Modern Ground Control Management

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Resolution Copper Mining

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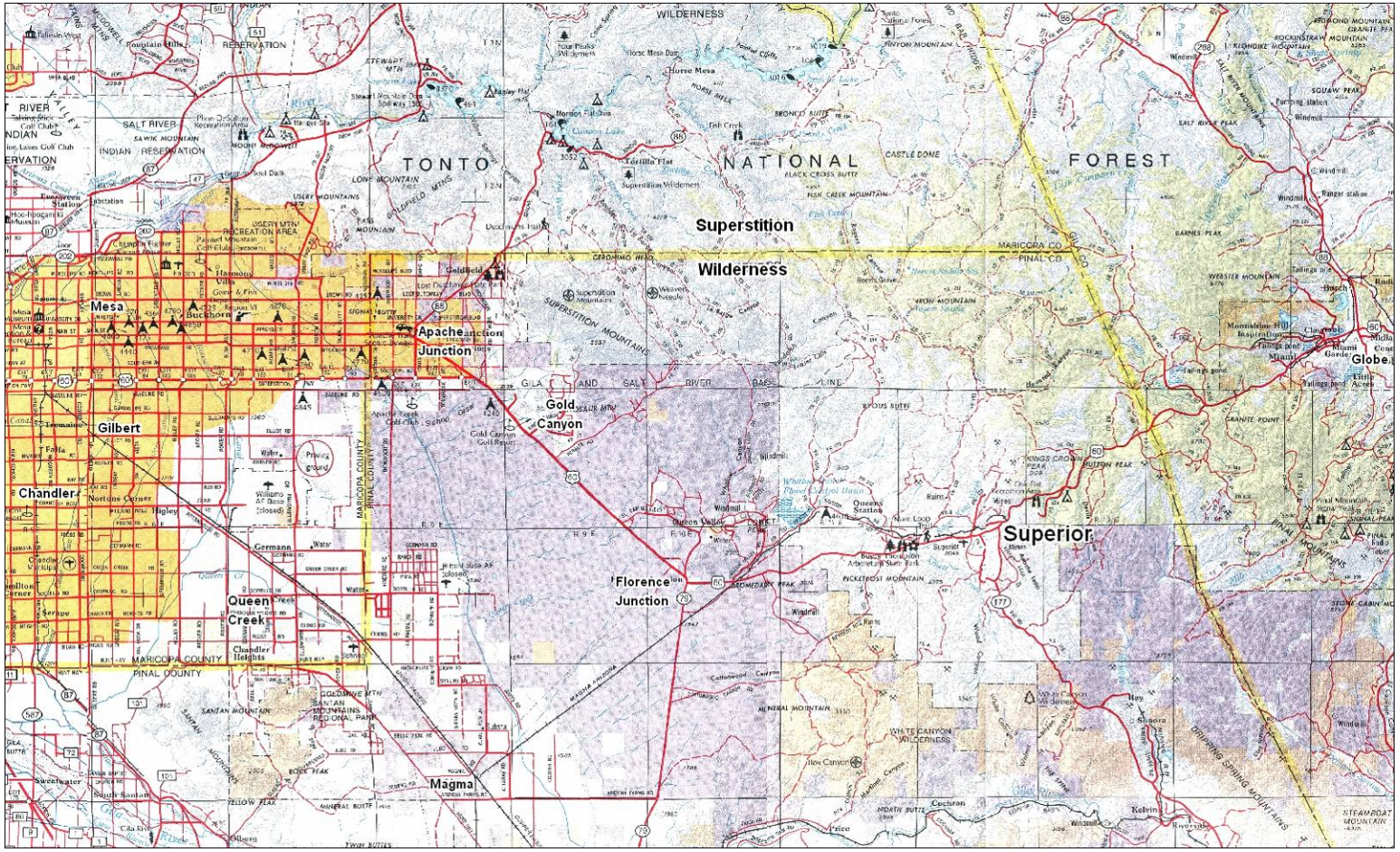
Resolution Copper Mining

- **Resolution Copper Mining (RCM) is a limited liability company**

- **Ownership:**
  - **Resolution Copper Company (55%), a Rio Tinto plc subsidiary**
  - **BHP Copper, Inc. (45%), a BHP-Billiton plc subsidiary**

- **Resolution Copper Company is the manager of RCM**

Regional Map

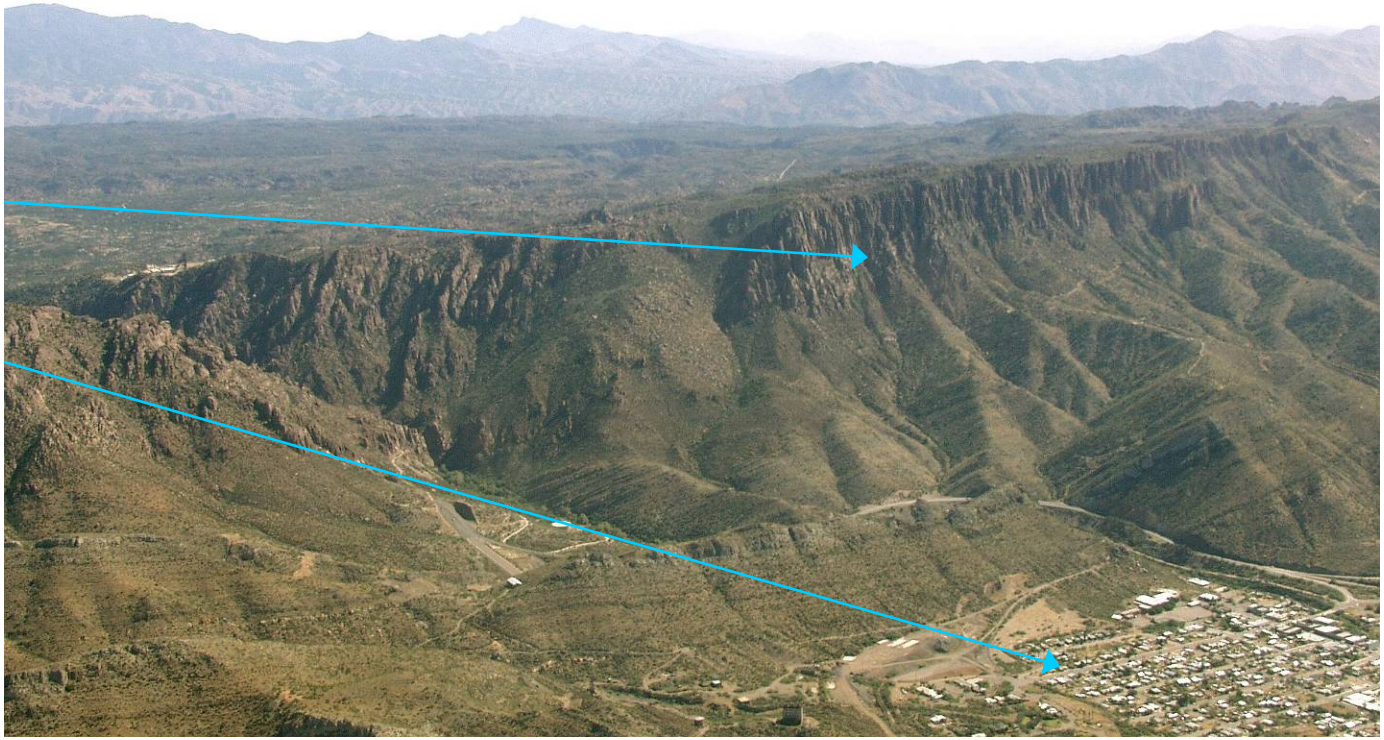


  August 4, 2010

Local Area

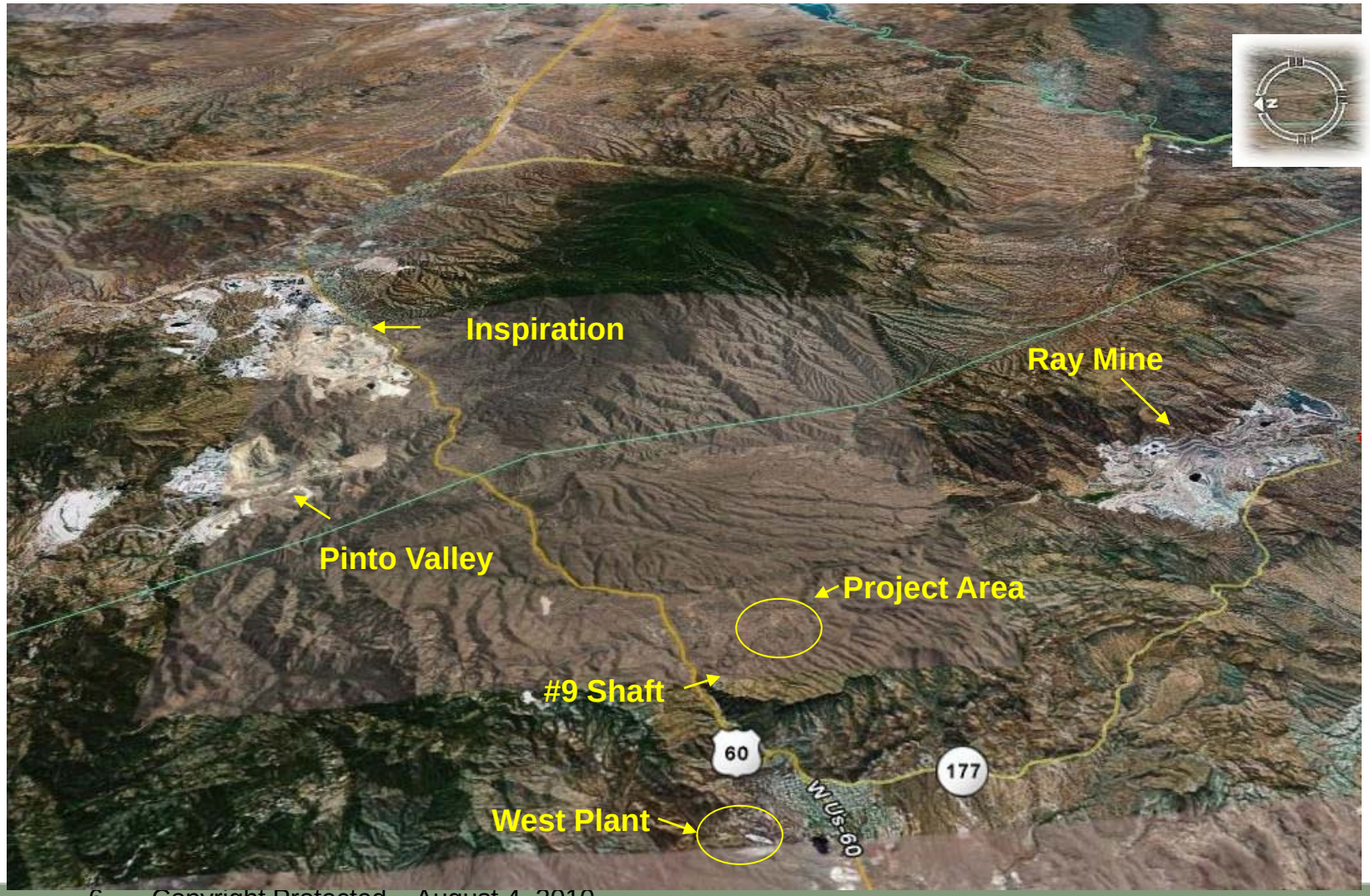
Apache Leap

Town of Superior



Project Area Aerial View

Resolution Project Area Perspective

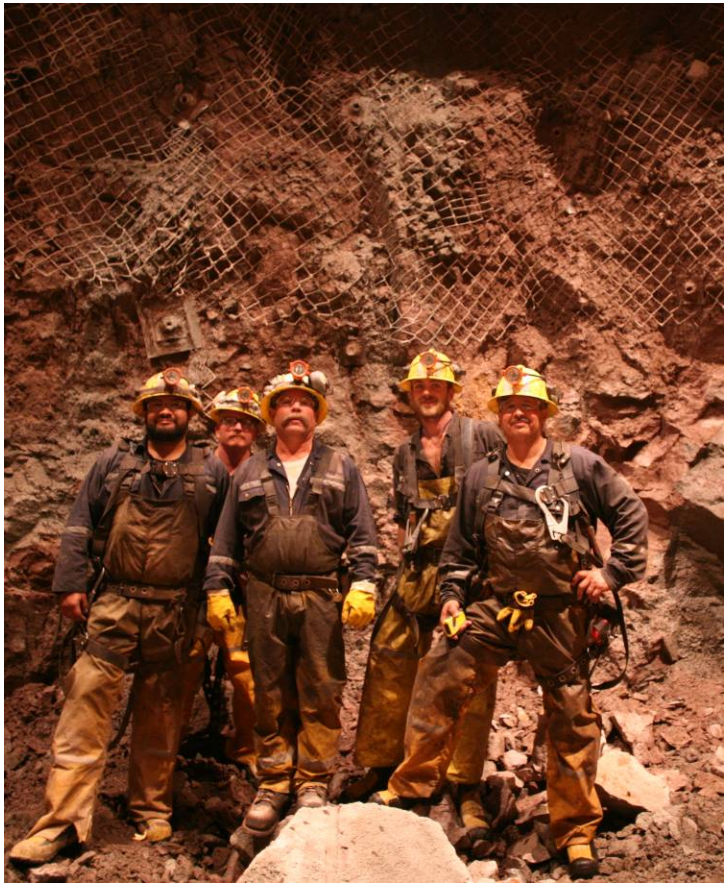


Ground Control Management

- **Ground Control Management Plan**
  - **Describes the methodology for development of minimum ground support standards, where and how they are stored and how they are implemented and verified**
  - **Design, Implement, Verify**
- **Detailed Breakdown Structure**
  - **Define Responsibilities/Determine Necessary Skill Sets**
  - **Rock Mass Characterization /Recognition of Ground Conditions**
  - **Geotechnical Design Methodology and Communication**
  - **Quality of Installation and Workmanship**
  - **Monitoring/ Verification**
  - **Optimization**
  - **Repeat**

Roles and Responsibilities

- **Define the roles and responsibilities of personnel involved in ground support activities**
- **Identify the geotechnical skill-sets required for each role, including the necessary training**
- **Only qualified individuals must perform ground support designs and inspections**
- **Determine accountability matrix (Responsible, accountable, support)**



Roles and Responsibilities (Cont.)

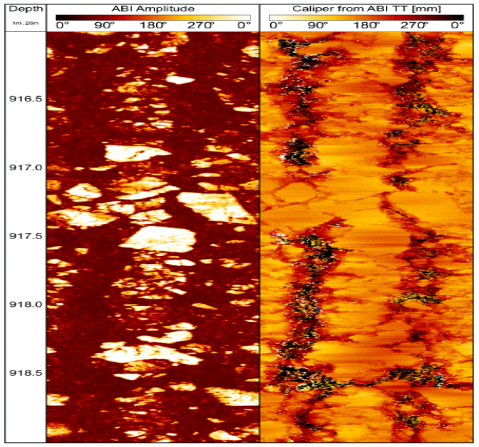
- **Personnel Development/ Training**
  - **Training**
    - **Onsite-Training by geotech engineer**
    - **Specific classes related to ground control administered by third party**
    - **MSHA Training**
    - **New Hirer Training**
  - **Personnel**
    - **Relationships are important**
    - **Miners (Knowledge/ skill set)**
      - **Must be able to identify changes in ground conditions**
      - **Must understand how support should be installed**
    - **Engineers (Knowledge / skill set)**
      - **Able to identify changes and how to control specific types of failures**
      - **Be familiar with different types of support systems**

Rock Mass Characterization

- **What information is required for this design?**
- **What detail is required to perform the design?**
- **In what manner should the data be collected?**
  - **Drill Holes**
  - **Surface Mapping**
  - **Drift Mapping**

Rock Mass Characterization Example

- **Core Logging**
  - **Structure Orientation**
  - **Geotechnical Data Collection**
    - **Joint Information**
    - **RQD**
    - **Mirco-defects**
  - **Strength Estimates**
    - **Point Load Test**
    - **UCS Testing**
    - **Triaxial Testing**
- **Data Verification**
  - **QA/QC**



Rock Mass Characterization Example (Cont.)

- **Photogrammetry**
  - **Adam Technology is being utilized for rapid mapping and data collection**
  - **Geology and Geotech information is being collected on a routine basis**
- **Uses**
  - **The systems are being used for a number of things, including but not limited to:**
    - **Geotechnical Characterization**
    - **Geologic Mapping**
    - **Quality Control**
    - **Shaft Sinking**
    - **Lateral Development**

Recognition of Ground Conditions

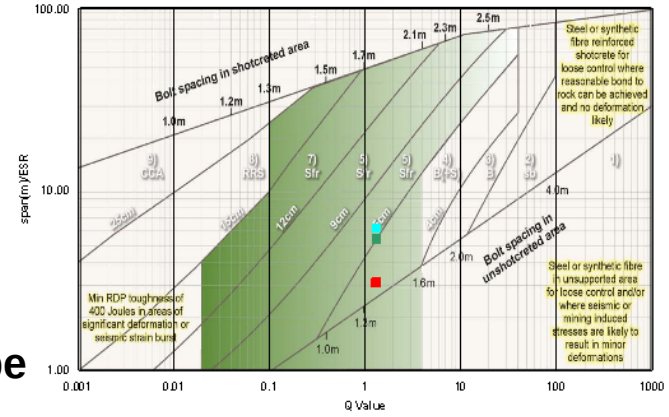
- **Understanding the Rock Mass**
  - **Failure**
    - **Stress**
    - **Gravity**
    - **Seismicity**

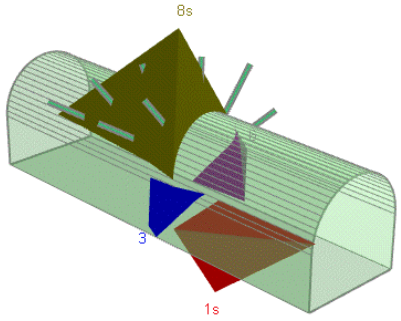
Recognition of Ground Conditions (cont.)

- **Controlling the Rock Mass**
  - **Blasting Practices**
  - **Available Information**
    - **Current ground conditions (Communication)**
    - **Has work been conducted in this type of ground before?**
    - **Other operator's experience with similar ground**
  - **Simulated**
    - **Numerical**
      - **FLAC**
      - **Phase**
    - **Empirical**
      - **Rock mass ratings**
      - **Ground Response Curve**

Ground Support Design Methodology

- **Past experience**
  - Review previous ground support designs
  - Internal and external communication
- **Empirical Relationships**
  - Q, RMR, GSI
  - Determines initial ground support spec to be further compared with other methods
- **UNWEDGE**
  - Perform wedge analysis and determine bolt length, capacity and spacing for comparison with empirical estimates
- **Numerical Analysis**
  - Use Phase or FLAC to perform stress analysis



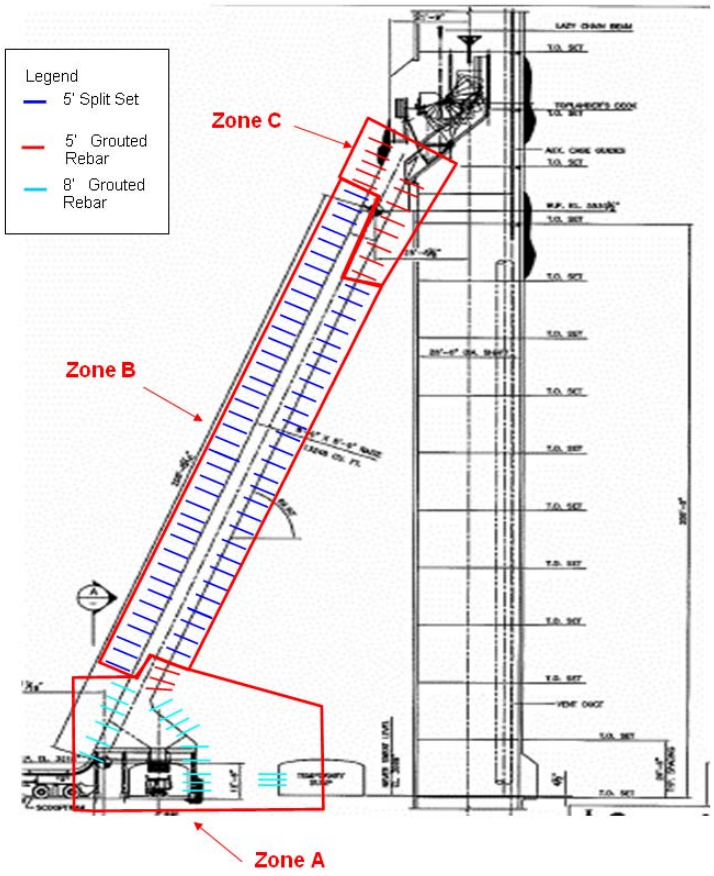


Support System Selection

- **How will it be installed?**
  - **Jack Legs**
  - **Modern bolting rigs**
  - **Shotcrete?**
- **What are the limitations and potential safety issues with installing the required support?**
  - **Jack Legs**
    - **Resin Rebars**
    - **Mesh Handling**
  - **Manual spraying of shotcrete?**
- **Final design communication**
  - **How does the information get distributed?**

Quality of Installation and Workmanship

- **Clear instructions for installation**
  - **Blast design**
  - **Timing of installation**
  - **Installation steps**
- **Design Specifics**
  - **Bolt Spacing**
  - **Bolt Lengths**
  - **Surface Support Requirements (Mesh, shotcrete)**
  - **Hole Diameters**
  - **Encapsulation requirements**
  - **Bolt angle**



Monitoring/ Verification

- **System performance**
  - **Pull Testing**
  - **Bolt appearance**
    - **Corrosion**
    - **Pull through**
  - **Bolt supplier**
    - **Material Properties**

- **Excavation Monitoring**
  - **Extensometers**
  - **Closure monitoring**
  - **Visual inspection (water, loose, cracks)**
- **Has everything been installed to design standard?**

Optimization

- **Lessons Learned**
  - **Applying new information to current design or future designs**
  - **Communicating the information**
- **Support Optimization**
  - **Waste Reduction (bolts, shotcrete, etc …)**
  - **Better rock mass response**
  - **Over-break reduction**
  - **Installation speed and safety**

Potential Design Deficiencies

- **Design Issues**
  - Failure not correctly identified
  - Bolt length or capacity insufficient
  - Input parameters incorrect
- **Installation Issues**
  - Below standard blasting
  - Hole Diameter Incorrect
  - Resin pass due
  - Material issues (bolt quality)
  - Improper bolt angle
  - Poor blasting

Closing

Your Contribution

Everybody has a role to play

Take pride in the quality of the underground workings

Be safe

Thank you!

Questions?