The Chiemgau crater field: traces of the (largest known) impact in the Holocene? ……

Václav Procházka (ÚHIGUG)

Pavel Kalenda (ÚSMH AS CR)

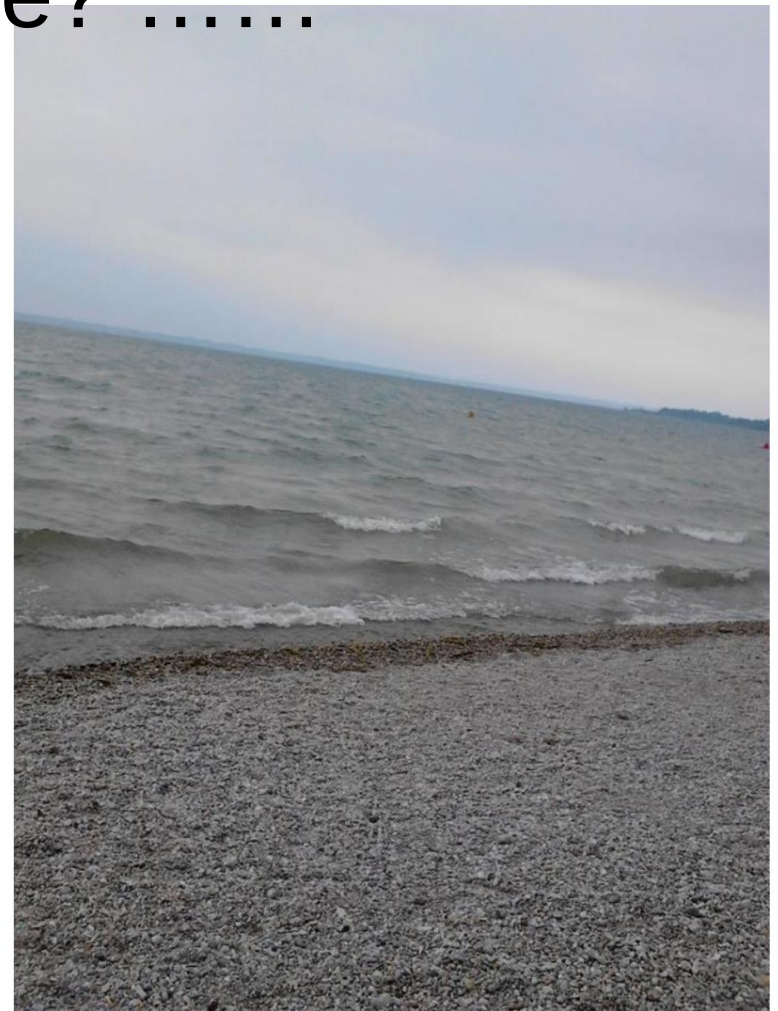
Günther Kletetschka (ÚHIGUG)

Tomáš Trojek (FJFI CTU)

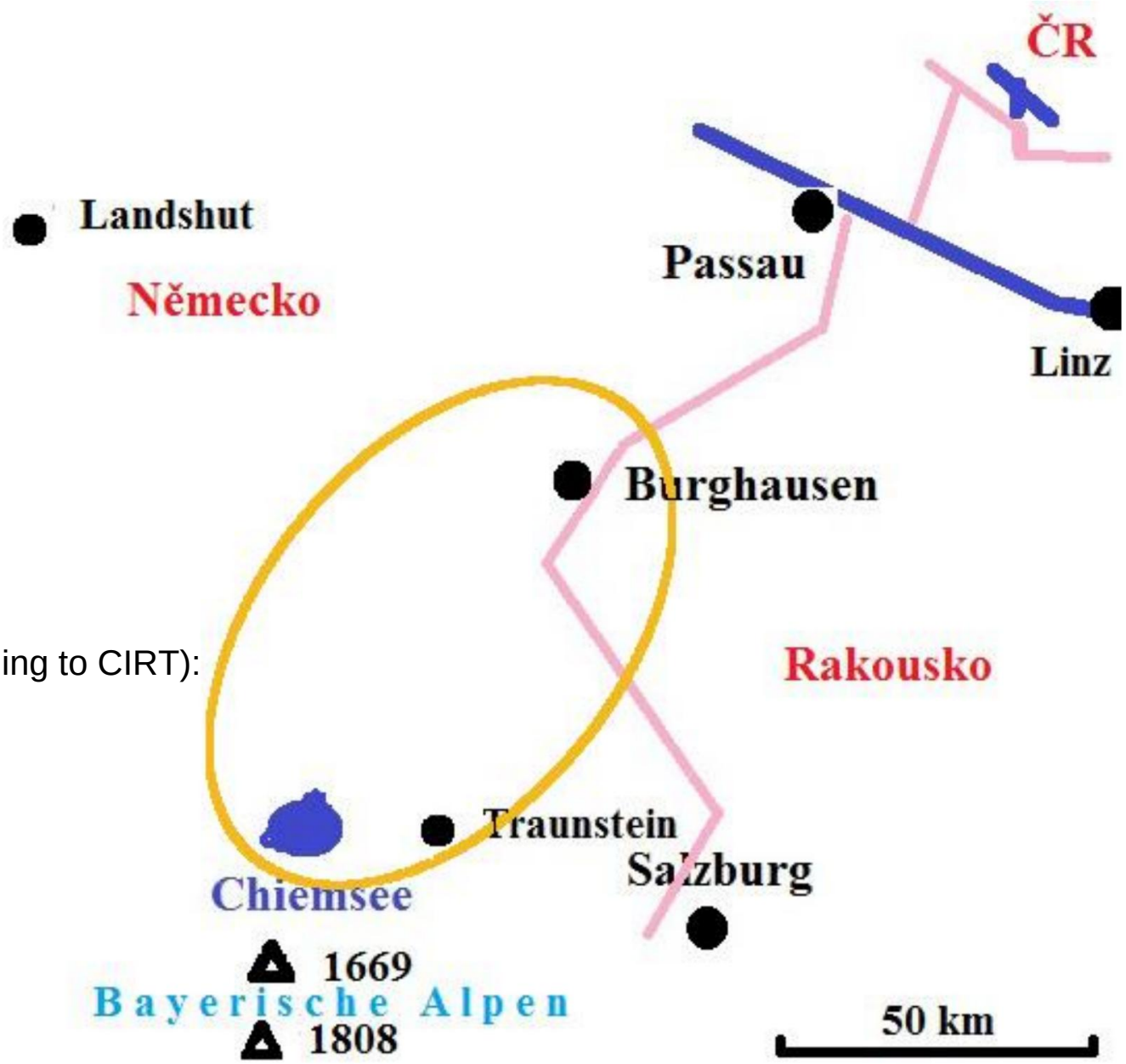
Petr Martinec (ÚGN AS CR)

Kamil Souÿek (ÚGN AS CR)

Lucie Georgievská (ÚGN AS CR)



fall field (according to CIRT):



Geology

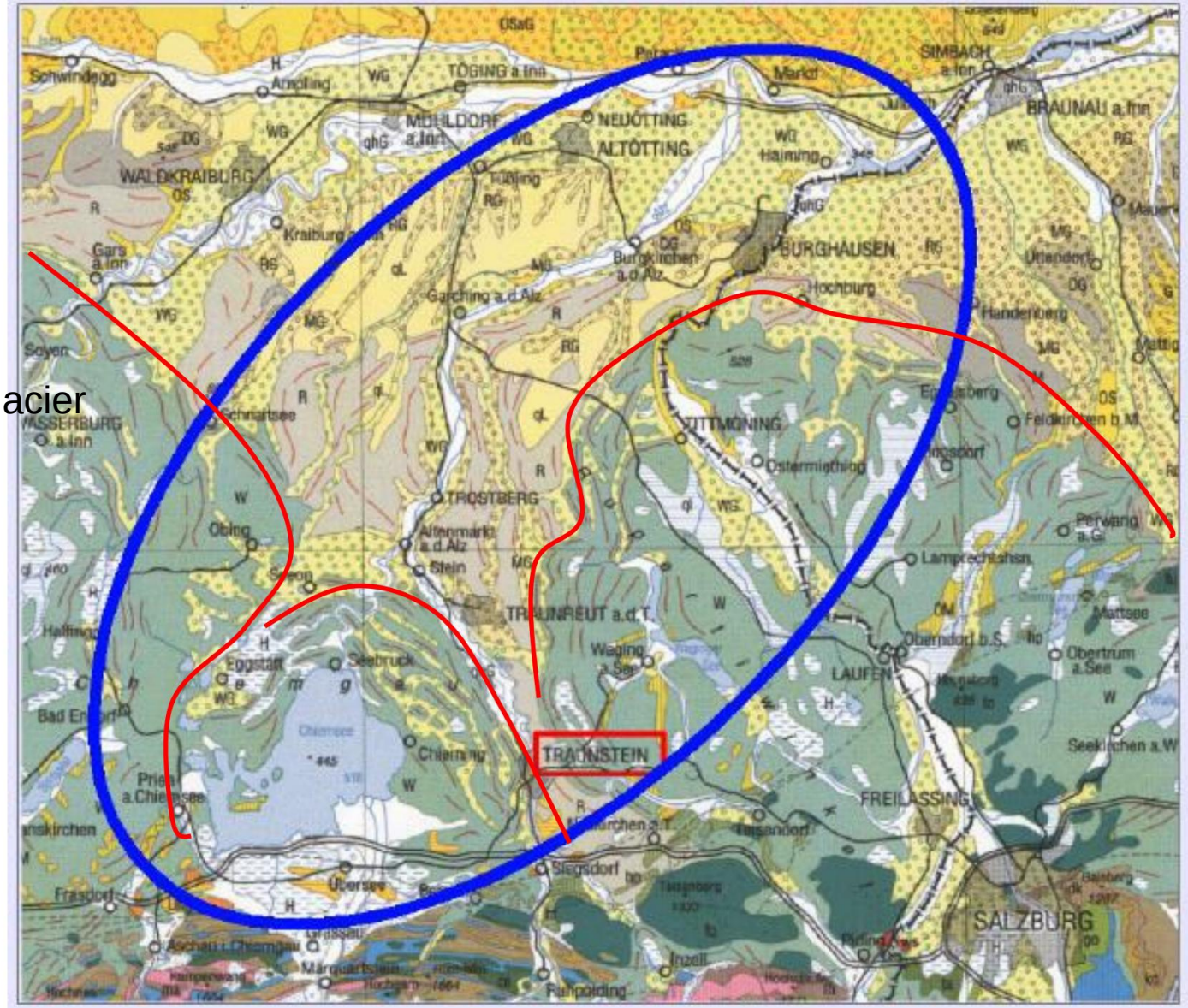
- Pleistocene terraces: boulders from the Alps – limestone, orthogneisses, quartzites, calcareous sandstone (Kieselkalk), metabasites – craters cannot be older than the Late Glacial – according to geophysics, they do not lie on tectonic structures – sometimes there are lake sediments in the crater (Chiemsee was bigger) -> creation up to av. revolution excluded

- ejecta dating back about 2,500 years (Late Bronze Age) were found in the archaeological profile ; reflection also in mythology (Phaeton)? (Neumair et al., 2010; B. Rappenglück et al., 2010)

border of the

moraine of the Alpine glacier

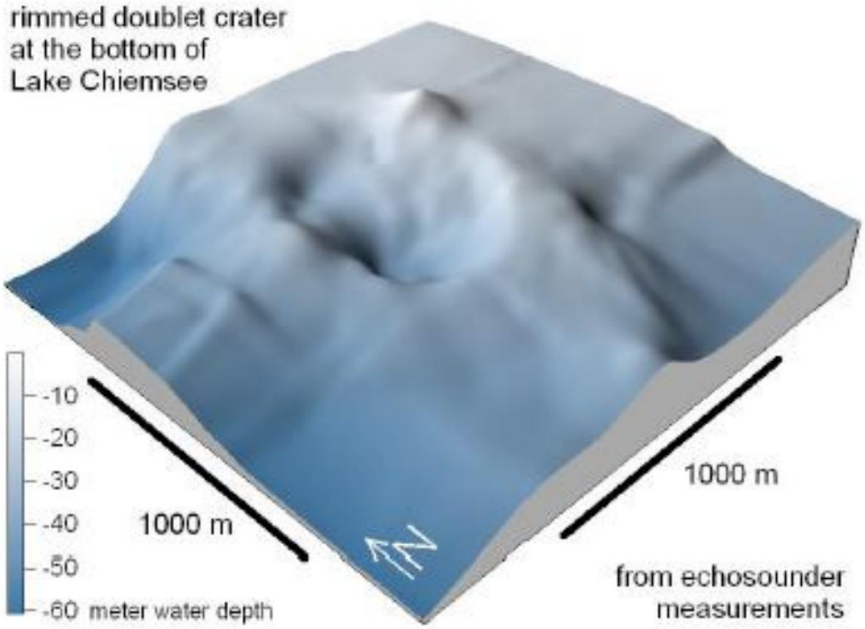
Falling field according to CIRT



Two bodies fell into a pre-existing lake; probable traces of the tsunami found in the vicinity in soundings and gravel pits

(Ernstsson, 2010, 2016)

- the largest verified crater in the fall field so far



weir. Tüttensee: 2nd-3rd? the largest crater

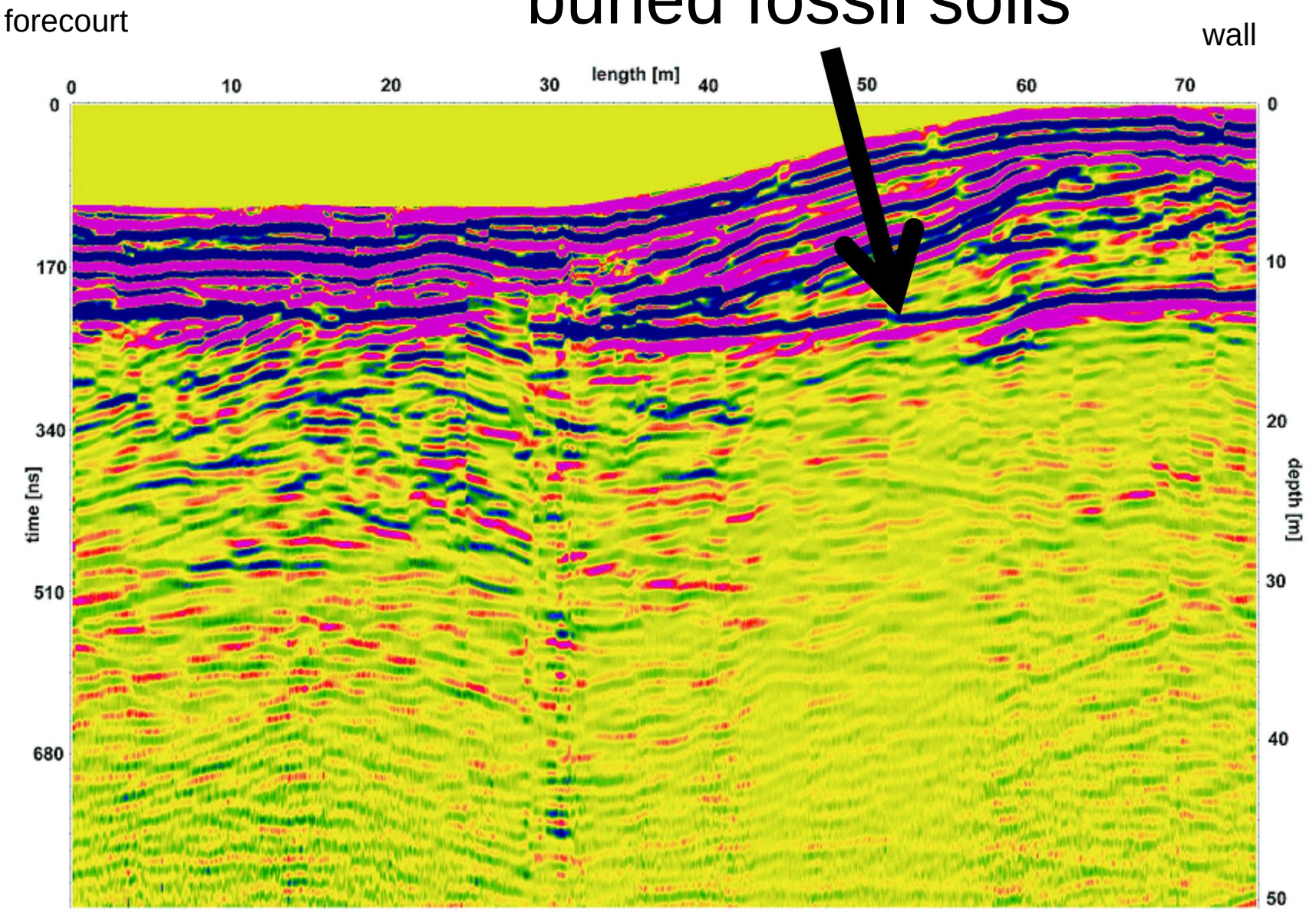
- "Toteisloch" - a hollow after fossil ice -

  passed down from the 19th century (also Doppler and Geiss, 2005; Koeberl)

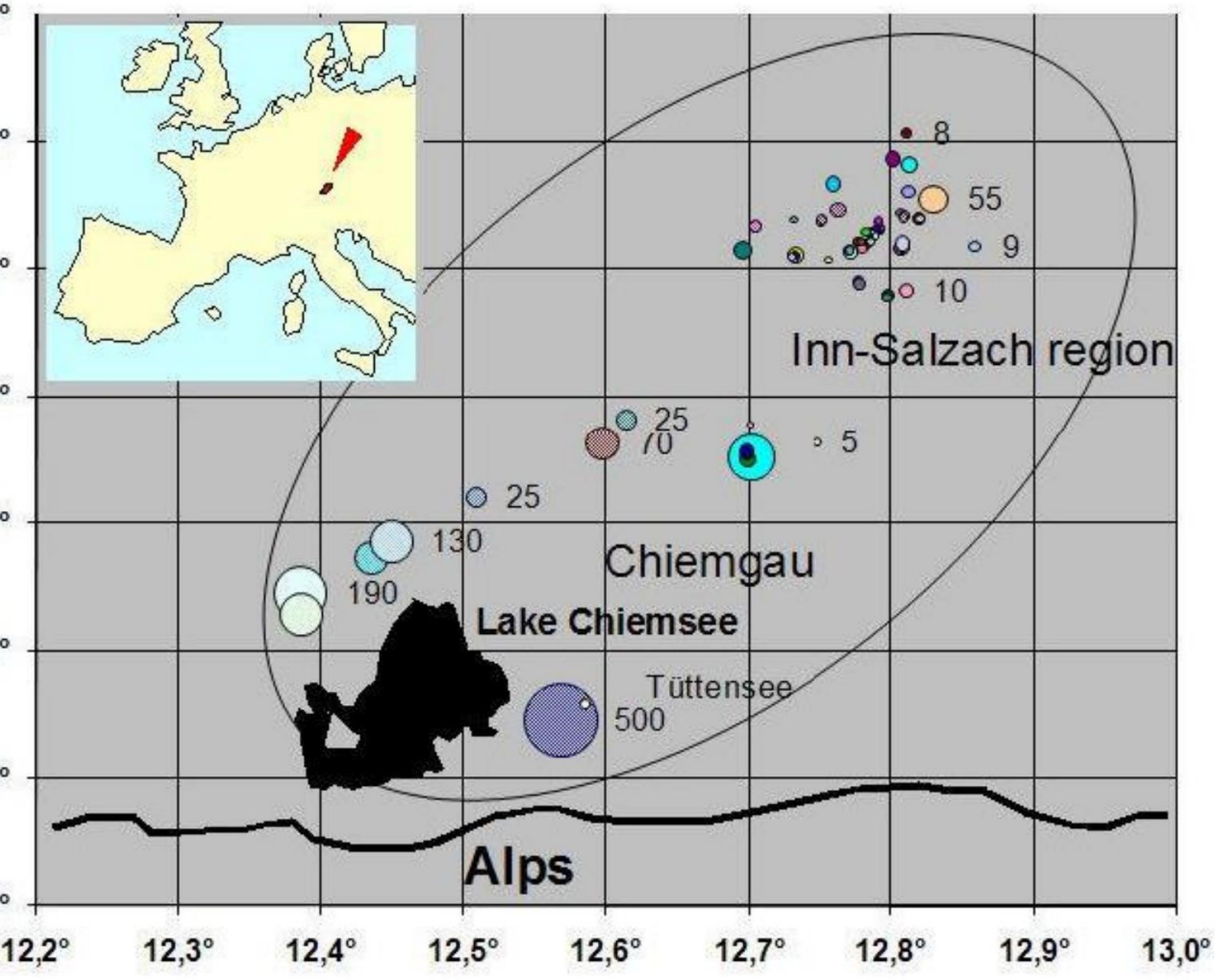
Georadar
disproved the glacial
origin theory: evidence
of buried fossil soils
(X. 2015 - Kalenda, Tengler)

Tüttensee – georadar profile:

buried fossil soils



Small craters: Ø several meters (NE) -> 190 m (SW); length of the fall field 58 km



- most of the craters have a wall - part of the craters have been leveled by current agricultural activity (original on hist.photog.)

Location: Marktl near Weiler Dornitzen

small craters with HT, HP and boulder deformation

(to this day sinkholes are formed - "Donnerloch", without met.; is it related to the destabilization of the subsoil by impact??)

- elsewhere such small craters are only penetrative (preserved meteorite, without shock. metam. in rocks) – meteorite remains even in Barringer crater (d = 1.2 km) •

at least in 5 craters (Kaltenbach, Emmerting...) shock met. (vitrification of boulders...); no meteorite

- no artefacts (~ "Roman limestone" etc.) • from voj.

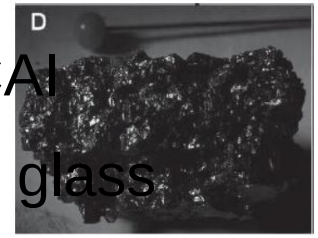
point of view, the distribution of craters does not make

sense in gamma spectrometry: no anomalous radionuclides...

Shock Metamorphosis + Space Material? – previous research:

(Ernstsson, Rappenglück, Shumilova, Neumair, Fehr ... collaboration: ZEISS Electron Microscopy, Oxford Instruments NanoTechnology); research • Fe silicides:

xifengite, gupeiite, hapkeite Fe2 Si; sometimes shock phenomena; often with other exotic miners. (TiC…) •



carbides: chamrabajite (Ti,V,Fe)C, moissanite SiC • CAI

(inclusions rich in CaO and Al2O3) • forms of carbon: glass

(often in deformed fossils), carbines (–ÿÿÿ–ÿÿ ÿ–) , (=ÿ=ÿ=ÿ=ÿ=) ; nanodiamonds and diam. similar carbon (DLC), probably also diamond

• occurrence of planar deformation of quartz (PDF) in boulders (U. Schüssler)

Impactor fragmentation and explosions in the air:

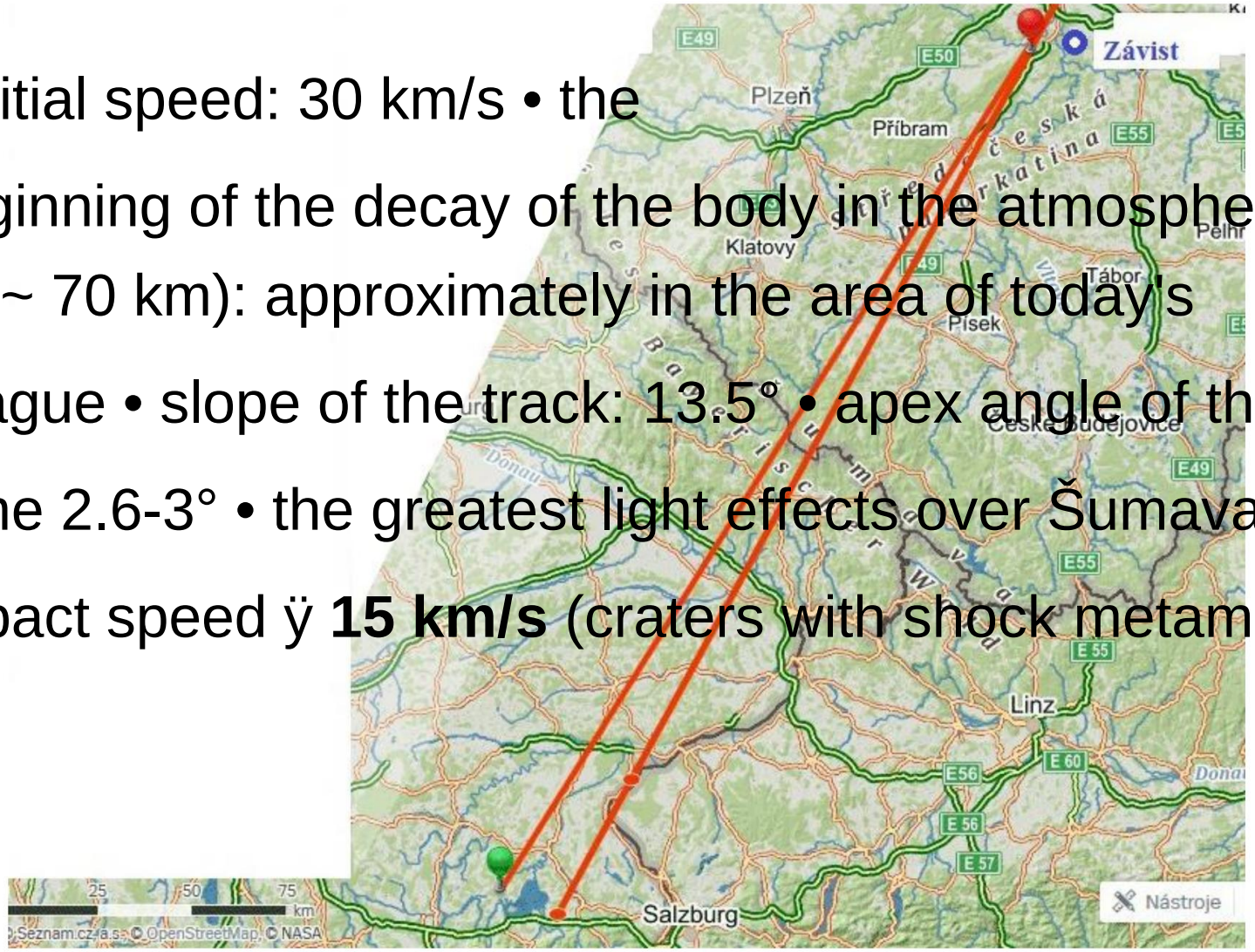
known cases • Chelyabinsk meteorite •

Tunguska meteorite: did the debris fall XX km from the epicenter? • groups of small craters: Morasko, Kaalijärvi... • meteor shower: Sichote-Alin (pair of craters: Ries-Steinheim, Clearwater East – C. West, d = 4 – 36 km: rather two bodies from the beginning)

There is still no known case where the relat. small meteorites hit the surface at > 10 km/s (record: Carancas approx. 3 km/s).

Body trajectory model

• initial speed: 30 km/s • the beginning of the decay of the body in the atmosphere (~ 70 km): approximately in the area of today's Prague • slope of the track: 13.5° • apex angle of the cone 2.6-3° • the greatest light effects over Šumava • impact speed ÿ **15 km/s** (craters with shock metam.)

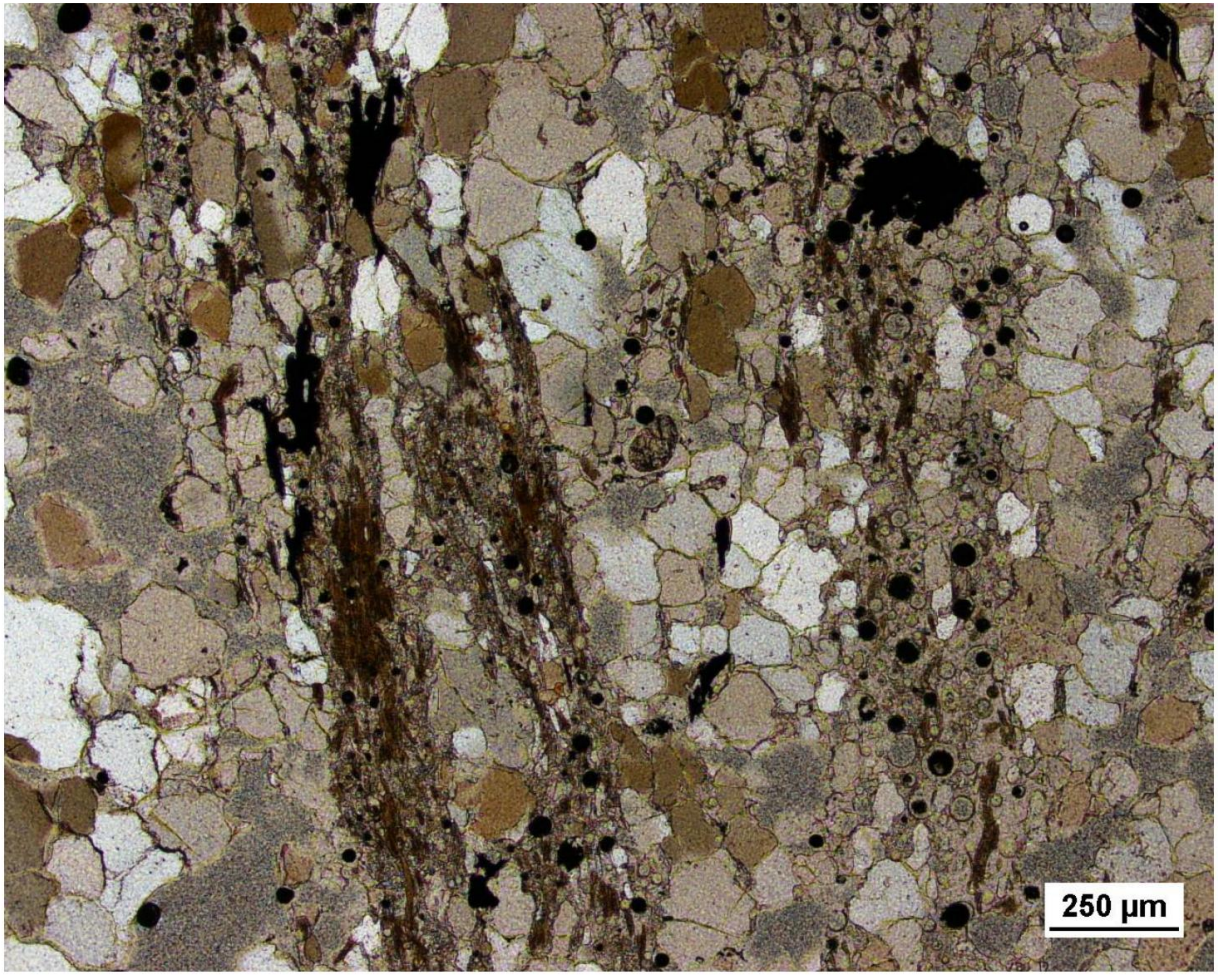


impactor fragmentation and explosions in the air - nature of the body:

- Chondrites dynamically fragment explosively at a height where the dynamic pressure on the face of the meteoroid is comparable to the tensile strength (mostly between 50 and 10 km above the ground). At high velocities greater than 20 km/s, most meter-diameter meteoroids completely vaporize already

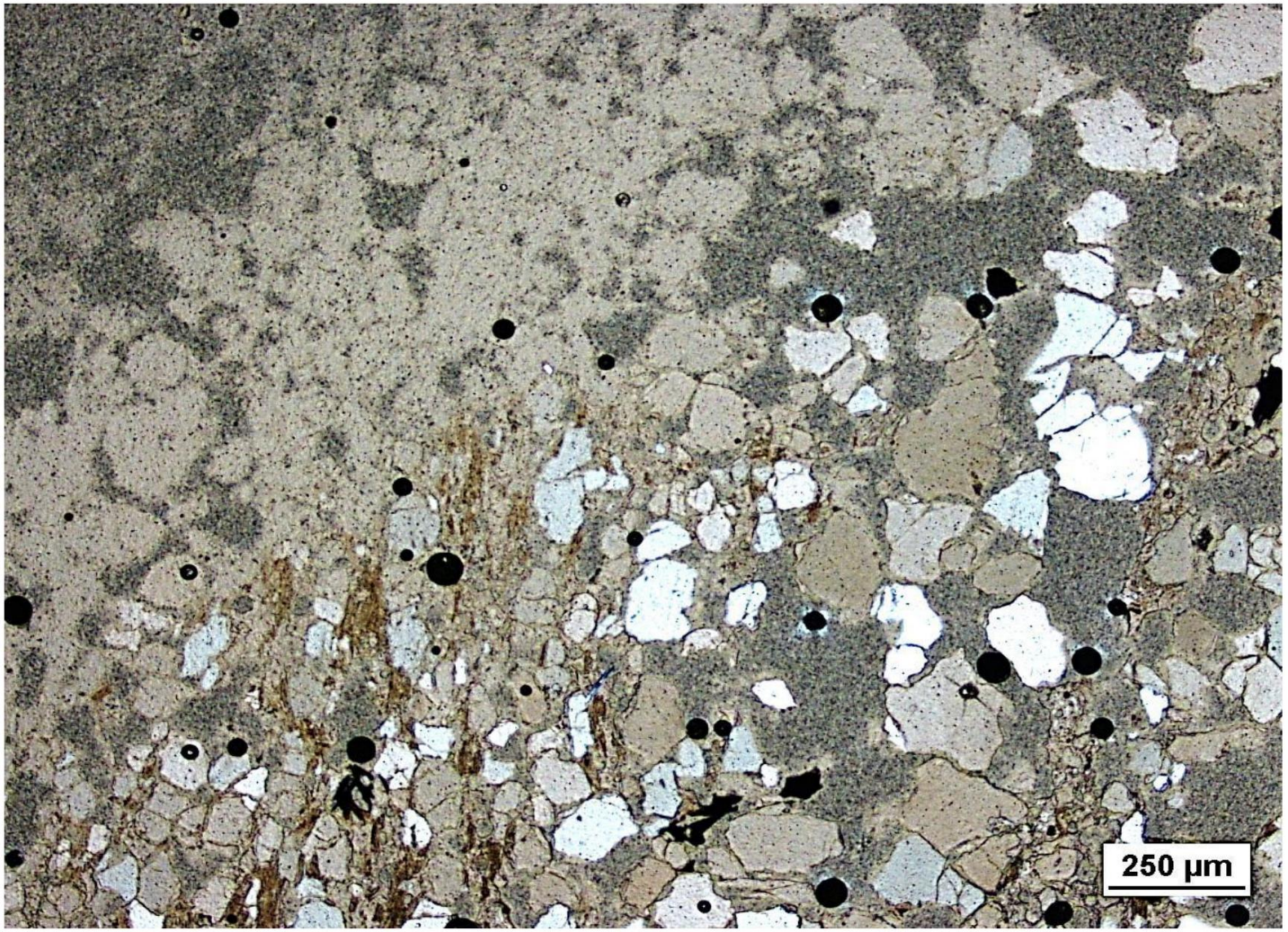
above the troposphere. • Chiemgau: several very solid bodies (iron meteorites?) fell , but they quickly and easily separated from each other (gravitational cluster ??)

Biotitic quartzite with coal content, strongly fractured to disintegrating (oblique nicols):

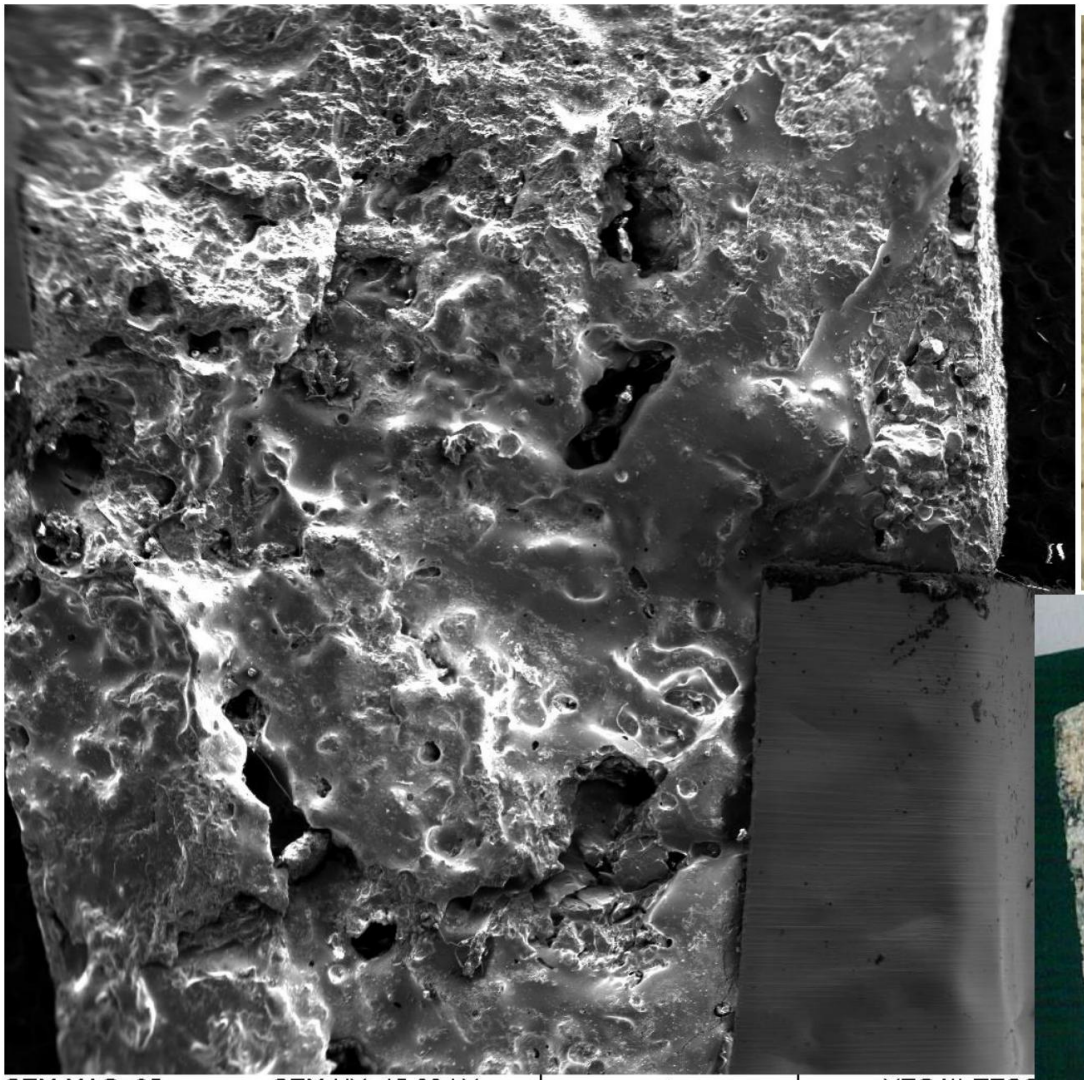


the inner part of the boulder

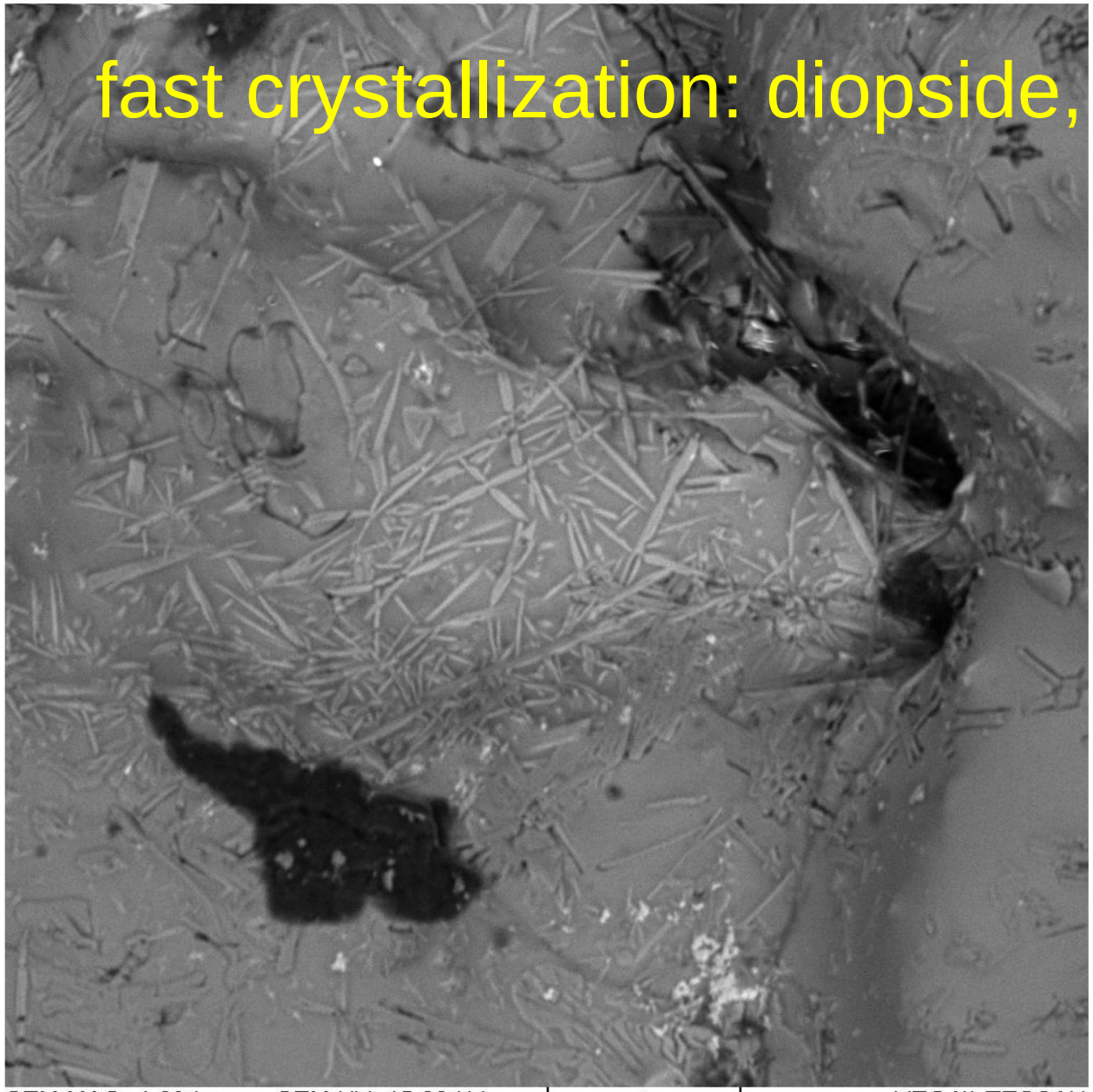
The same glass-coated quartzite that is discordant to the foliation (oblique nicols):



vitreous surface: boulder of orthogneiss



fast crystallization: diopside, plagioclase

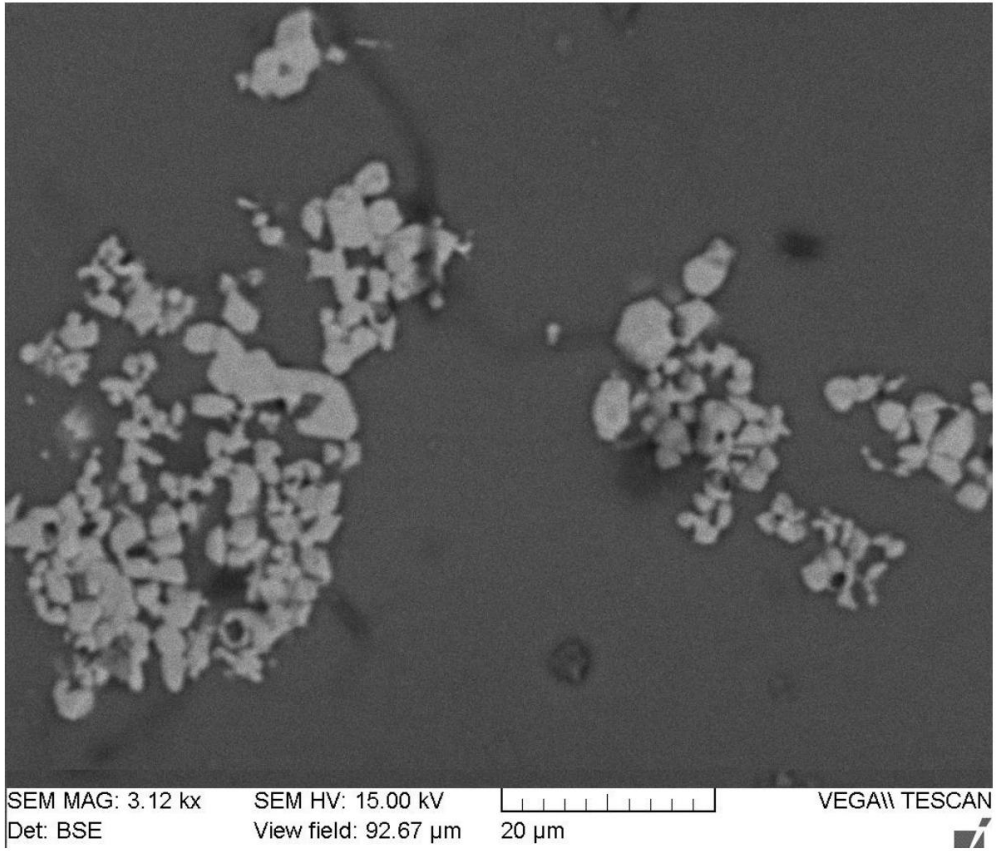


- cooling

fast, but not instant

vz. 420, vitreous coating

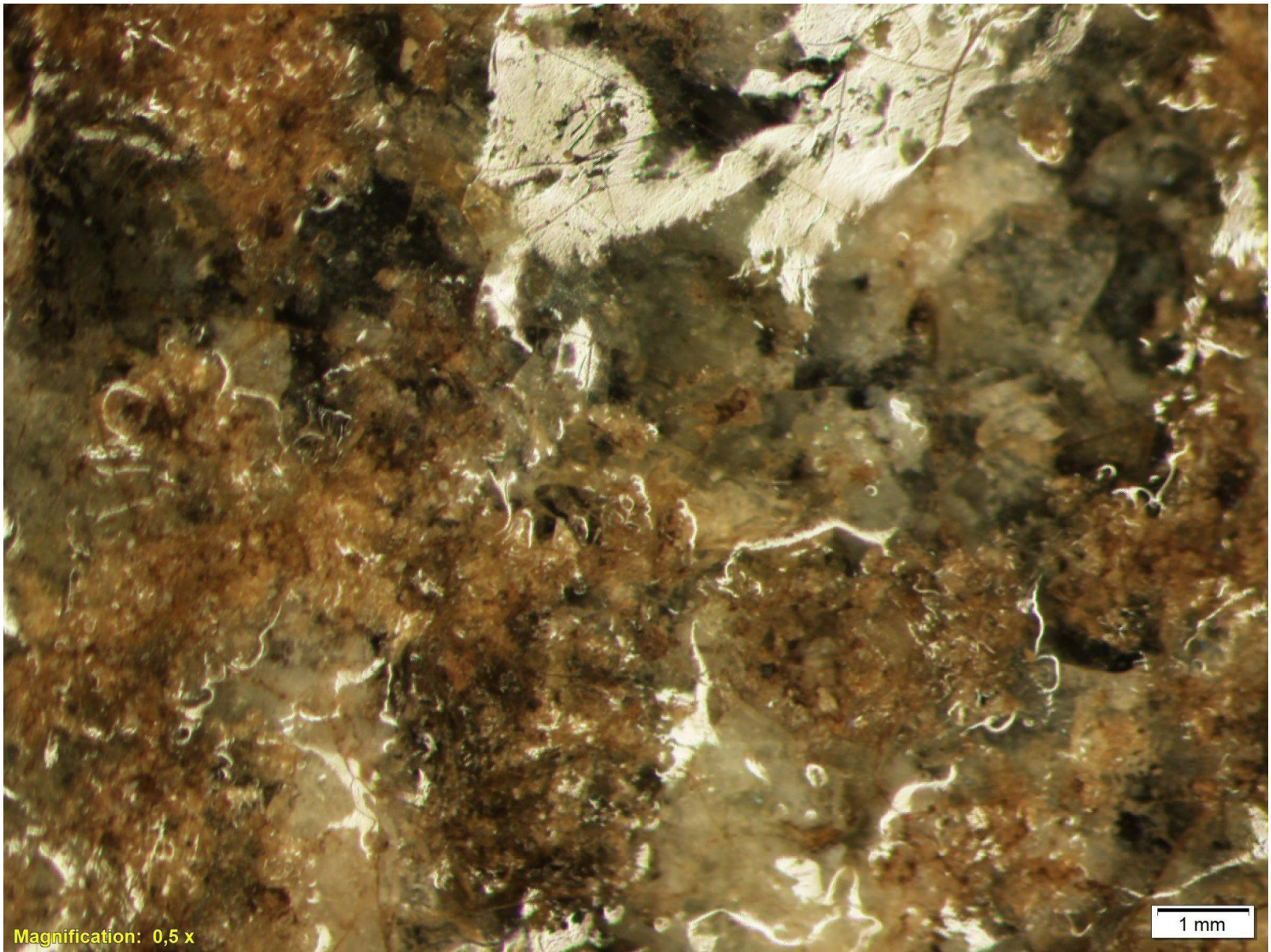
Crystallization from the melt: magnesioferrite $MgFe_2O_4$?



vz. 420, vitreous coating

- zircon remains in the glass: probably dissolution in melts; 1550 °C not reached (it would decompose to baddeleyite + SiO_2)

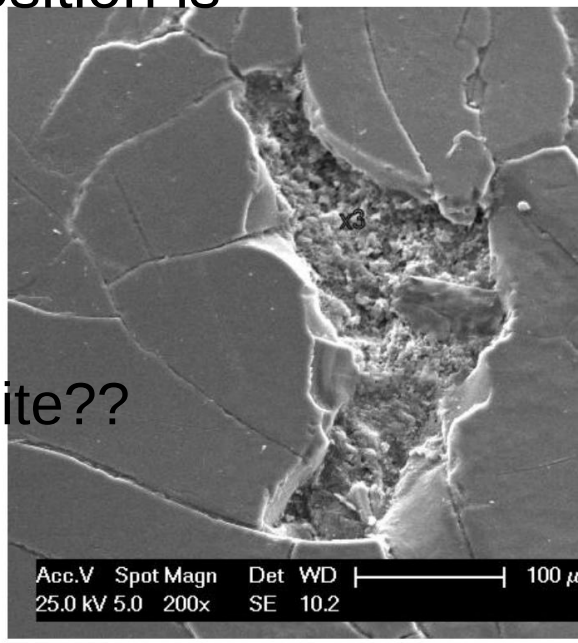
the glass covers the original weathered surface:



Chemistry of glass coatings

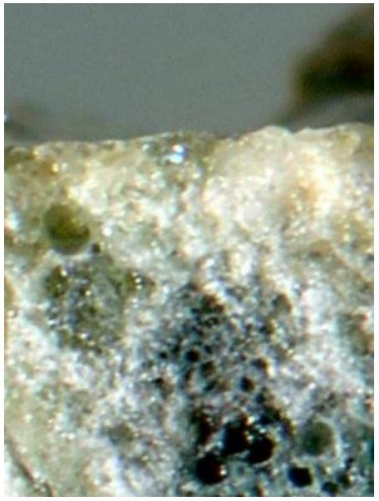
• up to 90% SiO2 (A. Neumair) -> up to 1500 °C • high Na, K • usually a lot of Cu (up to 450 ppm) – from abrasion of bronze tools?? (where is the Sn?) • the glass comes from outside, the composition is not determined by the boulder rock

– why are they mostly missing on limestone? • brown glass: remains of a meteorite?? (W. Schüssler)



(X)RF analyzer Delta Premium (ÚHIGUG)

chemistry at < 0.1 mm level: RF apparatus for fine scanning (FJFI CTU)

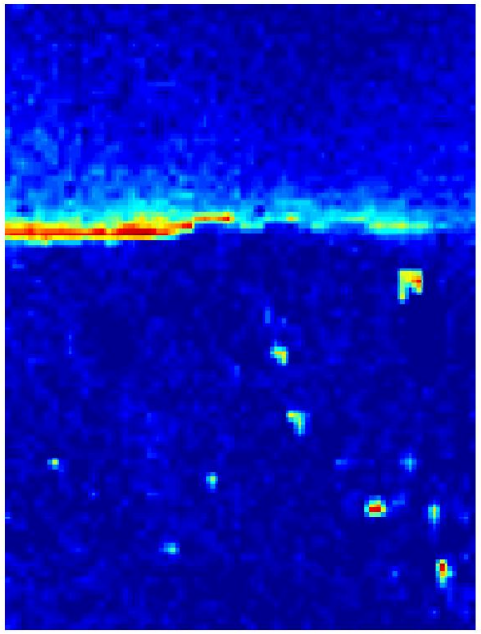


RF Scan - Thin Glass Coated Section: Area 3 x 4 mm

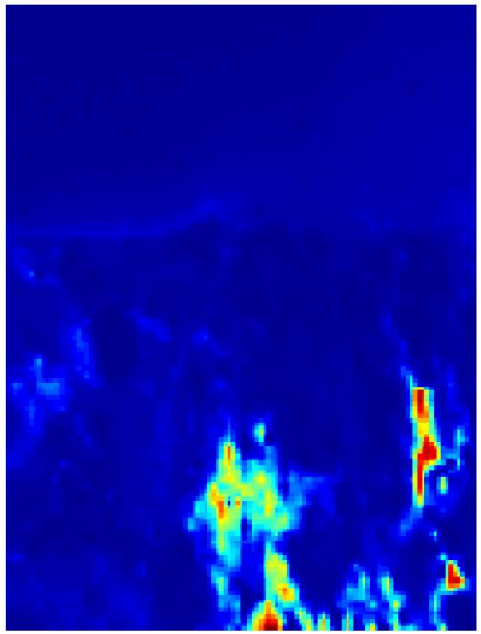
Resolution (step) 50 µm

maximum Cu in glass:

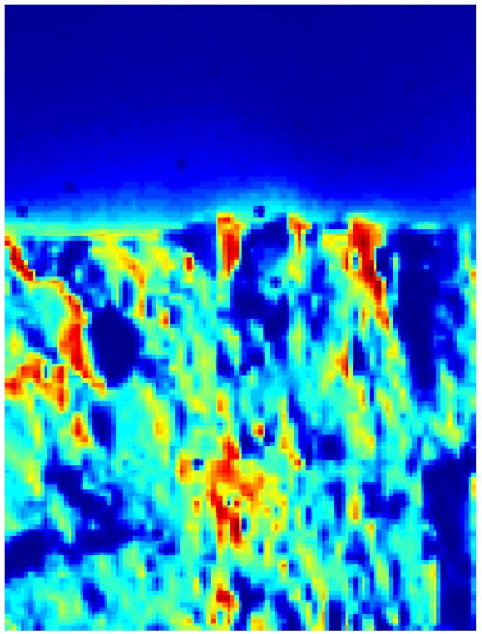
Cu



Fe



TO

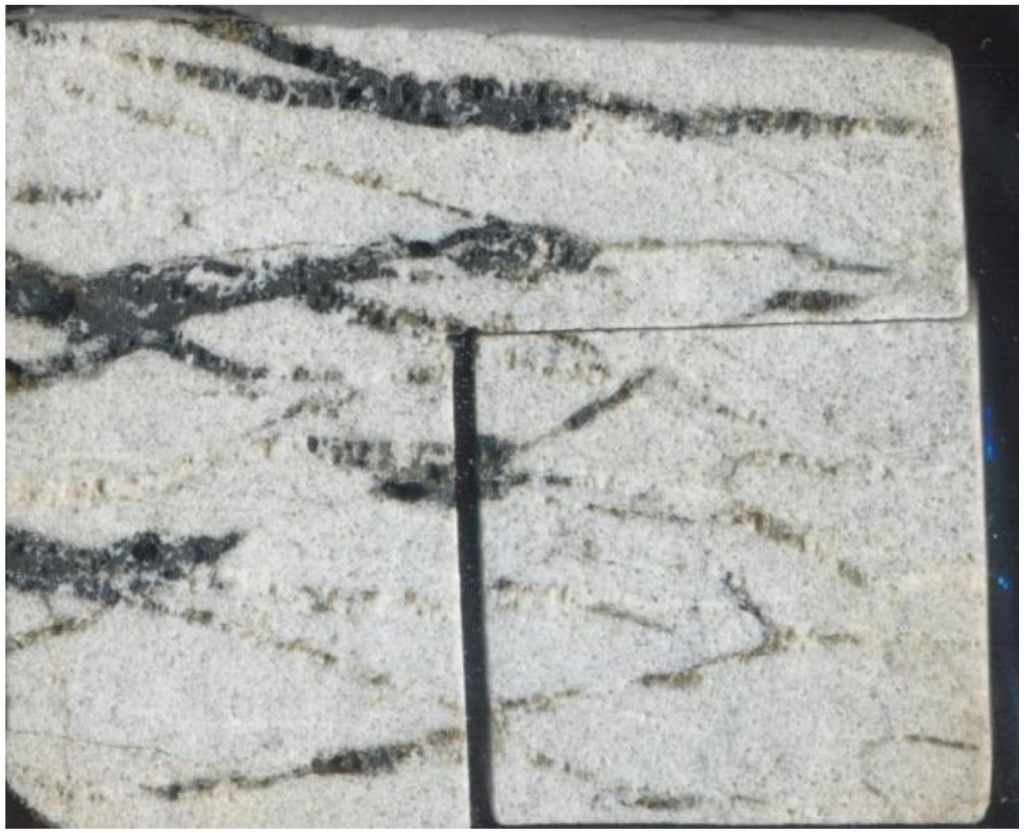


Foamy veins inside boulders

- melting during decompression; sometimes injections from the outside into the cracks?

  – decompression melts especially biotite, chlorite (compressible) –

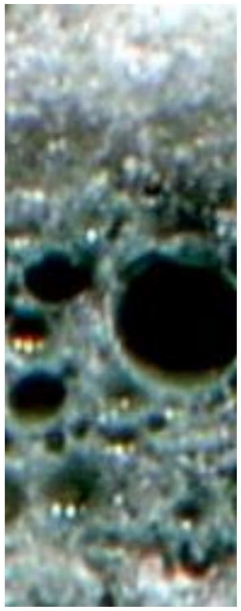
  escape of gases, especially water vapor



foamed veins in orthorule (vz. 123):

Chem.: more Fe in the green "slag".

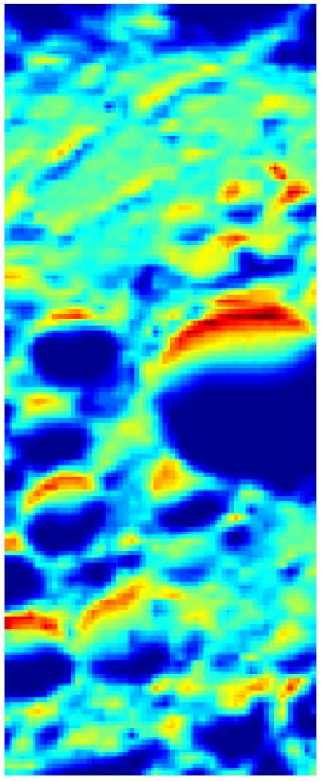
RF scan: peaks of Fe and at the same time K – biotite melt



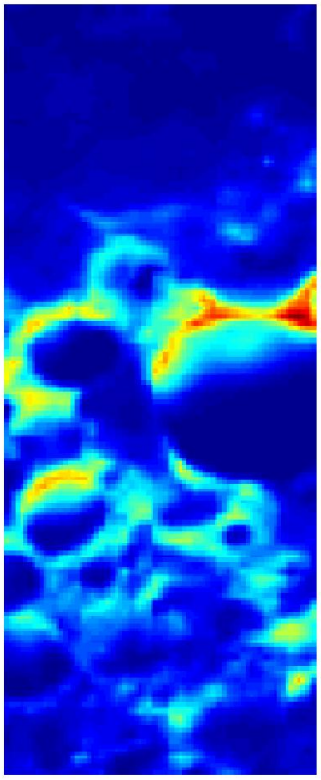
Area: 1mm x 2.5mm

Resolution (step): 25 µm

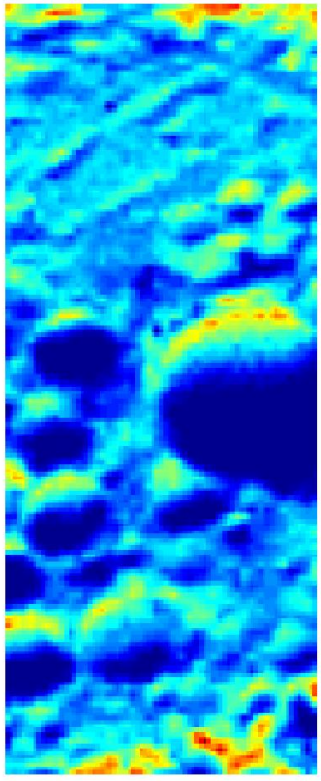
TO



Fe



You are



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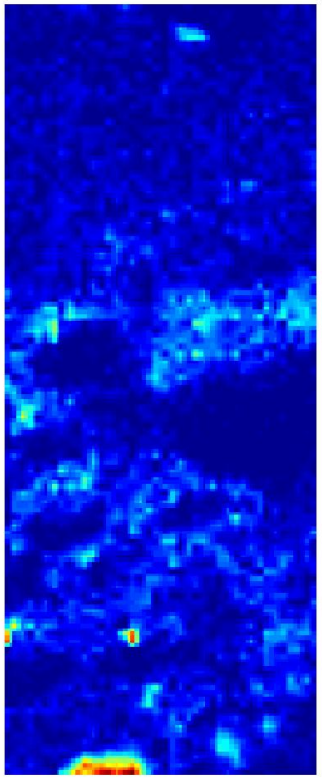
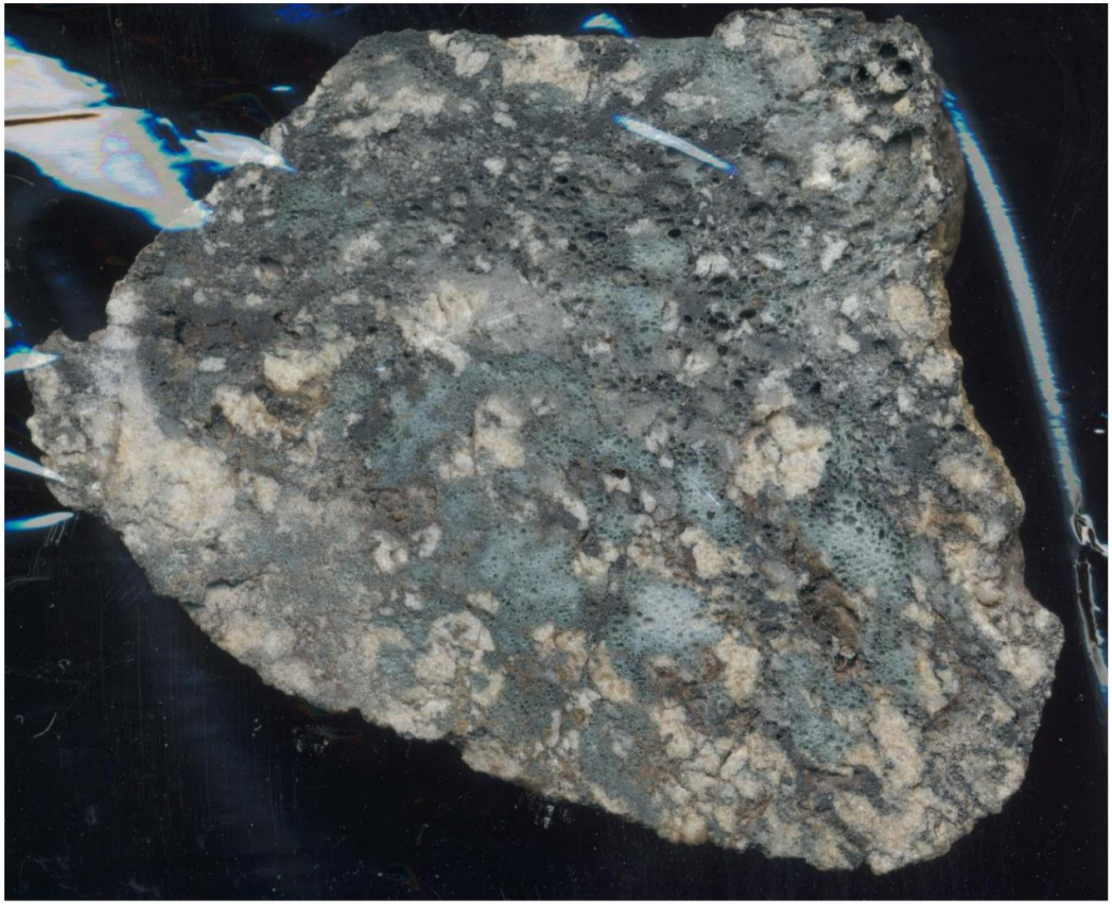
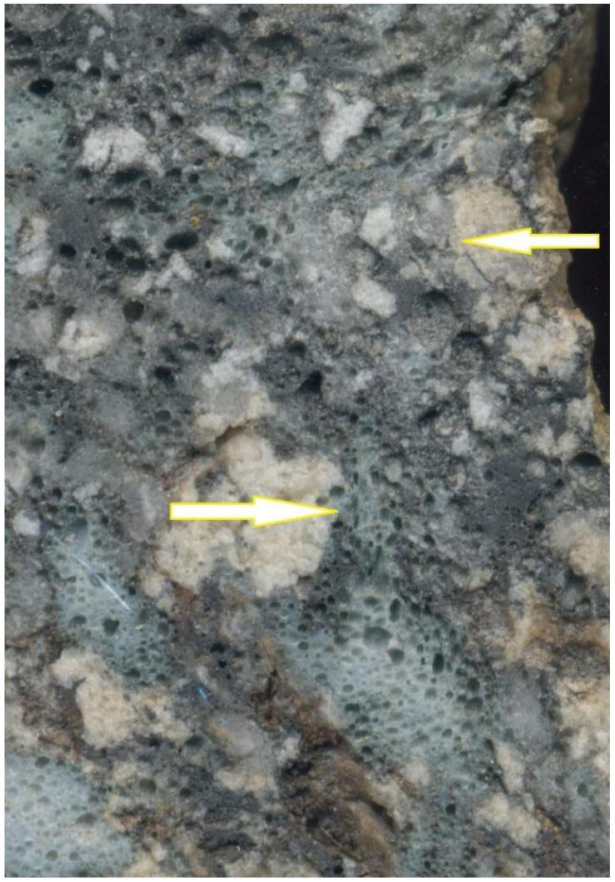
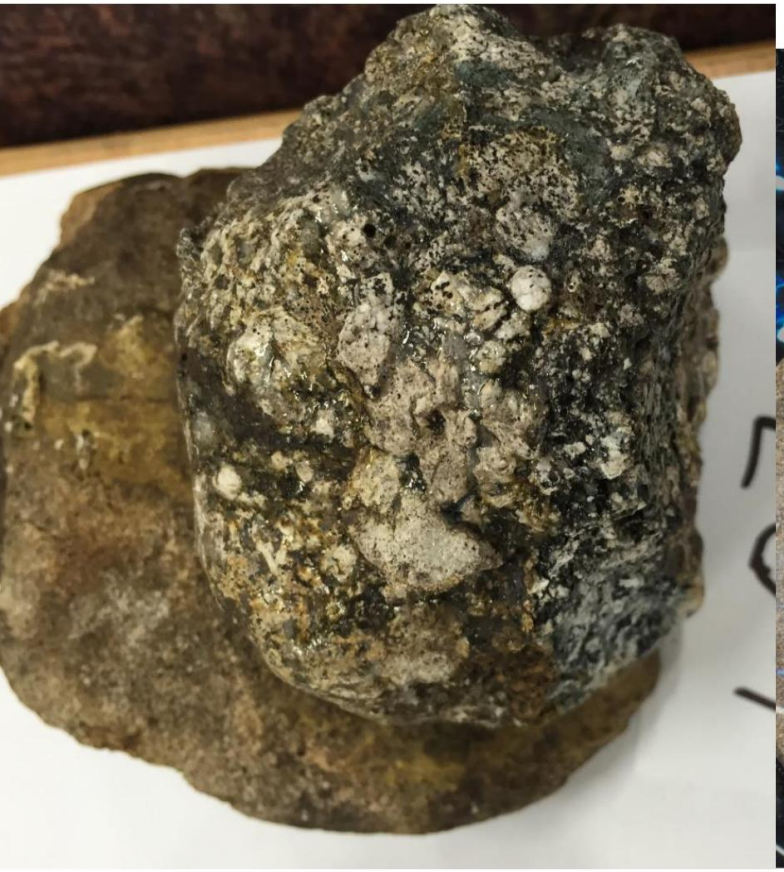


More advanced smelting; and melt deformation (granitoid, vz. 407):



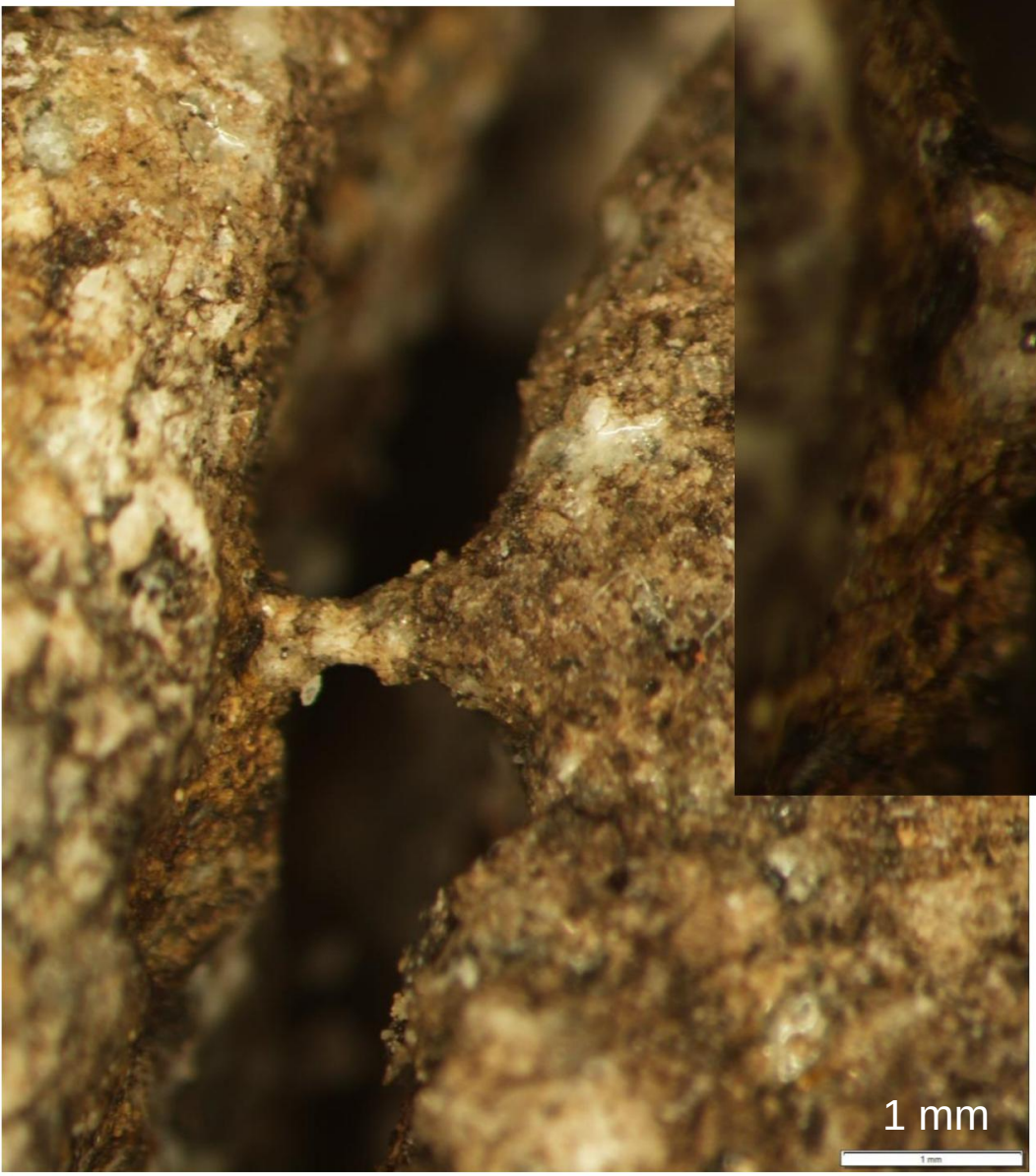


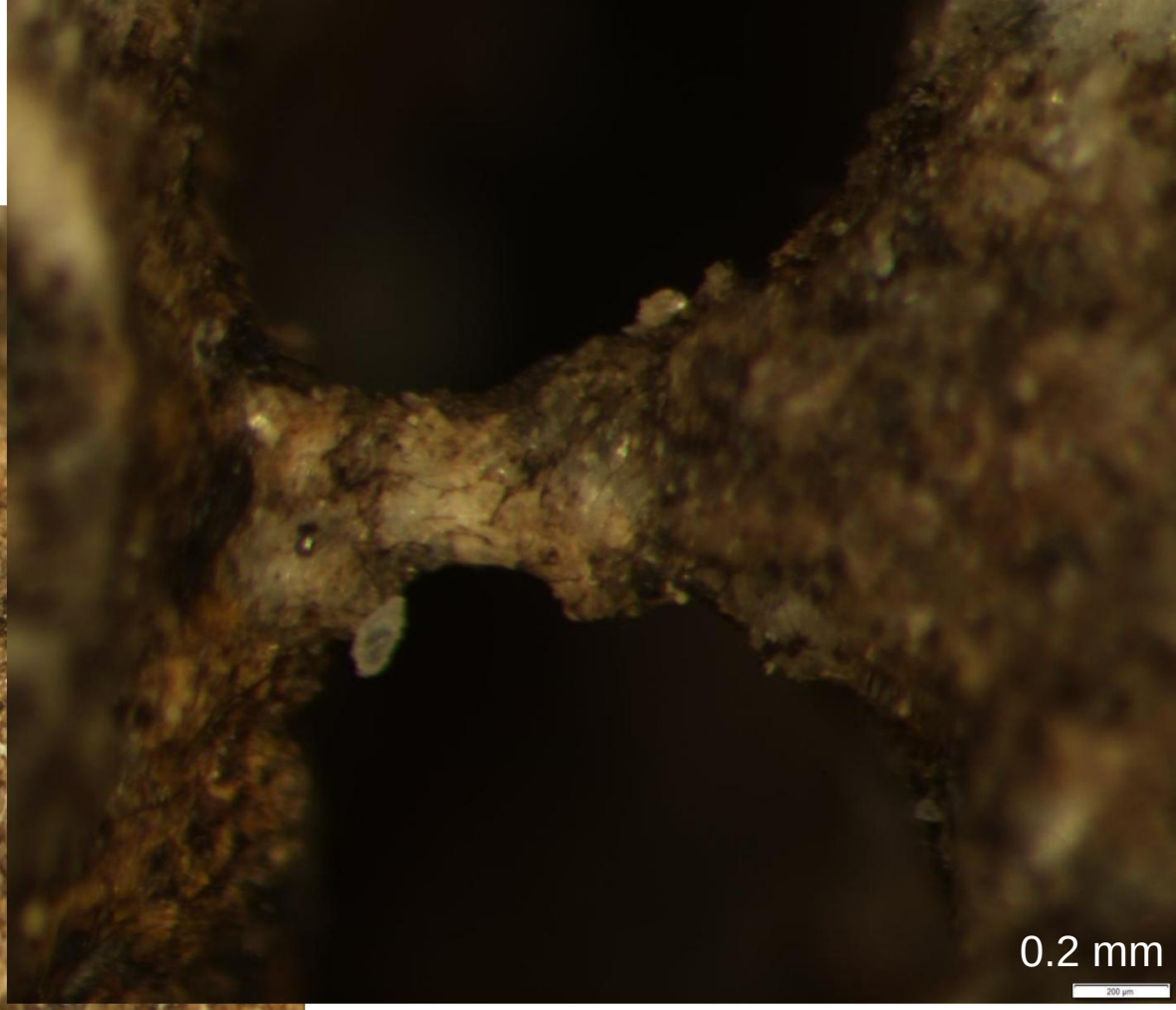
Connection of two boulders by melt: granitoid melted inside, only a small tongue on the sandstone (vz. 407)



strongly deformed granitoid boulder:

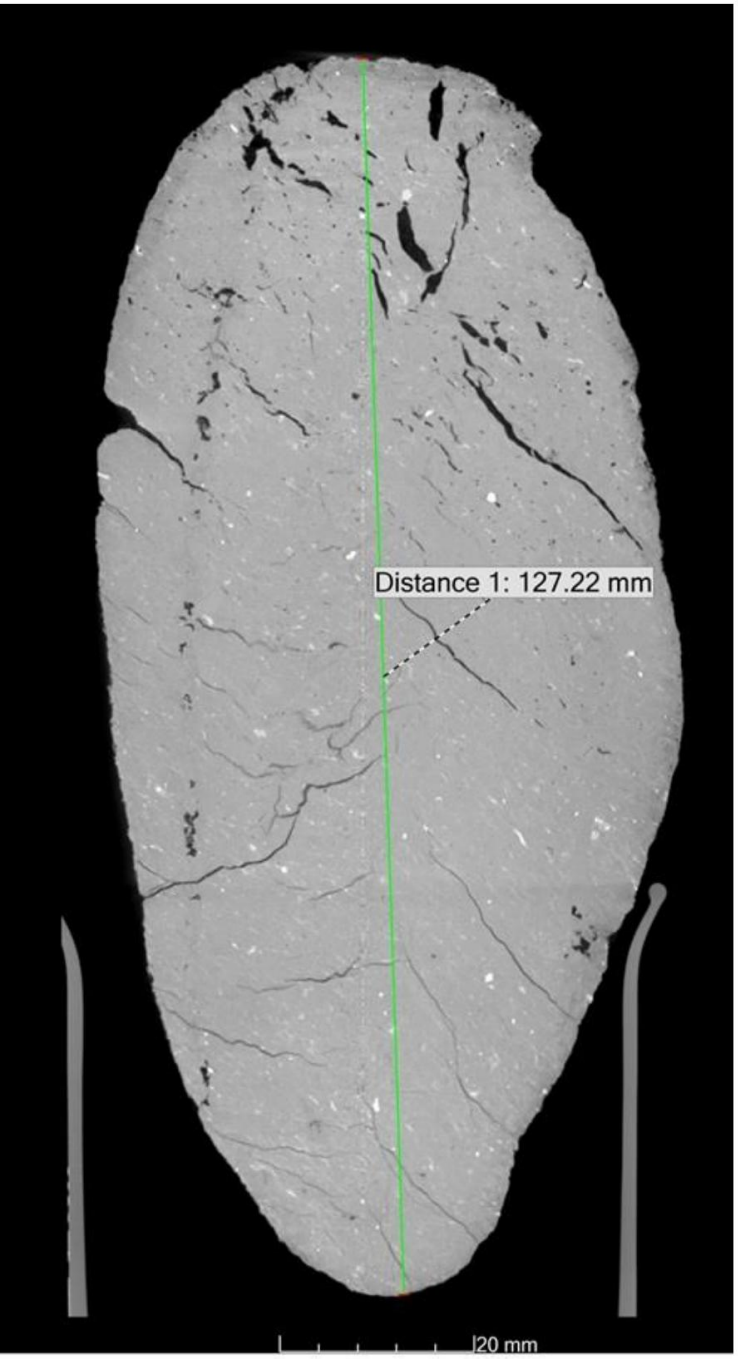
glass coating only in places, inside the biotite melt





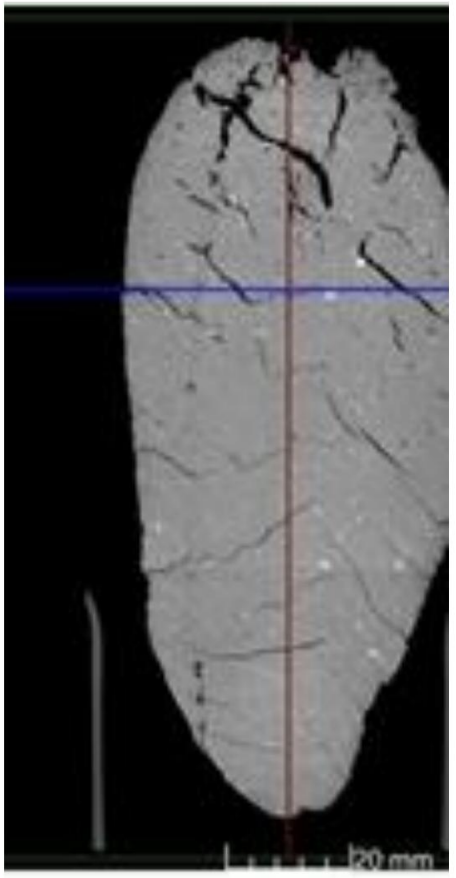
Extreme deformation:

bridging a crack -
probably without melting



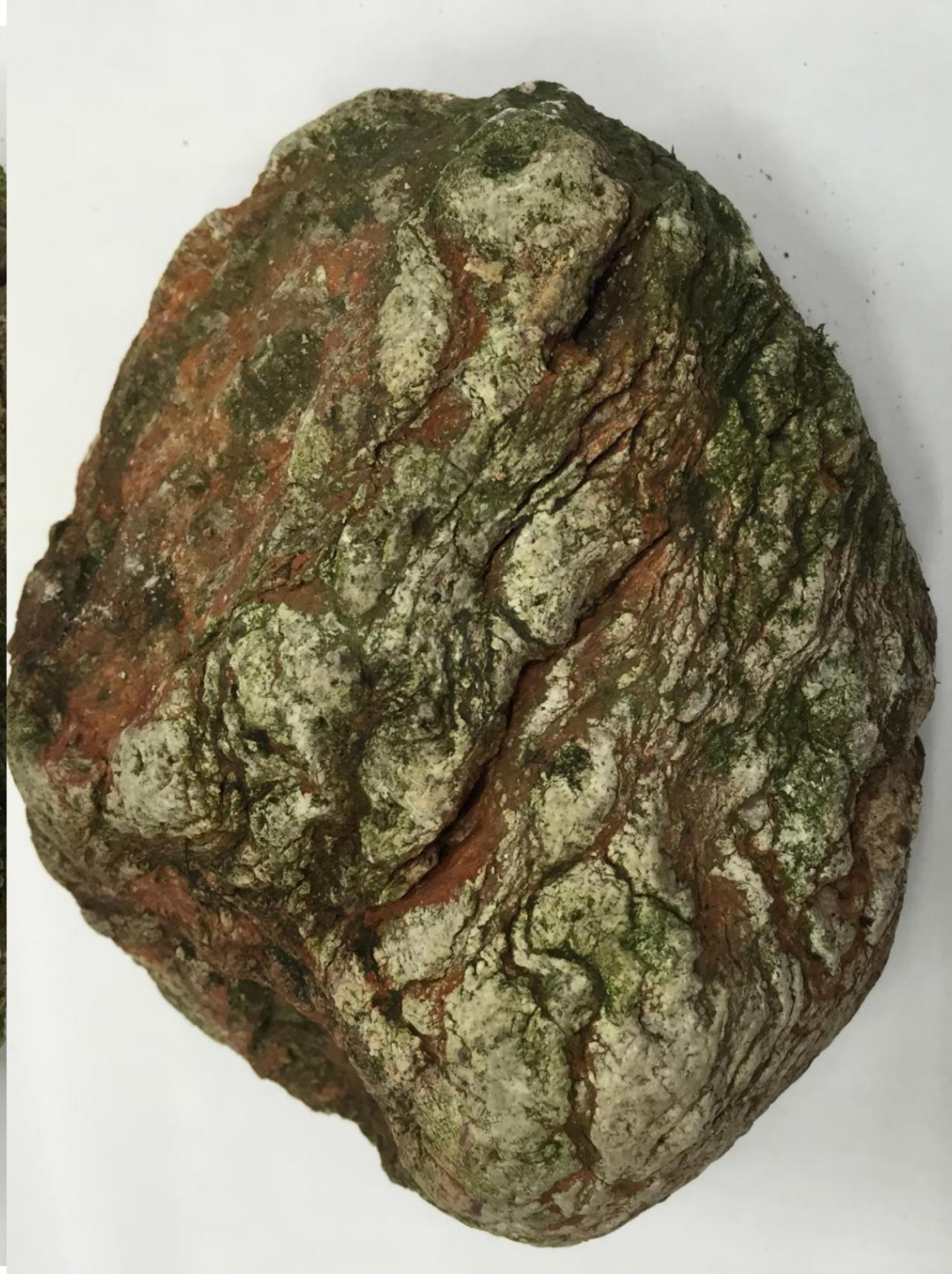
non-destructive imaging of cracks inside the boulder:

CT-tomography (CT)



limestone •

does not melt at surface pressure, but decomposes • often brecciations; thick crusts • sometimes surfaces shaped by gas leakage • rarely a thin coating of glass (rich in K, not Ca!)



Magnetometry

- an abnormally high susceptibility and remanent magnetization of some limestones was demonstrated (Neumair a Ernstsson, 2011) •

formation of magnetic minerals by shock dehydration of Fe hydroxides?

- extreme magnetic field on impact?

magnetometry

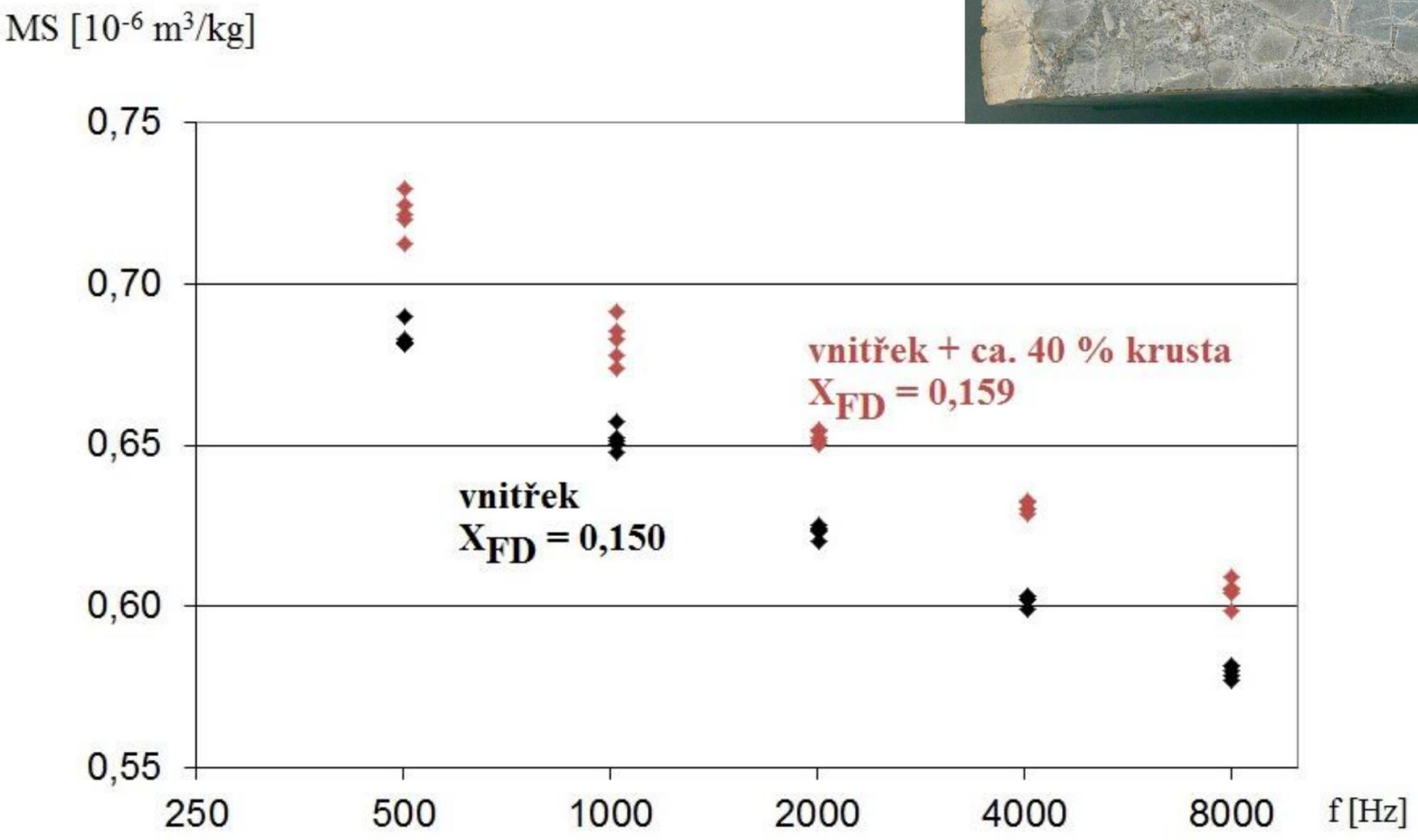
Frequency dependence of magnetic susceptibility: significant in limestones, sometimes also in dark glasses ÿ Superparamagnetic particles (tens of nm)

– little time for crystal growth; they probably grew when heated from the outside - more likely in the crusts (nucleation could have already occurred during the shock)

– magnetite or maghemite? (if maghemite, the effect of weathering is possible)

frequency dependence:

limestone (field 20 A/m; vz. 417)



Thanks

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