Pedostratigraphy and micromorphology of soil thin sections as a tool in paleoseismology: deciphering past processes interacting with tectonics

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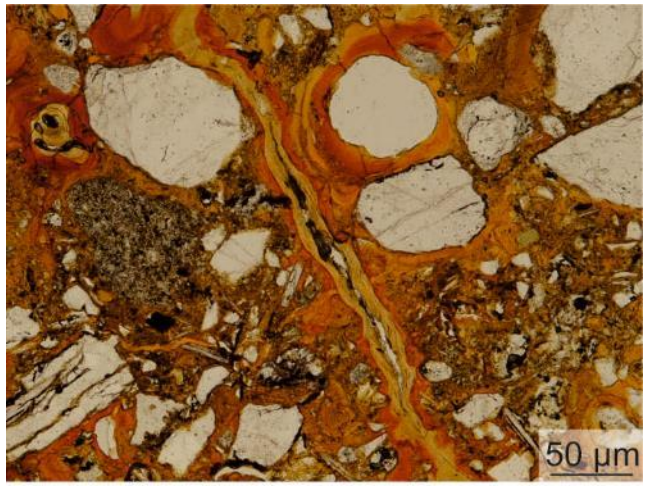


Problem statement

Can pedostratigraphy and pedogenetic features provide additional chronological constraints to paleoseismology?

⇩

e.g., Nelson 1992; Previtali 1992; Amit et al., 1996; McCalpin, 2009; Livio et al., 2014

crosscutting relationship between pedosedimentary deposits and tectonic structures

The pedogenetic processes are continuous
→ istantaneaous tectonic events can disturbed the soil structure

✚

→ pedofeatures linked to specific climatic phases
can give a relative chronology to seismic deformations

In the existing literacture…

- Boul et al. 1973

  "*Seismipedoturbations*: *upsets, deformations and collapses in soil profile due to tectonic activity"*

- Previtali, 1992

  "seismic events could disturb the internal arrangement of many soils, leaving behind macroturbations"

- Khatwa and Tulaczyk, 2001; Larson et al., 2016; Menzies and Reitner, 2016

  "*stress features in the glaciotectonic context*"

…what does Paleoseismology need?

A tool as *micromorphology of soil thin sections* to decipher past processes interacting with tectonics

(Livio et al., 2014)

The studied sites:

- Monte Netto (BS) _ Livio et al., 2014; Zerboni et al., 2015
- Pecetto di Valenza (AL) _ Frigerio et al., in press

Compressional tectonic environment

Complex sequences of
Late Pleistocene loess-paleosols

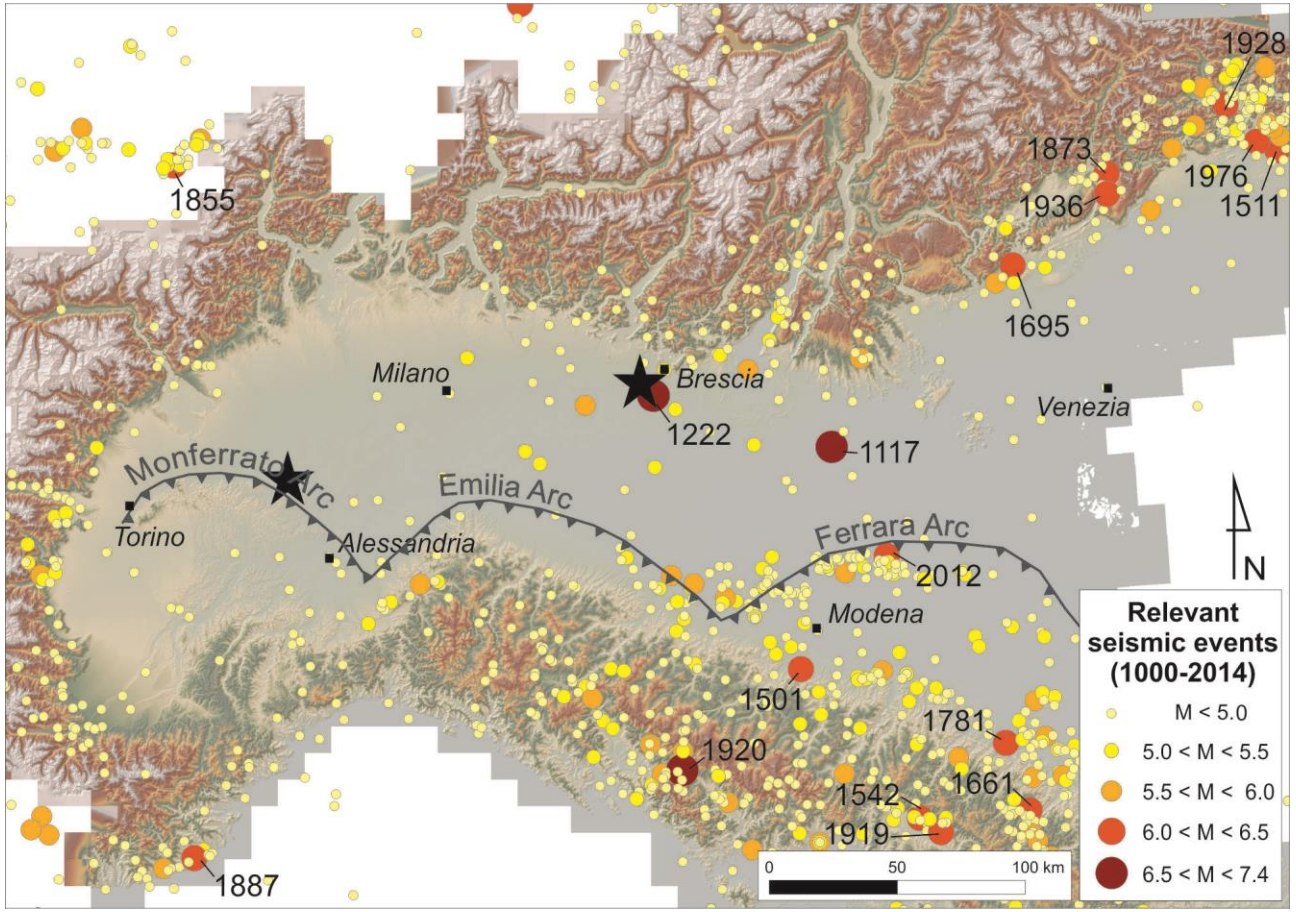
Low deformation rate & Low sedimentation rate

Tectonic imput not bleached

But

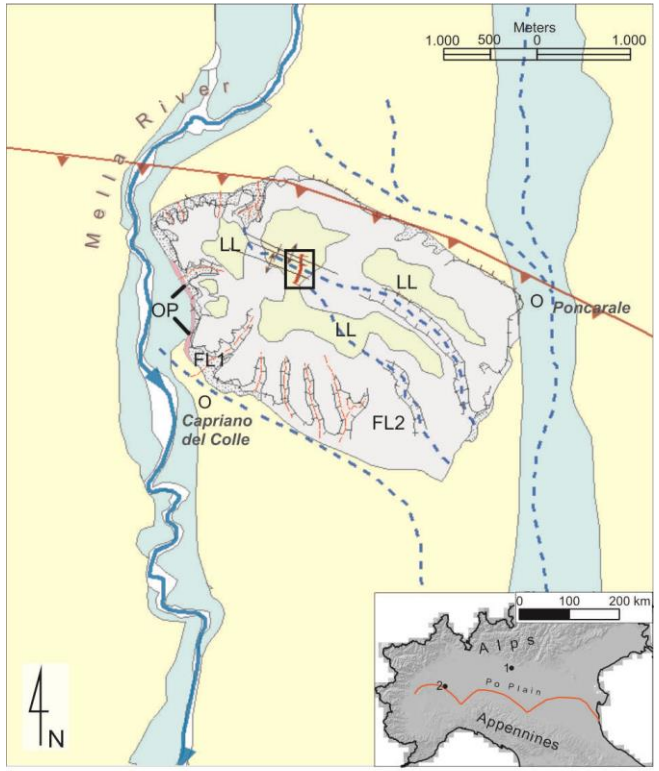
recorded into soils/paleosols

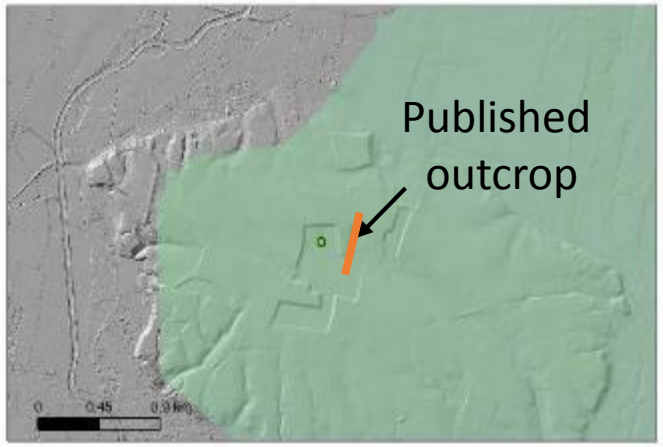
Interpretation in Soil Thin Sections

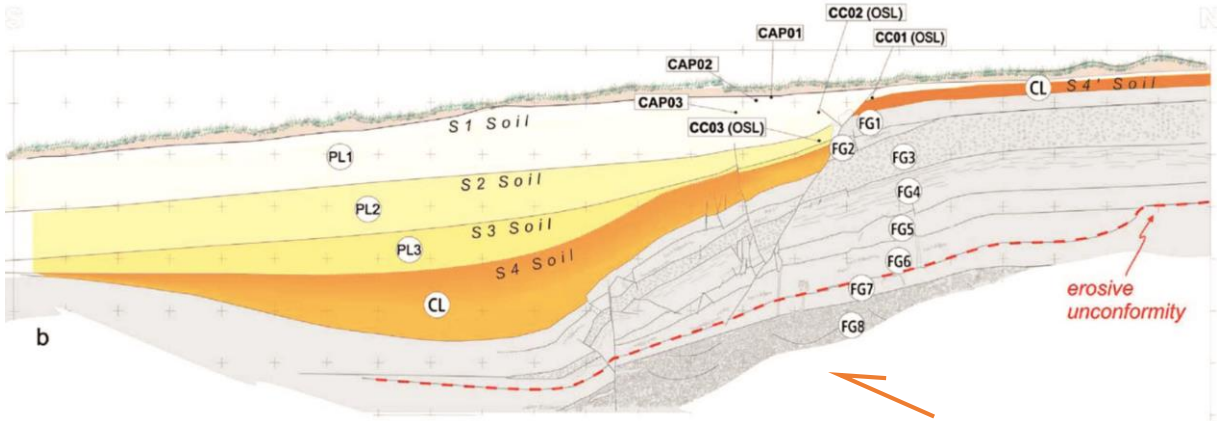


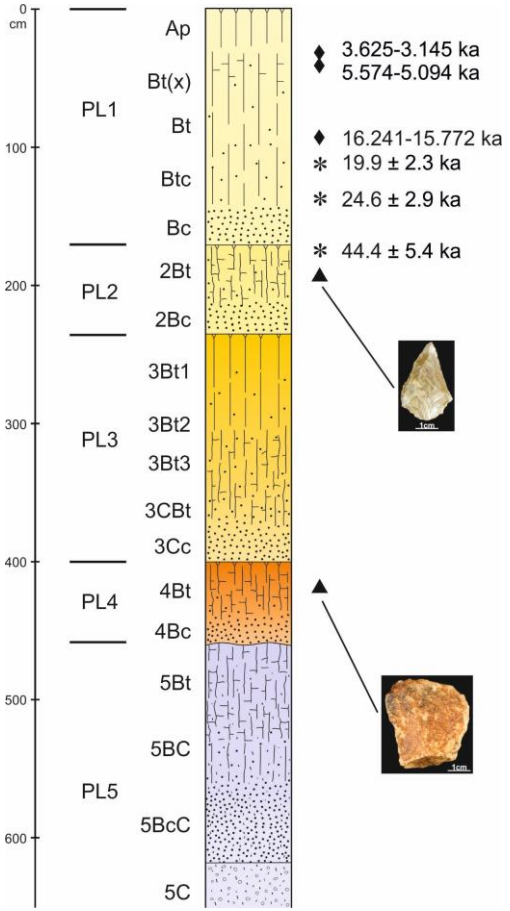
Monte Netto site: the published outcrop

(Livio et al., 2014; Zerboni et al., 2015)



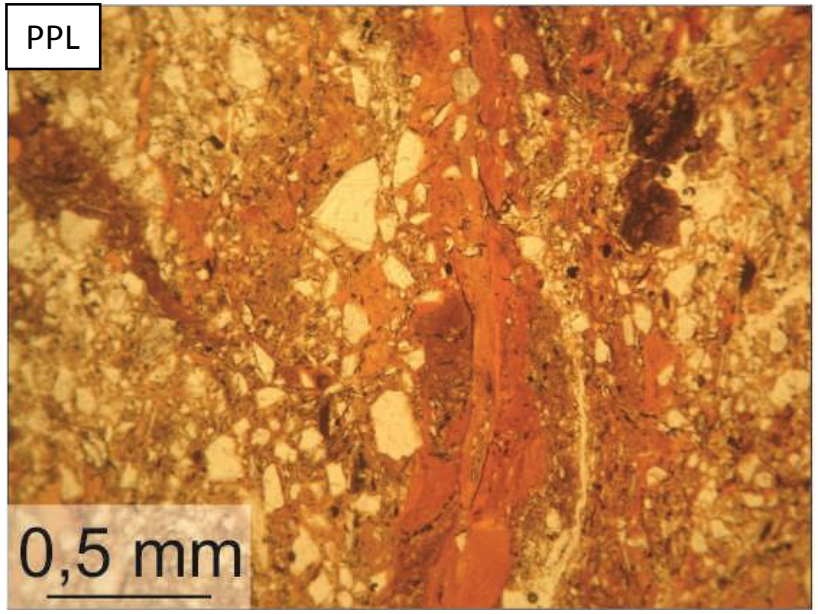


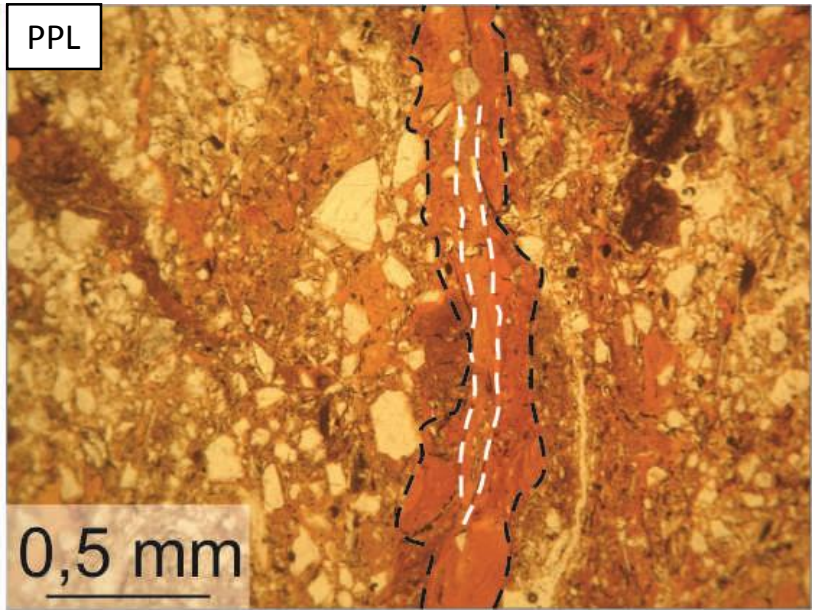




Micromorphological observation

Sub-vertical fractures filled by
two different generation of illuvial clay

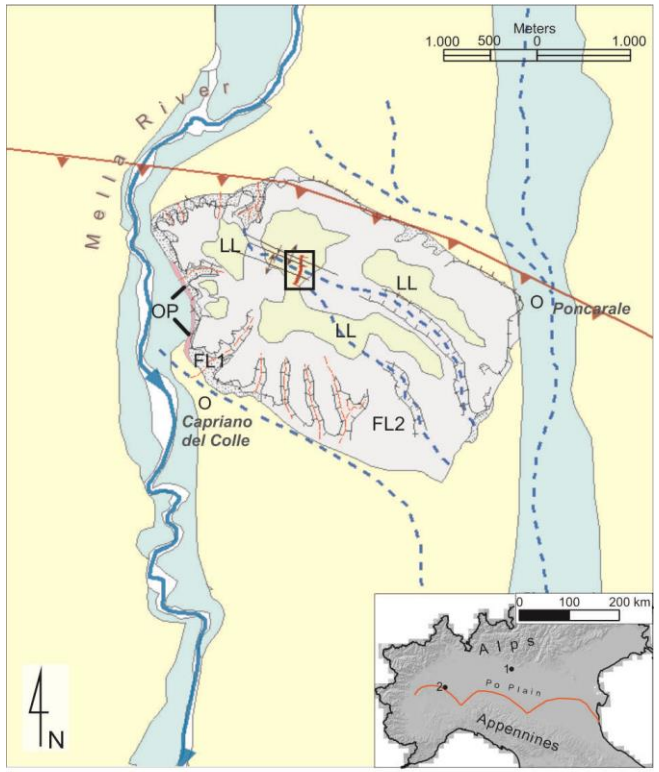


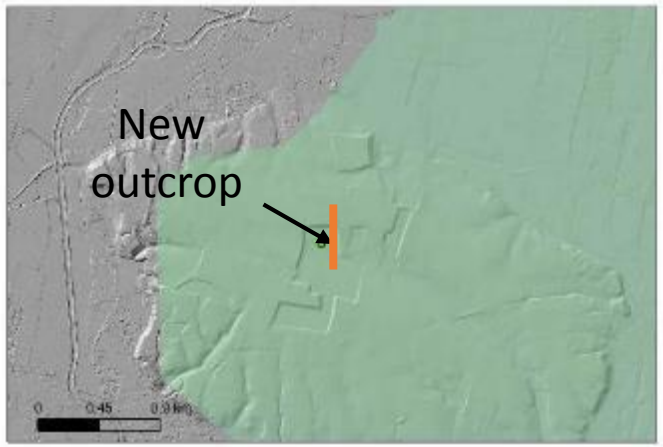


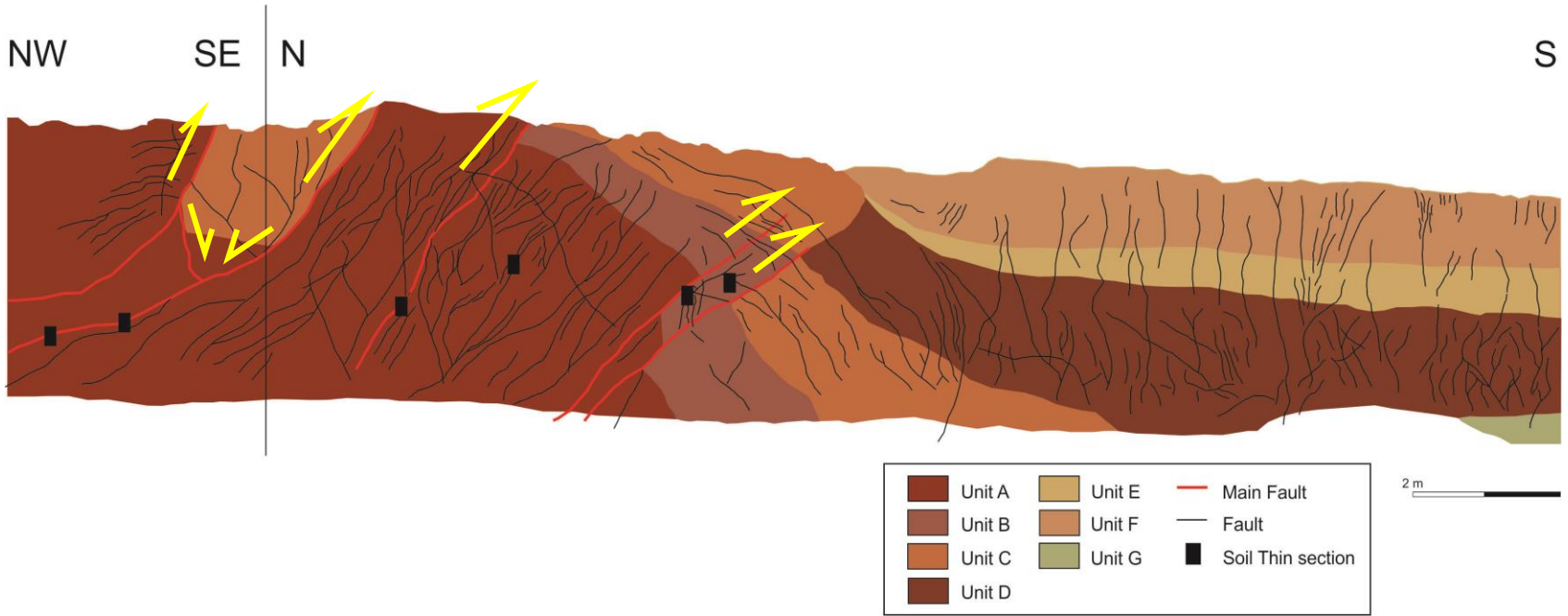
Interpretation

Multistep process of fissures opening and infilling by pedogenetic clay, related to subsequent coseismic movements

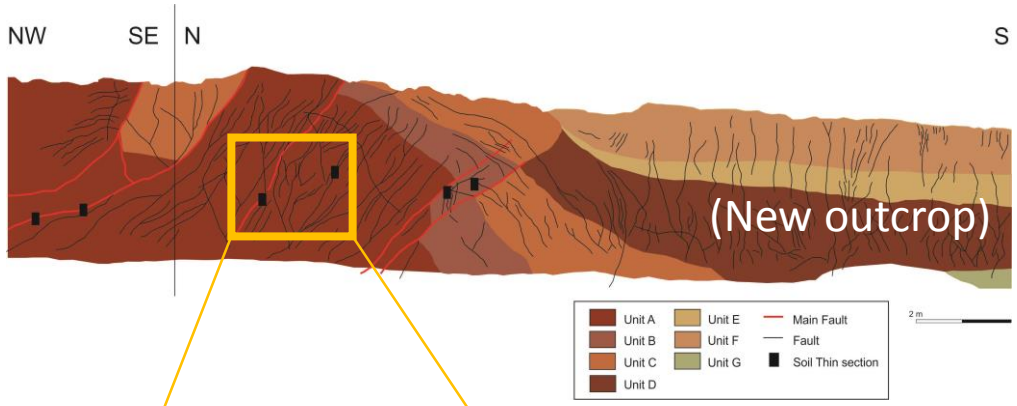
Monte Netto site: the new outcrop

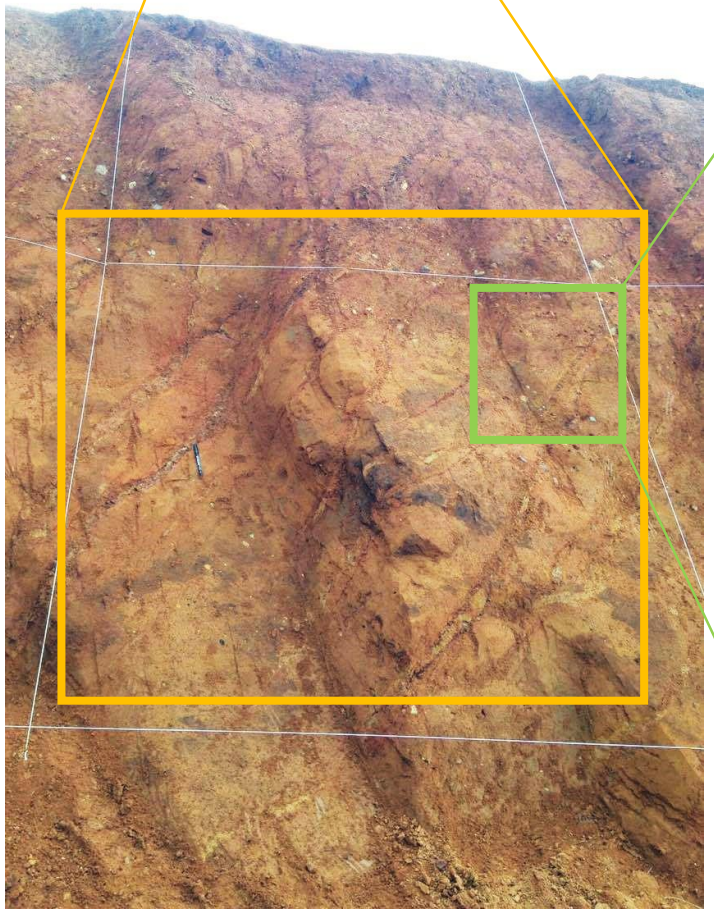


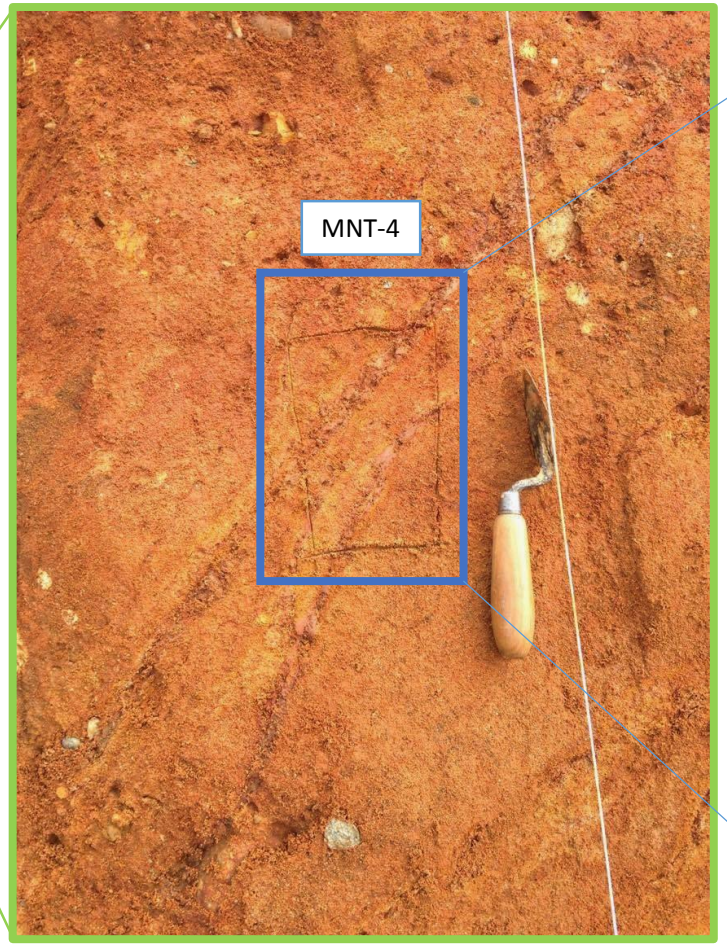




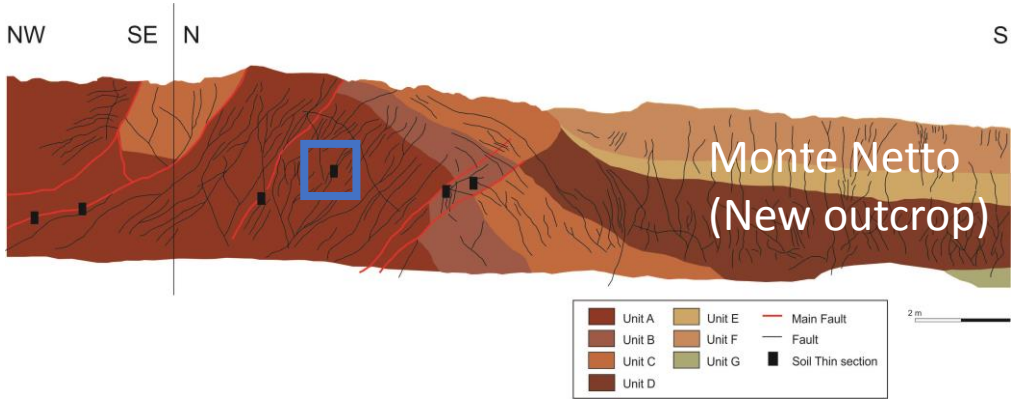
Monte Netto
Field evidences



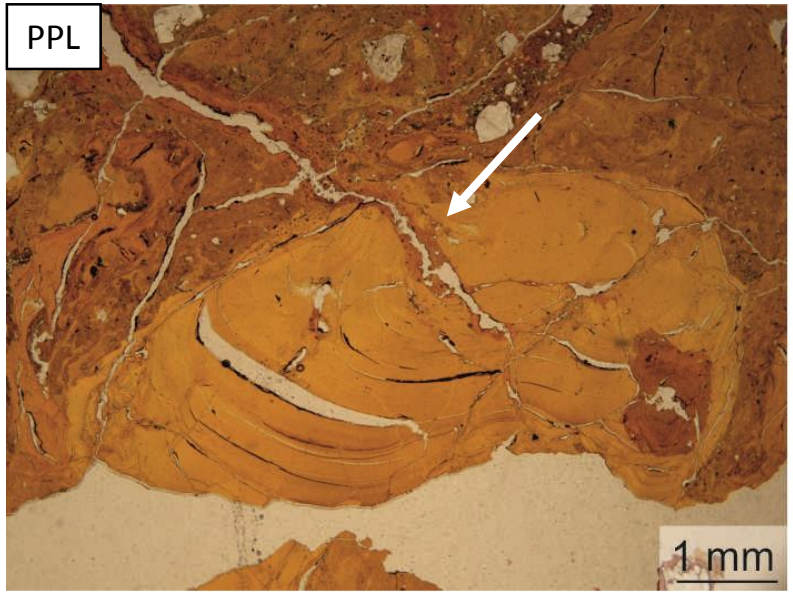


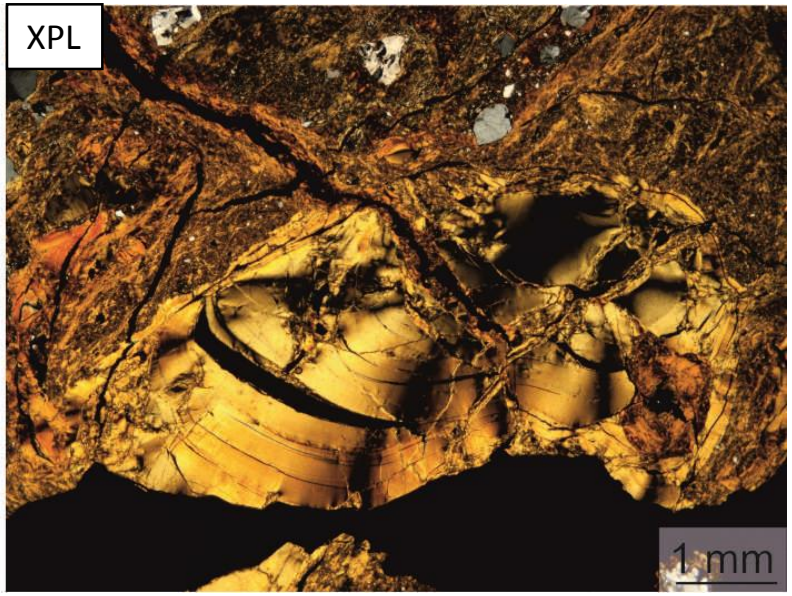


Micromorphological observation



Fractured clay coatings filled by illuvial clay

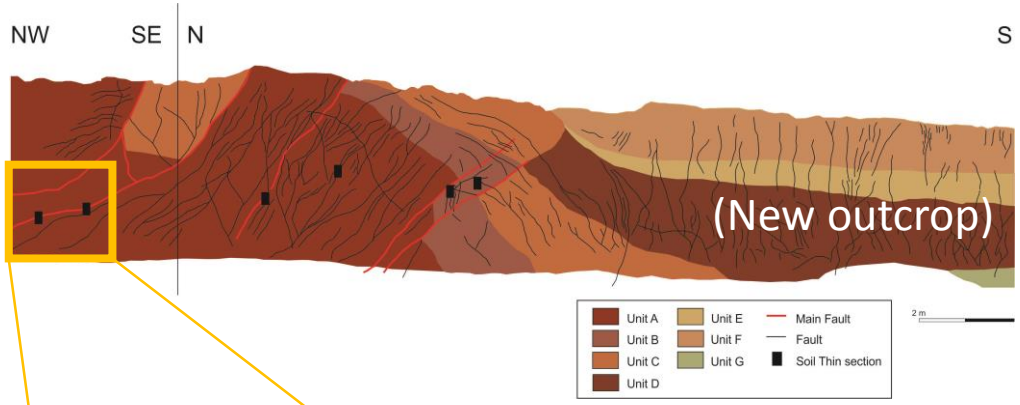


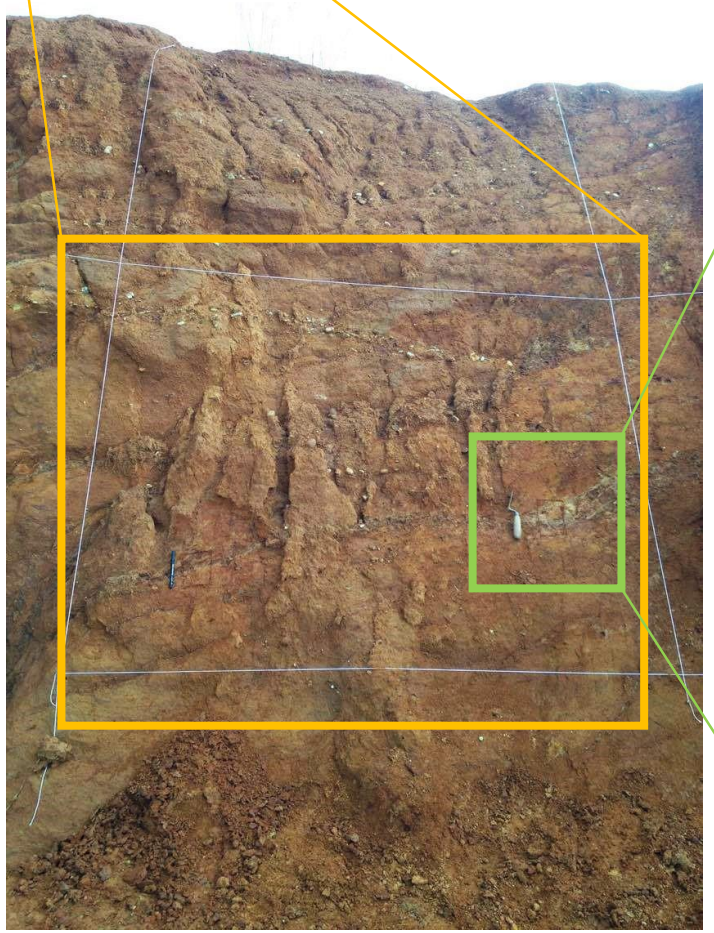


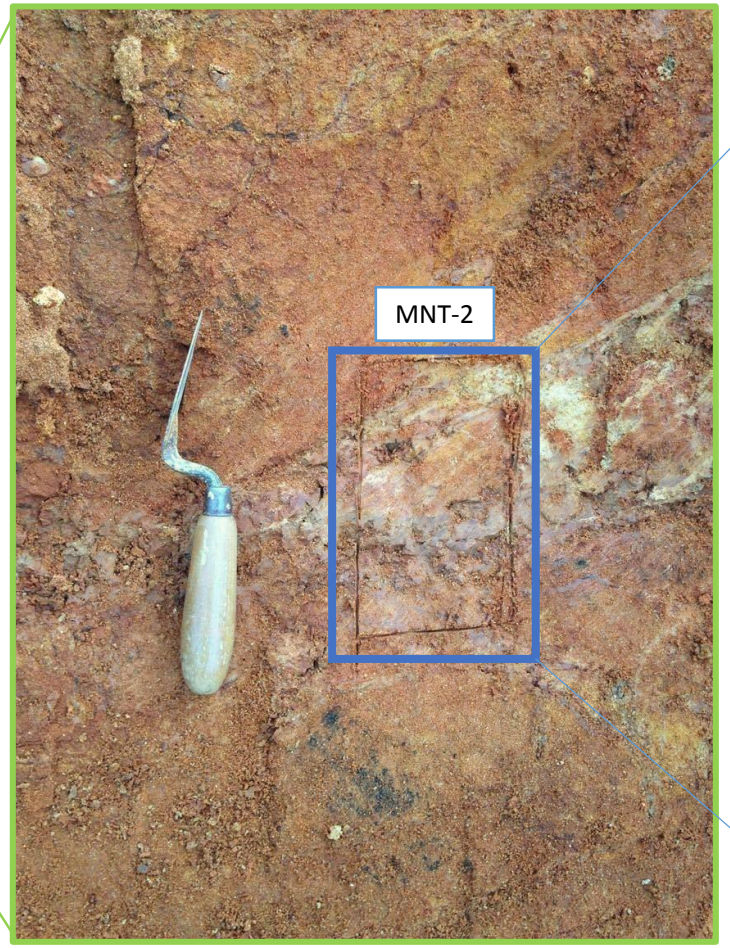
Interpretation

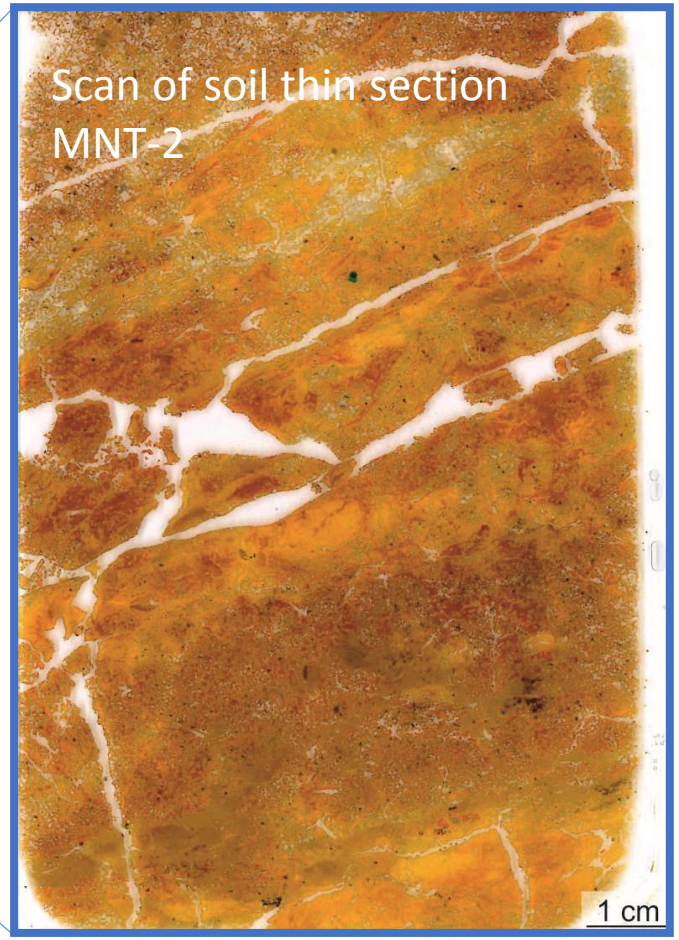
Coatings of illuvial clay after tectonic movements, which displaced a pre-existing coating

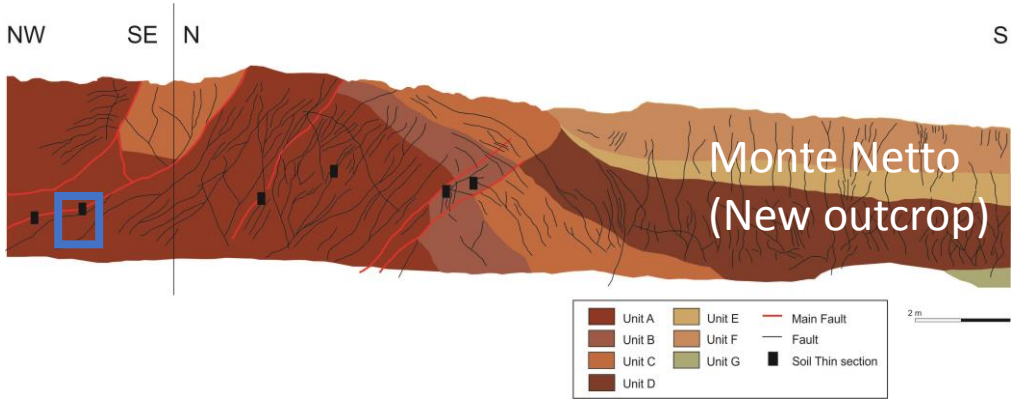
Monte Netto
Field evidences









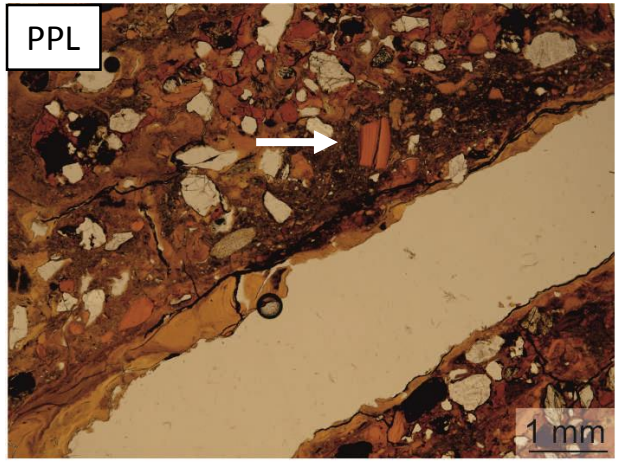


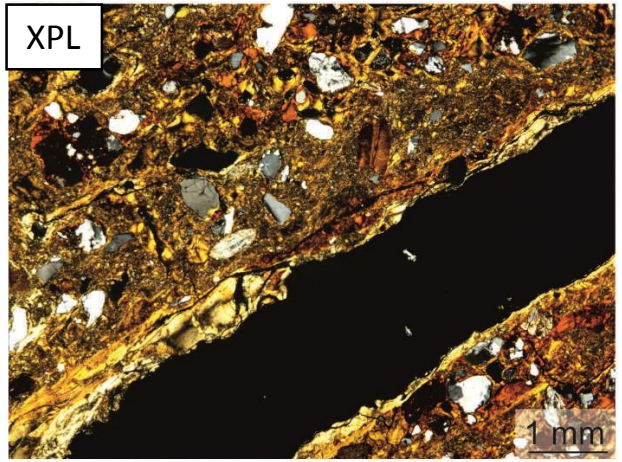
Micromorphological observation

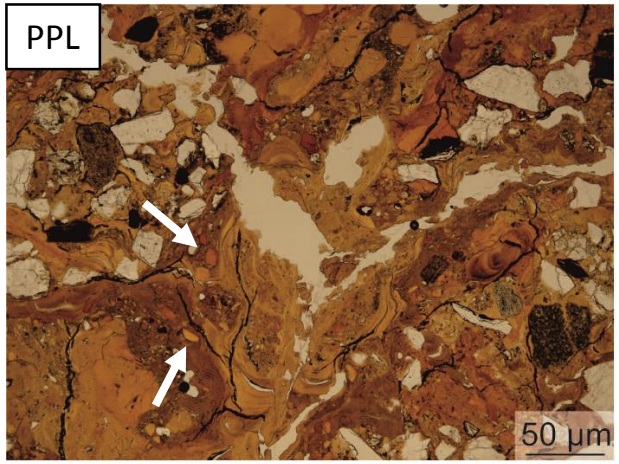
Clay fragments (clay chips) widespread in the micromass

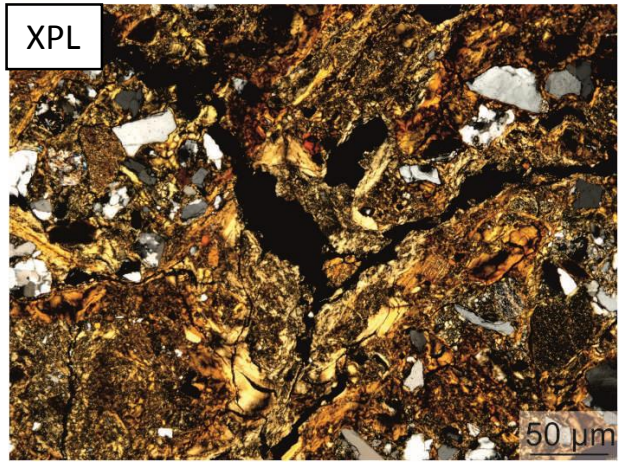
Interpretation

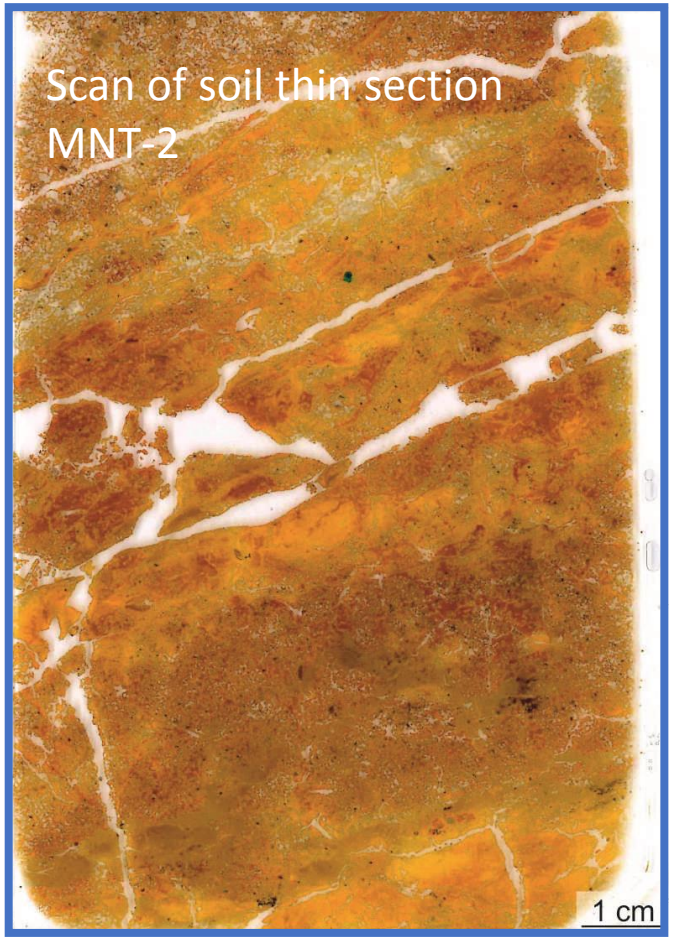
Reworking of pre-existing coatings and infillings due to deformation events



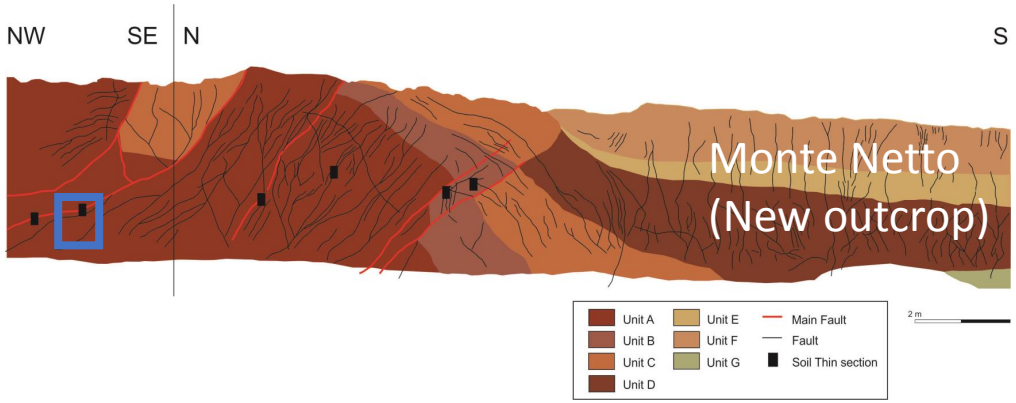






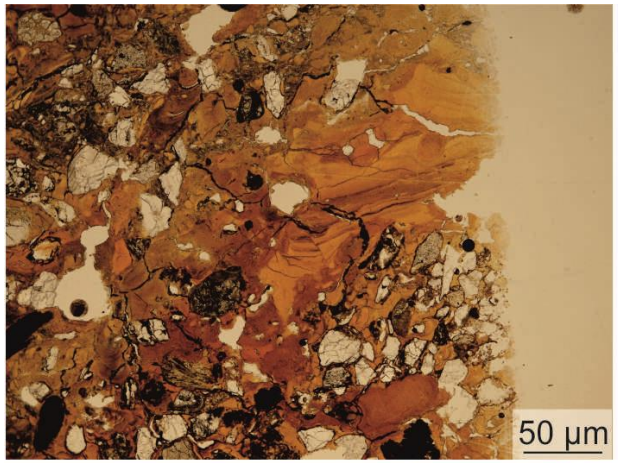


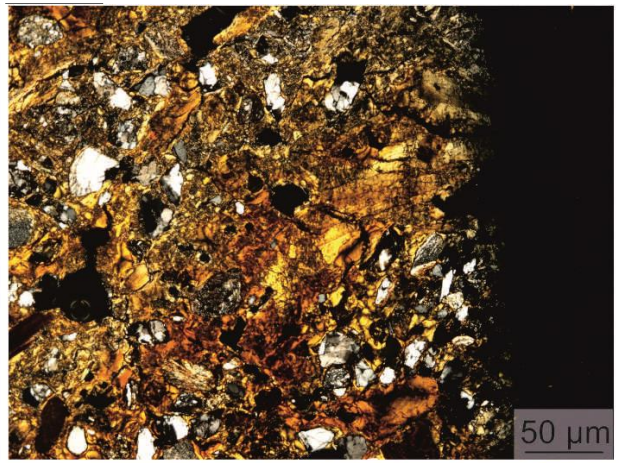
Micromorphological observation

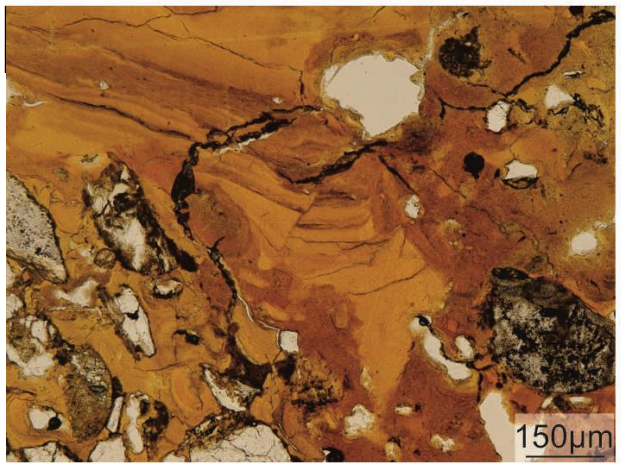


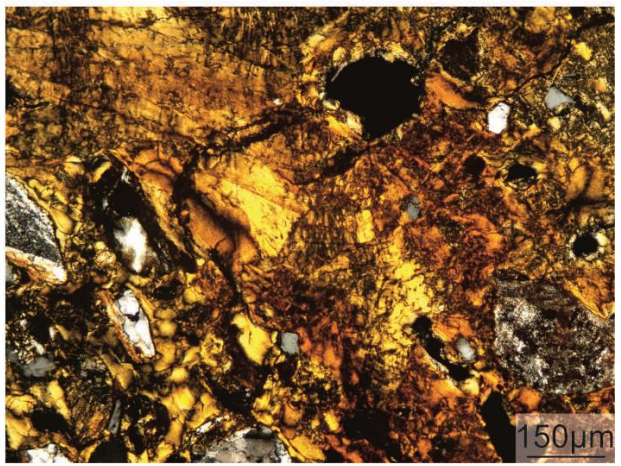
Interpretation

Dislocation due to tectonic movements

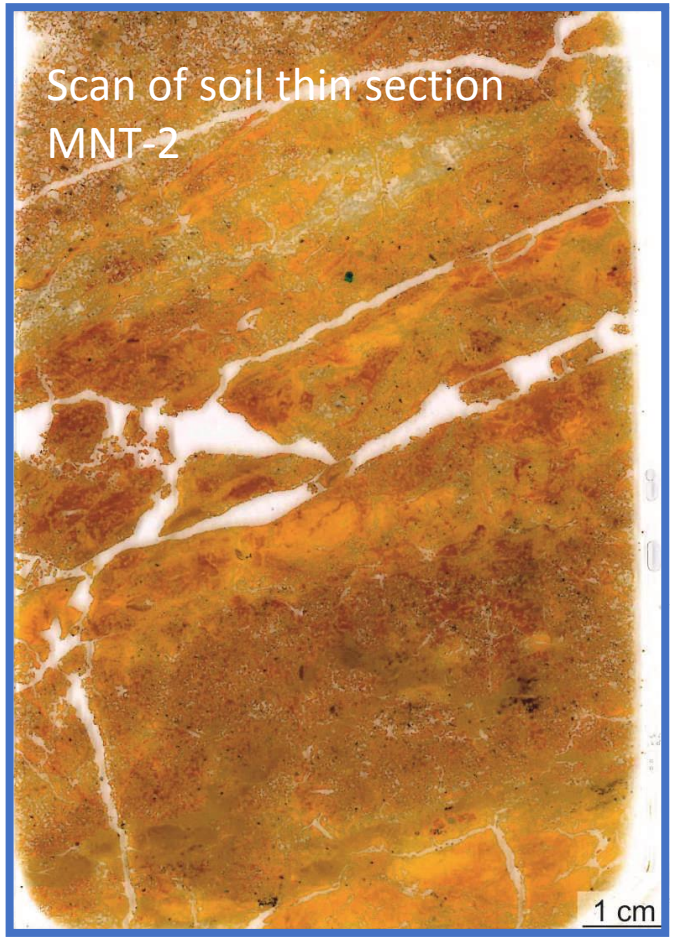




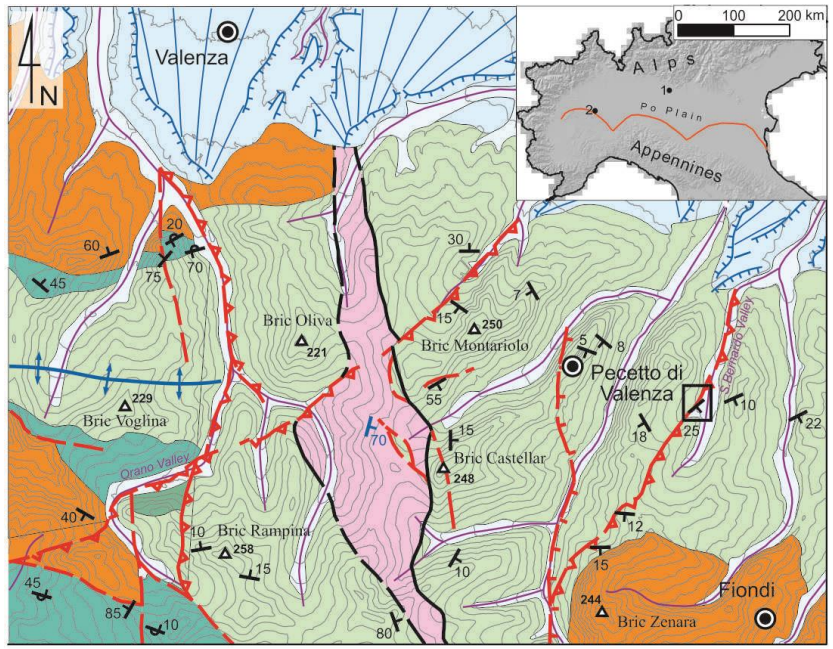




Clay infilling dislocated



Pecetto di Valenza site (Frigerio et al., in press)



QUATERNARY SUCCESSIONS

- Alluvial deposits *Holocene*
- Alluvial deposits *Middle Pleistocene*
- Marne di S. Agata Fossili (**SAF**); coarse-grained lenses (**SAFa**); euxinic shales (**eu**) *Tortonian - Messinian*

CENOZOIC SUCCESSIONS

- Cassano Spinola Formation (**CSS**) *Messinian*

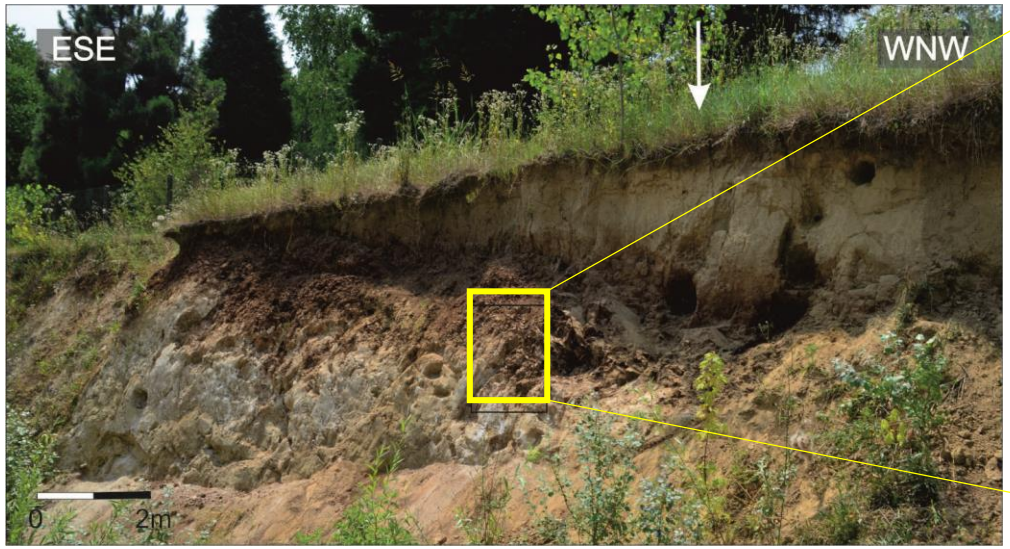
LIGURIAN UNITS

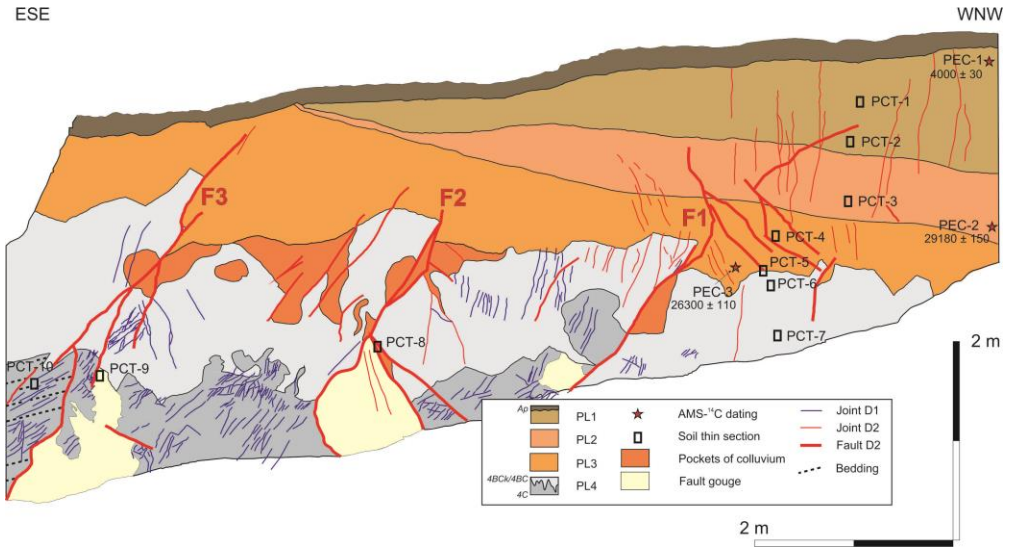
- Argille Varicolori (**AVC**) Late Cretaceous - Eocene

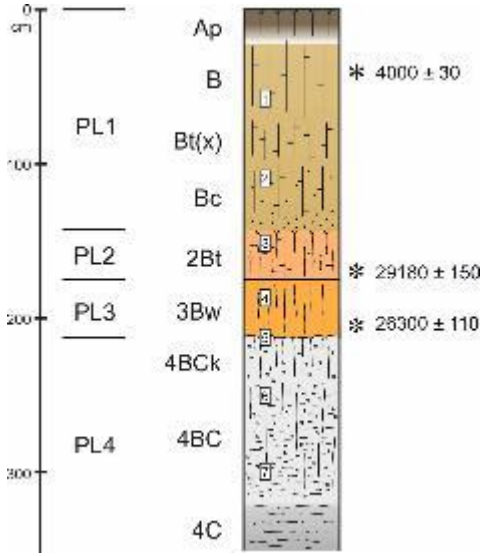
- Tectonic (strike-slip?) detachments, bordering the tectonic mélange) defined, inferred
- Normal fault (ticks on the hanging wall) defined, inferred
- Reverse fault (triangle on the hanging wall) defined, inferred
- Undetermined fault defined, inferred
- Fold axis
- Terrace scarp
- Alluvial fan

Attitude of bedding

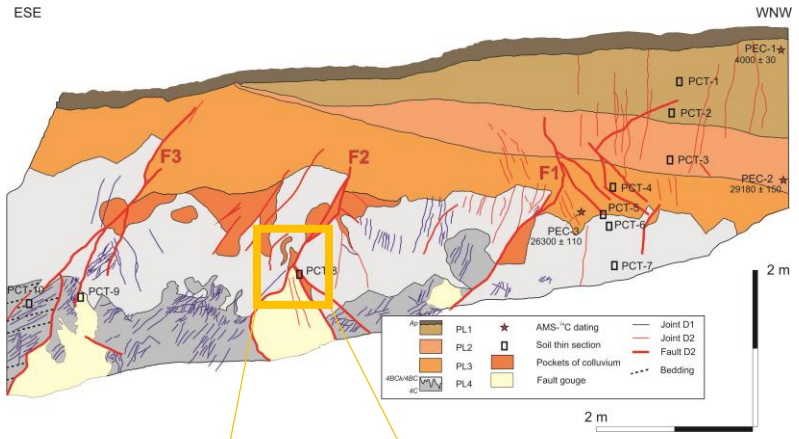
15 upright 25 overturned 15 cleavage

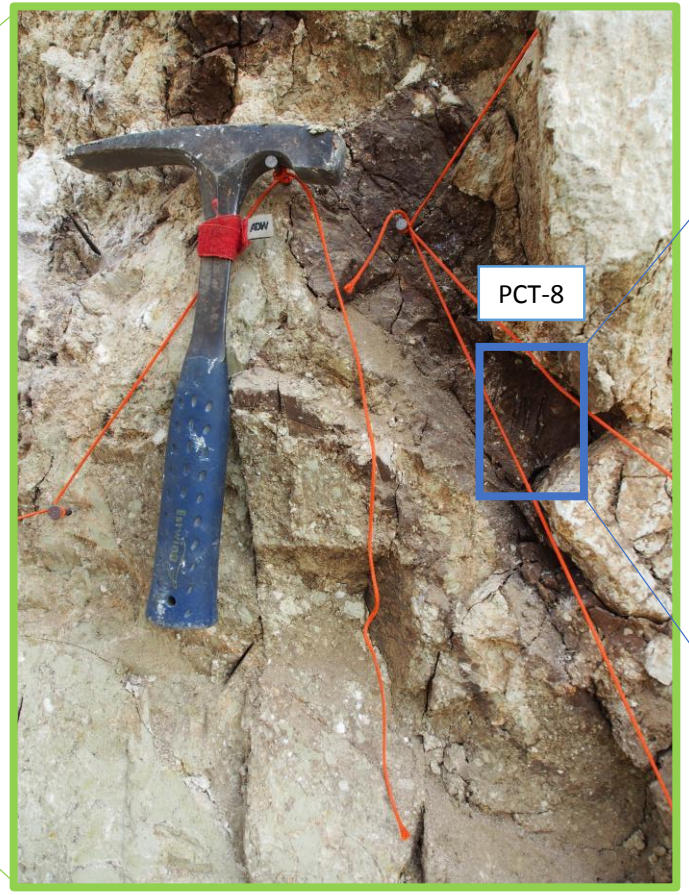


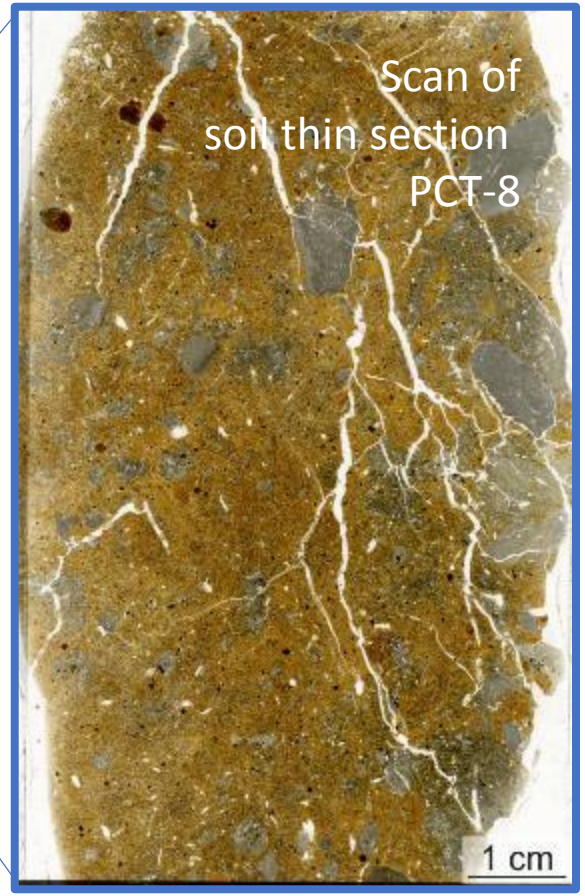




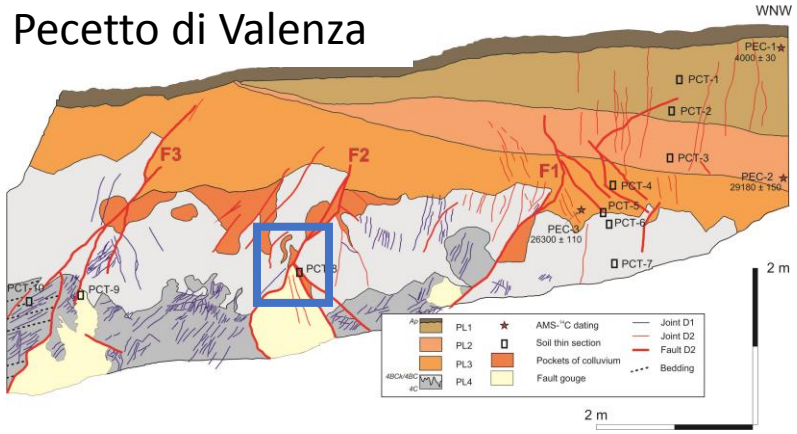
Pecetto di Valenza
Field evidences





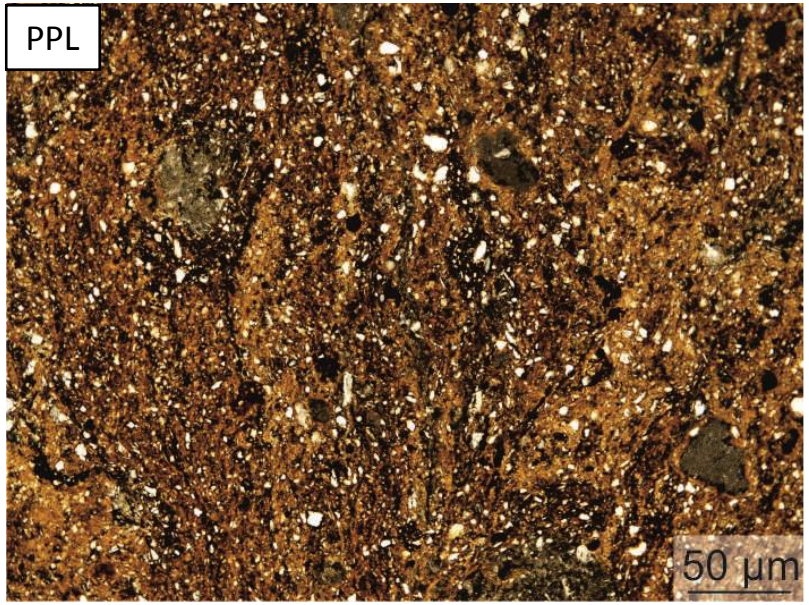


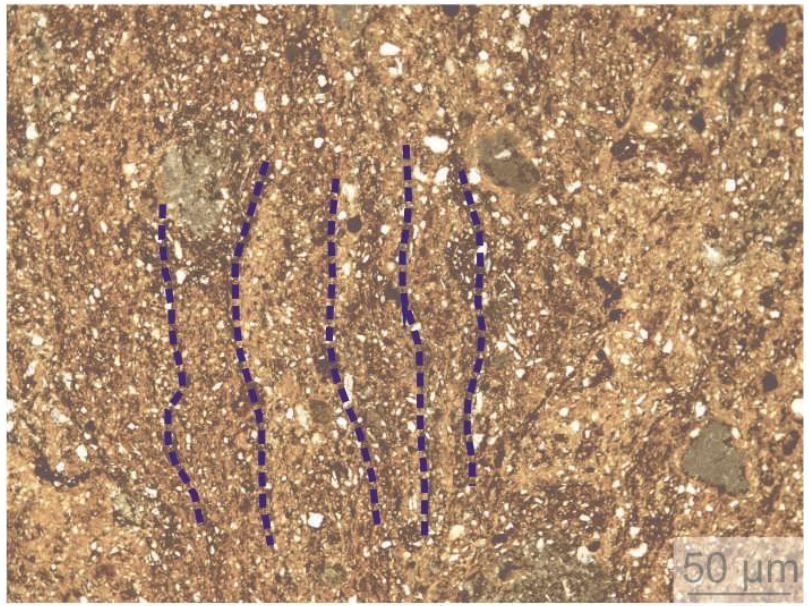
Pecetto di Valenza

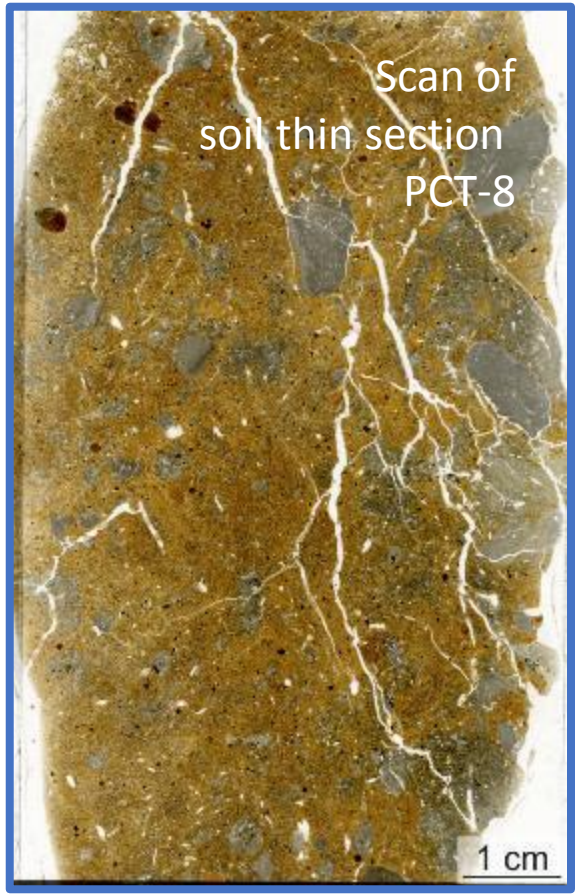


Micromorphological observation

Parallel sub-vertical orientation of the coarser elements of the micromass



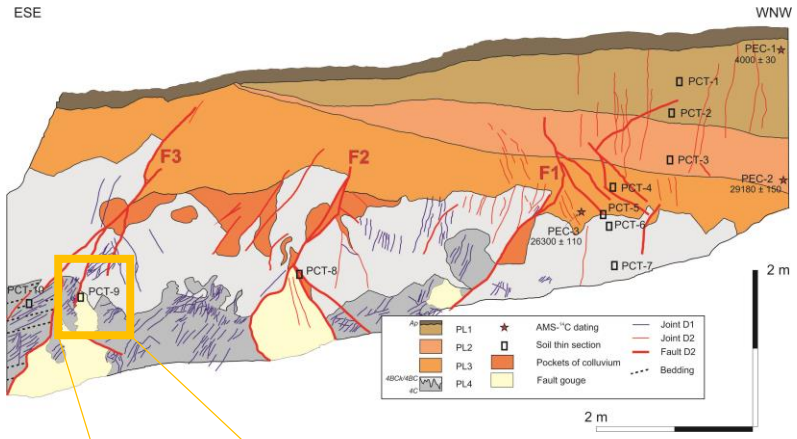


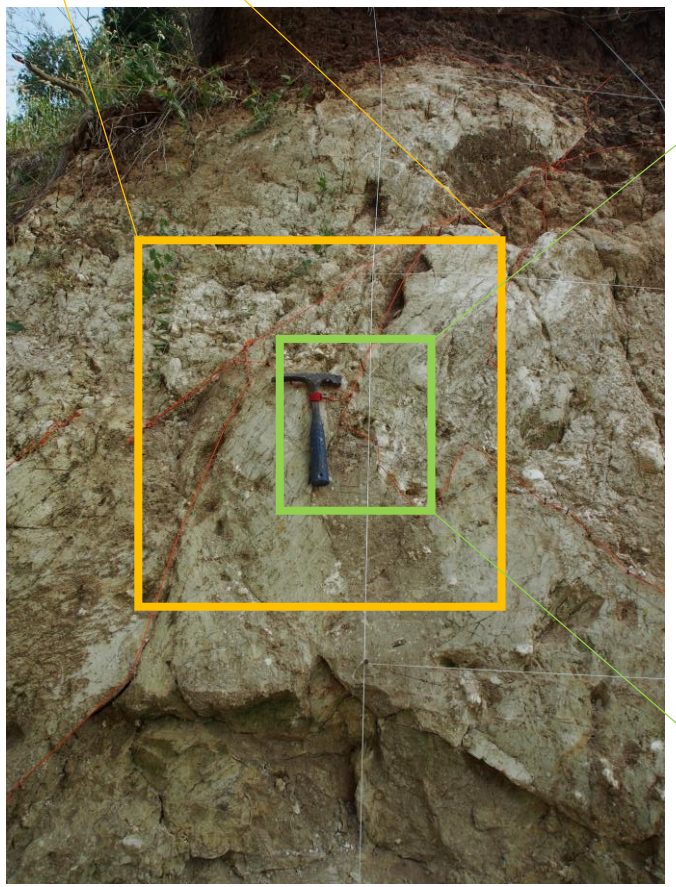


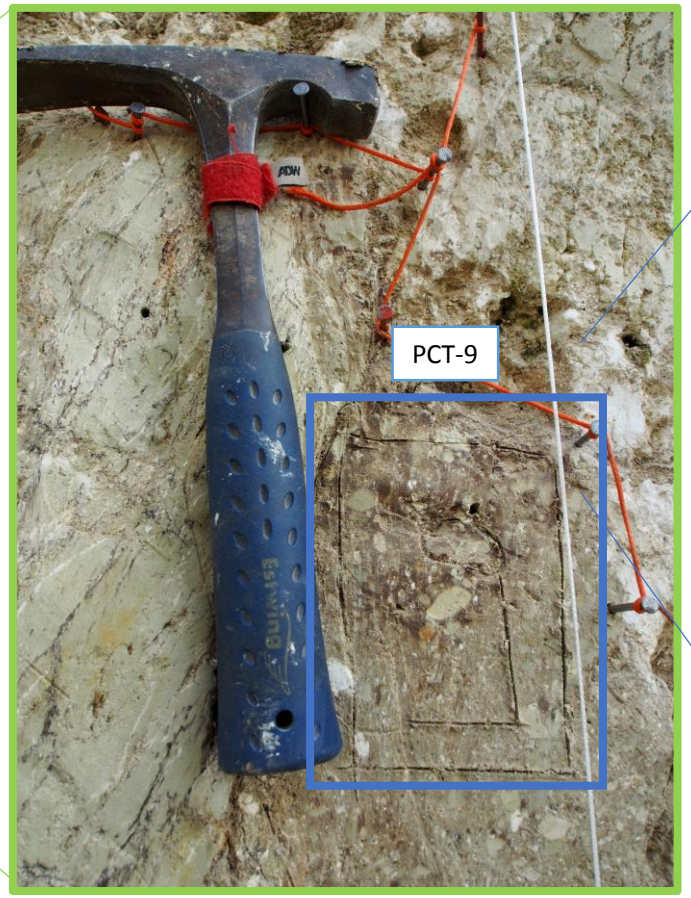
Interpretation

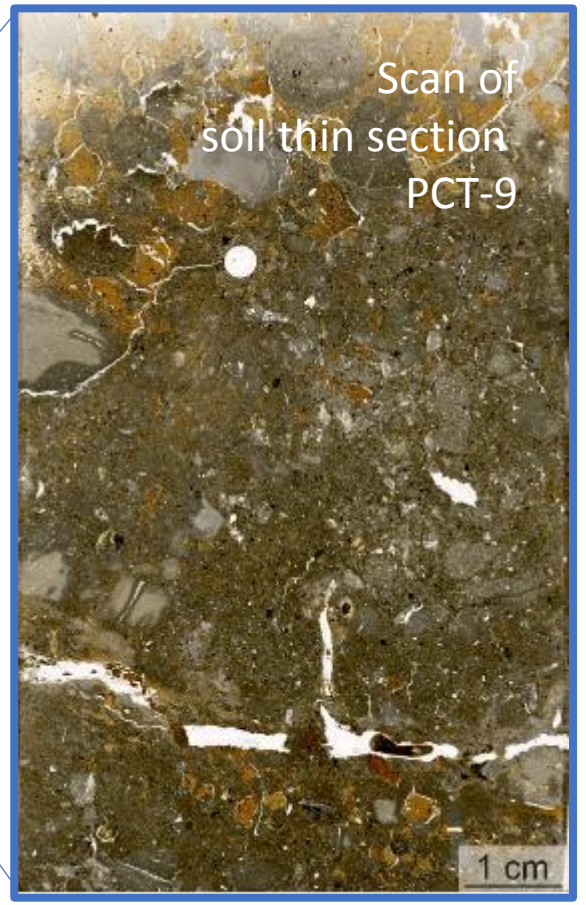
Alignment due to tectonic strain

Pecetto di Valenza
Field evidences

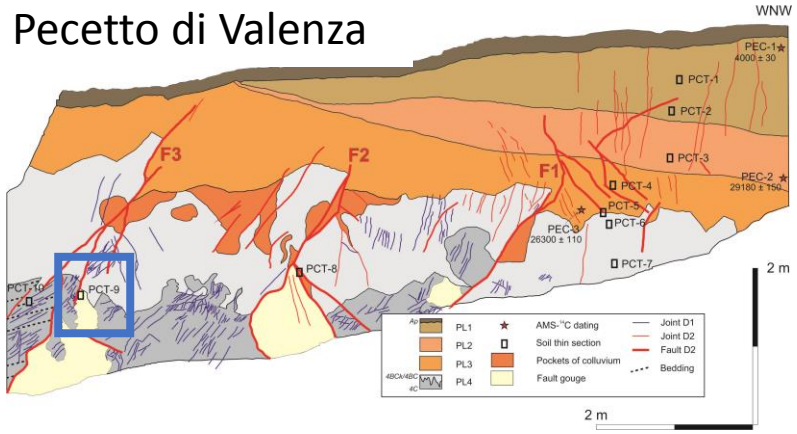






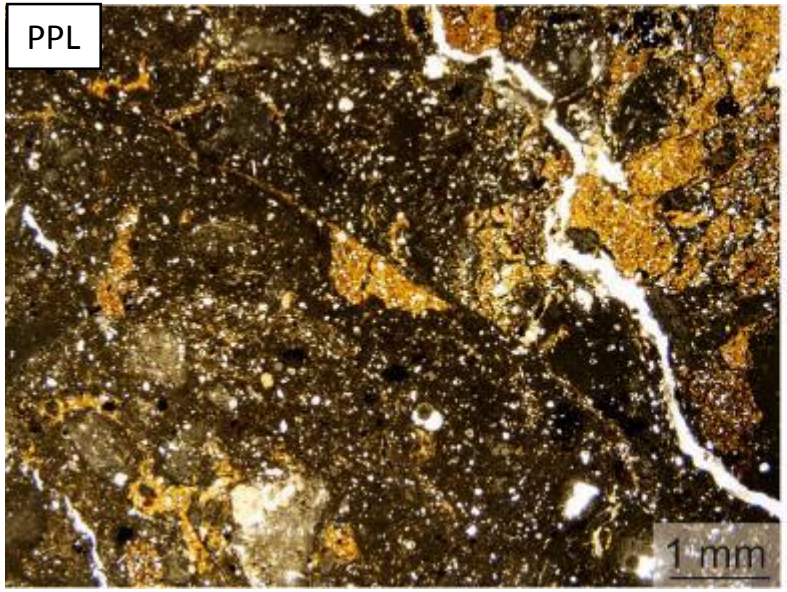


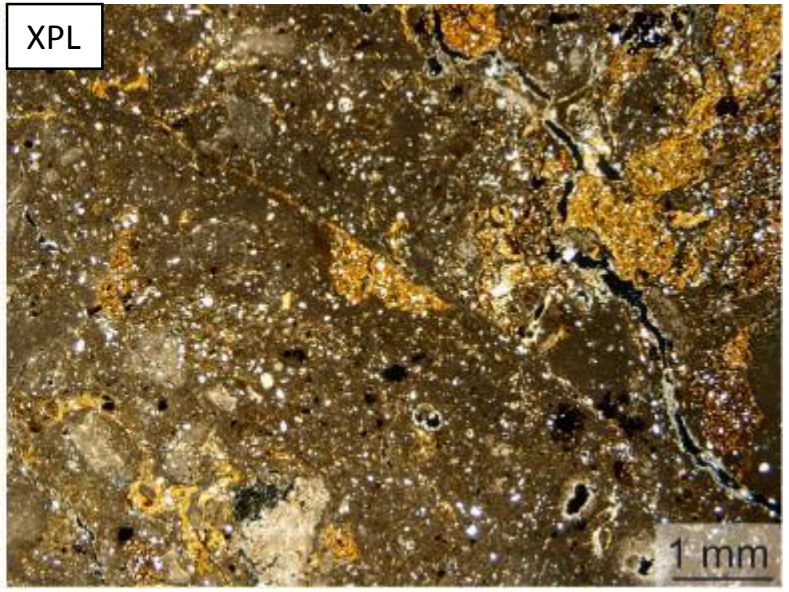
Pecetto di Valenza

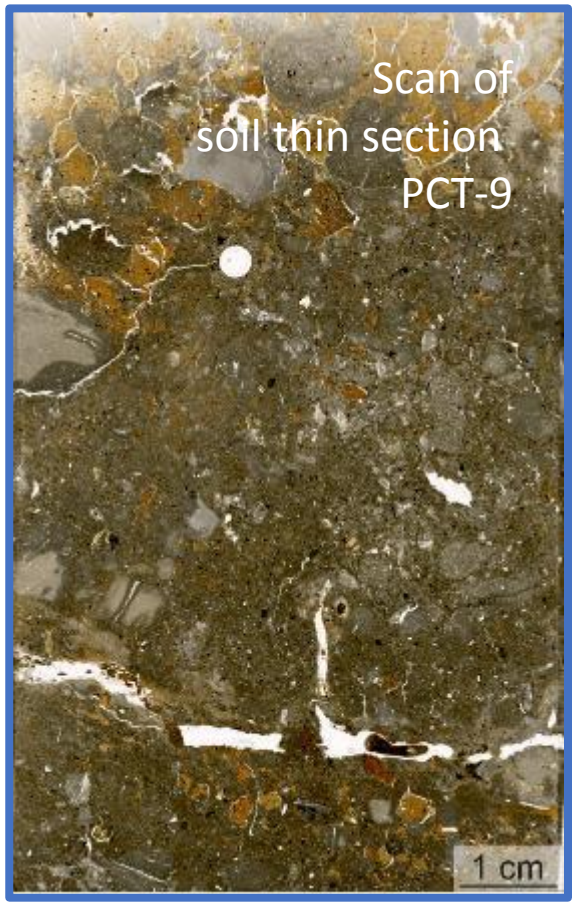


Micromorphological observation

Soil fragments widespread in the weathered marl and sharply cut



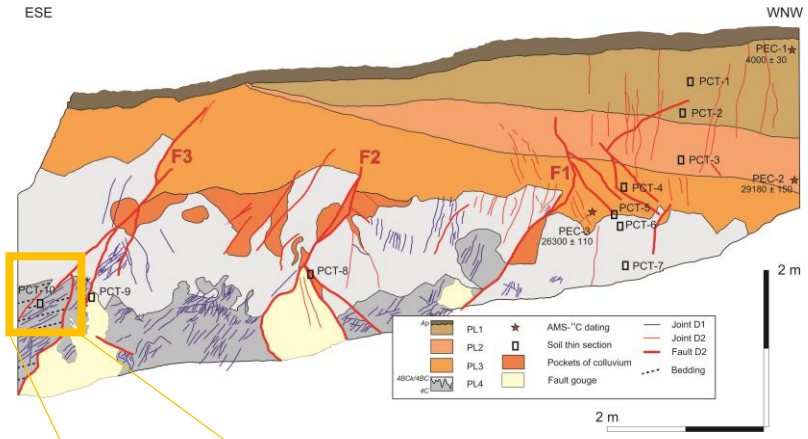


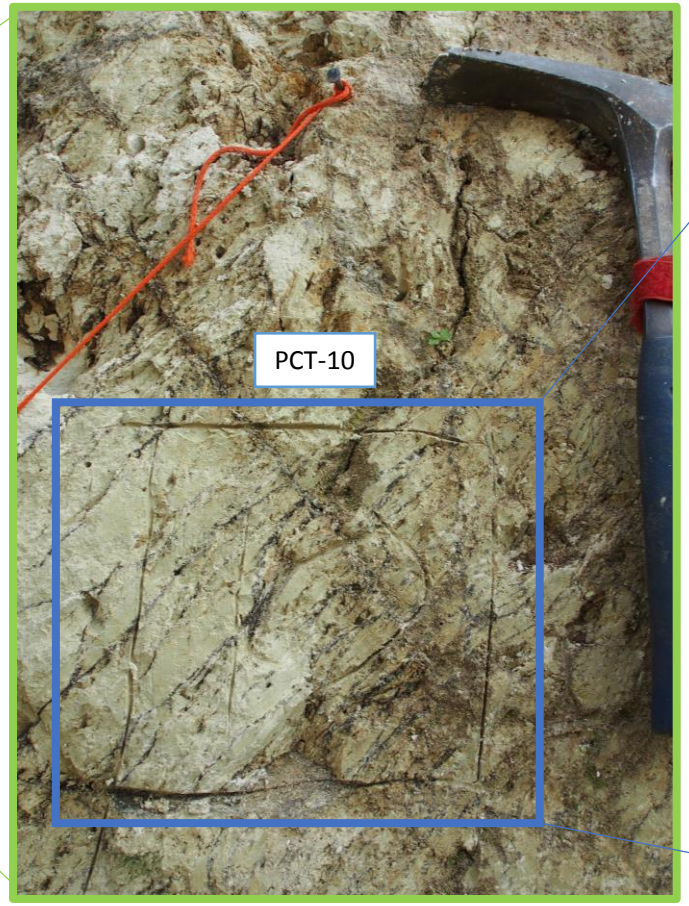


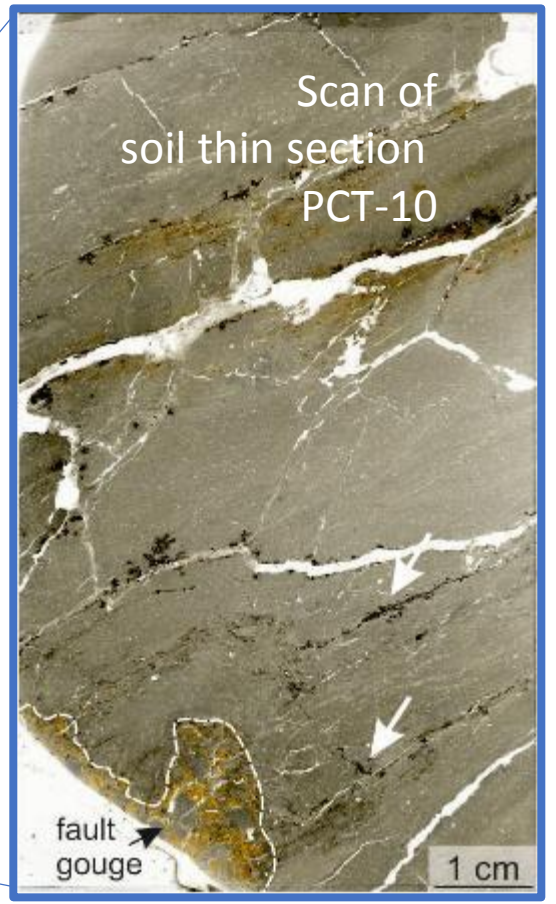
Interpretation

Soil fragments pinched from the base of the colluvium during a coseismic offset, subsequently cut during a new deformation phase

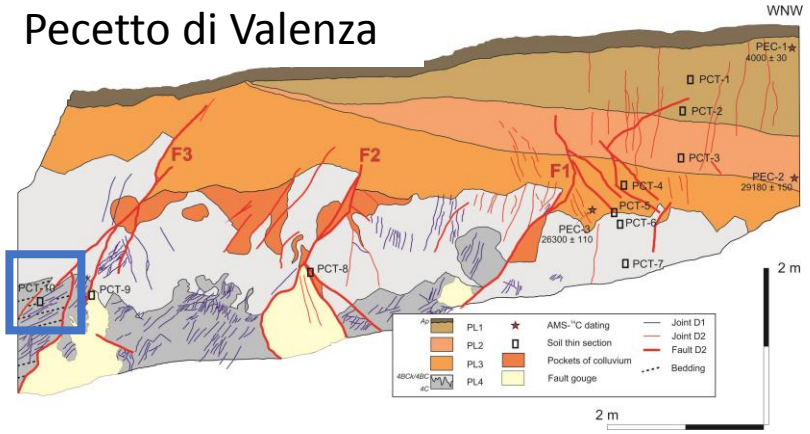
Pecetto di Valenza
Field evidences







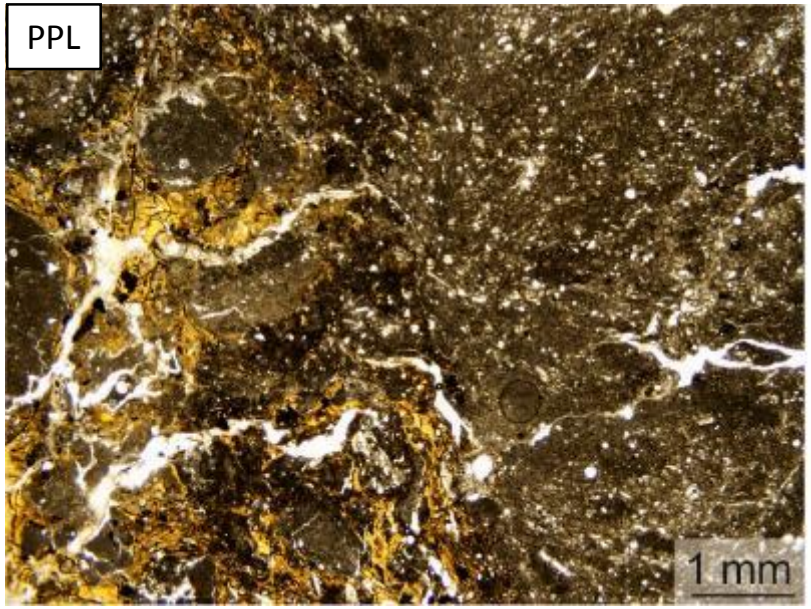
Pecetto di Valenza

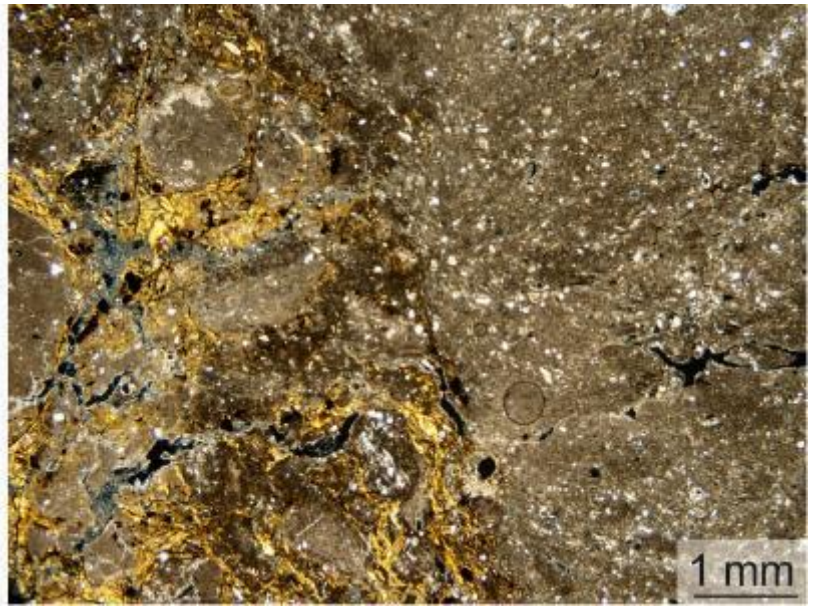


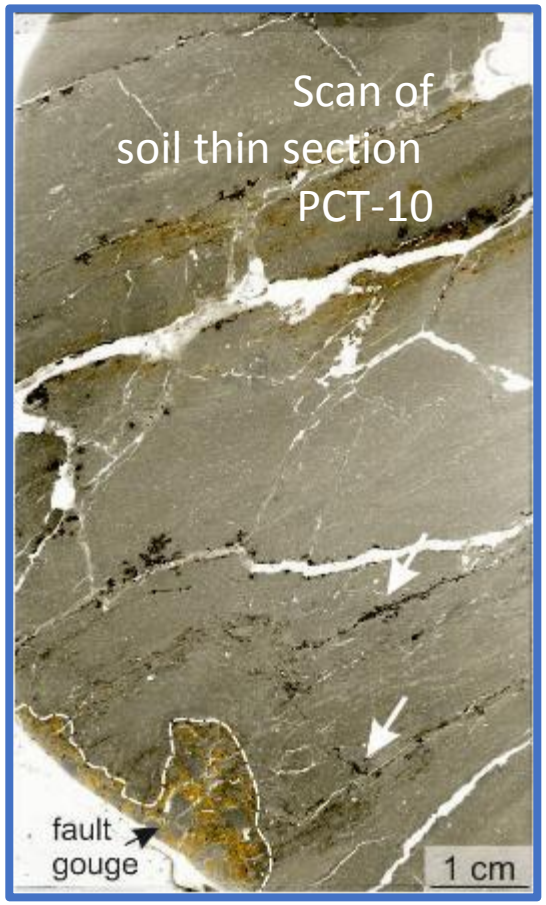
Micromorphological observation

Fe-Mn oxides-hydroxides along planar voids, crosscut by a weathered marl locally infilled by illuvial clay and deformed in a small-scale kink band anticline

PPL







Interpretation

Joints marked by Fe-Mn orthic nodules ascribable to a first deformation phase, crosscut by the fault gouge associated to a later faulting event

Conclusions

The micromorphologiacal approach highlights:

- the usefulness of paleosols in giving an additional data to reconstruct the relative chronological framework of seismic deformations;
- the recognition of repeated tectonic events that disturbed/formed specific pedofeatures is possible in the case of continuous pedogenetic processes;
- the potential applicability of this tool to sedimentary and geomorphological settings characterized by e.g., low or discontinuous sedimentation rates, high erosion activity etc.

Grazie per l’attenzione