

Seismic reprocessing of lines TB01-ST & 95AGS-T4 SW of Ross, Tasmania

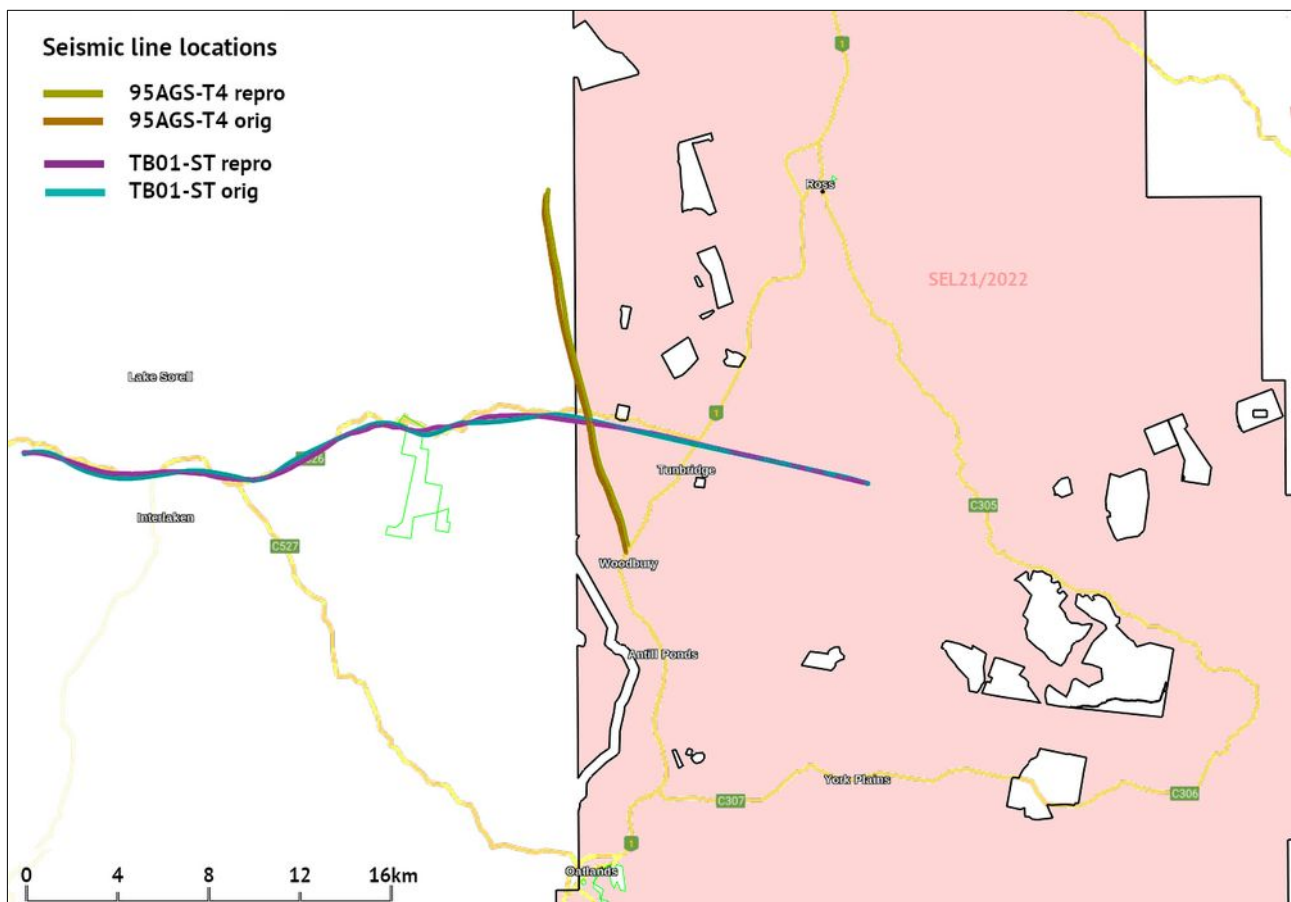


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1. INTRODUCTION

This report describes the reprocessing of two vintage seismic lines south-west of Ross, Tasmania.

Although the lines were acquired decades ago, reprocessing has resulted in a significant improvement of the shallow and deep sections enabling more reliable exploration.

Each line was depth reprocessed by Internode Seismic in January 2025 because the lines intersect on Solution Energy's tenement SEL21/2022.

Mitre Geophysics were responsible for interpreting the reprocessed data.

2. SEISMIC ACQUISITION

The two 2D seismic lines were recorded with the following parameters:

95AGS-T4 was acquired in 1995 by AGSO as part of the L139 TASGO survey Line 95AGS-T4 was acquired in a N-S direction and had low elevations. Source Type: Dynamite Source Interval: 240m Recievers: 120 channels Spread Pattern: 2380-0-2400m Station Interval: 40m Fold: 10 Recording Filter: 08-178Hz Record Length: 20sec Sample Interval: 2msec Tape Format: SEGD 6250 Shot Range: 3021-3850 CDP Range: 8000-8798 CDP Interval: 20.0m	TB01-ST was acquired in 2001 by Trace Energy as part of the North Midlands Survey Line TB01-ST was acquired in a E-W direction with elevations ranging from 1000m (west) to 100m (east) separated by an escarpment. Source Type: Vibroseis Source Interval: 25m Recievers: 360 channels Spread Pattern: 4487.5-12.5-0-12.5-4487.5m Station Interval: 25m Fold: 180 Recording Filter: Hz Record Length: 6sec Sample Interval 2msec Tape Format: SEGD Shot Range 2499-283 CDP Range: 1950-5000 CDP Interval 12.5m
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The 95AGS-T4 raw data X and Y location coordinates were in AGD66 / MGA Zone 55.

The TB01-ST raw data X and Y location coordinates were in GDA94 / MGA Zone 55.

3. ORIGINAL REPROCESSING

95AGS-T4 ORIGINAL PROCESSING FLOW

Reformat to internal format
Resample to 4ms S.I.
2D Land Crooked Line Geometry
Spherical Div Correction $V^2 \cdot T$
Spectral Balancing
CDP Sort
Velocity Analysis
NMO/Mute/Stack
Coherency Filtering
Bandpass Filter
AGC 250ms
Migration
Post Stack Processing
SEG Y Output

TB01-ST ORIGINAL PROCESSING FLOW

No original processing sequence is listed in the EBCDIC header of the original stacks, its blank. The GLSM 2D seismic survey final report contains section "3.3 PROCESSING All data "A" class recording tapes were sent to Fugro Seismic Imaging in Perth for processing." Fugro processed all TB02 lines in the Tasmanian Basin (using the same acquisition). The following original processing flow was most likely performed by Fugro.

Reformat to internal format
Gain Recovery
Phase Conversion
CDP Sort
Deconvolution
Floating Datum Correction
Velocity Analysis & Residual Statics (1st Pass)
Velocity Analysis & Residual Statics (2nd Pass)
DMO
Velocity Analysis (3rd Pass)
NMO Correction
Mute
Pre-Stack Equalisation
Floating Datum To Final Datum
CDP Trim Statics
CDP Stack
Spectral Balance
Finite-difference Migration
Bandpass Filter
Post Stack Scaling
SEG-Y Output

4. 2025 REPROCESSING

The processing objectives included producing:

- an image with good signal-noise ratio and high resolution in comparison to the original processing
- a velocity (RMS) model and optimal migration to accurately position the reflectors *in time*
- an interval velocity model that will accurately position the reflectors *in depth* (AHD)
- final files in SEG-Y format for archiving and tas.gov.au submission
- a report documenting technical details including the reprocessing flow.

1) REFORMAT TO INTERNAL FORMAT

The SEG-Y field data and support documents were received from archives on December 2024.

2) RESAMPLE TO 4 MSEC SAMPLE INTERVAL

The sample interval was resampled from 2ms to 4ms.

3) 2D LAND GEOM CROOKED LINE

The lines are crooked as shown in Fig 1. Crooked-line acquisition minimises time and cost via acquisition along existing roads and are common and practical in a hard rock environments despite violating the implicit assumption that seismic line direction coincides with the dip direction of the subsurface structures.

Binning involved defining common depth point (CDP) bins at regular intervals along a crooked line (which was a smoothed version of the actual acquisition profile).

The bins were expanded away from the CDP line (perpendicular to the acquisition direction). Those lying outside the specified maximum lateral distance from the bin centres were dropped. Line geometries were defined based on the analysis of the source and receiver coordinates and the distribution of the mid-points.

The optimal geometry information was computed and assigned to each trace header including source, receiver and CDP locations, offsets, elevations and CDP fold.

4) SPHERICAL DIVERGENCE CORRECTION $V^2 \cdot T$

An amplitude scaling correction $V^2 \cdot T$ was applied to compensate for the decrease in wave strength or amplitude with depth from wavefront spreading and attenuation. The divergence correction was applied to equalise the amplitudes for noise attenuation algorithms which use amplitude thresholds.

5) REFRACTION STATIC (RESIDUAL)

First breaks were picked on every shot gather to obtain an initial near-surface model. Using the entire record, a refraction solution was sought via an inverse iterative solution to solve for the near-surface velocity field.

The refraction statics algorithm applies tomo-static correction to the refraction travel times excluding direct waves and generates travel times, the high frequency component, after removing the smooth part, are inverted back to sources and receivers for surface consistent residual statics solutions iteratively.

A smoothed, surface consistent, long wavelength statics is produced then a short-wavelength refraction residual statics correct for short period statics, by decomposing the picked travel times and the residuals of the refraction tomography in a surface-consistent way, to determine the rapidly varying perturbations creating time-shifts.

The refraction velocities show that the weathering layer varied in thickness between 10-140m along the two line segments. The layer was very shallow on the plateau (west) and much deeper in the eastern lowlands especially where fluvial systems has incised the near-surface layers.

6) FK NOISE ATTENUATION

Typical of data acquired around the turn of the century, there was abundant shot noise on the near offsets and in the first 700msec. This resulted in abnormally high, shallow amplitudes along the entire line which required attenuation. FK incoherent noise attenuation removes anomalous high amplitude noise by iteratively FK filtering noisy traces. The process was run in the shot domain.

Each input gather is converted to frequency-wavenumber domain by means of a Fourier transform. Application was performed independently for each time window of the gather. Time windows were tapered and summed to create the resulting gather. The algorithm was applied, noise model computed then noise subtracted so that the actual shots do not have to be transformed and inverted. Shot gathers were output with noise attenuated.

7) FX NOISE ATTENUATION

FX incoherent noise attenuation removes anomalous high amplitude noise by iteratively FX filtering noisy traces. The process was run in common shot domain. Each input gather is converted to frequency-space domain by means of a Fourier transform. The filter applied was a complex Wiener-Levinson prediction filter with a filter length of 5 samples, a 7 trace wide prediction window and over a length of 500ms. Application was performed independently for each time window of the gather. Time windows were tapered and summed to create the resulting gather. The algorithm was applied, noise model computed then noise subtracted so that the actual shots do not have to be transformed and inverted. Shot gathers were output with noise attenuated.

8) VELOCITY ANALYSIS

The purpose of velocity analysis was to calculate a velocity to accurately compensate for the effects of move-out by flattening reflection events across all gather offsets. To improve the velocity analysis, additional processing was applied beforehand.

Then the final interval depth model was produced by combining the shallow refraction (described in step 5) and deep model as follows: 1) converted velocities to interval (VintT) 2) converted to depth (VintZ) 3) combined refraction model and VintZ then output.

The interactive velocity analysis used velocity spectra, moved-out gathers and stacked panels to assist in careful interpretation of stacking velocities.

9) SURFACE CONSISTENT DECON GAP=24MS

Wiener-Levinson deconvolution is a statistical process based on the least-squares estimate of linear prediction filters, to restore the wavelet to the form it had before the filtering actions of the propagation, of the source and receiver, of the near-surface etc., or to reduce these effects. Gap deconvolution targets infinitely-repeating echoes with period equal to the gap generated by a minimum-phase system, and compresses the wavelet to the length of the gap.

Gap deconvolution was applied using a 24ms operator with a total length of 200 ms and 0.5% of white noise was added to stabilize the solution. It was applied with a complete surface-consistent constraint.

10) SURFACE CONSISTENT STATICS x 2

Surface consistent residual statics were calculated and applied using a maximum cross-correlation residual statics method, with a maximum shift limit of 18 ms. Calculations were conducted for 8 iterations or until the RMS of the change in the computed statics was 12 ms.

11) NOISE ATTENUATION OFFSET DOMAIN

See above sections 6 and 7 for more details.

12) VELOCITY ANALYSIS

Final velocities were picked every 500 m. The interactive velocity analysis used velocity spectra, moved-out gathers and stacked panels to assist in careful interpretation of stacking velocities.

13) NOISE ATTEN CMP DOMAIN (applied only on seismic line TB01-ST)

See above sections 6 and 7 for more details.

14) DMO (applied only on seismic line TB01-ST)

DMO was applied to migrate each trace to a zero offset (coincident with the source). Coherent noise with implausible steep dips was removed.

15) NMO/MUTE/STACK

NMO (Normal move out) correction removes the moveout effect on traveltimes and is calculated using the velocity model (section 12). Outside muting removes NMO stretch in the shallow on the far offsets. Stacking then sums all trace samples at a single time to improve the signal-to-noise ratio and to decrease the size of the dataset. The nominal stacking "fold" is the theoretical number of traces stacked.

16) KIRCHHOFF MIGRATION

An anisotropic post-stack Kirchhoff migrations are true relative amplitude preserving. The Kirchhoff algorithm is a trace-by-trace migration, which treats each output sample as the apex of a diffraction curve. In that way the reflector image is built by constructive interference. The positional accuracy of the final migrated section is dependent on the quality of the migration velocity model. The migration with high dip-limit appeared to add more noise without improvement. The final migration parameters were set to 4000m aperture and 48 degrees dip limit. The bending-ray kirchhoff post-stack time migration provided better images and sharper faults. Finite-difference migration was also tested but the Kirchhoff migration result was better.

17) COHERENCY FILTER

Median filter 7 traces trace was applied on the stack to improve the coherency of the results and the filter was applied. Bandpass filter 10-16-80-90 Hz was applied to the data.

18) TIME TO DEPTH CONVERSION

Depth conversion is a technique that applies the final interval velocity model to improve reflector positioning. Please refer to step 8 above describing how the interval velocities were produced.

19) SHIFT TO DATUM 1000M

The first sample on each trace was shifted from the processing datum to the final datum, set to -1000m (AHD).

5. DELIVERABLES

Line 95AGS-T4 positional headers are in AGD66 zone 55S

PRODUCT	FILENAME	FORMAT
Original migration	Seismic_95AGS-T4_ORIG_32j03.sgy	SEG-Y
Final depth migration	Seismic_95AGS-T4_REPRO_31j01.sgy	SEG-Y
Final interval velocities	Seismic_95AGS-T4_VINT_34j01.sgy	SEG-Y
Refraction inversion velocities	Seismic_95AGS-T4_VREF_33j01.sgy	SEG-Y

Line TB01-ST positional headers are in GDA94 zone 55S

PRODUCT	FILENAME	FORMAT
Original migration	Seismic_TB01-ST_ORIG_32j01.sgy	SEG-Y
Final repro migration	Seismic_TB01-ST_REPRO_33j01.sgy	SEG-Y
Final interval velocities	Seismic_TB01-ST_VINT_34j01.sgy	SEG-Y
Refraction inversion velocities	Seismic_TB01-ST_VREF_33j01.sgy	SEG-Y

This combined final reprocessing report was delivered in pdf format.

6. SUMMARY

PHASE AND POLARITY

As far as the polarity and the phase are concerned, the input data was correlated at zero phase in the field and follows the SEG standard polarity.

CONCLUSION

The pre-processing flow focused on robust static solutions and denoise particularly when applied in multiple domains (leaving as much signal as possible). Velocity analysis unambiguously demonstrated the presence of shallow high velocities (indicative of dolerites) along both seismic lines. The post-stack processing flow focused on high-resolution imaging which improved the reflector definition and resolution. Significant improvements derived from application of those stages.

Overall, the reprocessed datasets are better in a number of ways when compared to the original results. Important insights such as the imaging evidence of dolerite feeders on TB01-ST are evident.

The new, high-quality datasets image the subsurface reliably, meet the project objectives and are fit-for-purpose.

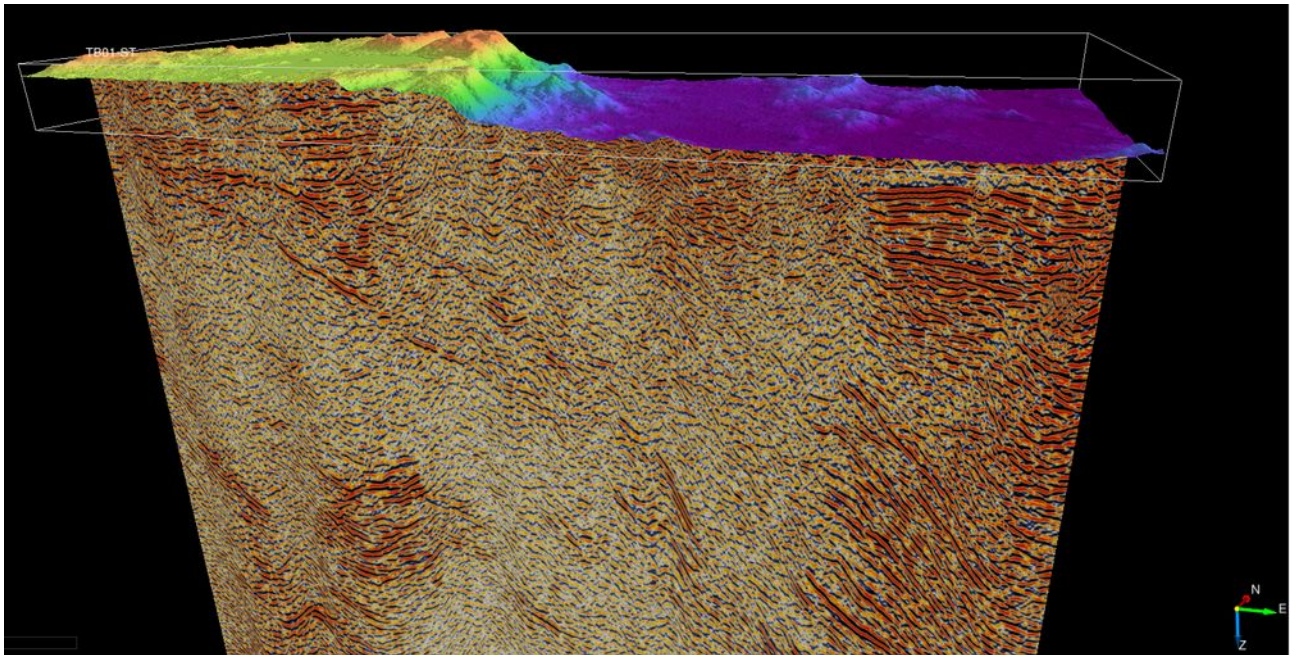


Fig 2 3D perspective of **reprocessed** seismic line TB01-ST and ground level horizon (SRTM data).

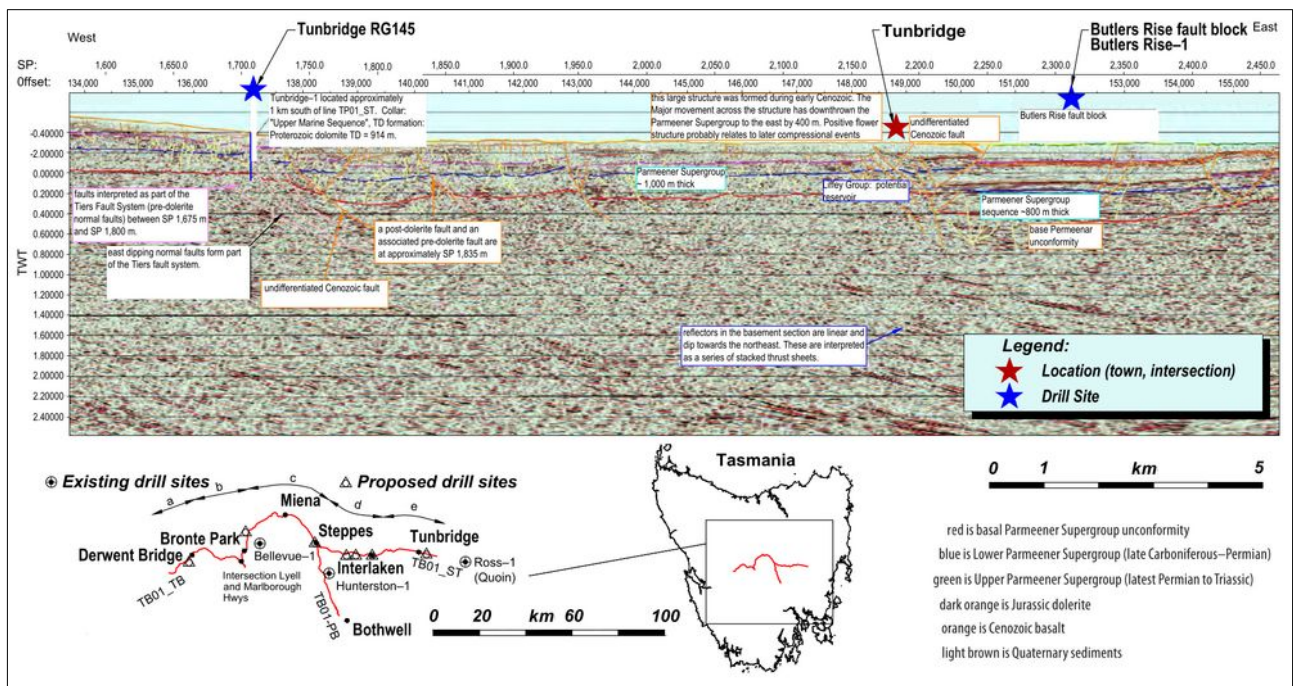


Fig 3 2D interpretation of **original** seismic line TB01-ST.