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FWF Der Wissenschaftsfonds.

Chesapeake Bay impact structure: Investigations of the impact breccia section (1397-1551 m) in the ICDP-USGS Eyreville drill core

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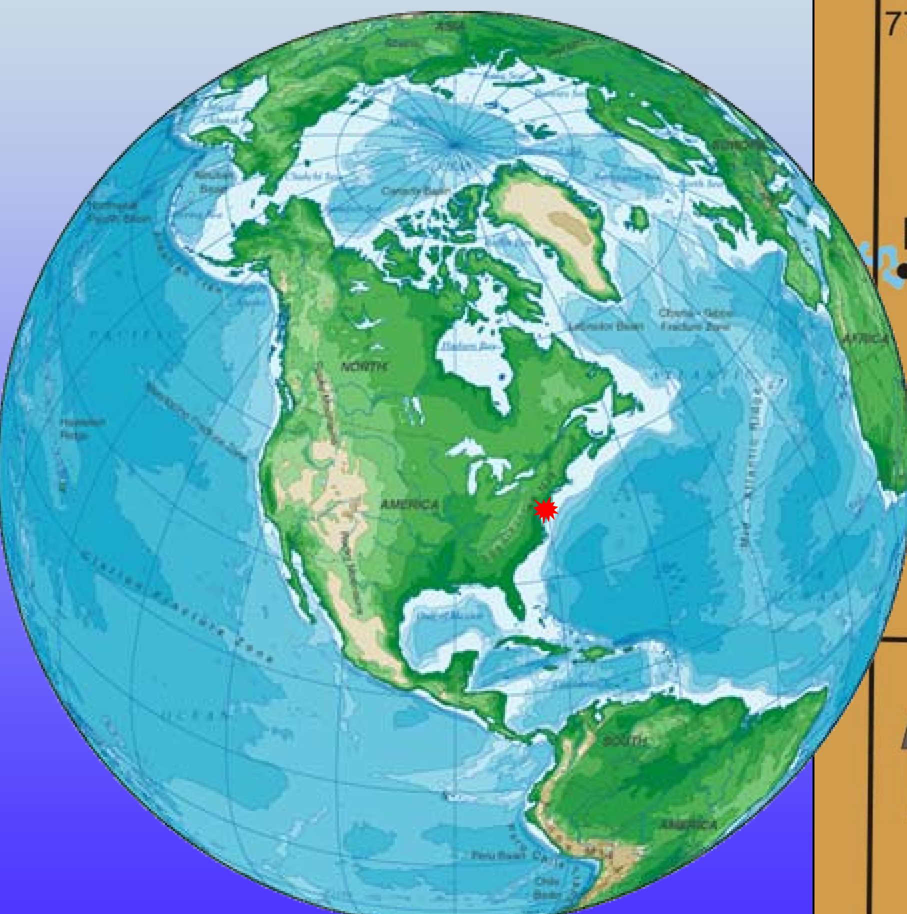
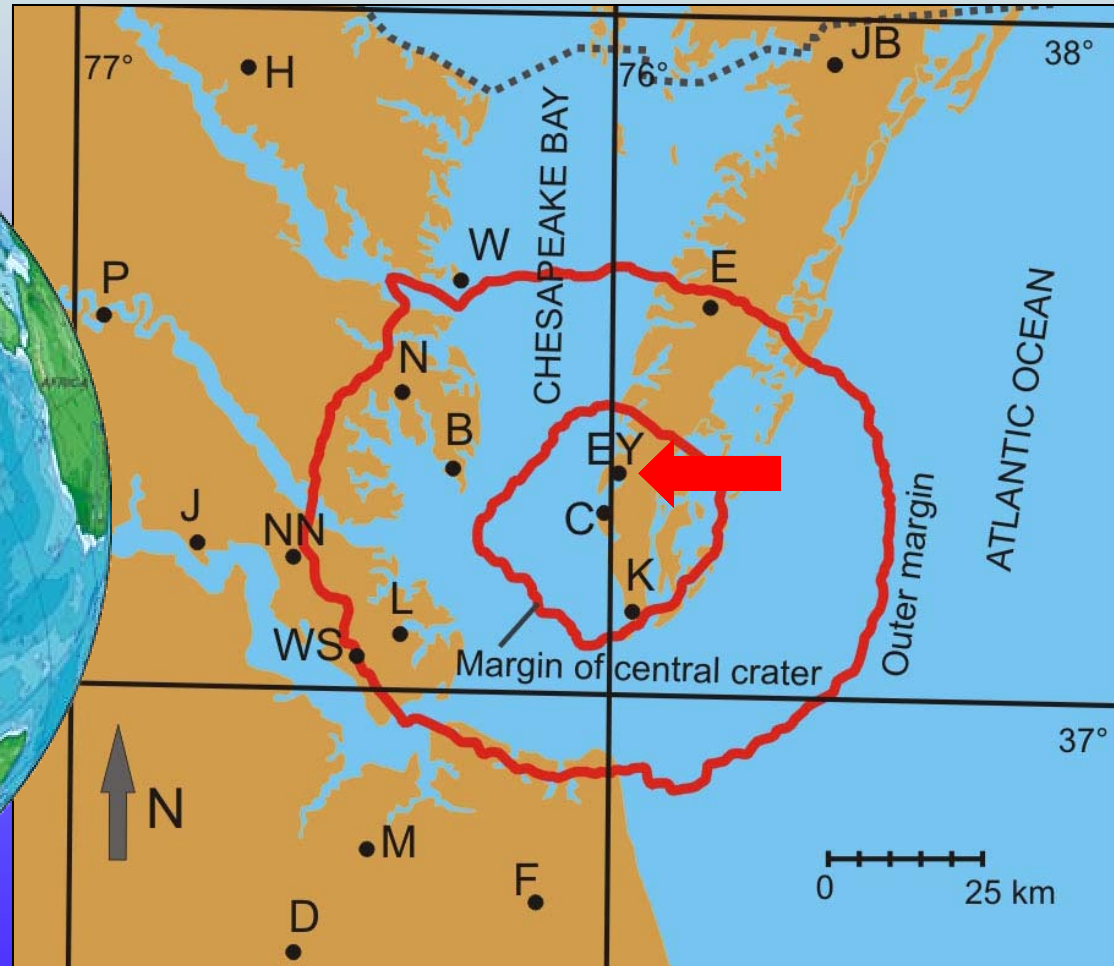
OUTLINE

- **Chesapeake Bay impact structure**
- **Eyreville drill core**
- **Petrography and stratigraphy of the impact breccia**
- **Melt particles**
- **Shock metamorphism**

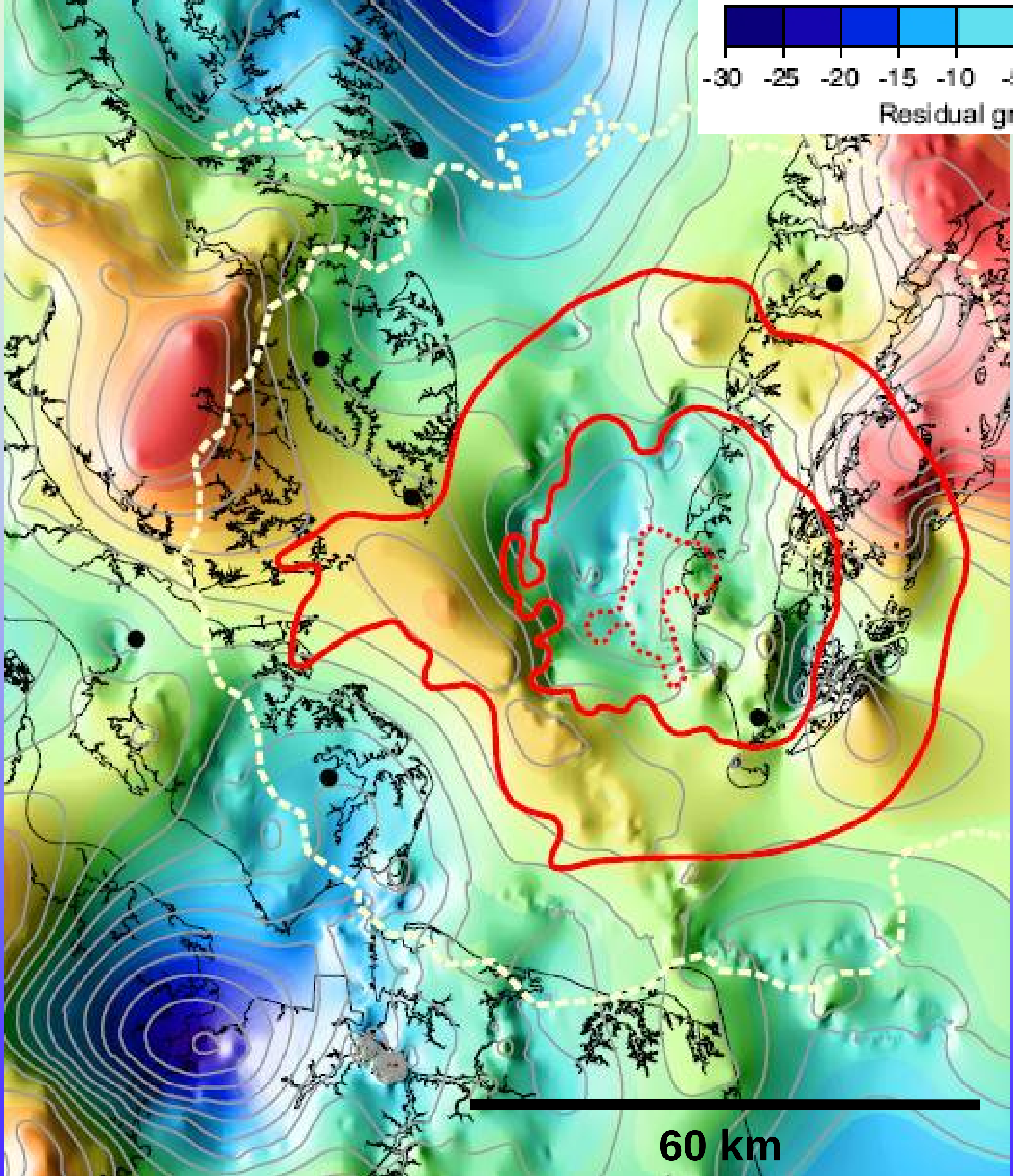
CHESAPEAKE BAY IMPACT STRUCTURE

35.3 Ma old, 85 km in diameter



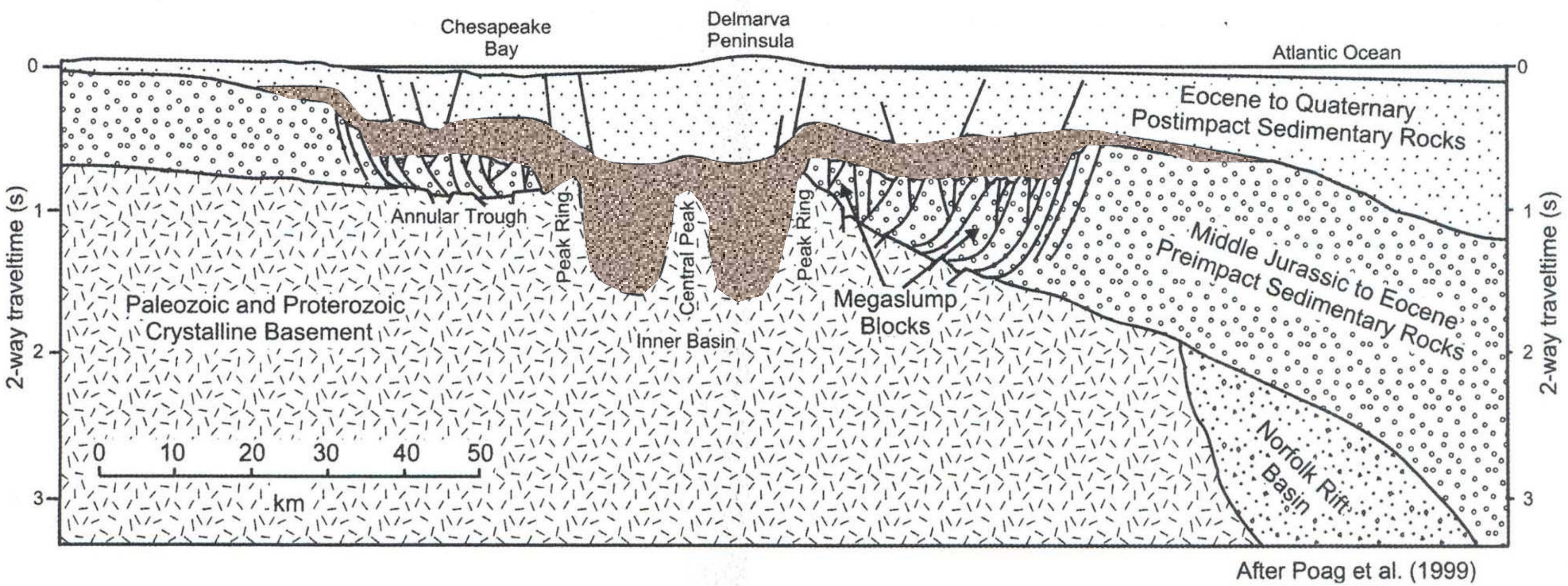


Gravity anomalies



(Poag et al., 2004)

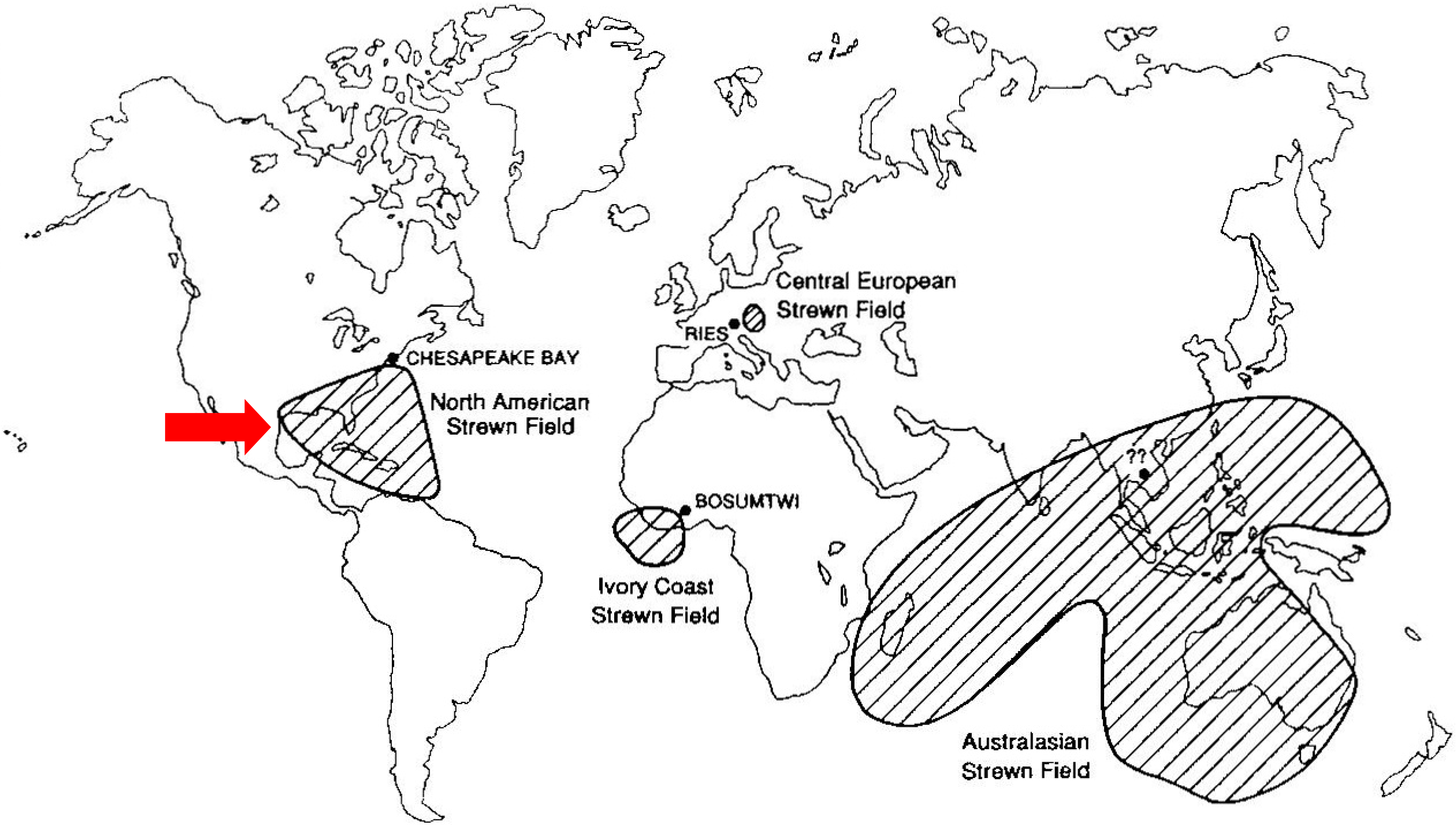
Chesapeake Bay impact structure



Cross sectional structure and morphology
Based on seismic reflection profiles and boreholes

(Poag et al., 2004)

Tektite strewn fields



(Montanari and Koeberl 2000)

0 m

ICDP-USGS EYREVILLE DRILL CORE

(Gohn et al., 2006; Horton et al., 2009)

Post-impact sediments

444

Exmore breccia
sediment-clast breccia and sedimentary blocks (interpreted as resurge breccia)

1096

Granite and granitic gneiss megablock

1371

Gravelly sand (contains an amphibolitic block)

1397

Suevitic impact breccias

1551

Basement-derived pegmatite/granite alternating with schist

1766

POST-IMPACT

EXMORE BRECCIA

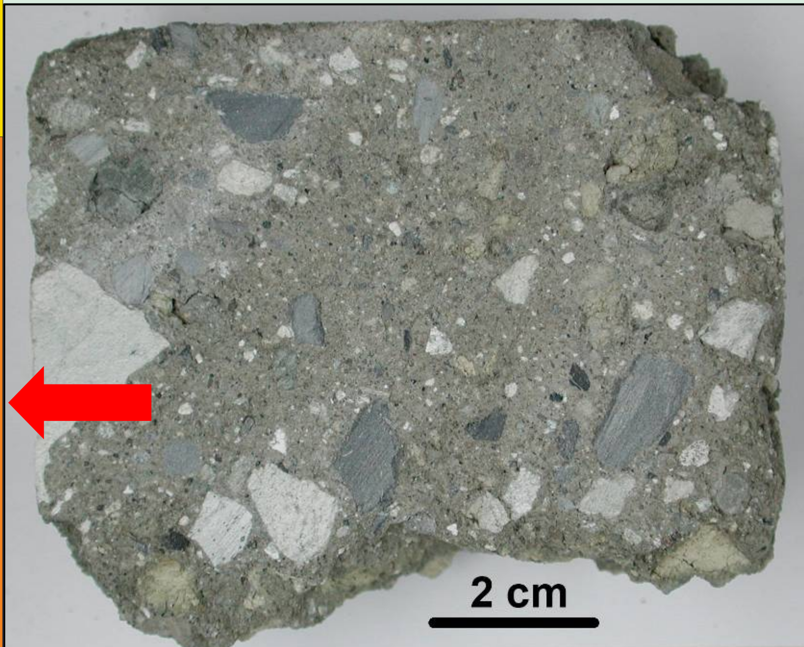
GRANITE

SUEVITE

SCHIST AND PEGMATITE

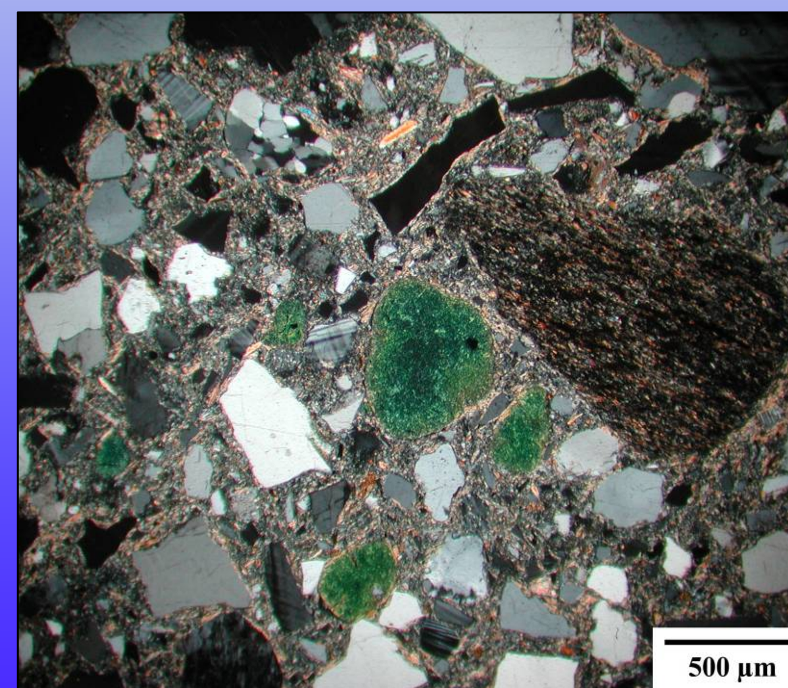
Exmore breccia

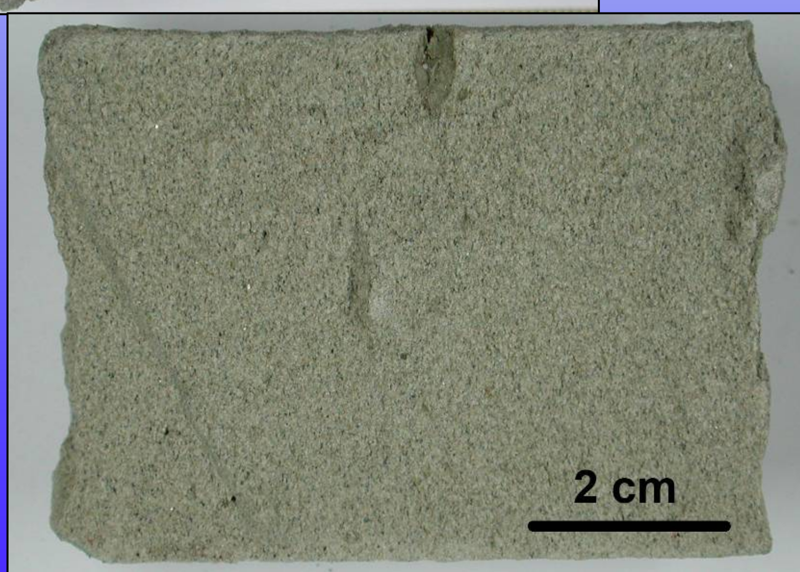
444-1096 m



CB6-036
532.3 m

CB6-020 492.7 m





CB6-066
940.3 m

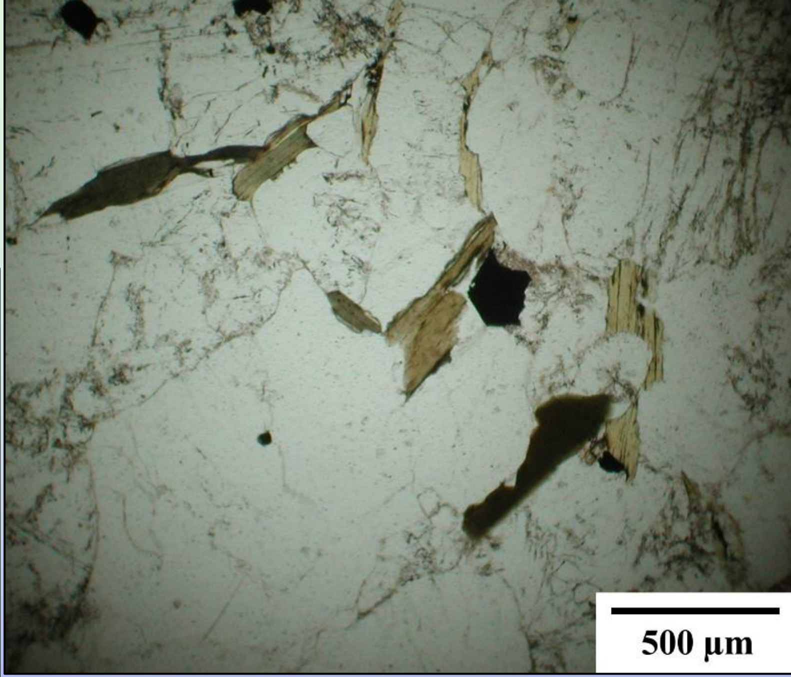
POST-IMPACT
EXMORE BRECCIA
GRANITE
SUEVITE
SCHIST AND PEGMATITE

Granitic megablock

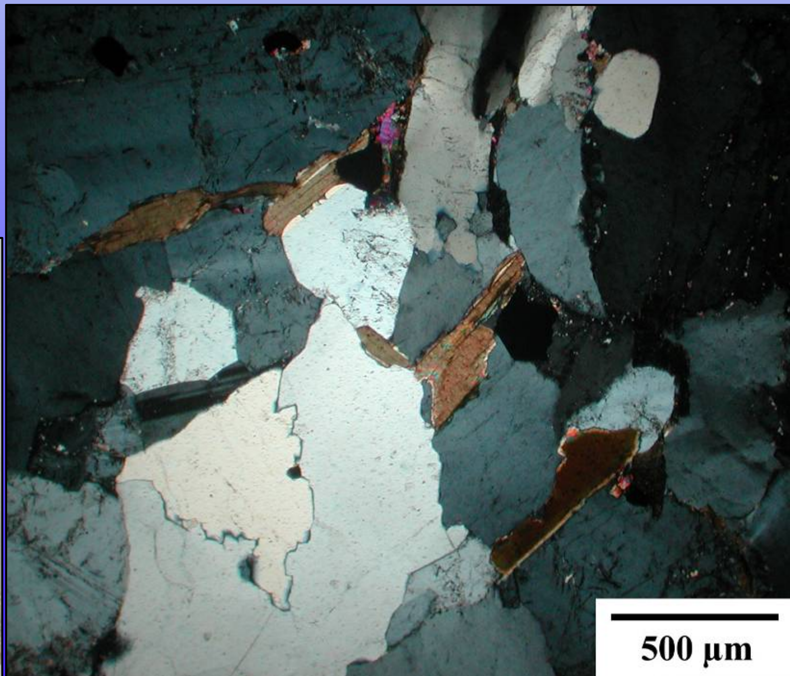
1096-1371 m

CB6-075
1140.5 m

CB6-079
1212.4 m



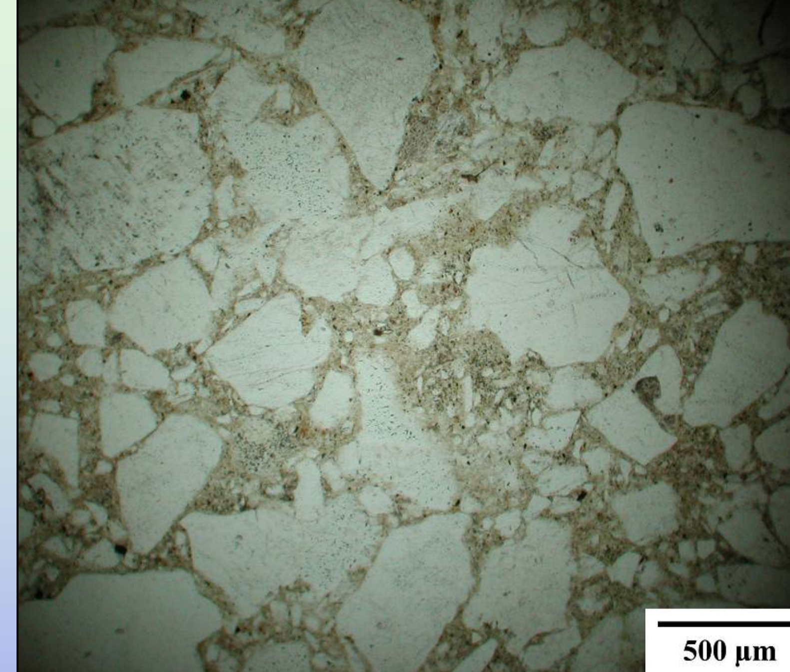
CB6-082 1346.4 m



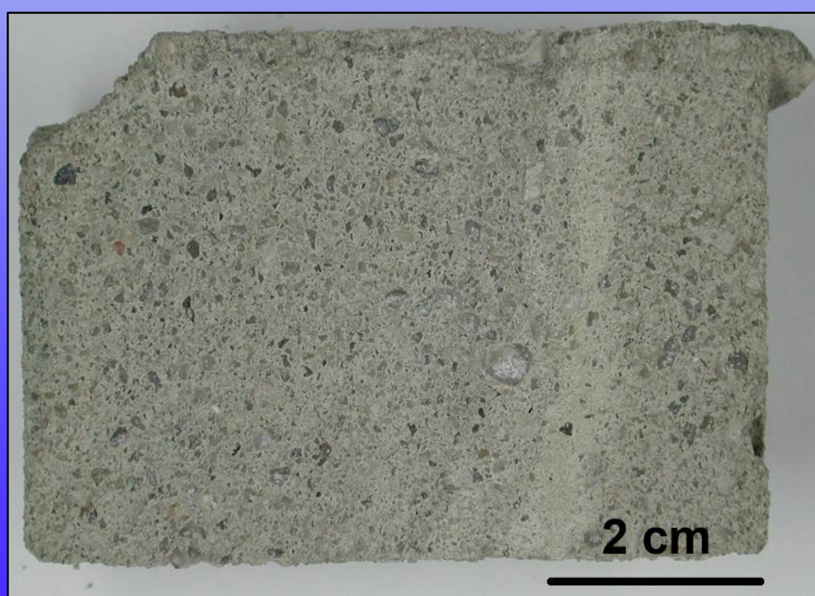
POST-IMPACT
EXMORE BRECCIA
GRANITE
SUEVITE
SCHIST AND PEGMATITE

Gravelly sand
1371-1397 m

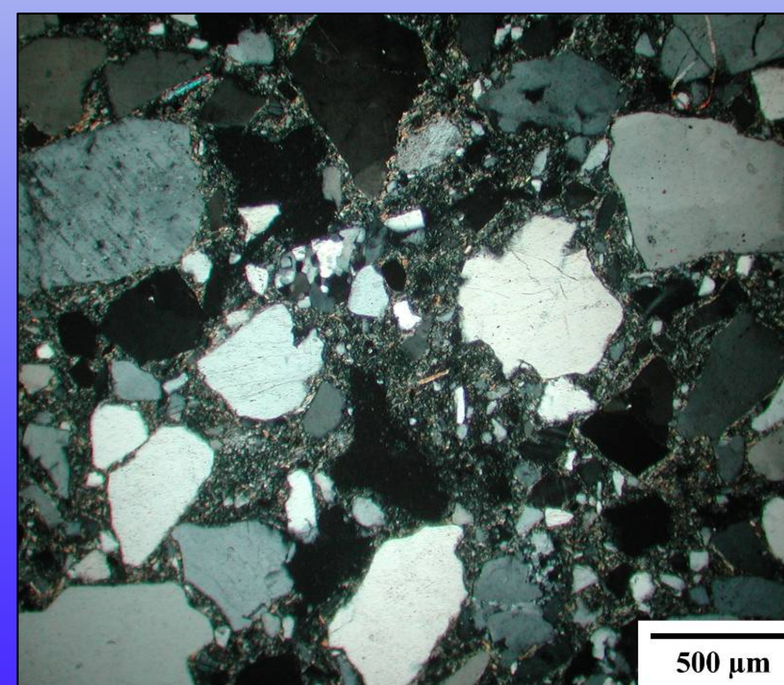
CB6-089 1375.6 m



CB6-091 1390.4 m



CB6-091
1390.4 m



POST-IMPACT

EXMORE BRECCIA

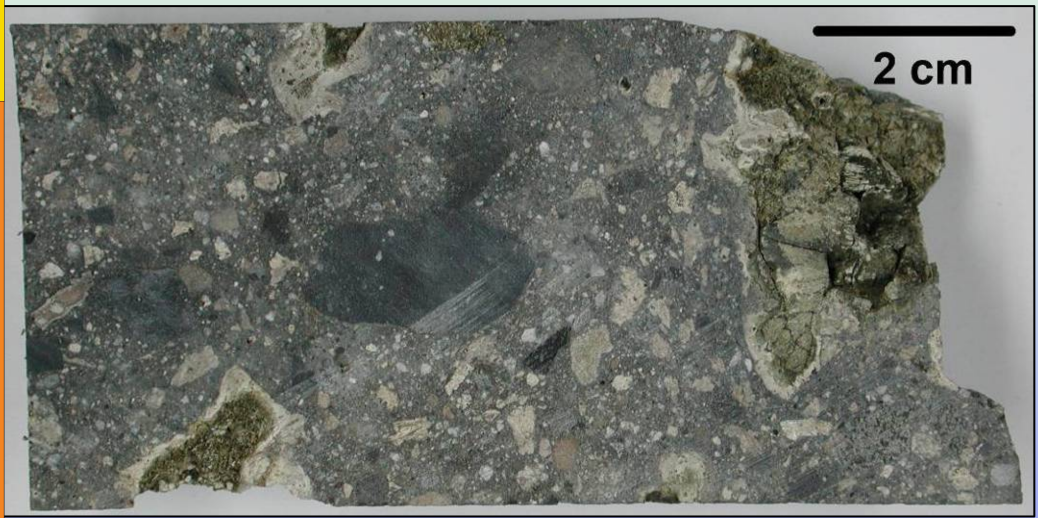
GRANITE

SUEVITE

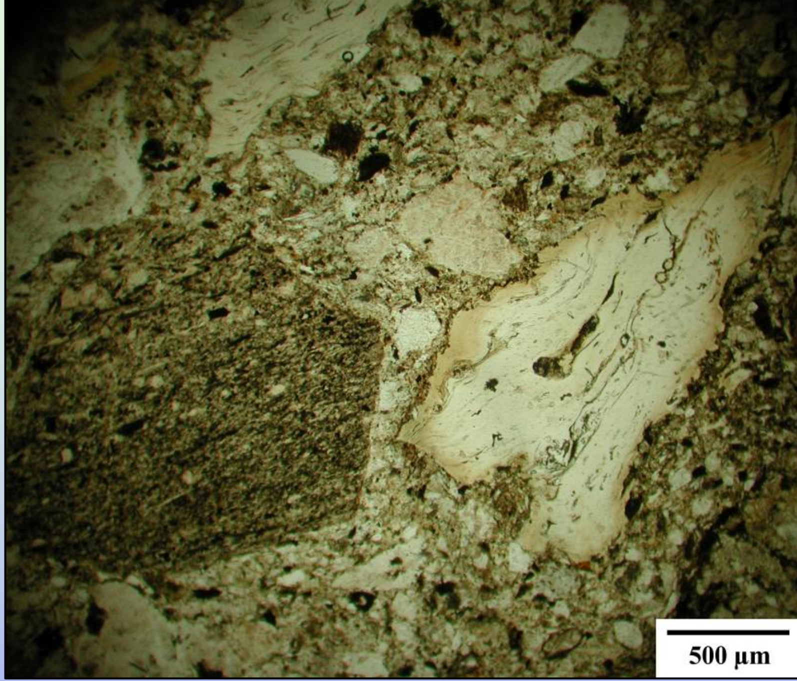
SCHIST AND PEGMATITE

Suevite

1397-1551 m

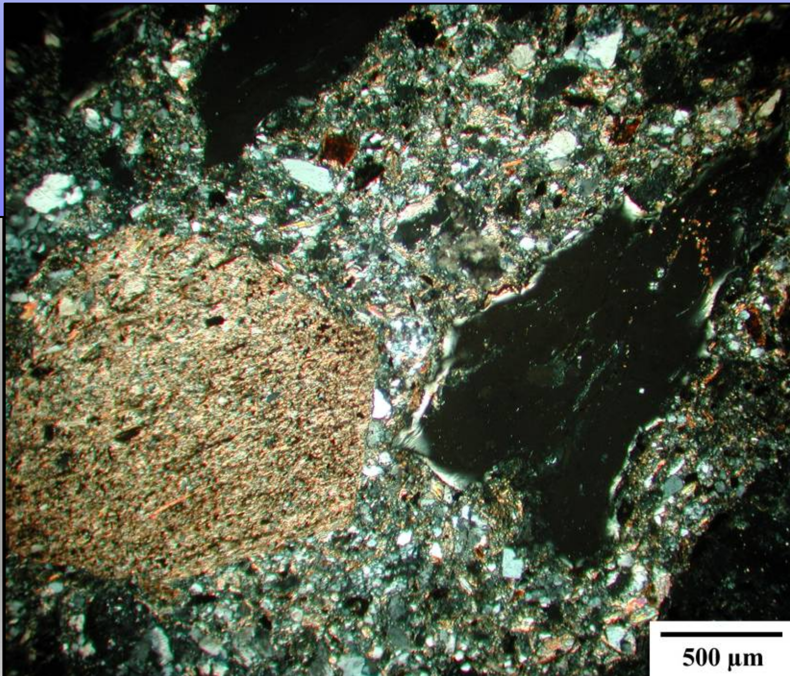


CB6-094 1399.7 m



CB6-098 1418.8 m

CB6-107 1449.8 m



POST-IMPACT

EXMORE BRECCIA

GRANITE

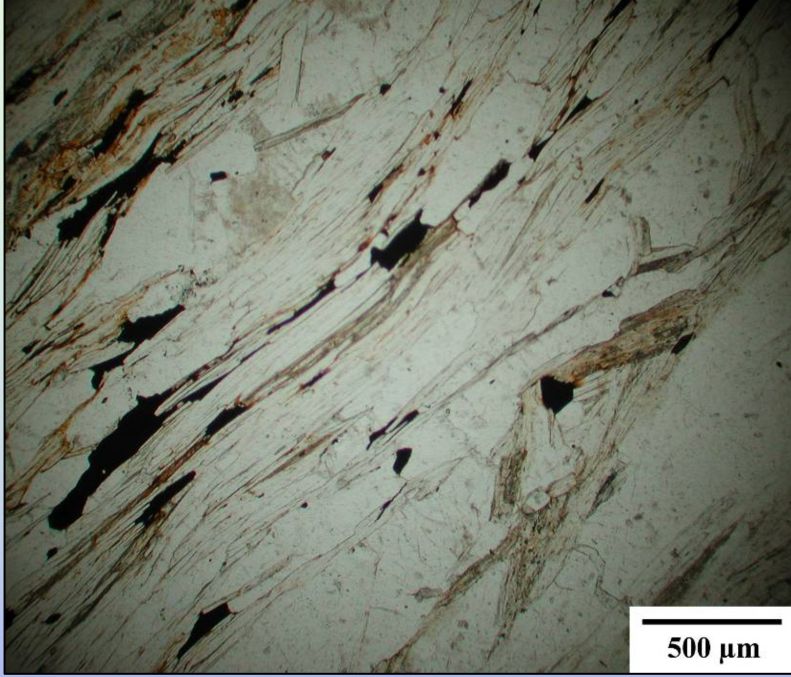
SUEVITE

SCHIST AND PEGMATITE

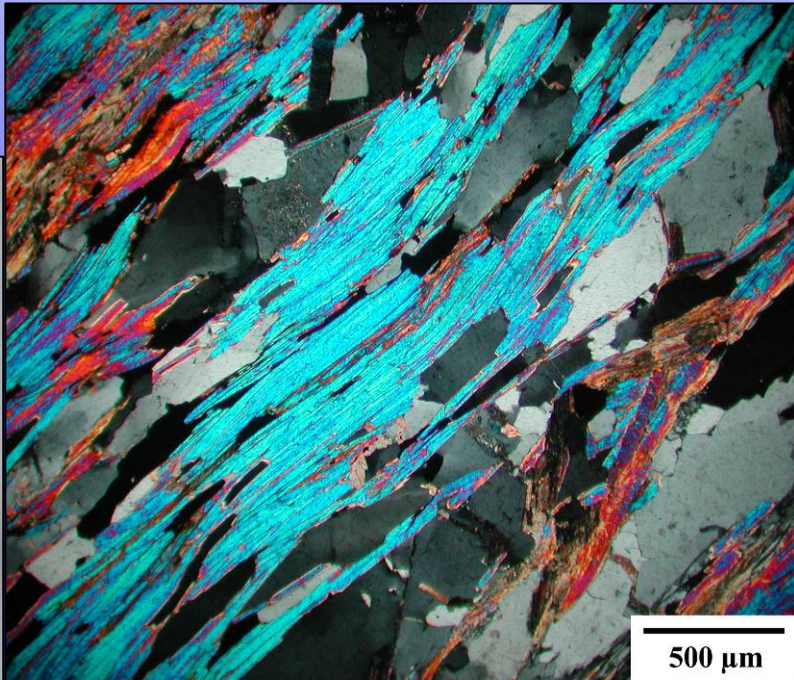
Schist and pegmatite

1551-1766 m

CB6-145 1667.8 m



CB6-141 1627.8 m



CB6-148 1700.2 m

POST-IMPACT
EXMORE BRECCIA
GRANITE
SUEVITE
SCHIST AND PEGMATITE

PETROGRAPHY OF THE IMPACT BRECCIA

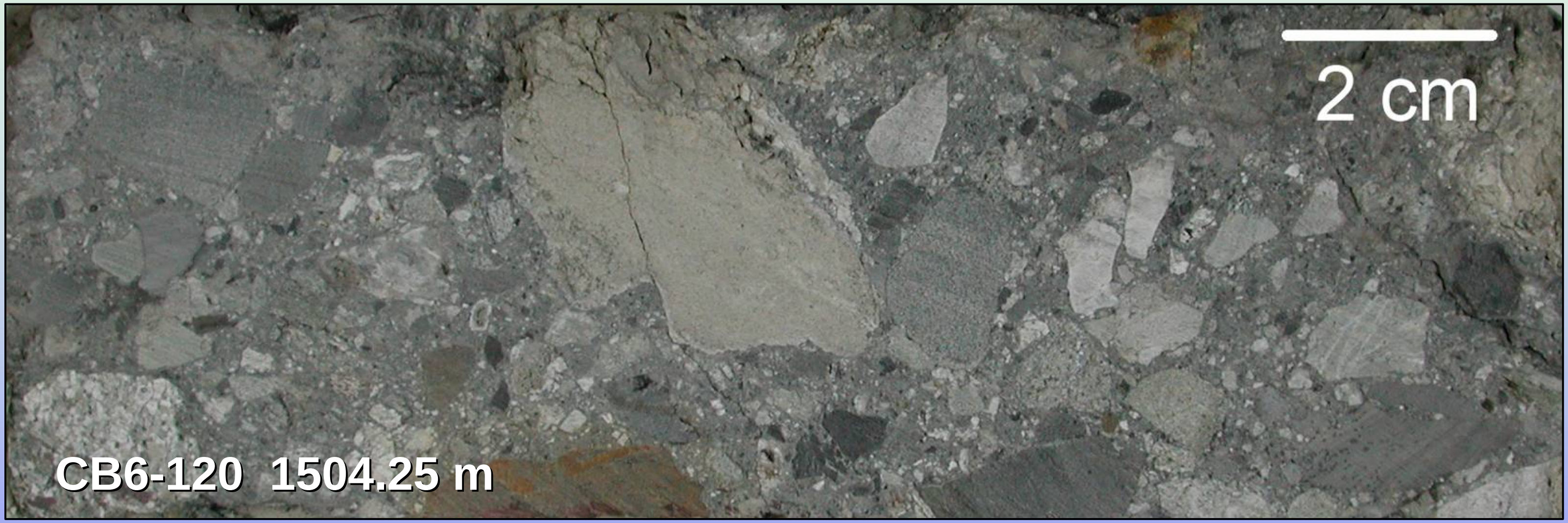
- mostly polymict and suevitic
- two thin layers of impact melt rock (upper part)
- large blocks of cataclastic gneiss (lower part)

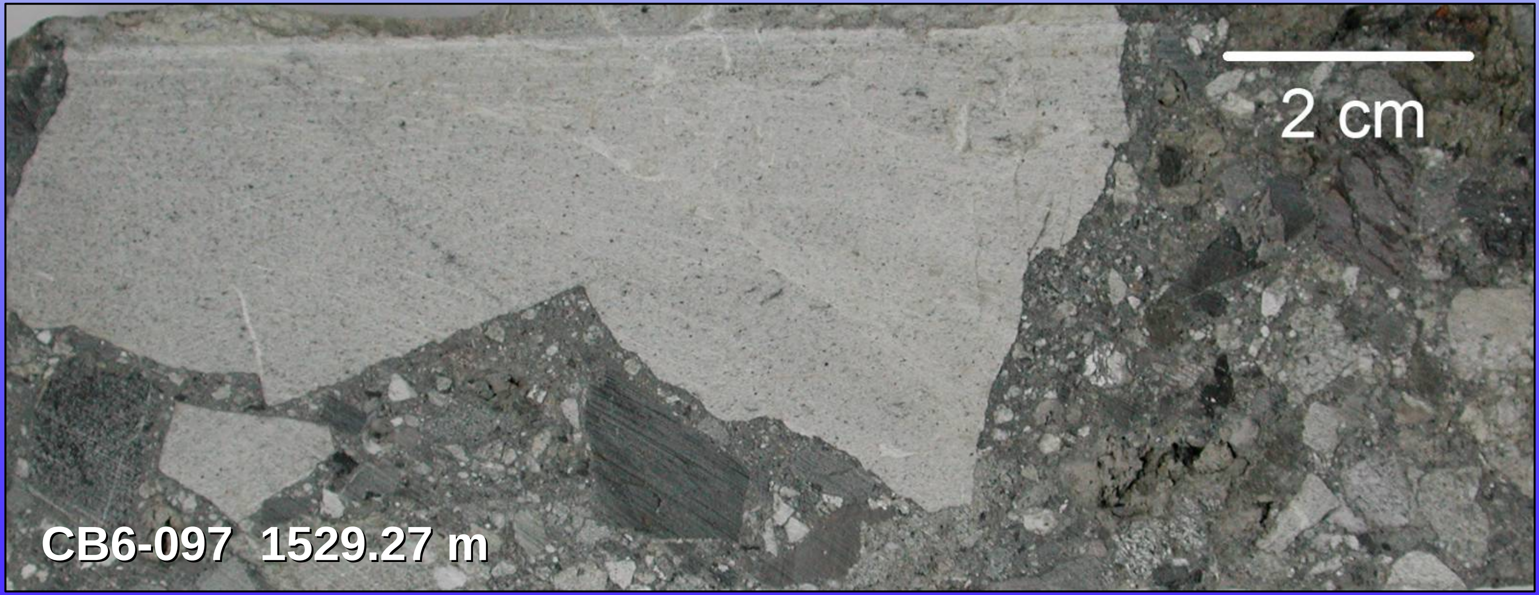
- various types of lithic clasts, generally the clast size increases with depth in the impact breccia section
- minerals present - quartz, K-feldspar, plagioclase, mica, opaque minerals, accessories, secondary minerals
- matrix mostly clastic, grayish, fine-grained

CB6-099 1421.7 m

Melt-rich suevite

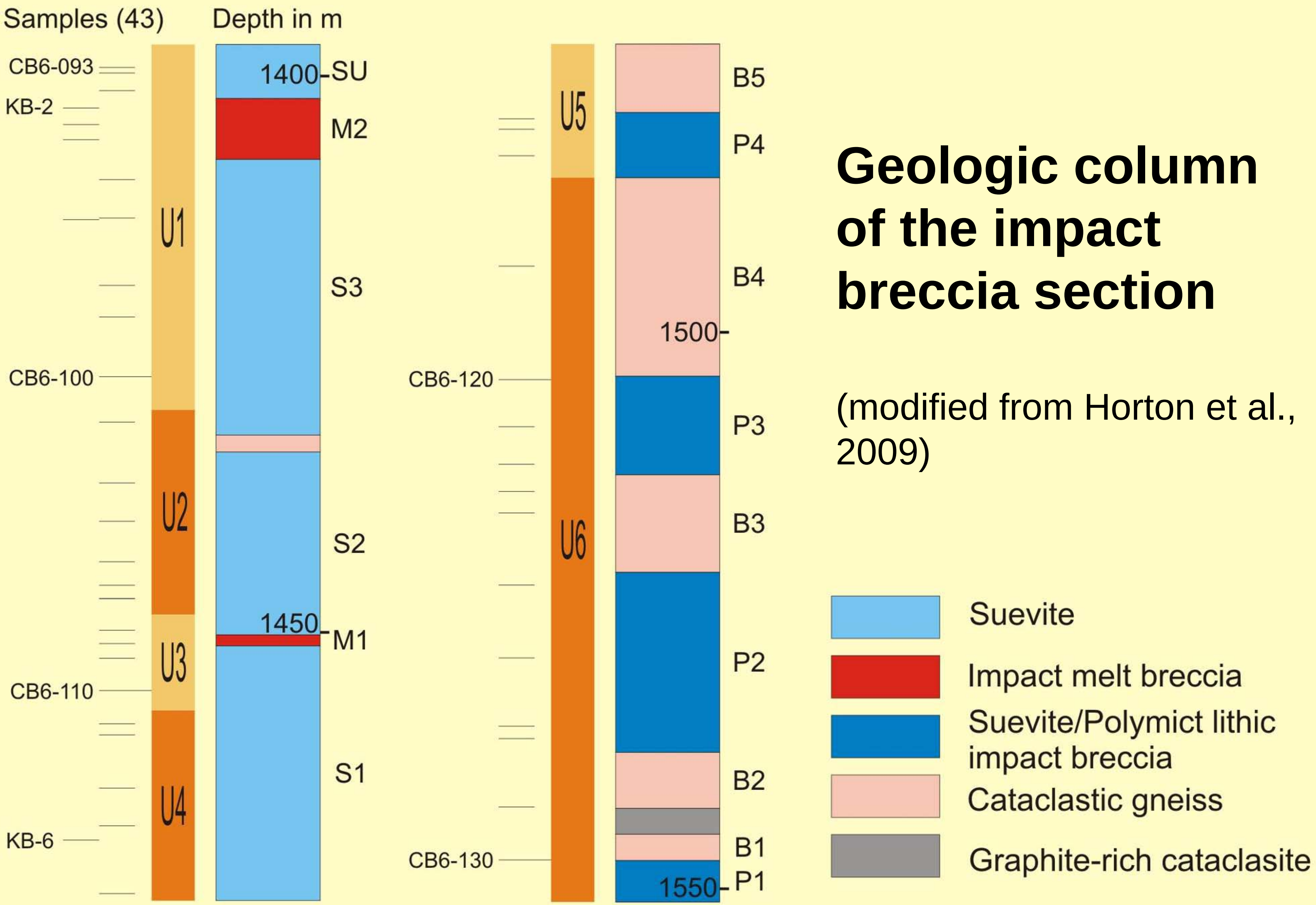
Lithic clast-rich suevite





Geologic column of the impact breccia section

(modified from Horton et al., 2009)



Stratigraphy of the impact breccia section - interpretations

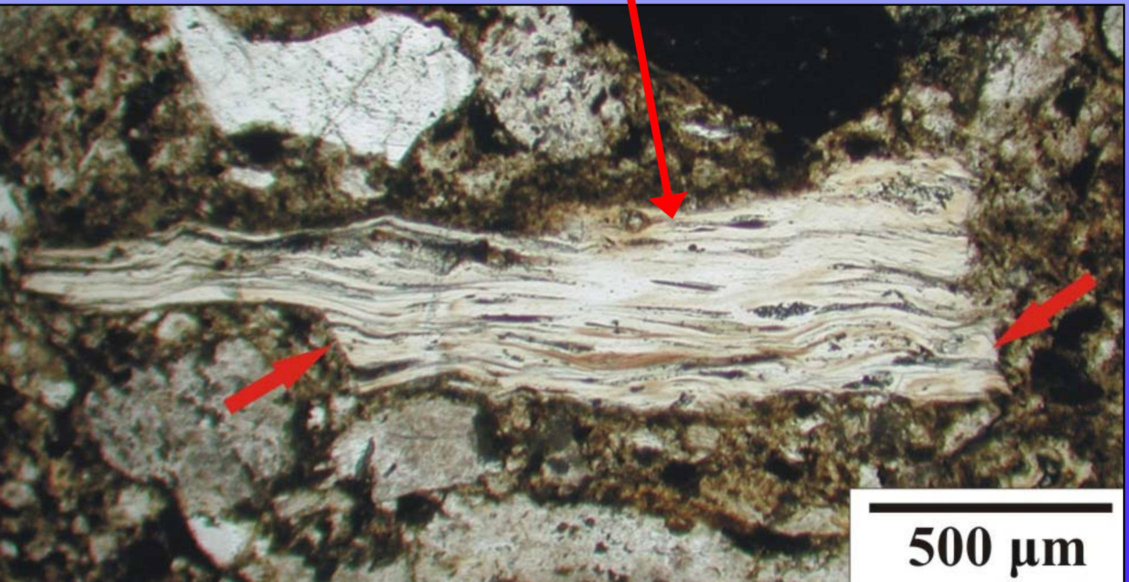
- The subunit U1, above 1430 m - with smallest clasts of all different target lithologies, most abundant matrix and abundant melt particles - represents fallback material.
- Melt-poor, crystalline clast rich subunit (U2) might represent ground-surge material or material slumped from the central uplift or transient crater margin.
- Subunit U3, which contains abundant melt particles, probably represents fallback material
- Subunit U4 may be a mixture of ground-surge and fallback material.
- The lowermost part of the impact breccia section (subunits U5 and U6, below 1474 m) - with large clasts, large blocks of cataclastic gneiss, relatively melt-poor - represent ground-surge material.

MELT PARTICLES

- millimeter- to centimeter-sized (up to 5 cm)
- frequently ovoid to amoeboid in shape
- mostly altered
- often with flow structures
- some are shard-like

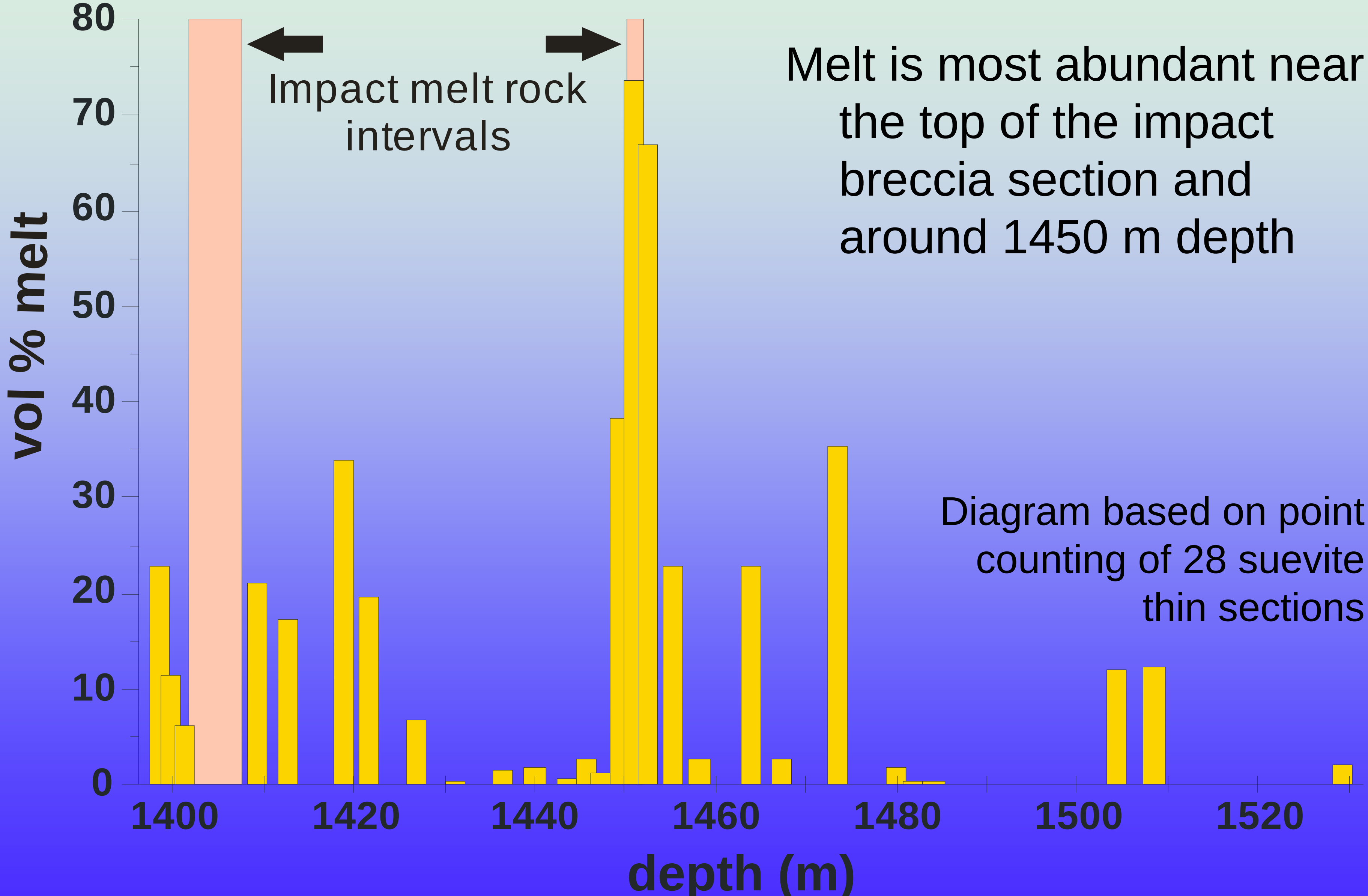
(in the upper part of the impact breccia section)

~ 1413.0 m



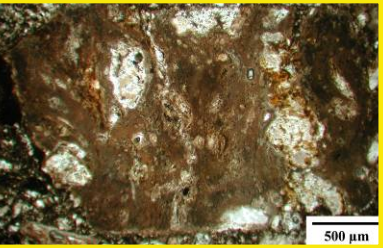
CB6-098
1418.8 m

Melt distribution

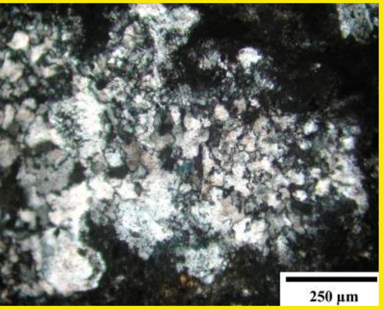


Melt types

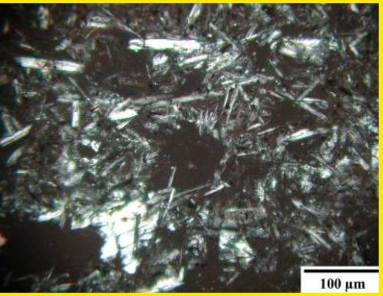
1) clear, brownish, or greenish, unaltered glass with high silica content



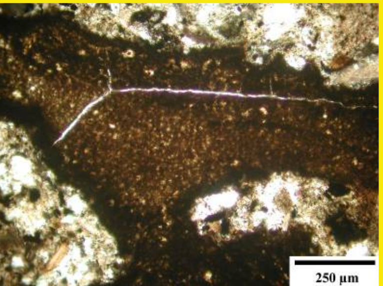
2) brown melt, entirely altered to fine-grained phyllosilicate minerals



3) recrystallized silica melt



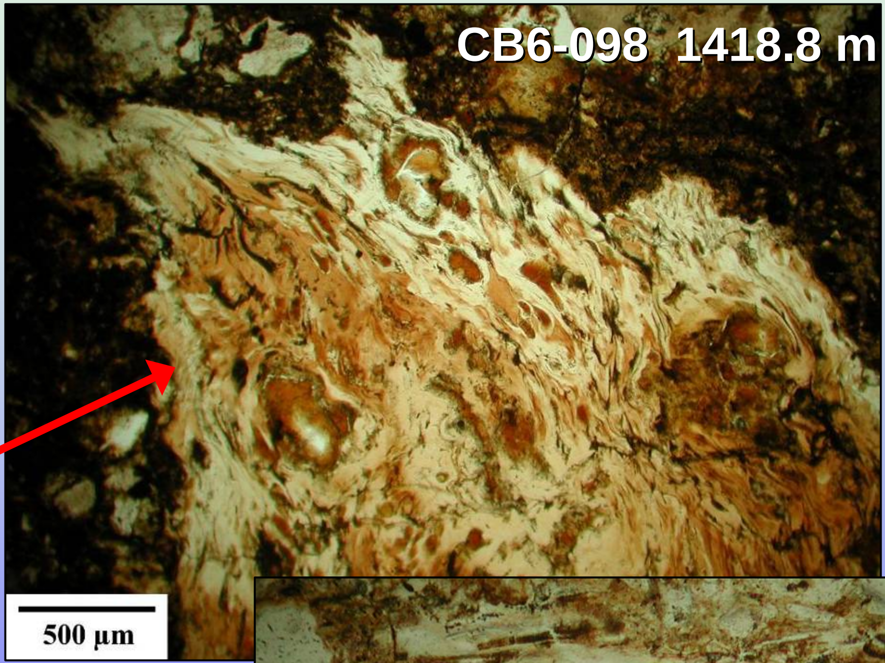
4) melt with feldspar and/or pyroxene microlites, with intersertal or microporphyritic texture

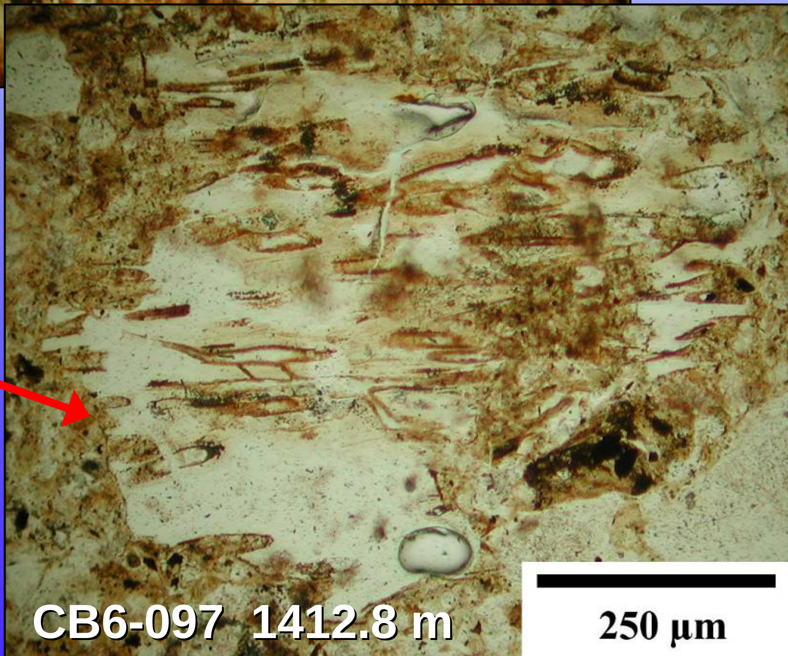


5) dark brown melt

Melt type 1 (occurrence: 1399.2-1452.3 m)

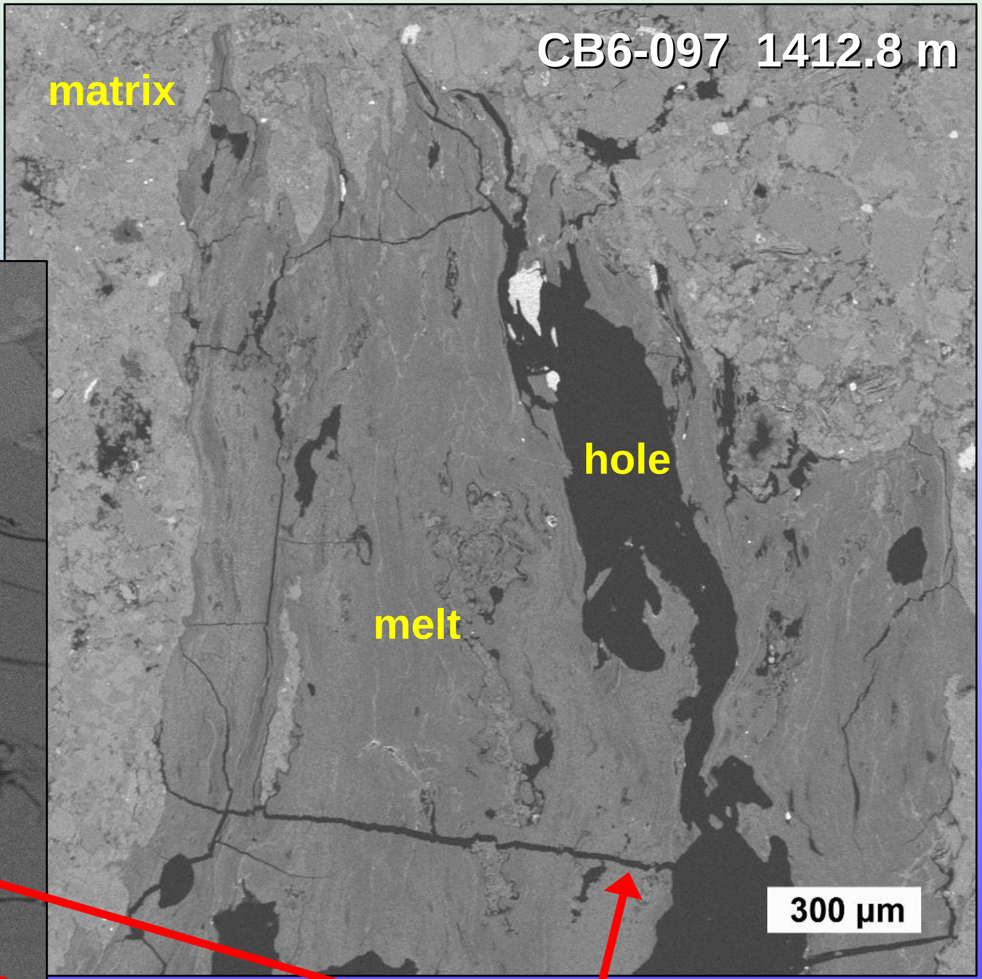
- clear, brownish or greenish glass
- only slightly altered
- often with flow texture
- amoeboid, some flame-shaped structures
- some shard-like with sharp contacts with the matrix
- rarely undigested grains or vesicles

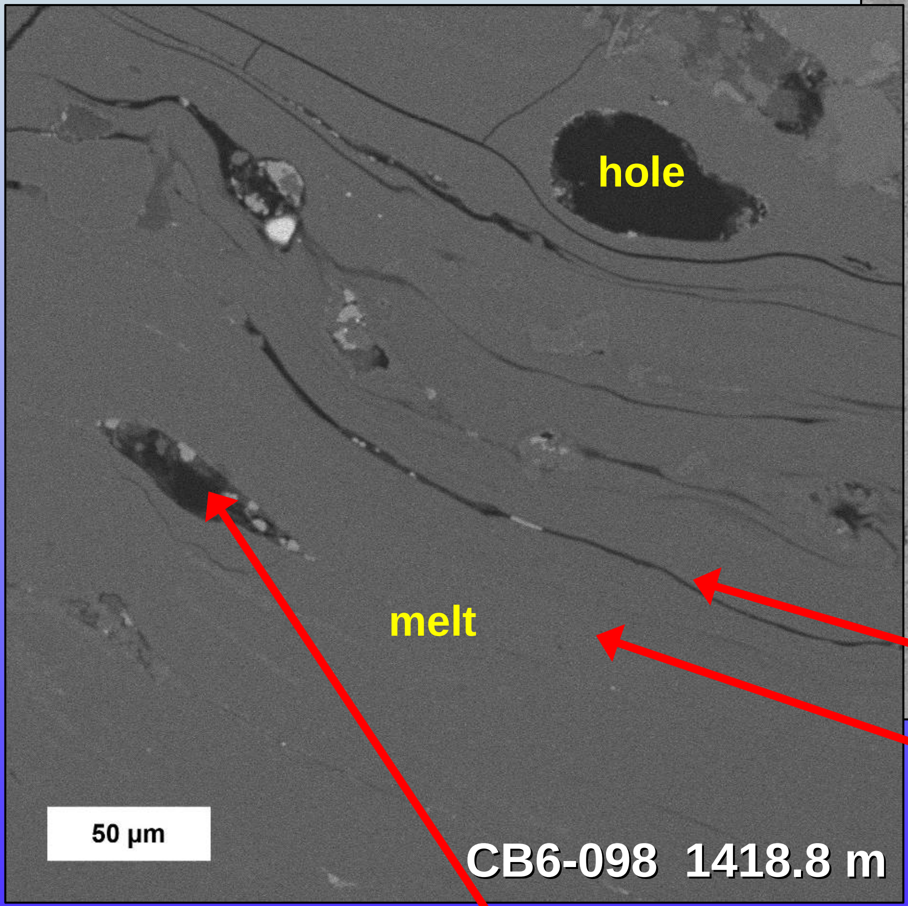




Melt type 1

back-scattered
electron images

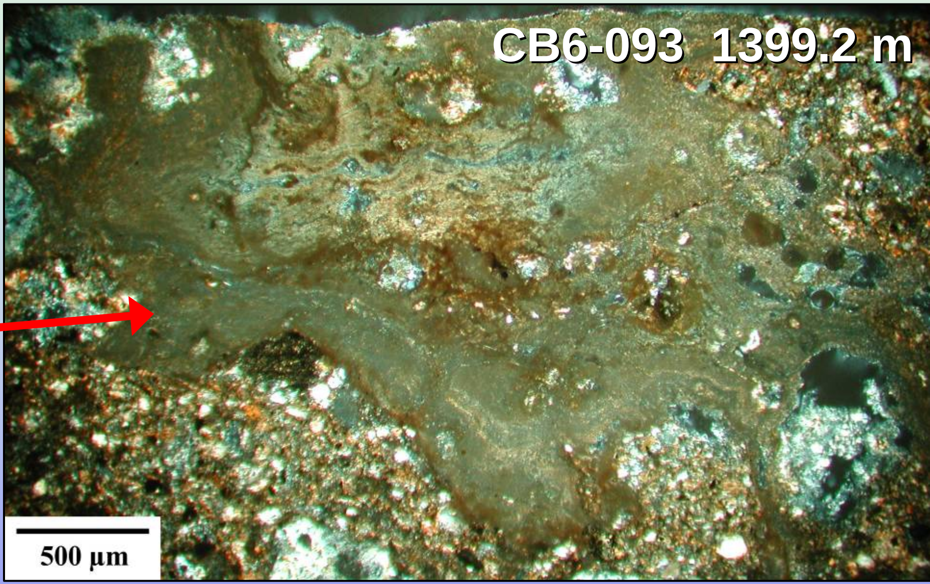


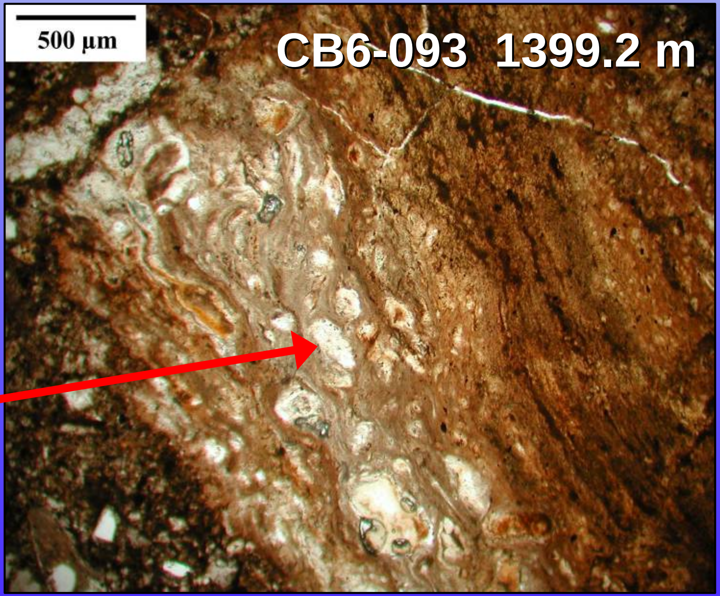


fluidal texture, cracks, some filled
with secondary minerals

Melt type 2 (occurrence: 1399.2-1508.5 m)

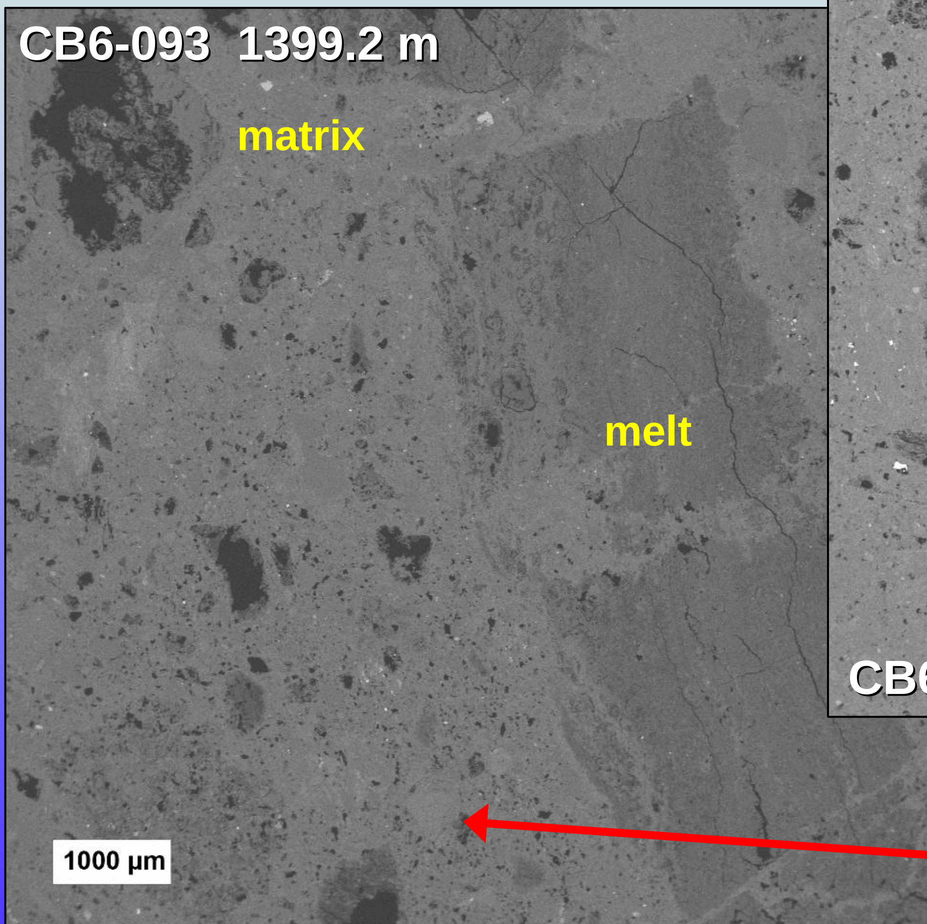
- altered melt
- most abundant melt type
- ovoid to amoeboid
- completely altered to fine-grained phyllosilicates, e.g., smectite
- commonly fluidal texture, many cracks
- commonly with undigested grains (mostly quartz)

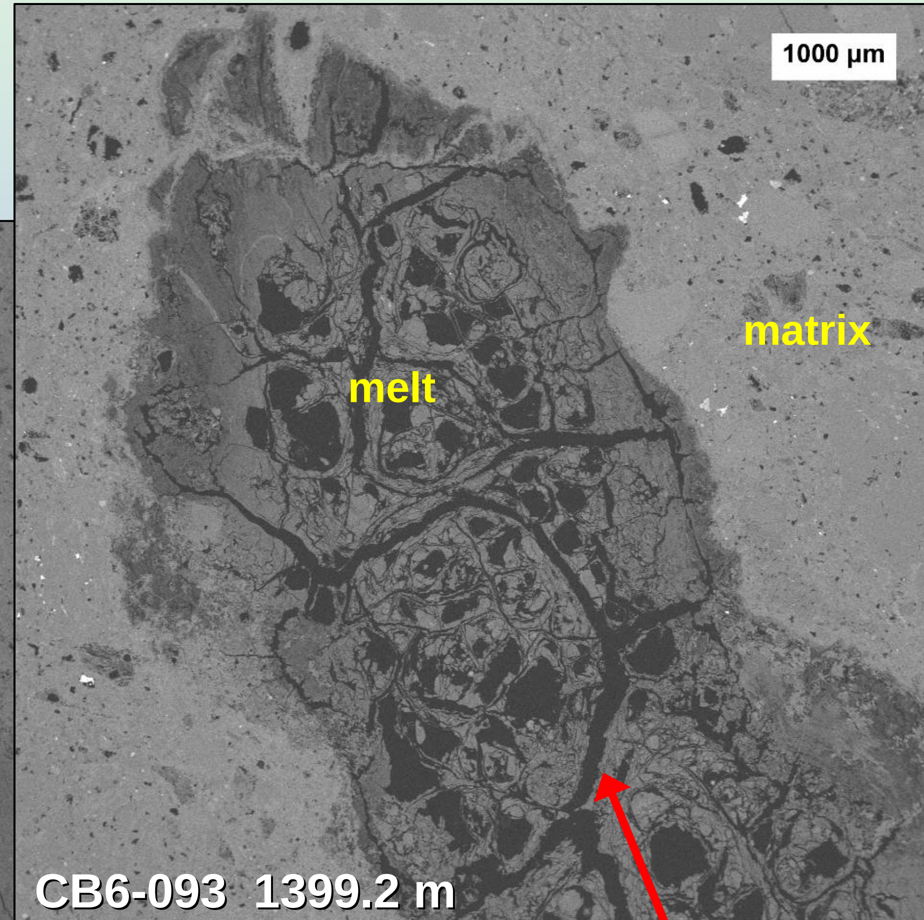




Melt type 2

back-scattered
electron images

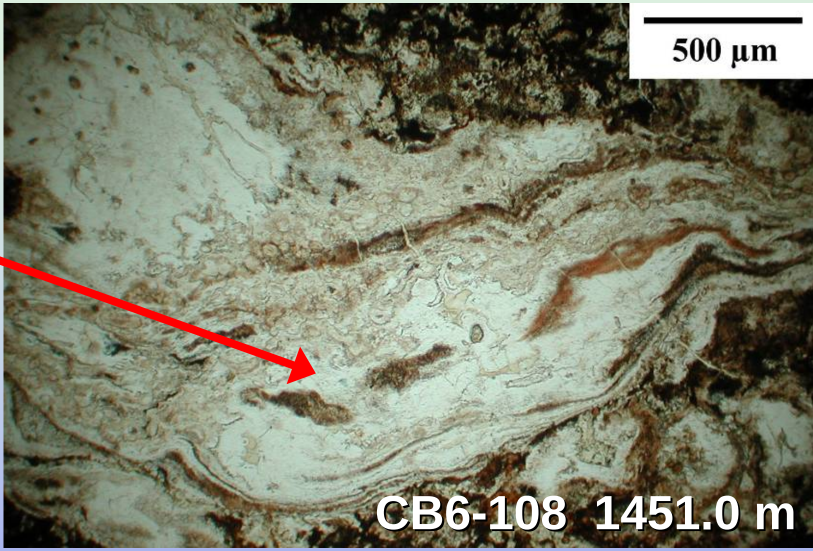


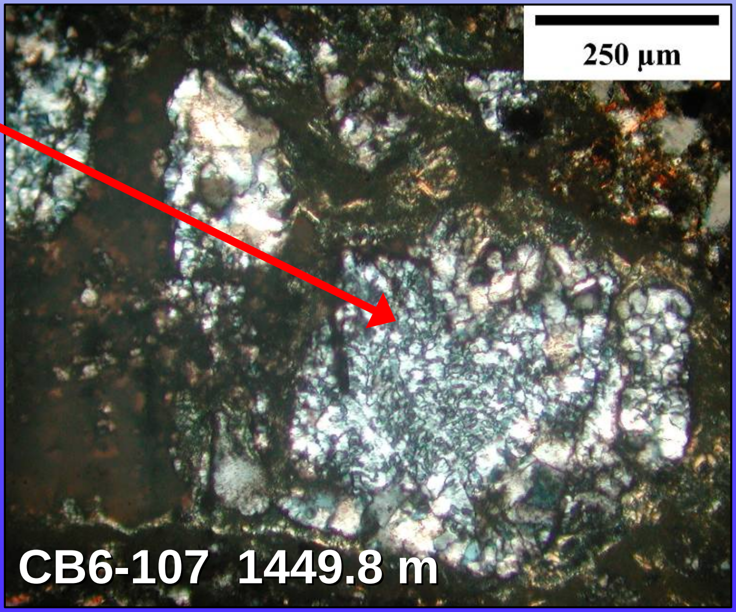


altered, with cracks,
undigested grains

Melt type 3 (occurrence: 1399.7-1452.3 m)

- recrystallized silica melt
- colorless, some brownish patches
- amoeboid, globules, some preserve shapes of the original clasts
- some have a cherty texture
- in melt rich intervals can be recrystallized to ballen quartz
- probably melted clasts of quartz and quartz-rich rocks



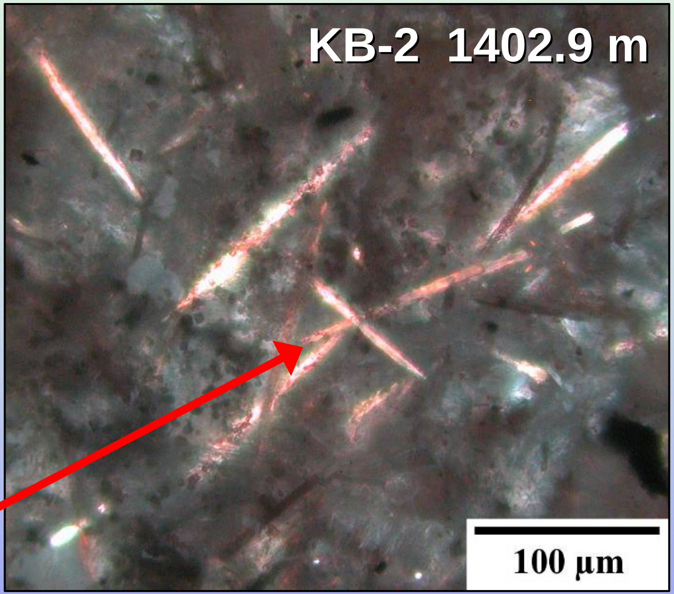


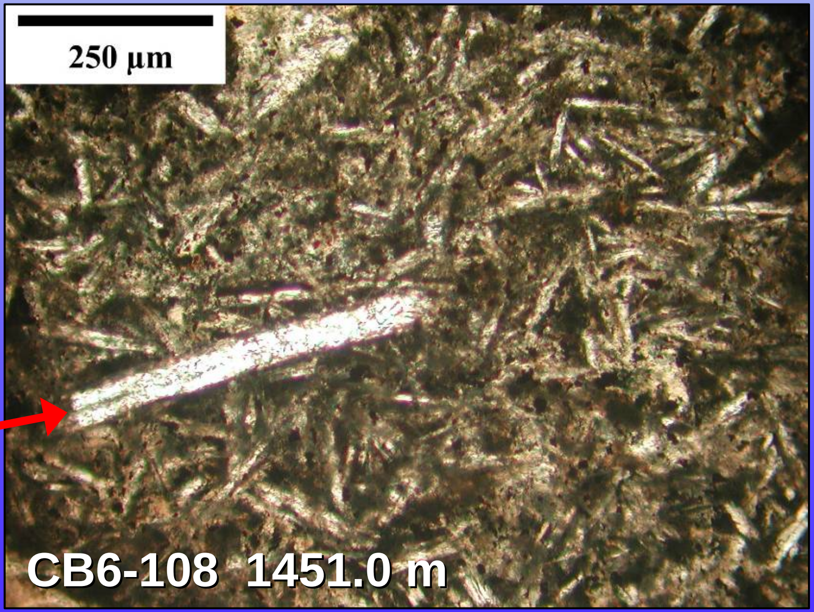
Melt type 4 (occurrence: 1402.9 - 1455.2 m)

- melt with intersertal or microporphyritic texture
- forms matrix in impact melt rock intervals or rare single particles
- irregular shapes
- tiny crystallites of pyroxene

  (Al-rich pyroxenes)

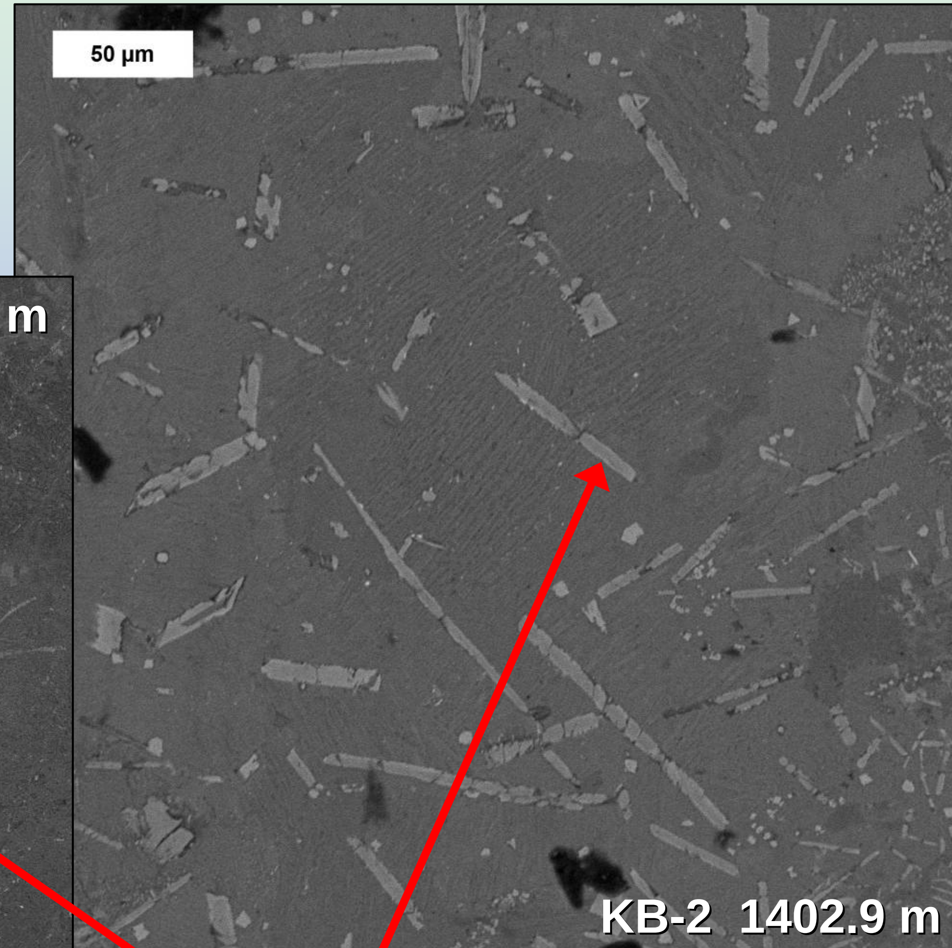
  or plagioclase (labradorite)

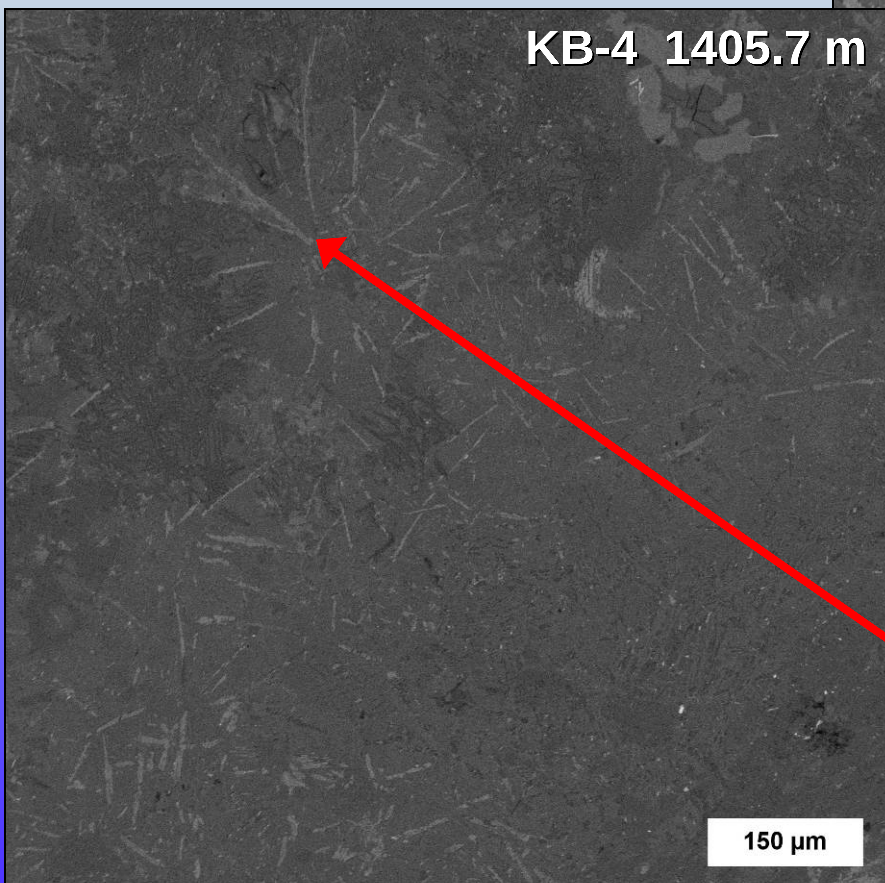




Melt type 4

back-scattered
electron images

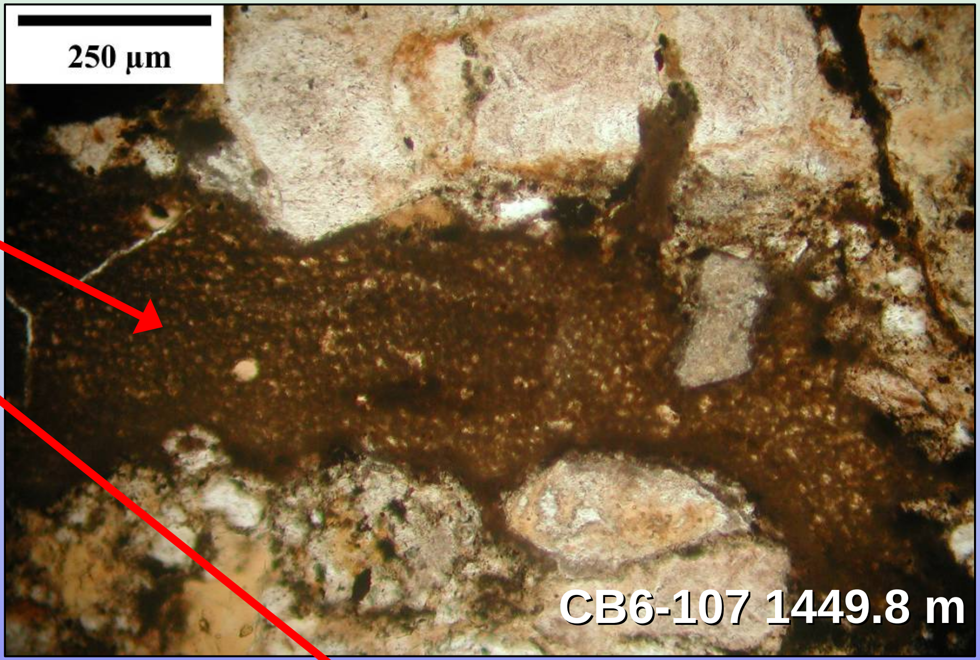


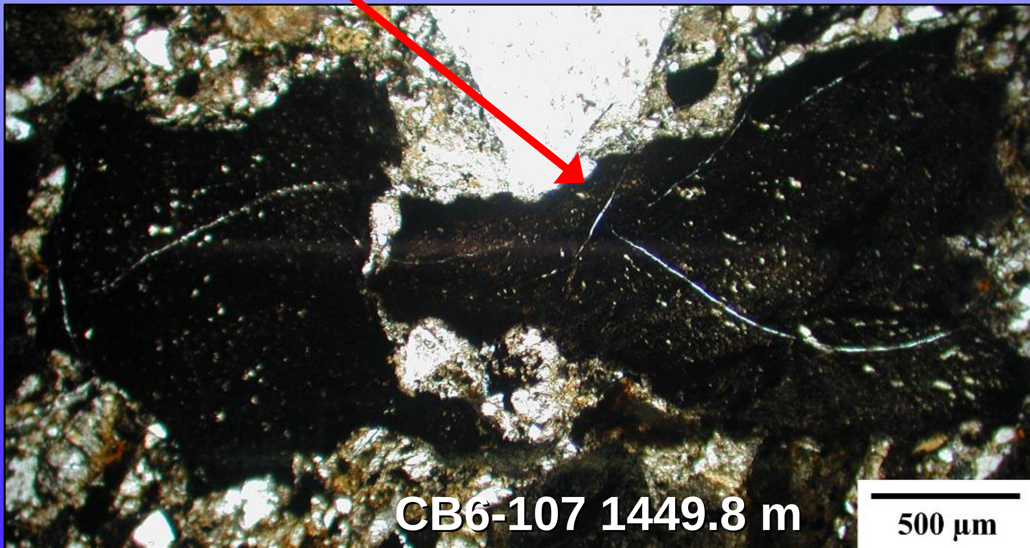


impact melt with
pyroxene crystallites

Type 5 (occurrence: 1443.7-1535.4 m)

- dark brown melt
- oval to amoeboid in shape
- possibly melt of shale or a fine-grained sediment
- altered
- commonly small undigested grains (mostly quartz)





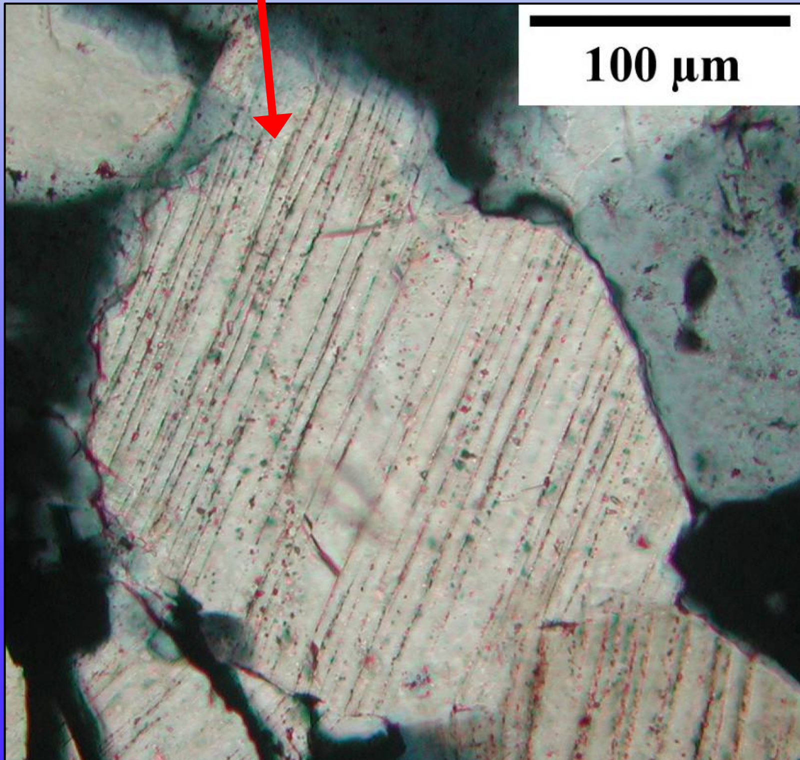
Melt particles

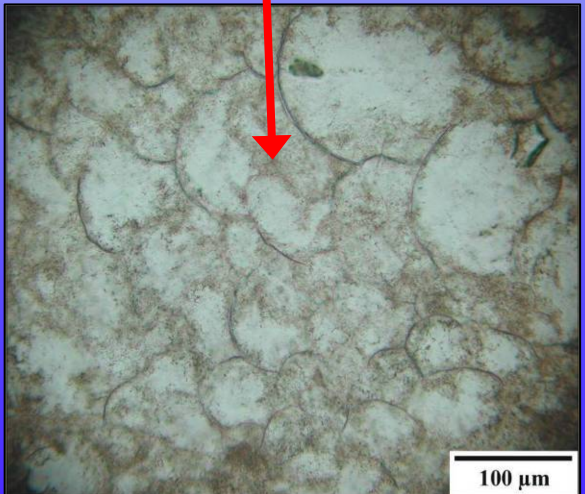
- Generally the melt is more abundant in the upper part of the impact breccia
- Most abundant melt can be found around 1405 and 1450 m depth, where the suevite grades into impact melt rock
- We have distinguished five different types of melt particles
- The melt types have different appearance, and somewhat different but overlapping chemical composition and depth of occurrence
- Most of the melt particles are altered to secondary minerals, such as phyllosilicate minerals; only slightly altered melt particles are relatively rare (occur only in the upper part)

SHOCK AND RELATED EFFECTS

- Planar fractures (PFs) in quartz
  - 1>>2 sets
- Planar deformation features (PDFs) in quartz - 1, 2, rarely more sets per grain
- toasted appearance of quartz
- ballen quartz
- rare PDFs in feldspar
- kink banding in mica

CB6-100
1427.0 m



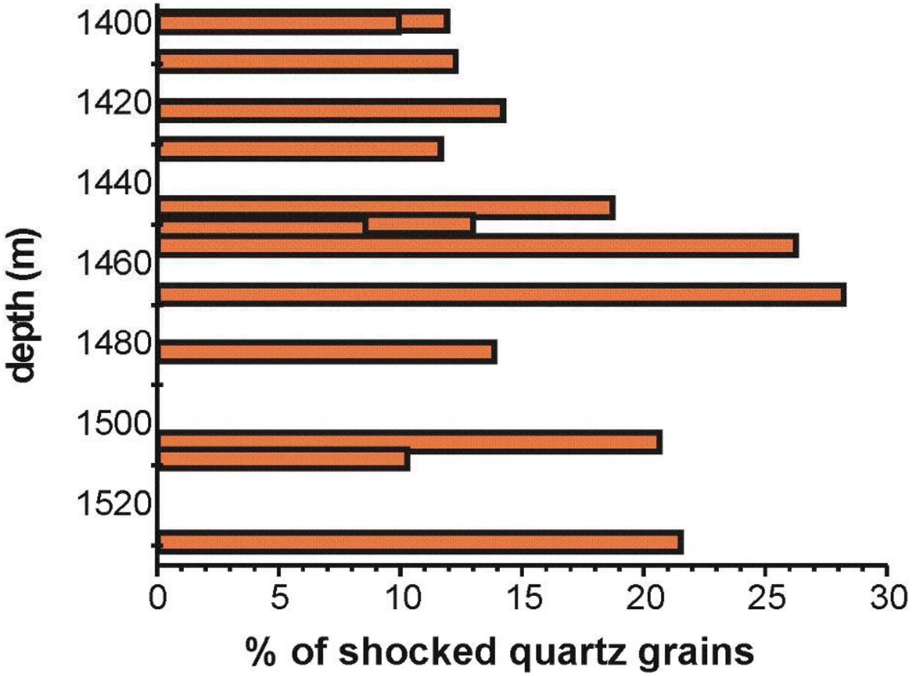


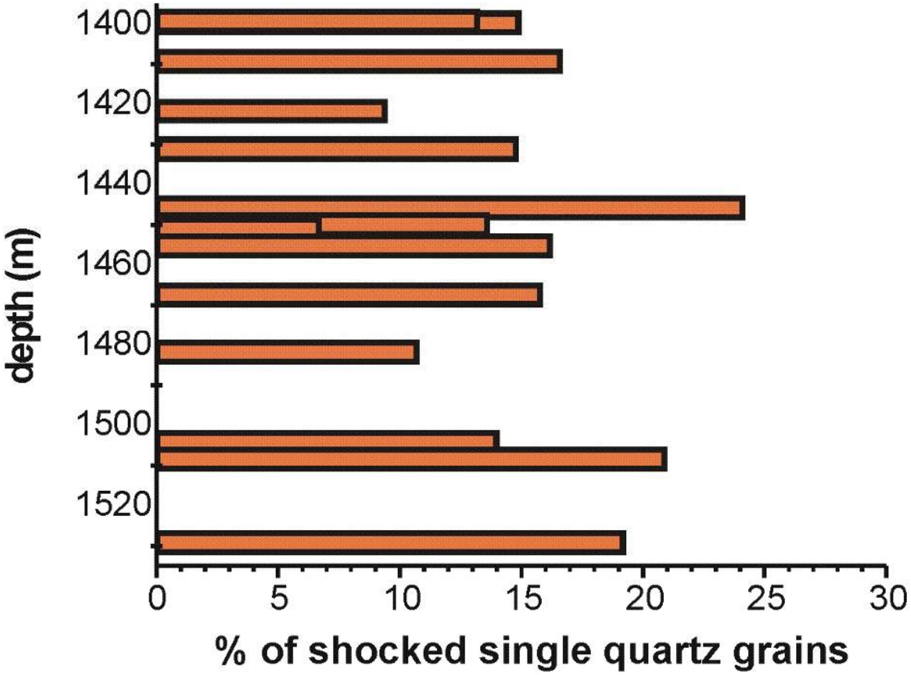
KB-4
1405.7 m

Proportion of shocked quartz grains

(grains with PFs and/or PDFs)

Based on thin section point counting

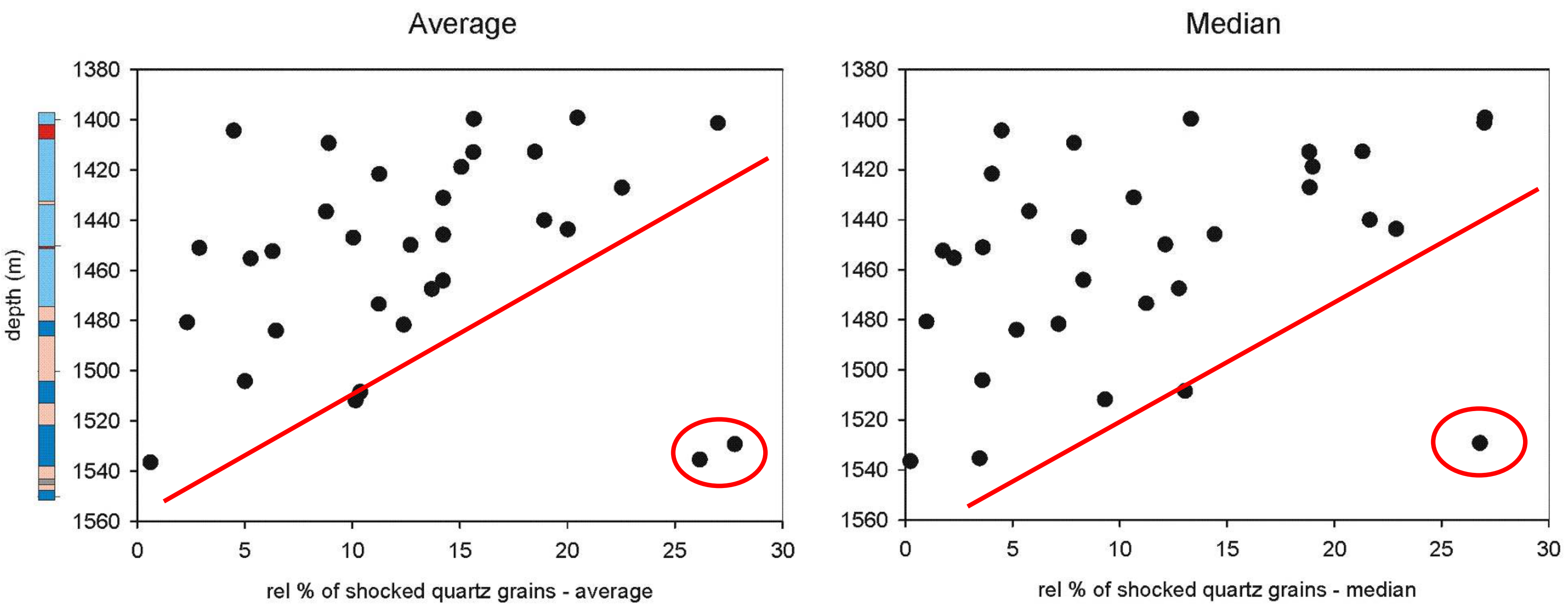


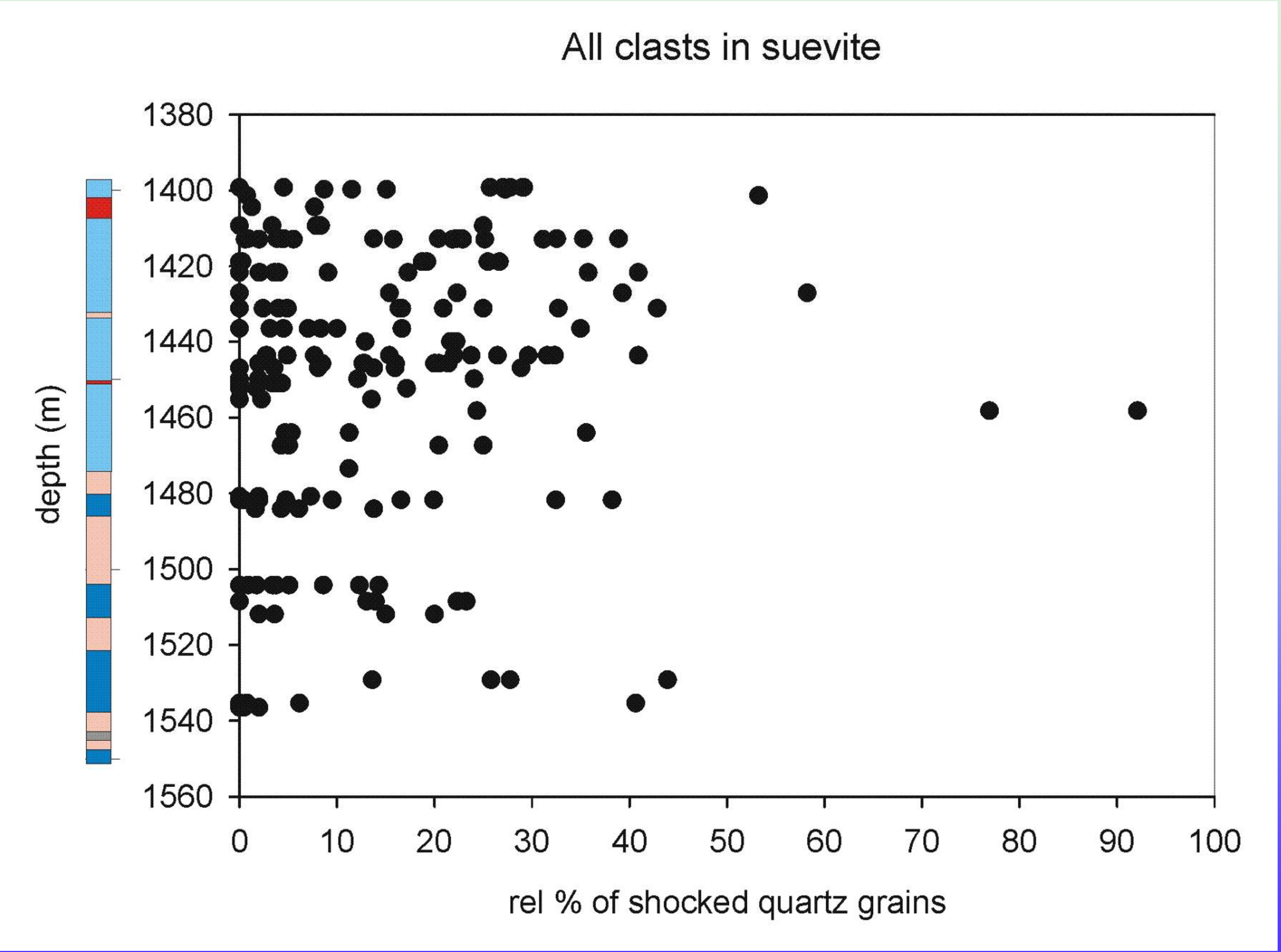


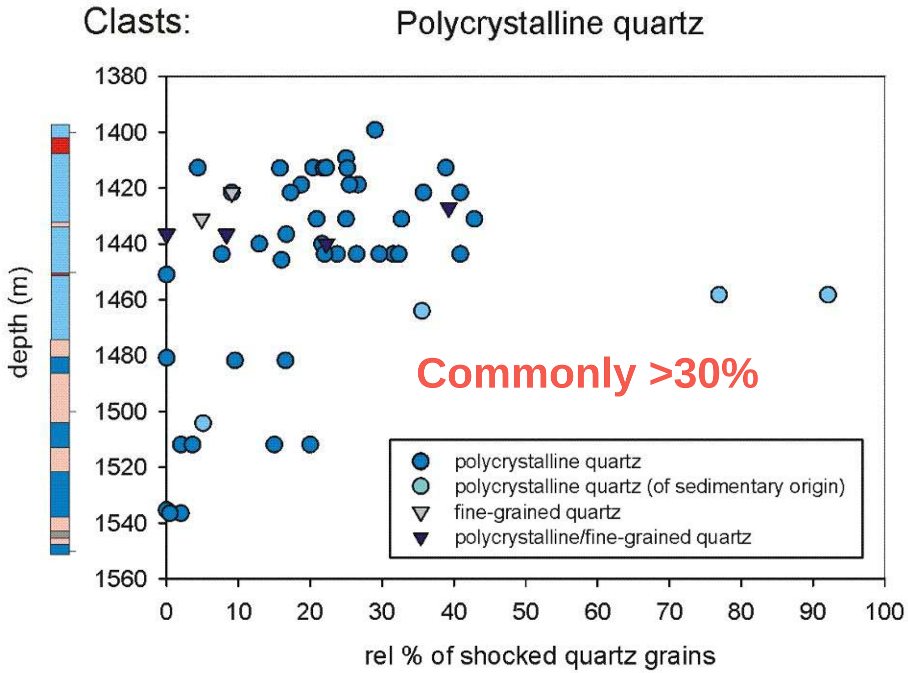
No trend with depth

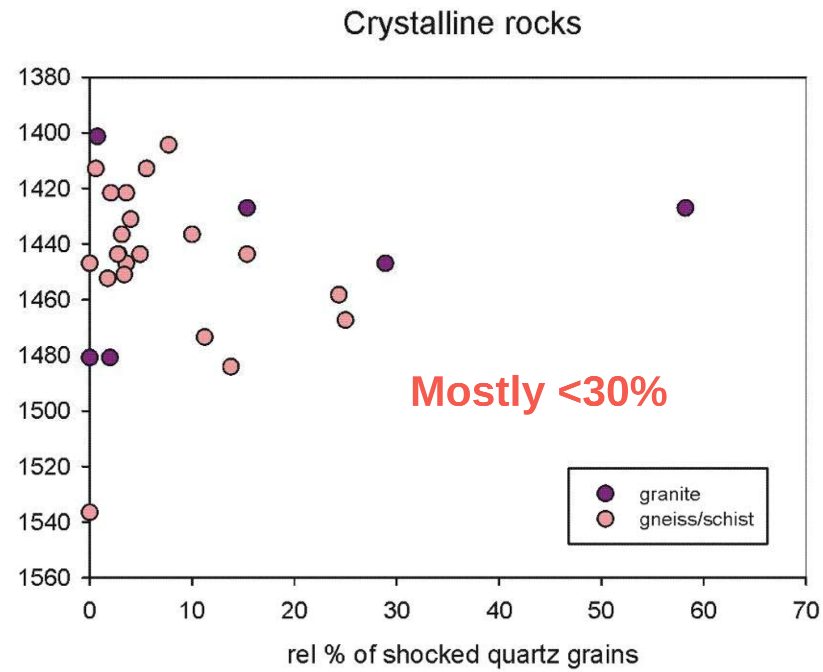
Percentage of shocked quartz grains in clasts

- There is no linear trend
- Generally the abundance of highly shocked clasts decreases with increasing depth
- Some exceptions

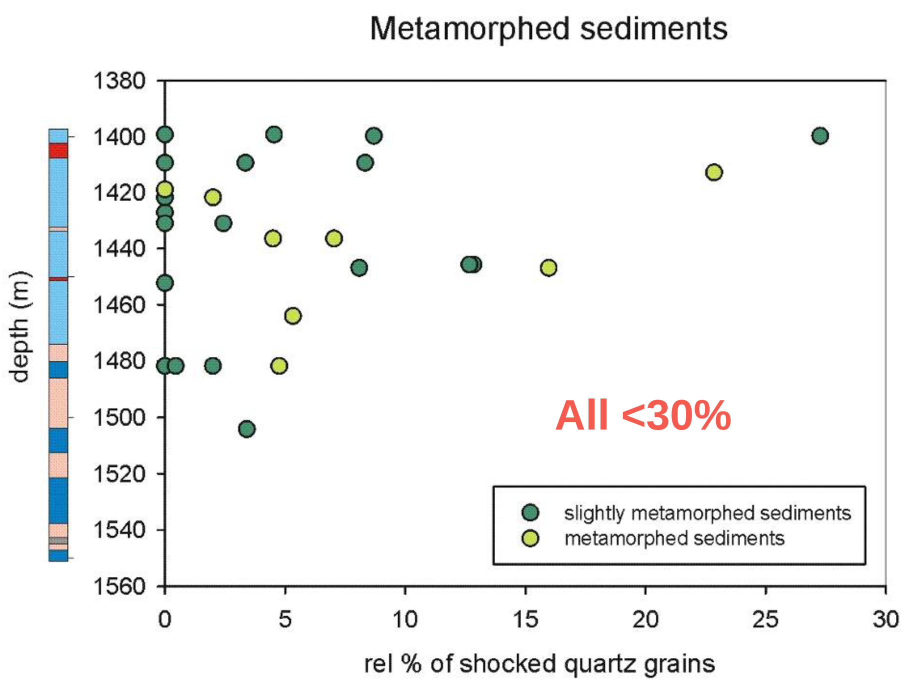


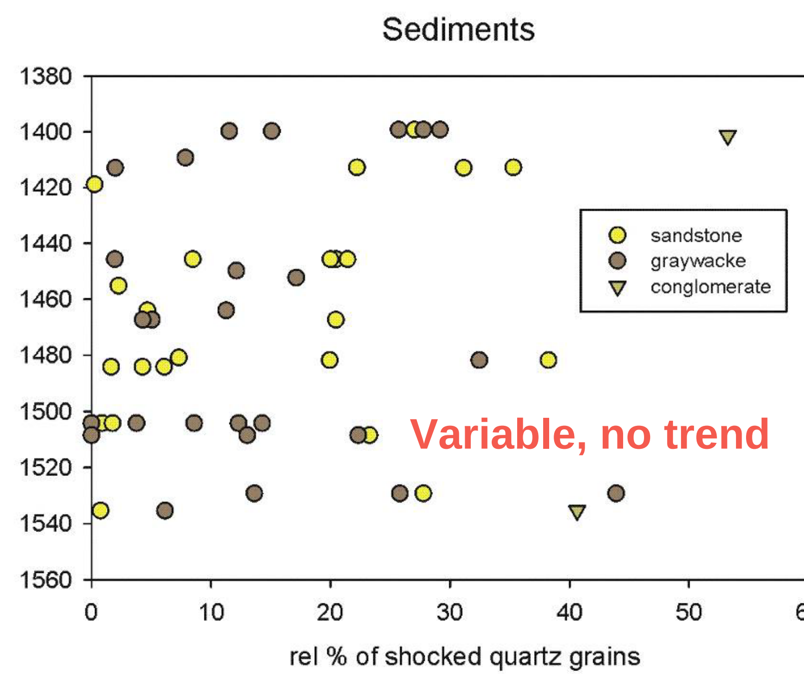

All clasts in suevite
depth (m)
1380
1400
1420
1440
1460
1480
1500
1520
1540
1560
0
10
20
30
40
50
60
70
80
90
100
rel % of shocked quartz grains





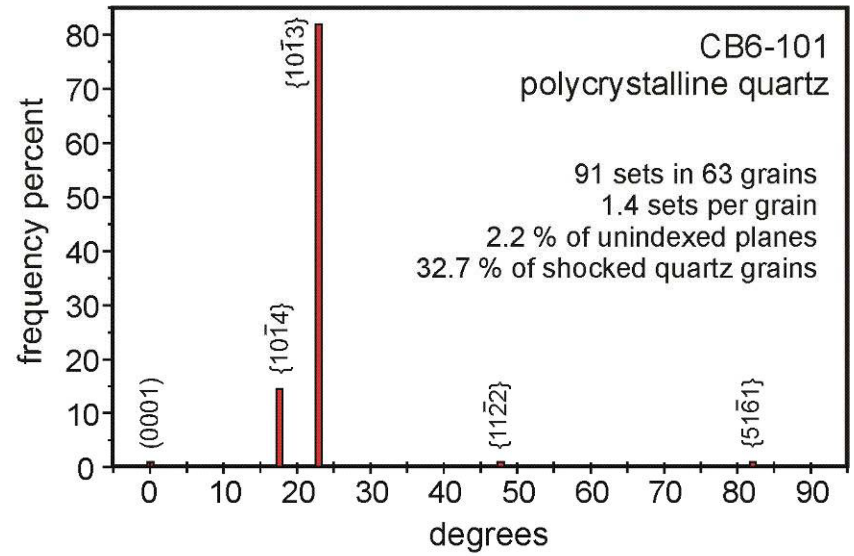
Note the different horizontal scales!

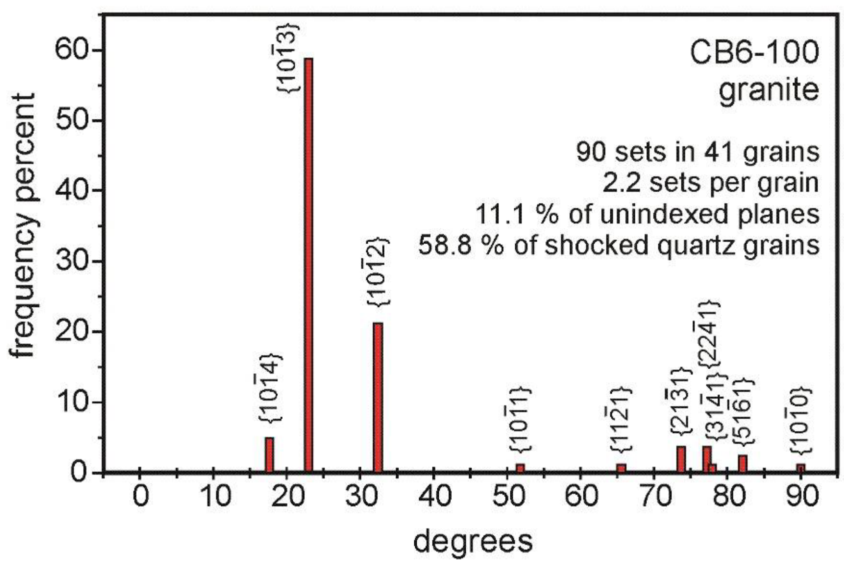


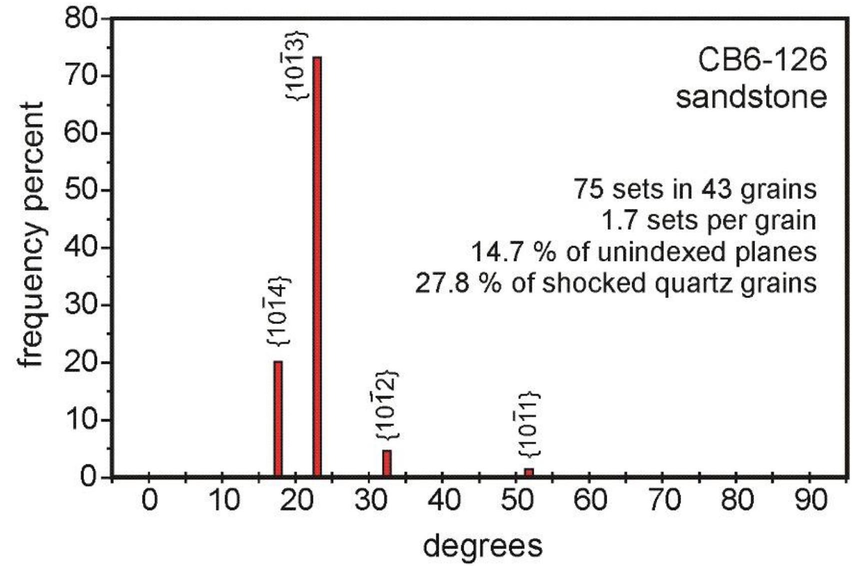


U-stage

PDF orientations:
Most abundant: $\{10\bar{1}3\}$
Some: $\{10\bar{1}2\}$
Also: $\{10\bar{1}4\}$
Rare other orientations







Shock metamorphism

- The suevite shows a variety of shock metamorphic effects, including abundant PDFs.
- On average, about 16 rel% of all the quartz grains are shocked (show PFs and/or PDFs) in the suevite.
- No trend in proportion of shocked quartz grains with depth was found.
- Presence of highly shocked as well as unshocked material implies mixing of the different target rocks, previously shocked at different pressures according to their original positions.
- The presence of impact melt rocks indicates that at least some target rocks experienced pressures of >60 GPa and temperatures >1500 °C.

Shock metamorphism - clasts

- Clasts with higher proportion of shocked quartz grains (sqg) become generally less abundant with depth.
- Clasts derived from the upper part of the target (i.e., the pre-impact sediments) show a wide range of proportions of sqg, but include many clasts with higher proportion of sqg.
- The clasts of polycrystalline quartz are mostly highly shocked.
- Clasts derived from the deeper part of the target (i.e., the crystalline basement and metamorphed sediments) show mostly lower proportions of sqg.
- This is in agreement with attenuation of the shock wave with depth.
- The PDF orientations imply that the investigated clasts were moderately shocked, probably at 10–20 GPa

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Thank you for your attention