ITASCA™

Sjömalmen — Cave Modeling and Prediction of Ground Deformations

PROJECT DESCRIPTION
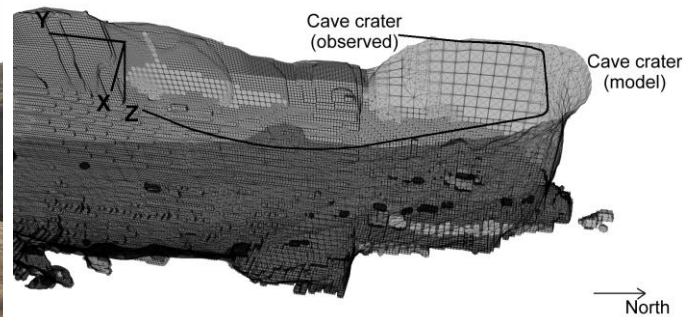
LKAB

Kiruna Mine, Sweden

FLAC3D™

The city of Kiruna is partly located on the hangingwall side of the LKAB Kiirunavaara Mine. In the long-term perspective, it is not possible to have any residential buildings or infrastructure within the fracture zone and cave zone resulting from mining. An urban transformation process for the Kiruna city center is thus currently underway. The current prognosis is empirical based on observations since the early 1960s until today. However, in the Sjömalmen (Lake orebody) area (the northern portion of the orebody), mining started quite recently. This portion of the orebody is non-daylighting with mining under a cap rock. Existing prognosis tools thus needs to be supplemented with numerical modeling approaches.

ITASCA'S ROLE

In this study, a 3D numerical model, using the *Itasca Caving algorithm*, has been applied to simulate future sublevel cave mining, down to Level 1365 m, see also Sjöberg et al. (2017). The *Caving algorithm* is using the strain-softening CaveHoek constitutive model in *FLAC3D*. Observational data on cave development, surface cratering, and measured ground surface deformations, were used to calibrate the numerical model.

Left: The cave crater and the city of Kiruna in the fall of 2016, looking towards east.
Right: The cave crater in 2014, modeled (3D-volume) and measured (line), looking towards west.

PROJECT RESULTS

The model results were evaluated in terms of surface cratering, the location of the environmental criterion limit on the ground surface and the limit angles for the environmental criterion. The results show a steady growth of the cave crater with deeper mining. Ground deformations are not arrested by bulking and/or increased confinement with depth. Future mining will likely lead to continued caving and ground deformations to, at least, the same extent as experienced so far. However, for the northern part (tip of the orebody), the model indicated limit angles, which are steeper than those currently used for prognosis.

REFERENCES

Sjöberg, J., F. Perman, D. Lope Álvarez, B-M. Stöckel, K. Mäkitaavola, E. Storvall, and T. Lavoie. 2017. "Deep sublevel cave mining and surface influence" in ***Deep Mining 2017 (Perth, March 28-30, 2017)***, J Wesseloo, Ed. Perth: Australian Centre for Geomechanics.