2018 Southeast Lachlan Seismic Survey: New Heights

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SUMMARY

Six hundred and twenty nine kilometres of deep crustal reflection data were collected for the Southeast Lachlan 2D seismic survey during March to April 2018. The purpose of the survey was to image the Lachlan Orogen geology, as a key to the geodynamic evolution and mineral potential of Victoria and New South Wales with implications for eastern Australia as well as natural hazard mapping. The project is a collaboration between Geoscience Australia, the Geological Survey of Victoria, the Geological Survey of New South Wales, and AuScope Ltd. The seismic data were collected by Terrex Seismic and processed by Downunder Geosolutions, and posed significant challenges in both phases. The project has been successful in obtaining final images of the whole crust in this area of the Lachlan Orogen and fundamental structural information on the crustal architecture in southeast Australia.

Key words: Seismic, Southeast Lachlan, Geology, Geophysics

INTRODUCTION

Six hundred and twenty nine kilometres of deep crustal reflection data were collected for the Southeast Lachlan 2D seismic survey along three transects: 18GA-SL1 (302 km), 18GA-SL2 (163 km) and 18GA-SL3 (164 km) during March to April 2018. The location of the survey is shown in Figure 1. The purpose of the survey was to image the Tabberabbera, Omeo, Deddick, Kuark and Mallacoota Zones (west to east) of the Lachlan Orogen at a high angle to their structural grain, as a key reference section for the study of the Paleozoic geology, geodynamic evolution and mineral potential of Victoria and New South Wales with implications for eastern Australia as well as natural hazard mapping. The project was initiated, funded and driven by the Geological Survey of Victoria, with support and collaboration provided by Geoscience Australia, the Geological Survey of New South Wales, and AuScope Ltd.

This survey posed particular challenges owing to the crookedness of the roads and tracks that were used for the deployment of equipment, and the great variation of elevation encountered along the transect. Terrex Seismic were contracted to acquire the seismic data. Processing of the data was undertaken by Downunder Geosolutions who worked with Geoscience Australia to develop a processing approach to handle the complications of the acquisition geometry. Good results were obtained, and we were able to image the entire crust in this section of the Lachlan Orogen where little information was previously available on the crustal architecture at depth.

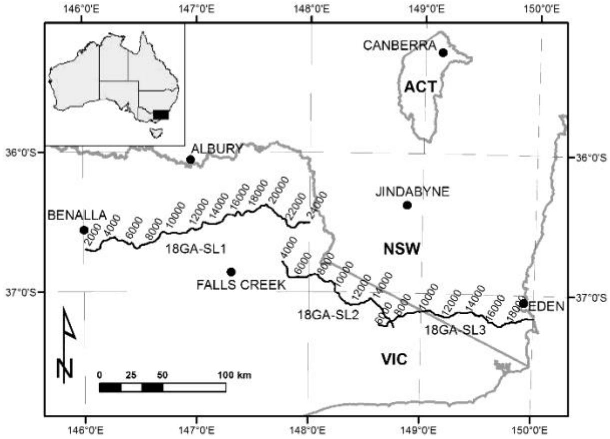

Figure 1. Map showing location of the L208 Southeast Lachlan 2D seismic survey transects with CDP numbers

ACQUISITION

Terrex Seismic were included in pre-survey scouting of the lines to advise on the logistics required and choice of recording equipment suitable for the chosen route, and acquired the seismic data between 7th March and 29th April 2018. The operation along part of the survey on forestry tracks required coordination and safety planning, due to active logging operations, as well as potential fire risk, and the possibility of snow at the high altitude areas. The area also experiences increased tourist traffic during school holidays. The optimum time chosen for the seismic operations was commencement in early March 2018. A source array of three AHV-IV vibrators was used on line with one spare, and the data were recorded on SmartSolo IGU-16 nodes. Table 1 summarises the acquisition parameters used. SmartSolo nodes were used to record the data, as the deployment and handling of a cabled system along the route was considered to be too great a safety risk for the acquisition personnel.

The use of a nodal system enabled the collection of continuous data, as well as uncorrelated and cross-correlated shot gathers. Terrex Seismic deployed a harvesting truck to download the continuous receiver gathers and manipulate them to create uncorrelated and correlated shot gathers. The nodes were set to record continuously for 23.5 hours per day with 0.5 hours of self -testing. The total data volume collected for the survey was more than 30 terabytes.

The crew was accommodated in a mobile camp and operated out of eight different town locations over the course of the survey. Approximately $250,000 was contributed to the local economy during the survey. A traffic management company was used to deploy warning and speed reduction signs along the roads and tracks used around the operations. Figure 2 shows an aerial perspective of the three vibrator array and support vehicle operating on line 18GA-SL1. The most significant access issue occurred where the line 18GA-SL2 traversed the McKillops Bridge over the Snowy River, where the vibrators had to detour 300 km via Orbost on a low loader. To reduce downtime, two vibrators were operated for the last 5.5 km before the bridge while the remaining two were floated to the other side of the bridge to operate as a pair until one of the other vibrators reached their location, when normal parameters were resumed.

Data quality was monitored on a daily basis by creating field stacks of the daily production using elevation statics and picked NMO velocities.

Table 1. Data acquisition parameters

PARAMETER	VALUE
Date	March - April 2018
Acquired by	Terrex Seismic
System type	SMARTSOLO IGU-16
Data format	SEG-D demultiplexed (Rev2)
Data media	USB
Record length	20 s
Sample rate	2 ms
Filters	0.826 nyquist linear phase
Field files	1 to 37783
Field reels	L208_usb
Source type	3 x AHV IV PLS-364 62000 lb
Sweep type	1 x 24 s sweep, 4-96 Hz
Source array	25 m centred between pegs
Vibe configuration	12.5 m pad/pad
VP interval	40 m
Spread pattern	Ch1. Ch700 * Ch701. Ch1400
Offsets (m)	-6995m ... -5m * 5m ... 6995m
Group pattern	Single point
Group interval	10 m
Coverage	350 fold (nominal)

Figure 2 Aerial view of a tight bend during acquisition of the L208 southeast Lachlan 2D Seismic Survey

PROCESSING

Downunder Geosolutions processed the data in their Perth processing facility. The main challenges for the processing include the very crooked line geometry, extreme elevation variation and hard rock environment. Because of the significant bends in the lines and the resulting wide midpoint distribution around those bends, the binning of the data posed a significant problem. Two alternative approaches were eventually decided on to image the data, a 2D crooked line binning approach, and a pseudo-3D binning approach, both based on a smooth 2D CMP line picked through the scatter of midpoint locations. The data were processed through a post stack 2D Time Migration path, as well as 2D Prestack Time Migration path, as shown in Table 2, and a Pseudo-3D Prestack Time Migration path.

Although the Pseudo-3D approach did not result in a true 3D image of the subsurface, we were able to compare the 2D migrations with the pseudo-3D to isolate some reflections that were coming from out of plane of the 2D CMP line. Figures 3 and 4 show comparisons of the two different migration techniques and show the different resulting imaging. Figure 4 in particular illustrates a reflector that is imaged in the 2D approach, but is not visible on the pseudo-3D migration stack. This shows that the reflection energy being imaged in the 2D migration most likely is reflecting from an interface that is out of plane of the CMP line, and should be interpreted as such. Figures 5, 6 and 7 show the full crustal images of each of the lines of the survey and essentially show the crustal structure on a transect from West to East, from near Benalla in Central Victoria to near Eden on the South coast of New South Wales.

CONCLUSIONS

The 2018 Southeast Lachlan Deep Crustal Seismic Survey posed many challenges, including acquisition on very crooked roads and tracks in areas of significant elevation changes with associated operational considerations, but through excellent collaboration in the planning, acquisition and processing of the data the result is a valuable dataset that provides a fundamental structural framework for understanding the geology of the southeastern Lachlan Orogen.

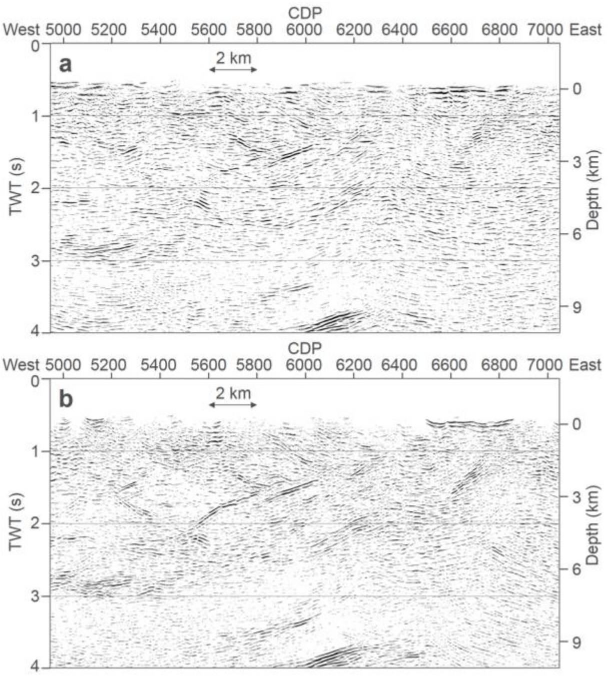

Figure 3. L208 18GA-SL1 prestack time migration stacks; a) using 2D geometry and b) using pseudo 3D geometry with improved imaging at bends in the line, e.g. CDP 5500 to 5800 1.5 to 2 s. The vertical scale is equal to the horizontal scale with depths from surface approximated assuming an average crustal velocity of 6000 m/s

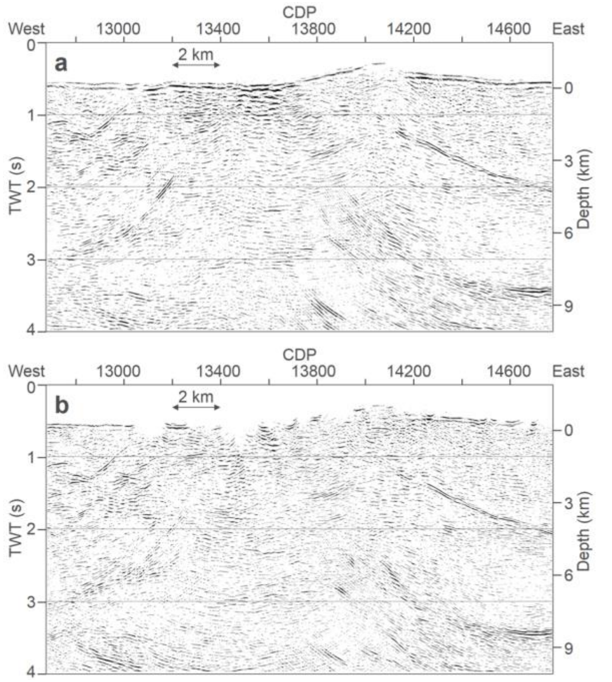

Figure 4. L208 18GA-SL1 prestack time migration stacks; a) using 2D geometry and b) using pseudo 3D geometry with improved imaging in regions with bends in the line. Possible out of plane event seen in a) at CDP 13200, 2 s is migrated out of plane in b) The vertical scale is equal to the horizontal scale with depths from surface approximated assuming an average crustal velocity of 6000 m/s.

Table 2. General processing sequence for 2D PSTM.

PROCESSING STEPS
1) Reformat from SEG-D to DUG Insight internal format
2) Trace edit 3) Merge geometry database
4) Zero to minimum phase correction
5) Spherical divergence correction Tpower=0.5
6) Refraction statics application 7) Correction to floating datum
8) Noise attenuation (shot domain)
9) Surface consistent amplitude correction + shallow gain clip
10) Deconvolution 48 ms gap 320 ms operator length
11) Residual statics pass 1 and 2 application
12) Denoise 2 and Surface-consistent amplitude corrections
13) Crooked line CMP bin (1000 m max perp. offset)
14) Kirchhoff 2D pre-stack migration using scaled velocity
15) Back off scaled velocity, apply final stacking velocity
16) Post-migration gather denoise 17) Angle mute 45 degree
18) Stack 19) Post-stack denoise 21) Post-stack AGC 2500 ms
22) Shift to final datum (SRD): 1650 m AMSL; replacement velocity: 5200 m/s
23) Output to SEG-Y 24) Resample to 4 ms
25) Coherency enhancement (digistack 0.5 and FK-power 1.3)
26) Tscale AGC 2500 ms window.

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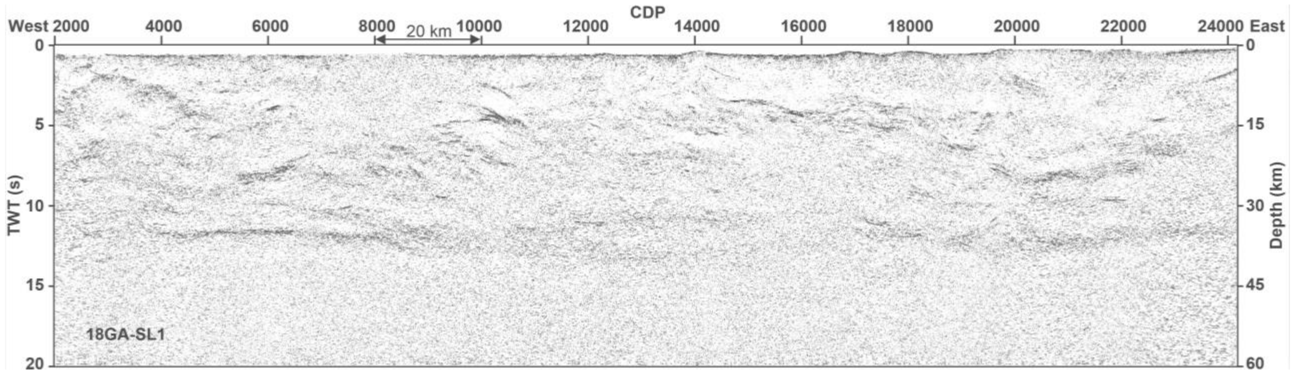

Figure 5. L208 prestack time migration stack 18GA-SL1. The Moho can be seen at approximately 12 s, most distinctly at CDPs 4000 to 8000. The vertical scale is equal to the horizontal scale with depths from surface approximated assuming an average crustal velocity of 6000 m/s.

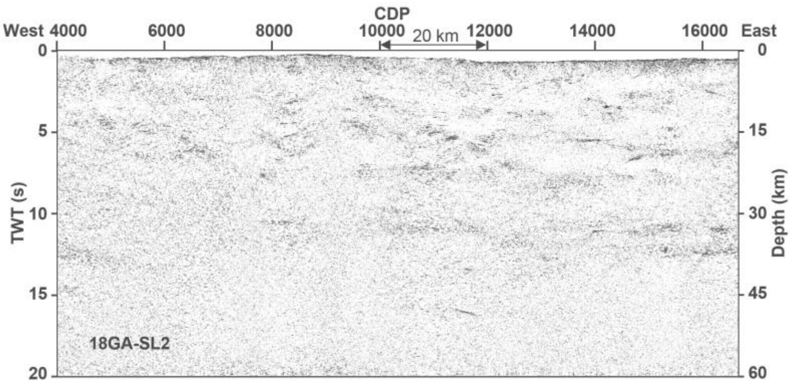

Figure 6. L208 prestack time migration stack 18GA-SL2. The vertical scale is equal to the horizontal scale with depths from surface approximated assuming an average crustal velocity of 6000 m/s.

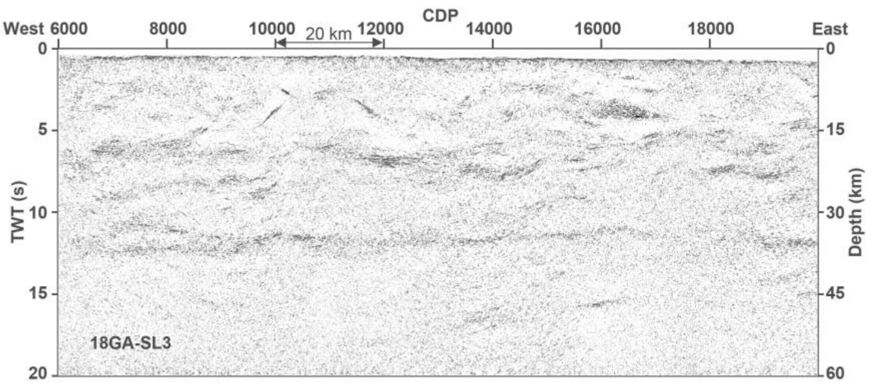

Figure 7. L208 prestack time migration stacks 18GA-SL3. The vertical scale is equal to the horizontal scale with depths from surface approximated assuming an average crustal velocity of 6000 m/s.