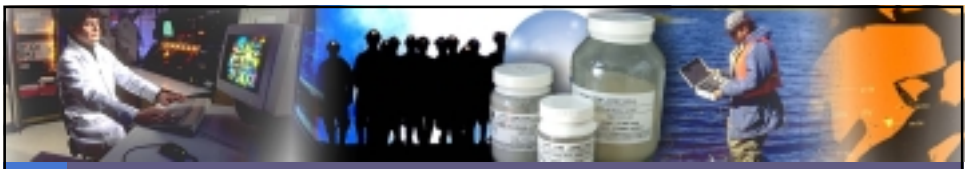

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Numerical Modelling, a Key Engineering Tool for Long-term Site Stability Assessment

Presentation to the U.S. Interstate Technical Group
on Abandoned Mines
May 1-3, 2002

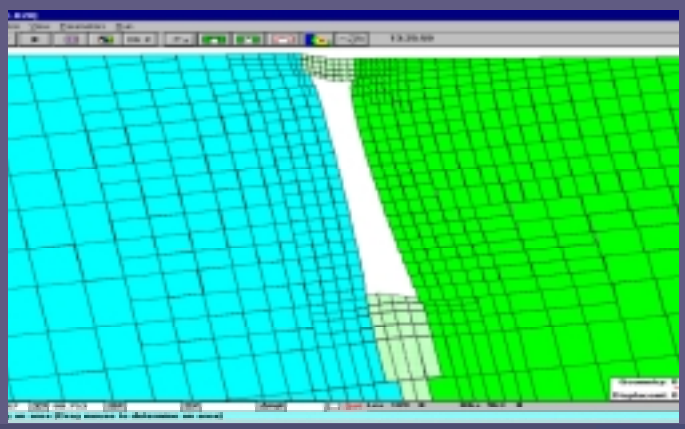
Dr. Marc C. Bétournay

Why Is Numerical Modelling Key?

- It considers all influencing factors: rock mass properties, ground stresses, material behaviour, opening geometry, artificial support, groundwater.
- Conventional theoretical or empirical rock mechanics approaches will not adequately represent these factors and the failure mechanics
- In hard rock (room and pillar coal mining?) each case (opening) is unique
- It can provide accurate and quantified surface reaction to mining

What Is Numerical Modelling?

Simulation of material behaviour under imposed conditions using computational techniques (equation solving).



Modelling Types

Continuous

- Linear (elastic)
  - Isotropic
  - Anisotropic
- Non-linear
  - Elasto-plastic
  - Elasto-viscoplastic

Discontinuous

- Elastic blocks
- Non-elastic blocks

Boundary elements
- Direct
- Displacement discontinuity

Finite difference

Finite elements

Surface profile & strains provided

Commercial Types

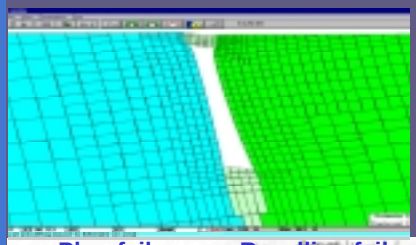
Finite Elements	Finite Difference	Direct Boundary Elements	Displacement Discontinuity	Block
2DCANSAFE VISROCK	FLAC2D		MINTAB	UDEC BSM2D
ADINA ROCK3D		EXAMINE3D BEAP3D		3DEC BSM3D

Numerical Modelling Caveats

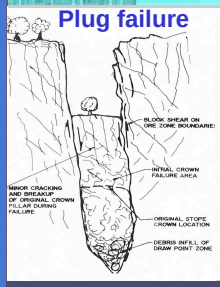
- Use quantified rock mass and in situ ground stresses data input instead of approximations
- Select 2D/3D according to the geometry of the opening(s)
- Consider major discontinuities and anisotropies
- Incorporate nearby openings and surface elements
- Use higher mesh density for opening peripheries, weak rock mass, and potential failure mechanism paths/planes
- Use appropriate load-deformation material response
- Select code for adequately simulating failure mechanism

Failure Mechanism and Modelling Type

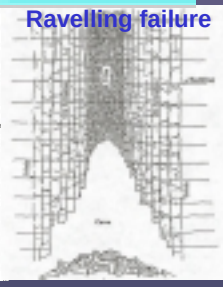
Metal Mining - Block codes



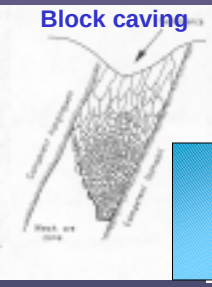
Plug failure



Ravelling failure



Block caving



Destratification

Blocky rock mass, failing piece

Failure Mechanisms and Modelling Type

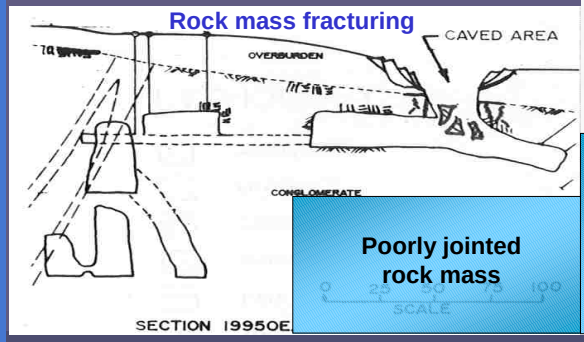
Metal Mining

Finite element elastic, finite difference, boundary element codes

Finite element elastic, finite difference codes

Destratification

Rock mass fracturing



Poorly jointed rock mass

Thick, rigid strata

Failure Mechanism and Modelling Type

Metal Mining

Finite element elasto-plastic, finite difference codes

Weak rock mass

Chimneying disintegration

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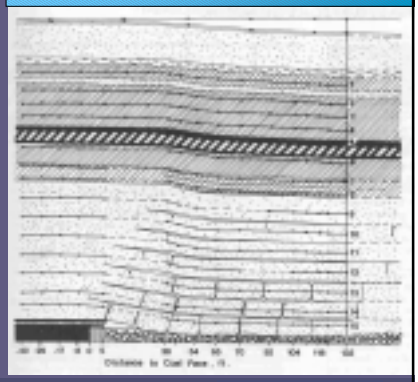
Failure Mechanism and Modelling Type

Coal Mining - Longwall

Finite element, non-elastic, finite difference

Strata caving



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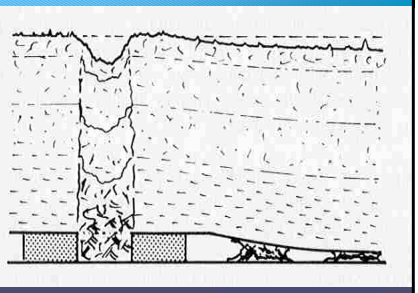
Failure Mechanism and Modelling Type

Coal Mining - Room and pillar

Strata caving, chimneying disintegration



Finite element, non-elastic, finite difference

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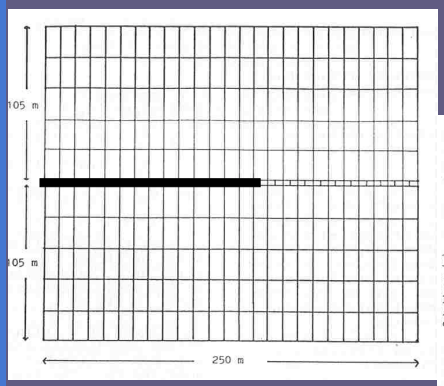
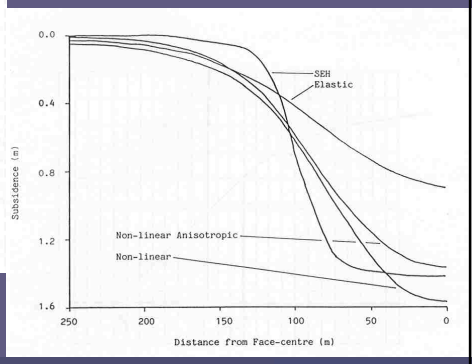
Case Study - Single Seam Longwall

2D finite elements, linear/non-linear/non-linear anisotropic





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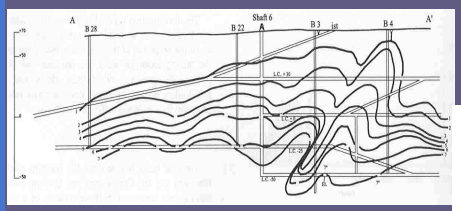
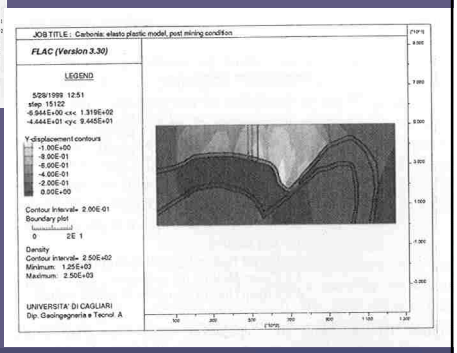
Case Study - Multiple Seam Longwall

2D finite difference





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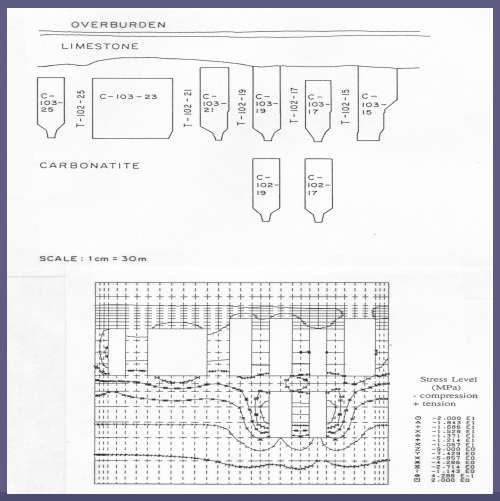
Case Study - Metal Mining, High Rock Mass Quality

3D finite elements, linear



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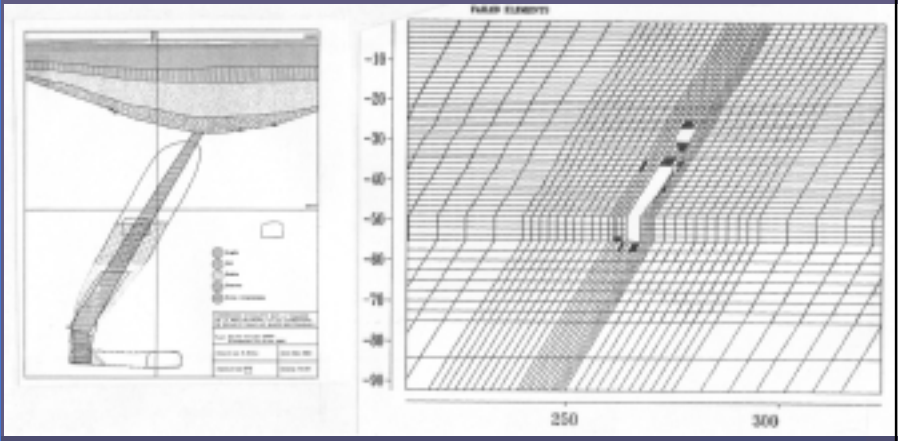
Case Study - Metal Mining, Low Rock Mass Quality

2D finite elements, non-linear



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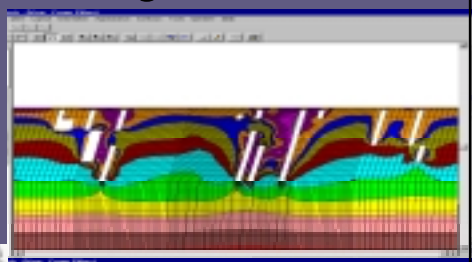
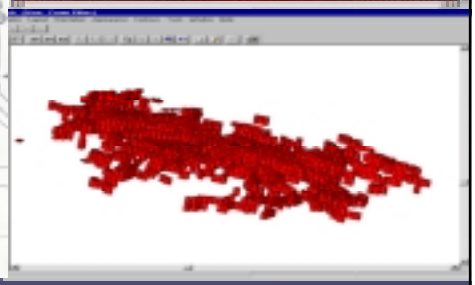
Case Study - Regional Destress Impact Metal Mining

3D finite elements, linear





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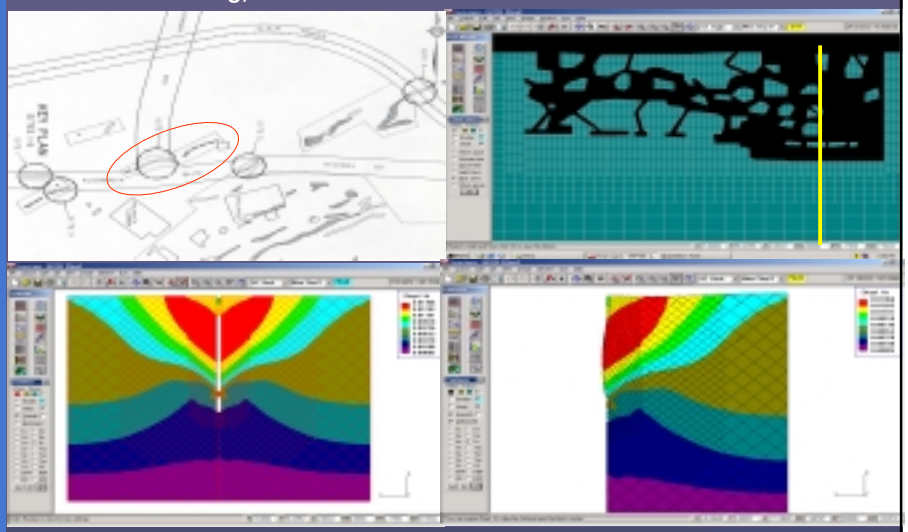
Case Study - Regional Destress Impact Metal Mining

3D block modelling, linear



Conclusions

- Numerical modelling can be used to evaluate long-term surface effects of mining
- Codes exist to cover the range of mining and rock mass conditions/behaviour
- Results approximate closely the actual subsidence and strain values to evaluate effects to infrastructure
- Modelling can be used as a predictive tool ahead of rock mass failures
- The application of representative data and modelling techniques is important to obtain accurate results