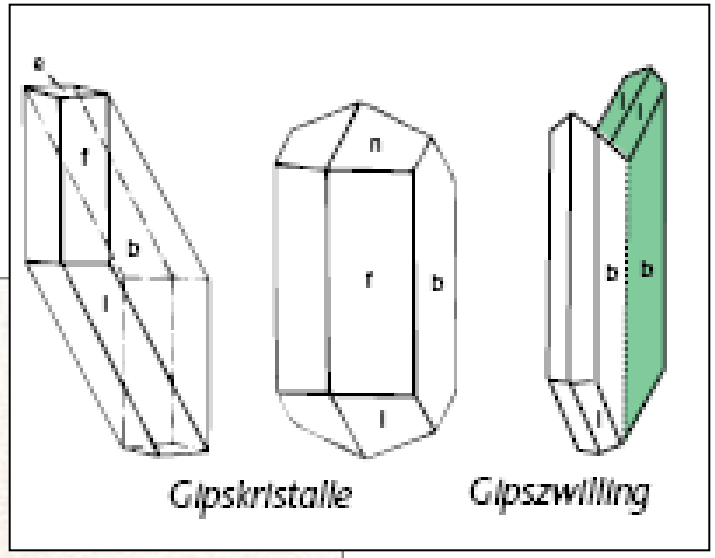
Calcium sulfates

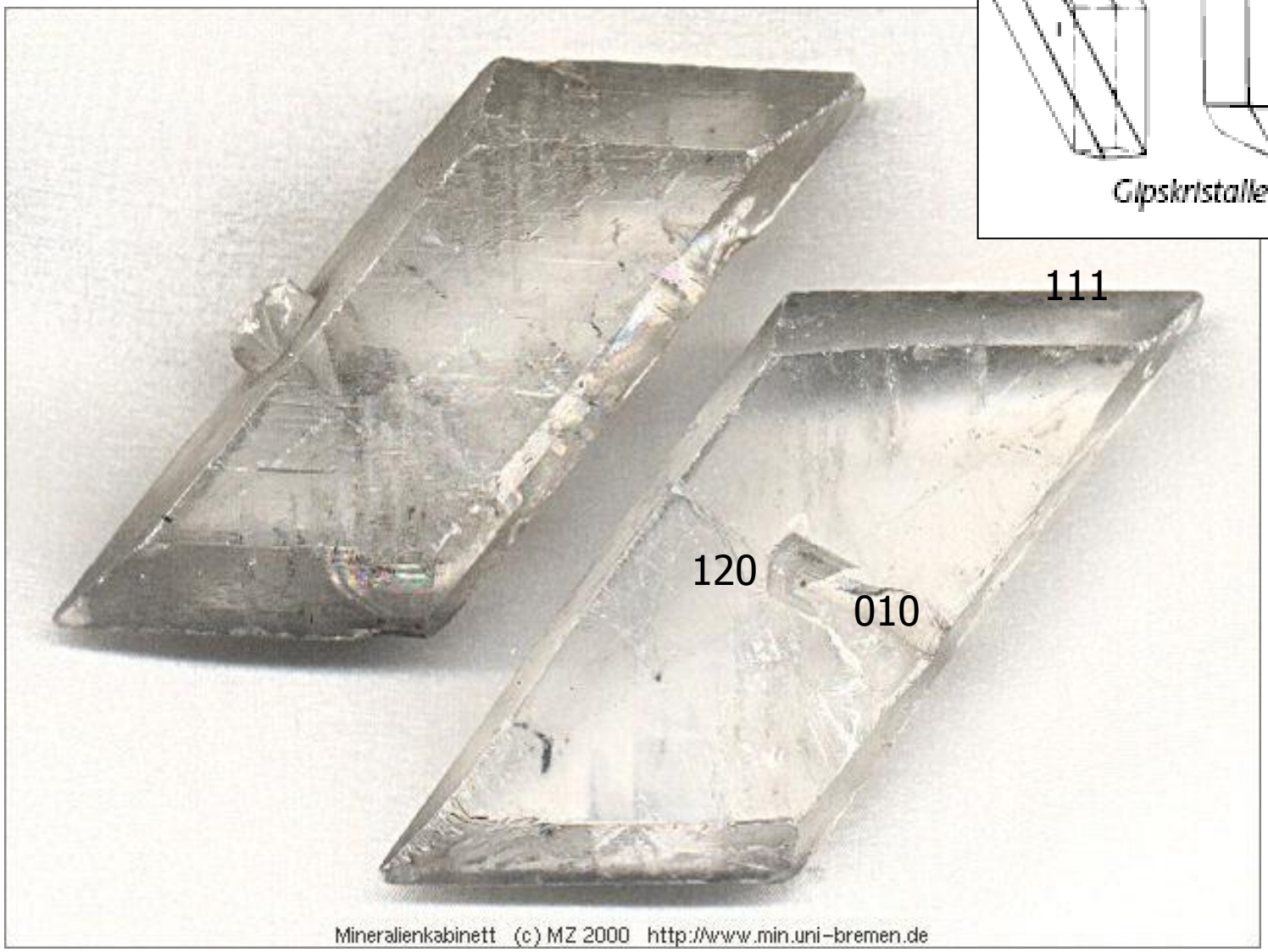
- **Gypsum** $CaSO_4 \times 2\ H_2O$ (monoclinic)
  - hardness 2
  - density 2,3 g/cm^3
- **Anhydrite** $CaSO_4$ (orthorhombic)
  - hardness 3 - $3^1/_2$
  - density 2,9 g/cm^3

→ formed often together in evaporites.
→ gypsum may appear as tabular crystals (**gypseous spar**) and/or as butterfly twin

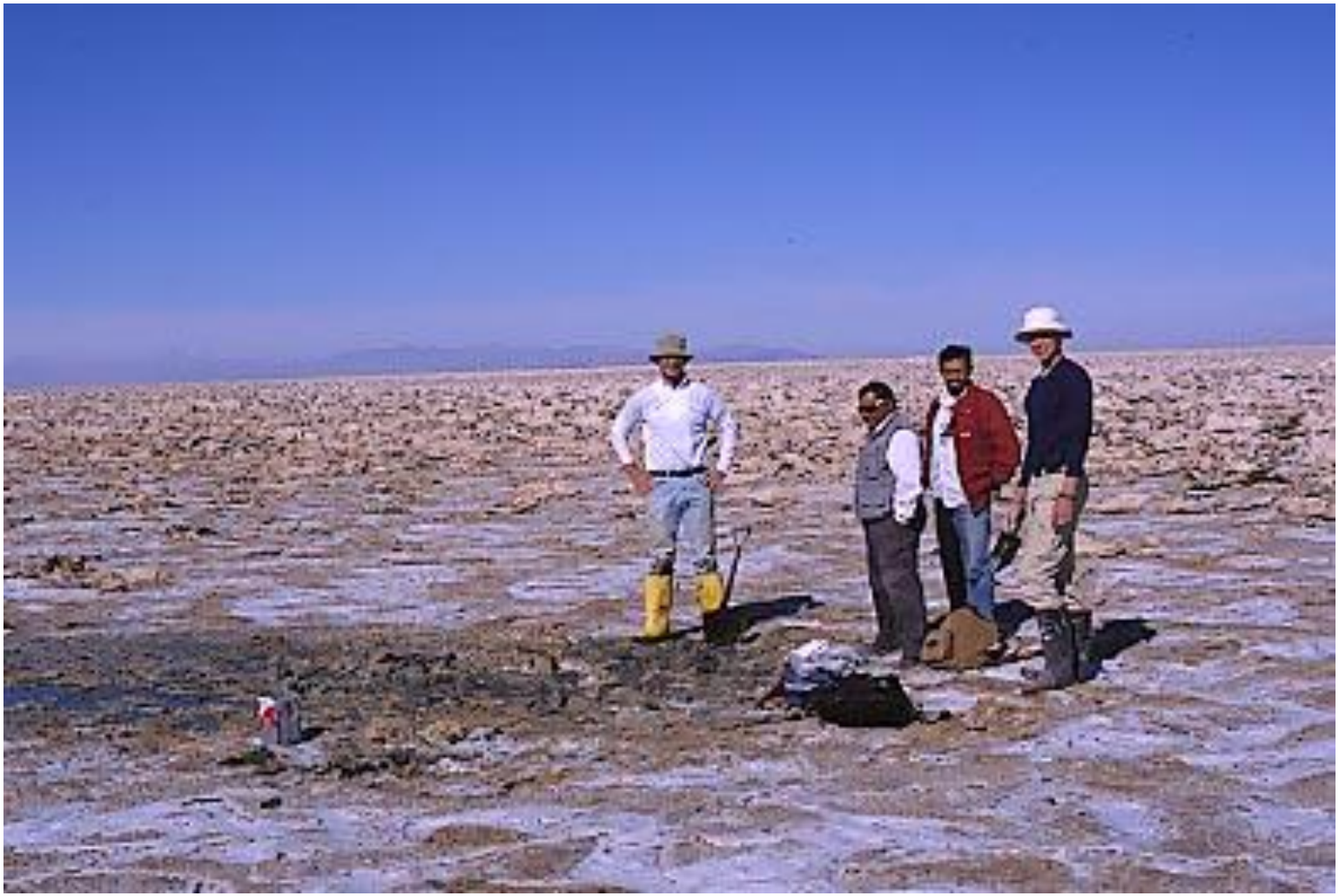
Gypsum ($CaSO_4$ x 2 H_2O)

Idiomorphic formed Gypsum crystals from Ellsworth, Mahoning, Ohio, USA..





Chemical sediments:
Gypsum and other salts at Salar de Atacama, Chile



www.geol.binghamton.edu/faculty/lowenstein/ata/slide/3

Barite (heavy spar)

Baryt aus Felsöbanya, Ungarn

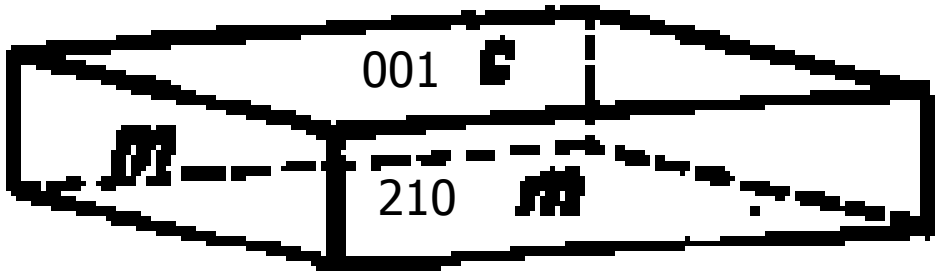
- $BaSO_4$
- orthorhombic
- hardness: 3 - $3^1/_2$
- density 4,5 g cm^3
- colorless (sometime light pink, light blue, light yellow)
- usually tabular, crystals with good cleavage
- formed in hydrothermal mineralization and sedimentary.

Barite (heavy spar)

Importance as raw material:

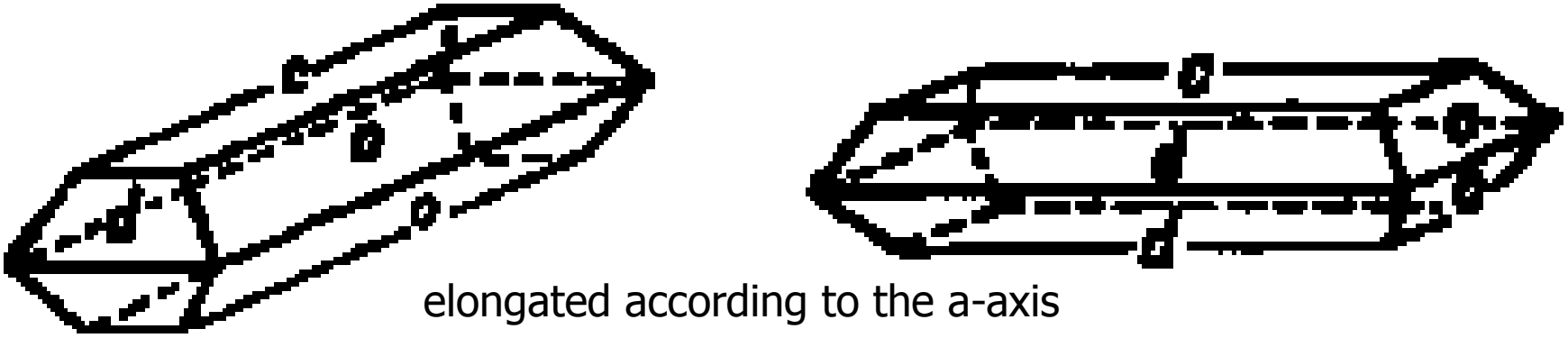
- raw material for white color
- for weighting of the drilling water in oil and gas drillings
- barium meal in the medicine as radiation protection in the x-ray procedure
- part of barium concrete

Barite crystals



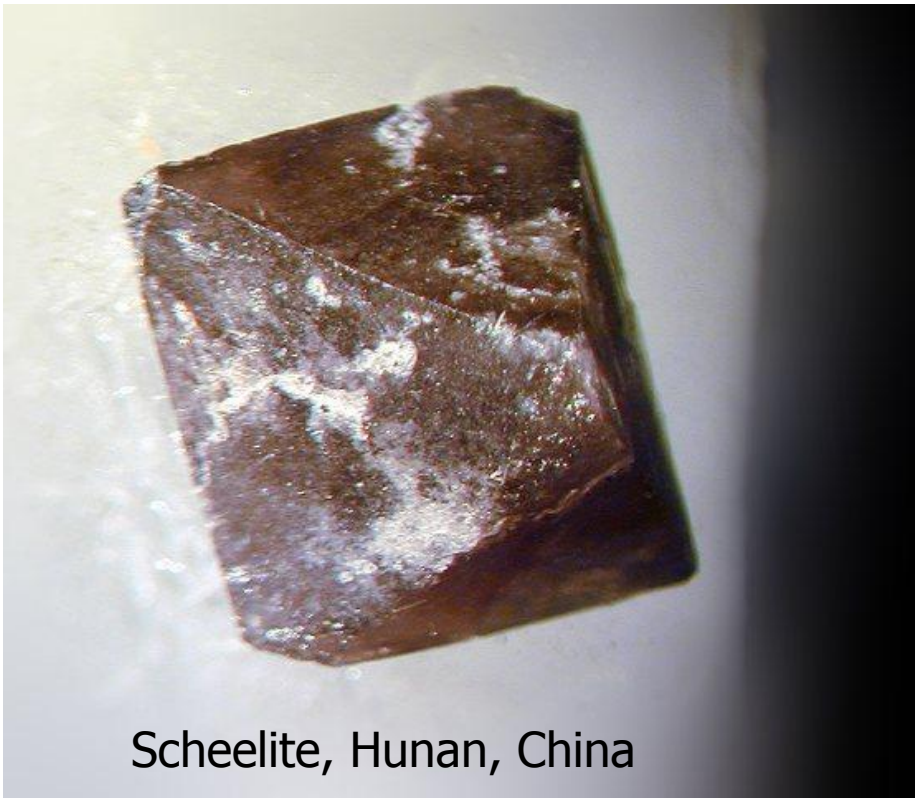
tabular according to (001)

elongated according to the b-axis



elongated according to the a-axis

Wolframates


Scheelite, Hunan, China

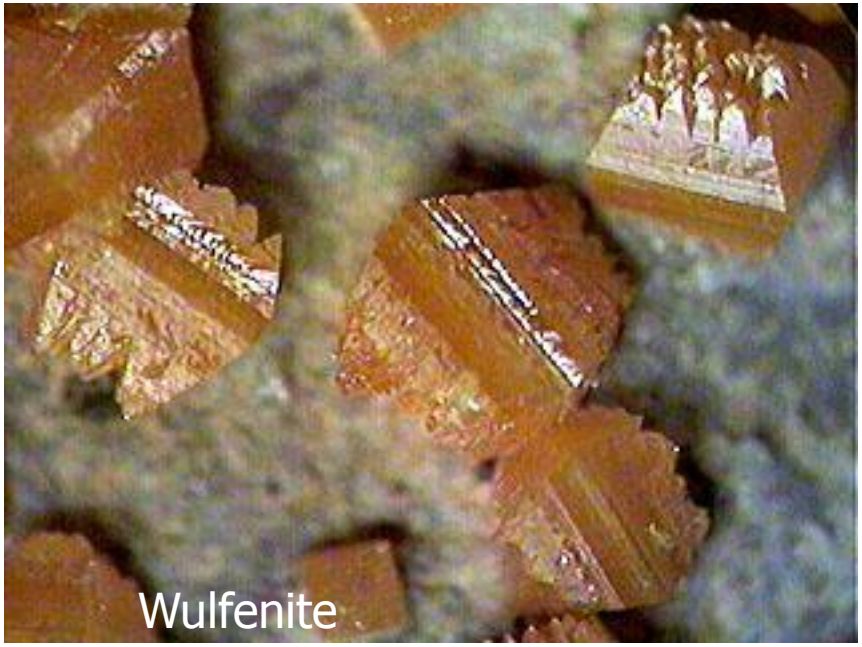
- (Fe, Mn, Ca) WO_4
- monoclinic
- hardness 5-5,5
- density 6-7,5 g/cm^3
- wolframite and scheelite are the main wolfram ores
- complete solid solution between $FeWO_4$ and $MnWO_4$
- wolframates are formed hydrothermal together with cassiterite, molybdenite, pyrite and chalcopyrite.
- wolfram is a steel refiner and cathode material for X-ray tube

Molybdates and Chromates

- chromates and molybdates are formed in the nature only in presence high oxygen-concentrations and are relative rare.

- the main mineral of this group: wulfenite ($PbMoO_4$)

- wulfenite may to replace molybdenite (MoS_2) pseudomorphic (pseudomorphism).


Wulfenite

VII. Phosphates, Arsenates, Vanadates

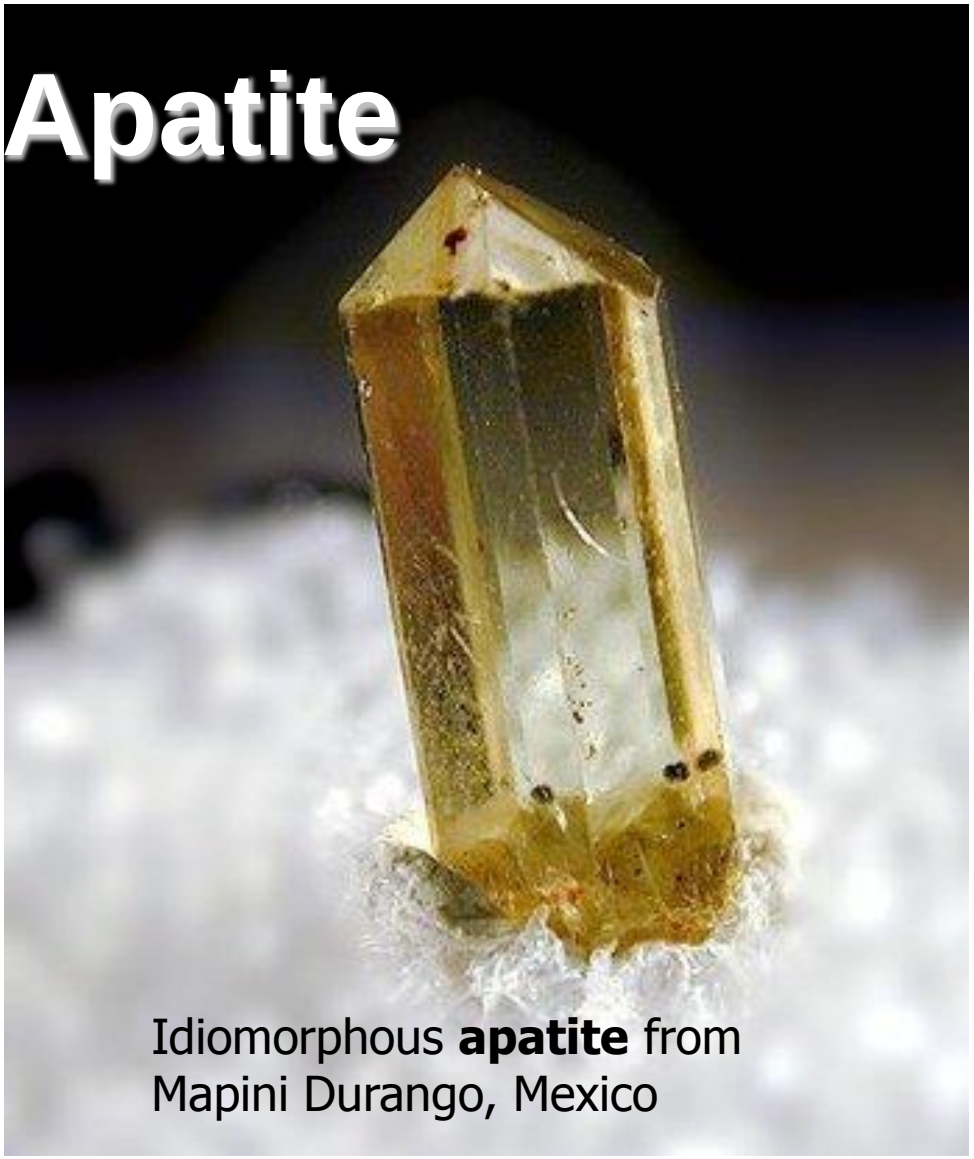
- for phosphates is bonded the 2-fold negative anions complex $(PO_4)^{2-}$ to different cations.
- 2-valued cations: iron, magnesium, copper and calcium
- 3-valued cations: iron, aluminium, lithium and rare earths
- 4-valued cations: lead, thorium, and zirconium
- the type of cations determines the specific weight, color and often also the economic significance .

wavellite

Apatite

- $Ca_5(PO_4)_3(F,Cl,OH)$
- hexagonal
- hardness 5
- density 3,2 g/cm_3
- accessory in volcanic rocks, metamorphic rocks and sediments
- decimeter until meter size crystals in pegmatites

Apatite

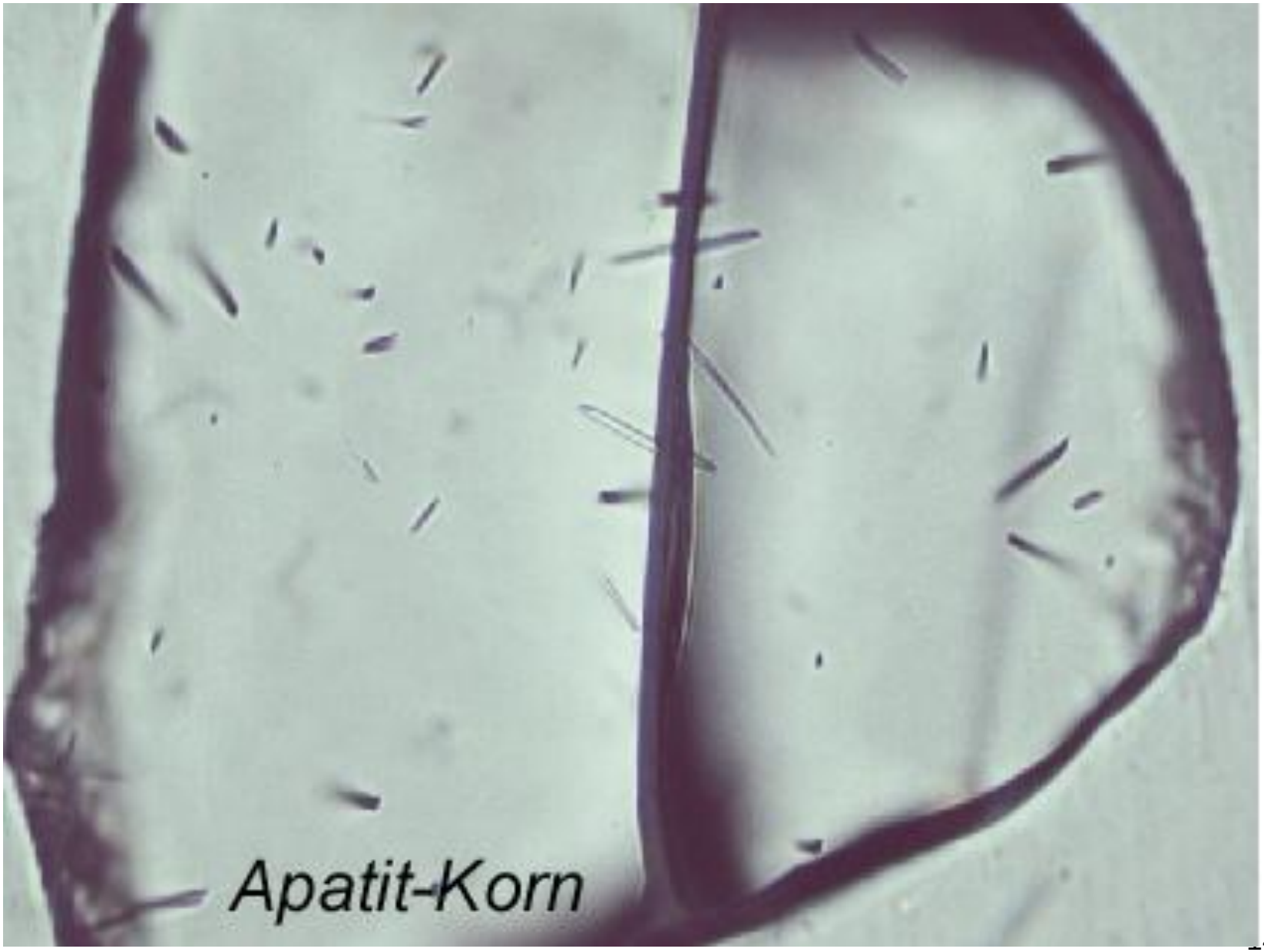


$Ca_5(PO_4)_3(F,Cl,OH)$

Apatite

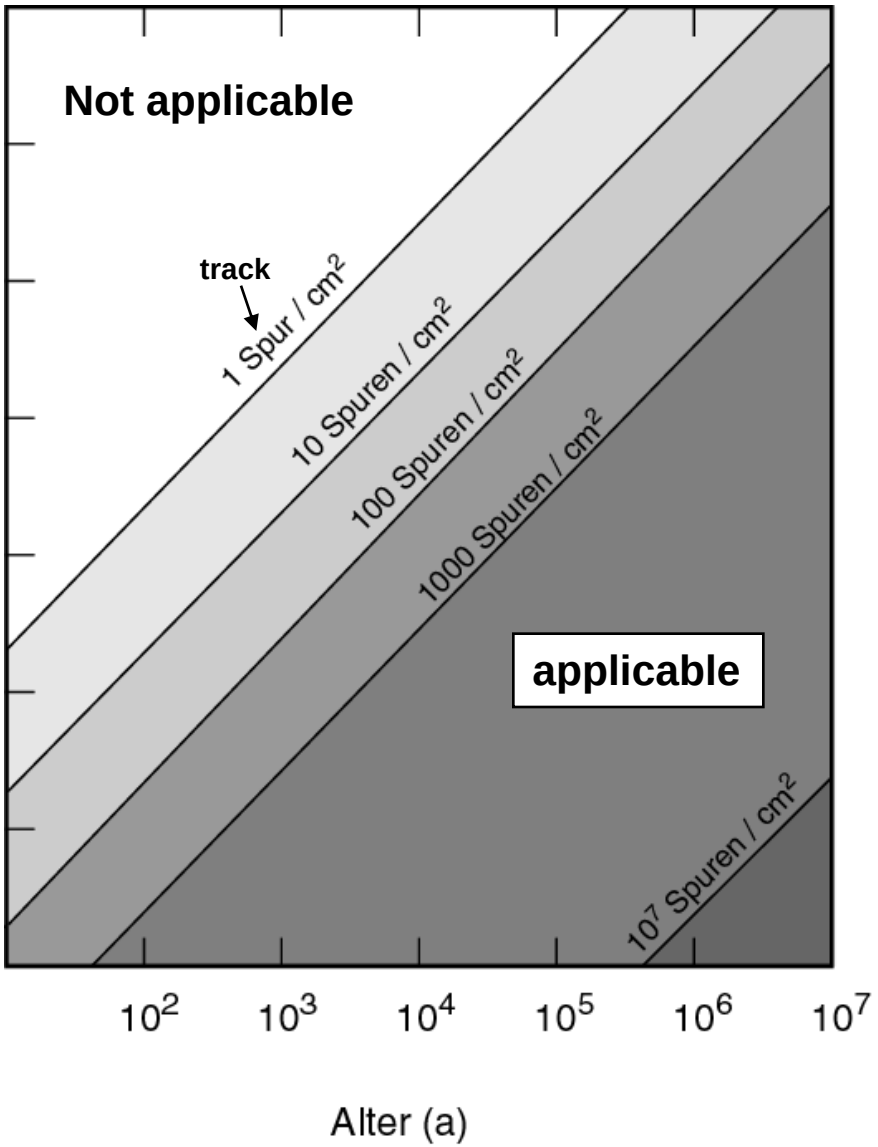
- crytocristalline major constituent of phosphorite ➔ fertilizer industry
- hydroxyapatite forms hard substances in bones (osteolithe) and teeths (odontholithe)
- contents radiogenic uranium ➔ decay produces fission track ages below the closure temperatures (<125°C) ➔ exhumation and erosion history of the mountains

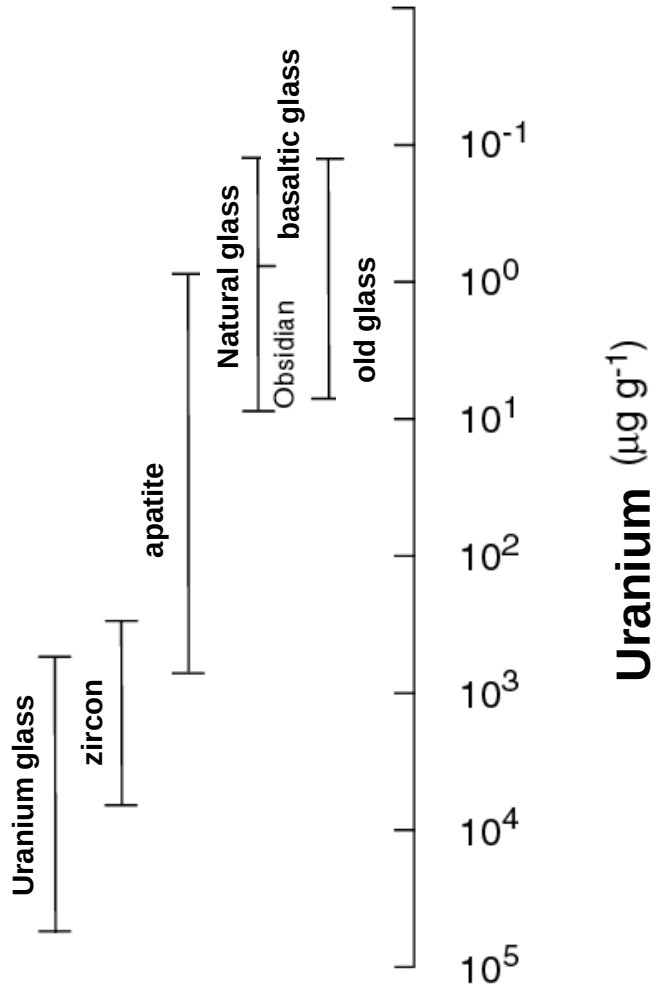
Model of fission tracks (Raab 2002)



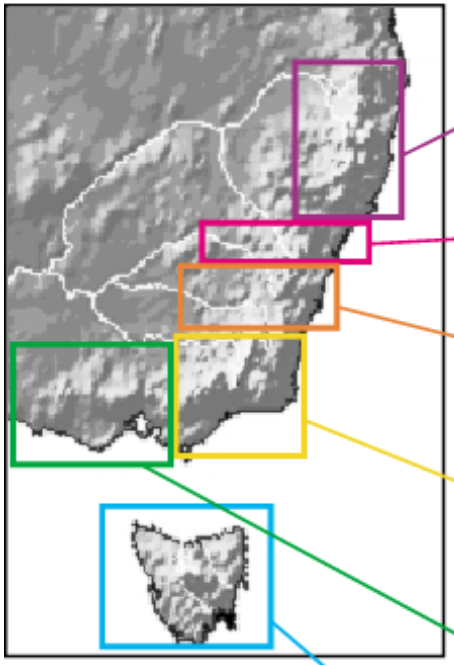
Fission track ages

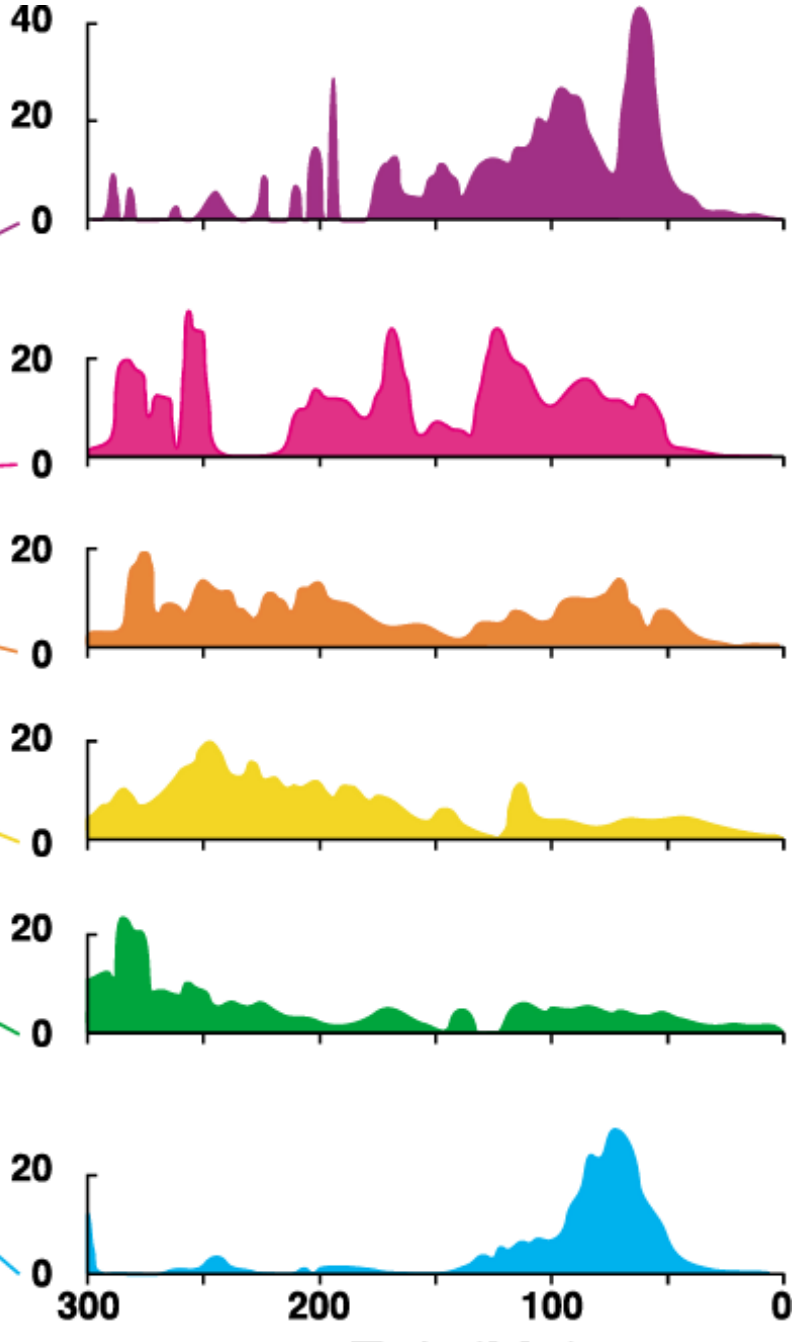
➔ Particles/Fission tracks in different minerals since below a certain temperature, below which the radiation damage does not heal more (>1000 years until > 200 Ma)





Derived from fission tracks
Denudation rates (m/Ma)





In south-western Australia

Turquoise

Lazulite from the Pretulalpe, Steiermark, Austria

- $CuAl_6[PO_4]_4 (OH)_8 \times 4\ H_2O)$
- weathering product of copper oxide and sulphide
- ornament and gemstone

Exercise 1:

A: Sufur can occur as anions and cations.
X: Oxygen can form simply and double negative anions .
V: The bivalent iron is smaller than the positive trivalent iron.
Z: The big halide ions occur only in salts.

M: Diamonds are formed under old cratons associated with high geothermal gradients.
N: Carbonates can be formed from the weathering of rocks.
O: Fibrous red iron ore constitutes a volcanic glass.
H: Calcite splits after rhomboedron, although it belongs trigonal crystal system .

R: There are three modifications of calcium carbonate.
Z: Carbonates contain, among others, the stable carbon isotopes ^{12}C, ^{13}C, ^{14}C, ^{16}O, ^{18}O.
X: Mg and Ca form in carbonates a full range solid solution.
Y: Carbonates can be dissolved in rainwater.

Exercise 2:

D: Apatite occurs in all magmatic rocks.

F: In fluor-apatite are formed fission tracks by means of decay of fluor.

R: Apatite is a mineral of the Moh‘s hardness scale and the hardest framework creator.

Z: Gypsum has a higher density than anhydrite.

H: Sulfides can be formed by weathering in the earth surface.

I: Pyrite can be formed in sediments under anoxic conditions.

J: Carbonates do not contain radioactive elements.

K: Sulphides can occur magmatic but not sedimentary.

A: Siderite and azurite form a complete solid solution.

B: Calcite splits after rhomboedron, because it belongs rhombic crystal system.

C: In the aragonite series are preferred small metal-cations than in the calcite series.

D: Sulfur occurs in barite.

Solution word of exercises 1-2 ??

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