Design Methods for Variable-Stress, Variable-Geology Environments

Designmetoder för bergmassor med varierande geologi och spänningsförhållanden

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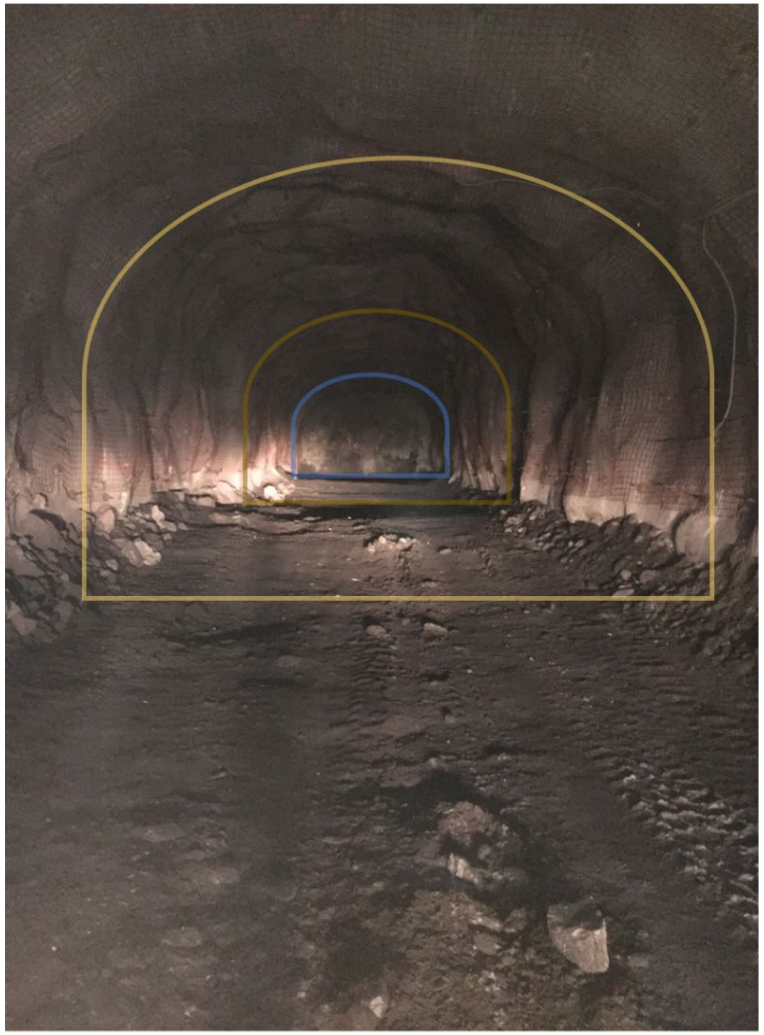
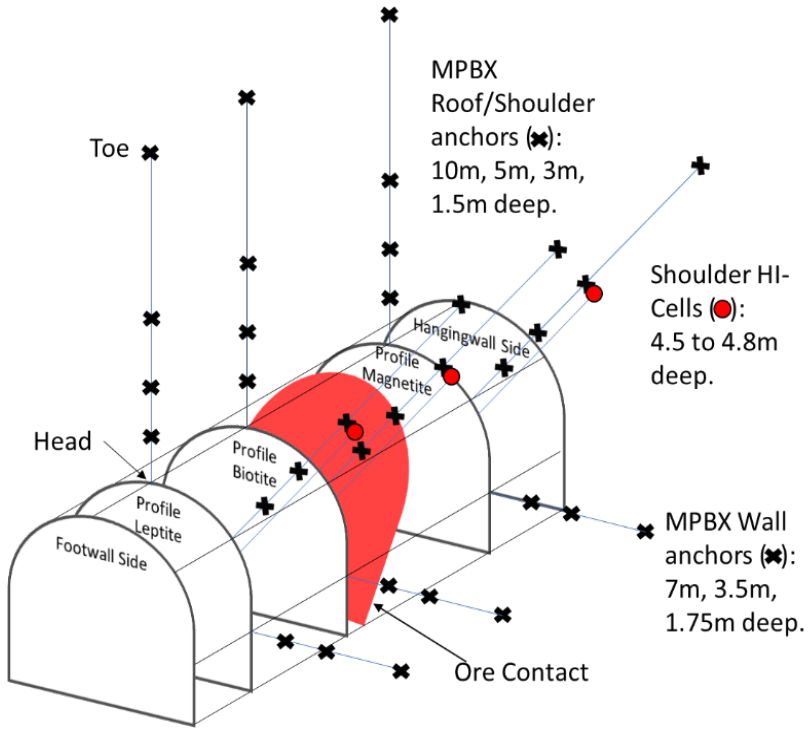
Empirical Modelling for Better Understanding of Stress, Damage, Deformation in Different Closely-Spaced Rock Types

Profiles installed in 5 crosscuts covering both multiple-level and single-level scenarios to better understand depth and excavation-sequence related stress changes.





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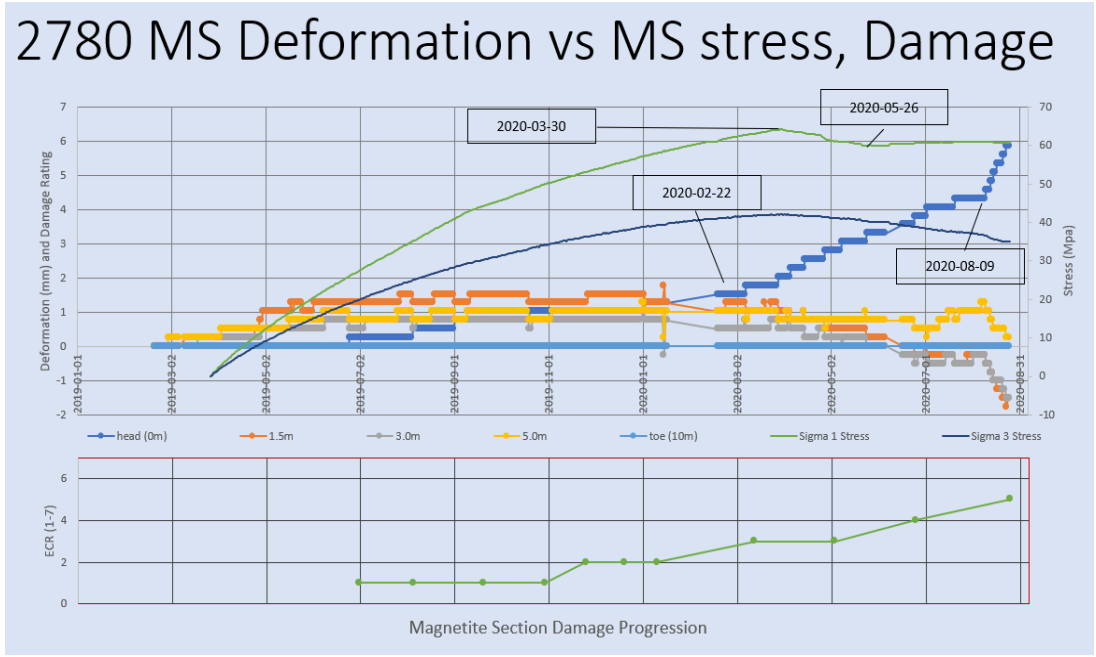
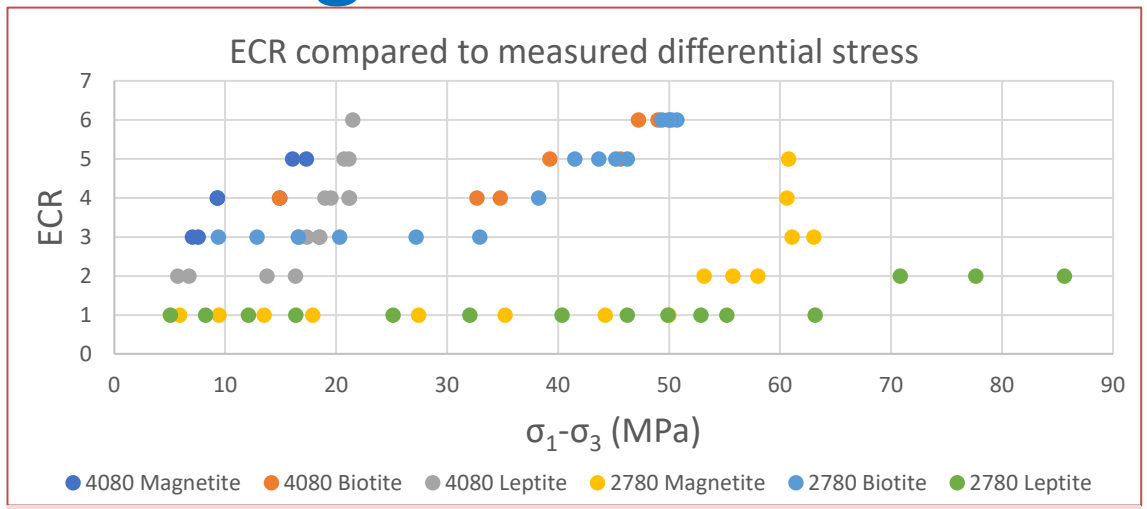
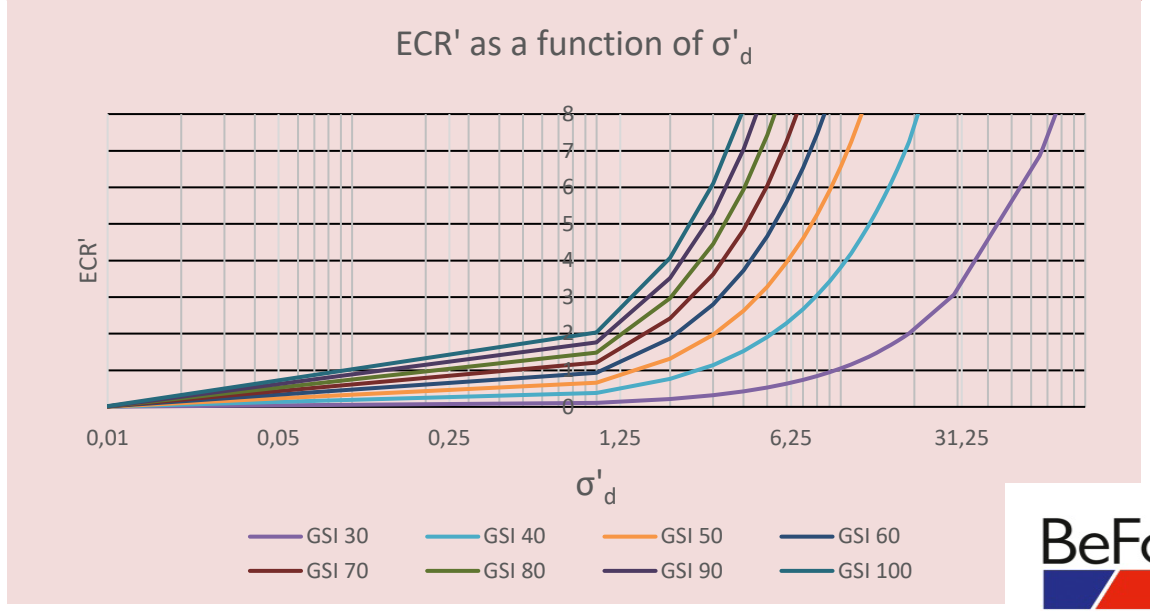
Damage Mapping Correlated to Differential Stress and GSI – Allows Future Damage Prediction



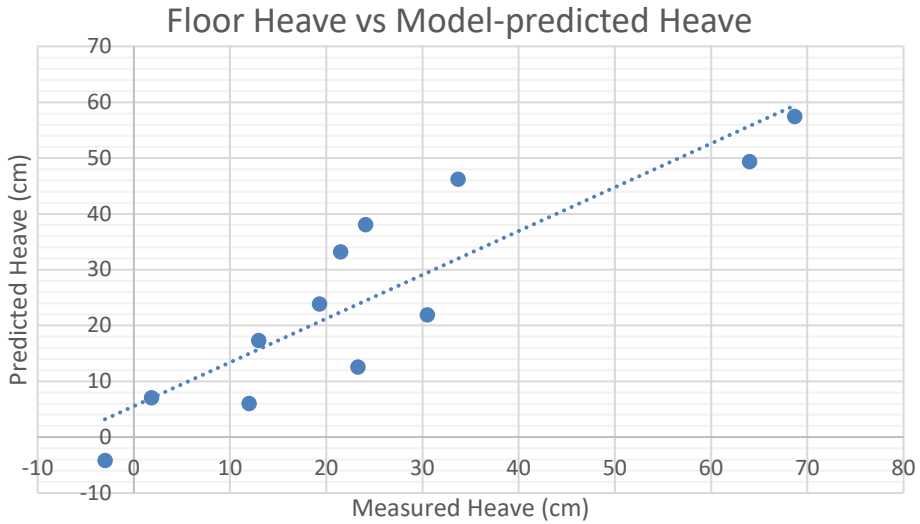




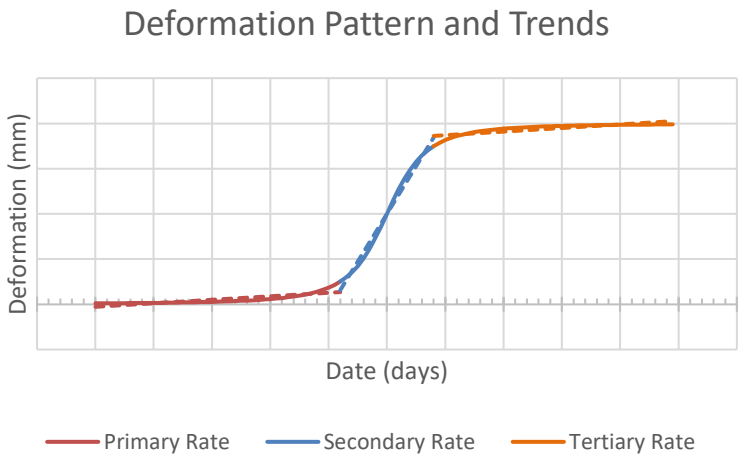
Damage mapping and entry ratings linked measured changes to real-world consequences. Interesting predictive tools developed based on rock quality.

Floor Heave Prediction, Deformation Mechanisms, Prediction of Deformation

Theoretic/analytic-based model developed to describe observed floor heaving. Shows good correlation between Measured and Predicted heave.



$$H = 2.318\psi - 2.313\alpha + 2.258\sigma_1 + 27.293$$



$$\delta_p = \lambda_1 t_1 + \lambda_2 t_2 + \ldots \lambda_n t_n$$

Identification of patterns of deformation, their causes, time duration in each stage, and stage-based deformation rates, allow for deformation prediction.

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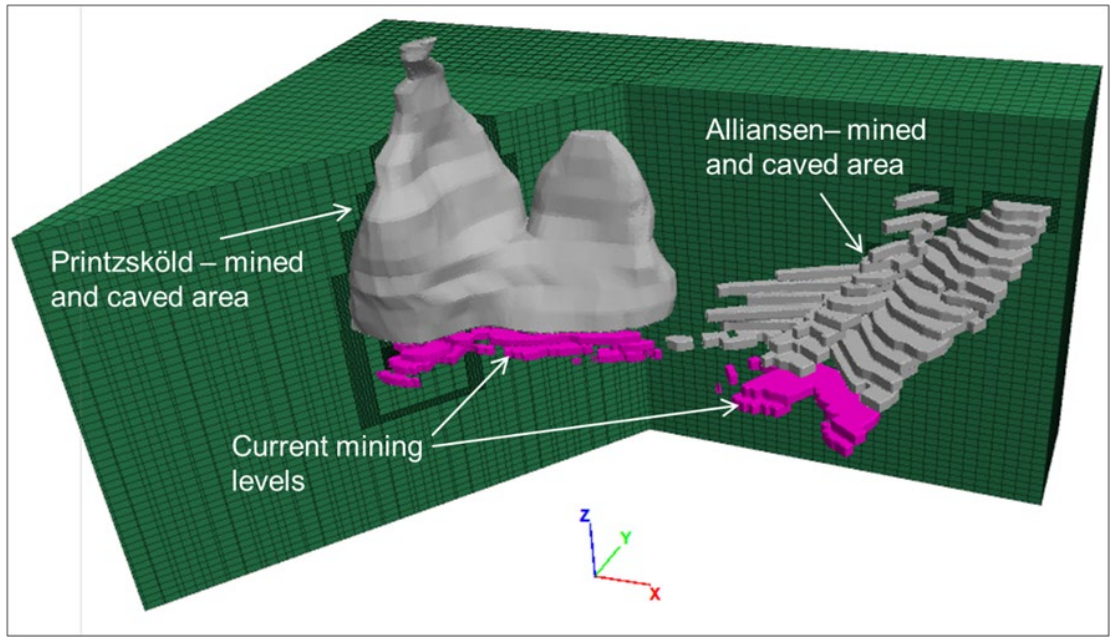
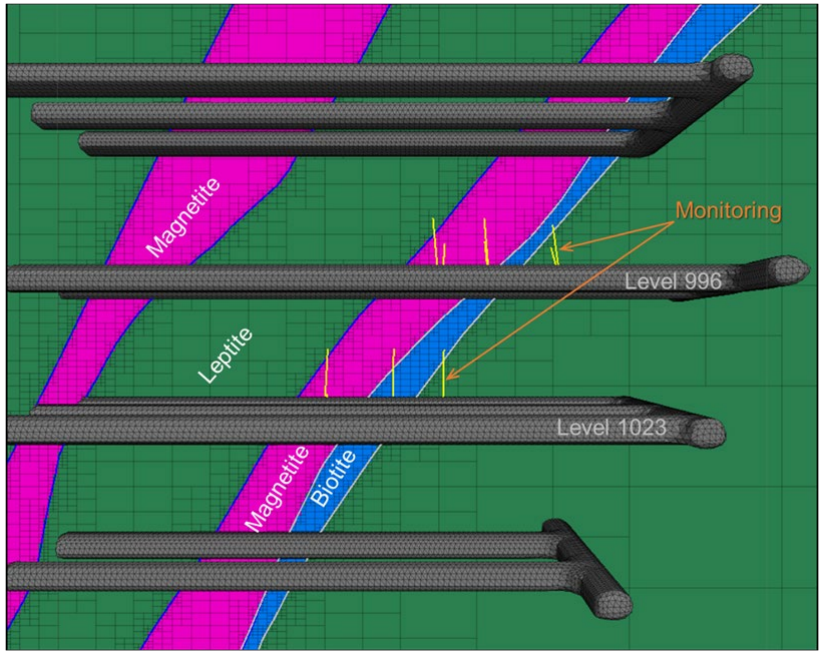
Numerical Modelling

Numerical modelling was conducted in FLAC3D to compliment the monitoring program

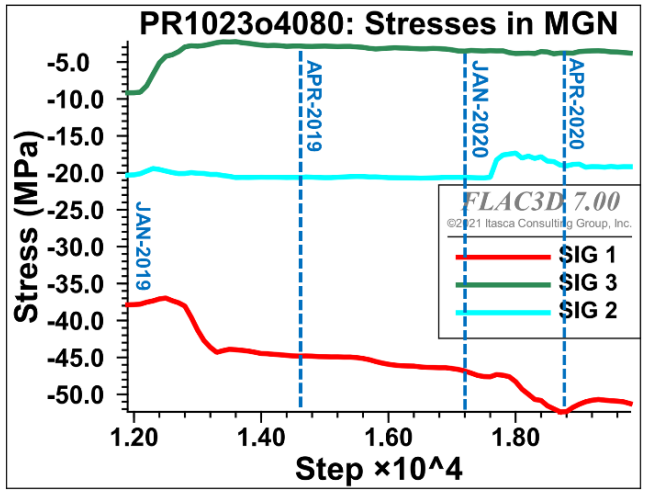


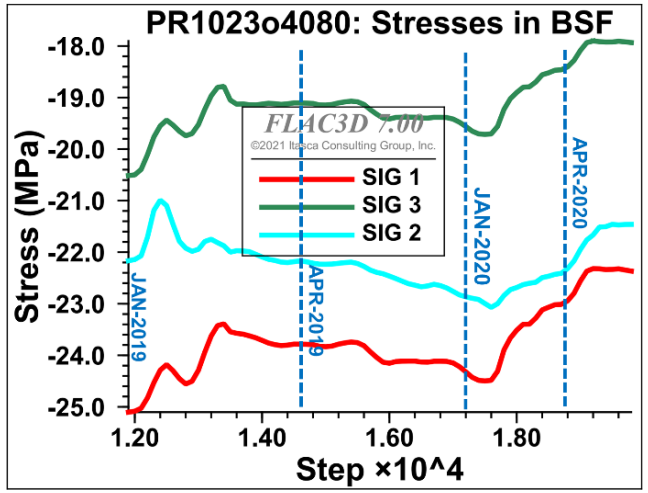
FLAC3D model encompassing the Printzsköld and Alliansen mining areas

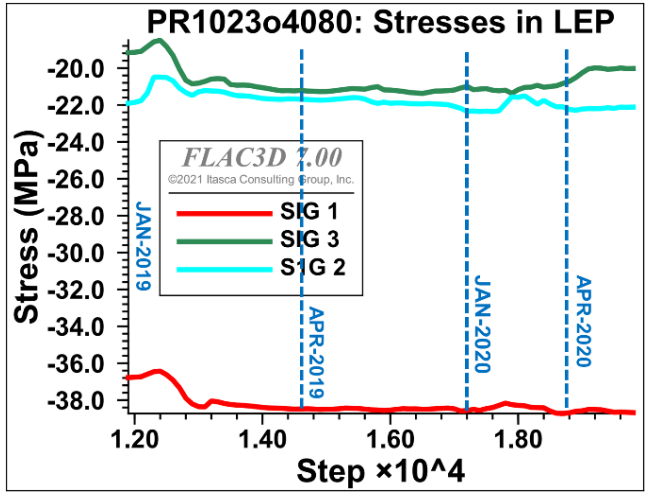


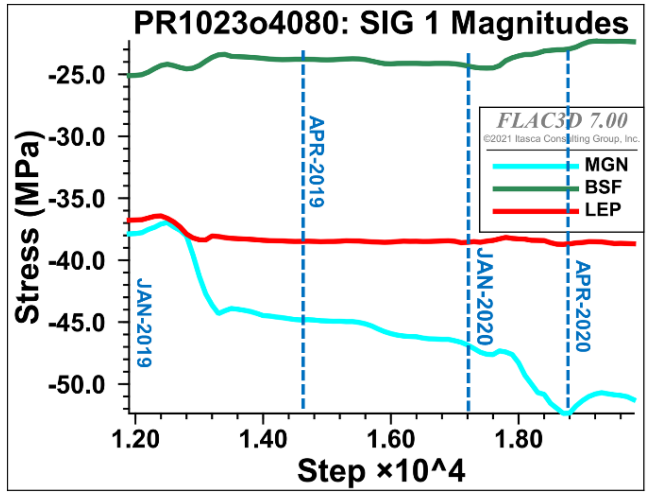
FLAC3D model featuring the geology and instrumentation in Printzköld monitoring area.

Stress changes were monitored numerically in the cross-cuts instrumented with HID stress cells









Example of numerical stress changes in a cross-cut in Printzsköld. The numerical measurement points correspond to the locations of HID stress cells installed within different rock units.

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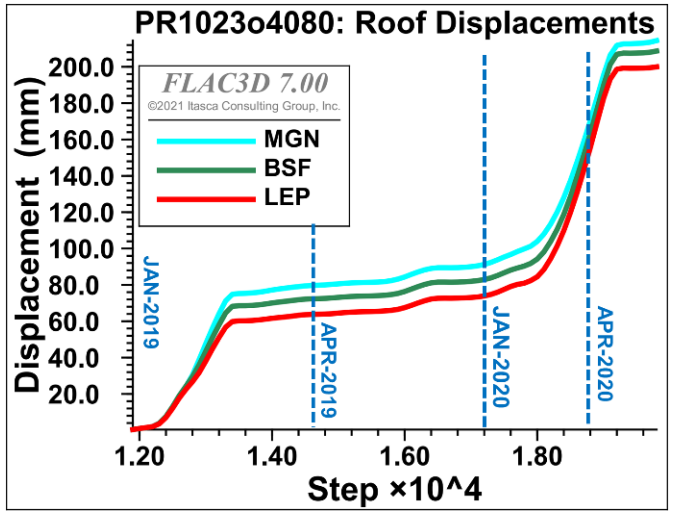
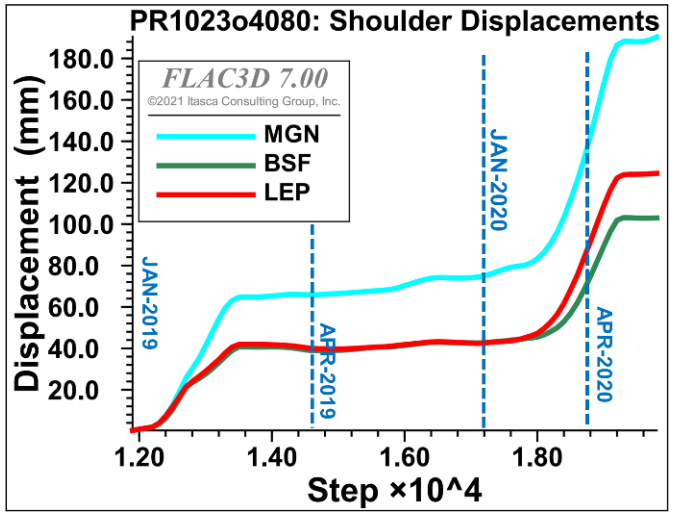
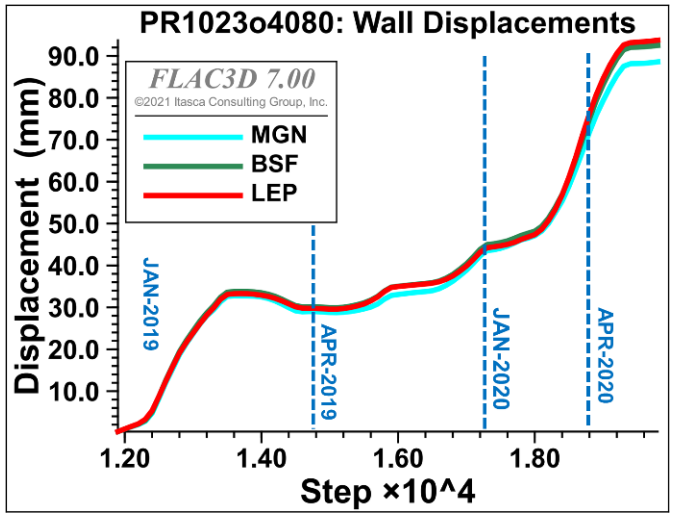
Displacements were also monitored numerically in the cross-cuts instrumented with MPBX (multi-point borehole extensometers)







Example of numerical displacements recorded in a cross-cut in Alliansen. The numerical measurement points correspond to the locations of MPBX located in the roof, shoulder and the wall.

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Overall Summary

- Work led to new understandings of how and why stress changes occur in multiple-opening excavations. Importance of proper sequencing has been demonstrated.
- Methods used can be adopted for other sites. While the predictive tools are site-based, the methods are widely applicable.
- Linkages between observed damage patterns and stress and deformation measurements create the potential for model-based predication of when and where to install supplementary support.
- Numerical modelling complimented the empirically-based ideas to provide support for the conclusions.
- Future monitoring recommended to occur in absolute stress conditions.