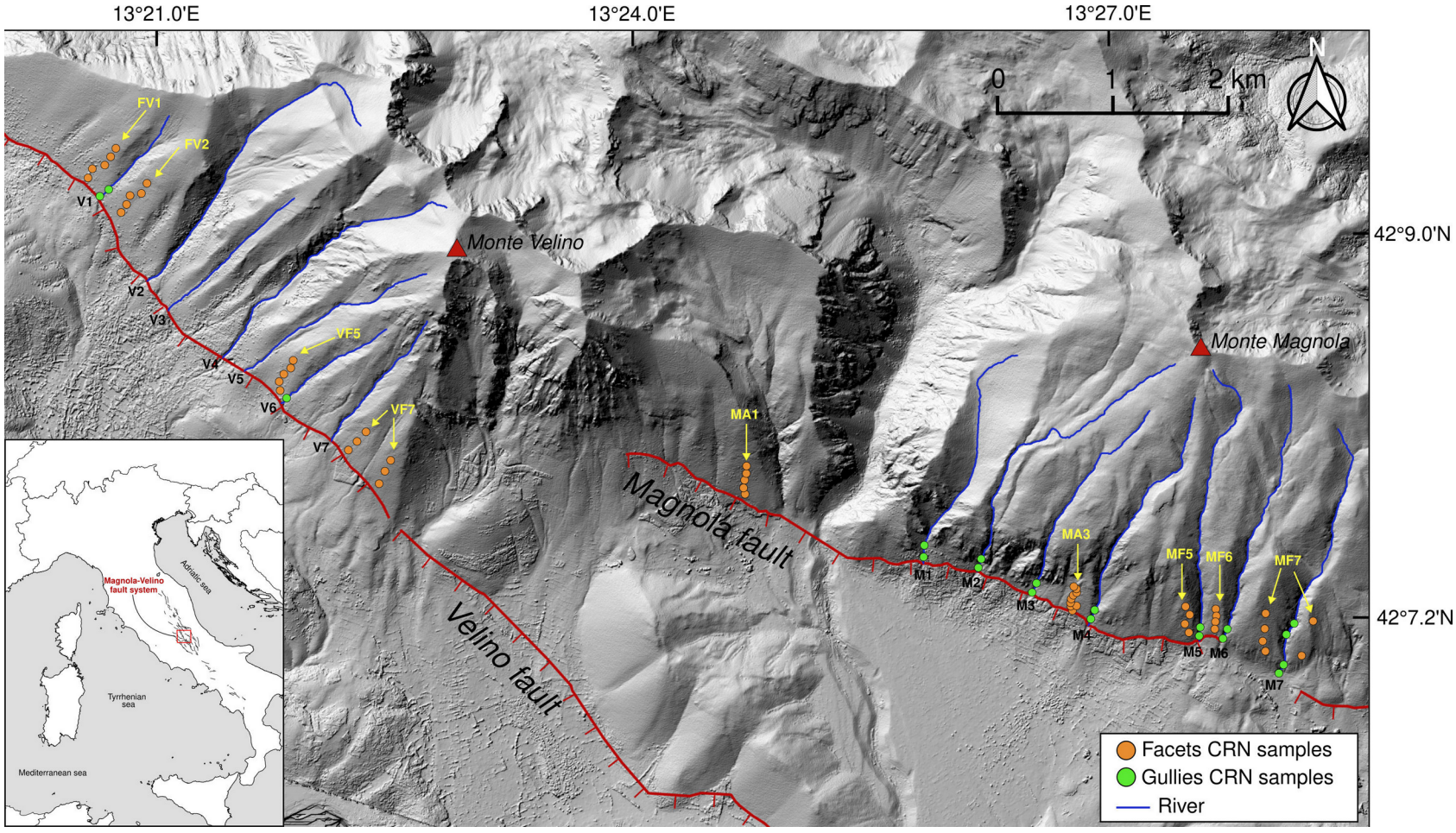
The Magnola-Velino normal fault sytem

- 25-30 km long NW-SE orientation
- Preserved facets up to 300-800m high
- A well-constrained and studied fault system (Tucker 2011, Schlagenhauf 2011, Benedetti 2013, Tesson 2021)

Benedetti et al., 2013
" Earthquake synchrony and clustering on Fucino faults (Central Italy) as revealed from in situ 36Cl exposure dating", Journal of Geophysical Research: Solid Earth

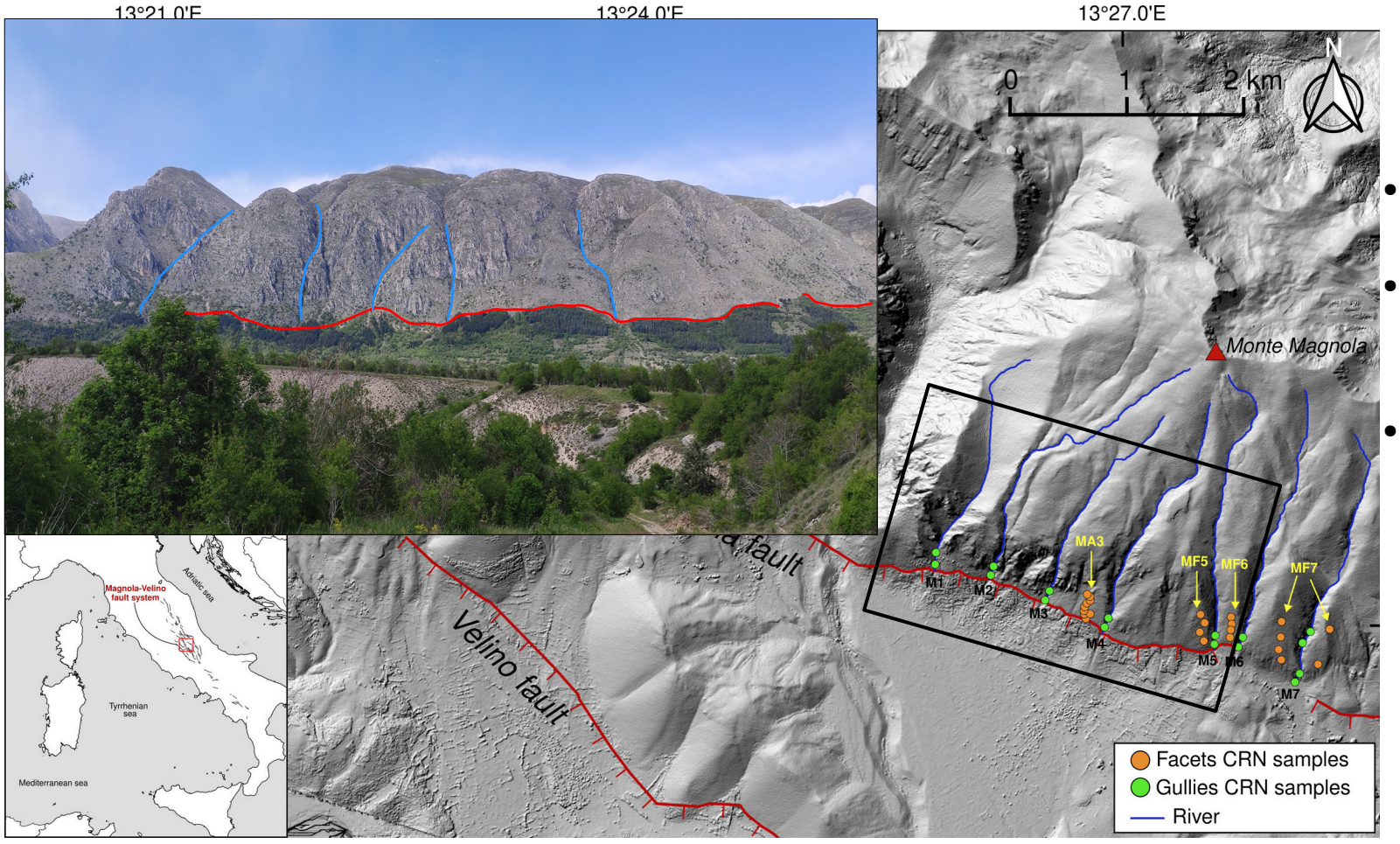
Study area

The Central Apennines and the Magnola-Velino fault system



Study area

The Central Apennines and the Magnola-Velino fault system

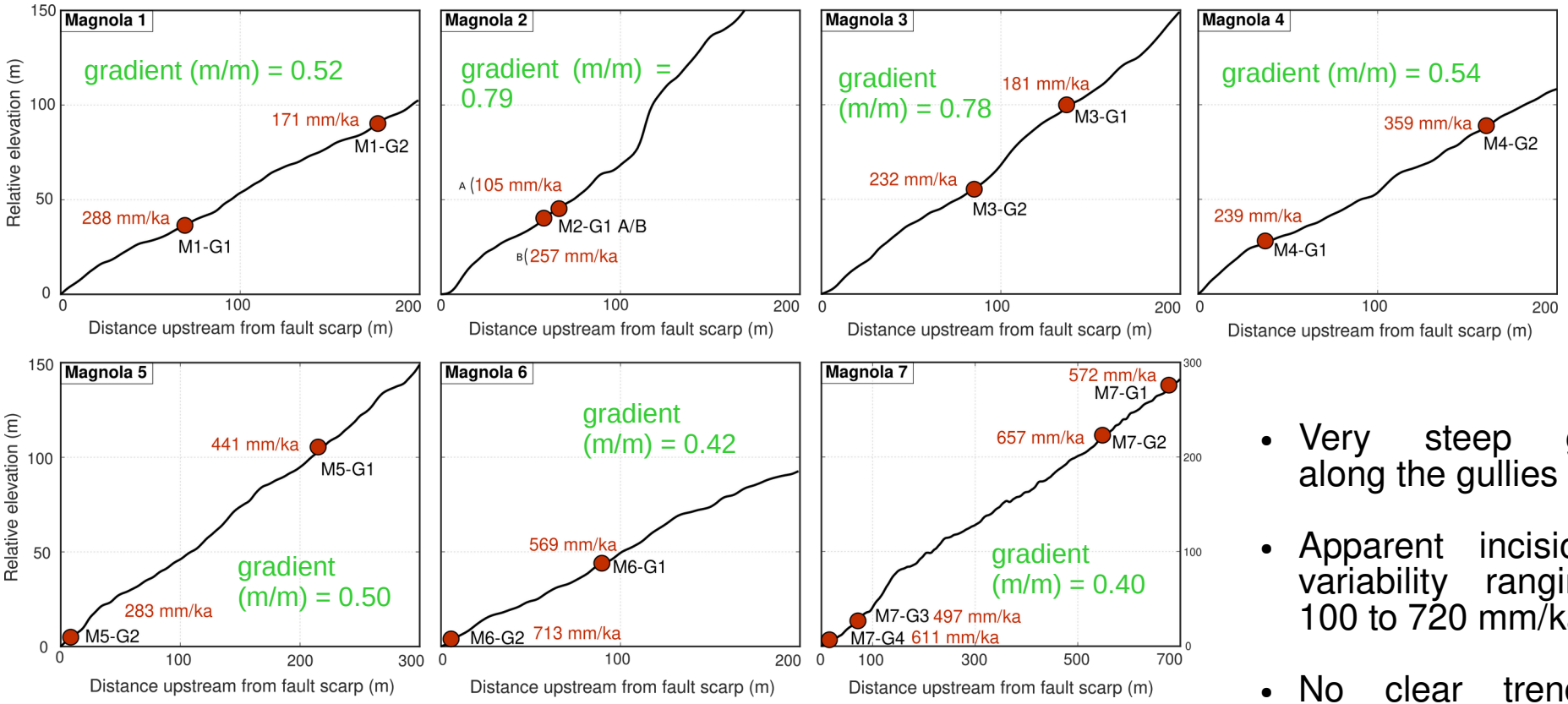


Sampling

- 19 sampled from gullies bedrock
- 33 sampled from bed rocks on facets profiles
- 2 more CRN profiles on facets from Tesson et al., 2021 (MA1, MA3)

Results & Discussion

Gullies profiles and apparent incision rates along the Magnola fault

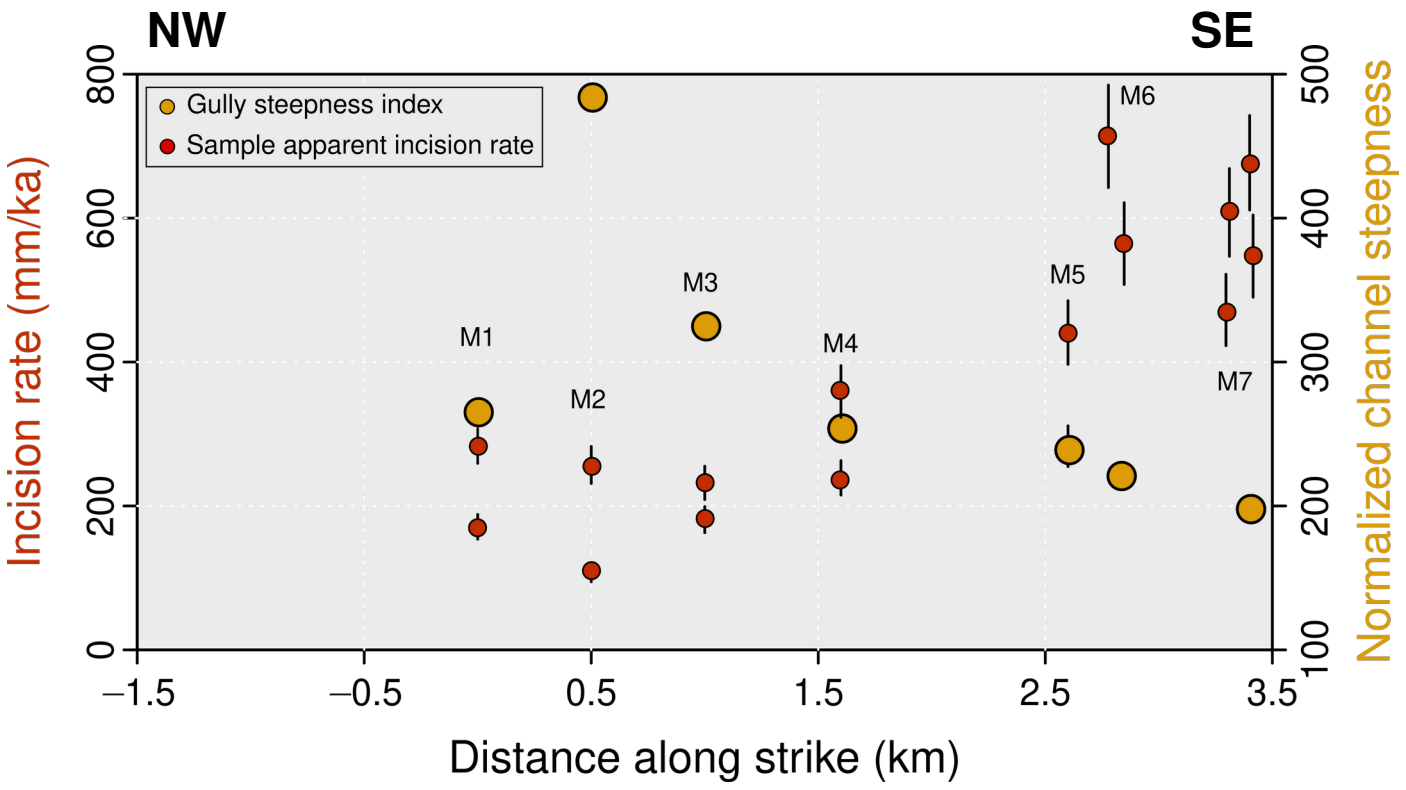


- Very steep gradients along the gullies
- Apparent incision rates variability ranging from 100 to 720 mm/ka
- No clear trend along individual profiles

Relative elevation is elevation upstream from the fault scarp

Example :
0.20 gradient (m/m) ~ 11.5 degree
0.60 gradient (m/m) ~ 34.4 degree

Apparent incision rates and channel steepness along the strike

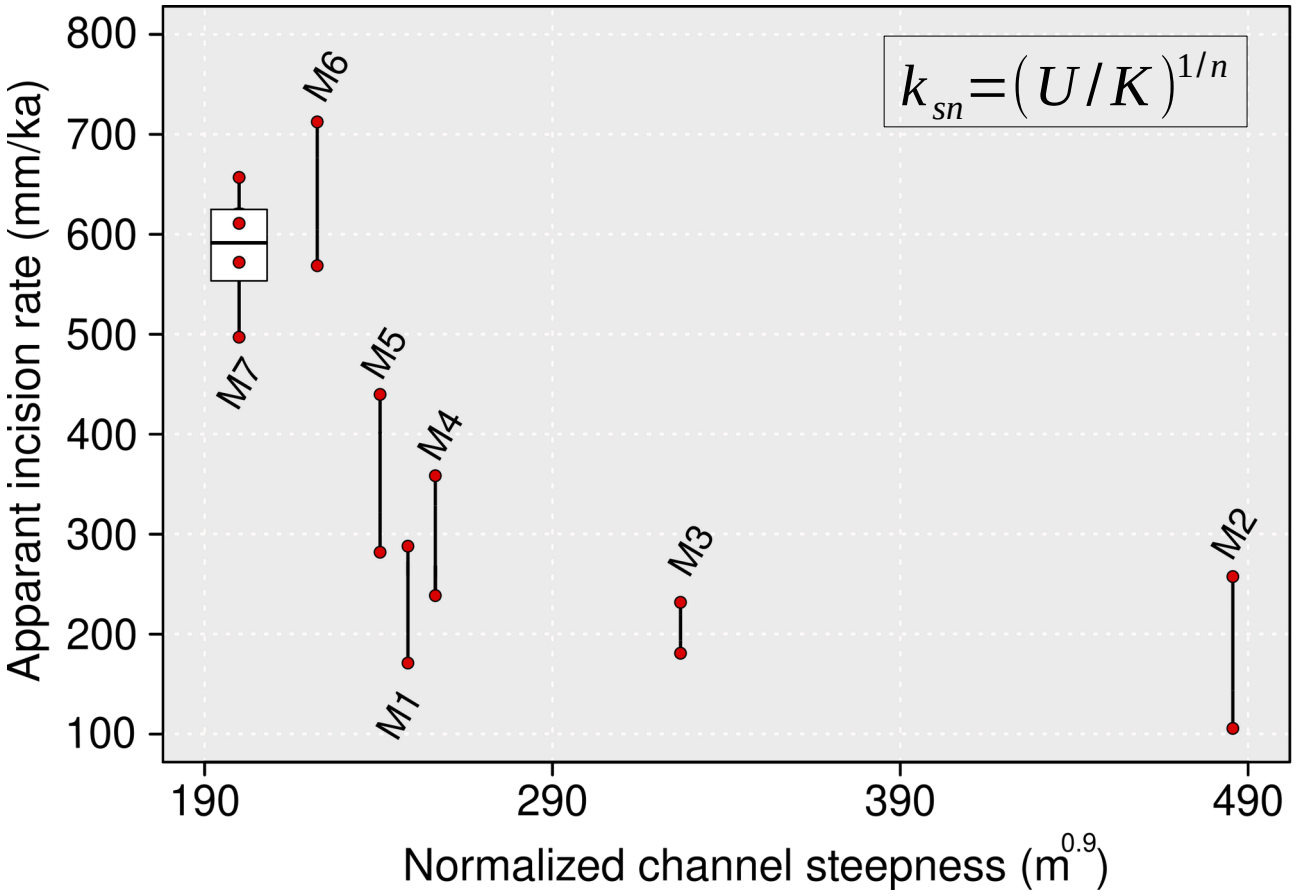


- Variation of incision rates and channel steepness along the strike
- A long-term variation in slip rates ?
- A variation with other parameters ? facets slope, slip rates, dip fault → to be tested

Channel steepness : *normalization of river slope by drainage area. Reflect a competition between uplift U and erodability/climate K* → $k_{sn} = (U/K)^{1/n}$

Results & Discussion

Relationship between apparent incision rates and channel steepness



In theory and most of studies :

E and k_{sn} positively correlated

$$E \uparrow \Rightarrow k_{sn} \uparrow$$

Here, on the Magnola fault :

Inverse relationship

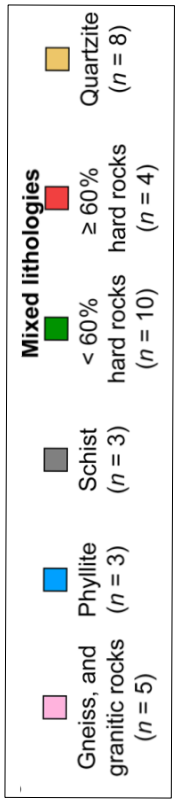
$$E \downarrow \Rightarrow k_{sn} \uparrow$$

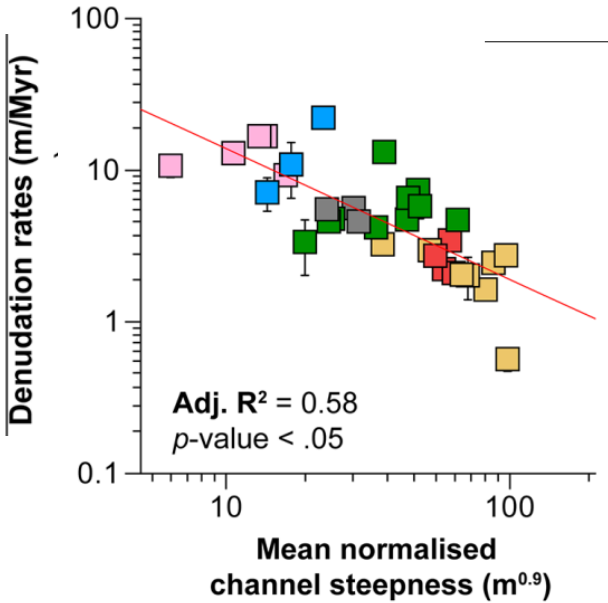
Why this relationship ?

Hypotheses to explain the inverse relationship

1) Lithological variation along the strike ?

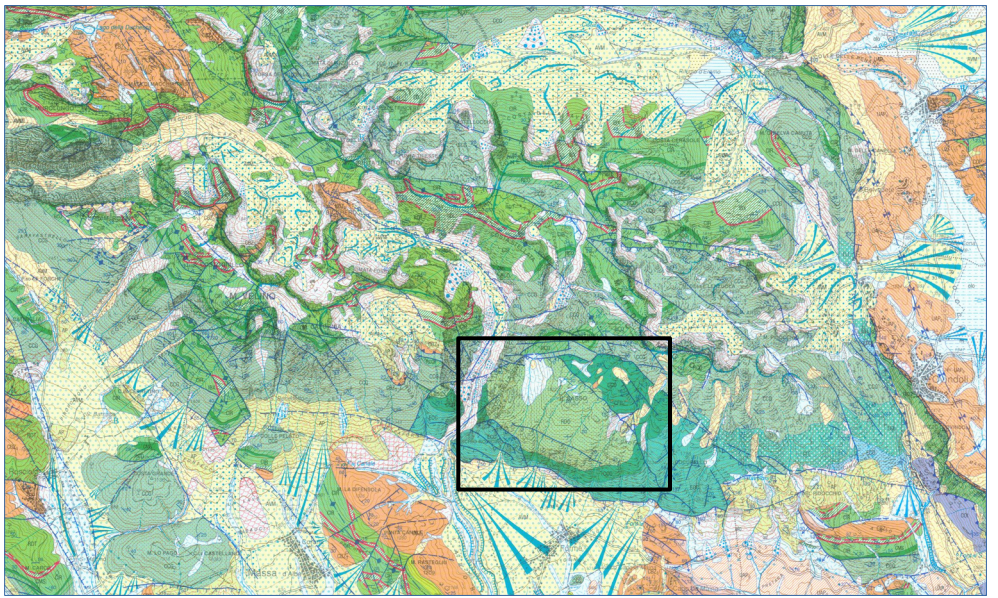
- similar type of limestone along the strike ... Least likely





modifed from Peifer et al., 2021
" Growing topography due to constrasting rock type in a tectonically dead landscape" Earth Surface Dynamics

A similar situation on the Magnola system ?



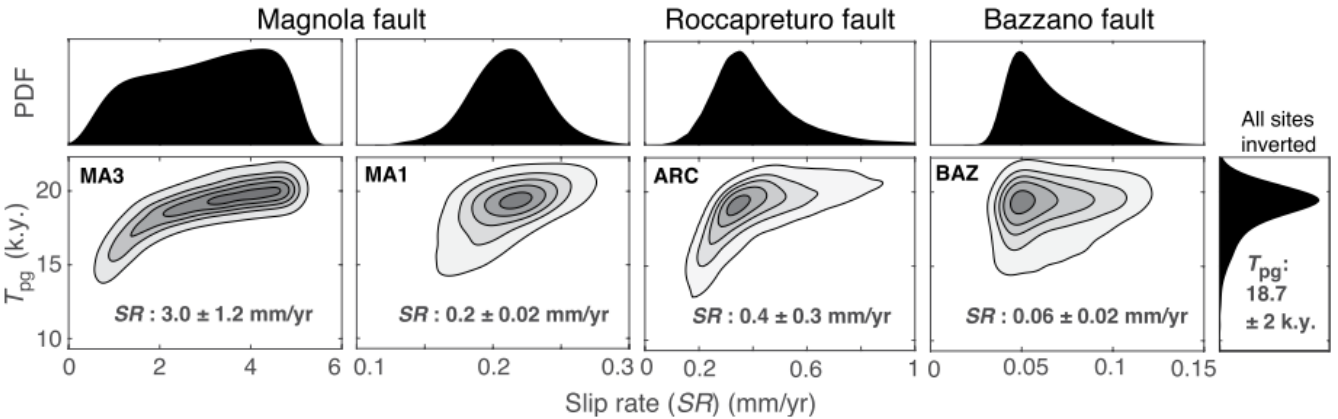
No, only limestone rocks with similar propreties

Hypotheses to explain the inverse relationship

2) Is there a transient response ?

- Variation in climate (rainfall, precipitation, glacial cycle)
- Variation in uplift (tectonic and slip rates)
- Different time scale

Spatial variation of slip rates to be tested ?



from Tesson et al., 2021
" Slip rates determined from cosmogenic nuclide on normal fault facets"
Geology

→ 36Cl facets profiles and inversion model to quantify long-term slip rate ?

Work in progress on our cosmogenic nuclide samples

Hypotheses to explain the inverse relationship

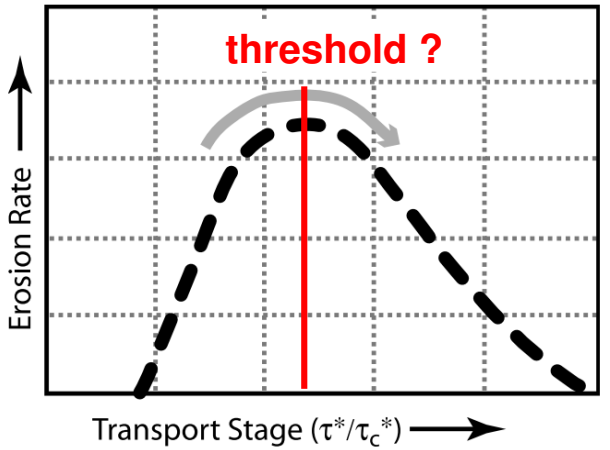
3) Link with very steep gradient ?

- modification of transport stage over a treshold
- Increasing of solid charge and cover effect on bedrock

→ decrease of incision

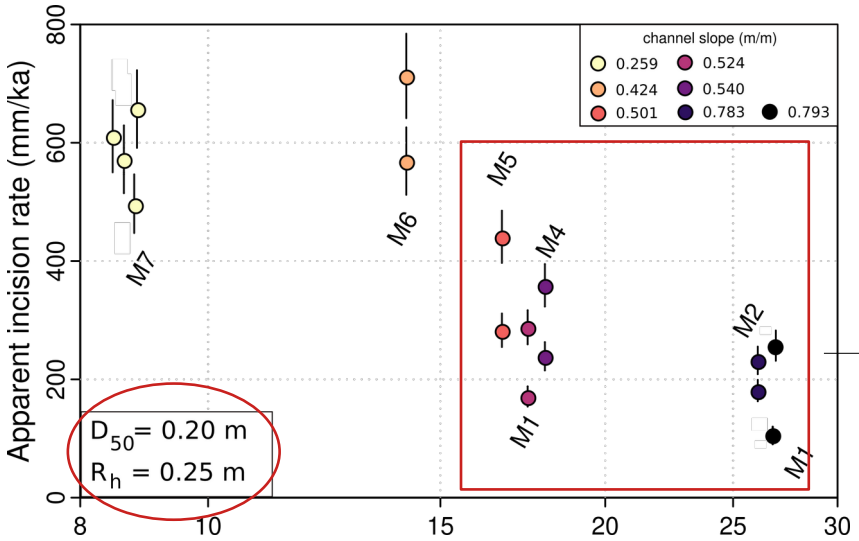
- bedrock protected from cosmic rays by cover effect

→ decrease of apparent incision rates

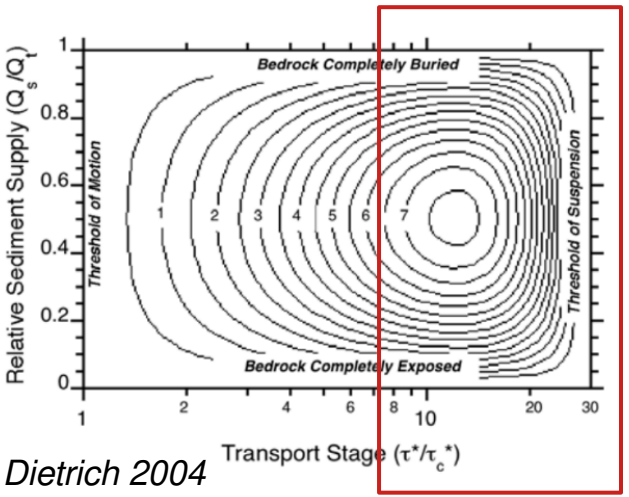


modified from Wobus et al., 2006

" Hanging valleys in fluvial systems : Controls on occurrence and implications for landscape evolution", Journal of Geophysical Research: Earth Surface



Transport stage is dependant of median grainsize and hydraulic radius



From Sklar & Dietrich 2004

Decrease of incision due to channel slope increase ?

Work in progress

Thank you for listening !

Questions ?
Suggestions ?
Discussions ?

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