TERRAVISION
INTELLIGENT EXPLORATION

Surveying for Gold

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

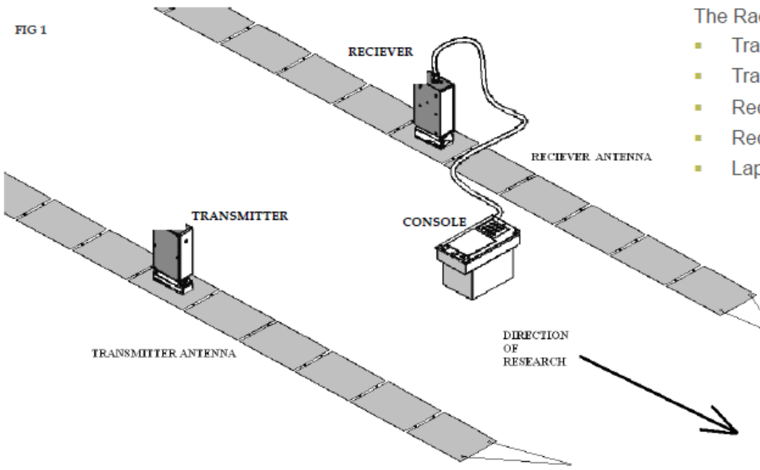
The transmitter uses a high-pressure hydrogen discharge, which operates in stand-alone mode without synchronization. The traditional ground penetration radar's mechanics have been completely revised: pulse transmitter power has been increased by a minimum of 100.000 times, and the stroboscopic transformation 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]



The Radar is configured as follows:

- Transmitting Antenna
- Transmitter
- Receiver
- Receiving Console
- Laptop with proprietary software

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.

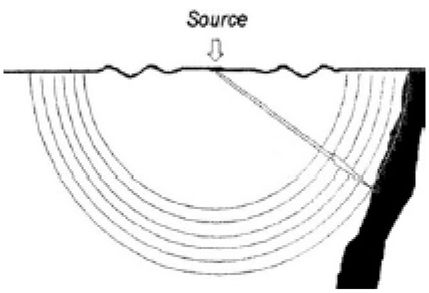
Fig 3. Console showing wave form on right and structure on left.

[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.



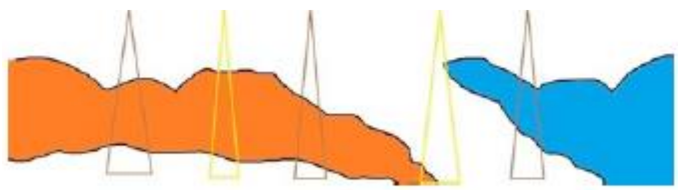


Fig 5. Capturing structural data (left) and 'Shot' spacing can be varied to suit clients aims (right).

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:

- Oxide zones or alluvial cover over hard rock
- Oxide ore over fresh basement, (surficial cover and base of oxidation)
- Narrow sporadically mineralised shears
    - Small concentrations of metals, including gold create enough changes in the dielectric constant to be discerned by the Terravision system.
- Intrusions
- Pipes and dykes
- Felsic porphyry or ultramafic bodies
- Massive sulphide deposits.

Terravision Surveying for Gold

Overview
Terravision Radar has over 4 years of experience working on numerous minerals and across southern Africa, India, Europe and Latin America. A majority of clients have been gold miners and explorers with a broad range of geological contexts found. The remainder of the document covers a series of case studies for these different situations. These include

- Hardrock gold
    a. Volcanic Breccias
    b. Greenstone
    c. Polymetallic Copper-Gold porphyry. (A separate case study detailing our success on copper-gold porphyries is available on our website)
    d. Strata-bound mineralisation
    e. Hydrothermic ore shoot mineralisation
- Alluvials. Calibrated examples – (A separatecase study detailing our capabilities on alluvial products is available on the website.)

Terravision Radar has proven that it can identify relatively narrow sporadically mineralised shears. Small concentrations of metals, including gold create enough changes in the dielectric constant to be discerned by the Terravision system. The technique appears to work equally well for steeply dipping and more shallowly dipping mineralised structures.

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

How Terravision Identifies Areas of Potential Gold Mineralisation

Oxide Zone: For Example - oxide/saprolite zone boundaries will be well defined.
Association: What is the Au associated with? Semi massive sulphide mineralisation. Ankerite / exhalite association? – we need to review available core data in detail.

Sulphide Mineralisation: Terravision may identify relatively narrow sporadically mineralised shears. Small concentrations of metals, including gold create enough changes in the dielectric constant to be discerned by the system. The technique works equally well for steeply dipping and more shallowly dipping mineralised structures.

Volcanic Breccias: Any mineralised kicks seen in drill data should be clearly discernible. In general, we expect to see the main structural characteristics of the surveyed area.
Terravision have experience of surveying for Greenstone gold deposits in Africa. Deposits consist largely of narrow often **high-grade veins** and often more **subtly mineralised shears** in a variety of cross-cutting orientations. The veins are often associated with sulphides, but normally in quite small tenors.

Gangue mineral assemblages and associated alteration patterns are very variable, though typical gangue assemblages are quartz and carbonates dominated. These minerals normally have little geophysical contrast with typical greenstone host rocks.

Terravision Methodology

METHODOLOGY

- Terravision would commence work on known areas of interest:
- Profiles would be run through the DH sites, and perpendicularly across the feature.
- 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 profiles generated could then be correlated with existing DH data, geochemical and geophysical information.
- We would expect to see geo-chemical /mineralisation anomalies with the structural anomalies we will pick up.
- We will therefore be able to deduce the “scale” of the mineralisation process, and the reason for the origination of mineralisation.
- We might then deploy into non-drilled areas to identify similar structure/anomalies to target drilling.

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.
- Intuitively clear results from the study of the sections.
- The possibility of profiling across the trend of the main sections and ore control structures. Profile planning exactly perpendicular to the trend of the ore-hosting rock allows for the finding of the structural peculiarities of the massif under study (tectonics, contacts, ore-material). Linear structures, along with the faults and other types of structures connected to them, can be linked to the centers of secondary mineralization (hematite, magnetite, manganese).

In summary, Terravision Radar provides a fast and efficient method for a preliminary estimation of the potential of the territory under study.

Case Studies

Case Study 1 - Volcanic Breccias

Objective

- Work on a greenfield site (no drill info) to identify appropriate drill targets.

Geological Description:

- It was believed that there was potential Reef hosting structures along faults, at contacts between greenstones & porphyries.

Fig 7 shows a cross cutting intrusion - or "disturbed" and "non-disturbed" zones. This analysis may also show correlation of geo-chemical anomalies with the structural anomalies we see. We will be able to show the "scale" of the mineralisation process, and the reason for the origination of mineralisation.

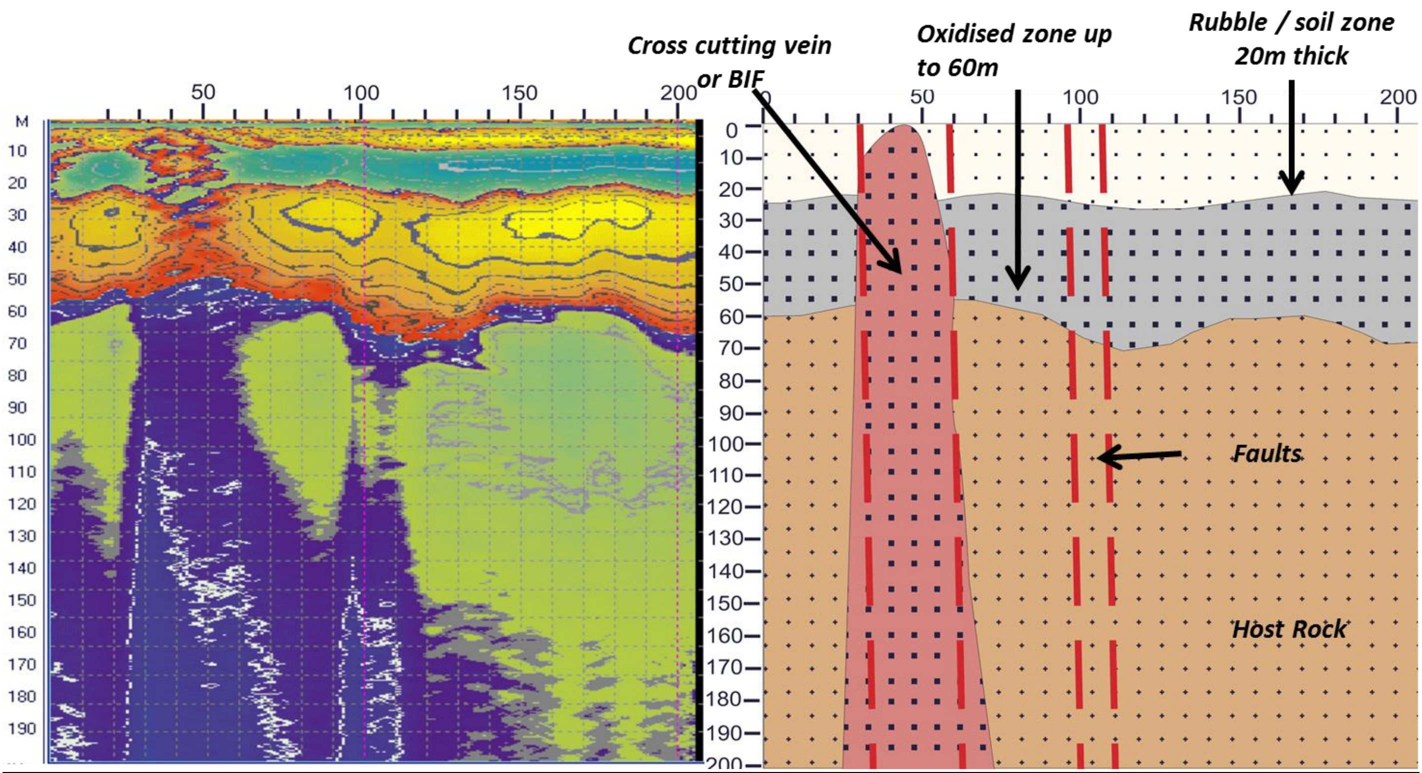


Fig 7. Radargram (right) and corresponding schematic showing intrusive and faulting.

Section 2

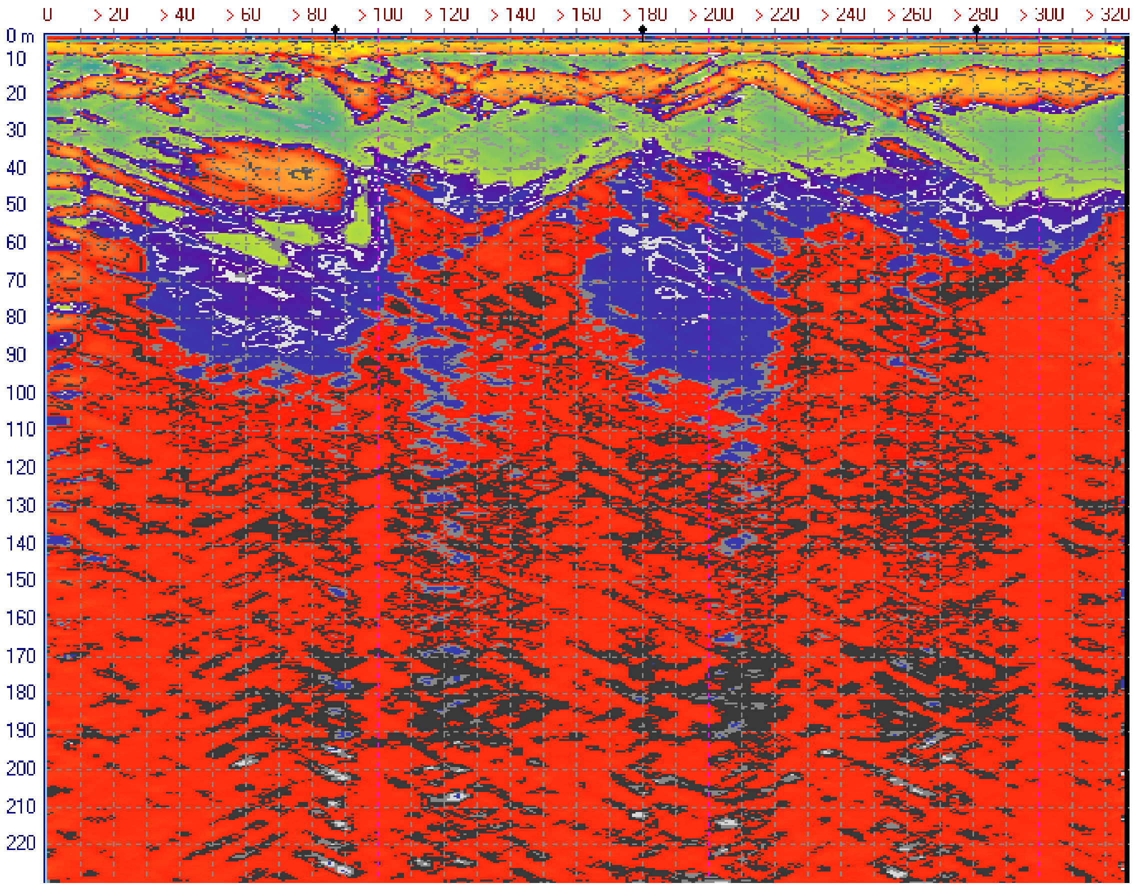


Fig 8. A second radargram from the same project

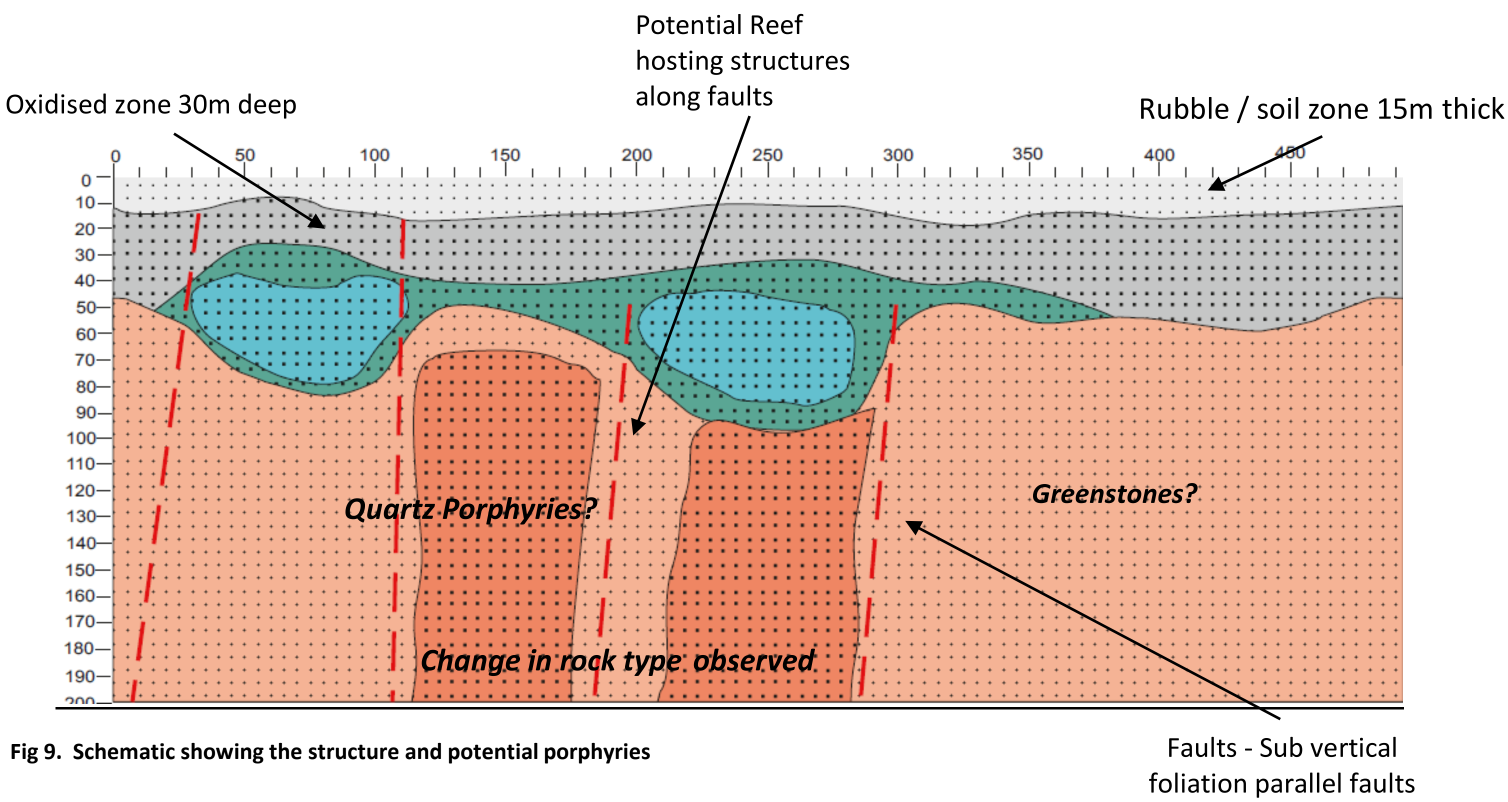


Fig 9. Schematic showing the structure and potential porphyries

Case Study 2 - Greenstone Gold – Zimbabwe – Farvic Mine

Objective:

- Magnetics and radio metrics have proved useful in defining general target areas.
- Neither magnetics nor IP has delineated the reef zones satisfactorily.

Geological Description: Reef is 1–3m thick quartz bearing shear zone. Strikes E – W, dips 35 N. Reef is a parallel shear 60m into the HW.

Control: The target area had ground magnetic and IP data in addition to RC intercepts
Good geological control; ie able to compare IP, magnetics, RC drill intersections, to GPR

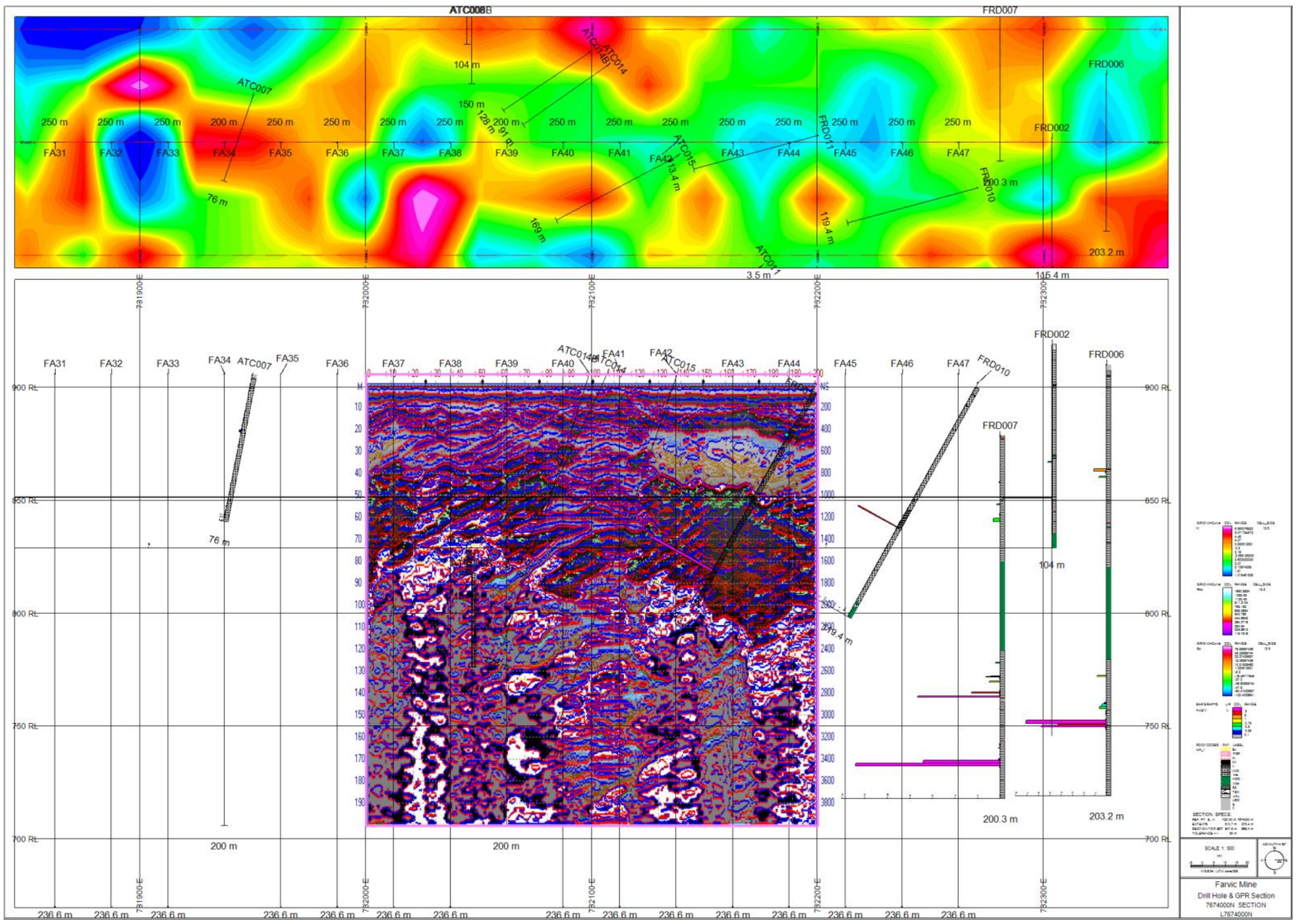


Fig 10. IP and RC data with radargram overlaid to confirm GPR findings

The drill holes; specifically FRDO010 to the right of the radar section, intersected two reefs bands; the Main Prince Olaf, and the overlying HW/Act shear which are both clearly visible on the profile.

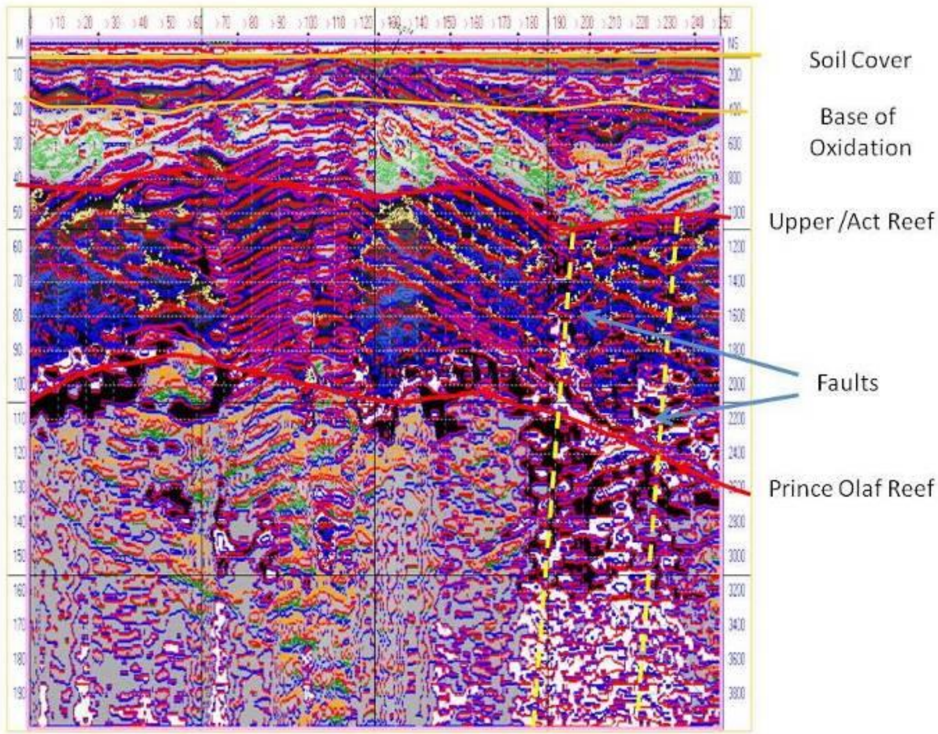


Fig 11. Radargram with reefs highlighted.

Outcome:

- Lower Reef confirmed at 100m depth
- HW shear ; the upper Reef confirmed at 60m depth
- Surface rubble zone up to 5m deep, with oxidised zone up to 30m
- Vertical cross-cutting faults identified.

Case Study 3 - Polymetallic deposit – target is copper/gold mineralisation

Objective: To rapidly extend in to the greenfield site to identify further ore zones and suggest a drilling position. Also to indicate the overburden.

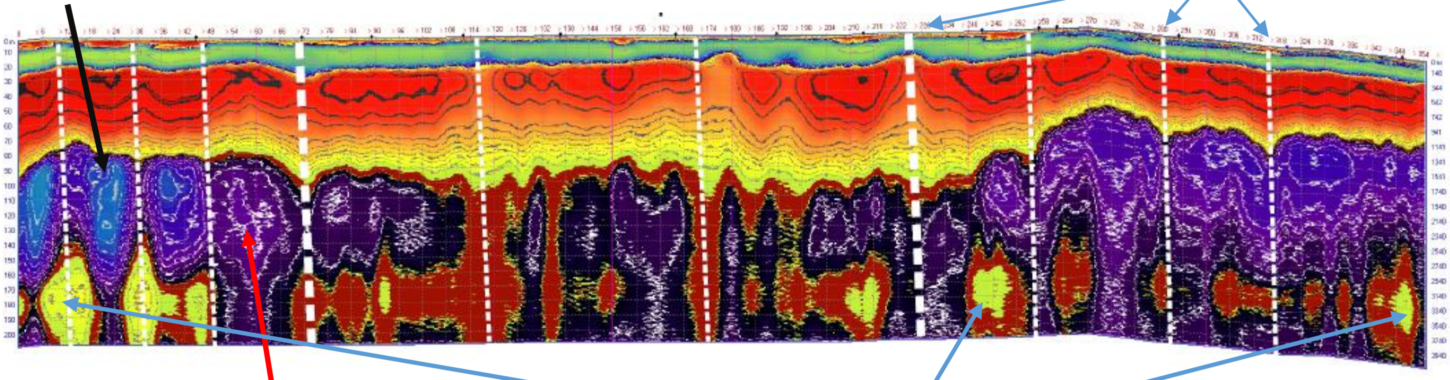


Fig 12.

Dielectric: blue to purple is the reduction of polarization, purple is zero polarization, where there is generally no metal content.

Conductivity: Areas with high polarization show materials with electromagnetic properties – i.e. high metal content. Other materials do not have these properties.

Outcome: Drilling – This image shows our recommended drill position and angle for S11

In this example, mineralised ore is concentrated at the external borders of faults, the faults were in the middle of the process of secondary mineralization. The fractures contain calcite (carbonates), this should be secondary mineralization, that possibly once had a lot of iron inside the fault, but today they are empty.

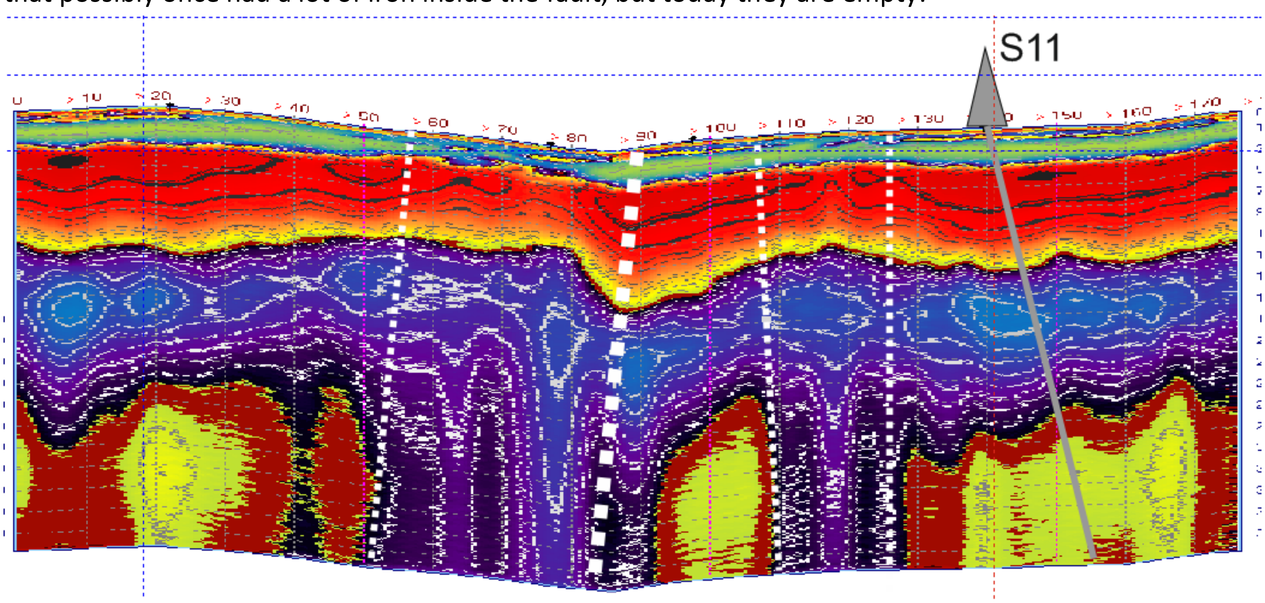


Fig 13. Indicating proposed drill site (S11)

Case Study 4 – Cu-Au Thin Vein Deposits- Chile

Objective: Identify the copper and gold deposits

Background: The bedrock comprises dioritic and andesitic volcanics, quartz/iron oxide veins host the high grade copper and gold mineralisation

Outcome: Profile of 800m to a depth of 50m. The purple colouring highlights the target veins.

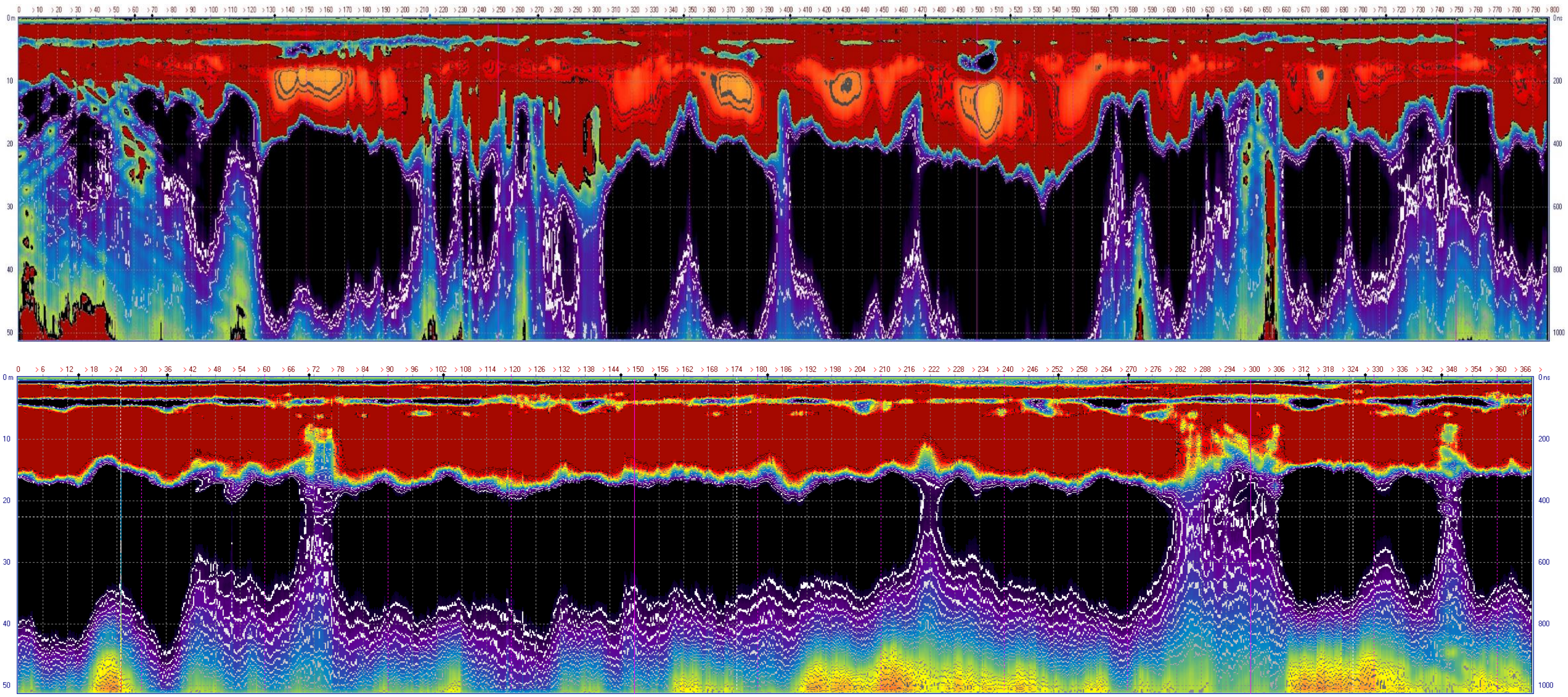


Fig. 14: Radargrams of two separate profiles show purple vertical anomalies in signal, these are the target Cu-Au veins.

Case Study 5 – Strata-bound BIF hosted Mineralisation

Objective: Identify the continuation of the mineralised zone after the disruption from the fault

Geological Description: Banded Ironstone with mineralisation at the “contact” with the oxide zone and sulphides in the intrusion to depth.

Control: Existing assay data.

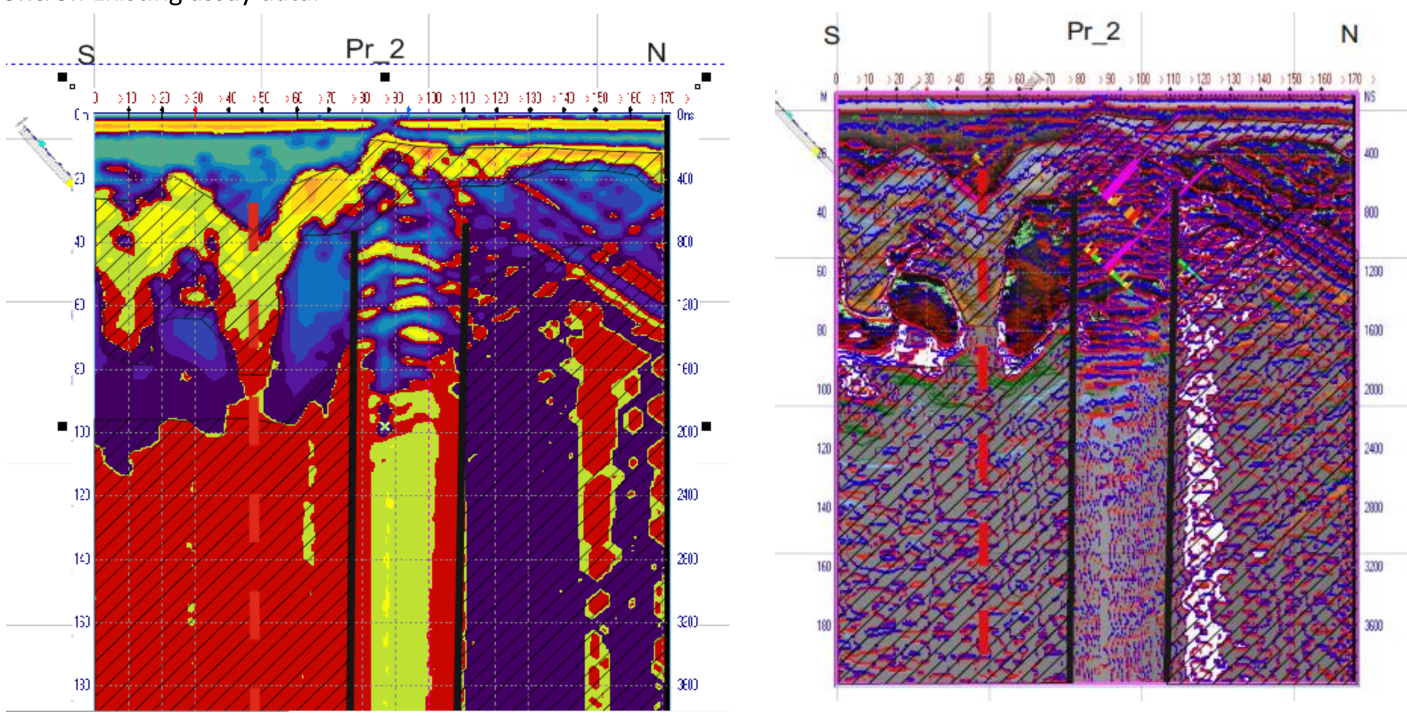


Fig 15 Radargram illustrating BIF in different filters.

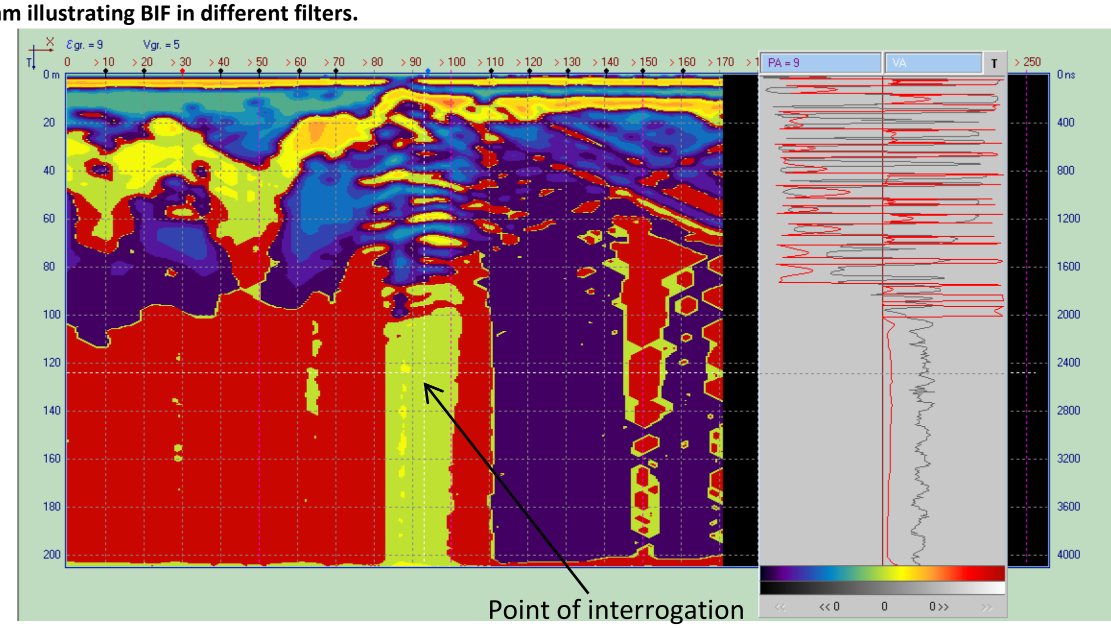


Fig 16. Same section as Fig 15 showing a “screenshot” of the wave properties on the right hand side (Grey line is raw data, Red is after filtering). The right hand side of the “analysis box” shows conductivity, the left side resistivity.

Outcome: The feature or interest shows up as a prominent yellow marker.

Case Study 6 – Mineralised Ore Shoots (Latin America)

Objective. Add further accuracy to the previous IP work conducted to support accurate targeted drilling.

Geological Background: Terravision Radar conducted a trial in mountainous jungle of the Andes. A series of gold veins run through the concession.

Control: Drilling and IP previously conducted on site.

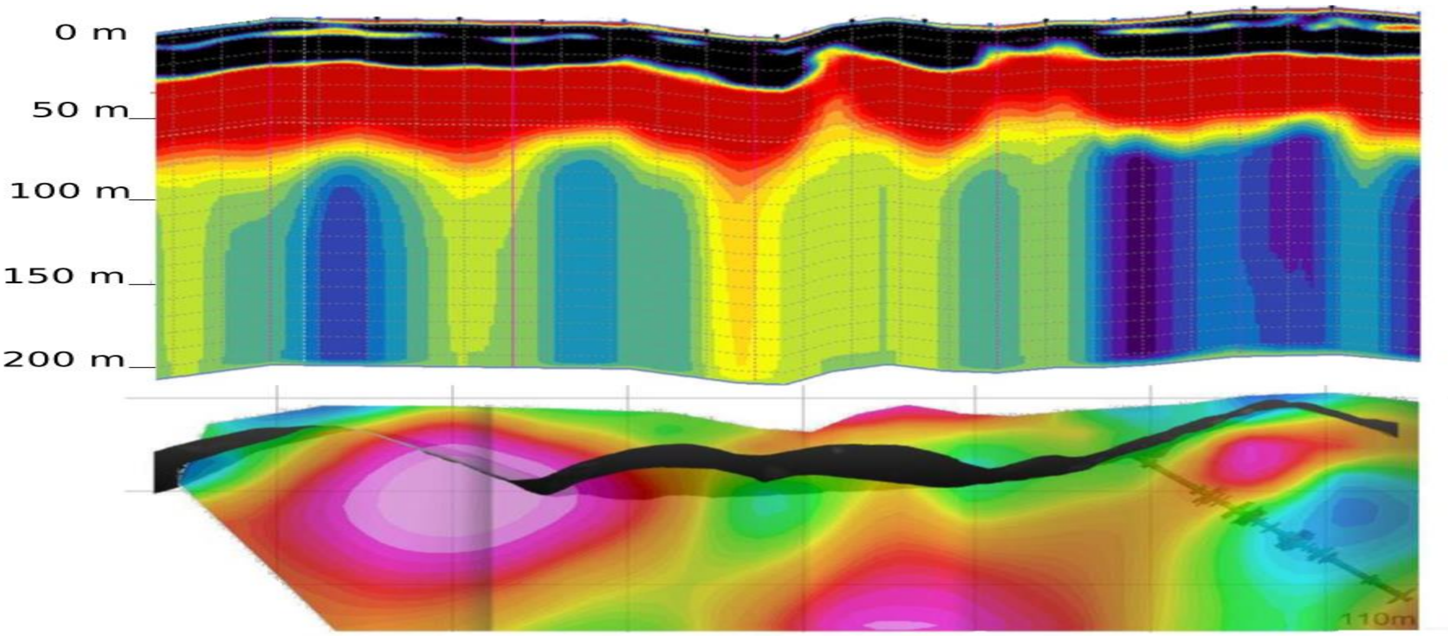


Fig 17. Top: Terravision Radargram. Dark blue (vertical) areas representing mineralized zones. Bottom: IP survey of the same area.

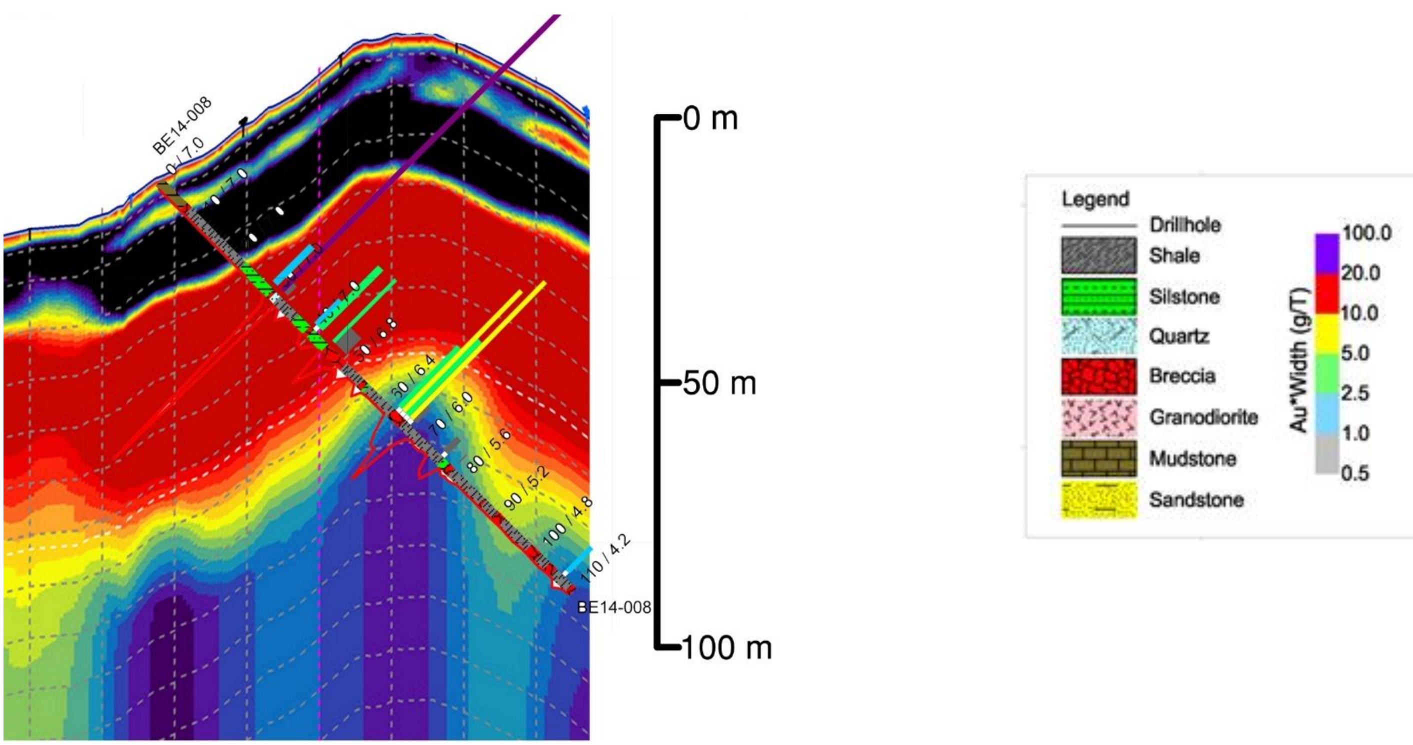
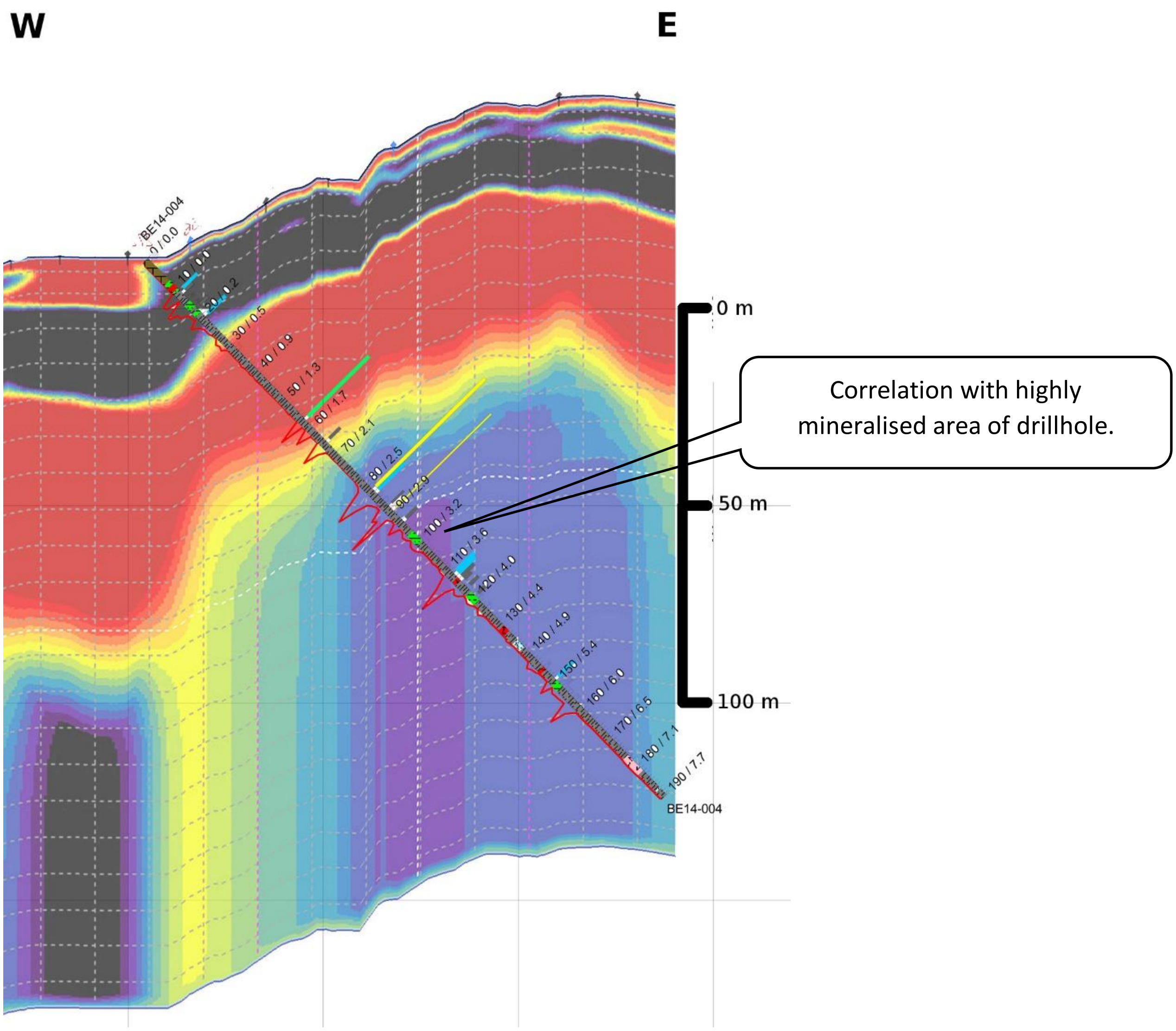


Fig 18. Radargram with drill hole assay data to correlate to and confirm GPR findings.



Fi. 19: Another radargram demonstrating the correlation of the results with the borehole data.

Case Study 7 –Thin vein gold – Continental, Colombia September 2014

Objective: Identify gold vein clusters

Geological Background: The following survey was conducted in steep conditions in the Andean mountain range where the mobilisation of drill equipment is a challenge and as such there was a premium on targeting each hole. The veins were all too thin to be individually identified however as a 'cluster' the anomaly was easily identifiable.

Outcome: Fig. 20 shows the data in its raw format, this highlights a cluster of vertical anomalies c. 85-170 m. Fig. 21, 22 and 23 have had further processing to better highlight the geological contrasts. They succeed in isolating the vertical structural abnormalities, specifically the main area of interest, but also isolated anomalies. Also, when the analysis is focused only to a depth of 100m (Fig 22.) and 50m (Fig 23) the detail within the radargram is increased and a clear outline of the zone of altered rocks and implemented, vertical irregularities is evident.
In Fig. 23 (to 50m) managed to increase the detail and distinguish more of the veins within the main zone, with the main vein at the 95-100m distance along the profile. Also 2 small structures, possibly veins, can be seen at the start of the profile and at the 275m mark.

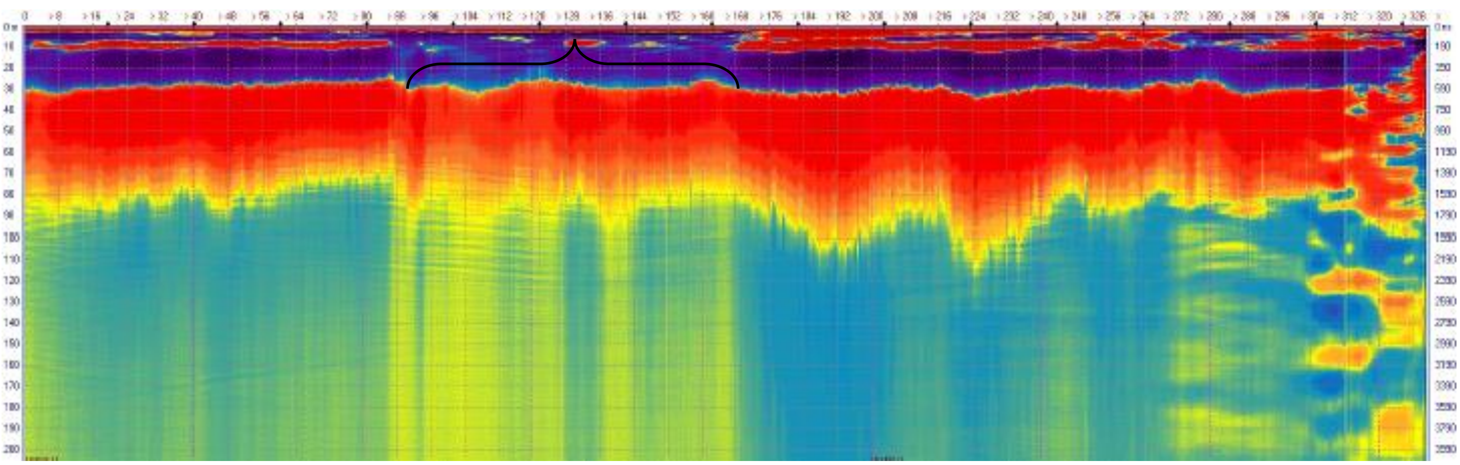


Fig 20. Raw Data Radargram without the use of filtering and other signal amplification clearly highlighting zone of altered rocks.

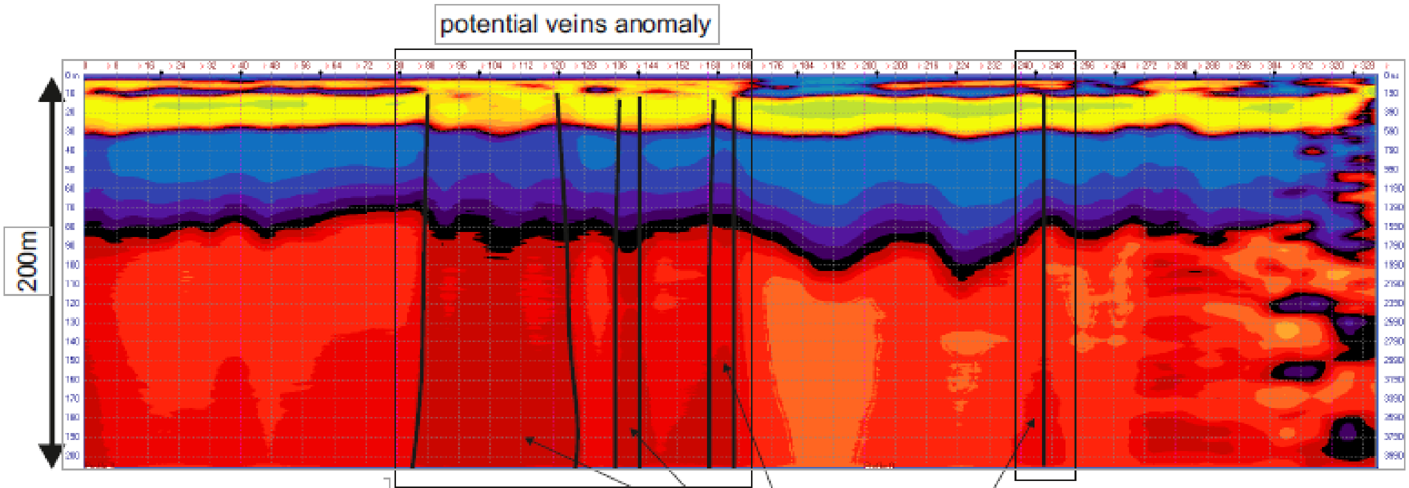


Fig. 21: Processed to 200 m

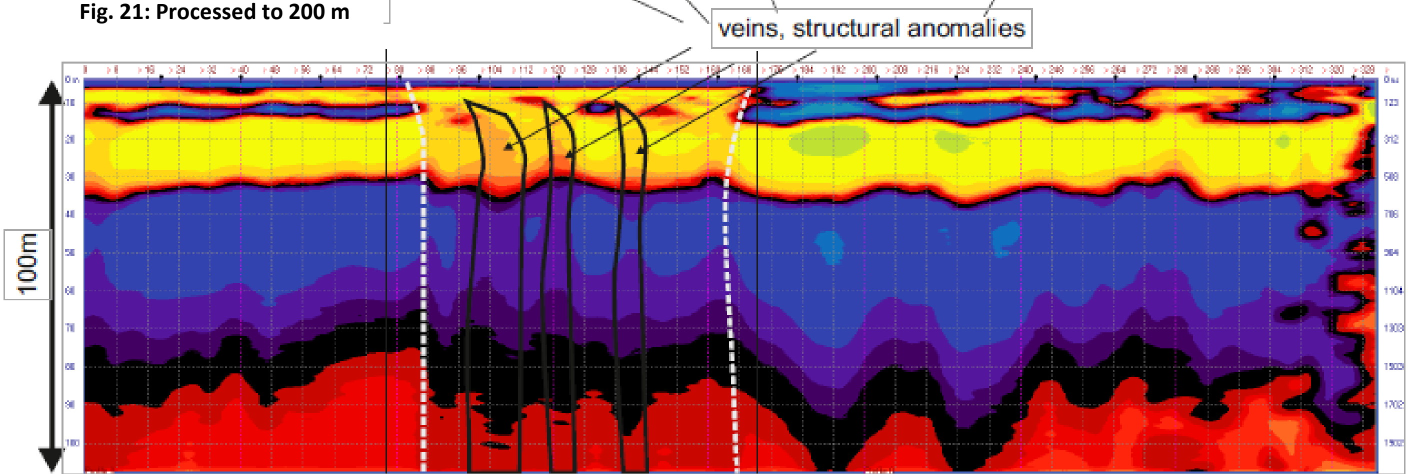


Fig. 22: Processed to 100 m

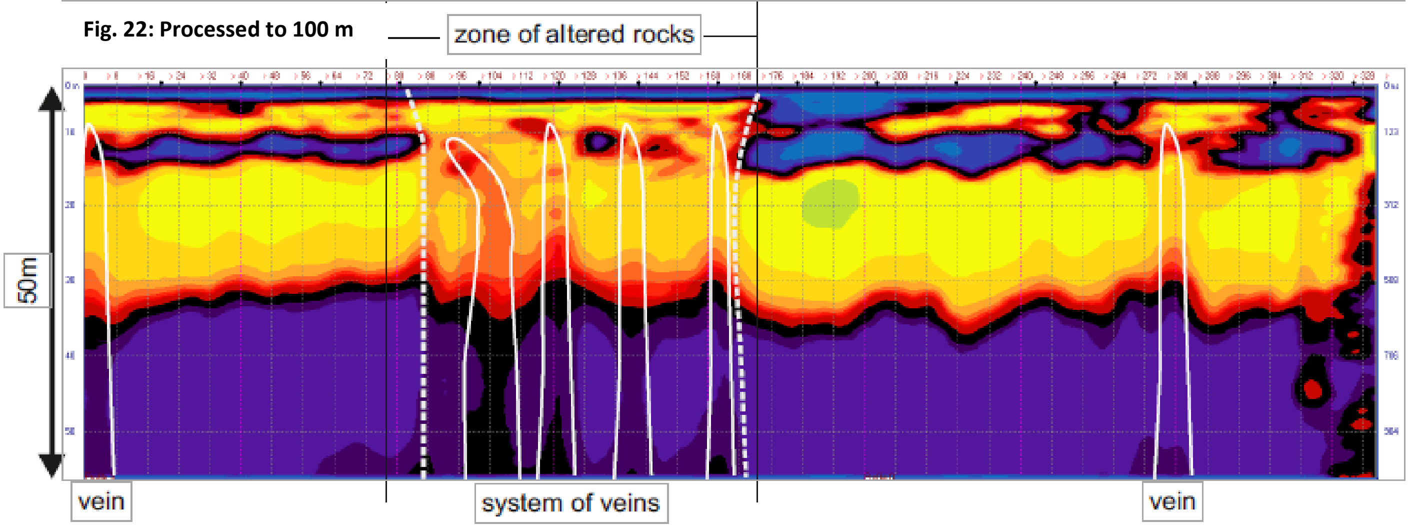


Fig. 23: Processed to 50 m

Case Study 8 – Alluvial Deposits

Terravision has extensive experience in alluvial surveying. These can be found in a case study on the website. Below is a small example of the type of product created. Further work including water catchment areas and volumetric calculations (tailings etc.) have also been conducted.

Alluvial Gold – Zimbabwe – August 2012
Profile of 200m in length. Interval shot measurements at 50cm. Depth of section is 45m. Profile performed from the river up the hill.

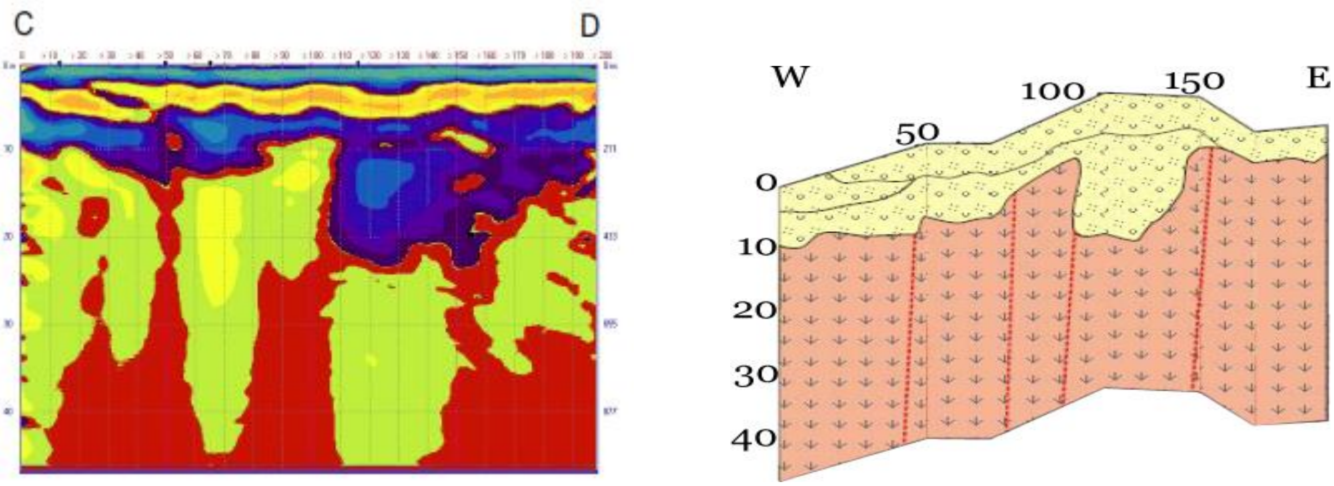


Fig 24. Radargram and schematic. 45m depth, illustrating paleochannels

This profile is of greatest interest because it clearly showed the paleo channel from 110 to 150m. The depth of the channel is more than 20m. The remaining depths of the alluvial material from the river to the identified paleo channel is between 7 to 10m.

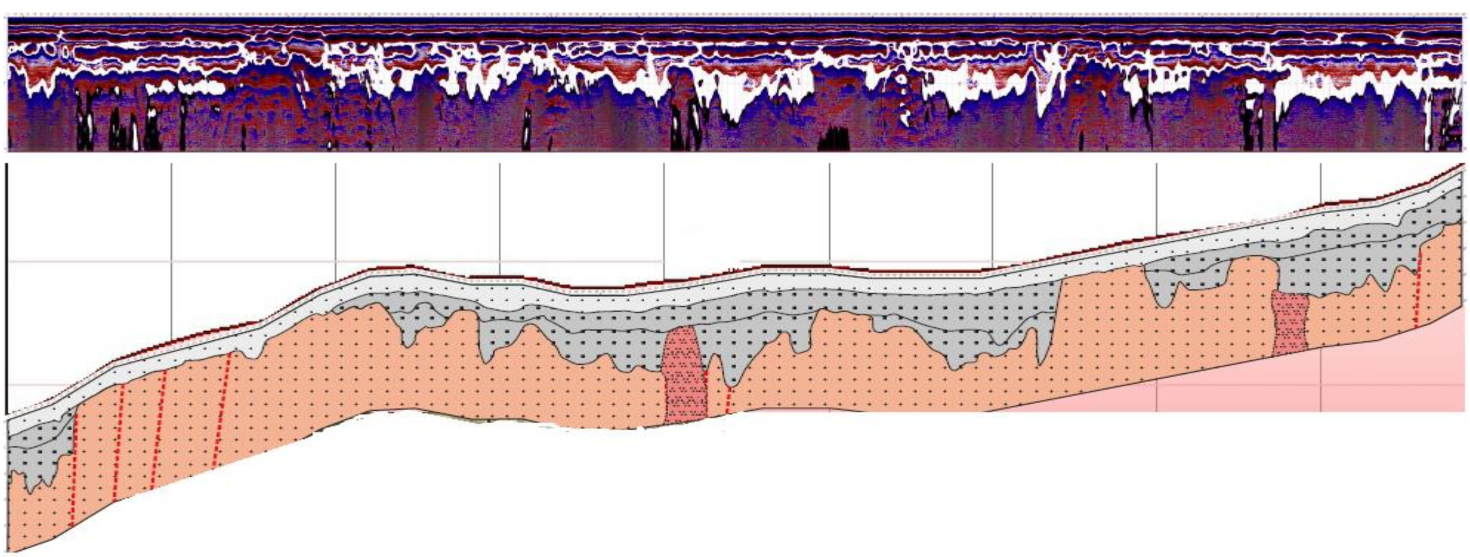


Fig 25. 2500m long profile with schematic clearly showing faults, intrusives and sedimentary layers within the Paleochannels. The survey was started at the present river bank (to the left of the image.).

Comparison with Induced Polarisation (IP)

Gold Environment.

Traditional direct geophysical techniques are often not effective for mapping out auriferous veins, though of course magnetics is a powerful structural as well as lithological mapping tool. Structures well–mineralised in sulphides can be defined by IP and EM, though those lacking high sulphides levels or extensive mineralised haloes will not be clearly discernible.

Operational Benefits.

Terravision Radar - Quick, Lightweight, Real Time Feedback - has much quicker data collection than IP.

High productivity of the GPR method – 1km in 1-1.5 hours.

Intuitively clear results from the study of the sections.

Terravision Radar allows for the profiling across the trend of the main sections and ore control structures. Profile planning exactly perpendicular to the trend of the ore-hosting rock allows for the finding of the structural peculiarities of the massif under study (tectonics, contacts, ore-material). Linear structures, along with the faults and other types of structures connected to them, can be linked to the centers of secondary mineralization (hematite, magnetite, manganese).

IP pumps currents in the ground that are rapidly switched on and off. IP requires a power source, usually a generator, and passes currents into the ground via cables and electrodes, or ceramic pots. The arrays are often hundreds of meters long, and the teams at the Tx, Rx and generator need to be in phone/HF radio contact. Over-voltages' are measured in the receiver array/voltmeter.

IP typically requires teams of 9 – 10 workers are required per survey. (Terravision has 2 operators)

IP product comes in the form of a series of "o waves;" the shape of which is a measure of the apparent metal content.

Terravision surveys are 16 Frequency EM (white noise) and turned around in days and delivered as profiles.

IP Comparison Images

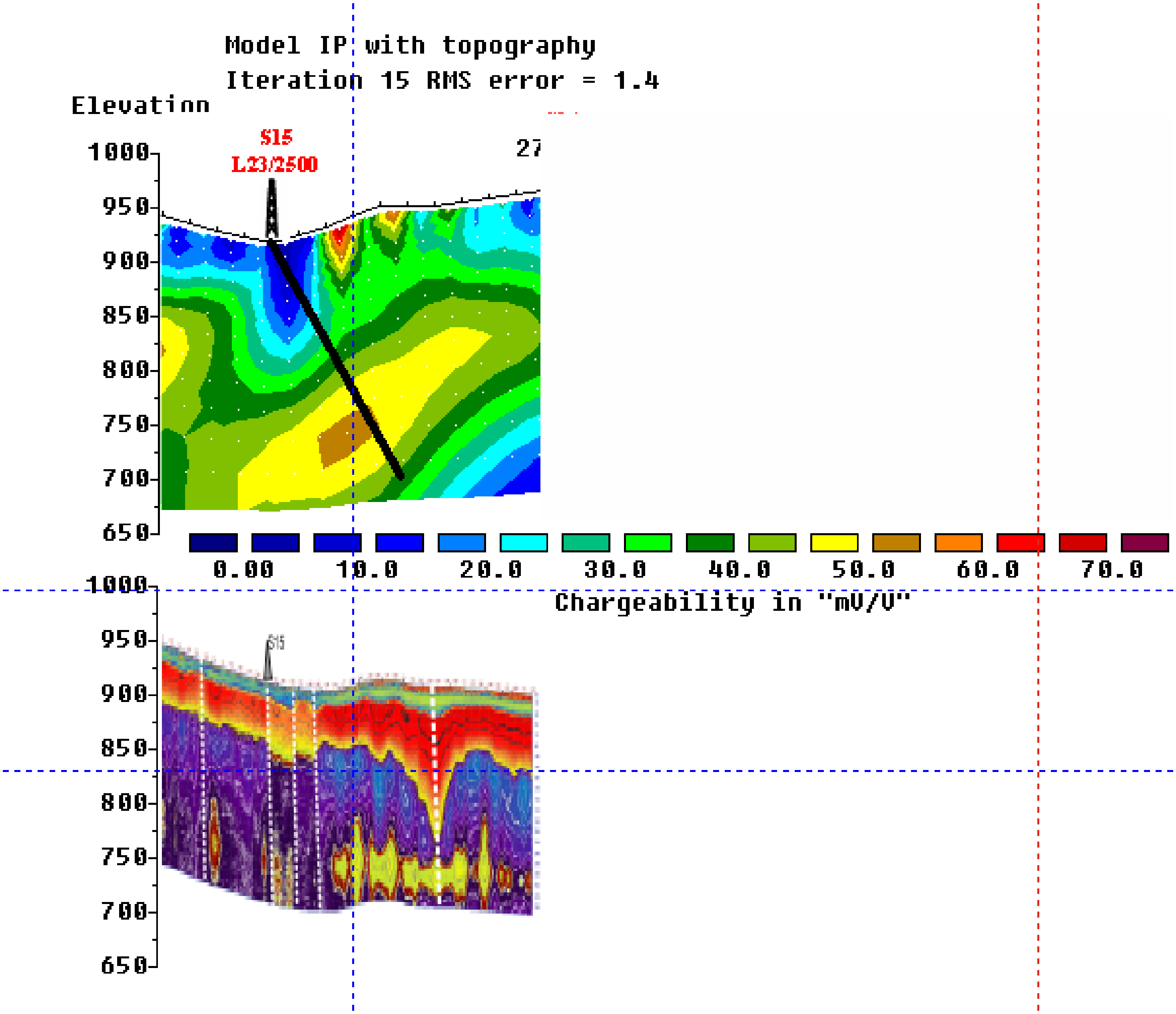


Fig 26 Example 1 of how Terravision corresponds to IP.

We have identified that the drill position and target issued by the IP provider was over a faulted area.
Please note that the terrain was heavily undulating – we took a route in the same direction as the IP survey, but on a different path that was accessible for walking.

Mineralised Ore shoot IP comparison

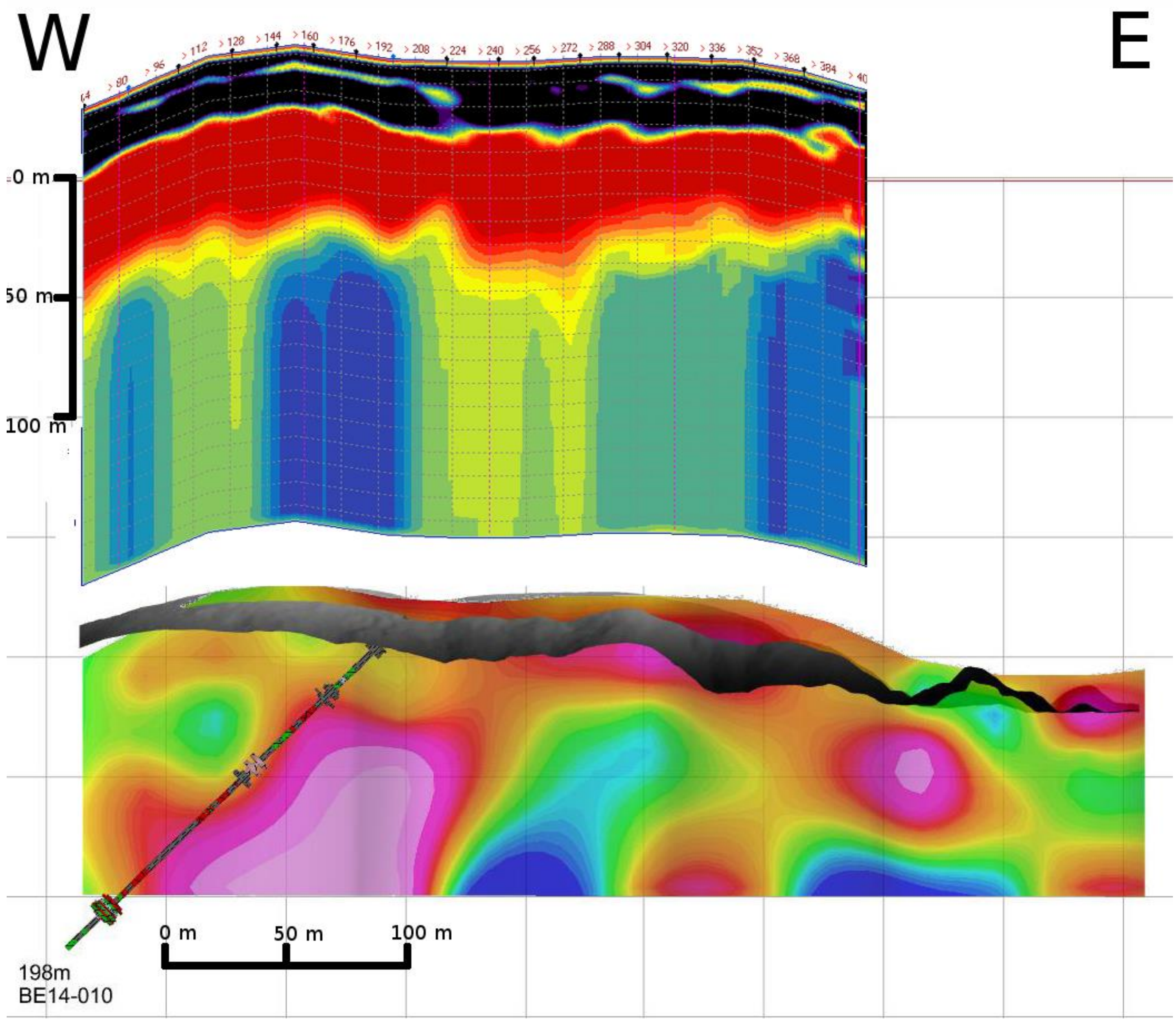


Fig 27. Example 2 s comparing IP with GPR results.

Control

Drill hole control data overlaid on GPR radargram from example 2

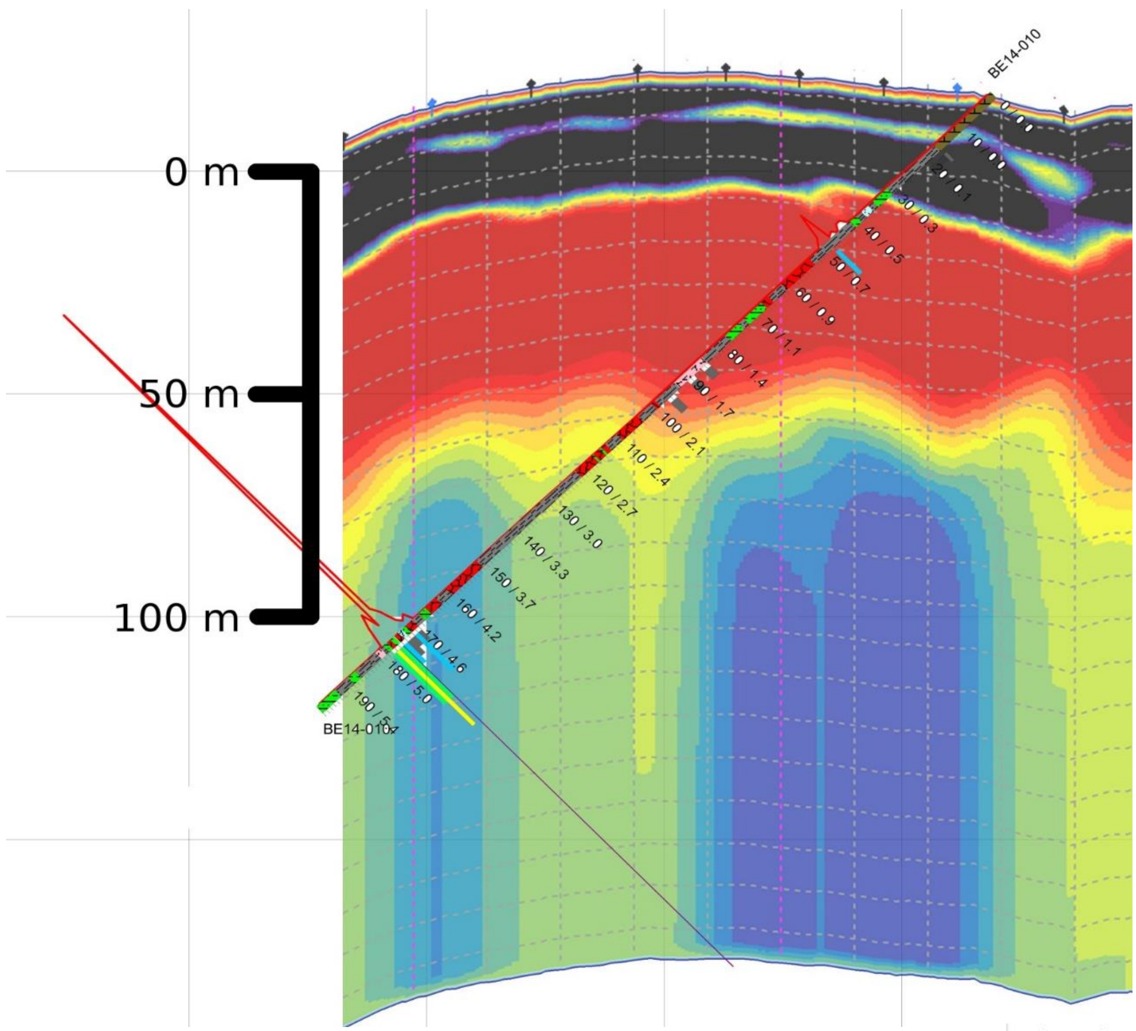
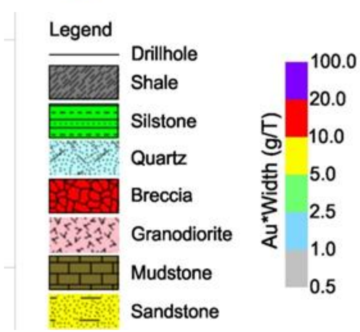
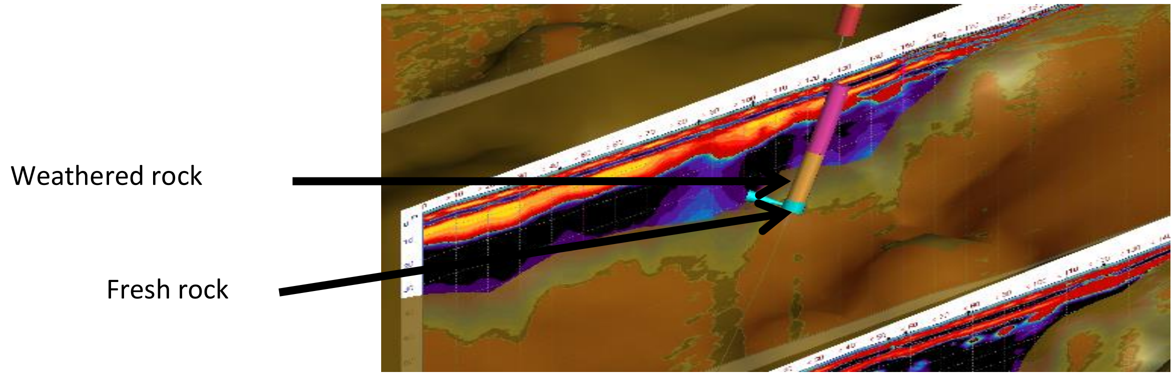


Fig 28. GPR with drill hole data overlaid retrospectively.



3D Modelling

Data from Terravision surveys can be rapidly downloaded and processed while still on site. The data format is 2D profiles, these can then be seamlessly integrated into modelling software with existing mining models/ Common formats of the Radargrams for integration include; TEXT files, JPEG, BMP files. Correlation of contrasting signal horizons in the GPR to key lithological changes or assay data gives confidence to the interpretation.



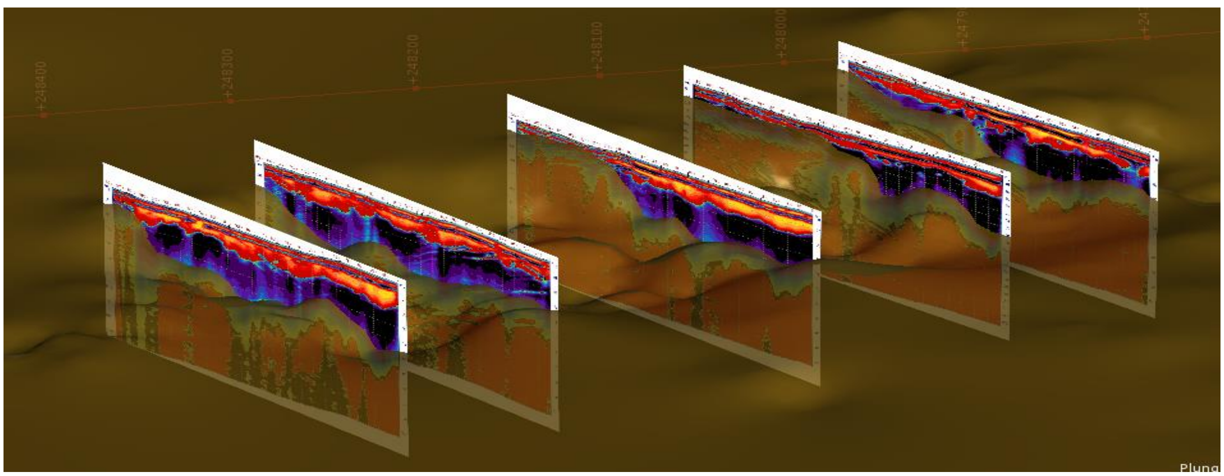


Fig 29. Radargrams were used in Leapfrog to map the weathering horizon in 3D using the available borehole data for calibration.

Analysing GPR alongside existing maps, geophysical data and borehole data allows for the true potential of the Technology to be realised, leading to more robust models. Being able to demonstrate the GPR using 3D visualisation allows for the findings to be communicated effectively.

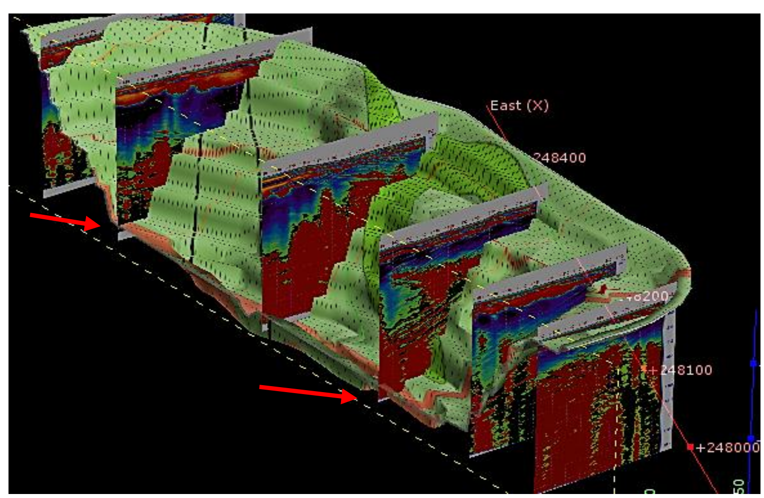


Fig 30. Slice through the pit model shows a mineralised vein mapped in the pit aligns with the electrophysical anomalies in the Radargrams.

Operations and Clients

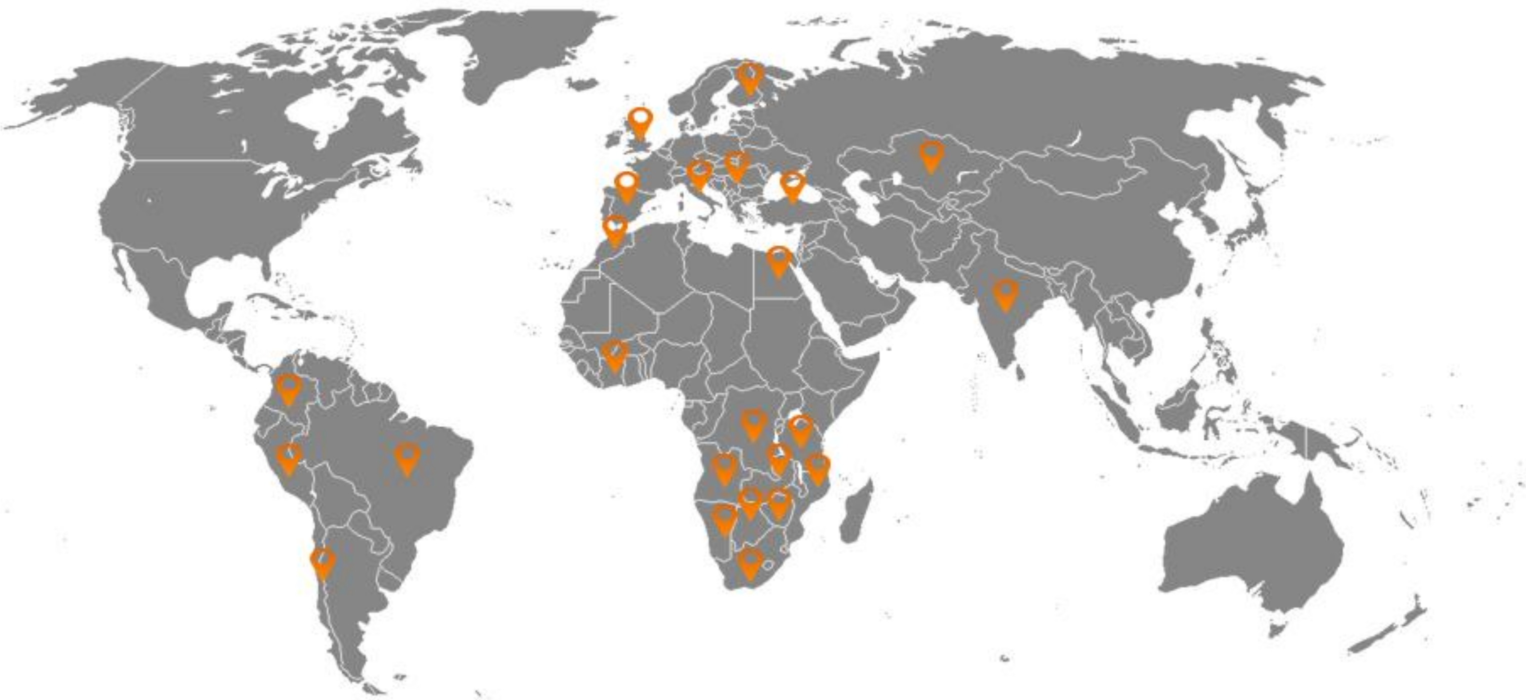


Fig 31. Terravision is working with industry leading mining majors and governments, through to junior exploration companies across Africa, Asia, South America and Europe.

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

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