Application of Passive Seismic to estimate the thickness of the Leonora Breakaways, Western Australia

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Australian Regolith Geoscientists Association

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- Results
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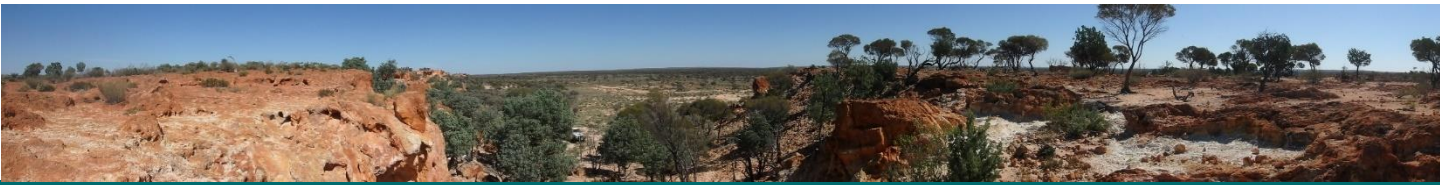
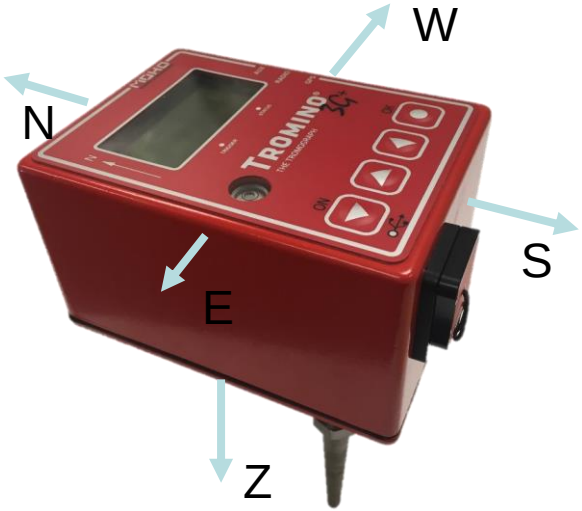
Passive Seismic

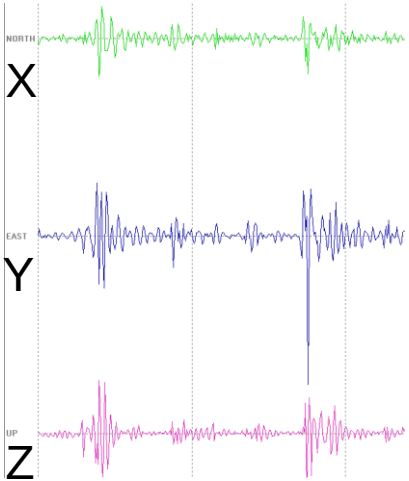
- Rapid, non-invasive technique
- Does not require controlled seismic source
- Records ambient, natural noise in the subsurface at the broad range of frequencies (0.1 – 2048 Hz), over a set time intervals (generally 5-30 minutes)
- Two methods
  - Single-station
  - Array - based
- Successful application to estimate cover thickness



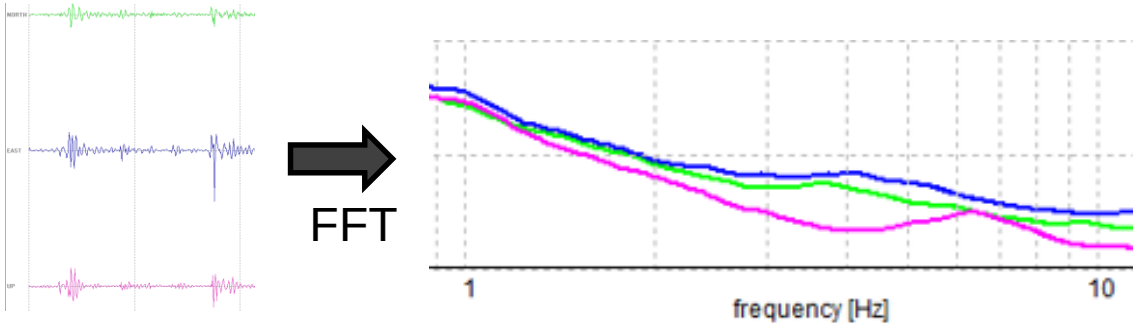
Tromino seismometer

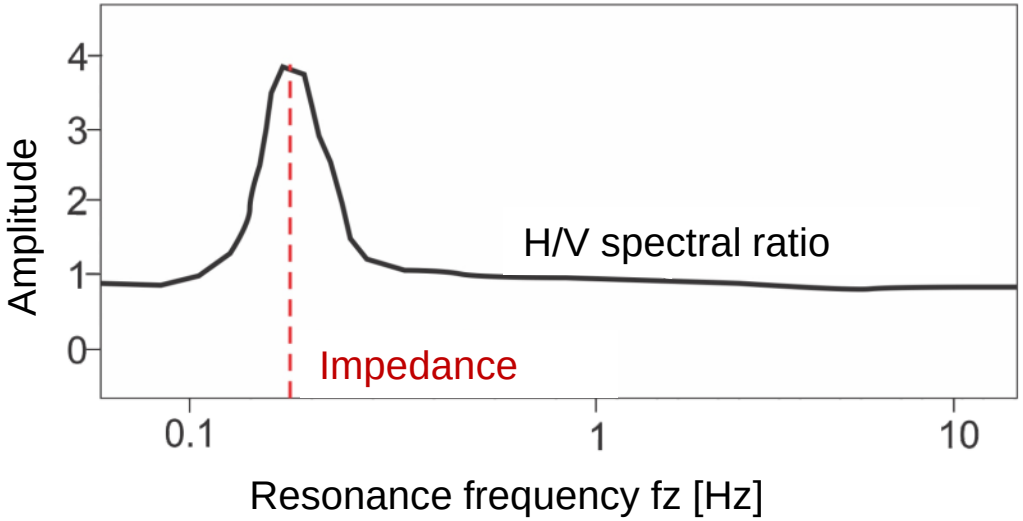


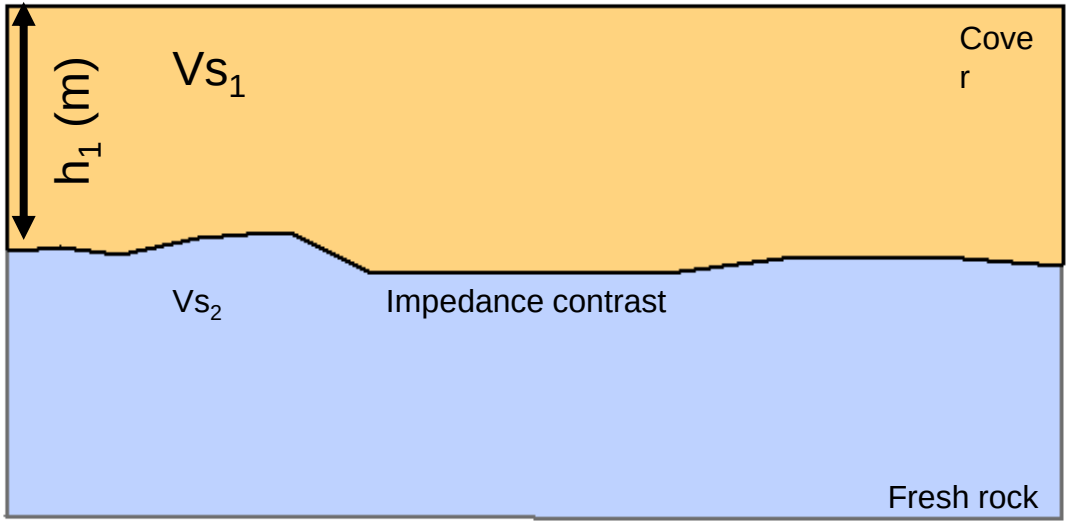
HVSR method (Nakamura Technique)- three -component measurements of ambient seismic noise to determine resonance frequency



- The time-series data recorded by Tromino are transferred into frequency spectra by Fast Fourier Transfer (FFT) and presented as a power spectrum
- Horizontal components are usually very similar, unless there is strong anisotropy in the near surface
- Vertical component dips where resonance occurs from trapping by underlying layers




Amplitude
4
3
2
1
0
H/V spectral ratio
Impedance
0.1
1
10
Resonance frequency fz [Hz]



$$fz = \frac{Vs_1}{4 * h_1}$$

The respondent fz at which the peak occurs corresponds to the thickness (h) and the shear-wave velocity (Vs) of the layer above the impedance

- Trominos can detect the depth from shallow regolith thicknesses of <200 m to the depths of >700m
- Deeper bedrock shows up as lower frequency peaks

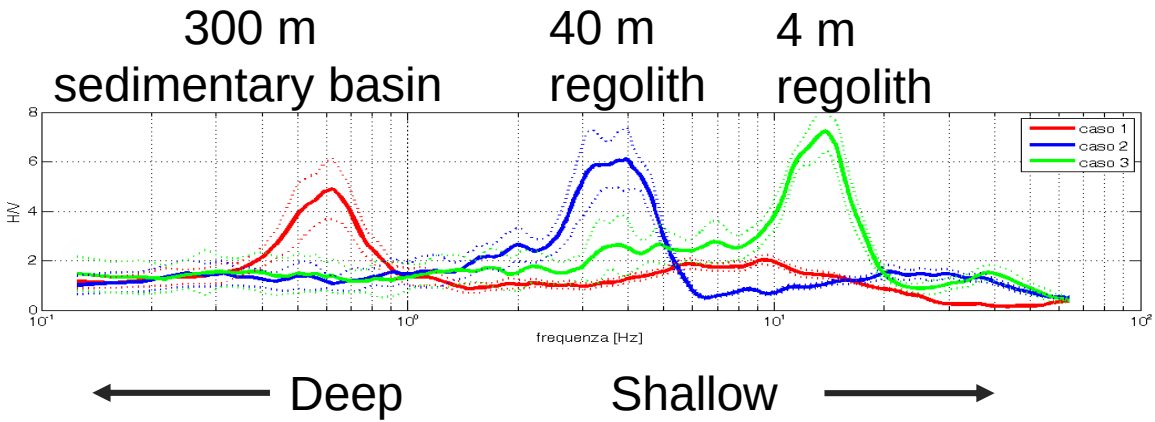


Image courtesy of Jayson Meyers, Resource Potential

Multiple frequency peaks are possible contrast between layers, and a peak will occur at the resonant frequency corresponding to each subsequent layer

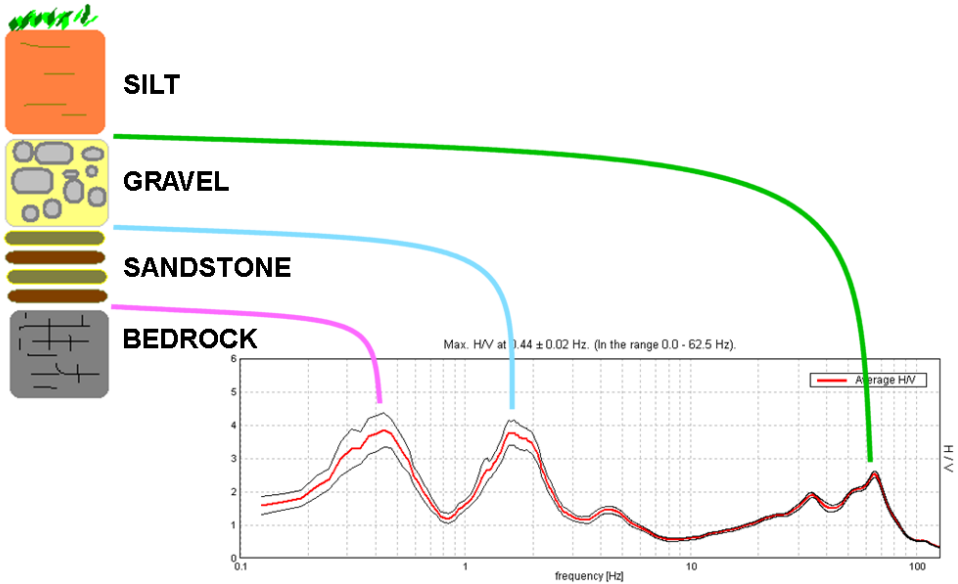
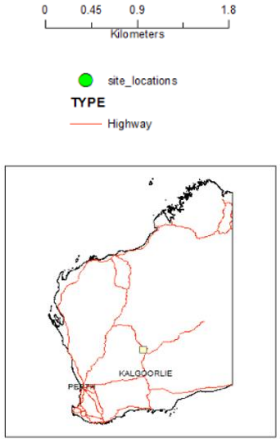
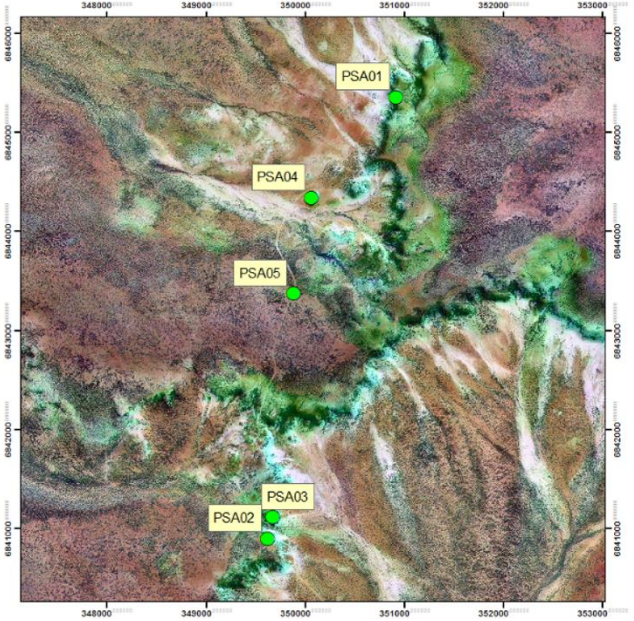


Image courtesy of Jayson Meyers, Resource Potential

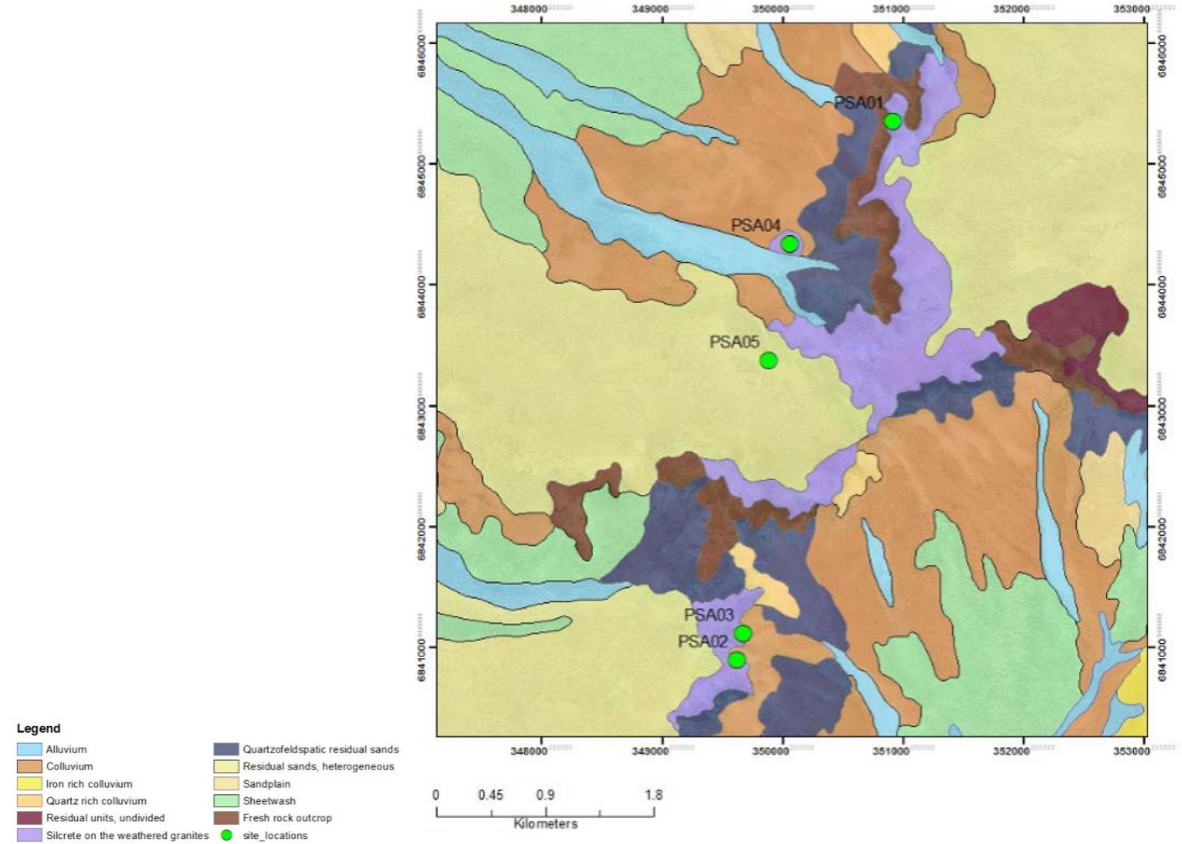
Study Area- Landsat image





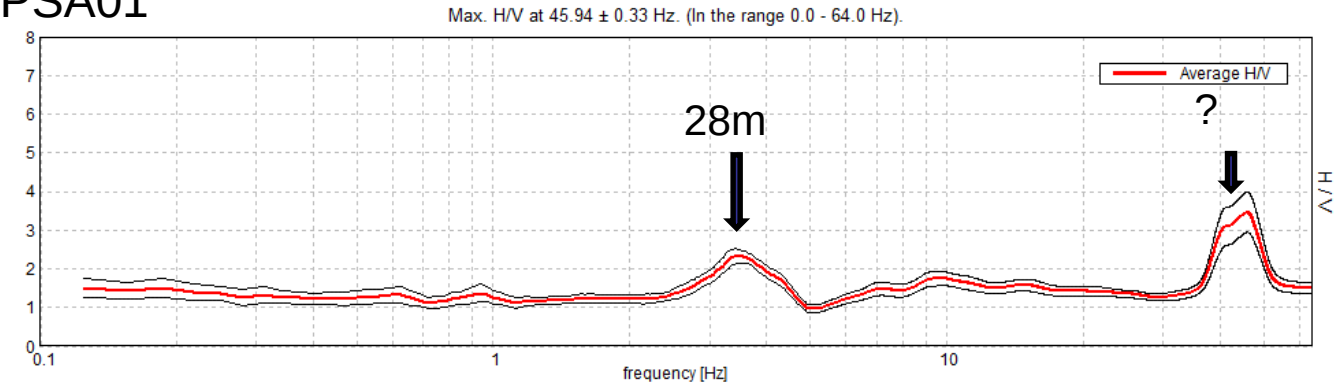
- Sandplains – purple
- Breakaways- green
- Sheetwash- brown

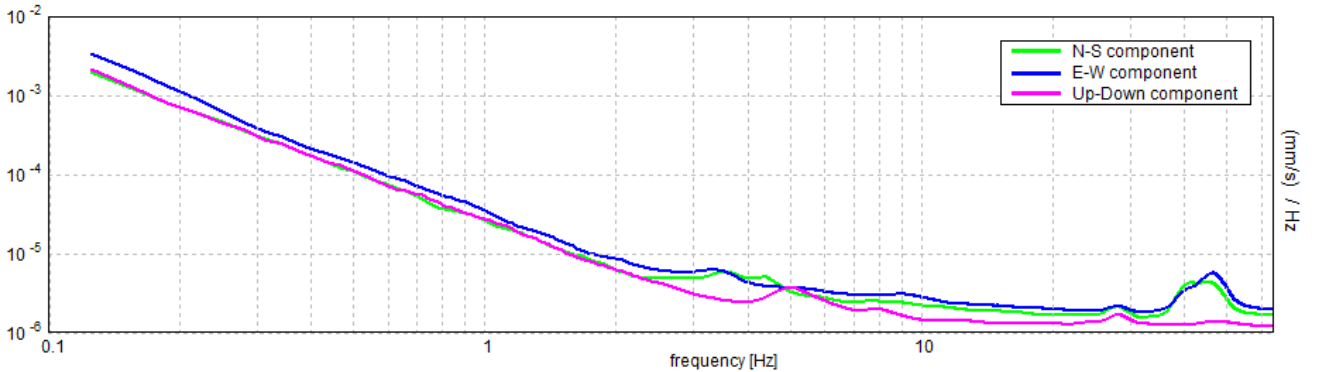
Regolith Landform Map



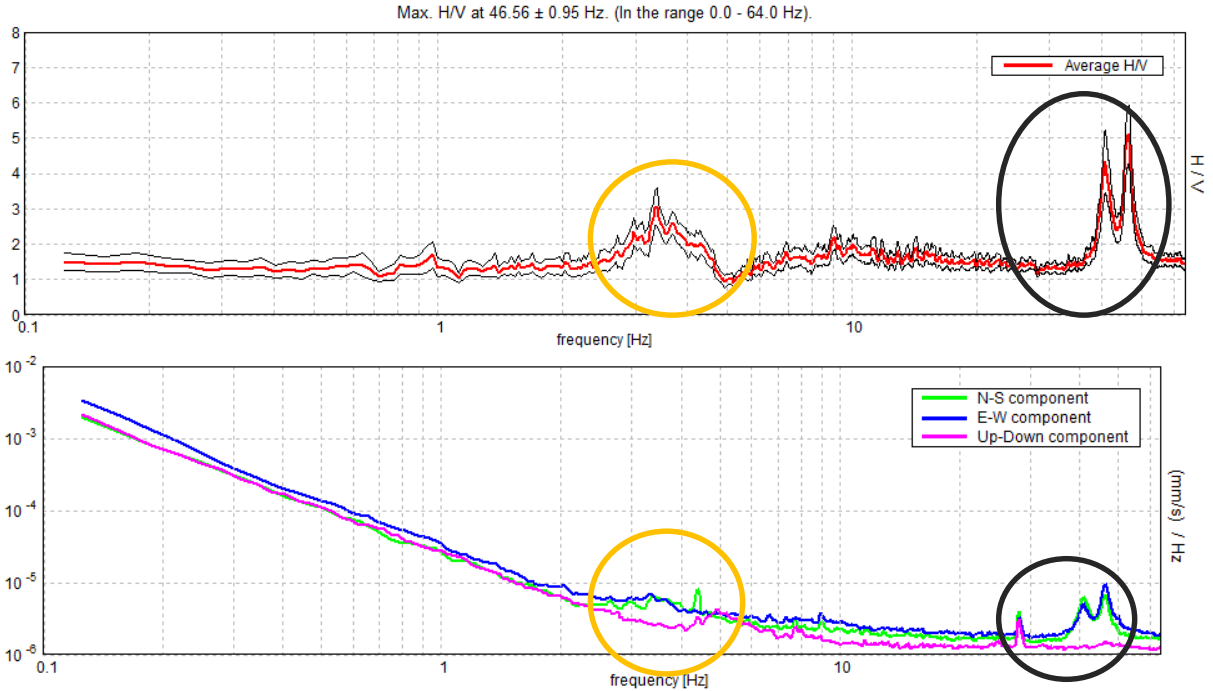
Results

PSA01

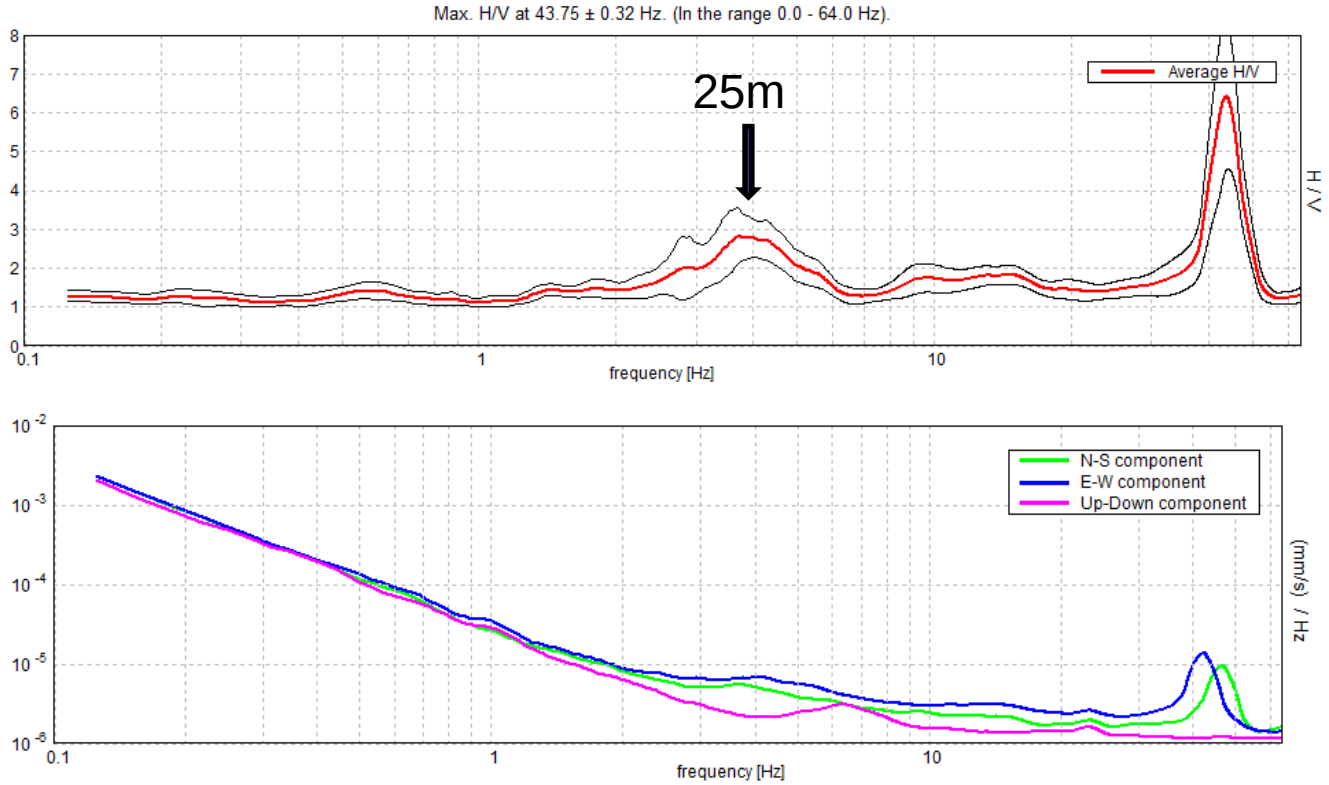




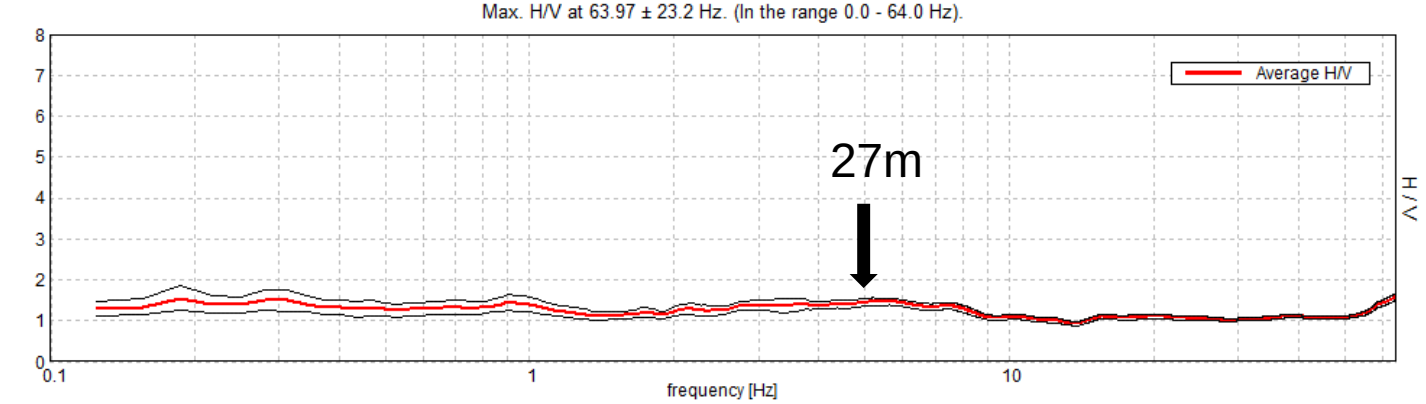
Smoothing dropped to 1%

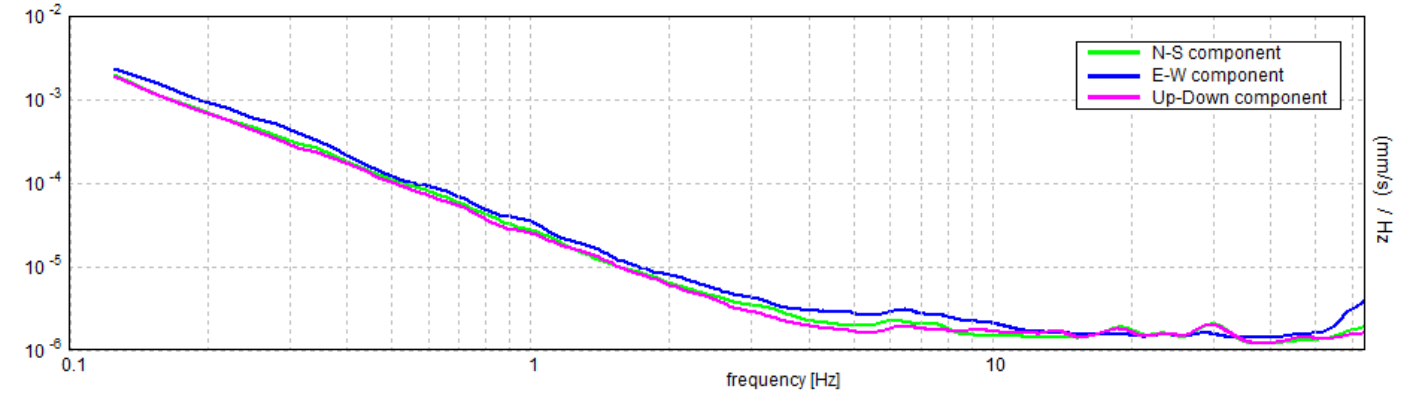


PSA02

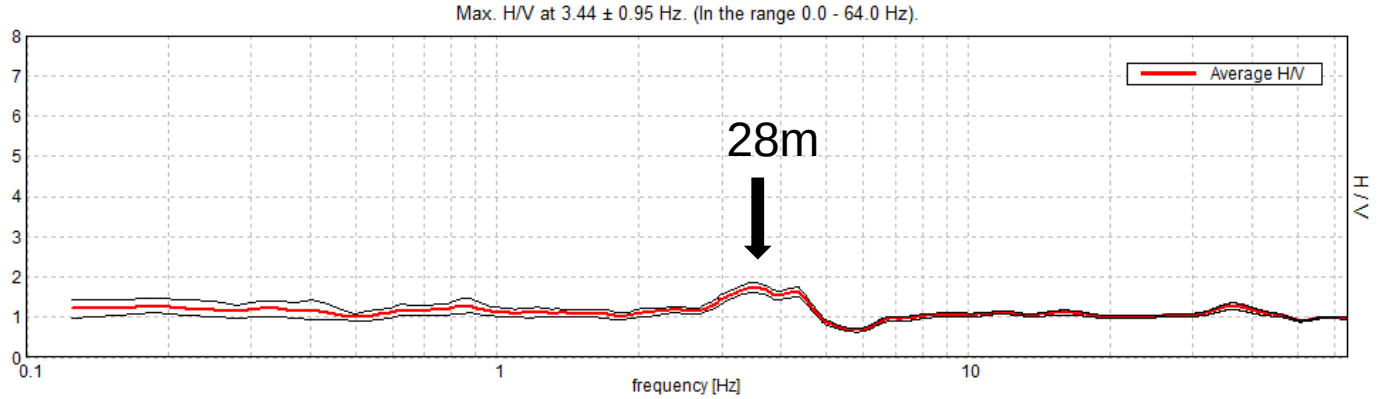

Max. H/V at 43.75 ± 0.32 Hz. (In the range 0.0 - 64.0 Hz).
25m
Average H/V
H / V
frequency [Hz]
N-S component
E-W component
Up-Down component
(mm/s) / Hz
frequency [Hz]

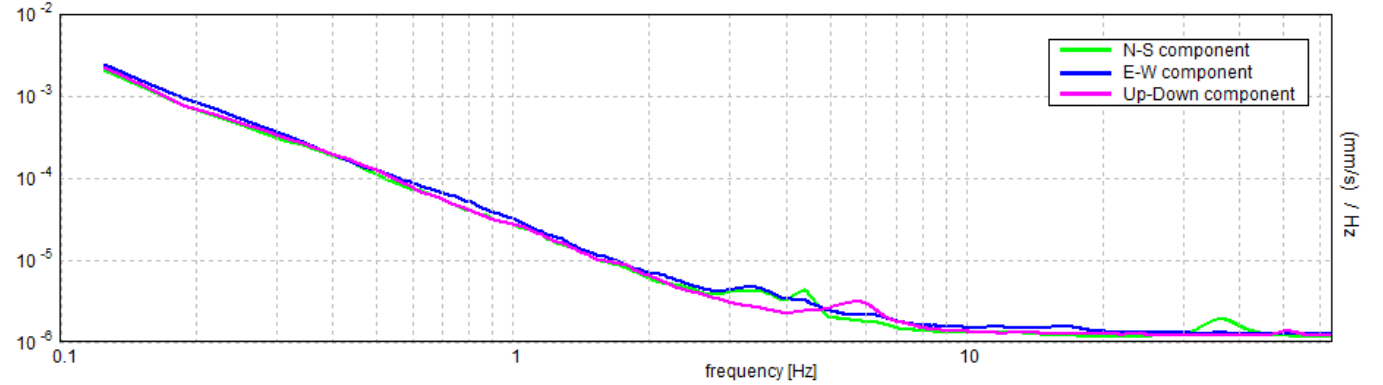
PSA03


Max. H/V at 63.97 ± 23.2 Hz. (In the range 0.0 - 64.0 Hz).
Average H/V
27m
H / V
frequency [Hz]

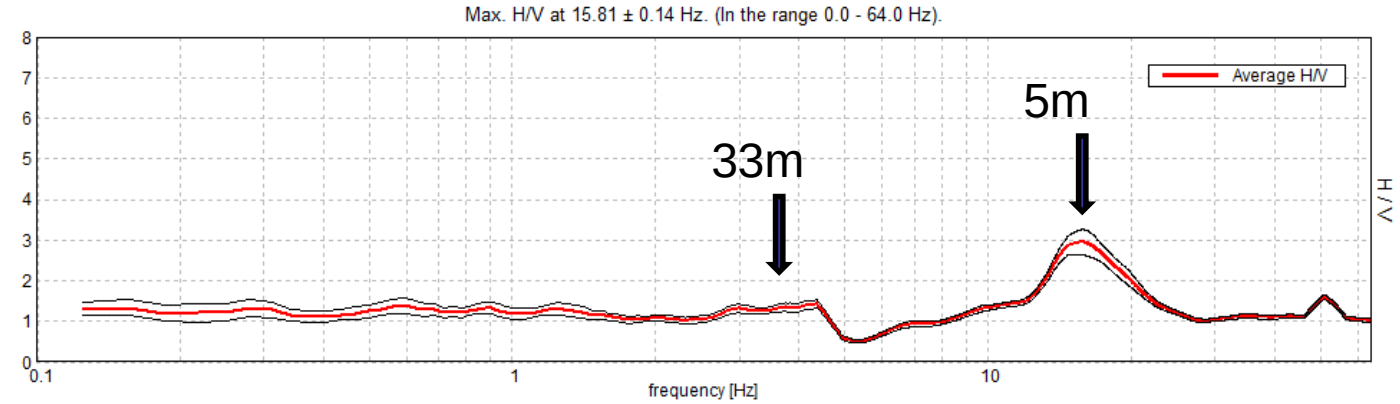

N-S component
E-W component
Up-Down component
(mm/s) / Hz
frequency [Hz]

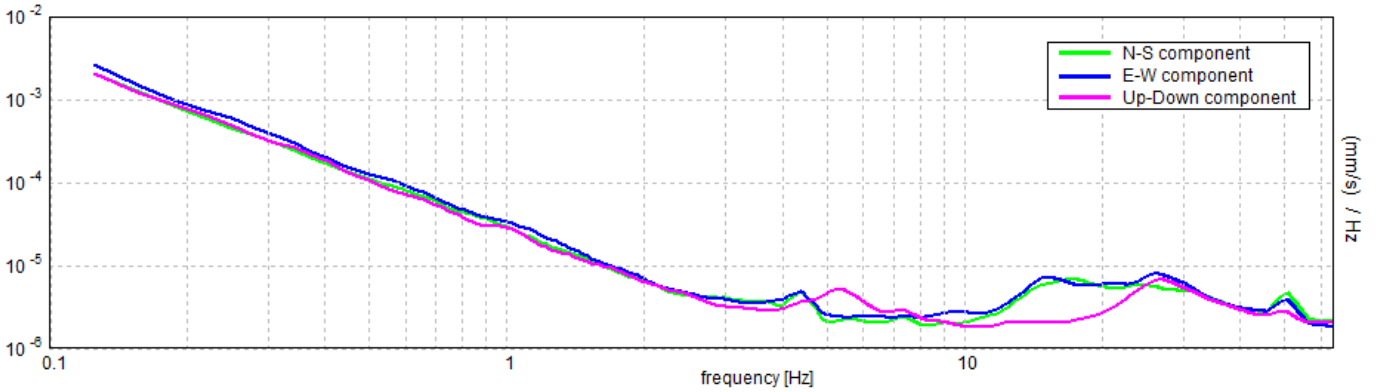
PSA04


Max. H/V at 3.44 ± 0.95 Hz. (In the range 0.0 - 64.0 Hz).
Average H/V
28m
H / V
frequency [Hz]


N-S component
E-W component
Up-Down component
(m/s) / Hz
frequency [Hz]

PSA05


Max. H/V at 15.81 ± 0.14 Hz. (In the range 0.0 - 64.0 Hz).
Average H/V
5m
33m
H / V
frequency [Hz]

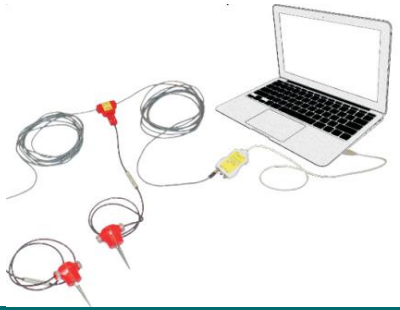

N-S component
E-W component
Up-Down component
(mm/s) / Hz
frequency [Hz]

Conclusion

- The passive seismic profiles for PSA01-PSA04 show that the estimated interface between weathered granite and fresh rock is between 25 and 29 m.
- PSA05 shows two peaks
  - An interface between relict sandplain and the weathered granite at 5m
  - An interface between the weathered granite and fresh rock at 33m

What is next

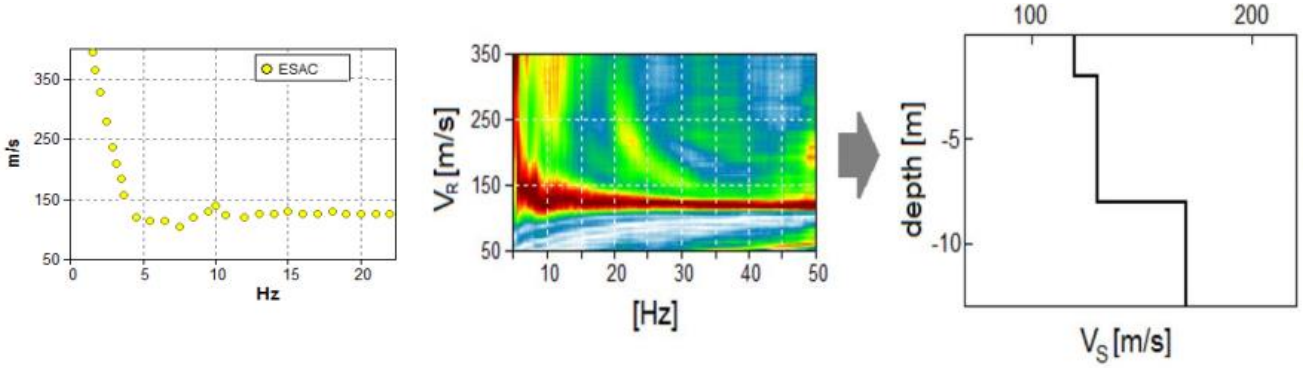
- Tromino- also contains accelerometers, radio triggering and synchronisation for active seismic MASW and REMI, recording in arrays, and engineering applications
- Array Trominos and SoilSpy for obtaining accurate shallow velocity where there are no drillholes.

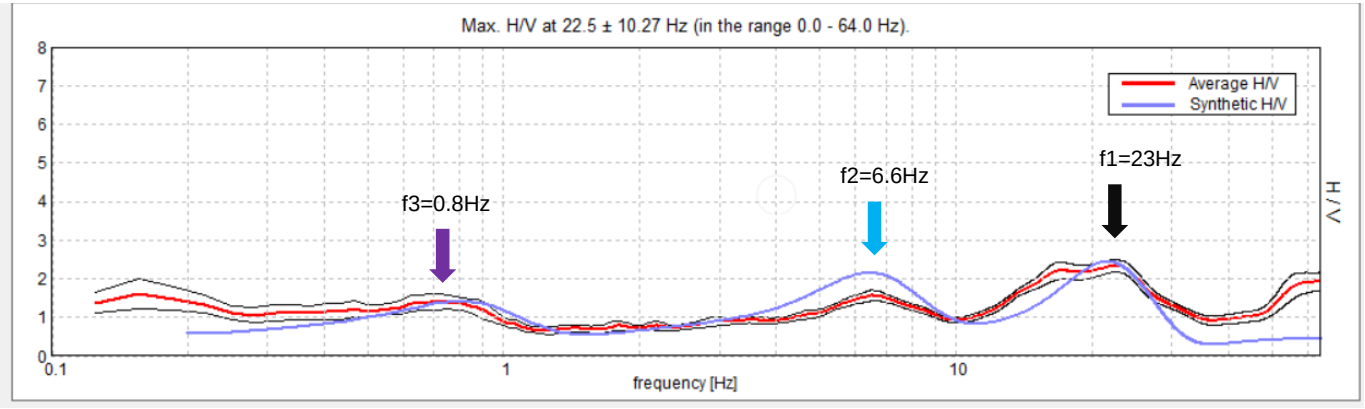


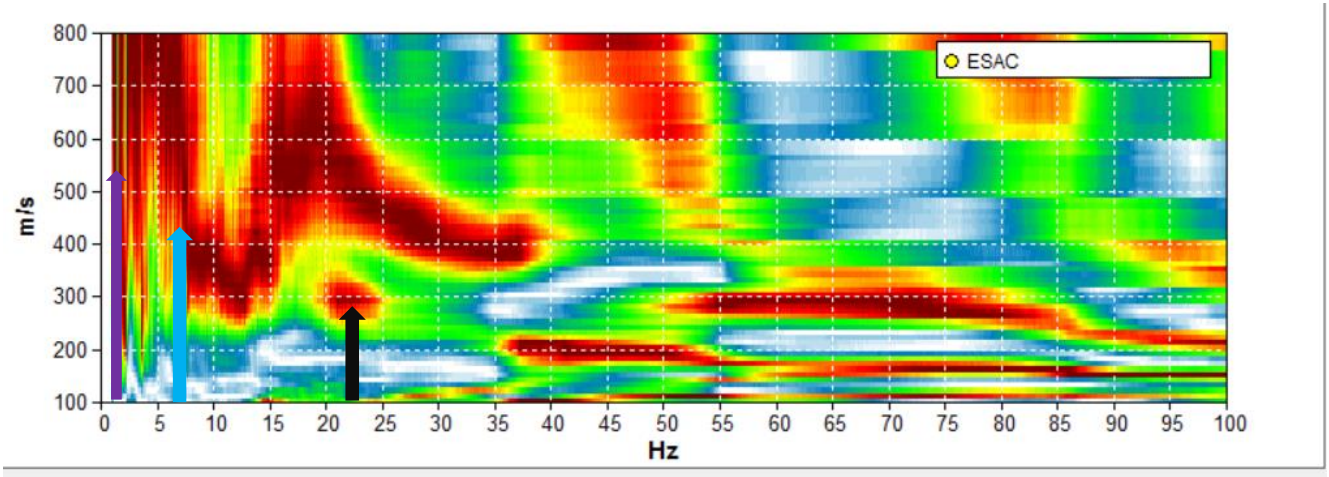
The techniques to determine surface wave phase velocity 1D/2D configuration and active/passive mode

- **SPAC**-Spatial AutoCorrelation (2D passive technique, circular array, 3+ Trominos & radio/GPS synchronisation)
- **ESAC**- Extended Spatial AutoCorrection (2D passive technique, any array geometry, 3+ Trominos & radio/GPS synchronisation)
- **ReMi**- Refraction Microtremor (1D passive technique, linear array, 2+ Trominos & radio/GPS synchronisation)
- **SASW**- Spectral Analysis of Surface Waves (1D active technique, linear array, Tromino with wireless trigger or SoilSpy with 2+ geophones)
- **MASW**- Multichannel Analysis of Surface Waves (1D active technique, linear array, Tromino with wireless trigger or SoilSpy with 2+ geophones)

- Unlike P and S waves, surface waves are frequency dependent
- Dispersion Curve- relationship between frequency and the velocity of surface wave propagation
- SPAC/ESAC- single value dispersion curves
- ReMi/MASW/SASW- contour dispersion curve




Max. H/V at 22.5 ± 10.27 Hz (in the range 0.0 - 64.0 Hz).
Average H/V
Synthetic H/V
f3=0.8Hz
f2=6.6Hz
f1=23Hz
H / V
frequency [Hz]


ESAC
m/s
Hz

Paleochannel mapping

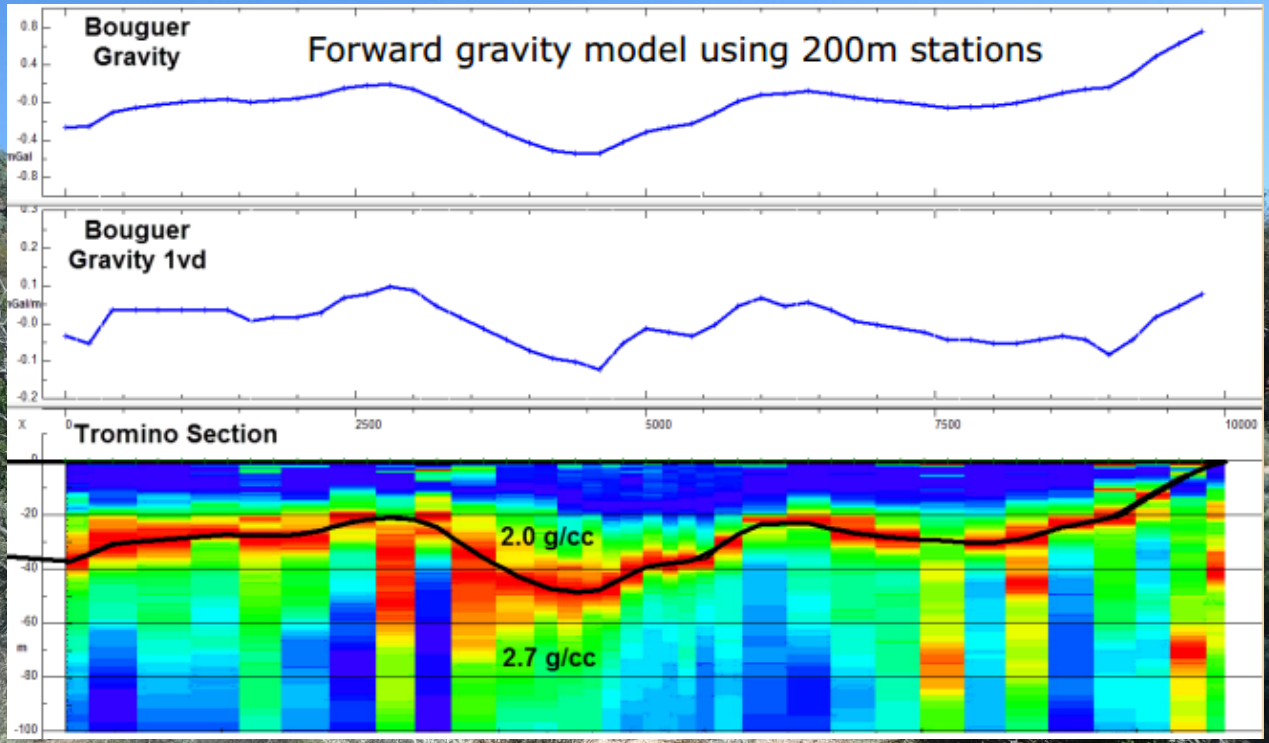


Image courtesy of Jayson Meyers, Resource Potential

Mapping the **cover**!