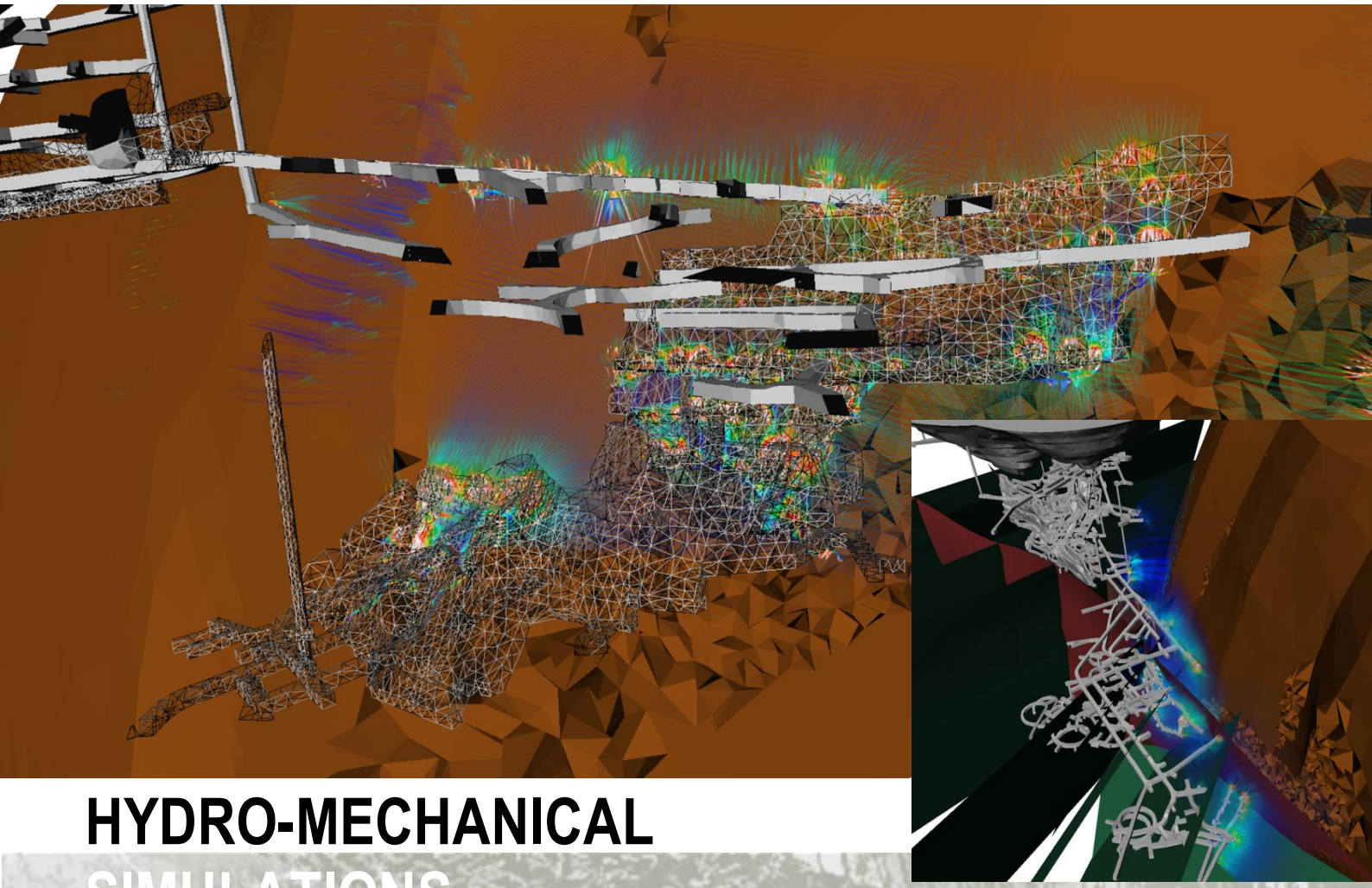
BECK ENGINEERING



# HYDRO-MECHANICAL SIMULATIONS

**BECK ENGINEERING'S MAIN EFFORT IS SIMULATION AIDED ENGINEERING FOR DIFFICULT GEOTECHNICAL ENVIRONMENTS.**

**THIS CAN ONLY BE ACHIEVED USING UNCOMPROMISED PHYSICS BASED HYDRO-MECHANICAL SIMULATIONS THAT MAKE FEWER ASSUMPTIONS, INCORPORATE MORE OF THE AVAILABLE MEASURED DATA TO CONTINUOUSLY IMPROVE SIMULATION RESULTS.**

The presence of groundwater has an impact on productivity at underground operations.

Conventional design approaches focus on either hydrological or mechanical simulations, without acknowledging the interconnectivity of both problems.

To overcome this limitation Beck Engineering developed a framework to efficiently solve hydro-mechanically coupled problems even for large-scale, three dimensional, discontinuum models with complex geometry and multiple excavation sequences.

Our simulations capture the increase in hydraulic conductivity due to the evolution of rock mass damage. They also accurately predict the developing flow paths along discontinuities.

Beck Engineering has been developing coupled hydro-mechanical models since 2007 for some of the world's largest open pit and underground operations.

Speak to one of our engineers to learn more about our simulation techniques and capabilities.

Beck Engineering is an Australian-based engineering firm that specialises in mining and rock mechanics analysis for the global mining industry.

We apply realistic physics-based simulations to forecast the geotechnical performance of underground and open pit mines, across a broad range of mining methods, geotechnical conditions and commodities. Our experienced mining engineers work with our clients to integrate these performance forecasts into practical mine designs, schedules and operating plans.

**Beck Engineering shares a common goal with our clients: To design, plan and operate safe, productive and reliable mines.**

# HYDRO-MECHANICAL SIMULATIONS

## OUR SIMULATIONS

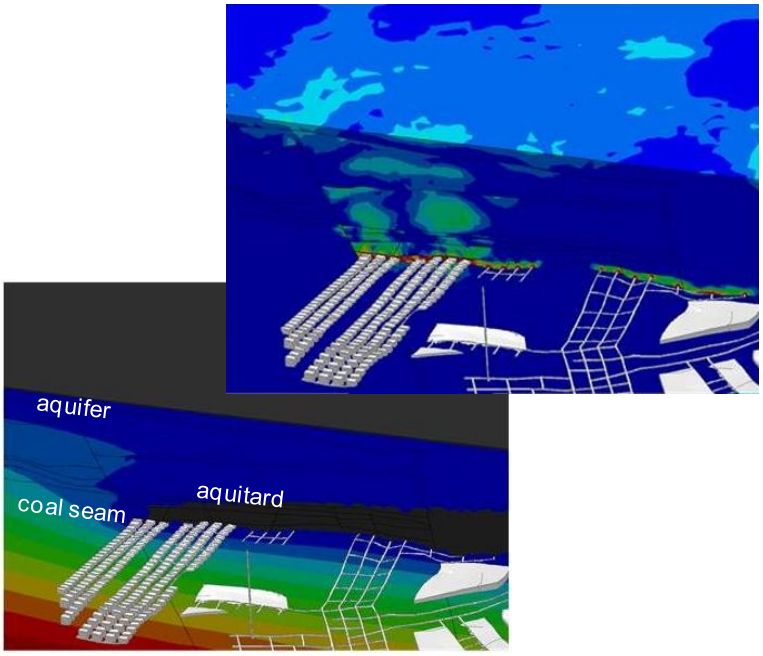
- Complex geometry and mining sequence: Accurate simulation of rock behaviour for each geotechnical domain, as well as explicitly built discontinuities allowing realistic slip, separation and damage.
- Hydraulic properties of each domain can be
  - isotropic, orthotropic, fully anisotropic,
  - rock mass damage dependent: nonlinear increase in permeability with increase in rock mass damage
- Flow along and across discontinuities at different scales.
- Transient or steady-state analyses.
- Solution dependent boundary conditions.

## WHAT YOU GET

- Over 15 years of experience in building and running sophisticated geotechnical models for the mining industry
- An international team of mining and rock mechanics engineers with more than 100 years of combined professional experience
- High resolution models with high similitude forecasting of rock mass performance
- Results are presented in a form that is unambiguous and which can be more easily understood
- A simulation framework designed to your specifications and not limited due to implementation constraints
- Full three-dimensional results database available for site engineers to use for ongoing confirmation, analysis and refinement.
- Full transparency: We will assist you how to get the most out of the results, what information would improve the forecasts and work with you to continually improve your mine.

## CASE STUDY 1

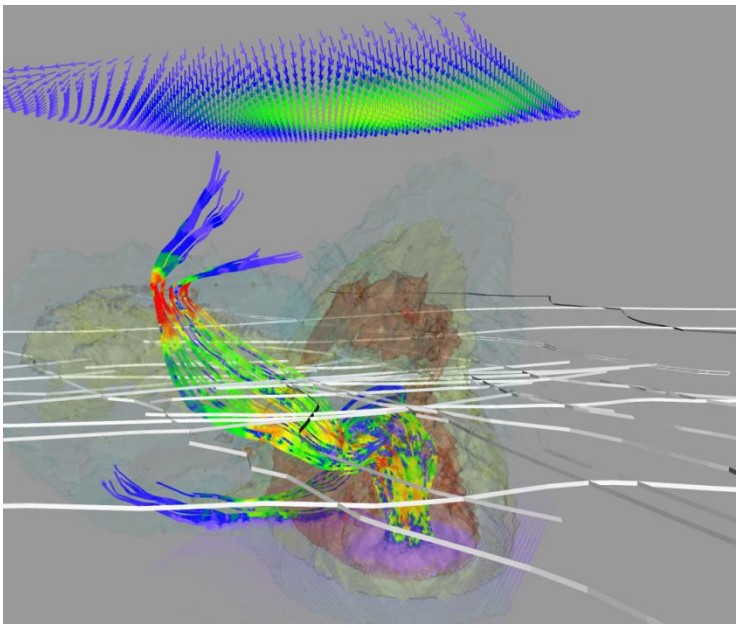
Case study 1 presents an example for the assessment of hydraulic interconnectivity between two hydraulically active material domains separated by an aquitard. The evolution of rock mass damage along faults presented a potential risk for additional flow paths.




Coal mining induced damage distribution (upper) and pore pressure profile (lower).

## CASE STUDY 2

Case study 2 is a parametric study of orebody formations due to fluid exsolution of a cooling magma chamber. The hydro-mechanical coupling framework allows for the assessment of fluid driven rock mass damage causing additional fluid flow paths as well as resulting subsidence pattern.



Very significant damage, as well as a high flow system evolves at the confluence of major fault structures due to fluid influx through the magma chamber at the bottom of the image.

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