

Principal Engineer

<i>Expertise</i>	Geotechnical and Mining Engineering
<i>Education</i>	Ph.D. (Geological Engineering), 1994, University of Minnesota M.S. (Geological Engineering), 1977 B.S. (Geological Engineering, with High Honors), 1975
<i>Honors</i>	Itasca Presidential Award, 2010 Applied Rock Mechanics Award, American Rock Mechanics Association, 2003 Rocha Medal, International Society for Rock Mechanics, 1995 Bush Foundation Leadership Fellow, 1993 Award for Research in Rock Mechanics, U.S. Rock Mechanics Society, 1976
<i>Professional Experience</i>	
<i>2011 - Present</i>	<i>Itasca Consulting Group, Inc., Minneapolis, Minnesota Principal Engineer</i>
<i>2005 - 2011</i>	<i>Itasca Denver, Inc., Colorado Principal Engineer</i>
<i>2001 - 2005</i>	<i>Bechtel SAIC Company, LLC, Las Vegas, Nevada, Yucca Mt. Project Subsurface Design Manager/Manager of Seismic Studies</i>
<i>1985 - 2001</i>	<i>Itasca Consulting Group, Inc., Minneapolis, Minnesota Senior Mining/Geotechnical Engineer</i>
<i>1982 - 1985</i>	<i>University of Minnesota, Ph.D. Student Itasca Consulting Group, Minneapolis, Minnesota Science Applications, Inc., Salt Lake City, Utah, Part-time Employee</i>
<i>1981 - 1982</i>	<i>Science Applications, Inc., Salt Lake City, Utah Mining Engineer</i>
<i>1978 - 1981</i>	<i>TerraTek, Inc., Salt Lake City, Utah Mining Engineer</i>
<i>1977 - 1978</i>	<i>Rockwell Hanford Operations, Richland, Washington Mining Engineer</i>
<i>1976</i>	<i>University of Minnesota, Department of Civil and Mineral Engineering, Master of Science Student Hecla Mining Company, Casa Grande, Arizona, Lakeshore Mine, Part-time Employee</i>
<i>1974 - 1976</i>	<i>Hecla Mining Company, Wallace, Idaho/Casa Grande, Arizona Star, Lucky Friday and Lakeshore Mines Mining & Rock Mechanics Engineer</i>

Project Experience

Dr. Board is a geotechnical engineer with over 30 years of experience in ground-support specification, mine planning and design, underground-mine stability assessments, backfill specification, open-pit slope stability assessments, field geotechnical characterization, rock instrumentation and numerical modeling. Underground mining experience includes work in block and panel caving, blasthole open stoping, cut-and-fill, room-and-pillar, and longwall in base metals, evaporates, stone and coal.

Mine Design and Rock Engineering Experience

Over the past 25 years at Itasca, involvement in numerous mine-design projects world-wide, from short-term stability assessments to feasibility and conceptual design studies. Examples of significant projects over the past 15 years include:

- *Bingham Canyon Mine, Keystone and Cornerstone Projects, Rio Tinto* — Geotechnical consultant for the scoping and prefeasibility studies for long-term mining of the Bingham Canyon Mine. Work includes: study of major open-pit pushbacks that will take the pit to 1300-m depth, as well as mining of several orebodies beneath the pit by block caving and sublevel open stoping; geotechnical characterization and development of a 3D geotechnical block model, rock properties assessments, stability assessment of the ultimate pit slopes, detailed interaction of the pit and underground during the transition, including cave growth prediction, slope subsidence, design of the cave-mine production and undercut levels, and placement of permanent infrastructure. Assisted Rio Tinto in interaction with an international geotechnical review board.
- *Ernest Henry Mine, Cloncurry, Australia, Xstrata Copper* — Geotechnical studies supporting feasibility of a proposed sublevel-caving operation beneath a 500-m deep open pit. Work includes: assessment of geotechnical model and rock mass properties, numerical stress analysis for simulation of cave propagation, impact on pit-slope stability and subsidence; layout and stability assessment of production-level excavations and infrastructure; assessment of geotechnical hazards, including seismicity.
- *Cadia East Project, Newcrest* — Geotechnical studies on the prefeasibility and feasibility of the Cadia East Mine in Orange, Australia. Studies included prediction of caveability, cave propagation, stability and ground support for the undercutting and production levels, seismicity prediction and design of ground support for crusher infrastructure.
- *Chuquicamata Mine, Calama Chile, Codelco* — Geotechnical studies supporting the feasibility assessment for a proposed 140,000-tpd caving operation beneath the Chuquicamata pit. Responsibilities involve planning and coordinating the geotechnical activities in support of the major feasibility study for the caving operation. Work included: specification of underground mapping for exploration of the orebody; analysis and interpretation of geotechnical characterization for estimation of rock properties and design input; numerical assessment of caving and subsidence of rock slopes; stability assessment of the undercut and production levels; assessment of infrastructure stability and setback; working with mine planners on optimization of a caving method. Currently consulting on geotechnical exploration activities for construction of 3 shafts, approximately 50 km of ventilation, conveyor and men/material declines from the surface to underground.
- *Henderson Mine, Empire, Colorado, Freeport-McMoran* — Assessments of cave propagation and cave front directions for the 7210 production level. Prefeasibility study of the proposed Dailey caving level at depth beneath the existing mine. Three-dimensional numerical modeling of panel-caving

alternatives, and prediction of stresses and stability of production level. Annual or semi-annual mine geotechnical inspection surveys and review.

- *Yucca Mountain Project, Bechtel* — Service as manager of mining and geotechnical engineering for the Yucca Mt. Project, the U.S. national nuclear-waste project. Supervised the underground design of the facility and managed a staff of approximately 50 engineers and project-controls staff. Led the team through the feasibility design of a room-and-pillar mine that would (if constructed) include 110 km of TBM (7-m diameter) tunnels and 7-m to 8-m diameter shafts. Wrote the seismic/mechanical effects portion of License Application submitted to the U.S. Nuclear Regulatory Commission in 2008.
- *Solvay Mine, Green River, Wyoming, Solvay Minerals*— Design of longwall panels and pillaring geometries for large trona mines in the Green River Basin. Investigated large panel collapse and developed methodology for assessing collapse potential and design of room-and-pillar panels. Assessment of the regional stability of solution mining of previously mined room-and-pillar panels.
- *Lucky Friday Mine, Deep Shaft Design* – Ground support design for large hoist room and ore-storage and handling facilities for new shaft construction at the Lucky Friday Mine. Infrastructure is in poor rock conditions at approximately 5000’ depth. Shaft ground-support design, shaft to be sunk to over 9000’ depth in laminated argillaceous rock.
- *Onaping Depth Project, Sudbury, Ontario, Falconbridge, Ltd.*— Geotechnical consultant lead on prefeasibility design of a new nickel mine at great depth below the Onaping-Craig operations. Worked with a team to develop a mechanized undercut-and-fill operation to mine-wide, high-grade zone under high stress conditions at depths of 7500 to 10,000’. Currently act on a geotechnical and mining review board for the prefeasibility of the project.
- *Mine D, Kidd Division, Timmins, Ontario, Falconbridge, Ltd.* — Geotechnical consultant on the mine planning, layout and economic assessment for deep extensions of the Kidd Mine. Design of a blasthole stope, and pillar layout and extraction scheme for extraction of orebody from 6000’ to 10,000’ depth. Assisted in development of bankable feasibility study.
- *Other major mine planning/assessment projects with significant participation:*
 - *El Teniente and Andina Mines, Chile, Codelco (caving)*
 - *Caracoles Project, Chile, Antofagasta Minerals (caving scoping study)*
 - *Snap Lake Project, DeBeers, NW Territories, Canada (room-and-pillar/paste fill)*
 - *Orapa and Letlakhane Mines, DeBeers, Botswana (open-pit slope stability)*
 - *Myra Falls Mine, Campbell River, BC, Canada, Boliden Mineral (cut-and-fill and blasthole)*
 - *Kristineberg, Garpenberg, Renstrom and Garpenberg North Mines, Boliden, Sweden, Boliden Mineral (cut-and-fill)*
 - *Premier and Bultfontein Mines, South Africa, DeBeers (panel and block caving)*
 - *Brunswick Mine, Bathurst, NB, Canada, Noranda, Ltd (blasthole)*
 - *Onaping, Craig and Strathcona Mines, Onaping, Ontario, Canada, Falconbridge, Ltd (cut-and-fill)*
 - *Buffelsfontein Mine, Klerksdorp, South Africa, GENMIN, (deep, narrow reef gold)*
 - *Sifto Salt, Goderich, Ontario, Canada, Sifto Salt Company (room-and-pillar)*

- *Troy Mine, Troy, Montana, USA, Revett Minerals (room-and-pillar)*
- *Coeur/Galena Mine, Wallace, Idaho, USA, Coeur d'Alene Mines (cut-and-fill, blasthole)*
- *Campbell Mine, Redlake, Ontario, Canada, Campbell Mining (cut-and-fill)*
- *Macassa Mine, Kirkland Lake, Ontario, Canada, Kinross Mining (cut-and-fill)*
- *Laronde Mine, Cadillac, Quebec, Canada, Agnico-Eagle (blasthole)*
- *Hope Brook Mine, Stephenville, NF, Canada, Royal Oak (blasthole)*
- *Star Mine, Burke, Idaho, USA, Hecla Mining (undercut-and-fill)*

Rock Instrumentation and Field Experience

Extensive work in planning, installation and analysis of data from most types of rock instrumentation, including TDR cables, rock stress change, concrete stress and strain, displacement, tilt, temperature, groundwater pressure and flow, cross-hole acoustic measurements, and seismic instruments. Numerous in-situ stress measurements by hydraulic fracturing and overcoring. Installation of several microseismic monitoring systems for rockburst monitoring and control. Numerous field projects in geotechnical characterization including detail line mapping, core logging, etc., and estimation of in-situ rock mass properties. Installation of instrumentation and conducting field tests for major waste-disposal projects in Sweden, Colorado and the Nevada Test Site. Construction and instrumentation of several circular, concrete-lined shafts, including the Silver Shaft at the Lucky Friday Mine, Mullan, Idaho (6200' depth), Solvay and General Chemical Mines in Wyoming. Developed undercut-and-fill mining method for rockburst control for the Star Mine in Burke, Idaho (7900' depth), and supervised the mining trials of this method.