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# Lemont regional tectonostructural analysis from integration of gravity, magnetics and deep seismic reflection imaging

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Nick Direen

1:250 000 Map Sheets SK5502& SK5504 Northeast Tasmania & SK5508 & SK5506 Southeast Tasmania

Company: Solution Energy Pty Ltd



30 May 2025

Nick Direen

Principal Geoscientist

Mitre Geophysics Pty Ltd

Email: [nick.direen@mitregeophysics.com.au](mailto:nick.direen@mitregeophysics.com.au)

John Bishop, Director, Solution Energy Pty Ltd

Fiona Levings, Exploration Manager, Solution Energy Pty Ltd

Dear John and Fiona

Please find in my report below the outcomes of Mitre reprocessing and interpretation of two depth converted and well-tied deep seismic reflection lines TB01-ST and 95AGS-T4 through Lemont, Tasmania, as well as the interpretation of the reprocessing and filtering of gravity and magnetic data for this region.

The structures interpreted in map and section have been tied together using a model for the tectonostratigraphic evolution of Tasmania derived from extensive literature review, and calibrated against maps and other seismic sections of the basins around Tasmania.

The new interpretation goes well beyond the previous attempts to interpret the seismic and potential field datasets made by Great Southland Mineral/Empire Energy, Hot Dry Rocks and KUTh Energy and their consultants. In particular, the ability to interpret the remigrated seismic data in depth, and in the context of a velocity model, has allowed greater details to be elucidated from the seismic data. The upgrading of the potential fields datasets with modern high resolution coverage, and the application of modern filters allowing the extraction of incredible detail to enhance geothermal exploration.

Some key findings of this work include: a lack of evidence for granite bodies beneath Lemont (*contra* Leaman 2012); the stacking of slices of Mathinna Supergroup (and possible Ordovician ocean crust) beneath Lemont; and the lack of control on the present day stress field in Tasmania from borehole and neotectonic data. All of these findings suggest further studies should be undertaken before committing to a geothermal exploration program that may critically depend on knowing these parameters.

Best regards,

Nick Direen

Mitre Geophysics





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## Summary

This report summarises the integration of three pieces of work conducted by Mitre Geophysics through January-May 2025:

- 1) A comprehensive literature review of the tectonostratigraphic evolution of Tasmania, focussing on tectonic events in eastern Tasmania between the Devonian to Recent. This review identified 6 major tectonic events that created or reactivated structures, along with evidence supporting the orientation of the principal horizontal stress direction ( $\sigma_1$ ), and the likely orientation of related structural elements in the brittle crust.
- 2) Interpretation of two reprocessed deep seismic reflection lines in depth, and with the addition of a tomographic interval velocity model for each line, supplied by Internode Seismic. Interpretation was made using a seismic facies approach to identify panels of rock with similar reflector geometry and impedance, as well as bulk velocity, and tied to a deep well and the mapped geology at surface to derive a constrained interpretation within the limited time available.
- 3) With the benefit of elements 1 & 2, the interpretation of advanced filtered potential field datasets to identify structures in map view that could then be attributed for geometry and temporal tectonic activity, to build up a detailed picture of the structural evolution of the Lemont area from the Devonian to the Recent, and a prediction of the current responsiveness of the interpreted structure in the currently (modelled) stress field. The 6 main events were attributed onto structures oriented at the correct angles to the principal horizontal stress to identify faults active as normal, reverse, and in various strike slip modes. This analysis has value for determining the likely bulk permeability of structures to fluid flow during any time period (noting that any individual structure's permeability is determined by lithological constraints such as gouge development and lithology along the fault zone: Morrow et al. (1984)).



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# 1 Introduction

In December 2024, Solution Energy approached Mitre Geophysics (Mitre) to assist with geophysical analyses related to geothermal projects at Lemont and in the Fingal Valley region of Tasmania (Figure 1).

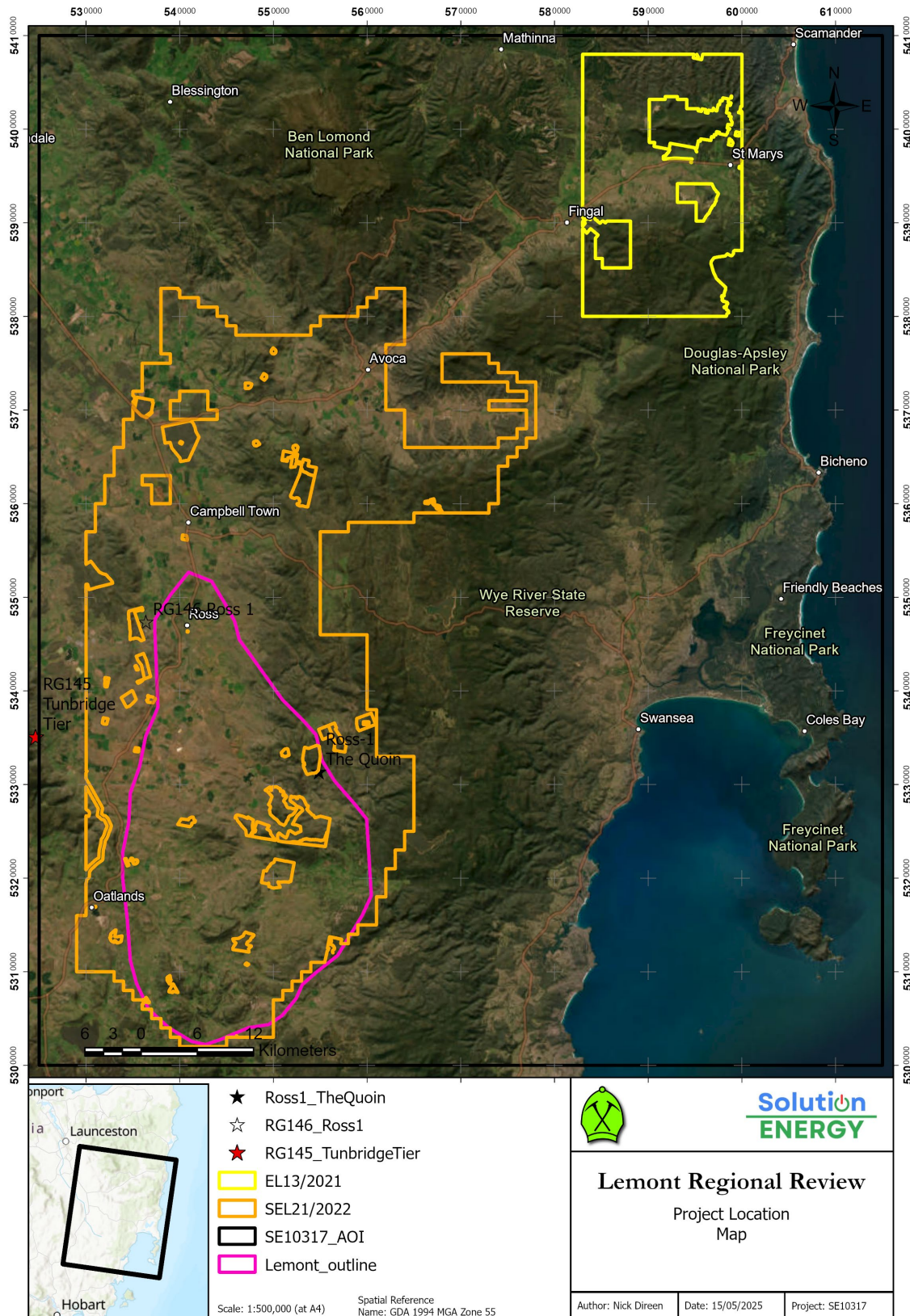


Figure 1: Lemont Project location map, displaying the AOI, and Solution Energy exploration tenements.



## **2 Regional Geology & Tectonics**

The Lemont region has been mapped at surface by Mineral Resources Tasmania and its predecessor organisations, and is covered by both 1:250 000 scale maps (Forsyth et al., 2024; McClenaghan et al., 2011), as well as 1: 50000 and 1:63360 sheet mapping covering the Oatlands, Interlaken, Longford, Snow Hill and St Marys sheets (Blake, 1959; Calver et al., 1988; Forsyth, 1989a; Forsyth et al., 1976; Gulline et





al., 1991; Matthews, 1974; Matthews et al., 1996; Turner et al., 1987).

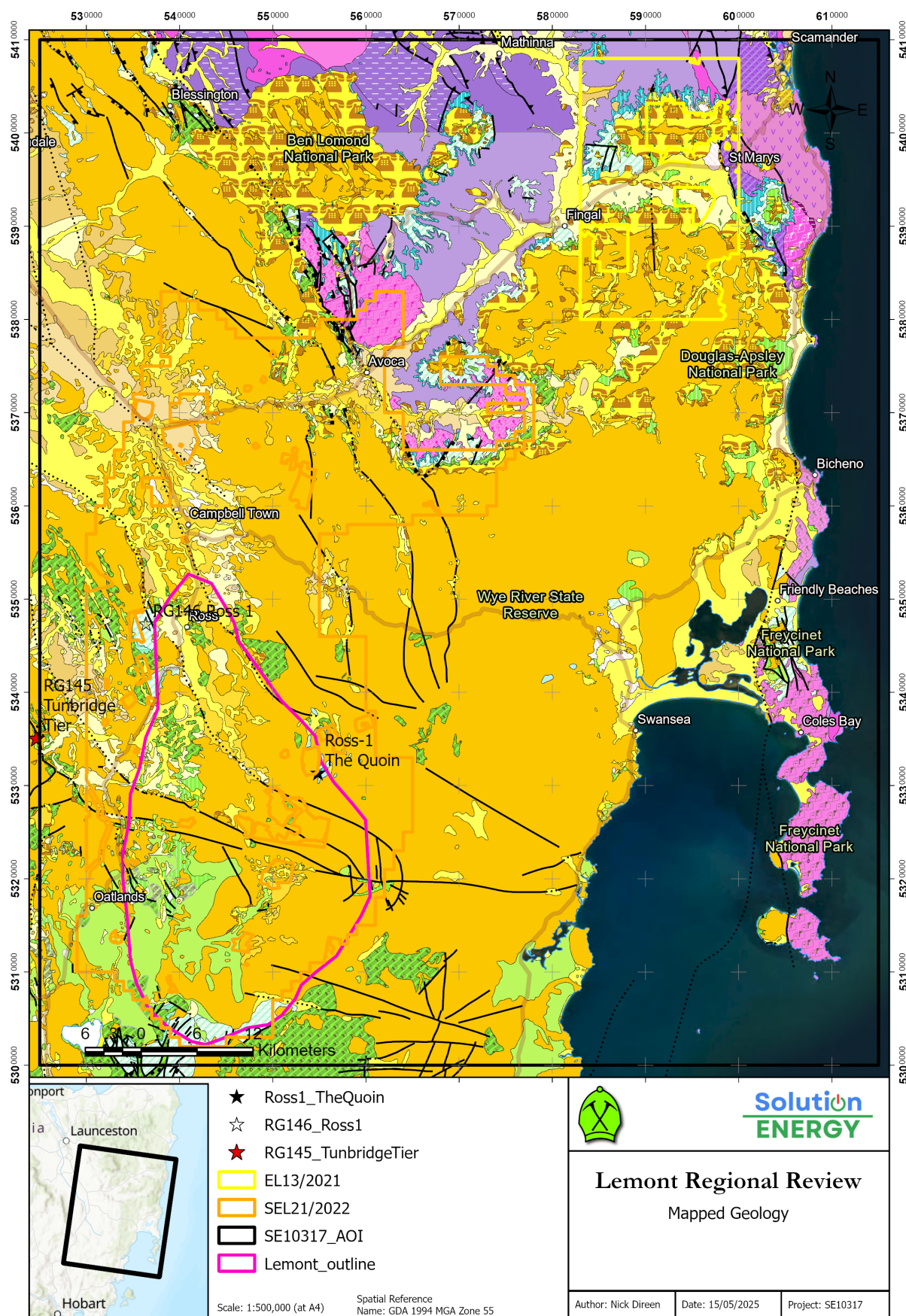


Figure 2: Regional geology of Lemont (modified from Forsyth et al. 2024 & McClenaghan et al., 2011).





In descending order of age, stratigraphic sequences recognised include (largely unconsolidated) Quaternary alluvial, aeolian and talus deposits; and Tertiary basalts, ferricretes and unconsolidated lake and alluvial deposits. These lie unconformably on the Mesozoic-Palaeozoic Parmeener Supergroup of the Tasmania Basin (Reid, 2002; Reid and Burrett, 2004; Stacey and Berry, 2004), which has been extensively intruded by sheets of Jurassic dolerite (Bromfield et al., 2007; Cruden et al., 2020; Cruden et al., 2022; Everard et al., 2014; Leaman, 1995). The Tasmania Basin was in turn developed unconformably on Early Palaeozoic to Neoproterozoic sequences of the Western and Eastern Tasmania terranes (Berry and Bull, 2012; Berry et al., 2025). Inliers of the Neoproterozoic and Cambrian Western Tasmania terrane basement rocks are exposed on the Lake River sheet, west of Campbell Town (Matthews et al., 1996), and inliers of the Devonian granites and Ordovician-Devonian Mathinna Supergroup of the Eastern Tasmania terrane are exposed to the north on the Snow Hill sheet (Gulline et al., 1991).

The tectonic evolution of central & eastern Tasmania has been recently documented by Calver et al. (2014); Everard et al. (2014); Quilty et al. (2014); Reid et al. (2014); and Seymour (2014), building on earlier work including Direen (1999); Reid and Burrett (2004); Seymour and Calver (1995); Stacey and Berry (2004); and Stacey (2009). Additional useful information about the evolution of the Bass Strait, Tasman Sea and related basins that extend into north and eastern Tasmania can be found in Blevin and Cathro (2008), and Korsch et al. (2009). Other more recent updates of geochronology for certain parts of the Tasmanian stratigraphic column can be found in Gray et al. (2024); Mortensen et al. (2015); Mulder (2017); and Mulder et al. (2020). I have summarised the tectonic evolution of Tasmania in the accompanying time-space tectonostratigraphic spreadsheet (SEPL\_Tectonostrat\_v0.xlsx). Analysing the sequence of tectonic events is critical for interpreting the structures present in both the seismic data and from the potential field datasets; the following 6 events are important in the overall tectonic history of the Lemont area, from youngest to oldest:

1. Palaeocene (~56 Ma) inversion. This event is well documented from the Durroon Basin and northeast Tasmania near St Helens (Hill et al., 1995), and produced inversion on NNW-SSE oriented faults due to orientation of  $\sigma_1$  in an east-northeast-west-southwest direction. The cause is inferred to be the 67-60 Ma failed rifting in the Bass Basin (Blevin and Cathro, 2008).

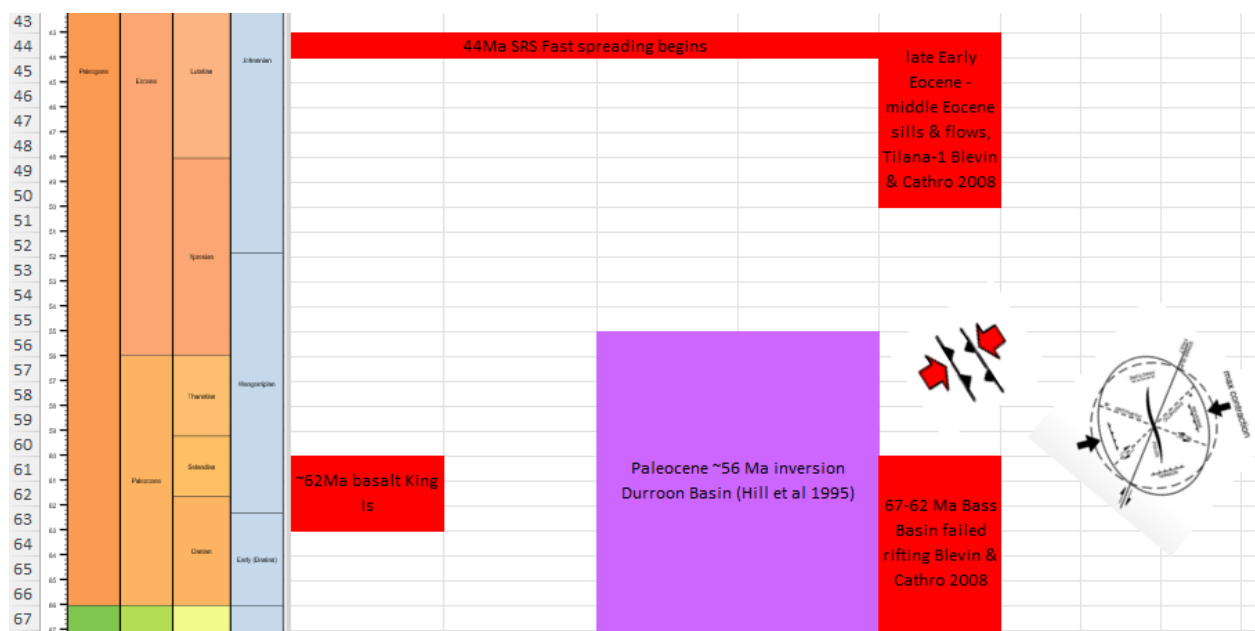


Table 1: Extract from tectonostratigraphic chart for the Palaeocene event

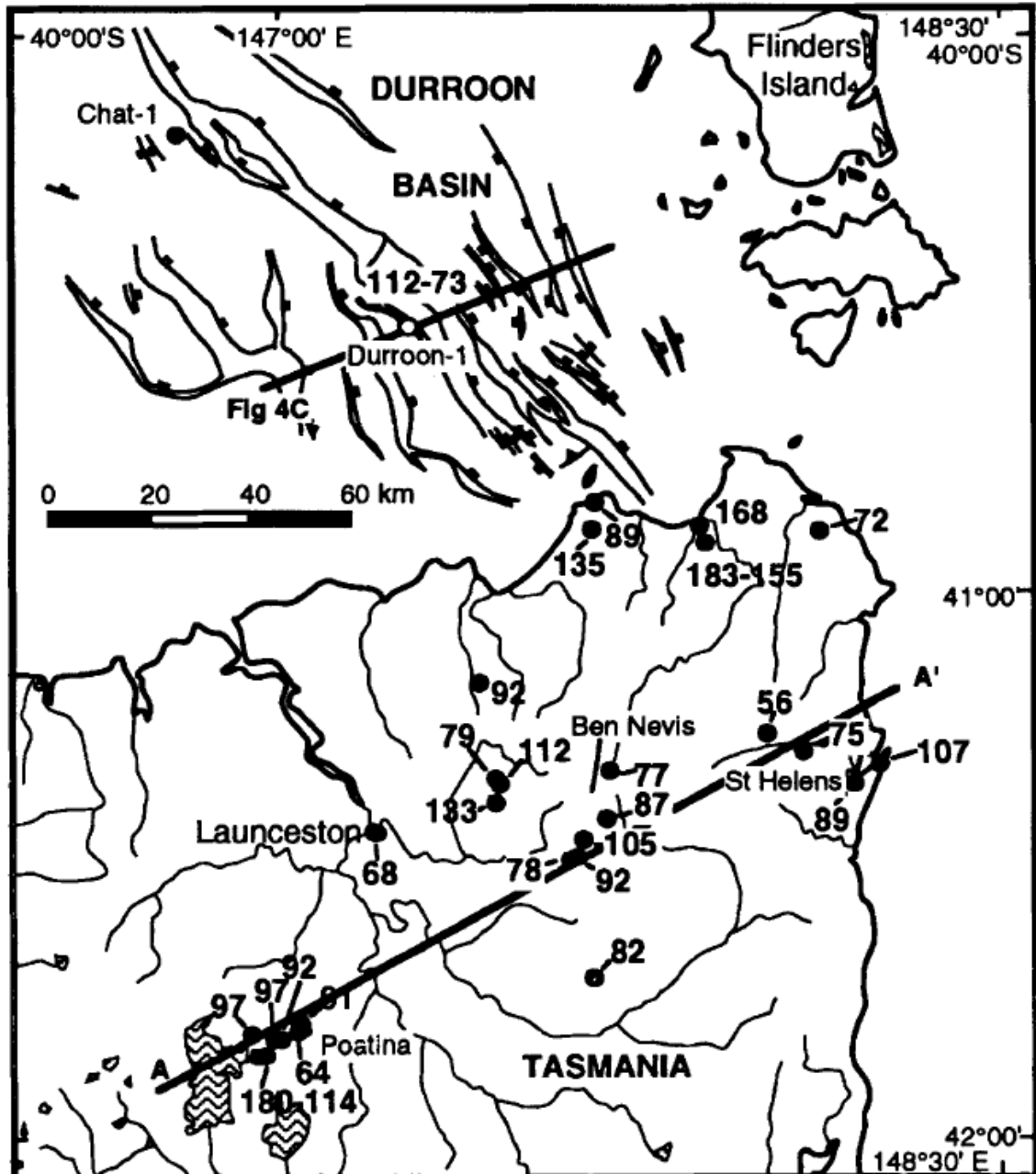


Figure 3: Location map for seismic line showing inversion in NE Tas & Durroon Basin

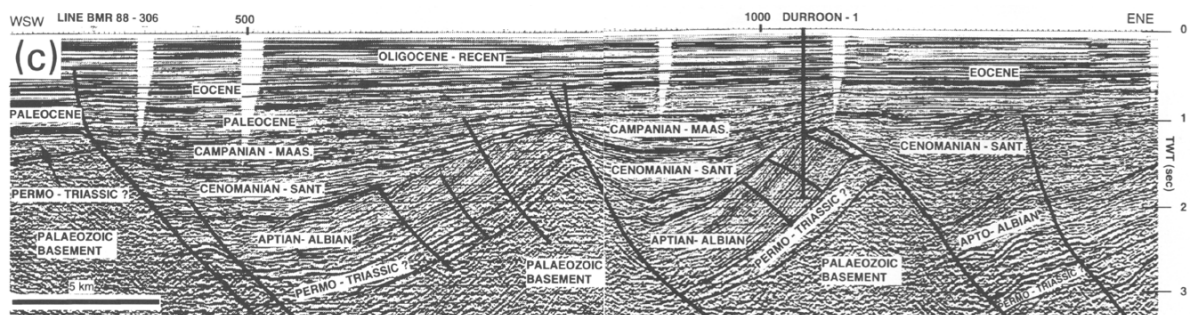


Figure 4: Palaeocene inversion Durroon Basin (adapted from Hill et al. (1995)). Location shown in Figure 2.

2. 94-85 Ma Tasman Sea rifting and 83-80 Ma Southern Rift System breakup (Blevin and Cathro, 2008; Direen et al., 2007; Sayers et al., 2001). This event produced NW-SE trending normal faults due to orientation of  $\sigma_1$  in an east-northeast-west-southwest direction. The event may have



partially overlapped with the 99-95 Ma Port Cygnet Complex (<https://asud.ga.gov.au/search-stratigraphic-units/results/15465/port-cygnet-complex>) (see also Fig. 5 for distribution of the alkaline syenite complexes). Cretaceous half-grabens in the Durroon Basin from this event are also shown in Figure 3, and it is thought that basins such as the Longford Basin also originated at this time (Direen and Leaman, 1997).



Table 2: Extract from Tectonostratigraphic chart for the mid Cretaceous event

- 150-125 Ma Kimmeridgian-Barremian Late Jurassic-Early Cretaceous NNE-SSW rifting, which has been documented off King Island, and in the Bass & Durroon Basins (Blevin and Cathro, 2008), forming grabens with ENE-SWS trends.

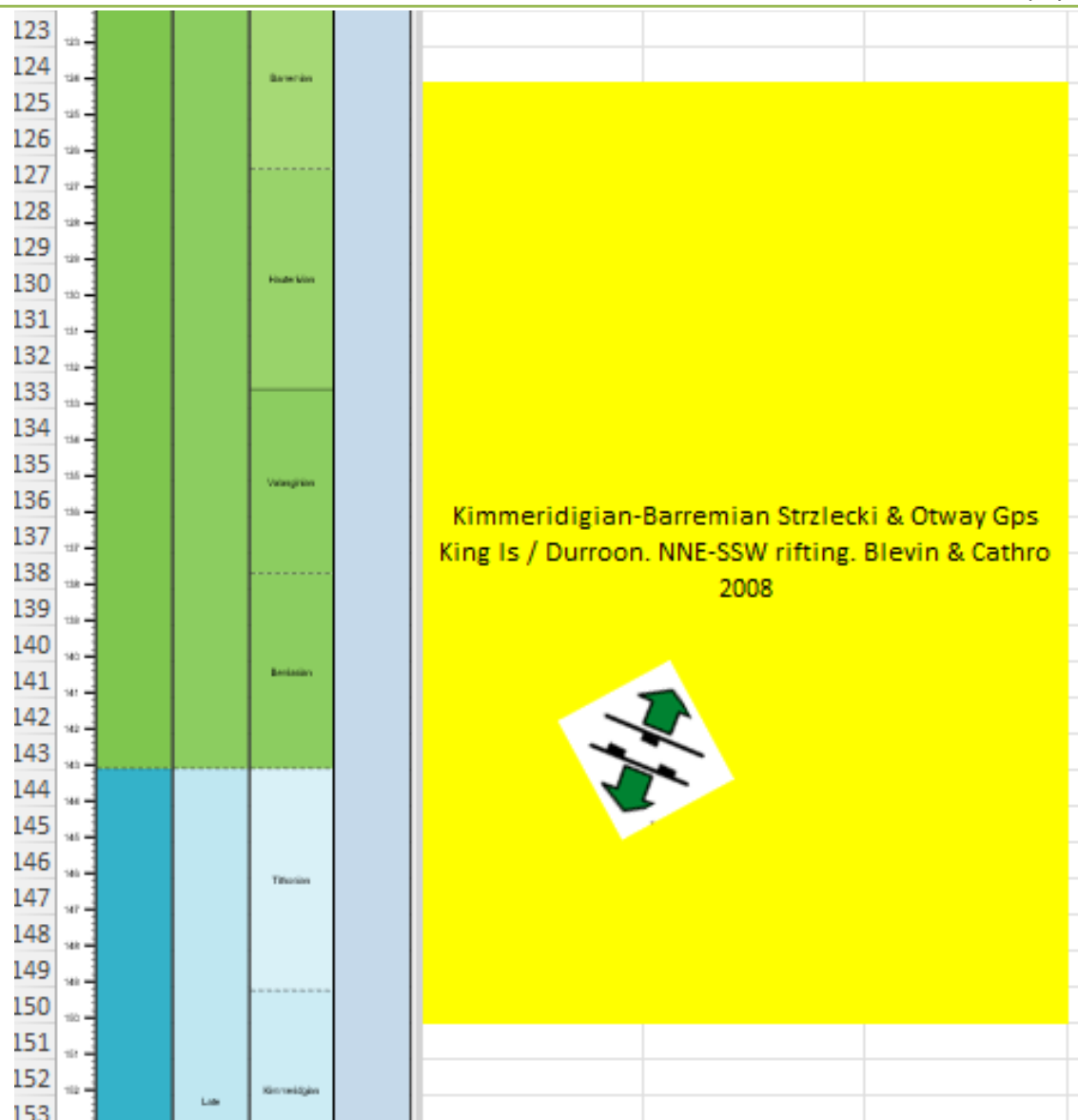


Table 3: Extract from Tectonostratigraphic chart for the late Jurassic event

4. 186-180 Ma Jurassic dolerites (Bromfield et al., 2007), with  $\sigma_1$  oriented vertically, producing “saucer-shaped” sill complexes (Everard et al., 2014; Leaman, 2002; Leaman, 1995).

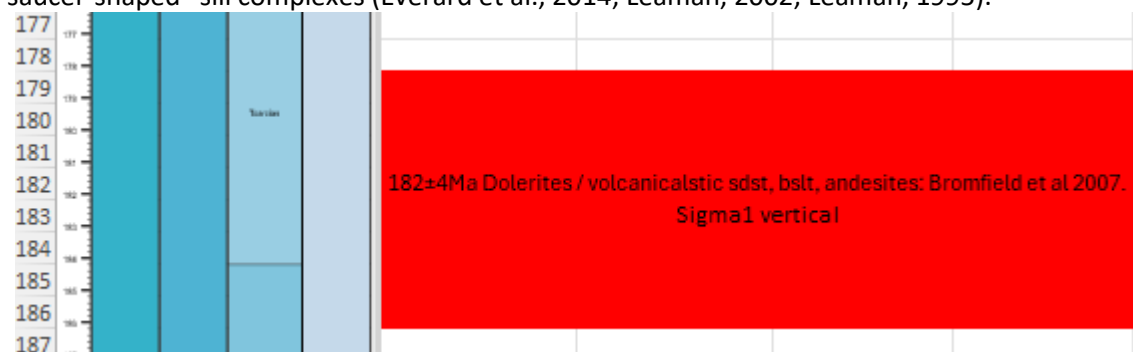


Table 4: Extract from Tectonostratigraphic chart for the mid Jurassic dolerite intrusion event

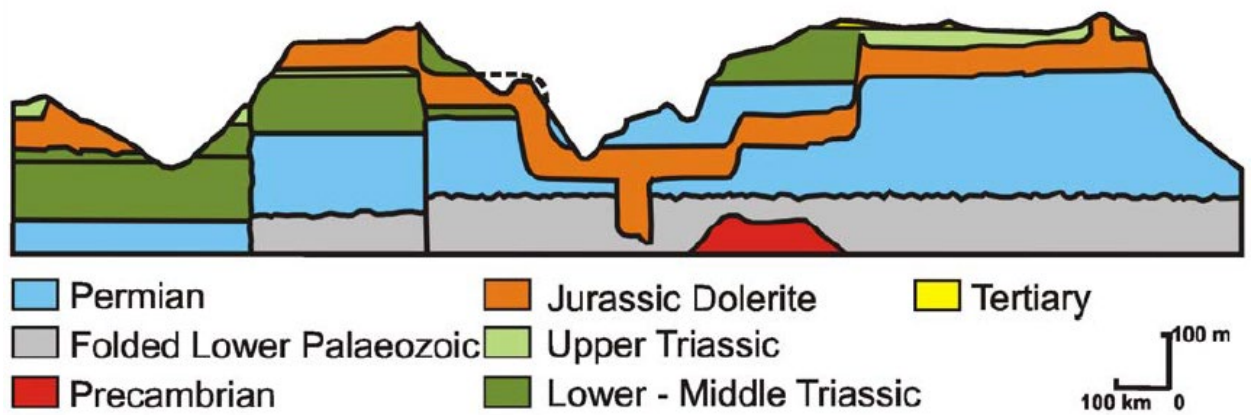


Figure 5: Intrusive form of dolerite sills. Modified from Stacey (2001) after Leaman (1975)

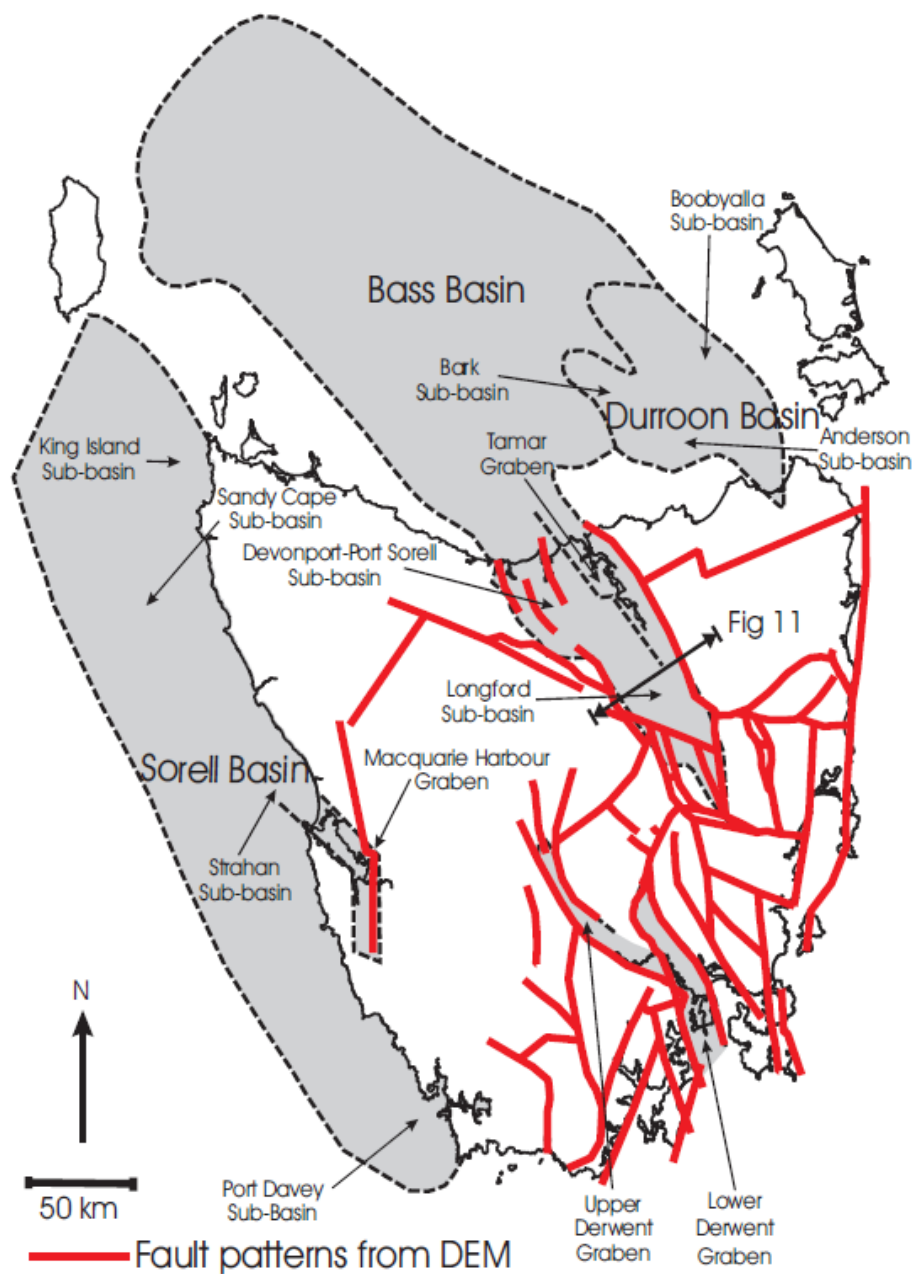


Figure 6: Jurassic-Tertiary fault patterns (from Stacey & Berry 2004)





5. Late Carboniferous (Bashkirian-Sakmarian) rifting, coincident with formation of the East Australian Rift System (Sydney-Gunnedah-Bowen-Tasmania Basins: Korsch et al. (2009). Cryptic growth faults within NNW-SSE trending depocentres were described by Reid (2002), and in Stacey (2009), suggesting  $\sigma_1$  oriented ENE-WSW.

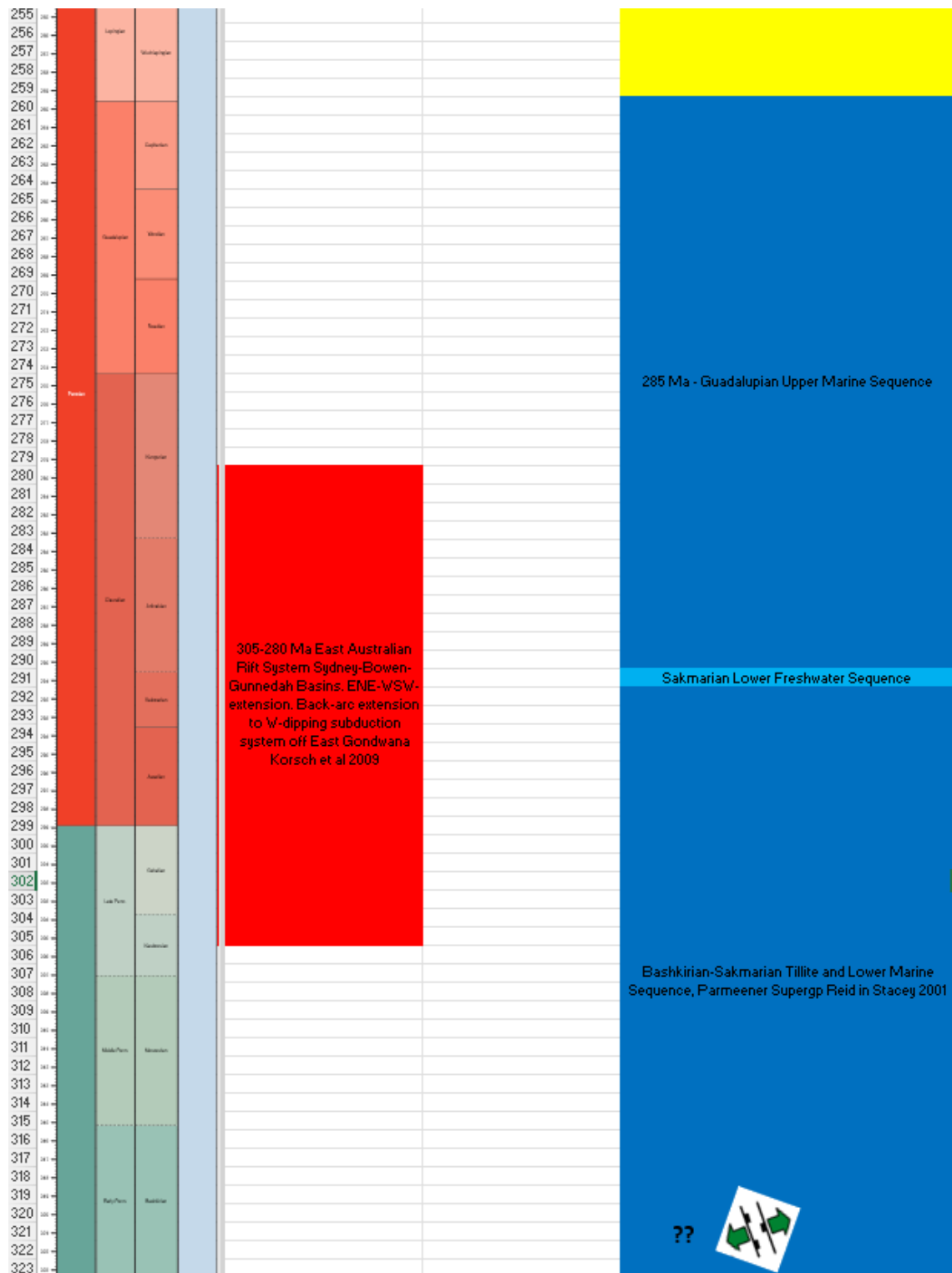


Table 5: Extract from Tectonostratigraphic chart for the Carboniferous-Permian rifting event

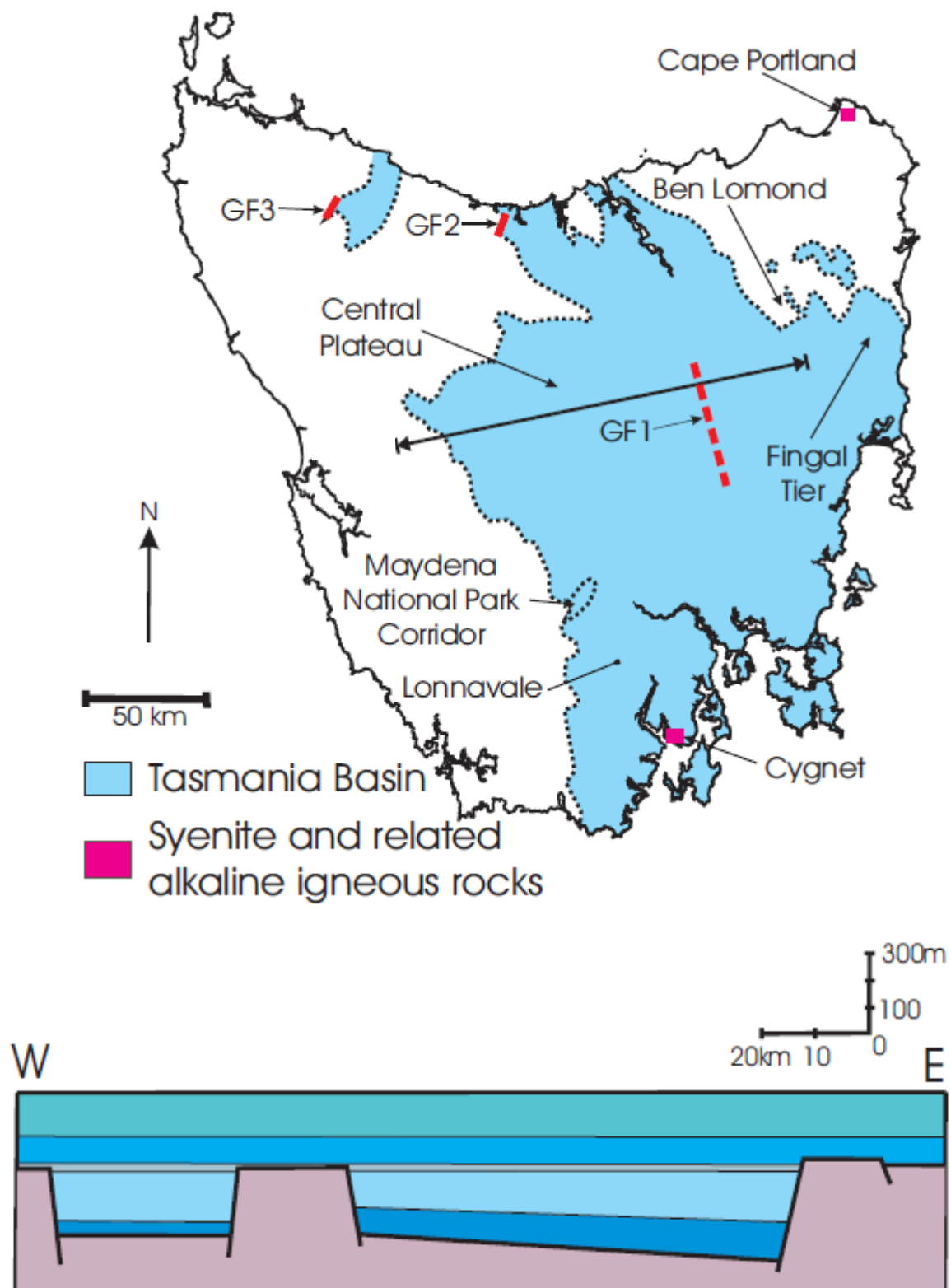


Figure 7: Extent of Tasmania Basin, with schematic cross-section showing cryptic Carboniferous-Early Permian extensional faulting (from Stacey & Berry, 2004).

6. 400-380 Ma (Devonian) Tabberabberan Orogeny (Seymour, 2014; Stacey and Berry, 2004). This major orogenic event produced N-S oriented folds from E-W shortening, and affected both the eastern and western Tasmanian terranes.

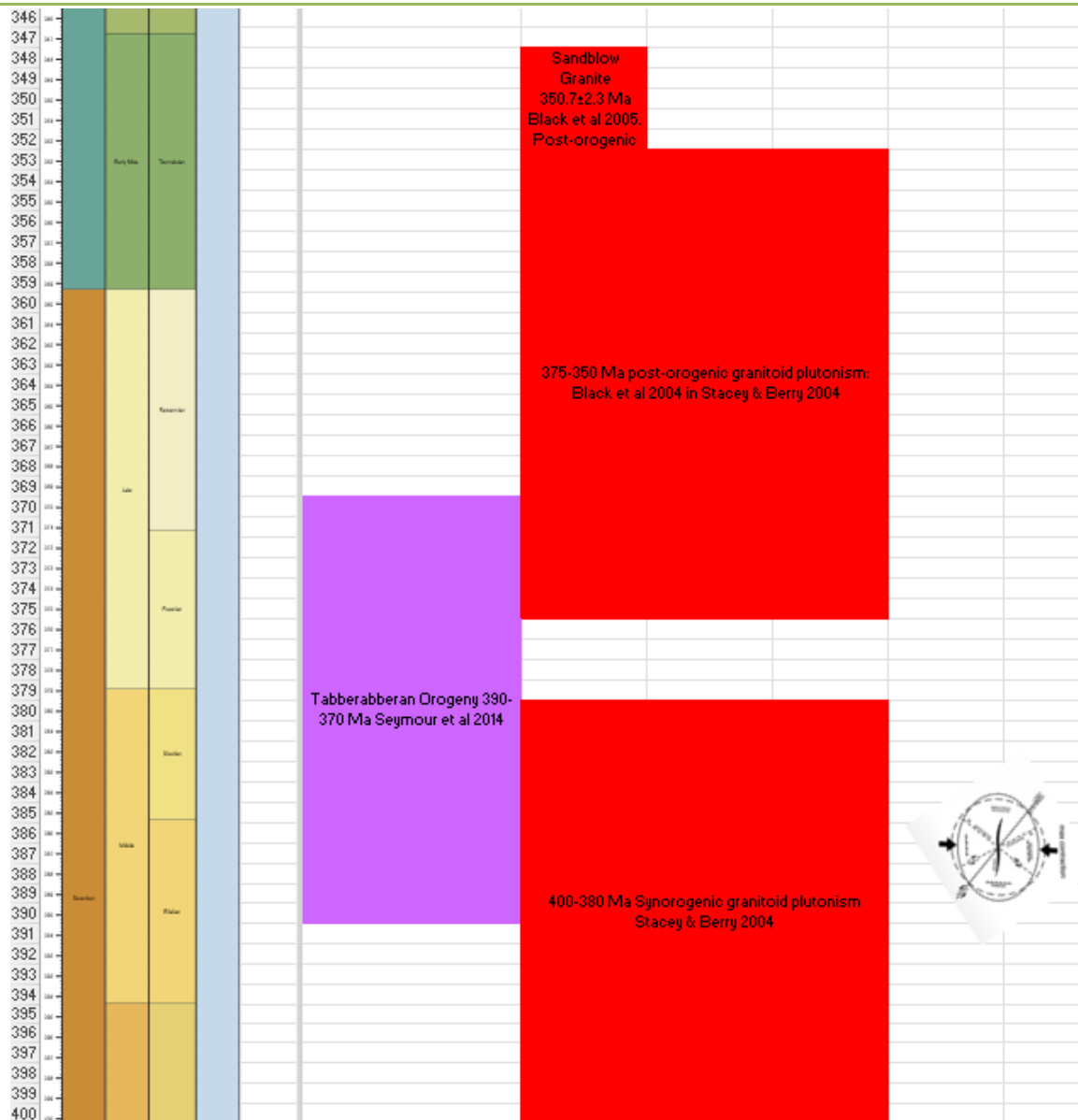


Table 6: Extract from Tectonostratigraphic chart for the mid Devonian Tabberabberan Orogeny.

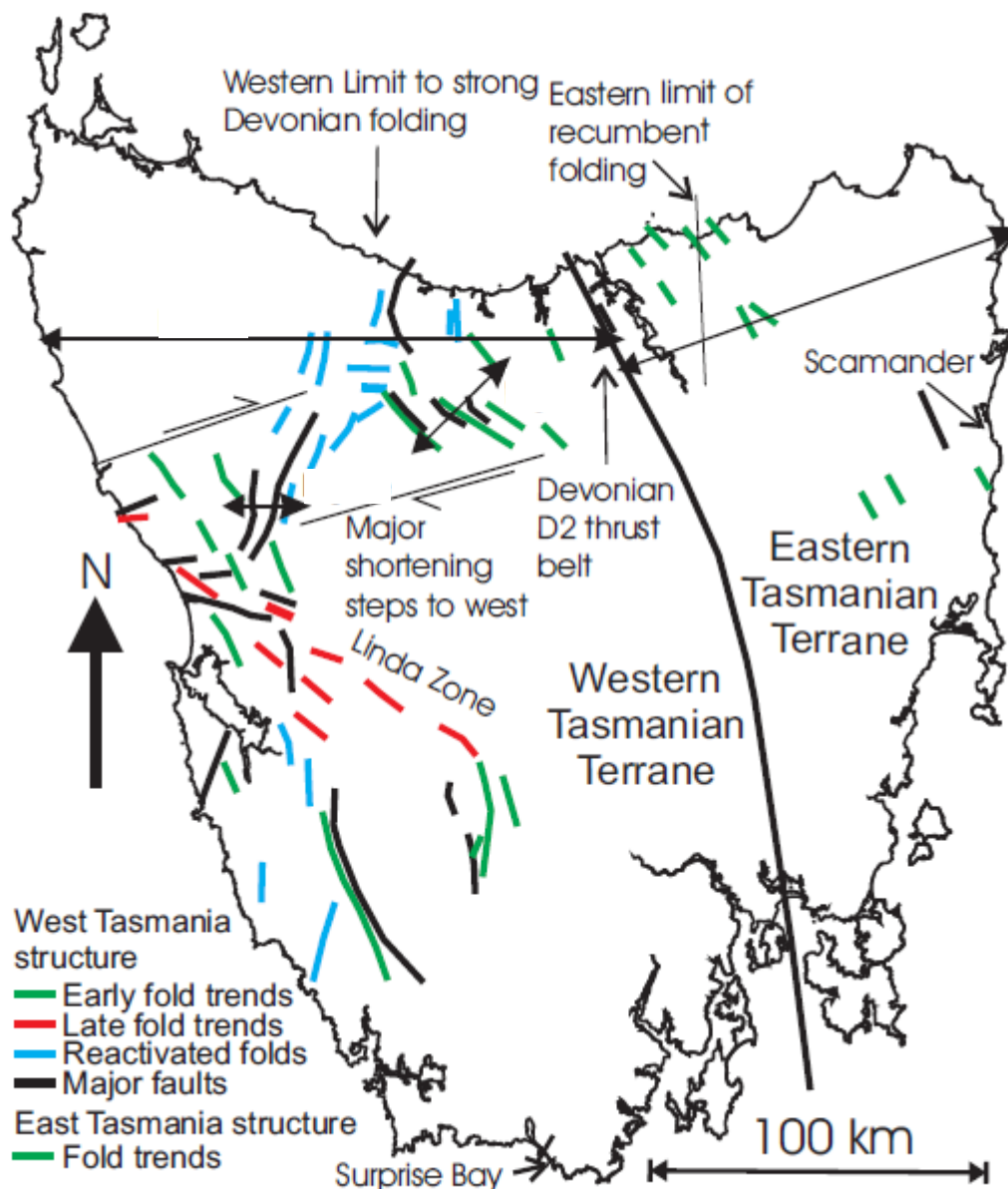


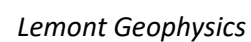
Figure 8: Devonian structural trends, from Stacey & Berry (2004)

### 3 Geophysical datasets

#### 3.1 Gravity

A total of 9177 ground gravity stations were supplied from Mineral Resources Tasmania from the Tasmanian Gravity Database (M Duffett, pers. Comm, 29 Jan 2025). These were supplied as isostatically and digitally terrain corrected Complete Bouguer Anomaly values (i.e. terrain and spherical cap corrected), reduced at a density of 2.67 g/cc (see Duffett (2016)). The dataset specifically includes many stations acquired for KUTh Energy on the Lemont project in 2007 and 2010 (Solo Geophysics & Co, 2007; Solo Geophysics & Co, 2010). Gravity values were gridded using minimum curvature at an 250m cell size. This cell size was chosen as a compromise between achieving reasonable resolution and minimizing artefacts due to variations in station spacing across the area.







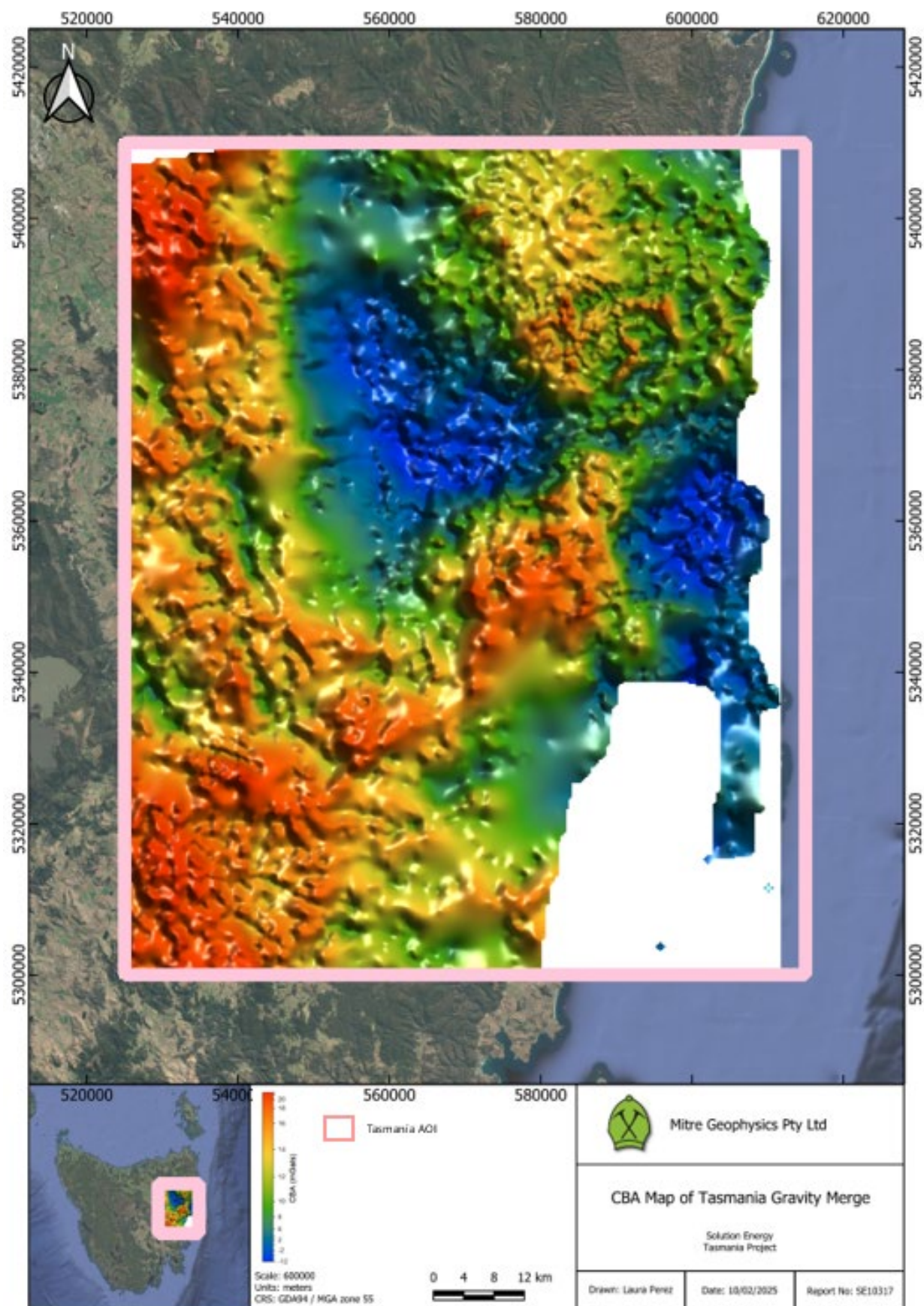


Figure 10: Complete Bouguer Anomaly (CBA) map of the Lemont AOI Gravity Merge, displayed with histogram equalization and NE sun illumination.



### 3.2 Magnetics

Sixteen separate aeromagnetic surveys were identified within the AOI; however, MRT had already stitched 14 of these together into a Tasmanian statewide 40m Magnetic Merged grid in 2024. This dataset contains two airborne surveys acquired for KUTh Energy over the Lemont area (Baigent Geosciences, 2009; Thomson Aviation, 2009). A further two, more recently acquired, public domain datasets were available covering the AOI, the 2021 40m P5003 Tasmanian Tiers airborne dataset (MAGSPEC Airborne Surveys Pty Ltd., 2021), and the 2022 P5020 40m East Tasmania dataset (MAGSPEC Airborne Surveys Pty Ltd., 2022).



Figure 11: Outline of aeromagnetic surveys covering the Lemont AOI.



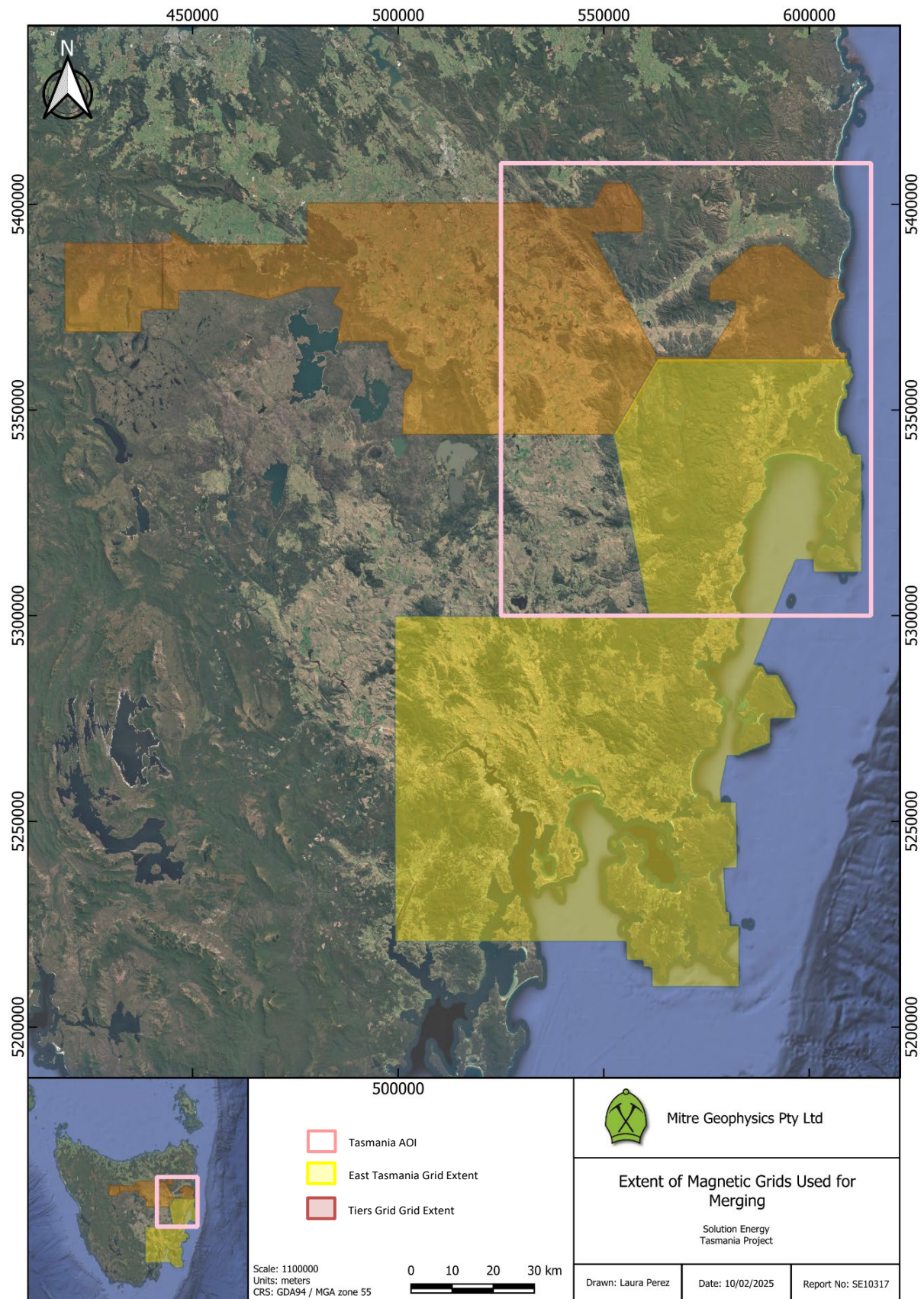


Figure 12: High resolution East Tasmania (yellow) and Tasmanian Tiers (orange) aeromagnetic datasets that were merged by Mitre with the 2024 TAS 40m statewide Magnetic Merge grid.

Further details of the merging can be found in Mitre’s previous memo (Direen and Perez, 2025).





The final product was the TMI Reduced to Pole data to which other derivative filters were applied.

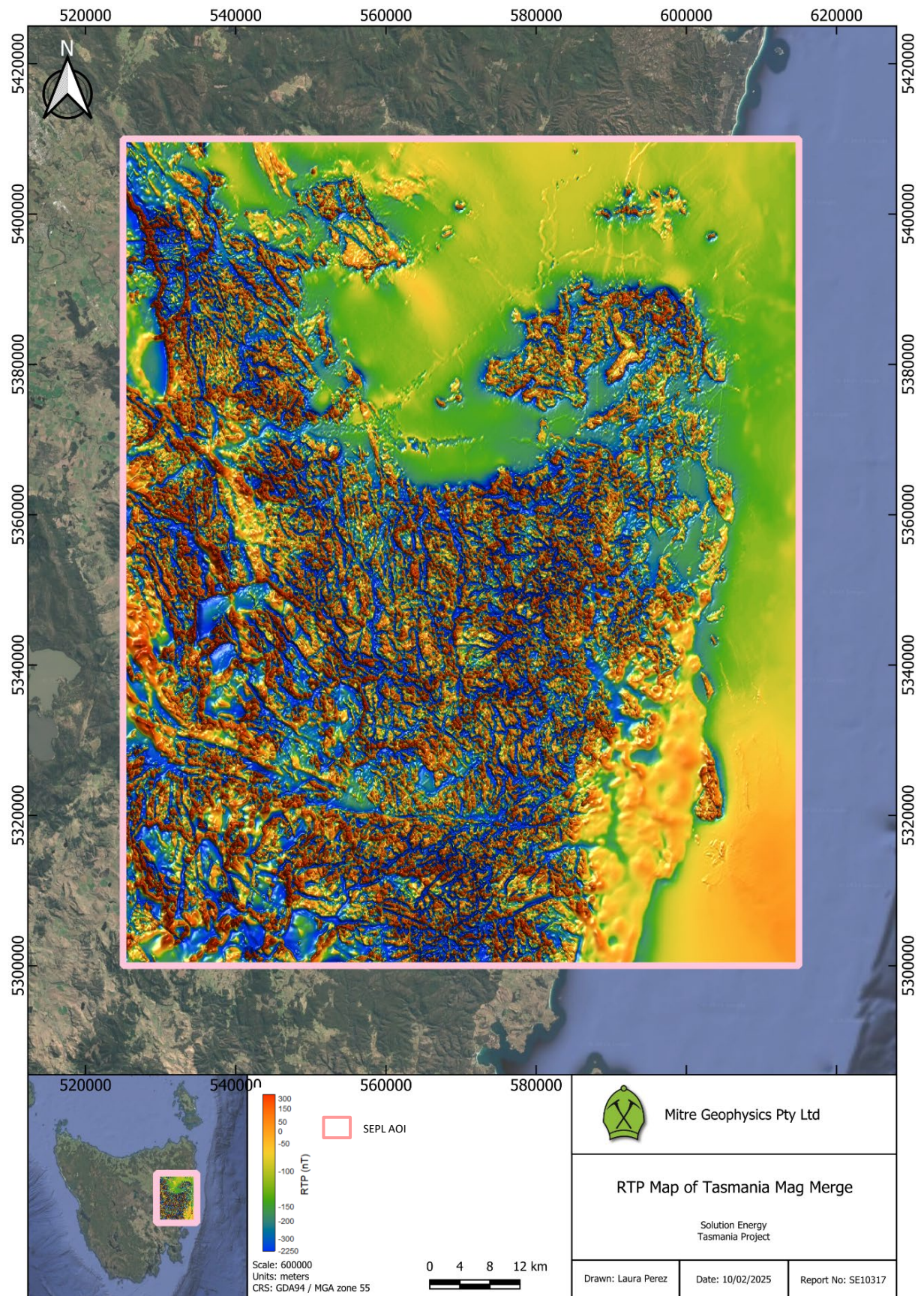


Figure 13: TMI RTP Magnetic dataset for the Lemont AOI.





### 3.3 Seismic Reflection Data

Two seismic reflection lines were interpreted in this study. Approximately east-west Line TB01-ST was acquired in 2001 by Trace Energy for Great Southland Minerals (see Bendall et al. (2015)). North-northwest-south-southeast Line 95AGS-T4 was acquired in 1995 by AGSO as part of the L139 TASGO surveys (see Barton et al. (1995); Barton (1999); Drummond et al. (2000)). Both datasets were reprocessed by Internode Seismic of Perth WA in February 2025, and details of the original and new reprocessing streams can be found in the Internode report (Internode Seismic, 2025). Particular attention was paid by Internode to developing a detailed tomography model for the near surface to enhance shallow reflectivity that had been muted in the original processing which was intended to look at deep crustal structures, down to and through the Moho cf. Drummond et al. (2000), but which had suppressed structural details in the upper crust (C Calver, pers comm 28/2/2025).

The line locations are shown in the map below.

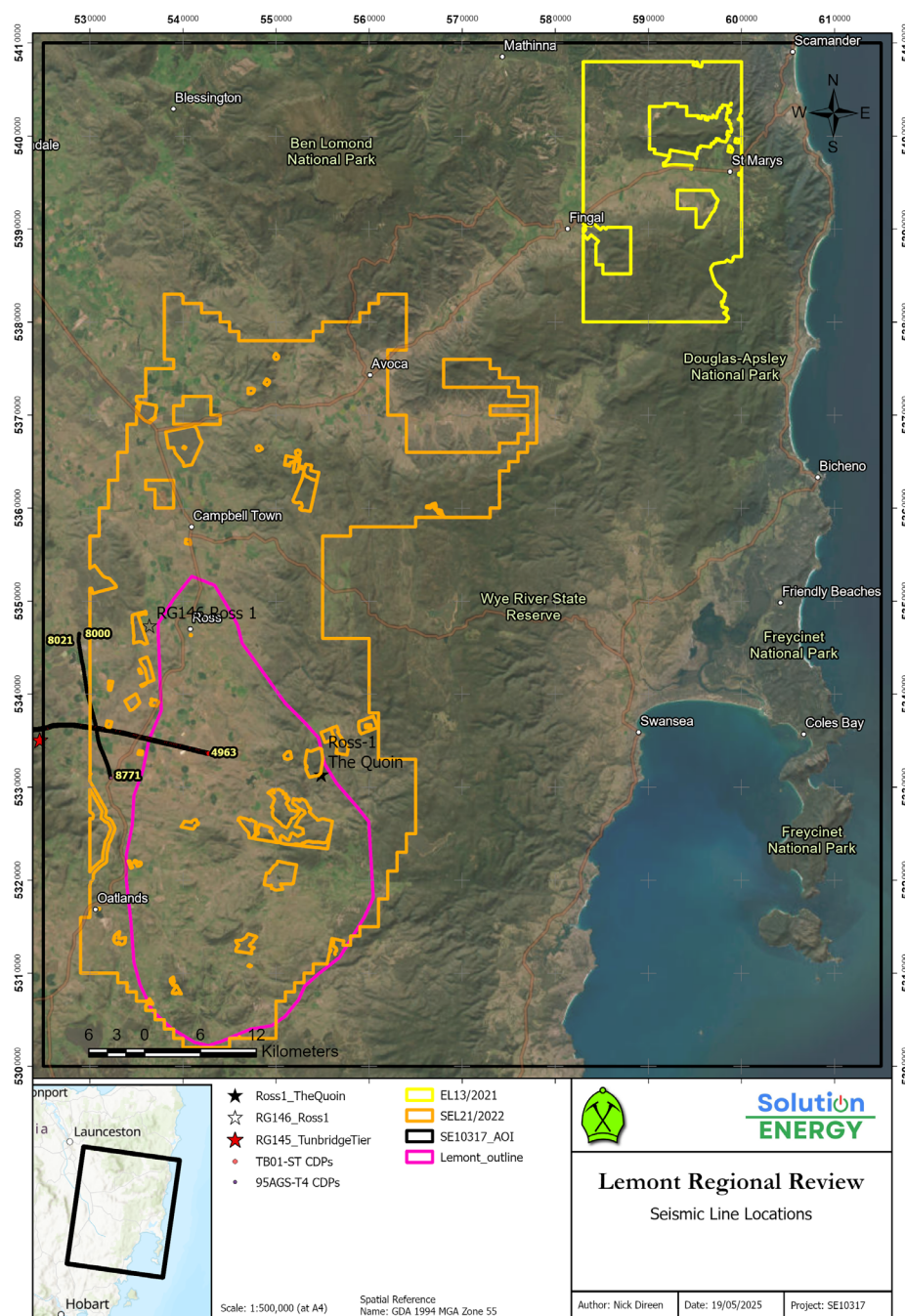


Figure 14: Seismic reflection line locations used in this review.





## 4 Seismic Interpretation

The seismic interpretation completed for this project was by no means exhaustive, due to time limitations. In addition, single 2D lines in onshore hard rock environments are notoriously difficult to interpret with accuracy, compared to marine 3D seismic surveys, for a variety of reasons, including (but not limited to), limited fold, crooked line geometry due to acquisition constraints; energy loss due to near surface high velocity stratigraphy; complex surface topography and statics; complex steep or near vertical faulting that may be difficult to image without long offsets; inability to fully migrate and collapse diffractions; and general low velocity and seismic impedance contrasts. All of these make individual reflectors difficult to trace with any certainty, and even interpretation of structures may become problematic cf. Jones et al. (2003).

The methodology applied here was to identify distinct seismic facies within the lines – seismic facies being groups of reflectors with similar reflectivity and geometry; in this regard, the seismic interval velocity field produced by Internode was also very helpful, as some of the facies have distinctive P wave seismic velocity contrasts (see also Leaman (1973)). Using the surface mapped geology as a guide, and a single well tie that penetrated to basement beneath the Parmeener Supergroup (RG145 Tunbridge Tier: see Berry et al. (2025); and Forsyth (1989b)) (Fig. 19 below), identities could then be reasonably assigned or inferred for the different seismic facies.

Breaks and offsets within and between facies groups could then be reasonably interpreted as structures, as well as direct mapping of faults and stratigraphic boundaries from the surface contacts onto the seismic line along the trace of the line (keeping in mind that correction of the crooked line geometry to CDPs may lead to some uncertainties in position).

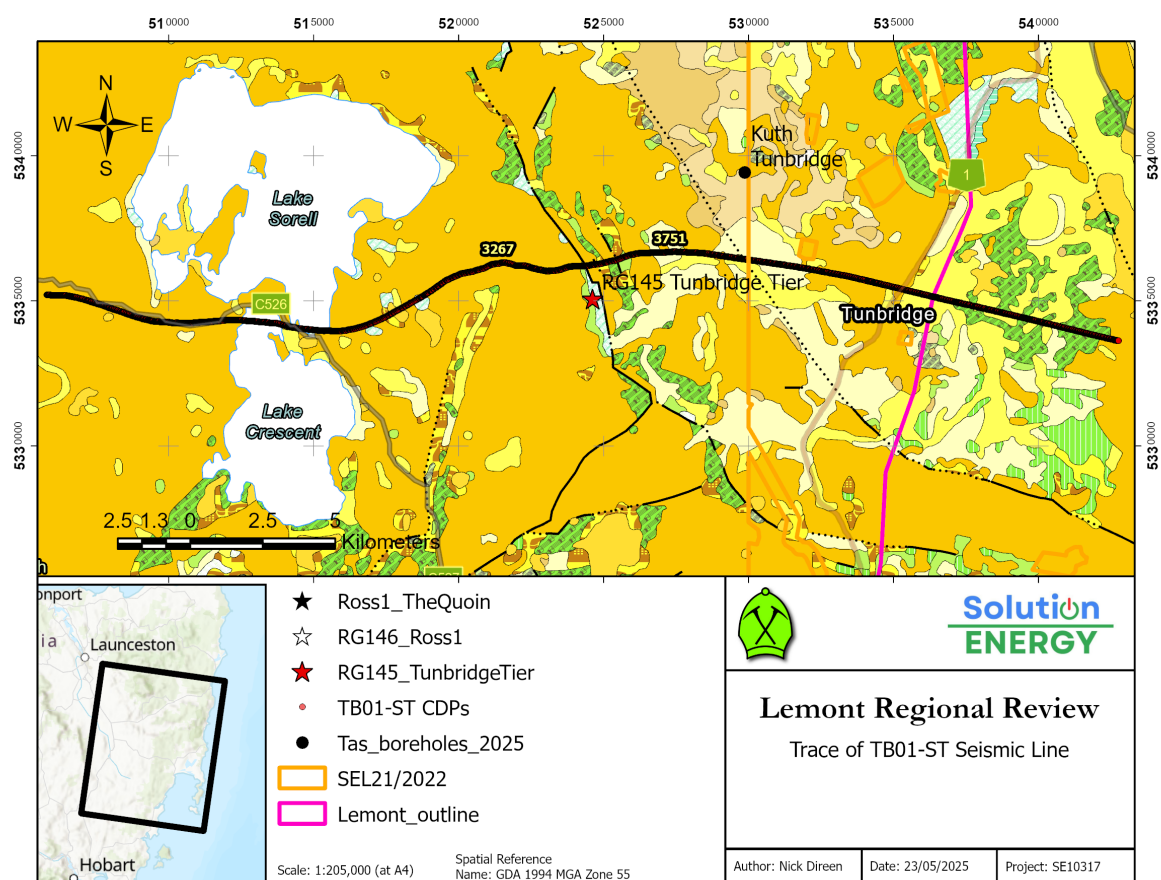


Figure 15: Trace of TB01-ST Seismic line on 1:250000 geological map, and nearby drillholes

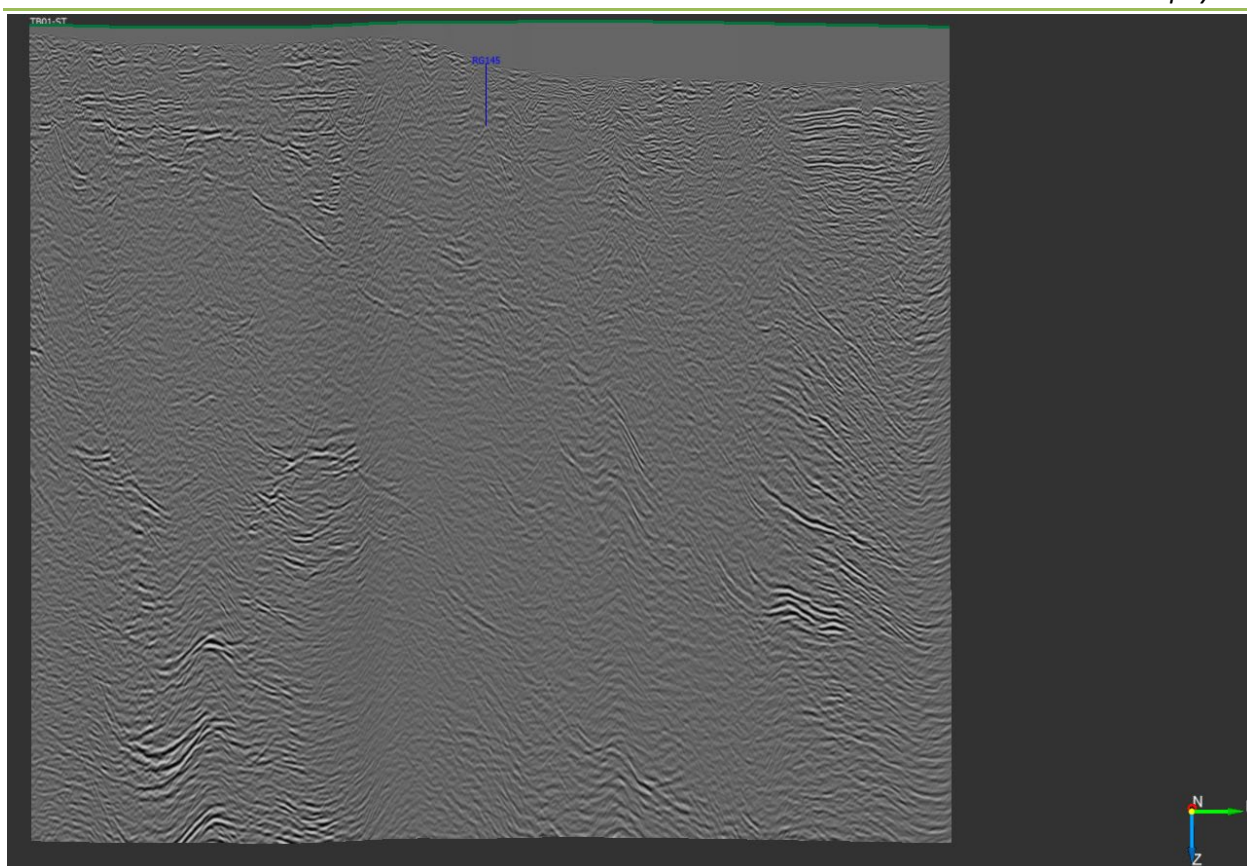


Figure 16: Grayscale, uninterpreted line TB01-ST, with well tie RG145 posted in **blue**. Looking north.

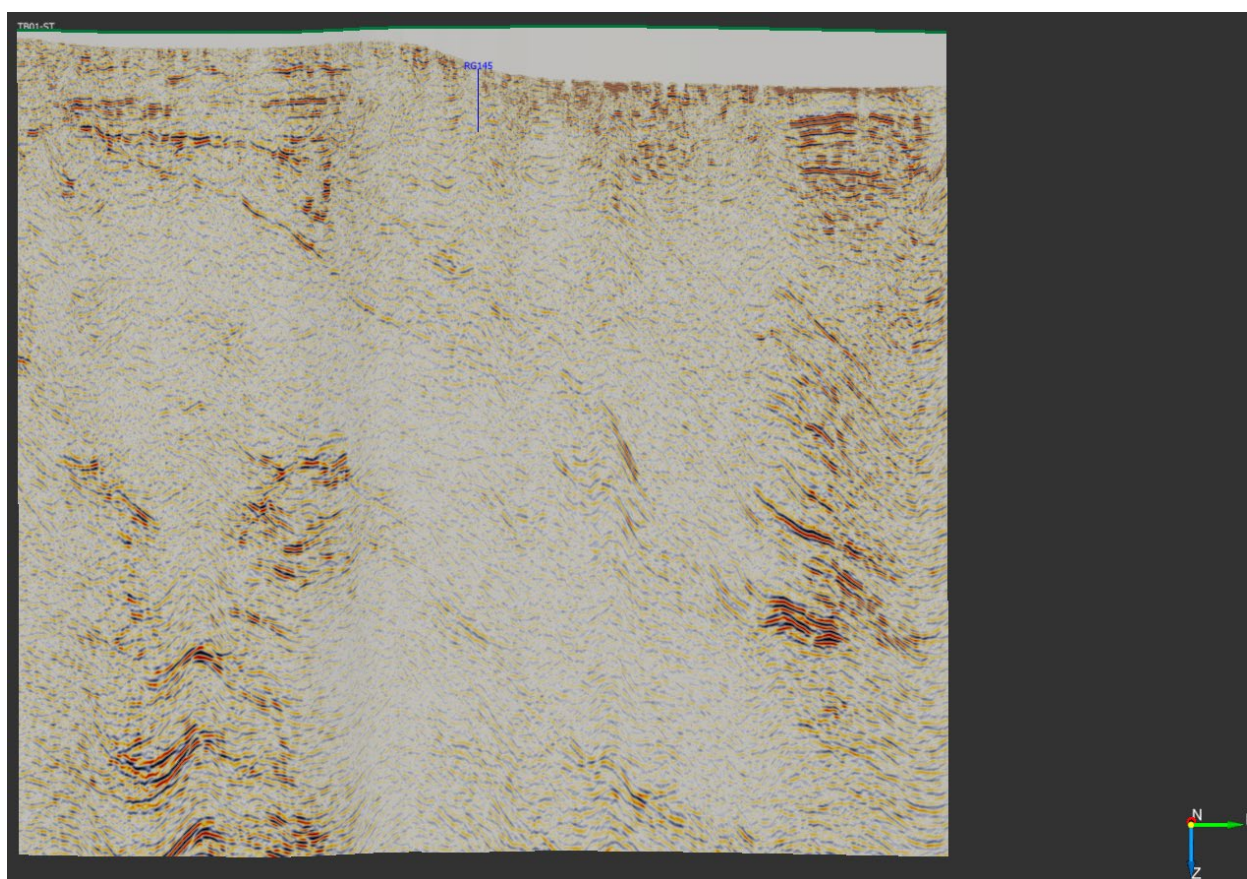


Figure 17: "Seismics" amplitude display uninterpreted line TB01-ST, with well tie RG145 posted in **blue**. Looking north.

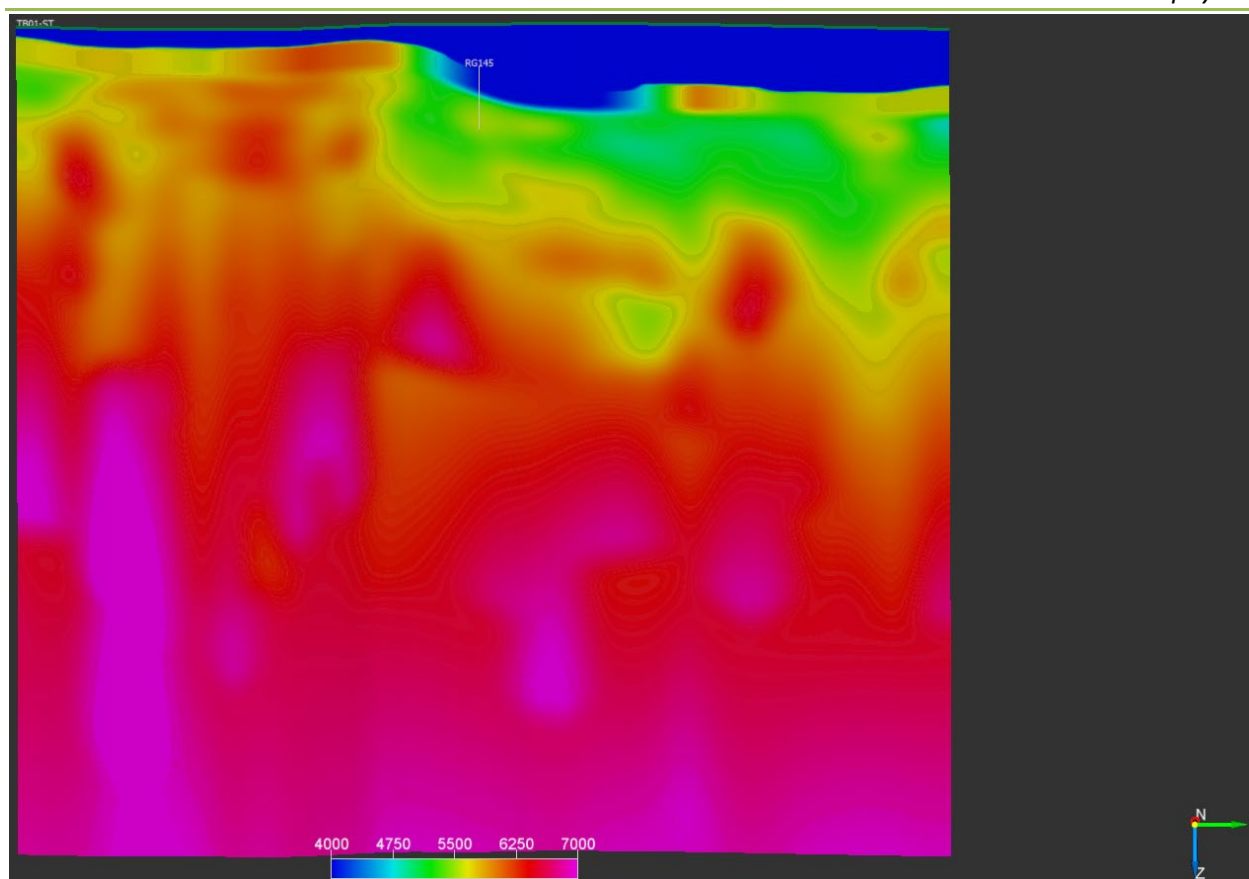


Figure 18: Interval velocity section, blue-pink colour map from 4000-7000  $\text{ms}^{-1}$ , uninterpreted line TB01-ST. Looking north. Note the distinctive low velocity of the Tertiary basin in and around RG145 tie, and the high velocities to the east and west of this, associated with at-surface Jurassic dolerite sheets.



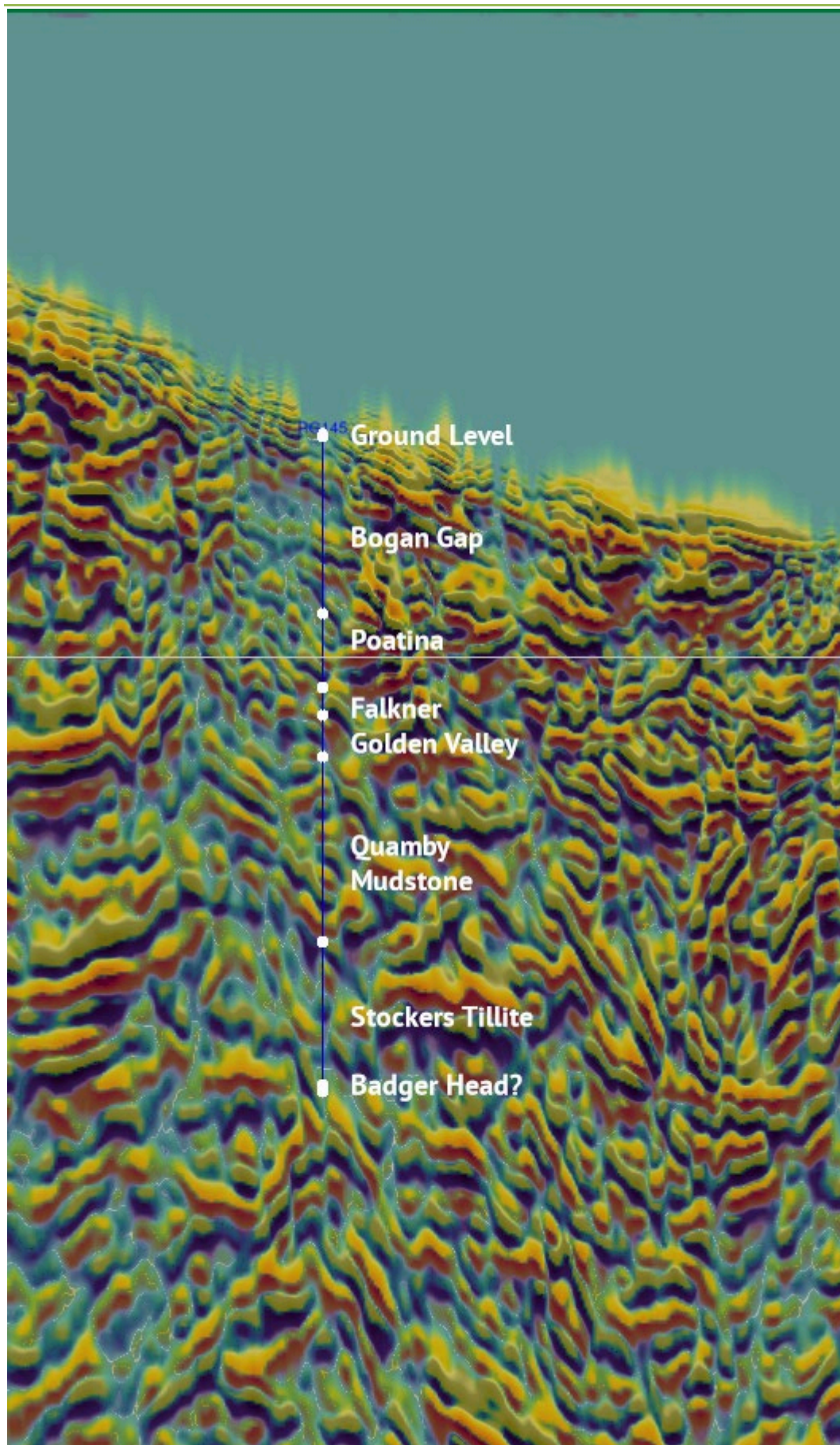


Figure 19: RG145 Tunbridge Tier well tie with strat picks in depth over amplitude display seismic.



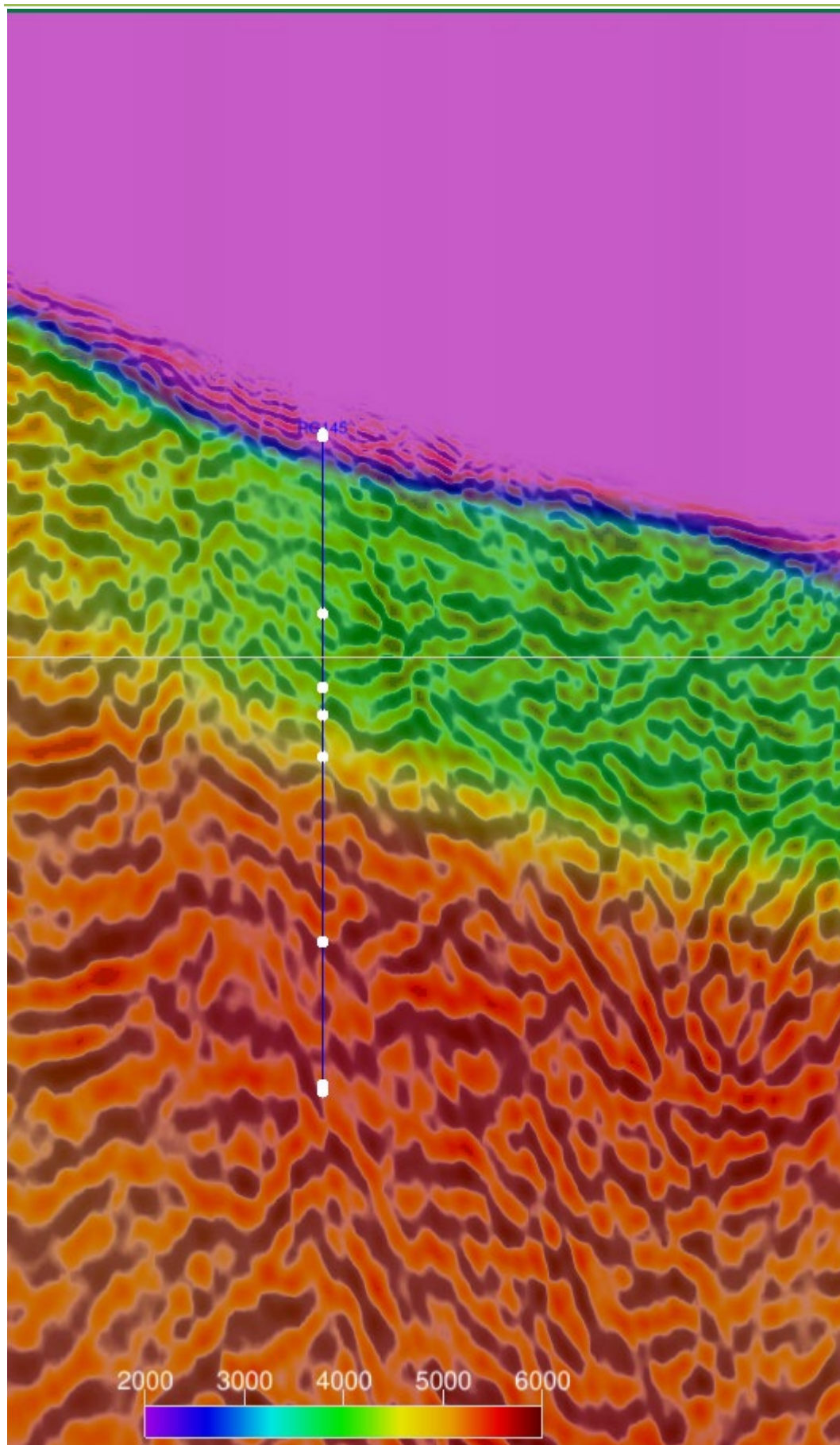


Figure 20: RG145 Tunbridge Tier well tie with stratigraphic picks in depth over interval velocity model. Note the Stockers Tillite (Carboniferous) interval of the Parmeener Supergroup has a velocity not dissimilar to the underlying



(metasedimentary) basement, interpreted here as Badger Head Gp which is now considered equivalent to the Onah Fm (Corbett et al., 2014)

Line 95AGS-T4 was shot in a south-southeast direction west of the towns of Ross and Tunbridge in an area of low relief between the Great Western Tiers and Macquarie Tier.

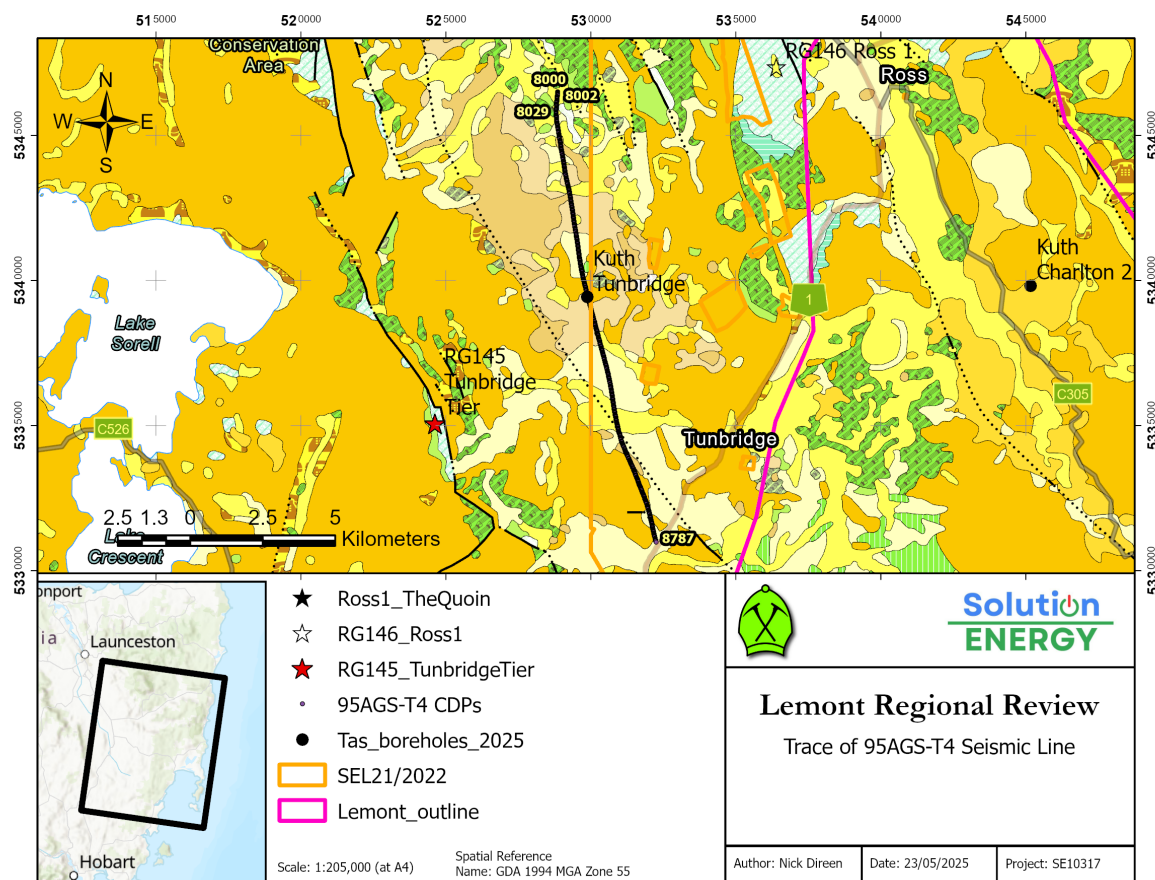


Figure 21: Trace of Seismic line 95AGS-T4 on 1:250000 geological map, and nearby drillholes.

KUTH drillhole Tunbridge was drilled on the seismic line in 2008; the log of this hole is described in Ward et al. (2008), where from a collar position at 525 masl, it intersected alternating Jurassic dolerite and Upper Parmeener Supergroup rocks (Triassic siltstone, sandstone and felspathic sandstones) to a depth of 252.6m TD (132.6masl).

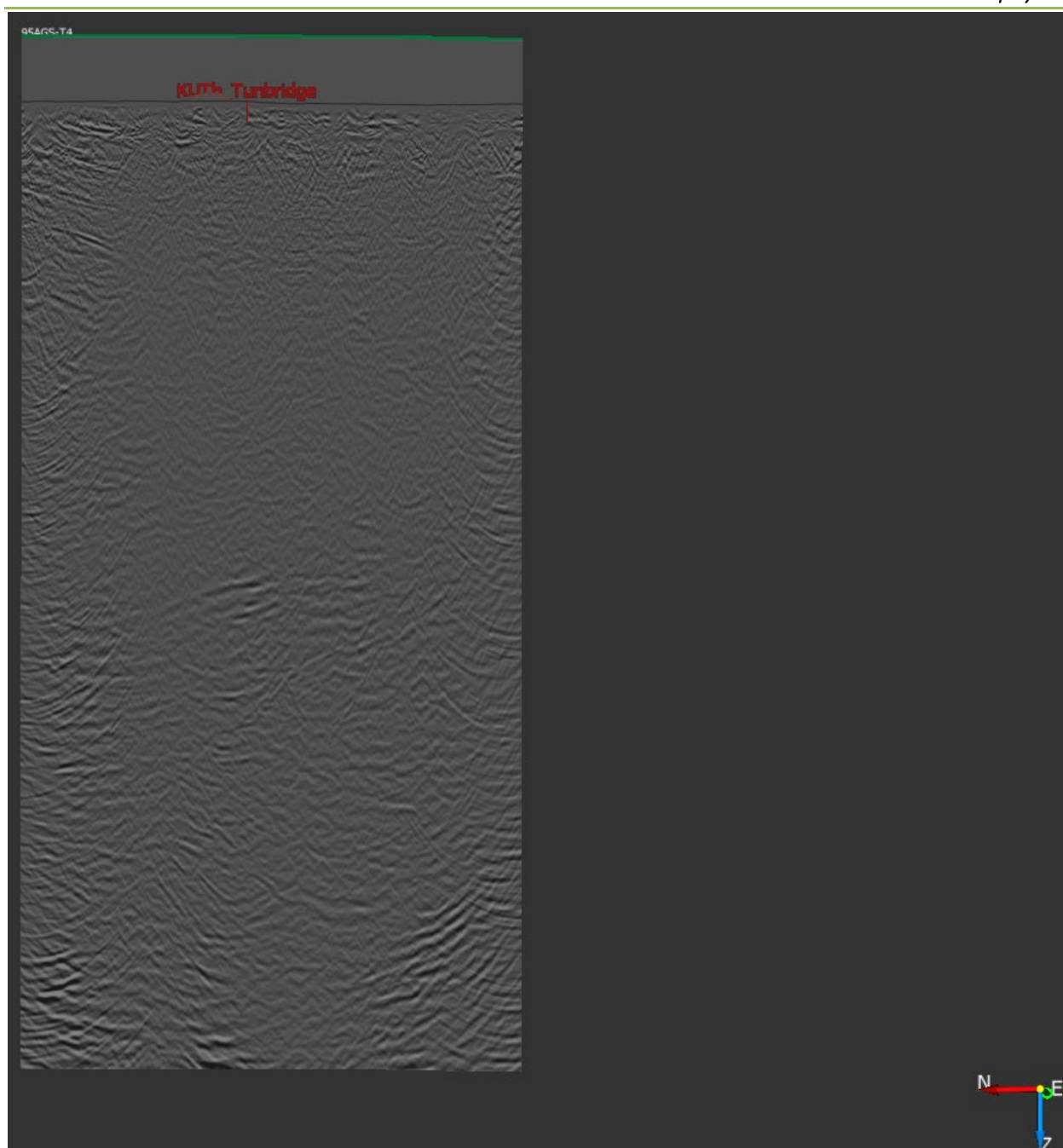


Figure 22: Line 95AGS-T4, grayscale, uninterpreted. KUTh Tunbridge in red. View looking east.



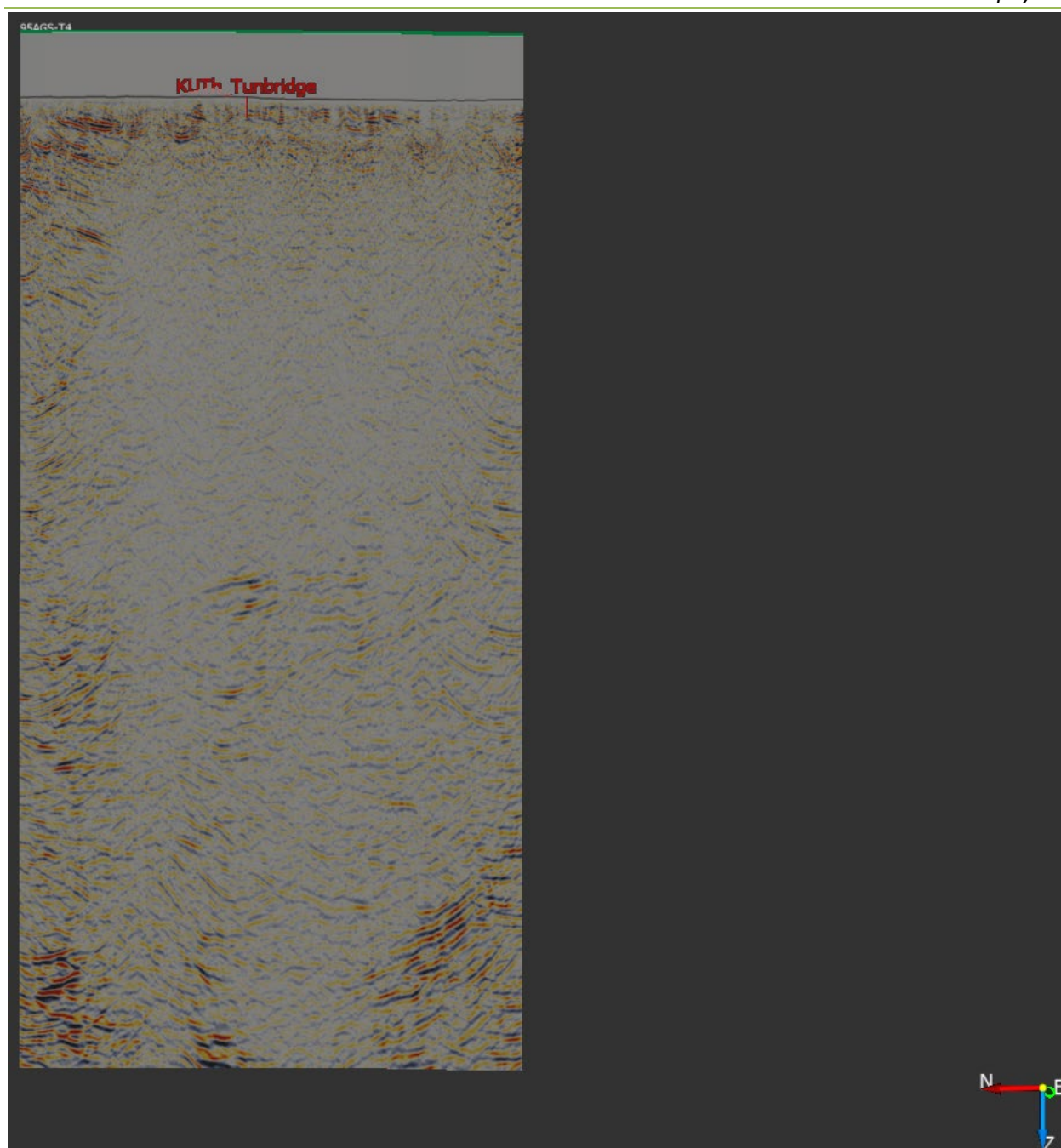


Figure 23: "Seismics" amplitude display uninterpreted line 95AGS-T4, with well tie KUTH Tunbridge in red. Looking east.

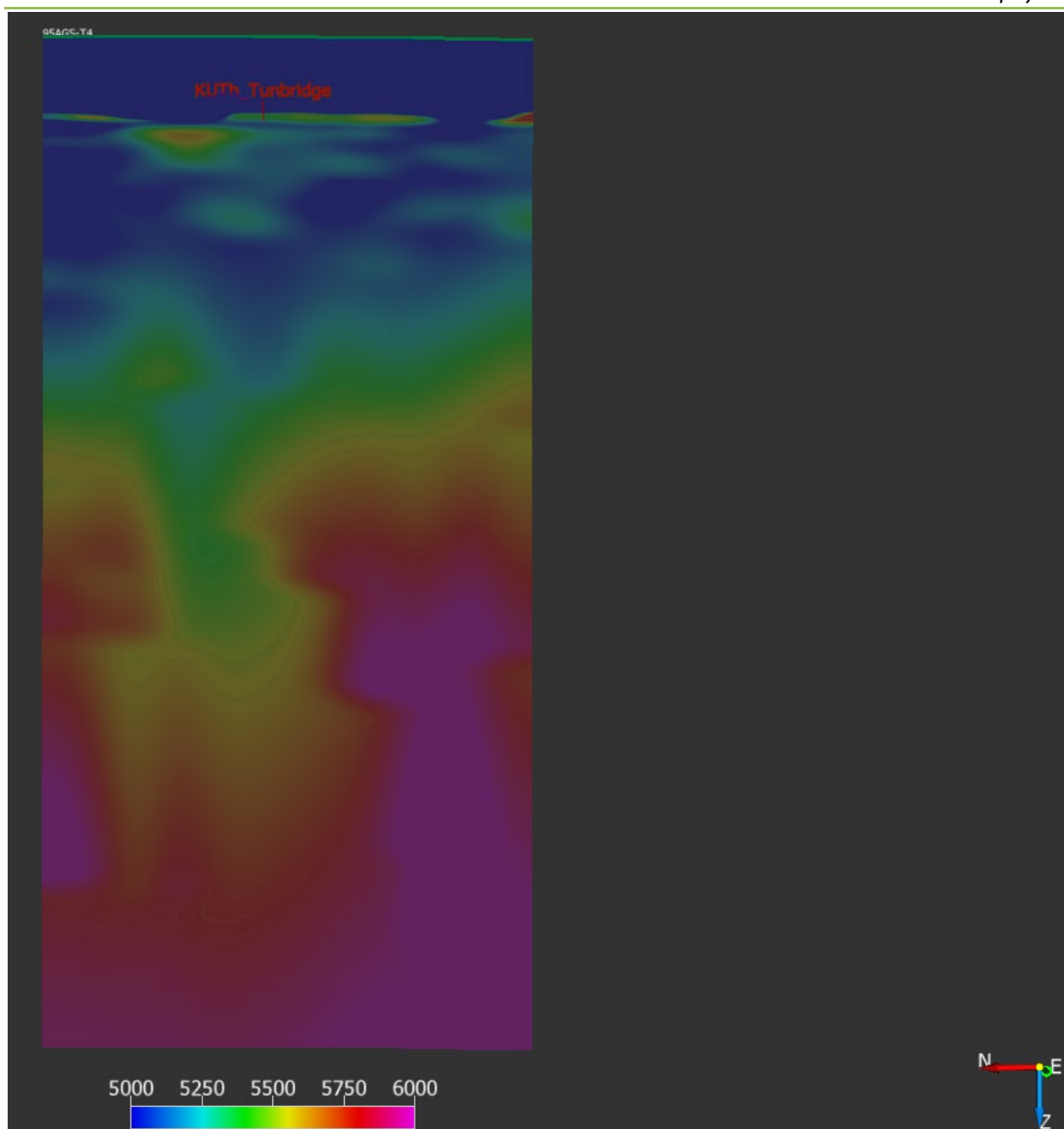


Figure 24: Interval velocity section, blue-pink colour map from 4000-7000 ms-1, uninterpreted line 95AGS-T4. Looking east. KUTH-Tunbridge hole shown in red.

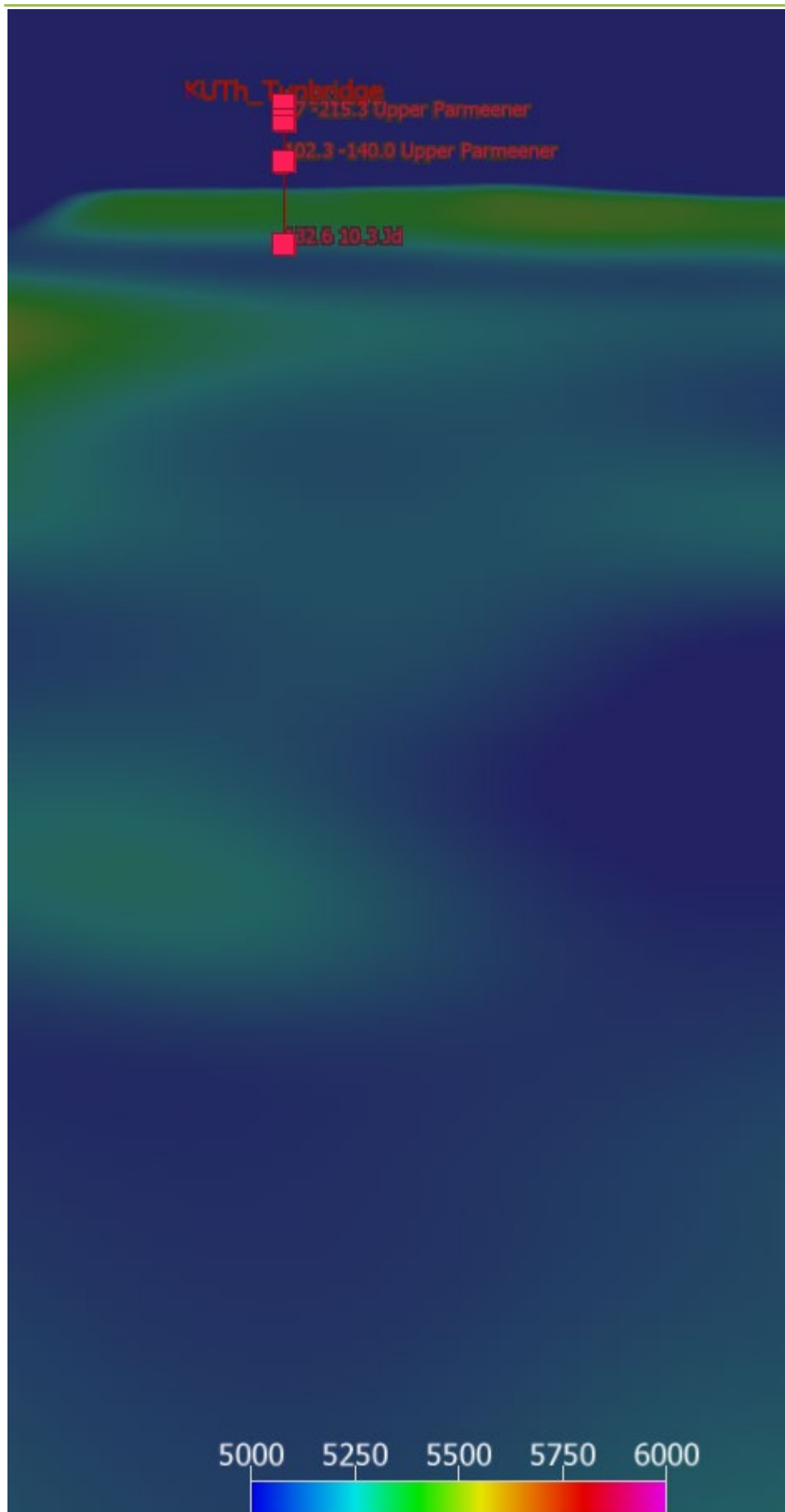


Figure 25: Zoom in of KUTH Tunbridge with picked markers on interval velocity in colour. The Parmeener is clearly lower velocity than the Jd, as expected.





## 4.1 Prior interpretations of seismic data

### 4.1.1 95AGS-T4

Line 95AGS-T4 was previously interpreted by Leaman (1996), who probably used paper records rather than digital data. His interpretation is shown below:

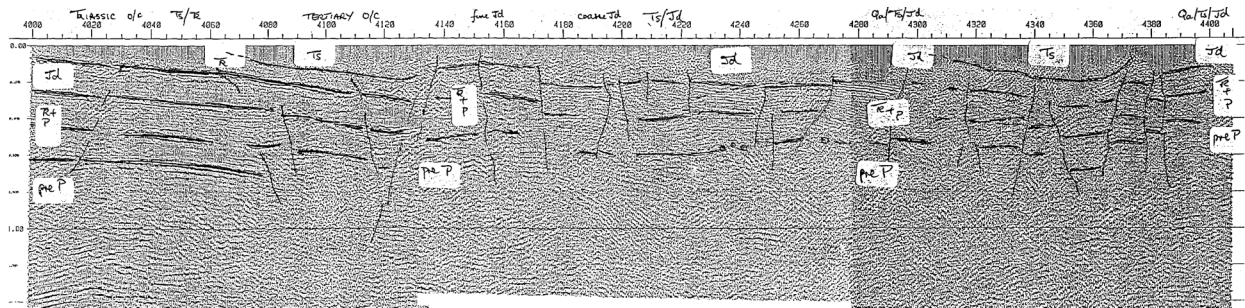


Figure 26: Leaman (1996) interpretation of 95AGS-T4 for Great Southland Minerals. Jd = Jurassic dolerite. Ts = Tertiary sediments. Tr+ P = Parmeener Supergroup (Permian, Triassic). preP = undifferentiated pre-Permian.

Leaman's interpretation tied to the surface geology as follows: "At the north end (start) there is a thin Tertiary and Recent cover on Triassic (quartz sequence) rocks. The Triassic rocks appear to dip SW at about ten degrees and are intruded by at least one dolerite intrusion. The central section of the line samples Tertiary sediments overlying dolerite. The grain textures suggest the top of a sheet. The change from Triassic basement (to Tertiary. cover) to dolerite can be related to faulting and offsets extending from the Tiers along the valley of the Isis River. The south end of the line (end) appears to involve a thin Tertiary or Recent cover on dolerite, but textures here indicate a much lower level within the dolerite sheet (lower part of top third). The thickness and composition of any alluvials, sand cover or Tertiary materials is not known."

He concluded that "Most of the structuring interpreted along the line can be associated with the Late Cretaceous and Tertiary development of the area even though this line orientation cannot suggest true, shapes for the structures." (This was based on the line being oriented almost sub-parallel to the major strike). He continued "There is some slight suggestion that the thickness of Permian(?) rocks may vary along line although this inference may be based on a varying amount of, combined, Permian and Triassic rocks beneath a dolerite sheet which is stepping across the sequence."

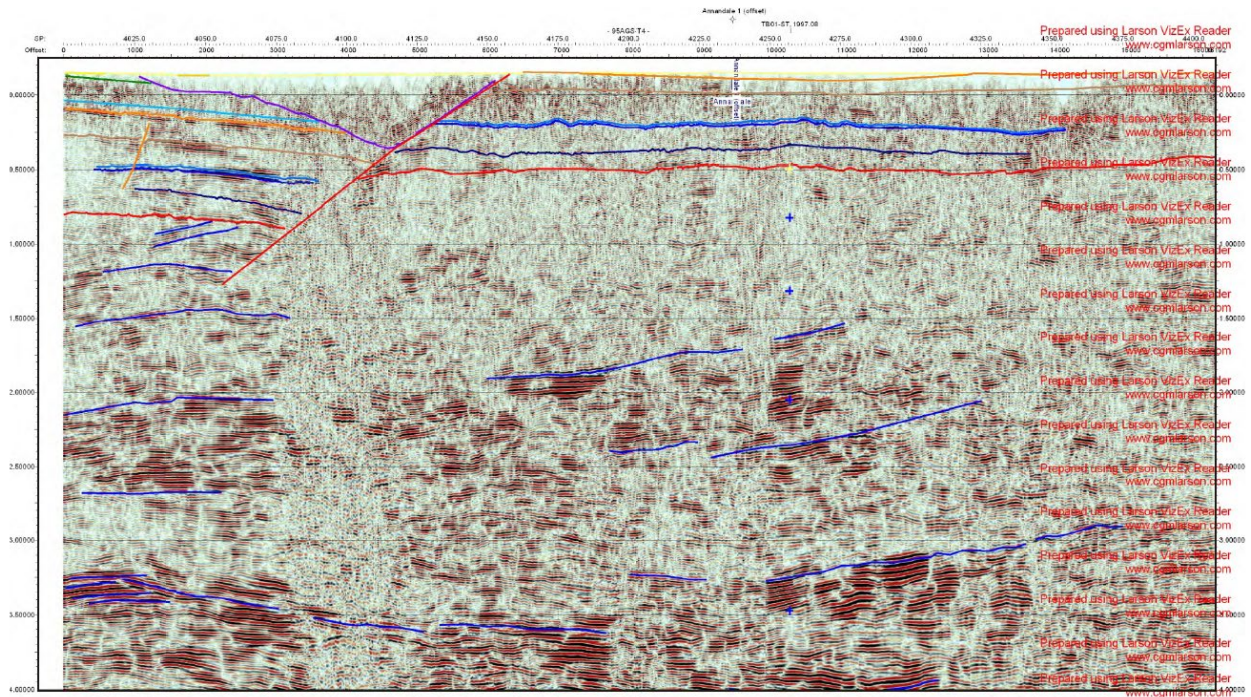


Figure 27: Stacey (2009) interpretation of 95AGS-T4

Stacey (2009) thought the data quality quite poor, except in the northern end, where he interpreted a south dipping dolerite sill 500m below surface, intruding Parmeener Supergroup. This was separated from a dolerite sill at surface to the south by a fault-controlled Tertiary half-graben.

Basement was interpreted below 3.0 s TWT, as faulted sequences of bright reflectors, but the identity of this crust was not interpreted.

#### 4.1.2 TB01-ST

Line TB01-ST has been interpreted by numerous prior workers, including Bendall et al. (2015); Blackburn (2004); Cooper et al. (2009); and Stacey (2009).



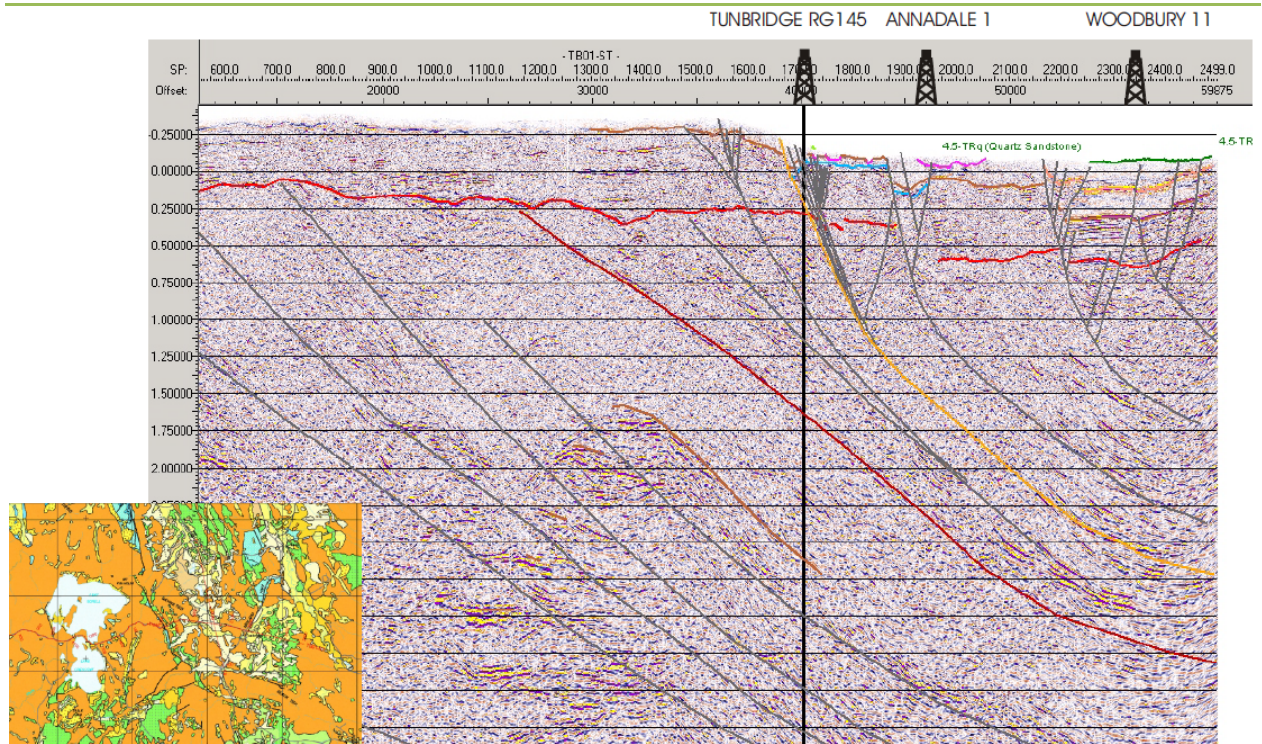


Figure 28: Blackburn (2004) TWT interpretation TB01-ST

Blackburn (2004) interpreted west-directed thrusting within Proterozoic basement prior to erosion and deposition of the Parmeener Supergroup; he assigned the thrusting a Tabberabberan age, but also observed “minor re-activation of some pre-existing thrust faults produced some syndepositional normal faulting during the Permian”. He also interpreted that “extension during the Middle Jurassic enabled dolerites along these old trends, with major sills often formed on the downthrown blocks of the major re-activated faults.” He further interpreted that further major extension occurred during the Palaeocene, producing grabens. I would interpret this as the Late Cretaceous extension event. These grabens were then wrenched “later” – presumably during the Palaeocene inversion event ~60-56 Ma – to produce inversion and flower structures.

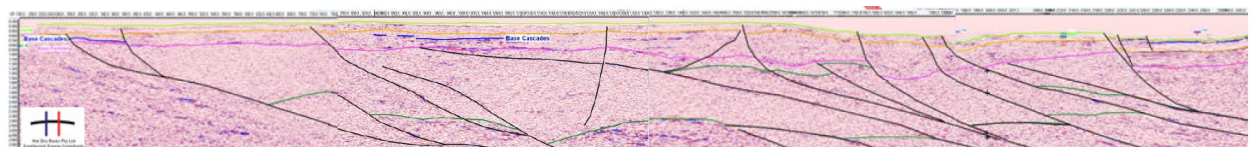


Figure 29: Cooper et al (2009) TWT seismic interpretation TB01-ST

Cooper et al (2009) interpreted north-east dipping faults in the shallow crust (<3.6s TWT), with net extensional offset; they interpreted these as Ordovician-Silurian extensional faults i.e. “at the time of Mathinna deposition”, that were inverted -presumably in the Tabberabberan Orogeny- as they relate the inversion to the thin skinned orogenic style of the Lachlan Orogeny. They interpreted the deeper section as an older duplex system, related to the Tyennan Orogeny, and observed no linkage between the two sets of thrust faults (although this has been observed in western Tasmania cf. Seymour et al. (2014); Stacey and Berry (2004). They interpreted the high amplitude deep reflections as “Precambrian basement”. Shallow faults at the eastern end of the line were interpreted to sole into the older thrust faults, and were interpreted as active in both Permian and Tertiary extension; they interpreted the Permian extension event to have involved stratal growth on some of these structures. Some of the structures were also interpreted as active in extension in the Cretaceous (post-Jurassic dolerite), as the dolerites show extensional offset in some places.

Basement was interpreted as competent layered lithologies such as metasandstone and limestone, i.e. unlike the thrust imbricated Lachlan foldbelt “turbidite pile” (cf (Direen et al., 2001). No Mathinna





Supergroup was interpreted by these authors on this line, which is now recognised as incorrect, after the work of James (2019) and Berry et al. (2025)

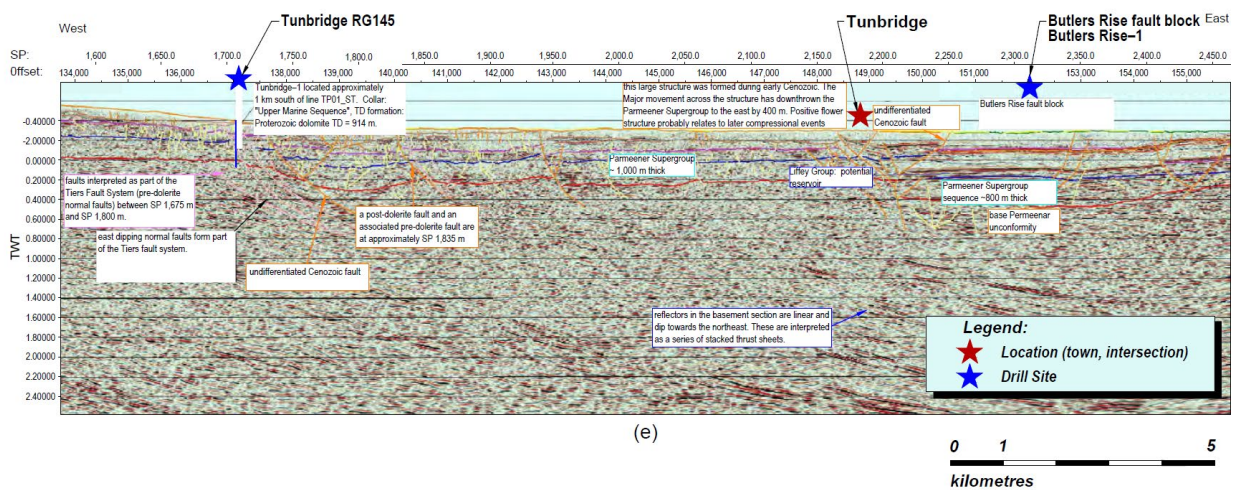


Figure 30: Bendall et al. (2015) TWT interpretation TB01-ST

The Bendall et al. (2015) interpretation largely follows that of Blackburn (2004), identifying Tabberabberan northeast-dipping basement thrusts, but did identify the major phase of Cretaceous extension associated with Tasman Sea opening, and correctly associated these with extensional reactivation of the older basement (thrust) faults, including at the Tiers Fault.

## 4.2 Mitre Interpretation Line TB01-ST

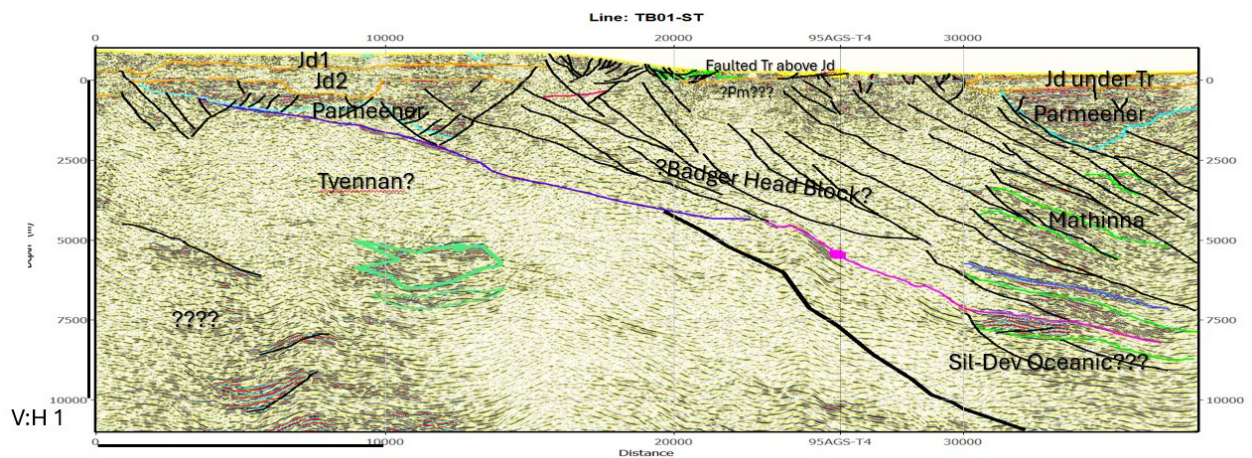


Figure 31: Mitre interpretation TB01-ST in Depth, 1:1 i.e. no vertical exaggeration. "Seismics" amplitude enhanced display.



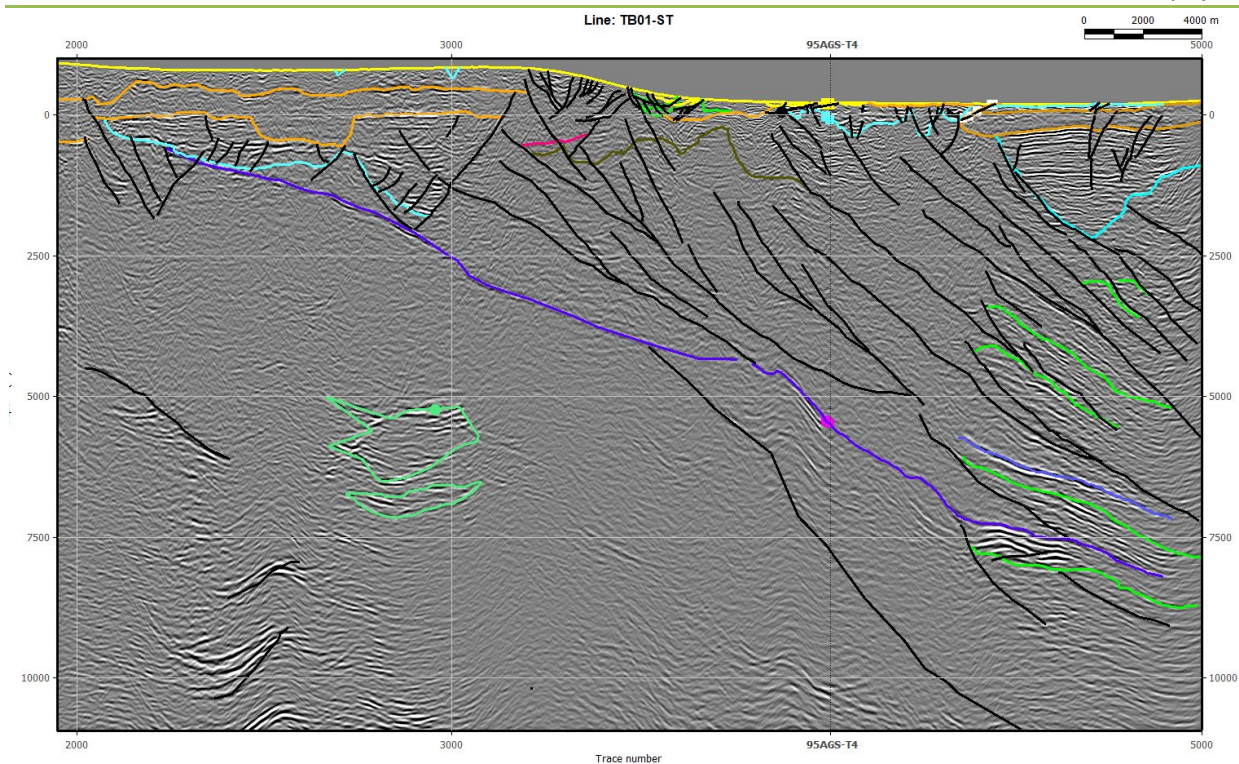


Figure 32: Mitre interpretation TB01-ST in Depth, VE ~2:1. Grayscale display.

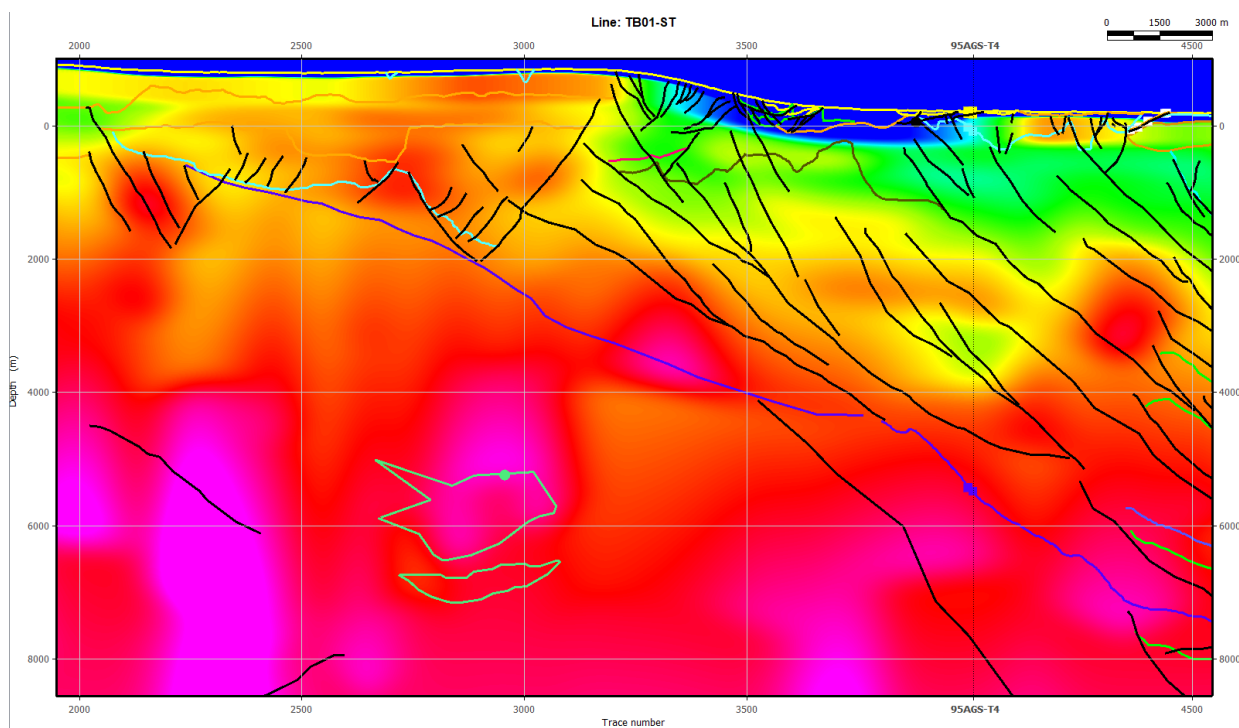
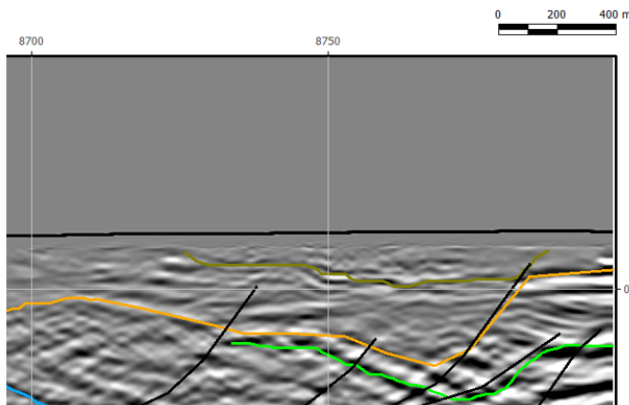


Figure 33: Mitre interpretation TB01-ST in Depth, VE ~2:1. Interval Velocity model display, stretch 4000-7000 ms<sup>-1</sup>.



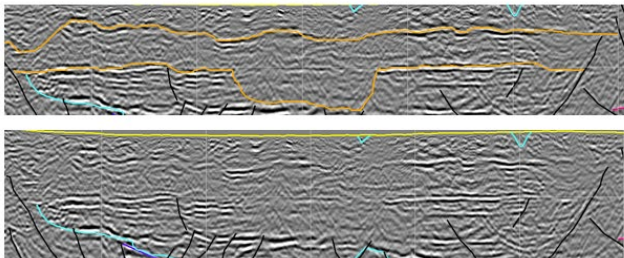
#### 4.2.1 Seismic Facies Interpretation

##### Tertiary Basins

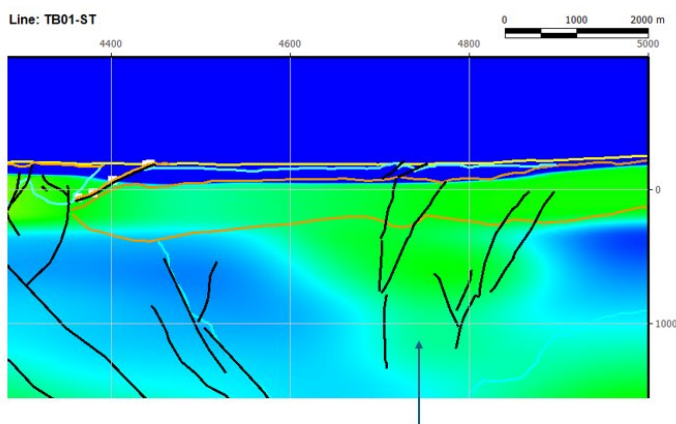


- The Tertiary basins are best seen on line 95AGS-T4 as moderately sag-like veneers. There are occasional brighter reflectors near the base (basalt?, sandier layers) with more bland discontinuous reflectors above..
- These latter are interpreted as lacustrine basin fill (Direen and Leaman, 1997; Direen, 1995).
- Some normal fault control is apparent as in the example left, but no growth of strata against the faults is observed, suggesting this was not an active rifting phase, but more passive infill of a faulted landscape.

##### Jurassic Dolerite



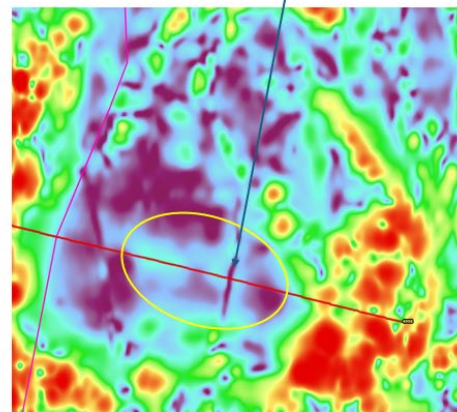
- Typically, very bright, positive impedance upper and lower reflection surfaces
- Bland internal character, with muted refractions
- Up to 500m thick sheets with slightly undulating contacts
- Feeder zones may be up to 3.3km across, and are “flat cone” or “frustum” shaped”, possibly controlled by underlying normal faults



Dolerite feeder zone

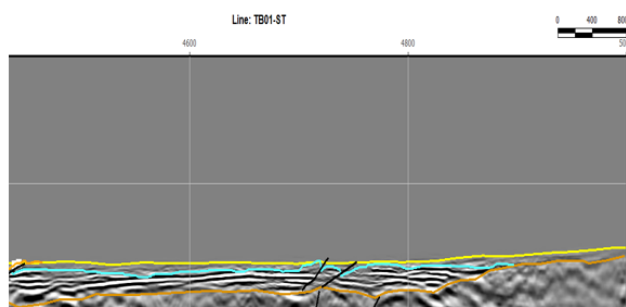
Imaged feeder zone on TB01-ST eastern end is high velocity cone shaped and associated with steeply dipping fault sets transecting the Pm wallrocks.

Only a subtle magnetic feature associated with the feeder in AnSig image below between CDPs 4600-4800 although the faulting is obvious (reactivated and crosscuts the dolerite, possibly with magnetite destructive alteration in the fault:

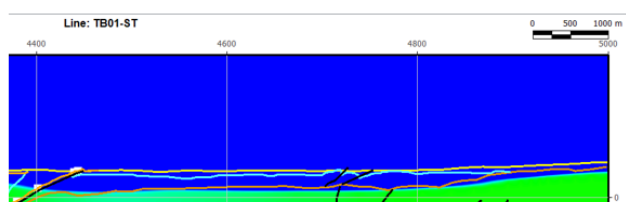




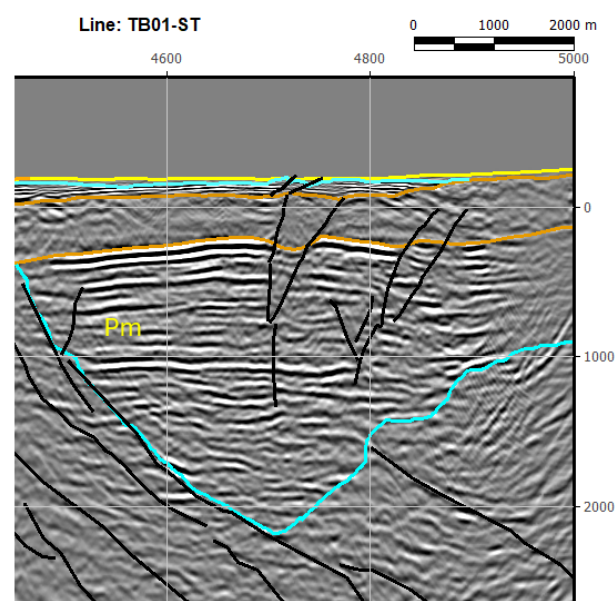
### Upper Parmeener Supergroup -Triassic



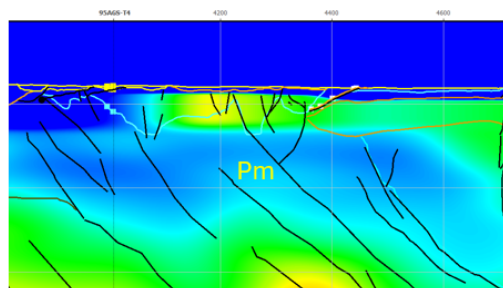
- Continuous bright interbedded layering reflecting sandstone-mudstone pairs, possibly with some coal.
- Velocities lower than 5000 ms<sup>-1</sup>



### Lower Parmeener Supergroup -Permian



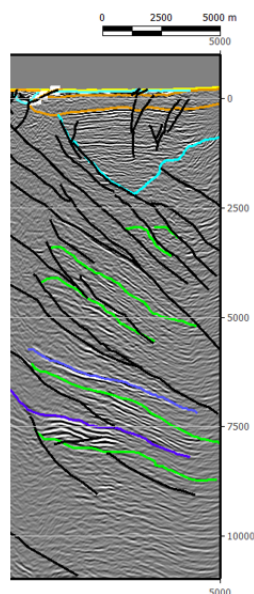
- Well layered, positive and negative impedance long continuous reflectors. Possibly coal, and/or interbedded sandstone and mud layers.
- Not continuous across each depocenter
- Deposited in apparent fault controlled half grabens.
- Some reflectors build out from the basin margins and shingle into the deeper basin which may be more mud rich
- Lower velocities (4500-5000 ms<sup>-1</sup> than Jd) where not intruded by dolerite:



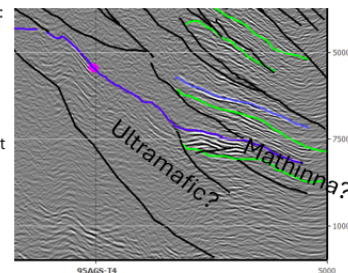




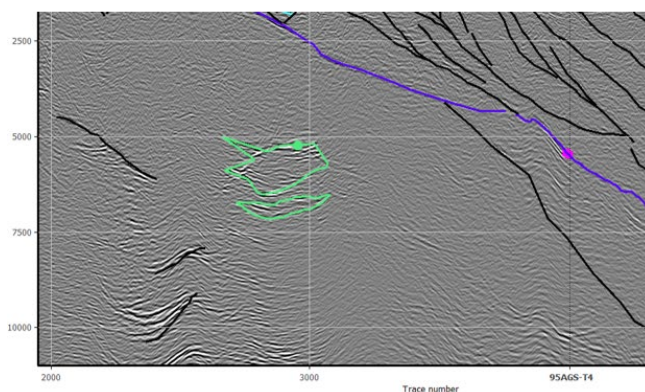
## Mathinna Supergroup



- The Mathinna Supergroup (originally defined by Powell et al. (1993), and refined by Reed, 2001) is a thick series of Ordovician to Devonian turbiditic sandstones and mudstones, dominated by upright and chevron folds as a dominantly east verging foldbelt but with west-vergent thrusting near the Tamar River (Keele et al., 1995; Patison et al., 2001; Scott et al., 2022).
- I have interpreted an east-dipping imbricate stack of thrust sheets from 2.5km to ~10km depth at the eastern end of the TB01-ST as the Mathinna Supergroup.
- Each sheet has a series of bright continuous reflectors, and a blander, less reflective sequence, with the upper sheets in the stack being dominated by the blander reflectivity.
- The most obvious interpretation of these sheets is that the bright reflectors represent thicker sandier packages, whereas the blander reflectivity may be more mud dominated facies.
- The stack is thrust onto the sheet interpreted as a possible MUMC:
- The Mathinna sheets also appear interleaved with another set of low reflectivity sheets, possibly equivalent to the Ordovician western Tasmania terrane rocks (Gordon Gp equivalents).
- With 9 sheets, the stack is significantly thicker than the three sheet stacks shown by Powell and Baillie, (1992), Keele et al. (1994) or Patison et al (2001).

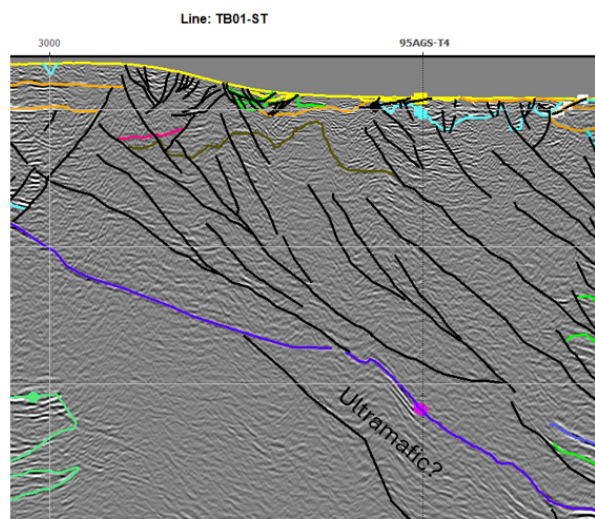


## Tyennan Basement



- Mostly seismically bland, with short discontinuous reflectivity, reflecting complexly isoclinally deformed Meso- to Neoproterozoic schists, pelites, quartzites.
- High amplitude folded and thrust units deep in the section to the west may represent marbles which are known low in the pile (Gray et al., 2024).
- The highly reflective cusped bodies (green pick) in the middle of the section probably represent some form of intrusion, but the age and composition is unknown, and may be Cambrian, Devonian-Carboniferous, Jurassic, or Tertiary.
- The Tyennan block dips below the Badger Head Block

## Badger Head Block Basement



- The area east of the Tyennan from about the Tiers escarpment is seismically similar in amplitudes and character to the Tyennan Block, but appears to be formed of a series of apparently east-dipping sheets in TB01-ST. This is interpreted as contiguous with the allochthonous Badger Head Block as originally proposed by (Leaman et al., 1973), Leaman (1992) and Leaman et al. (1994). Outcropping sequences at Badger Head comprise metatubiditic quartz-mica schists and sandstones/ quartzites (Elliott et al., 1993).
- Reed et al. (2002) proposed the Port Sorell Fm (which is of much higher metamorphic grade) to be an exhumed subduction complex.
- In the Badger Head Region part of the sequence includes the (highly magnetic: Zengerer, 1999) Cambrian Andersons Creek Ultramafic Complex. Such a unit is inferred to be present in the crust by Murphy et al., 2003 in the 3D model of Tasmania, but there is no obvious magnetic anomaly as the magnetic field is dominated by the fractured Jurassic Dolerite at or near surface.
- One possibility is that the bright folded reflectors below the badger Head Block (below the blue pick) and above the black pick may represent this unit. A magnetic model may be able to be constructed to see if this interpretation is correct cf. Roach 1994
- On the cross line 95AGS-T4, the same package of rocks apparently dips to the north, meaning the overall dip must be to the northeast, and implying an overall south-westward transport direction in agreement with the Middle Devonian (D2) Tabberabberan deformation summarised by Woodward et al. (1993).





### 4.3 Mitre Interpretation Line 95AGS-T4

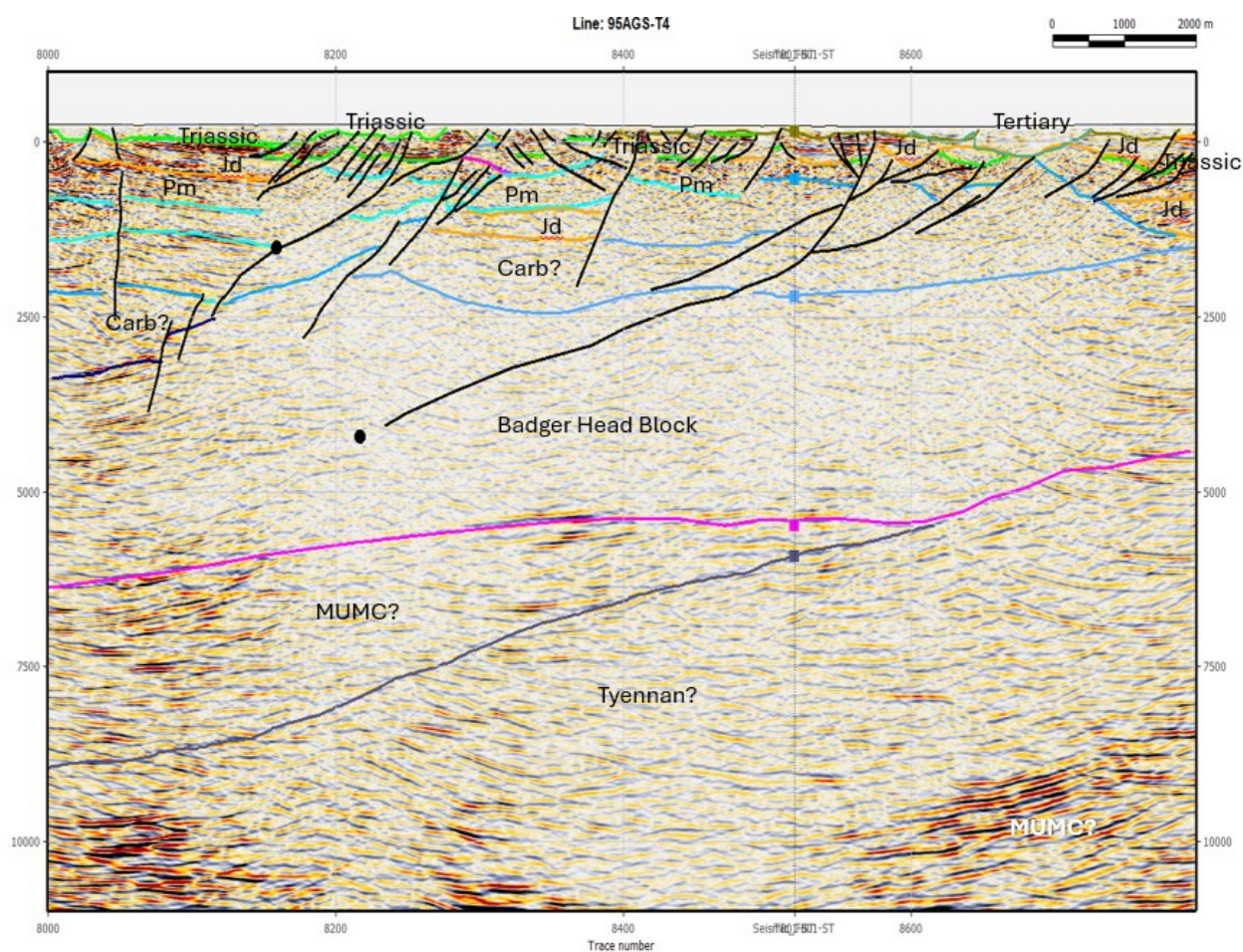


Figure 34: Mitre interpretation 95AGS-T4 in Depth, 1:1 i.e. no vertical exaggeration. "Seismics" amplitude enhanced display.

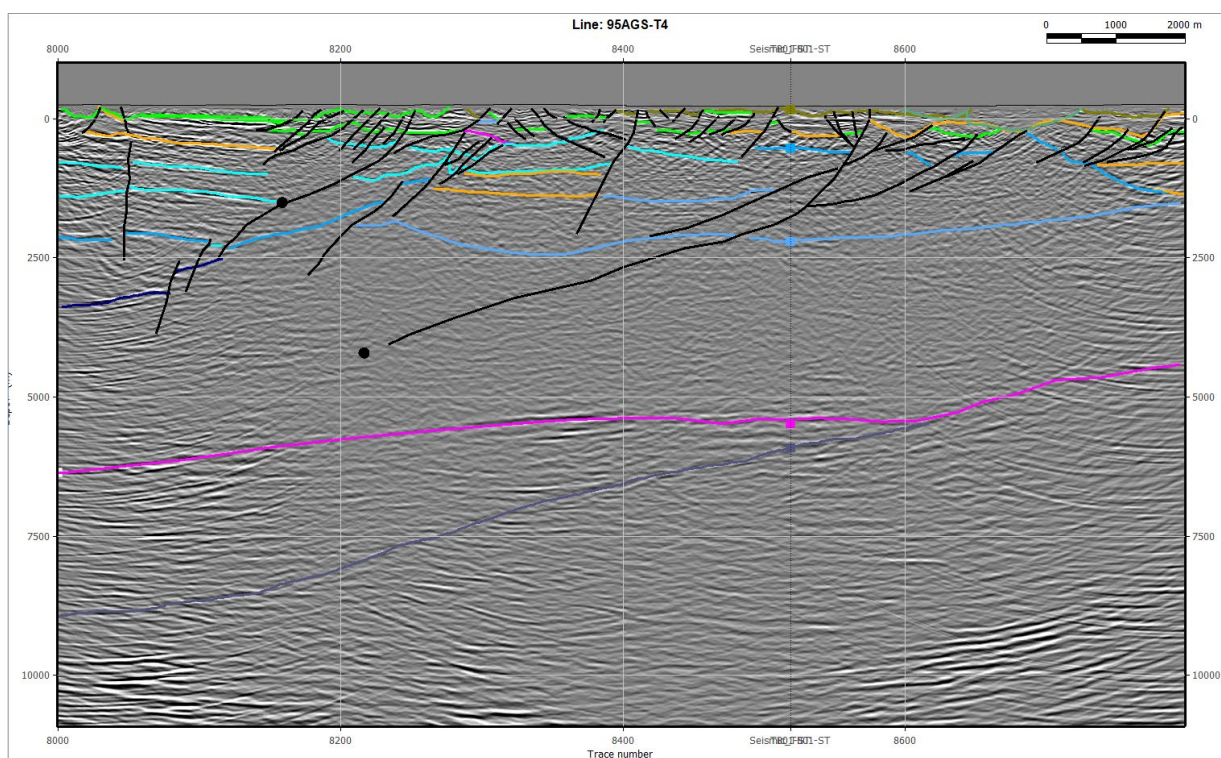


Figure 35: Mitre interpretation 95AGS-T4 in Depth. Greyscale display. V:H ~0.8

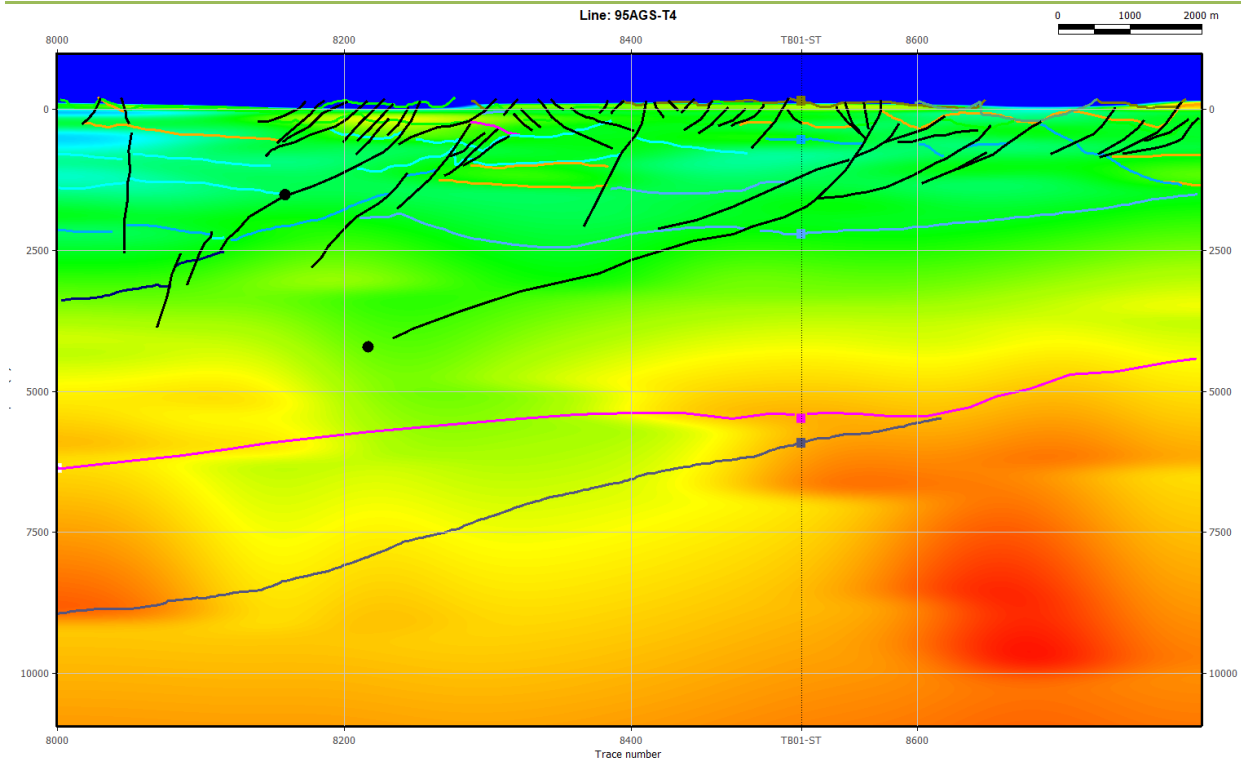


Figure 36: Mitre interpretation 95AGS-T4 in Depth. Interval Velocity model display, colour stretch 4000 (blue) -7000 (red)  $\text{ms}^{-1}$ .  $V:H \sim 0.8$ .

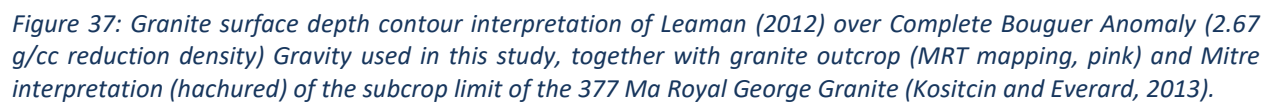
#### 4.4 Granite – or not?

Note that in the forgoing interpretations there is no mention of any granite interpreted within the seismic sections; this is in contrast to the interpretations of Leaman (Leaman, 2007; Leaman, 2010; Leaman, 2012) who interpreted regional gravity data to infer a significant batholith margin dipping below the Lemont AOI to considerable depths.

It has been known for a long time that the lack of internal fabrics with significant impedance contrasts mean that granitoid bodies typically lack internal seismic reflection character, and can appear seismically transparent (Améglio and Vigneresse, 1999; Vigneresse, 1990). A well-studied Australian example is shown below (Fig. 36). No transparent or seismically bland zone like this has been identified in the seismic data studied here, particularly on the high quality data from line TB01-ST which trends across the interpreted contours of Leaman (2012).

Notably, none of the other interpreters of this line (Bendall et al., 2015; Blackburn, 2004; Cooper et al., 2009; Stacey, 2009) interpreted granite in this section either. Given the high heat production that this granite plays in some geothermal models (Lewis, 2005), this is a significant finding.





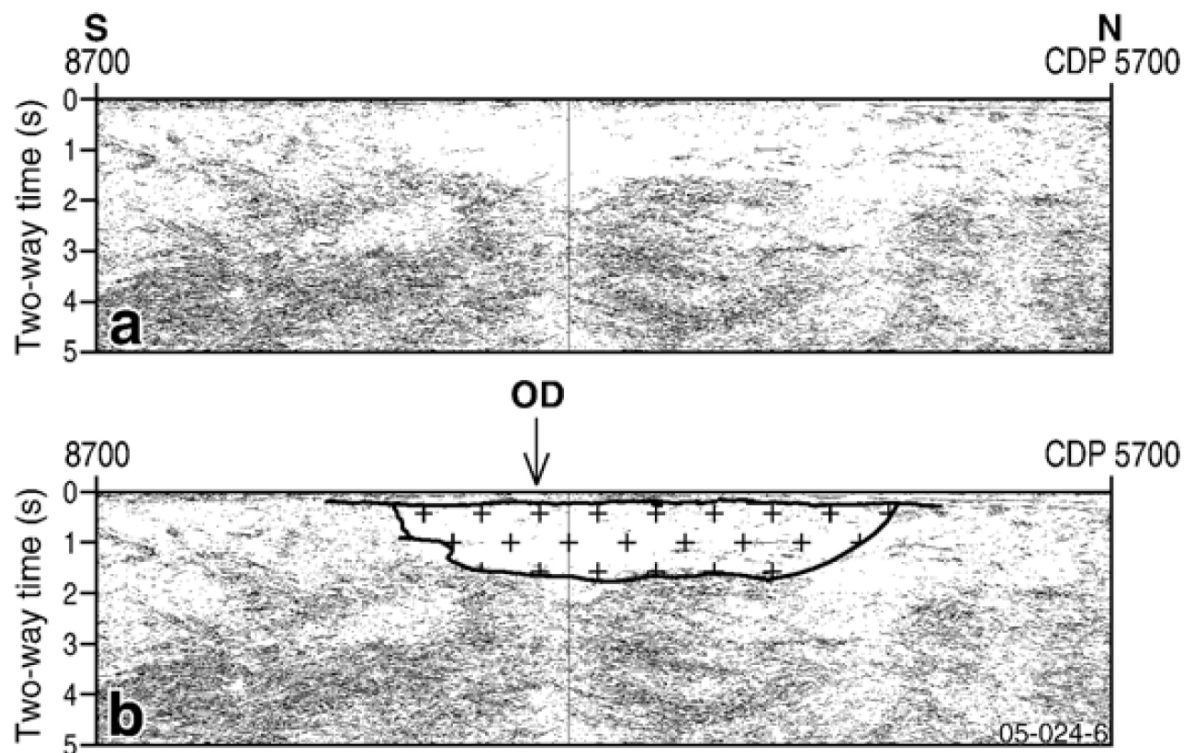


Figure 38: Typical seismic facies associated with granite intruded into multiply deformed host rocks: Burgoyne Batholith / Olympic Dam granite, South Australia. From Drummond et al. (2006). Upper panel – uninterpreted TWT seismic data; lower panel interpreted TWT data. Note the transparent seismic zone associated with the batholith.

## 5 Structural Interpretation from potential fields

A previous attempt to interpret the upper crustal structures from potential field data was made by Godber (2009) and is shown below. In addition, comments on that set of structures have been made by Berry (2019), building also on the work of Stacey & Berry (2004) (see Fig. 5).



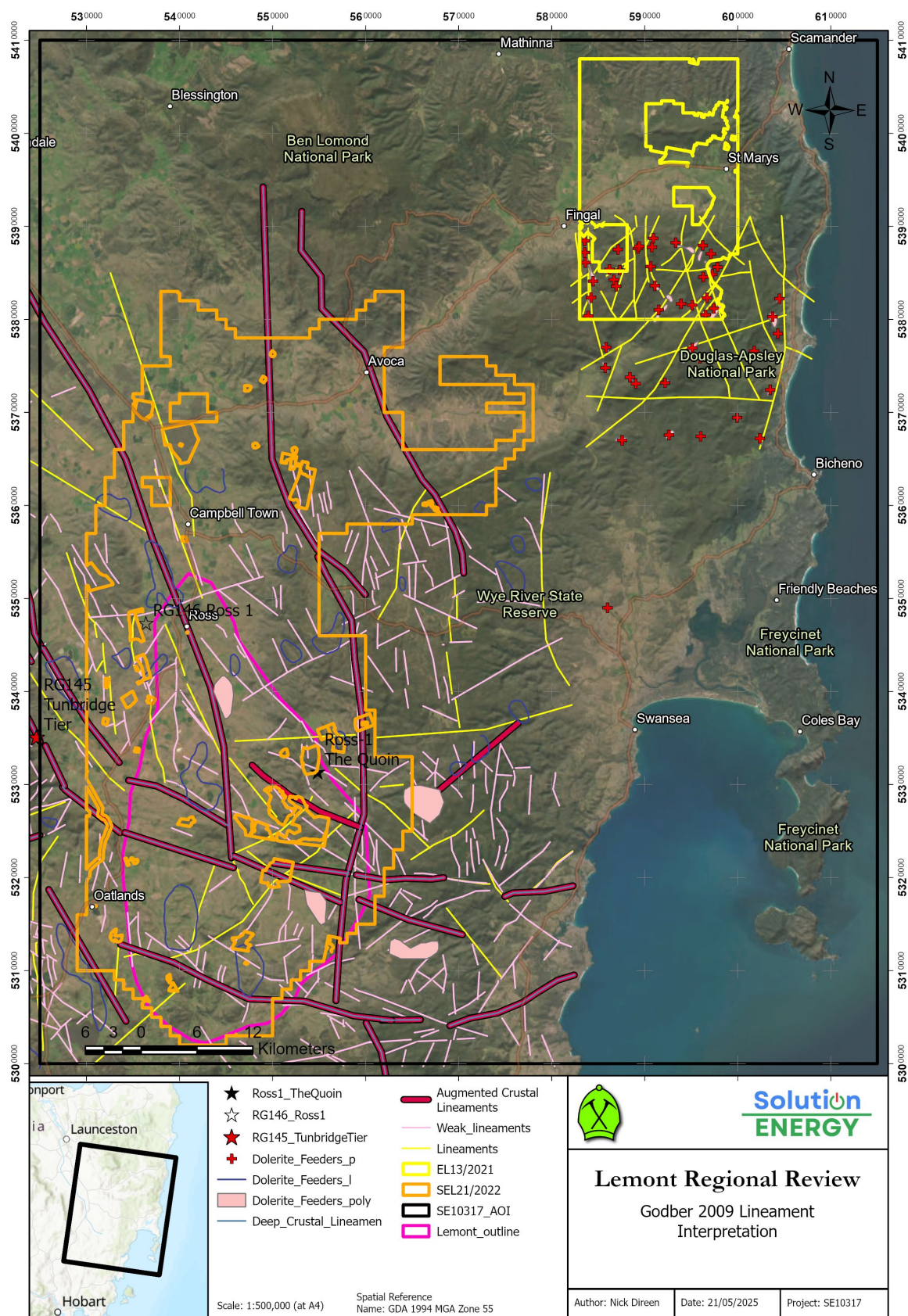


Figure 39: Godber (2009) lineament interpretation.



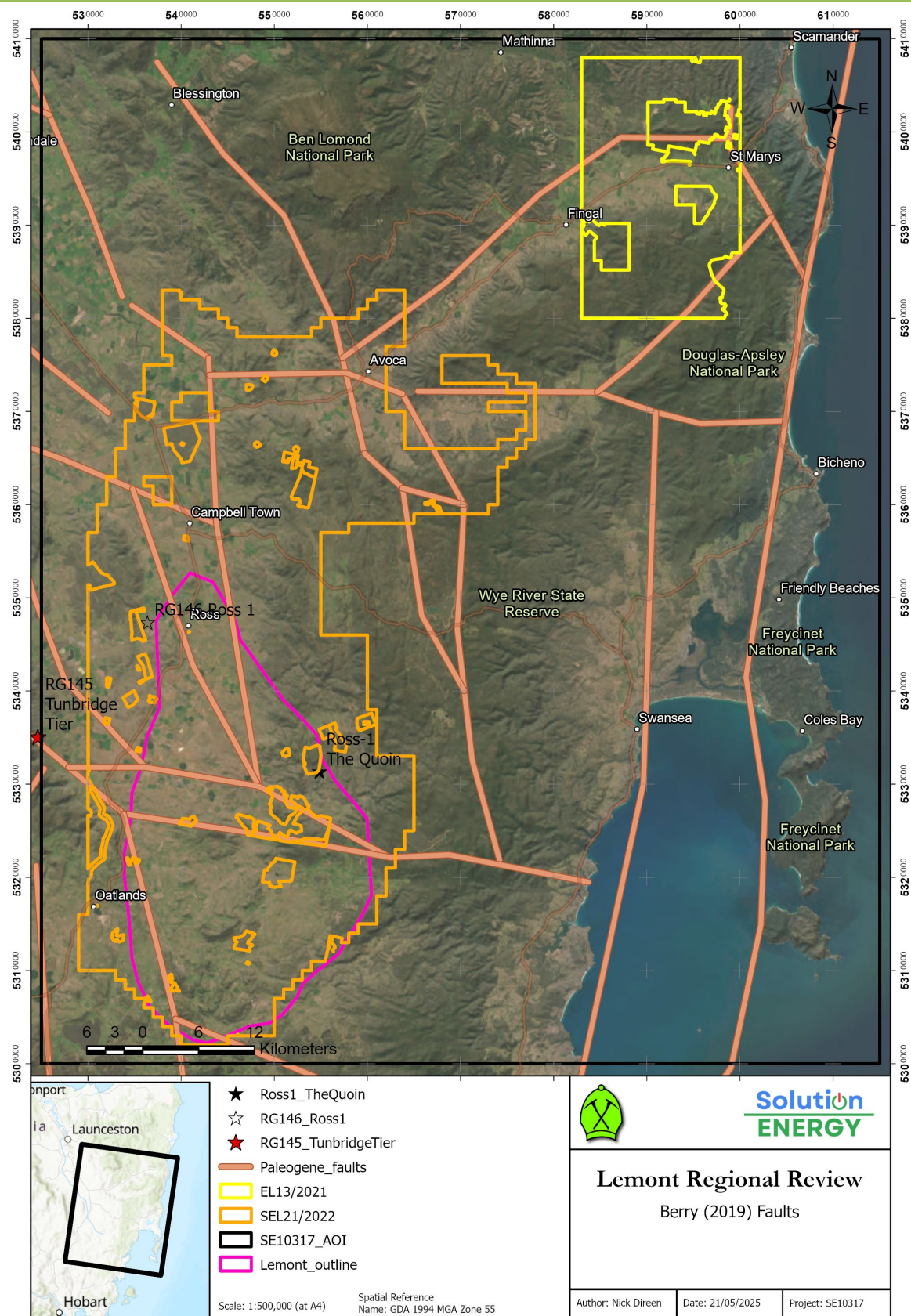


Figure 40: Berry (2019) fault interpretation



## 5.1 Mitre Interpretation

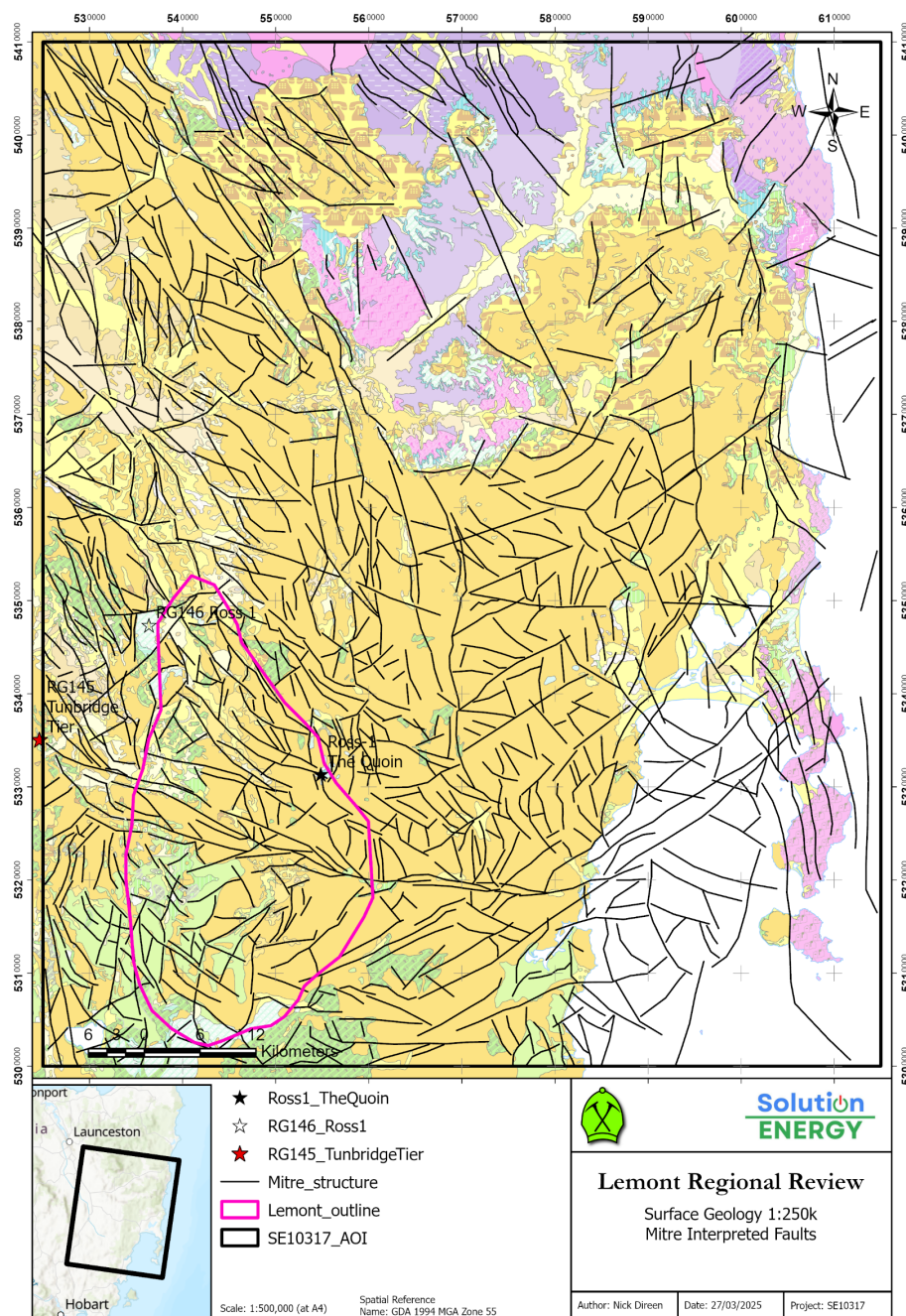


Figure 41: Mitre fault interpretation.

- In this study I have interpreted an extensive fault and fracture network based on the patterns of gravity and magnetic anomalism due to the Cretaceous and Palaeocene dismemberment of the dense, magnetic Jurassic Dolerite sheets.
- Multiple fault sets can be identified:
  - NNW-trending braided faults – probably steeply dipping, and strike slip. Probably Tertiary in age but linking into deep seated thrust stacks that are likely Devonian in age and reactivated in the Permian (Blackburn, 2004) (and this study).
  - Curvilinear WNW-ESE trending faults. These have more shallow dips to the NE. These are likely Mesozoic: see Berry (2015).





3. NE trending linear structures (transfer segments?), and N-S ?normal faults in the east. These have been linked to Tasman Sea opening in the Late Cretaceous, as they trend offshore into the Tasman Sea (this study).

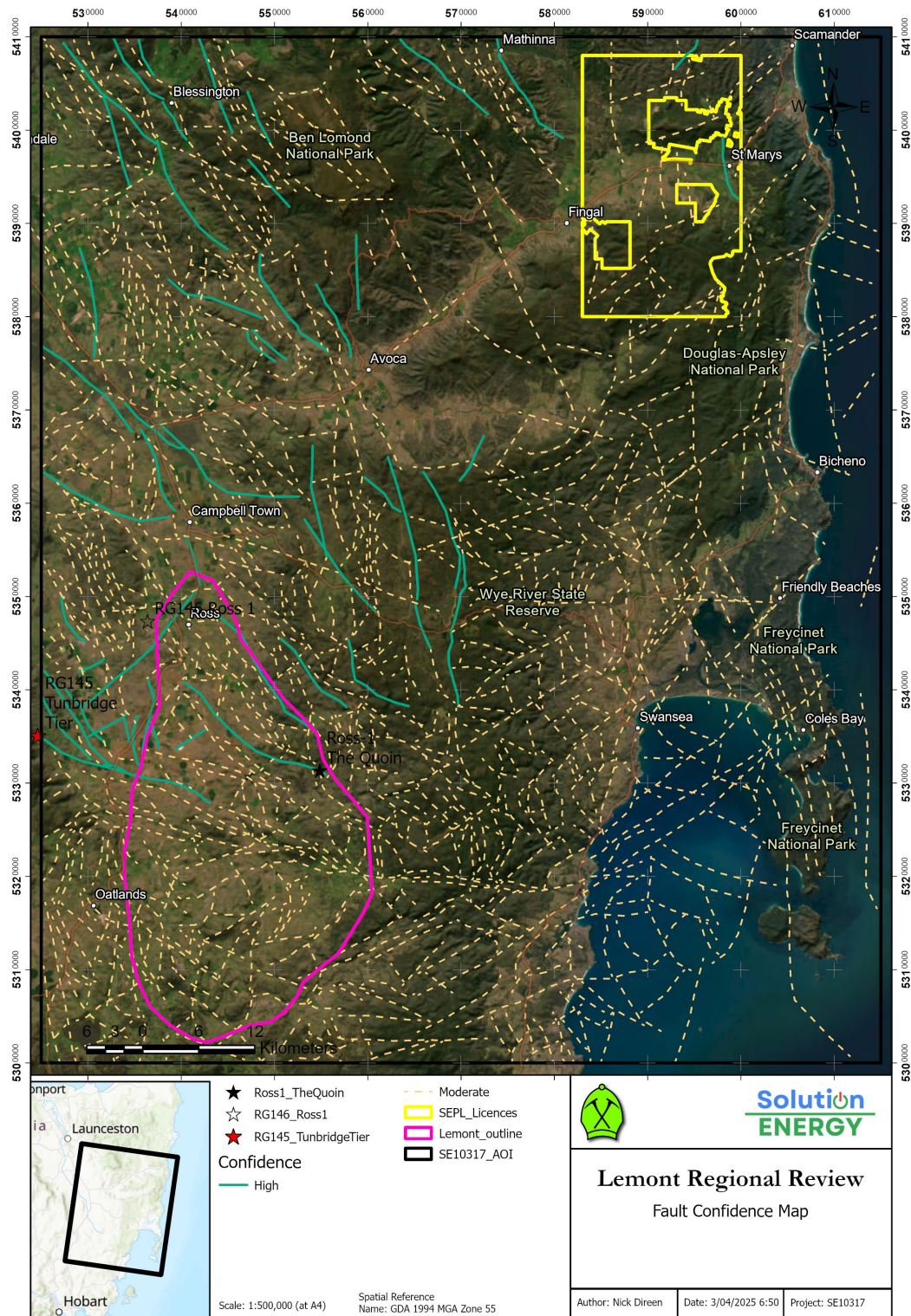


Figure 42: Fault confidence map. High confidence faults are also either mapped at surface or visible in the seismic lines. Moderate confidence faults are seen in the gravity and magnetic imagery.





## 5.2 Fault Families

Unlike the work of Godber (2009), the fault interpretation herein has been linked to the seismic interpretation and the tectonic events framework to try and better understand the geometry and kinematic evolution of the structures. Several maps are shown below elucidating this, and showing how this additional effort leads to a better overall understanding of which structures were active at different times in the past history, and therefore, possibly how they will behave in the present strain field of (Rajabi et al., 2017).

From oldest to youngest:

~390 Ma Tabberabberan Faults

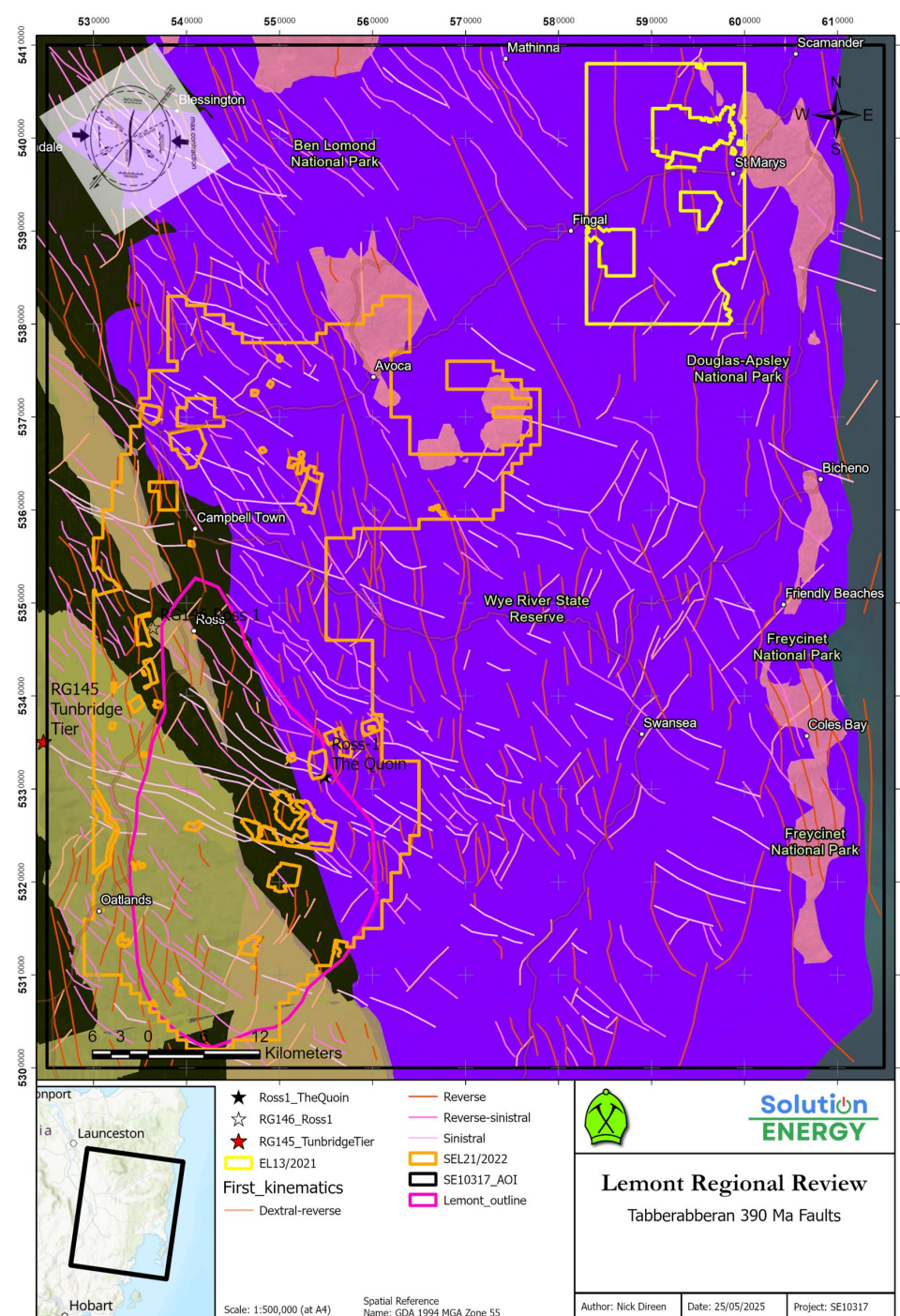


Figure 43: Predicted Tabberabberan faults, kinematics and pre-Tabberabberan solid geology (from Tasmanian 3D Geology model: Murphy et al. (2004)).





~320 Carboniferous-Permian rift faults – these extensionally reactivate the Tabberabberan thrusts.



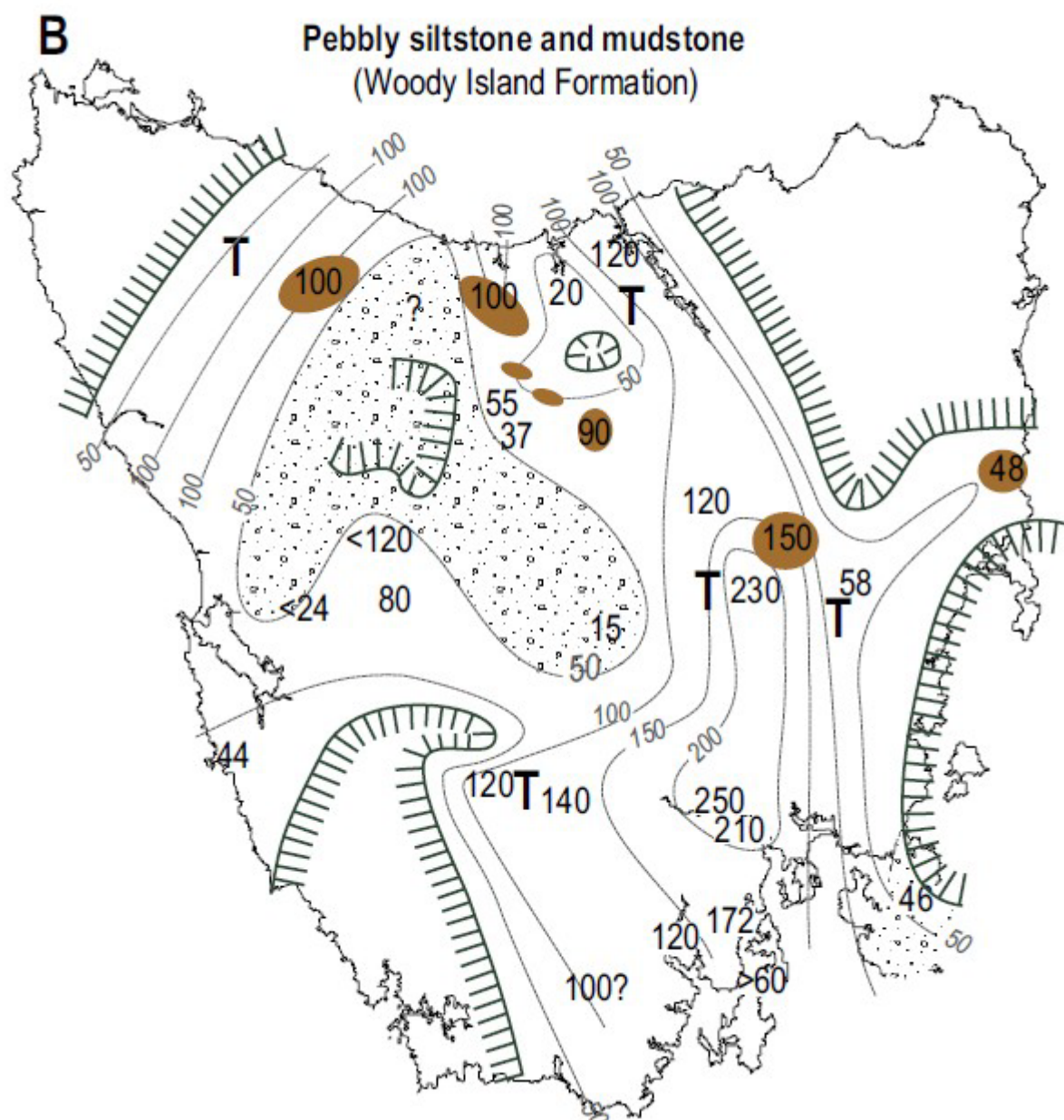
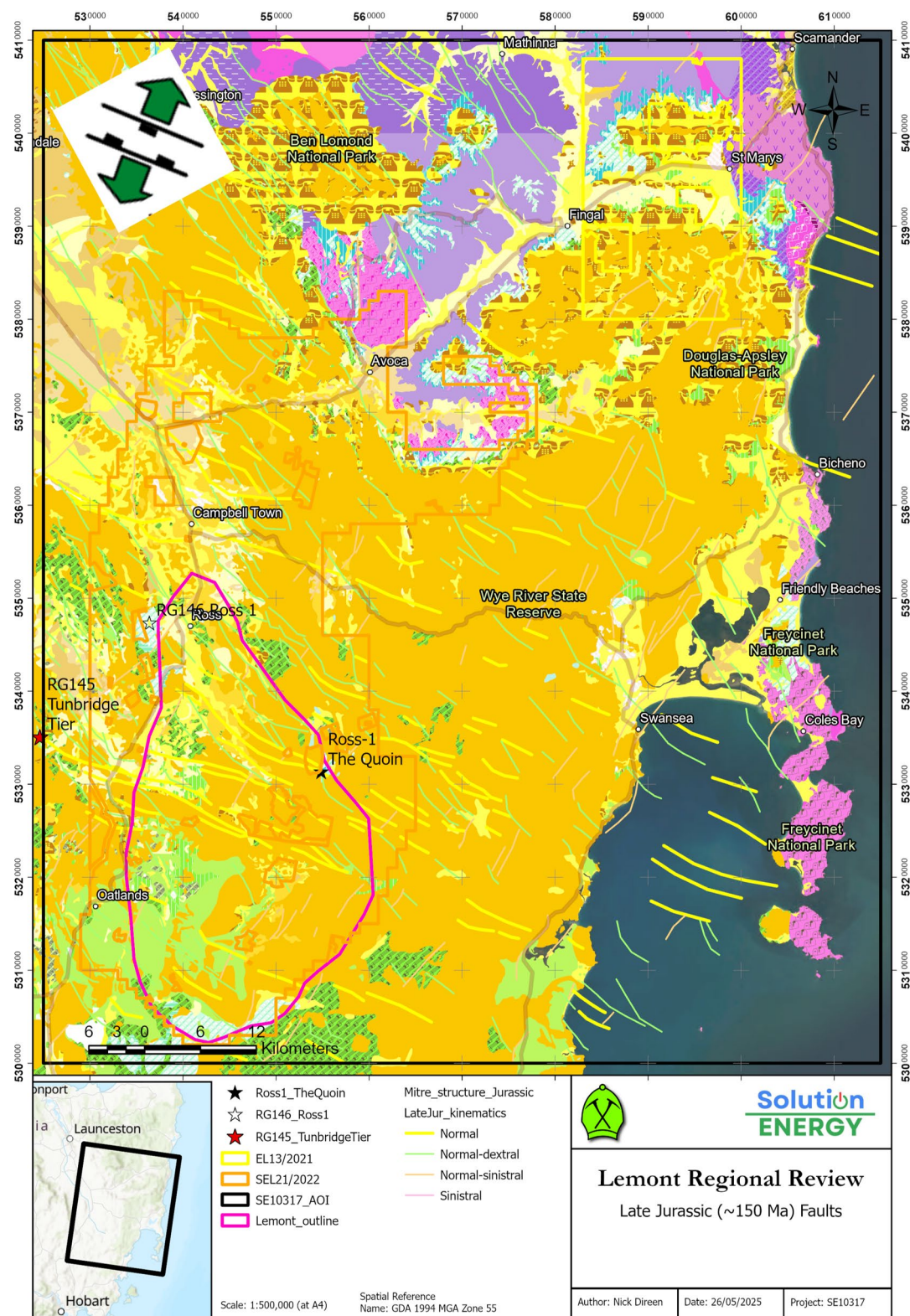


Figure 45: Lower Permian (Woody Island Formation) isopach from Reid and Burrett (2004). Numerical values are borehole thicknesses of the formation; red circles are locations with penetrations of the Tasmanites oil shale. Comparison to Fig. 43 above shows the definite fault control of this isopach in the NNW direction. The anomalous NE trending thick towards Bicheno on the east coast is likely a contouring artefact of Permian thicks broken up by younger cross-faulting.





~150 Ma Gondwana breakup faults – this is a new fault fabric from a stress regime oriented nearly orthogonally to the older fabrics dominated by the Tabberabberan structuring, and resulted in the segmentation of the Permo-Triassic basin compartments and Jurassic dolerite sheets.







~95 Ma Tasman Sea opening:

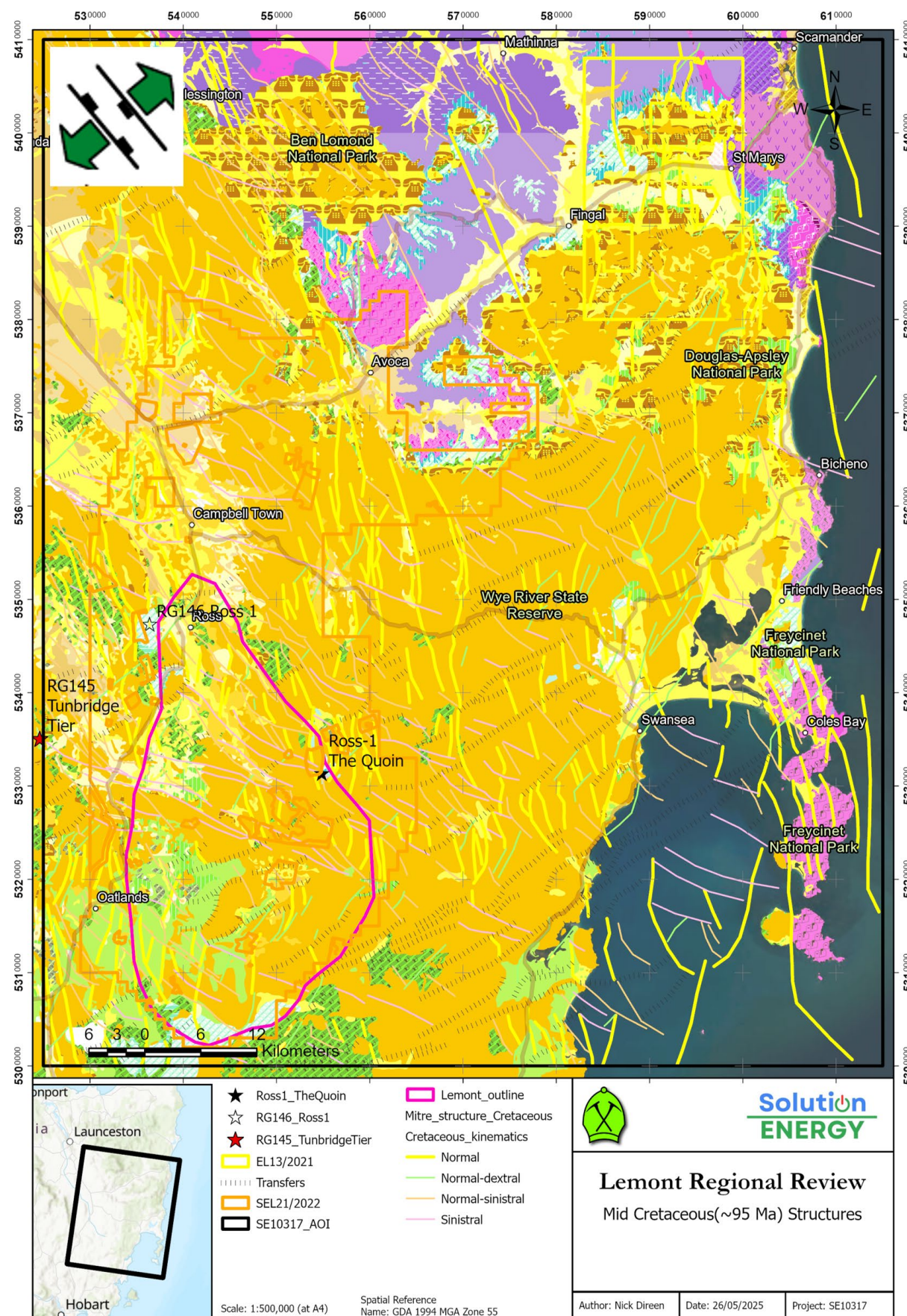


Figure 47: Mid-Cretaceous structures active during opening of the Tasman Sea cf. Blevin and Cathro (2008)





Structures reactivated during Tasman Sea opening mimic those predicted active during Carboniferous-Permian extension that created the Tasmania Basin – unsurprisingly as the  $S_{hmax}$  extensional was oriented in a very similar direction – in the latter case by rifting off of the Lord Howe Rise microcontinent; in the former by backarc rifting in the New England Orogen (see Jessop et al. (2019) and Korsch et al. (2009)). The main additional fabric at this time appears to be the very strongly developed ENE-WSW-trending transfer faults / fractures that go offshore into continental shelf, and perhaps link to transform faults in the Tasman Sea oceanic crust.

### ~60-56 Ma Palaeocene Inversion (Bass Strait failed rifting)

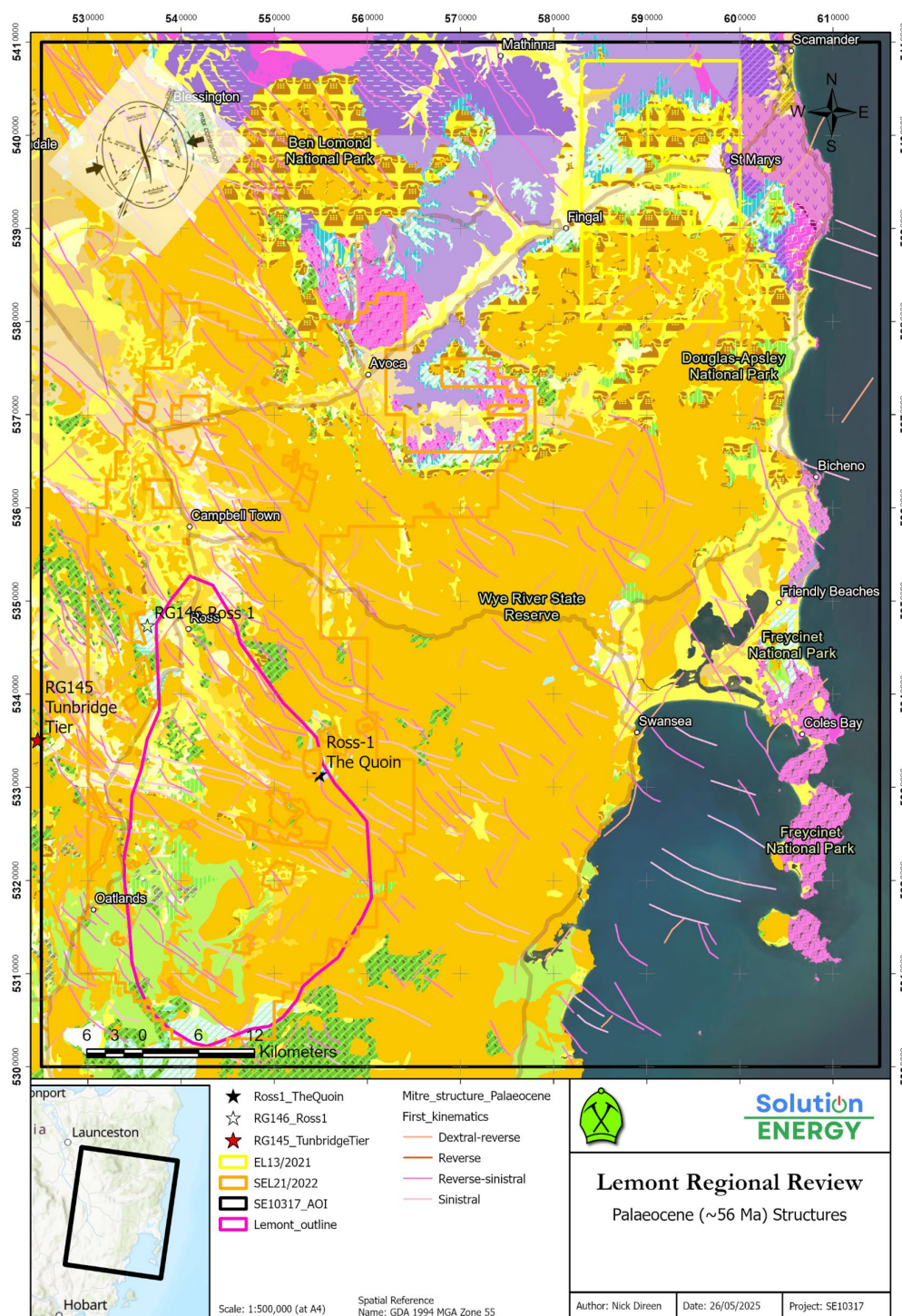


Figure 48: Palaeocene inversion from failed Bass Basin rifting (after Blevin & Cathro, 2008).





This event, reactivating most of the old NNW-oriented Tabberabberan / Permian/Tasman Sea extensional fabric as strike slip features, is likely responsible for the flower structures interpreted by Blackburn (2004):

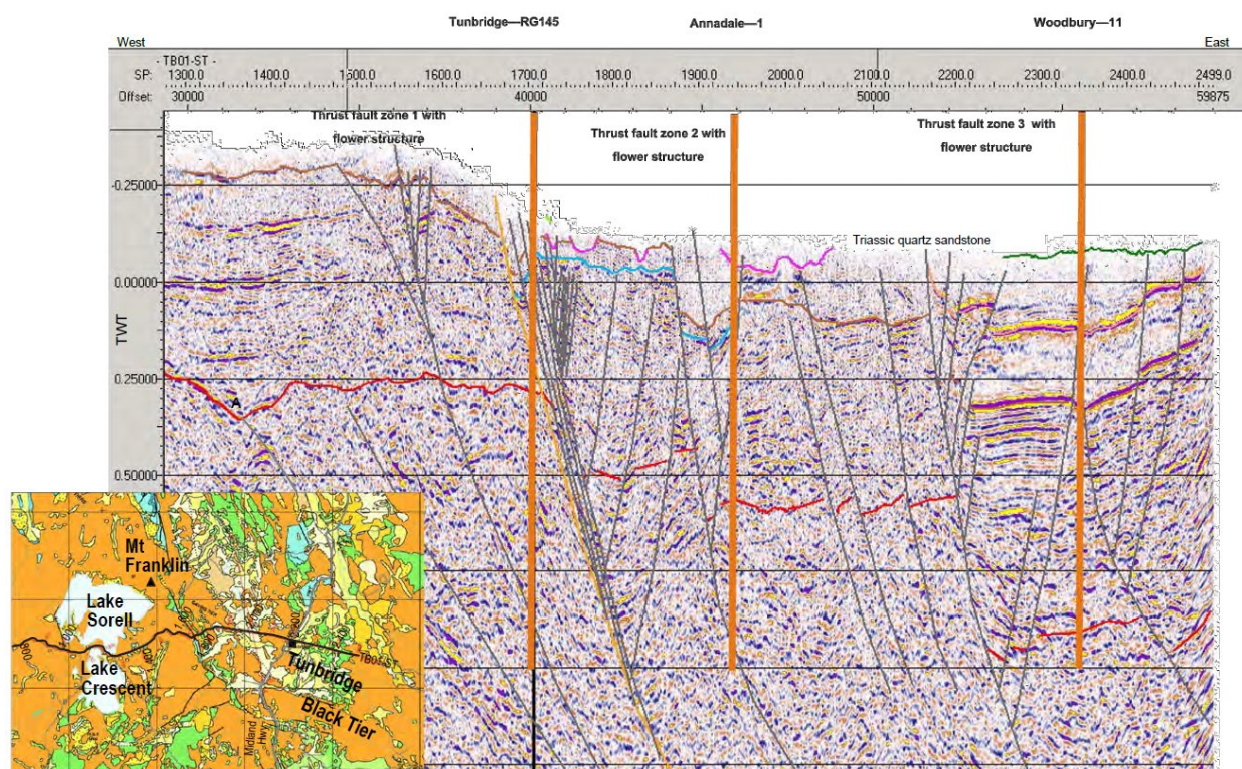


Figure 49: Flower (strike slip) structures in the shallow crust from strike-slip reactivation of older thrust structures - Blackburn (2004) interpretation TB01-ST.

and also interpreted by me in several locations on TB01-ST:

Line: TB01-ST

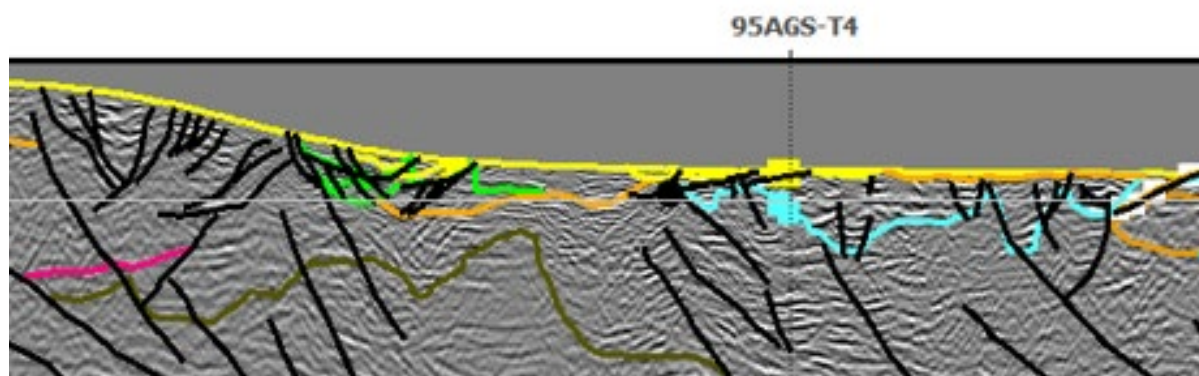


Figure 50: Flower (strike slip) structures in the shallow crust from strike-slip reactivation of older thrust structures - Mitre interpretation TB01-ST.



## Present Day stress

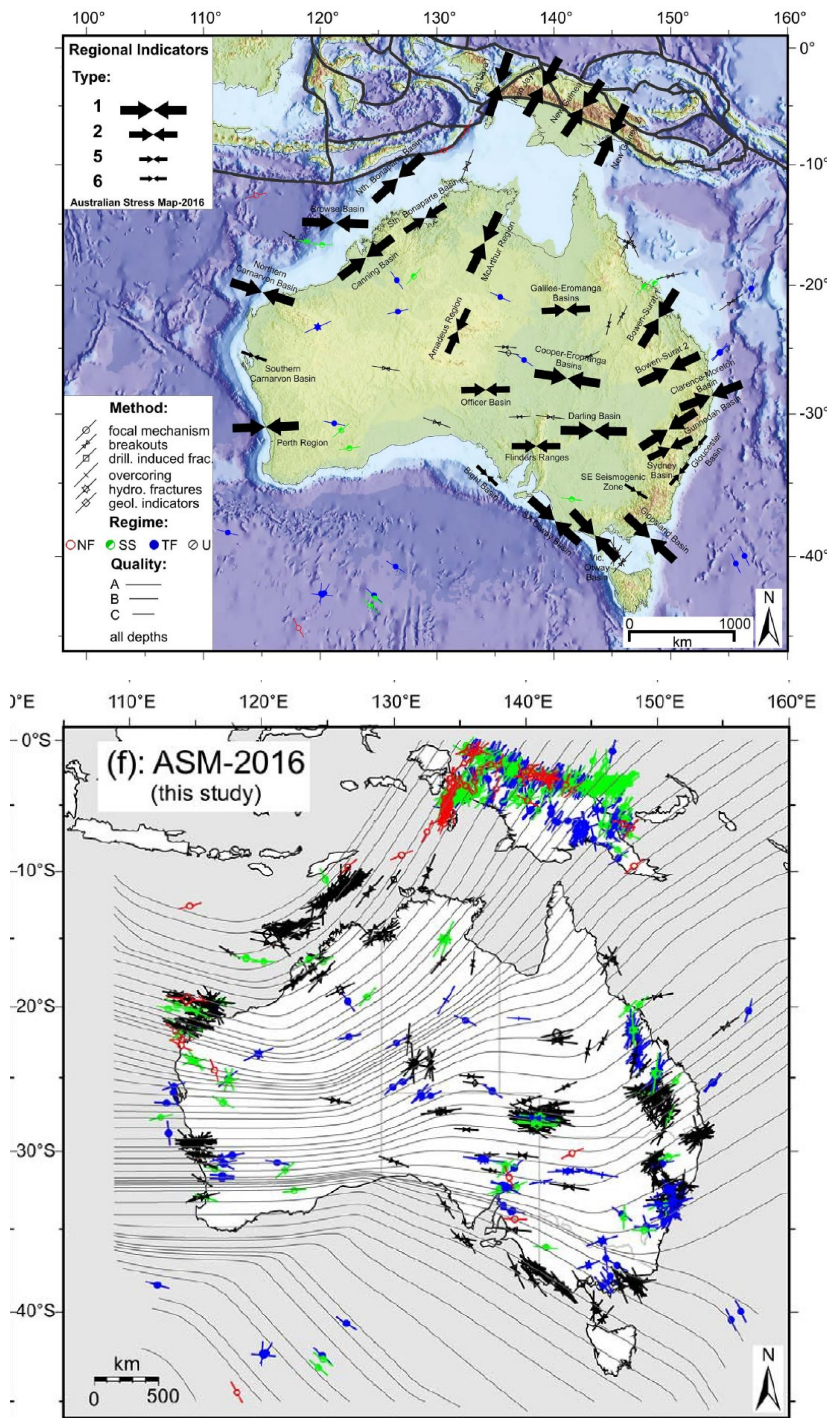
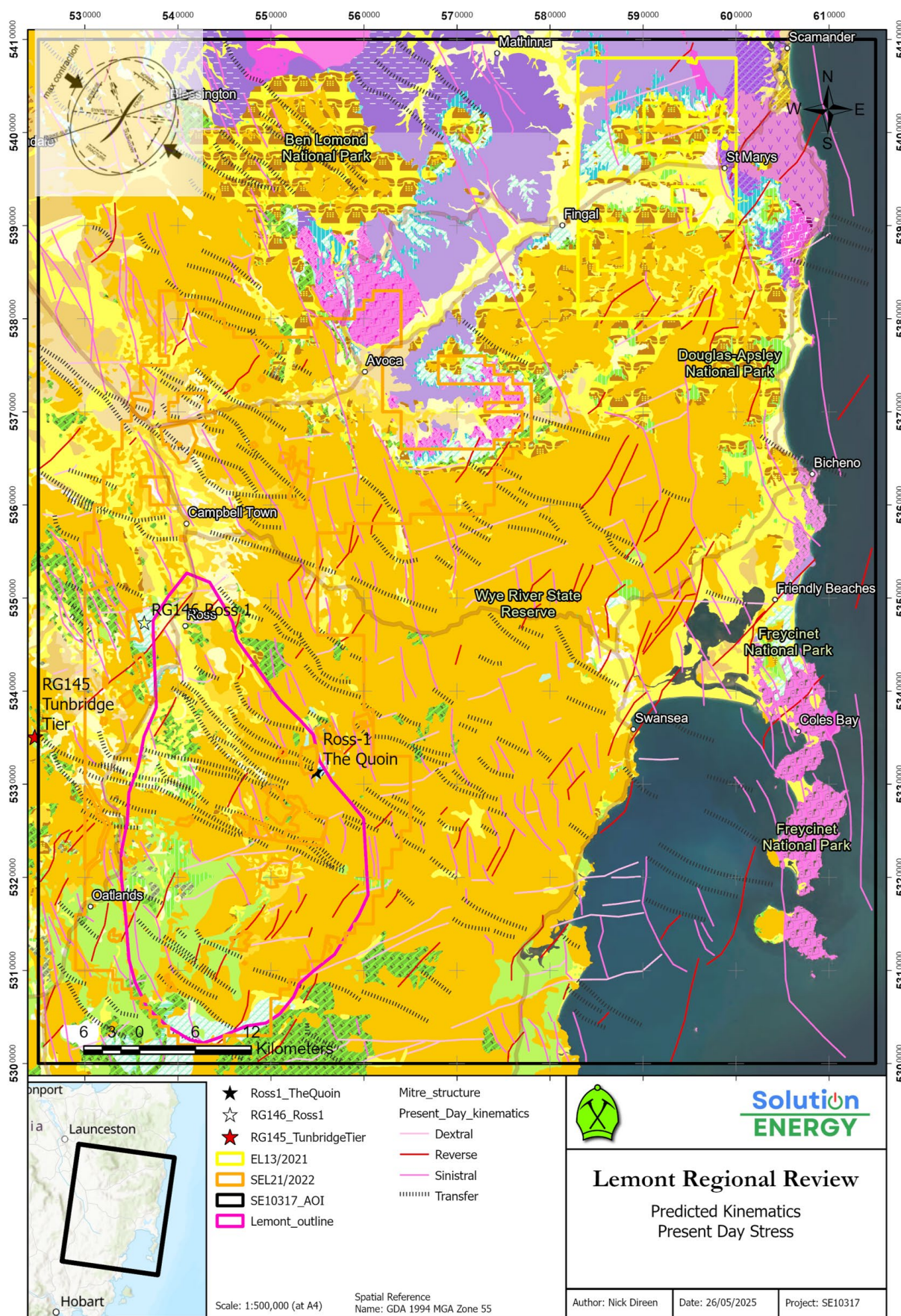


Figure 51: Present day stress regimes in the Australian Plate (Rajabi et al., 2017). Note lack of control points in Tasmania, which based on Victorian data, is under a compressional  $S_{hmax}$  oriented NW-SE.

The present day stress field has been modelled in detailed by numerous authors from borehole breakout and neotectonic data, most recently by Rajabi et al. (2017) for the whole Australian Plate. These authors found a highly variable stress field throughout the plate, which does not readily correspond to present day plate motion vectors. In Tasmania -although there is a complete lack of data points to control it – the modelled present day field is in NW-SE compression.









One corollary of the lack of control points to correctly orient the principle horizontal stresses in Tasmania is that, given the necessity for knowing the stress fields to develop an engineered geothermal system and its permeable fracture orientations (Baisch, 2020; Baisch et al., 2015; Baisch et al., 2009; Reynolds et al., 2004), some experimental geotechnical drilling to test for borehole breakouts in and around the AOI should be considered to test / validate the predictions above.

## **6 Summary and Recommendations**

This report summarises the integration of three pieces of work:

- 1) Literature review to identify the main tectonic events and tectonic stress directions in eastern Tasmania, covering the Lemont AOI and surrounds (summarised in the accompanying tectonostratigraphic chart);
- 2) Interpretation of two depth converted seismic lines, TB01-ST and 95AGS-T4 that are spatially close to the Lemont geothermal AOI;
- 3) Interpretation of structural fabrics revealed in filtered potential field datasets over the Lemont AOI.

The seismic interpretation in depth, and using improved and updated tomographic velocity models, can be used to constrain the identity of rock packages to a depth of 10 km.

The interpretations herein go beyond the level of knowledge developed from earlier interpretations of the same data, using a seismic facies (including velocity) interpretive method to define packages of rocks including the Tyennan basement, Badger Head block, Cambrian mafic-ultramafic sheets, Ordovician oceanic crust, Ordovician -Devonian Mathinna Supergroup, Paleozoic Tasmania Basin (including Upper and Lower Parmeener Supergroup sequences), Jurassic dolerites (including a feeder structure), and fault bound Tertiary basins. No granitoid body as interpreted in either of the seismic lines, although from gravity data, the extent of the Royal George Granite can be inferred and has been mapped. The interpretation of granite extents differs significantly, and materially from that of Leaman (2012).

The interpreted rock packages are affected by a variety of structures aged from probably the Cambrian Tyennan Orogeny (in the deep section), and in the upper crust, from the Devonian Tabberabberan Orogeny, with reactivation in a subsequent five tectonic events from the Carboniferous (~320 Ma) to the Palaeocene (~56 Ma). The current predicted behaviour of these structures in the modelled present day stress field is also examined. In the latter case, there is a dearth of control points to constrain the modern day stress field in Tasmania, and further studies of this from geotechnical borehole drilling are recommended before committing to a geothermal deep exploration hole.

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