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

Dr Sara Jakica, GSWA
Sara.Jakica@dmirs.wa.gov.au

ARGA 2018, Wallaroo, SA
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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

FFT

frequency [Hz]

1 10
The respondent $f_z$ at which the peak occurs corresponds to the thickness $(h)$ and the shear-wave velocity $(V_s)$ of the layer above the impedance contrast.

$$f_z = \frac{V_s}{4\times h_1}$$
• Trominos can detect the depth from shallow regolith thicknesses of <200 m to the depths of >700 m.
• Deeper bedrock shows up as lower frequency peaks.

Multiple frequency peaks are possible contrast between layers, and a peak will occur at the resonant frequency corresponding to each subsequent layer.
Study Area - Landsat image

- Sandplains – purple
- Breakaways – green
- Sheetwash – brown
Regolith Landform Map
Results

PSA01

Max. H/V at 45.94 ± 0.33 Hz. (In the range 0.0 - 64.0 Hz).

Frequency [Hz]

H/V

28m

N-S component
E-W component
Up-Down component

Hz / [s^2]

Frequency [Hz]
Smoothing dropped to 1%
PSA02

Max. H/V at 43.75 ± 0.32 Hz. (In the range 0.0 - 64.0 Hz).

25m
Max. $H/V$ at 63.97 ± 23.2 Hz. (In the range 0.0 - 64.0 Hz).

27m
PSA04

Max. H/V at 3.44 ± 0.95 Hz. (In the range 0.0 - 64.0 Hz).

28m
Max. $H/V$ at $15.81 \pm 0.14$ Hz. (In the range 0.0 - 64.0 Hz).

- 33m
- 5m
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
Paleochannel mapping

Mapping the **cover**!