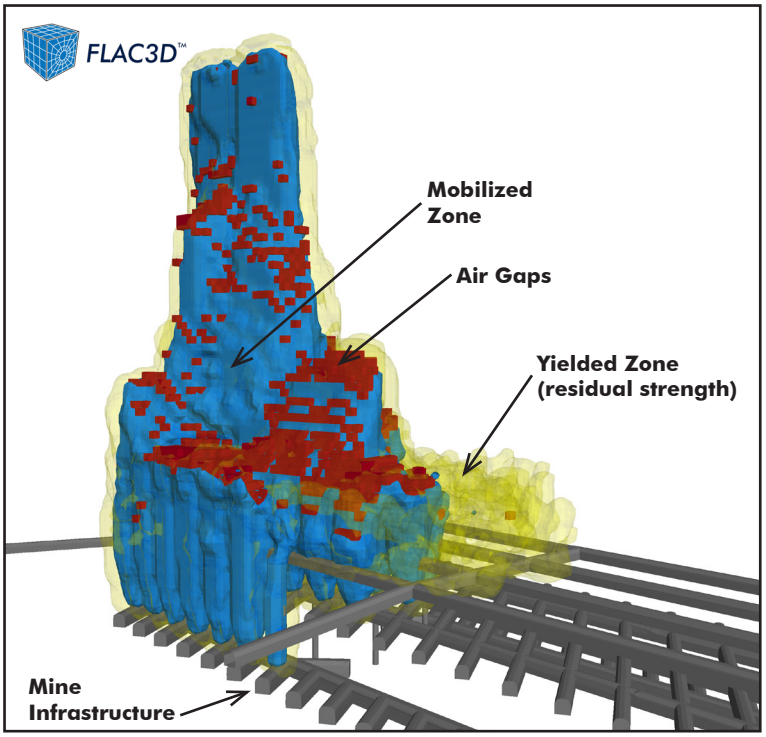
CAVE MINING
Consulting & Software

ABOUT ITASCA

Itasca is an engineering consulting, research, and software development company specializing in solving complex engineering challenges. Our global, diverse, and interdisciplinary engineers use geomechanical, hydrogeological, and microseismic analyses for application in the fields of civil, energy, environmental, materials, and mining.

Itasca has been at the forefront of cave mine engineering for over 30 years, pioneering the development of industry-leading tools and experiential guidelines and empirical relations. Applied at more than 30 block, panel, and sub-level caving operations and projects worldwide, our tools and work have been validated through direct comparison of observed and predicted behaviors. Itasca also has been a leader in research contributing to both the International Caving Study (ICS) and Mass Mining Technology (MMT) projects.



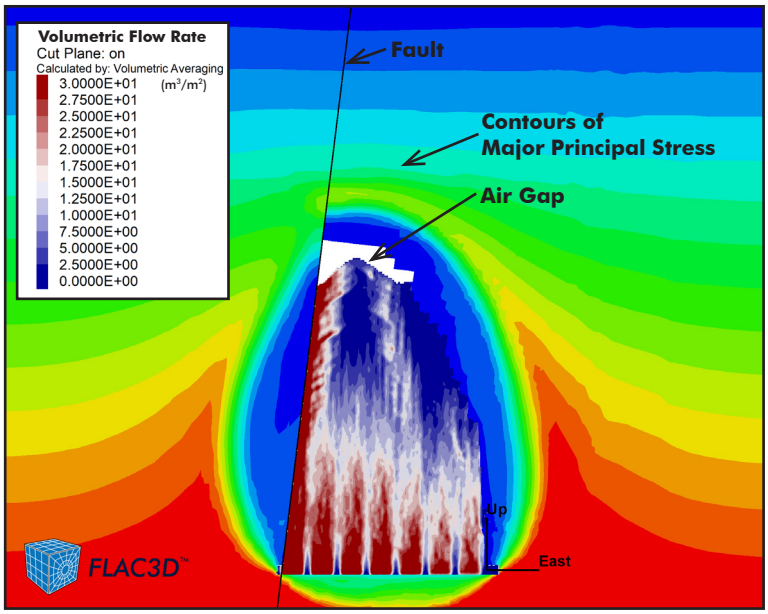
FLAC3D/REBOP model indicating the influence of friable faults leading to chimneying - funneling.

GEOMECHANICS

Caving is being applied to increasingly deep, large, strong, and heterogeneous ore bodies. This increases the risk of stranded reserves in overhangs, potential for cave stall and air-blast, infrastructure rehabilitation or loss, and large-scale caving-induced subsidence.

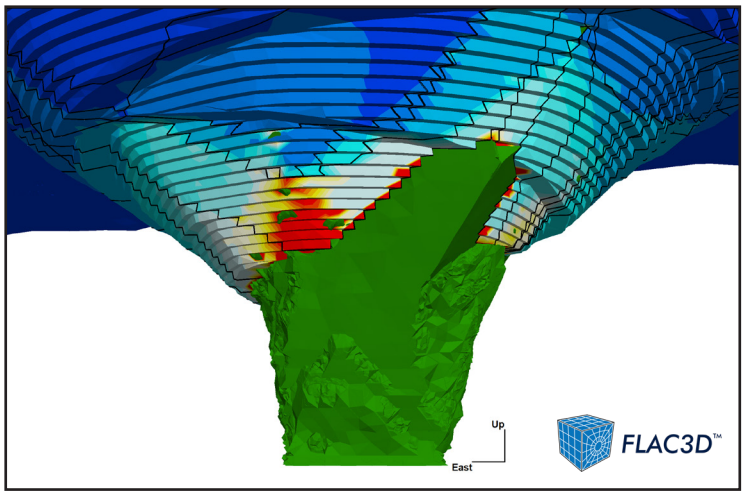
Geomechanical analyses are therefore critical to understand and predict:

- cave growth and shape;
- primary and secondary fragmentation;
- extraction level stability;
- recovery and dilution; and
- surface subsidence.

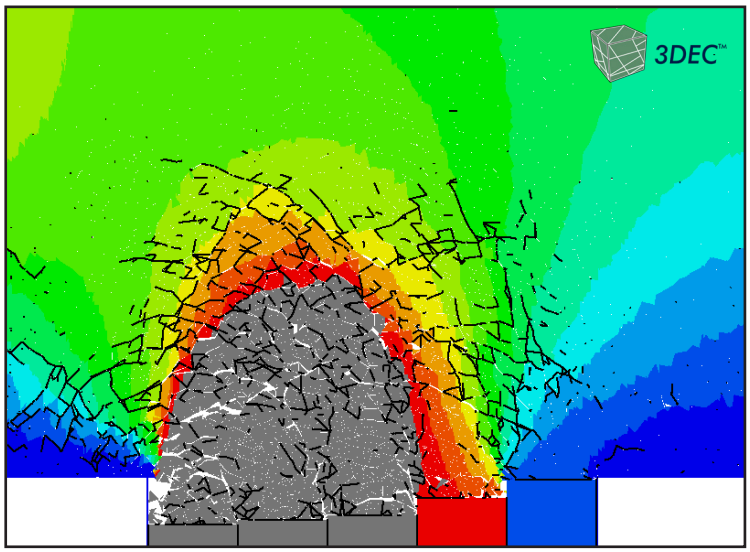


FLAC3D/CAVESIM model plot showing the influence of a major fault on the cave after 1 year of uniform draw (east-west cross-section through cave center).

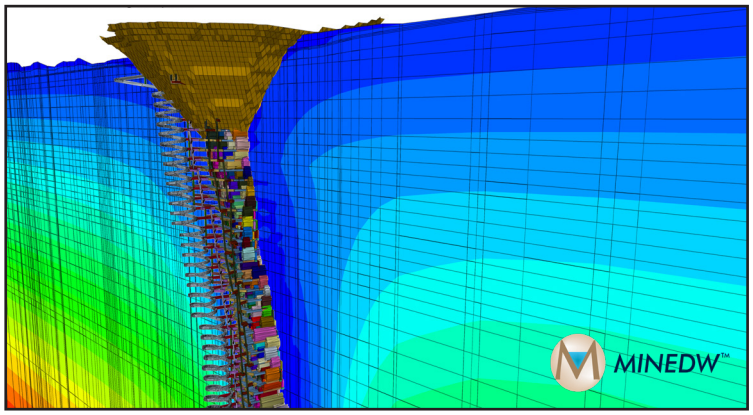
Itasca simulates mine caveability and subsidence using the continuum program *FLAC3D* and the



Simulation of cave propagation and interaction with an open pit using a *FLAC3D-CAVESIM* coupled approach.



3DEC Bonded Block Model simulating progressive undercuts. Block displacement contours and fracturing (lines) are shown.



MINEDW model predicting pore pressures around a combined open pit and underground sub-level retreat mining operation.

discrete element programs *3DEC* and *PFC* to predict the progressive failure and fragmentation of the rock mass from an intact/jointed to a caved material. Both *FLAC3D* and *3DEC* can utilize Itasca's CaveHoek material model, whereas both *3DEC* and *PFC* can utilize bonded or free-flowing blocks/particles. Coupled with our deterministic, physics-based code *REBOP* or the statistical, cellular automata code *CAVESIM*, the collapse, bulking, and movement of caved rock can be better accounted for. The coupled method captures many important aspects of caveability affecting cave design, such as hang-up formation, material recovery, timing of surface breakthrough or interaction with other lifts, crater development, and surface subsidence.

HYDROGEOLOGY

Itasca hydrogeologists have developed the program *MINEDW* specifically for mine dewatering simulation and have extensive experience in assessing key hydrogeologic issues related to caving projects, including:

- groundwater inflow to mine workings for determining mine pumping requirements;
- pore-pressure distributions for assessing underground infrastructure and slope stability;
- prediction of moisture content for evaluating mud-rush potential; and
- prediction of water quality for discharge limits.

MICROSEISMICS

Microseismic monitoring provides insight into the location and extent of fracturing induced by the stress changes associated with mining processes in general. The spatial characteristics of the observed microseismicity provide valuable validation for the back analysis of fracturing processes (e.g., caving, preconditioning) through numerical models. It also provides a tool for the future validation of forward cave models that predict the extent and location of the seismogenic zone and the transmission properties of the damaged rock. Itasca has developed the *InSite* suite of programs for the analysis of microseismicity.

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