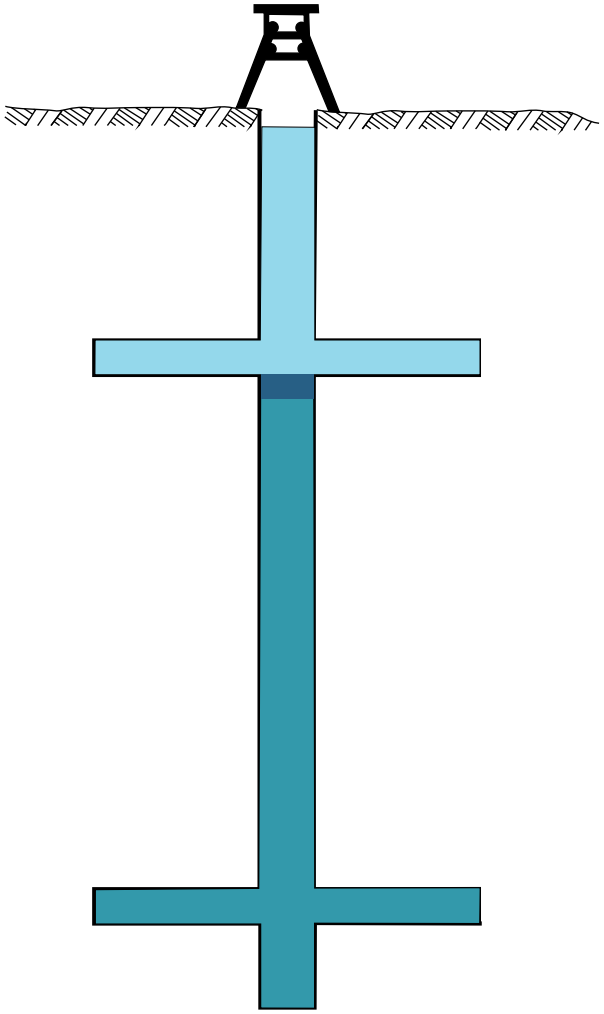
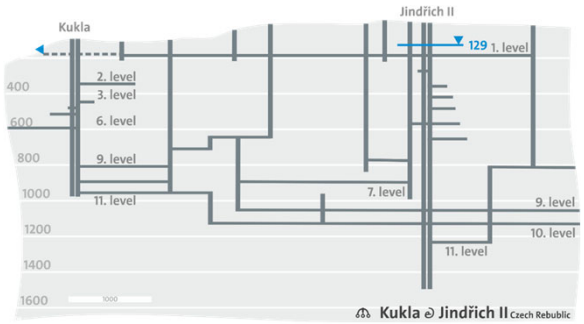


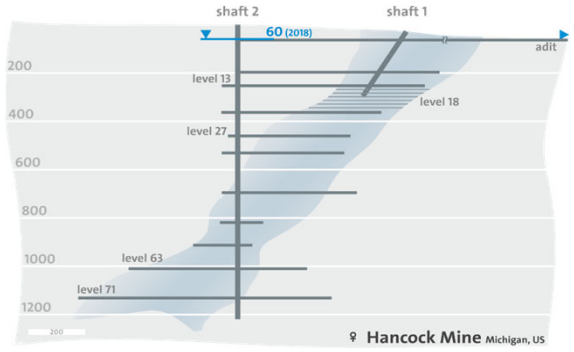
Advancing sustainable mine water management through understanding stratification in flooded underground mines

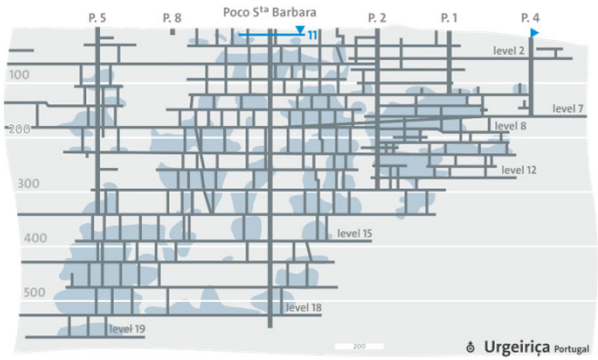
Elke Mugova & Christian Wolkersdorfer

TU Bergakdemie Freiberg | South African Research Chair for Acid Mine Drainage Treatment

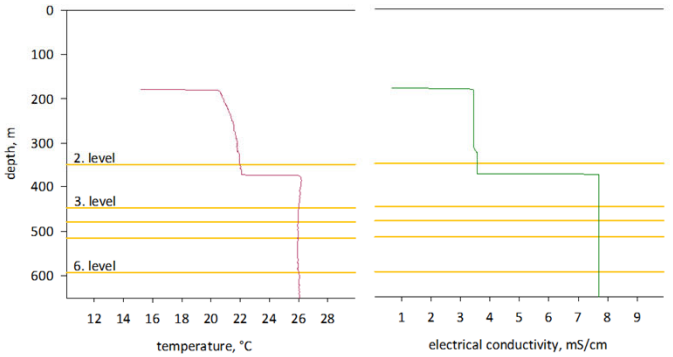
What do these flooded mines have in common?



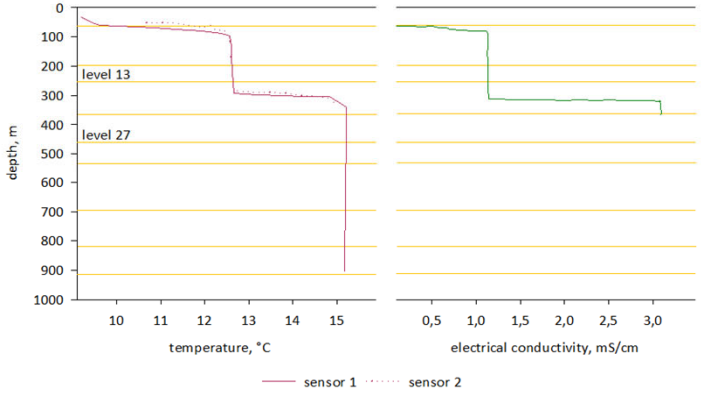




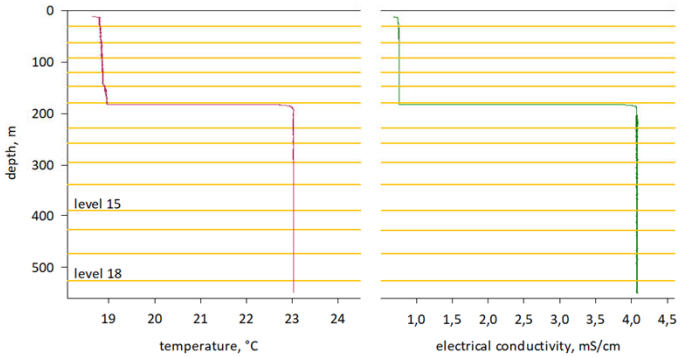
Rosice-Oslavany coal basin: Kukla shaft (2004-



Hancock Mine: Shaft 2



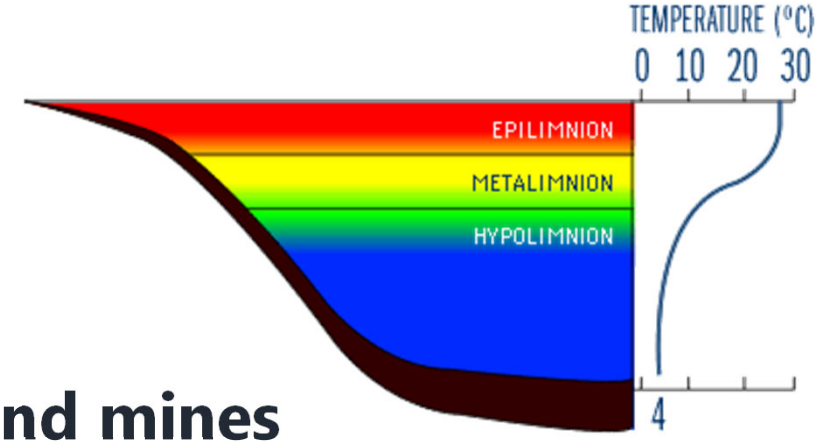
Urgeiriça mine: St. Babara shaft (2019-09-19)



stratified water bodies

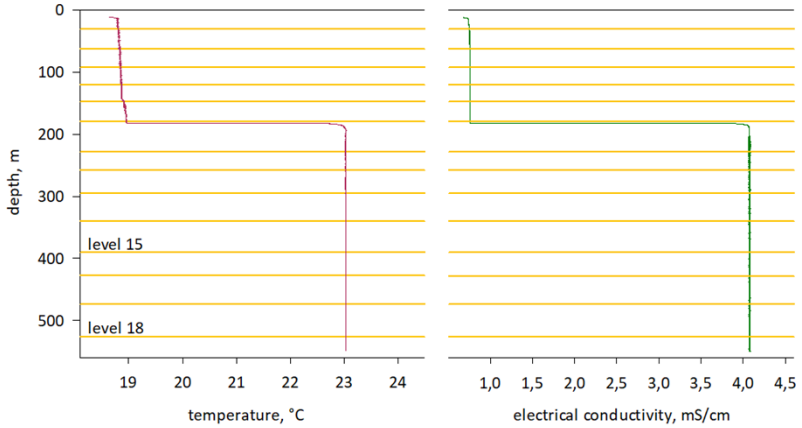
Density stratification

- Stratification mostly known
  from natural lakes and pit lakes

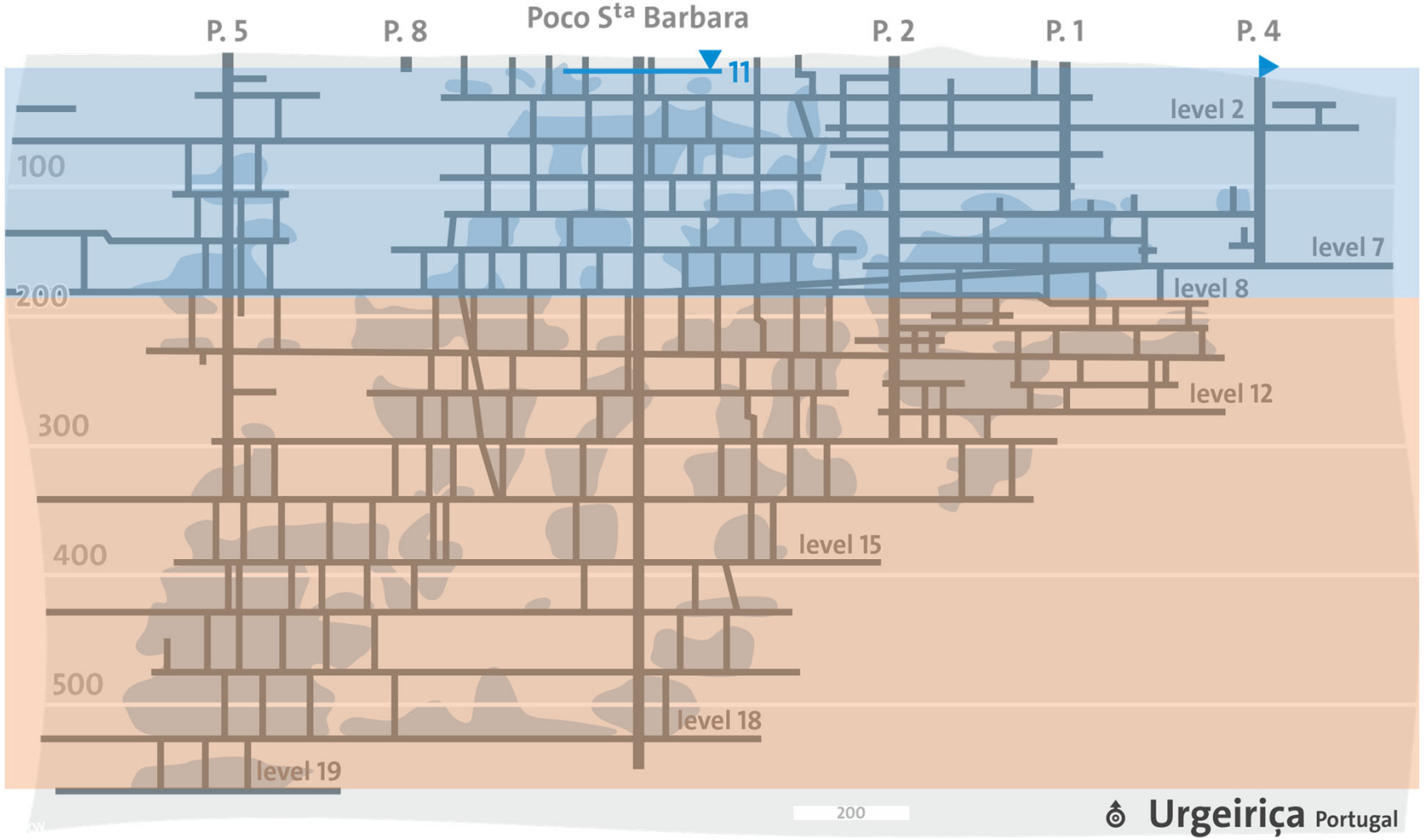


- but also occurs in **flooded underground mines**
  - studied since the 1960s
  - water samples or
  - use of downhole probes/dippers

➡ **electrical conductivity/temperature**



Example of stratified, flooded mine in Portugal

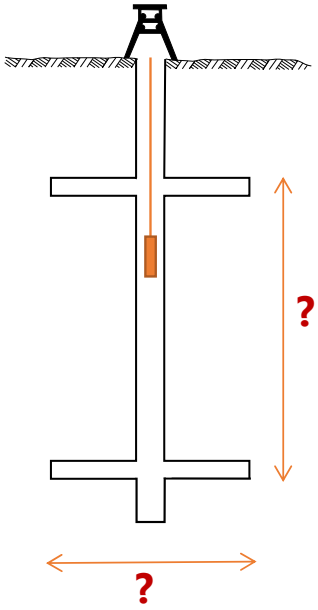


CF
cold fresh water body

WM
warm mineralised water body

Why is more research about stratification in mines needed?

- stratification in flooded underground mines not yet well know in the mine water community
- crucial for good mine water management decision
- only individual cases known, but no general overview



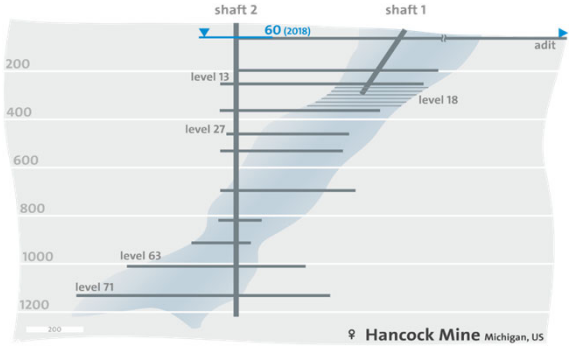
we

comprehensive assessment of over 60 mines,

29 with available **temperature/EC profiles** & available

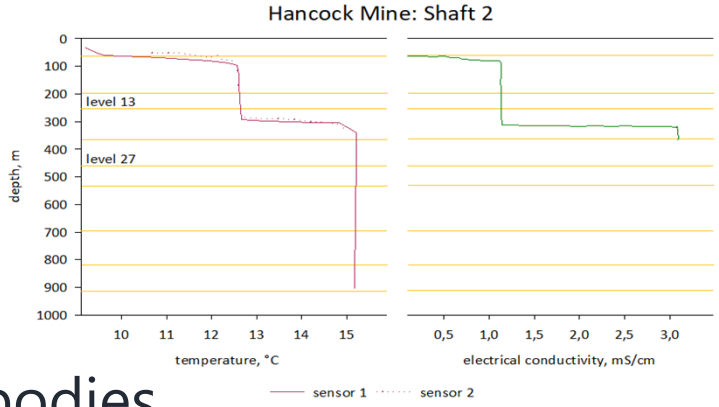
cross sections chosen to find **cross links** between the mines

Data acquisition for evaluation



- depth profiles and cross sections
  - 12 coal mines
  - 17 ore mines
  - predominantly flooded

  } **78** profiles in total



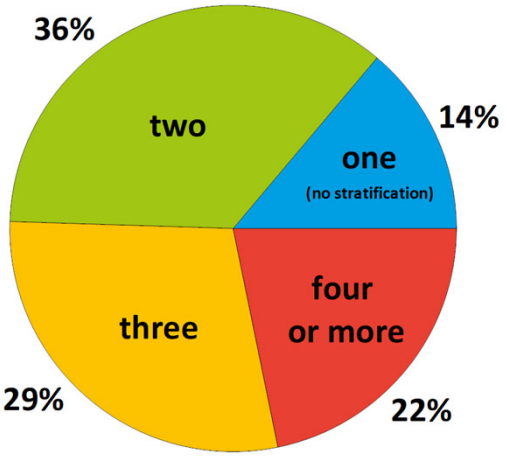
- **database** with specific subsets like
  - number of water bodies
  - depth of intermediate layer
  - mean/median temperature CF/WM water bodies
  - depth profile
  - depth mine shaft
  - …

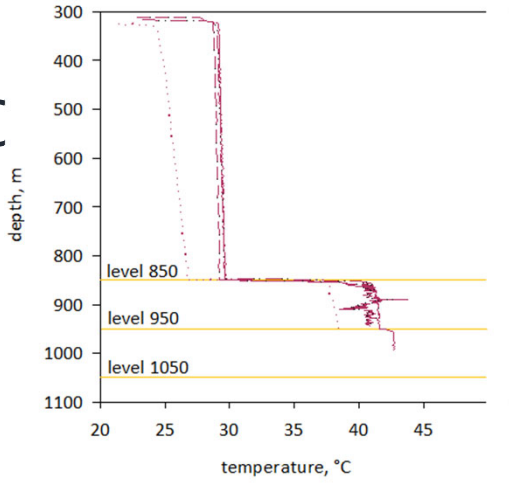
Results

- in most cases CF over WM water body
- no correlation between mine type (single shaft vs. multiple shaft) and stratification/number of water bodies
- mostly 2 or 3 water bodies
- large ranges of min/max water temperature and EC

  (e.g. CF water body 5.3°C – 31.8°C)
- large range of “jumps”

  (e.g. 0.1 mS/cm but also 163 mS/m)



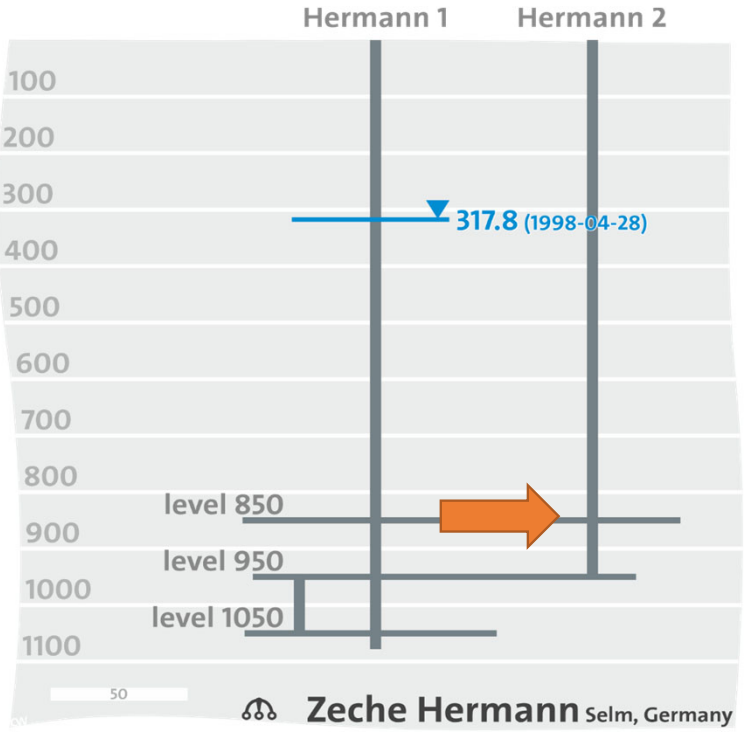


Results

- location of topmost intermediate layer (between CF and WM water body)

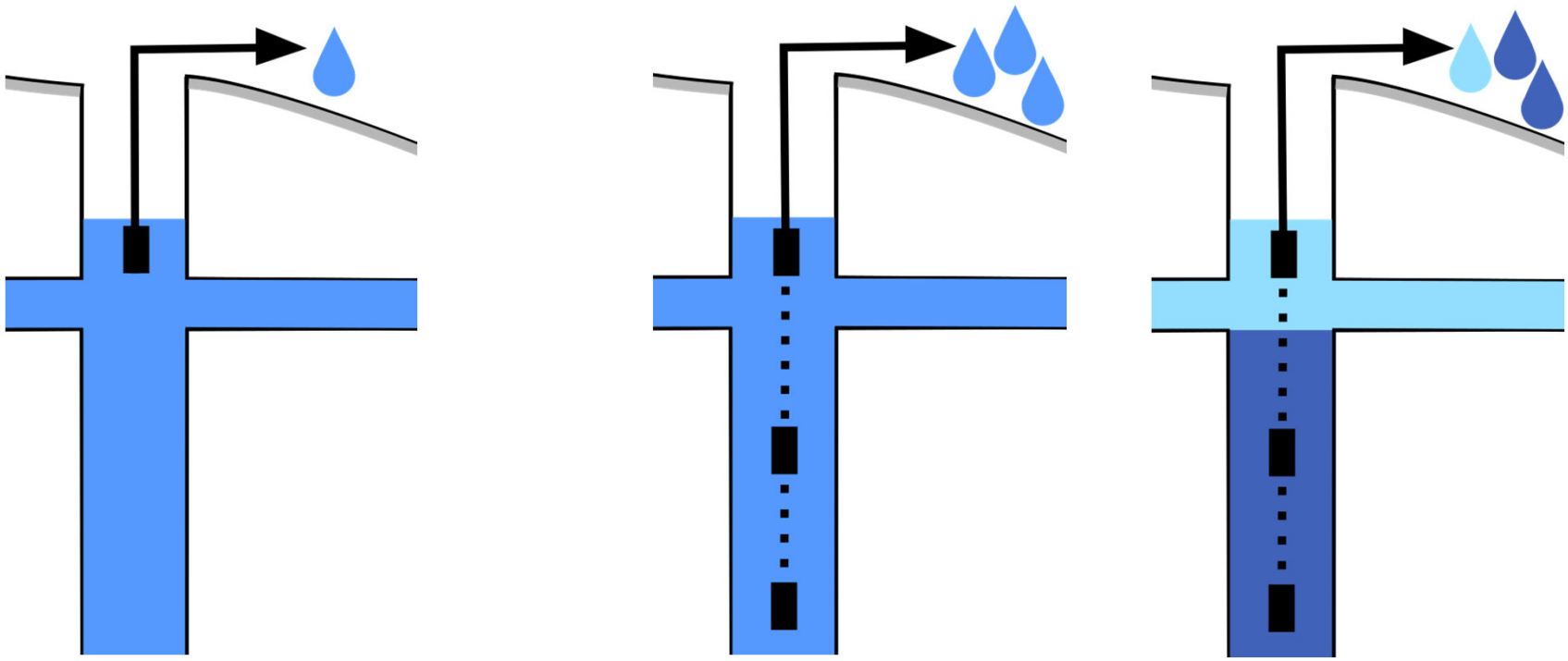
  → upper part of the mine, first or second connected level to the shaft

- **NO** stratification:
  - just a few flooded shafts with no stratification
  - connected galleries might have broken down (not proven)
  - disturbance of stratified water bodies when forced flow, e.g. **pumping activities** (proven)



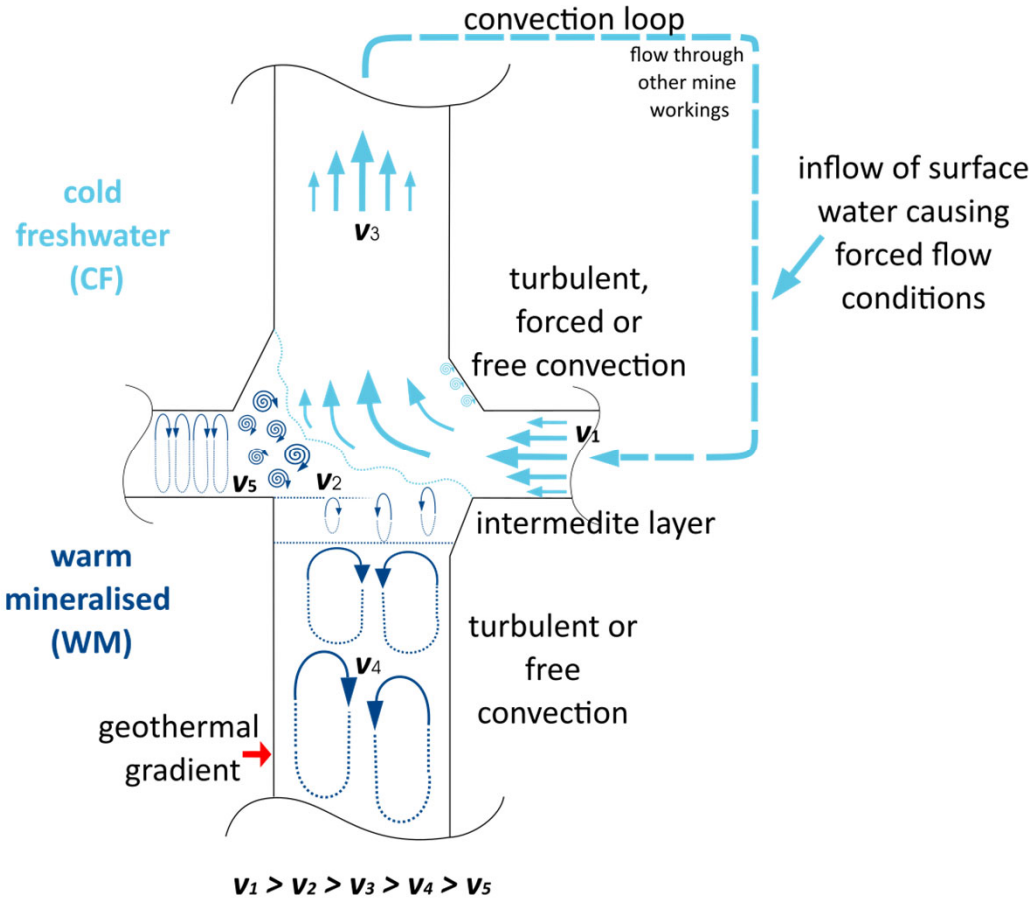
Is mine water stratification important for mine water investigation?

➡ Yes, can change results and influence decisions

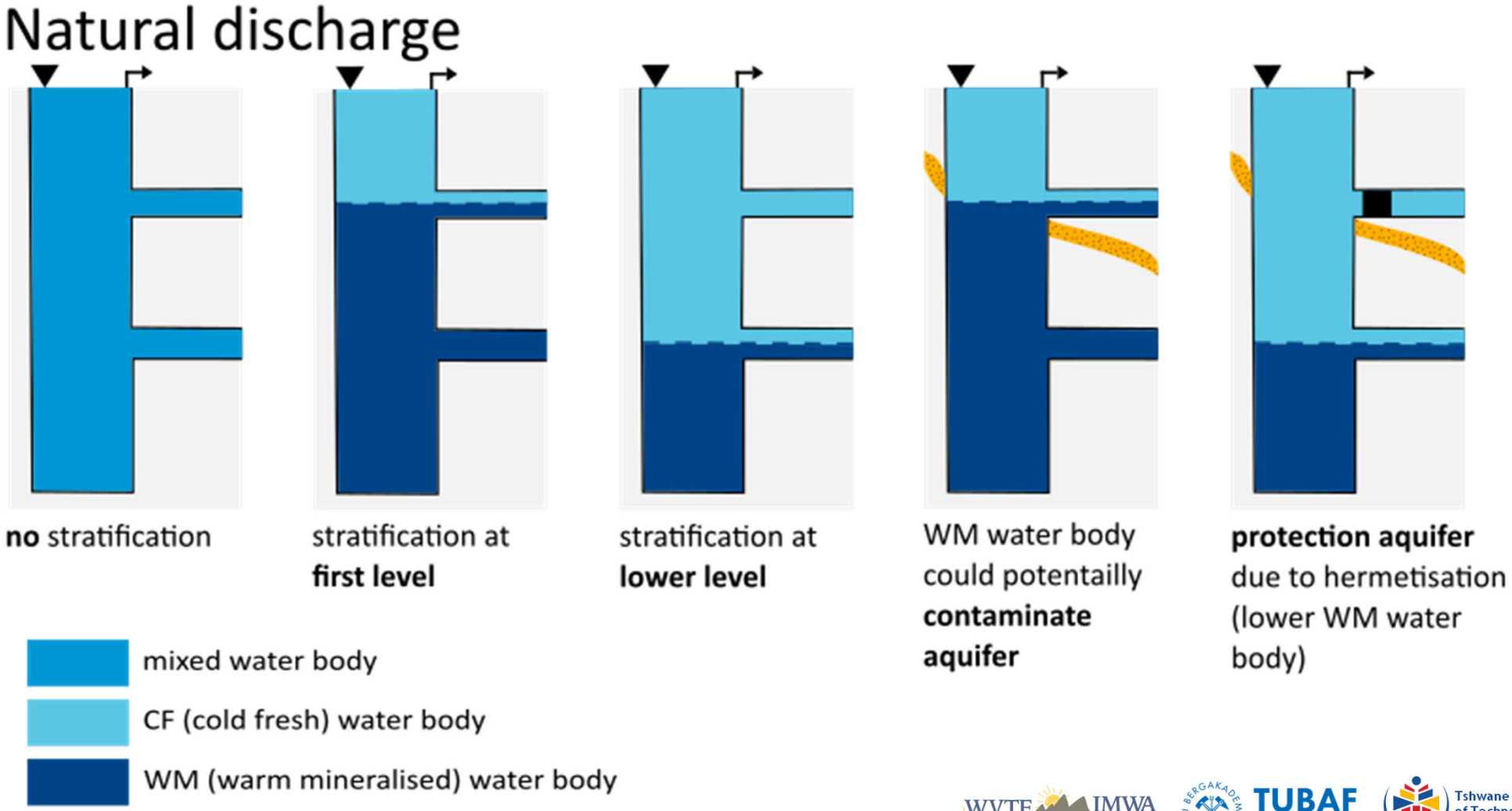


Further Discussion

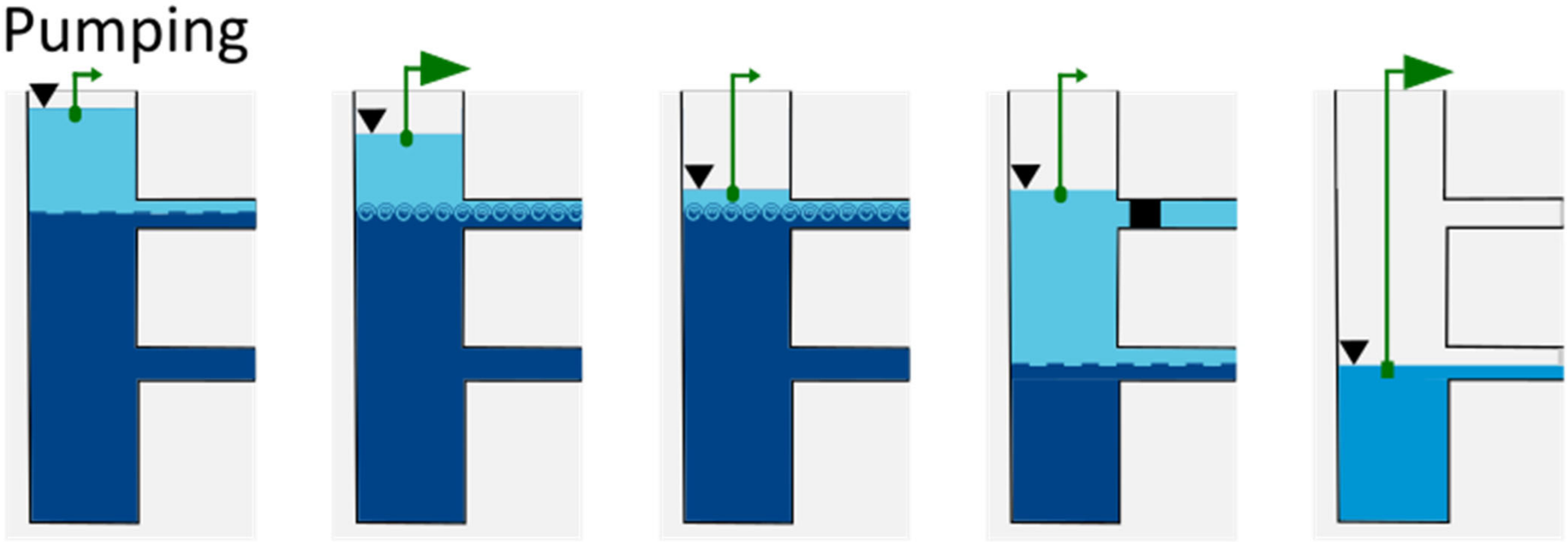
- from observations: boundary between CF and WM water body mainly determined by infiltration water
- different hydrodynamic processes that influence **occurrence** and **location** of stratification



Overview of different stratification scenarios



Overview of different stratification scenarios



low pumping rate, pump above stratification → stratification breakdown less likely

high pumping rate, pump above stratification → stratification breakdown likely

pump **close** to stratification → stratification breakdown likely

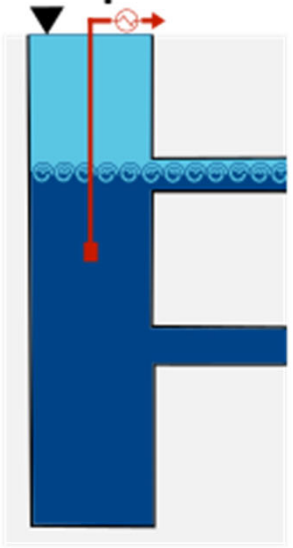
hermetisation of first level, stratification at lower level → stratification breakdown less likely

dewatering → stratification breakdown

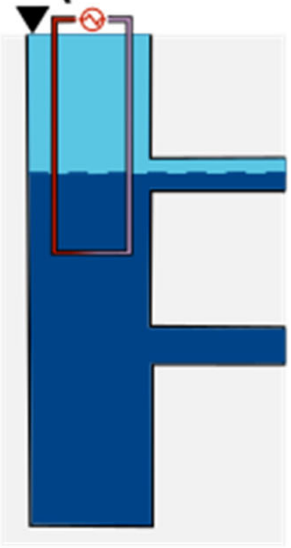
Overview of different stratification scenarios

Geothermal exploitation (without lowering water level)

pump rate equals withdrawal rate, **sufficiant distance** between pump and stratification
→ stratification breakdown less likely



pump rate equals withdrawal rate but **pump in WM** water body (below stratification)
→ stratification breakdown likely



closed loop system
→ stratification breakdown less likely

mixed water body

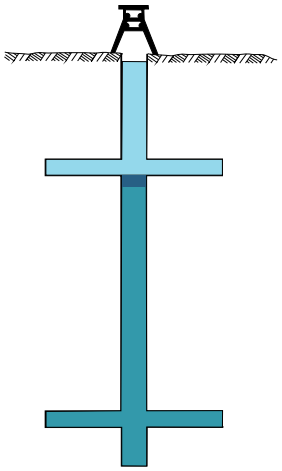
CF (cold fresh) water body

WM (warm mineralised) water body

Conclusions, Recommendations and Outlook

- **pumping** activities (forced flow) might breakdown stratification

➡ should be **avoided**, otherwise **deterioration** of **mine water quality**



- if pumping necessary (maintaining water level, geothermal exploitation)
  - **investigate** if stratification in mine water body
  - pump **low rate** and keep **distance** to intermediate layer
  - **don't switch pumps** on and off (change mine water beach)

Understanding of stratification and keeping stratification in flooded mines **stable** is essential for successful and sustainable mine water management!

Keep your eyes open for stratification!