Passive seismic HVSR surveying for karst-style supergene gold mineralisation targeting at Lakanfla Gold Project, Mali

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Resource Potentials

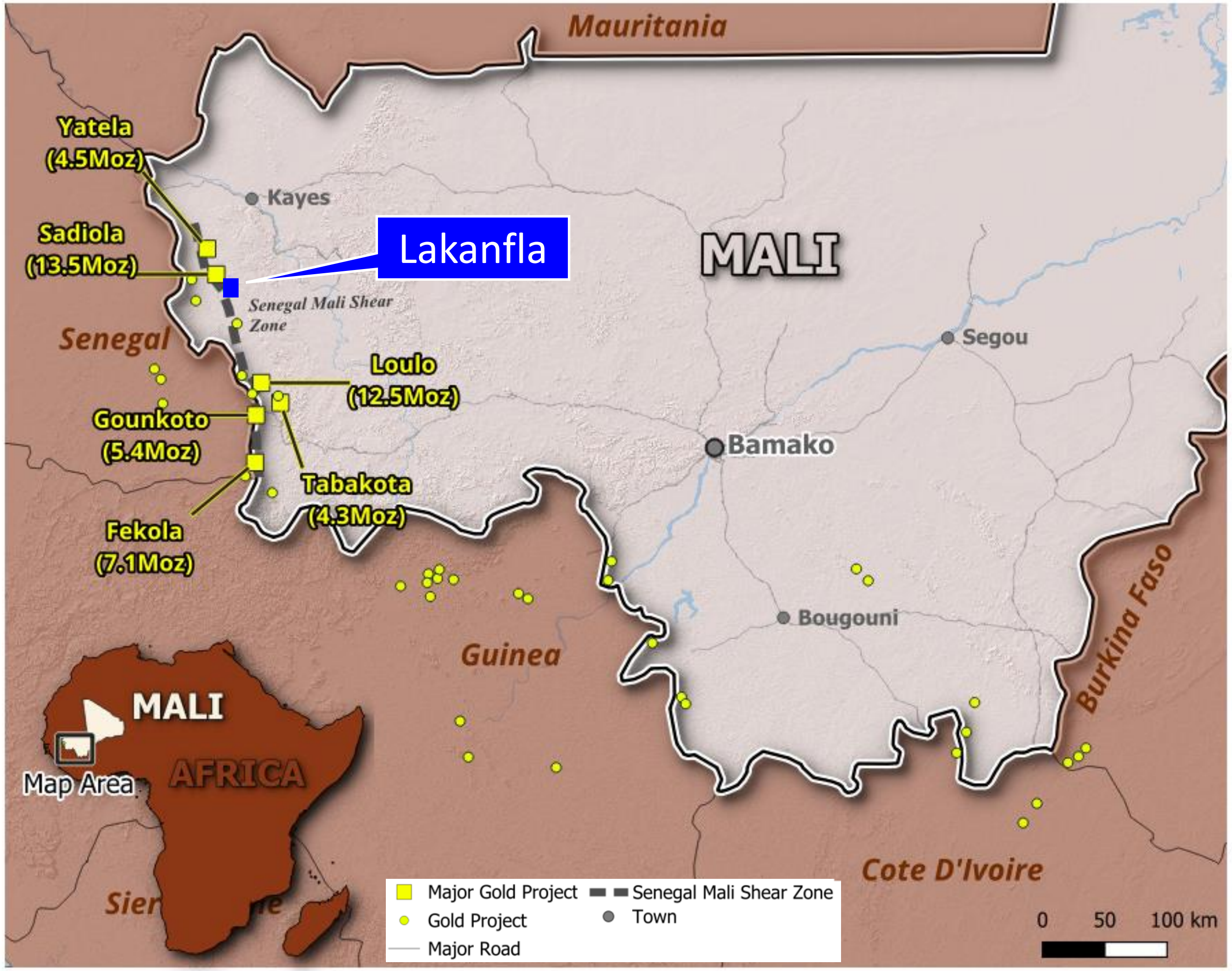
Special thanks to Chris van Wijk

MARVELGOLD

Introduction and Location

Resource Potentials

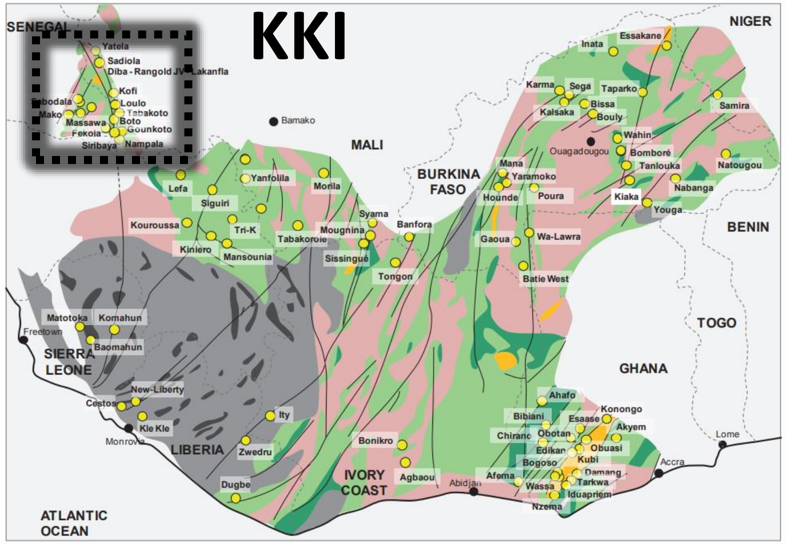
- Located in western Mali, near the border with Senegal, ~411 km northwest of Bamako, Mali capitol.
- Sits within a Birimian granite-gneiss-greenstone terrane, along the gold endowed Senegal-Mali Shear Zone.
- Prospective for both orogenic gold and karst-style supergene gold mineralisation.
- Along trend of the world class Sadiola gold project (orogenic and supergene mineralisation) and the Yatela gold project (karst-style supergene mineralisation), as well as other gold projects and numerous gold occurrences.
- Legend Gold (Altus Strategies PLC) identified primary gold mineralisation around 2011 through drill testing of surface geochemical anomalism. Follow-up exploration included geological mapping, field reconnaissance, GAIP and ground gravity surveying.
- Legend entered into a JV with Marvel Gold in 2020, who advanced exploration through drilling and additional geophysical surveys, including passive seismic HVSR to assist with subsurface mapping of karst-style supergene gold potential in the project area.



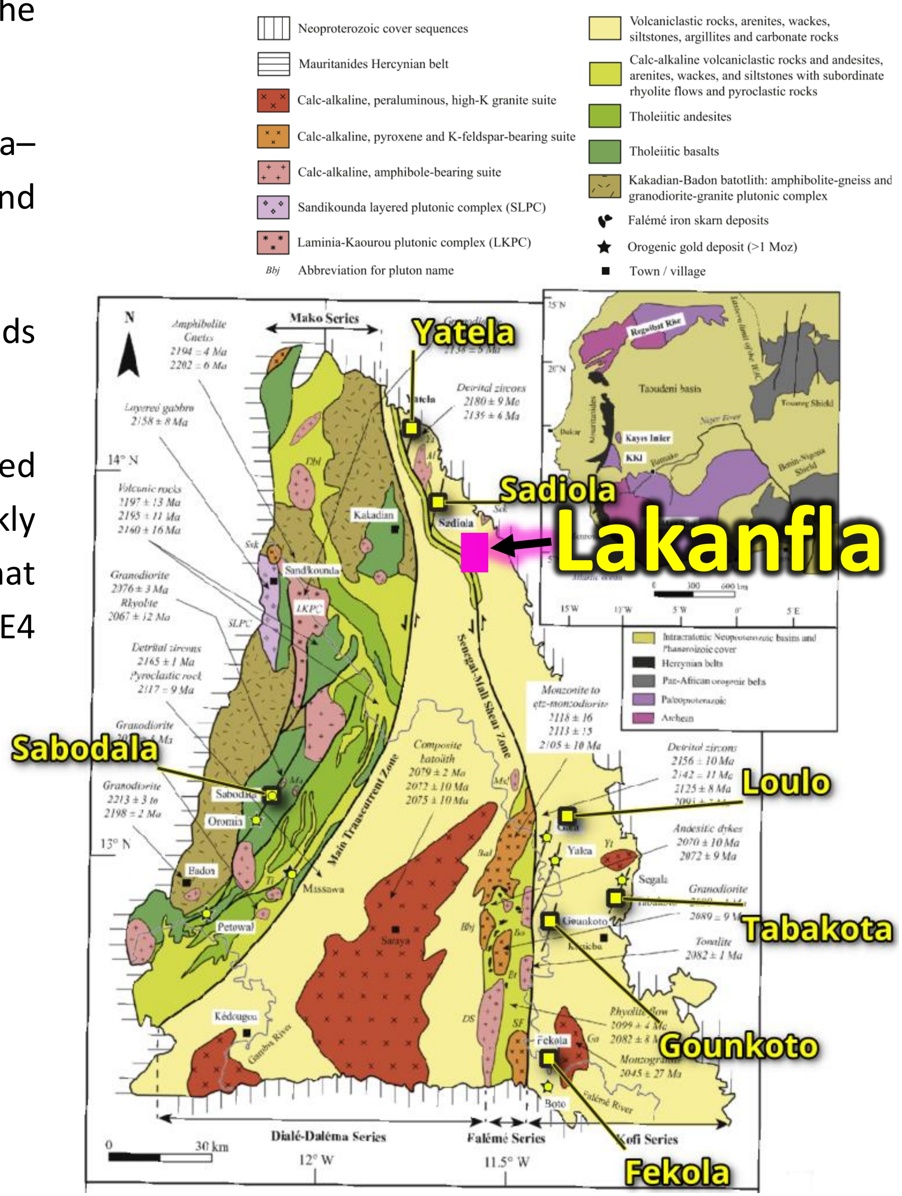
Location of the Lakanfla Project.

Regional Geology

- Located within the Kédougou–Kéniéba Inlier (KKI), which represents the western most exposure of the Paleoproterozoic Birimian terrane of the West African Craton.
- KKI hosts multiple world-class gold districts (e.g. Loulo–Gounkoto, Sadiola–Yatela, and Sabodala–Massawa), which are focused around major shear zones that control hydrothermal fluid flow and regional orogenic gold mineralisation.
- KKI is dominated by metavolcanic and metasedimentary sequences intruded by syn-kinematic granitoids providing heat, fluids and structures for hydrothermal gold mineralisation.
- Unlike other Paleoproterozoic belts, the inlier contains abundant carbonate host rocks, represented locally by the Kofi Series. Karst processes play a critical role in secondary gold enrichment, where weakly Au mineralised carbonate hosted zones undergo dissolution to form deep troughs and cavities that upgrade gold through supergene enrichment processes (e.g. Yatela gold deposit and Sadiola FE3 and FE4 pits).
- Lakanfla sits adjacent to the northern extension of the crustal-scale Senegal-Mali Shear Zone, about 6.5 km to the south of Sadiola FE3 and FE4 pits and 35 km to the south of the Yatela.



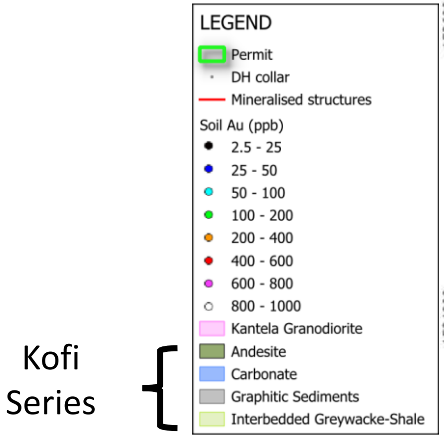
Simplified geological map of the West African Craton showing main gold deposits (yellow dots) (re-produced from André-Mayer et al., 2015).

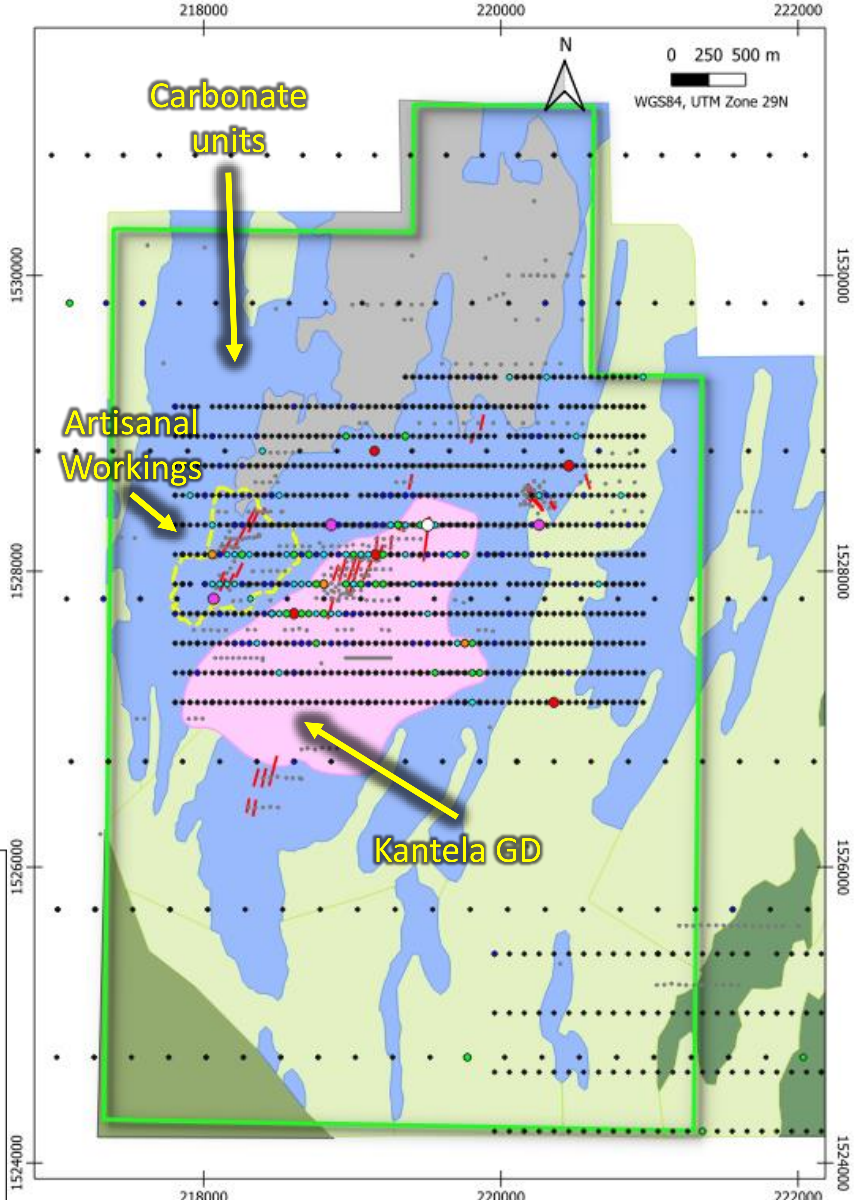


1:250,000 scale geological map of the Kédougou–Kéniéba Inlier (re-produced from Masurel et al., 2016).

Local Geology and Gold Mineralisation

- Carbonates and metasediments of the Kofi Series are intruded by the syn-kinematic Kantela granodiorite which provided heat, fluids and structural contacts and faulting for focusing hydrothermal Au mineralisation.
- Lakanfla hosts a number of active and historical artisanal Au workings that coincide with strong surface Au geochemical anomalies and mineralised structures observed in outcrop and geophysical anomaly images.
- Primary mesothermal Au mineralisation is structurally controlled forming breccia and fault zones in the Kantela granodiorite intrusion and surrounding carbonate country rocks.
- Historical drilling mainly targeted orogenic gold within structures, and did not test for potential karst supergene Au mineralisation which may be blind and formed enrichment zones at depth.
- Evidence of ground collapse sometimes occurs at the surface related to karstification and related voids formed at depth within carbonate rocks.
- Lakanfla is geologically analogous to the major Yatela gold project located just to the north.





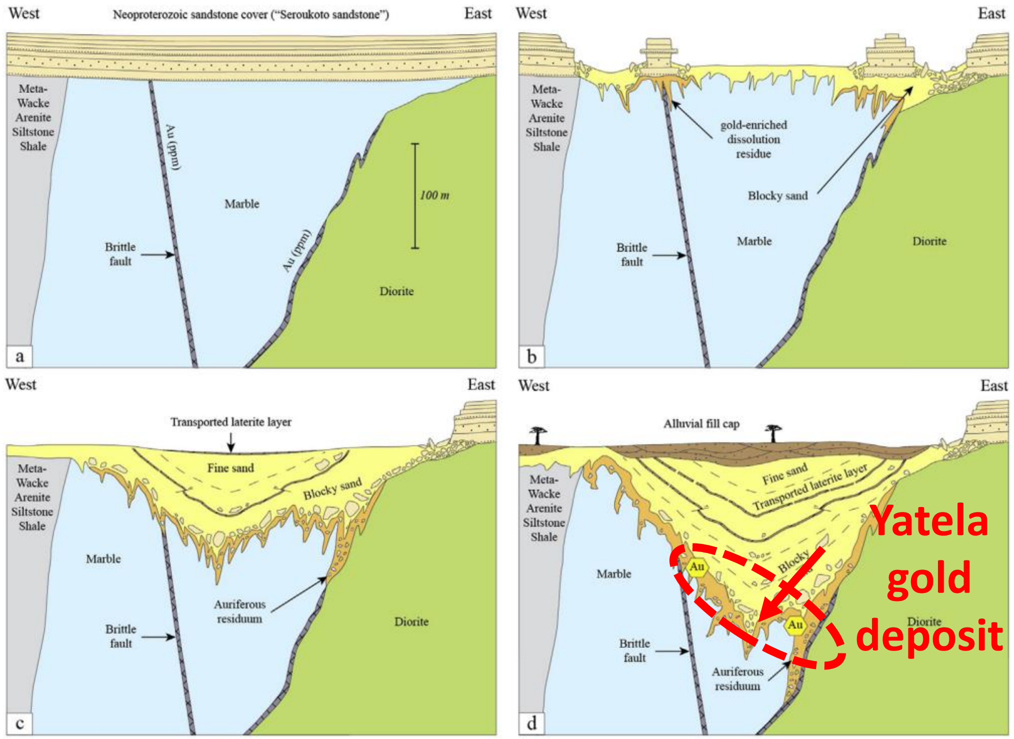
Local bedrock geology overlain by drill collars and soil samples coloured by Au (ppb).

Yatela Karst-Style Supergene Au Mineralisation North of Lakanfla

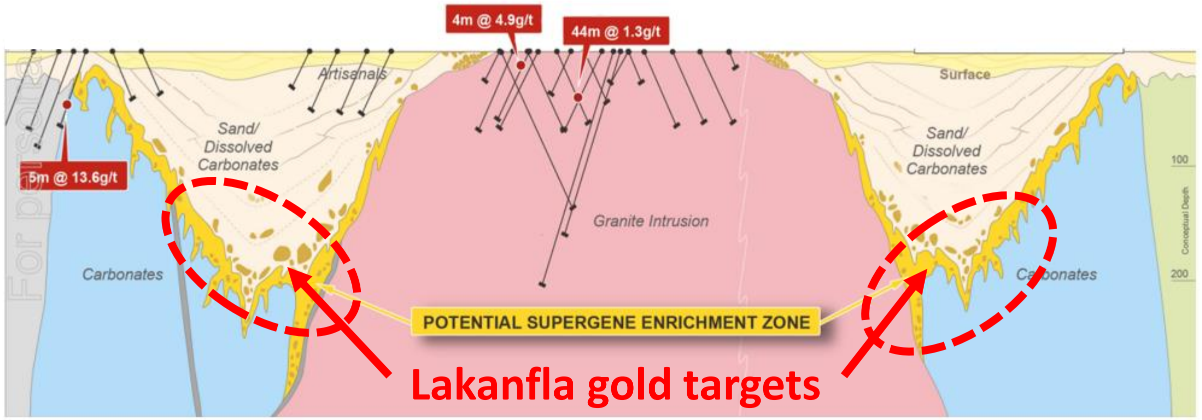
Yatela key features	Lakanfla
Marble and metasedimentary rocks of the Kofi Series intruded by a diorite acting as a mineralising related source and host rock	✓
Primary Au mineralisation occurs along breccia and faults structures	✓
Evidence of karst formation (voids, collapsed material and sands) in historical drilling and artisanal workings proximal to the diorite	✓
Good correlation between gravity lows and weathered carbonate units adjacent to diorite as an indicator of karst development at depth	✓
Supergene gold deposit zones result from dissolution of lower grade Au mineralised carbonate rocks	TBC

- The Lakanfla karst-style supergene Au targets were not drill tested due to the company focusing exploration drilling and resource definition at their Tabakorole Au Project in southern Mali.
- Lakanfla has a similar geological setting to Yatela, where dissolution and collapse of weakly Au mineralised carbonate rocks, associated with the emplacement of the granodiorite, could form supergene gold deposits at the base of the deep weathering profile similar to Yatela.

YATELA



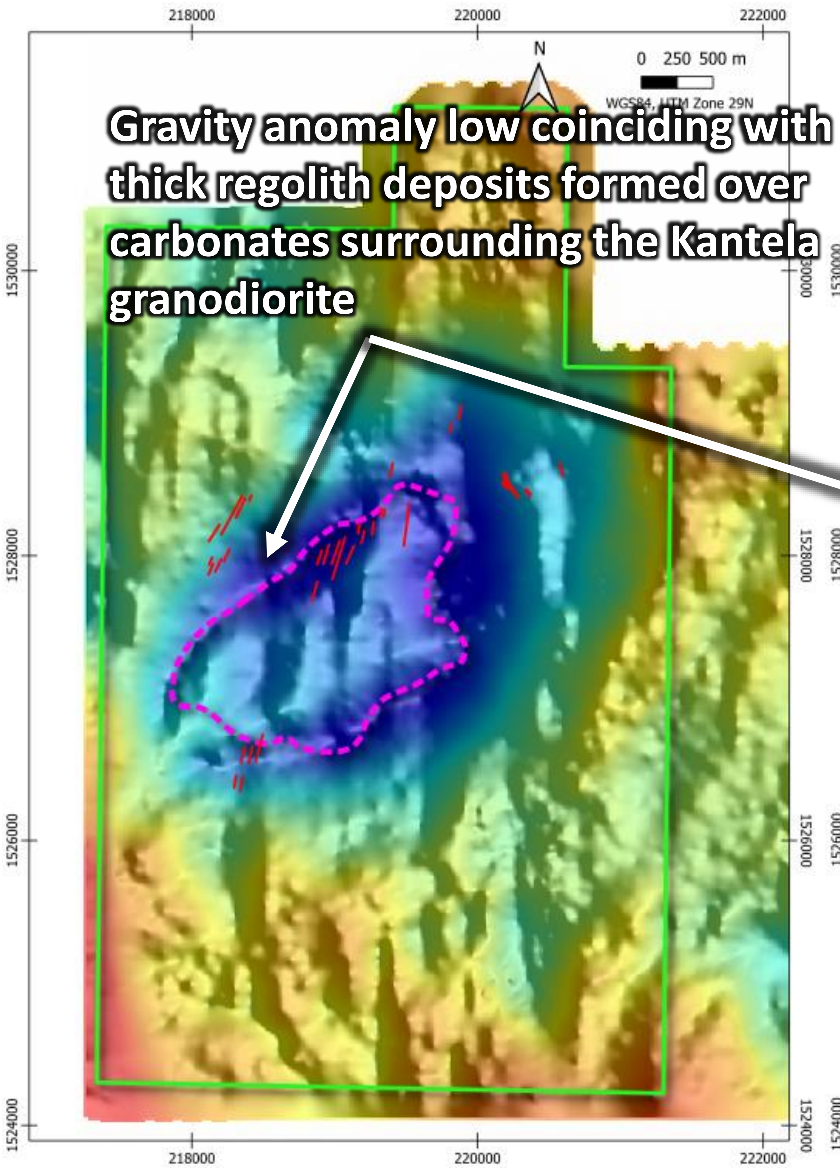
Yatela-type karst model schematic (re-produced from Masurel et al., 2015).



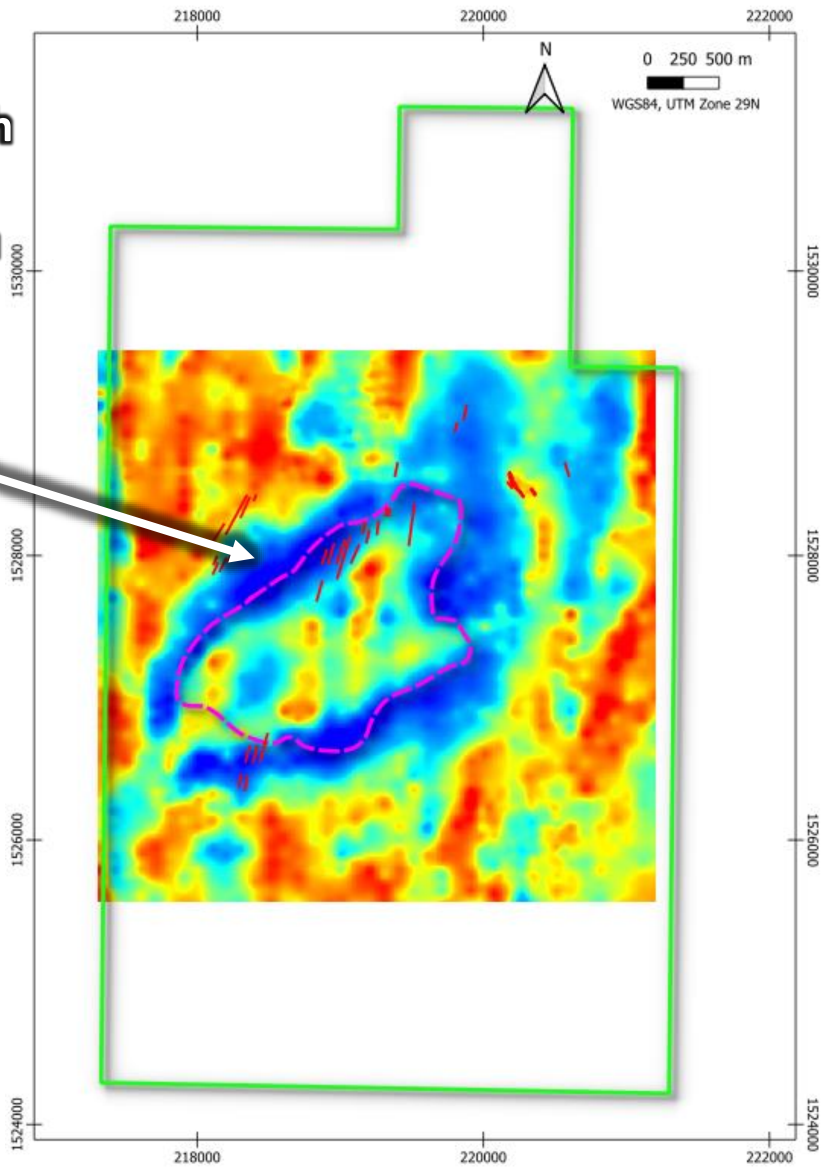
Geological cross section over Lakanfla (re-produced from Graphex Mining Presentation July, 2020).

Ground Gravity

- Ground gravity surveying was completed to assist with mapping gravity anomaly low zones related to low density granitic intrusions, deep weathering and collapse fill in carbonates, lithological units and structures.
- Gravity successfully mapped a ring-shaped, moat-like gravity anomaly low coinciding with the carbonates encircling the slightly higher density Kantela granodiorite.
- Gravity low moat caused by thick deposits of low density young sands and carbonate collapse fill overlying fresh bedrock, consistent with the development of a substantial karst zone surrounding the intrusion.
- This ring-like gravity low structure is considered highly prospective for targeting supergene Au mineralisation, especially at deeper zones crossed by Au mineralised structures.
- Passive seismic HVSR surveying was completed to compliment gravity survey results by mapping acoustic fresh bedrock topography and thicknesses of the weathering zone to target supergene Au mineralisation and predict drilling depths, with the bedrock topography from HVSR to be used for project development if exploration drilling was successful.



Ground gravity image with NE sun shading overlain by interpreted outline of Kantela granodiorite and gold mineralised structures.



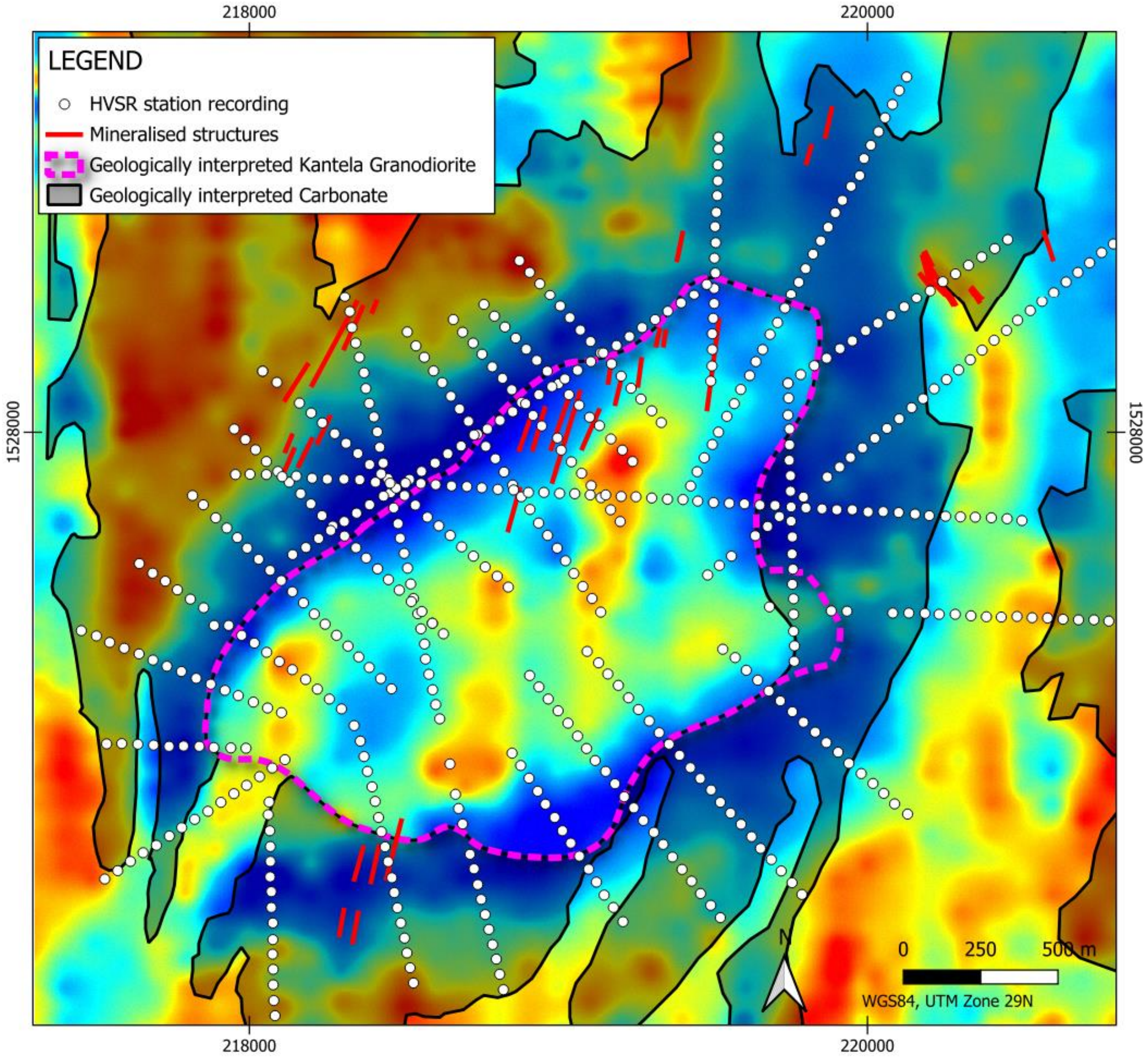
Residual filtered ground gravity image overlain by interpreted outline of Kantela granodiorite and gold mineralised structures, emphasizing the circular deep weathering "moat" surrounding the intrusion.

Passive Seismic HVSR Surveying

- HVSR survey lines were orientated across the Kantela granodiorite intrusion and the surrounding ring-shaped gravity anomaly low coinciding with deeply weathered carbonate rocks.
- HVSR data acquired using 4x self contained Tromino® ENGY TE3 seismometers in a leap-frog fashion.
- Passive seismic HVSR data were acquired using a sampling frequency of 128 Hz and an acquisition recording time of 20 minutes per recording station
- HVSR data acquired over a 2-week period by local Marvel staff in 2020.
- Total of 559 HVSR station recordings acquired along 25 survey lines using 50 m HVSR station spacing, for a total of 37.4 survey line-kms.

Tromino® ENGY TE3 seismometer specifications:

- Manufacturer: MoHo s.r.l.
- Dimensions: 10 x 14 x 8 cm
- Weight: 1.1 kg
- Vibration sensors: 3 orthogonal velocimeters
- Sampling rate: 64 kHz per channel
- Output sample rate: 128 Hz
- Sensor frequency range: 0.1 - 1024 Hz



Passive seismic HVSR station locations, Au mineralised structures, outlines of the Kantela granodiorite intrusion and carbonate units shown as grey shading, overlain on a residual filtered ground gravity anomaly image (GBA, resUC100m).

Example HVSR Recording Station - Editing and Cleaning (slide 1/2)

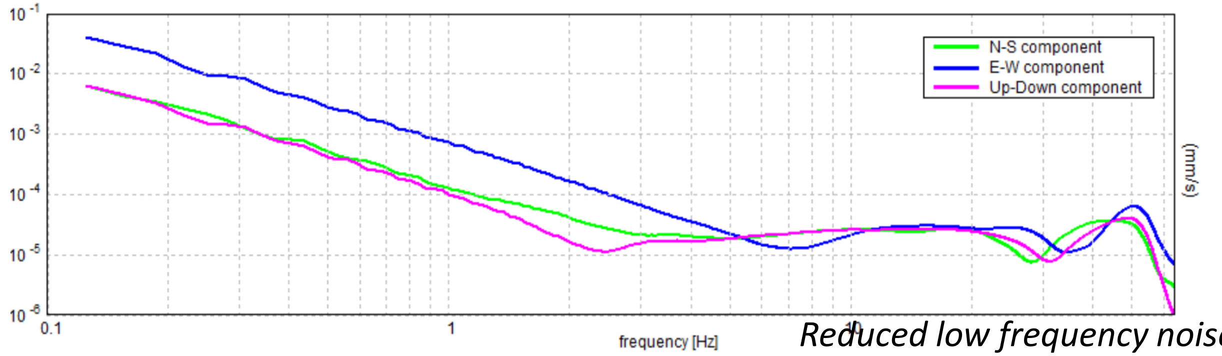
Resource Potentials

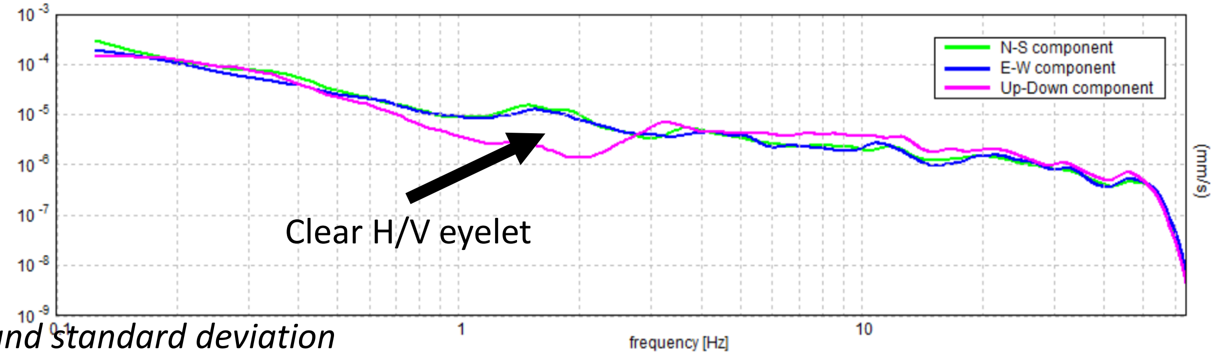
- The majority of HVSR station recordings were of good data quality, with only minimal editing required to improve HVSR bedrock peak frequency responses.
- Main HVSR bedrock peak frequency response interpreted to be top of hard and fresh granodiorite or carbonate bedrock.

RAW

CLEANED

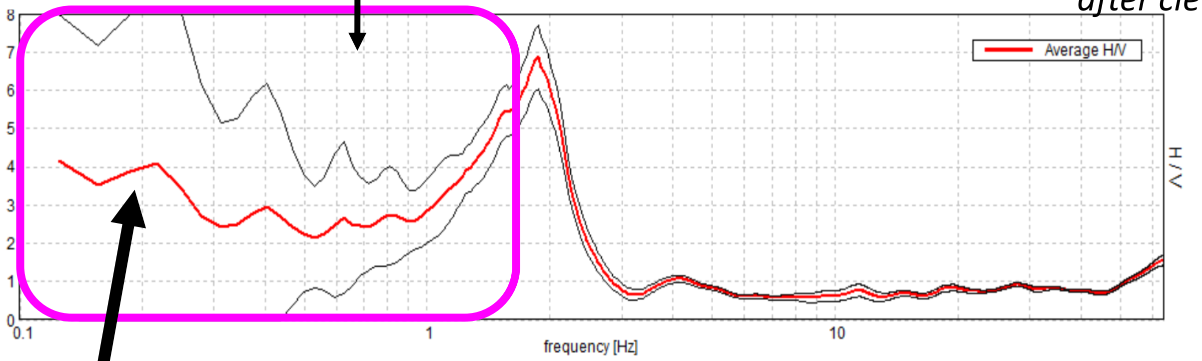
Line 13 – station 206

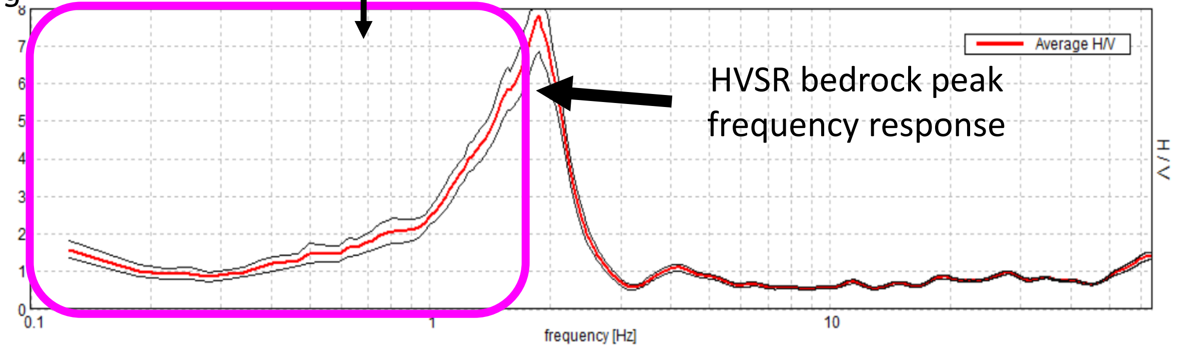




Clear H/V eyelet

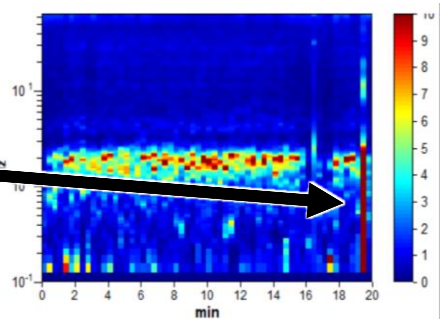
Reduced low frequency noise and standard deviation after cleaning

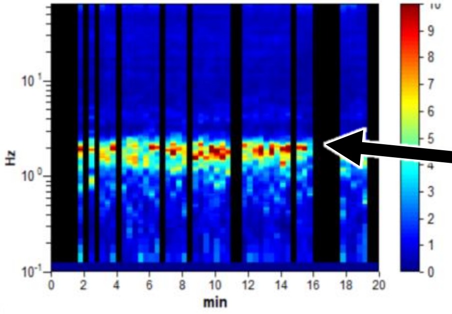




HVSR bedrock peak frequency response

Elevated low frequency noise caused by wind



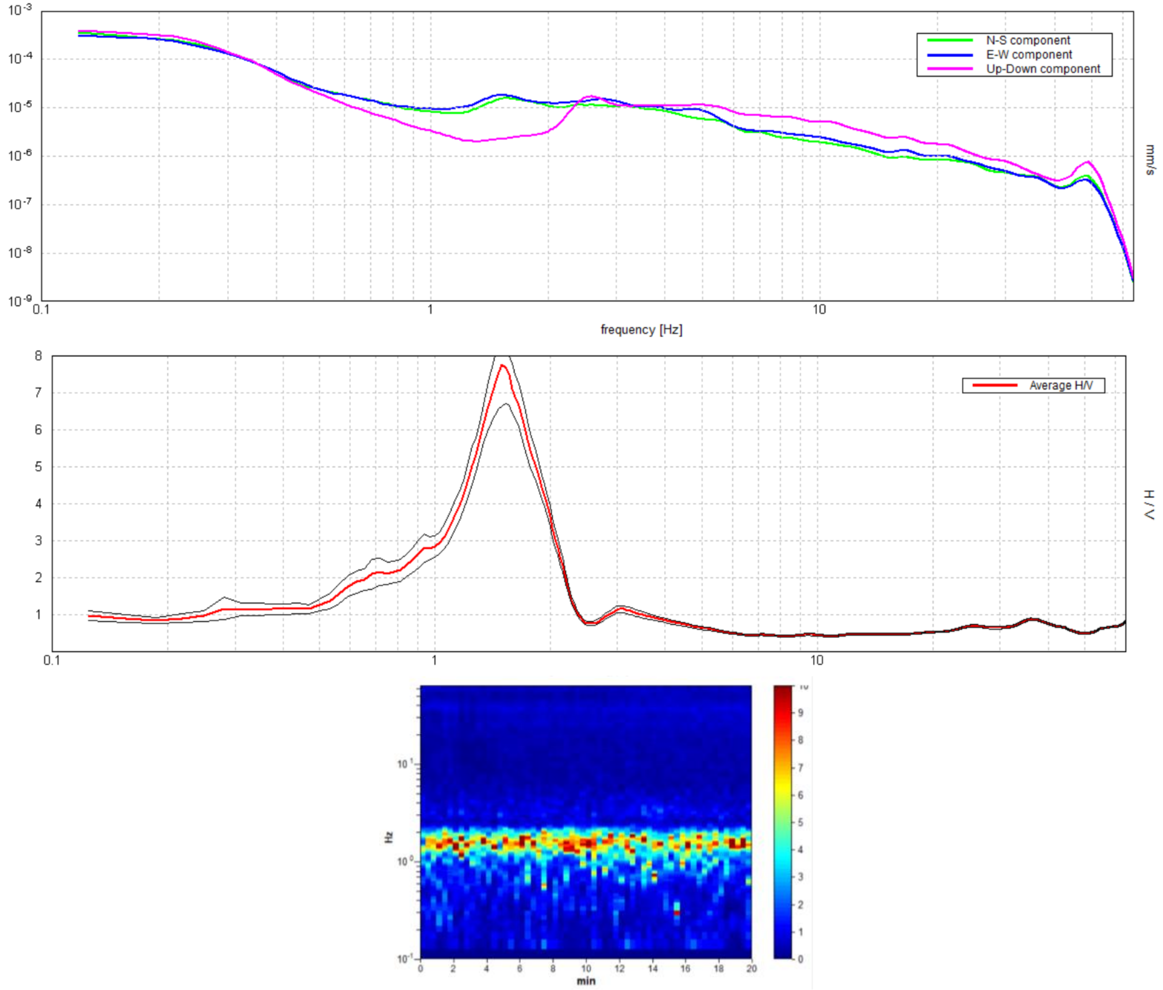


Time windows with noise events removed (black spaces)

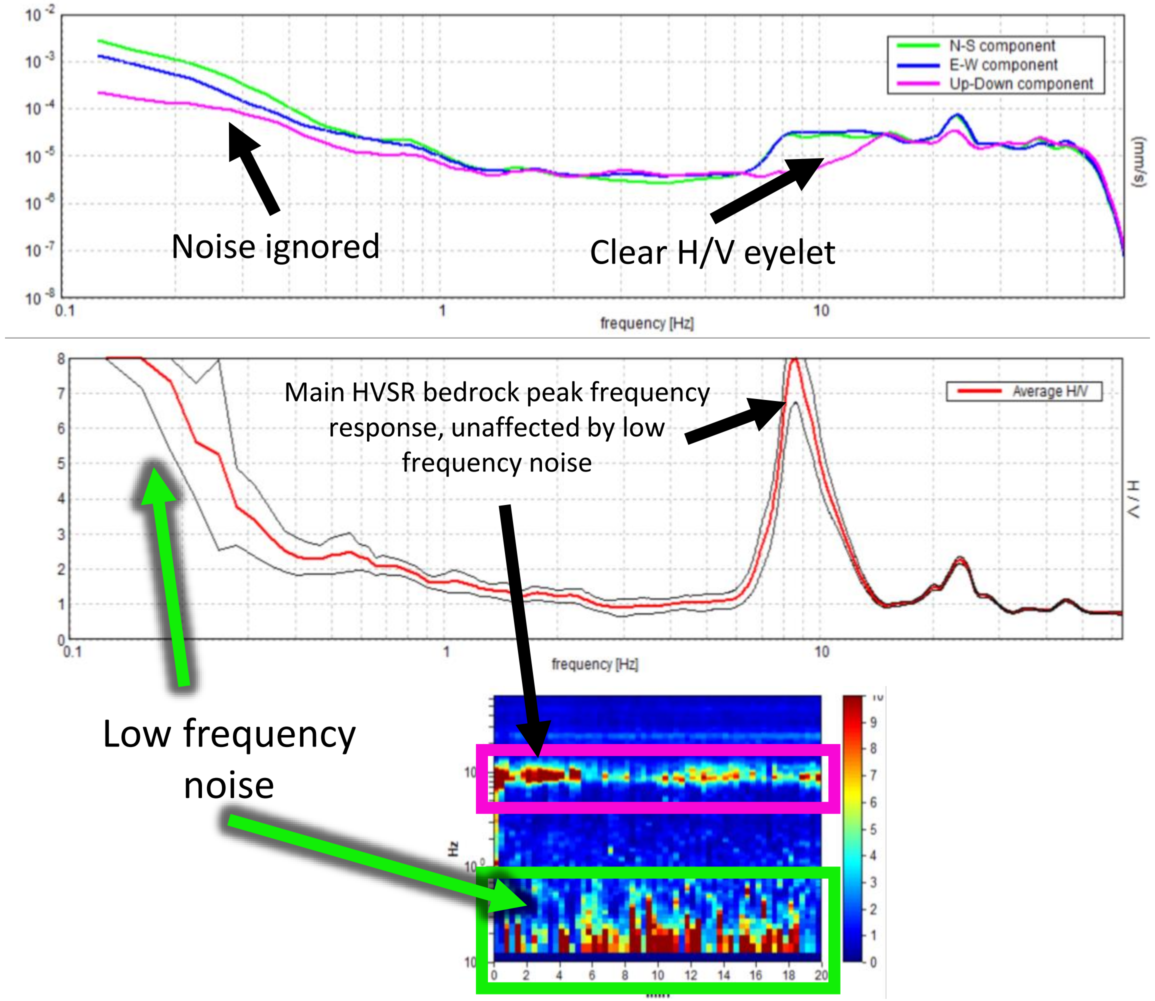
Example HVSR Recording Station - Editing and Cleaning (slide 2/2)

Resource Potentials

- A number of HVSR station recordings were of very high quality and did not require data cleaning.



- A number of HVSR station recordings displayed low frequency noise continuous across the full 20-minute recording time, but the main HVSR bedrock peak frequency response was not affected, and therefore data were not cleaned and responses below 1 Hz were ignored.

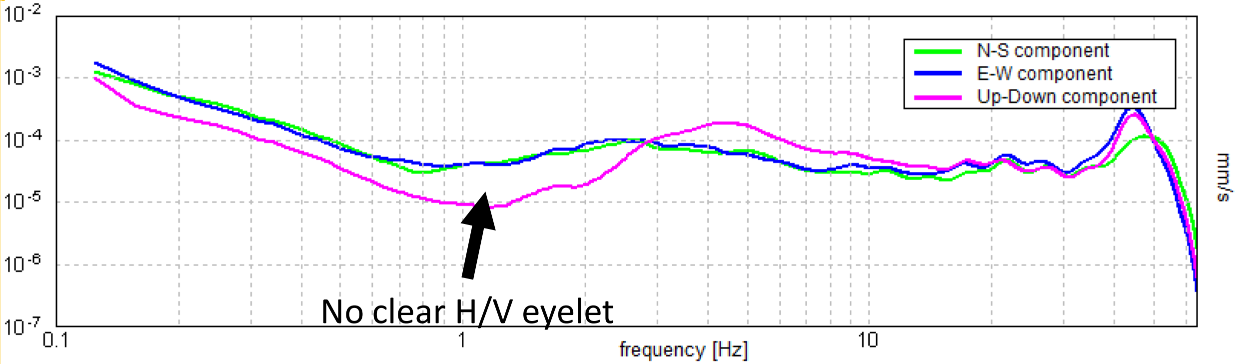


Example HVSR Repeat Station Recording

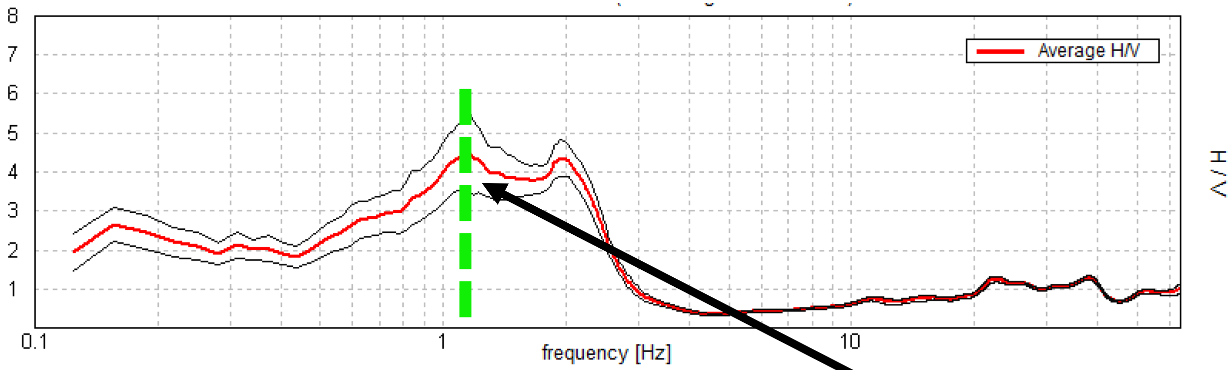
- A handful of HVSR station recordings were repeated due to low frequency noise during the entire recording period that swamped the main HVSR bedrock peak frequency response and were unable to be cleaned.
- These noisy HVSR station recordings were therefore repeated to confirm that the noise responses were likely caused by strong wind events, or in some cases outcropping fresh bedrock.

Line 19 – station 347

ORIGINAL

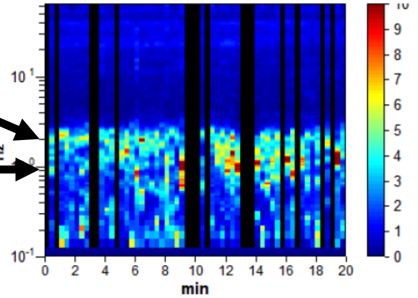


No clear H/V eyelet



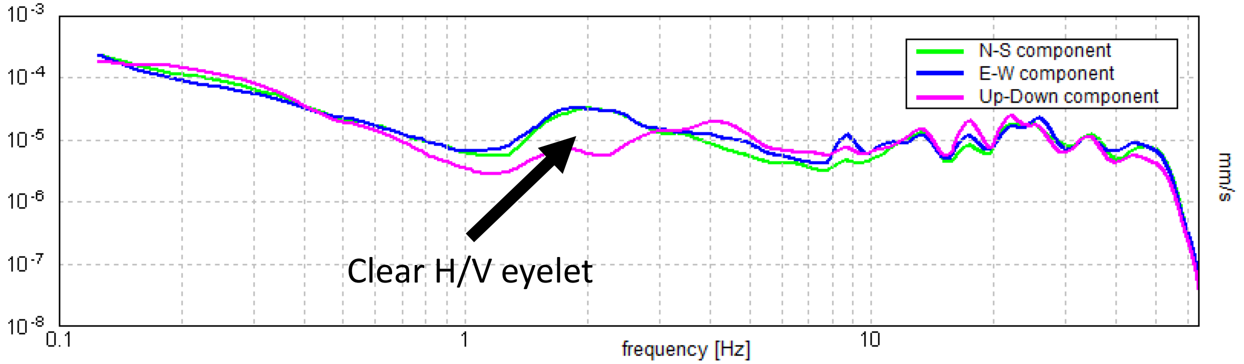
Consistent HVSR response across full time recording

Inconsistent and sporadic responses most likely caused by wind

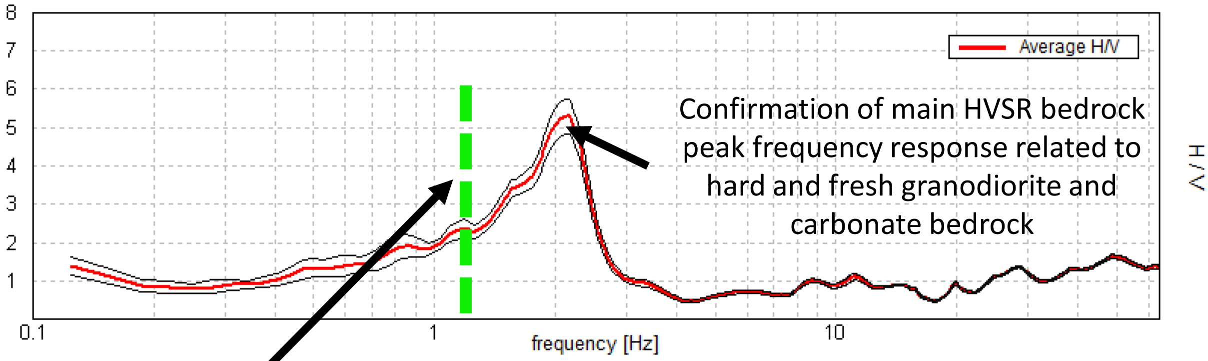


False HVSR peak response caused by wind disappears after repeating

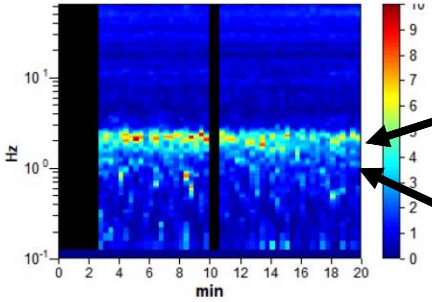
REPEAT



Clear H/V eyelet



Confirmation of main HVSR bedrock peak frequency response related to hard and fresh granodiorite and carbonate bedrock

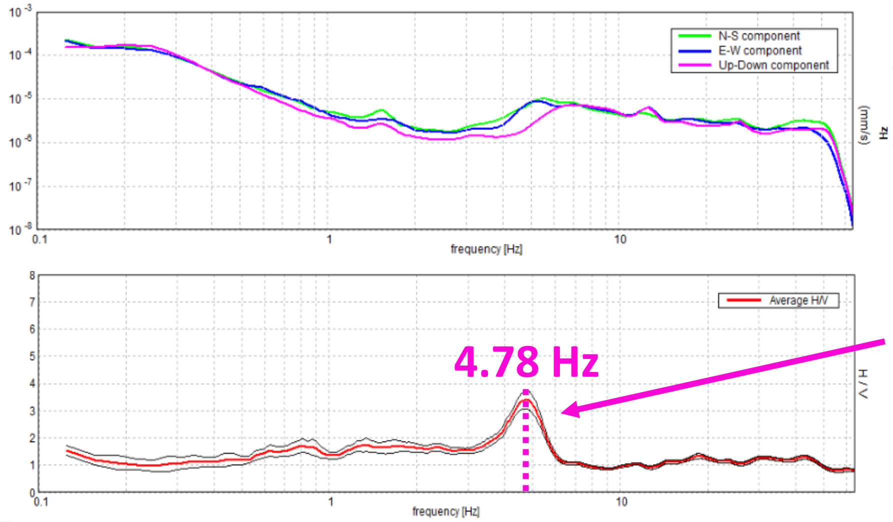


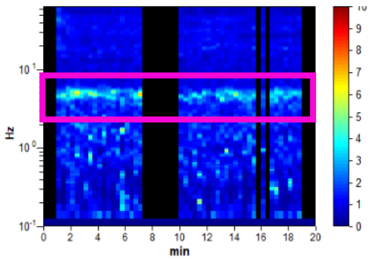
Consistent HVSR response across full time recording still observed

Inconsistent and sporadic wind noise not repeated

Examples of Typical HVSR Station Recordings

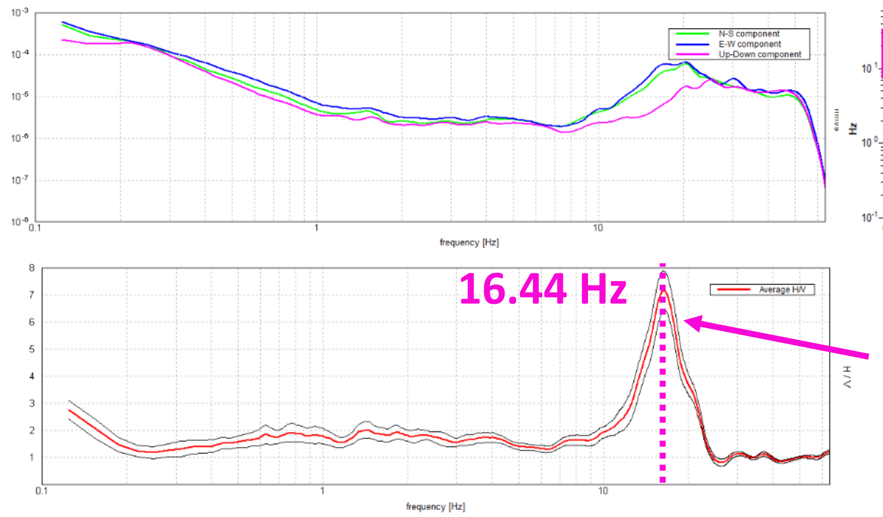
Line 04 – station 45

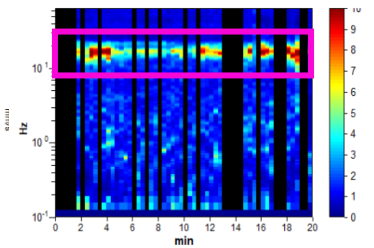




Low amplitude and mid frequency HVSR bedrock peak frequency response.

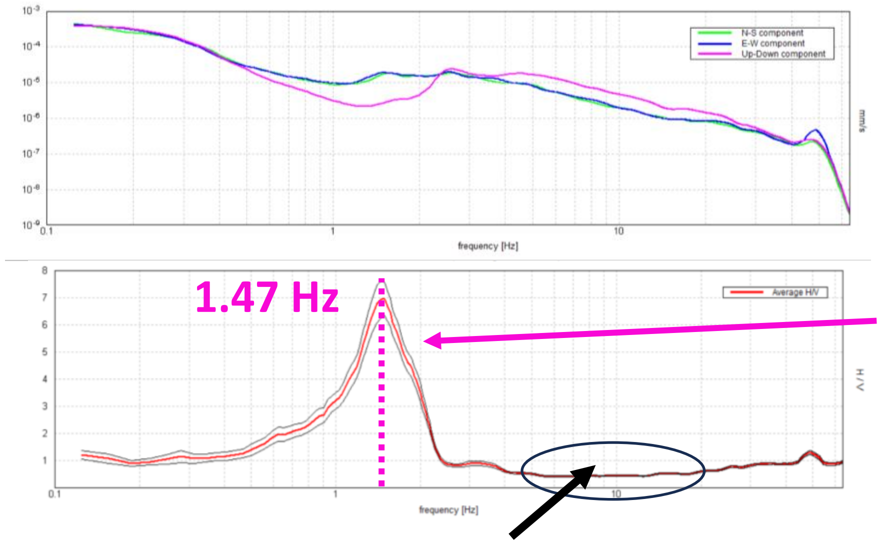
Line 03 – station 30

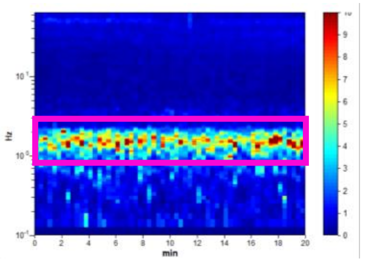




High amplitude and high frequency HVSR bedrock peak frequency response.

Line 22 – station 477

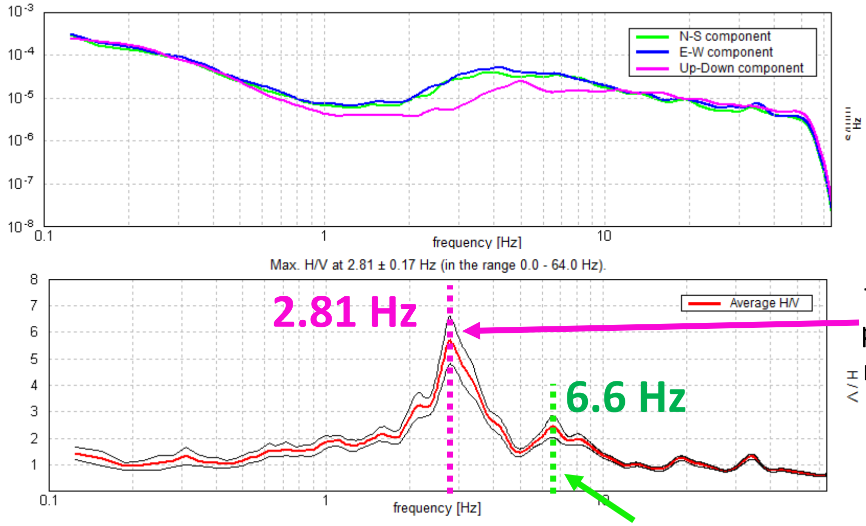


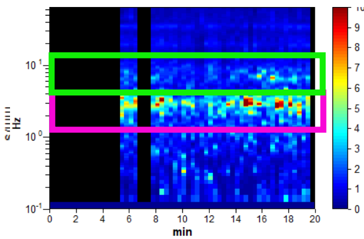


High amplitude and low frequency HVSR bedrock peak frequency response.

Velocity inversion likely caused by mud layer

Line 24 – station 511





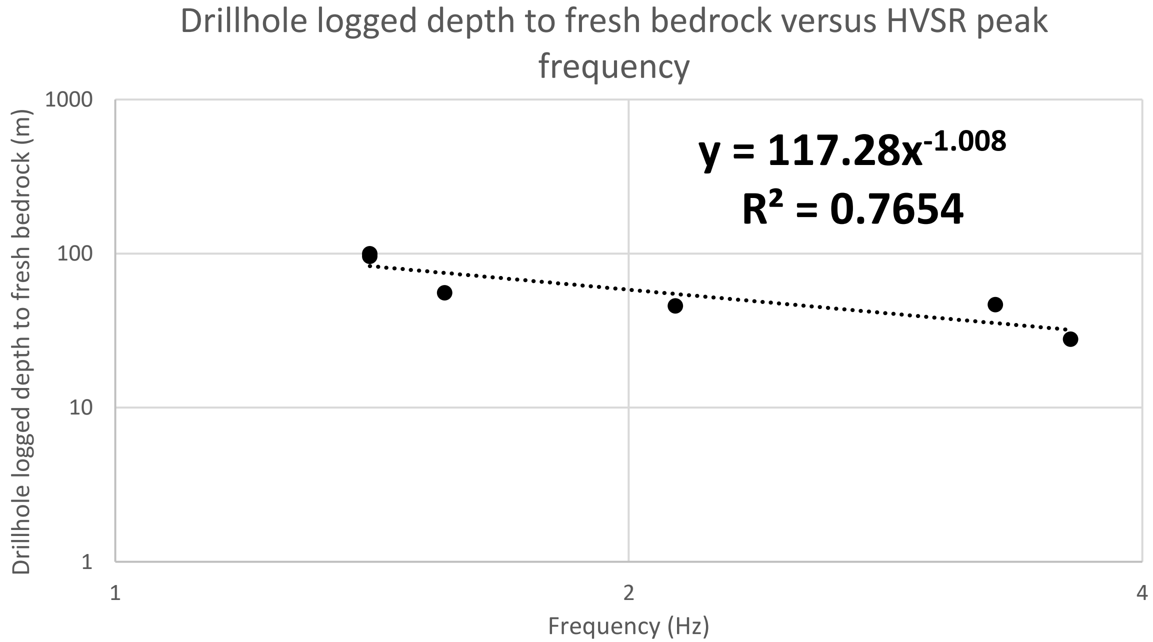
High amplitude and low frequency HVSR bedrock peak frequency response related to hard and fresh granodiorite or carbonate bedrock.

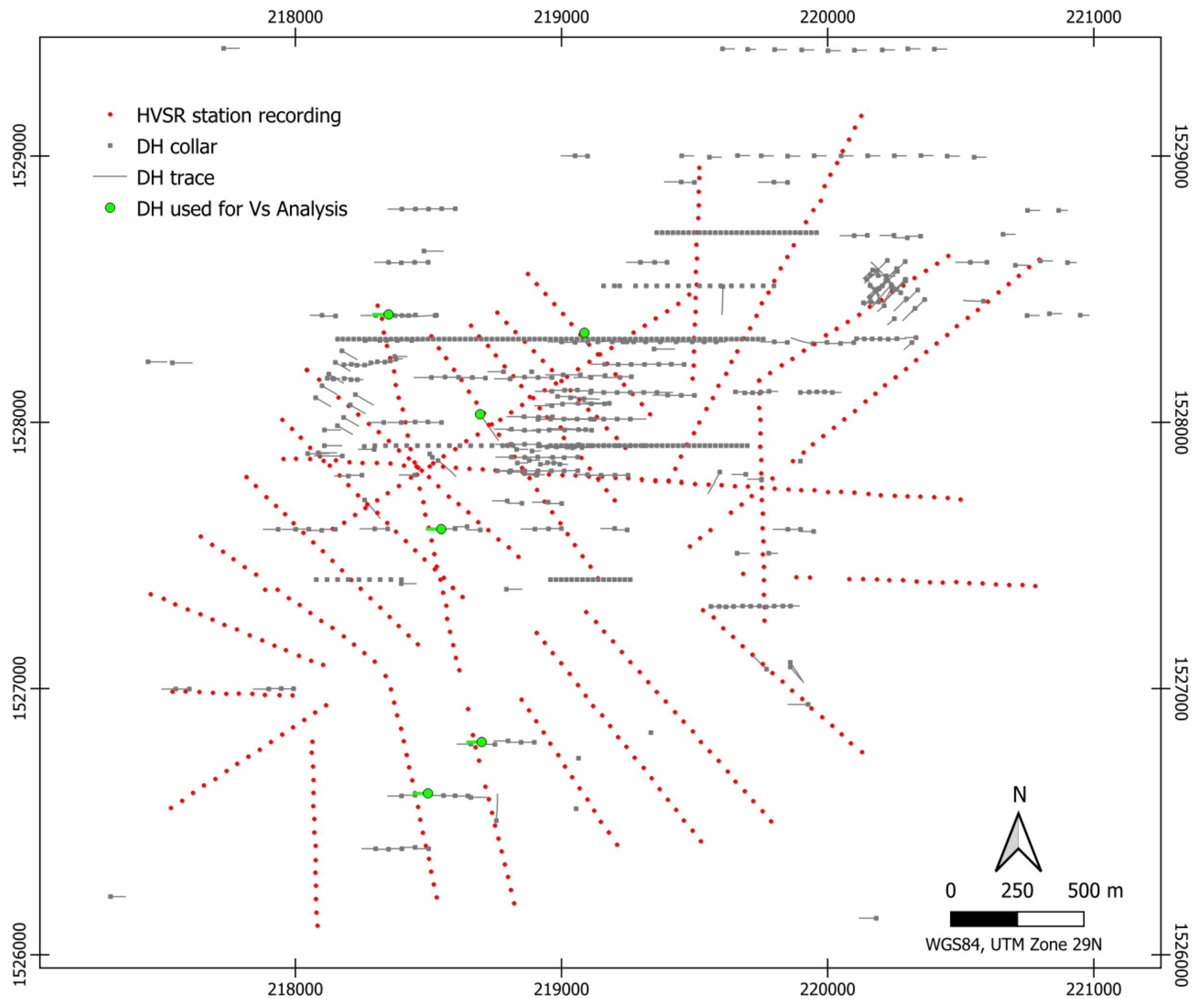
Secondary HVSR peak frequency response relating to an acoustic impedance contrast within the regolith cover likely caused by blocks of carbonate rocks or with layering within the regolith, such as clay/sand layers or cementation bands.

Shear Wave Velocity Analysis and Frequency Depth Conversion

Resource Potentials

- HVSR frequency data converted to depth by calibrating HVSR bedrock peak frequency (f_0 in Hz) responses to coincident fresh bedrock depth from drillholes.
- HVSR station recordings within 20 m of drillholes intersecting fresh bedrock were used to calculate a trendline equation relating these two parameters.
- Note the high correlation coefficient of 0.8.
- Many drillholes did not log weathering information, only lithology, and therefore they were excluded from the Vs analysis.
- Using Nakamura's equation, an average Vs of the regolith was calculated to be 480 m/s, which is typical for transported sediments?

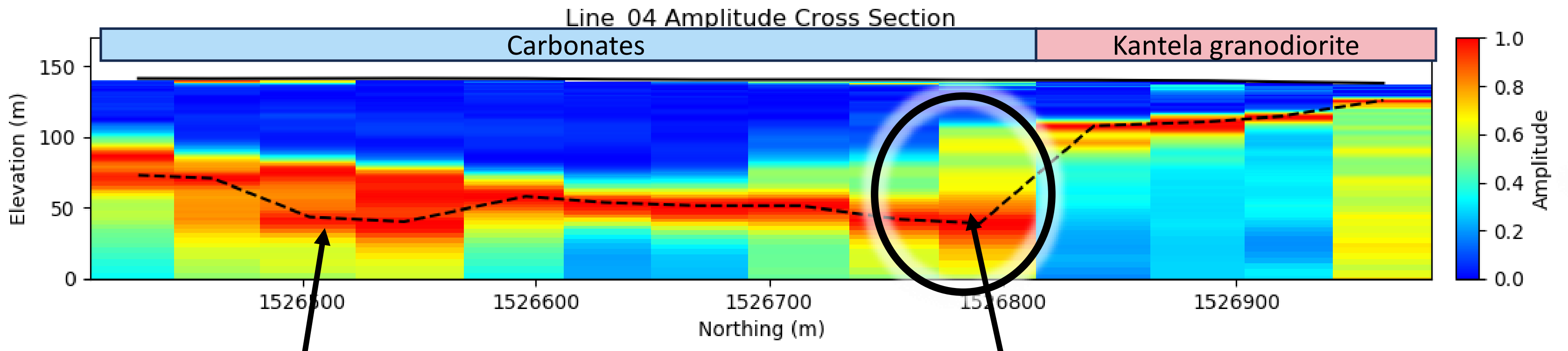




Map showing drillholes used for Vs analysis versus passive seismic HVSR station locations and all drillhole collars.

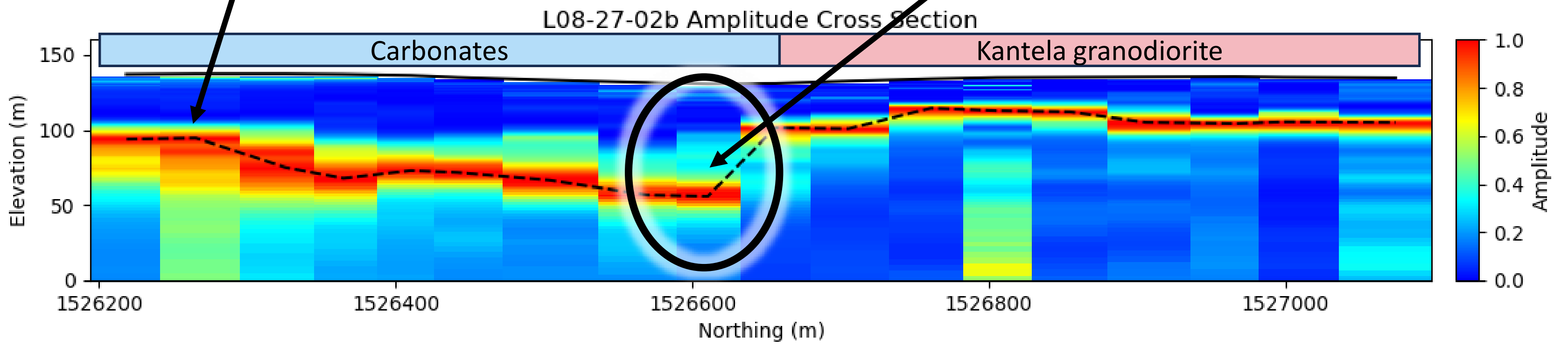
HVSR Cross Section Examples (slide 1 of 3)

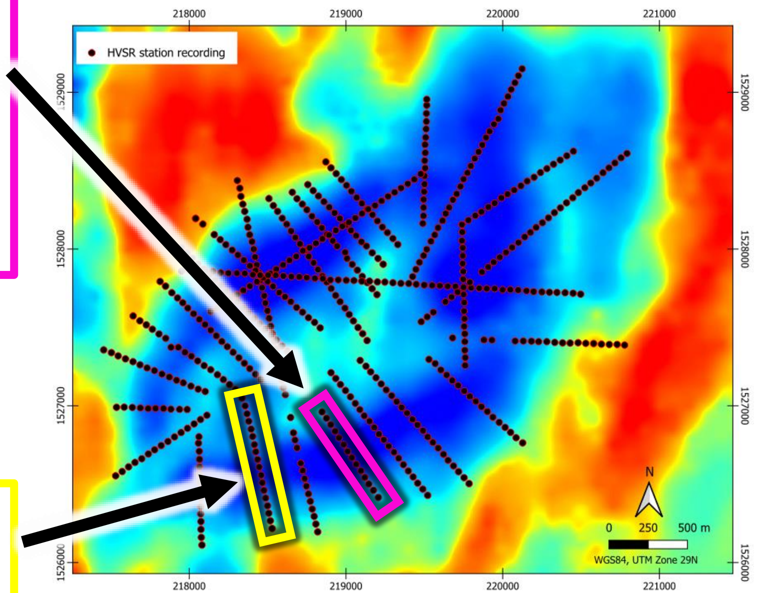
- A laterally continuous and undulating acoustic bedrock has been resolved on all survey lines relating to the interface between transported sands and saprolite overlying hard and fresh carbonate bedrock or granodiorite bedrock.
- Deeper acoustic bedrock occurs along the margins of the granodiorite intrusion where primary heat and fluid flow were greatest during and after intrusion, this has lead to zones of deeper weathering which now represent targets for supergene Au mineralisation.



Black line represents the acoustic bedrock of hard and fresh carbonates and granodiorite

Deeper acoustic bedrock resolved along margins of the granodiorite intrusion



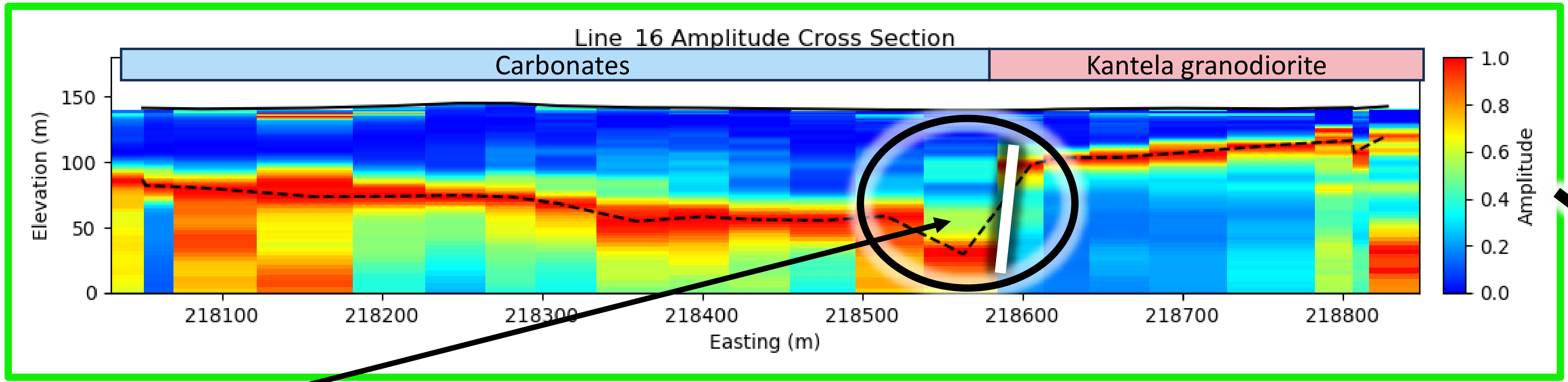


Passive seismic HVSR station locations over residual filtered gravity (HP5km) image.

HVSR Cross Section Examples (slide 2 of 3)

Resource Potentials

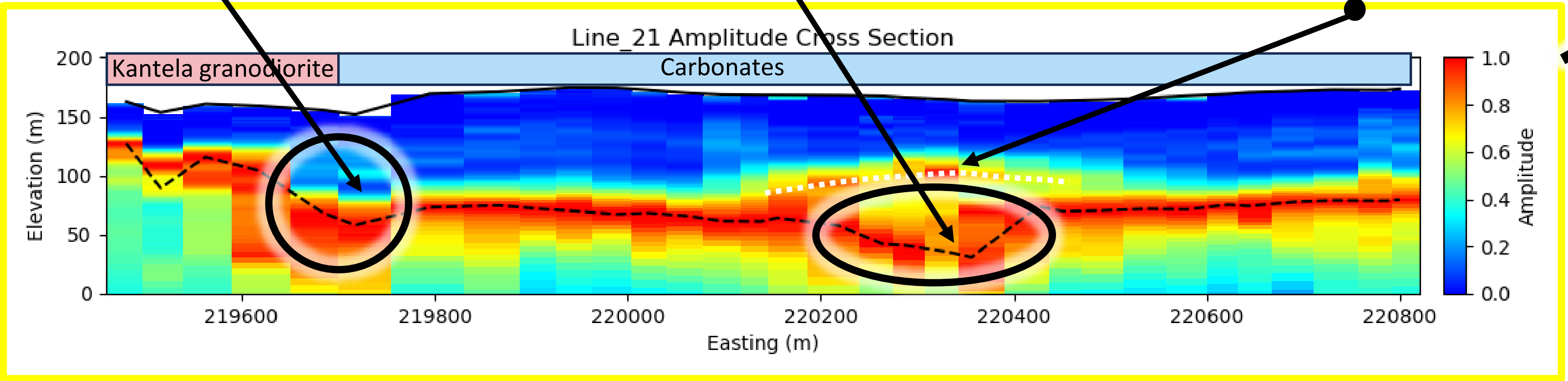
- Multiple acoustic impedance contrasts resolved, with the shallower response caused by blocks of more competent carbonates or layers within the regolith cover, such as clay/sand layers or cementation bands.
- Deeper acoustic bedrock resolved away from the margins of the intrusion could represent deeper weathering along fault/shear structures, some of which may host Au mineralisation and related sulphide alteration. These zones of deeper weathering are supergene Au targets for drill testing.

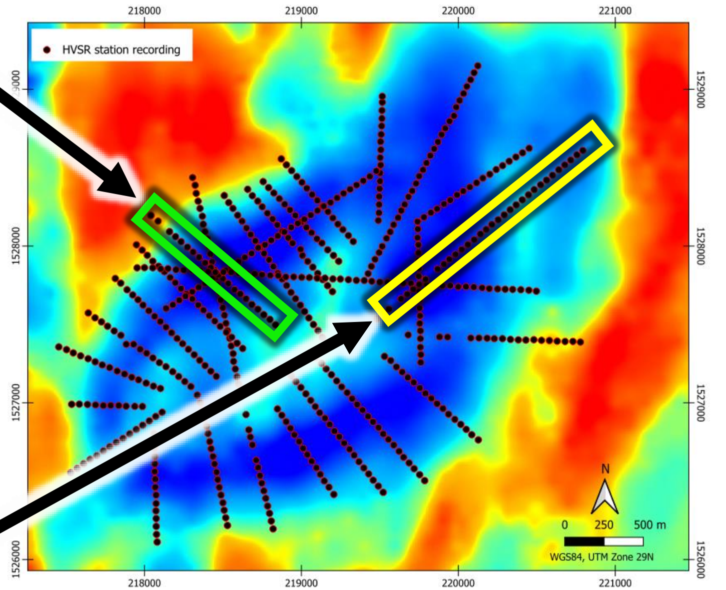


Deeper acoustic bedrock resolved along margins of intrusion

Deeper acoustic bedrock resolved away from the intrusion margin and possibly representing deeper weathering along a structure

Two HVSR layer responses resolved, shallow layer could represent more competent carbonate zones sitting above a dissolution void

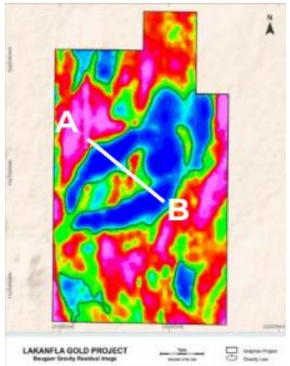


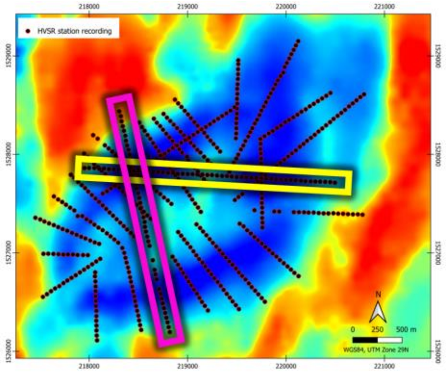


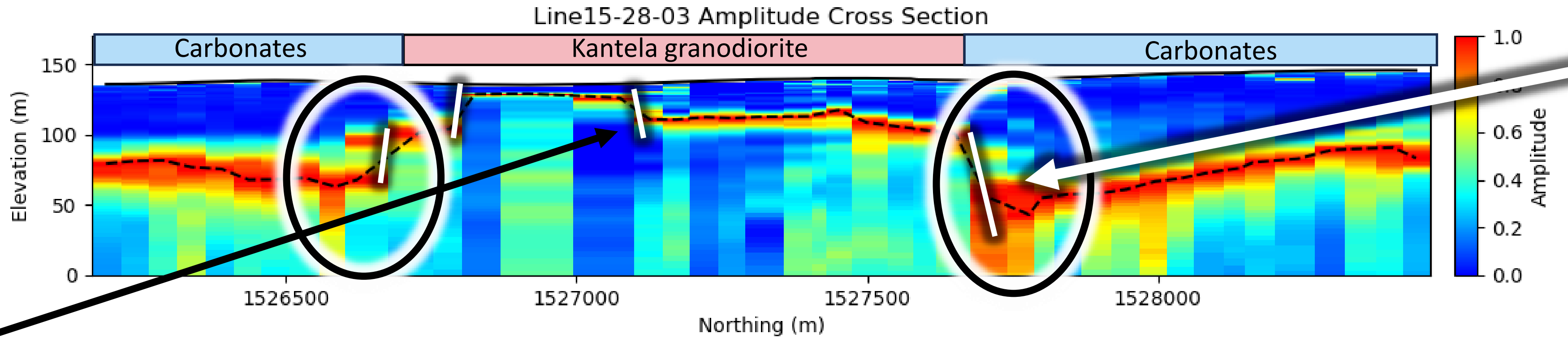
Passive seismic HVSR station locations over residual filtered gravity (HP5km) image.

HVSR Cross Section Examples (slide 3 of 3)

Conceptual geological cross section closely matches passive seismic HVSR cross section!

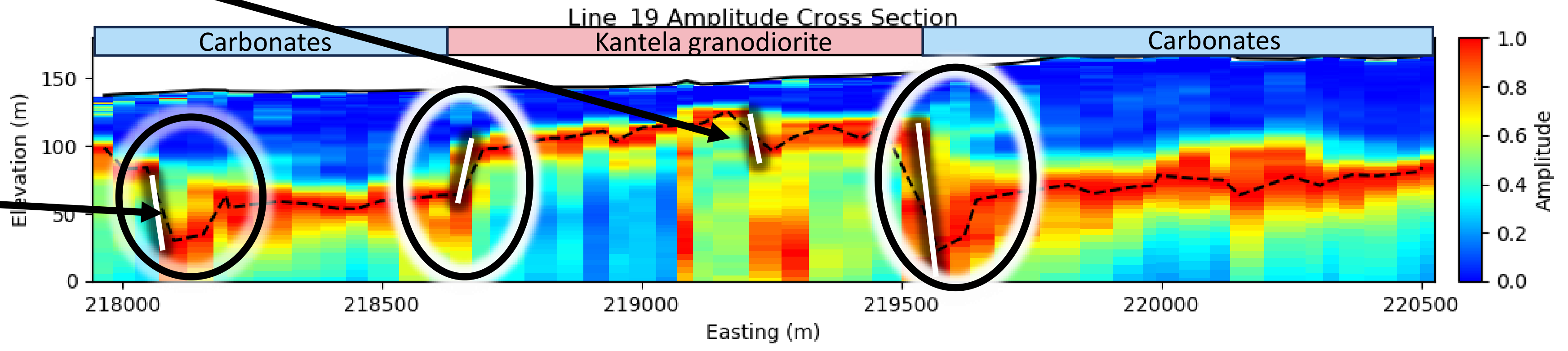






Deeper acoustic bedrock resolved along margins of intrusion representing supergene gold targets!

Potential faults within granodiorite representing gold targets

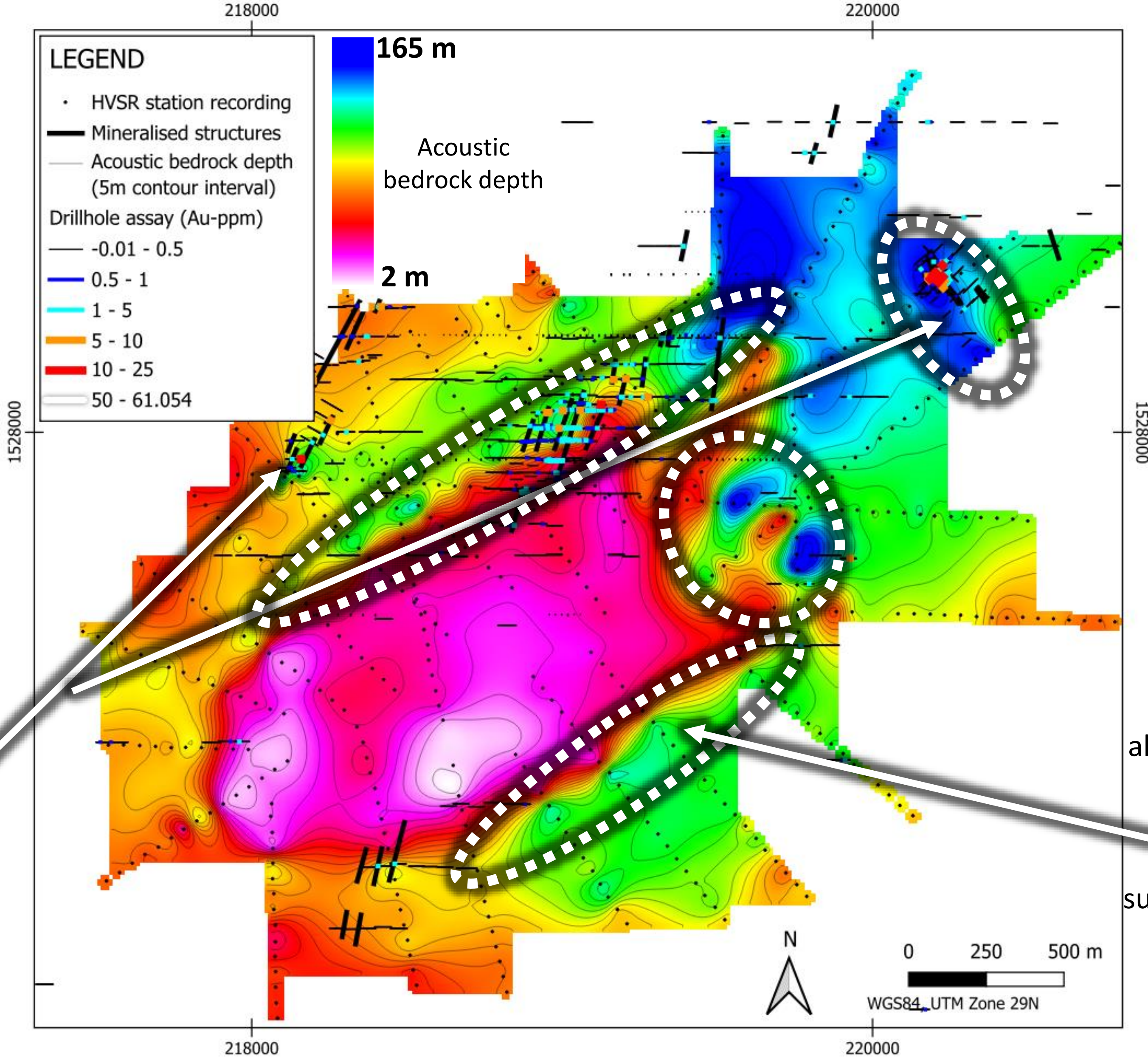


Deeper acoustic bedrock resolved within carbonate – potential deeper weathering along a fault/shear zone

HVSR Acoustic Bedrock Topography

- Calculated depth to acoustic bedrock ranges from 2 m to 165 m below land surface.
- HVSR survey resolves an asymmetrical, moat-shaped ring of deeper acoustic bedrock surrounding the intrusion, and formed by carbonate dissolution and collapse, followed by infill of young sedimentary deposits.
- Historical drilling (<100 m true depth) available at the time of this study was generally focused along the northern boundary of the Au mineralised granodiorite along vein systems, and around extensive artisanal Au workings, but the karst related supergene Au mineralisation targets similar to Yatela were not tested at Lakanfla at the time of this study ☹.

Zones of deeper acoustic bedrock located further away from the granodiorite intrusion correlate to artisanal Au workings and structures observed in gravity and magnetic anomaly images

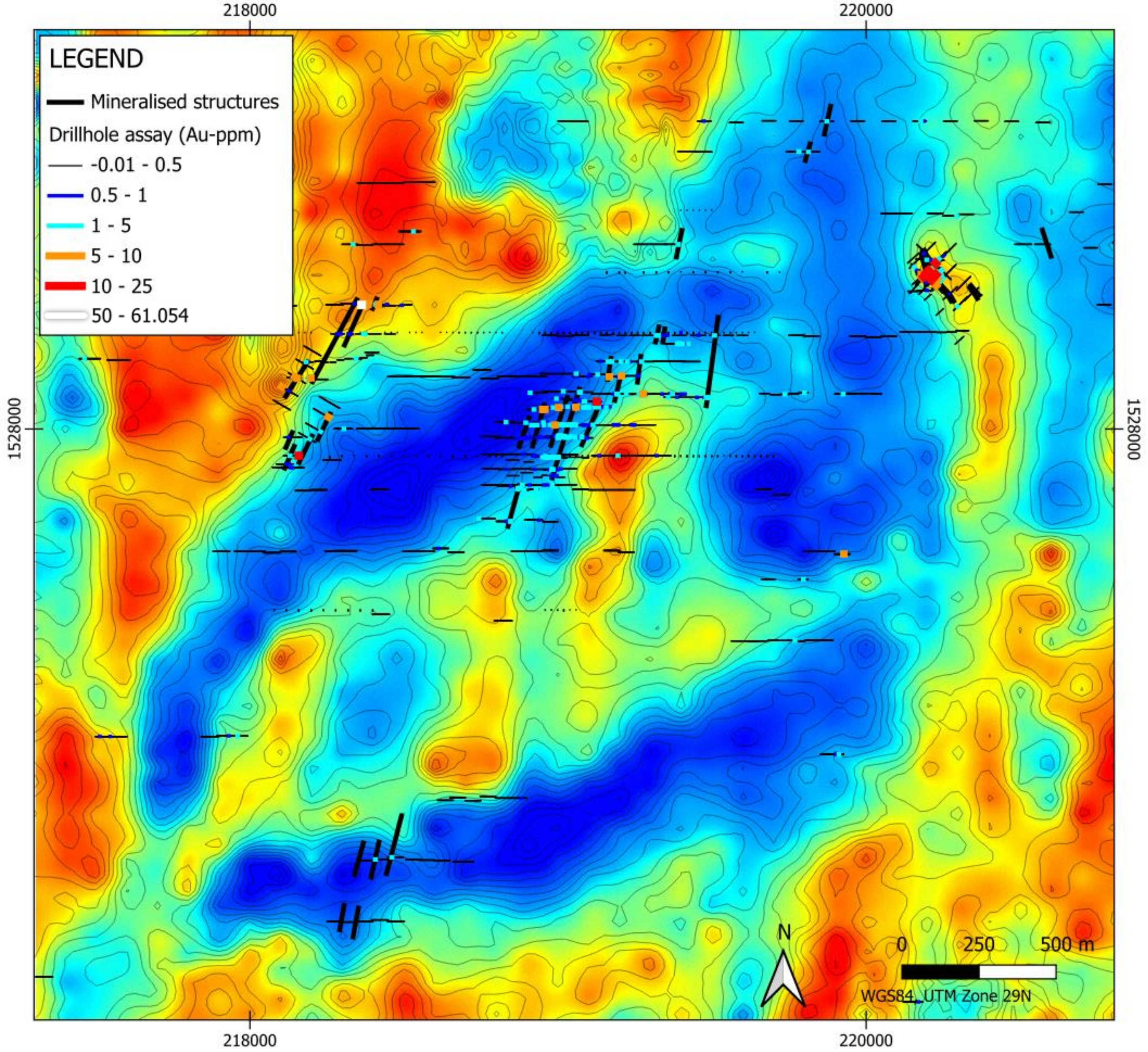


Passive seismic HVSR acoustic bedrock depth from land surface with contours.

Deeper acoustic bedrock resolved along margins of the granodiorite intrusion representing supergene Au targets

- Good correlation occurs between acoustic bedrock topography and filtered gravity anomalies, due to the thick regolith features surrounding the granodiorite intrusion and following faults/shears and other geological contacts.

- Passive seismic HVSR surveying providing reliable depth information for targeting deeply weathered zones within the low density moat surrounding the granodiorite intrusion, including predicting fresh bedrock depth ahead of drilling.



Residual ground gravity images with contours.

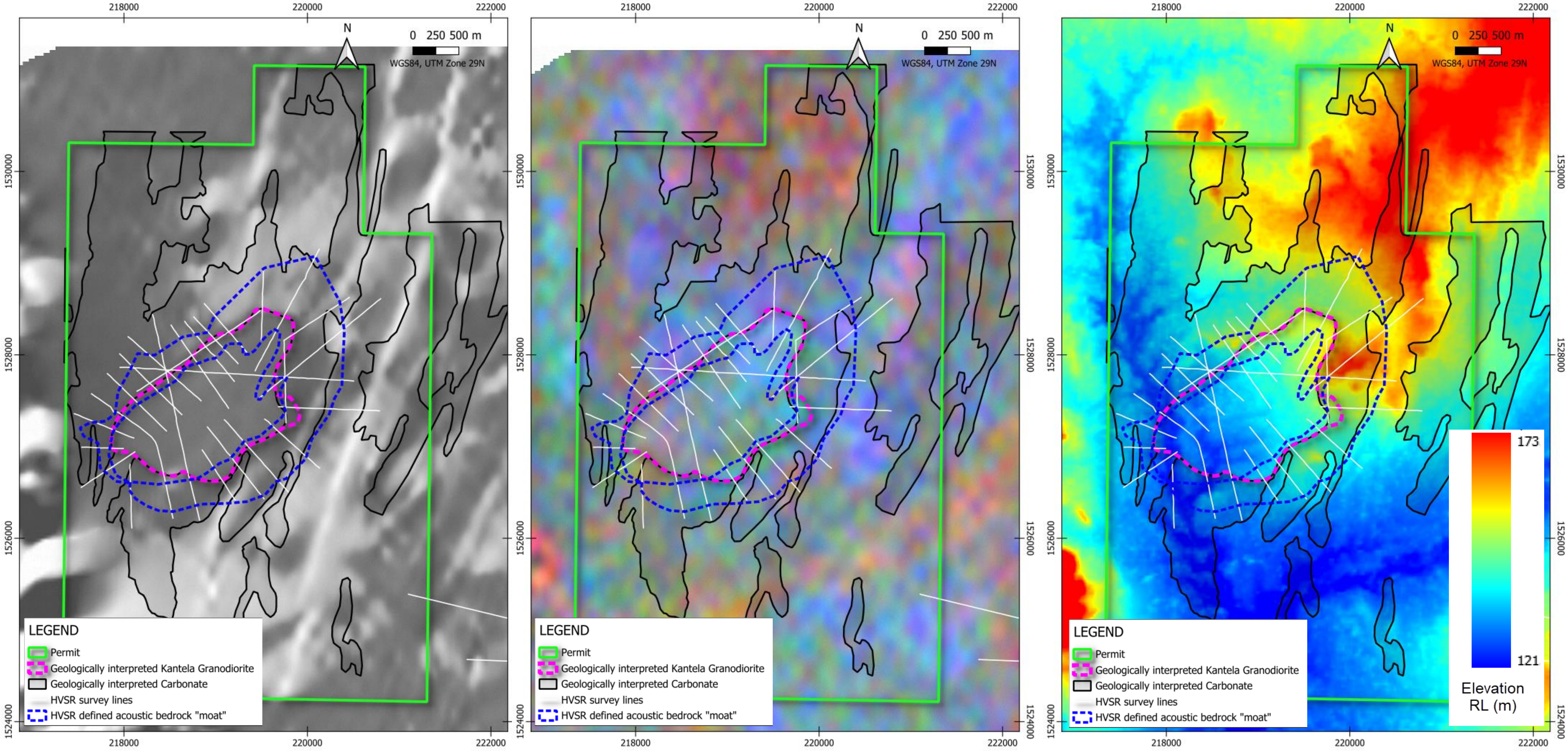
HVSR Acoustic Bedrock "Moat" Compared to other Geophysical Survey Datasets (slide 1/2)

Resource Potentials

Filtered magnetic anomaly image (TMIRTP1VDAGC)

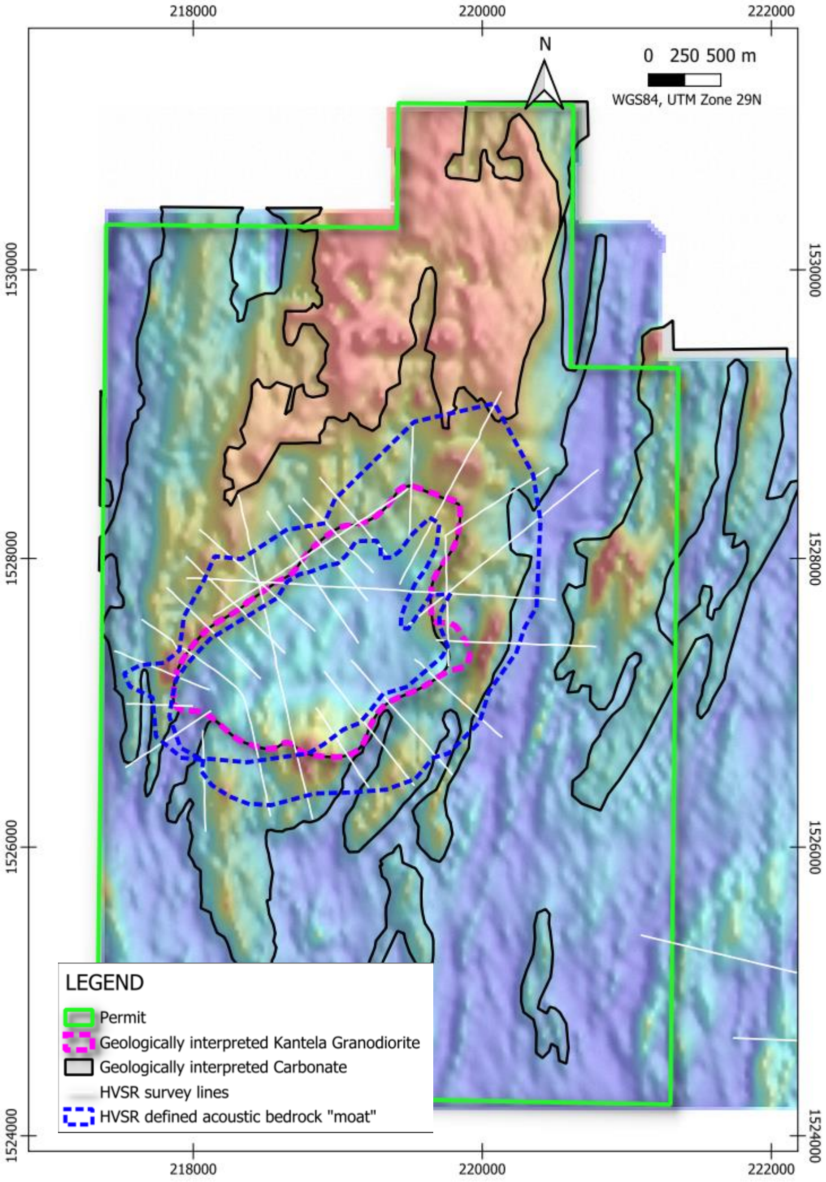
Radiometric ternary image (red=K, green=Th, blue=U)

SRTM elevation (red = high, blue = low)

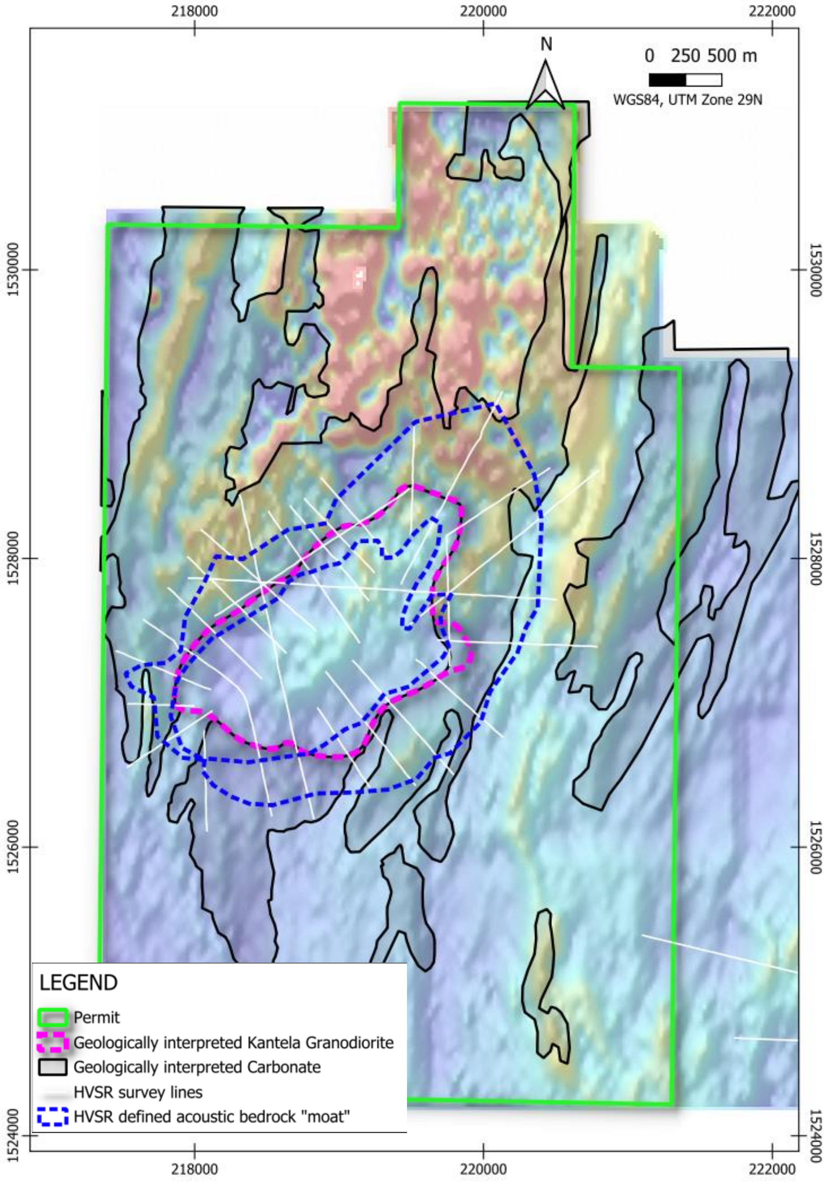


HVSR Acoustic Bedrock "Moat" Compared to other Geophysical Survey Datasets (slide 2/2)

GAIP conductivity (red = high conductivity, blue = low conductivity)

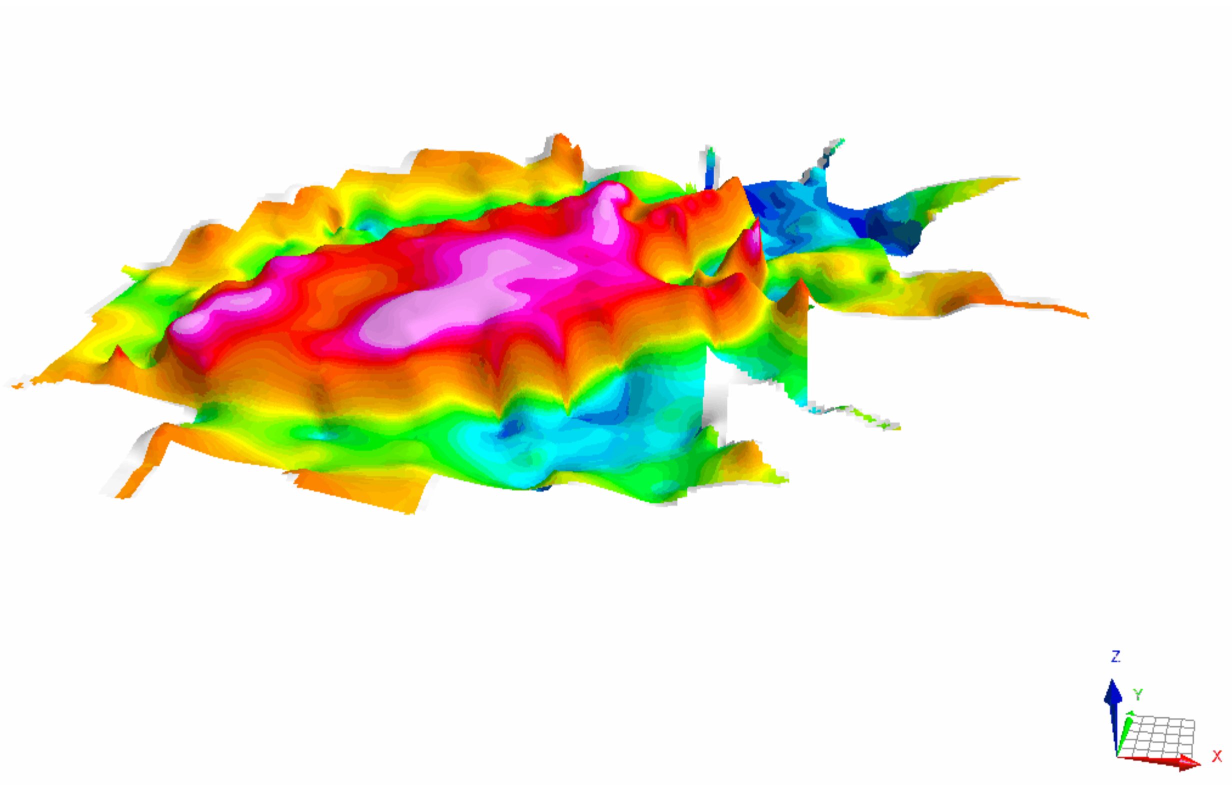


GAIP chargeability (red = high, blue = low)

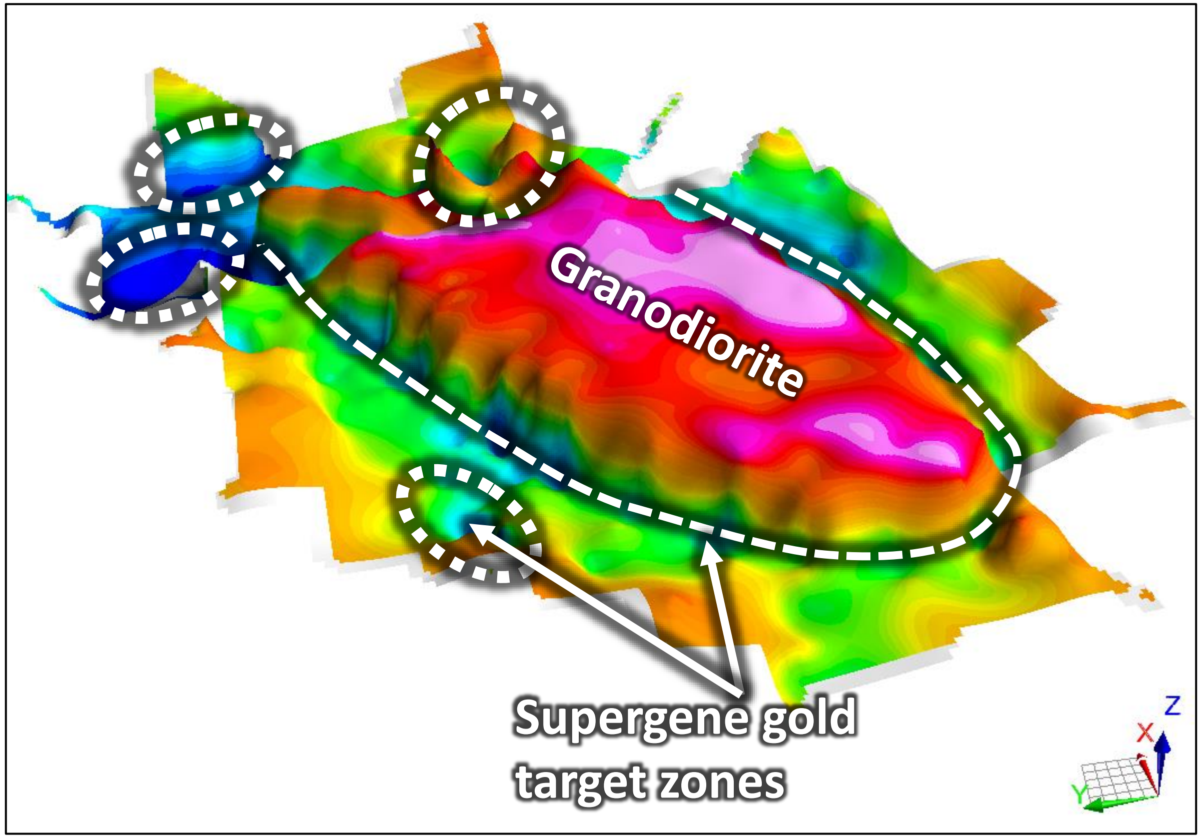


Conclusion

- Passive seismic HVSR surveying at Lakanfla has identified several prospective target areas for karst-style supergene Au mineralisation drill targeting.
- Local survey operators completed 37.4 survey lines-kms of HVSR surveying in a remote area over a 2-week period whereby the results produced significant new subsurface information quickly and affordably.



Movie of acoustic bedrock topography.



3D view of acoustic bedrock topography.