High-resolution, short-range, in-mine geophysical techniques for the delineation of South African orebodies

The CSIR Research and Innovation Conference

Natural Resources and the Environment

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our future through science

Agenda

- Introduction to geophysics
  - What does a geophysicist do?
  - (An analogy)
- Gold and platinum mining in South Africa
  - An overview – why, where, how.
- Geological problems
  - Potholes (platinum)
  - Reef slopes and terraces (gold)
- Geophysical techniques
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  - Borehole radar
  - Electrical resistance tomography (ERT)
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  - Western Platinum Mine (ERT)
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Introduction to geophysics

An analogy…

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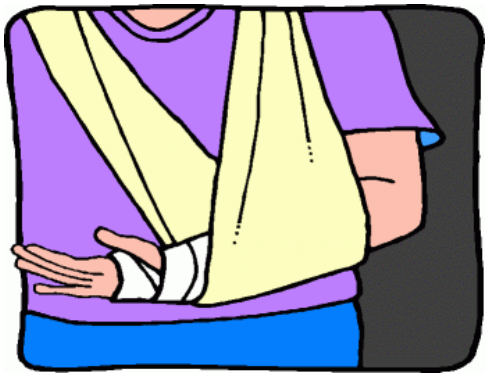
What does a geophysicist do?

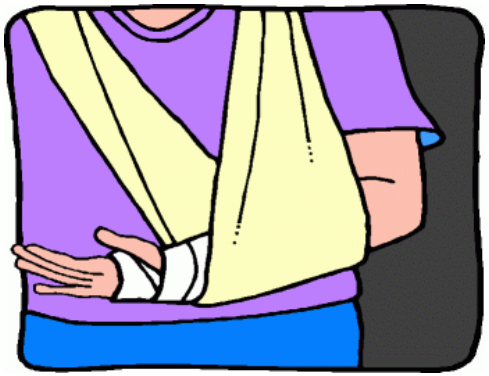
- Like any applied science it starts with a problem…

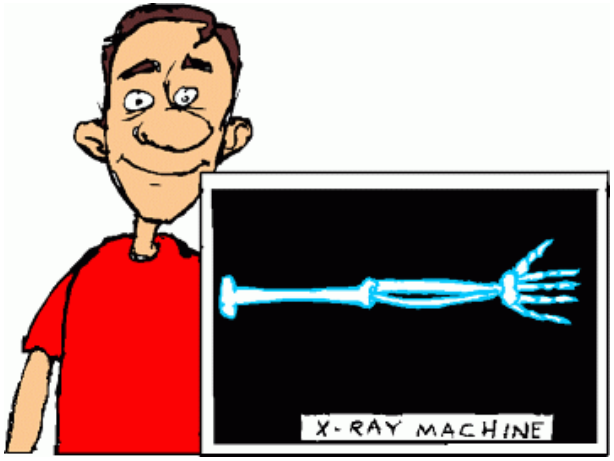


What does a geophysicist do?

- that requires an accurate assessment…

  A quantitative assessment of the problem is required to help define the most appropriate course of action



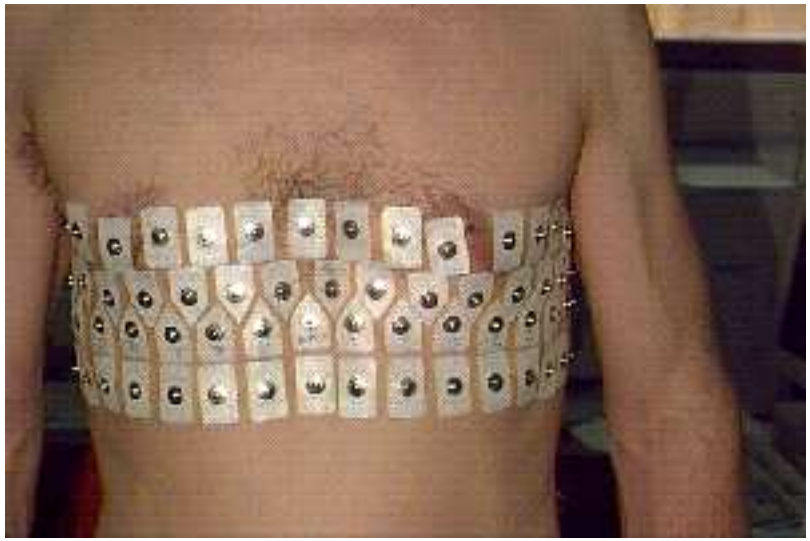


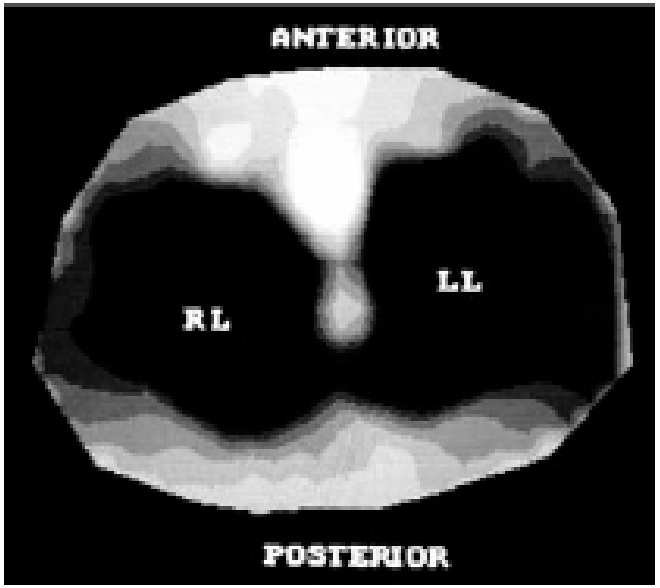
What does a geophysicist do?

- *“A geophysicist does to the earth what a radiologist does to the human body”*

What does a geophysicist do?

- Some of the techniques we use are adapted versions of the medical equivalent – e.g. electrical resistance tomography (ERT) is based on medical impedance tomography





Gold and platinum mining in South Africa

An overview

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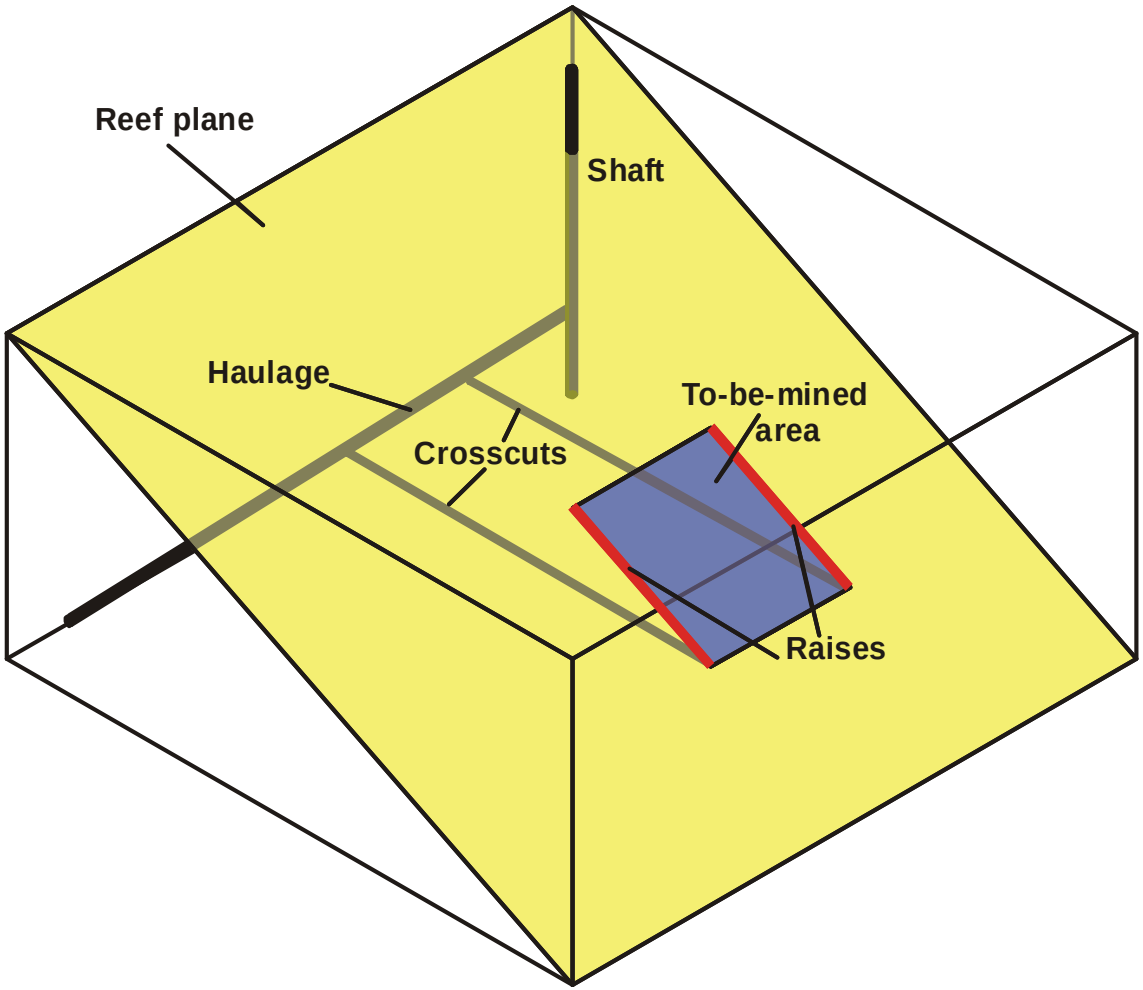
Gold and platinum mining in South Africa

Economic impact

- South Africa produces approximately 75% of world's platinum and 14.5% of world's gold
- The bulk of the above Pt and Au is extracted from only two geological occurrences, the Bushveld Complex (Pt) and the Witwatersrand Basin (Au)
- Significant reserves and resources remain to be extracted
- Orebodies are relatively easy to mine because of their planar geometry

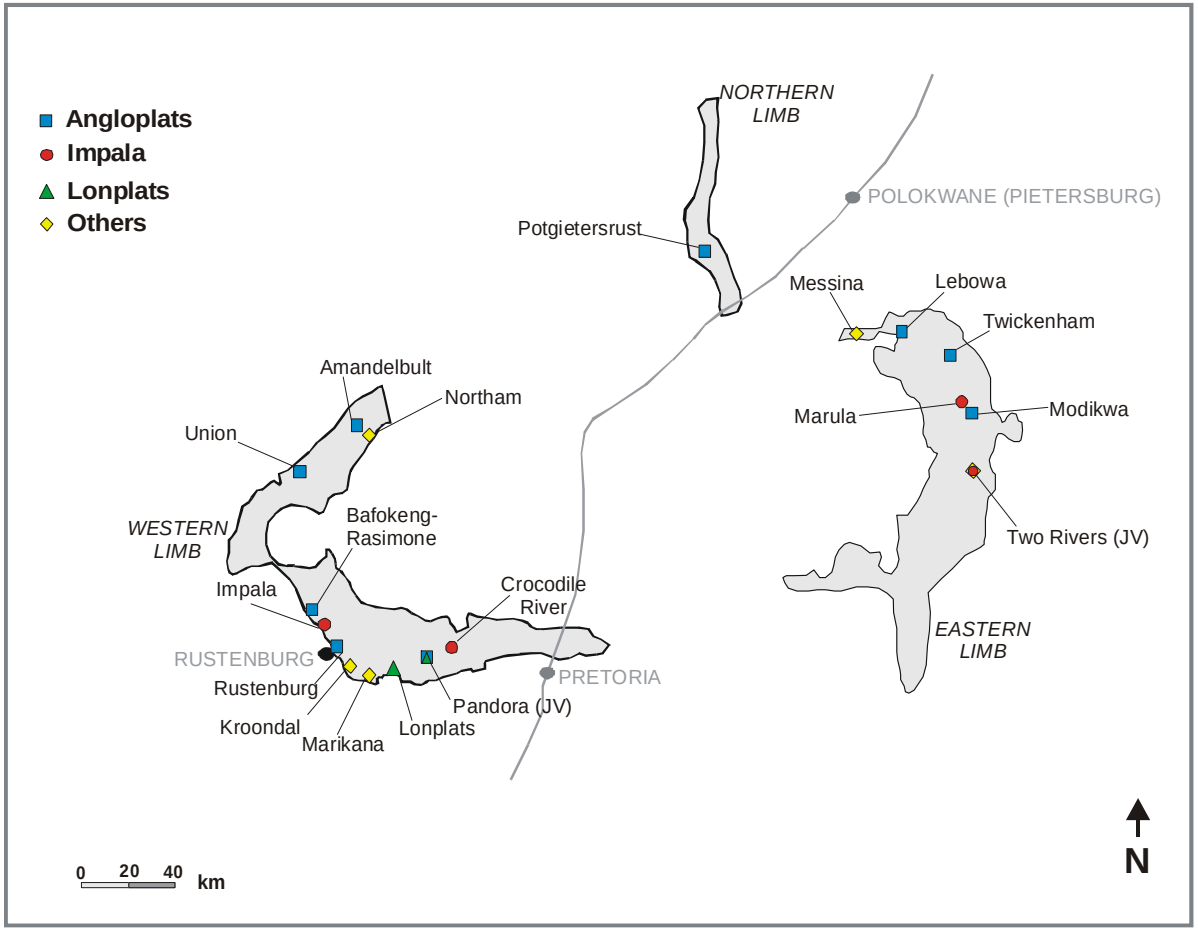
Gold and platinum mining in South Africa

Typical mining layout



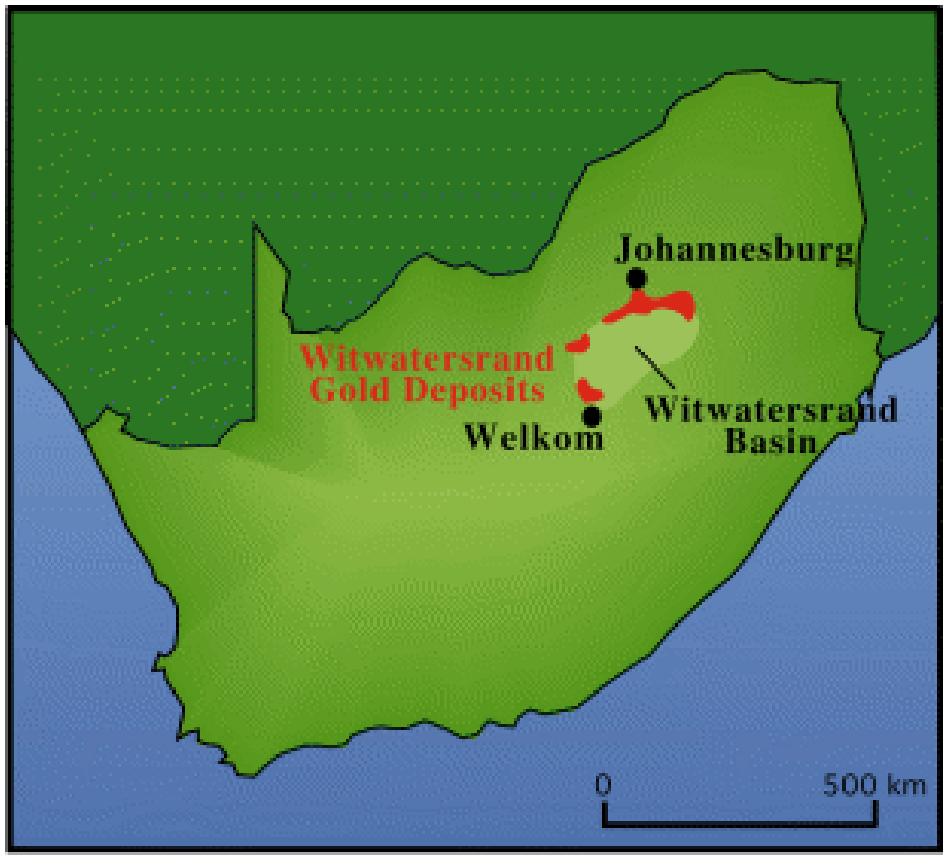
Gold and platinum mining in South Africa

Bushveld Complex (Pt)



Gold and platinum mining in South Africa

Witwatersrand Basin (Au)



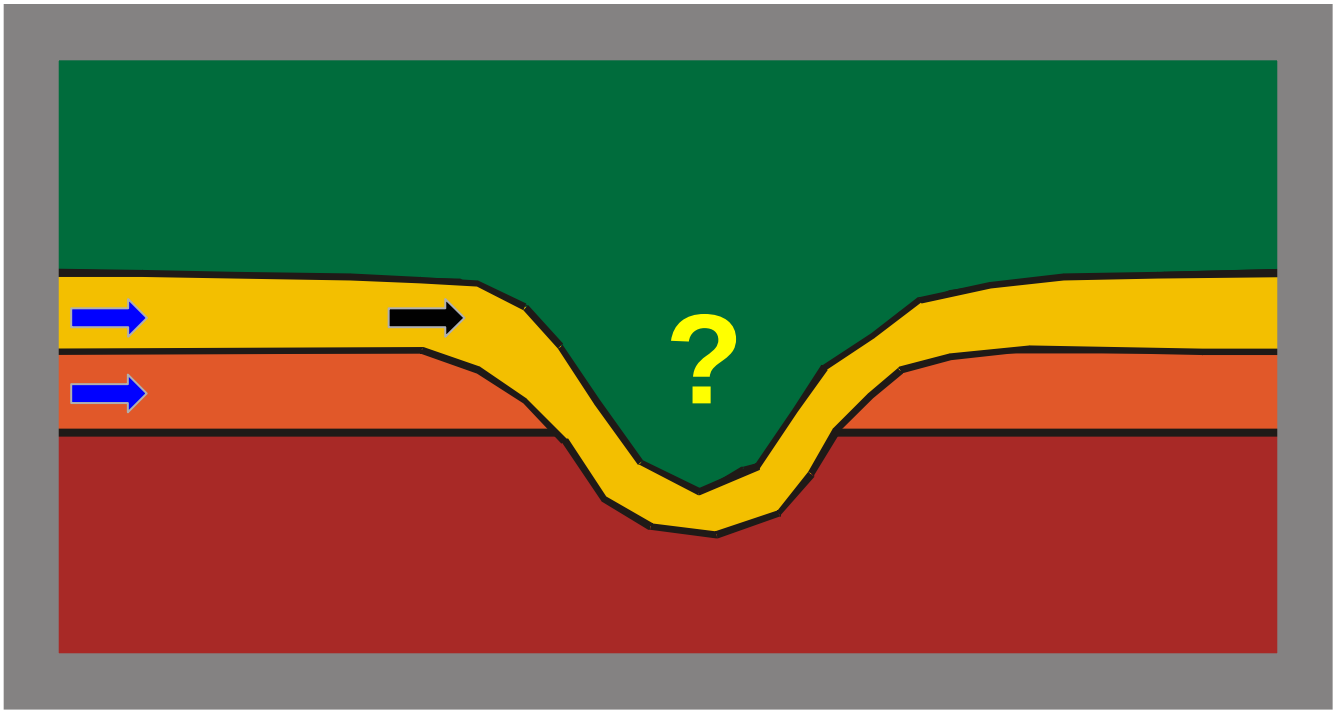
Geological problems

Geological problems

- On a regional scale, the planar reefs are remarkably continuous and fairly straightforward to map ahead of mining
- On a mine-scale, disruptive geological features often distort or displace the economic horizon, thereby complicating mining:
  - Geological faults
  - Rolls
  - Terraces
  - Dykes
  - Potholes
  - Iron-rich ultramafic pegmatite (IRUP) bodies

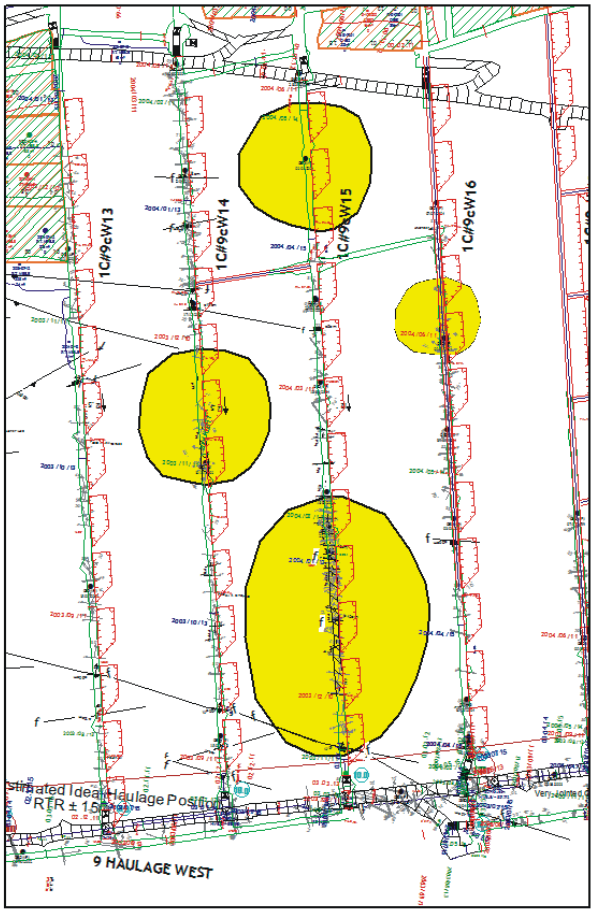
Geological problems

Bushveld Complex - potholes



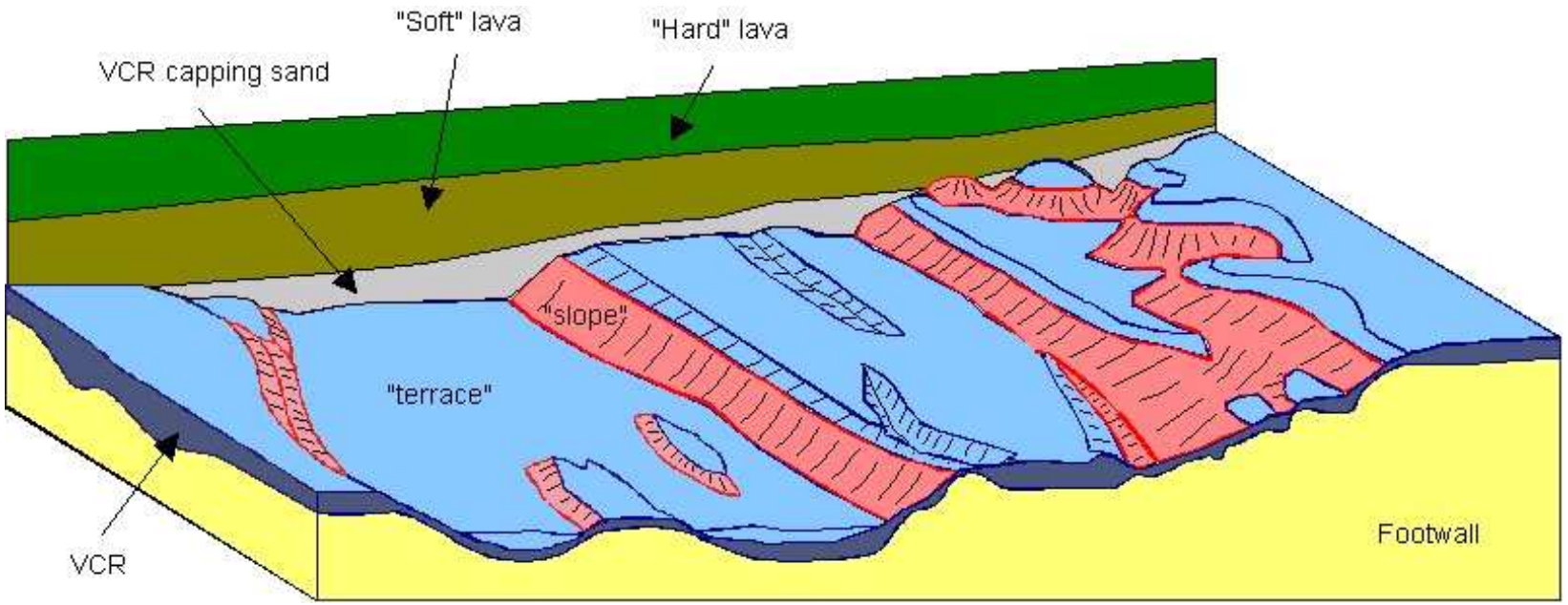
Geological problems

Bushveld Complex - potholes



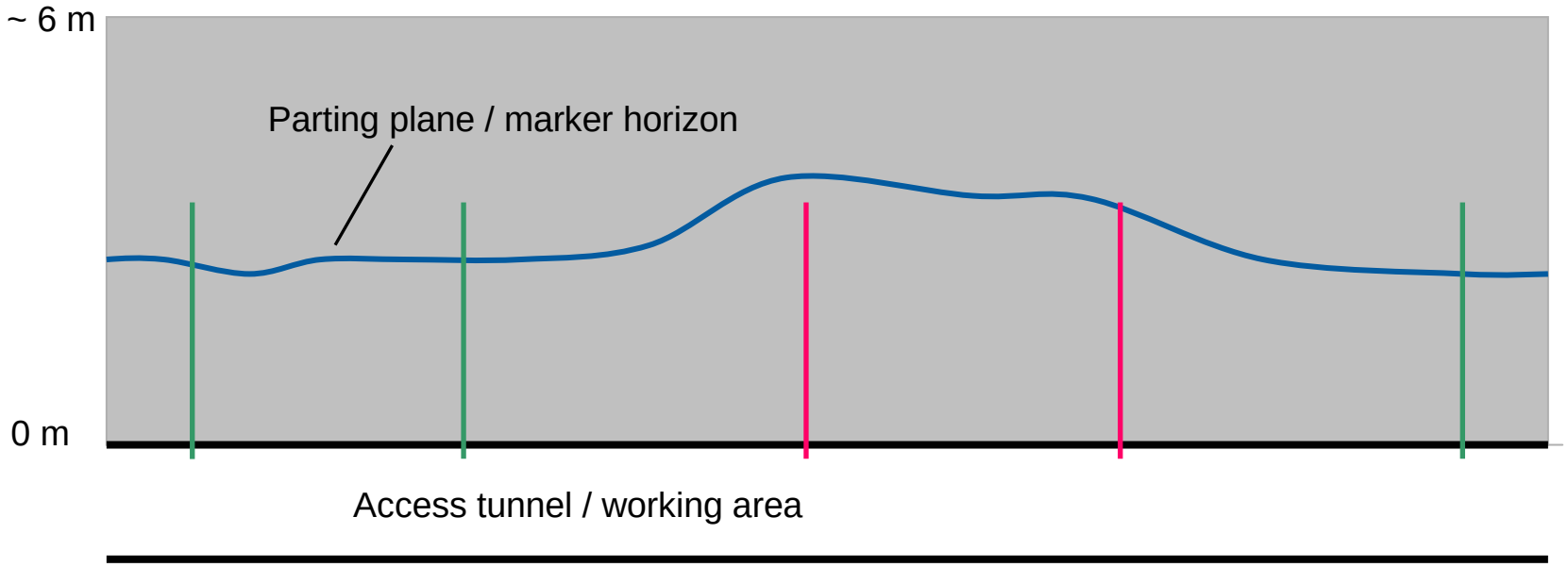
Geological problems

Witwatersrand Basin – slopes and terraces



Geological problems

Rock engineering / safety issues



Geological problems

Impact

- Distorts / displaces the economic horizon
- Uneven grade distribution
- Poor ground conditions
- Compromises safety
- Hampers production

Geophysical techniques

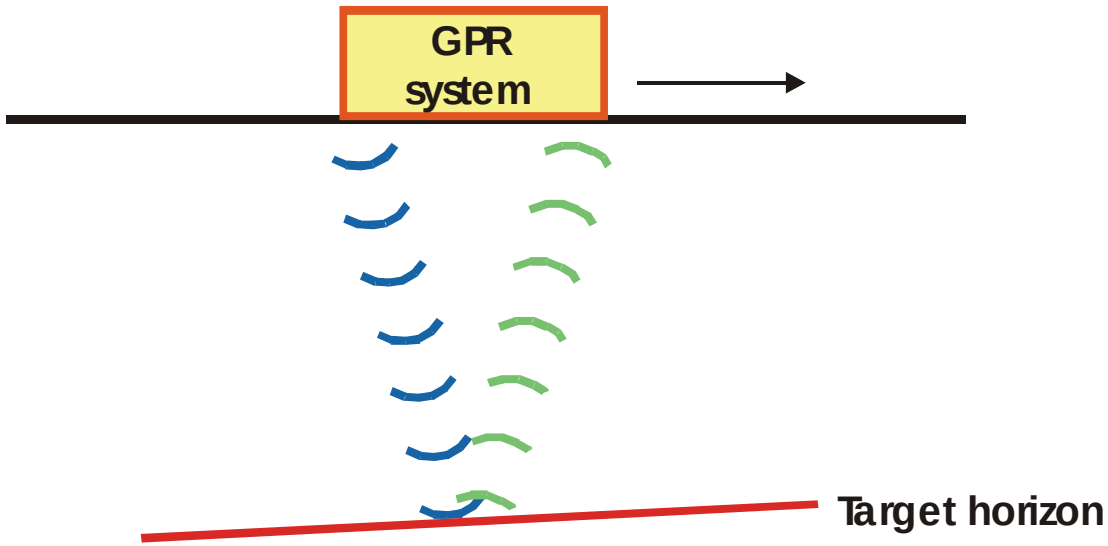
Ground penetrating radar (GPR)

Borehole Radar

Electrical resistance tomography (ERT)

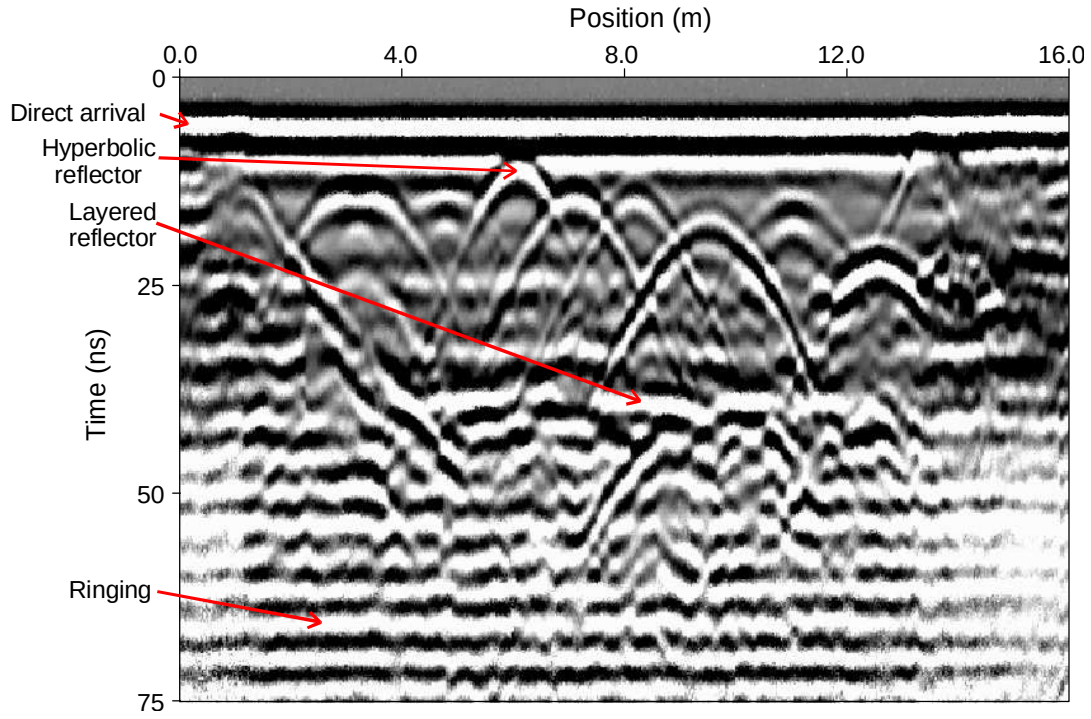
Ground penetrating radar (GPR)

Concept



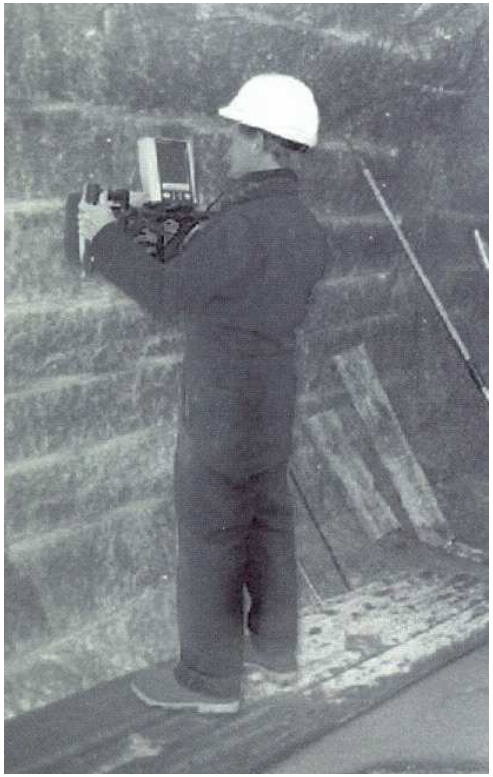
Ground penetrating radar (GPR)

Typical output



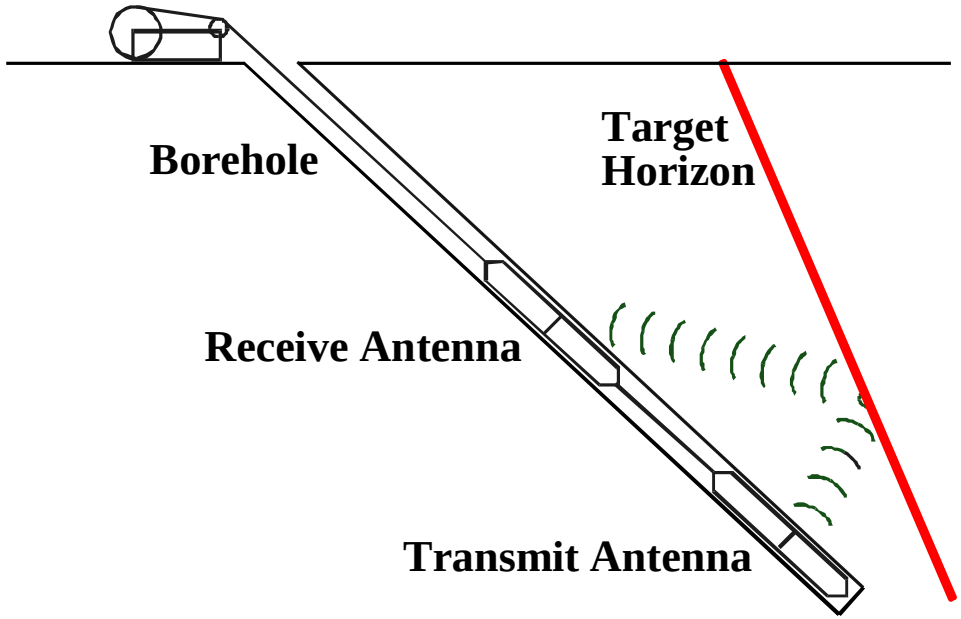
Ground penetrating radar (GPR)

Commercial equipment



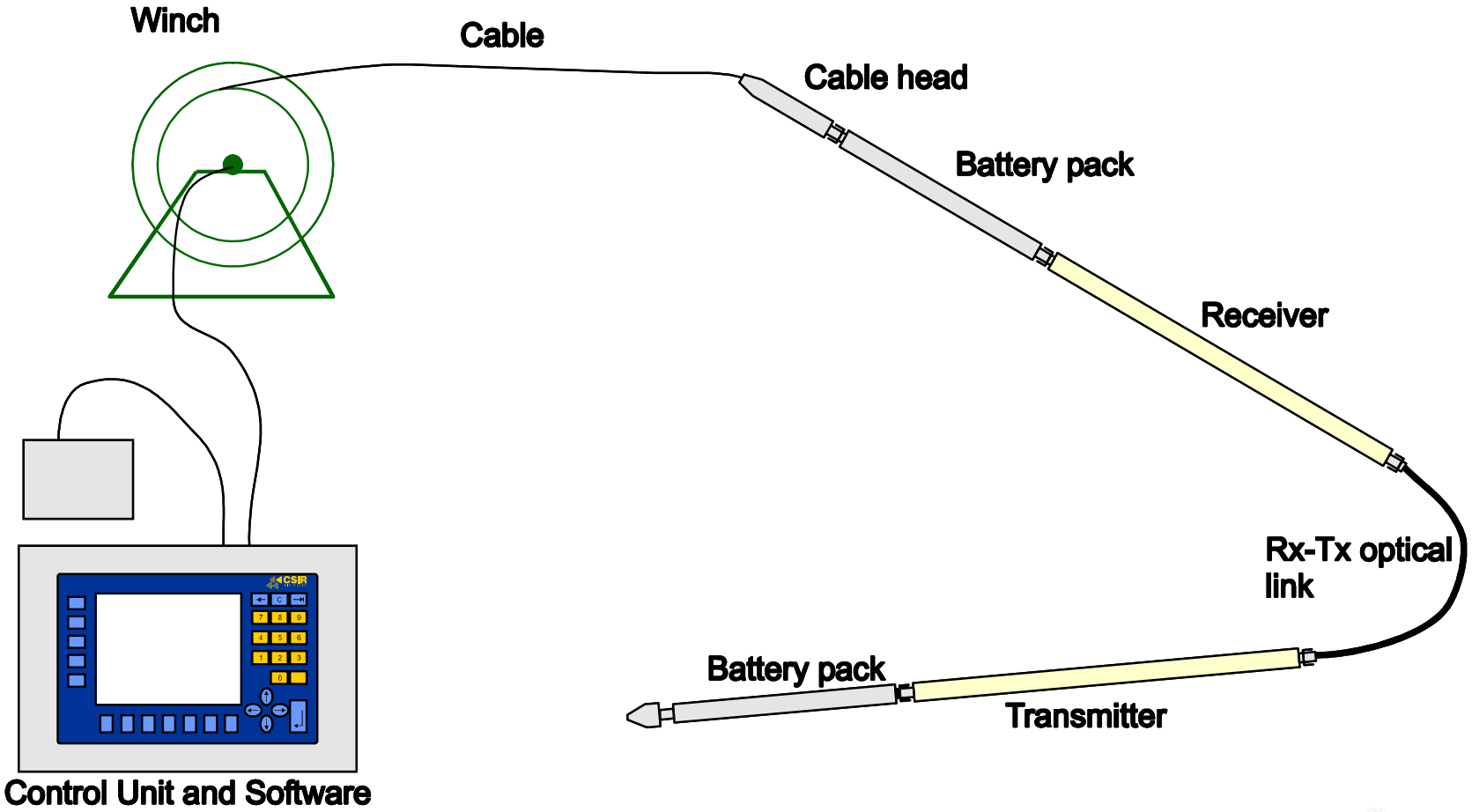
Borehole radar

Concept



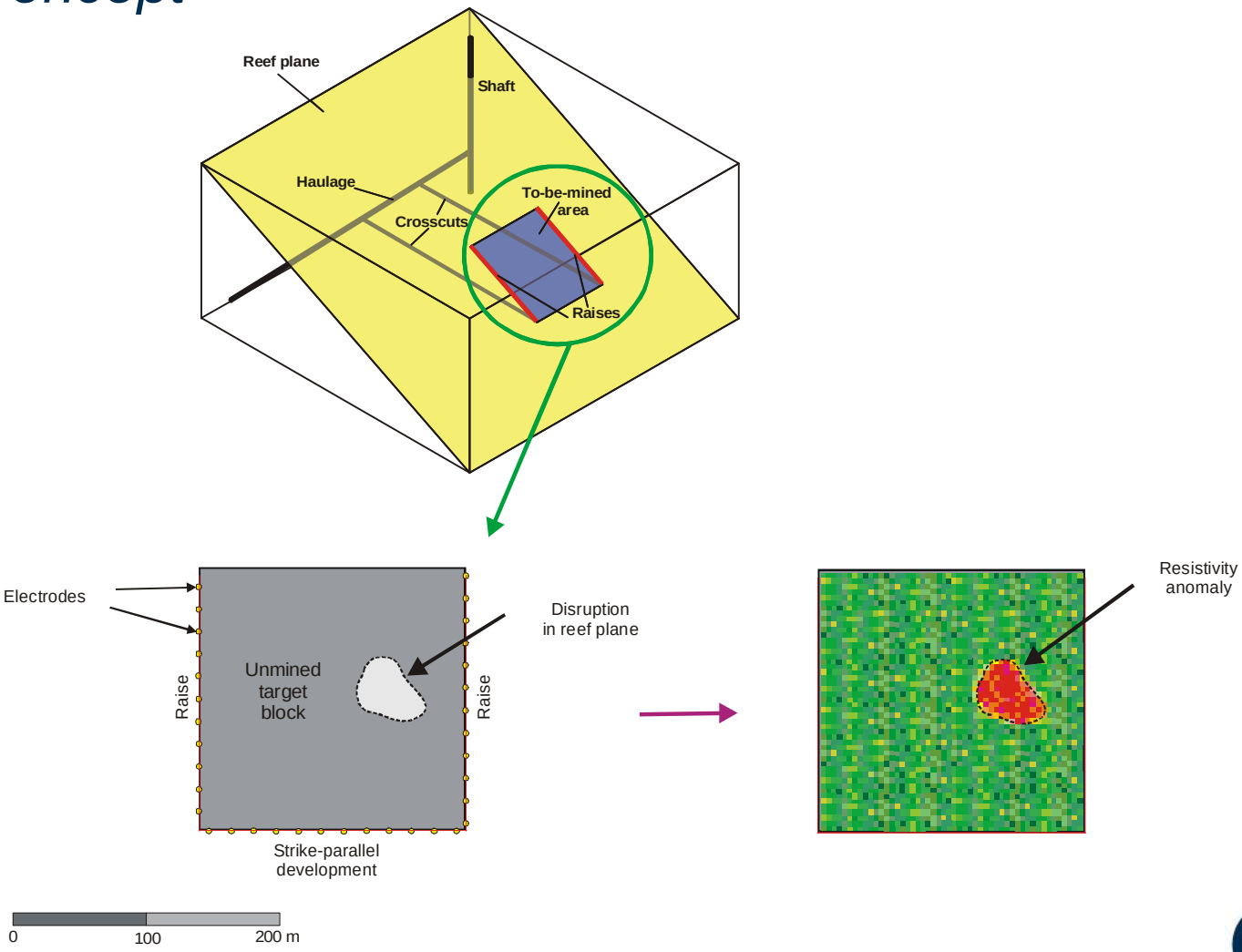
Borehole radar

CSIR's Aardwolf system



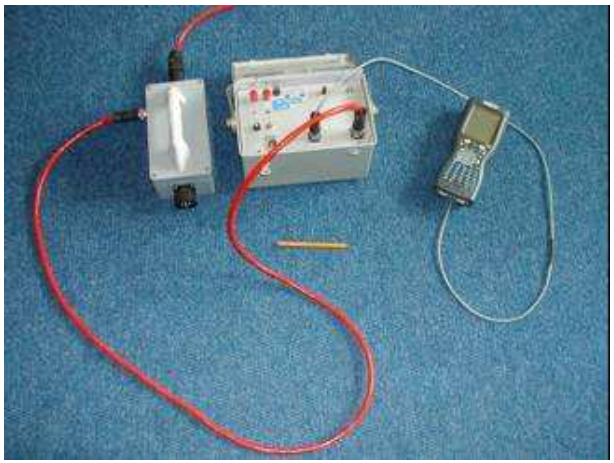
Electrical resistance tomography

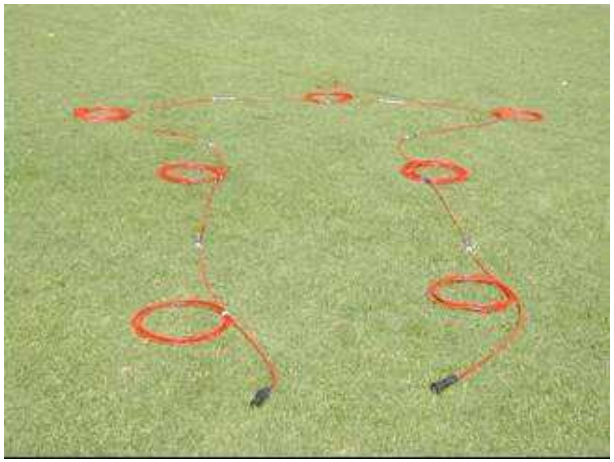
Concept



Electrical resistance tomography

In-mine ERT system





Case studies

GPR – Waterval Platinum Mine

Borehole Radar – Mponeng Gold Mine

ERT – Western Platinum Mine

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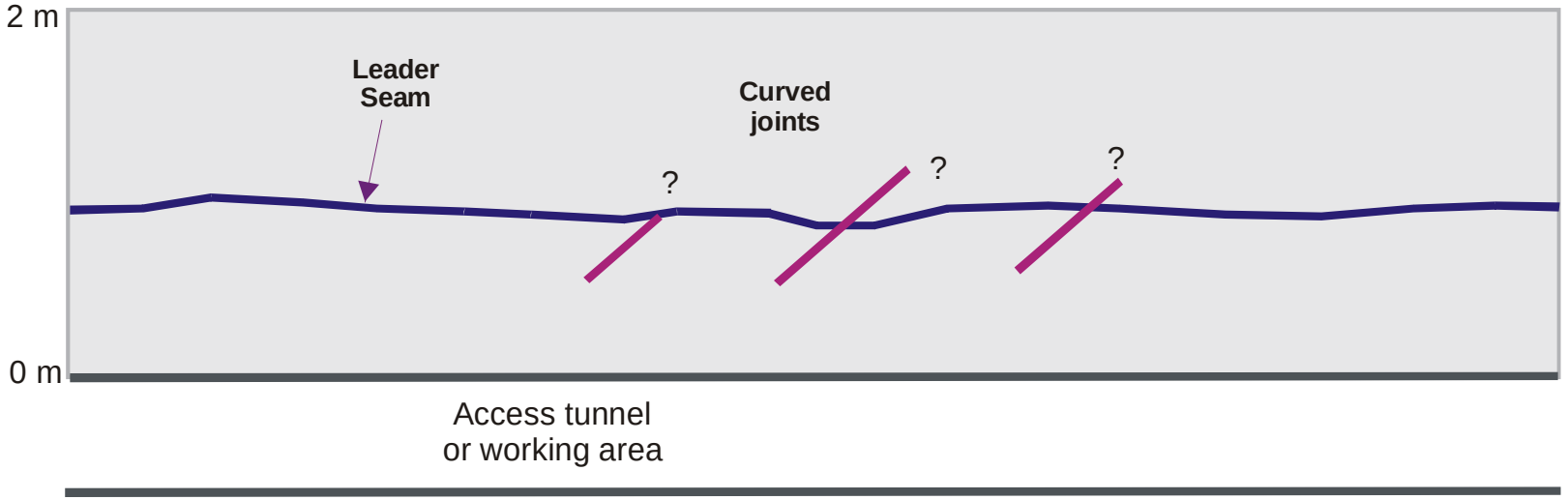
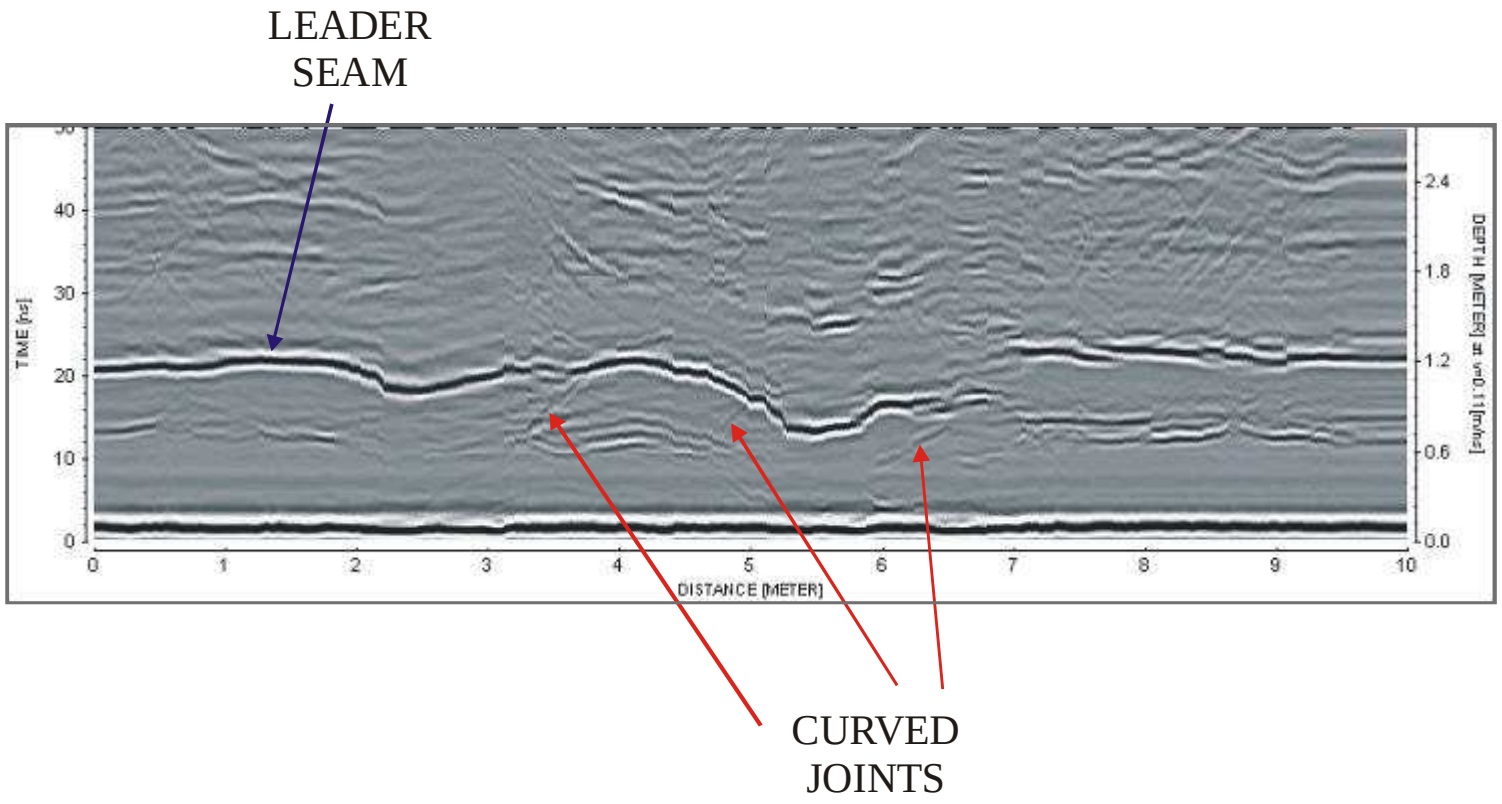
Ground penetrating radar (GPR)

Waterval Platinum Mine



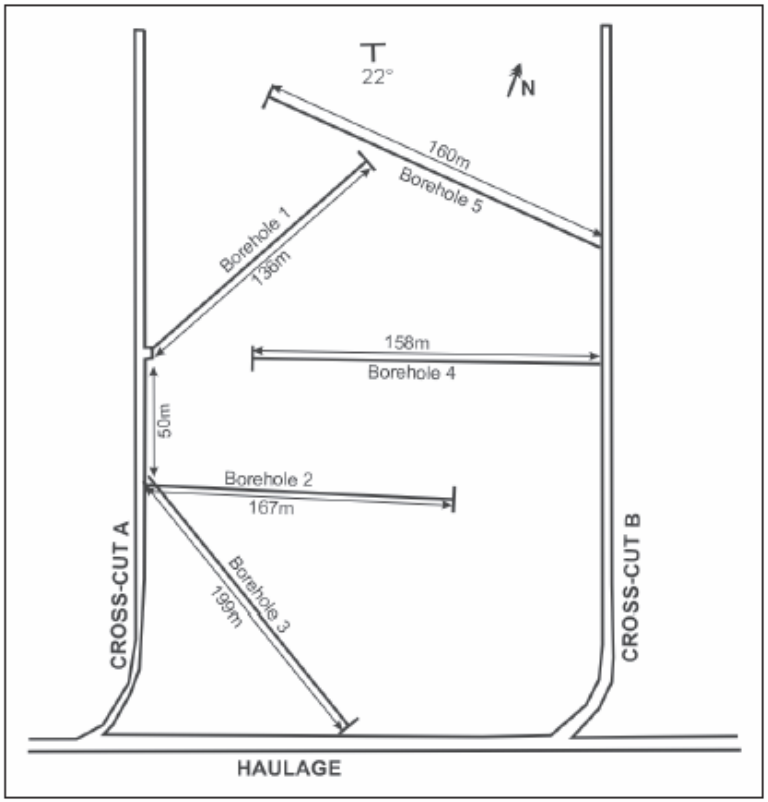
Ground penetrating radar (GPR)

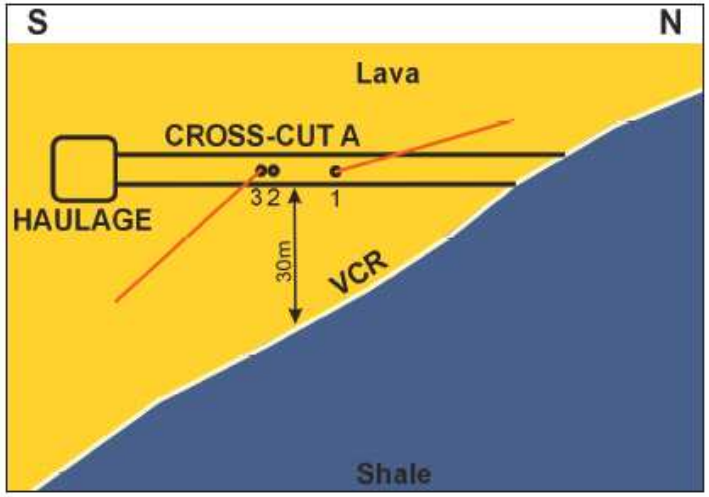
Waterval Platinum Mine



Borehole radar

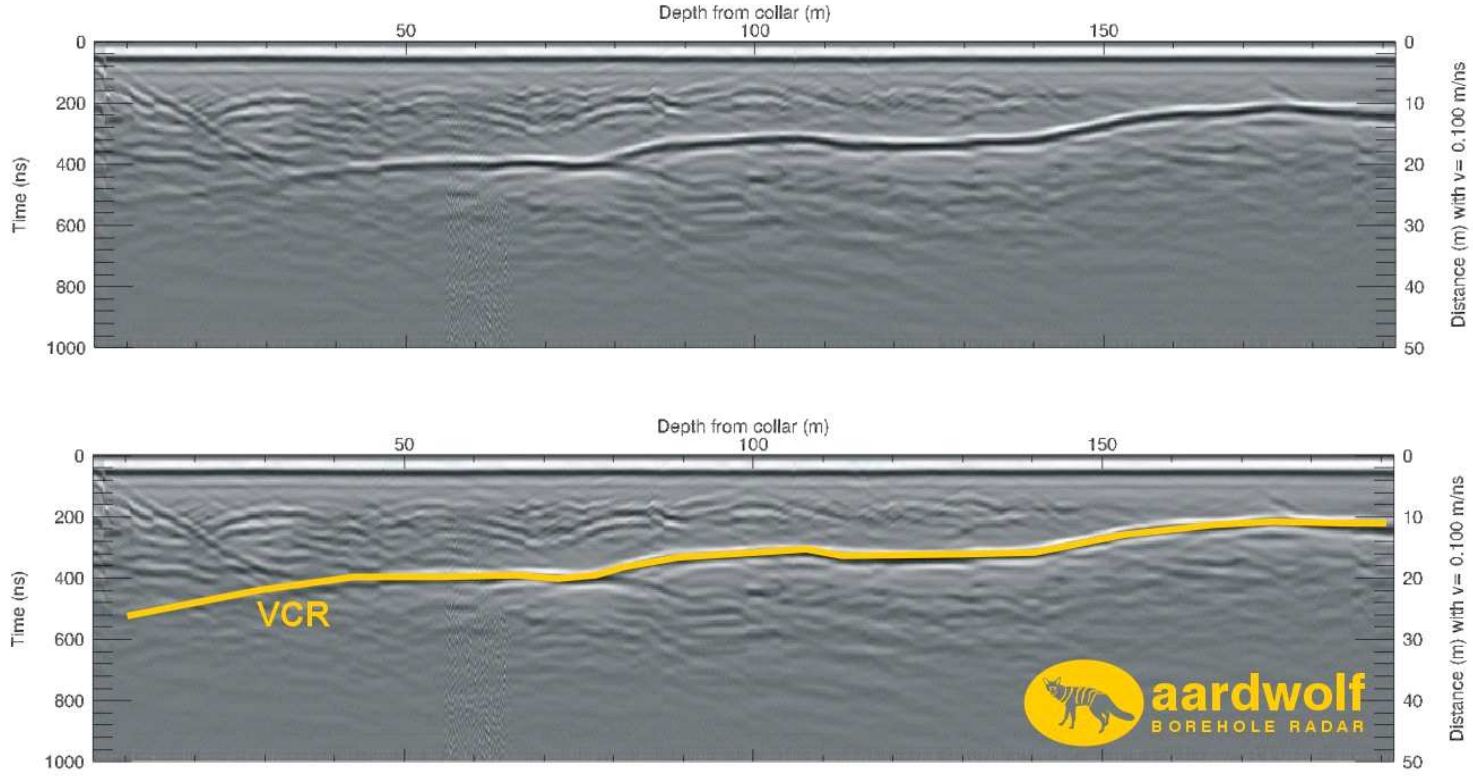
Mponeng Gold Mine





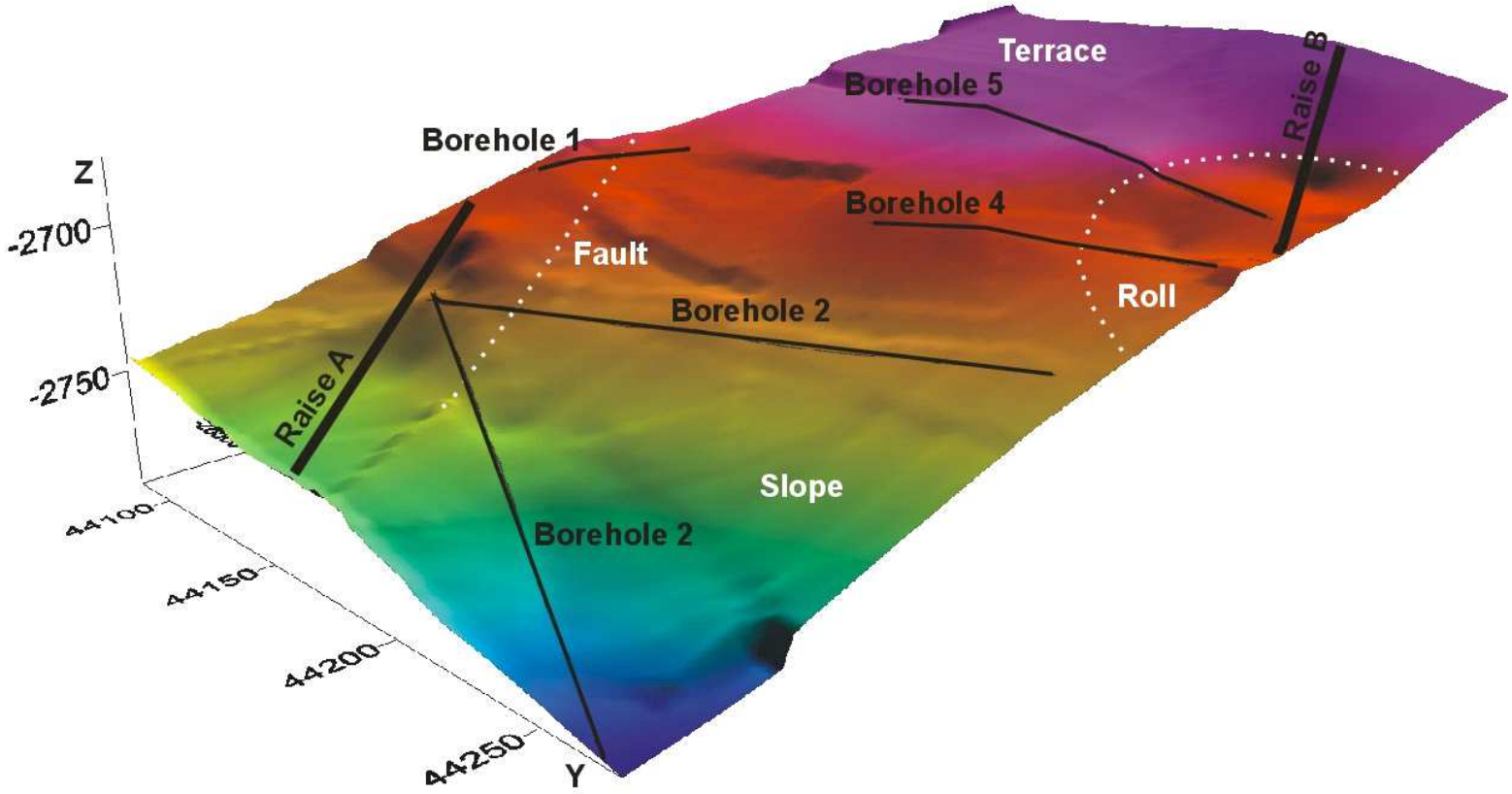
Borehole radar

Mponeng Gold Mine



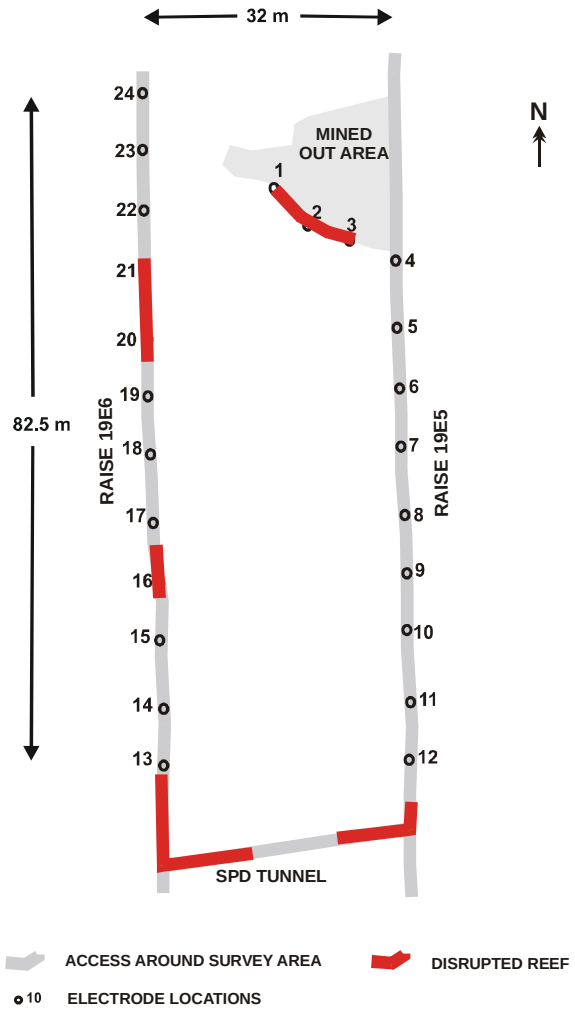
Borehole radar

Mponeng Gold Mine



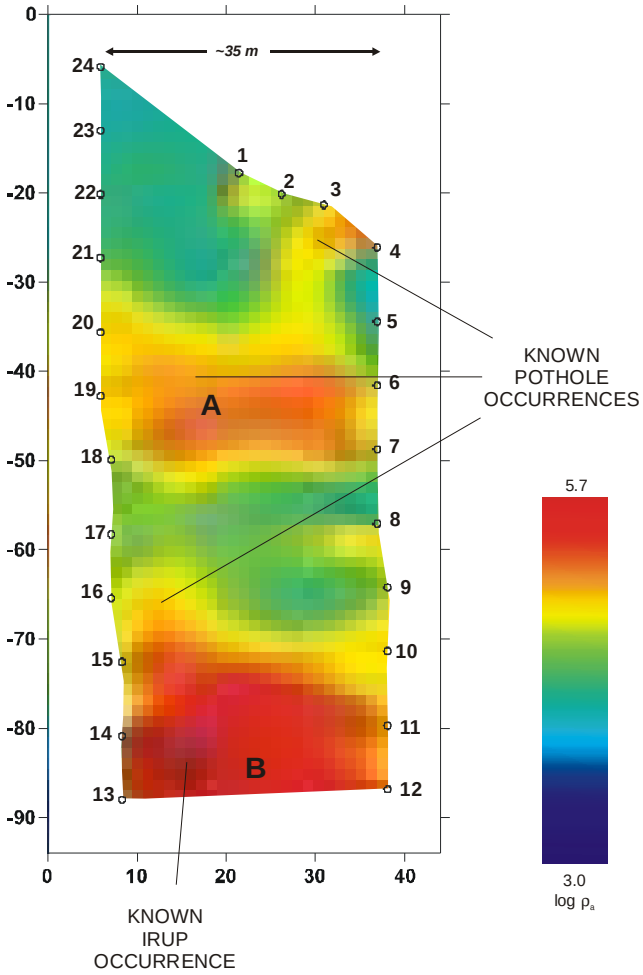
Electrical resistance tomography

Western Platinum Mine



Electrical resistance tomography

Western Platinum Mine



Integrated geophysical (*"toolbox"*) approach

	GPR	Borehole Radar	ERT
Maximum Range	~ 8 m (500 MHz)	~ 50 m (100 MHz)	100-200 m
Resolution	Few centimetres	Few tens of centimetres	Few metres
Applications	Mapping continuity and topography of marker horizons and parting planes in roof Identification of hazardous structures e.g. joints (i.e., mainly for rock engineering purposes)	Mapping reef continuity and topography at exploration phase Following-up ERT anomalies to obtain info of third dimension (depth)	Mapping of potholes, IRUPs in unmined blocks Mapping of grade variations

Conclusions

Conclusions

- High-resolution geophysical techniques can be used to predict reef topography ahead of mining
- Choice of techniques allows mine to use an integrated geophysical assessment approach
- Routine application of geophysics can result in significant savings
  - Reducing the amount of conventional exploration drilling
  - Selective extraction of higher grade areas
- In-mine geophysics can make a valuable contribution to safety
  - Identifying hazardous roof conditions
  - Optimum placement of roof bolts

Future research

Magnetic resonance sounding (MRS)

Induced polarisation (IP)

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Future research

- The use of the magnetic resonance sounding (MRS) technique to detect hazardous water and gas occurrences ahead of mining developments.
- Supplementing existing in-mine ERT technique with the induced polarisation (IP) technique to improve target discrimination and resolution.

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