Ambient Noise Tomography for Lithium Pegmatite Exploration: Case Study from the Bynoe Field Northern Territory, Australia

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SUMMARY

Core Lithium Ltd conducted a blind test of the Ambient Noise Tomography (ANT) technique in an attempt to image the BP33 pegmatite. A definitive low velocity zone was imaged at the BP33 location showing a vertical dyke-like structure as confirmed with drilling. The lower seismic velocities were predicted by drill core sonic measurements.

While not as clear as the BP33 pegmatite, other potential pegmatite targets were mapped as low velocity zones with vertical extents. Core Lithium has treated these as additional exploration targets to be tested. Additional near surface structural features were identified in the top 100m using the ANT data. These NW trending structures are host to many other pegmatites within the Finniss Project.

Key words: Ambient Noise Tomography, Passive Seismic, Lithium, Pegmatites

INTRODUCTION

The Bynoe Pegmatite Field, located just 15 km south of Darwin (Figure 1), has been a small but busy Sn-Ta production hub in the Northern Territory for over 100 years; however, it was not until mid-2016 that its credentials as a potentially world-class lithium district were recognised.

The Bynoe pegmatites are classified as LCT (Lithium-Caesium-Tantalum) pegmatites that likely evolved from the S-type Two Sisters Granite ca 1850 Ma (Frater, 2005). This granite is exposed ~5km to the southwest of the field (Figure 1) and is not immediately evident in the regional magnetic data (> 500m line spacing) available from the Northern Territory geological survey. It was emplaced under conditions favourable for the development and injection of volatile-rich structurally controlled pegmatite dykes into the overlying turbiditic Burrell Creek Formation. The regional magnetic data hints at the structural corridor in which the pegmatites of the Walker Creek, River Anne, Observation Hill, and Captains Table Groups intruded.

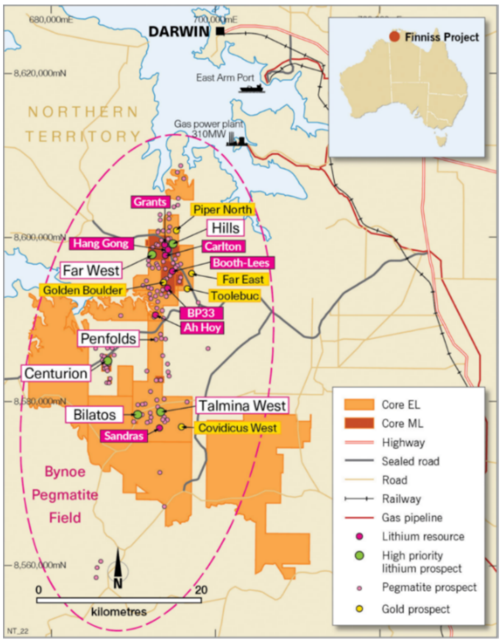

Figure 1: Map and prospect details of the Bynoe Pegmatite Field (Bennett, 2023)

Core Lithium (Core) has concentrated exploration in areas of historical Sn-Ta workings, and this strategy has proven highly successful, leading to the development of the Grants Lithium Mine, as well as definition of a number of other lithium mineral resources as part of the Finniss Lithium Project. Due to weathering, no spodumene is present in the surface expression of the pegmatites, although some geochemical trends were recognised. Only when Core conducted deep RC drilling were ore grades of Li_2O encountered.

Regional open file geophysical datasets available for the area include:

- Compilation of legacy airborne magnetic data with line spacing in excess of 500 m available form the Northern Territory government, and
- Newly collected 500 m station spacing ground gravity data, collected as part of a Northern Territory government grant in 2020 (Rawlings, 2021).

As seen in Figure 2, the gravity data provides good regional geological mapping capability, while the open file magnetic data only hints at the geological complexity of the area. Higher resolution magnetic data has been useful in identifying structures and fold patterns. When looking at the first vertical derivative of the residual gravity data the Two Sisters and Ringwood granites can be seen as gravity lows in the west and southeast respectively. This was expected as the granites have lower density than the Burrell Creek Formation. Interestingly, a third gravity low is present in between the two aforementioned granites, and this has been interpreted to be a third, deeper granite body. The gravity data has also been useful in categorising the geometries of the known pegmatites with regards to their positions relative to the interpreted granites (Rawlings, 2021).

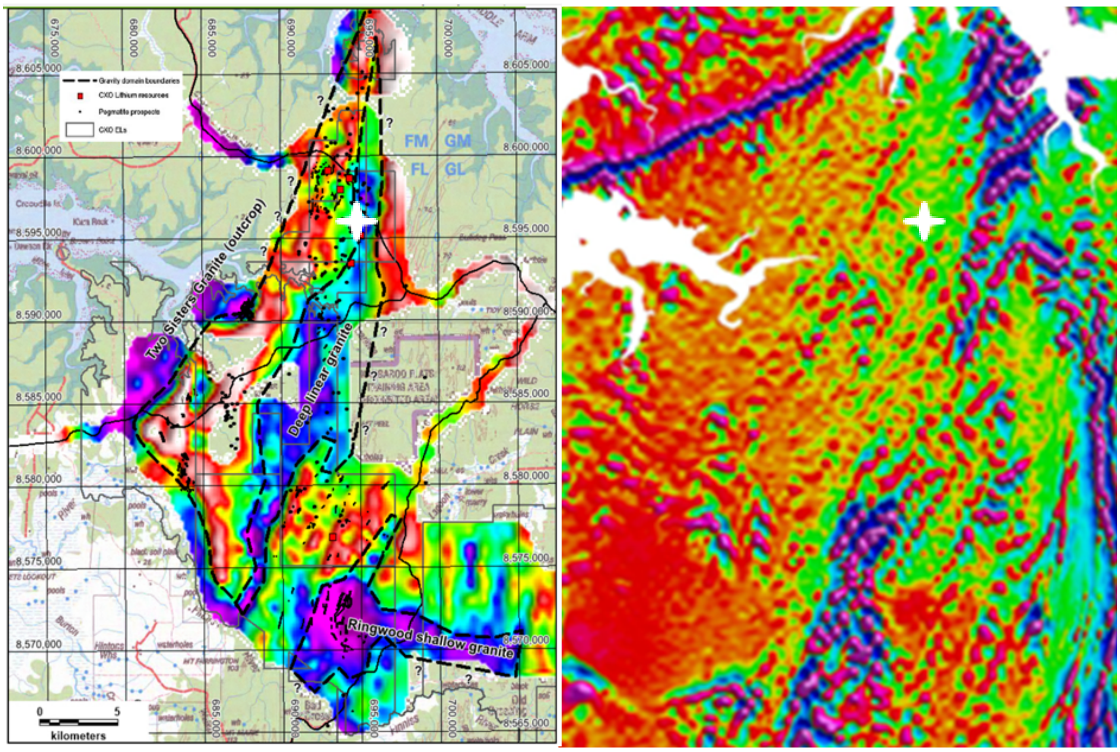

Figure 2: Finniss gravity survey,[t] first vertical derivative of residual gravity data, with regional geological interpretation (left); first vertical derivative of the RTP total magnetic intensity for the same area (right). The approximate BP33 pegmatite location is highlighted with the white star.

THE AMBIENT NOISE TOMOGRAPHY (ANT) METHOD

Ambient Noise Tomography (ANT) is a passive seismic technique that uses Earth's background noise as the signal for measuring subsurface velocity structure. An array of geophones records the arrival of low frequency surface waves created by natural and anthropogenic seismic sources. This technique is used to construct estimates of seismic Green's functions (Bensen *et al*, 2007) between station pairs such that every receiver is turned into a virtual active source that provides information about the subsurface. Inversion of the data can then be applied to construct a full 3D image of the seismic shear-wave velocity (Vs) structure at depth.

Fleet Space Technologies (Fleet) have commercialised an ANT service called ExoSphere that is notably different from industry norms in two ways (Olivier et al, 2022):

1. Bespoke geophones (Geodes) that provide increased sensitivity to low frequency signals used in the ANT process, and
2. Connecting the Geodes to a satellite network to provide monitoring and rapid processing of uploaded data on a cloud platform.

The ANT survey performed for Core was a functional test of the real-time connected system using a traditional geophone connected to a satellite modem. This setup provided real time data as per the current Fleet Geode but had a higher frequency geophone mechanism. Traditional geophones with no satellite connectivity were deployed as a back up to ensure data collection and processing could proceed if the functional test failed. The data used for the Core survey was ultimately collected using the backup NuSeis geophones. Having the two sets of geophones in the field was instructive, and an important step in the development of the current Fleet Geode.

CORE LITHIUM BP33 SURVEY

In 2022, Core undertook several ANT trial surveys in collaboration with Fleet to test if direct detection of pegmatites was possible in the Bynoe pegmatite field. Prior to commencing ANT trial surveys, Core performed hundreds of tests on drill core using a sonic velocity meter to measure the compressional velocity (Vp) – holes FDD009 and NMRD012 had sufficient samples of both the Burrell Creek phyllites and pegmatite targets for analysis and only values from these holes have been used in this paper. FDD009 is from the BP33 pegmatite and NMRD012 is from the Carlton prospect, 5 km to the north. The histogram of phyllite Vp measurements showed a mostly normal distribution of values peaking at around 5,500 m/s. The histogram of the pegmatite Vp measurements was more varied, with multiple velocity peaks in a range from 4,600 to 5,200 m/s. This trend of generally lower pegmatite Vp can also be seen on the Vp – depth logs for each drill hole in Figures 3 and 4. Forward modelling using Vp as a scaled proxy for how shear wave velocity (Vs) would behave, indicated that this velocity contrast was sufficient for ANT to detect the larger pegmatite bodies. This result provided the impetus for the trials to proceed.

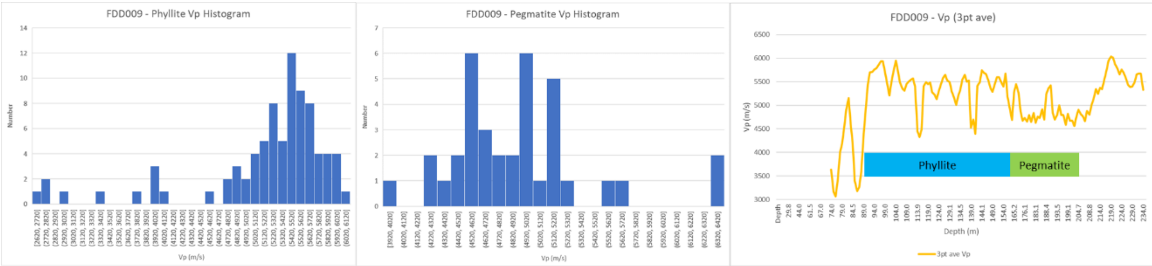

Figure 3: Sonic velocity measurements of core from hole FDD009. From left to right: phyllite Vp histogram, pegmatite Vp histogram, Vp log with lithology.

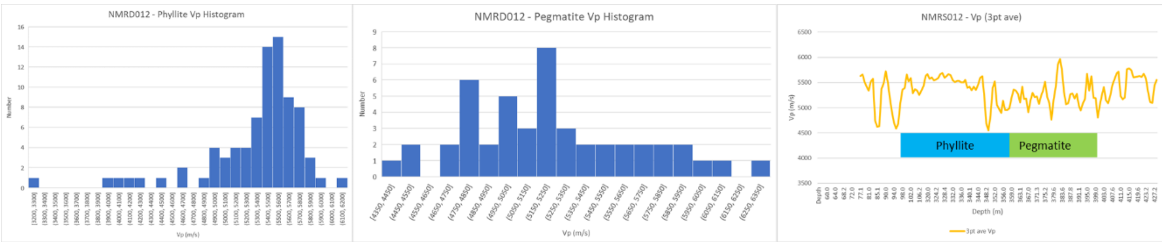

Figure 4: Sonic velocity measurements of core from hole NMRD012. From left to right: phyllite Vp histogram, pegmatite Vp histogram, Vp log with lithology.

The first ANT trial was located at BP33 (Figure 1), one of the largest known pegmatites in the Bynoe Pegmatite Field with a reported mineral resource of 10.1 Mt at 1.48% Li_2O (Core, 2023). Mineralisation at BP33 is hosted within a dominant, large, sub vertical pegmatite body and a smaller sill-like body on the northwestern side of the main pegmatite (Figure 5). Fresh pegmatite is composed of coarse-grained spodumene, quartz, albite, microcline and muscovite, with spodumene being the predominant lithium-bearing phase. The BP33 pegmatite is interpreted to be ~350 m in strike length and up to ~40 m in true width. There is a very strong, steep southerly plunge component with a depth extent now in excess of 800 m (Bennett, 2023).

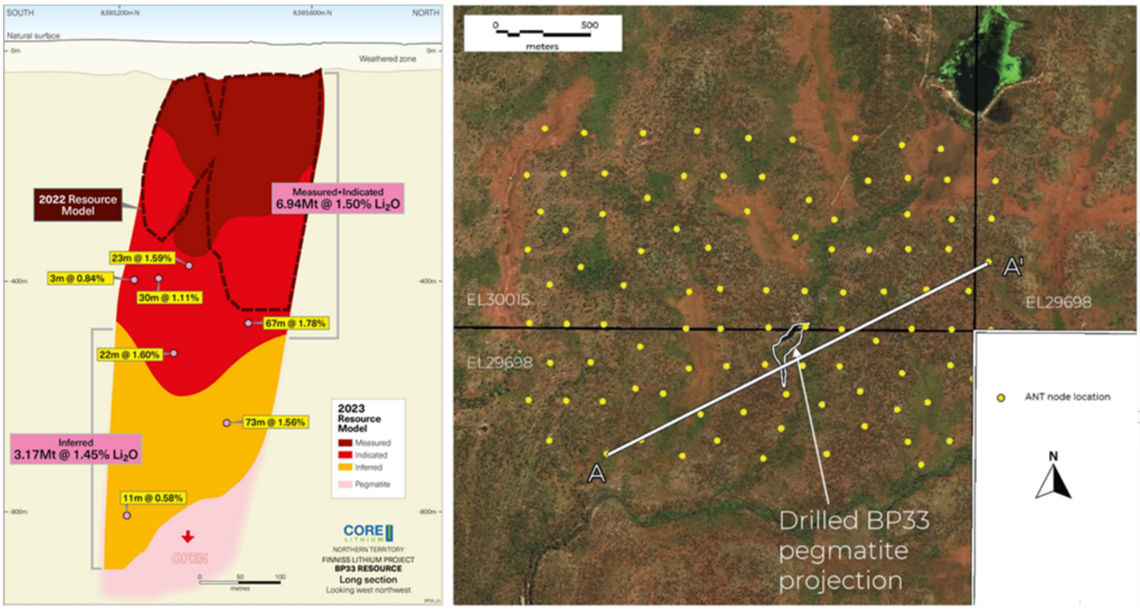

Figure 5: Schematic long section of resource model of BP33 pegmatite (left), and ANT survey grid showing location of cross section & BP33 pegmatite (right).

Results of the ANT trial at BP33 (Figure 6) were an outstanding success with the BP33 body imaged as a distinct low velocity anomaly, showing excellent correlation with the pegmatite body interpreted from drilling, including the dyke-like shape of BP33 (Figure 7 - bottom). The survey was done with 200 m-spaced stations on an approximately square grid, but with a reasonably short baseline of 1.5 km which meant velocities could be modelled to 500 m depth. The model highlighted a number of other low velocity zones (Figure 7 – top right), which represent new pegmatite targets that have never been drilled.

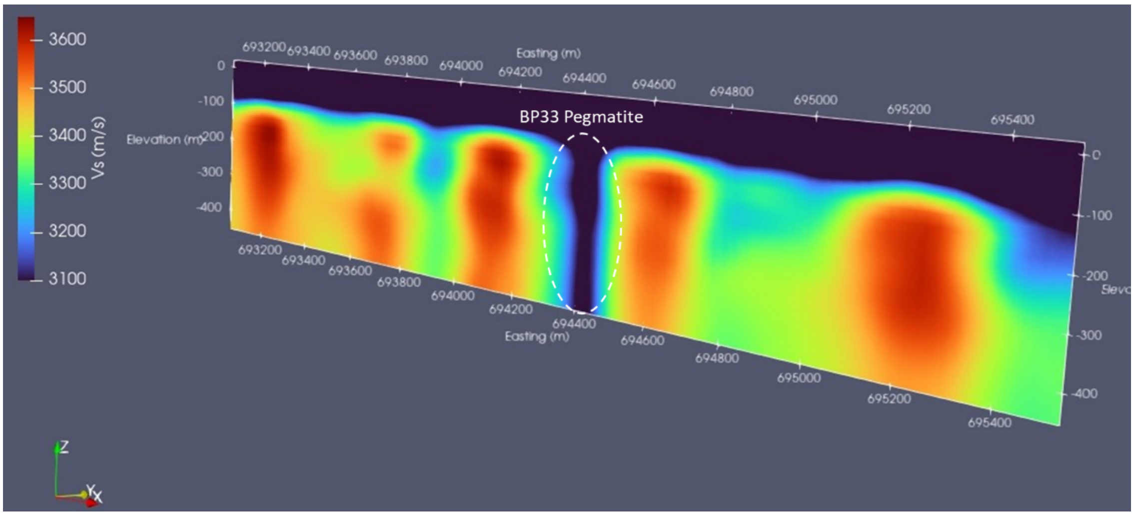

Figure 6: Cross section A–A' (Figure 5) showing section of 3D Vs model through the BP33 pegmatite

The ANT survey also provided imaging of geological structures, particularly in the near surface (Figure 7 – top left). There is some evidence to suggest that one of the structures imaged is a controlling geological feature for the Golden Boulder historic Gold mine. More importantly, the ANT data imaged a number of NW trending structures that are known to exist in this area – the two that intersect BP33 are called Shirley's trend. This trend hosts some thin, shallowly dipping pegmatite bodies. In general, the NW trending structures host pegmatite resources in other Core areas.

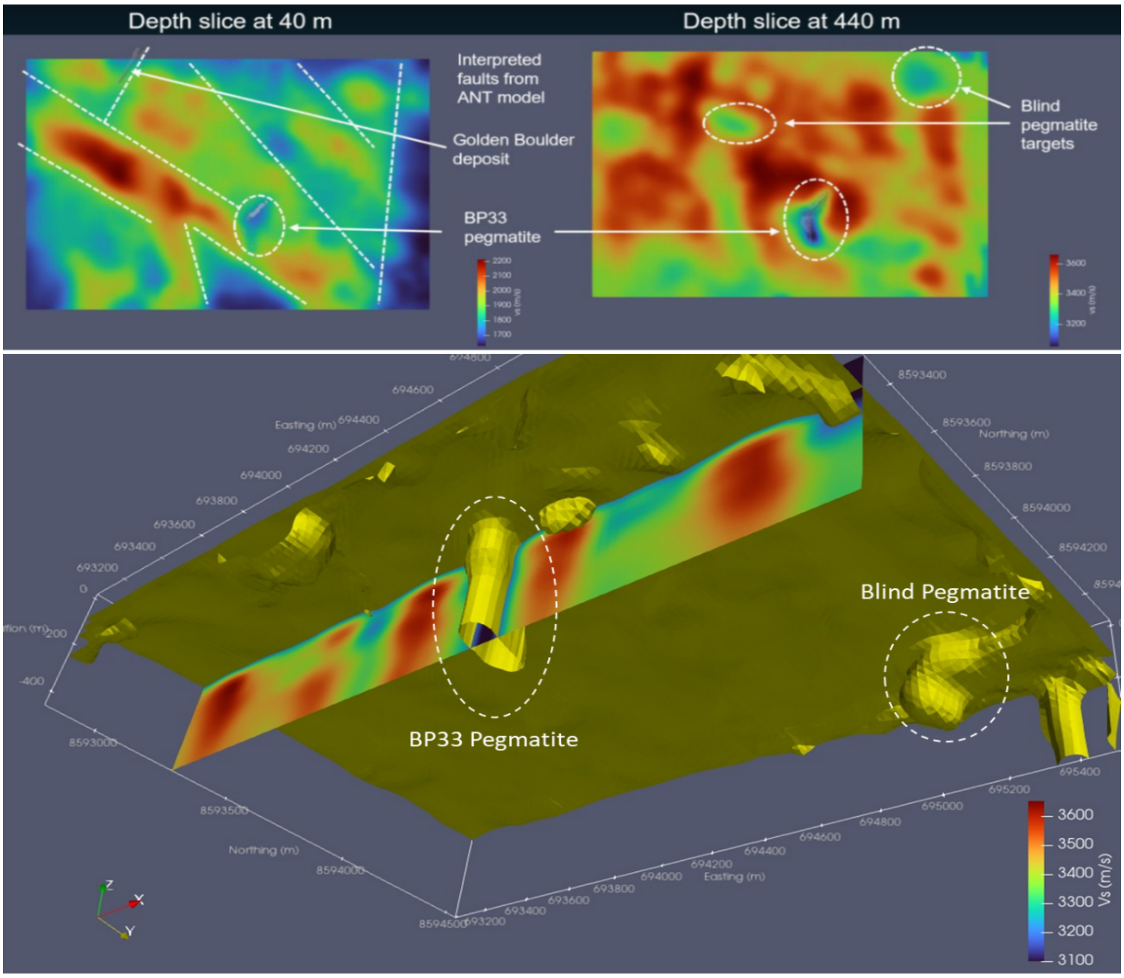

Figure 7: Depth slices at 40m and 440m below the ground surface through the 3D Vs model showing various geological features (top). Isosurface of values of 3,200 m/s highlighting the dyke-like shape of BP33 and a potential blind pegmatite body (bottom).

CONCLUSION

Ambient Noise Tomography is a relatively new geophysical application for project scale mineral exploration. However, traditional passive seismic data has long been used to map the deep velocity structure of the Earth, and other terrestrial bodies in the solar system. Core Lithium conducted a blind test of the Fleet's ANT service in an attempt to image the BP33 pegmatite. A definitive low velocity zone was imaged at the BP33 location showing a vertical dyke-like structure as confirmed with drilling. The lower velocities were predicted by drill core sonic measurements. While not as clear as the BP33 pegmatite, other potential pegmatite targets were mapped as low velocity zones with vertical extents. Core Lithium has treated these as additional exploration targets to be tested.

While potential field methods are useful for structural or stratigraphic mapping important for understanding the regional system, they do not directly detect pegmatites in this area. However, there is some evidence to suggest that ANT data does have the ability to detect, at least, very large pegmatite bodies such as BP33. Furthermore, structural mapping of important NW trending structures that host pegmatites within the region highlights the exploration value gained from this geophysical tool.

ACKNOWLEDGMENTS

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