Improving fault geometry interpretation through ‘pseudo-depth’ conversion of seismic data in the Penola Trough, Otway Basin.

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Abstract

Accurate interpretation of fault geometry is essential to the assessment of fault seal integrity in the Penola Trough, Otway Basin. Fault geometries in the Penola Trough are variable with complex kinematic interactions between younger, Early Cretaceous and older, Late Cretaceous fault populations. This complexity, combined with issues of seismic data quality, makes interpretation of fault geometry particularly difficult.

A laterally invariant velocity function was applied to the seismic time data of the area to redisplay the seismic in a form that gives a better representation of depth, here termed ‘pseudo-depth’ conversion. This technique appears to work well in the Penola Trough where lateral velocity variation, as revealed by well data and stacking velocities, is minimal. This new pseudo-depth seismic data set has shown that many of the apparent listric fault geometries in time data are in fact planar. Pseudo-depth conversion has also improved the clarity of the seismic data and shows almost identical depth matching of structure and horizon interpretation when compared with pre-stack depth-migrated sections.

The insights into fault geometry, which pseudo-depth seismic data provides, is having significant impact on a new structural interpretation of the Penola Trough. Different structural styles and the kinematic relationships of different fault populations are more clearly discernable on pseudo-depth seismic sections. This paper therefore demonstrates how depth conversion of time seismic data has provided a better domain in which to view, analyse and interpret fault geometry than the conventional time domain.

Keywords: Depth conversion, velocity function, fault geometry, structural interpretation, fault seal analysis.

Introduction

The Penola Trough is located within the onshore part of the western Otway Basin, South Australia (Fig. 1). Exploration interest in this area has waned recently due to the encountering of several breached and partially breached hydrocarbon accumulations in wells drilled on the flanks of five commercially producing gas fields: Katnook, Redman, Ladbroke Grove, Haselgrove and Haselgrove South (Fig. 1). The main target reservoir is the Pretty Hill Sandstone of the Pretty Hill Formation (Fig. 2). Most of the traps have fault-dependent closure. The regional Laira Formation top seal consists of abundant fine shale sealing units (Boult et al. 2002; Boult et al. this volume). Previous studies have demonstrated that these units have sufficient seal capacity to hold back gas columns of several hundred metres and are likely to be laterally continuous over Penola Trough prospects (Jones et al. 2000; Boult et al. 2002). These studies, combined with the empirical observation that most of the live columns and palaeo-columns are/were filled to structural spill point, suggest top seal risk is minimal (Jones et al. 2000).

Fault-related seal breach has thus been identified as the key geological risk in evaluation of prospects in the Penola Trough. There are two recently published hypotheses on the mechanisms which control seal breach in this area. Jones et al. (2000) proposed that seal breach had occurred as a result of recent fault reactivation within the in-situ stress tensor. Boult et al. (2002) proposed that seal breach had resulted from cap-rock failure caused by areas of high differential stress that occur locally around faults. The successful testing of which of these breach mechanisms is the most significant risk requires a full and systematic determination of the original fault sealing mechanisms i.e. whether or not juxtaposition and/or fault plane processes have provided a viable fault seal for the retention of hydrocarbons. Successful determination of the original fault sealing mechanisms and comparison of these findings with the distribution of breached and live columns, will provide the basis for the testing and calibration of predictive methods of seal breach (Boult et al. this volume; Lyon et al. in press). Of key importance to the analysis of juxtaposition, fault plane processes, recent fault-reactivation and intact-cap rock failure is the accuracy of fault geometry interpretation.

The Penola Trough shows complex fault geometries. It is characterised by an abundance of Early Cretaceous syn-rift faults that show a predominantly E–W direction across the 3D Haselgrove and Balnaves seismic volumes. Abrupt changes in dip direction of the faults are observed along strike. These zones of abrupt change in dip direction are characterised by distinct zones of intense faulting known as accommodation zones (Lovibond et al. 1995; Chanthrapsart et al. 2001). Fault geometries identified within shallower post-rift sediment packages show a more dominant NW–SE trend (Chanthrapsart et al. 2001; Boult et al. 2002). Fault geometry is thus complex in the Penola Trough with abrupt lateral changes in structural styles and also vertical changes in fault geometry and orientation.

Due to the structural complexity and the moderate quality of the seismic data in this region many interpretations of fault geometry are possible. It is difficult to resolve whether faults are planar or listric on time seismic data. Fault geometries imaged on time sections will appear listric even if their true depth geometry is planar, due to the increase in velocity with depth (Fig. 3). Furthermore, the apparent dips of faults in time can be misleading, making it difficult to assess geological validity of structural interpretation. Boult et al. (2002) concluded that identification and interpretation of the Early

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Cretaceous faults, younger overlying faults and their interaction is difficult to discern on time seismic data.

The authors decided it was important to understand more thoroughly the true depth geometries of the faults in a new interpretation of the area. Unfortunately, pre-stack depth-migrated seismic data (Furniss 2000; Willink and Lovibond 2001) was only available for one 2D line. Lateral velocity variations were found to be minimal in the area so a laterally invariant velocity function derived from checkshot and stacking velocities was applied directly to the time seismic data to reposition reflections by depth. The resulting seismic lines and volumes have been termed ‘pseudo-depth’ seismic data in recognition of the inherent error in absolute depth imaging by the application of a single velocity function across a large area. Nonetheless, these ‘pseudo’ depth sections have greatly aided interpretation. Many of the apparently listric faults in time are in fact imaged planar on pseudo-depth sections. Faults are also imaged with greater clarity by the planar interpretation of structural geometry and fault kinematic evolution of faults that pseudo-depth imaging provides is impacting on new interpretation of accommodation zones with NE–SW trending faults. The insight into true depth geometry compared to interpretation made in time, making 3D correlation of interpretation of fault segments on pseudo-depth sections aligned to reflector discontinuities. There is less scatter in interpretation of fault segments on pseudo-depth sections compared to interpretation made in time, making 3D correlation of interpretation more precise. The insight into true depth geometry of faults that pseudo-depth imaging provides is impacting on new interpretation of structural geometry and fault kinematic evolution of the Penola Trough.

This paper presents the method used to derive the pseudo-depth sections. Pseudo-depth sections and time sections are then compared to show that many of the listric faults are planar in geometry when displayed in pseudo-depth. The improvement in clarity, precision of fault interpretation, and the influence of pseudo-depth sections on the structural interpretation of the area are also discussed. A pseudo-depth section is compared to a pre-stack depth-migrated (PSDM) depth section and the limitations and errors associated with the pseudo-depth method are addressed.
throughout the deposition of the successive units of the Sherbrook Group and sediment packages of the Tertiary is likely to have been accommodated on several of the more prominent faults that appear to show evidence of successive reactivation events through time.

The prominence of faults identified cutting the excellent reflections of the Tertiary and Sherbrook Group sediments are of key significance. These fault trends are dominantly NW-SE over the whole trough and indicate a distinct NE–SW post initial rift extensional episode subsequent to the initial rifting (e.g. O’Brien et al. 1994).

A major change to a NW–SE compressional stress regime occurred in the Miocene due to significant changes to plate boundary forces along the northern and eastern margins of the Australian plate (Perincek et al. 1994) and ridge push from the developing Southern Ocean (Hill et al. 1995). In-situ stress determination has indicated that the present-day maximum principal horizontal stress is similarly orientated approximately NW–SE (Hillis et al. 1995; Jones et al. 2000) and the present-day stress regime is strike-slip (Jones et al. 2000).

Seismic data quality and interpretation challenges

Seismic resolution is good to two-way times of approximately 0.7 seconds, clearly imaging the displacement of relatively distinct high amplitude reflections from the Upper Cretaceous and Tertiary units. However, resolution generally reduces significantly through the Lower Cretaceous Eumeralla Formation where acoustic impedance contrasts are less. Furthermore, the general reduction in resolution due to progressive loss of high frequencies with depth makes interpretation of deep, Lower Cretaceous fault geometries increasingly uncertain. There is however, clear offset on several higher amplitude reflections from within the Lower Cretaceous Crayfish Group. In the deeper parts of the Trough, where the Pretty
Hill Formation reservoir of the Crayfish Group occurs at times in excess of 2.5 seconds fault recognition is much more difficult. Recognition of listric displacements in the well-imaged reflections of the Tertiary, Laira Formation and Pretty Hill Formation in time seismic data has often led in the past to interpretation of large listric faults. Boul et al. (2002) suggested that such interpretation is unlikely to be geologically valid by the recognition of two separate fault populations, significantly aided by variance volumes. However they concluded that distinction of younger faults from underlying syn-rift faults, particularly where these propagate down to the basal Eumeralla Formation unconformity, is difficult to determine on time sections.

The application of a depth conversion to the seismic data was therefore investigated as a means of clarifying structural geometry by removing the distortion inherent in time sections.

**Velocity analysis and pseudo-depth conversion method**

Borehole and processing velocity information were utilised to assess the degree of lateral velocity variation across the Penola Trough. A cross-plot of time-depth measurements from checkshot surveys in 15 wells across the study area shows that the points cluster tightly around a well-defined trend (Fig. 4). Assuming the wells are a representative sample of the velocity field, the plot indicates that there is very little lateral velocity variation across the area within the top four kilometres of section.

All of the stacking velocity functions derived from the reprocessing of the combined Haselgrove and Balnaves 3D seismic surveys were then analysed. These functions had been picked following DMO processing and were referenced to the seismic datum elevation. Dix interval velocities (Dix 1955) were calculated between successive picks on each velocity function, and from these and their respective times, the corresponding depth intervals were calculated allowing a time-depth curve to be constructed. This procedure yielded a second set of time-depth data which was densely sampled, and extended below the greatest depth penetrated by the wells (Fig. 4). These data are in excellent agreement with the well data at shallower depths support the conclusion, that lateral velocity variations within the Trough are small.

A sixth-order polynomial in two-way time was fitted to the combined data sets to provide a regional time-depth relationship (Fig. 4). This function was used to convert the seismic time volume to depth by first calculating depths for the sample times on each trace, and then interpolating the resulting depth trace at a constant depth interval. The data generated by this process has been termed 'pseudo-depth' seismic data in recognition of the limitations of using a single velocity function in converting to depth. The chief virtues of the method are the speed and simplicity with which it produces seismic depth data for loading into a workstation. The velocity data indicate that in the study area, the pseudo-depth seismic has sufficient accuracy that the insights it provides into the structure are reliable. In areas of more complex velocity variations, the method could easily accommodate a varying velocity function.

**Results**

Examples of pseudo-depth sections and the corresponding time sections are presented herein for comparison to show that pseudo-depth sections have:

- imaged many fault planes that appear listric in time as planar features;
- increased the clarity of fault geometries;
- increased the clarity of 3D correlation of fault interpretation;
- led to new insights into structural geometries, and;
- produced depth images similar to 2D PSDM depth sections.

**Listric to planar imaging**

A time seismic section through the Katnook Graben, the main gas field bearing structure in the Penola Trough (Fig. 1), was chosen to demonstrate how apparently listric faults in time are imaged planar in pseudo-depth converted seismic sections. The two main bounding faults of the graben are particularly well imaged as the seismic data over this structure has been reprocessed to enhance fault plane reflections. The faults show an apparently listric geometry when viewed on a time section (Fig. 5a). The substantial thickening of the Crayfish Group units within the graben fill indicates they are relatively old faults formed during the Late Jurassic/Early Cretaceous initial rift event. A comparison of the time section with a pseudo-depth converted section (Fig. 5b) shows that the Ladbroke Grove fault in particular is a planar feature in depth.

**Clarity**

The planar alignment of reflector truncations and fault plane reflectors observed in the pseudo-depth section of Figure 5b permits more clearer and confident picking of the faults when compared to the time section. The displacements on the high amplitude reflections within the Tertiary sediments at 250–750m are clearly aligned with the planar displacements through the deeper Crayfish Group horizons (top Crayfish Group, near top Pretty Hill Formation) on the pseudo-depth section. Interpretation of the fault on this section through the relatively lower amplitude reflections of the Eumeralla Formation can be made with much more precision. There is more scope for interpretation error where the interpreter has to interpolate a listric geometry between listric offsets on prominent reflections in time sections (Fig. 5a).
Interpretation precision and 3D correlation

Figure 6 shows a comparison of the 3D interpretation of part of the Ladbroke Grove Fault (Fig. 5) made in both time and pseudo-depth. The fault has been coloured by its dip values in both cases to show the apparent listric nature of the fault in time interpretation (Fig. 6a) and the planar imaging in pseudo-depth (Fig. 6b). The pseudo-depth interpretation shows a consistent dip of 55–65° on the fault whereas the time interpretation shows a much broader range of 20–60°. The consistency of interpretation made in the depth domain is much greater. This has been visually demonstrated by the display of a time slice and the equivalent depth slice on Figure 6. There is less scatter on the fault trace observed on the depth slice (Fig. 6b) than on the time slice (Fig. 6a). The listric interpretation of fault segments on time sections is more susceptible to interpretation inconsistency for reasons explained in the previous section. Pseudo-depth seismic data has allowed more consistency and thus greater precision in the picking of faults, which has considerably aided 3D correlation (Fig. 6). Furthermore, the use of horizontal seismic slices of variance attributes to correlate and recognise individual faults is maximised in pseudo-depth seismic where interpretation is more consistent along strike.

New structural interpretation

Previous seismic interpretation in the Penola Trough has often suggested that faulting in the Penola Trough is dominantly extensional (e.g. Perincek et al. 1994). Several authors have suggested that there may be a component of oblique slip to the normal faulting in the area (e.g. O’Brien et al. 1994). Jones et al. (2000) identify oblique trending slickensides in a core through a fault zone at Jacaranda Ridge. Recent 3D seismic interpretation work across the Katnook Graben has also highlighted significant spatial restoration problems at depth where very significant out of plane movement is likely (Bierbrauer pers comm. Origin Energy 2004). The pseudo-depth imaging of the Ladbroke Grove Fault as a relatively steep planar feature rather than a listric fault is more consistent with a combined dip slip and strike-slip fault geometry (Harding 1983; Nicol & Van Dissen 2002).

Further insight into the structural geometry of the Penola Trough is also evident from pseudo-depth sections. It has made younger, Late Cretaceous faulting and older, Early Cretaceous syn-rift faulting much easier to distinguish. Figure 7a shows a time seismic section from the western part of the reprocessed 3D Haselgrove-Balnaves survey. An example of a large listric fault...
whereas below this depth, the fault dip is approximately 35° below 2 km. Above 2 km, the fault dip is approximately 60°.

The abrupt dip contrast between the displaced reflections above and below 2 km is illustrated on the pseudo-depth section (Fig. 7b). This interpretation appears reasonable and was validated by viewing an inline 1 km to the west of the interpreted fault (Fig. 6a).

The pseudo-depth seismic traverse section through the Redman-1, Grove Fault (see Fig. 5) shows an almost perpendicular NW–SE strike on a variance slice at 3,200 m, showing less variation in the trace of the interpreted fault.

The throw profile has been mapped following detailed horizon interpretation across the faults to confirm that the Early Cretaceous and overlying fault were formed during separate faulting episodes (Fig. 9). The horizons used for throw analysis on the overlying fault were intra-formational horizons of the Eumeralla Formation and Tertiary succession shown on Figures 7b and c. There is no discernable sediment thickening of these units across this fault.

The overlying fault shows throw magnitudes of over 200 m at its central parts. Throw progressively decreases vertically and laterally to the seismically resolvable fault tips. This throw profile confirms that the overlying fault formed as a distinctly separate fault to the older, underlying Early Cretaceous fault. Hence the interpretation of two separate faults originally recognised on the pseudo-depth section of 7b appears valid.

Recognition and successful distinction of Early Cretaceous faults and Late Cretaceous faults, particularly where differences in strike are less obvious than the example presented in Figures 7, 8 and 9, can easily be omitted from interpretation in time. Interpretation of apparent listric faulting in the well-imaged Tertiary reflections easily can be, and previously have been (Boulton et al. 2002) interpolated down into the less-well-imaged abundant fault offsets in the Early Cretaceous. However, by imaging in pseudo-depth the contrasts in geometry—particularly dip—are more obvious on individual sections (Fig. 7) and allow easier recognition and interpretation of these faults.

**Comparison of pseudo-depth with PSDM depth seismic data**

The use of pseudo-depth converted seismic data as a reliable means of interpreting fault geometry in depth requires validation by comparison with other seismic depth conversion methods. One PSDM depth section from a 2D seismic line over the Penola Prospect was available for direct comparison with a pseudo-depth section. Figure 10a shows the post stack migrated time section with major, apparently listric faults, and two interpreted prominent reflectors. The interpretation of the same, more planar imaged faults, and horizons are displayed on the PSDM depth section (Fig. 10b) and pseudo-depth section (Fig. 10c). In all cases, horizons were autotracked as much as possible to exclude interpretation bias.

Comparison of the pseudo-depth section and PSDM depth section clearly show that the imaging of the structure in both techniques is very similar in terms of absolute depth (Figs 10b, c). The horizons interpreted on all three sections have been overlaid in Figure 10d to demonstrate visually the matching of absolute depth between these images. The pseudo-depth horizons and PSDM depth horizons show excellent correlation, across all the fault blocks. The greatest error is observed on the deeper Top Laira horizon interpretation to the far left of the sections where the pseudo-depth horizon is 85 m below the PSDM depth horizon. Nonetheless, this excellent correlation in terms of absolute depth between shallow horizons and deep horizons does highlight that pseudo-depth sections compare well with PSDM depth sections and are thus reliable for structural interpretation in the Penola Trough.

**Errors and limitations**

A pseudo-depth seismic traverse section through the Redman-1, Katnook-2 and Katnook-3 wells demonstrates the excellent match between formation tops picked from well data and the position of interpreted horizons (Fig. 11). Note that synthetic seismograms show that the actual top of the Pretty Hill Formation as observed in the wells is not characterised by a distinct seismic reflector. This accounts for the consistent mismatch of approximately 150 m between the top Pretty Hill Formation in the well and the interpreted ‘near top’ Pretty Hill horizon on the seismic section.
Figure 7a. Time section (inline 2426) showing an interpretation of a single listric fault. 7b. The same section after pseudo-depth conversion suggesting there are two sub-planar faults rather than a large listric fault. 7c. A pseudo-depth section 1km to west of b) (inline 2376), showing the two faults offset by their differences in strike.
Figure 8. Deep and shallow pseudo-depth variance slices showing the differences in strike between some of the major Early Cretaceous faults and overlying faults. The interpreted Early Cretaceous fault and overlying fault of Fig. 7 are indicated. 8a. Variance slice at 3000m showing the NE-SW trend of the Early Cretaceous Fault with similar trending adjacent faults. 8b. Variance slice at 500m showing the NW-SE strike of the overlying fault. 8c. Syn-sedimentary growth of the Sherbrook Group identified along section X-Y shown in b).
PSEUDO-DEPTH CONVERSION IN THE PENOLA TROUGH, OTWAY BASIN.

The excellent depth match between formation tops and seismic interpreted horizons is due to the lack of lateral velocity variation in the area confirmed by the checkshot data. However, it is important to at least consider the more significant scatter in the time depth relationship calculated from the stacking velocities. This more significant scatter may represent more appreciable variation in lateral velocity beyond well control. For these reasons an assessment was made of the potential error in the absolute depths of reflections on pseudo-depth seismic data across the entire area of seismic coverage, based on the observed scatter in the time-depth data (Fig. 4).

The difference between the predicted pseudo-depth for a particular two-way time—defined by the trend line—and the actual depth of each data point was calculated for each stacking velocity and checkshot derived time-depth data point between 1,500 and 2,500 milliseconds, the principal time range of interest for the reservoir. This allowed the production of a frequency histogram showing the expected normal distribution of potential error based on all the time-depth data for this time interval (Fig. 12). The mean error is -18 m, although the maximum error could be as potentially as great as ± 180 m.

However it is important to recognise that although a maximum error of ± 180 m is possible, this is of negligible significance to prospect analysis of fault geometry and seal potential. Although there may be an error of this size in the absolute depth imaging of seismic reflectors, the error is likely to be consistent over much smaller prospect scales of investigation. Hence the relative error in the depth imaging of fault geometry would be negligible, even though there may be significant error in absolute depth. Furthermore, the error in throw magnitude across the faults, used to calculate fault seal attributes such as shale gouge ratio (Yielding et al. 1997), would also be negligible.

Discussion

The use of pseudo-depth sections, in addition to time sections, has provided valuable insight into the true geometries of faults in the Penola Trough. This is significantly impacting on the interpretation of fault geometry and of structural kinematics in the area. The planar nature of many of the faults that are apparently listric in time is testament to the reliability of the technique in depth imaging of structure. Pseudo-depth horizons can also be reliably tied to formation tops identified in wells. The increased clarity and consistency in interpretation resulting from pseudo-depth imaging has significantly aided 3D correlation of fault segments interpreted on seismic sections.

The identification of significant NE–SW trending syn-sedimentary faults, west of the Katnook Graben, with obliquely trending separate overlying shallower faults (Fig. 9) is a new structural feature identified in this part of the Trough, and its recognition has been aided considerably by pseudo-depth converted seismic data. Smaller scale NE–SW faults have been identified by Chantraprasert et al. (2001) in accommodation zones to the east of this area. They suggest that the location of these accommodation zones is linked to the underlying NE–SW structural trends within the basement. The NE–SW strike of this fault (Fig. 9) and other similar trending faults (Fig. 8a) could also be attributed to a

Figure 9. The distribution of throw on the Early Cretaceous Fault and the overlying fault. Maximum throw on the overlying fault occurs in the central part and gradually diminishes towards the fault tips.
significant basement influence on Early Cretaceous fault geometry.

This structural style, west of the Katnook Graben, is much different to that of the much larger Ladbroke Grove Fault which is a planar fault with a consistent E–W strike and dip of approximately 65° from its base (at greater than 5 km depth) to near surface units (Figs 5, 6, 8). The planar and consistent geometry of this structure from deep to shallow levels suggest that large E–W faults such as these were subject to progressive strain localisation during structural evolution of the Trough (Meyer et al. 2002; Walsh et al. 2003). That is, throughout extensional development of the area, the larger faults become the focus of extensional accommodation whereas minor faults, such as the Early Cretaceous NE–SW trending fault of Figures 7, 8 and 9, became inactive and subsequently ‘overprinted’ with younger NW–SE faults during a Late Cretaceous faulting event.

The continuously active major E–W faults such as the Ladbroke Grove Fault are likely to have experienced a component of strike-slip to extensional displacement suggested by conceptual restoration work (Bierbrauer pers comm. Origin Energy 2004). The interpretation of the Ladbroke Grove fault as a steep dipping planar fault is perhaps more characteristic of a significant component of strike-slip on such faults. Validation of these concepts requires further detailed fault and horizon mapping and consideration of the associated secondary faulting geometries (Schlische et al. 2002).

A detailed understanding of structural geometry and fault evolution through time is of fundamental importance, particularly in areas such as the Penola Trough where fault related seal breach is a key geological risk in prospect analysis. More detailed mapping of prospect-bounding faults using pseudo-depth seismic sections, which give a much better representation of both fault geometry and horizon throw than time seismic, will allow more specific conclusions on fault slip kinematics through time. The interpretation of the likely age of fault slip events, combined with assessments of reactivation potential in the in-situ stress tensor

Figure 10. Comparison of fault and horizon imaging on: 10a. a time section, 10b. PSDM depth section and 10c. a pseudo-depth section, over the Penley prospect (2D line, sr95-02). 10d. Comparison of the absolute depth of interpretation of the two autotracked horizons displayed on the pseudo-depth and PSDM depth section. The depth normalised horizon interpretation made on the time section is also shown for comparison.
vertical scaling is often pre-defined and hard-coded into interpretation of time and depth domain sections. Unfortunately depth scales—would be of considerable benefit to interactive time sections by a normalised scale—that is equivalent time and interpretation. Direct comparison of pseudo-depth sections and time and cost. It is thus a valuable aid to conventional time a seismic survey has been acquired and processed with minimal can be readily applied to large seismic volumes immediately after depth conversion permits this, and is a quick and easy method that of the depth implications of interpretation made in time. Pseudo-formation tops picked in wells showing a reasonable depth matching.

• The lack of significant lateral velocity variation, evident from velocity data obtained from both checkshot data and stacking velocities, has allowed the application of a laterally invariant velocity function to post-stack migrated time seismic data in the Penola Trough, Otway Basin to produce a ‘pseudo-depth’ converted seismic data set.

Conclusions
• Seismic data when scaled to depth can be a better domain in which to view and analyse fault geometry than the time domain.
• The insights into the true geometry of faults, that pseudo-depth seismic data provides, has had significant impact on a new structural interpretation in the area. Early Cretaceous faults and younger Late Cretaceous faults are more clearly distinguishable on pseudo-depth sections, which has in turn led to a clearer understanding of fault kinematics.
• This new pseudo-depth seismic data has shown that many of the apparently listric faults in time are in fact planar in depth.
• Pseudo-depth seismic sections have increased the clarity of fault geometry. This has resulted in greater consistency and precision of fault interpretation, which has greatly aided the 3D correlation of interpreted fault segments.
• The technique can be used in other petroleum provinces where lateral velocity variations are minimal. In areas of more complex velocity variations, this method could easily accommodate a varying velocity function.

Future work
A new interpretation of fault geometry facilitated by pseudo-depth converted seismic data will provide the basis for the assessment of fault-related seal breach in the Penola Trough. Fault geometry will be used as the key input to a systematic assessment of juxtaposition, fault plane processes and fault reactivation of a variety of traps in the Penola Trough (Lyon et al. in press).

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