



## Patrick Andrieux – Principal Engineer

Patrick is a mining engineer with over thirty years of experience at operating mine sites (both on surface and underground), as well as in research and development, instrumentation, technical services and support, and consulting. His project experience spans over 450 projects at more than 150 mine sites world-wide. His areas of specialisation are geomechanical mine design and sequencing, mine monitoring, geomechanics, practical ground control and ground support programs, and drilling and blasting engineering. He is the author of over 70 published technical papers. Patrick is a Registered Professional Engineer in Quebec and Ontario, as well as a Designated Consulting Engineer in the Province of Ontario.

### *Expertise*

- Geomechanical mine design and sequencing
- Geomechanics
- Ground control and ground support
- Geomechanical mine monitoring and instrumentation
- Drilling and blasting, and blast monitoring

### *Professional experience*

- 2015 – present: Principal Engineer at Andrieux & Associates Geomechanics Consulting, Inc., Montreal, Quebec, Canada.
- 2012 – 2015: Principal Engineer at Itasca Consulting Group, Inc., Minneapolis, Minnesota, USA.
- 2000 – 2012: Principal Engineer at Itasca Consulting Canada, Inc., Sudbury, Ontario, Canada.
- 1995 – 2000: Chief Ground Control Engineer at Noranda, Inc., Brunswick Mine, Bathurst, New Brunswick, Canada.
- 1988 – 1995: Senior Drilling & Blasting Research Engineer and Programme Leader at Noranda, Inc., Noranda Technology Centre, Pointe-Claire (Montreal), Quebec, Canada.
- 1985 – 1988: Mining, Drilling & Blasting, Pit and Projects Engineer at Miron, Ltd. Open Pit, Montreal, Quebec, Canada.



### ***Education***

- Ph.D. (Mining Engineering), 2005, Université Laval, Quebec City, Quebec, Canada.
- M.Eng. (Mining Engineering), 1996, McGill University, Montreal, Quebec, Canada.
- B.Eng. (Mining Engineering), 1985, École Polytechnique de Montréal, Montreal, Quebec, Canada.

### ***Registrations***

- Registered Professional Engineer in the Province of Ontario, Canada
- Registered Professional Engineer in the Province of Quebec, Canada
- Designated Consulting Engineer in the Province of Ontario, Canada

### ***Professional affiliation memberships***

- Association of Geohazard Professionals (AGHP)
- Canadian Institute of Mining, Metallurgy and Petroleum (CIM)
- Canadian National Rock Mechanics and Strata Control Committee (RMSCC)
- FragBlast
- International Society of Explosives Engineers (ISEE)
- International Society of Rock Mechanics (ISRM)
- Société de l'énergie explosive du Québec (SEEQ)

### ***Patents granted***

- Borehole Deviation Monitor, December 1992. Magnetometer-based differential system for surveying the location of deep non-breakthrough drill holes after they have been drilled.
- Real-Time Location of Deep Boreholes, April 1998. Passive acoustical system for surveying the location of deep non-breakthrough drill holes while they are being drilled (in real time).



### ***Project experience***

Spans over 450 projects at more than 150 mine sites world-wide, providing technical and consulting services to over 110 mining companies, consulting firms and contractors.

#### *Conceptual, scoping, pre-feasibility and feasibility studies*

- Geotechnical data review, consolidation and gap analysis
- Site characterization (mapping, core logging, Televiewer)
- Conceptual mine design for:
  - Longhole, Avoca, Vertical Crater Retreat, cut-and-fill, drift-and-fill, room-and-pillar, shrinkage, sub-level caving, block-caving, etc.
  - Longitudinal and transverse mining
- Backfill requirements
- Transition from surface to underground mining
- Winze and large underground excavations design
- Large surface excavations design

#### *Geomechanical and stability analyses*

- Empirical and analytical analyses
  - Stope dimensioning and design
  - Dilution estimates
  - Pillar stability assessment (for sill, crown, rib, barrier, post, nose and regional pillars)
  - Undercut sill mat stability assessment
  - Ground support
- Numerical modelling
  - Inelastic 3D numerical analyses of the performance of extraction sequences
  - Inelastic 3D numerical analyses of stopes, pillars, infrastructures, development and other underground excavations (with both continuum-based and discrete approaches), including remnant zones that are either highly stressed or crushed
  - Inelastic 3D numerical analyses of open pits and surface quarries (with both continuum-based and discrete approaches)



- Explicit stochastic 3D BBM (Bonded Block Model) and DFN (Discrete Fracture Network) discrete numerical analyses of strata unravelling, wedge instability and the effects of ground support systems
- Probability of failure analyses
- Coupled thermo-mechanical numerical analyses

#### *Elaboration of mining strategies*

- Assessment and mitigation of geotechnical risk
- Elaboration of geotechnical risk profiles
- Mining in high stress and failing ground
- Mining in weak/squeezing ground
- Mining in failed ground
- Tunneling through backfill

#### *Ground support systems*

- Design of ground support systems for static and dynamic conditions
- Design of ground support systems for underground excavations
- Design of ground support for open pit walls
- Ground support systems in nuclear waste repositories (in high temperatures)
- Ground support systems reviews and audits

#### *Instrumentation*

- Vibrating wire stress cells, thermistors, multipoint extensometers, ground movement monitors, convergence stations, Time Domain Reflectometry (TDR) probes, sloughmeters, pressure pads and pressure cells, instrumented cablebolts, tale-tells, crackmeters, etc.
- Elaboration of custom instrumentation for specific applications
- Mine-wide seismic surveillance systems

#### *Technical services and support*

- Ground control practice reviews and audits
- Ground control-related safety reviews
- Ground control-related incident investigations
- Ground fall investigations
- Seismicity and rockburst reviews
- Risk to infrastructure above shallow empty stopes or near open pit high walls



- Training courses on:
  - Vibrations and monitoring
  - Blasting engineering
  - Geomechanics, ground control and ground support
  - For engineering or production personnel (customised accordingly)
- Close technical support of site staff
- Expert witness (for litigations and court cases)

#### *Drilling and blasting*

- Technical reviews and audits (surface and underground)
- Design and implementation of:
  - Large-scale choked destress blasts
  - Mass-blasts
  - Targeted blasts for narrow ore zones in open pit
  - Shaft-sinking blasts
  - Smooth blasts
- Optimisation campaigns
- Muck pile profile optimisation
- Blast damage control in tunnel surfaces and pit walls
- Assessment of blast-induced damage to residential, commercial and industrial structures (including for insurance claims)
- Elaboration of anisotropic site-specific blast-induced vibration attenuation curves in various materials (rock, soil, backfill)
- Instrumentation (vibrations monitoring, VOD measurements, high-speed filming, fragmentation assessment)

#### *Research and development*

- Participation in field trials for:
  - Dynamic tests of ground support systems
  - Jellified hydraulic backfill
  - Surficial spray-on liner support systems
  - Mechanised high-pressure water scaler
  - Site-sensitized bulk emulsions
- Development of blast accelerometers and digital seismographs



- Development of real-time alarm systems for ground monitoring systems (connected to dataloggers / communication systems)
- Development of surveying instruments for blind drill holes