The formation, alteration and significance of pyrogenic magnetic fabric in mid-paleolithic burnt cave facies

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Site and sampling – Why ash?

In situ (anthropogenic) (gravitational-falling?) + 'post-burning'

Provide pioneering information to archaeologists about the forming and alteration of pyrogenic anthropic cave sediments.

The aims

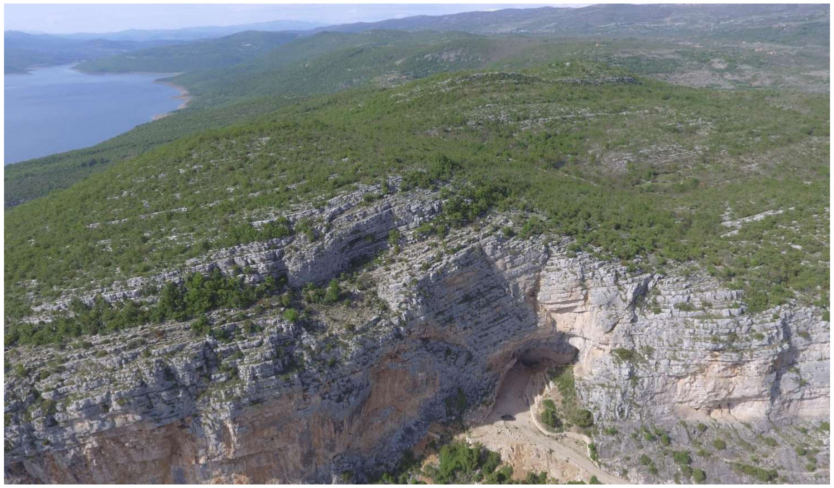
→ to evaluate the potential of cave ashes to record the Earth's magnetic field variations

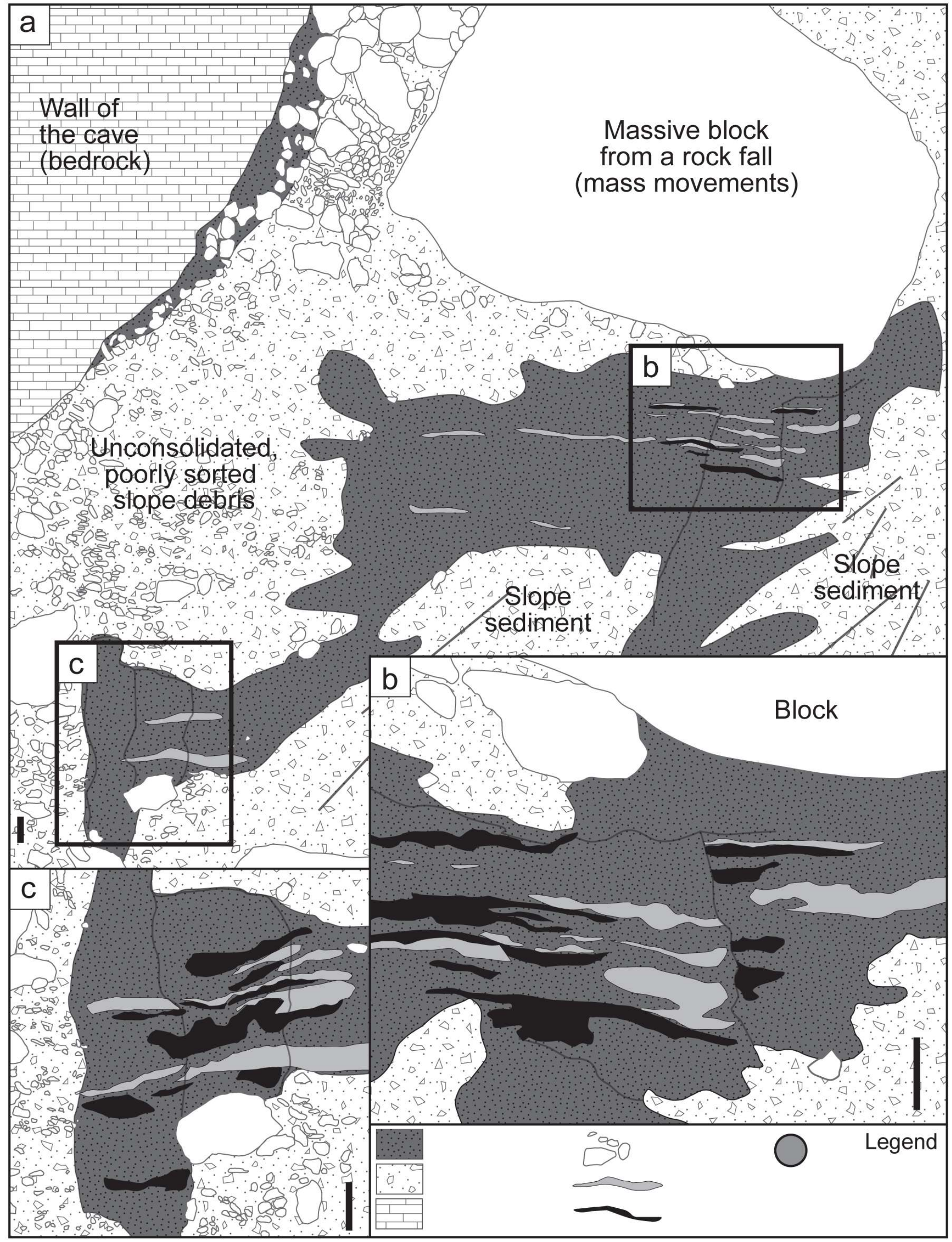
→ to reconstruct the burning conditions studying their magnetic properties

→ identifying the syn/post-burning taphonomical processes

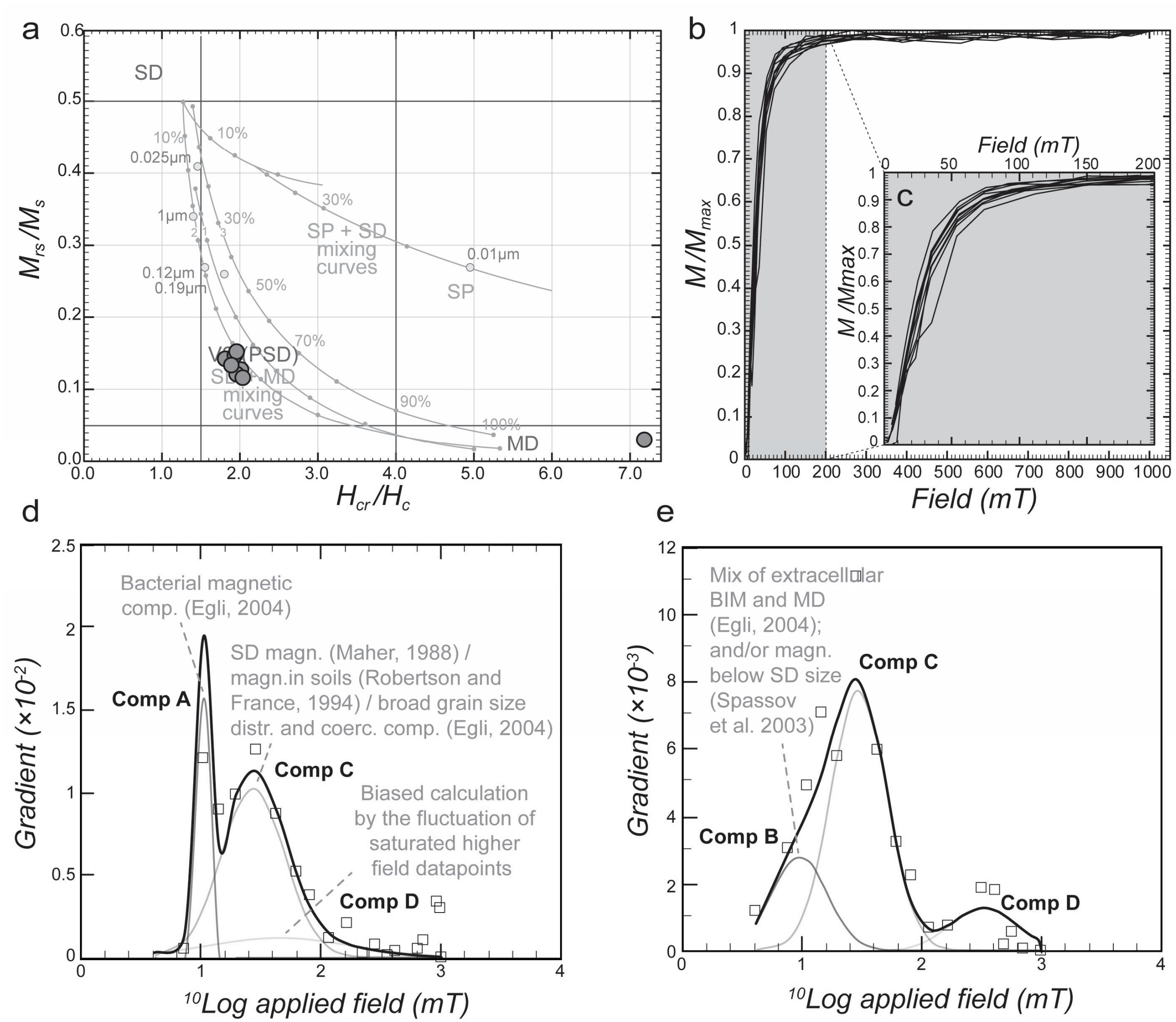
The rock shelter of Crvena Stijena (Montenegro) is one of the longest and best-preserved Middle Paleolithic sequences in southeastern Europe.

Crvena Stijena (meaning 'Red Rock') / Dinaric Karst





(Post)pyrogenic mineral forming – characteristics of magnetic contributors



a →very uniform grain size in a MD+SD (~75%:25%) [Day-plot]

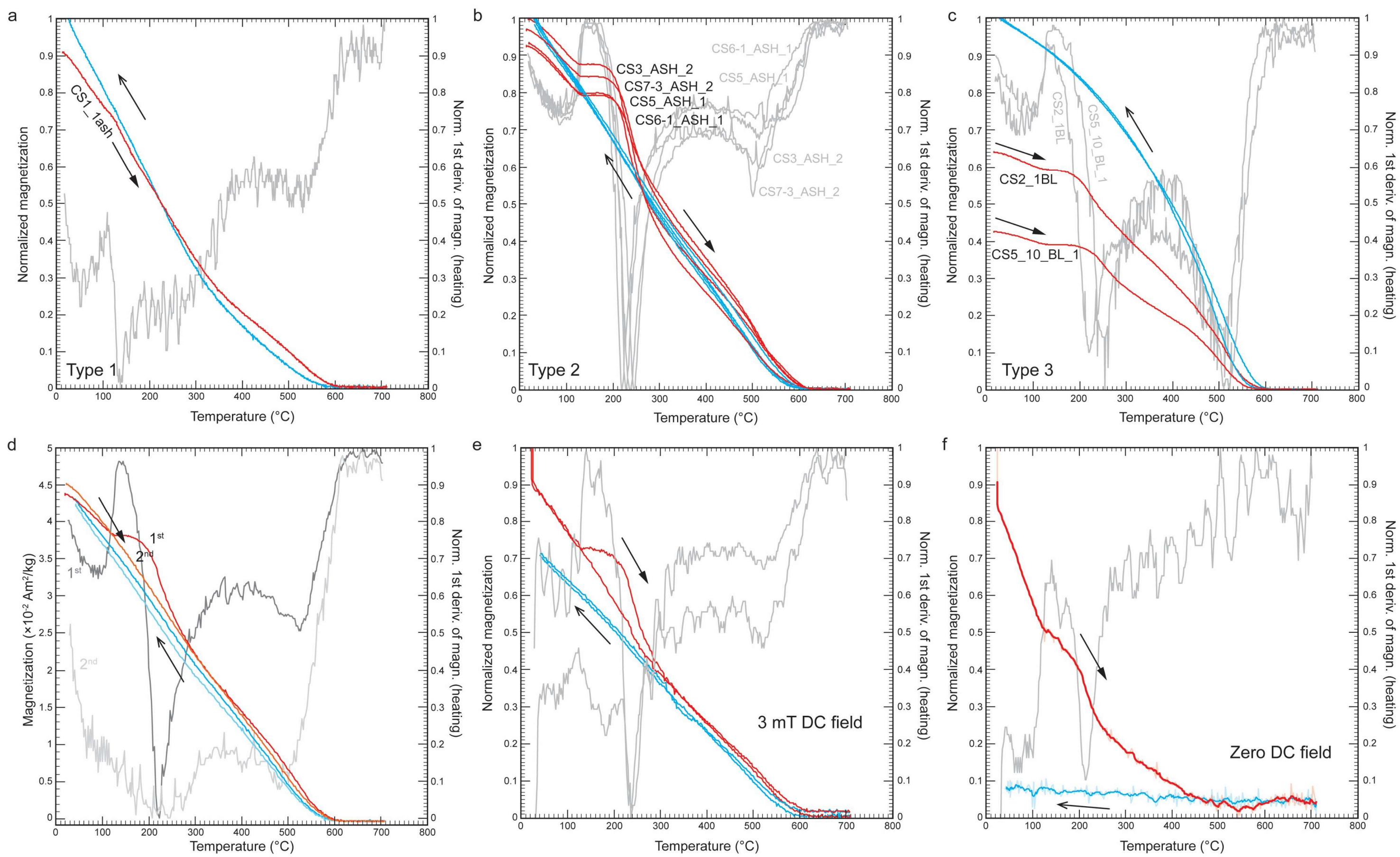
b →dominantly magnetically soft/low coercivity contributors [acquisition of IRM]

c,d → four characteristic population:

- Bacterial magn.
- SD magn.
- MD magn.
- Noise

[decomp. of IRM]

(Post)pyrogenic mineral forming – characteristics of magnetic contributors



a → *Type1*; quasi reversible curve and inflection around 300-400 ˚C

b → *Type2;* quasi reversible curve with a hump between 105-112˚C and 218-245 ˚C and inflection around 300-400 ˚C

c → same as *Type1* (a) and *Type2* (b) irreversible curve with mineral neoforming

d → repeating measurements of Type2 (b) curve – no hump at the second time: mineral neoforming

e, f → experiments in reduced and zero background field – same inflections [M(T) curves]

Magnetic contributors of ash (?) – the preliminary candidates

Magnetite → indicated in all sample by its Tc: 585˚C

~110 ˚C hump and the inflection between 300-400 ˚C (candidates):

Transition from **SD to SP behavior** → transition from SD to SP behavior in magnetic grains close to the SSD/SP (Day, 1975):
(+) supported by hysteresis and IRM; **(++)** result of mineral forming by burning;
(-) thermal experiments in various DC fields did not show significant change;

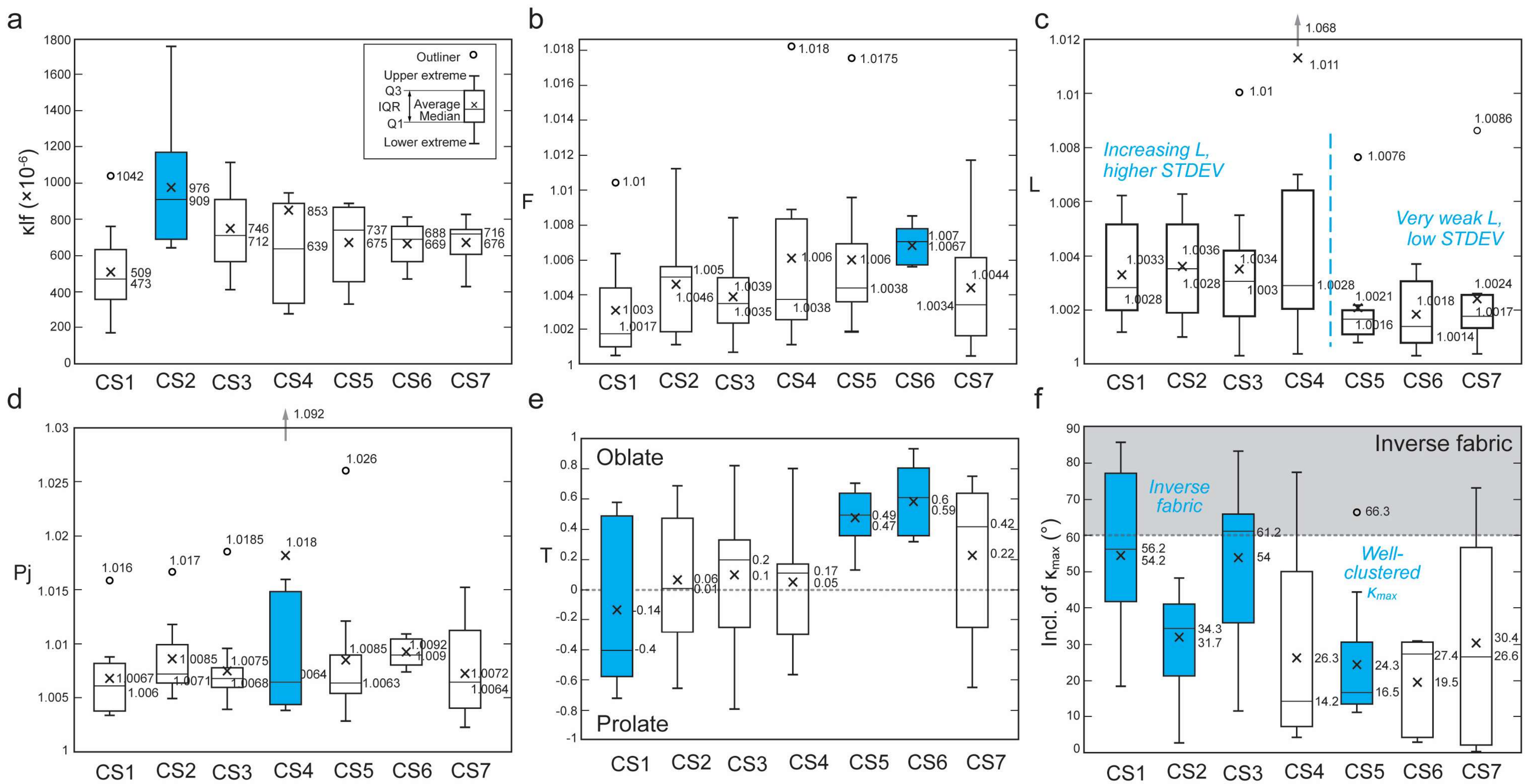
Siderite → decomp. ~250 ˚C (Pan et al. 2002). Additional Mn and Mg comp. decrease the decomp. T (Gallagher and Warne, 1981):
(+) authigenic minerals by precipitation from groundwater;
(-/+) inverse fabric
(-) no significant paramagnetic comp [hysteresis and M(T) curves]

Goethite → 'broad minor peak' just above 100 ˚C and defined as antiferromagneti (AFM)/paramagnetic (PM) transition (Néel temperature - TN) (Özdemir and Dunlop 1996);
(+) imperfect burning;
(-) non-significant amount of high coercivity component

Pyrrhotite and magnetite forming from **greigite** → ~95 ˚C the creation of pyrrhotite from greigite → ~125-250 ˚C the neoformation of magnetite (Aubourg and Pozzi 2010).

Theory: loose ash + (saturated) pore water + intense decomposition of organic matter → dissolved iron and sulphide → greigite/greigite-producing magnetotactic bacteria
(+) decomp of IRM.

Basic low field anisotropy of magnetic susceptibility (AMS) parameters

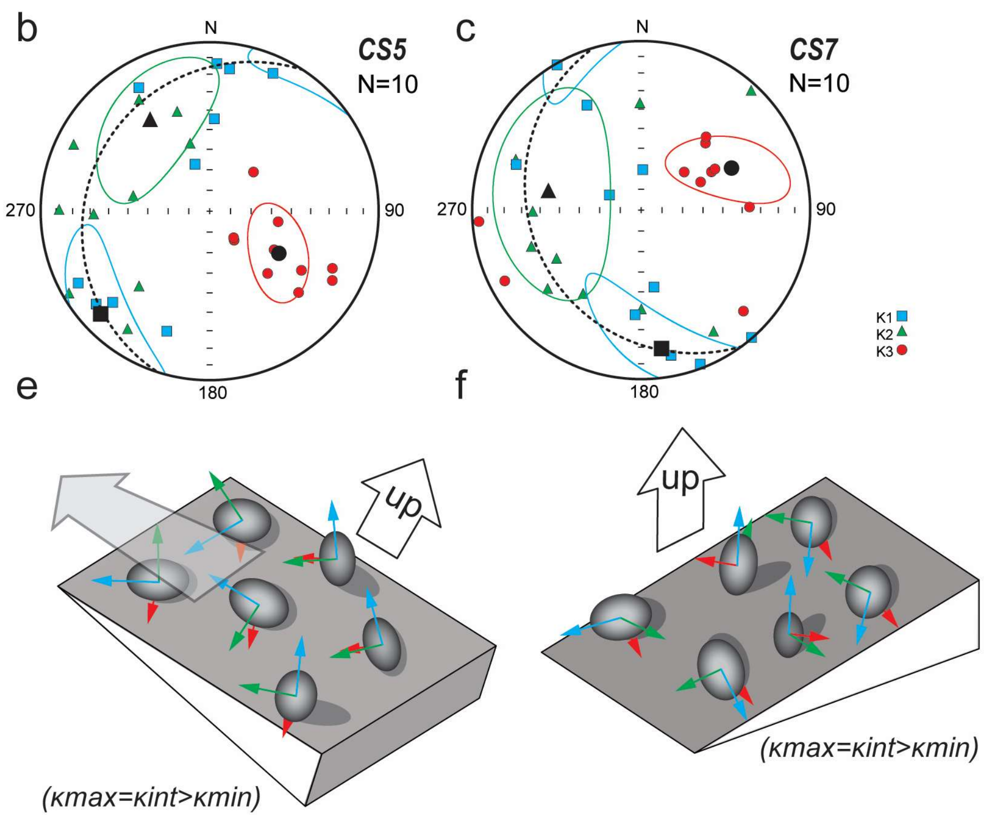


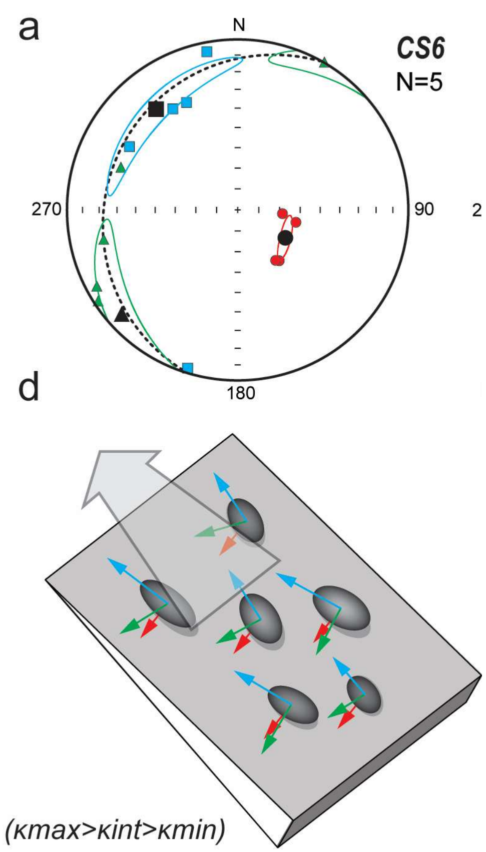
Fabric forming processes

CS5 and CS7
- initial pyrogenic MF, formed on slope
- influenced by gravity and slow slope processes

Infiltrating water into the loose ash strengthen
→ the influence of slope processes, triggered by the change in the consistency of the ash

→ the realignment of the grains toward vertical



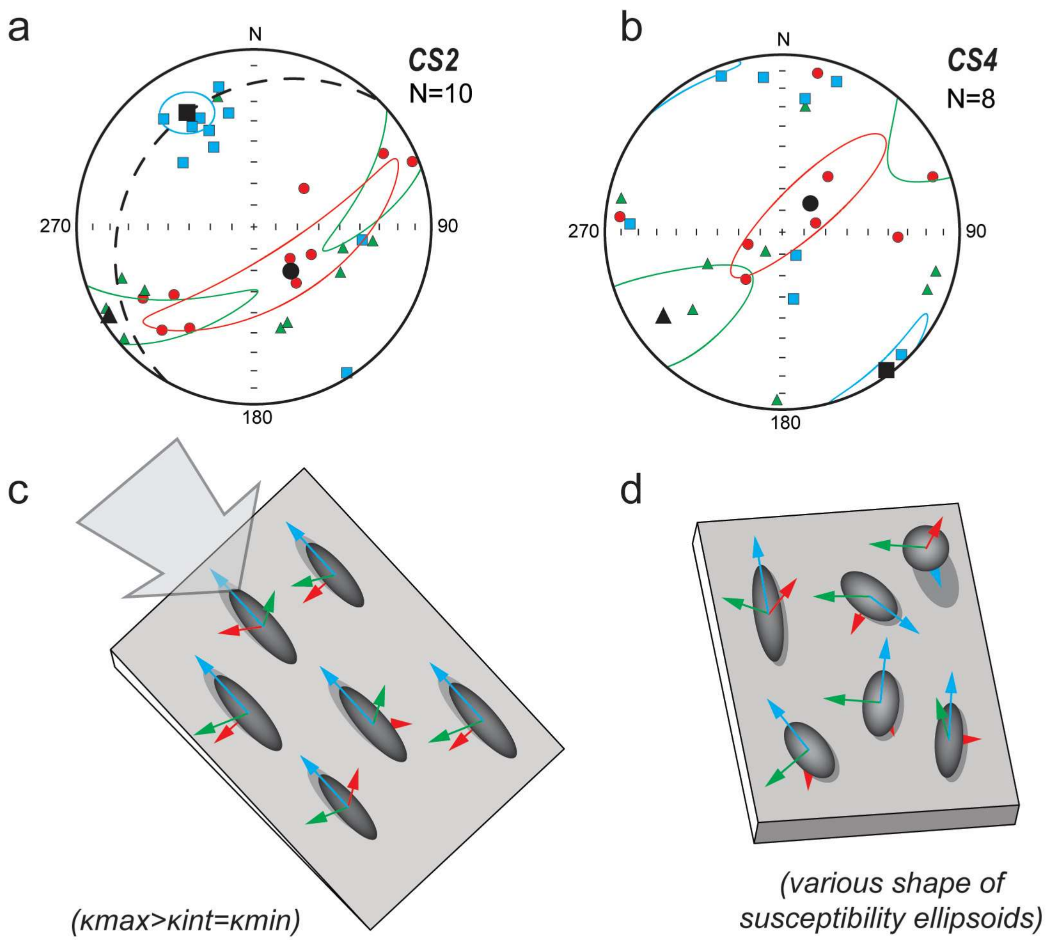


Gravity + slope processes + sheet wash (water-lain)

↓

Strengthening of the grains' alignment:
- slopeward orientation of the grains
- discrepancy of κ_{min} from vertical (→ imbrication; Nawrocki et al. 2006)

Fabric forming processes II. – *Under pressure*



a, b → Flow-transverse fabric (e.g. Mammoth Cave, Kentucky, Ellwood 1984) flowing water along the passages (CS2, CS4).

a → may indicate stress field, triggered by rockfalls and the impact of a huge block.

Analogue:

- L-type tectonites (Borradaile, 2001)
- Rock deformed by e.g. meteorite impacts (Yokoyama et al., 2012) (~huge block impacts into the ash.

Common in all type*: mark of forming /accumulation/redeposition on slope.*

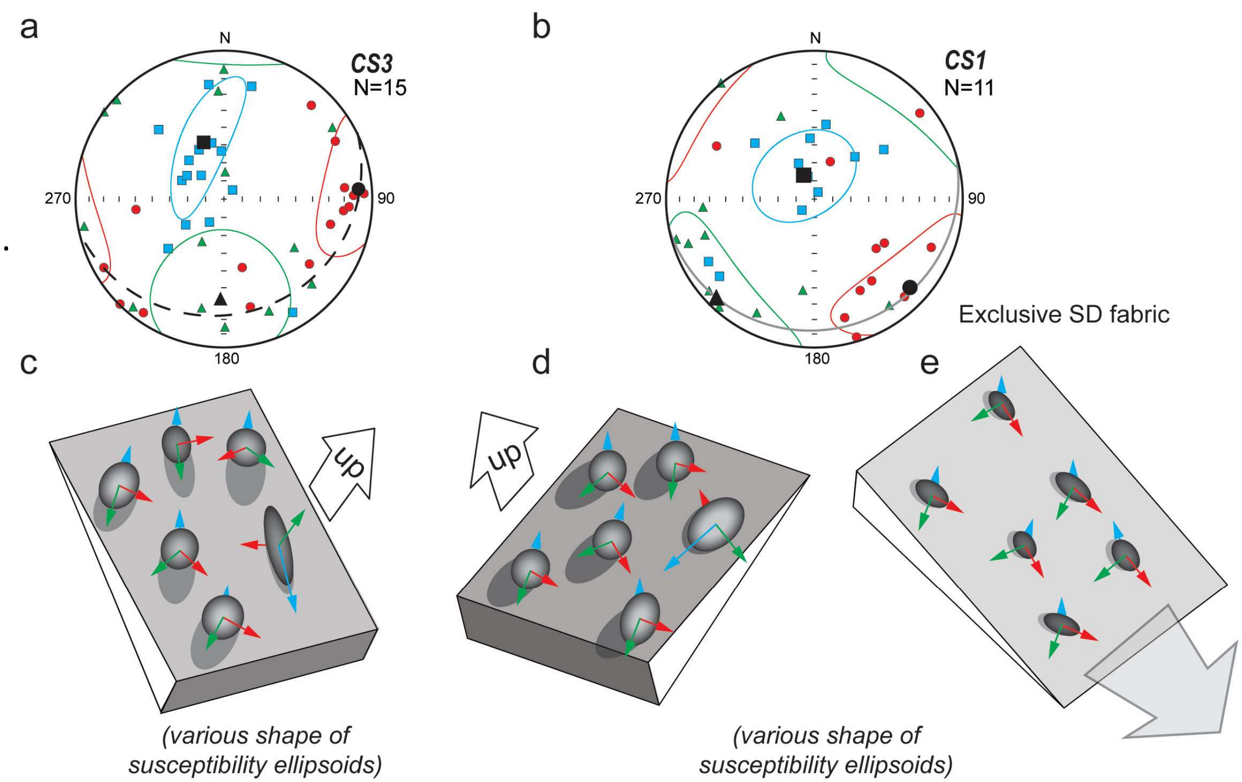
Fabric forming processes III. – *Versions for vertical*

Inverse fabric can be formed by:

→ water infiltration → vertical migration triggered re-orientation of grains (e.g. Bradák-Hayashi et al., 2016).

→ freezing thawing (+gelifluction and frost-creep on slope) → tension, triggered by the expansion of frozen pore water → vertical reorientation the grains

+→ the segregation of ice lenses further lead to vertical translocation, rotation and deformation of the material (Van Vliet-Lanoë, 2010).

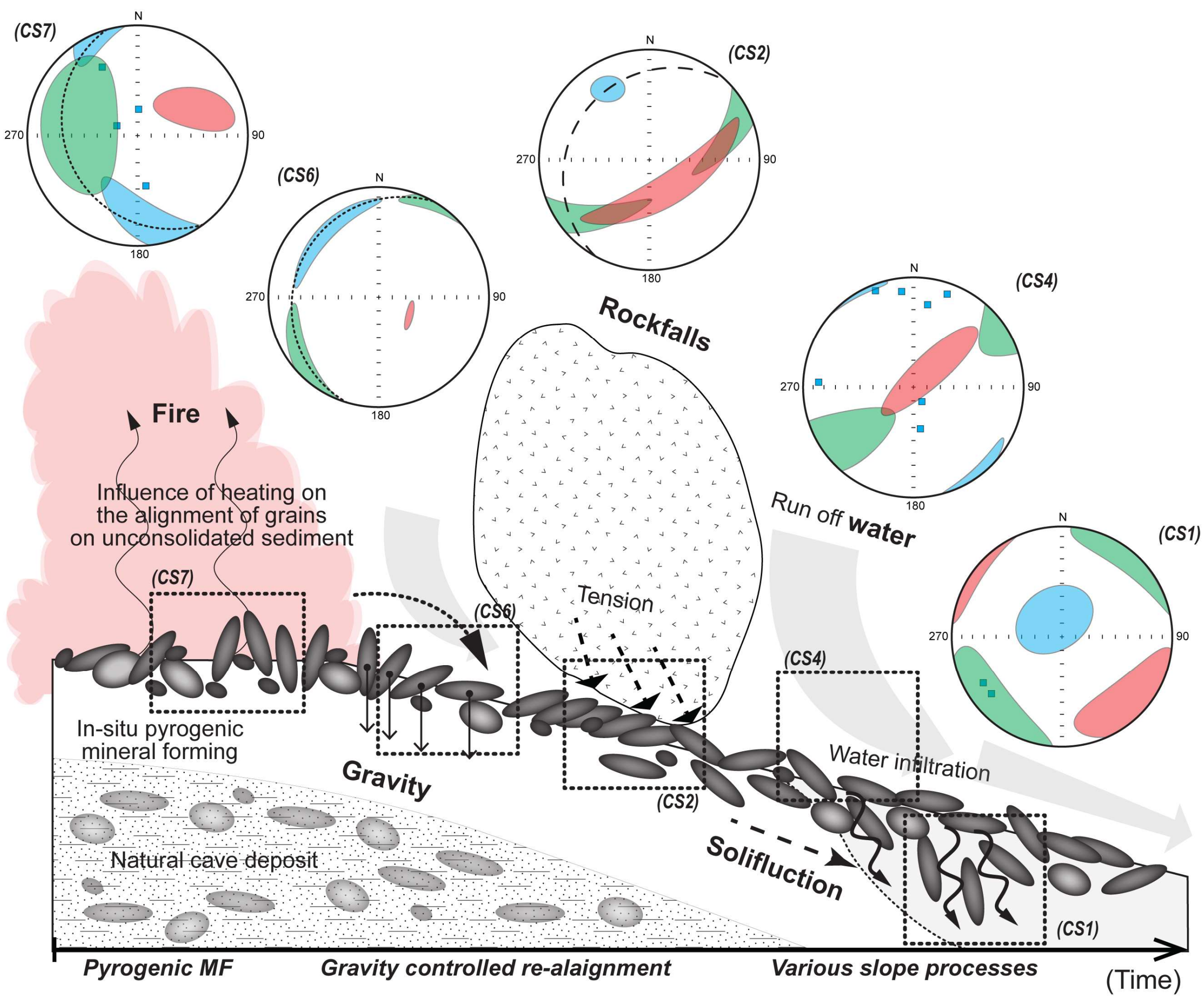


Exclusively SD magnetic grains (Hrouda, 1984) → inverse fabric 'looking' MF → BUT the kmax in fact indicates the shortest crystallographic axis → therefore the fabric is quasi-horizontally oriented
(-) Day-plot shows mixed SD and MD character

Forming and alteration of 'pyrogenic MF' – theoretical model

Scattering alignment of grains and discrepancy of the foliation plane from vertical (dip) → forming on slope

Mixed quasi-horizontal and vertical, and also poor orientation → lack of current or stress field → no strengthening force on the alignment of the grains



The referred MFs may influenced by

- rheomorphic processes - deformation of the MF due to the change in the (Tarling and Hrouda, 1993)
- low velocity slope processes (creeping, solifluction)
- water-lain processes (sheet-wash, water infiltration)
- stress field related mechanism.

Thank you for your attention

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