# A study of the stability mechanism within shallow mining operations that will impact on the sustainability of Platinum Mines

**The CSIR Research and Innovation Conference**

**Natural Resources and Environment**

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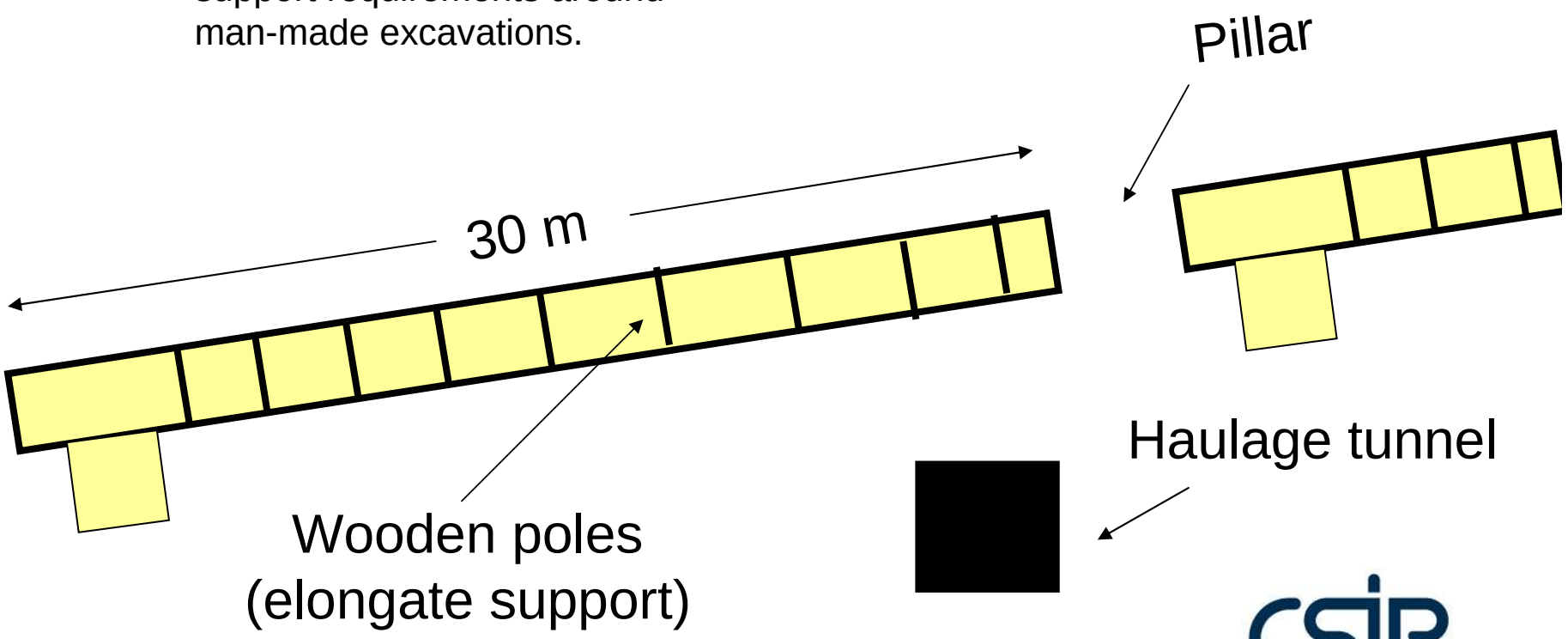
# Agenda

- Introduction
  What is rock engineering and the goals behind the programme?
- Significance
  What are the potential benefits of this research?
- Site description
  Stoping conditions under which the research was conducted.
- Observations & instrumentation
  Data collection for numerical models and development of behavioural theory.
- Elastic modelling
  Results of a numerical model compared to observations and instrumentation.
- Solutions
  Analytical and inelastic numerical modelling.
- Implications
  How the findings can be used.
- Conclusions
  Impact on short term profitability and efficiency and contribution to long term sustainability.

# Introduction

- What is rock engineering?

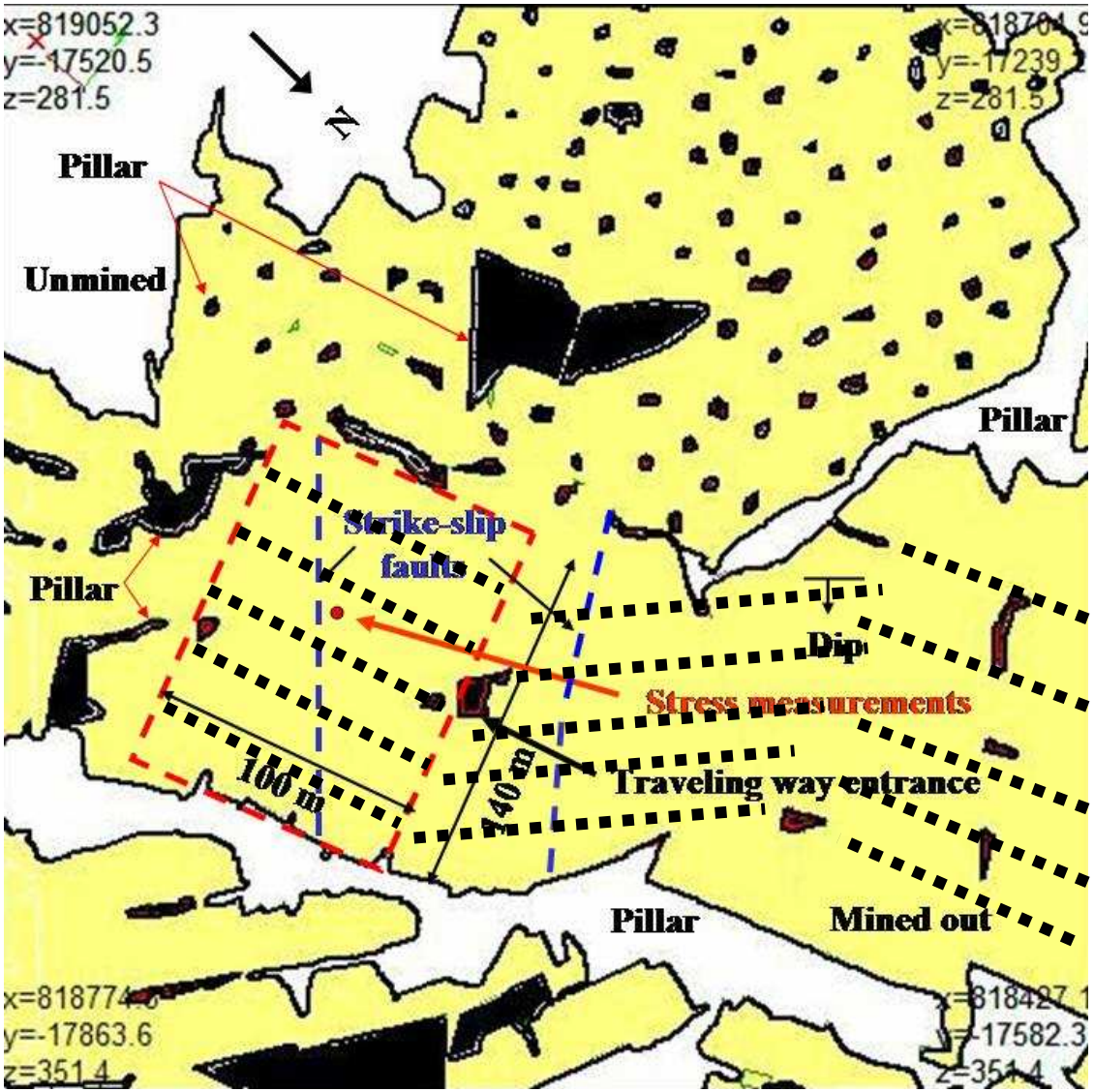
Study of rock behaviour and support requirements around man-made excavations.



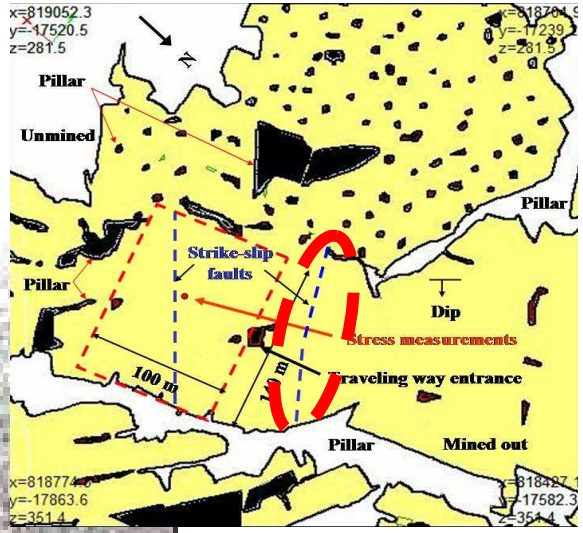
# Problem statement

- Support in shallow platinum mining operations is typically provided by in-stope pillars - a significant percentage of ore reserves are locked up in these pillars, which reduces the life of mine.
- If all pillars created in a single year across the Platinum industry were reduced in size by 1.0 m, approximately R1,0 billion profit could be realised annually.
- There is potential for increasing life-of-mine and thus a positive contribution towards sustainability.

# Plan of instrumentation site



# Strike slip fault to north of site





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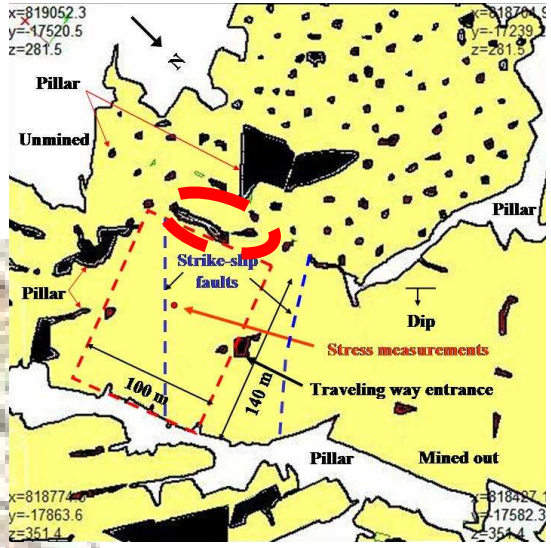
# FOG adjacent to stability pillar





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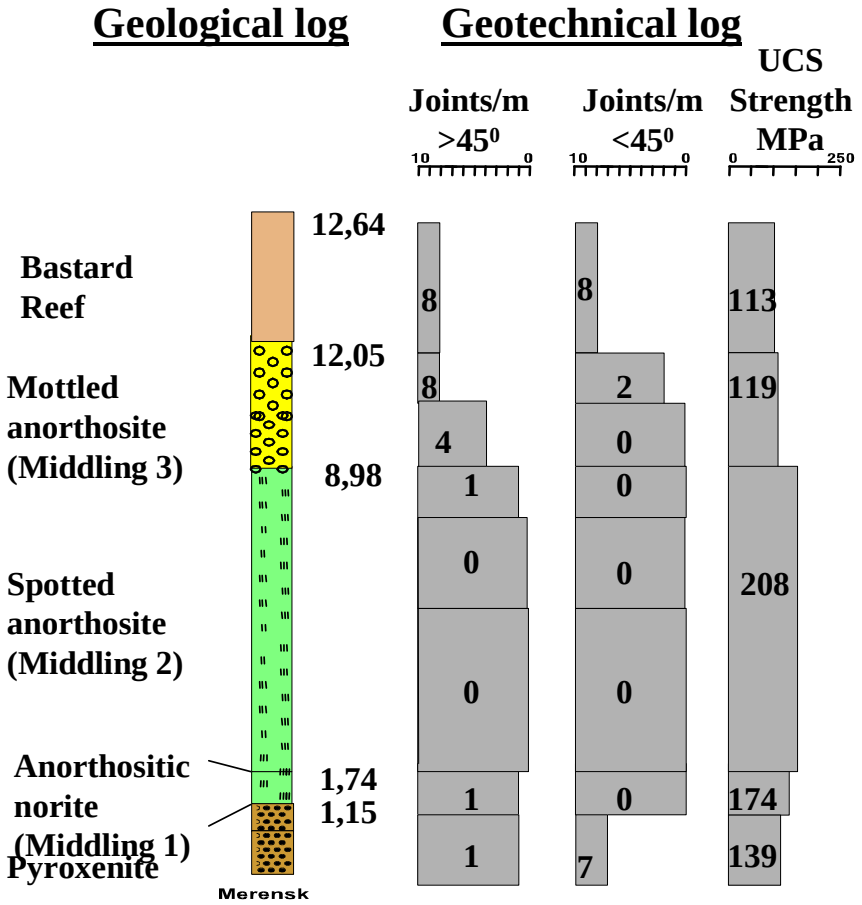
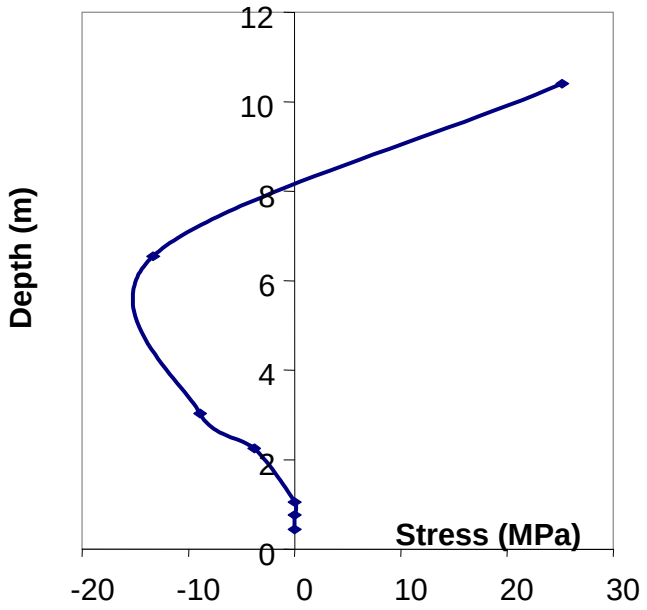
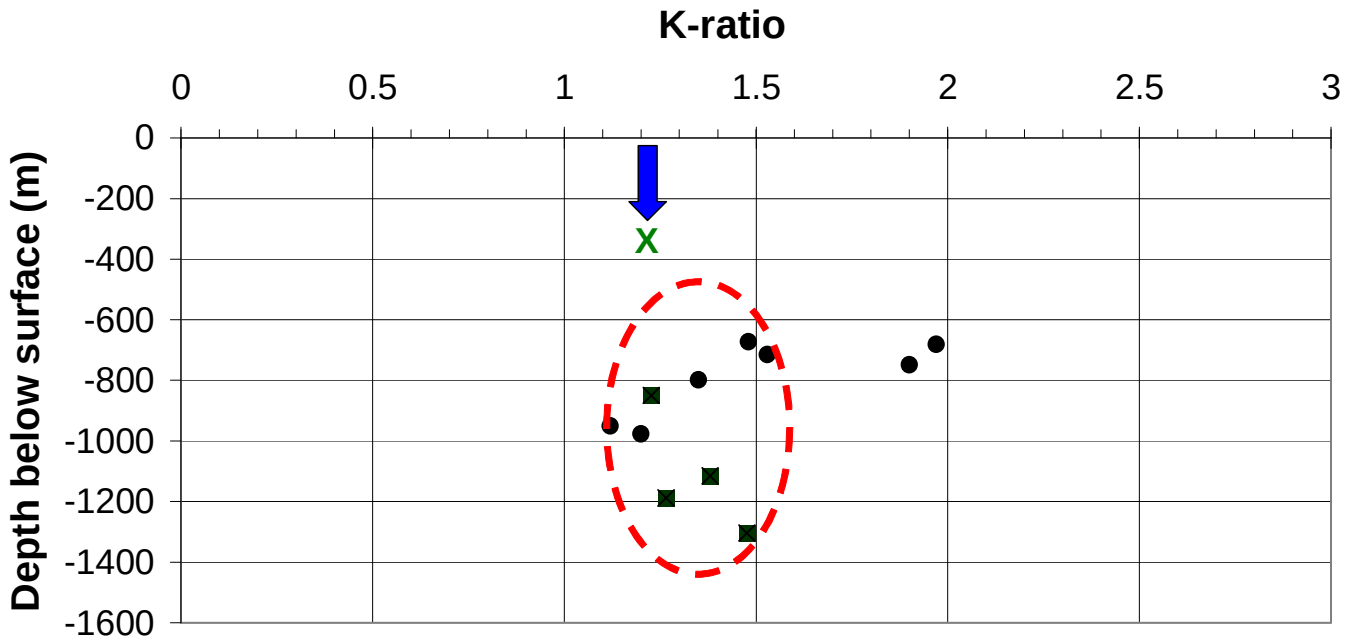
# Support in the evaluated stope

# Geotechnical and instrumentation results

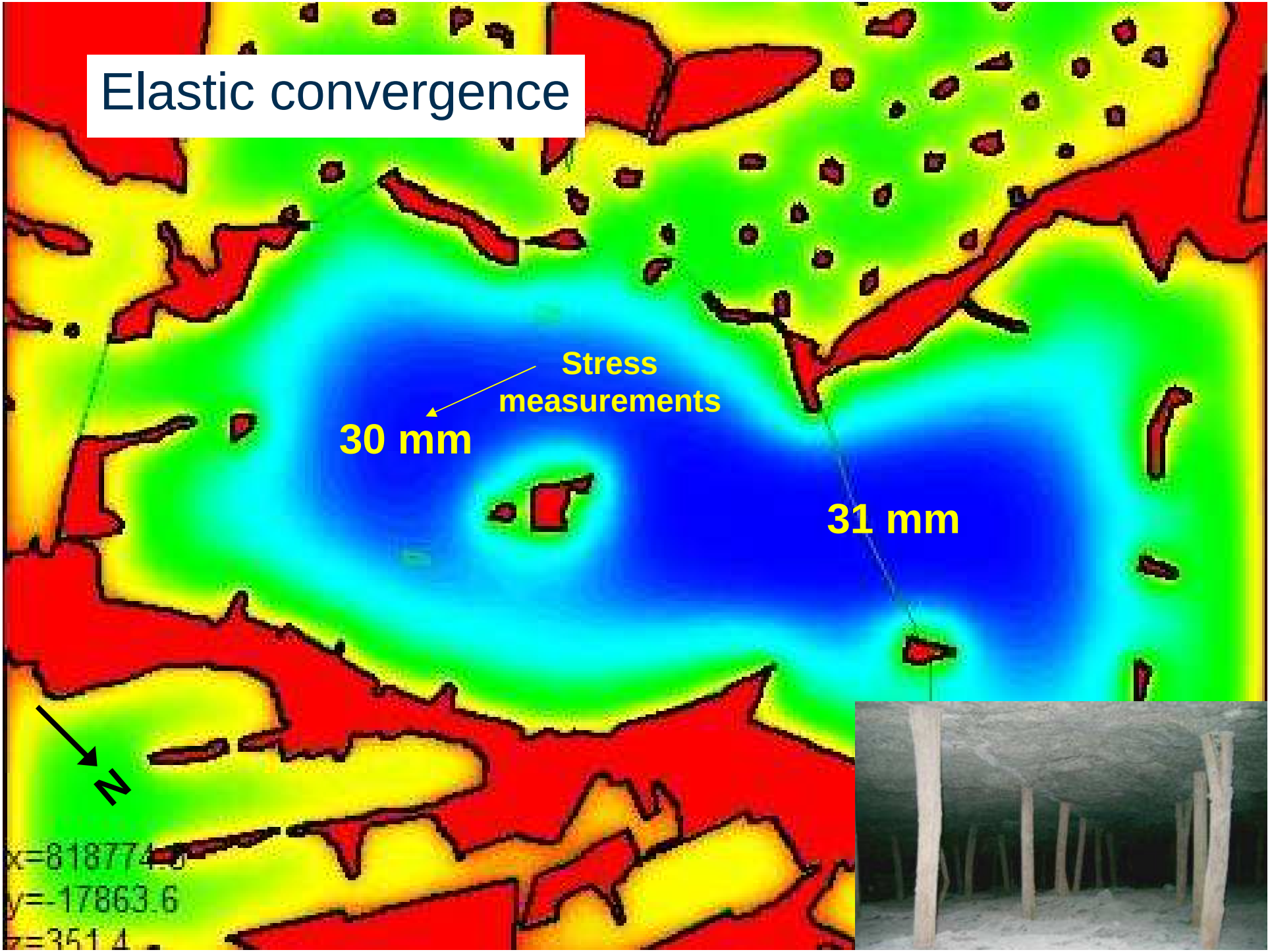


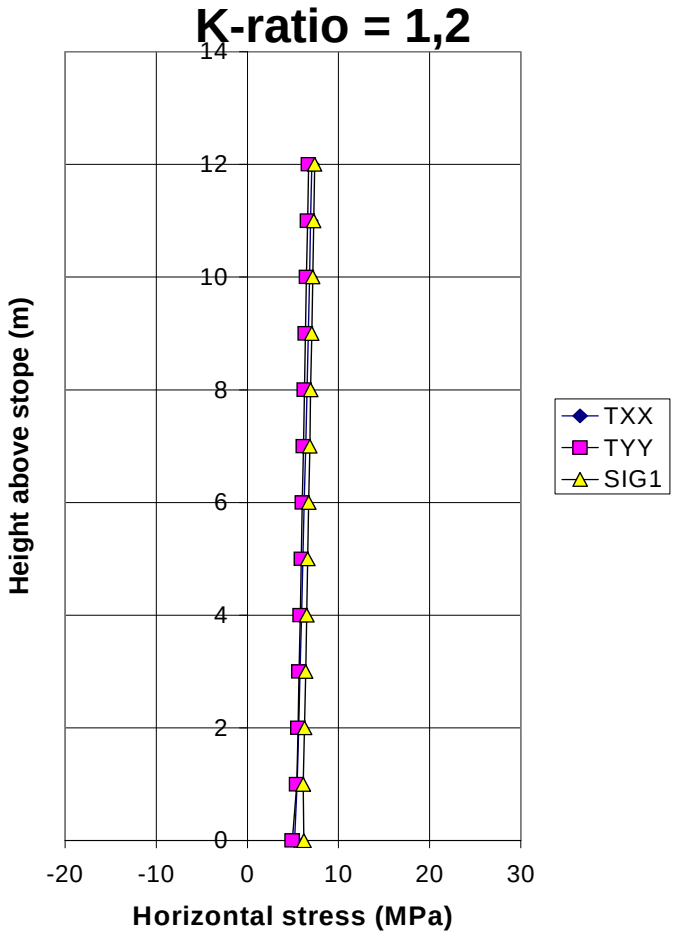
# Virgin stress condition

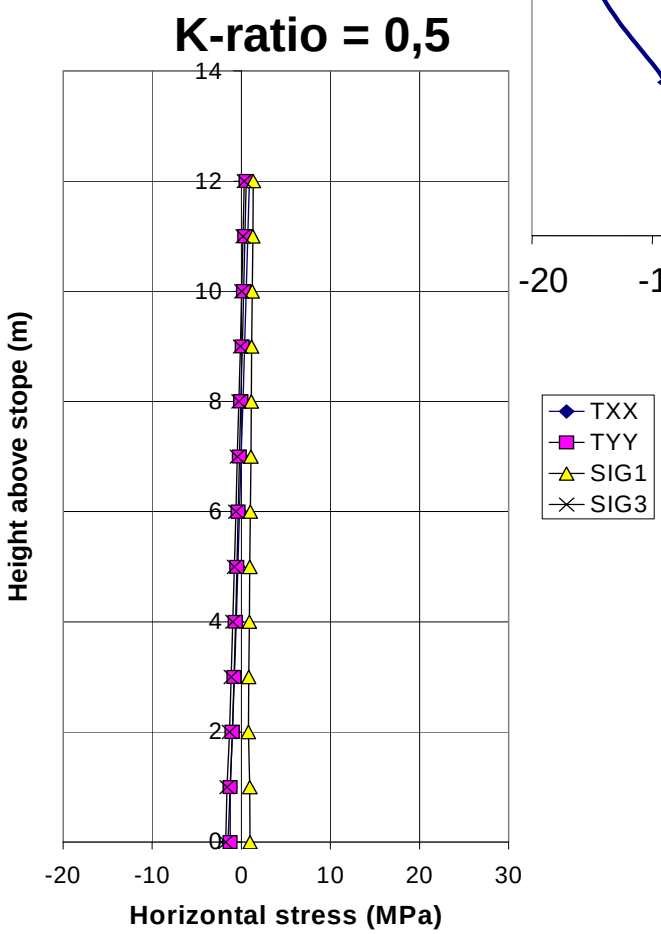


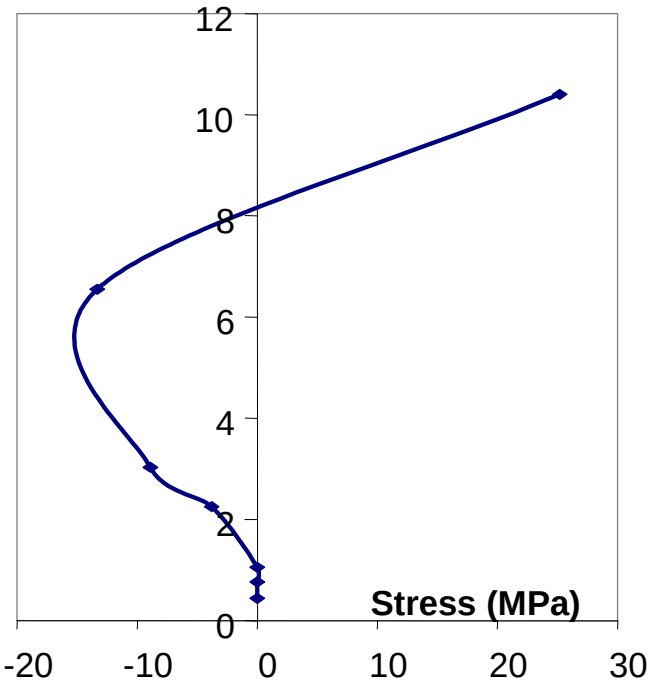
# Elastic convergence



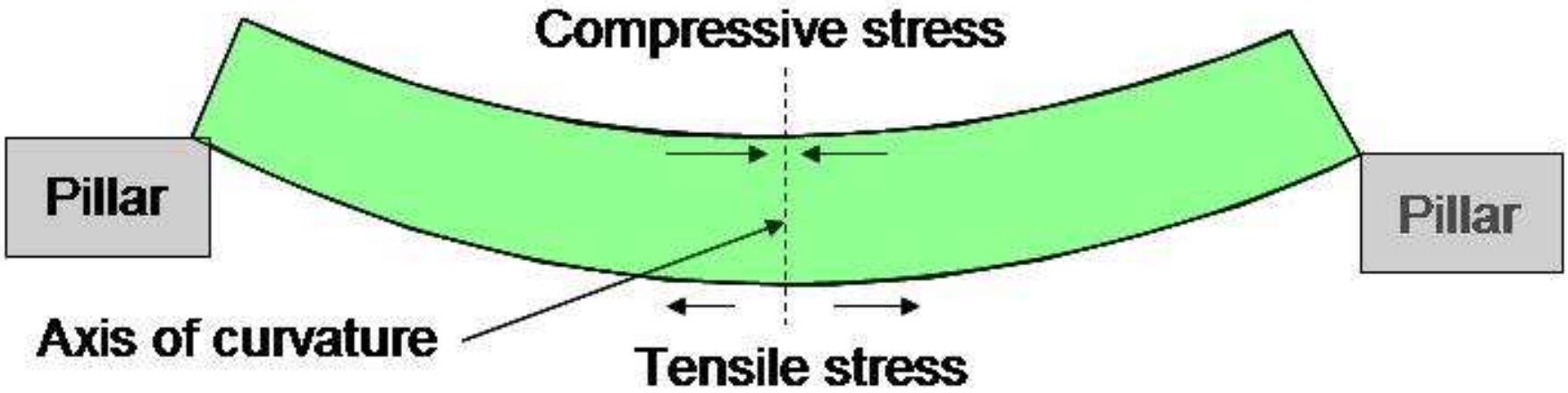
# Elastic stress results



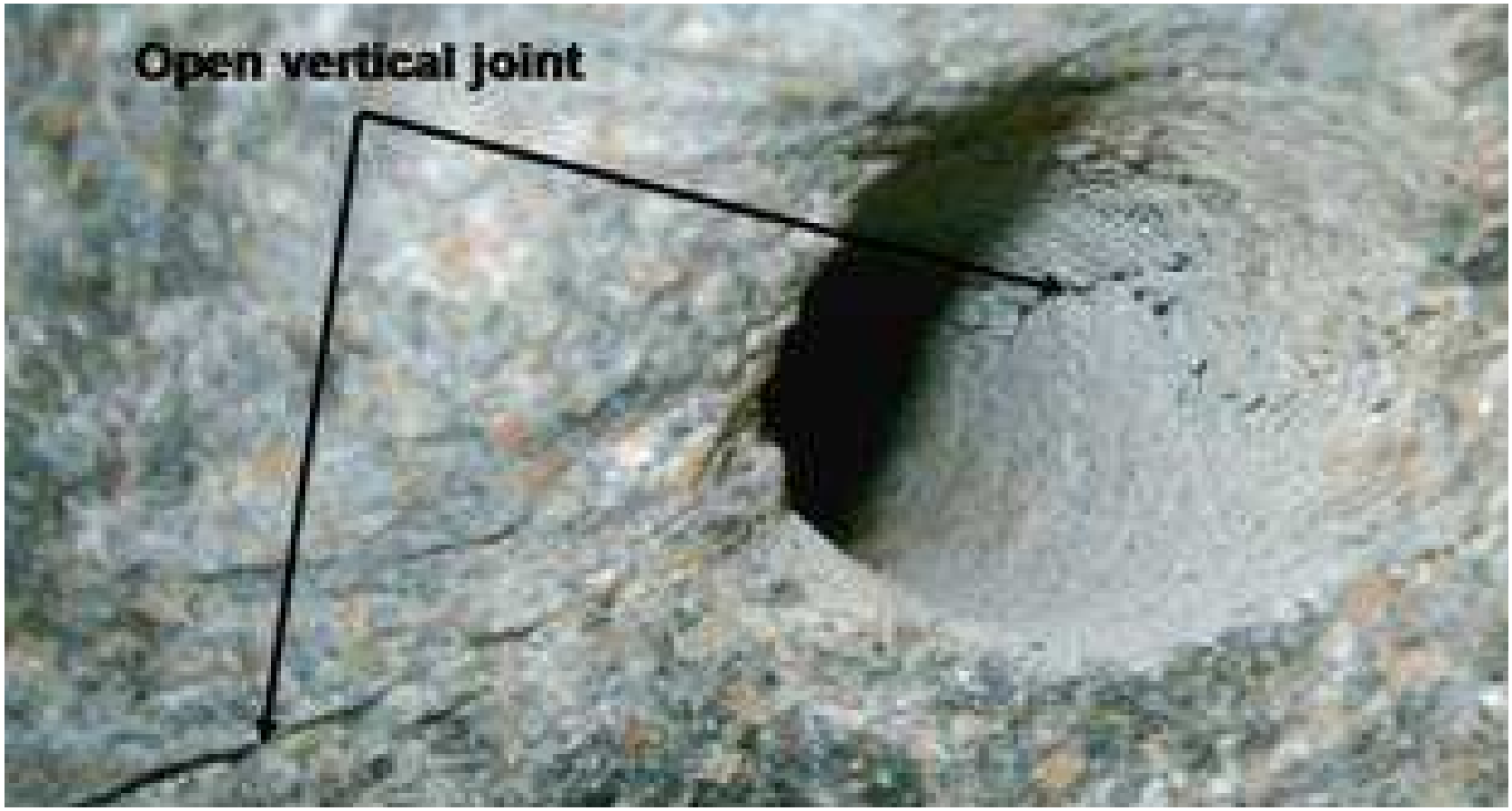



# Strike section showing possible plate formation



# Open vertical joint



# Standard beam solutions

- Built-in ends:

$$\sigma_{\max} = \frac{\rho g L^2}{4t} + \sigma_h$$

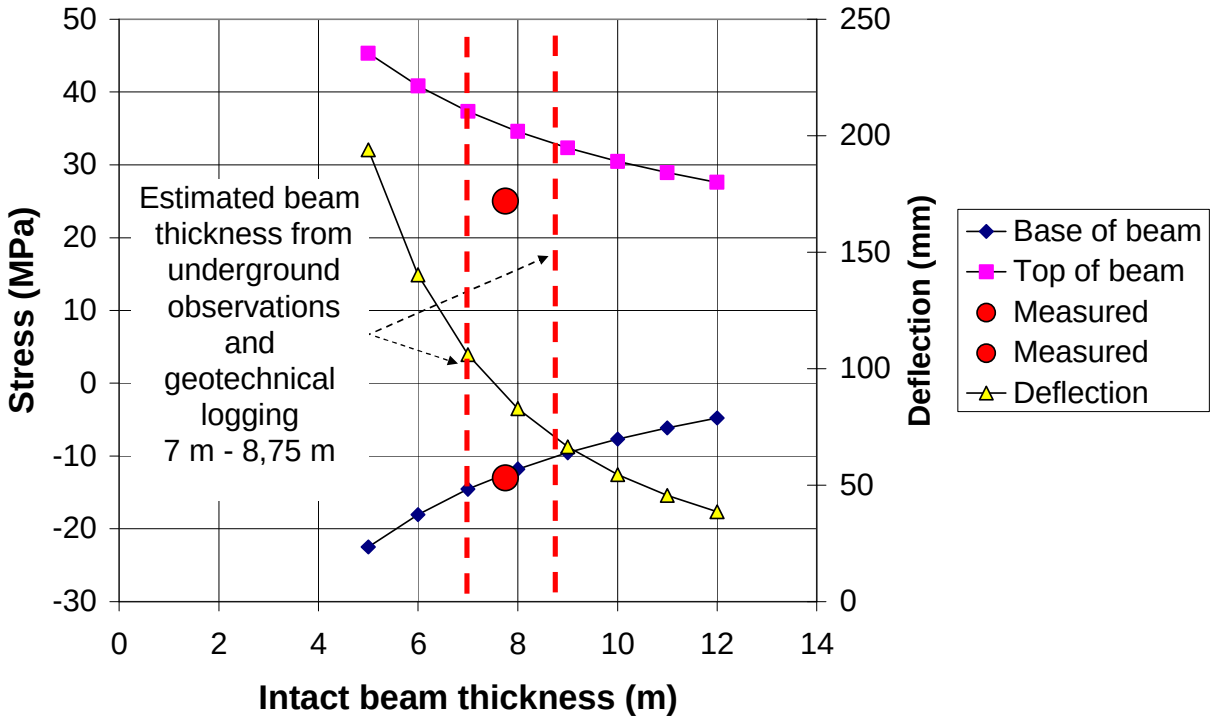
$$\delta_{\max} = \frac{\rho g L^4}{32 E t^2}$$

- Freely-supported:

$$\sigma_{\max} = \frac{3\rho g L^2}{4t} + \sigma_h$$

$$\delta_{\max} = \frac{5\rho g L^4}{32 E t^2}$$

# Freely supported beam



# Modified beam analysis (analytical solution)

- Built-in ends:

$$\sigma_{\max} = \frac{k\rho g L^2}{4t} + \sigma_h$$

$$\delta_{\max} = \frac{k\rho g L^4}{32 E t^2}$$

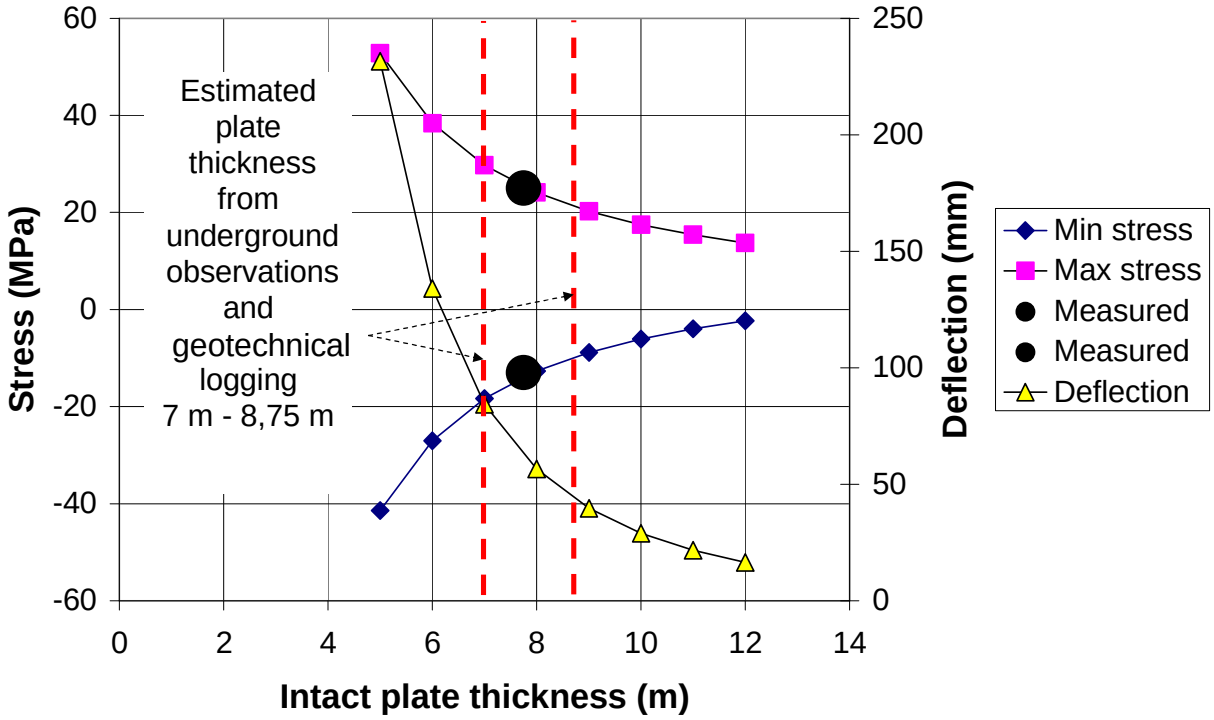
$$\left( k = \left[ 1 + \frac{(W_x - SR)}{W_f} \right] \right)$$

- Freely-supported:

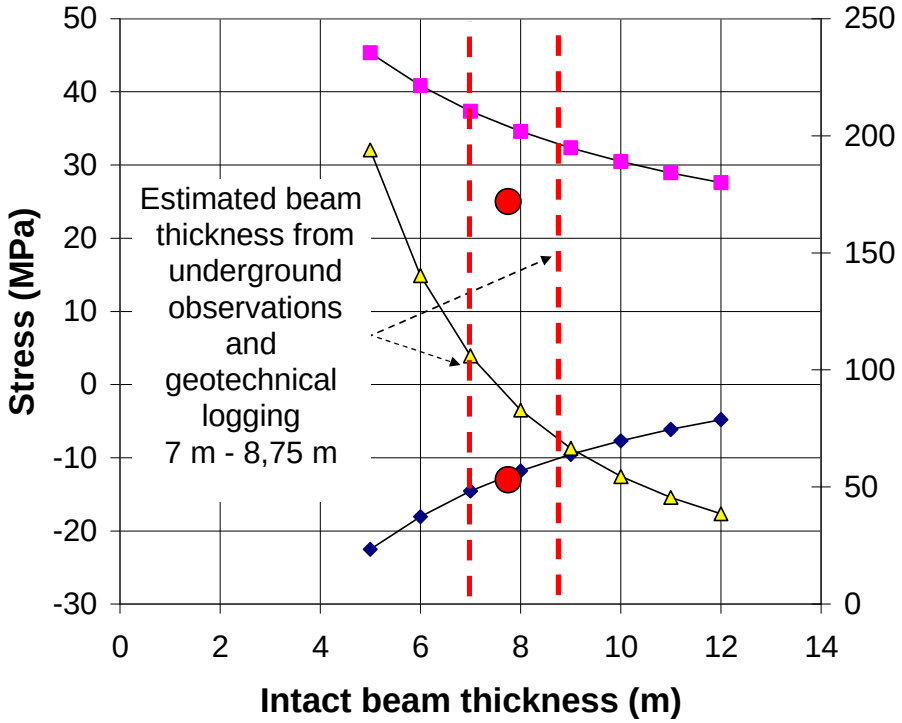
$$\sigma_{\max} = \frac{3k\rho g L^2}{4t} + \sigma_h$$

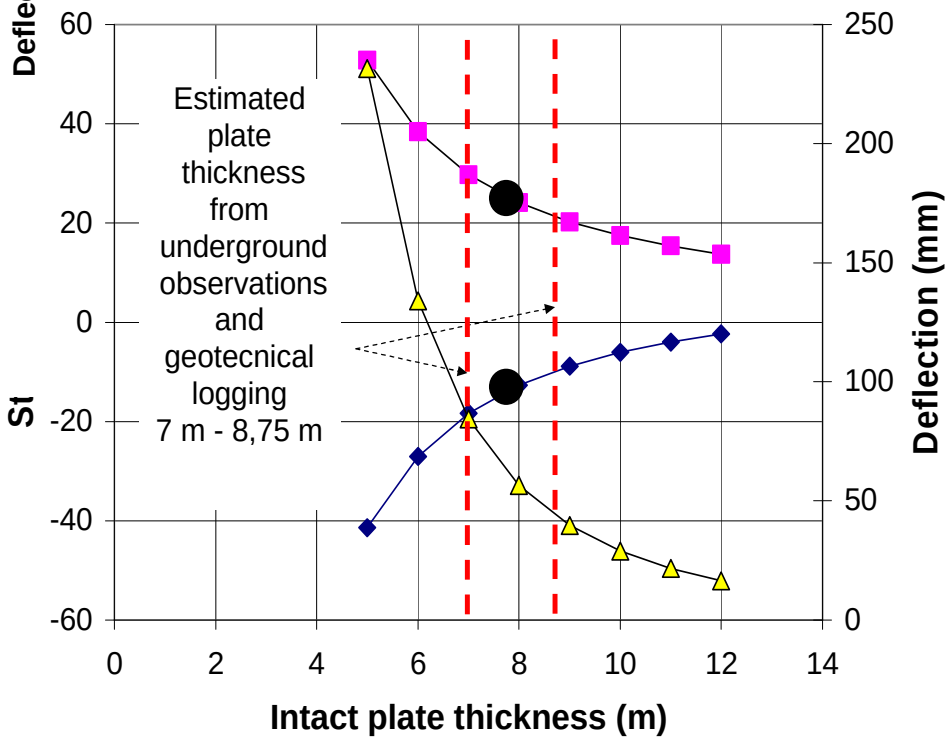
$$\delta_{\max} = \frac{5k\rho g L^4}{32 E t^2}$$

# Freely supported beam using modification

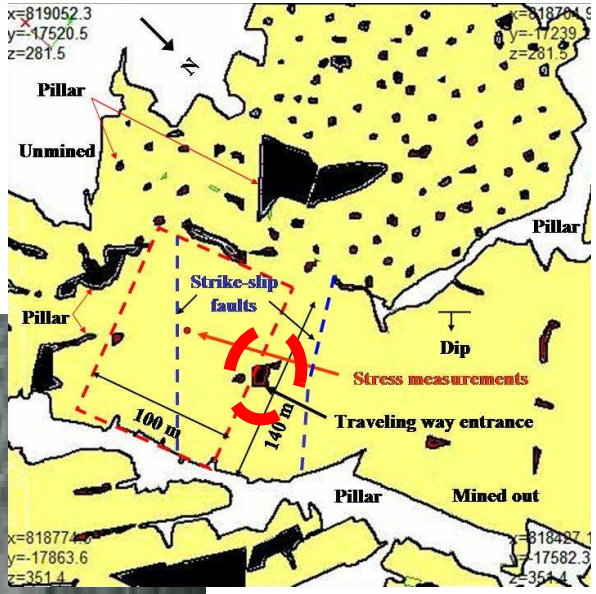


# Comparison between two freely supported beam methods

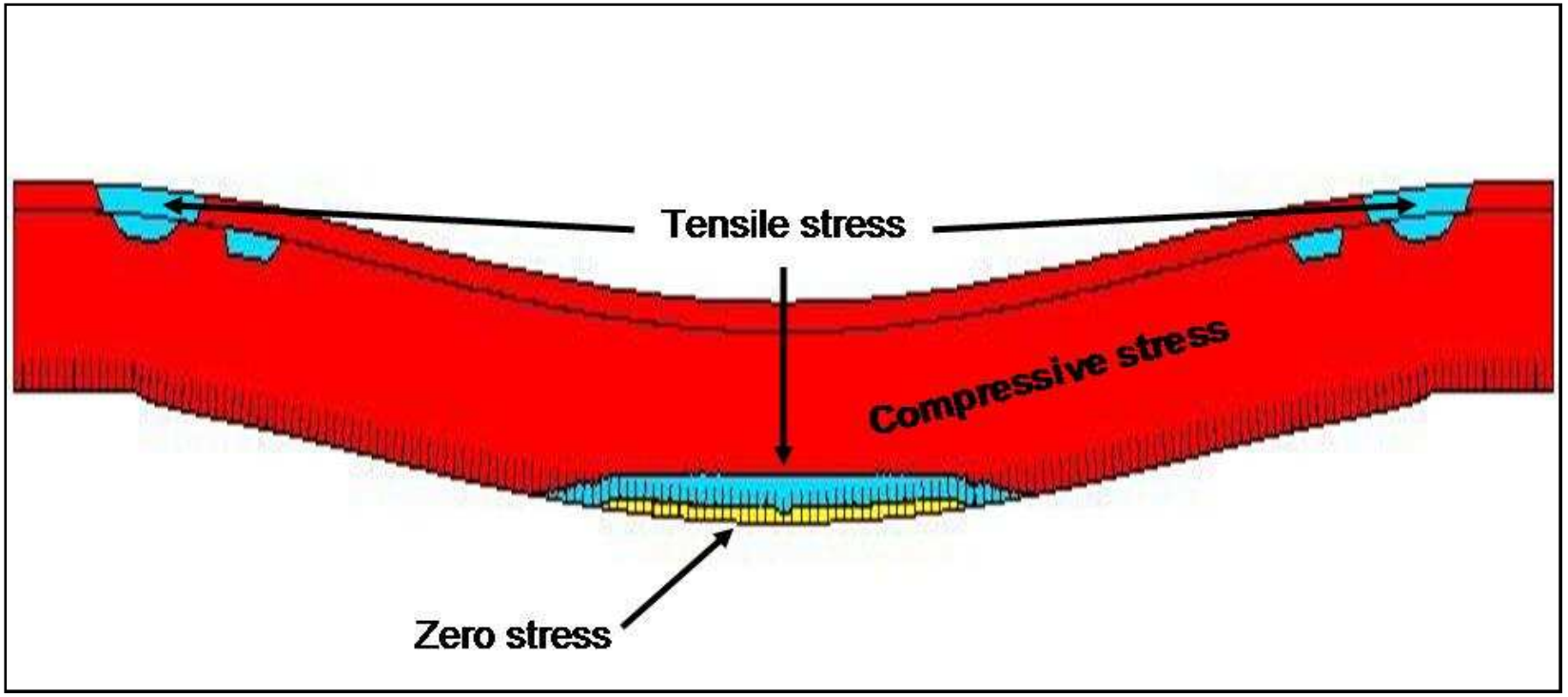


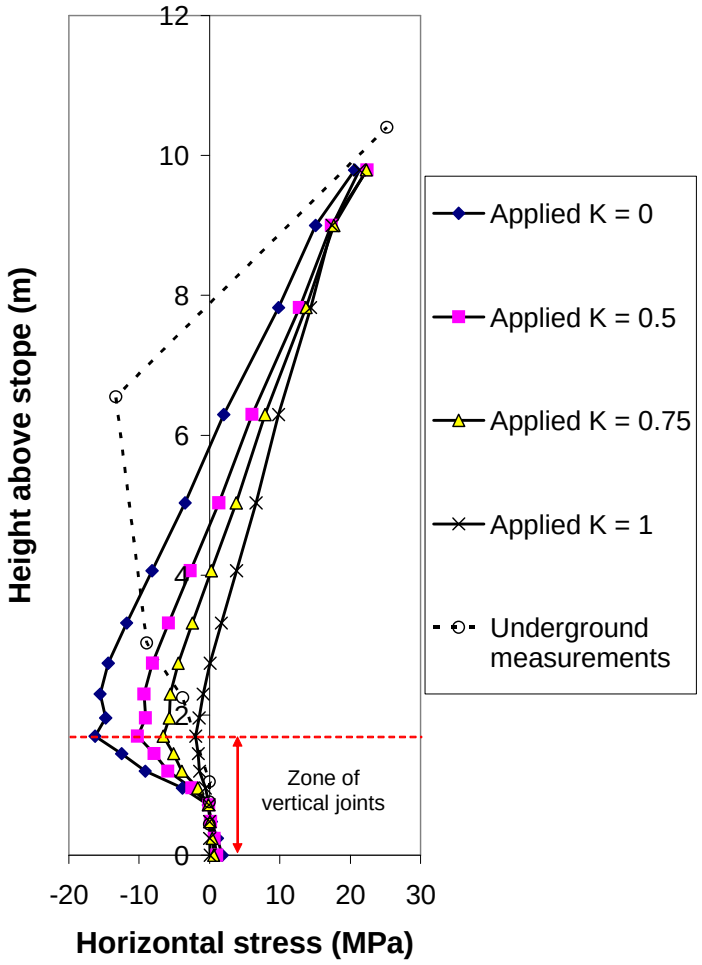
# Shear plane

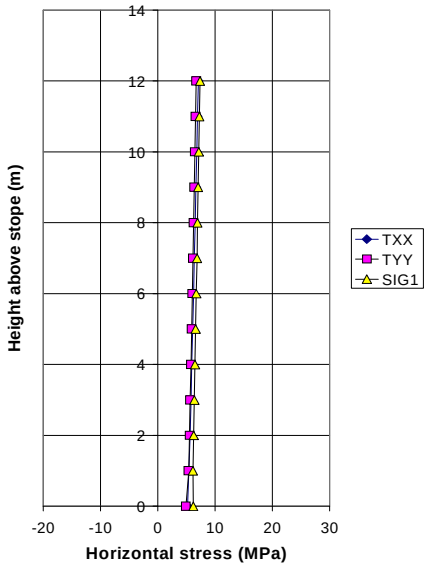


# Inelastic modeling showing compression and tensile stress zones



# Inelastic stress distribution above the centre of the panel




**K-ratio = 1,2**







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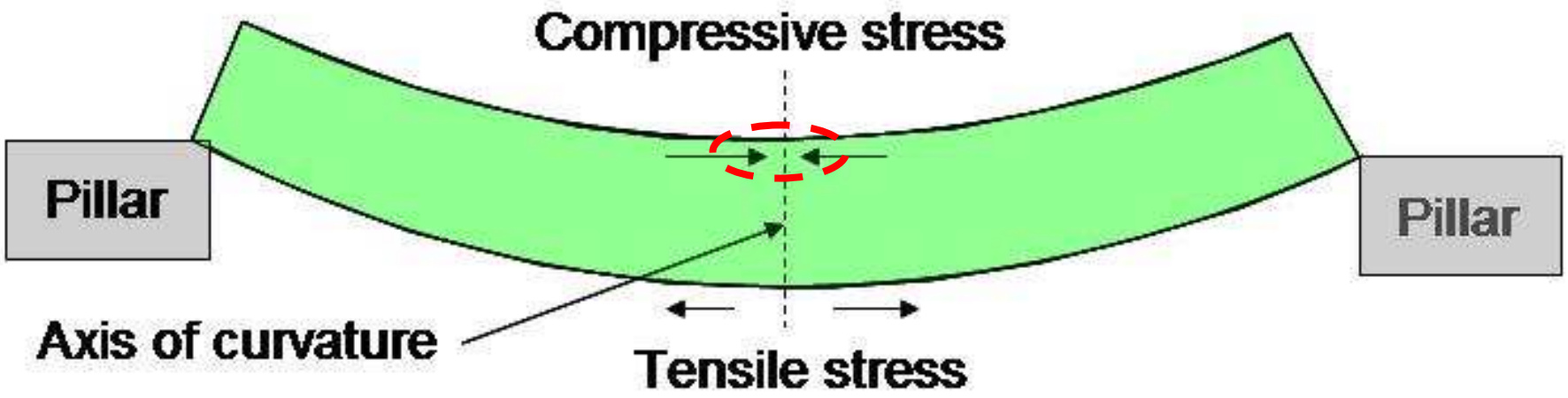
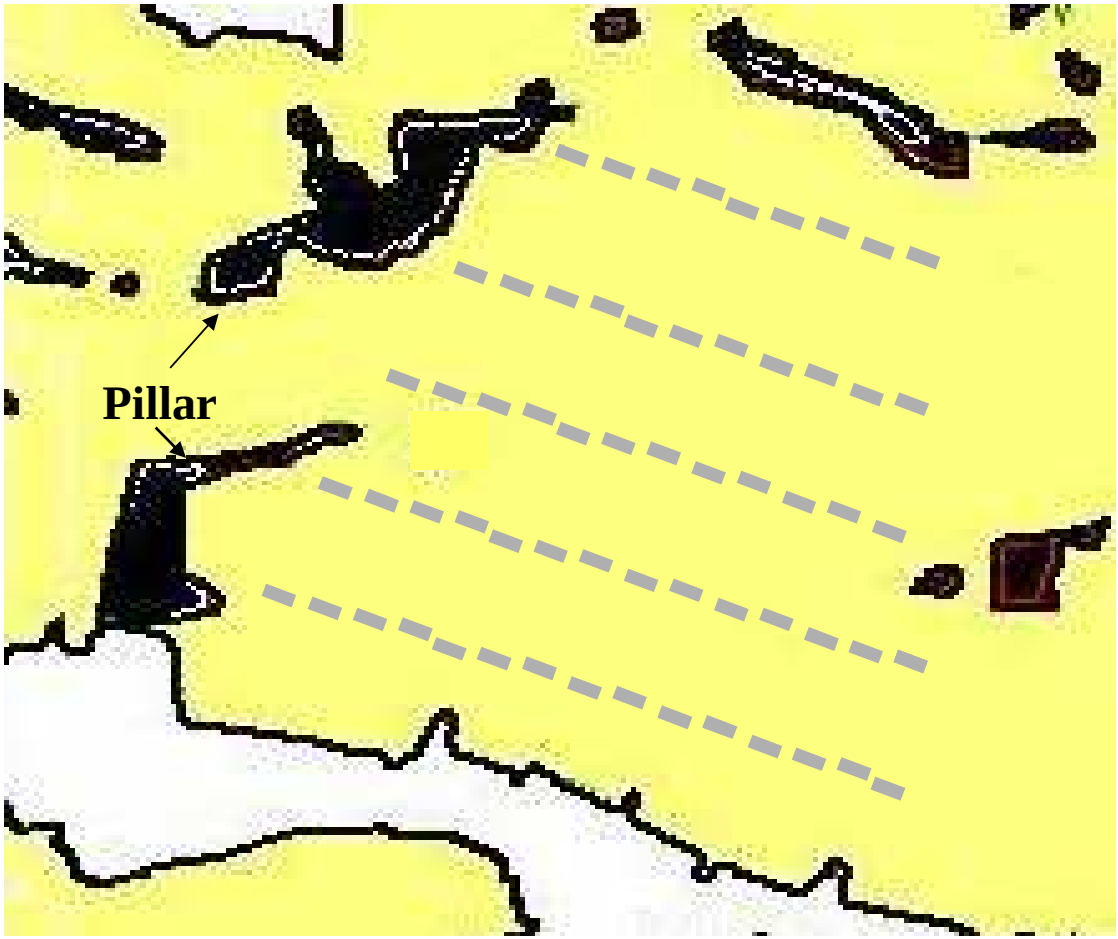
# Implications of the findings



# Significance of findings



# Conclusions

- The numerical and analytical analyses show that a complex beam or plate structure developed over the stope.
- The hangingwall behaviour is best described by a modified version of the freely supported beam theory.
- Stable stope spans may be determined by comparing the stress developed at the centre and edges of the beam to the rock strength.
- In-panel pillars left in old workings could possibly be partially or completely mined out on retreat at relative low cost.
- Extraction ratios of current workings can be improved slightly using the same procedure as for old workings.

# Contributing authors:

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- S Coetzer
- N Singh
- F Flanagan

Are acknowledged for their contribution