ITASCA™

40 YEARS

FLAC3D for New Users

October 2021

Panelists

Jim Hazzard
Software Manager

Zhāo Chéng
FLAC3D Product Manager

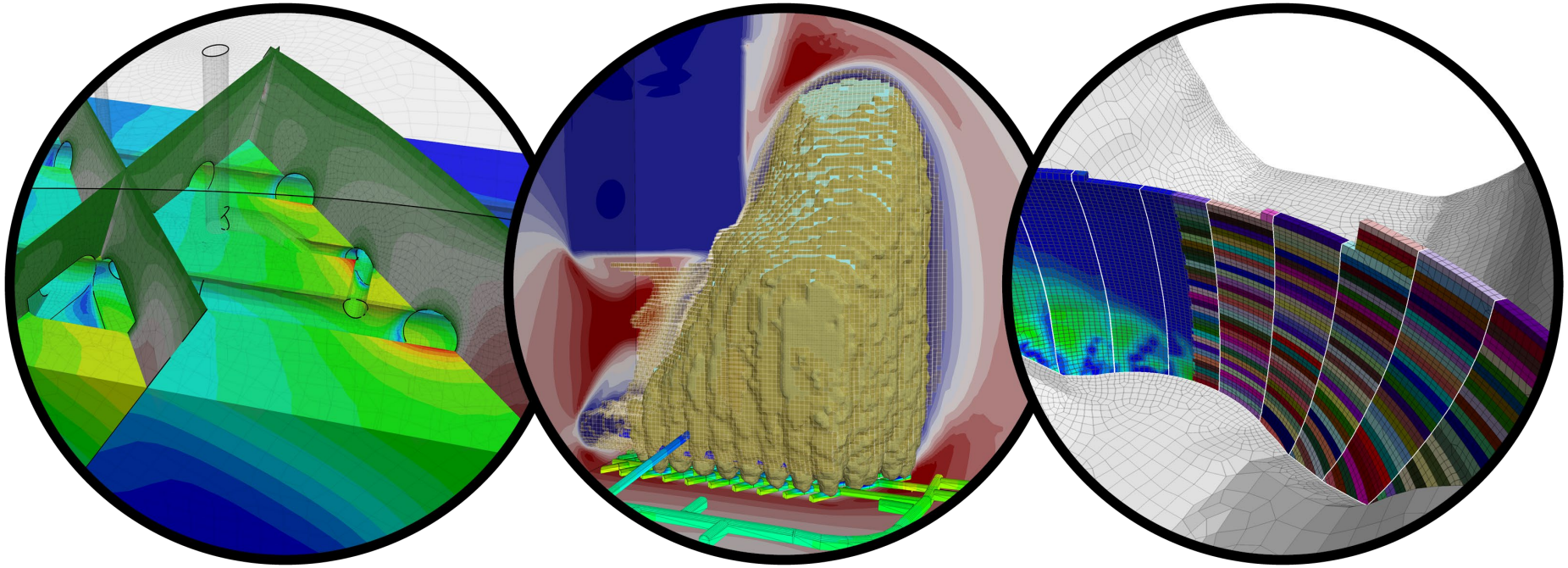
David DeGagné
Senior Engineer, Technical Marketing

FLAC3D for New Users

- What is *FLAC3D*?
- How it works
- Features
- Demo
- What's next?

What is *FLAC3D*?

- Continuum numerical modeling software for geotechnical analyses of soil, rock, groundwater, and ground support
- Used in civil, mining, geotechnical and petroleum engineering applications
- Analyses include engineering design, factor of safety prediction, research and testing, and back-analysis of failure



Applications

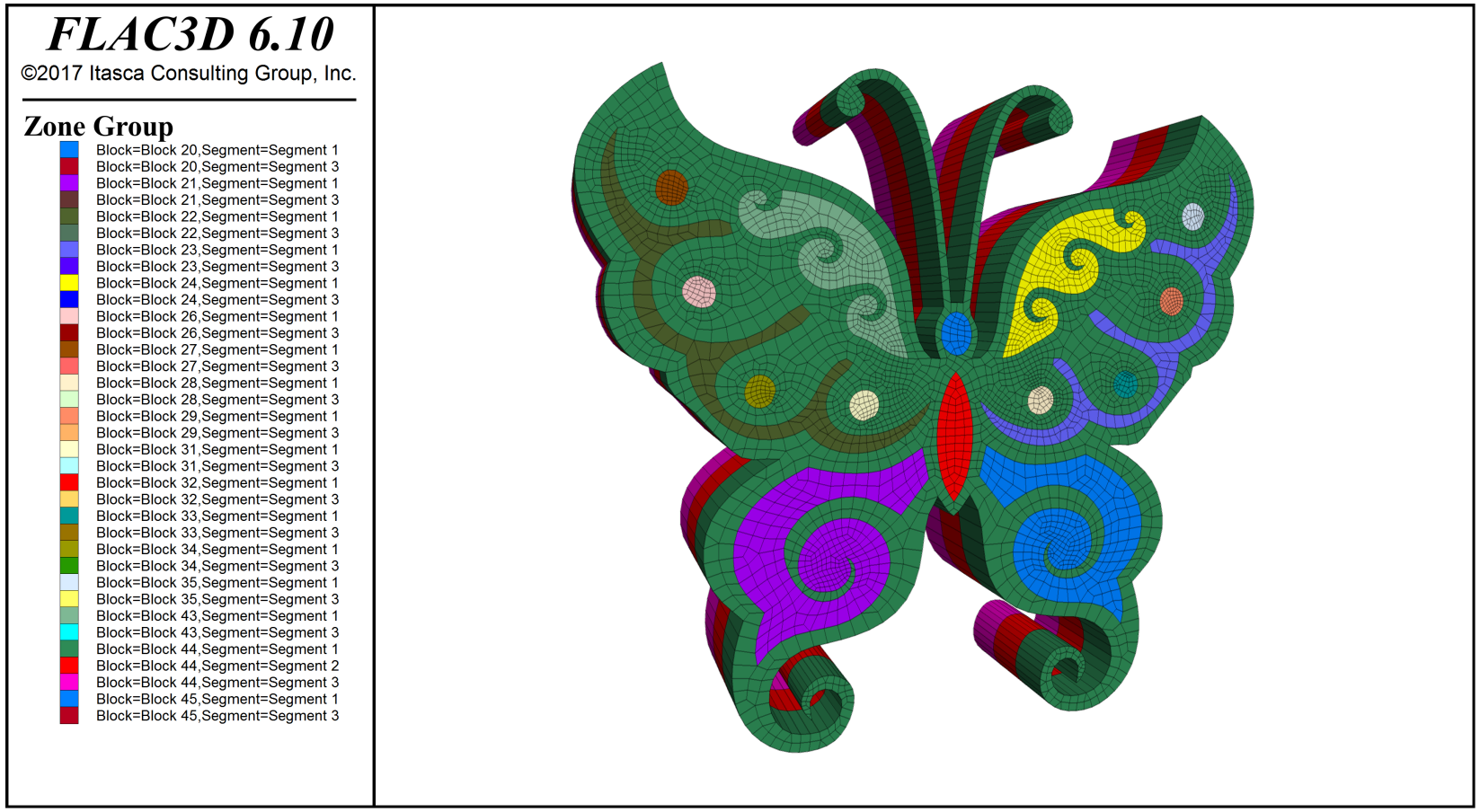
- Deformation and stability analysis of:
  - Slopes (embankments, open pit mines, rock and soil)
  - Tunnels (transportation tunnels, caverns, mining stopes)
  - Surface excavations (foundations, footings)
- Analysis of effectiveness of ground support
  - Cables, soil nails, tiebacks, piles
  - Liners, shotcrete
  - Geogrids, geotextiles
- Dynamic analysis
  - Earthquakes, liquefaction, rockbursts, microseismicity
- Faulted or jointed rock

FLAC3D for New Users

- What is *FLAC3D*?
- **How it works**
- Features
- Demo
- What's next?

How it works

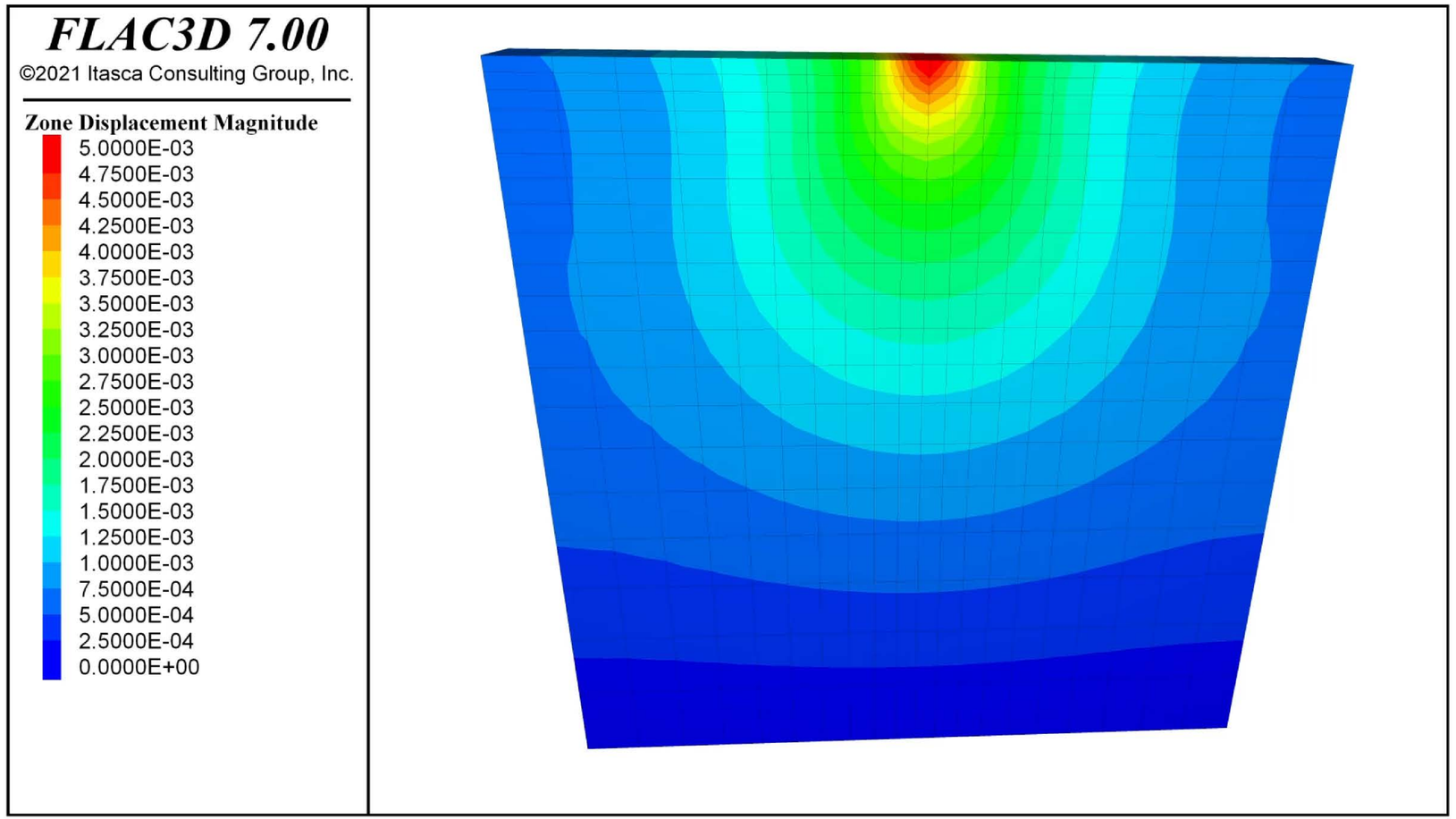
- *FLAC3D* uses an explicit, finite volume formulation



Finite volume formulation does not require a regular grid – unstructured meshes are possible

Explicit solution

- Explicit “time-marching” scheme models changing boundary conditions by propagating information across the model in a realistic manner



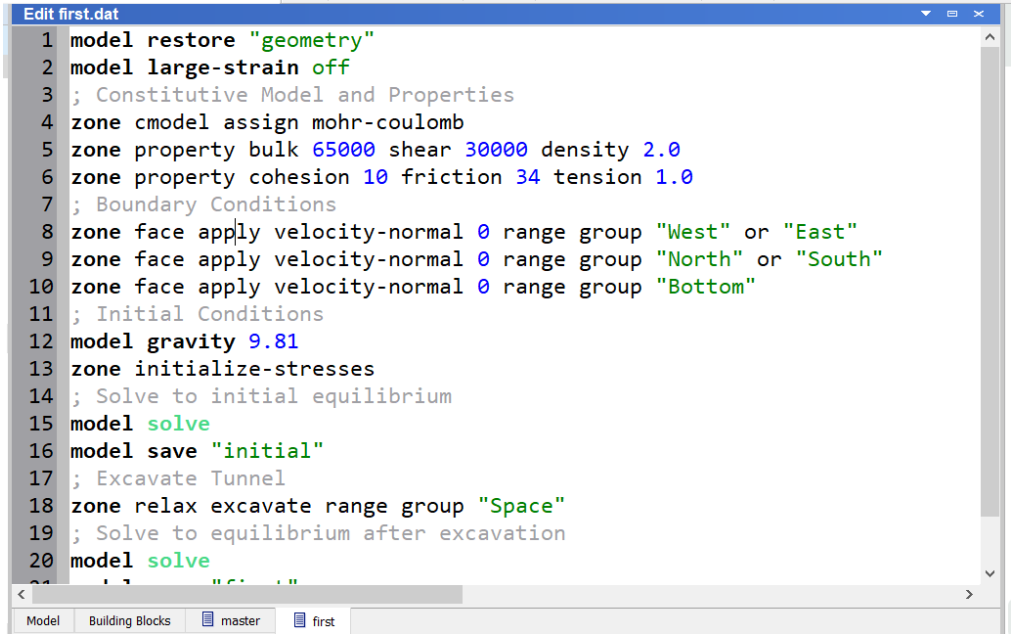
Explicit Solution Scheme

- Models physically unstable processes without numerical instability
- Explicit approach is good for:
  - Dynamics
  - Highly non-linear material behavior (e.g. strain softening)
  - Large strain
  - Severe instability (yield/failure over large area, total collapse)
- Explicit approach is less good for:
  - Elastic or near-elastic models

FLAC3D is (mostly) command driven

Why?

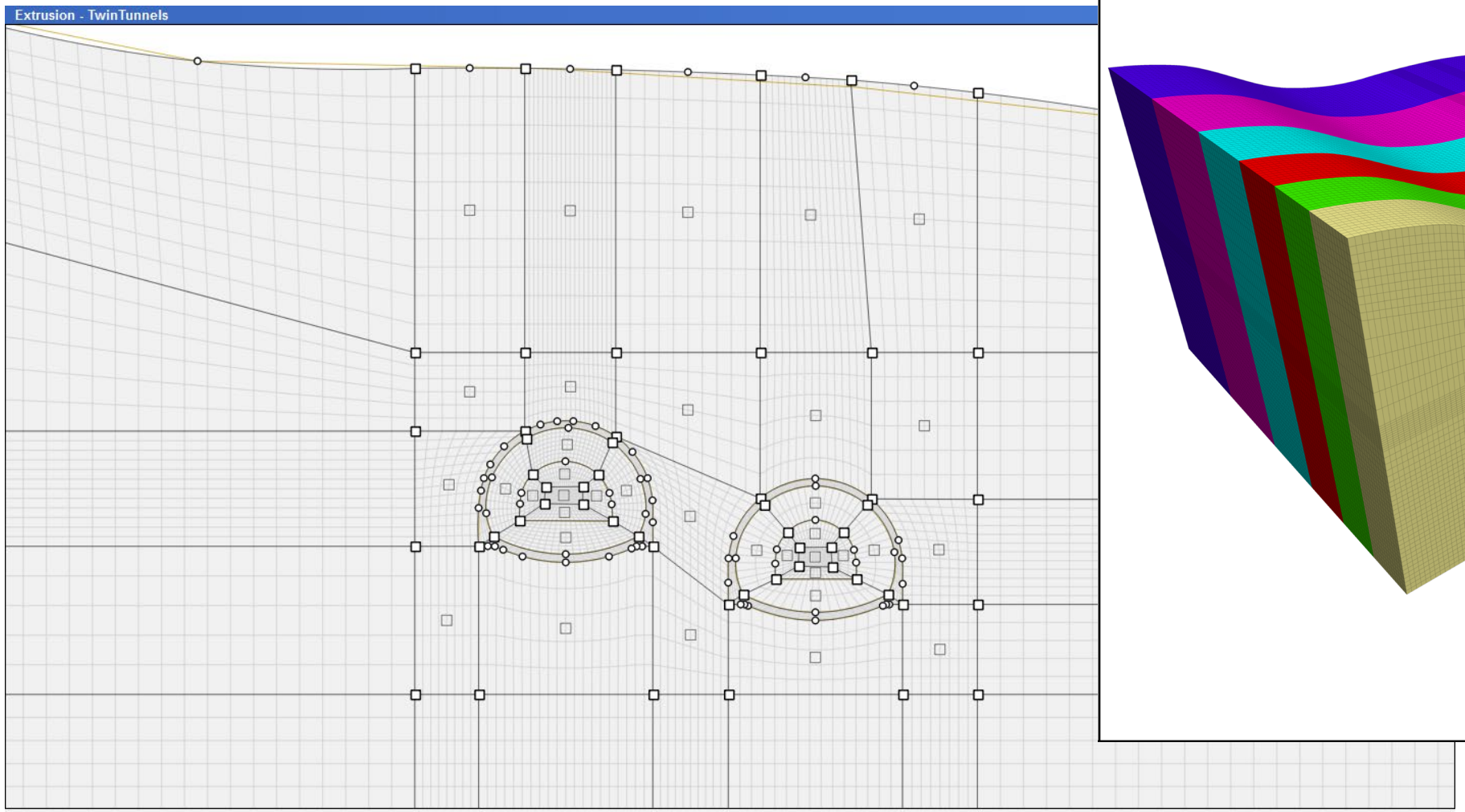
- Provides high level of flexibility and power without proliferation of buttons and menus
- Repeatability
- Easy to perform parameter studies
- Easy to add scripting

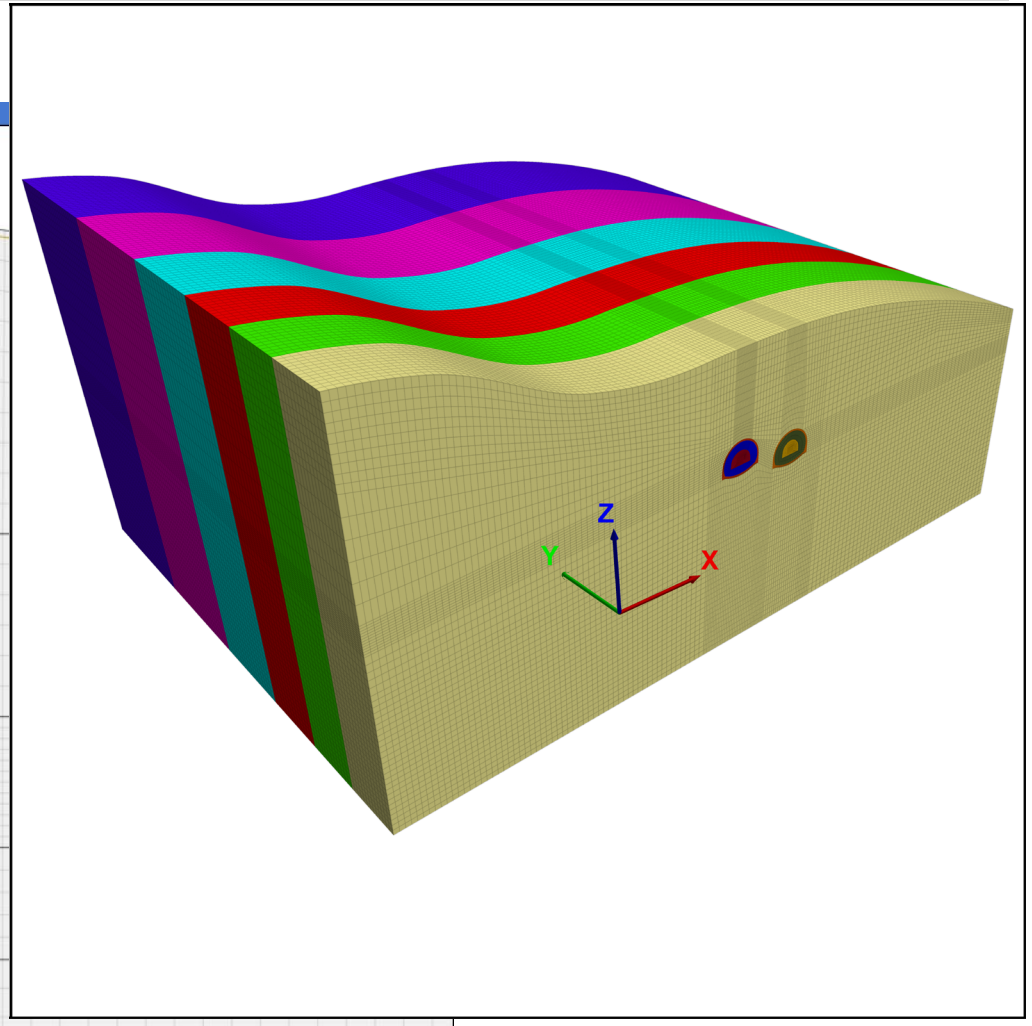


FLAC3D for New Users

- What is *FLAC3D*?
- How it works
- **Features**
- Demo
- What's next?

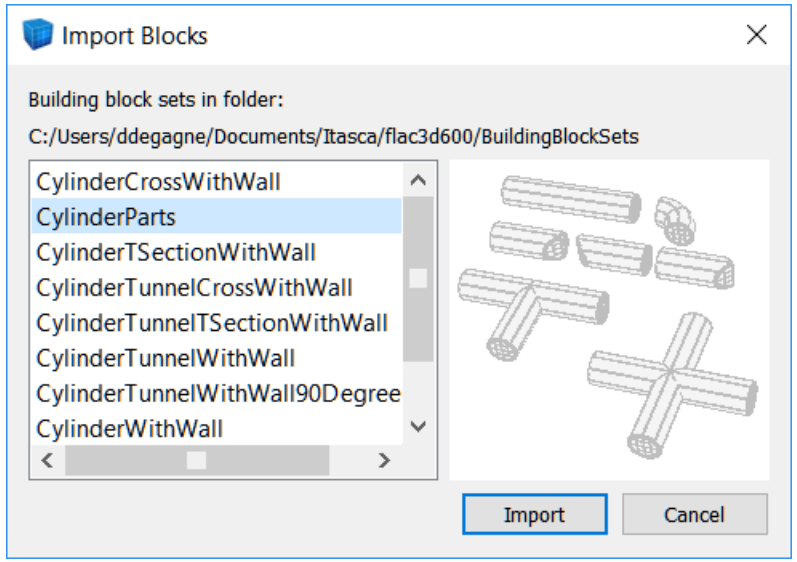
Model Building: Extrusion

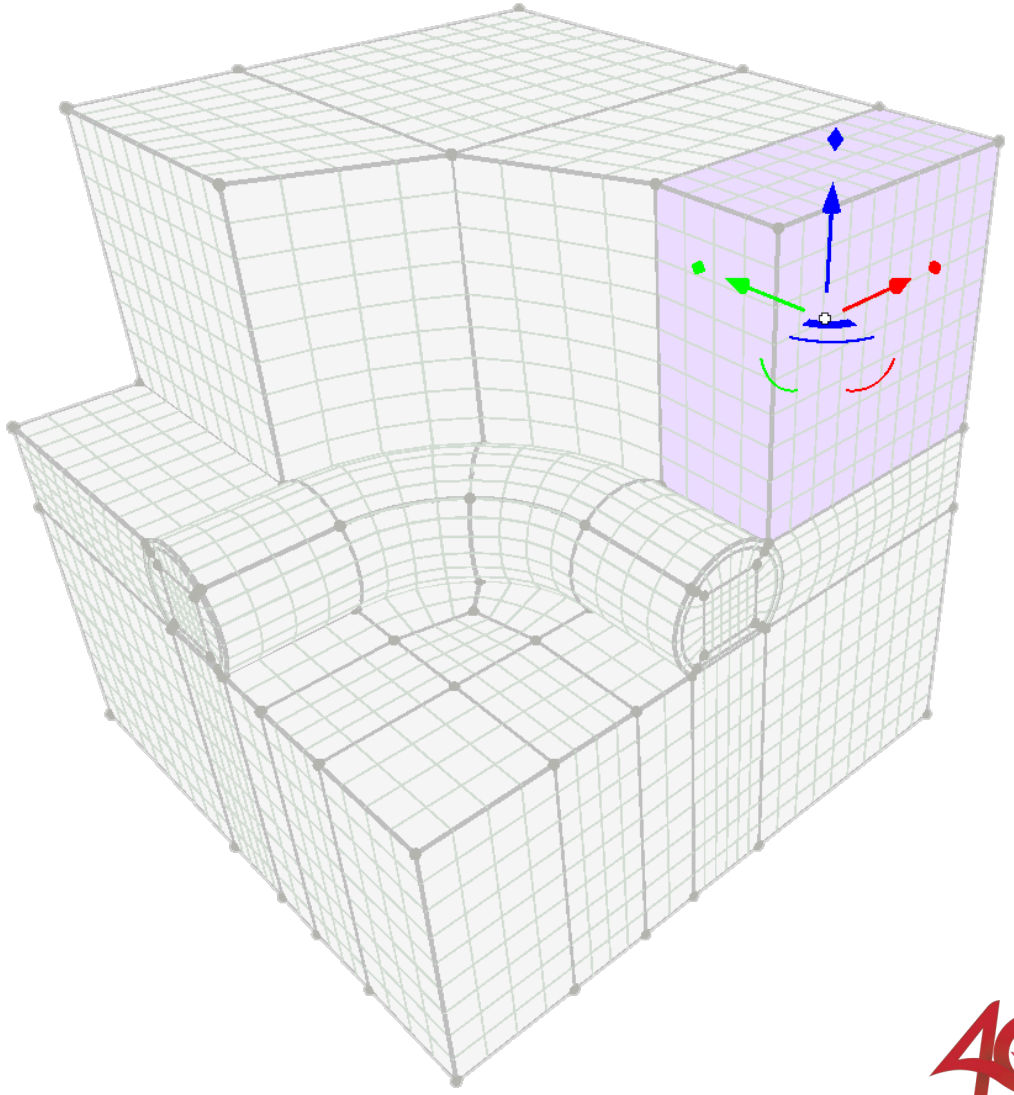




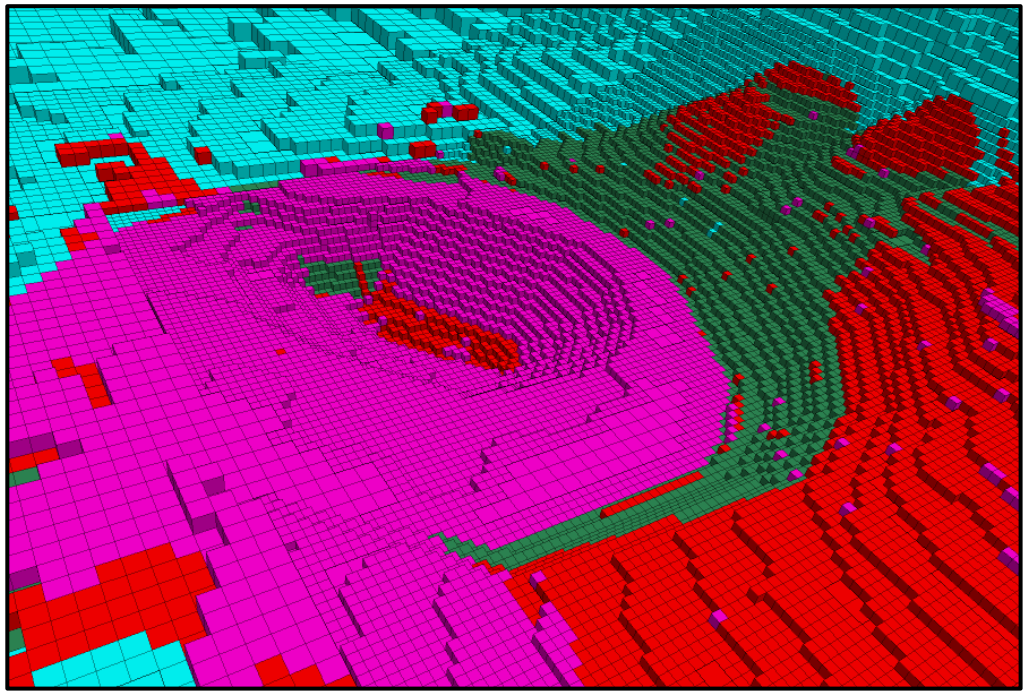
40 YEARS
ITASCA™

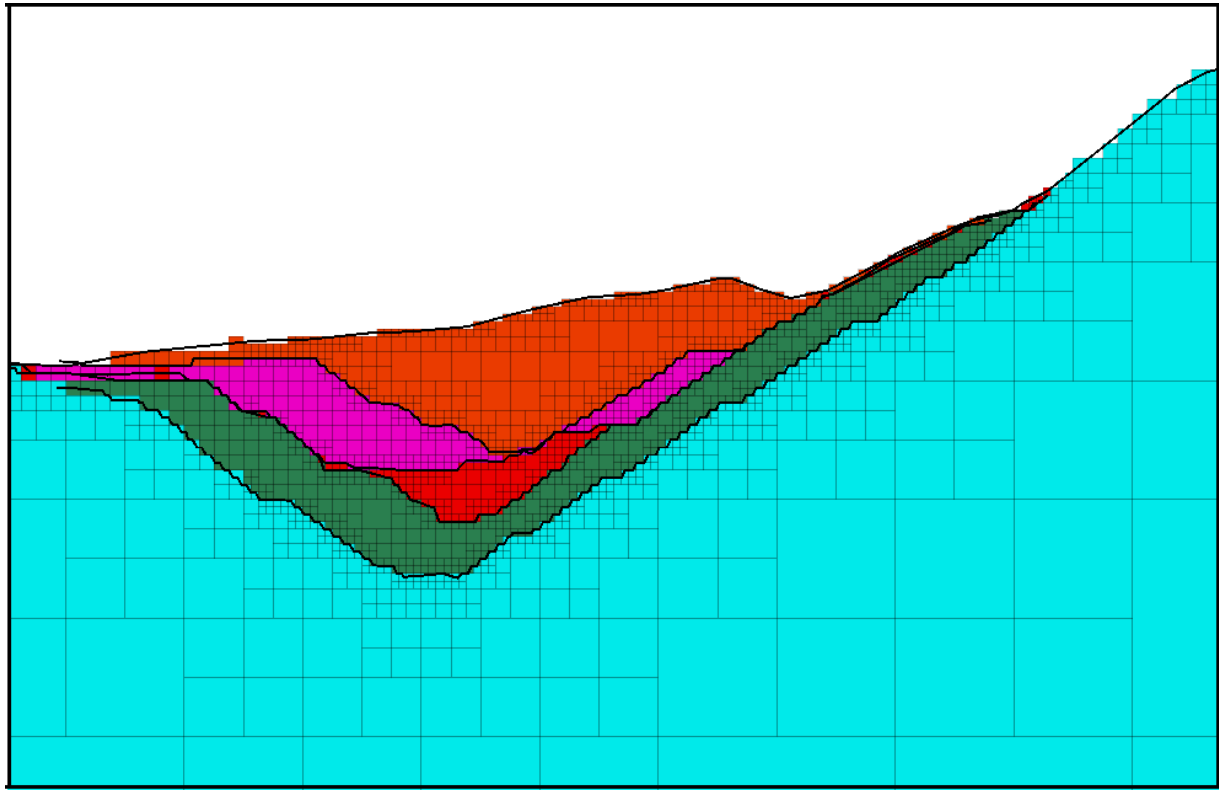
Model Building: Building Blocks





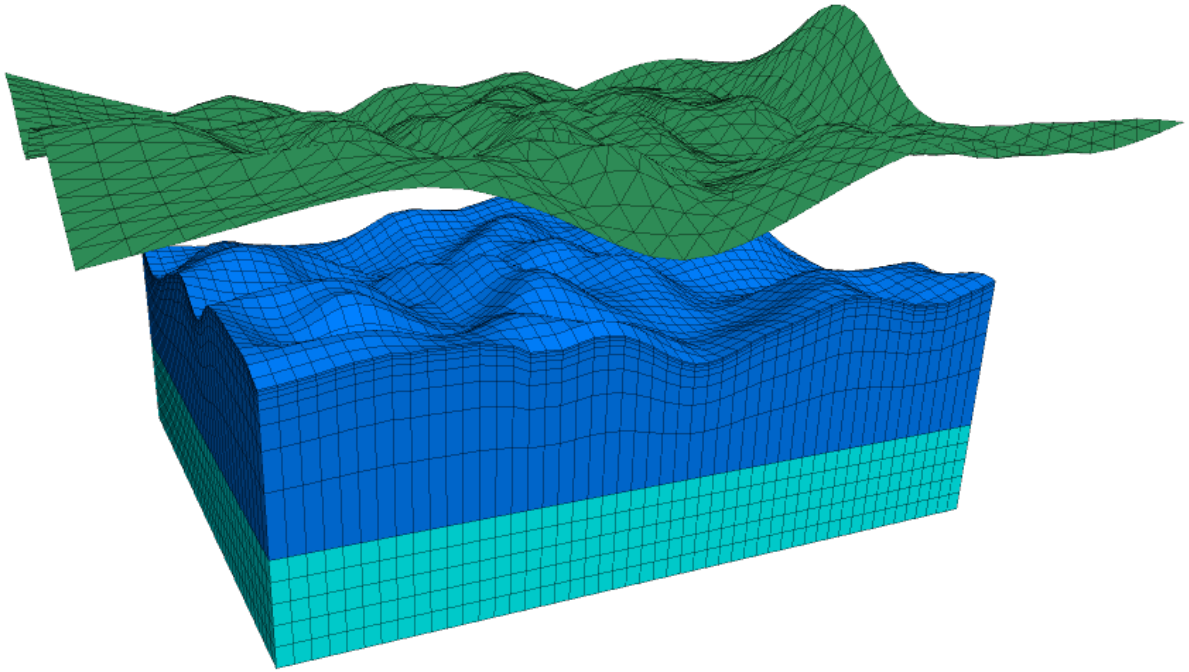
Model Building: Geometric Surfaces

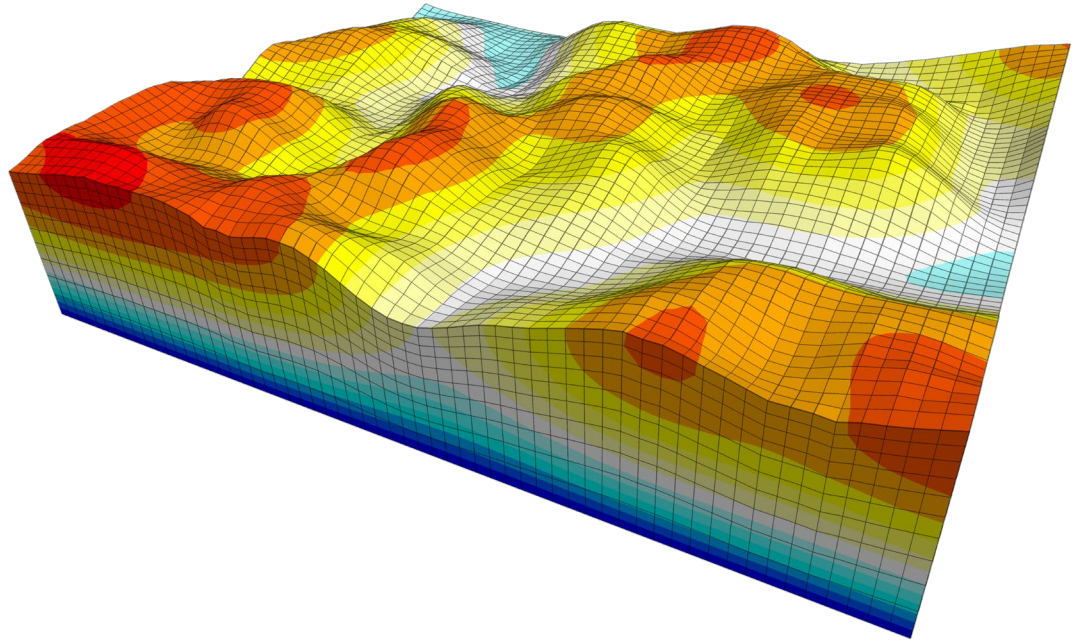




- Densify zones close to imported surfaces
- Name zones according to position relative to surfaces

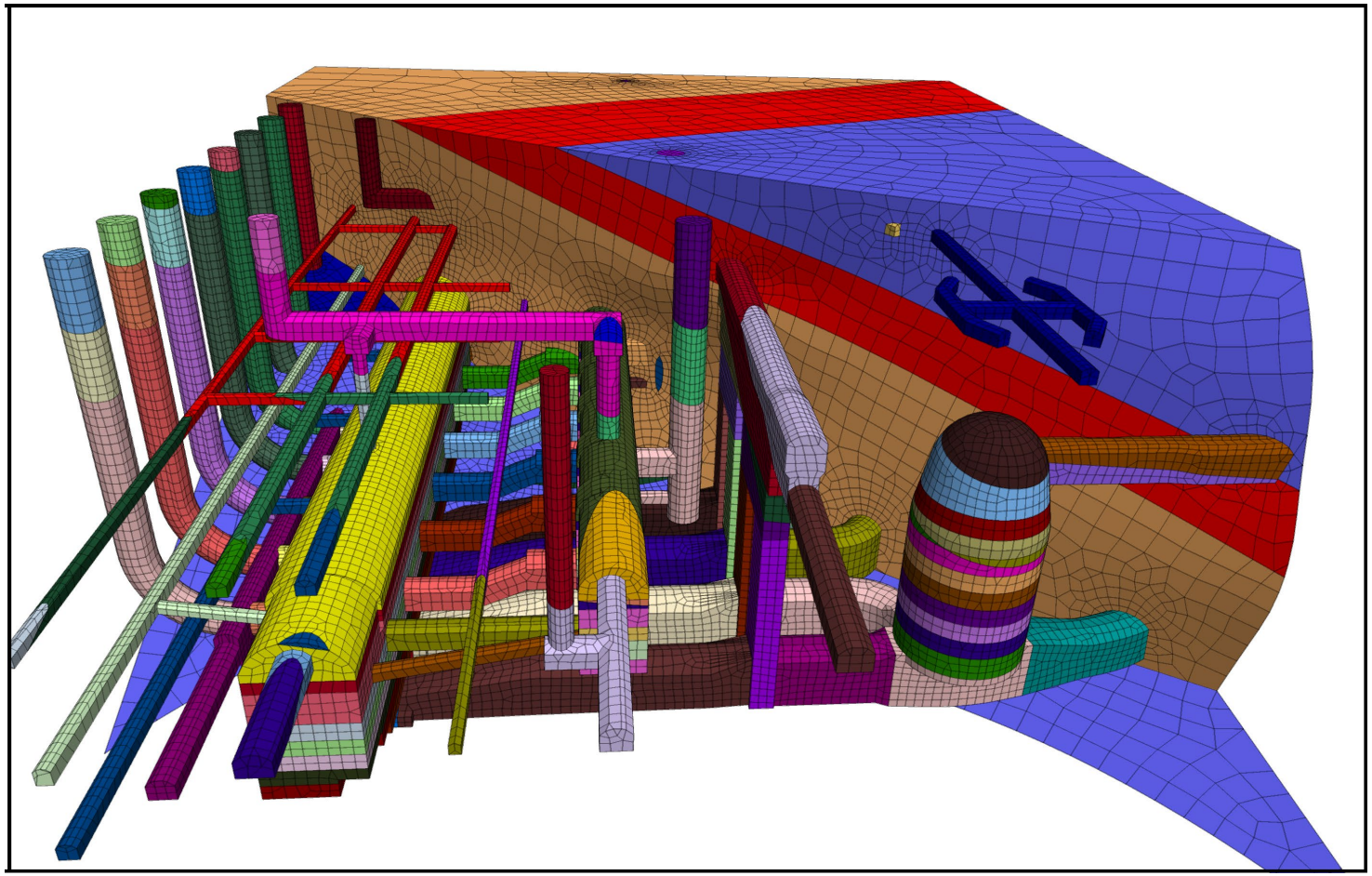
Model Building: Geometric Surfaces





- Fit zones to an imported topographic surface

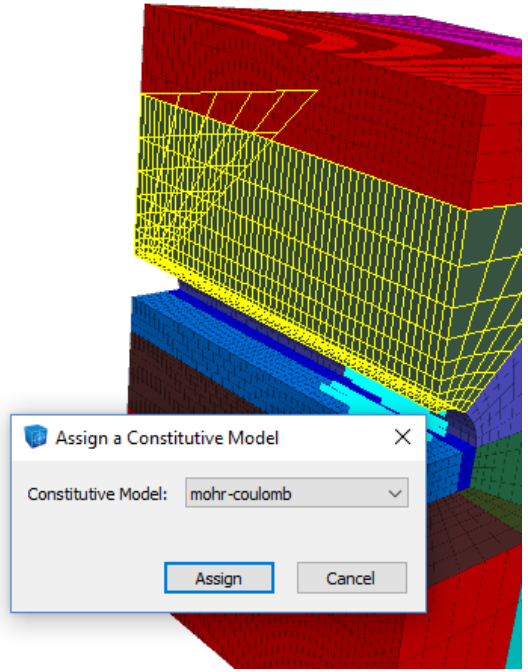
Mesh Import from Other Software

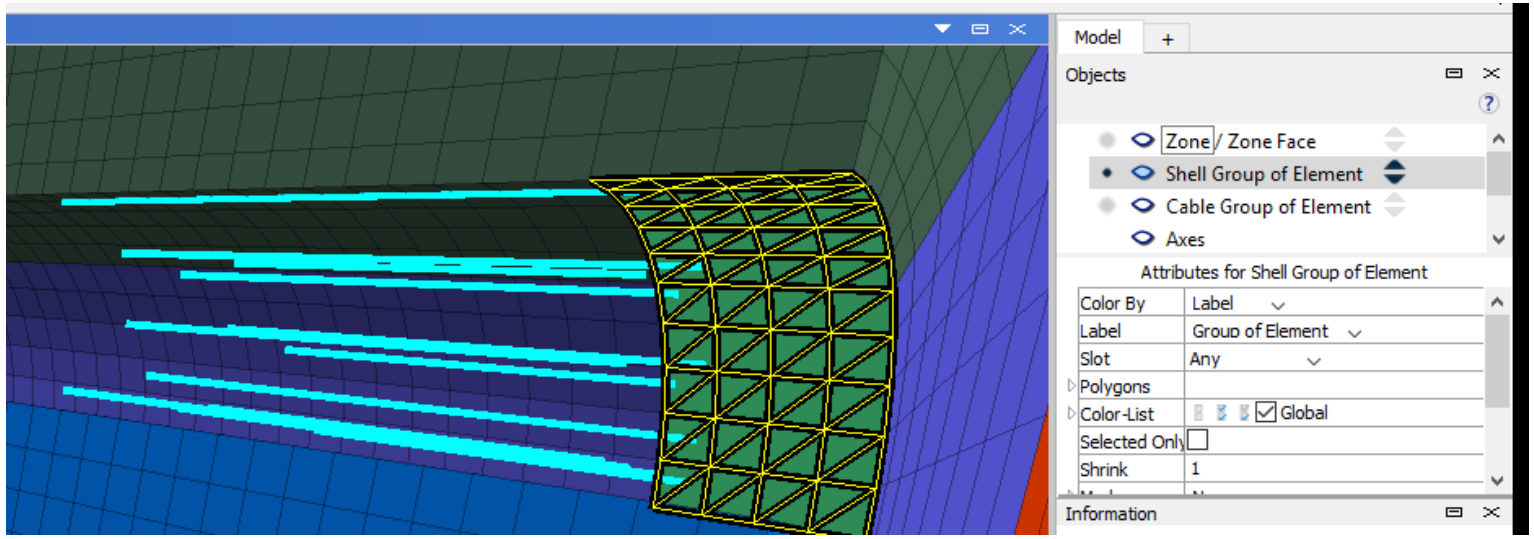


40 YEARS
ITASCA™

Model Manipulation

- Model pane allows for selecting volumes or surfaces and
  - Assigning names
  - Assigning constitutive models
  - Densifying zones (increase resolution)
  - Creating interfaces (faults/joints)
  - Creating structural elements (liners)

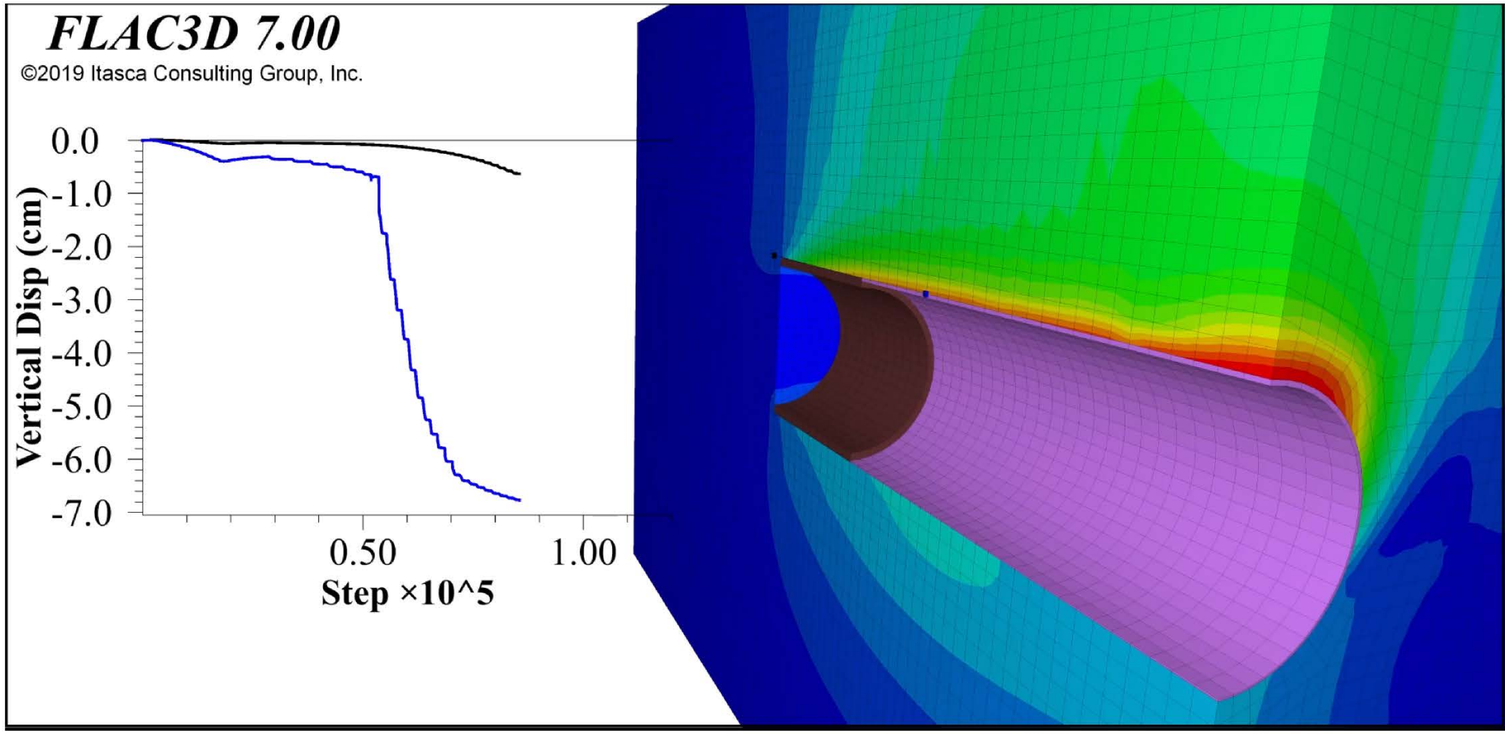




40 YEARS
ITASCA™

Loading, Excavation and monitoring

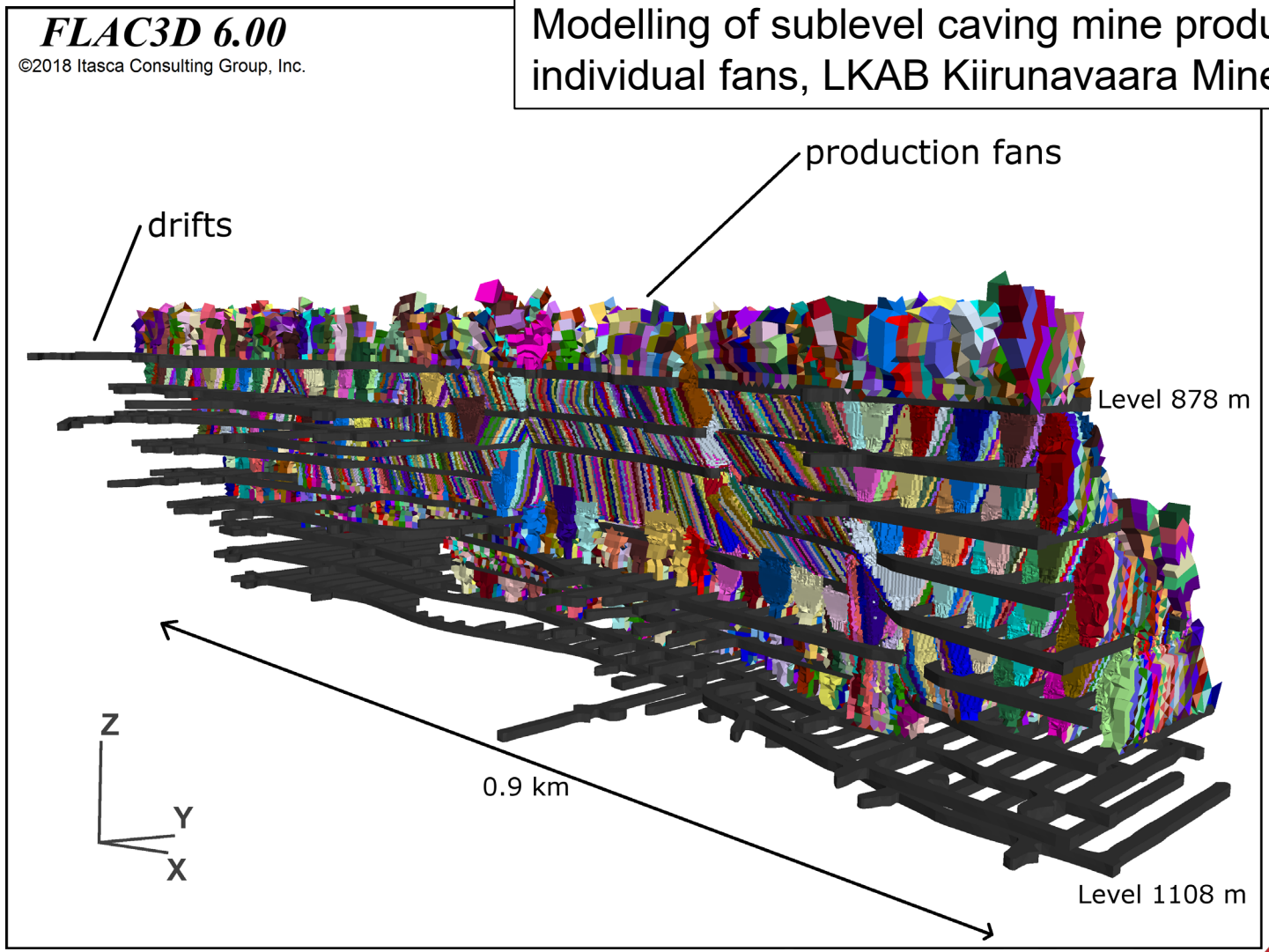
- Time-varying loads may be applied
- Complex staging of excavations possible
- Can view results as calculation progresses



40 YEARS
ITASCA™

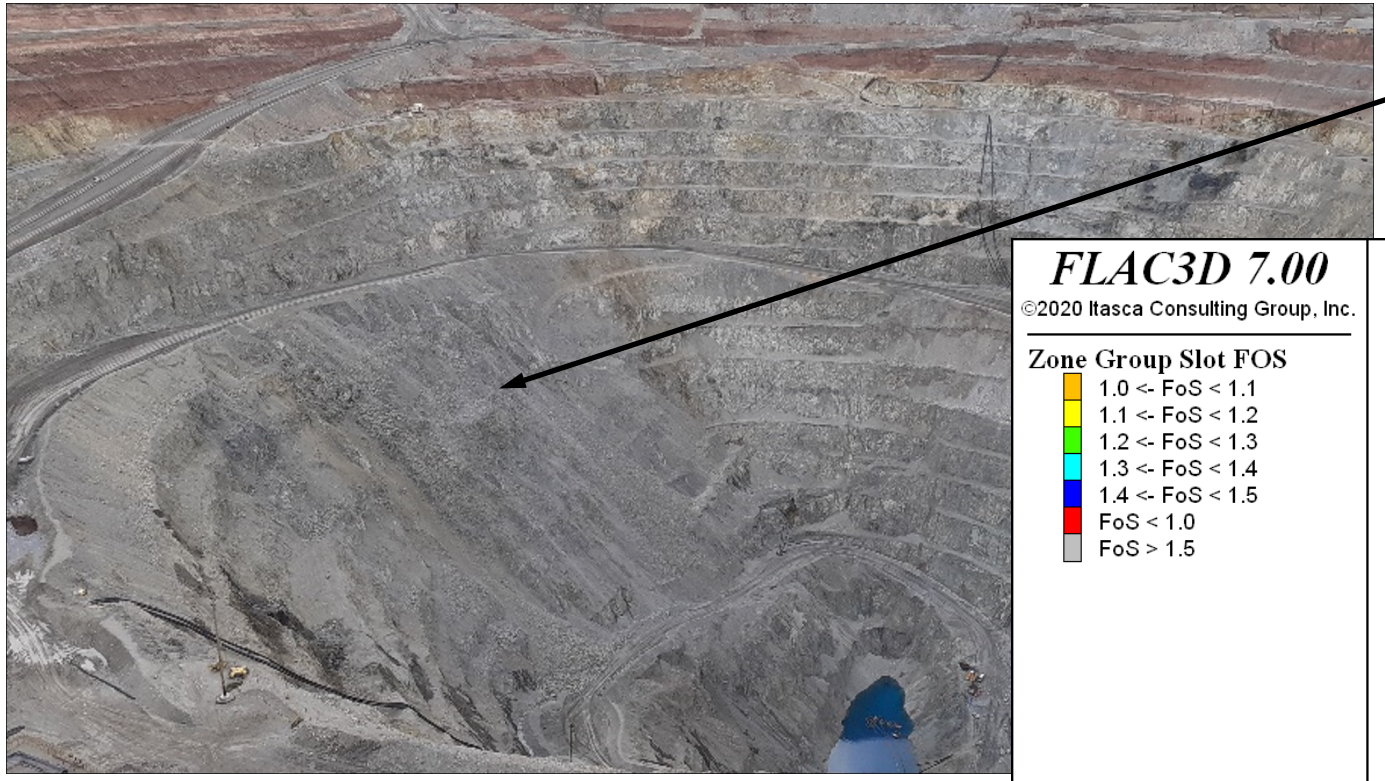
Staged Excavation

Modelling of sublevel caving mine production, showing individual fans, LKAB Kiirunavaara Mine, Sweden.

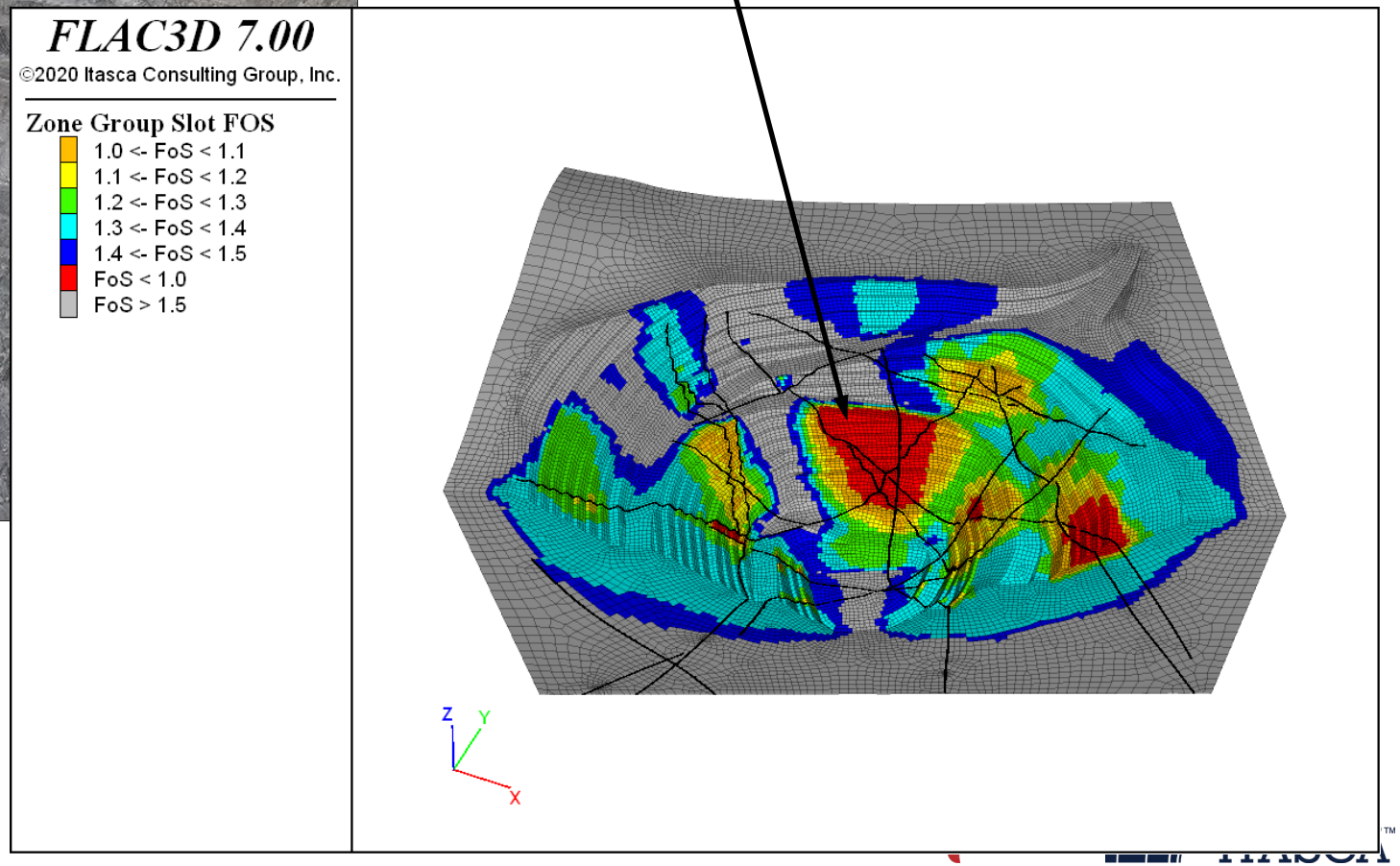


40 YEARS
ITASCA™

Factor of Safety

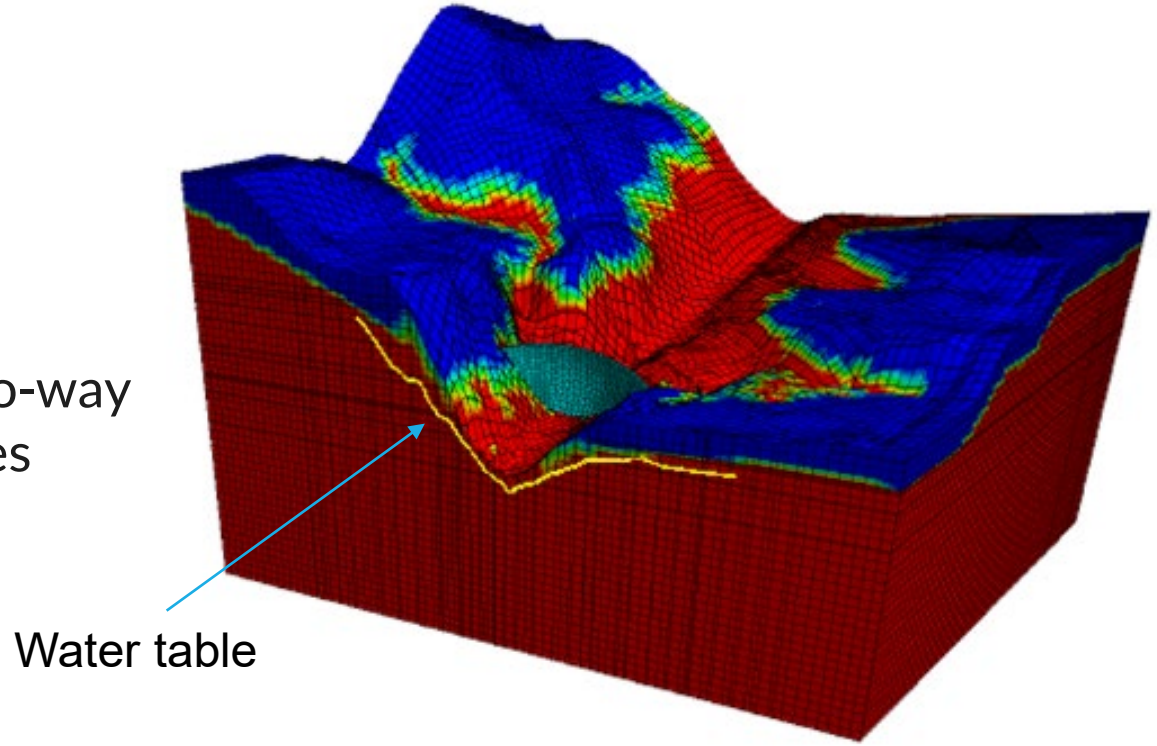


Factor of Safety < 1



Main Features: Fluid Flow

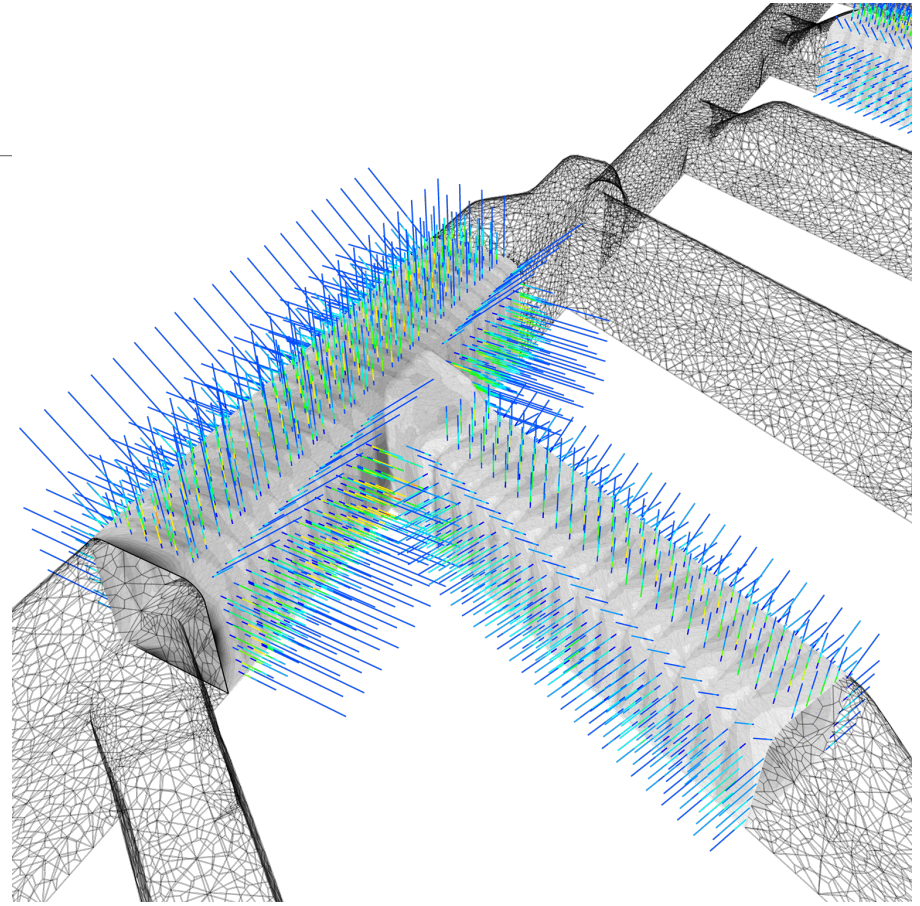
- Effective stress (water table)
- Steady-state flow
- Transient flow
- Partially saturated flow
- Couple fluid flow analysis to mechanical model (two-way coupling) as well as to dynamic and thermal analyses



Dam model with impounded water saturation contours shown

Main Features: Structural Elements

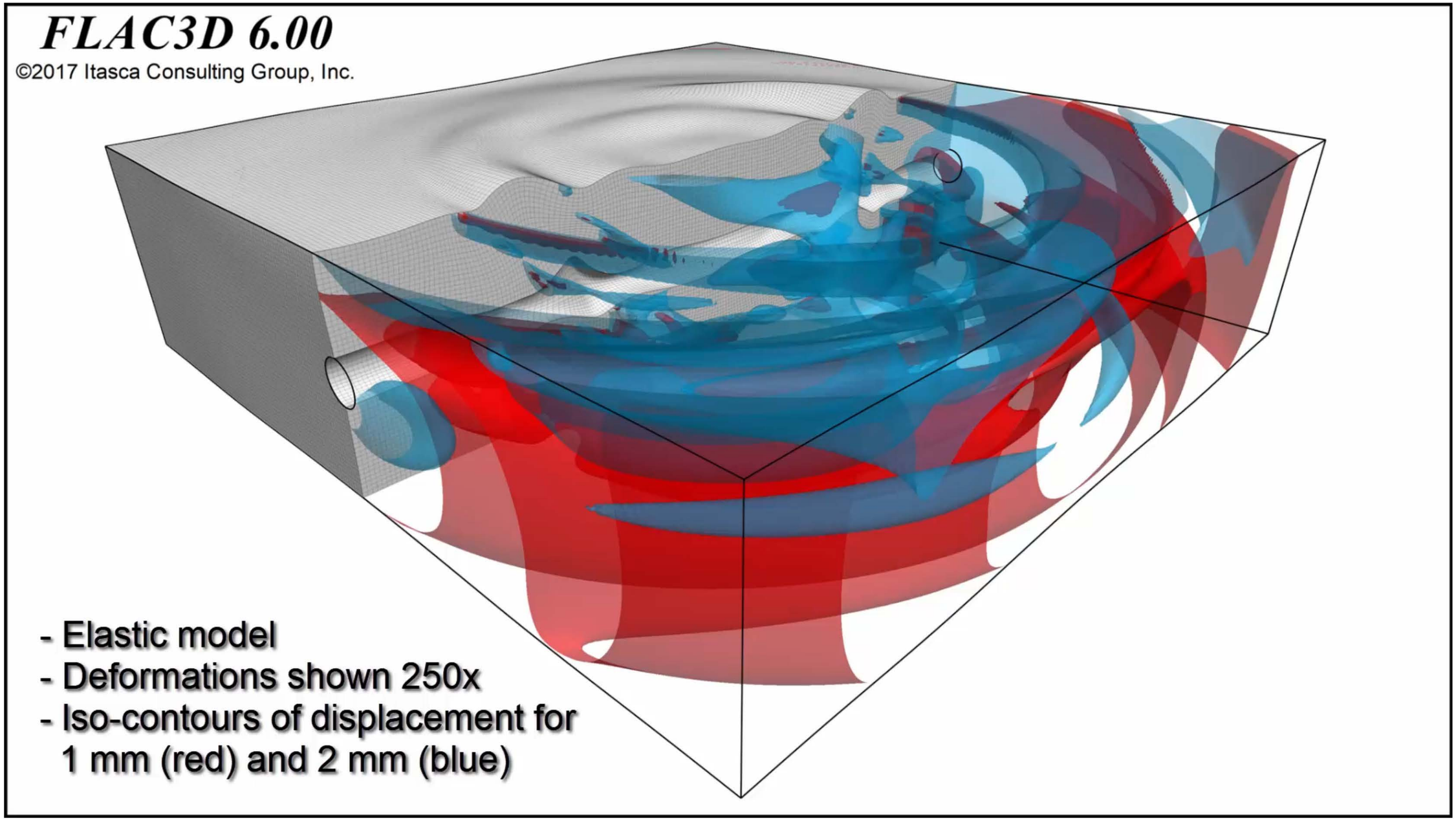
- Six forms of ground support:
  - Beam
  - Cable
  - Pile
  - Shell
  - Geogrid
  - Liner



- Can be joined to one another and/or the grid
- 2D structural elements (shells, geogrid, and liners) can be interactively defined using the Model Pane
- Structural element geometry can be imported from CAD software via DXF or STL files

Main Features: Dynamic Analysis

- Analyze earthquakes, seismicity, mine rockbursts, liquefaction, etc.
- Input acceleration, velocity or stress waves as boundary conditions
- Absorbing and free-field boundaries
- Can be used with structural elements and groundwater.


FLAC3D 6.00
©2017 Itasca Consulting Group, Inc.
- Elastic model
- Deformations shown 250x
- Iso-contours of displacement for
1 mm (red) and 2 mm (blue)

Main Features: Constitutive Models

- 26 mechanical and 9 creep models built-in
- Create your own constitutive model as a plug-in using C++
- Library of User Defined Models on the website https://www.itascacg.com/software/udm-library

•Null
•Elastic, Isotropic
•Elastic, Transversely Isotropic
•Elastic, Orthotropic
•Drucker-Prager
•Mohr-Coulomb
•Ubiquitous-joint (UBJ)
•Strain Hardening/Softening
•Bilinear Strain Hardening/Softening UBJ
•Double Yield
•Modified Cam-Clay
•Hoek-Brown
•Modified Hoek-Brown
•CYSoil
•Simplified CYSoil (CHSoil)
•Caniso **NEW in 7**
•Plastic Hardening (PH) **UPDATED** (small strain)
•Mohr-Coulomb Swelling
•Mohr-Coulomb Tension
•NorSand **NEW in 7**
•Soft-Soil **NEW in 7**
•P2PSand **NEW in 7**

Main Features: Scripting

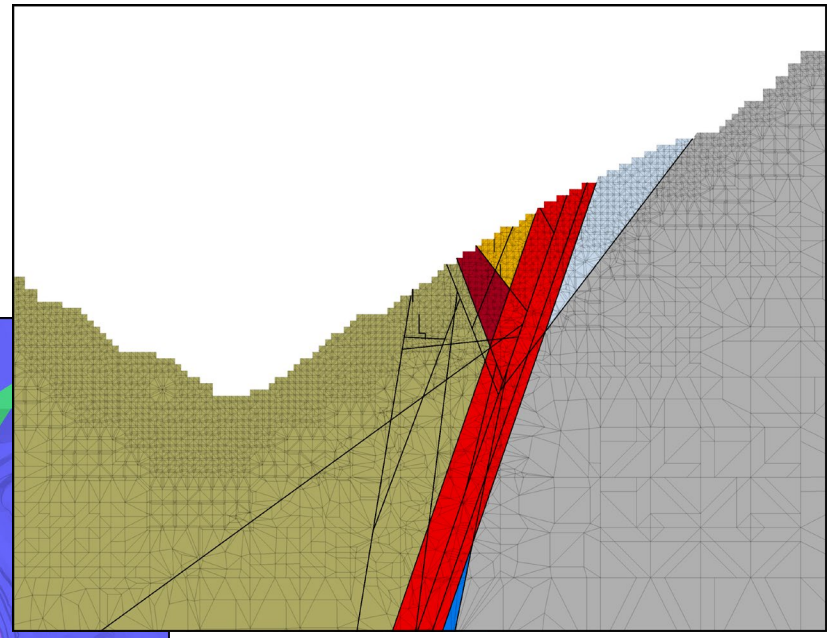
- Both *FISH* (*Flac*-ISH) and Python are fully integrated in *FLAC3D*
- The ability to combine model-creation commands with scripting in Itasca software is tremendously powerful
  - Parameter studies
  - Automating model sequences
  - Modification of physics
- *FISH* is multi-threaded
- Python includes scientific, mathematical and UI modules

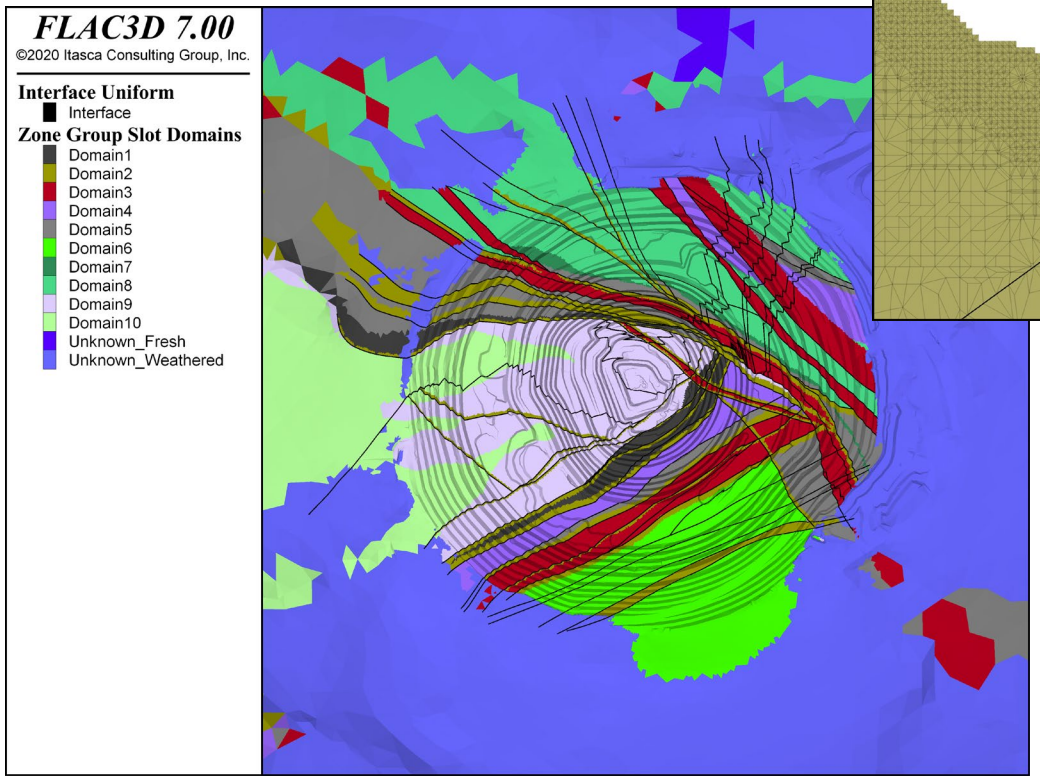
Edit ground_freezing.fis

```
1  program call 'freeze_zone'
2  fish operator ground_freezing(zone)
3      if zone.isgroup(zone,'frozen','state') then return 0
4      if zone.temp(zone) > 0.0 then return 0
5      freeze_zone(zone)
6  end
```

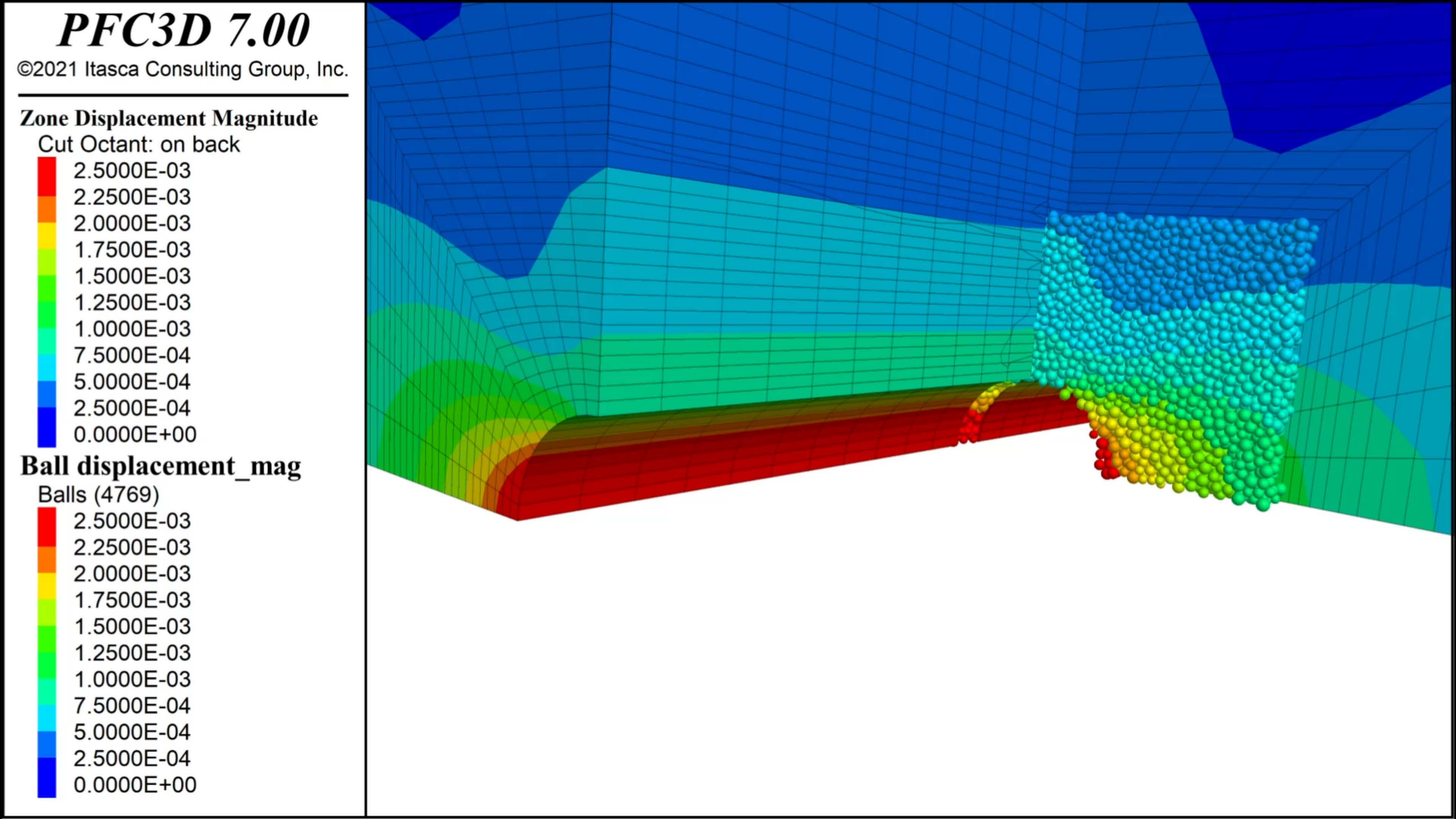
Other Features

- Interfaces (Joints and Faults)
  - ❖ Interfaces can shear and separate/close
- Discrete Fracture Network generation
- Thermal analysis
- Creep
- Large strain
- Coupling with *PFC*





40 YEARS
ITASCA™


PFC3D 7.00
©2021 Itasca Consulting Group, Inc.
Zone Displacement Magnitude
Cut Octant: on back
2.5000E-03
2.2500E-03
2.0000E-03
1.7500E-03
1.5000E-03
1.2500E-03
1.0000E-03
7.5000E-04
5.0000E-04
2.5000E-04
0.0000E+00
Ball displacement_mag
Balls (4769)
2.5000E-03
2.2500E-03
2.0000E-03
1.7500E-03
1.5000E-03
1.2500E-03
1.0000E-03
7.5000E-04
5.0000E-04
2.5000E-04
0.0000E+00

FLAC3D for New Users

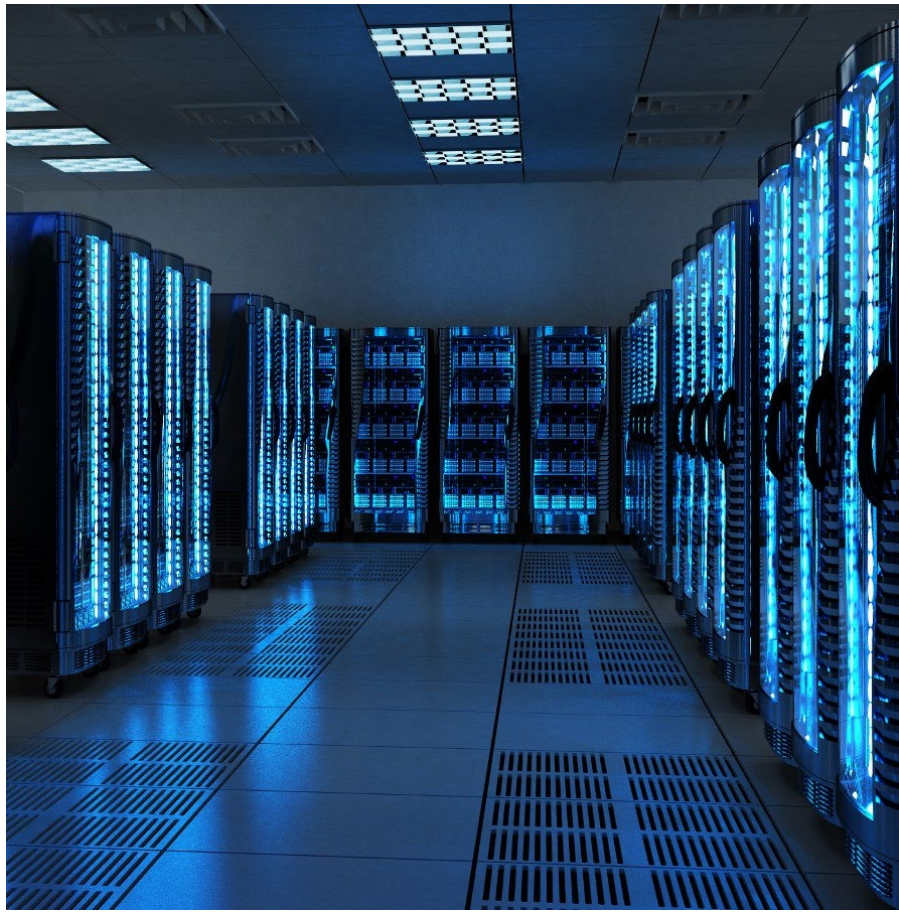
- What is *FLAC3D*?
- How it works
- Features
- **Demo**
- What's next?

FLAC3D for New Users

- What is *FLAC3D*?
- How it works
- Features
- Demo
- **What's next?**

What's Next

- Cloud computing
- *FLAC2D* → 2D version of *FLAC3D* (coming 2022)
- Improved GUI – more user-friendly
- Cluster version (parallel computing)
  - Linux
- And more!



Resources

- Online documentation: http://docs.itascacg.com/
- Examples: https://www.itascacg.com/software/support/examples
- Video tutorials: https://www.itascacg.com/learning/tutorials
- Download demo version: https://www.itascacg.com/contact-itasca/demo-downloads-request
- Spring training courses: Online for 2021. Details coming soon.

Thank You

- A survey regarding features you would like to see in *FLAC3D* will be sent out after this webinar
  - We appreciate your responses
- A recording of this webinar will be made available to all registrants shortly
- Questions?