Structural Complexity and Mechanics of a shallow crustal Seismogenic Source (Vado di Corno Fault Zone, Italy)

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Fondriest et al., JGR-Solid Earth, under review

Aim and motivation of the study

Quantifying the effect of structural inheritance, i.e. the geometry of a preexisting thrust zone, on the internal architecture of a seismically active extensional fault zone.

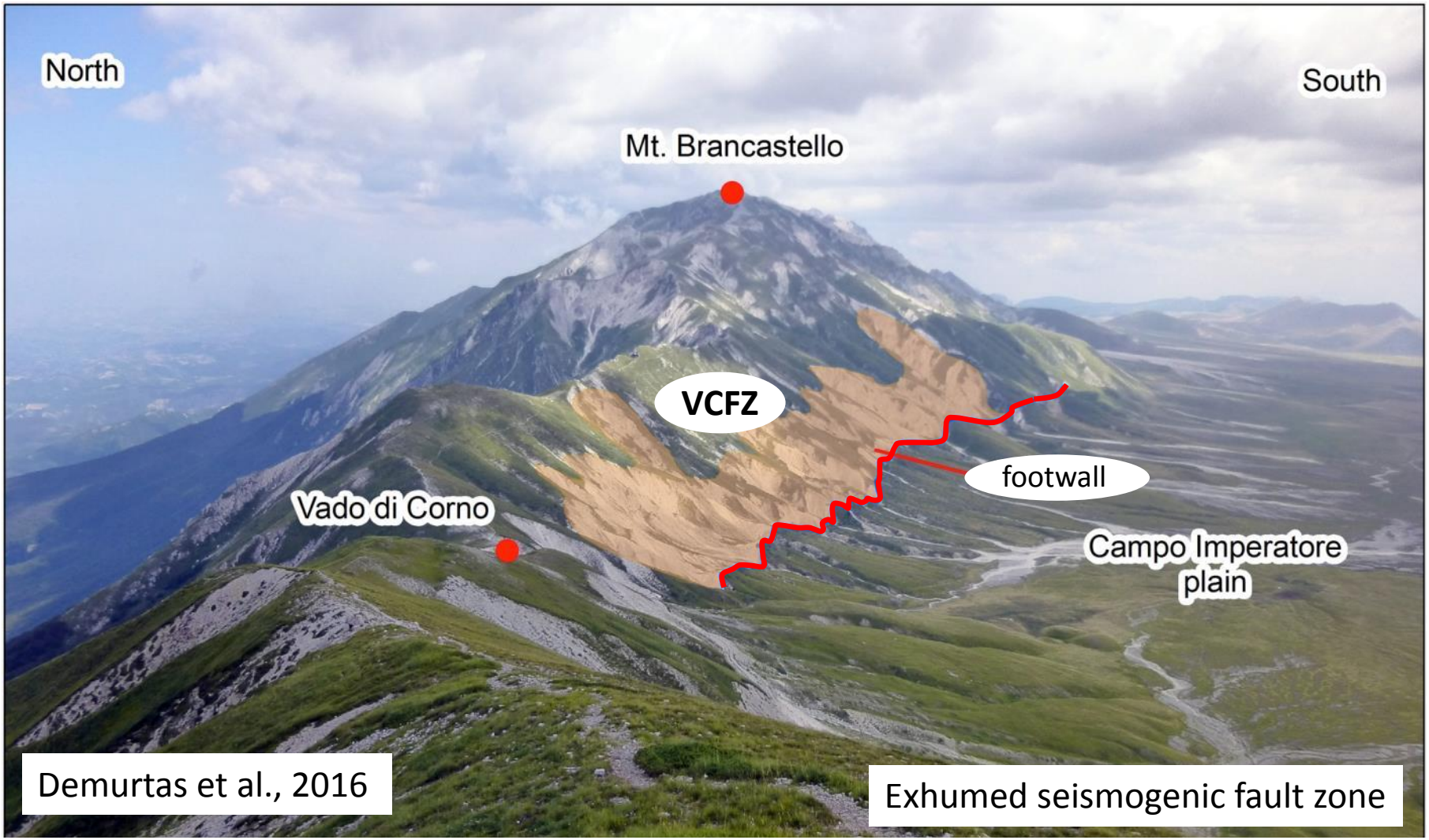
The arising geometrical and kinematic complexities may significantly affect the mechanics of fault zones, also during earthquake propagation.

Method

Detailed characterization of the internal structure of a ~ 2 km long segment of an extensional seismically active fault zone (Vado di Corno Fault Zone, VCFZ), cutting carbonates in the Central Apennines of Italy, by:

- high-resolution (scale 1:500) structural mapping of the exposed fault footwall block;
- building of a 3D fault network model integrating (i) fault surface geometry and topology, (ii) fault kinematics, and (iii) fault rock distribution;
- testing the 3D fault network in a boundary element mechanical model with applied remote stress field to retrieve slip distributions and partitioning.

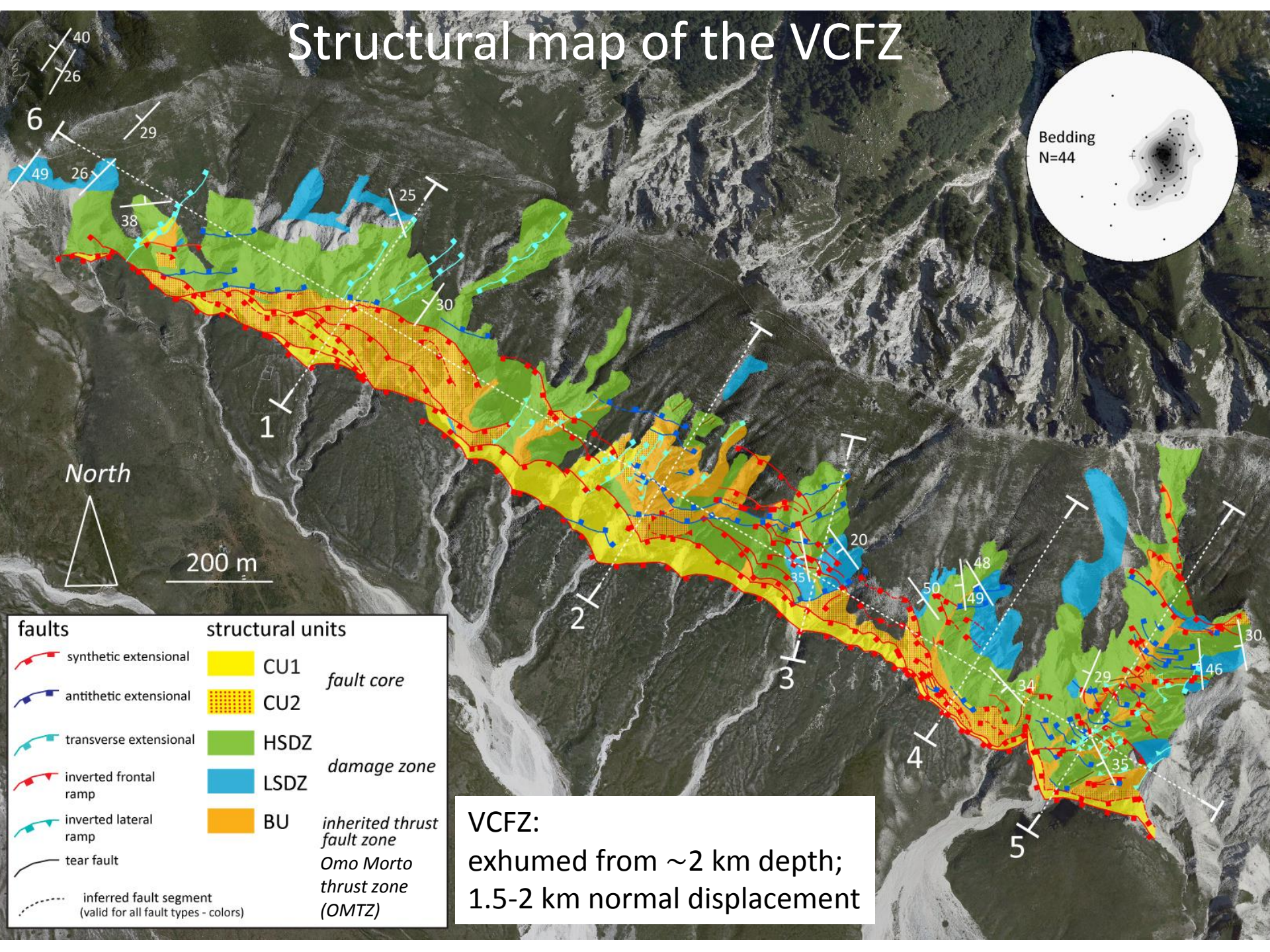
the exhumed Vado di Corno extensional fault zone (VCFZ)



Seismic activity of the VCFZ from:

- paleoseismology (expected EQ up to M 6.95, Galadini et al., 2003)
- micro-seismicity $M_L < 2.5$ (ISIDe Catalog, INGV)

Structural map of the VCFZ



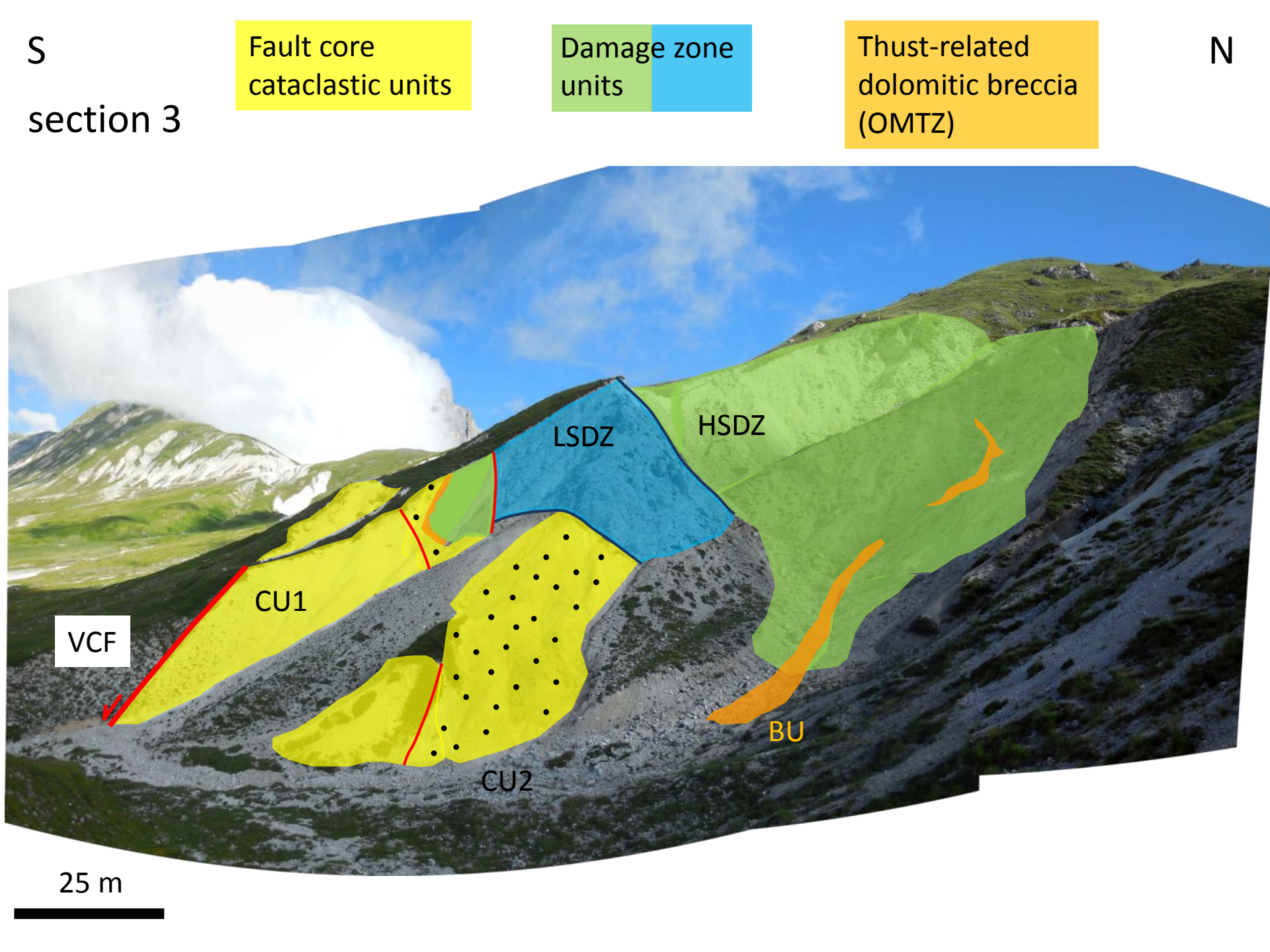
VCFZ:
exhumed from ~2 km depth;
1.5-2 km normal displacement

S

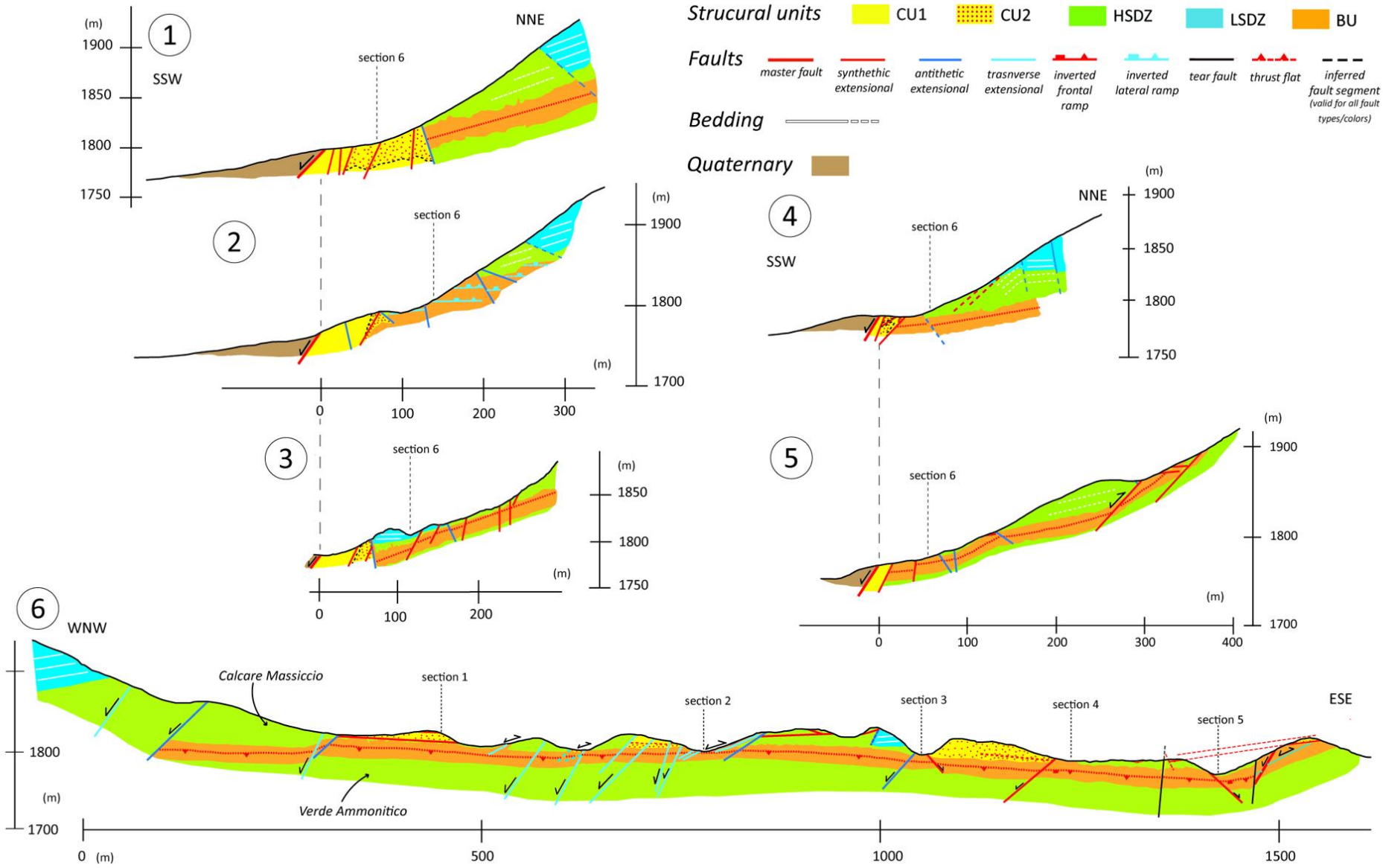
N

section 3

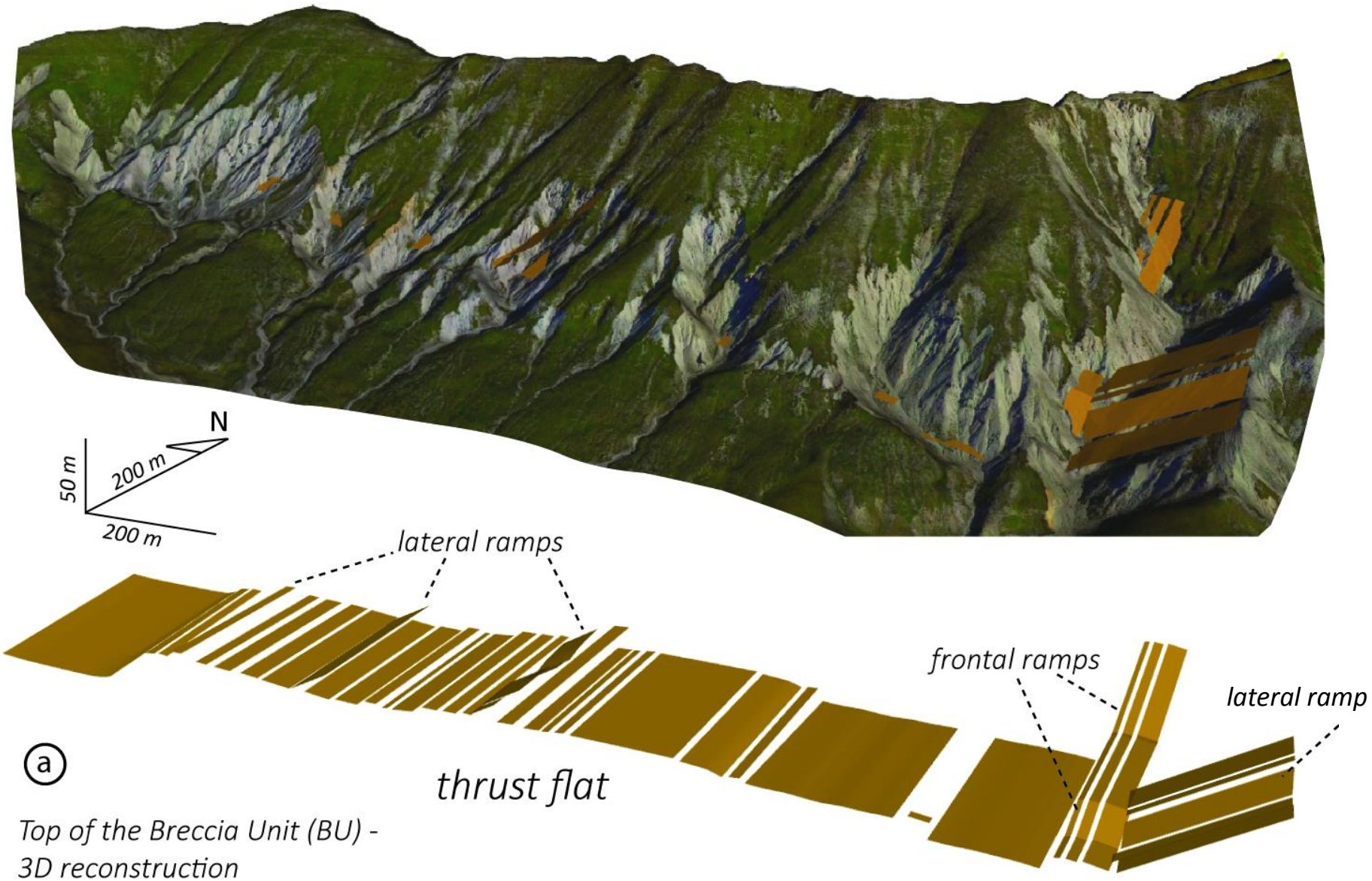
25 m


S
section 3
Fault core cataclastic units
Damage zone units
Thust-related dolomitic breccia (OMTZ)
N
LSDZ
HSDZ
CU1
VCF
BU
CU2
25 m

Extensional faulting (Pleistocene onwards) cuts through the Omo Morto Thrust Zone (OMTZ; Pliocene, orange unit) with partial reactivation in extension

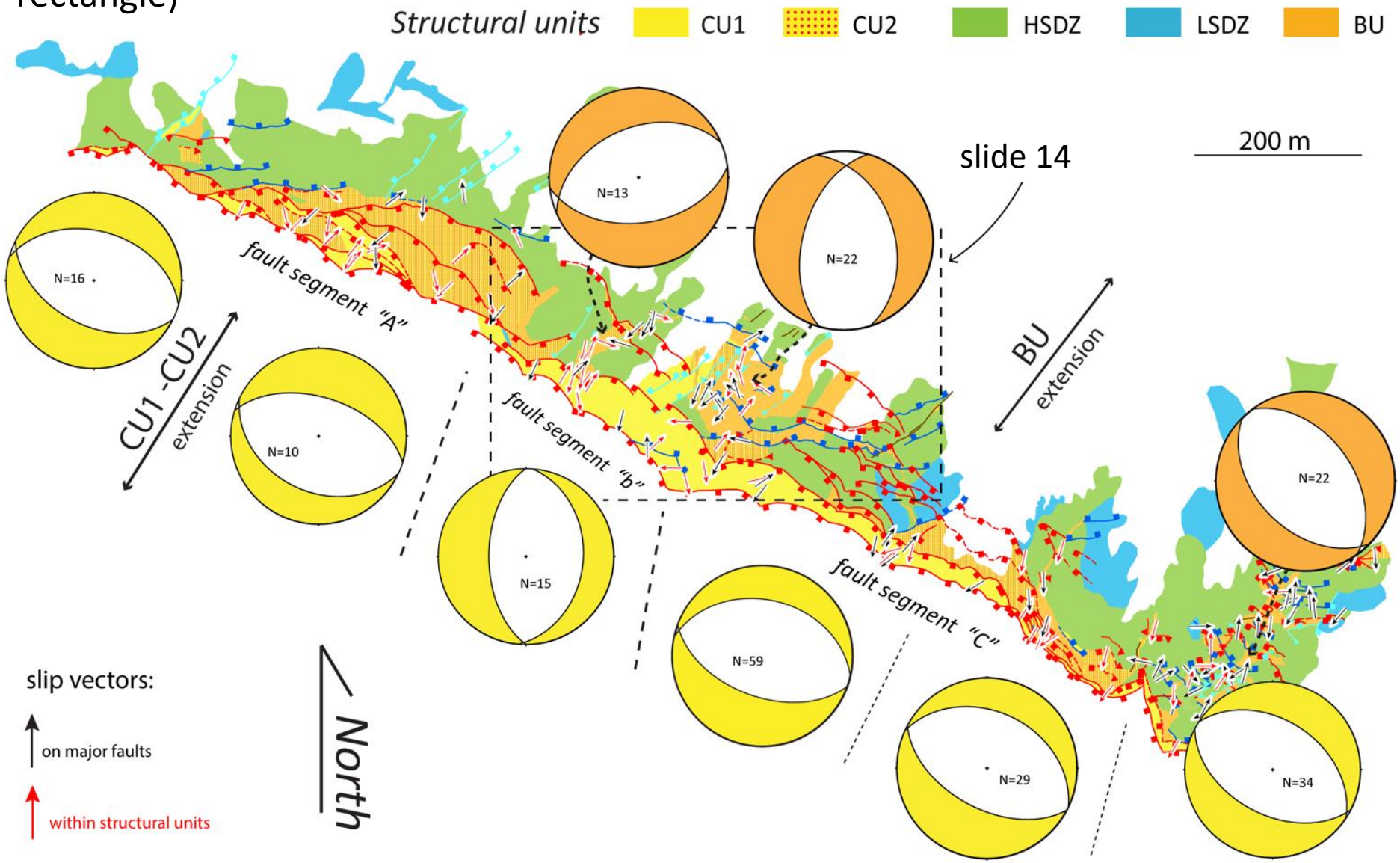


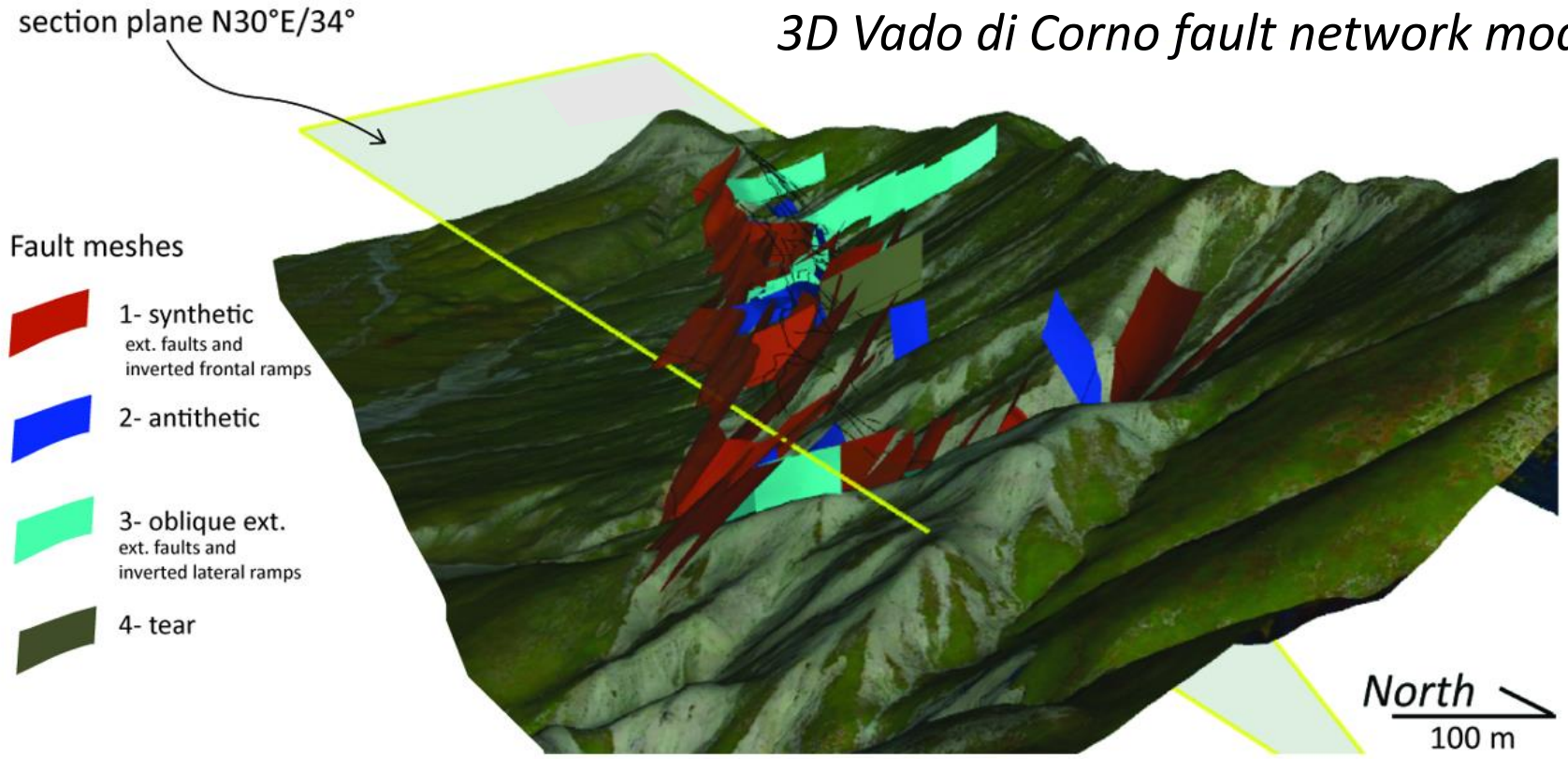
Omo Morto thrust geometry – lateral ramps

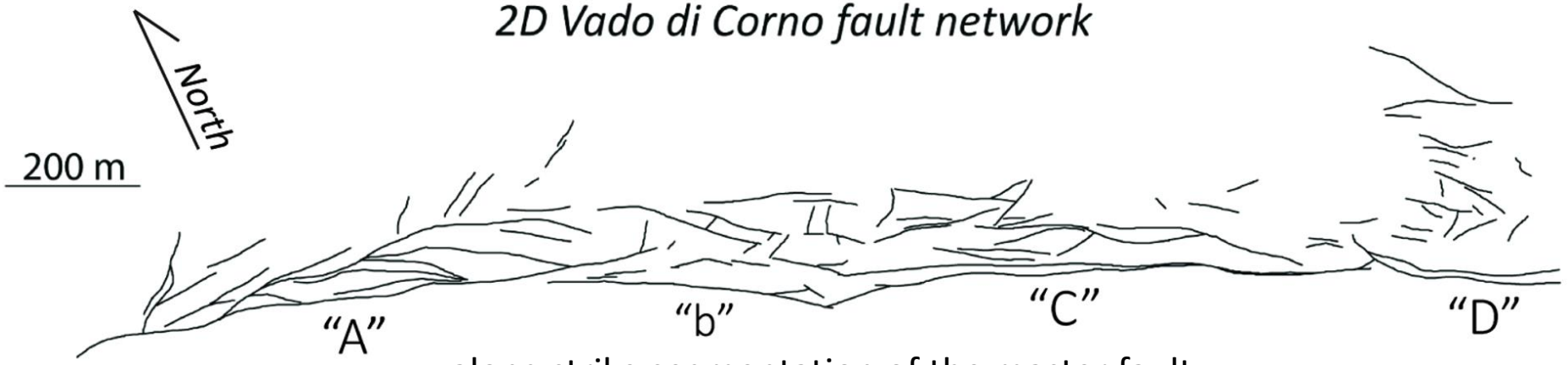


Top of the Breccia Unit (BU) - 3D reconstruction

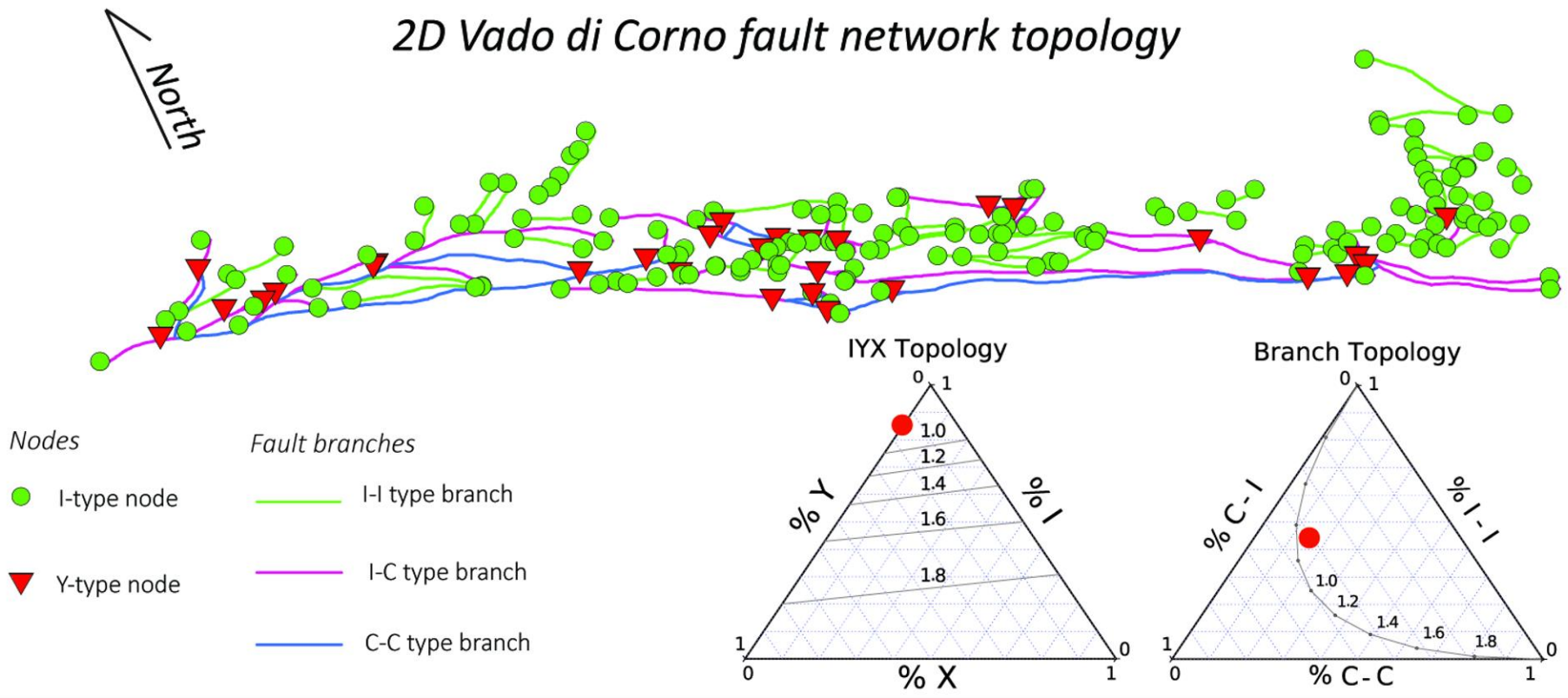
Complex geometry of the OMTZ (i.e. lateral ramps) determines kinematic irregularities along the extensional Vado di Corno Fault Zone (VCFZ) (dashed rectangle)







along strike segmentation of the master fault

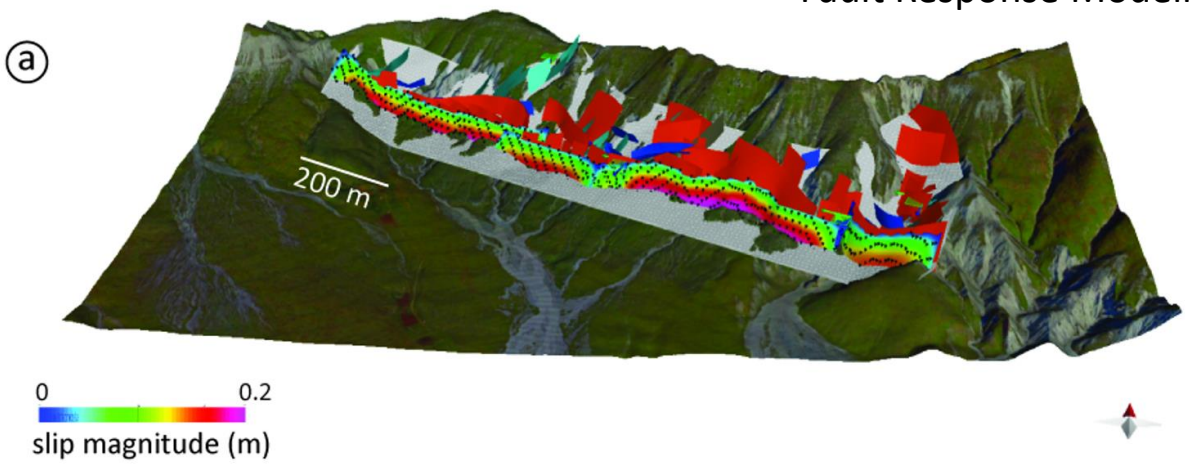


The location of the OMTZ lateral ramps is controlling the complexity of the VCFZ network (clusters of Y-type nodes) and the along strike segmentation of the master fault.

Insights from mechanical modeling (BEM)

Fault Response Modelling (FRM) module of MOVE – Petex

scenario 1
master fault not extended

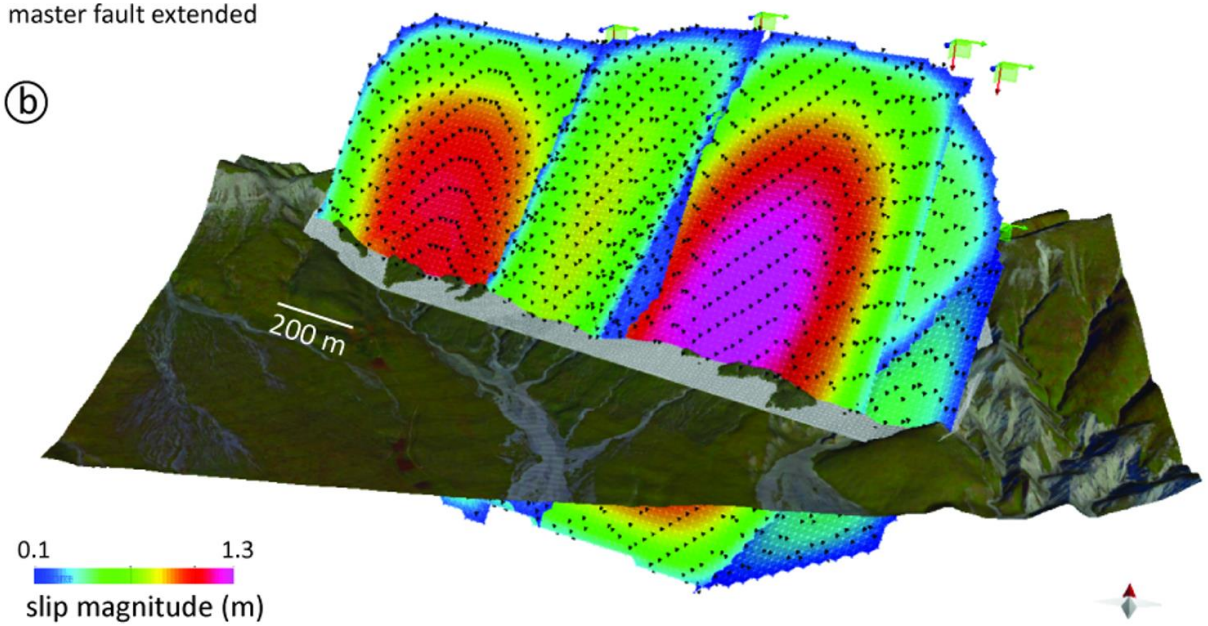


Remote loading

σ1 (N38/84°) = 51 MPa
σ2 (N298/1°) = 21 MPa
σ3 (N208/6°) = 12 MPa

slip on the master fault segments

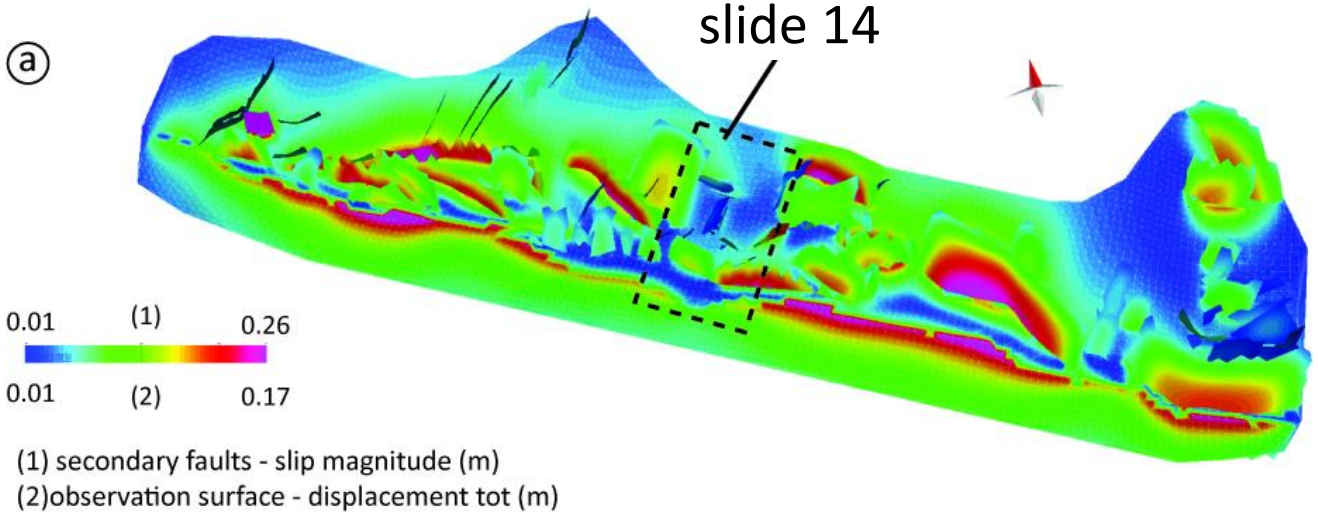
scenario 2
master fault extended



Insights from mechanical modeling (BEM)

scenario 1
master fault not extended

slide 14



(1) secondary faults - slip magnitude (m)
(2)observation surface - displacement tot (m)

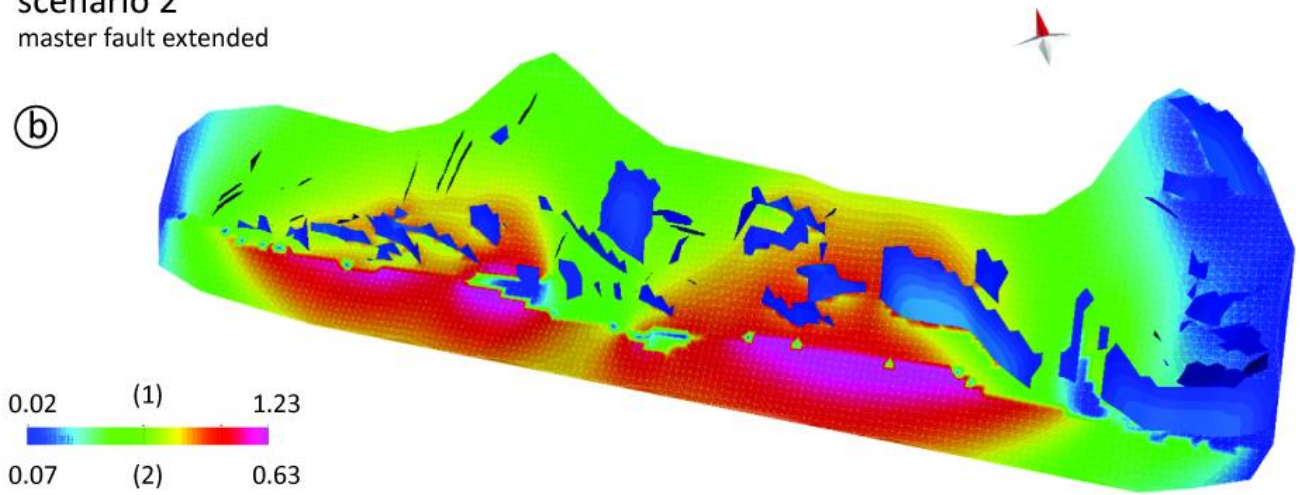
Remote loading

σ1 (N38/84°) = 51 MPa
σ2 (N298/1°) = 21 MPa
σ3 (N208/6°) = 12 MPa

350 m

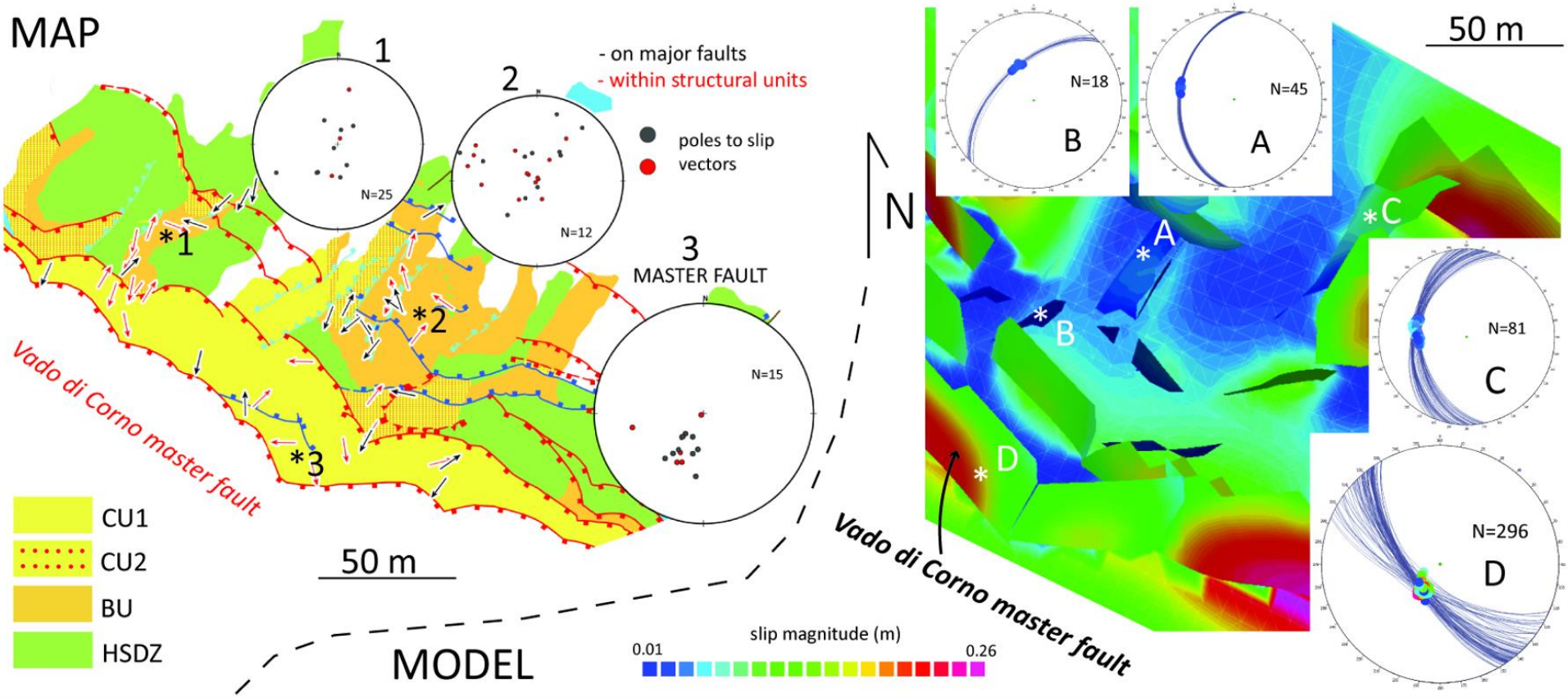
slip on subsidiary faults
& observation surface

scenario 2
master fault extended



(1) secondary faults - slip magnitude (m)
(2) observation surface - displacement tot (m)

Field data vs modelling



Kinematic map of the VCFZ central sector which is characterized by a kinematic decoupling between the fault core and breccia units.
Extensional slip vectors of the faults within the BU show scattered directions from NNE to SSW, due to the reactivation of inherited lateral ramps within the BU.

Modelled fault slips in the VCFZ central sector. The BEM mechanical model reproduced the kinematic decoupling between the fault core units and the BU. The occurrence of lateral ramps alters the along strike geometry of the OMTZ and determines the accommodation of small slips during later extension.

Conclusions

- High-resolution structural mapping and 3D fault network modelling depict the complex internal structure of the VCFZ;

- The combination of the structural map and the 3D fault network model with kinematic and topological analyses, pointed out the crucial role of the OMTZ geometry in controlling the along-strike segmentation and slip distribution of the VCFZ;

- Boundary element mechanical model highlighted the effects of inherited compressional features on the VCFZ internal structure and returned distributions and partitioning of slip comparable with those measured in the field;

- Similar along-strike and possibly down-dip geometrical asperities can significantly influence the mechanics of this fault zones, also during earthquake propagation

References

Demurtas, M., Fondriest, M., Balsamo, F., Clemenzi, L., Storti, F., Bistacchi, A., & Di Toro, G. (2016). Structure of a normal seismogenic fault zone in carbonates: The Vado di Corno Fault, Campo Imperatore, Central Apennines (Italy). *Journal of Structural Geology*, 90, 185-206.

Galadini, F., Galli, P., & Moro, M. (2003). Paleoseismology of silent faults in the Central Apennines (Italy): the Campo Imperatore Fault (gran Sasso range fault system). Annals of Geophysics, 46 (5), 793-813.

Move software – Petroleum Expert