Siphumelele 1 Mine Rockburst Investigations

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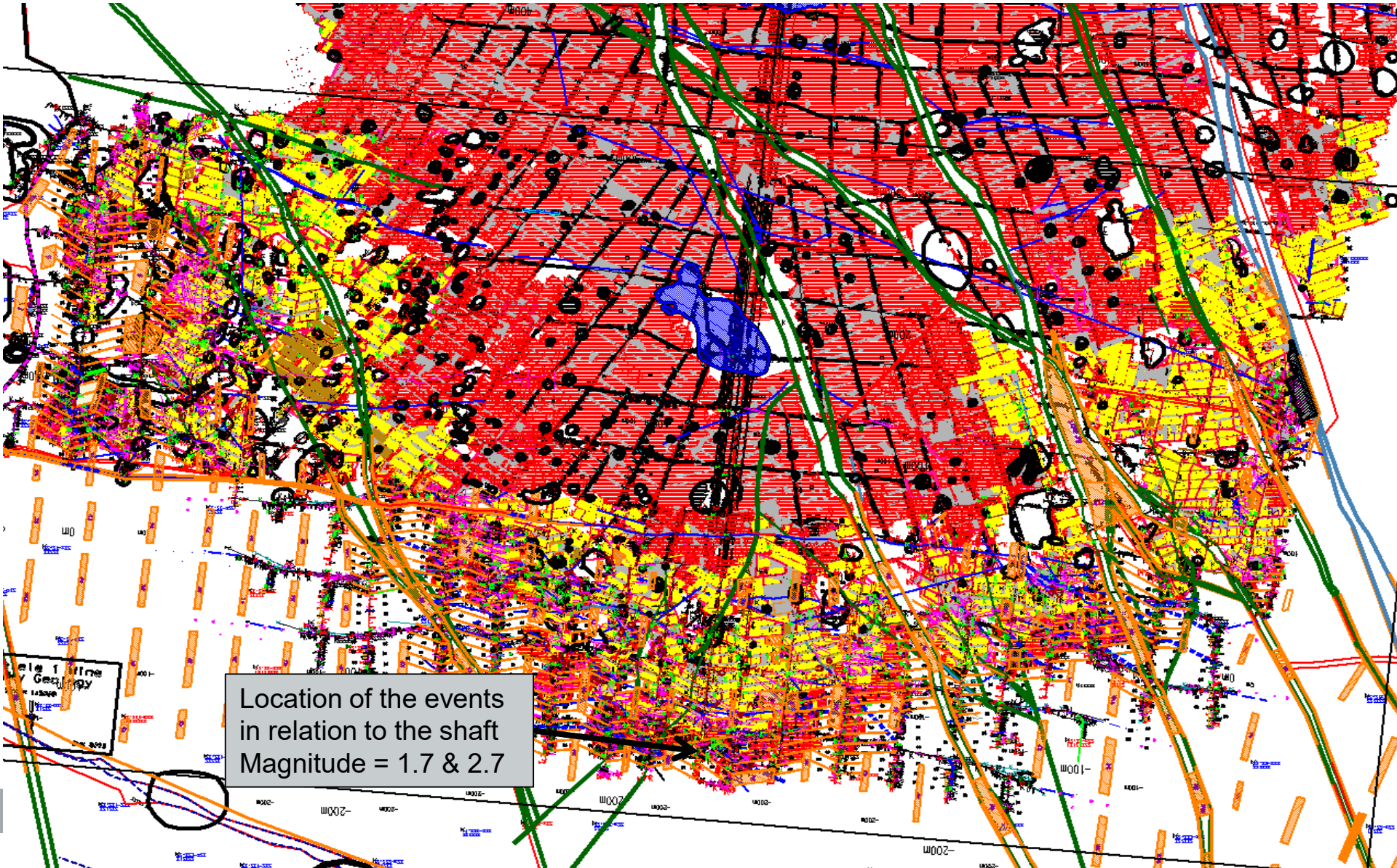
20 September 2017

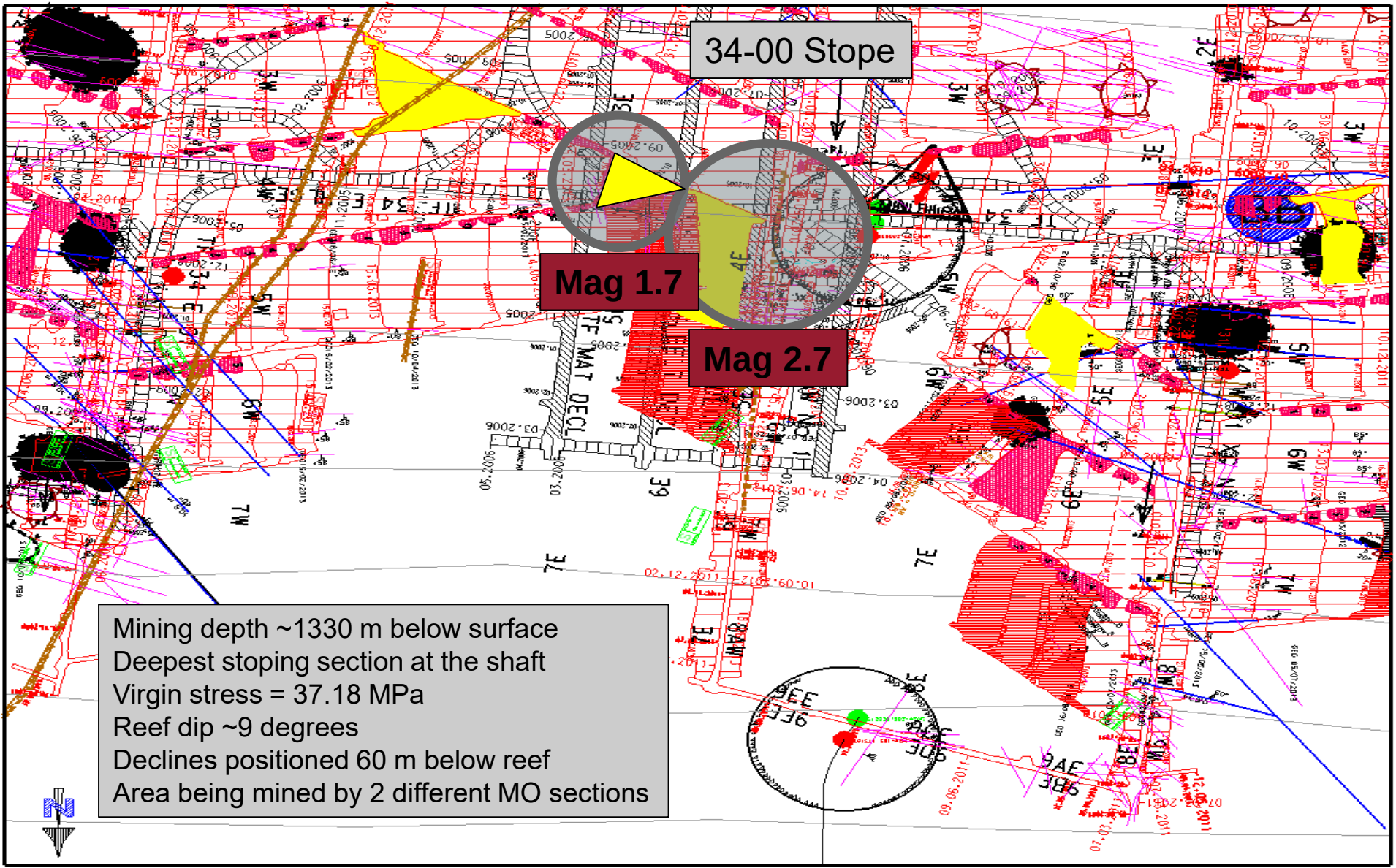
Contents

- Overview
- History of rock bursts
- Investigation, findings and recommendations
- Completed actions/changes – Future + Legacy
- Update on progress
- Way Forward
- Questions

Plan of Siphumelele 1 Shaft

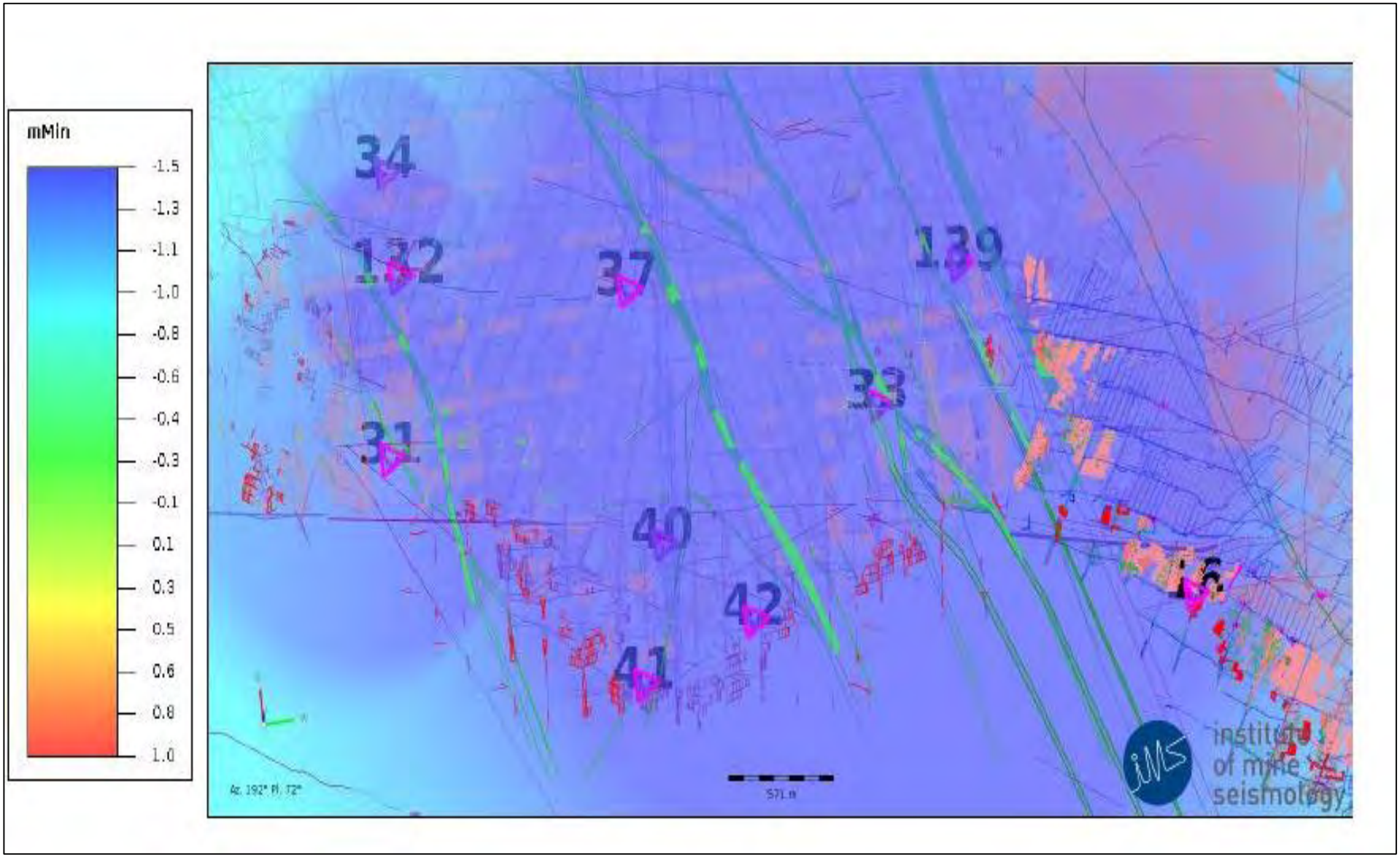


Plan of Siphumelele 1 Shaft

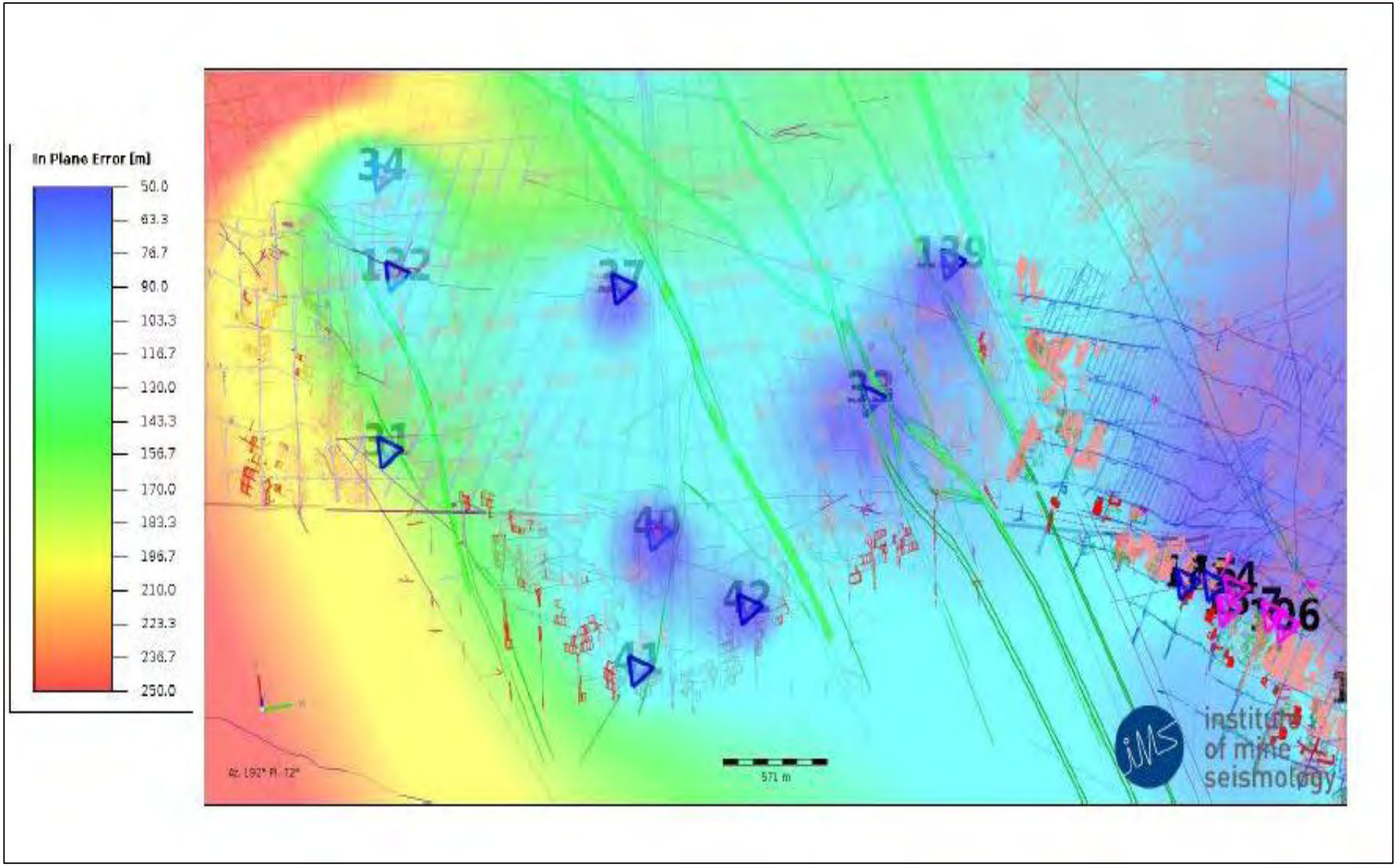


Mining depth ~1330 m below surface
Deepest stoping section at the shaft
Virgin stress = 37.18 MPa
Reef dip ~9 degrees
Declines positioned 60 m below reef
Area being mined by 2 different MO sections

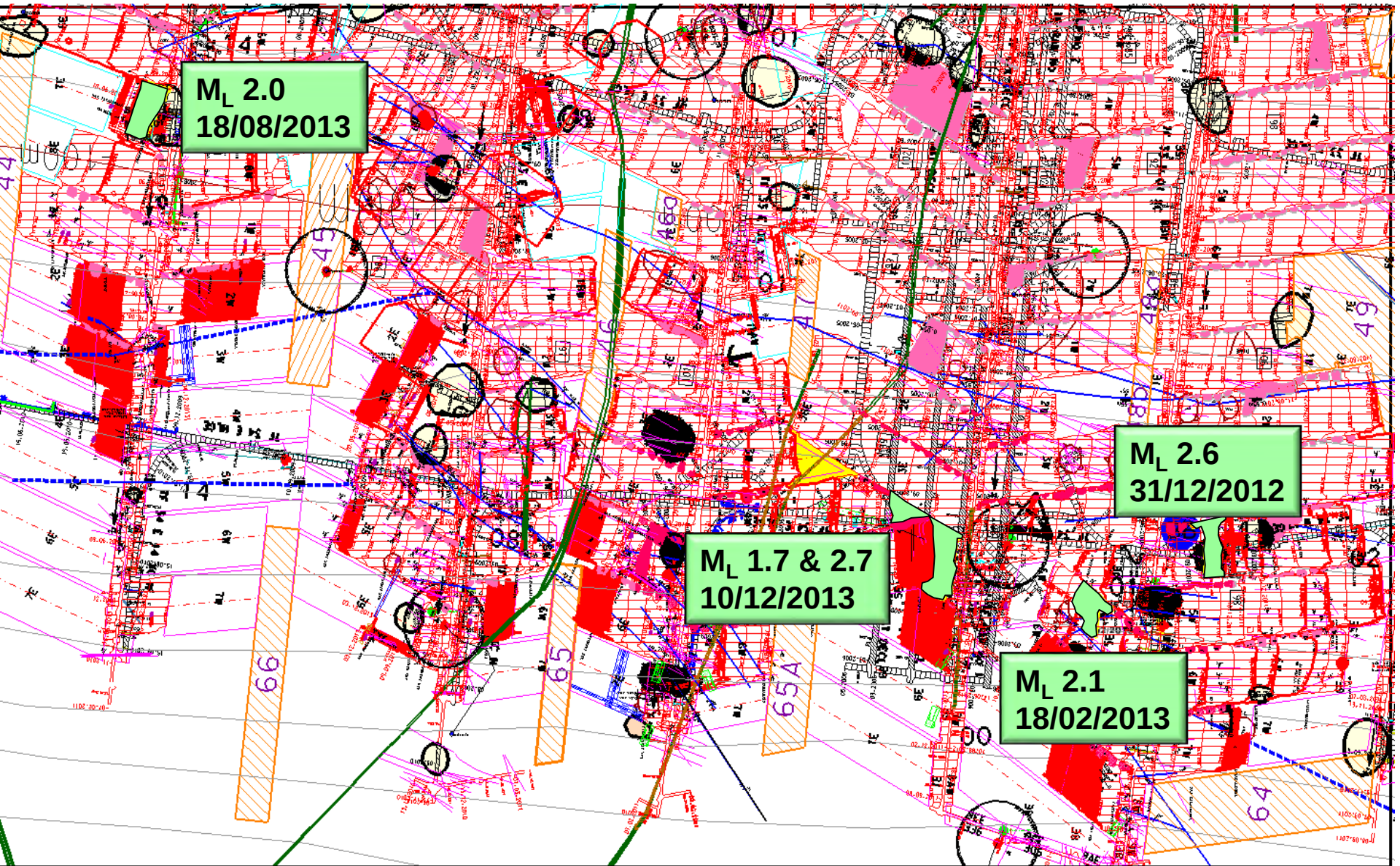
System Sensitivity



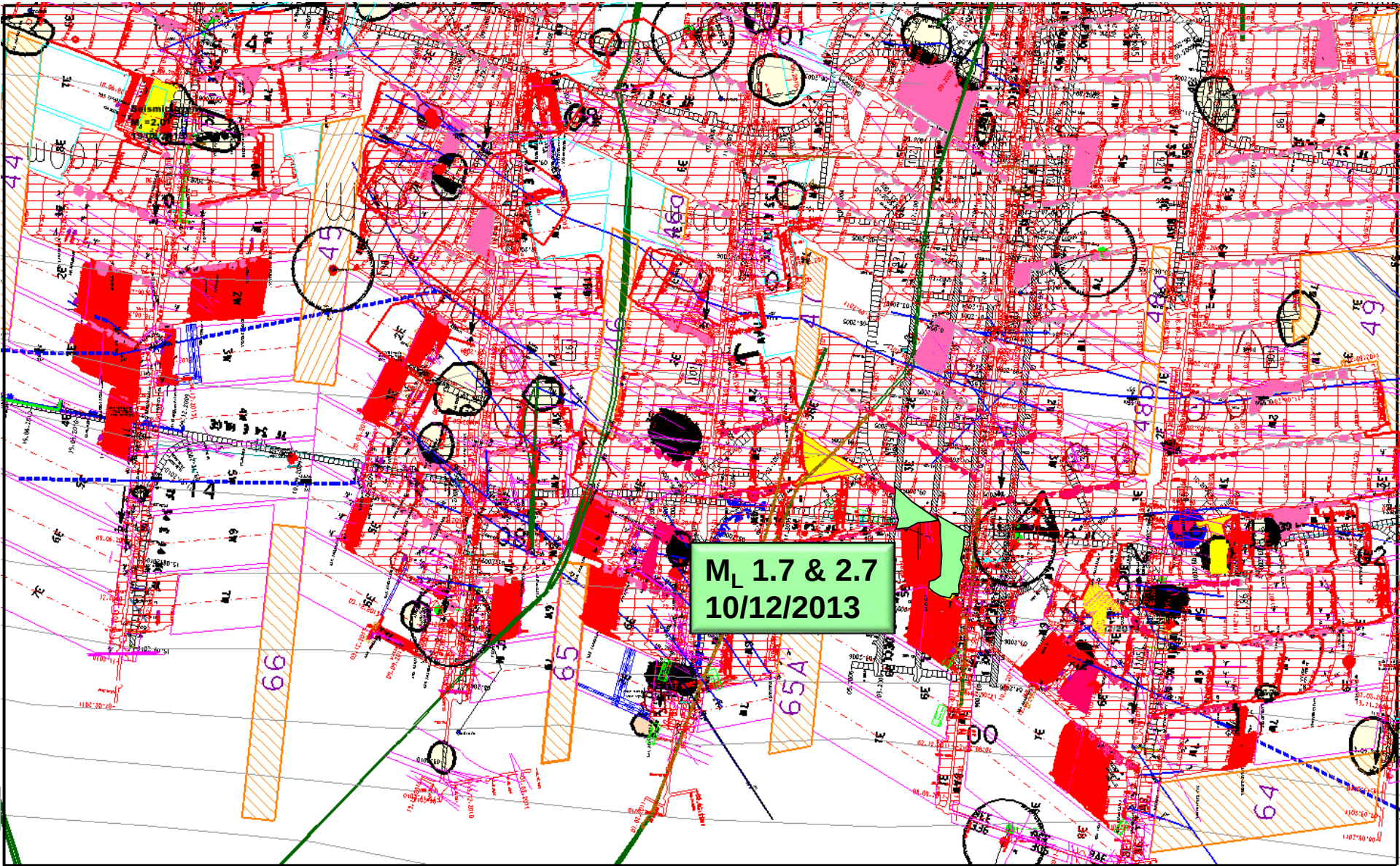
System Location Accuracy



Rock Burst History

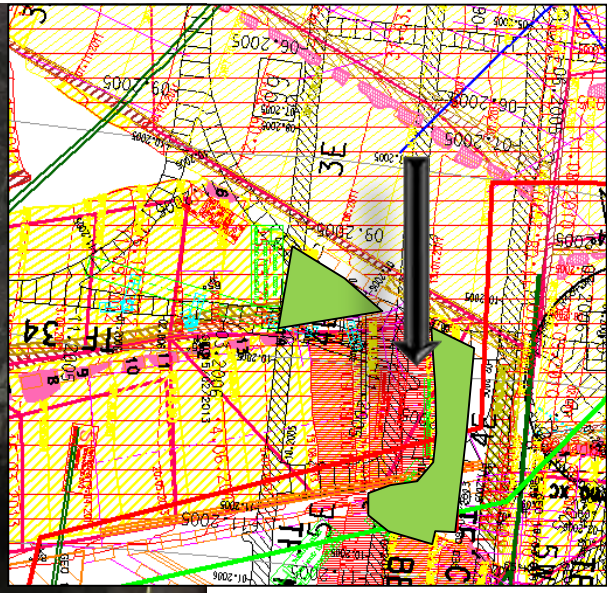


Events 10 December 2013



Conditions Prior to the Events

Condition of west mining face before the event



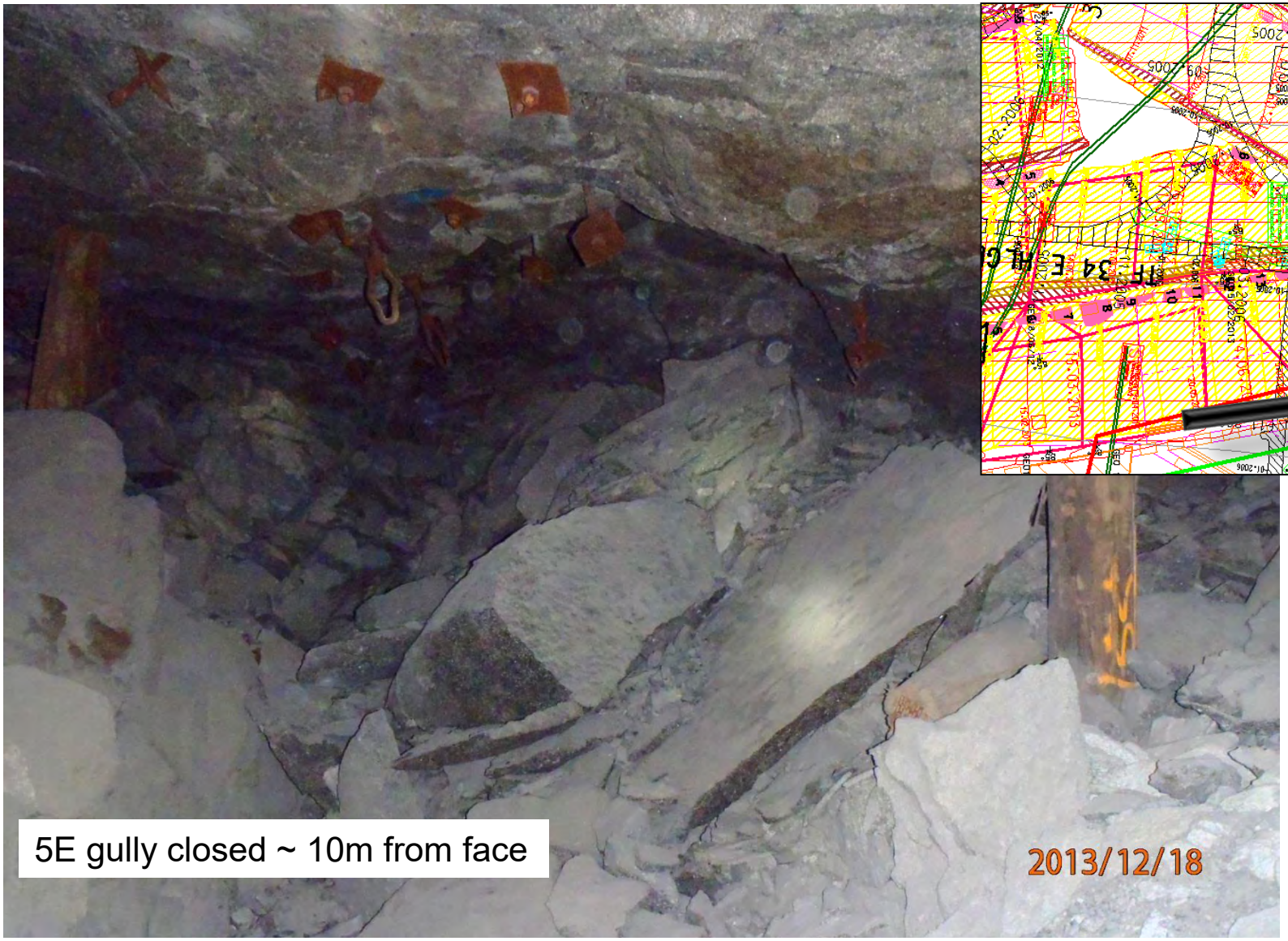
Rock Burst Damage

4E Gully closed from ~ 10m from face

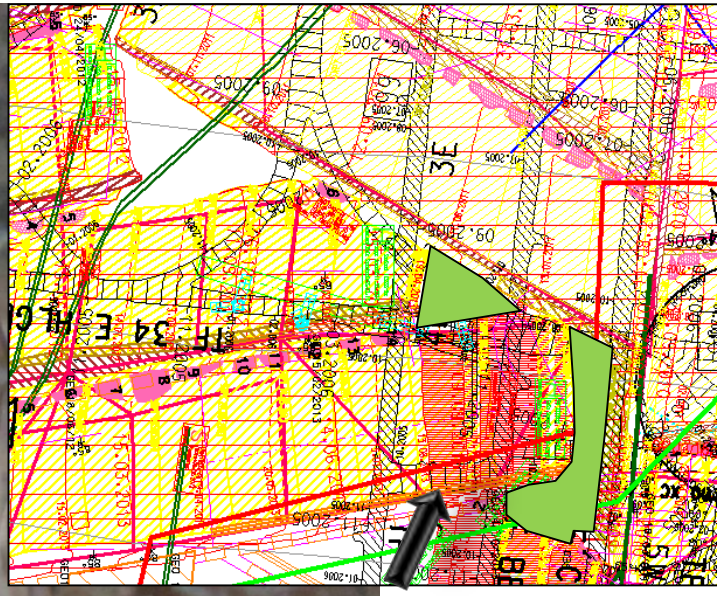
Rock Burst Damage

Elongate damage above 4E gully in back area

Rock Burst Damage



Rock Burst Damage



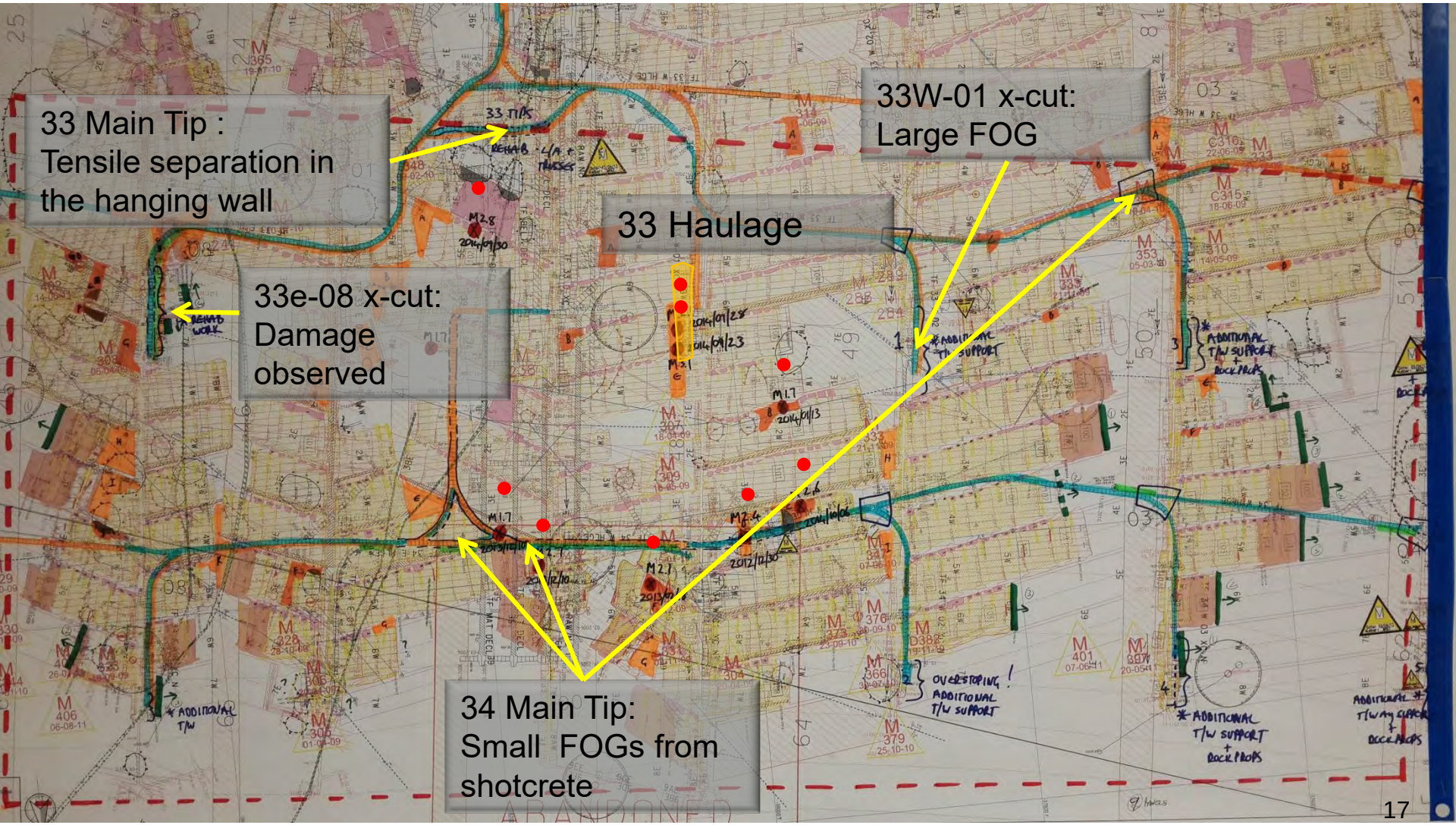
Complete stope closure just above 5E gully

2013/12/18

Rock Burst Damage

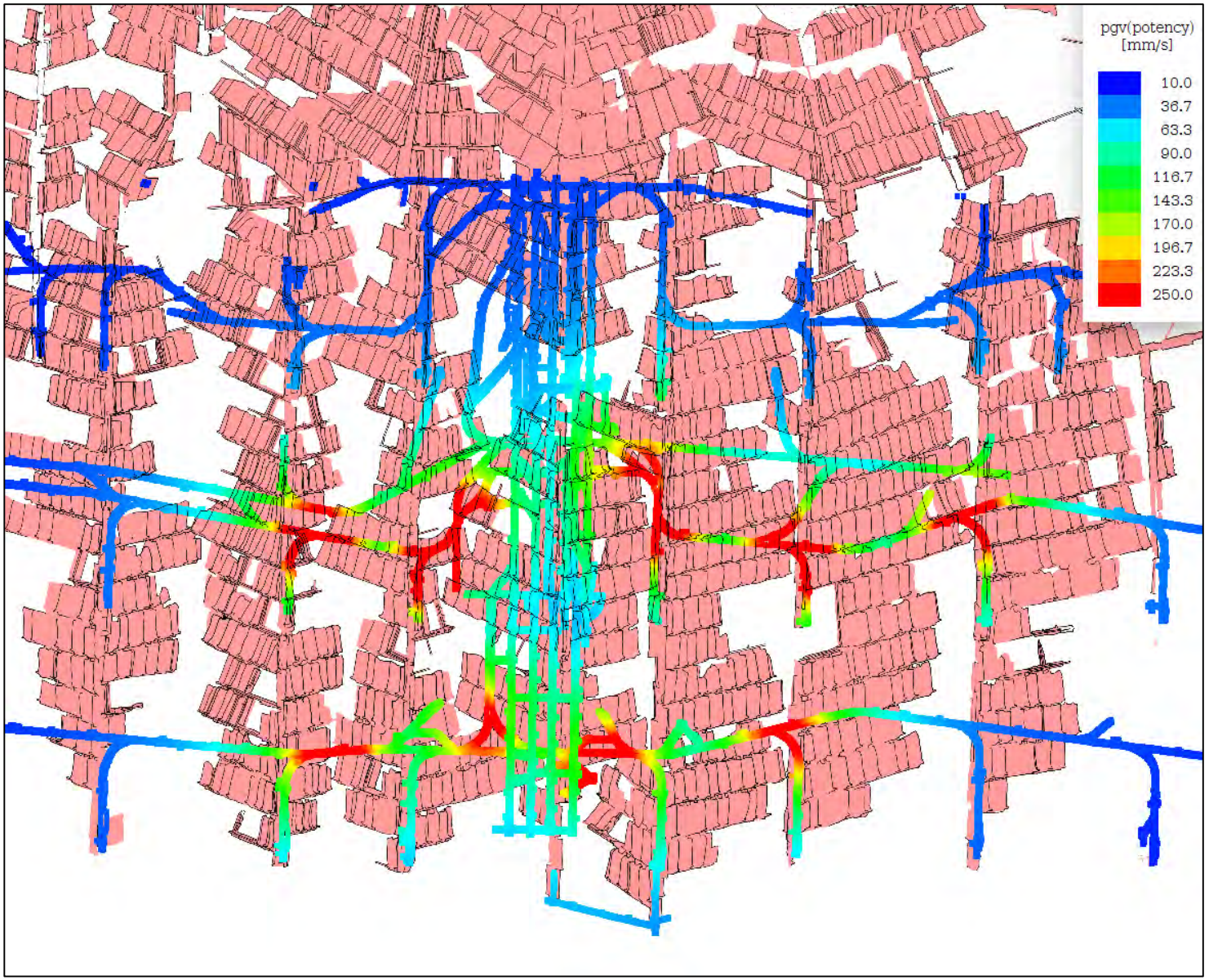
Events Post December 2013

Damage – Footwall Infrastructure



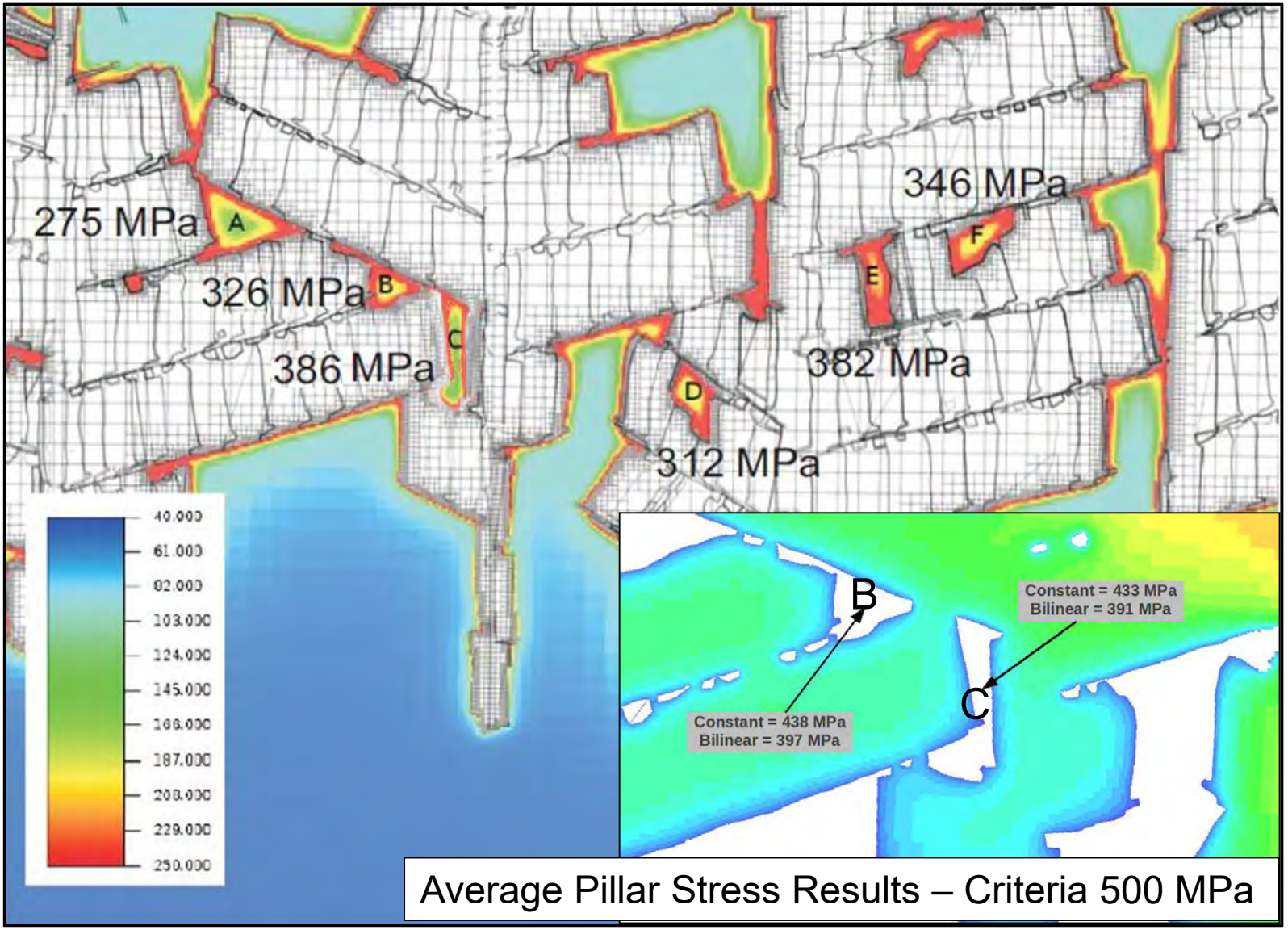
Hazard Assessment Footwall

Peak Ground Velocity



Hazard Assessment Footwall - RCF

Numerical Modelling Results - APS



Average Pillar Stress Results – Criteria 500 MPa

External Stakeholders

- All platinum RE HODs
- Simrac researchers
- IMS – Dr Gerrie van Aswegen
- Gold mine RE HODs
- Dr. Matthew Handley
- DMR

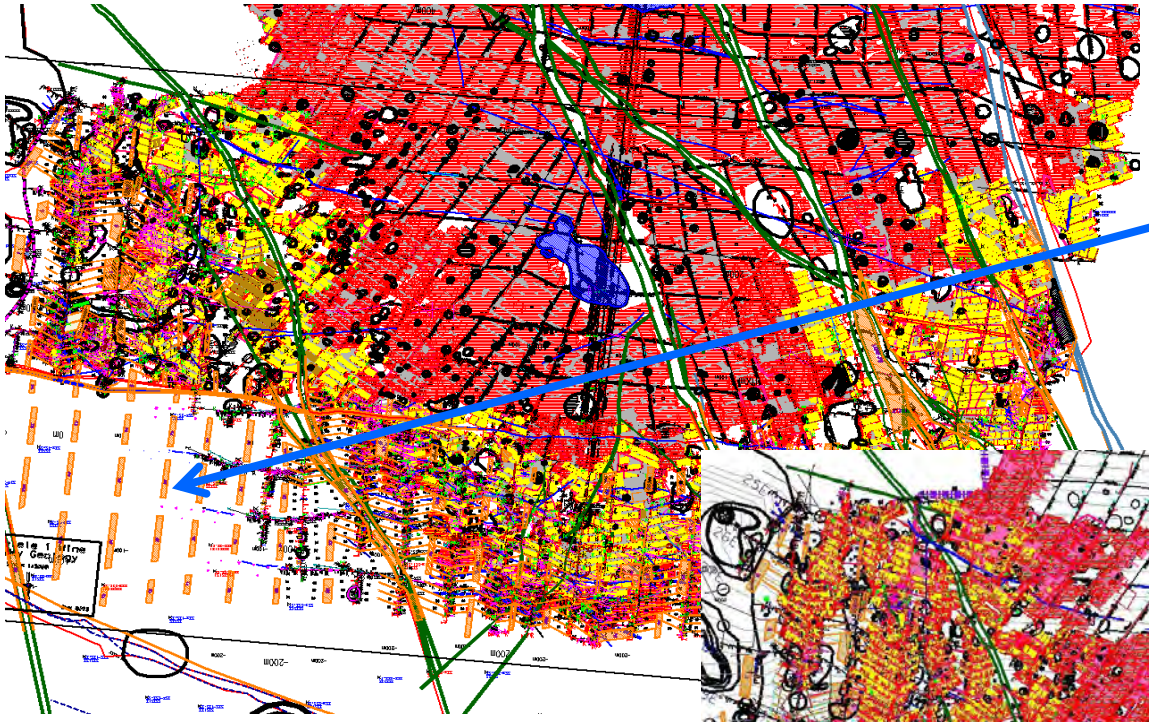
Findings

- Seismic events are associated with ad hoc and regional pillars
- Pillars punch into the footwall with extensive footwall heave in surrounding area
- Little to no damage to hanging wall
- Pillars that experienced seismic events had APS > 300 MPa
- Irregular shaped pillars
- Poor mining sequence in certain cases

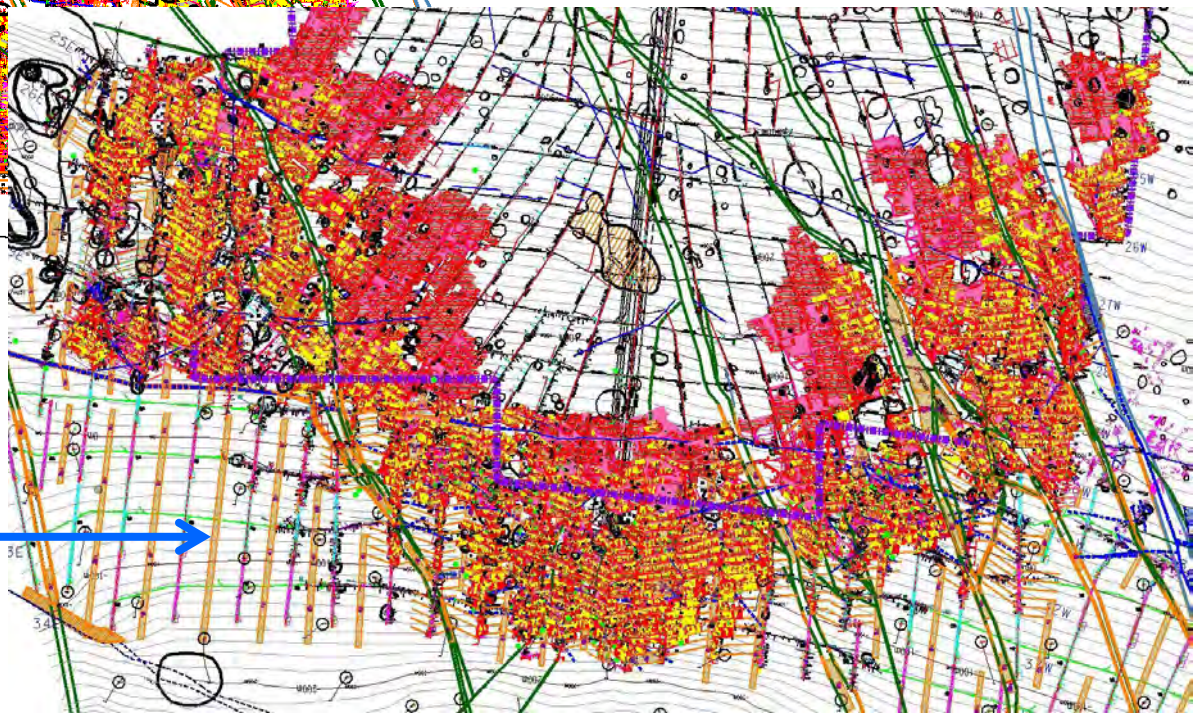
Actions

- Used numerical modelling to establish new design criteria (IMS patronage research)
- Stopped all mining in the central bottom area
- Changed all new designs to comply to new design criteria and confirmed with modelling
- Reviewed current active working places and adjusted designs where required (left additional pillars)
- Reviewed by external consultant
- Conducted risk assessment of infrastructure where legacy pillars exist
- Started program of secondary support based on risk assessment
- Various sessions with Siphumelele team on changing mind set
- Monthly monitoring in-stope pillar compliance
- Briefed other operations

Regional Pillar Design Changes



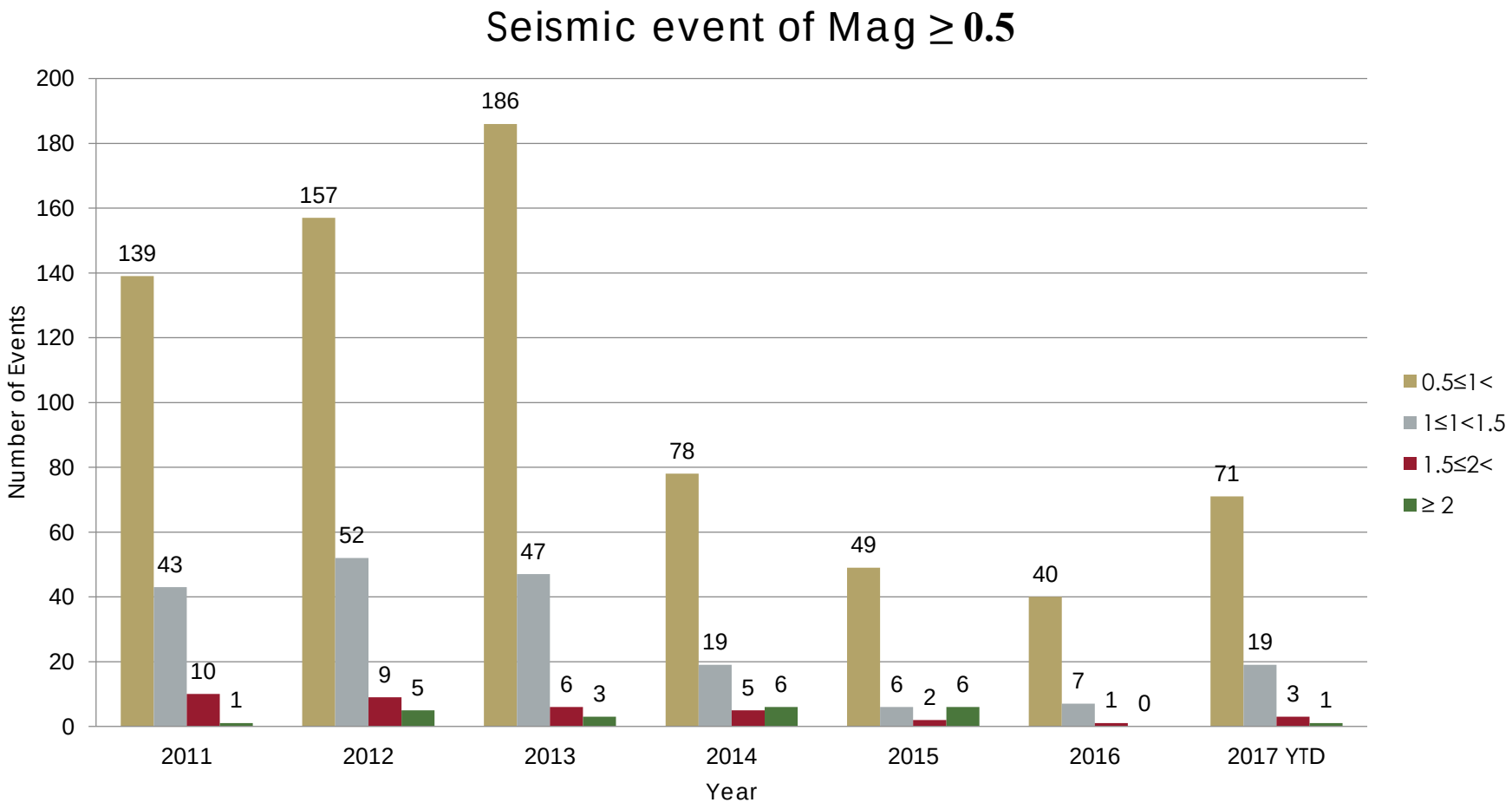
Broken dip pillars –
To overstope haulages



Solid dip pillars –
31 level downwards
Haulages 35 to 40 m
In footwall

Modelled Regional Pillar Design Changes

Seismic History - Before and After Design Changes



Final Changes Below 31 Level

- Regional pillar spacing 210 m and continuous (No holings)
- Regional pillar w:h ratio 20:1 and APS < 2.5 x UCS of footwall
- Ad hoc pillar w:h ratio 20:1 and APS < 300 MPa
- Strict adherence to overall mining sequence. No mining in opposite directions or from one side only.
- Leads and lags between panels = 15m
- Regular shaped pillars
- Strict adherence to in-stope pillar dimensions
- Install rock burst resistant support in haulages below pillars
- Mesh and lace x/cuts next to pillars and Rocprops and anchors beyond footwall marker