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
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:

1. magnitude
2. orientation

3. $\sigma_N$ & $\tau$ on fracture planes

Stress tensor
1. magnitude
2. orientation
Effects of $\sigma_N$ & $\tau$

- Numerous studies on the effect of normal stress variation ($\sigma_N$) on fracture transmissivity ($T_f$)

- Effects of shear stress ($\tau$) variation is even more important:

  High $T_f \uparrow$ ($x10^2$ +) after small shear displacement ($\approx 1$ 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

\[ \text{O}_2 \rightarrow \text{SO}_4^{2-} \uparrow \text{pH} \downarrow \]

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
Very low-pH water to deeper mine levels

C → H effects on fracture transmissivity ($T_F$)

Backfilling with sulfide-rich tailings
EFFECTS OF HYDROCHEMISTRY VARIATION ON HYDRAULIC PROPERTIES

Backfilling with sulfide-rich tailings

- 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)
Backfilling with sulfide-rich tailings

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

Further Questions

Sequential 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 developed 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

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<tr>
<th>Mine &amp; R.C. Well</th>
<th>Tunnel</th>
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Arithm. Mean

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
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Thank you for your attention