institute of mine seismology

Ramsay-Webbs passive seismic block – processing report

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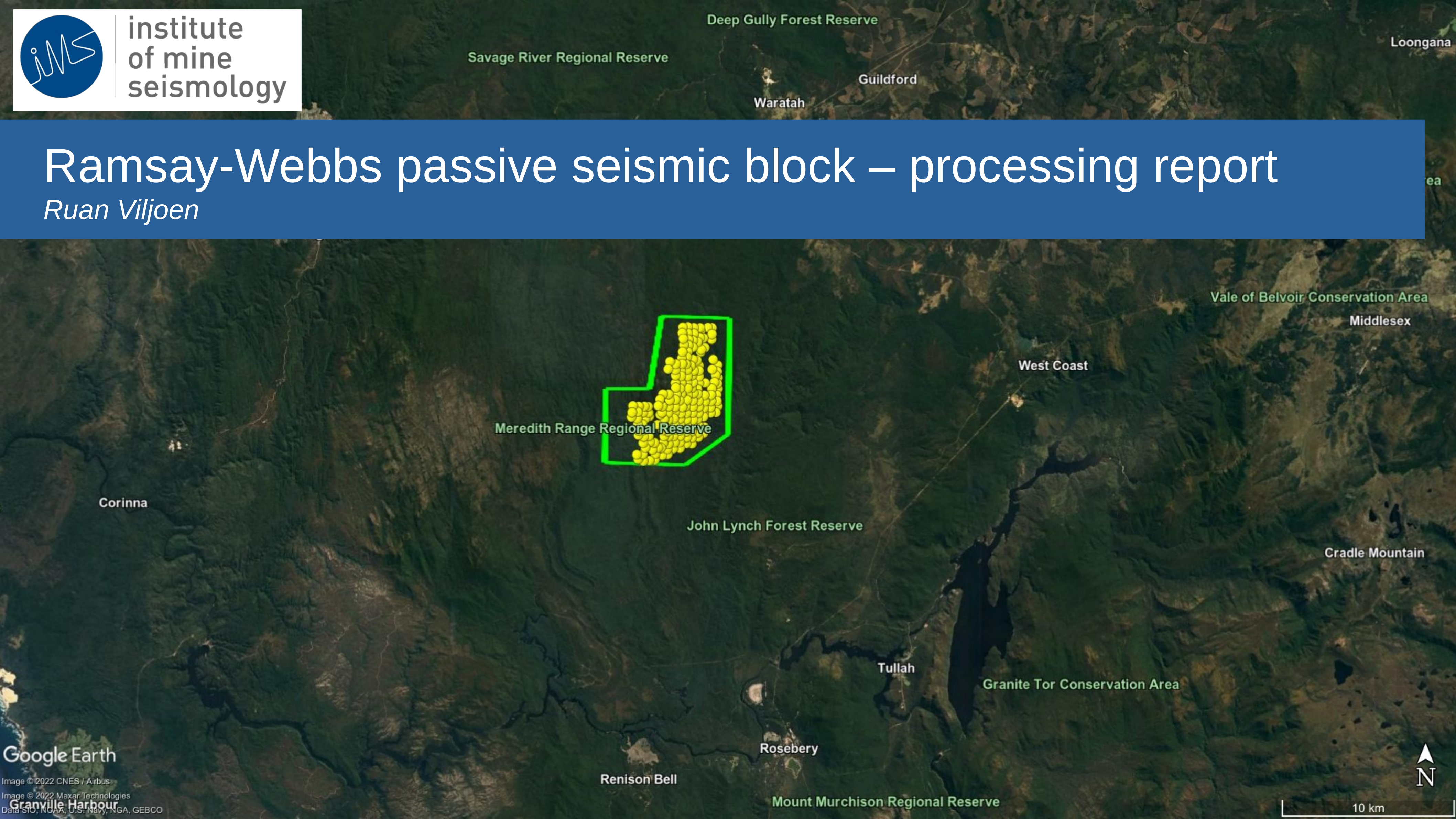
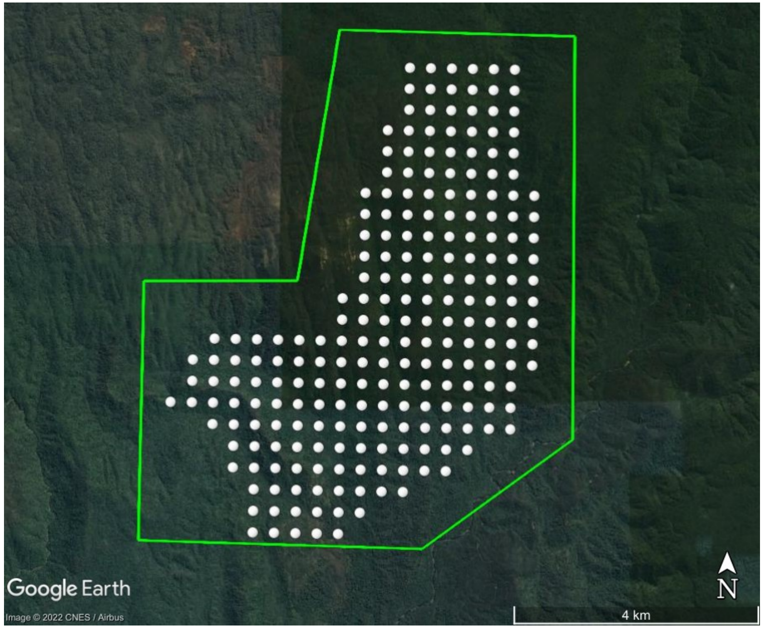


Survey deployment

A summary of the node deployment

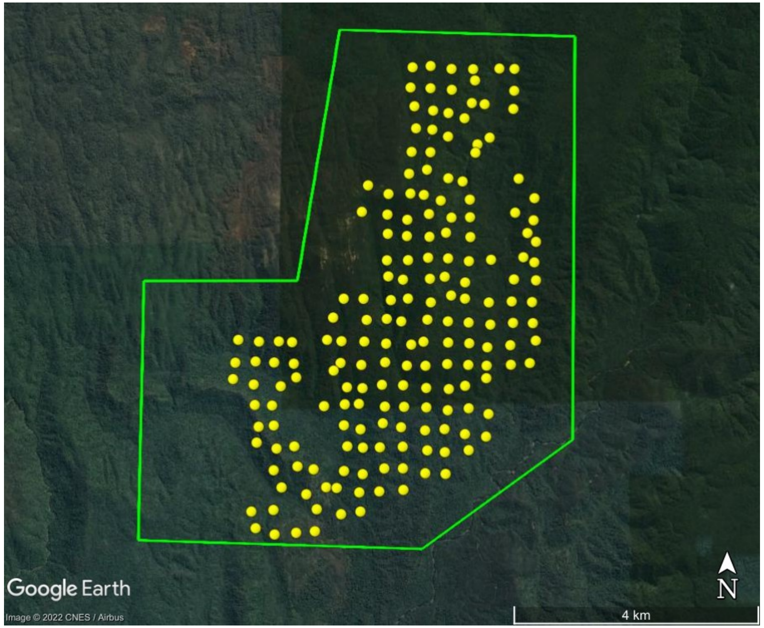
Deployment of the Ramsay-Webbs survey kicked off on 9 May ‘22, was fully deployed on 26 May ‘22, and scheduled to be collected from 6 June ‘22. Due to bad weather conditions retrieval was stretched over a few weeks with the last nodes retrieved in the week of 12 September ‘22.

Planned survey design



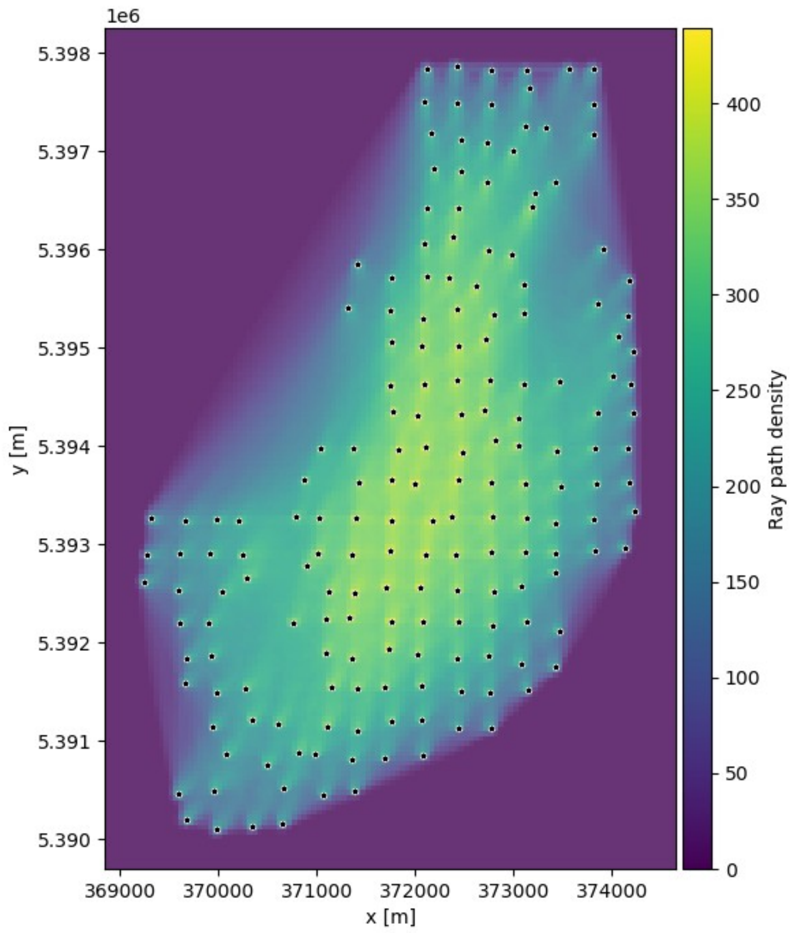
- Original layout with 227 nodes

Deployed survey



- Deployed 193 nodes, recovered 186 nodes, and 1 node’s data rejected during quality control

Good ray coverage across the deployed survey



Deviations from the planned survey resulted from physical access limitations in the survey area. The effect of these deviations can be observed in a 2D ray density map.

To generate such a map, the survey area is first discretised into 50x50 m grid cells. A ray path density value is then determined by counting the amount of rays that cross a grid cell. These values are assigned to their appropriate grid cells and displayed as an image with the colour indicating the density.

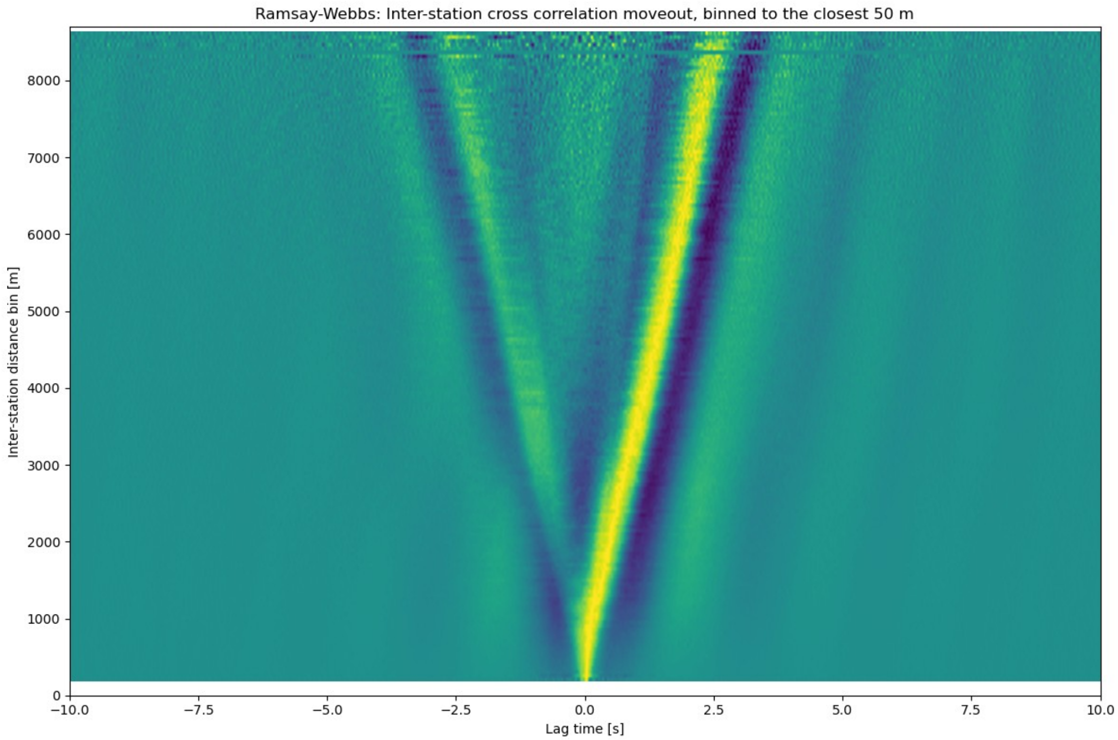
On this map we see:

- The ray path density is higher in the centre of the array and tapers off at the edges.
- In areas of the survey where access prevented node deployment, the ray density is sparser but still adequate.

Inspection of passive seismic data

Stable moveout across survey

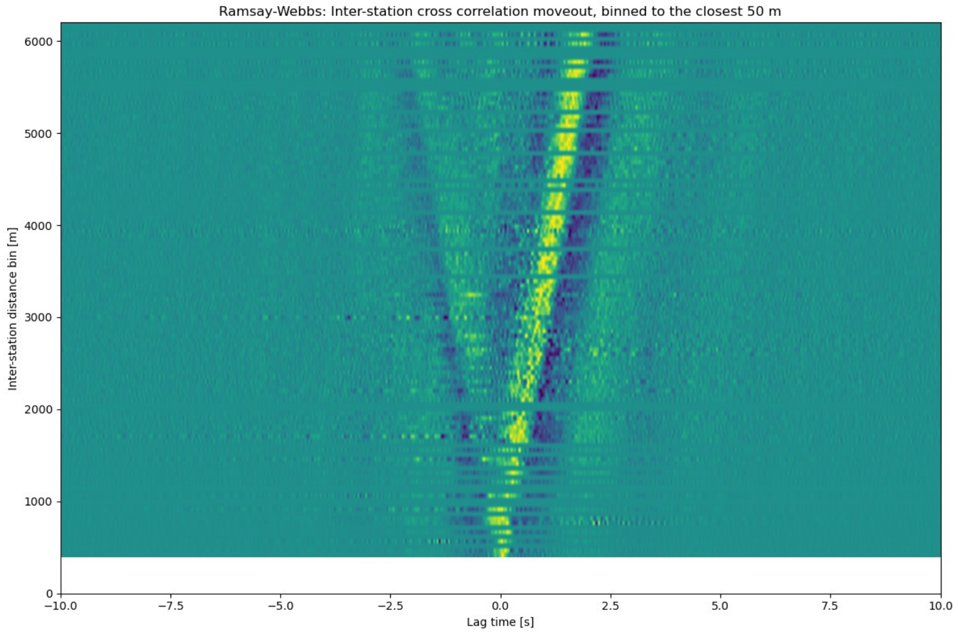
Cross-correlations were calculated for all unique node pairs. A distance binned moveout serves as a visual quality check for the these cross-correlations.

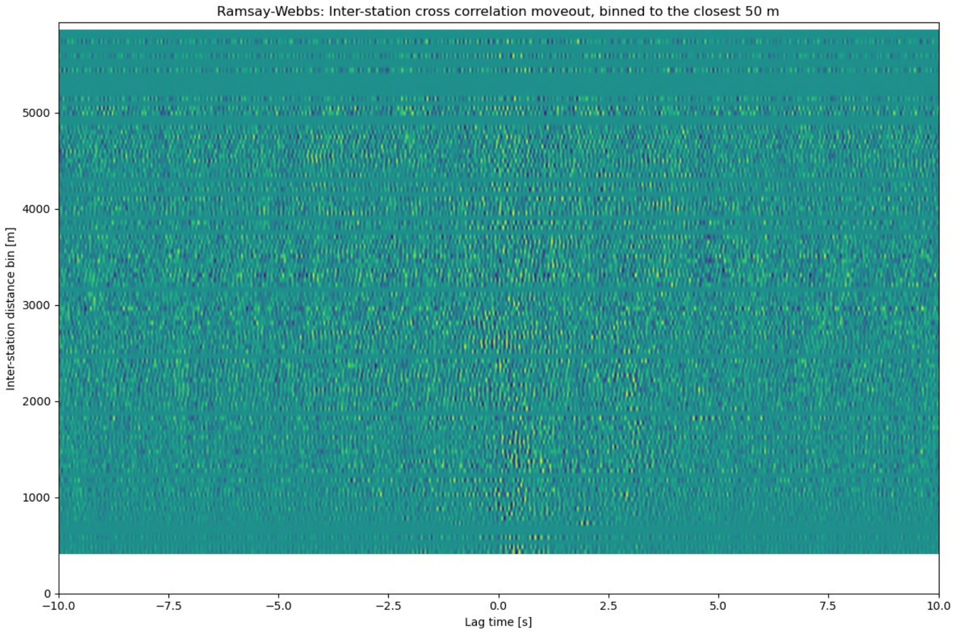


For this survey there is a clear moveout up to about 8000 m, indicating satisfactory ambient conditions throughout the survey.

Node data flagged for further investigation

During pre-processing some stations were flagged to have possible data quality concerns. Moveouts constructed by only considering cross-correlation pairs that contained the flagged stations indicated whether those pairs could be used.

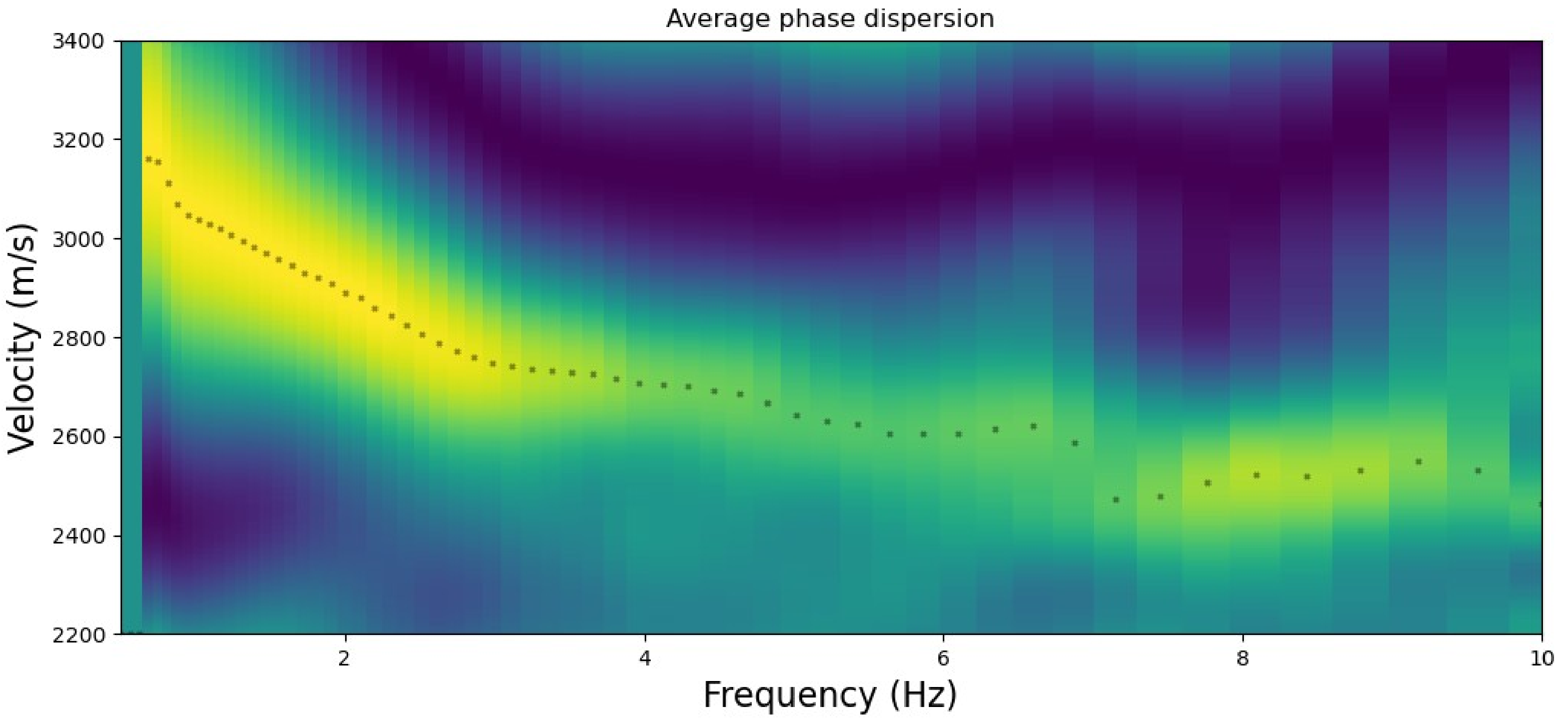




All but one of the flagged stations could be used. The moveout plot for the rejected station (shown on the right) showed no visible moveout and all of those cross correlations were removed from the data set. The other moveout plots (of which one is shown on the left) showed clear moveouts, but contained some ‘fuzzy’ cross correlations. These were included, but fuzzy cross-correlations were filtered out during later processing steps.

Average phase dispersion curve shows normal dispersive characteristics

The average phase dispersion curve, calculated during pre-processing, is another indicator of the data quality.



A very clear average dispersion can be seen up to ~3 Hz. At higher frequencies the velocity spread flattens out, but is still of adequate quality for velocity picking at those frequencies.

Inversion

Inversion parameterisation defines the inversion search space

An initial broad 3 layer parameterisation was performed and subsequently used to determine a more constrained parameterisation with additional layers.

Layer	Velocity ranges (m/s)		Depth ranges (m)	
Top 1	1500	3200	0	250
Top 2	2200	3500	0	750
Mid	2800	4000	500	1500
Bottom	2800	4000	750	2000
Halfspace	3000	5000		2500

The top two layers have broad overlapping depth ranges to allow for steeply dipping features in the model. This choice was informed by knowledge of the surveyed area.

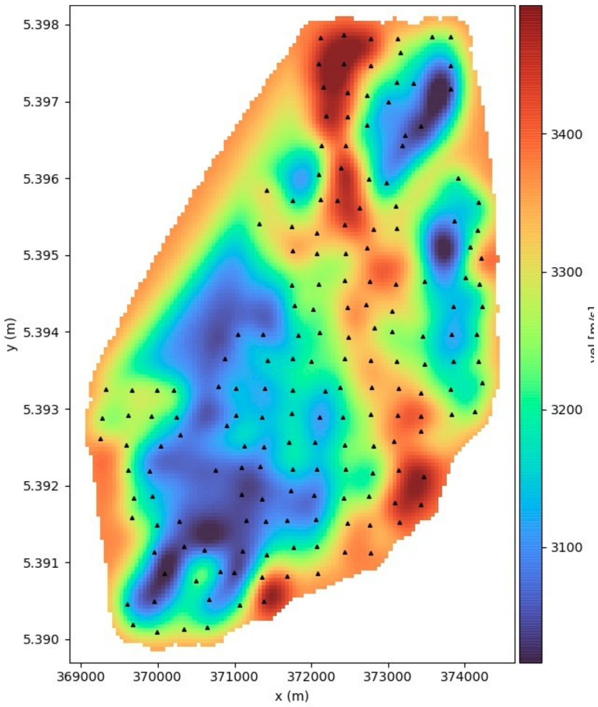
2D inversion produces 2D phase velocity maps

Phase maps are produced for a range of frequencies and represent 2D localised phase velocity variations in the survey area. These variations are linked to the material that the waves propagate through – materials with different properties will affect the phase velocity in different ways and so provide contrast.

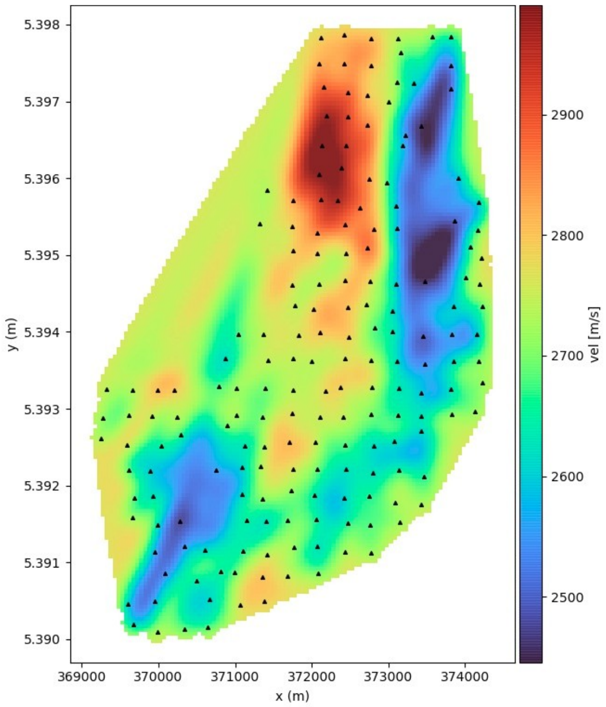
Phase maps constructed for the chosen frequency range are used to build the 3D velocity model and can also give an indication of what to expect in the 3D model.

Lower frequencies probe structures at depth while higher frequencies probe structures closer to surface.

0.7 Hz

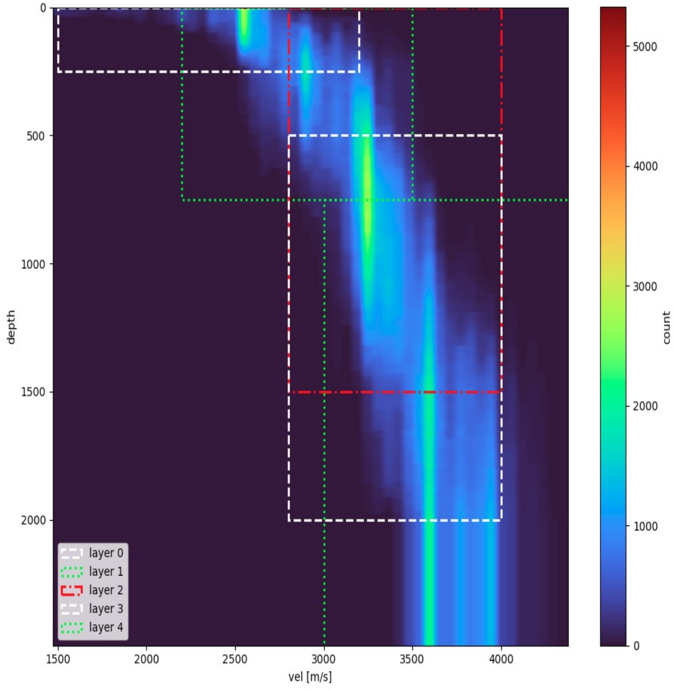


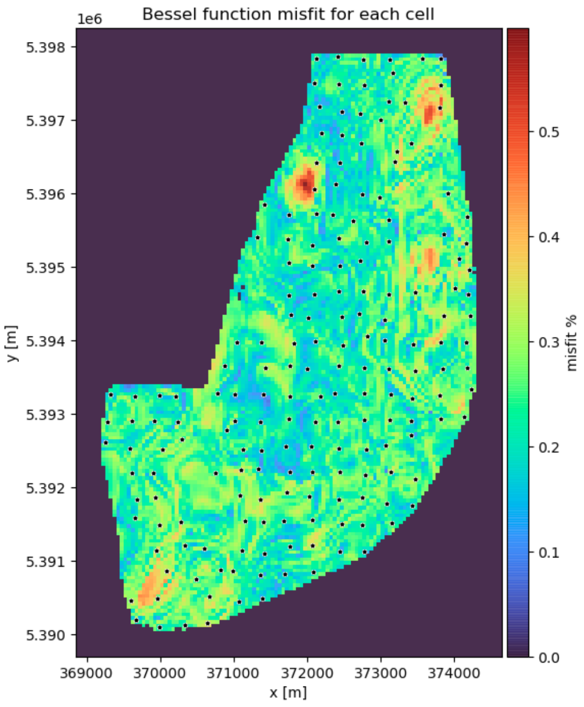
3.2 Hz



Model depth profiles fall well within constraints with overall low misfits

The velocity vs depth distribution (left image) of the constructed 3D velocity model shows depth profiles grouping at distinct velocities away from the edges of the parameterisation.





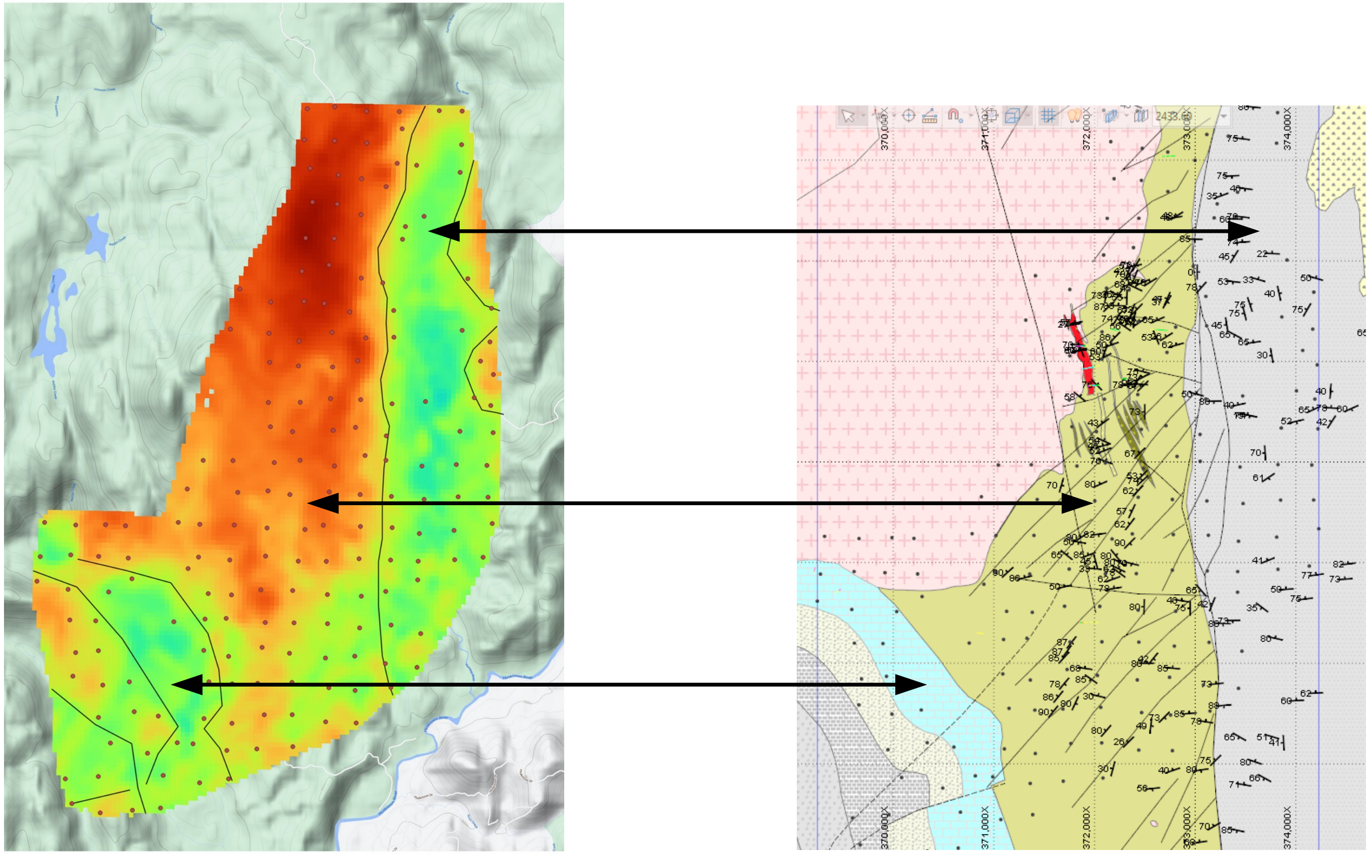
Velocities that are grouped close the edges of the inversion search space imply that the inversion is poorly constrained. This is not what we observe here.

Dense groupings of depths profiles can indicate the prevalence of a material at particular depths and can provide insights to the average depth transitions of materials.

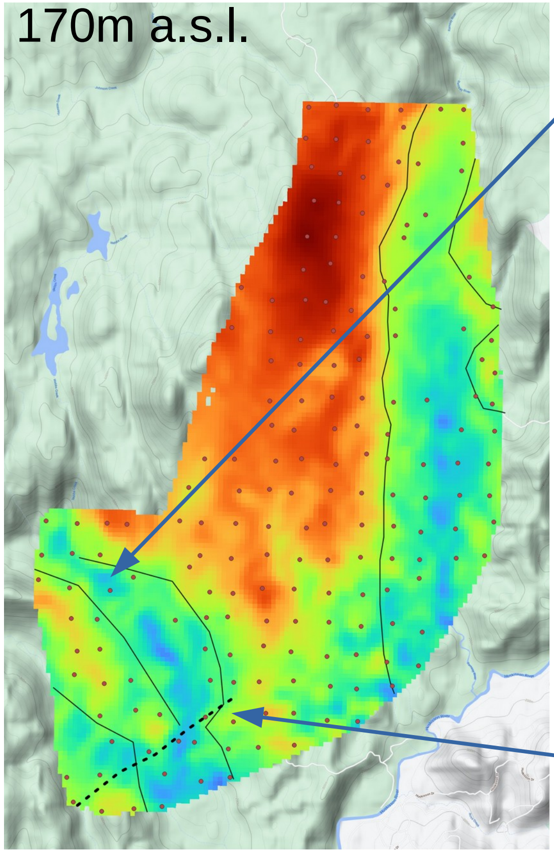
The misfit map (on the right) shows how well a depth profile in the inversion search space was matched to the set of phase velocities at different frequencies for each grid cell. The misfits for the produced velocity model are all below 0.6 % with the majority below 0.4 %.

Insights from the 3D velocity model

Depth slice through the model near surface closely resembles the expected geology



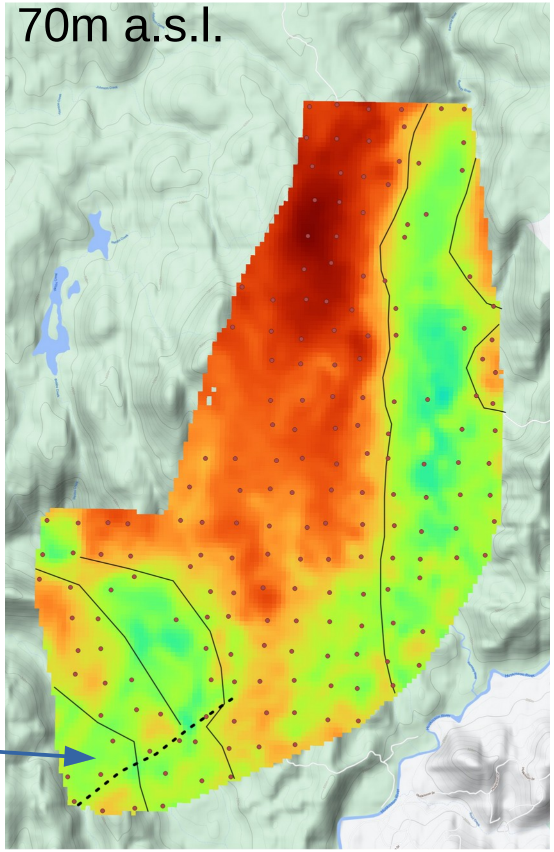
Depth slice through the model near surface closely resembles the expected geology

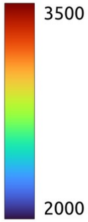


Possible weathering close to surface where rivers and creeks are present.

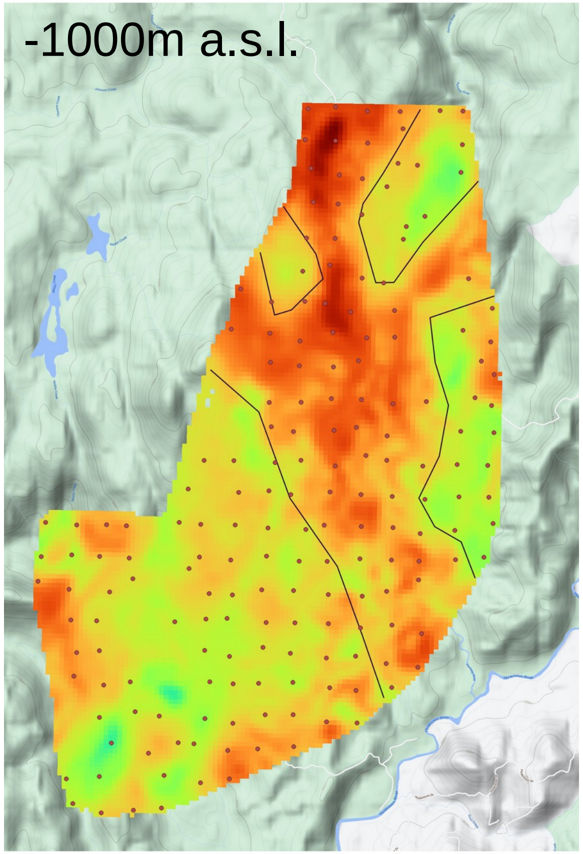
Another slice at lower depth (away from weathering influence) shows the same separation between regions

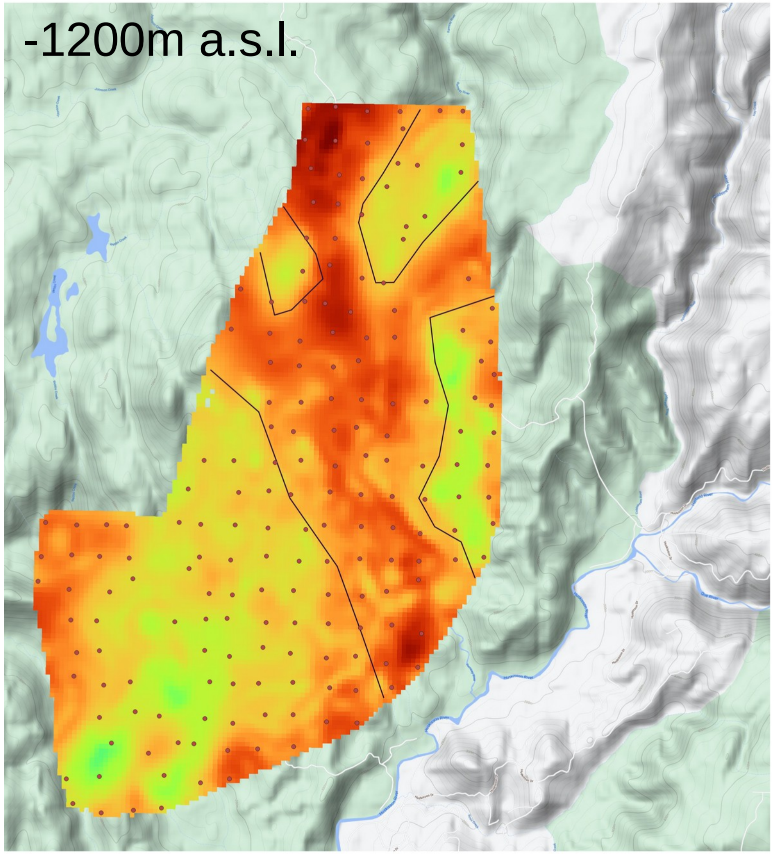
Fault identifiable in depth slices

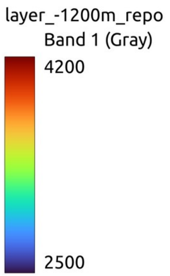




Depth slice through model





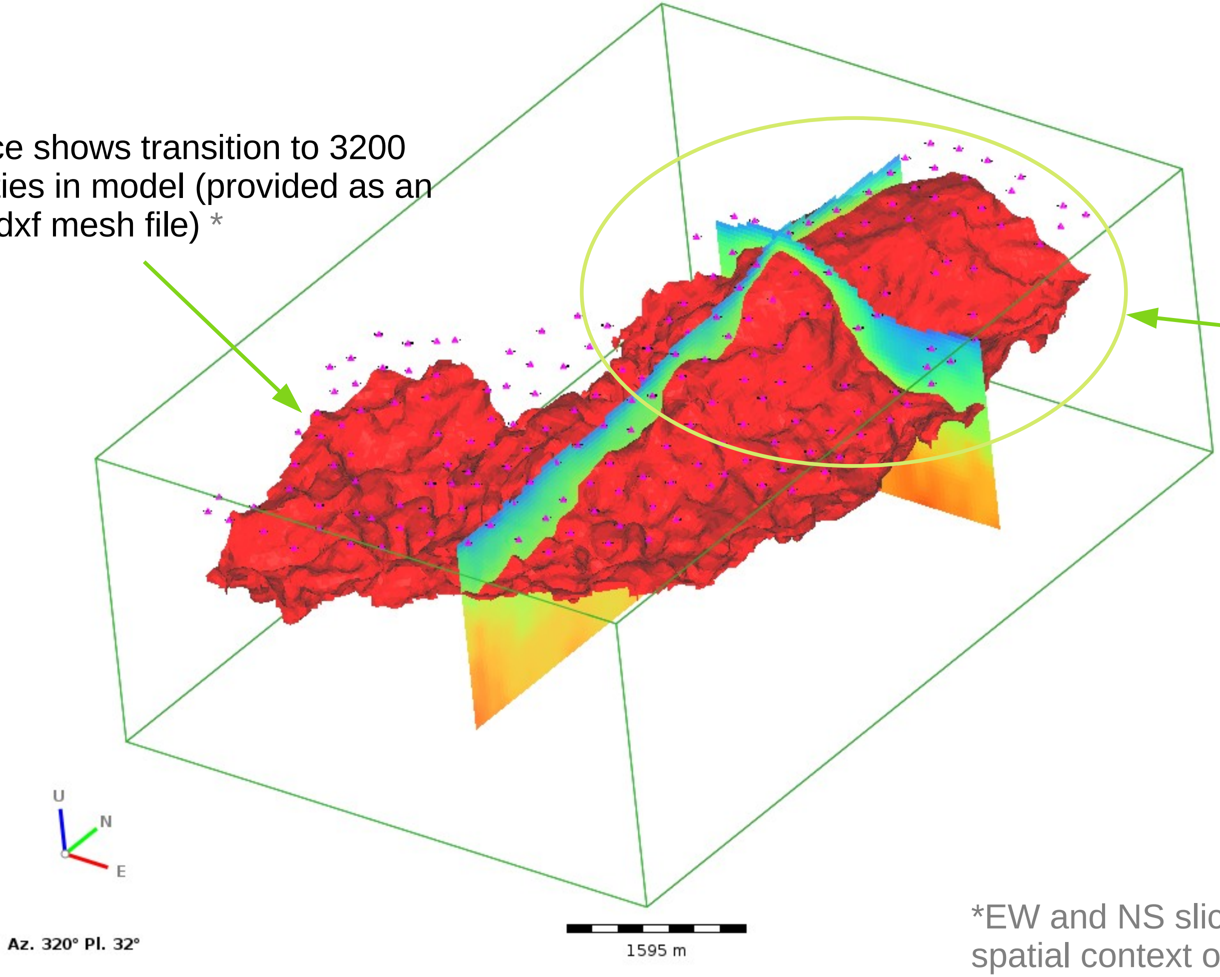


High velocity anomalies in the deepest parts of the model

Groupings of depth profiles at 3200 m/s could indicate transition of cover to granite

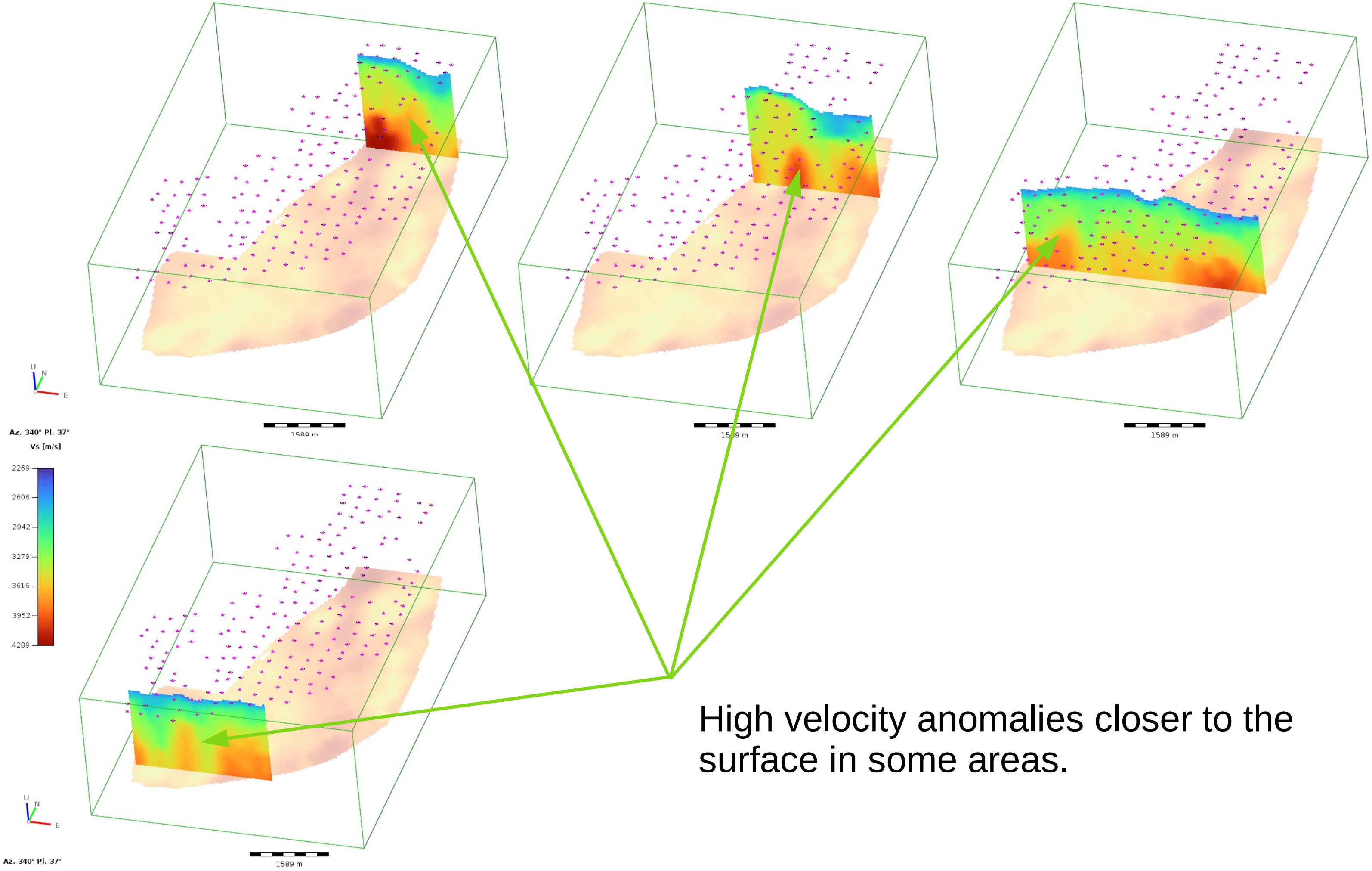
Red surface shows transition to 3200 m/s velocities in model (provided as an additional dxf mesh file) *

In northern half of survey the surface is likely the cover to granite contact.



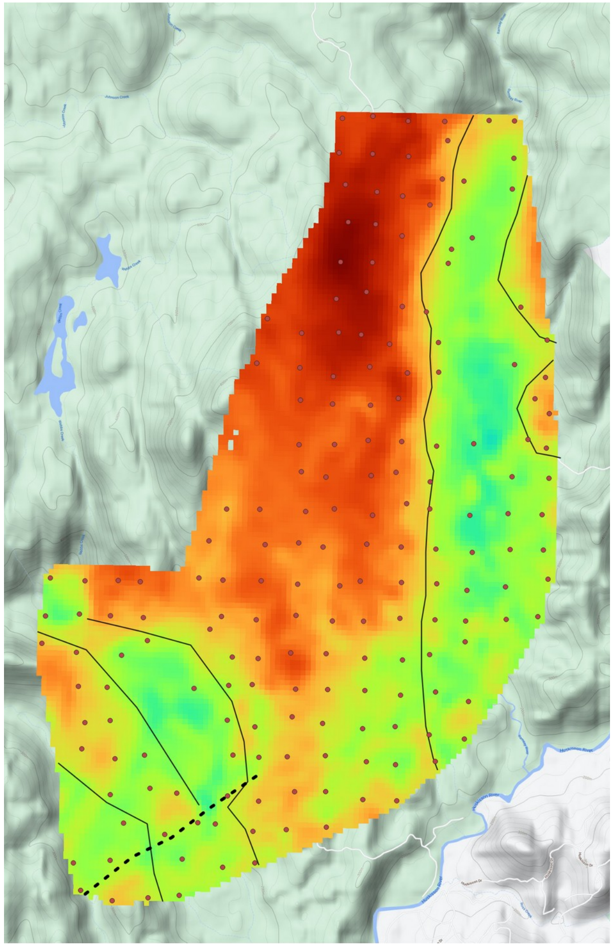
*EW and NS slices through model shown in aid of spatial context of surface.

EW slices through model with interesting anomalies



High velocity anomalies closer to the surface in some areas.

Conclusion



Cross-correlations of the seismic measurements taken at the Ramsay-Webbs seismic block were successfully used to generate a 3D velocity model of the survey area. This was due to good ambient noise conditions, with a clear wave moveout and clear dispersion characteristics - despite the difficulties of the survey deployment.

The 3D velocity model showed good acoustic contrast between rock types allowing for the matching of the model with known surface geology (as seen in vertical slices through model).

The velocity vs depth distribution of the model's depth profiles, showed many profiles group at 3200 m/s. Based on the available information for the survey area, this could be the cover to granite transition in the northern half of the survey.