The identification and mitigation of Geohazards using Shallow Airborne Engineering Geophysics and land-based geophysics for brown- and greenfield road investigations.

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The Geological Society
Ground Related Risk to Transportation Infrastructure Conference
London, 26 to 27 October 2017

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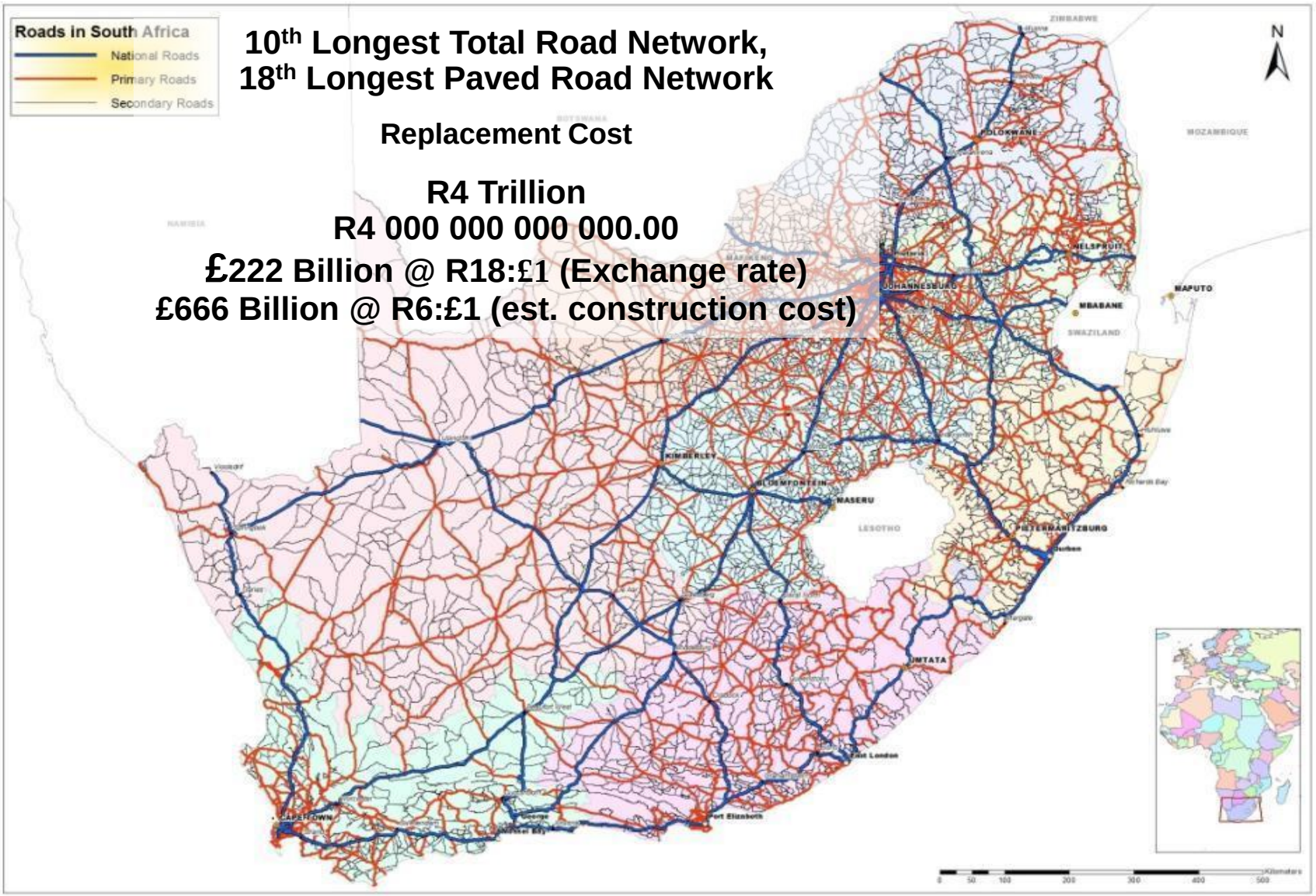
South African Road Network

10th Longest Total Road Network,
18th Longest Paved Road Network

Replacement Cost

R4 Trillion
R4 000 000 000 000.00
£222 Billion @ R18:£1 (Exchange rate)
£666 Billion @ R6:£1 (est. construction cost)



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Ground related infrastructure risk

- Geology complex, diverse and old.
- Risks include:
  - Collapsible soils
  - Expansive clays
  - Dykes and faults
  - Rapid weathering dolerites
  - Dolomites
  - Dispersive and Erodible Soils
  - And several other risks

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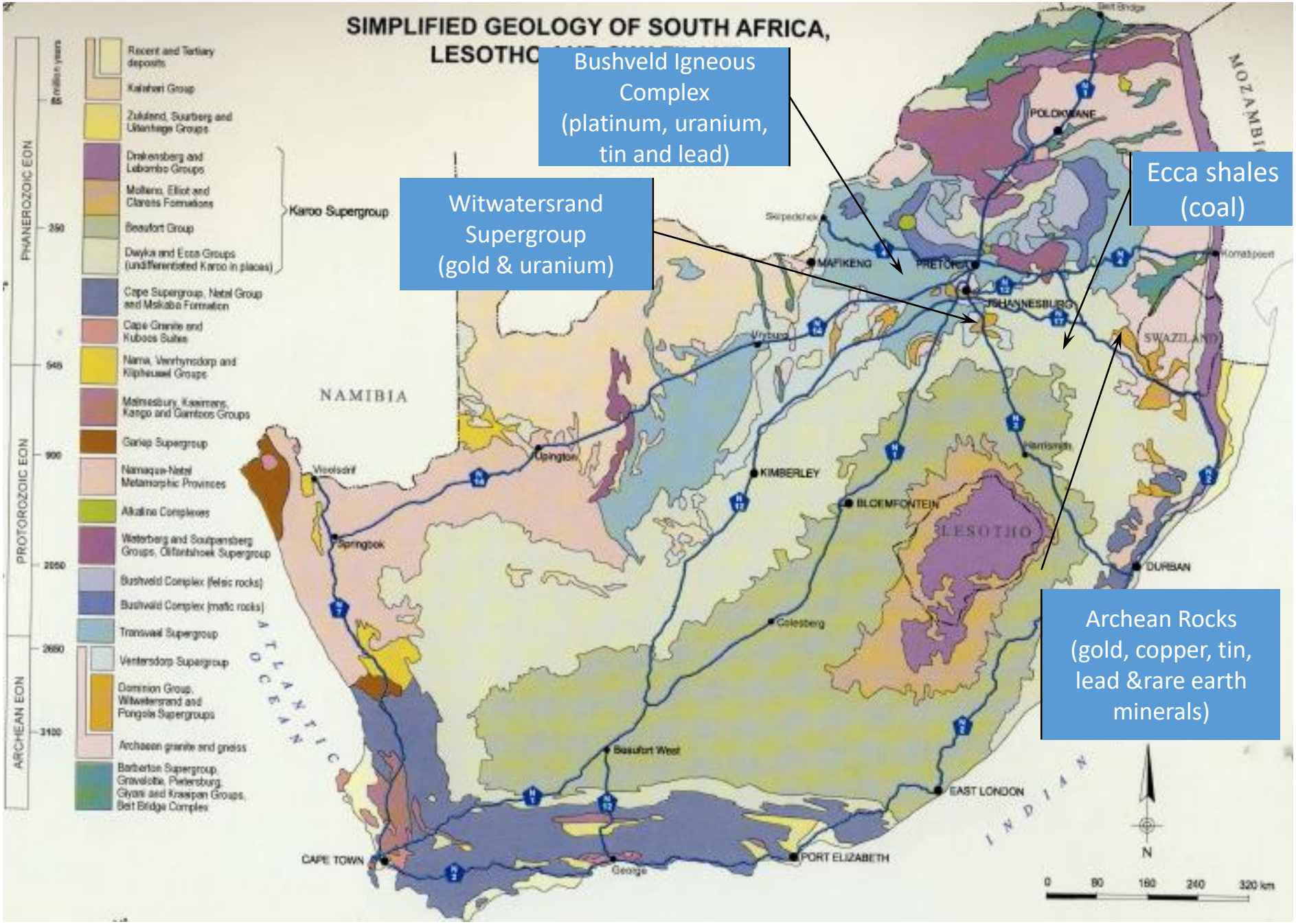
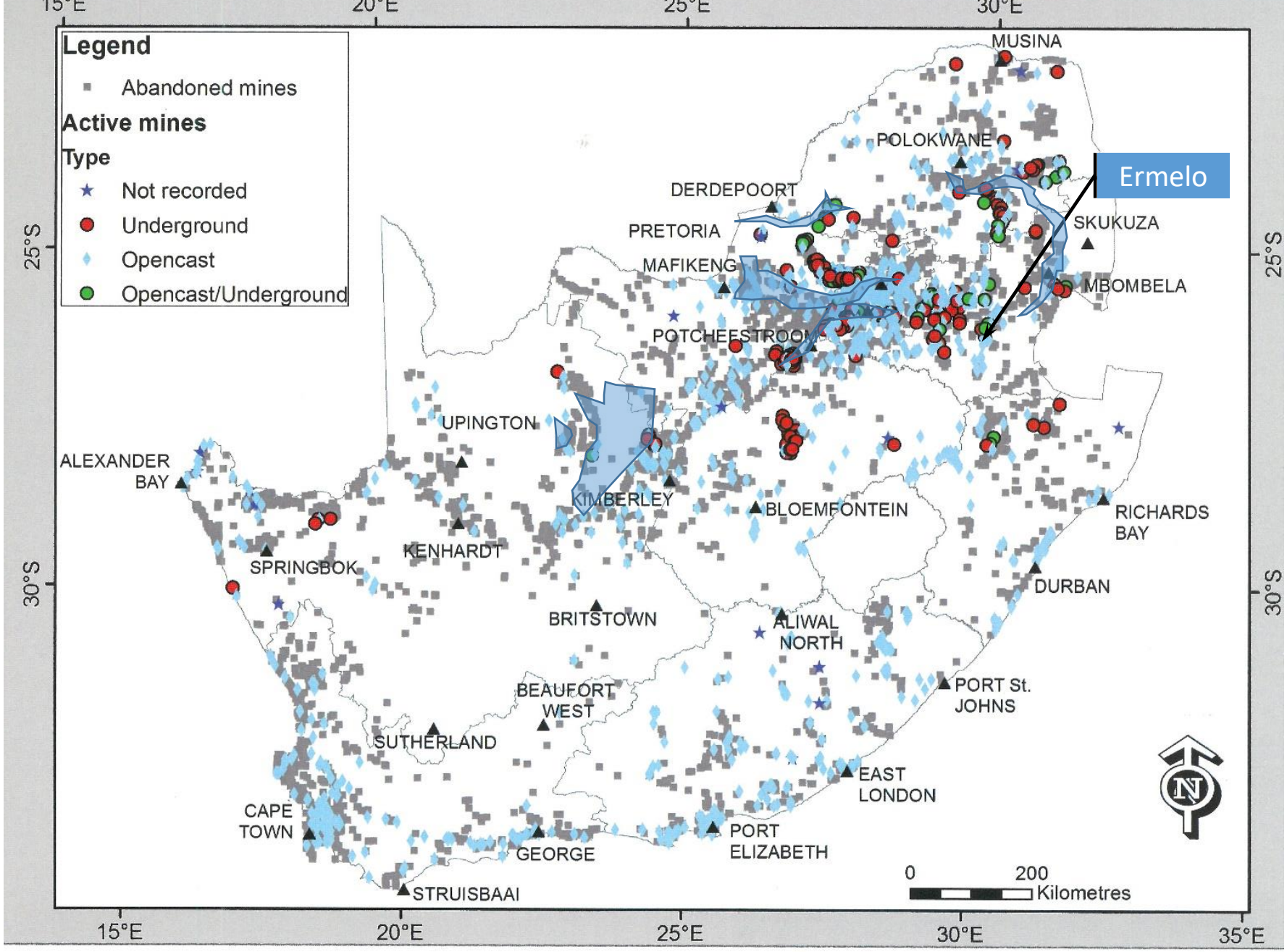
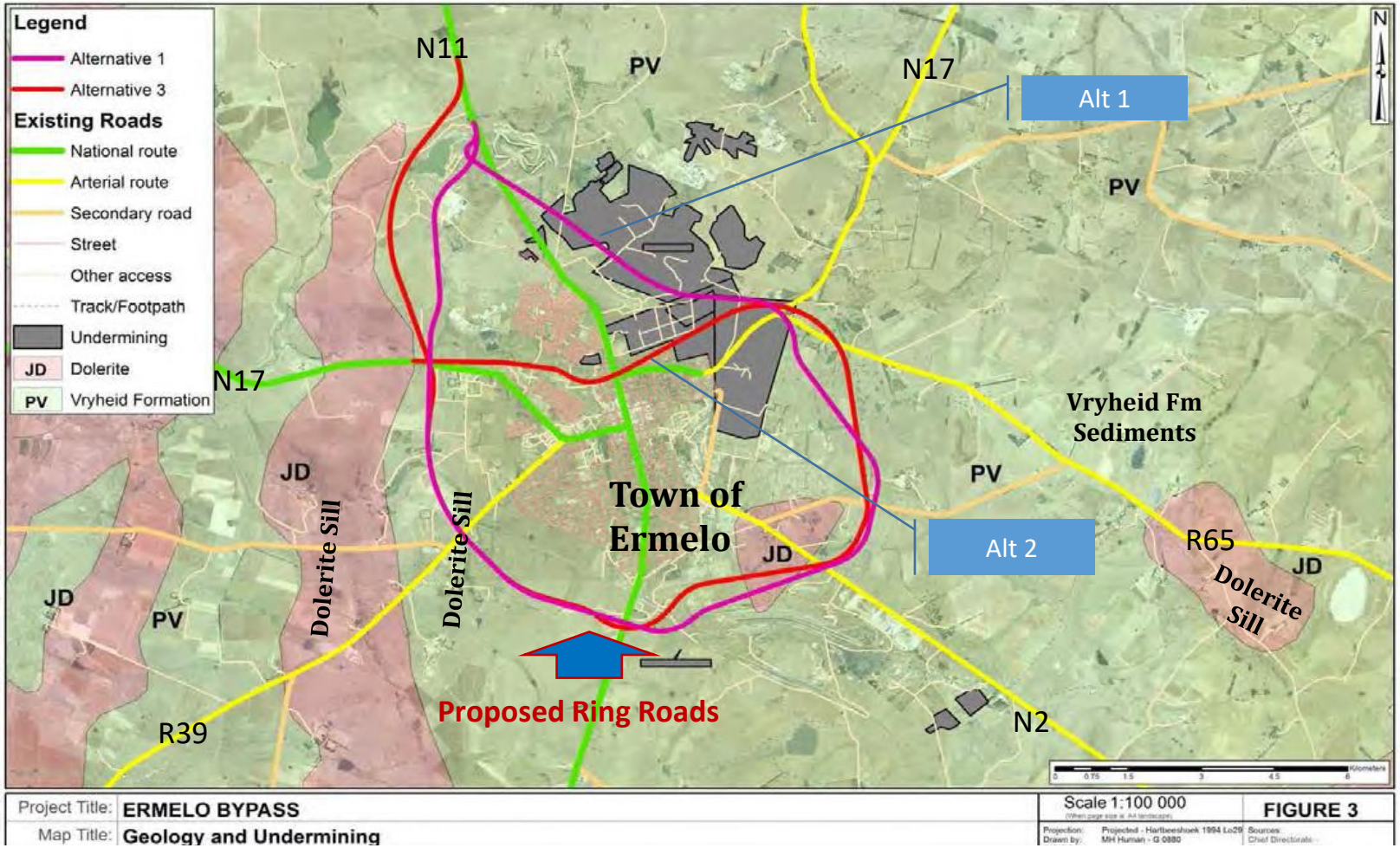


http://www.saforums.co.za/



Map 17: Distribution of mining activities in South Africa
South African Geological Hazards Observation System Atlas, 2015 Edition, Council for Geoscience

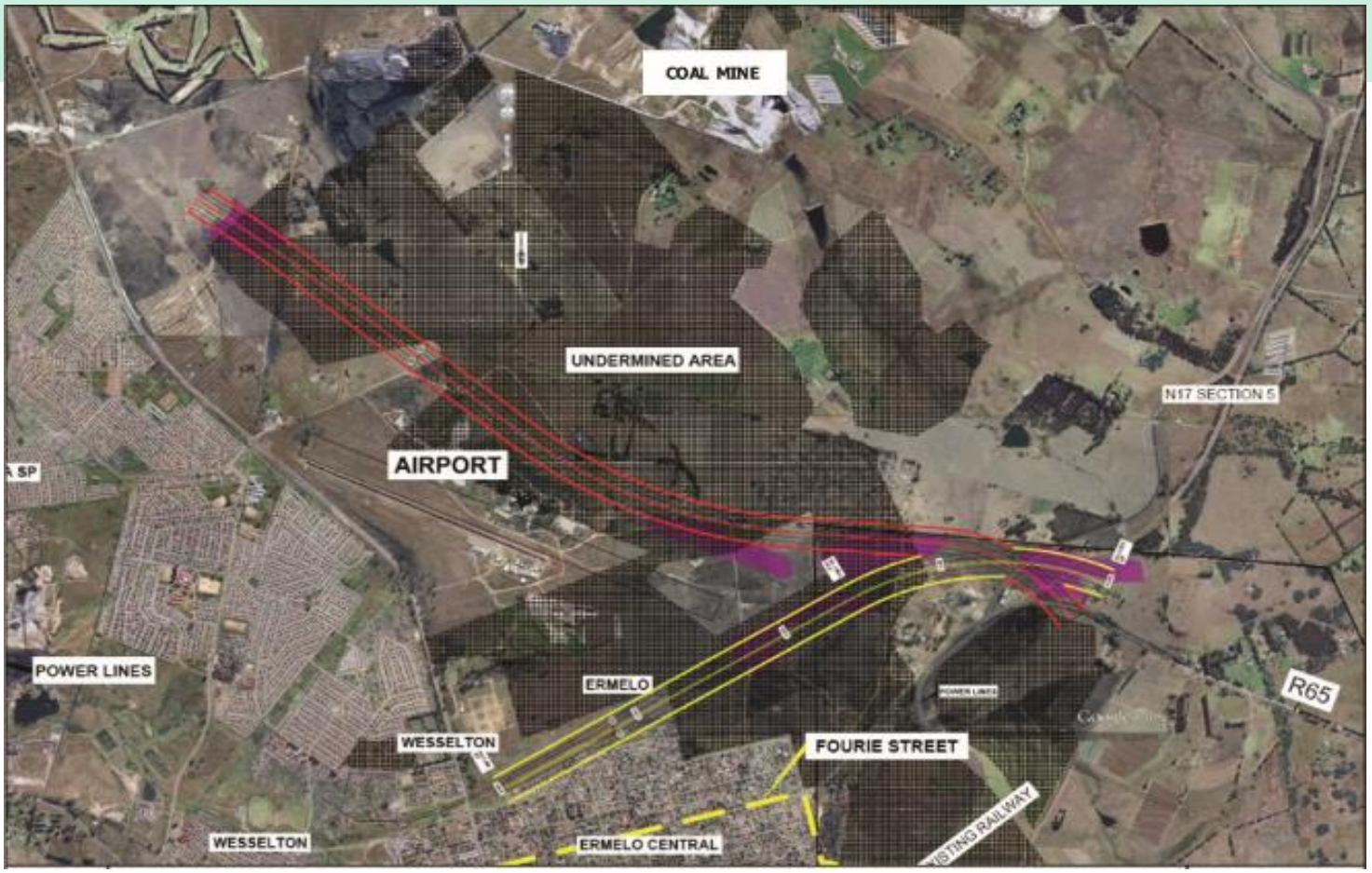
Case Study: Ermelo



Two potential alignments identified on northern side

1. Through already established urban area
2. Over ‘undermined’ area.

Alignment over ‘undermined’ ground



“Undermined” areas:

- Condemned ground – ie no development may take place
- classified as ‘*general undermining*’
- boundaries are not accurate.

Mining risks and unknowns

- Mine boundaries
- Mine extraction depth
- Pillar Geometry: if existing
- Primary and Secondary Extraction: extent
- Potential Undermining: Voids and extent
- Coal seam distribution: Thickness and quality
- Groundwater quality: Acid Mine Drainage (AMD)

Is the area suitable for road corridor development?

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Risk balancing

- **Cost** vs. **Risk** vs. **Outcomes**
- Balance between **technical** & **practical**
- Defensible process
  - Traceable
  - Repeatable
  - "Accurate"

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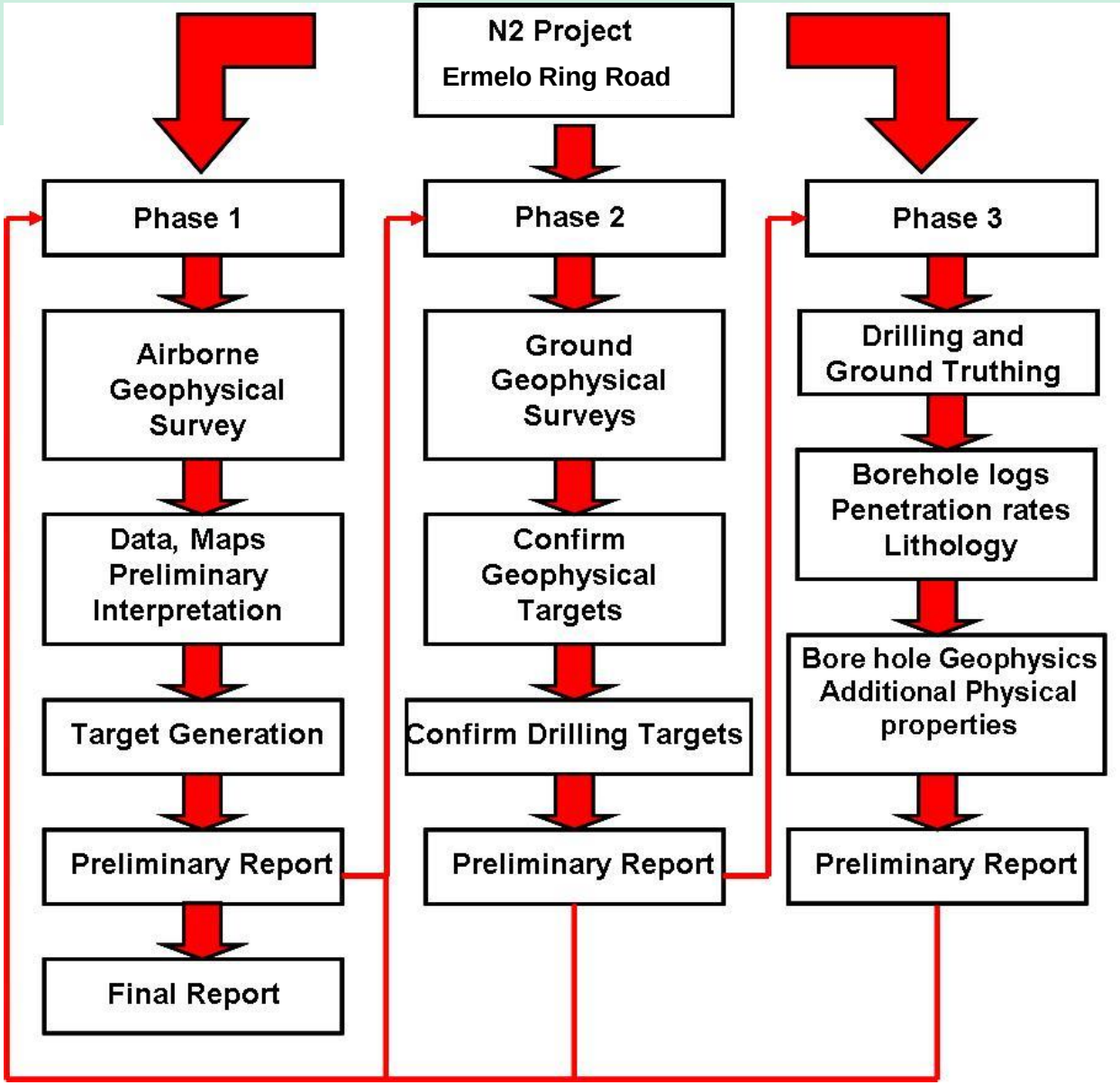
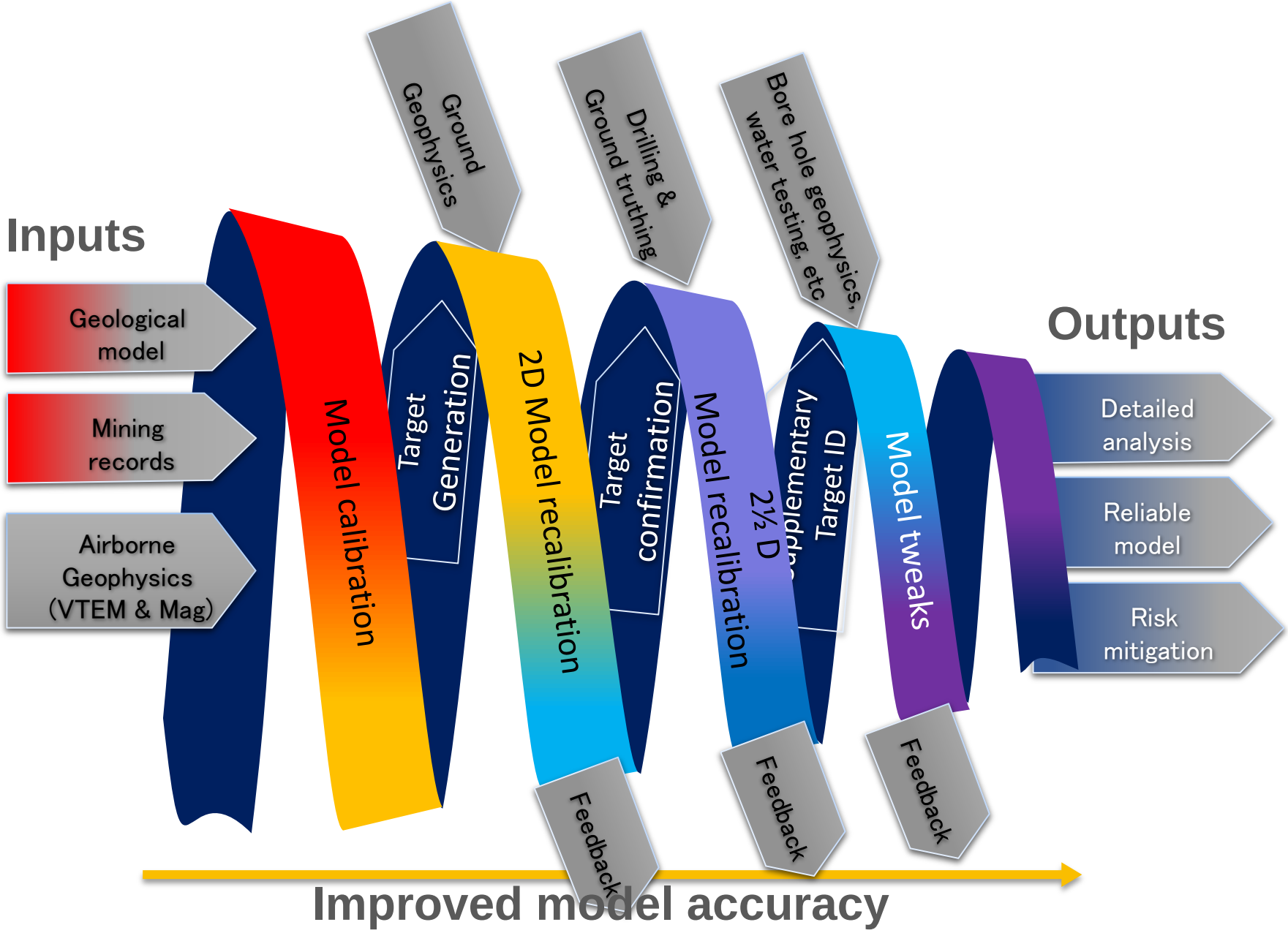
Multi Faceted Modeling Approach



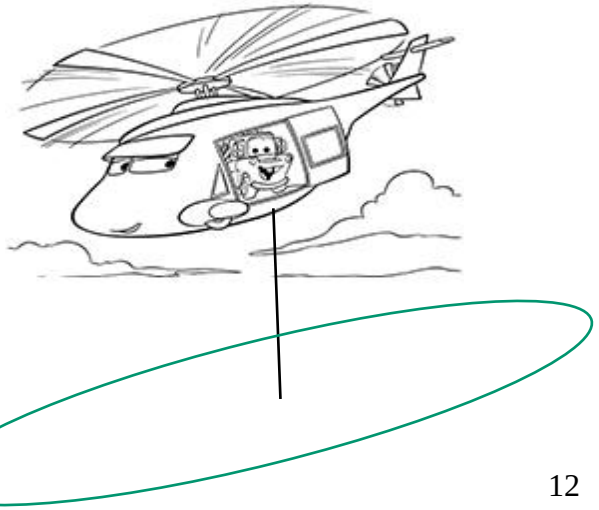
Flow chart depicting the planned process of investigation

Multi Faceted Modeling Approach



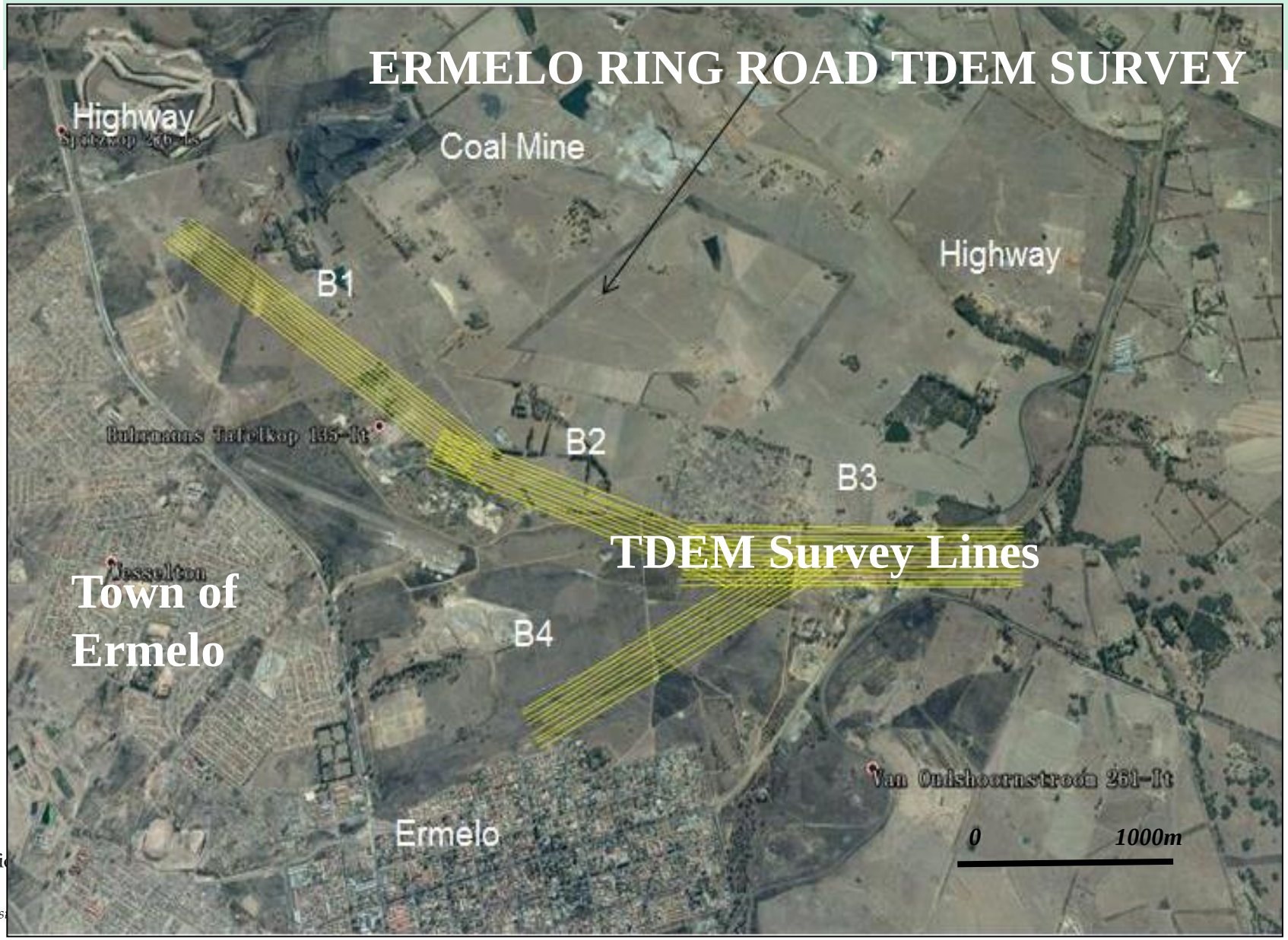
Phase 1: Air borne geophysics

- Airborne Time Domain Electromagnetics (TDEM – VTEM ™ System)
  - Induces an electromagnetic field in the geology.
  - The early time shows shallow anomalies.
  - The later times shows deeper anomalies.
  - AMW has low pH and is highly conductive.
- Airborne Magnetics
  - Delineates geological structure and lineaments

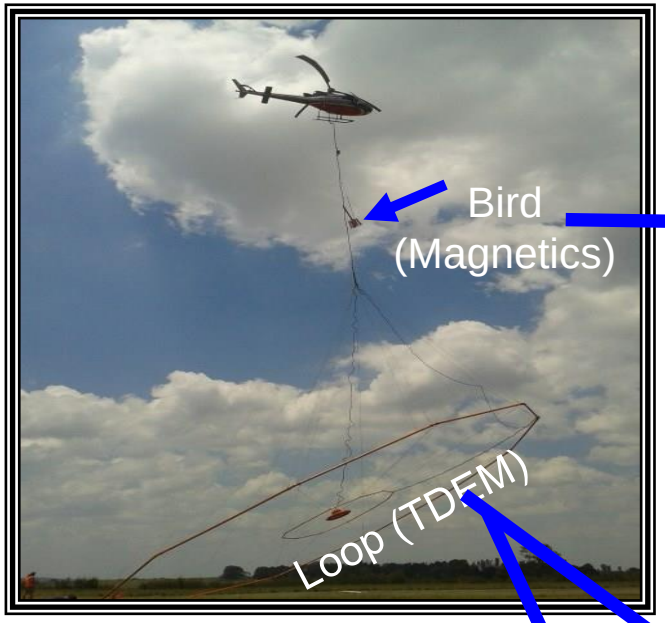


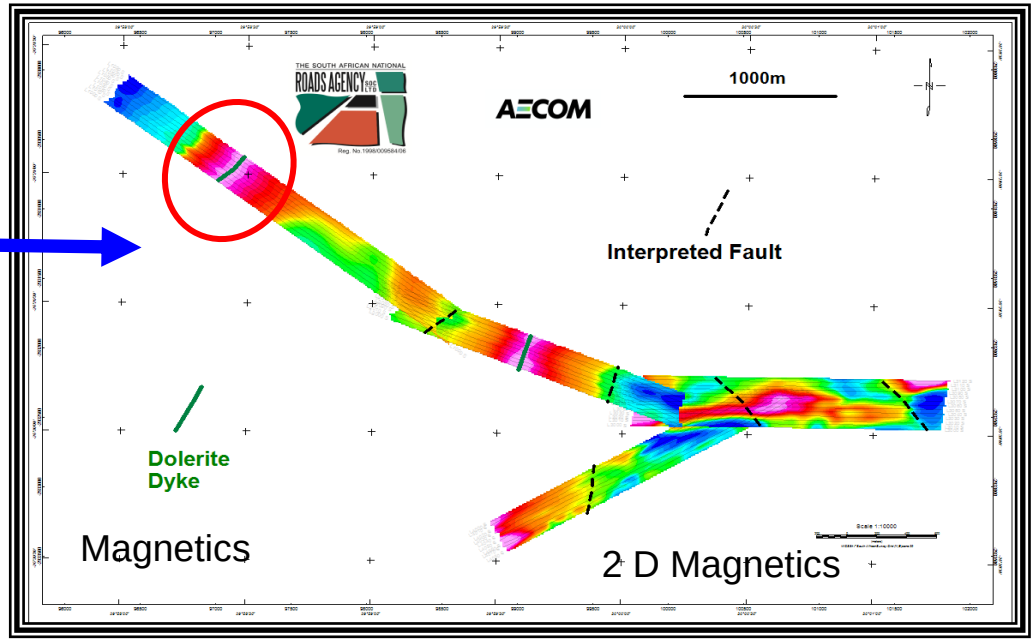
VTEM ™ – Geotech Ltd's TDEM system

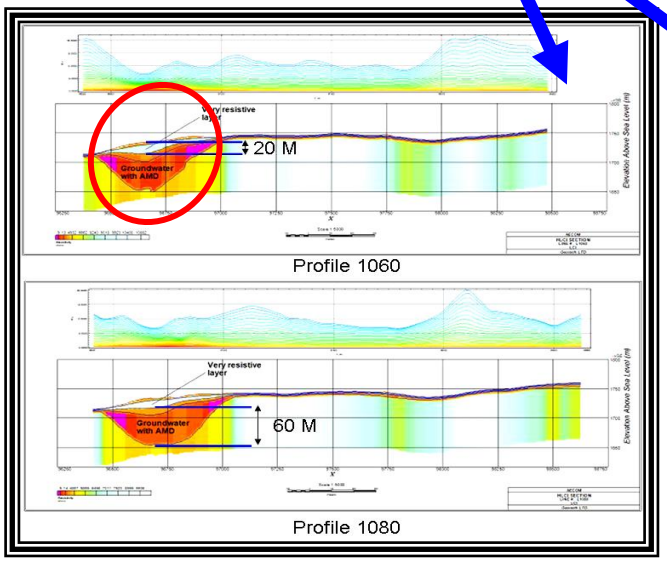
Phase 1: Air borne geophysics

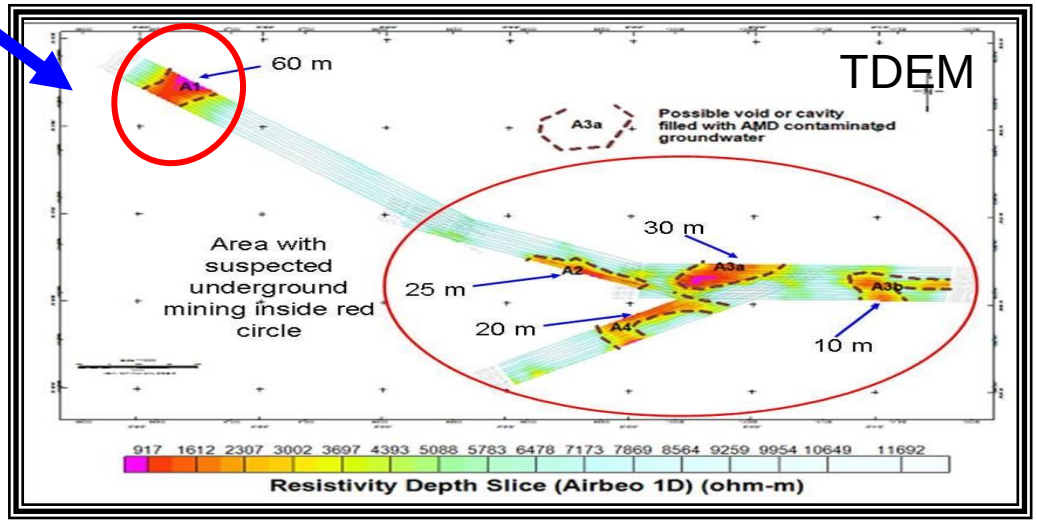


Airborne Geophysical Methods









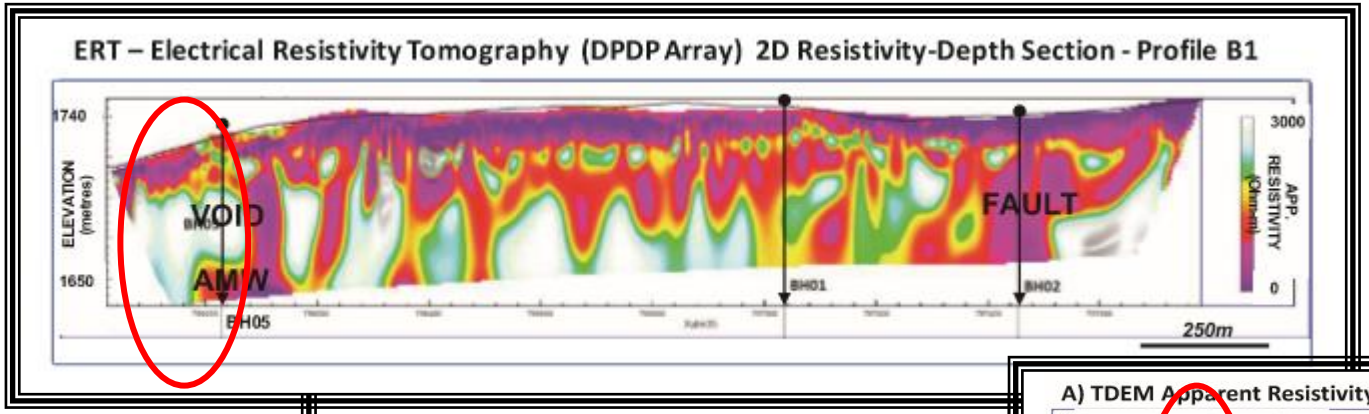
Targets generated through airborne geophysics

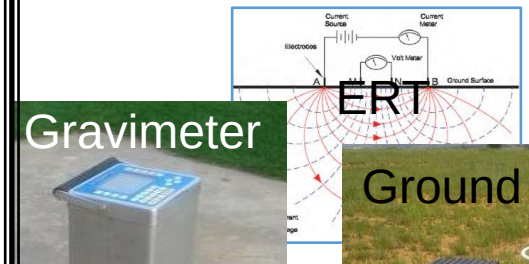
Phase 2: Ground geophysics

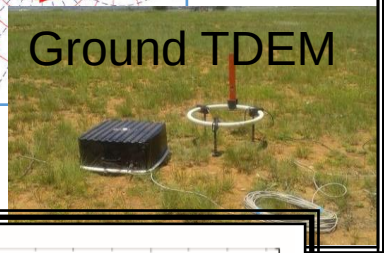
Three ground geophysical techniques were utilized:

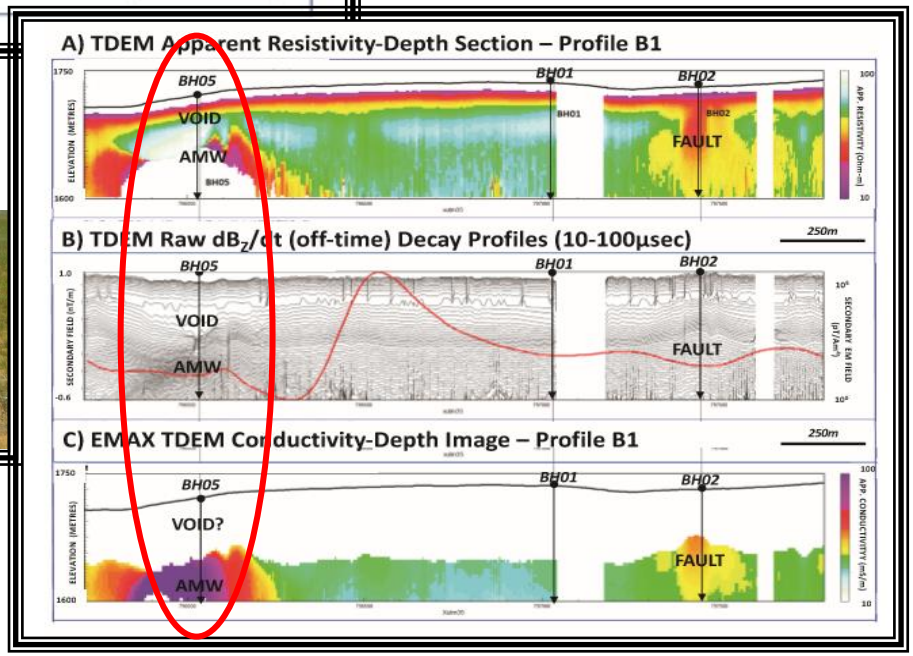
- **TDEM** - to target AMW.
- **Electric Resistivity Tomography (ERT)** - to differentiate rock or material horizons and cultural disturbances, sensitive to vertical geological structures.
- **Gravity** - very sensitive to lateral changes in density and therefore empty old mining voids.

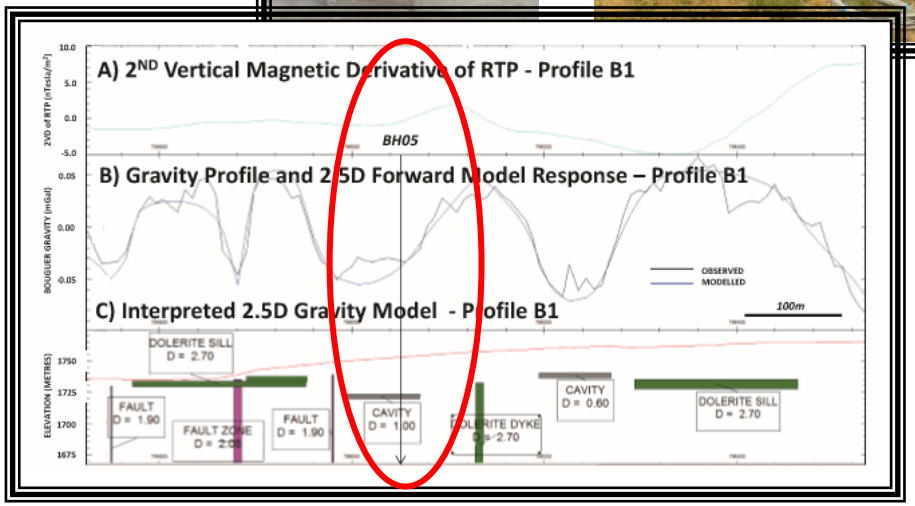
Ground Geophysical Methods











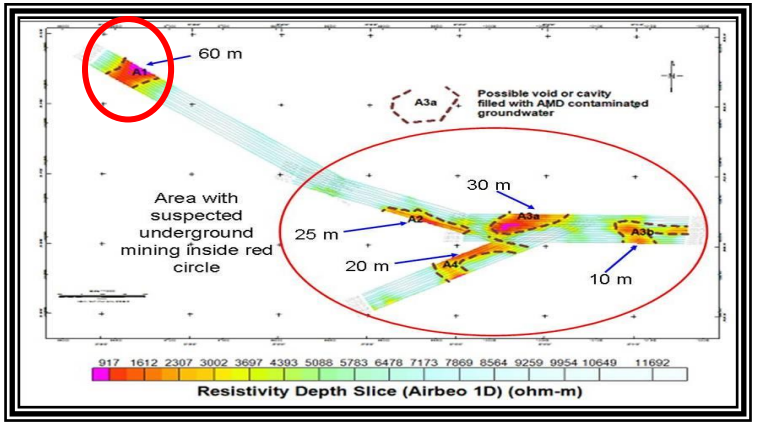
Results: more accurately identified and delineated areas of possible shallow undermined ground

Phase 3: Ground truthing

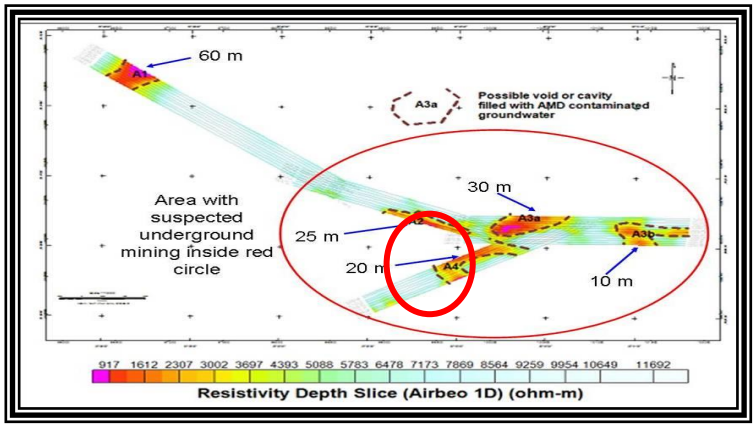
- Percussion boreholes (Reverse Circulation)
  - geological horizons and geotechnical parameters,
  - thickness and competency
- Water testing i.e. AMW
  - pH & conductivity
- Optical televiewer (Borehole camera)
- Borehole geophysics using same geophysical techniques

Drilling within borehole BH5 intersected a 5x5m cavity at a depth of 26m shown on a TDEM anomaly.

Borehole geophysics and Optical televiewer (Borehole camera)



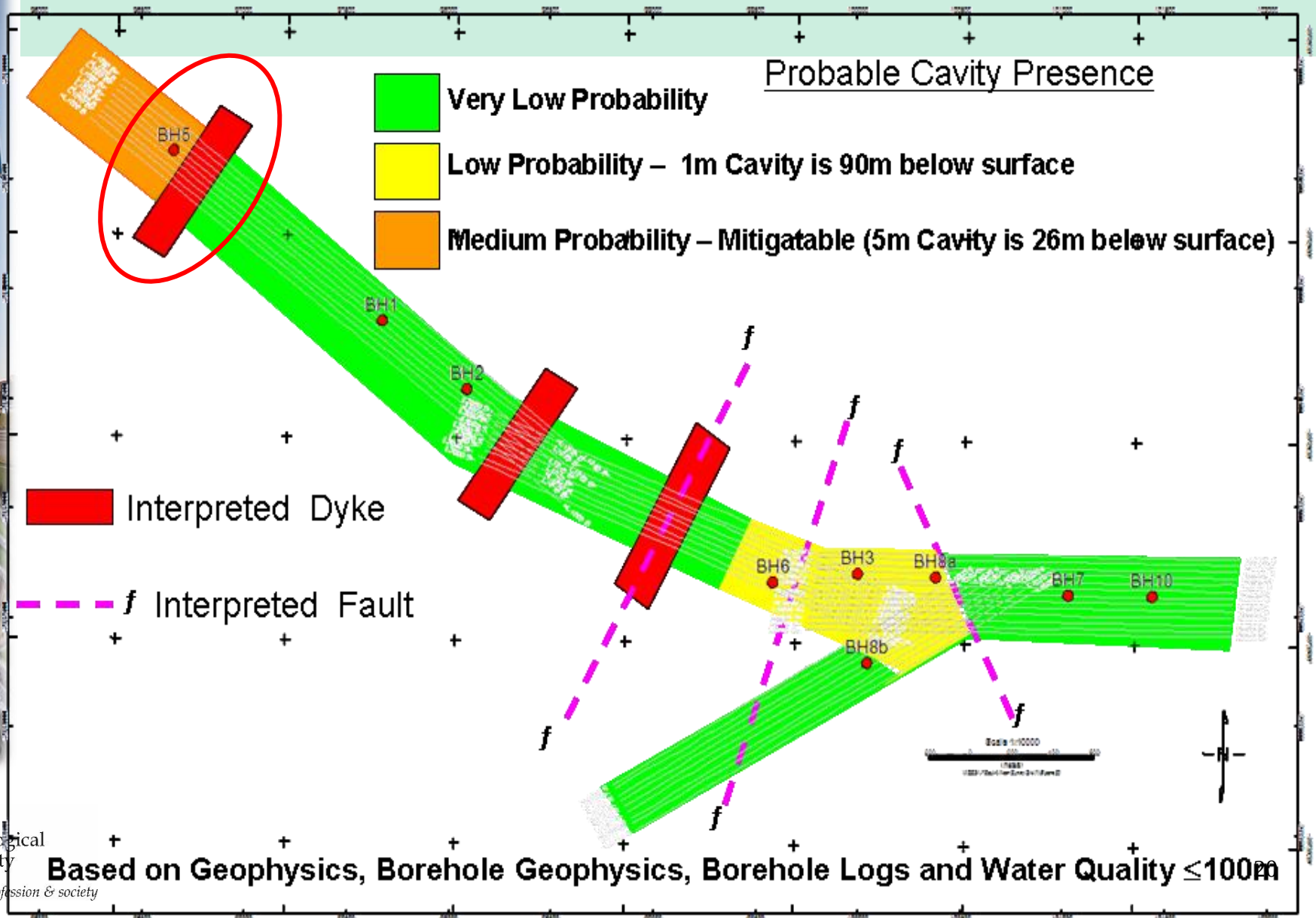
BH 06: Optical televiewer (Borehole camera)



The **geophysics** identified a **1x1m cavity at 90m in BH 06**.

Drilling confirmed the cavities **exactly!!!.**

Analysis of results & risk



Results

- Undermining (Voids and extent) detected & confirmed (BH3 and BH5).
  - Cavity at 90 m (1 m x 1 m) detected, drilled & confirmed.
  - BH5 Unknown access tunnel 25 m deep (5 m x 5m) detected, drilled & confirmed
- Structural Geology and Coal seam distribution clarified & mapped (Thickness and quality).
- Engineering Geophysics vs Ground Truthing successful.

Area is suitable for road corridor development.

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Conclusions

The Multi-Faceted Geophysical Modelling systems approach and the Geological Modelling was successful!

- Cost and time efficient.
- For successful, accurate outcomes:
  - Use more than one geophysical method.
  - Perform investigation in planned stages
    - Quick, high level, lower accuracy airborne progressing to more accurate ground geophysics.
  - Integrate & model all the geophysical data for higher accuracy and better target generation.
  - Ground truthing is critical

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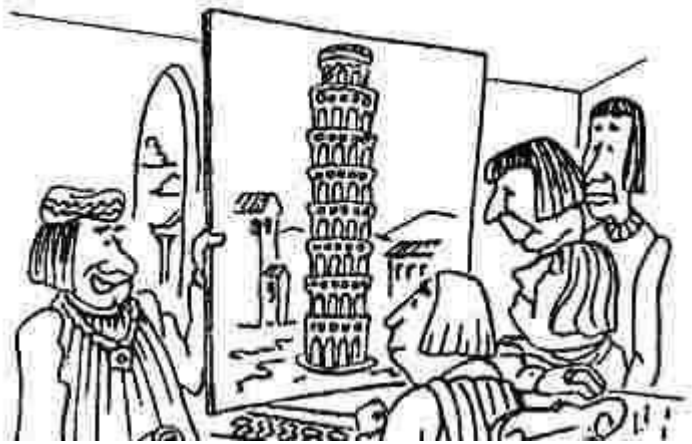
Thank you

"You pay for a geotech investigation, whether you do one or not.
Its just a heck of a lot cheaper to do it up front."



And gentlemen, you can save 500 Lire if you don't do a geotech investigation

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