TERRAVISION

INTELLIGENT EXPLORATION

Surveying for Voids

Contents

Introduction to Terravision

The Ground Penetrating Radar (GPR) system and Methodology

The Terravision system is a 4th generation enhanced Ground Penetrating Radar and is designed for studying subsurface soil structure at depths from a few meters to hundreds of meters, depending on the transmitter model, length of antenna[1] used and medium parameters. The operation is based on radiation of ultra-wideband electromagnetic pulses penetrating into the subsurface medium and registration of the reflected signals born at the medium interfaces or buried objects. These are primarily as a result of a change in density and/or a change in electromagnetic permeability.

Fig 1. Terravision radar using 3m antennas and 10MW transmitter. Africa 2014

The transmitter uses a high-pressure hydrogen discharge, which operates in stand-alone mode without synchronization. The traditional ground penetration radar's mechanics have been completely revised: pulse transmitter power has been increased by a minimum of 100.000 times, and the stroboscopic transformation replaced to direct detection of signal. The antennas use RC-Loaded dipoles. This ensures the exclusion of interference in the received signal that suppresses weak signals, whilst also permitting the reception of strong signals. This avoids the requirement for connecting lines which also introduce strong interference from the transmitter.

Technical parameters[2] include:

- The capacity of the EM transmitter is either 1, 10,20, or 48MW Megawatt
- Working frequency range (MHz) l-50
- Number of samples per scan (ns) 512, 1024, 2048,4096, 8192
- Antennas can be 1m, 1.5m, 3m, 6m, 10m and 15m, so allow better imagery at required depths.

---

[1] Length of antenna affects the frequency of the wave and the depth it can therefore penetrate

[2] Parameters can be set in a variety of modes to best suit specific geological requirements

The device is a lightweight, highly portable system which allows for rapid mobilisation and deployment and use in arduous terrain. The radar can be pulled either by hand or behind a 4x4 vehicle (up to 1km per hour) along cleared profile lines. The antennas remain flush with the surface with the highest performance achieved on machine prepared grids/lines. However this system has been used on variable types of terrain and so can be used in most environments, as an environmental, non-invasive and non-destructive survey tool.[3] On unstable land areas the kit may also be pulled along the survey line with a long rope collecting the data automatically, without the team needing to walk across the dangerous ground.

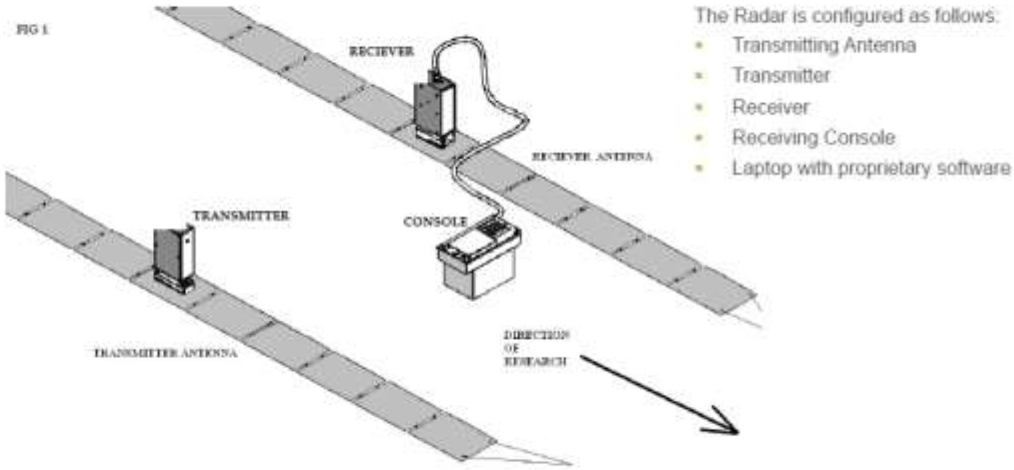


Fig 2. Antennas are more commonly moved one behind the other (series) however for diagrammatic purposes are shown here in parallel.

The horizontal resolution, ie the spacing of the 'radar-shots' taken along a profile is chosen according to the required scale of the target objects and in discussion with the client. For small objects (pipes, cables, small voids etc.) shots may be taken every 10-20 cm, for shallow geological surveys (e.g. alluvial deposits) spacing may be 50-100 cm.

At each measurement point, the arrival time of the signal is recorded from the geological boundaries. The profile 'radargram' is formed in real time on the operator's console LCD screen in the form of a binary plot depicting radar return time of the subsurface reflections. The EM wave travel times, depending on the reflector depth and propagation velocity, vary along the profile giving a picture of subsurface layered structures in real time.

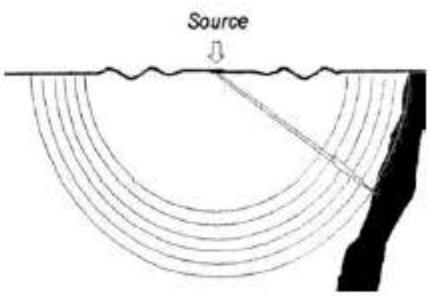
Fig 3. Console showing wave form on right and structure on left.

[3] There are often no permitting requirements such as those required for drilling.

Results of the survey, including the wave-forms for each point ('shot') in the survey, are stored in the console memory, which can then be instantly downloaded into a normal laptop computer for immediate review. This real-time capability means that the operator can mark features of interest as the profile is taken. This used along with a GPS can accurately mark points of interest. This allows the client to mark the features on his own software for subsequent actions to be accurately delivered (drilling etc.).

Fig 4. Immediate download of data to laptop for on-site analysis

Object Identification. The system identifies structures at all angles, including the vertical structure, we see - as the diagram below portrays. This system shows any structure well as the signal array returns from both the vertical and horizontal structures. Additionally, the Radar operator can either manually operate the 'firing switch' or it can be set to automatic. The 'shot' spacing is determined by the client's objective; and also by the speed of the traverse.



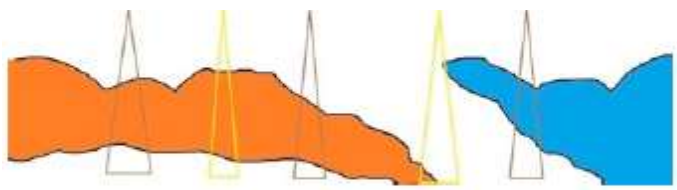


Fig 5. Capturing structural data (left) and 'Shot' spacing can be varied to suit clients aims (right).

Data is collected and downloaded onto a laptop for analysis on proprietary software typically taking 12hrs to fully analyse 1km line of data; however preliminary analysis on the laptop can be conducted immediately in the field to check data quality and features of interest. As well as real time viewing of data, it is also possible to set up the equipment and record 2.-5-4km of profile per day, showing its ease of use and quick usage.

Targets and features that are commonly seen by Terravision Radar include:

- Limestone karst caves
- Old mine workings
- Collapsed caves

Terravision Surveying for Voids

Overview

Terravision Radar has over 4 years of experience working predominantly in the mining sector, but with civil engineering ans security issues involving ground disturbances across Africa, India, Europe and Latin America. Voids have been detected in a broad range of geological contexts from near surface <35 m depth.

The remainder of the document covers a series of case studies for these different situations. These include

- Mining Projects
    a. Detecting old mine workings
    b. Detecting voids in underground tunnel walls
    c. Mapping the decline of old mine shafts
    d. Limestone caves; voids, collapsed, infilled
- Industrial/Security Projects
    a. Voids beneath a railway line
    b. Border tunnels
    c. Archaeological tunnels

Terravision Radar has proven that it can identify relatively small scale voids at depths traditional GPR cannot. Near surface tunnels, voids in bedrock or collapsed/infilled voids produce distinct contrasts in the geophysical signal.

The data reporting can be exported to compatible software programs, and examples of sections merged with mine models or drilling data to create a composite interpretation that greatly aids GPR analysis.

Terravision Methodology

METHODOLOGY

- Terravision would commence work on known areas of interest:
- Profiles would be run across a known void to calibrate the signal.
- We would expect to run 2km to 3km of profiles per day.
- 1 km of profiles takes 1 day to analyse.
- There is "real time" analysis when collecting the data, and data can be downloaded and checked on the ground.

ANALYSIS

- The control line profiles generated could then be correlated with known depth and scale of void.
- We would expect to see hyperbolas and/or disturbances in the geophysical horizons across the voids
- We will therefore be able to deduce the "scale" and depth of the void
- We might then deploy into unknown area to identify any further voids.

Fig 6. 6m antennas collecting in series in the bush

The following are a few of the benefits to using the enhanced GPR.

- High productivity of the GPR method – 1km in 1-1.5 hours.
- High mobility and flexibility of the antennae (can be dragged across unstable land collecting data automatically where voids pose a threat to persons walking over the area).
- Intuitively clear results from the study of the sections.

In summary, Terravision Radar provides a fast and efficient method for a preliminary identification of voids.

Case Studies

Case Study 1: Detecting old mine workings

Objective

- Identify the old mining tunnels

Geological Description: 300 year old gold mine workings in the South African greenstone belt.

Outcome: GPR successfully identified anomalies in the signal, in the form of hyperbolas, above locations of known tunnelling. Having proved its capabilities GPR was used to locate tunnels away from the control area. Below, the Radargram identifies a void at 5 m depth, the vertical anomalies directly beneath the void are reflections resulting from the concrete in the tunnel.

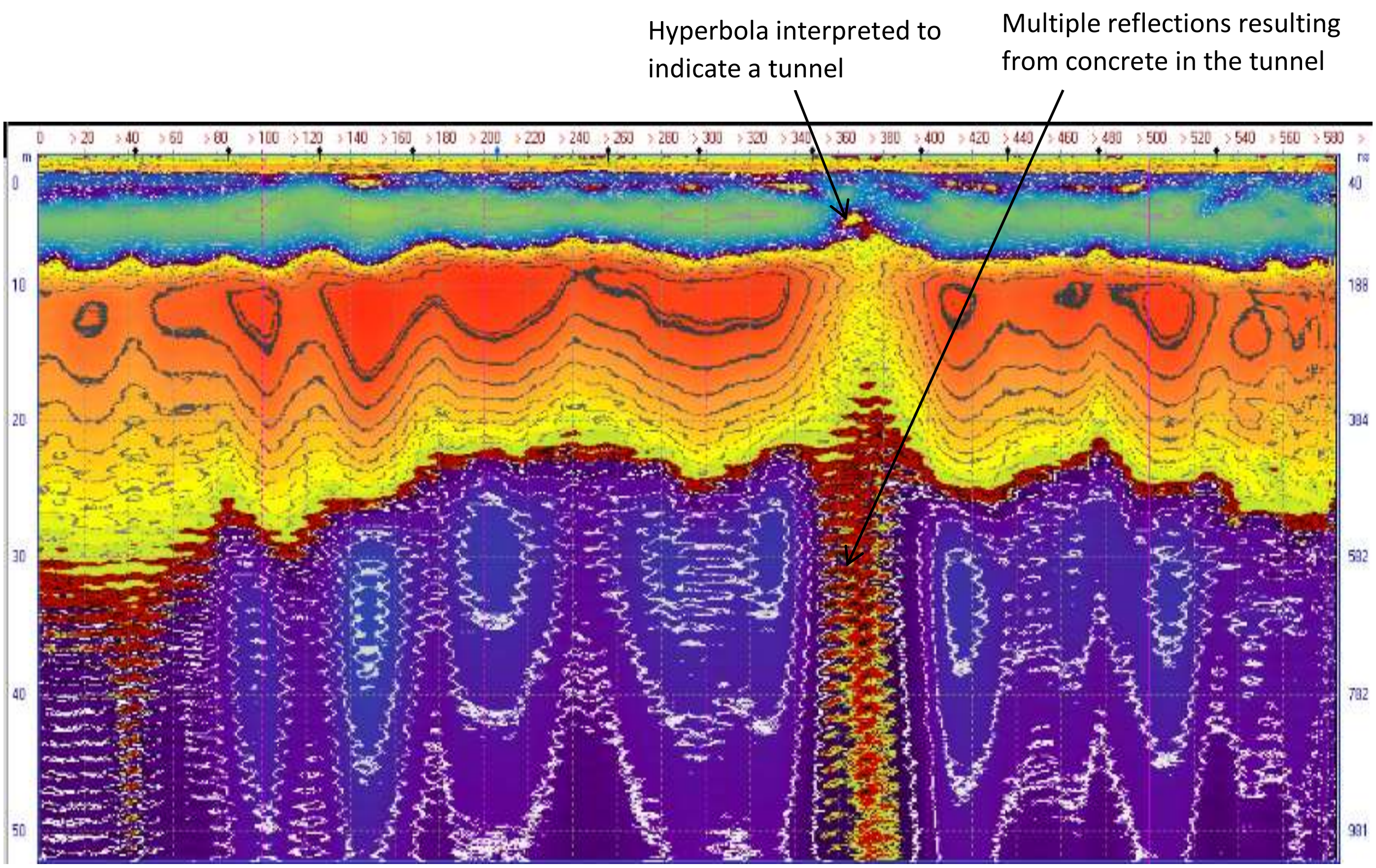


Fig 7. Radargram showing a void at 5 m depth interpreted as an old mine working.

Case Study 2 – Detecting voids surrounding mine tunnels

Objective:

- Identify voids in the walls of the mine tunnel
- Identify any fractures in the walls of the mine tunnel

Geological Description: Limestone utilities tunnel 500 m below ground. The client wanted to identify voids and fracture zone in the walls of the tunnel.

Outcome: Anomalies in the waveform were identified that indicated voids, water zone and fractures.

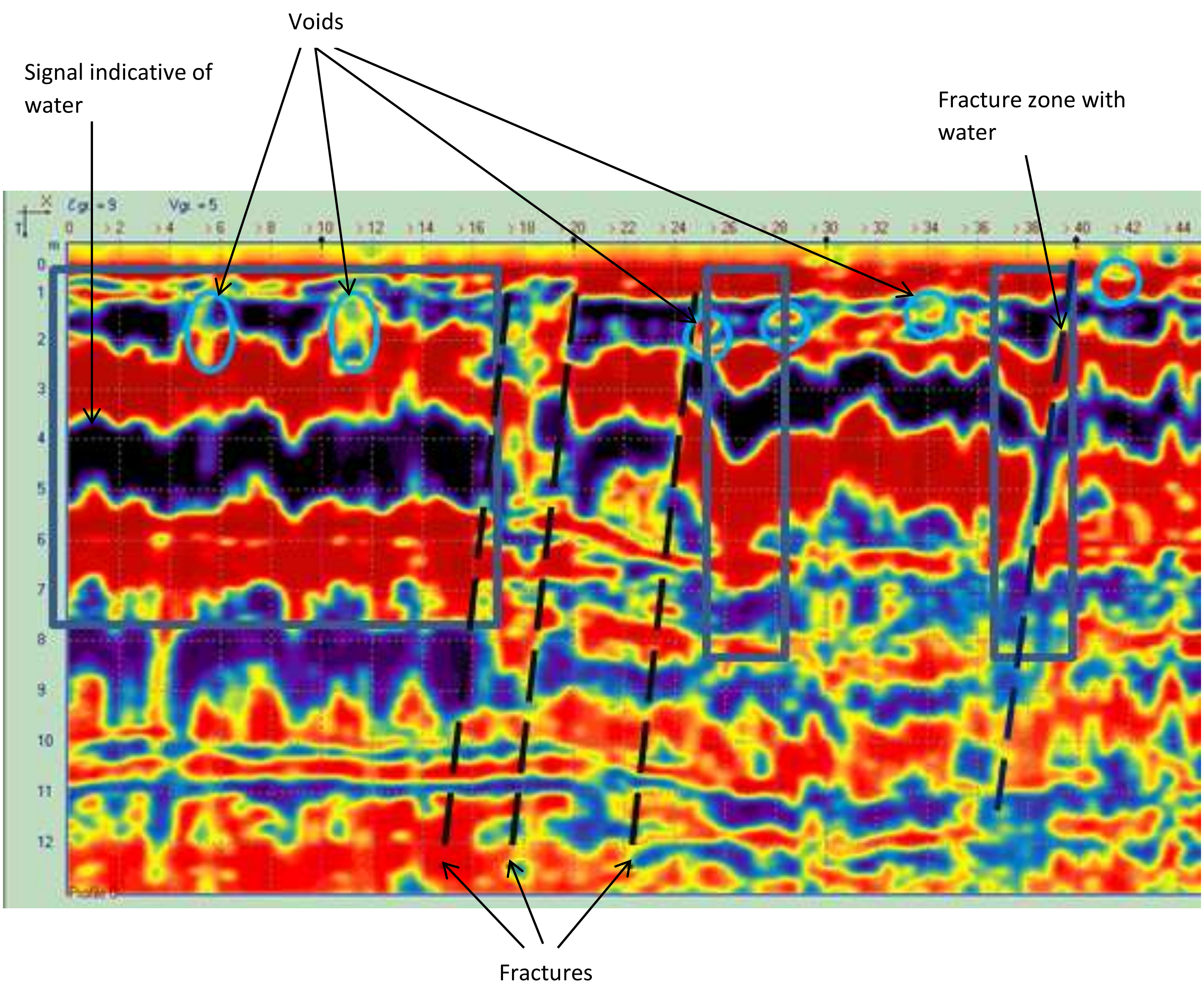


Fig 8. Radargram showing the fractures, voids and water zones interpreted from a section in the tunnel.

Case Study 3 – Mapping the decline of a mine entrance from surface

Objective: To map the route of an old disused mine shaft from its surface entrance to a depth of 40 m.

Background: A series of profiles were collected at 10 m intervals, perpendicular to the decline. The decline was 3 m wide, the client wanted to trace the route of the tunnel to 35 m depth. The 6 m antenna and 10 MW transmitter were used.

Outcome: The hyperbolas in the Radargrams below show the top of the decline, down to 35 m depth , below that there was not sufficient resolution to see features of this scale.

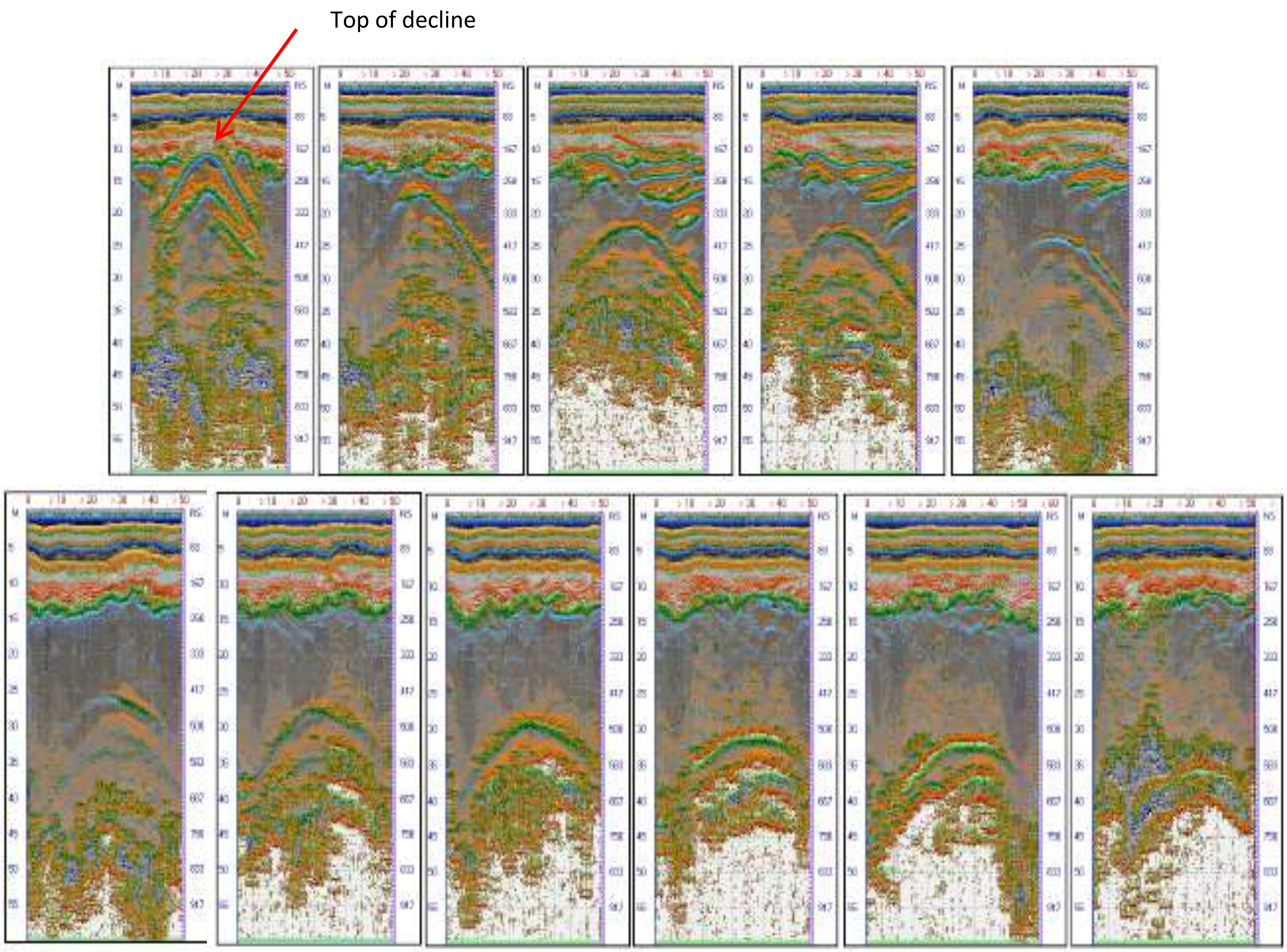


Fig 9. Radargrams taken at 10 m spacing showing the decline of a mine shaft.

TERRAVISION
INTELLIGENT EXPLORATION

Case Study 4 – Limestone caves

Objective: Provide a wider understanding of the geology of the area, **l**ocate any karstic features/old mine workings and indicate their geometry

Background: Data was collected on the margins of a limestone quarry. Borehole data was available to calibrate the geophysical horizons identified with known lithologies.

Outcome:. Low frequency settings were used to look to 200 m depth for the general trend of karst development, high frequency settings looked to 50 m depth with greater resolution to assess sinkholes, caves, cracks and various other structural elements (many were seen to owe their development to underlying processes). Geophysical horizons calibrated with the borehole data, near vertical structures and voids and related collapse zones were also identified.

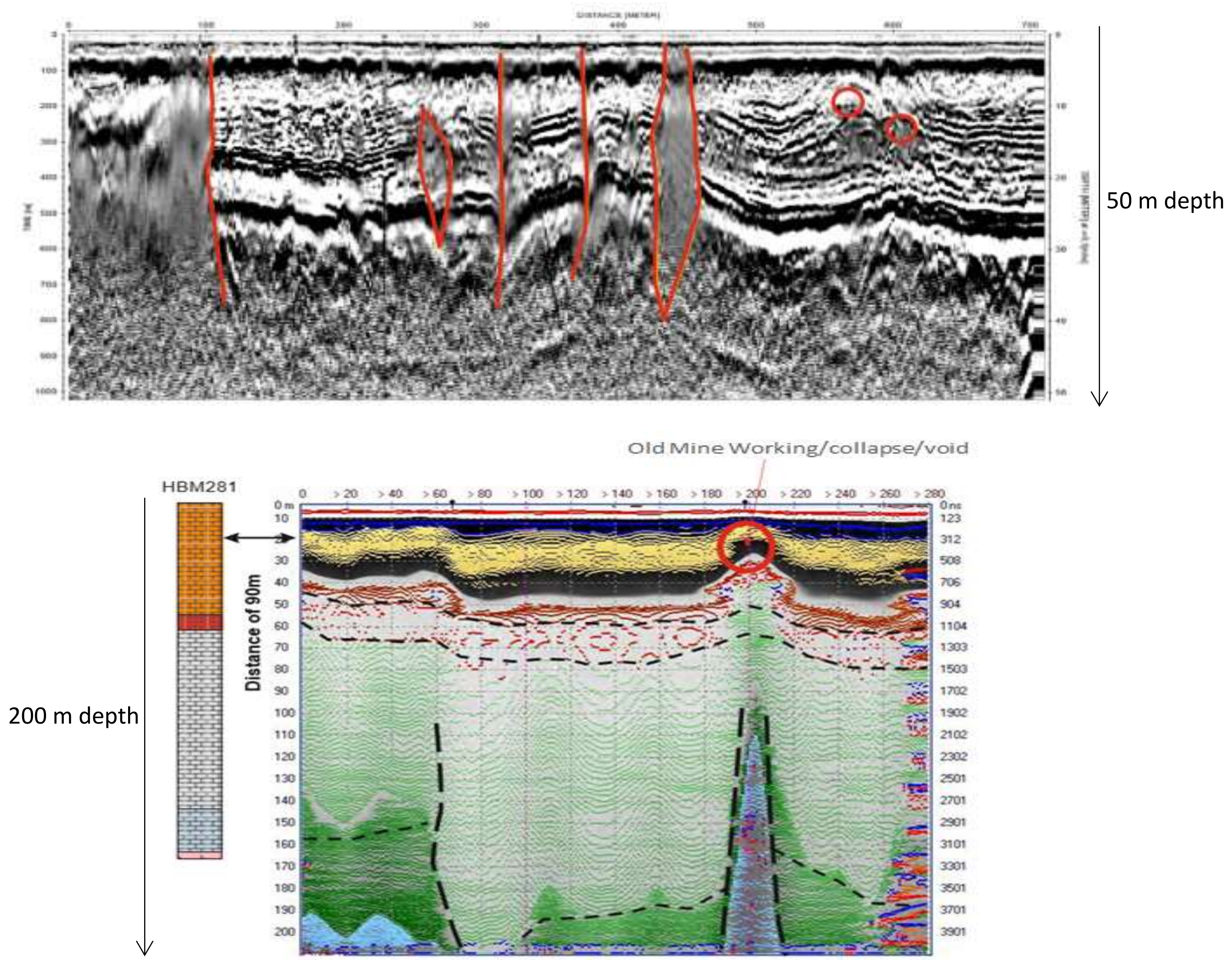


Fig. 10: Above Radargram shows Terravision data using REFLEX software to 50 m depth. The lower Radargram shows data from a different profile line in the Terravision software krot to 200 m depth

Case Study 5 – Voids beneath a railway line

Objective: Identify voids in high risk areas surrounding a railway embankment.

Background: The Rail Line had identified high risk areas based on ground subsidence and had used cement infill in the worst effected zones. GPR was used to locate the voids to help the engineering programme stabilise the land.

Outcome: The Radargram below shows the results of one of the profile lines. The red circles show zones of interference from electrical poles, cables and other objects. The numbers show;

1. Zone of vertical displacement of the upper geophysical signal indicating vertical strain
2. Zone of vertical displacement of slightly deeper geophysical signal indicating vertical strain.
3. Decompression zone in the middle part of the geophysical section (funnel)
4. Vertical decompression zone in the lower part of the geophysical section (void)

The blue circle shows the recommended drill site.

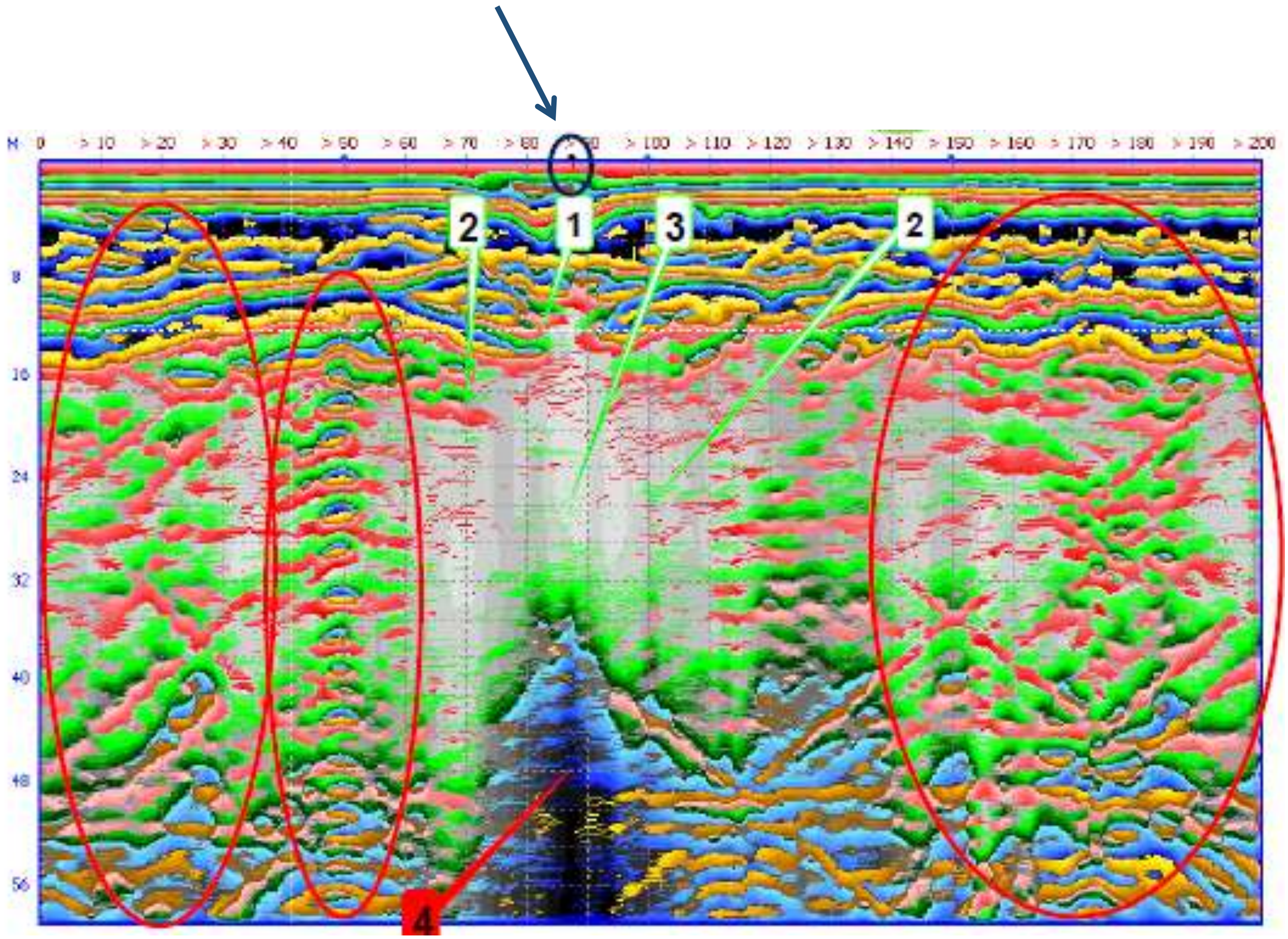


Fig 11. Radargram illustrating BIF in different filters.

Case Study 6: Archaeological tunnels

Aim: Identify archaeological tunnels associated with a sort after tomb.

Background: The survey was conducted across the archaeological site using both the 1.5 m antenna and 1 MW transmitter (to give better detail of smaller shallower features) and the 3 m antenna set and 10 MW transmitter (to locate tunnels deeper than the capability of the 1.5 m antenna but with lower resolution). The geology of the region was limestone.

Outcome: Meter scale voids were identified in the Radargram below, at 5 m depth. The blue circles beneath the interpreted tunnels are multiple reflections.

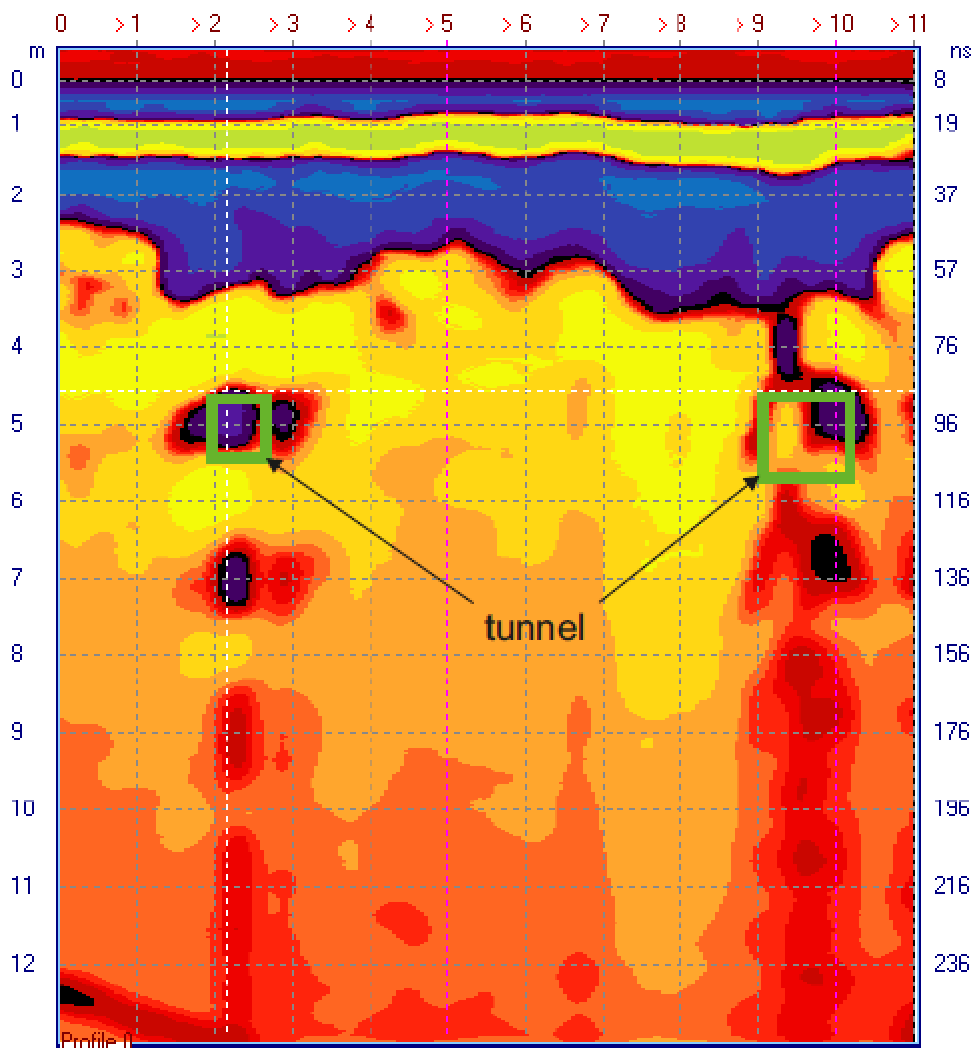


Fig 12. Radargram showing identified voids in the limestone.

Operations and Clients

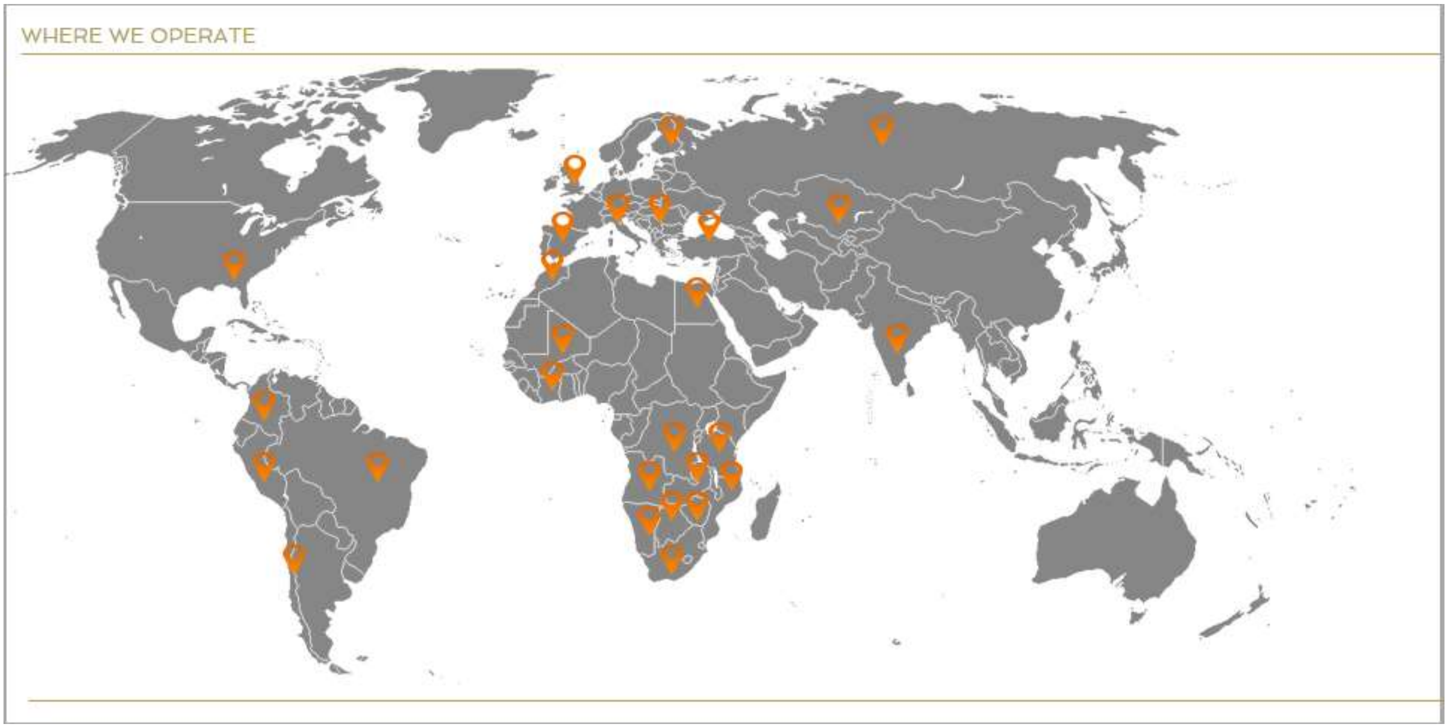


Fig 13. Terravision is working with industry leading mining majors and governments, through to junior exploration companies across Africa, Asia, South America and Europe.

Certification:

Terravision is certified to comply with EU Directives on;

Electromagnetic Compatibility (Directive 2004/108/EC)
Low Voltage Directive 2006/95/EC


CERTIFIKÁT
СЕРТИФИКАТ


СЕРТИФИКАТ СООТВЕТСТВИЯ


ПАТЕНТ

Contact

Further information on Terravision Radar can be found at www.terravisionradar.com
Or by contacting;

Charlie Williams, CEO
+44 07810 823858
Skype: cevwilliams
Email: charlie.williams@terravisionradar.com

Sergei Markov, Director
Skype: sergei.markov
Email: sergei.markov@terravisionradar.com

Victoria Howarth, Geologist
Skype: vfhowarth
Email: victoria.howarth@terravisionradar.com

Or: info@terrravisionradar.com

END OF DOCUMENT