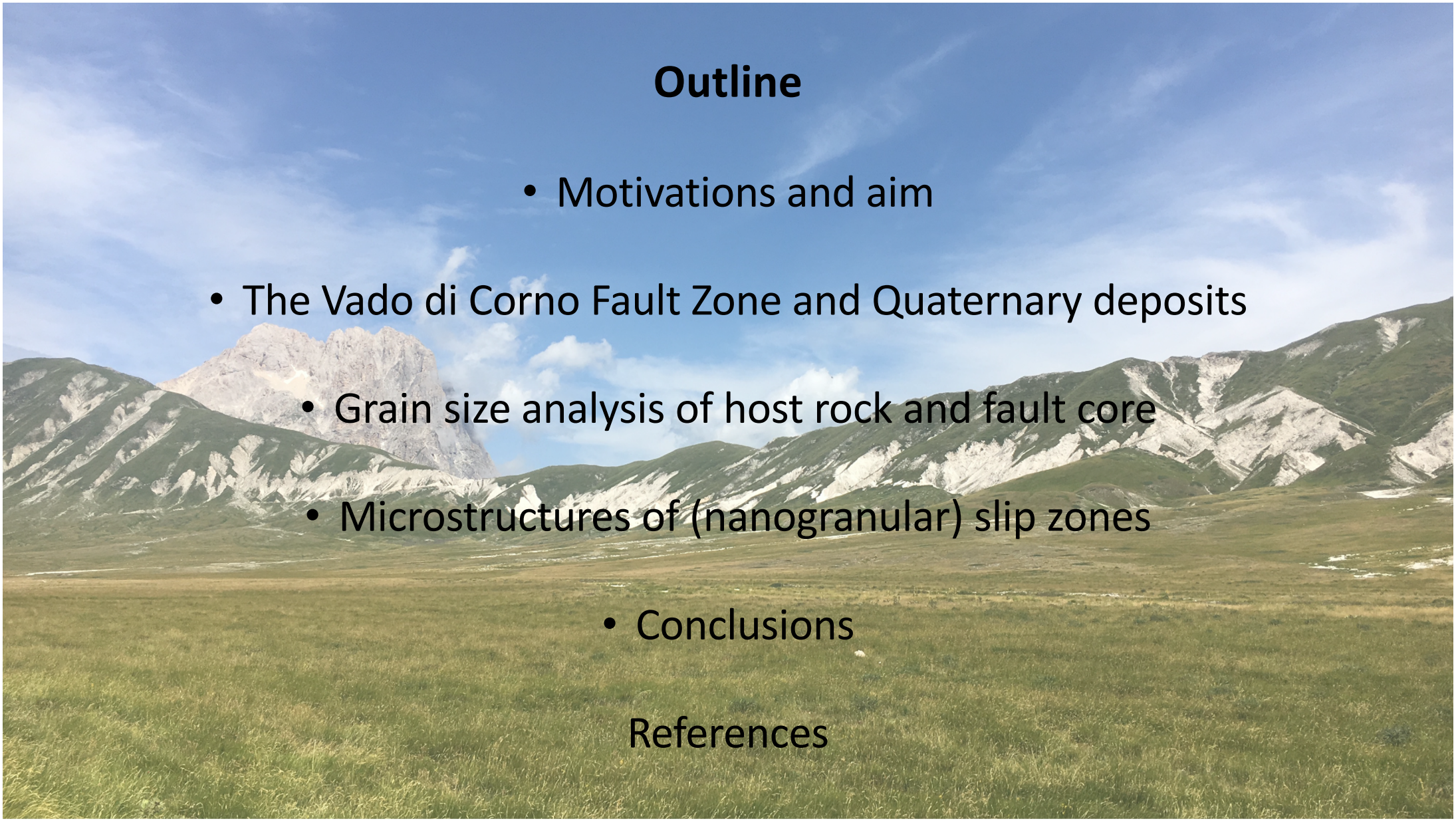
Signature of coseismic slip in unconsolidated Quaternary gravels, Campo Imperatore, Italy

Matteo Demurtas, Fabrizio Balsamo, Mattia Pizzati

matteo.demurtas@geo.uio.no

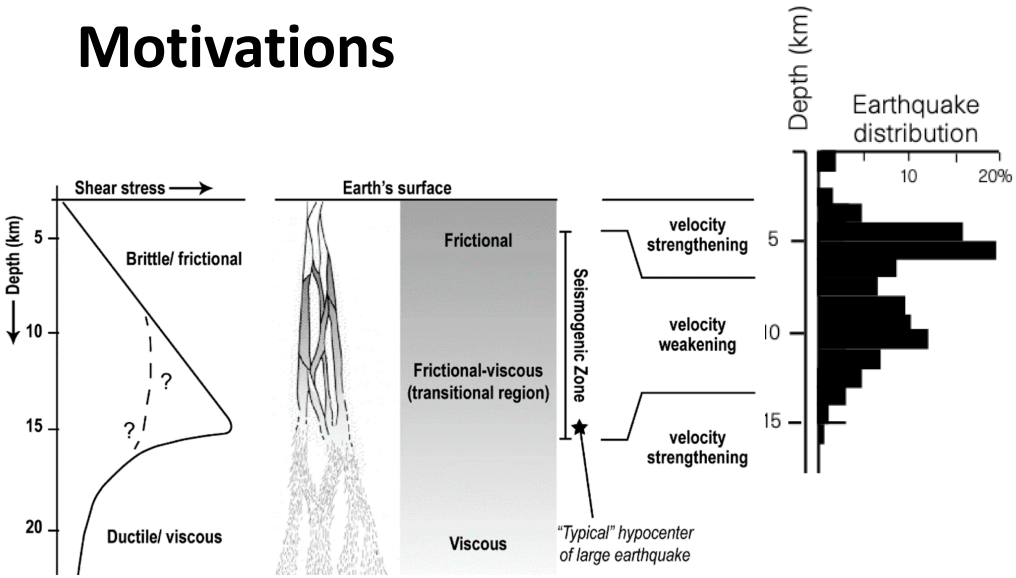


Outline

- Motivations and aim
- The Vado di Corno Fault Zone and Quaternary deposits
- Grain size analysis of host rock and fault core
- Microstructures of (nanogranular) slip zones
- Conclusions

References

Motivations



Scholz, 1998; Verberne et al., 2019

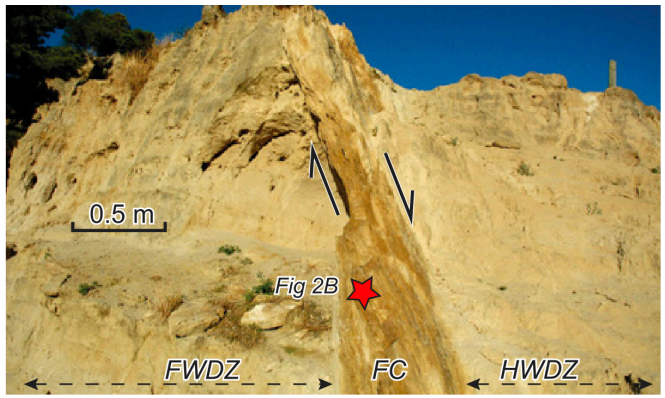
The shallow crust is typically characterized by unconsolidated to poorly lithified sediments (e.g., accretionary wedges in subduction zones, sedimentary basins).

Velocity strengthening behaviour of the shallow portion of the crust inhibits earthquake nucleation.

What are the mechanisms of seismic rupture propagation to the surface?

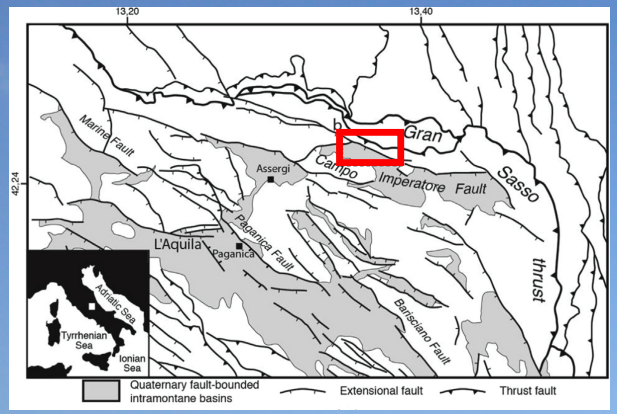
Aims

Uncover deformation mechanisms active during sub-surface faulting, through field and microstructural characterization of faults in unconsolidated Quaternary gravels at the hanging wall of an active normal fault system.



Balsamo et al., 2014

The Vado di Corno Fault Zone (VCFZ) (Campo Imperatore Fault System)



Demurtas et al., 2016

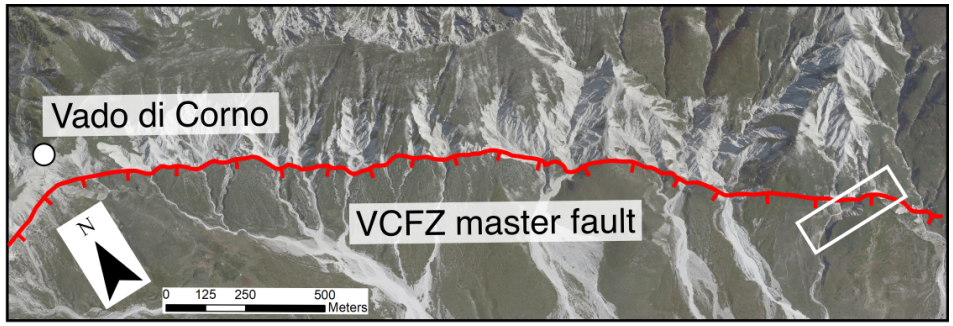
Past and recent seismic activity of the Campo Imperatore fault system from:

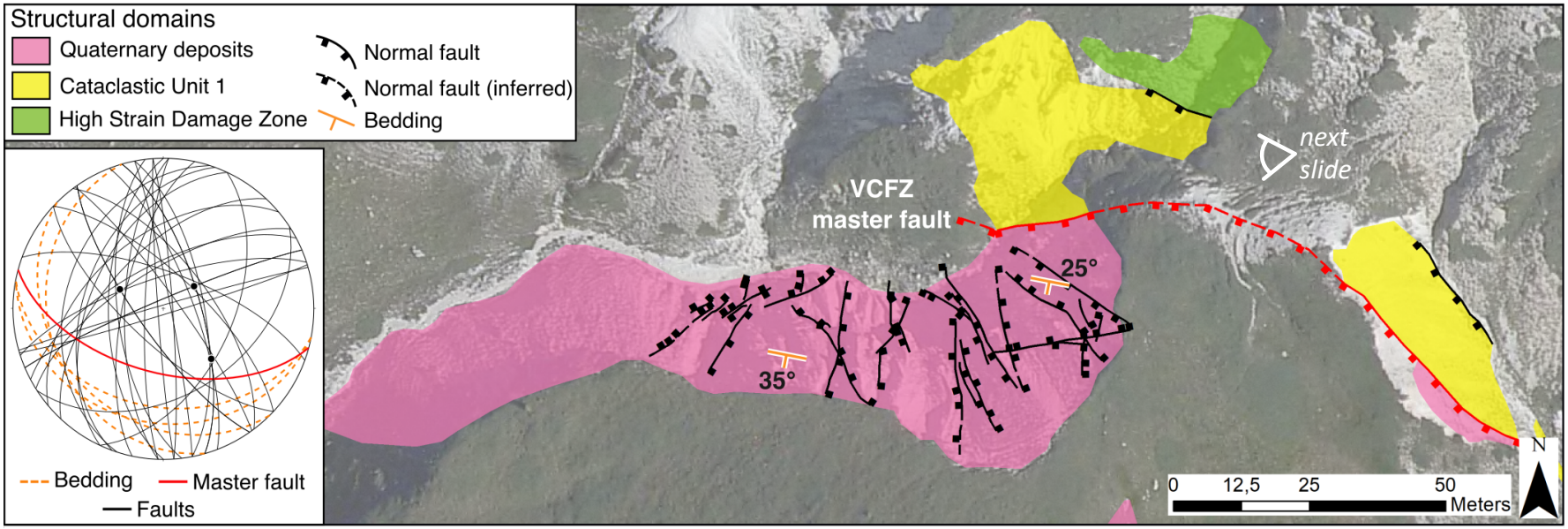
- field surveys and microstructural analysis within the footwall (Demurtas et al., 2016)
- paleoseismology: faulting in Quaternary deposits (e.g., Galadini et al., 2003)
- micro-seismicity $M_L < 2.5$ (ISIDe Catalog, INGV)

The internal structure of the Quaternary deposit

The Quaternary deposit studied are at the hanging wall, lie directly on the master fault and the cataclastic fault core and are made of unconsolidated gravels, locally cemented at the top of the conoid (see also next slide).

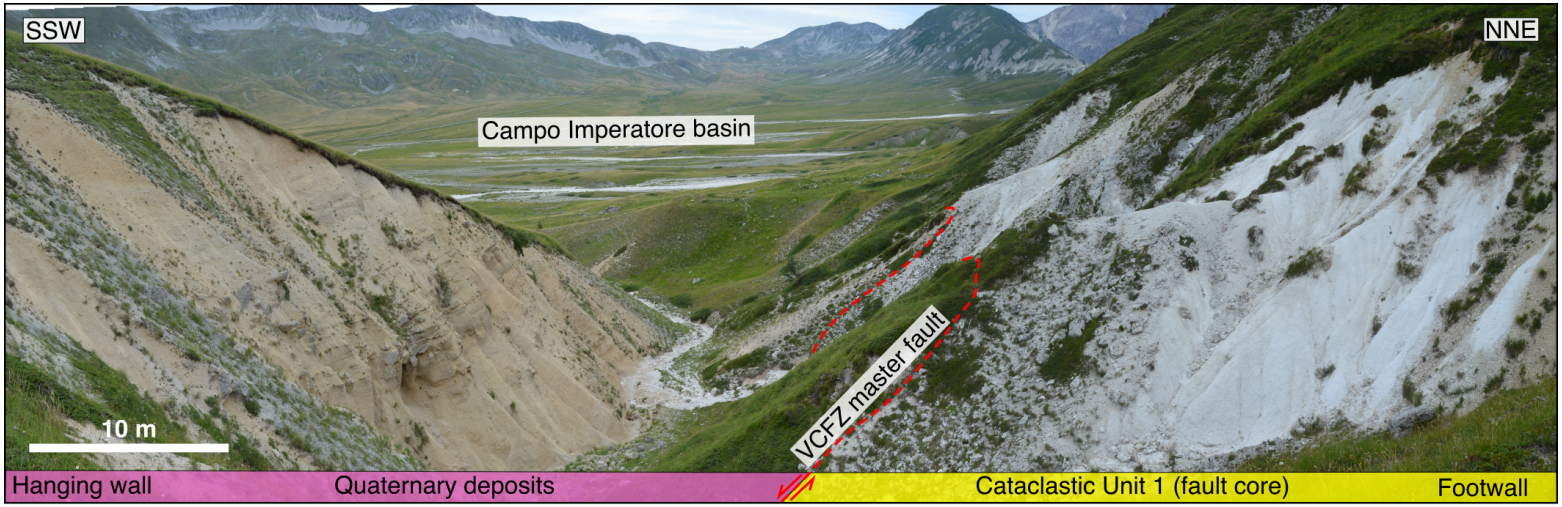
Faults within the deposit are organised in conjugate sets striking at high angle to the master fault (N-S striking). Smaller subsets of faults synthetic and antithetic to the main normal faults are present.





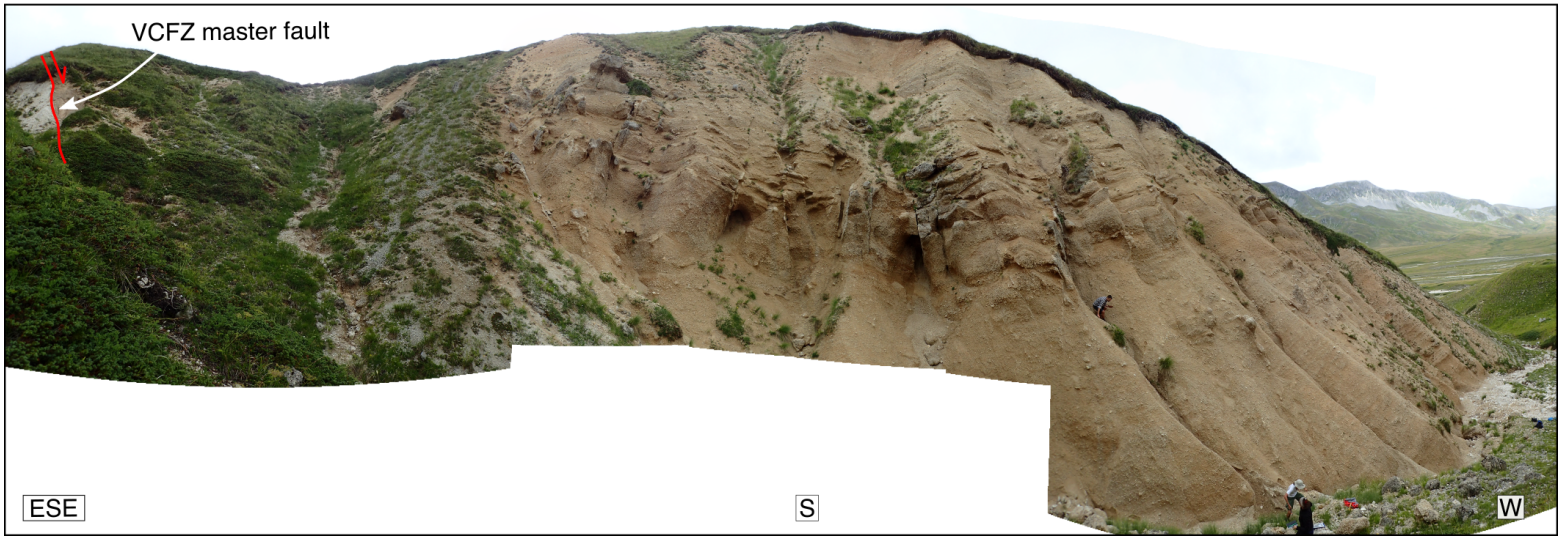
See Demurtas et al. (2016) for detailed description of the structural domains

The internal structure of the Quaternary deposit



Previous studies estimate the age of the deposits to be younger than the Last Glacial Maximum (c. 18 kyrs).

The outcropping deposit thickness is c. 20 m, and it likely did not experience more than a few tens of metres of burial.



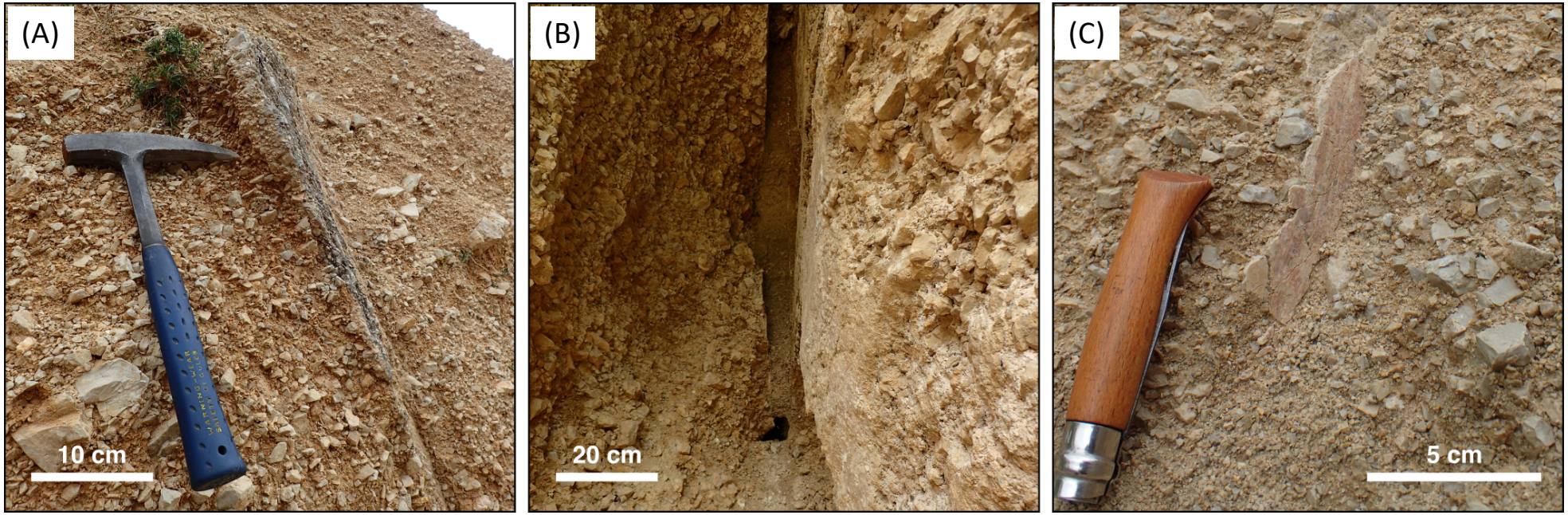
Coarse sand/fine gravel

Medium gravel

Coarse sand/fine gravel

Occurrence of (ultra-)polished faults

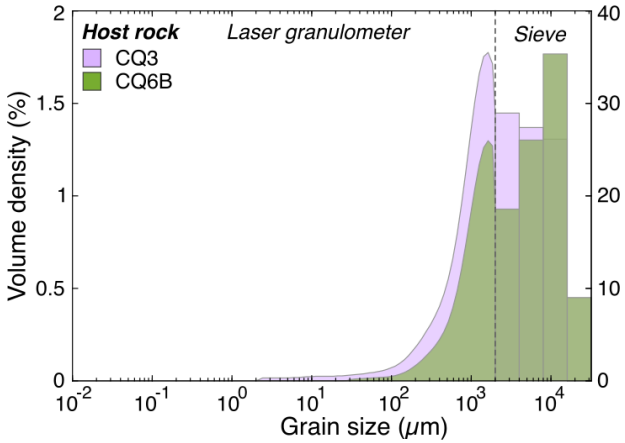
(A) Most faults show topographic relief, either due to cementation or compaction.
(B) Locally faults develop polished and lineated surfaces, embedding a cataclastic fault core up to 6-8cm in thickness.
(C) Ultra-polished fault surfaces with mirror-like appearance are rarely found in the finer grained part of the host rock.

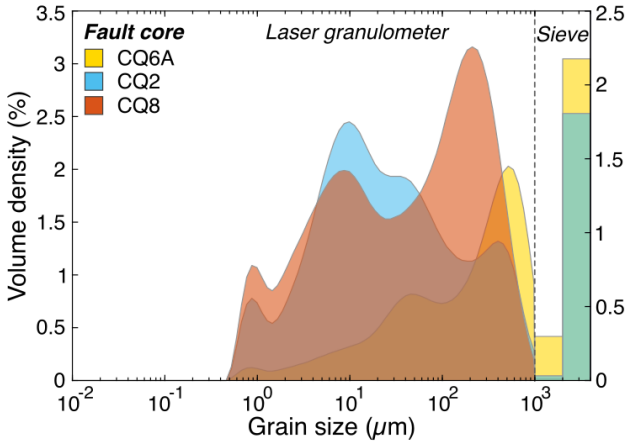


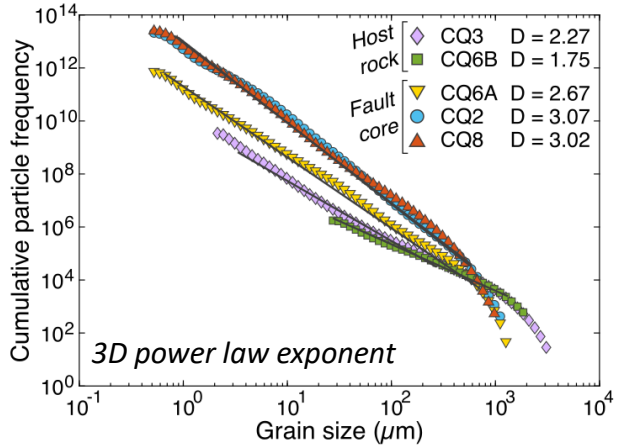
Lack of markers and irregular geometry of deposit layers in the conoid hinders precise measurement of displacement along faults, inferred to be in the order of few cm up to few tens of cm.

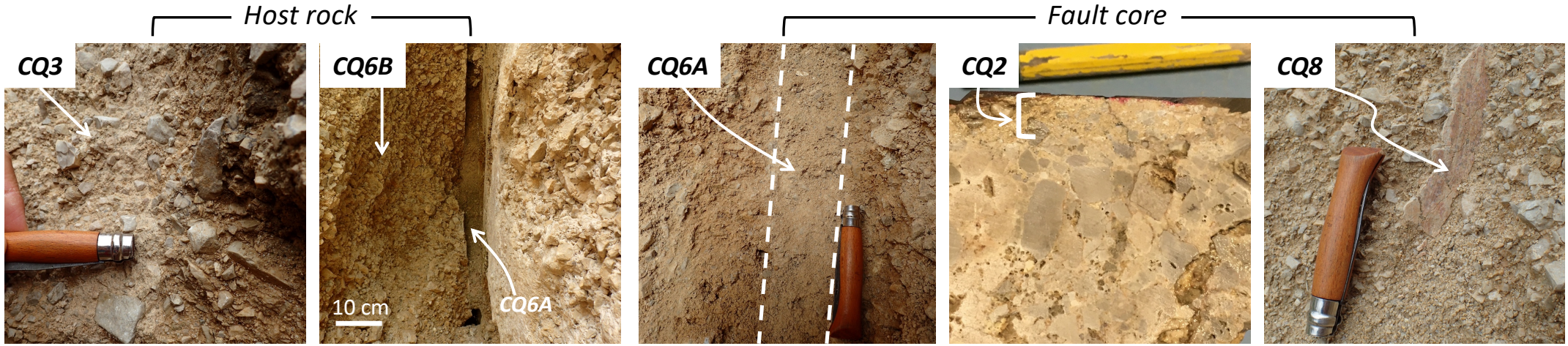
Grain size distribution analysis

The analysis was performed with a combination of manual sieving for grain sizes > 1-2mm, and laser granulometry (both in dry and wet conditions) for grain sizes < 1 mm. Samples were representative of different layers in the deposits and increasing strain localization along faults.





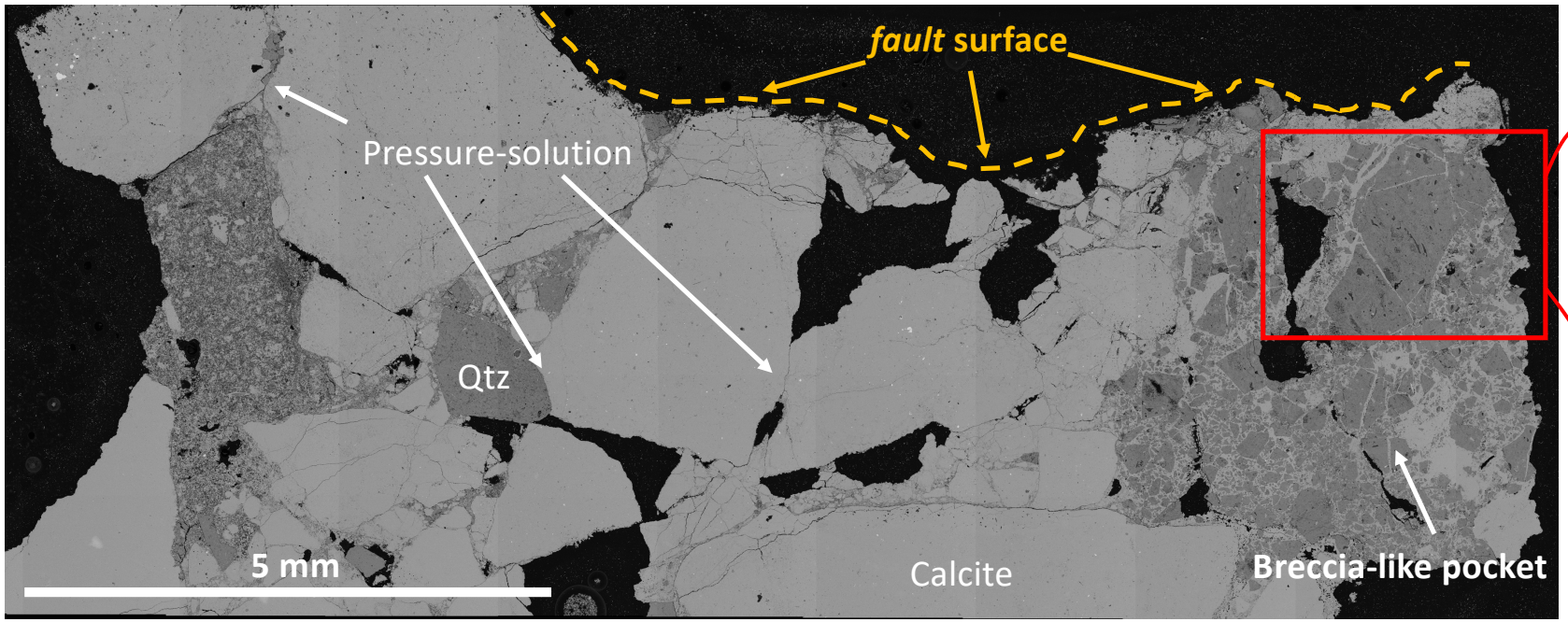


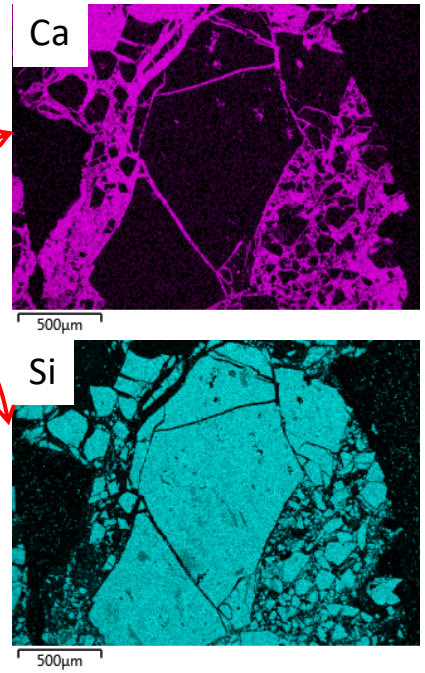


Microstructures of corrugated fault planes

Pressure solution is widespread between large calcite and quartz grains whereas fragmentation occurs in between the larger grains.

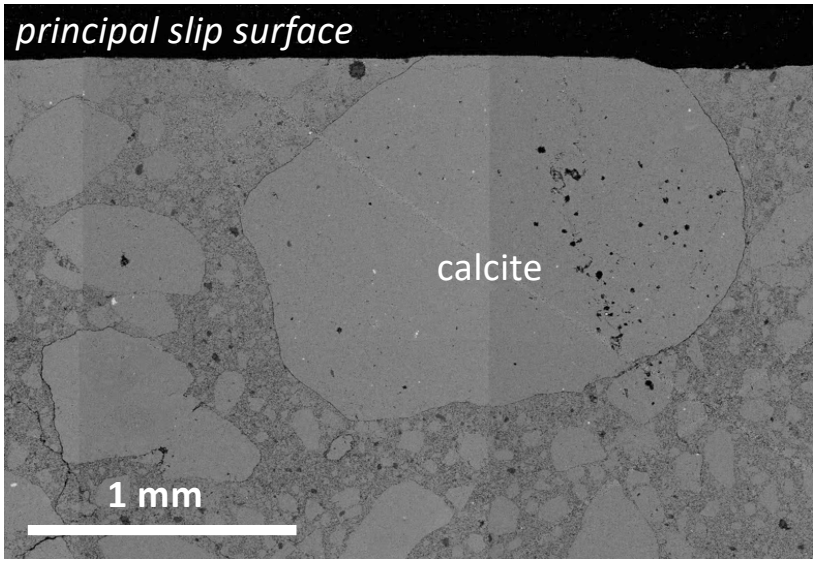
Locally, breccia-like pockets with angular quartz grains and a calcitic cement are observed near the fault surface.



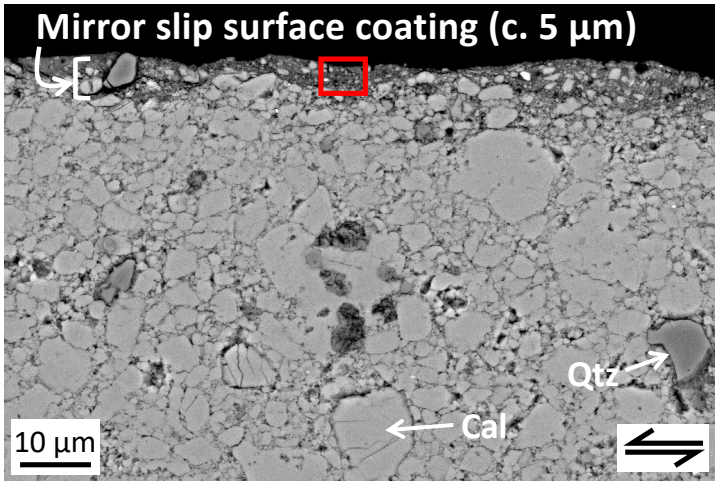


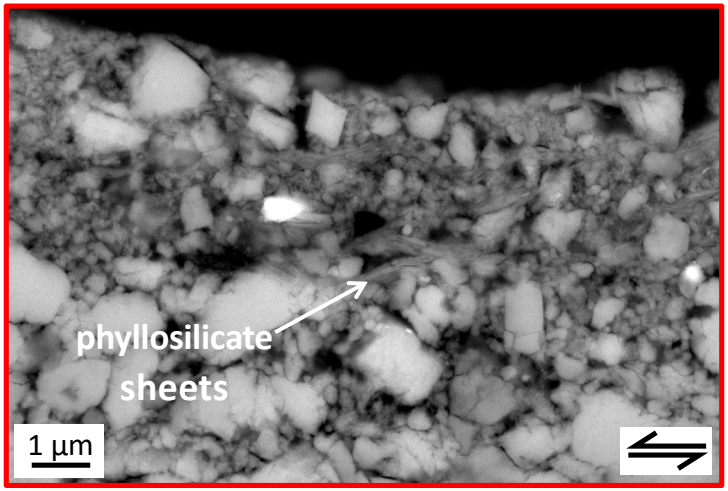
Microstructures of nanogranular slip zones

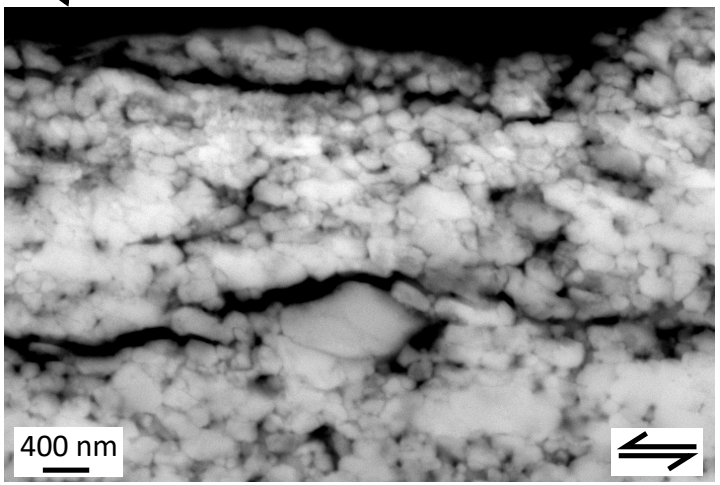
Cataclasis and pressure-solution are widespread in the slip zone. The principal slip surface sharply truncates large clasts.
Mirror-like patches are composed of a < 10 µm thick coating made of equant nanogranular calcite grains and phyllosilicate sheets.



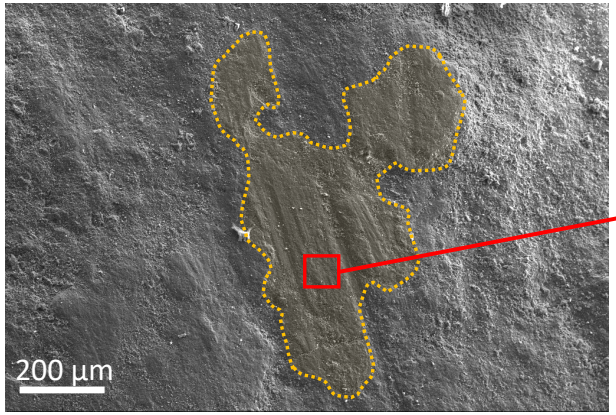
Locally, calcite nanograins are elongated and organised in trails consistent with sliding direction.

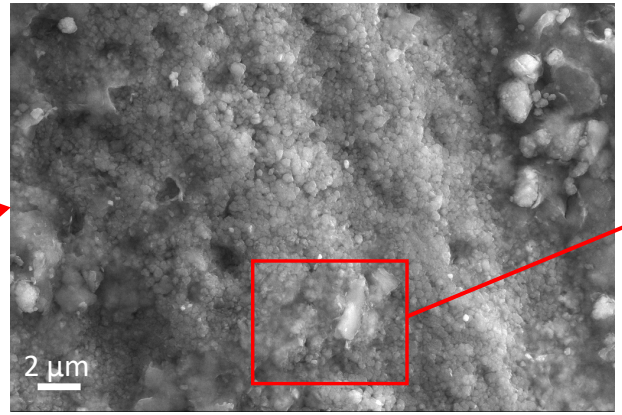


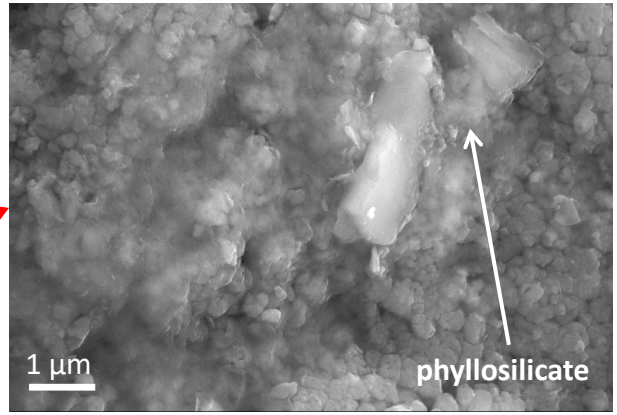




Microstructures of nanogranular slip zones

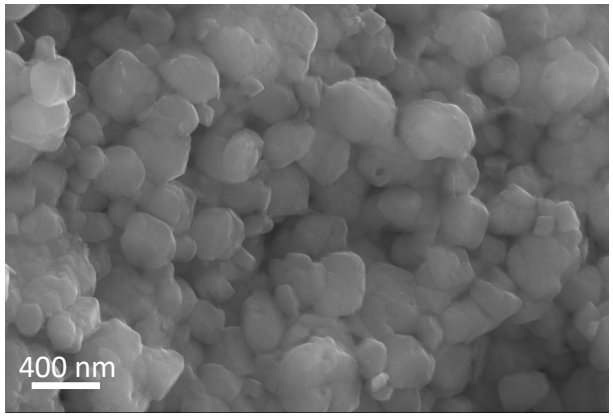




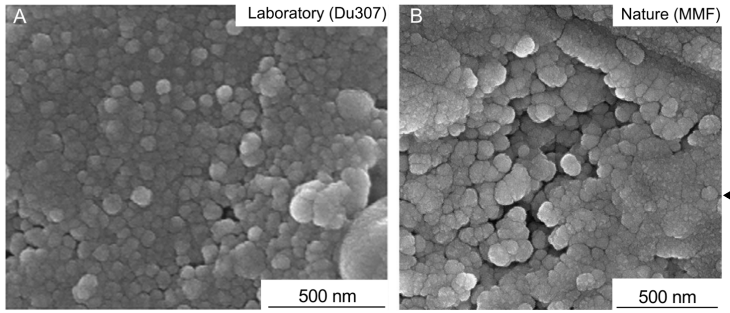


The microstructures of the mirror-like slip surfaces highly resemble natural and experimental faults deformed under coseismic sliding conditions (e.g., De Paola et al., 2015; Pozzi et al., 2018; Demurtas et al., 2019).

Calcite nanograins 100-200 nm in size appear to be made of aggregates of c. 20 nm in size grains. Possible results of calcite decomposition and fast recrystallization at very low ambient temperatures (e.g., Ohl et al., 2019)?



This study



De Paola et al., 2015

Conclusions

- Main set of faults striking N-S (sub-parallel to the elongation of the conoid) could be the results of either (i) surface expression of similar structures documented in the footwall, (ii) partial collapse/compaction of the deposit during to seismic shaking, or (iii) variation of seismic rupture directivity during upward (surface) propagation.

- Cataclasis and pressure solution are the main processes active during faulting, with pressure solution likely to be enhanced by infiltration of meteoric fluids within the deposit.

- Similarity between microstructures of experimental of seismic faults and those observed on our mirror-like faults suggests that seismic ruptures propagated within the conoid to the surface and same processes were active during deformation at the surface (e.g., flash heating, thermal decomposition, …).

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