BEDROCK AQUIFER CHARACTERIZATION BASED ON UNDERGROUND MINE SITE INVESTIGATION: RESULTS AND OPPORTUNITIES

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MINING & MINE WORKINGS

We know

Impacts on
- Economy
- Environnement

We know less

Research opportunities (fundamental and applied) on:

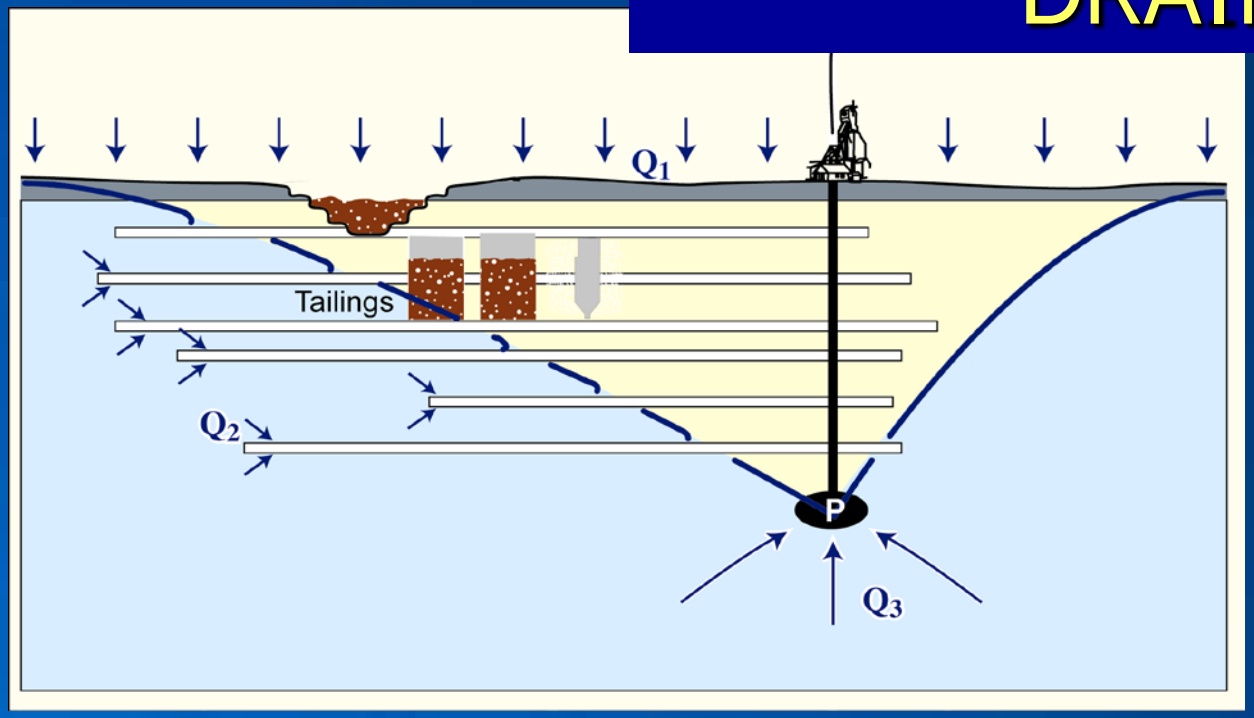
- Hydrogeological (H)
- Geomechanical (M)
- Geochemical (C)

} phenomenas

SUMMARY

1. **UNDERGROUND MINE DEWATERING**
2. HYDRO-MECHANICAL (H-M) PROCESSES
3. HYDRO-CHEMICAL PROCESSES (H-C)
4. REGIONAL HYDROGEOLOGICAL STUDY
5. CONCLUSION

EFFECTS OF MINE DRAINAGE



Important gw pressure decrease and water table drawdown, except:

- very low-*K* rock mass
- constant-head surface boundary, *e.g.* a lake

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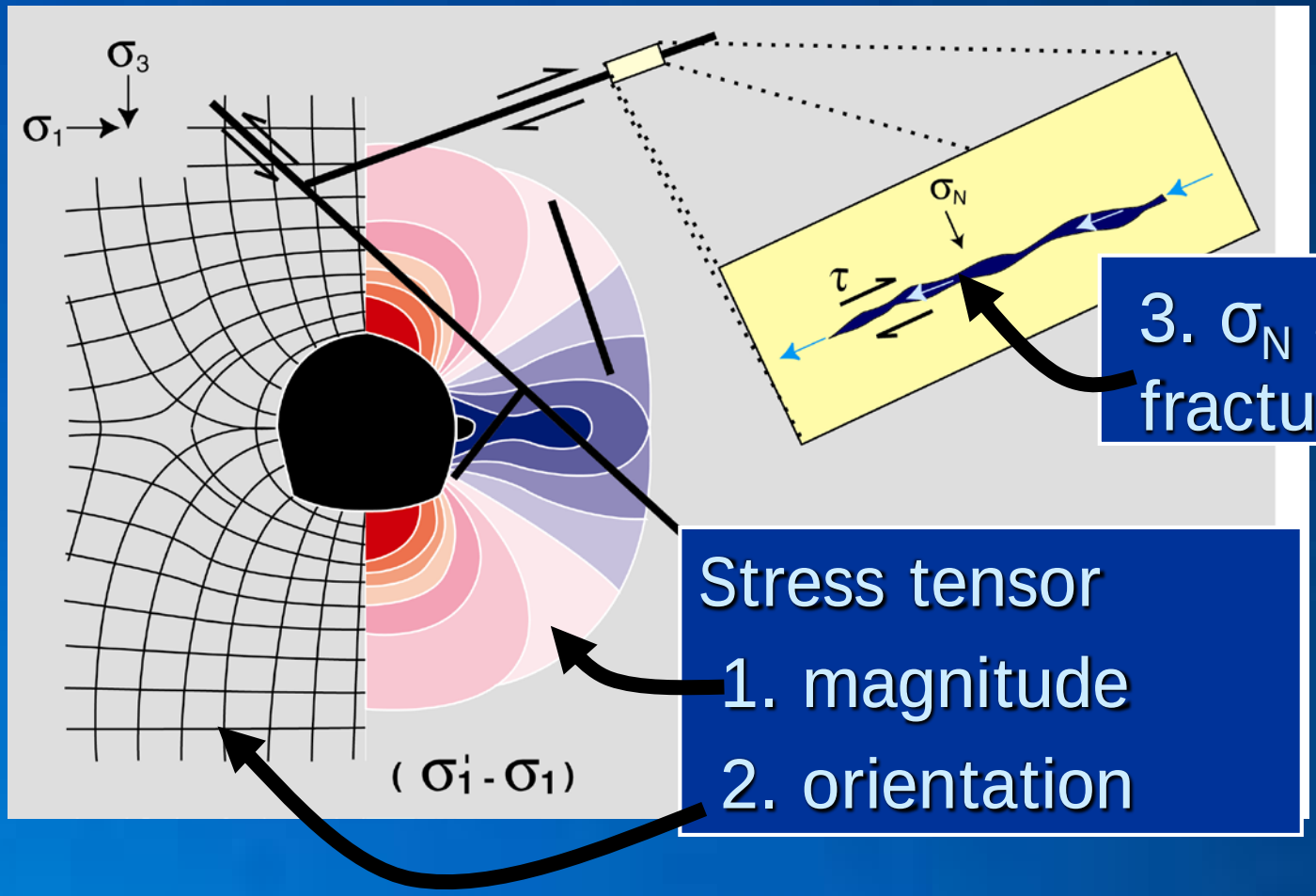
HYDRO-MECHANICAL (H-M) PHENOMENA

An excavation induces variations on:



3. σ_N & τ on fracture planes

Stress tensor
1. magnitude
2. orientation

Effects of σ_N & τ

- Numerous studies on the effect of normal stress variation (σ_N) on fracture transmissivity (T_f)
- Effects of shear stress (τ) variation is even more important:

  High T_f ⇧ (x10^2 +) after small shear displacement (≈ 1 mm), before failure

  (E. Lamontagne, 2001)

FURTHER QUESTIONS

- Field *vs* laboratory
- Incorporating in simulation models
- Stress disturbance around boreholes

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HYDRO-GEOCHEMICAL PHENOMENA AROUND MINE WORKINGS

- Hydrochemical & isotopic zoning
- Effects of hydrochemistry on rock mass permeability

HYDROCHEMICAL ZONING

Very recent recharge through desaturated rock mass

$O_2 \rightarrow SO_4^{2-} \uparrow$ pH ↓

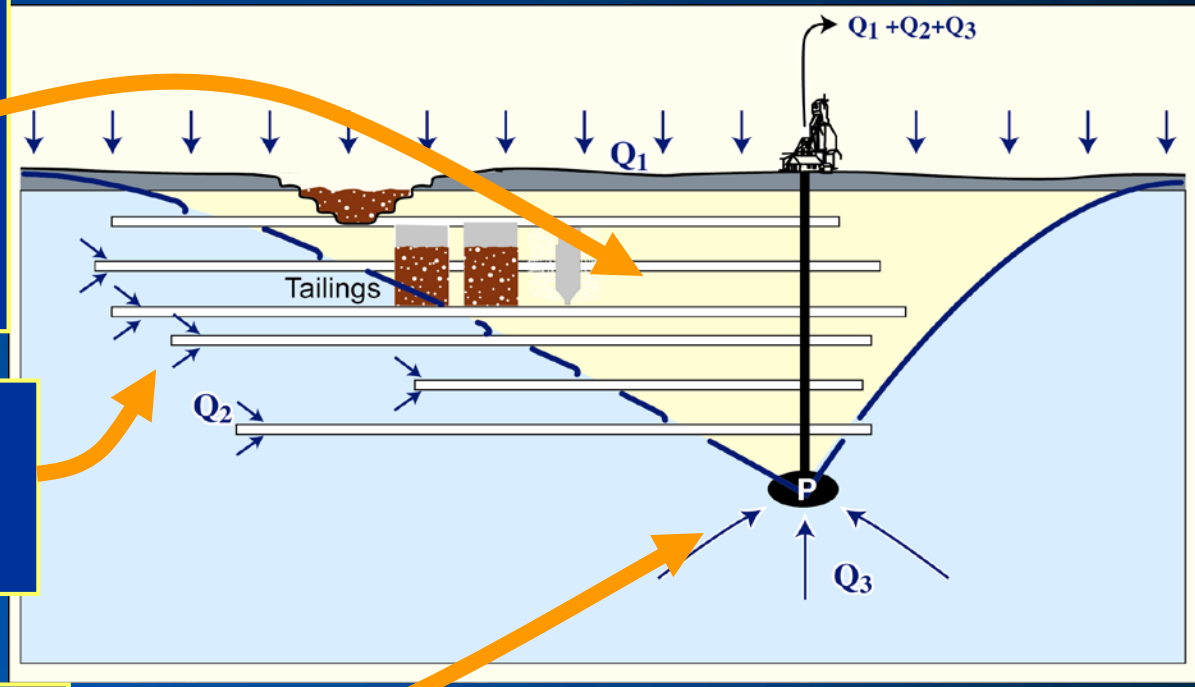
Modern recharge

TDS: 1,0 – 2,0 g/L

Deep brine

TDS: 20 – 80 g/L

Cl^{-1}: > 12 000 ppm



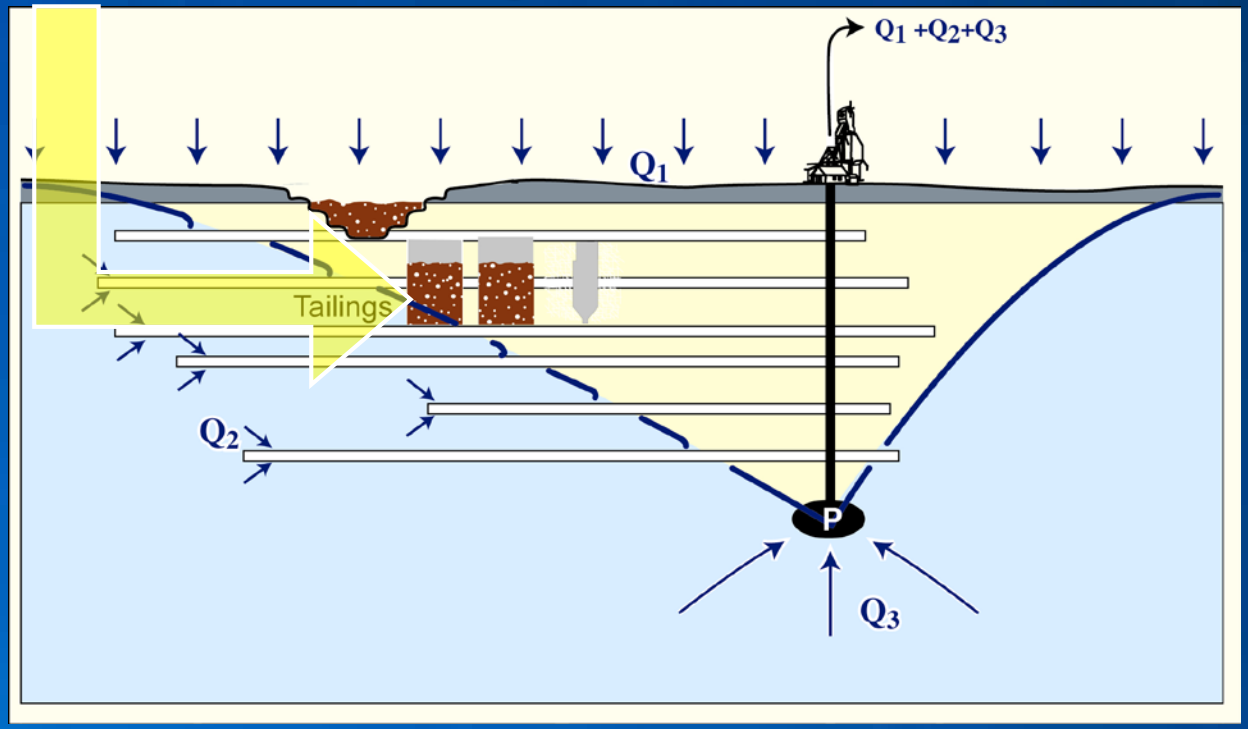
Ex: Mine Niobec (Que) (Benlahcen, 1996)

Similar zoning based on ^{3}H & ^{18}O isotopes

Ex: Con Mine, NWT (Douglas et al. 2000)

EFFECTS OF HYDROCHEMISTRY VARIATION ON HYDRAULIC PROPERTIES

Backfilling with sulfide-rich tailings



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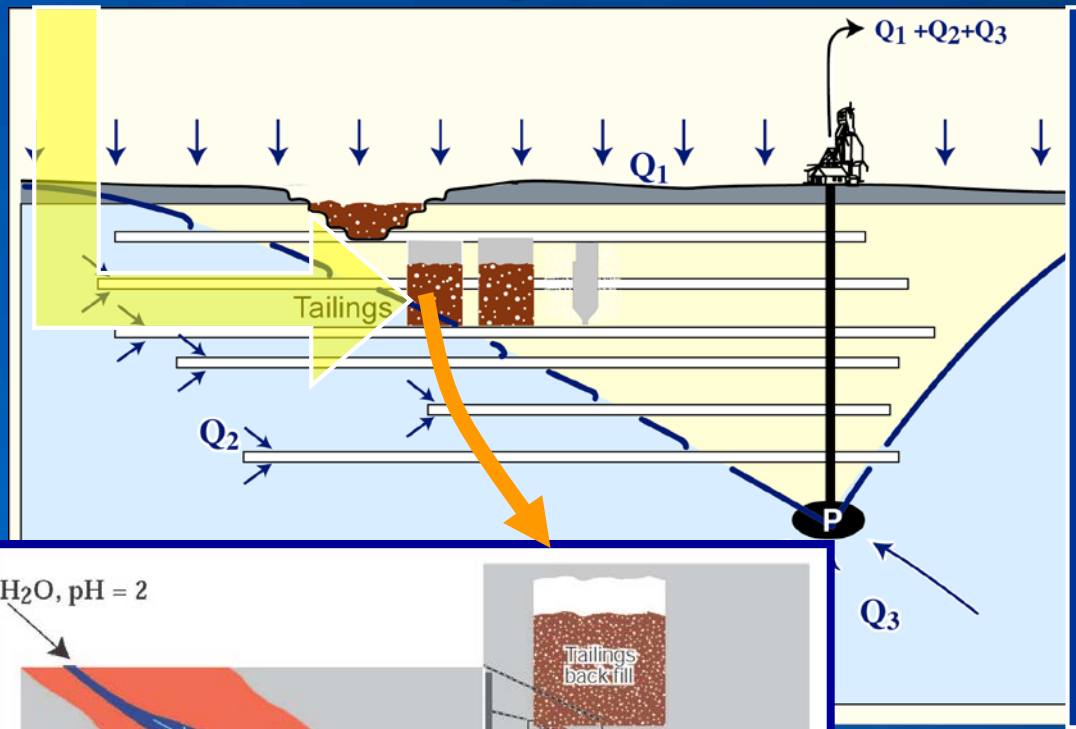

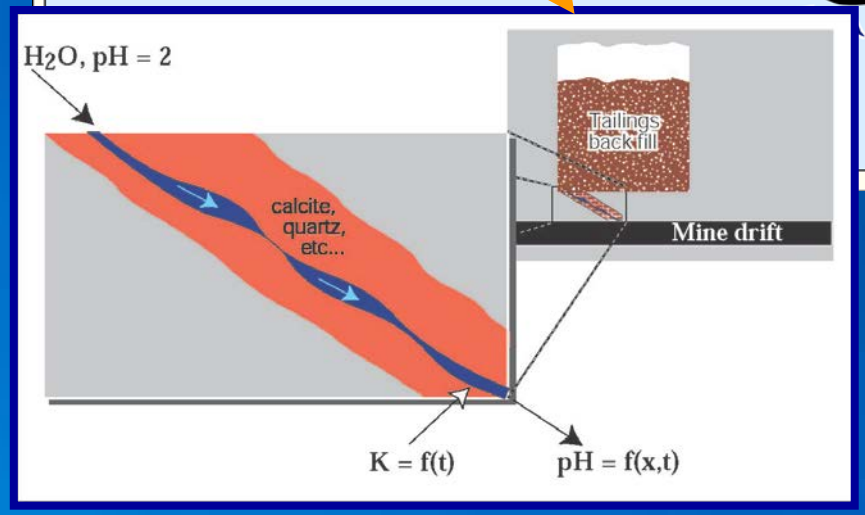

- Very low-pH water to deeper mine levels
- C –> H effects on fracture transmissivity (T_F)

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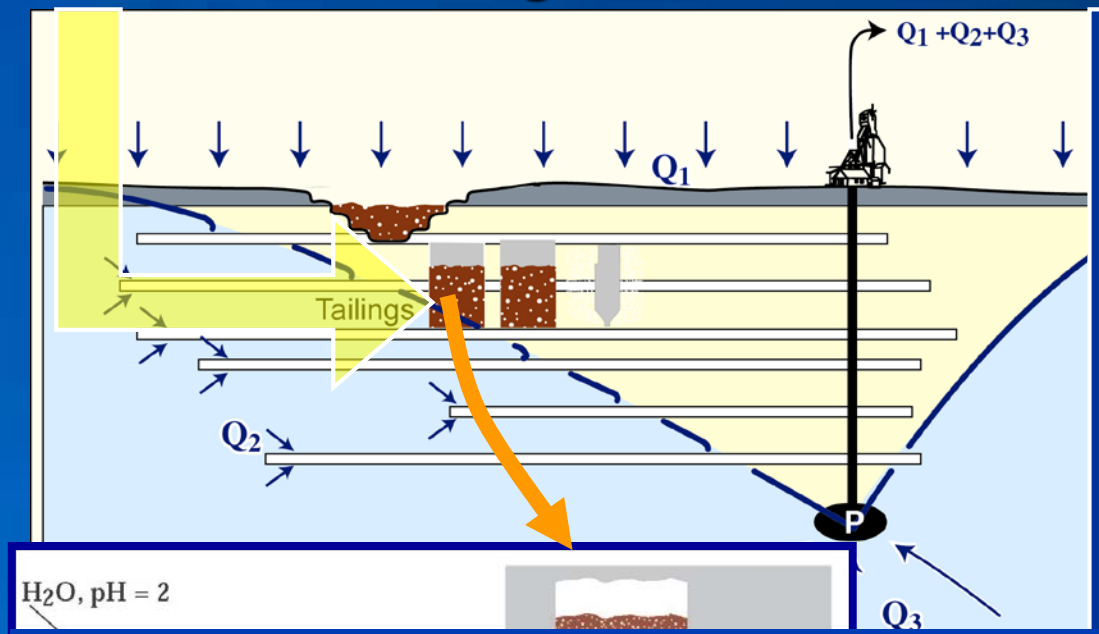

- Very low-pH water to deeper mine levels
- C –> H effects on fracture transmissivity (T_F)

Laboratory experiments:

- pH 2 –> T_F increases (calcite diss., channelling)
- pH 2.5 to 4 –> T_F decreases (oxy-hydroxyde precip.)

(A. Benlahcen, 2003)

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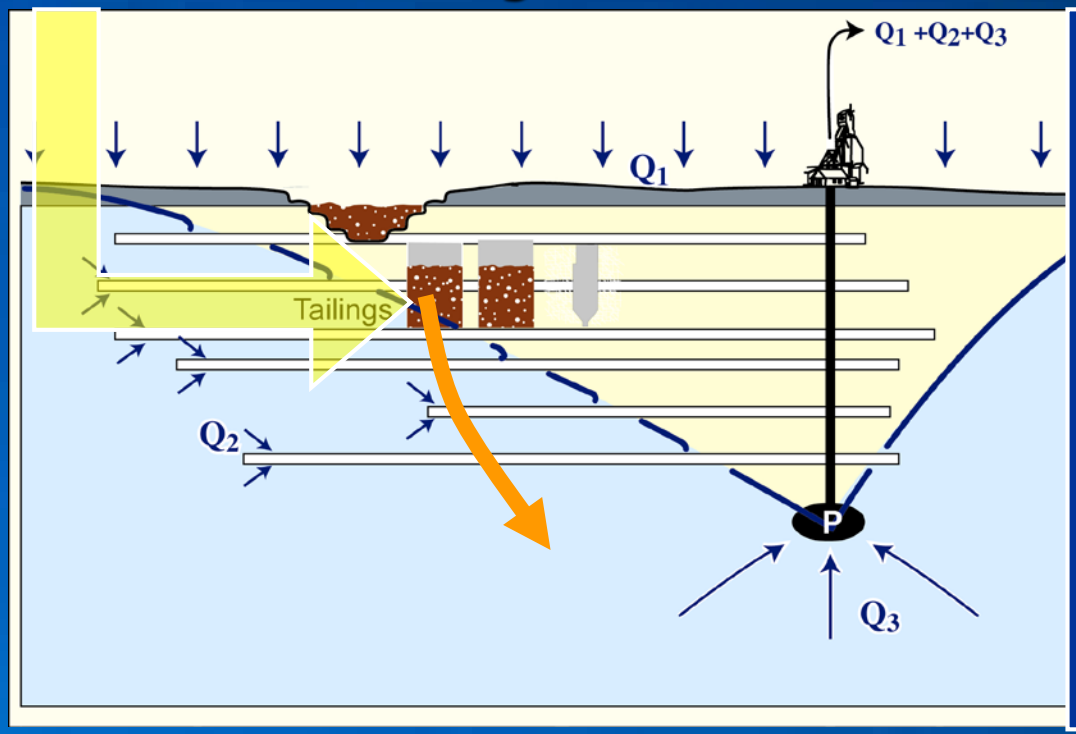

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FURTHER QUESTIONS

- Sequencial phenomena ?
- Process kinetics

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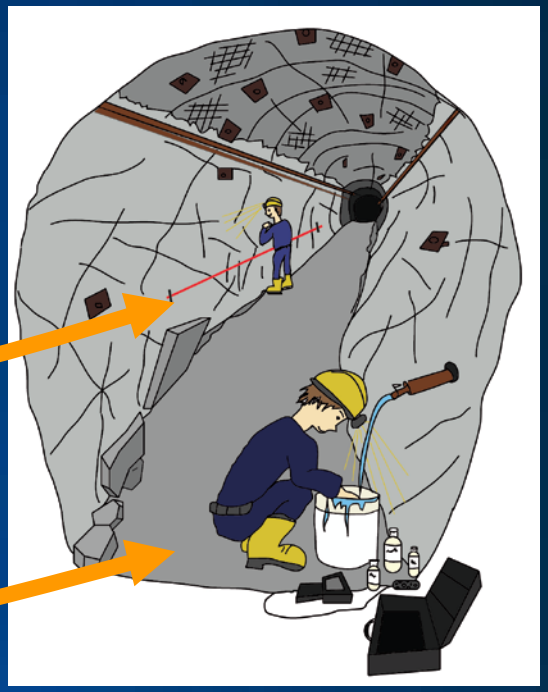
In spite of disturbances on geomechanical stress field, hydrochemistry and groundwater flow system

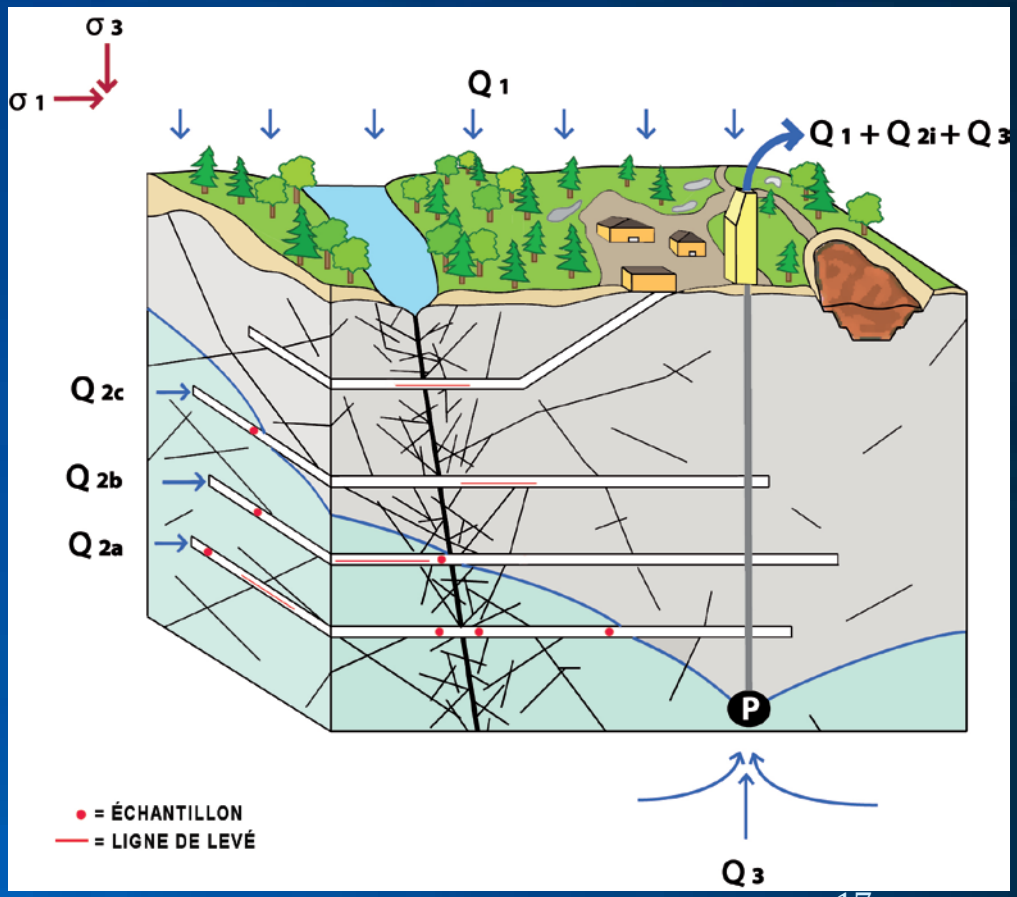
- Mine workings provide
  - Good observation windows for fractured rock aquifers
  - Numerous sampling points for groundwater



(E. B.Gagné, 2014)

In spite of disturbances on geomechanical stress field, hydrochemistry and groundwater flow system

- Important input in regional hydrogeological characterization
- Particularly in region with limited rock outcrops, *e.g.* Precambrian Canadian Shield

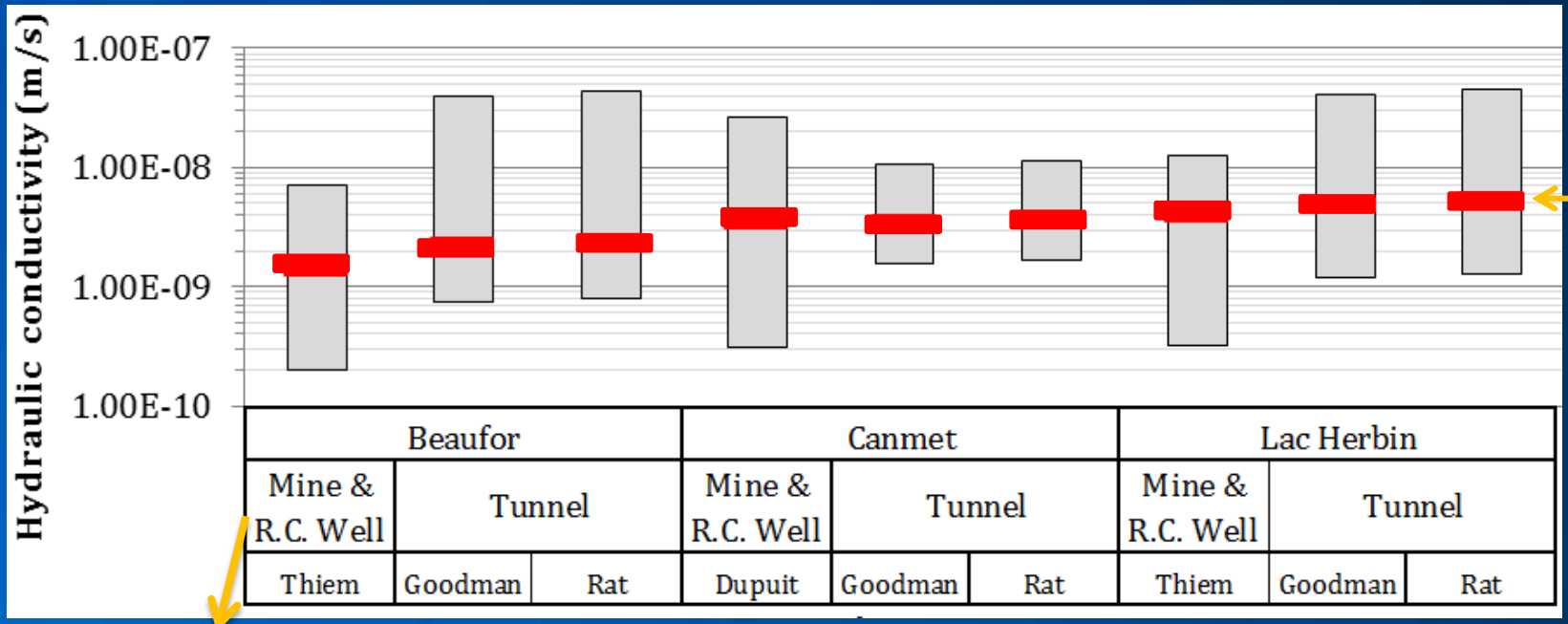


(E. B.Gagné, 2014)

An example: estimating rock mass *K* using analytical gw flow solutions and readily available data

- Analytical solutions developped to predict gw inflow to underground workings may be used to estimate *K* values of the bedrock around a mine
- Considered workings: tunnel, radial collector well, a mine as such
- Using realistic ranges of input values based on available data

Hydraulic conductivity estimates of the rock mass at 3 mine sites



Includes models developed for mines and for radial collector wells

(E. B.Gagné, 2014)

5. CONCLUSION

Mine workings

- Excavation and drainage

  Hydrogeological (H), geomechanical (M) and hydrogeochemical (C) disturbances

  ⇒ Studies on H-M-C coupling phenomena

- Access to fractured rock aquifers and groundwater sampling points

  ⇒ Important input in regional hydrogeological characterization

- Period of increasing mineral resources extraction

Thanks to

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Thank you for your attention