# Evolution de la mécanique des roches
# Point de vue d'une entreprise de GC

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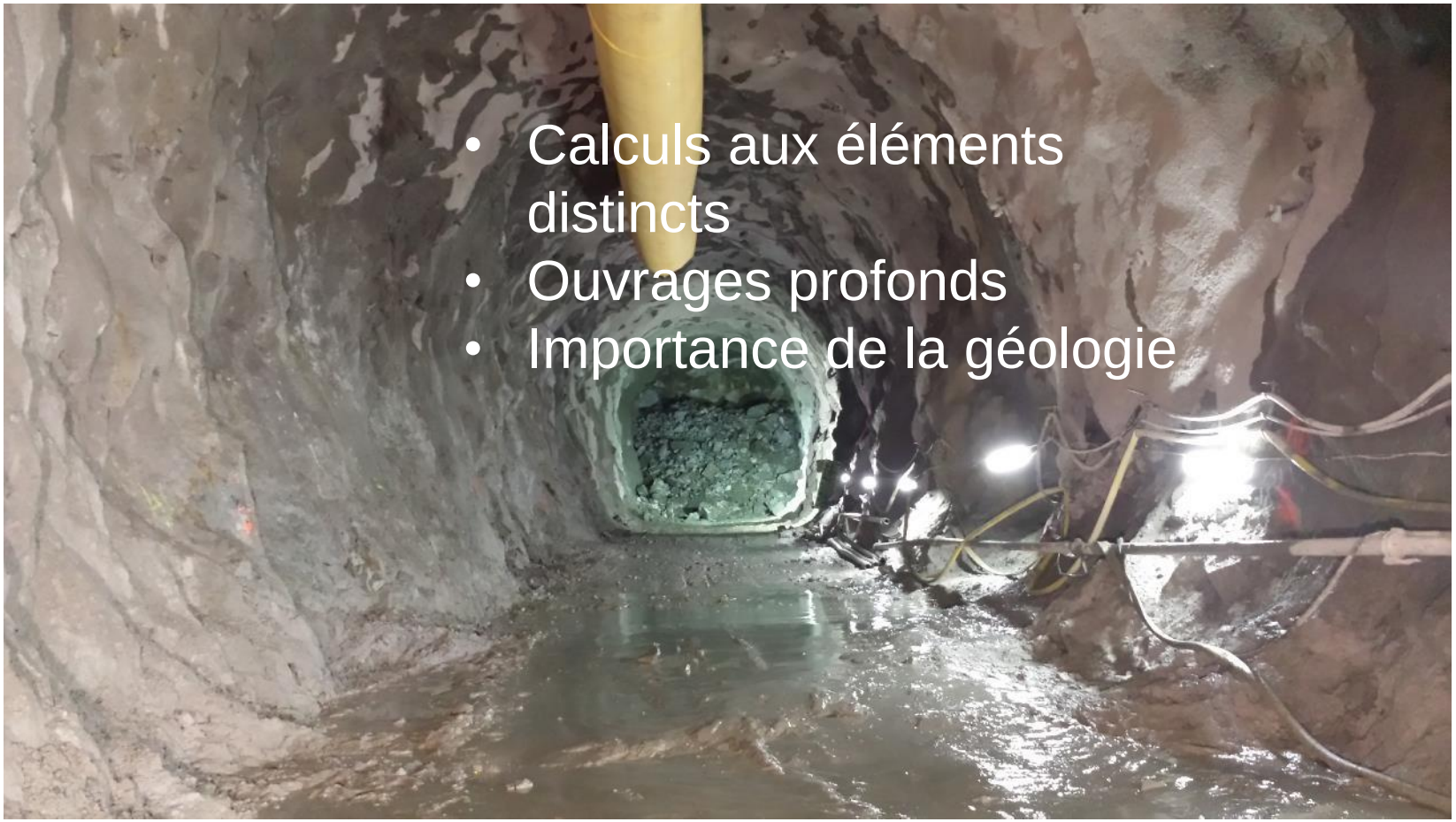
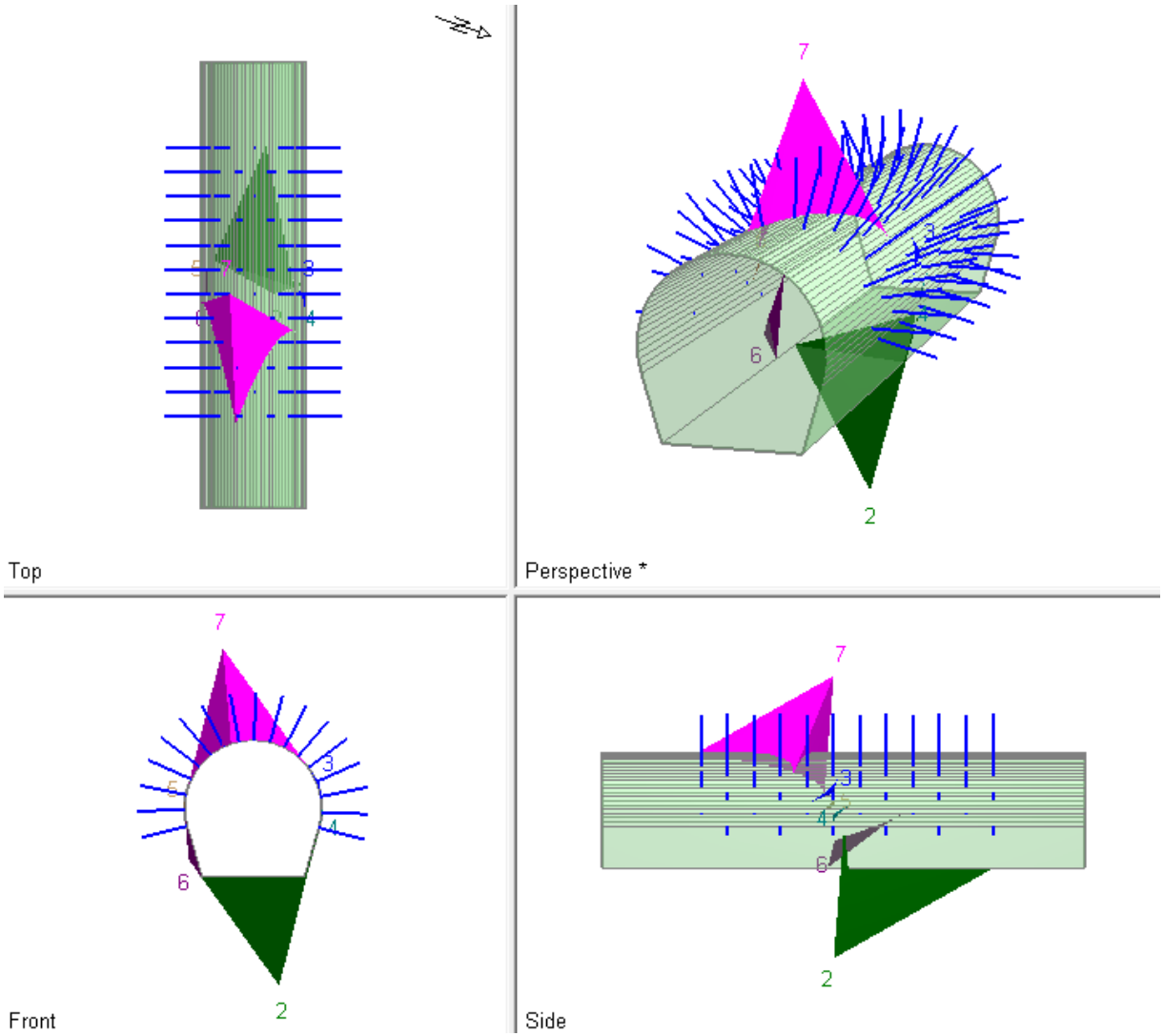
# Introduction

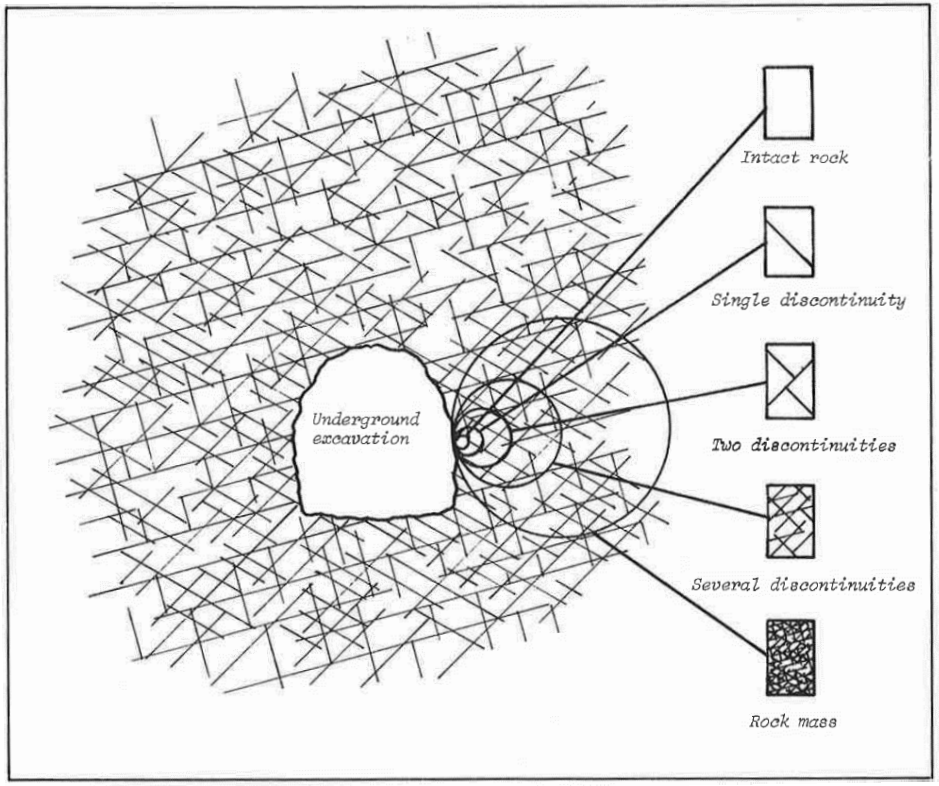


# Dimensionnement en milieu discontinu



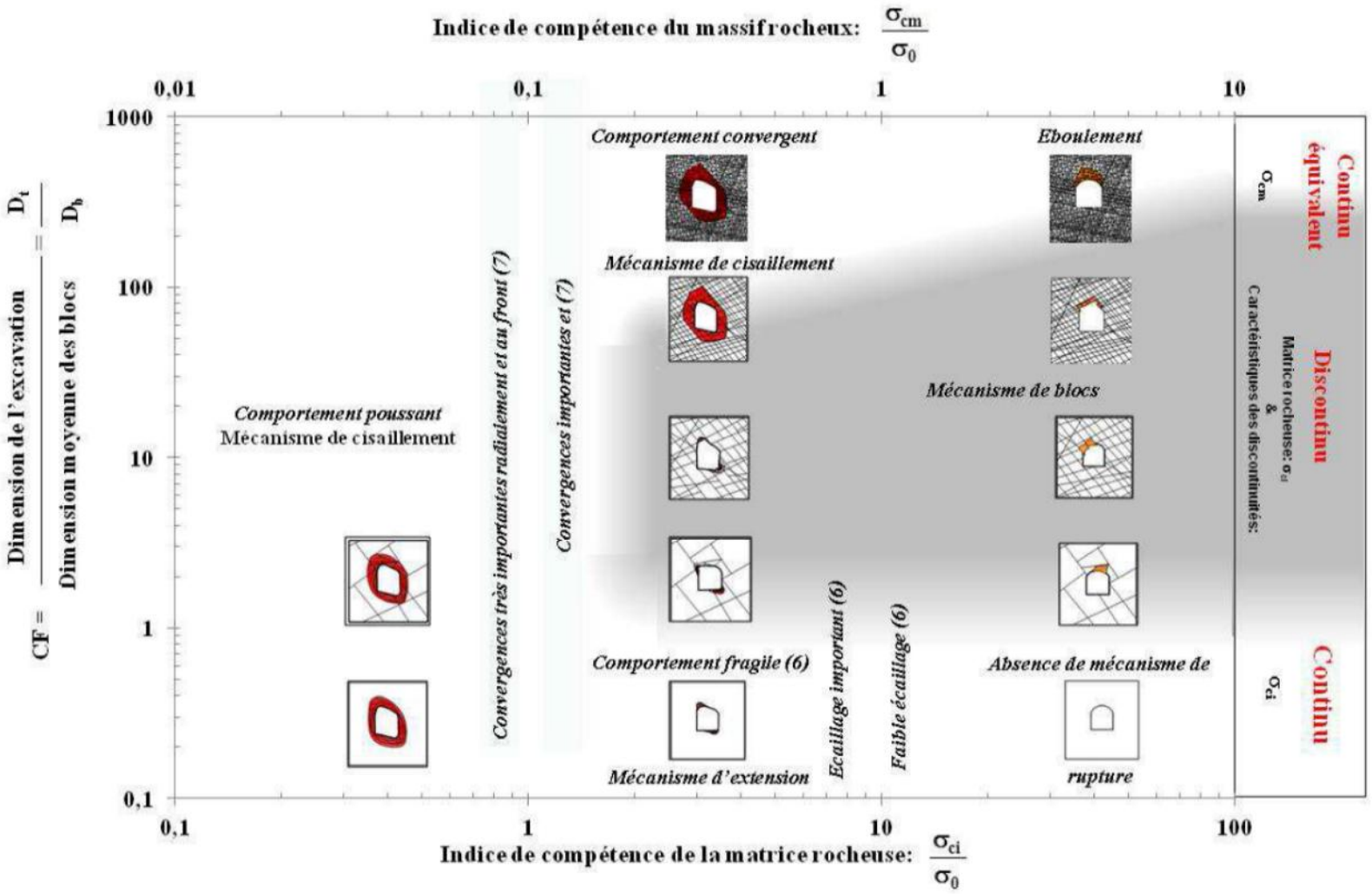

Calcul à la rupture du plus grand dièdre

# Caractérisation du massif en milieu continu ou discontinu



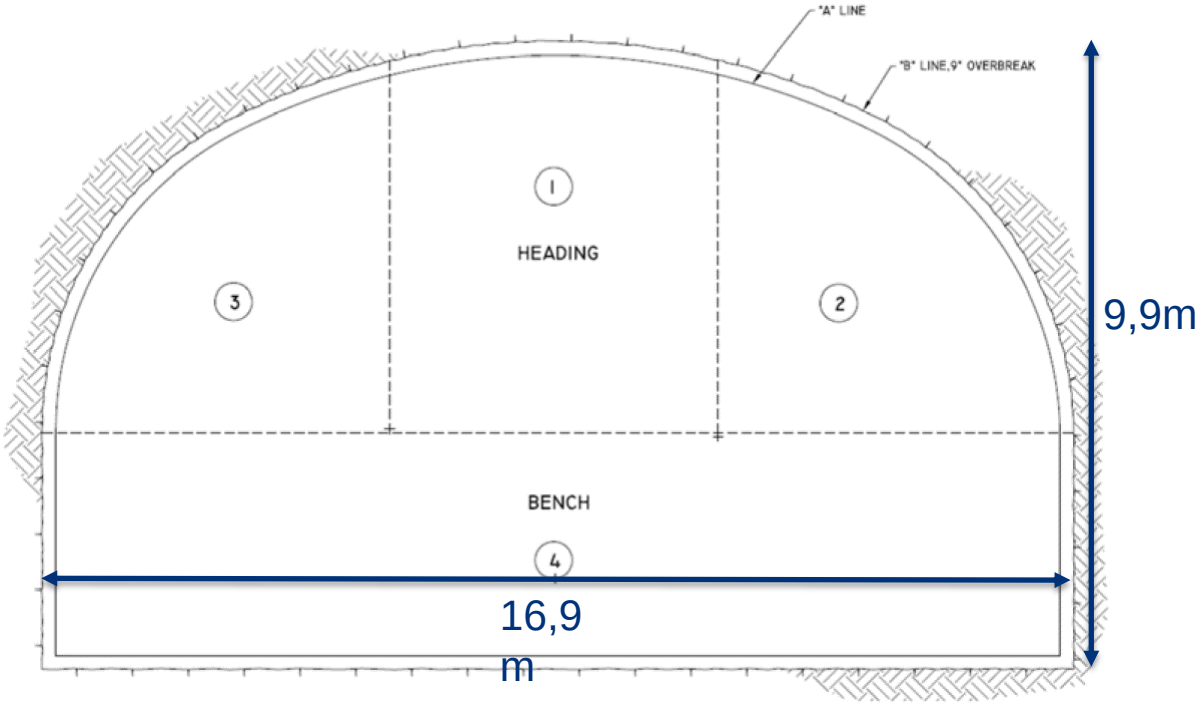

Rapport Taille du bloc moyen / Dimensions de l'ouvrage

# Notion d'état de contrainte / mode de ruine




Abaque extrait de la recommandation du GT30 – AFTES (préliminaire).

# Exemples d'un projet de tunnel routier




# Exemples d'un projet de tunnel routier

- 2 types de calculs effectués : FEM et DEM
- Hypothèses considérées :

| *Géométrie* | |
|---|---|
| Largeur d'excavation | 16.90m |
| Hauteur d'excavation | 9.90m |
| Pilier entre les 2 tunnels | 8.50m |
| Hauteur de couverture | 9.60m |

| *Soutènements* | | |
|---|---|---|
| Béton projeté | | 5cm |
| | Maillage | 1.80 x 1.80m |
| Boulons | Longueur | 3.60m |
| | Capacité | 102kN |

| Caractéristiques du rocher intact | Calcaire de couverture | Schiste argileux |
|---|---|---|
| Poids volumique | 2640 kg/m3 | 2640kg/m3 |
| Résistance à la compression | 110MPa | 80MPa |
| Résistance à la traction | 13MPa | 10MPa |
| Module d'Young du rocher intact | 44 GPa | 34GPa |
| Coefficient de Poisson | 0.3 | 0.25 |

# Exemples d'un projet de tunnel routier

## FEM

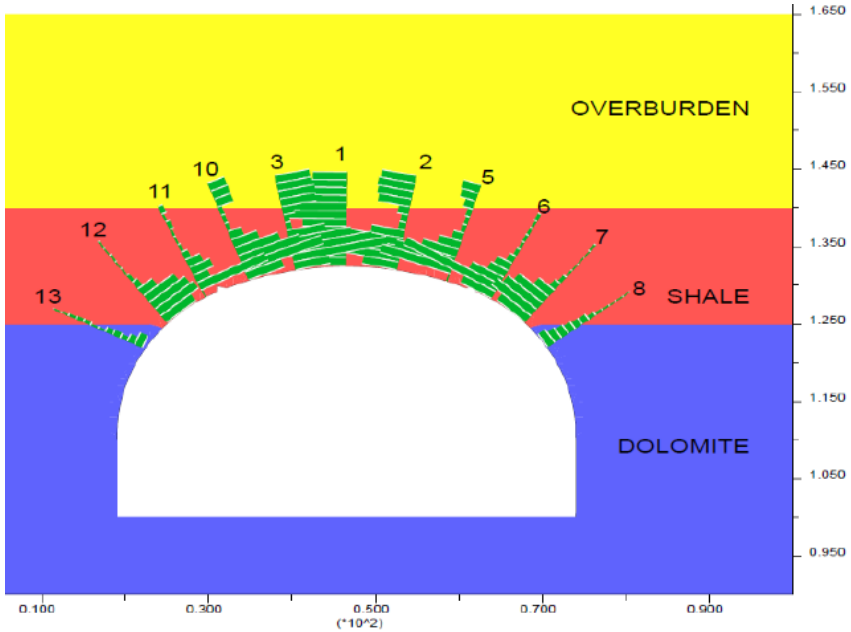
| *Approche par homogénéisation* | Calcaire de couverture | Schiste argileux |
|---|---|---|
| RMR | = sol | 41 |
| $\Phi_{massif}$ | 33° | 25° |
| $C_{massif}$ | 0kPa | 200kPa |
| $E_{massif}$ | 330MPa | 800MPa |

## DEM

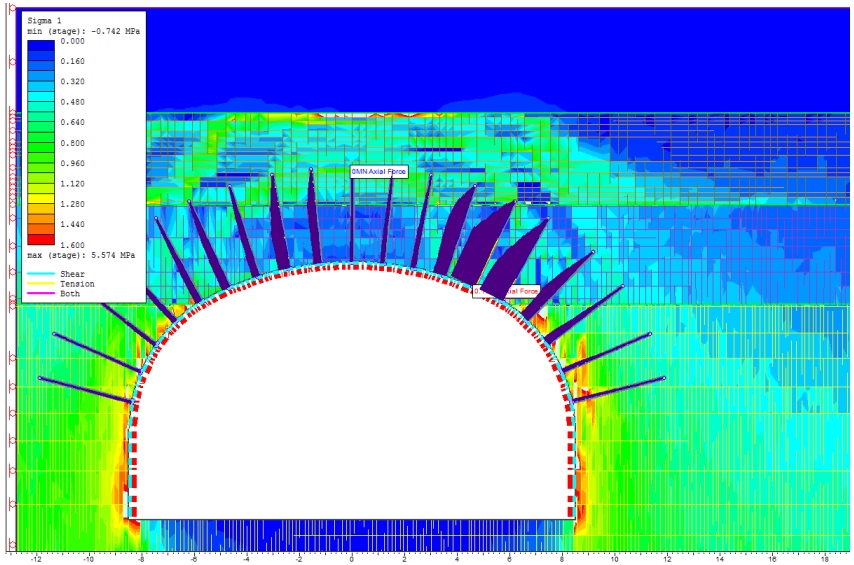
| *Approche par discrétisation* | | *Calcaire de couverture* | *Schiste argileux* |
|---|---|---|---|
| Persistance des joints | | 80% | 80% |
| Joints horizontaux | Espacement | 0.10m | 0.20m |
| | Longueur | 25.00m | 25.00m |
| Joints verticaux | Espacement | 0.30m | 0.20m |
| | Longueur | 3.40m | 3.40m |
| Résistance des joints | $\Phi_{résiduel}$ | 24° | 24° |
| | JRC | 5 | 5 |
| | JCS | 55MPa | 20MPa |
| Raideur des joints | Normale | 18 200MPa/m | 4500MPa/m |
| | Cisaillement | 7 000MPa/m | 1800MPa/m |

Nota : Pour le calcul par la méthode des éléments distincts, le maillage des boulons a été passé à 1.2 m x 1.2 m. Une couche de 15 cm de béton projeté est prise en compte dans le calcul.

# Exemples d'un projet de tunnel routier




Charge maxi = 42kN




Charge maxi = 105kN
plastification

# Exemple d’une caverne hydraulique

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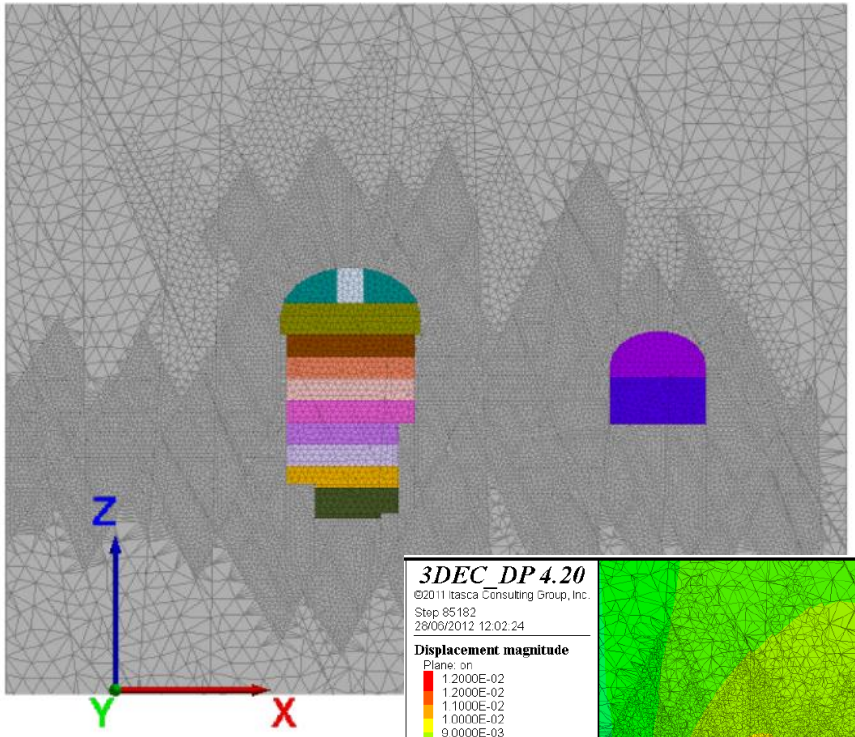
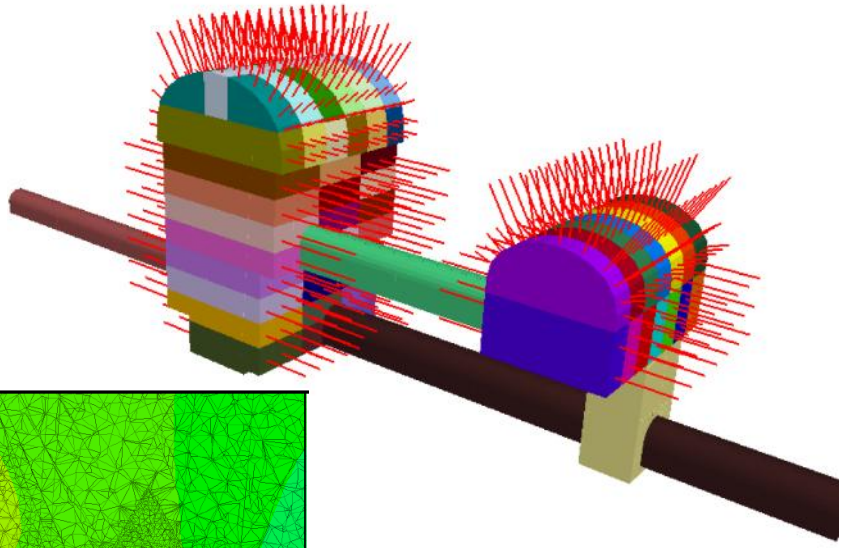
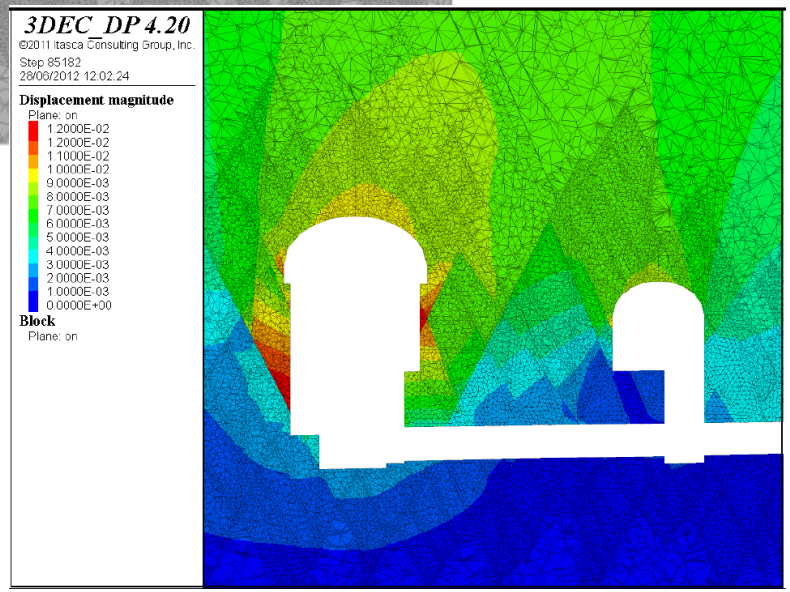


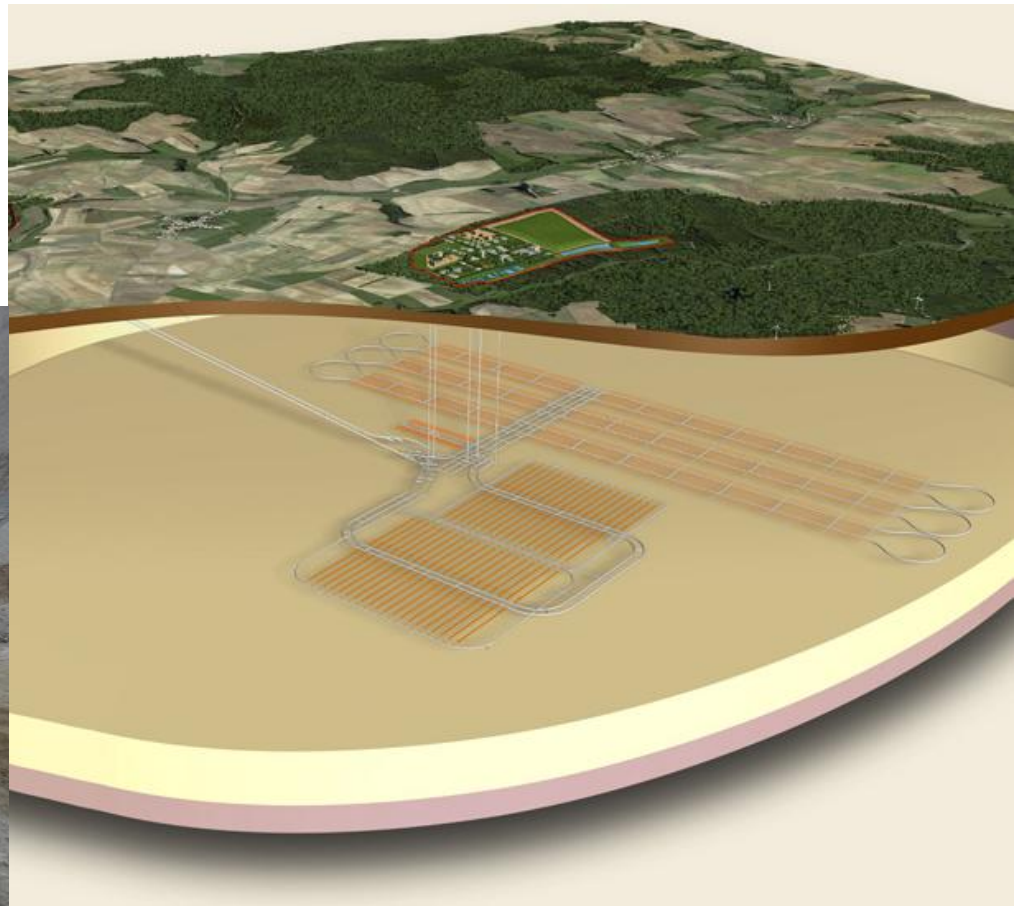





# Les ouvrages profonds

- Tunnels de base
- Stockage profond
- Projets d'équipement des mines

Mine de Chuquicamata (Chili)



Projet Cigeo - Andra

# Risques particuliers

- Convergences fortes
- Ecaillage
- Popping
- Rock bursting


# WG17 AITES

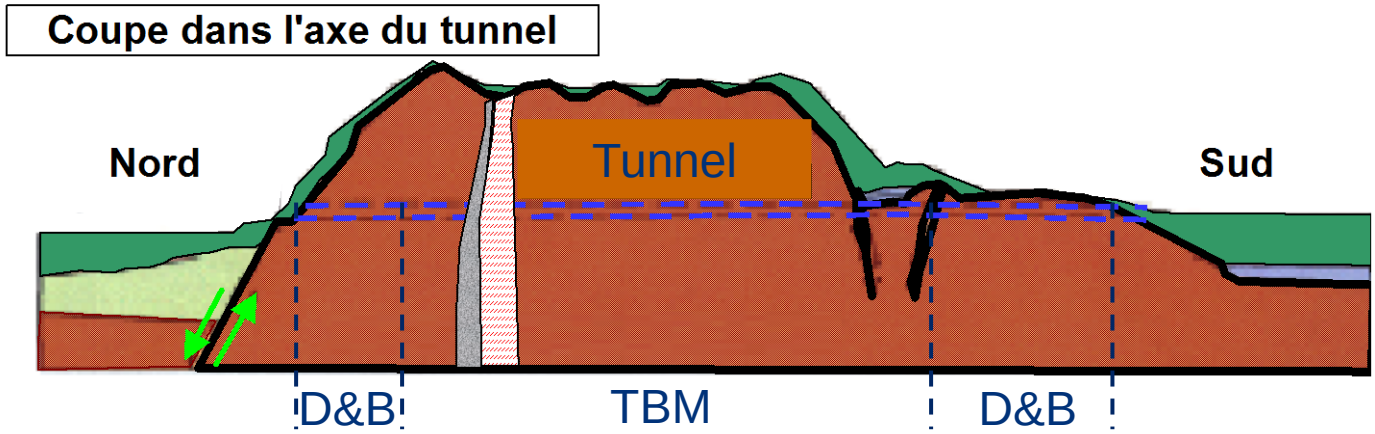
**Worldwide date base collected by the members of the ITA Working Group 17 on the TBM tunnelling experience in difficult rock conditions gained over the last 20 years**

| | LIST OF PROJECTS | | | | | DEFINITION OF THE HAZARD SCENARIOS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brittle behaviour | | Highly deformable behaviour | | Presence of water | | | | Environmental aspects |
| | Number | Project name | Country | Type of TBM | Diameter [m] | Spalling | Rock-burst | Buckling | Squeezing | Extremely high water inflow (clear water | High water pressure | Mud inrush | Face instability | High temperature |
| | 1 | Lake Mead | USA | Single shield | 7,2 | | | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | 2 | Frejus safety tunnel | France-Italy | Single shield | 9,46 | | | ✓ | | | | | | |
| | 3 | Gothard base tunnel - Lot Bodio | Switzerland | Hard Rock TBM with Grippers | 8,83 | | | | | | | | ✓ | |
| | 4 | Gothard base tunnel - Lot Faido | Switzerland | Hard Rock TBM with Grippers | 9,43 | ✓ | | | ✓ | ✓ | ✓ | | ✓ | |
| * | 5 | Olmos transandino tunnel | Peru | Hard Rock TBM with Grippers | 5,35 | ✓ | ✓ | | | | | | | |
| | 6 | Loetschberg base tunnel, south section (Steg and Raron drives | Switzerland | Hard Rock TBM with Grippers | 9,43 | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ |
| | 7 | Nant de Drance | Switzerland | Hard Rock TBM with Grippers | 9,45 | ✓ | | ✓ | | | ✓ | | | ✓ |
| * | 8 | La Maddalena exploratory tunnel | Italy | Hard Rock TBM with Grippers | 4,5 | | ✓ | | | | | | | ✓ |
| * | 9 | Uma Oya Multipurpose Develepment projetc tailrace tunnel | Sri Lanka | Double shield | 4,3 | | | | | | | | ✓ | |
| * | 10 | Pahang-Selangor Raw Water Transfer Project | Malaysia | Hard Rock TBM with Grippers | 5,2 | ✓ | ✓ | | | ✓ | | | | ✓ |
| | 11 | Hida tunnel - main tunnel | Japan | Hard Rock TBM with Grippers | 12,8 | | ✓ | | | ✓ | ✓ | | ✓ | |
| | 12 | Kargi tunnel | Turkey | Double shield | 9,84 | | | | ✓ | | | | | |
| | 13 | Niagara Tunnel Project | USA | Hard Rock TBM with Grippers | 14,4 | ✓ | | | | | | | | |
| | 14 | Lesotho Haighlands Water Project | Lesotho | Hard Rock TBM with Grippers | 5 | | | | | | | | ✓ | |

***NB : These datasheet will be fully completed in the next edition***

# Pas de mécanique sans géologie

- Connaissance de l'histoire d'un massif




Questions?