Fractures around stopes in the Wits and BIC

Gerrie van Aswegen and Marius Stander

Fractures around stopes

- Extension fractures in the stress field
  - Fossils of the stress field
- Morphology of extension fractures
  - Hackles (plumose features)
  - More fossils of the stress field
- Shear zones and extension fractures
  - Internal structure of a brittle shear zone as a function of the stress field
- The story of the T1,T2 and T3 extension fractures

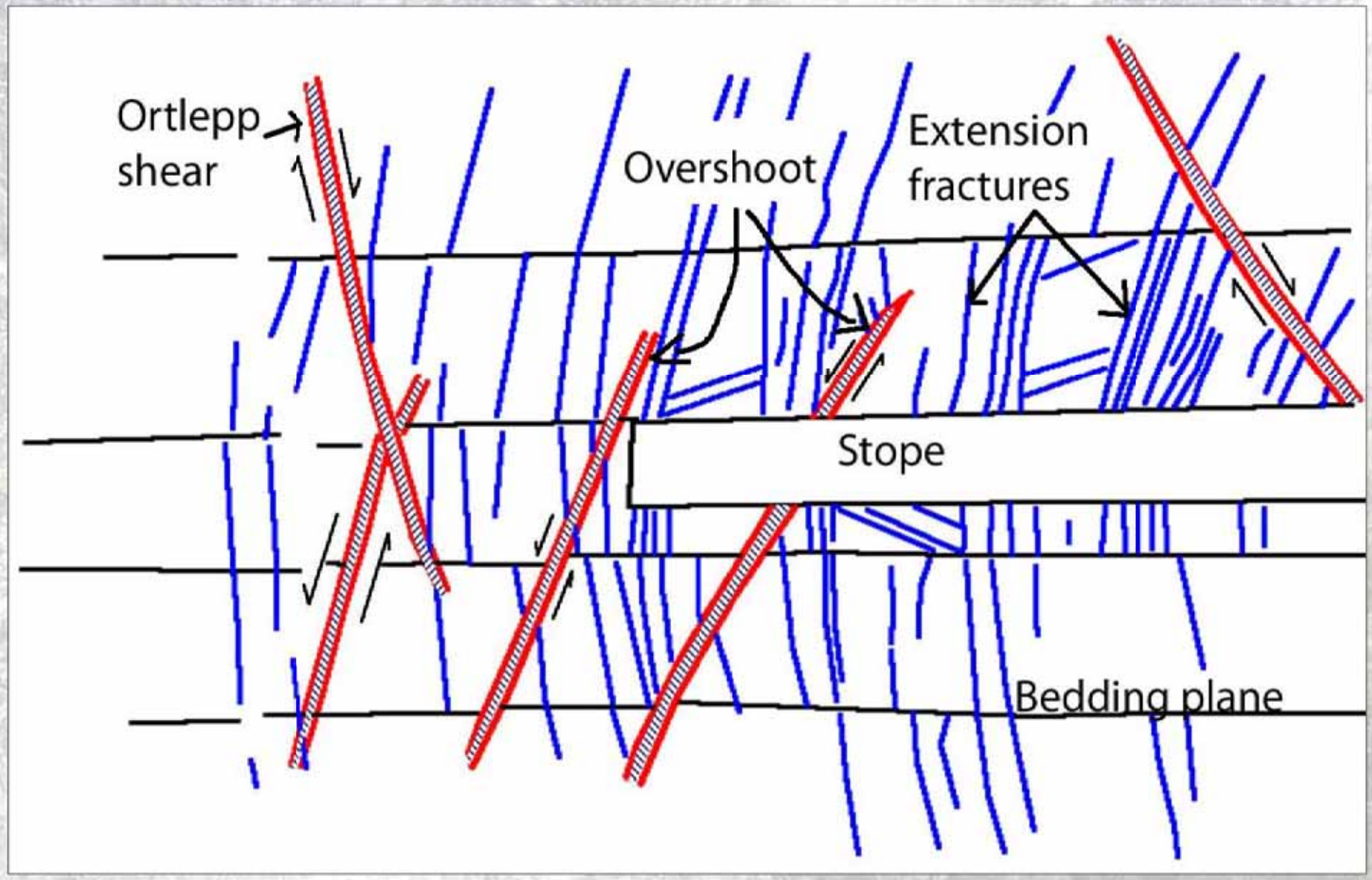
What is this?

The setting

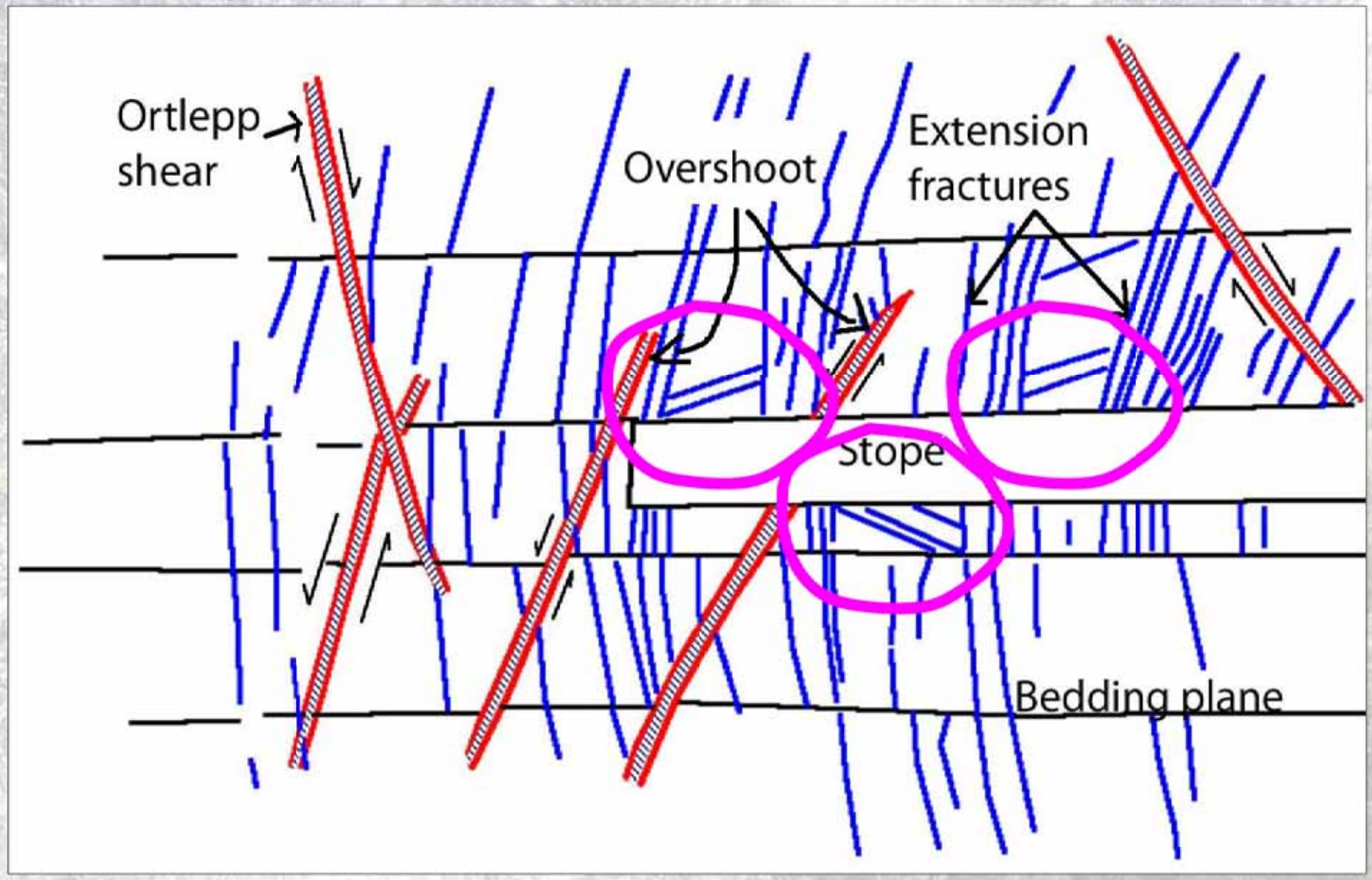
Another view


We'll come back to this later

Geometric relations between mine openings, extension fractures and Ortlepp shears

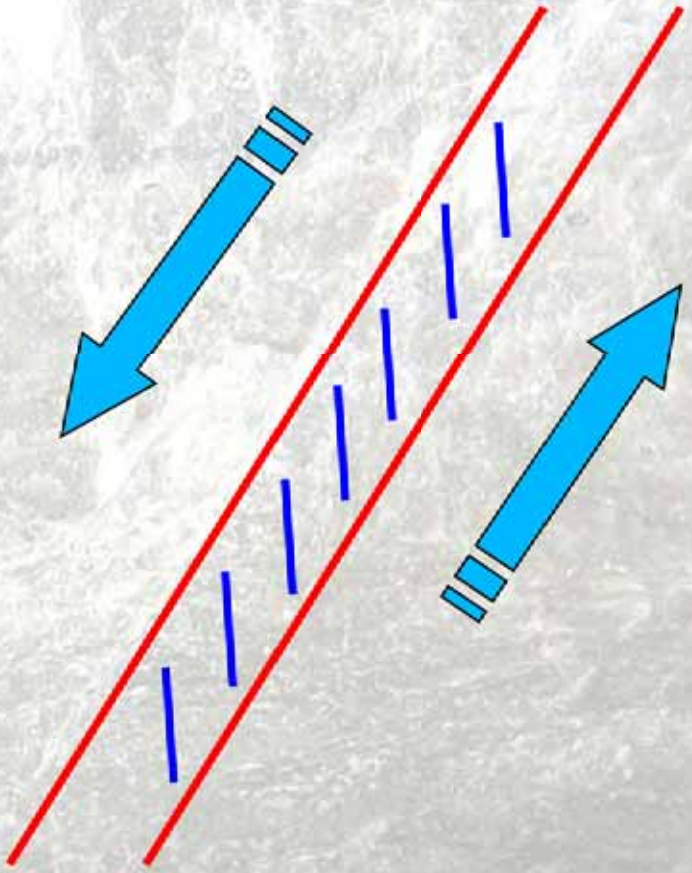


Geometric relations between mine openings, extension fractures and Ortlepp shears

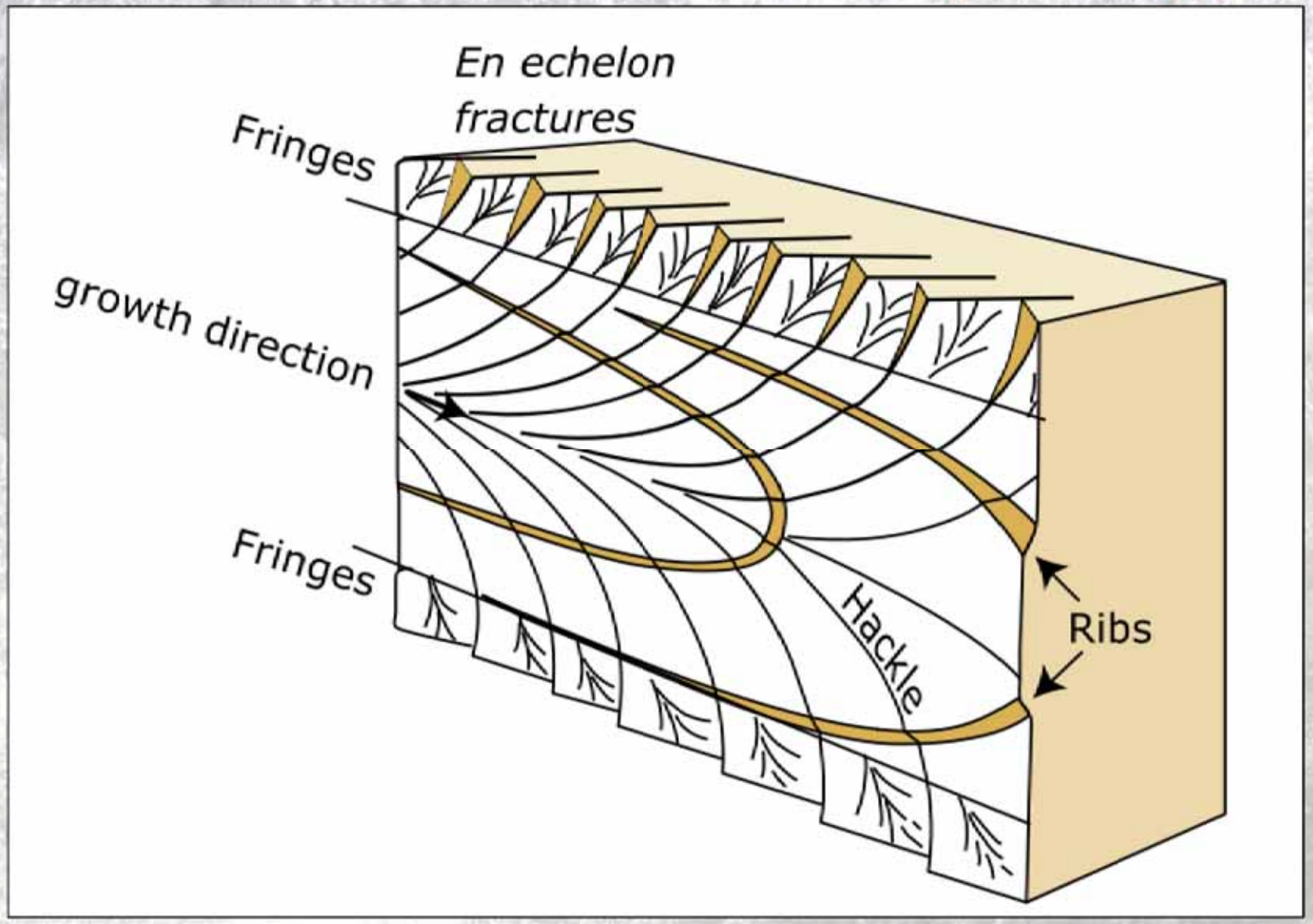


.. as I always remind you ...

- Rock fails in tension
  - Because it is weak in tension
- Rock deforms in shear
  - Because simple shear = plain strain = no volume change
- Extension fracture is an instantaneous mapping of the sigma1 trace
  - at the specific place where the fracture forms
  - at the very instant when the fracture forms

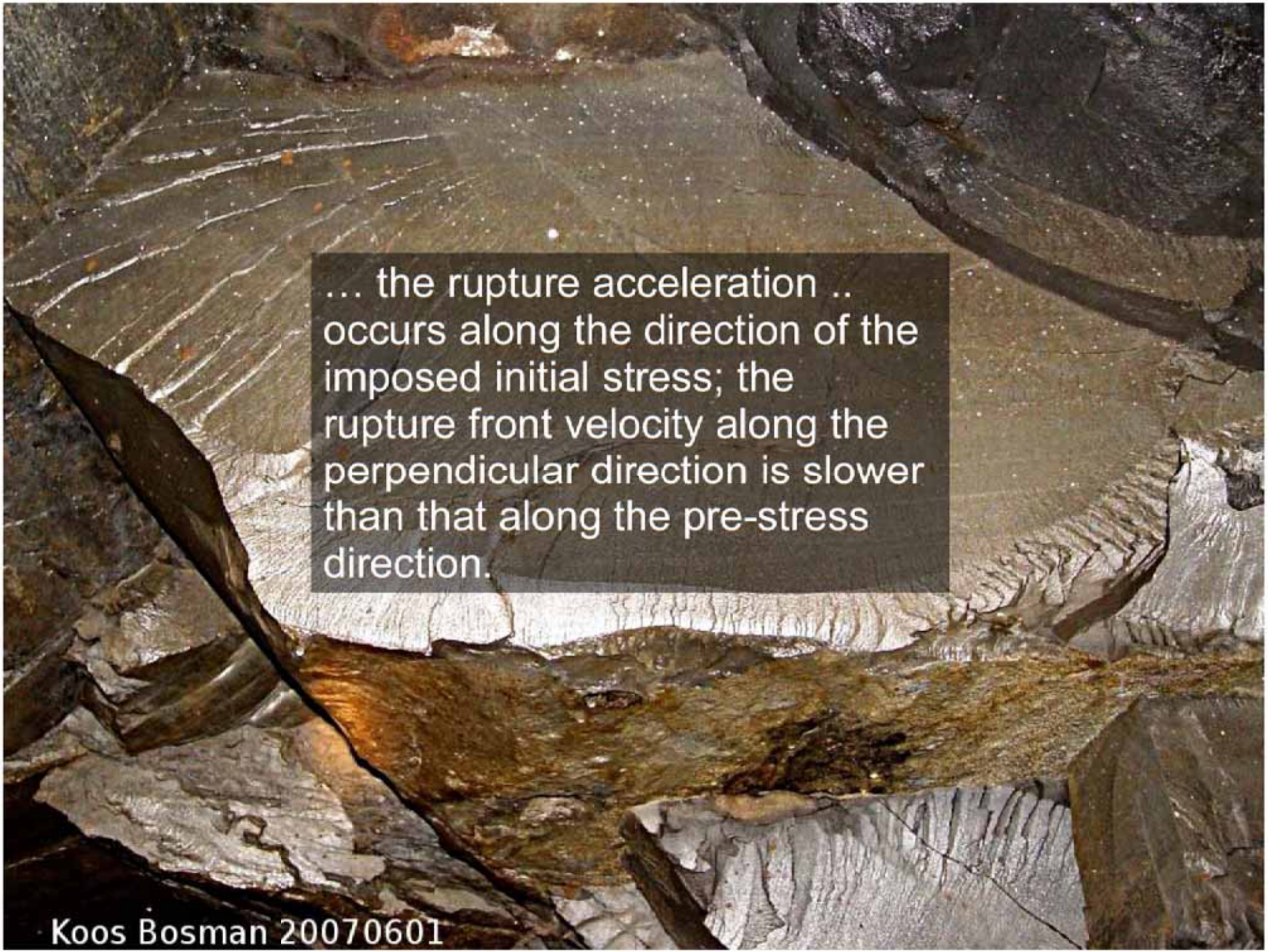


Extension fracture morphology



http://billy.geo.uib.no/struct/emodules.html

An example

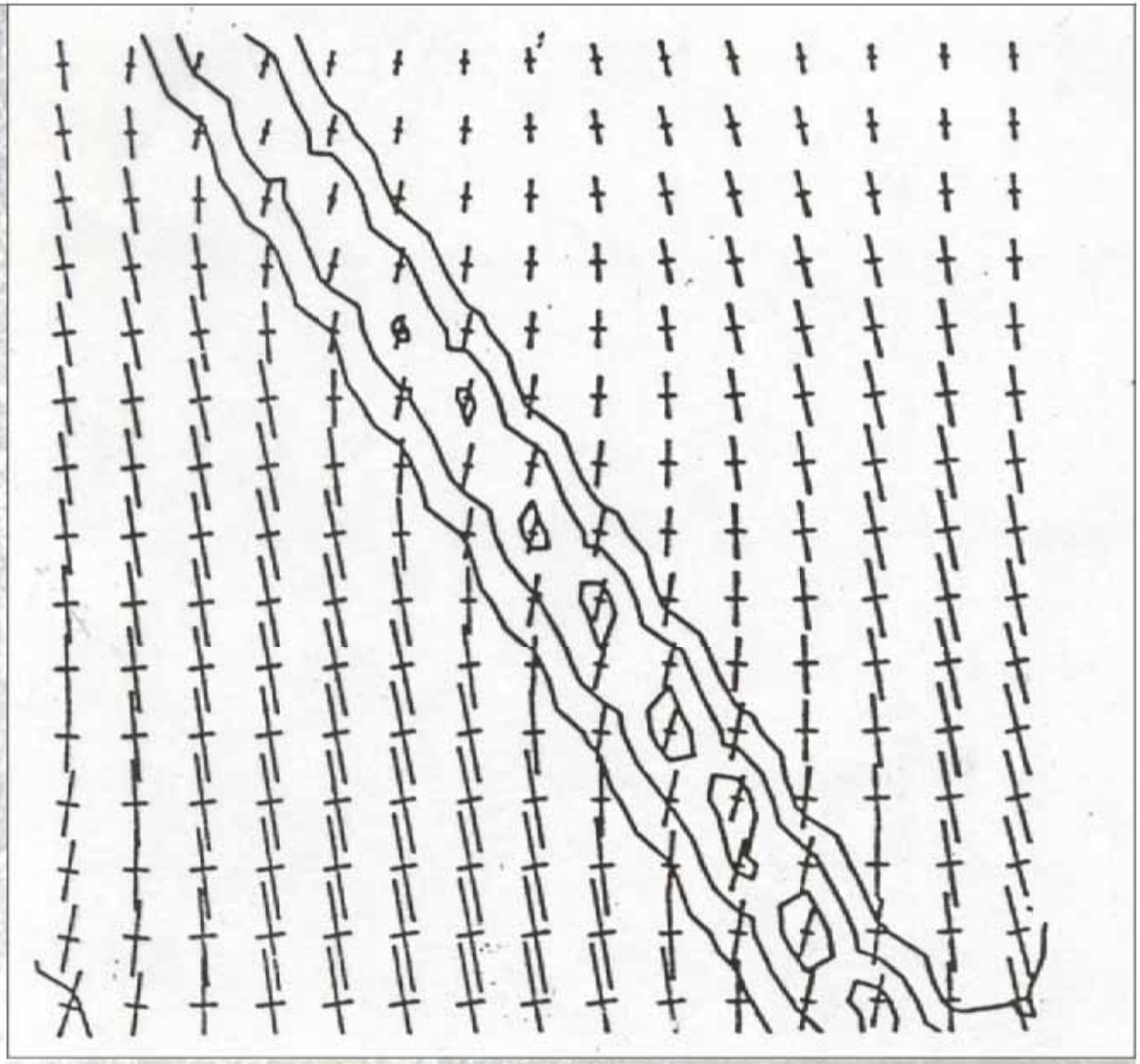

… the rupture acceleration .. occurs along the direction of the imposed initial stress; the rupture front velocity along the perpendicular direction is slower than that along the pre-stress direction.
Koos Bosman 20070601

So ...

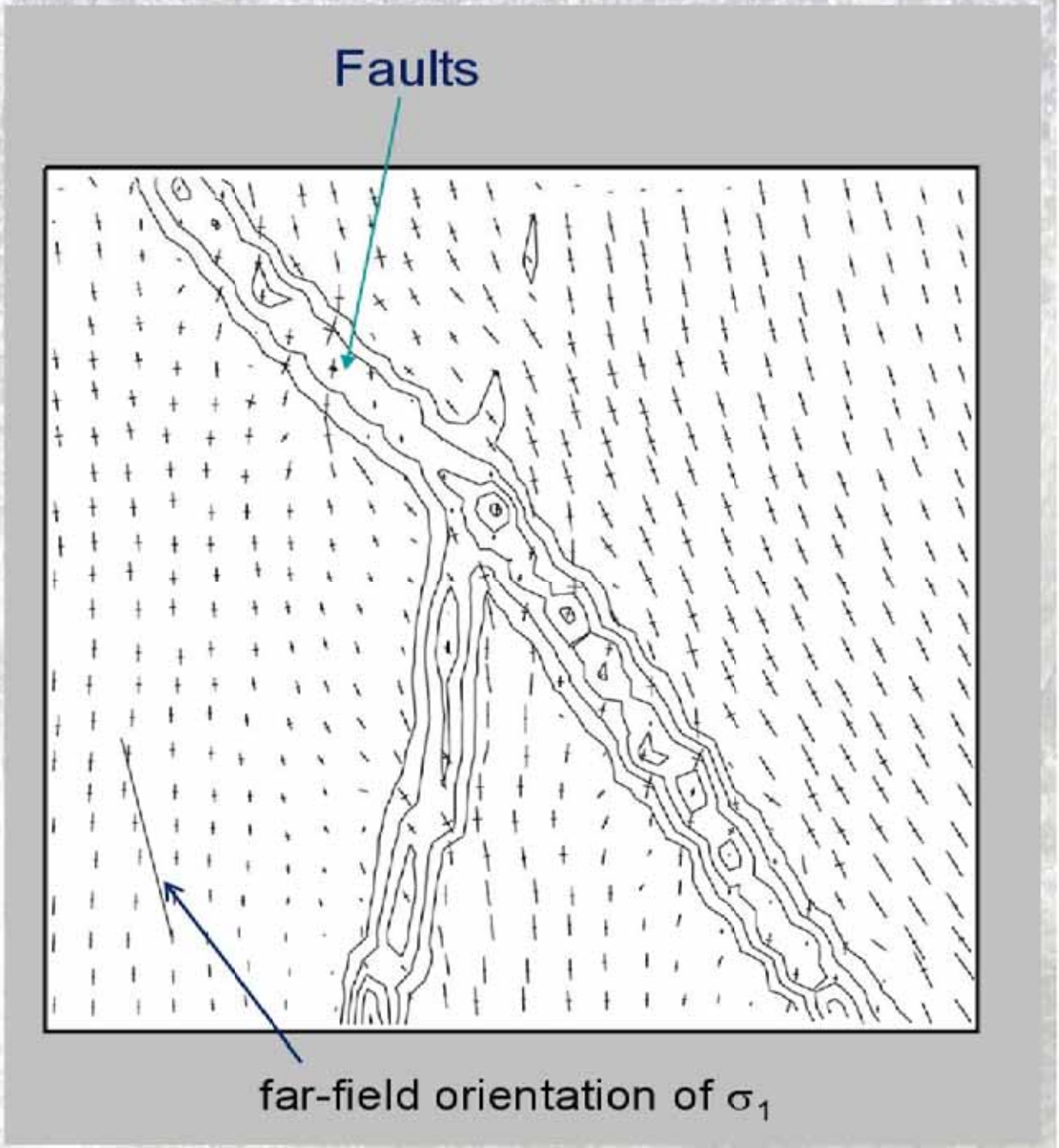
- Extension fracture is an instantaneous mapping of the S1S2 plane
  - at the specific place where the fracture forms
  - at the very instant when the fracture forms
  - The hackles show us
    - The direction of rupture propagation
    - The trace of S1 on the rupture plane,

    i.e. now we know the full orientation of the principle stress field at the time of rupture

We further know that stress rotates under variable strain conditions, mainly controlled by lithology and rock fabric

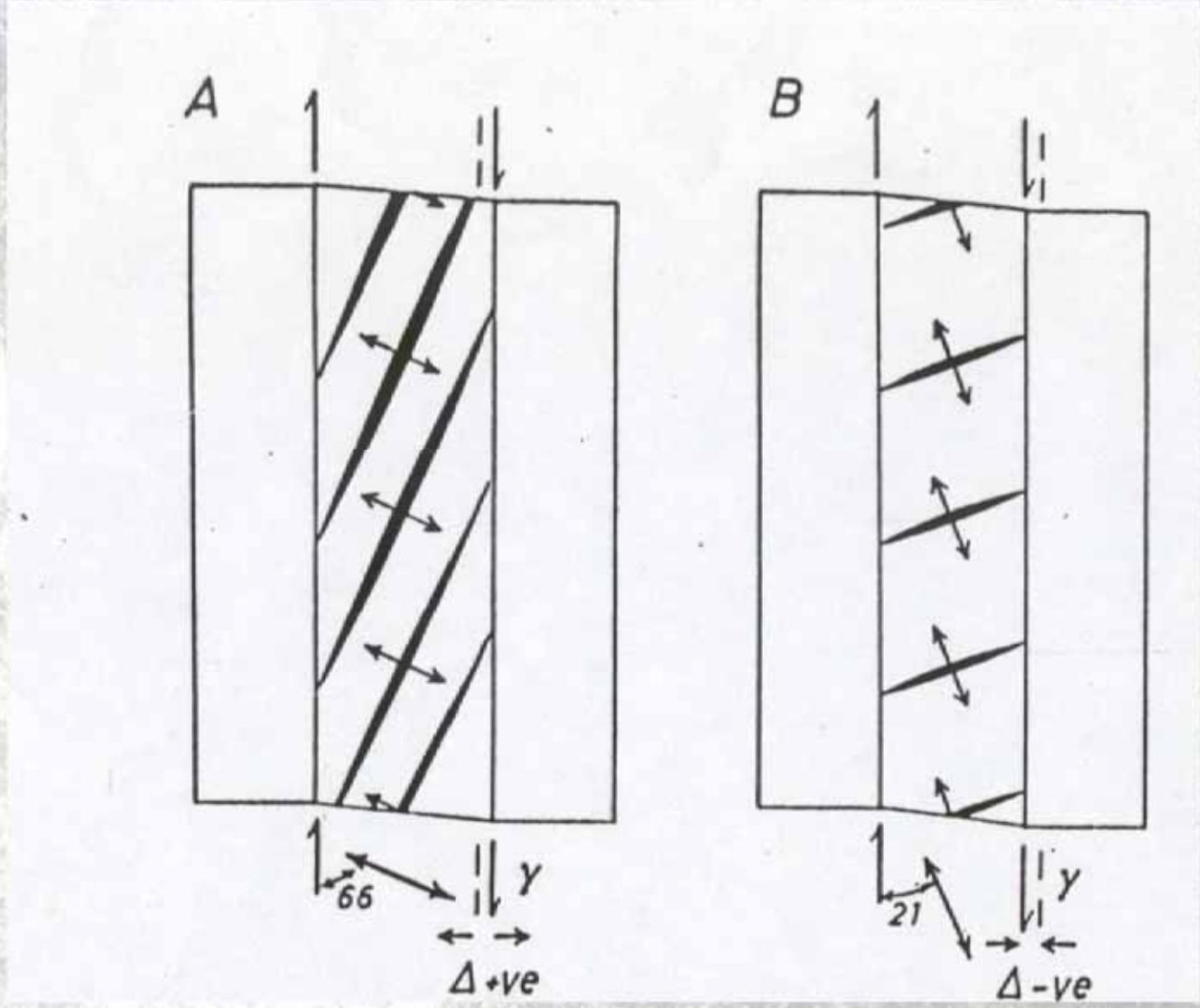


Cundall, 1991

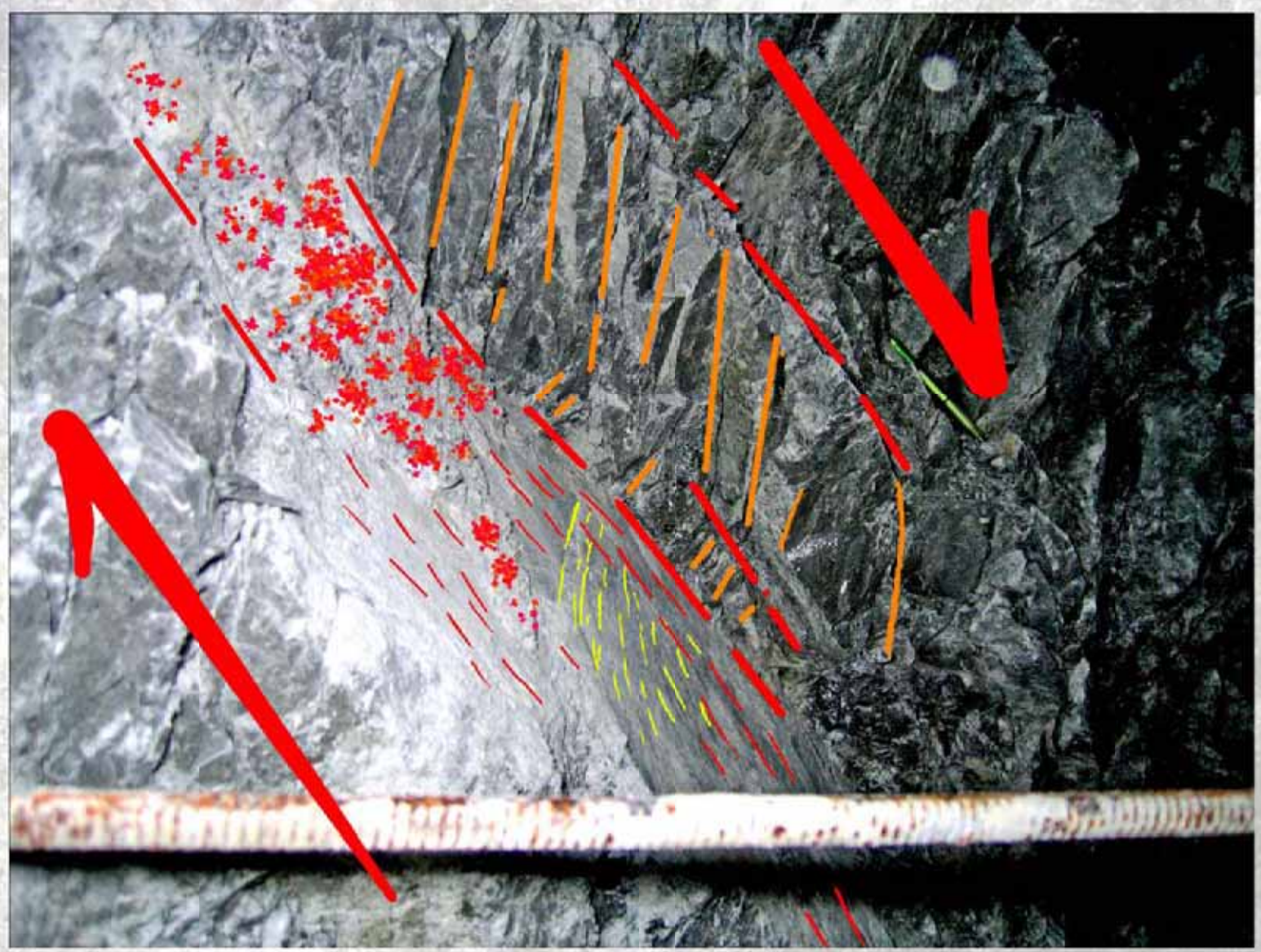


McKinnon, 2009

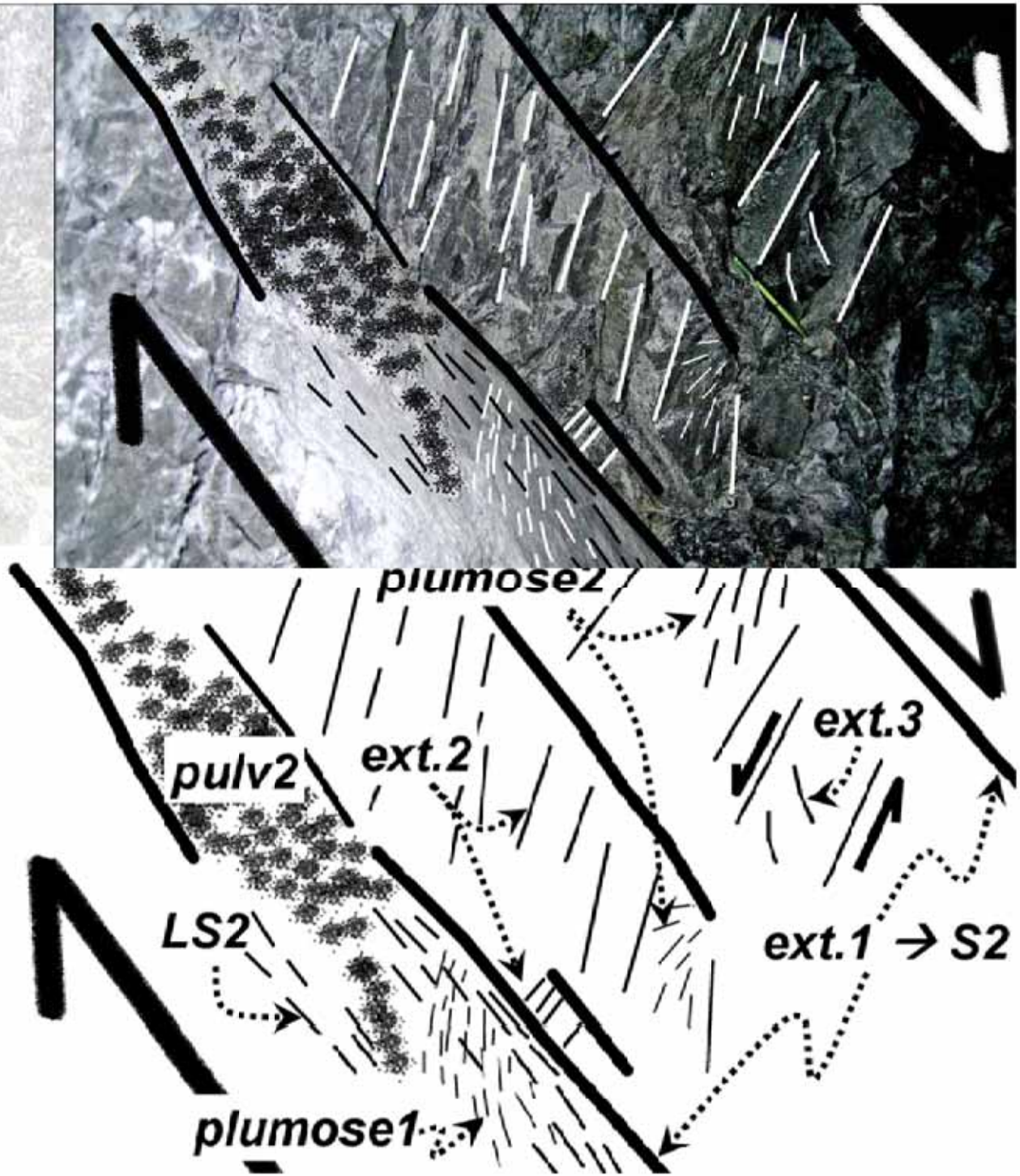
En echelon extension fractures and normal stress

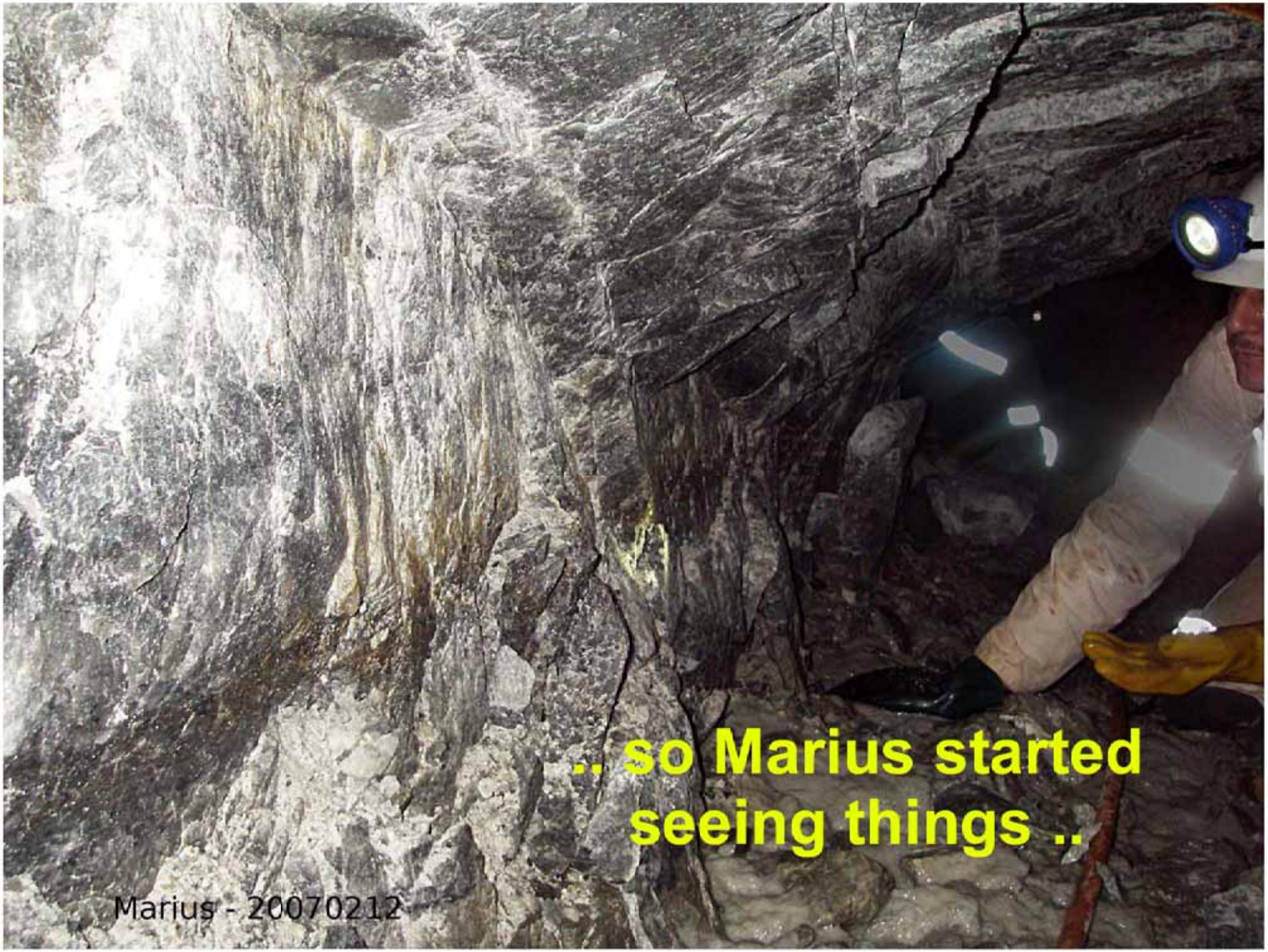


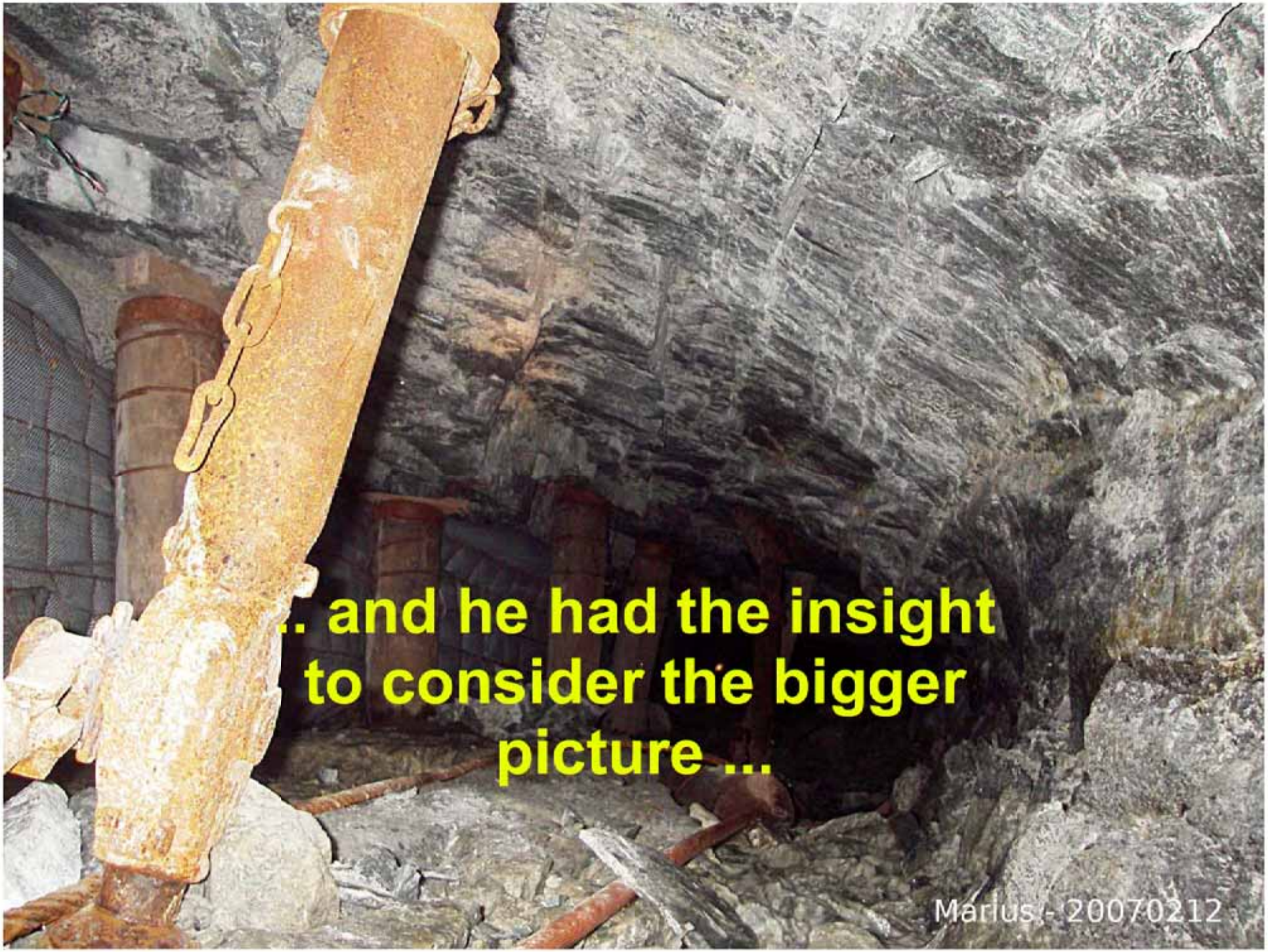
Slip striations, hackles etc.

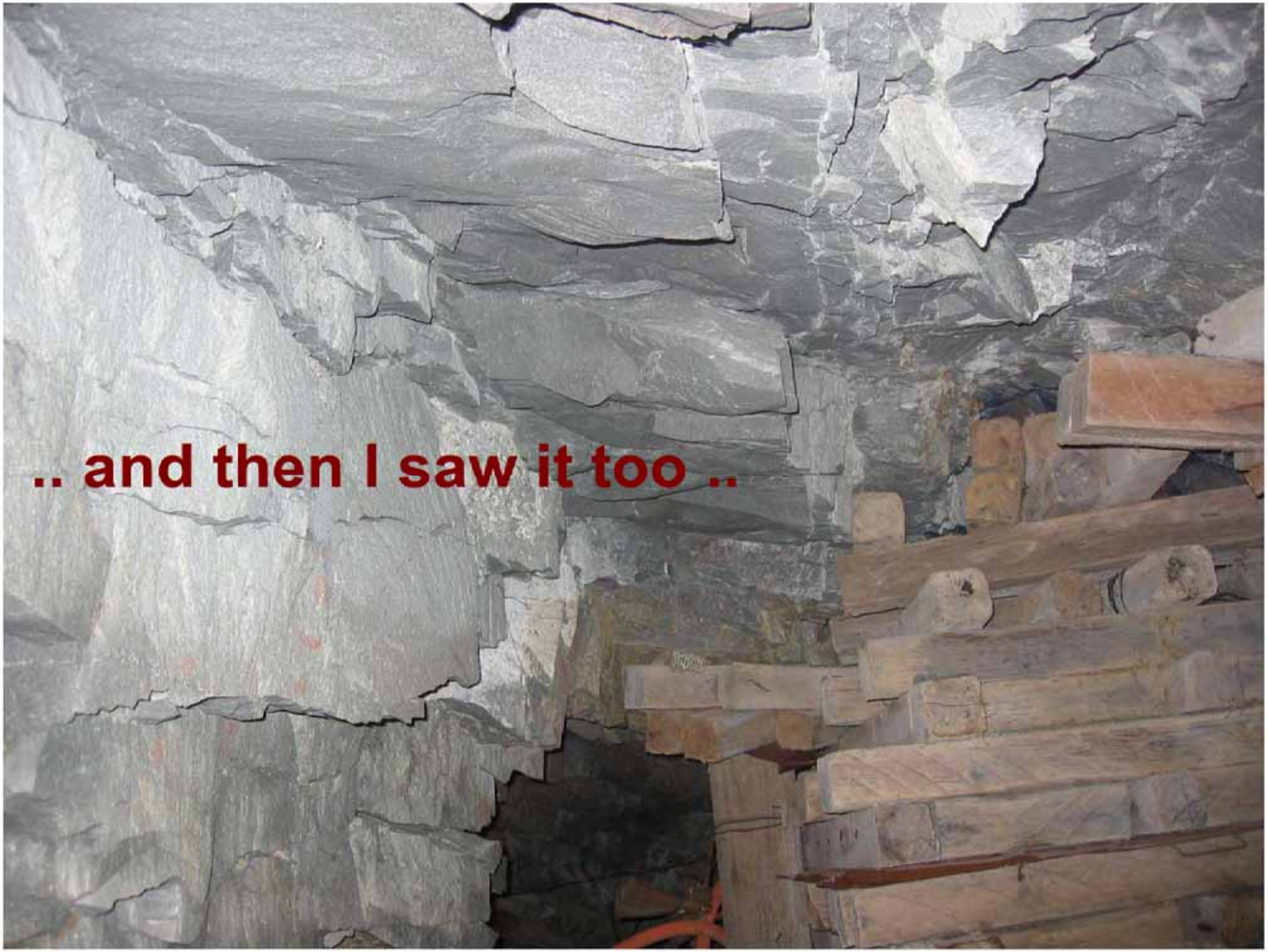


Slip striations, plumose structures – Case C

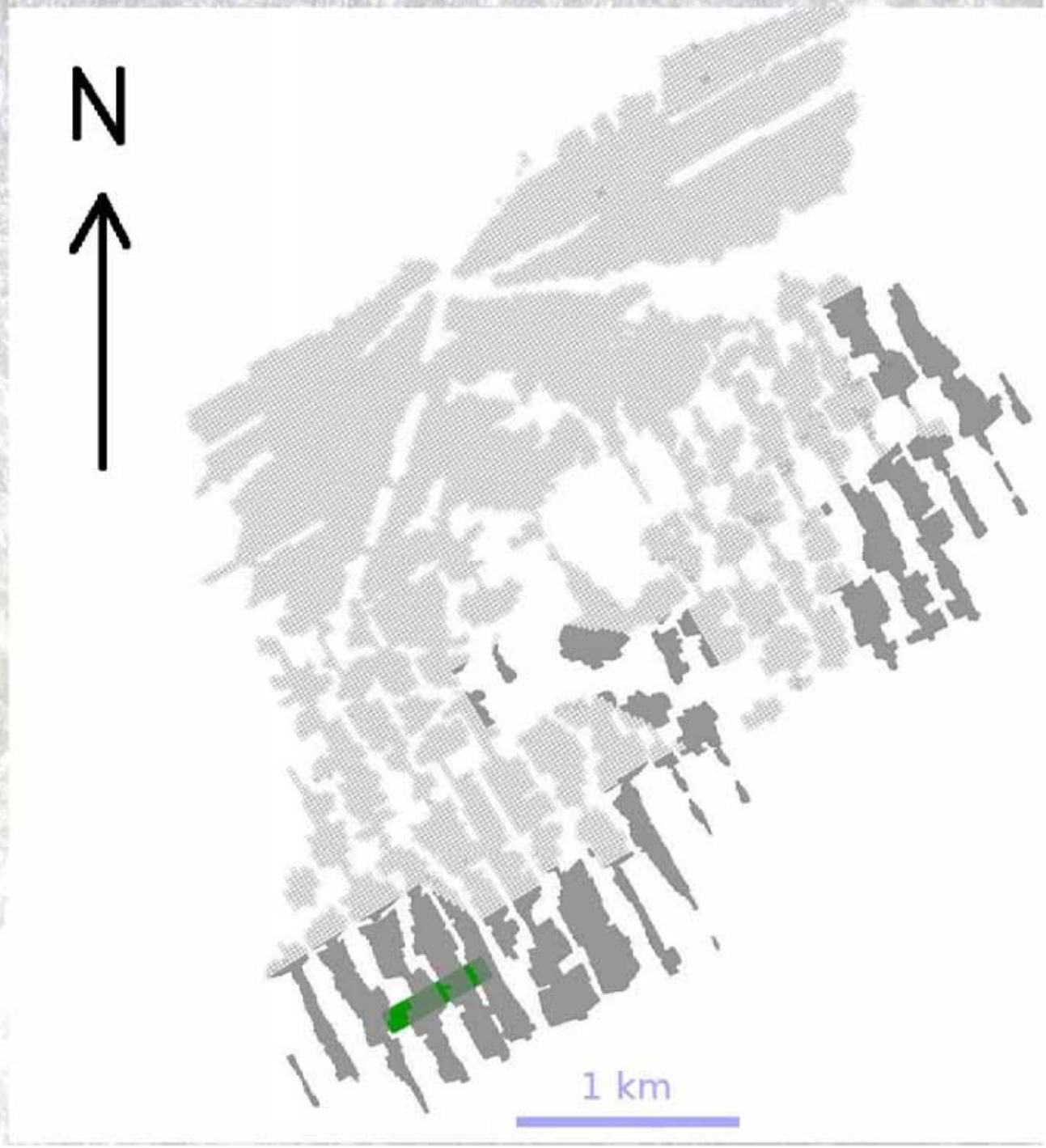



.. so Marius started seeing things ..
Marius - 20070212

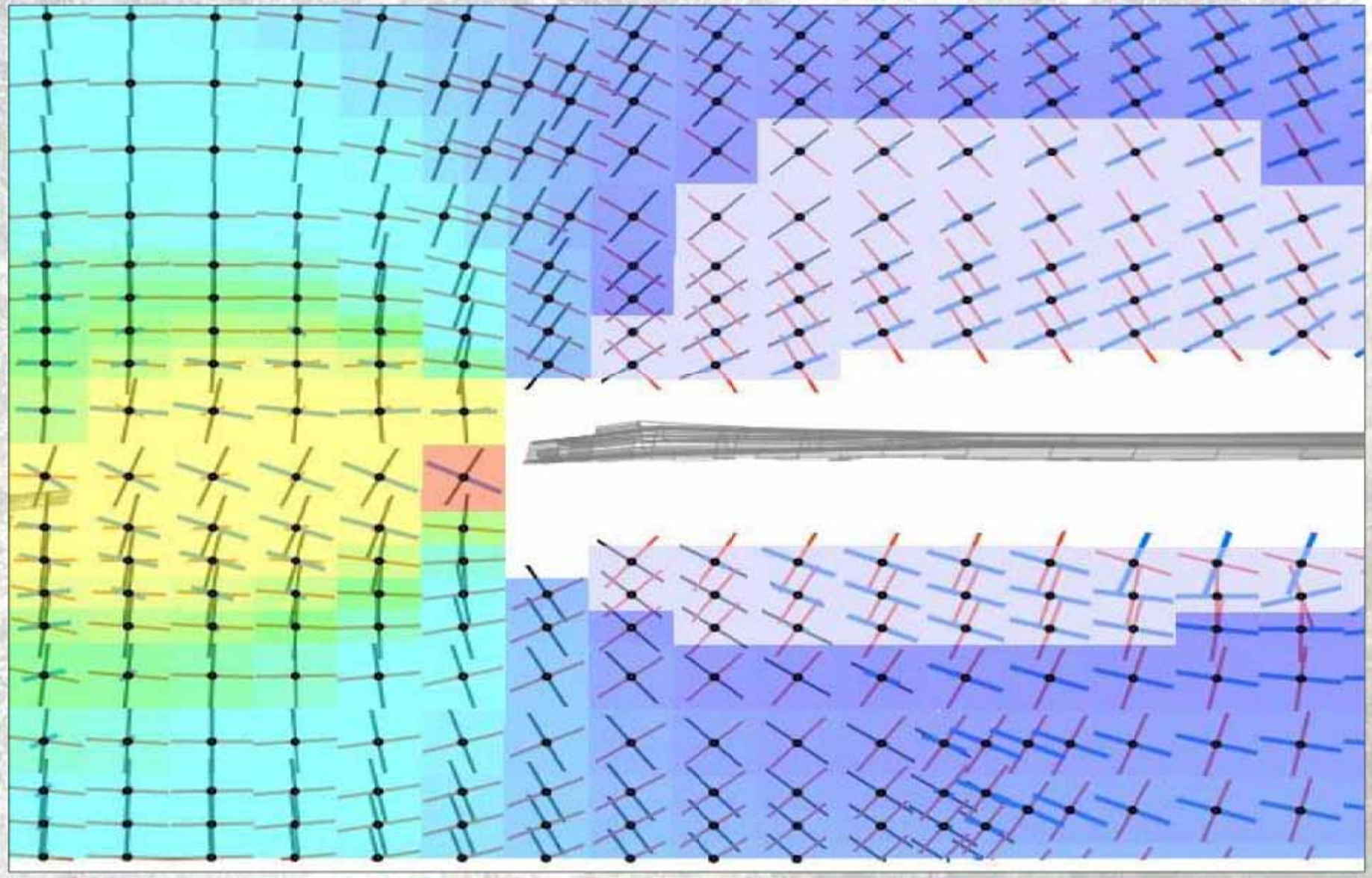

.. and he had the insight
to consider the bigger
picture ...
Marius - 20070212

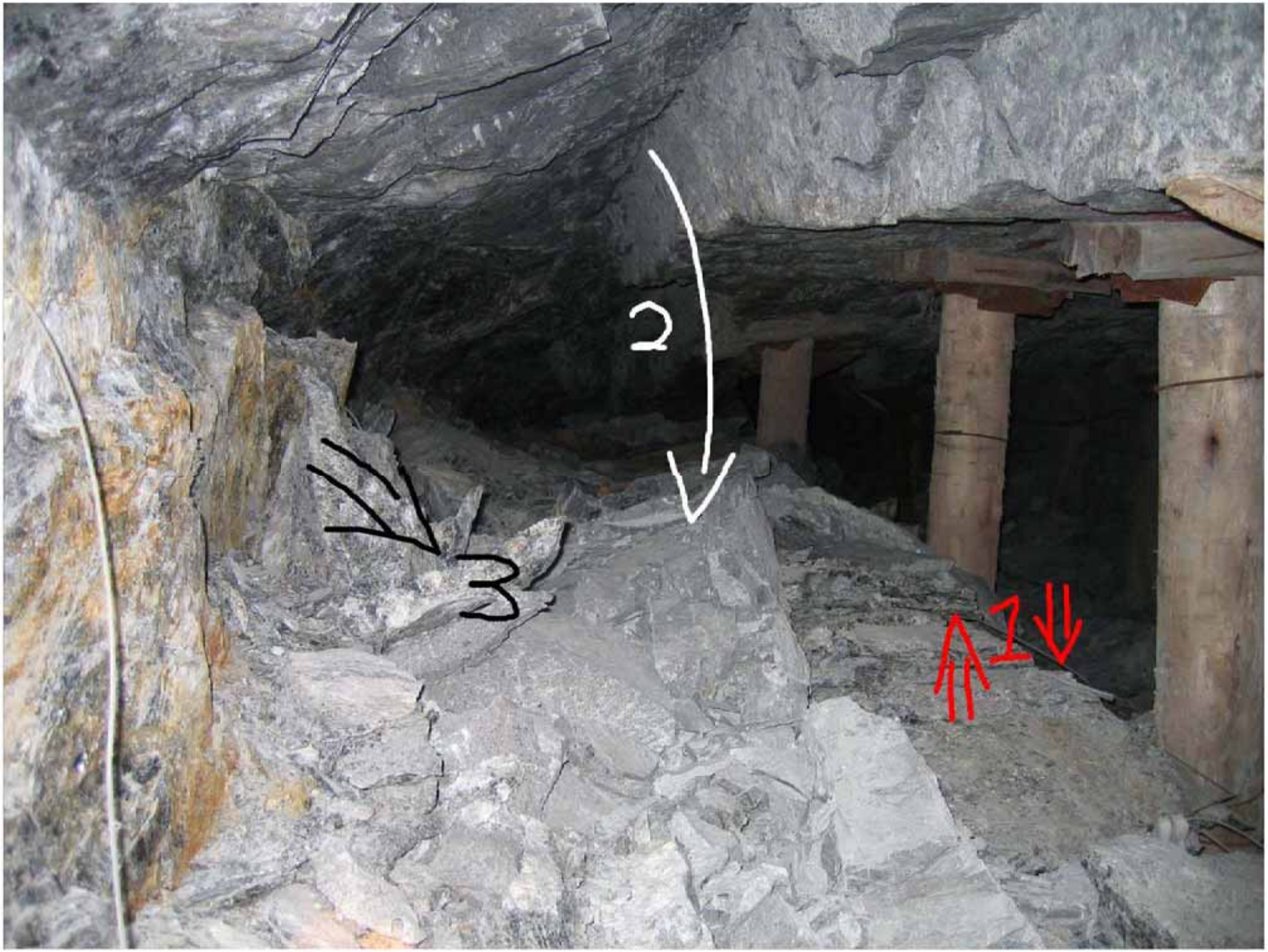

.. and then I saw it too ..

A deep Wits mine

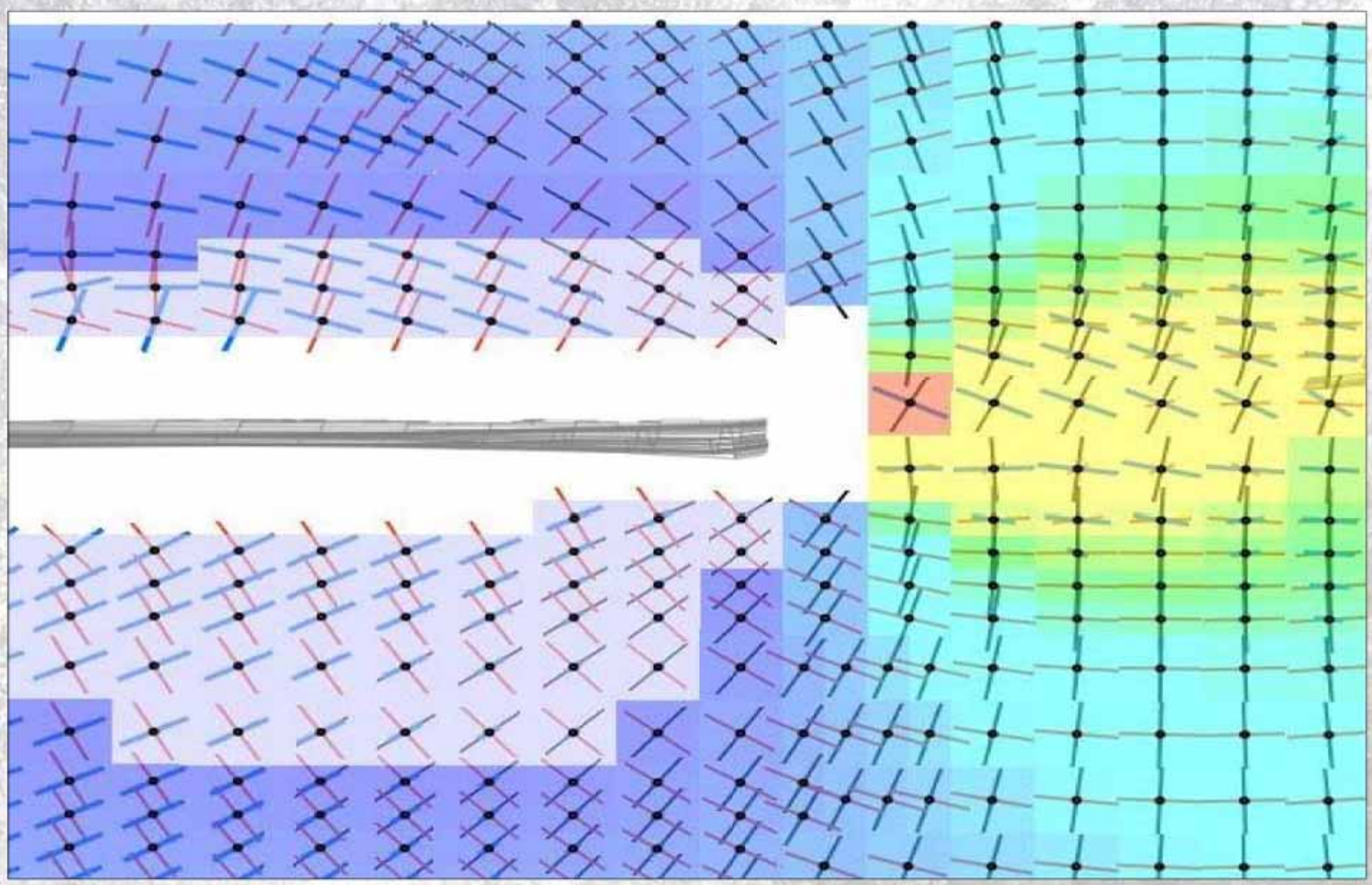


Stress around tabular stopes

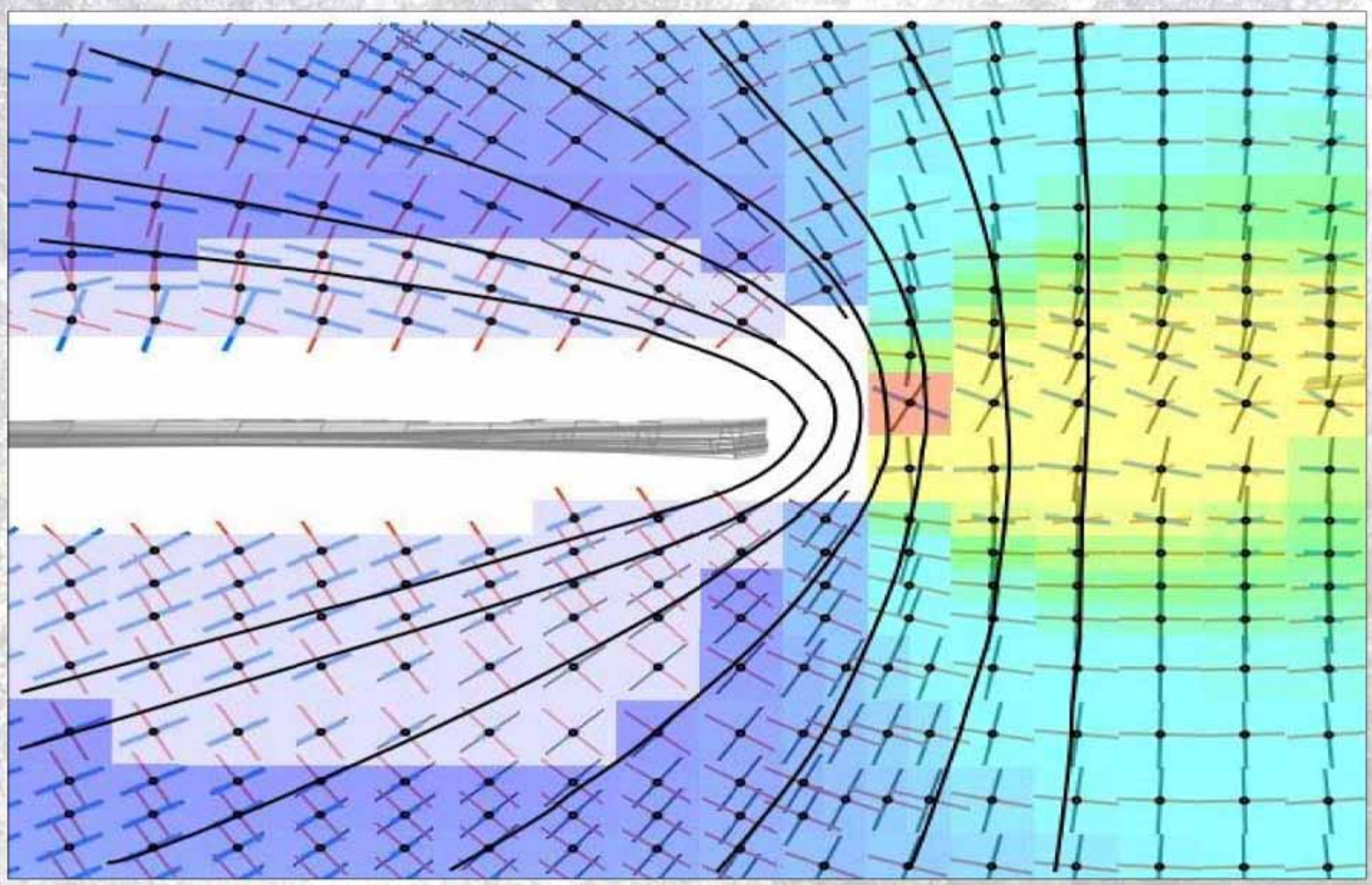



2
3
1

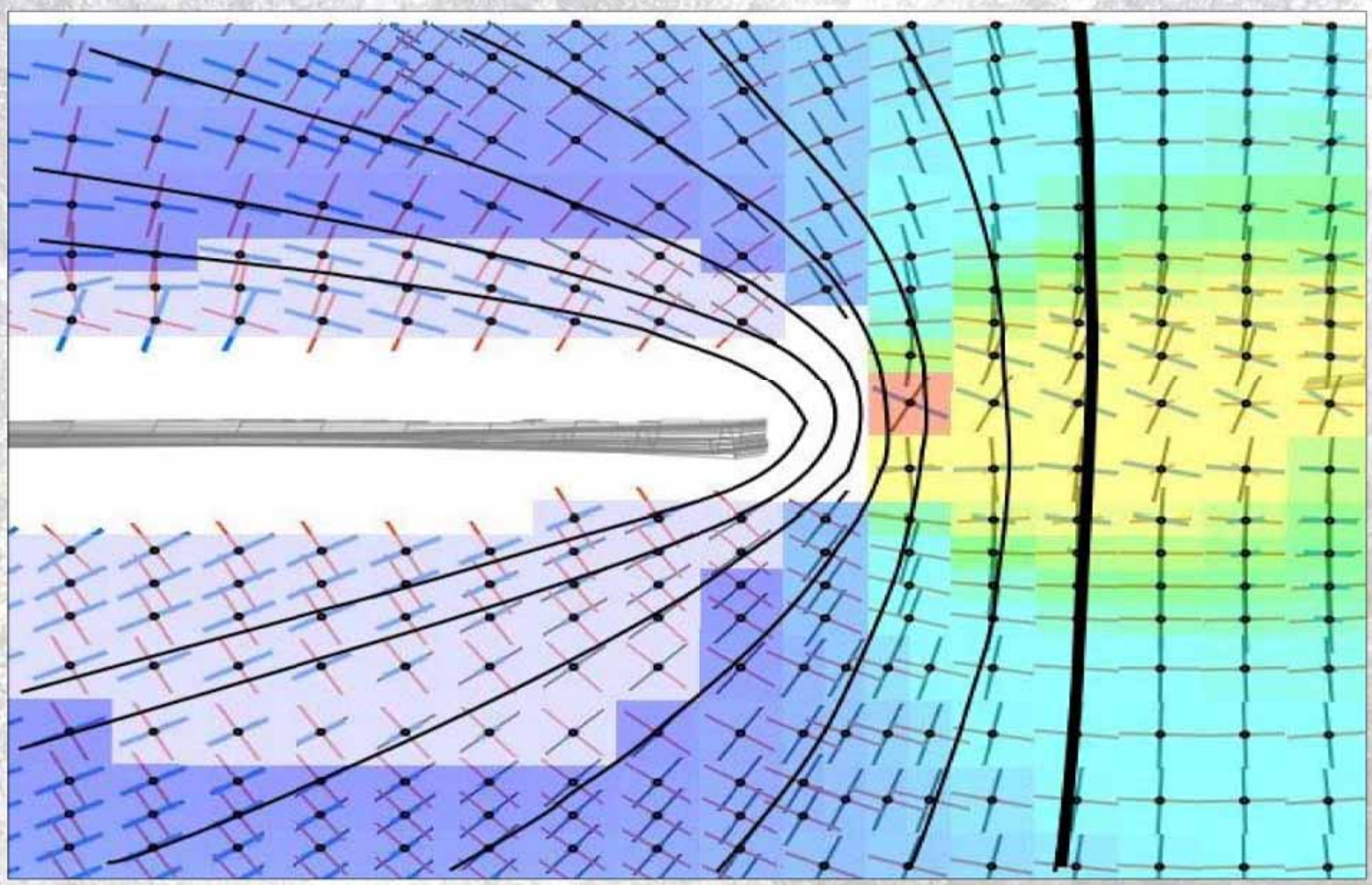
Colour depicts sigma3



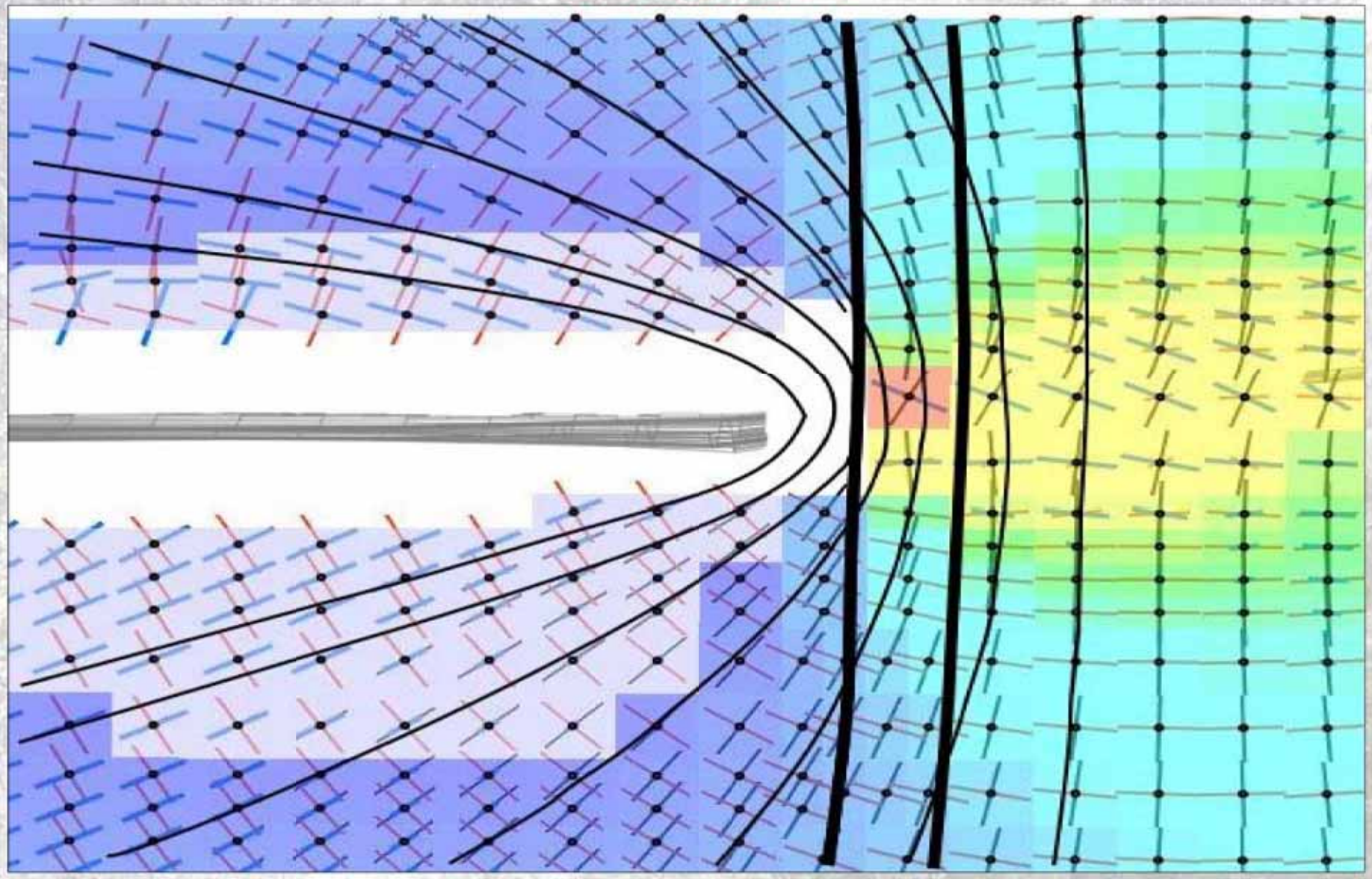
Stress trajectories



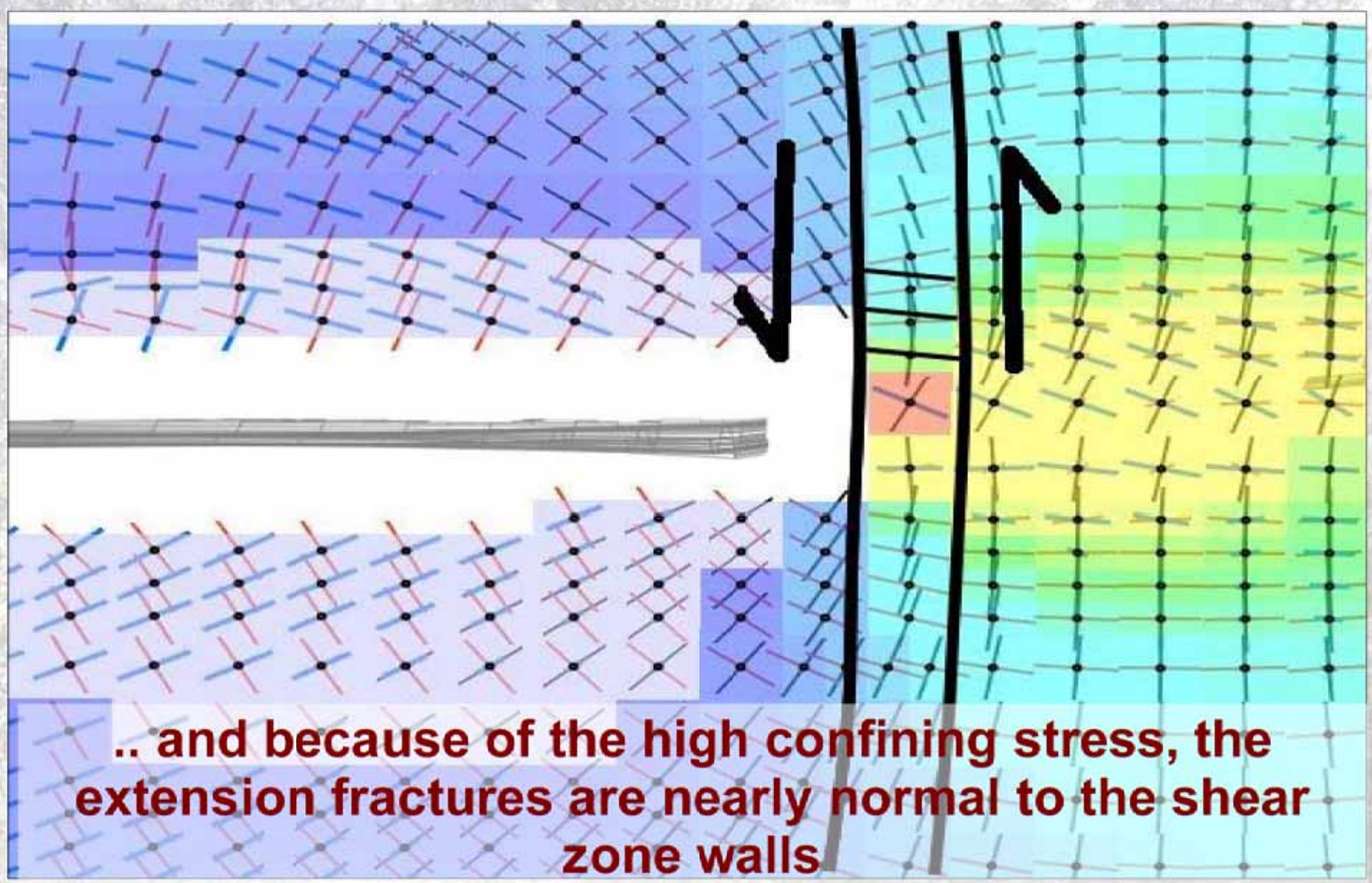
Extension fracture



Stope advances towards the extention fractures



Because of continuous stope closure, shear couples develop along extension fractures



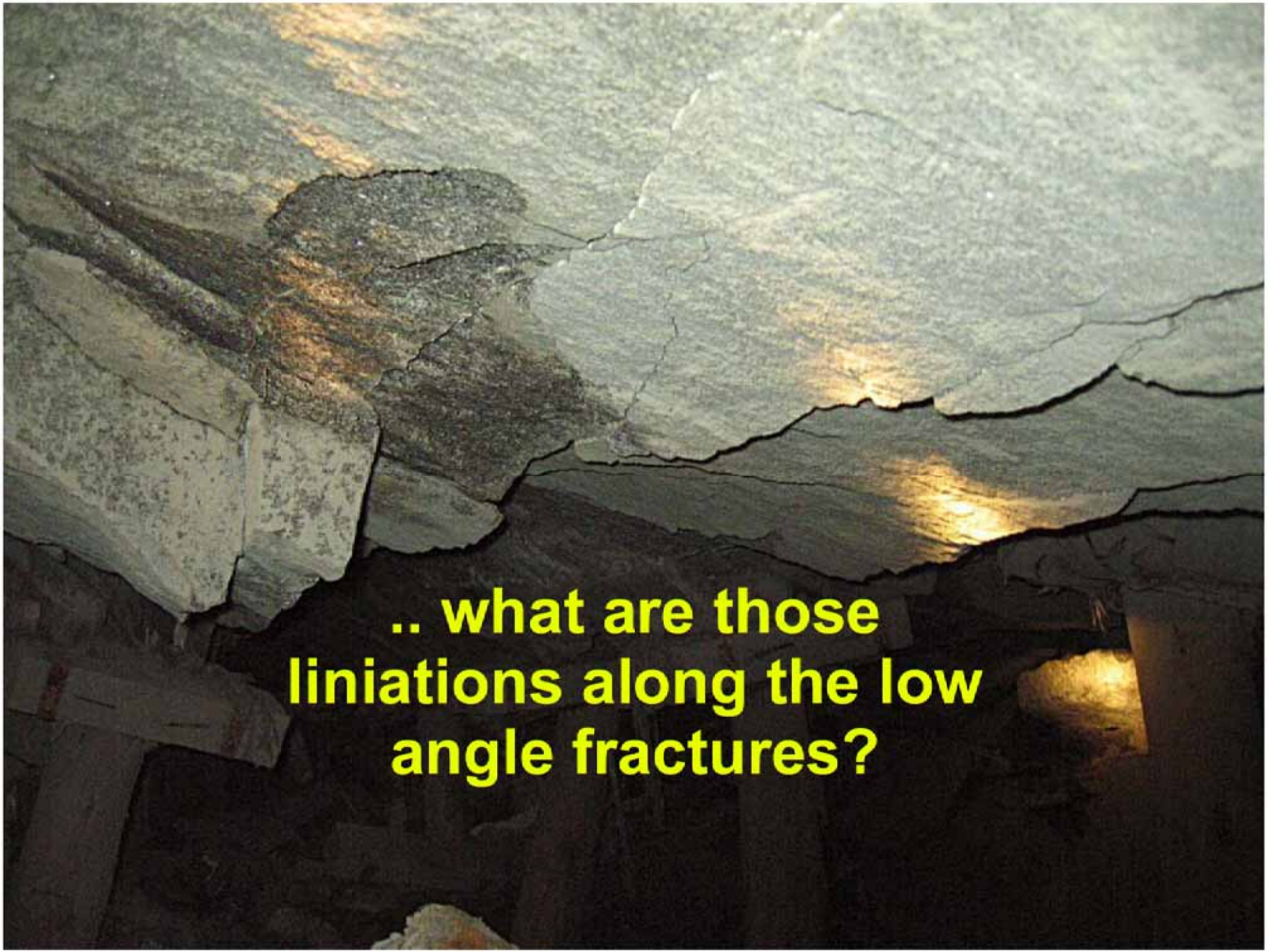
.. and because of the high confining stress, the extension fractures are nearly normal to the shear zone walls


T2 plumose
T1 plumose ruptured downwards
T1 plumose ruptured upwards
Schematic
.. and because of the high confining stress, the extension fractures are nearly normal to the shear zone walls

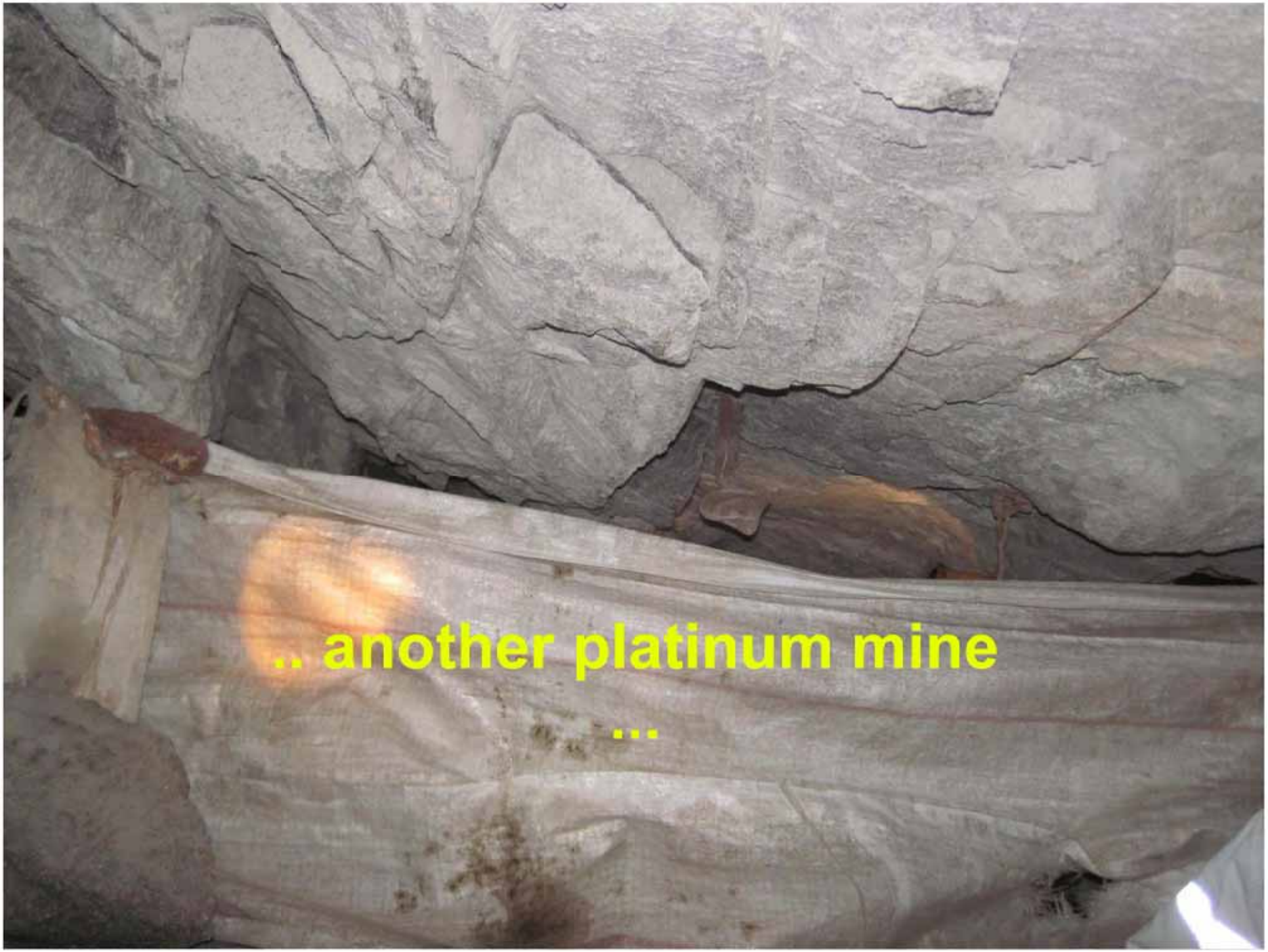

More T1's

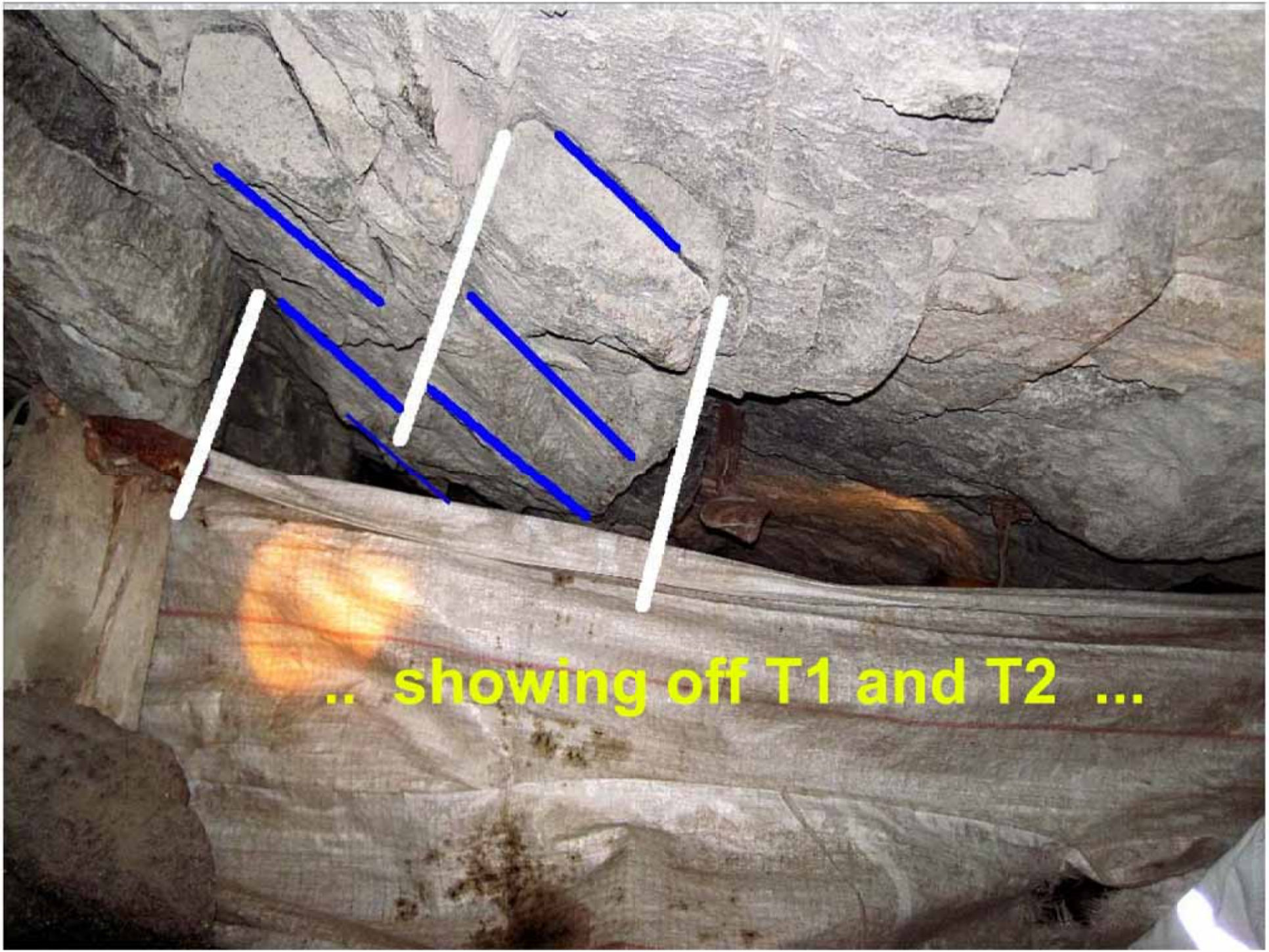

More T2's


.. so what about the
platinum mines ...

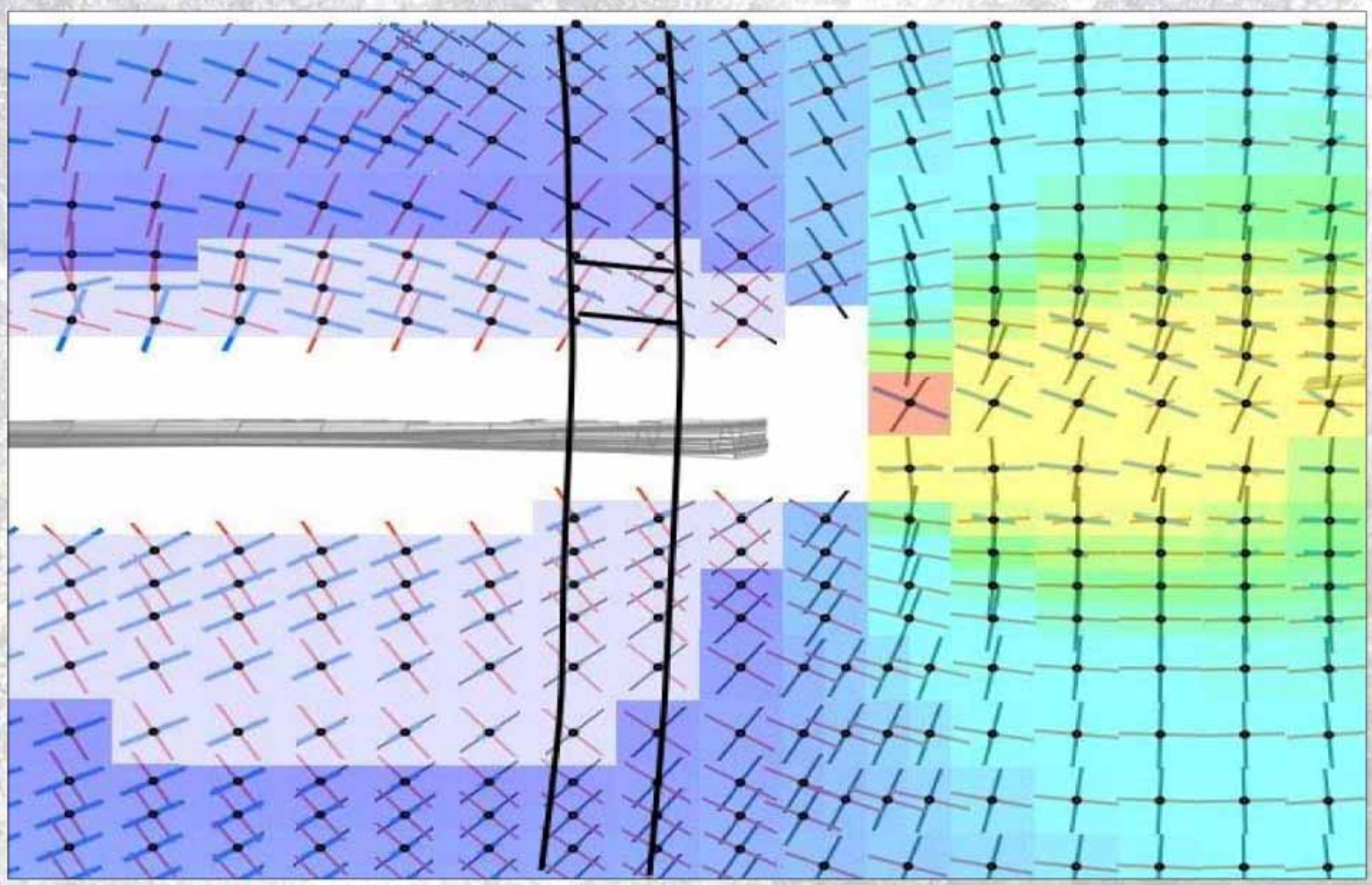

.. what are those
liniations along the low
angle fractures?


.. scary stuff ..

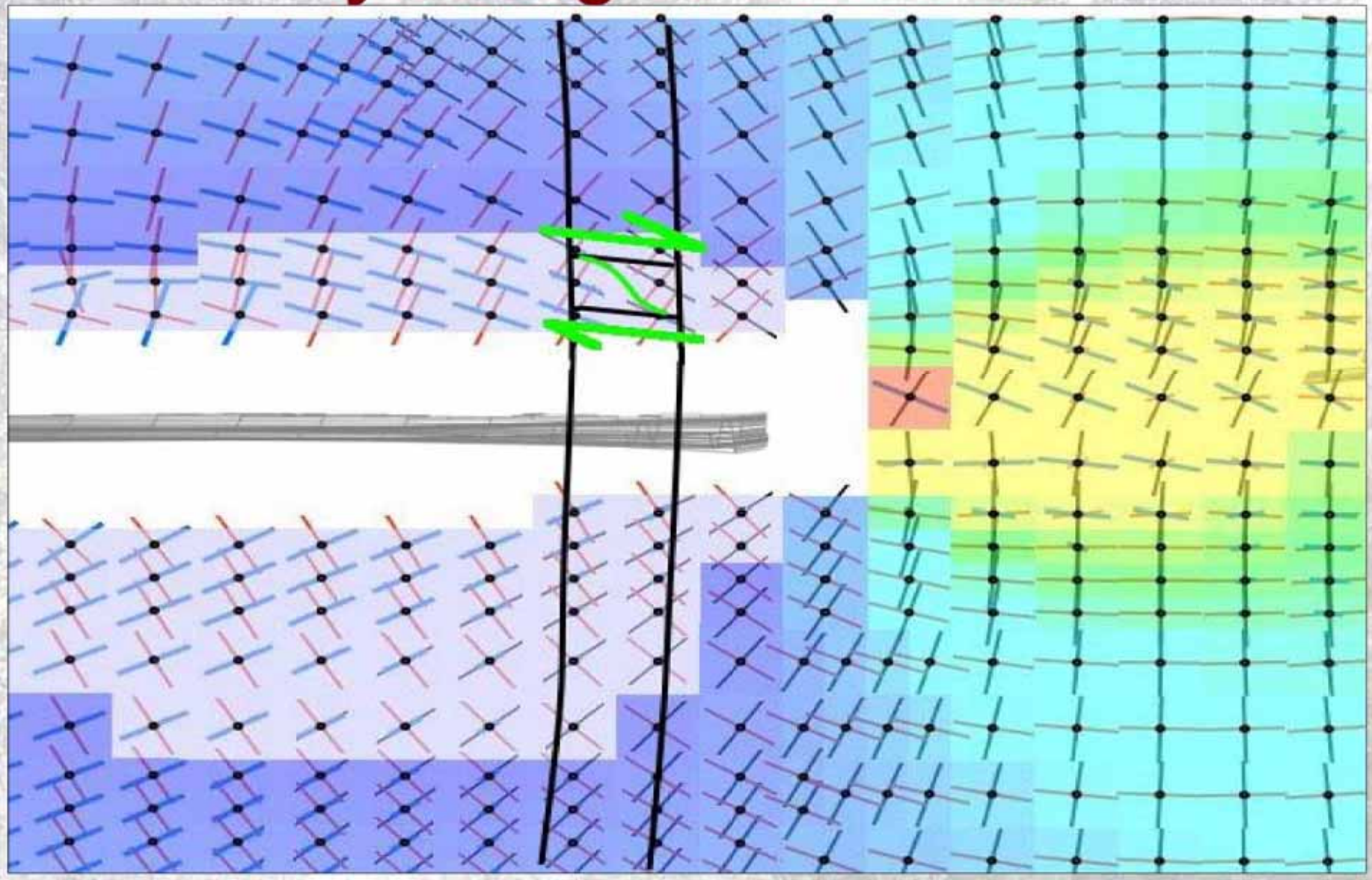

.. another platinum mine
...


.. showing off T1 and T2 ...

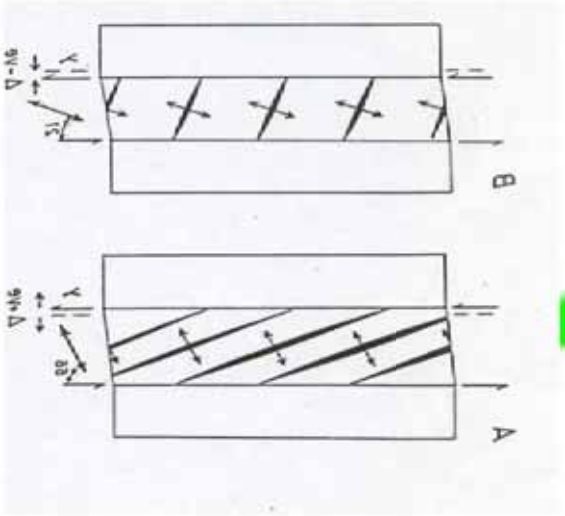
Stope advances further, moving the T2 fractures into a completely different stress regime

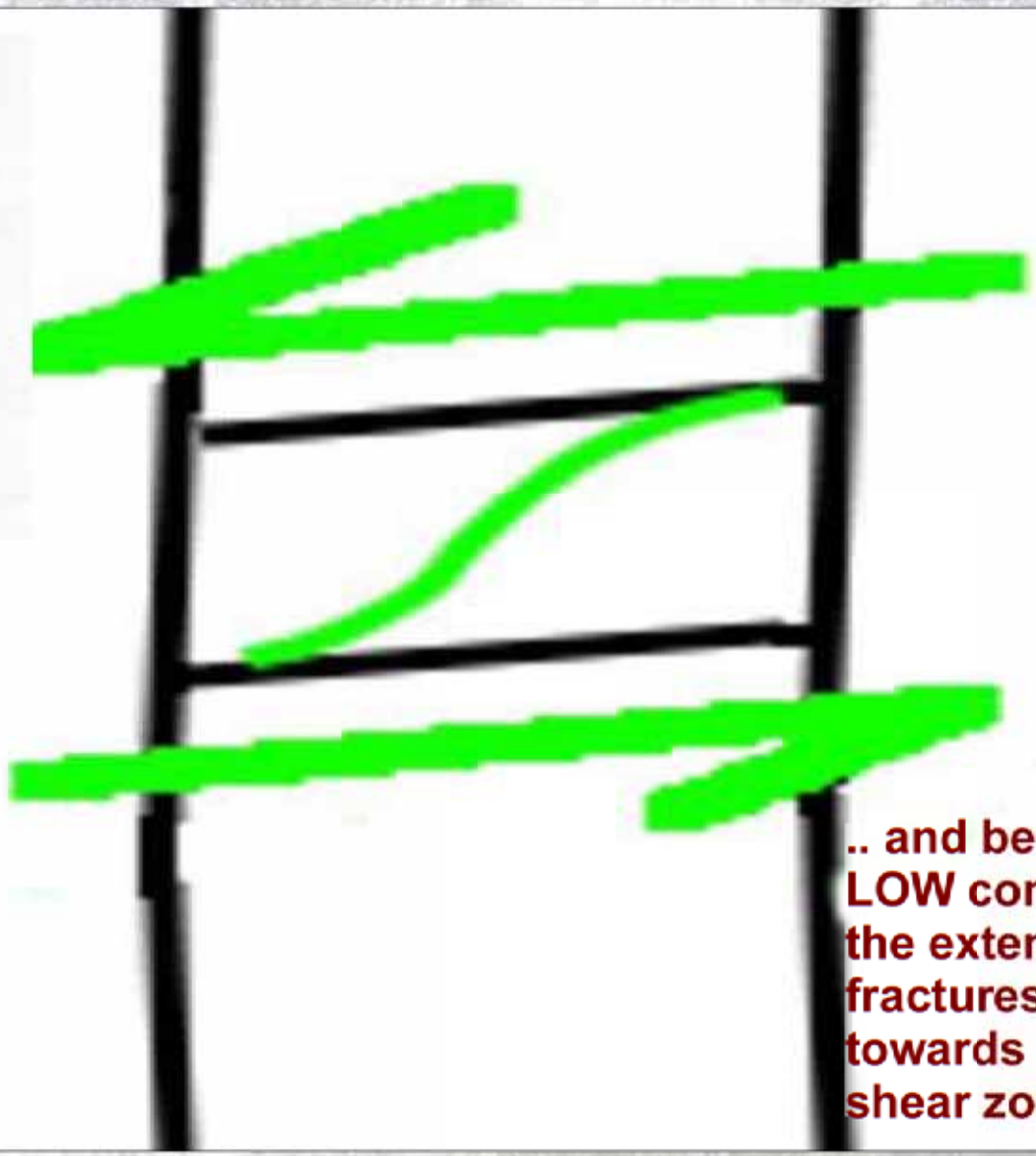


Resulting in a new shear couple, yielding T3 fractures

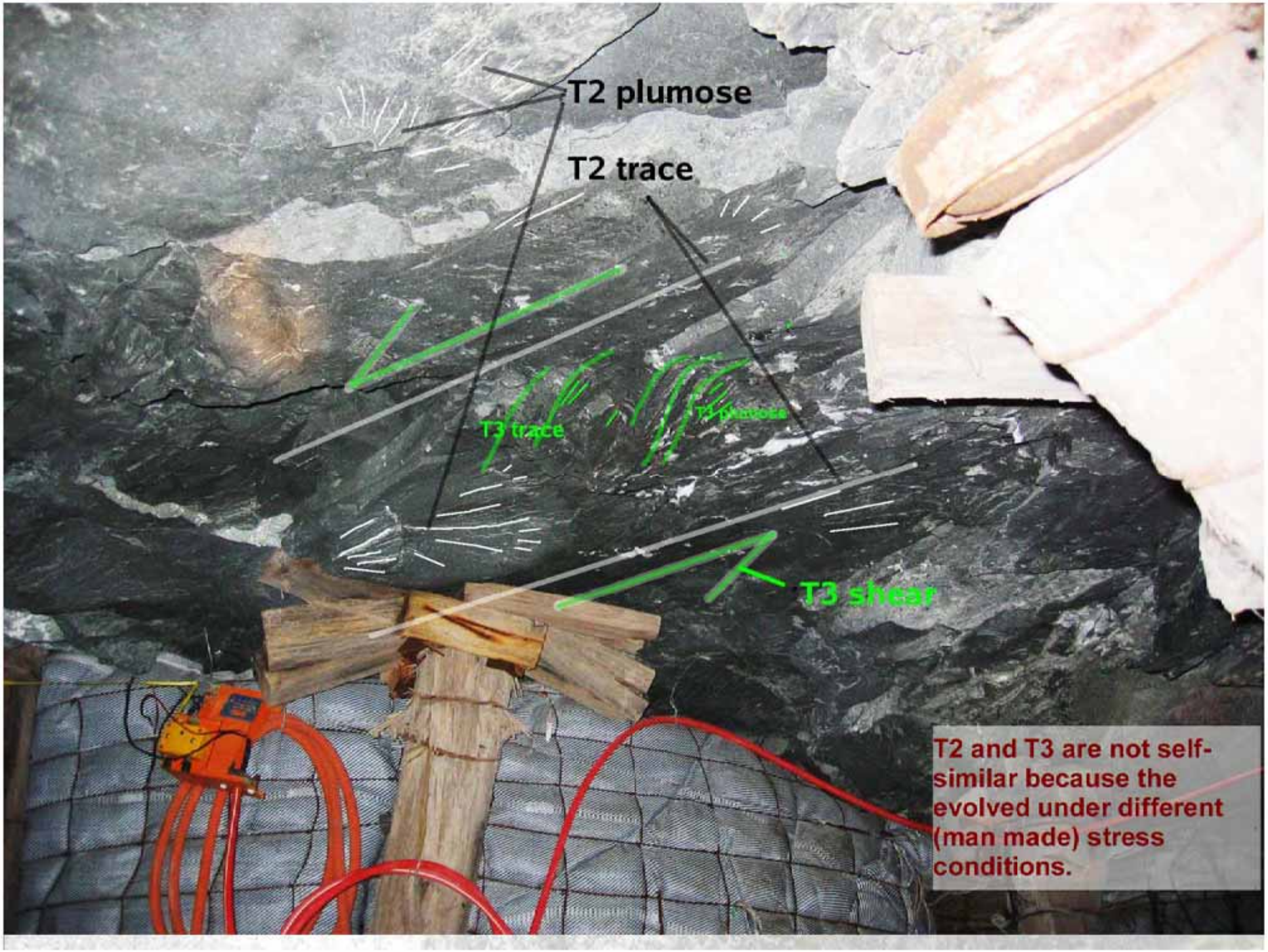


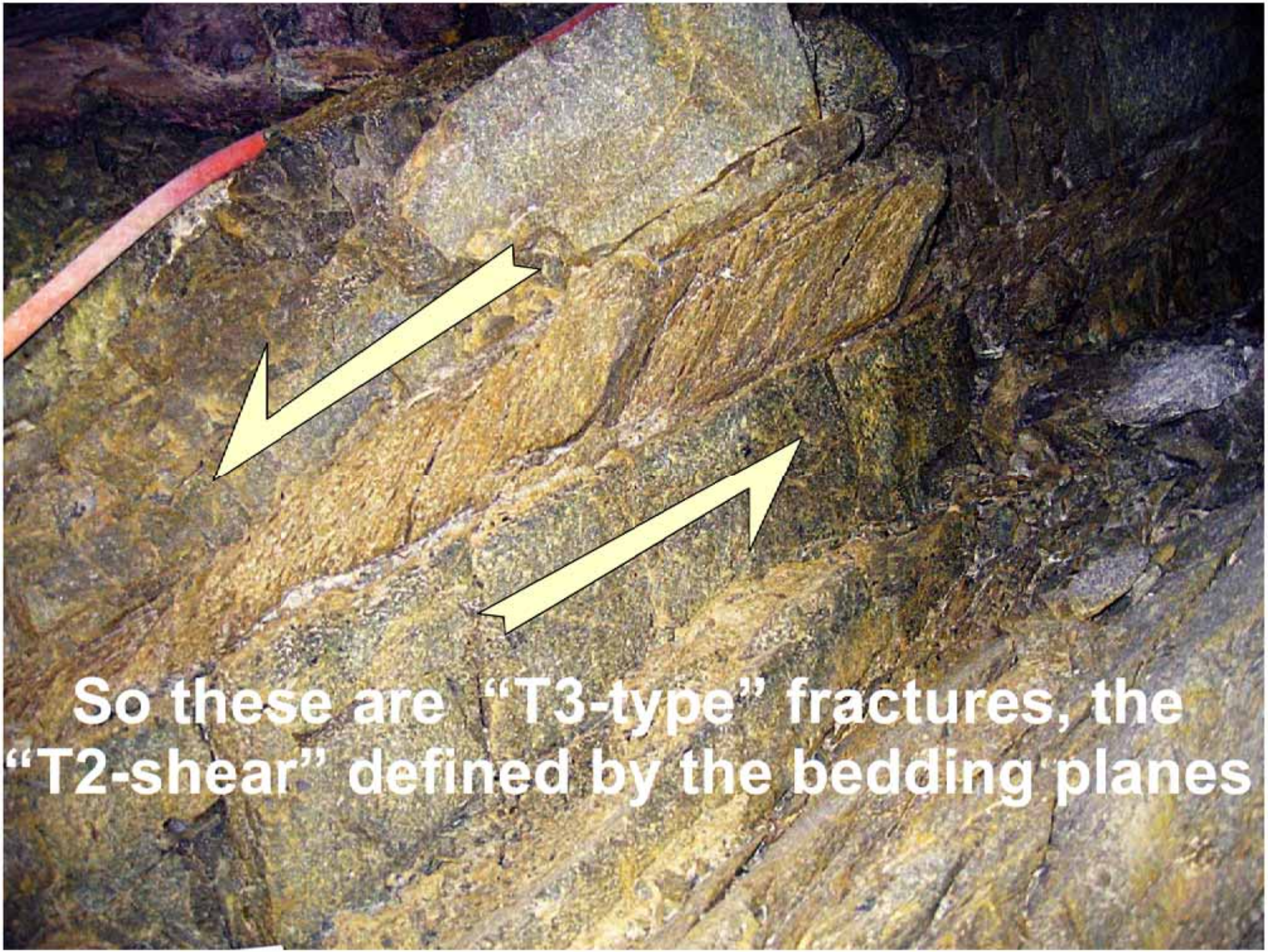
Because the normal stress is near negative along T2 surfaces, T3 is curved





.. and because of the LOW confining stress, the extension fractures rotate towards parallel to the shear zone wall


T2 plumose
T2 trace
T3 trace
T3 plumose
T3 shear
T2 and T3 are not self-similar because the evolved under different (man made) stress conditions.


So these are "T3-type" fractures, the
"T2-shear" defined by the bedding planes

Acknowledgements

Thanks a lot to

- AngloGold Ashanti – where we learned most of what we know about fractures around stopes
- ISSI – who allows me to waste time crawling through stopes
- All the rockies out there who help us get to interesting places