Time Slicing the Cooper Basin

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SUMMARY

An efficient and practical method of generating composite time slices using all available, non-confidential 3D seismic data recorded in the South Australian sector of the Cooper Basin has been developed. Twenty georeferenced tiff images of time slices between 1000 ms and 2900 ms at 100 ms intervals have been prepared and are intended to be made publicly available through the Department of State Development SARIG website. 2D seismic data has also been used in this project in an attempt to 'fill in' some of the gaps between 3D datasets. Forty eight 3D and 5076 2D seg-y data files were utilised in this project. All 3D and 2D segy files were scaled to normalise amplitude levels for gridding and imaging.

The ability to time slice 3D volumes of seismic seg-y data is a basic method employed in seismic interpretation. This method is usually applied to a single survey as commonly used software packages are not designed to view and analyse multiple 3D surveys at the same time or such functionality is not yet well implemented. For large scale regional interpretation, such constraint limits interpreting potential, especially in terms of basin wide correlation of main structural features.

Whilst the methodology developed in this project retains the quality and resolution inherent in the variety of surveys used, it provides a cost effective method of generating basin wide time slice images, compared to costly reprocessing required in merging of 3D data sets into one 3D volume.

The time slice data suite prepared complements other value-added regional datasets prepared by the Department of State Development to stimulate petroleum exploration in South Australia.

Key words: Cooper Basin, composite time slice, seismic data

INTRODUCTION

The Cooper Basin with the overlying Eromanga Basin is Australia's largest onshore producer of conventional oil and gas. Since 1969 it has produced more than 6.5 Tcf of gas and over 300 MMbbls of oil. It remains an internationally recognised, attractive petroleum province. As well as conventional petroleum targets, the Cooper Basin is an active exploration area for unconventional oil and gas, with tight gas, shale oil and gas and deep CSG. Shale gas has been in production since 2012.

Since 1959, vast amounts of 2D and 3D seismic data have been recorded. The first 3D survey recorded in the Cooper Basin was at Cuttapirrie in 1981. Since then, over 80 3D surveys have been recorded in South Australia. Polygons representing 3D surveys used in the project are shown in Figure 1

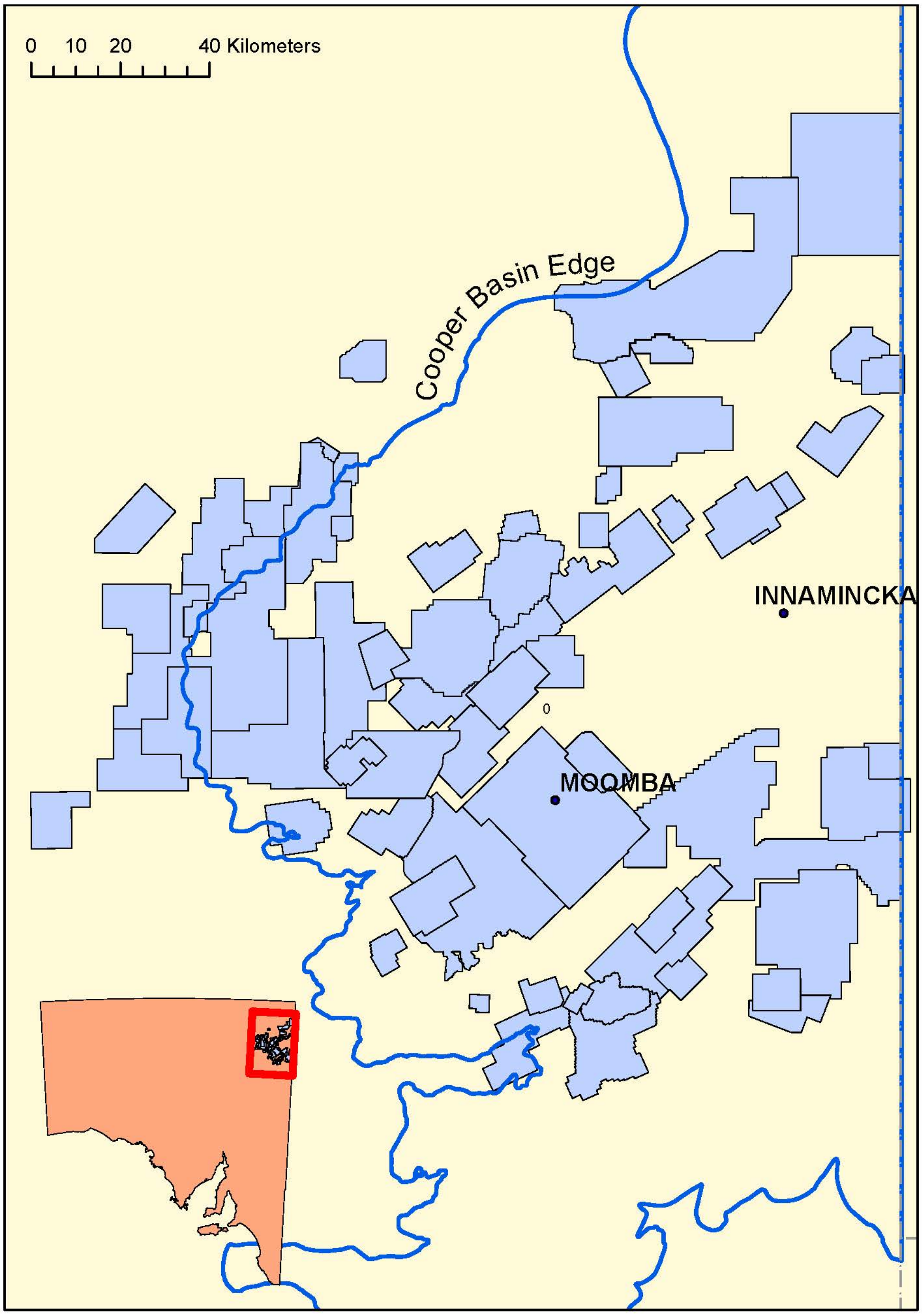

Figure 1. Cooper Basin and location of 3D seismic surveys used in this project.

As part of the South Australian regulatory regime, these data are required to be submitted to the State Government for archiving and potential use for future explorers. The Department of State Development (and former agencies) have utilised these data to stimulate investment in the State, particularly when acreage becomes vacant. As well as providing data as submitted, the Government value-adds to this geotechnical data by preparing regional seismic horizon and isopach maps, other geological maps, consolidated digital datasets and databases. These products have been used substantially by new explorers to the Cooper Basin over the past 18 years, facilitating basin-wide analysis and focusing of exploration interest.

Seismic data is a key data asset and 3D seismic data is particularly valuable, as it offers superior imaging and detail over 2D data interpretation capabilities. One of the key tools available in 3D data interpretation is the ability to intersect seismic volumes using vertical and horizontal planes. Horizontal cross-sections are called time slices and these provide a plan-view image of the seismic volume at a chosen Two Way Time (TWT) level. Time slices are fundamental in interpreting structural setting and lateral variation in sedimentary deposition. The current project utilises this technology over all available 3D volumes acquired in the South Australian portion of the basin to provide another value-added dataset facilitating exploration. Approximately one third (35,000 sq km) of the Cooper Basin lies within South Australia. The 3D seismic coverage within this portion totals almost 18,000 sq km (50%). The recording parameters and processing routines of each survey vary considerably, resulting in a variety of quality of seismic imagery and resolution. The current project did not attempt to mathematically merge all the existing data into one uniform seismic volume, rather, it used existing volumes and extracted time slices from them. Whilst this retains the quality and resolution inherent in the various surveys, it provides a cost effective method of providing time slices across the Basin. It is expected that access to this dataset, along with other value-added datasets and information will be available through the Department's spatial data delivery portal SARIG, as far as practicable.

METHOD AND RESULTS

Due to software constraints in handling large volumes of 3D seismic data, they are almost exclusively analysed on a survey by survey basis. In the Cooper Basin, a number of the 3D surveys partially overlap and explorers have merged the data from several surveys together into new, combined volumes. In large scale regional interpretation the lack of ability to manage vast volumes of data from multiple surveys and analyse these at the same time on one screen seems to be a serious impediment for most players. It is likely that in the future, new software and improved computing capabilities may eliminate this problem. In the meantime, the geophysical team within the Energy Resources Division of the Department of State Development developed the idea of preparing georeferenced tiff images representing composite time slices, generated from various individual 3D seismic volumes, supplemented with 2D seismic data. Although this does not offer the full spectrum of interpreting capabilities it gives geoscientists a basin-wide overview of the structural setting and provides another technique for a better understanding of the sedimentary deposition environment. This is complementary to existing seismic horizon and isopach maps and other geological datasets that the Department has prepared over the South Australian portion of the basin since the mid 1990's.

Data Selection

Due to different approaches in handling 2D and 3D data, the project was divided into 2 stages. The project aim was to incorporate all the 3D surveys recorded in the Cooper Basin, which were open files, as of September 2015. As some of the original 3D surveys had been reprocessed and merged with adjacent volumes by explorers, the total number of seismic 3D seg-y volumes used for the project was 48, compared to the original acquisition of more than 70 surveys.

For the 2D component of the project, 5076 SEGY files were selected. These files represent all available 2D data from the Cooper Basin, recorded between 1975 and 2012. All these seg-y data are available for download and viewing from the departmental SARIG website: https://sarig.pir.sa.gov.au/Map

Data Preparation

One of the main problems encountered during the initial investigation were large differences in amplitude levels between selected seg-y files. A consistent amplitude range for all seismic volumes was needed in order to provide proper data for gridding of each time slice level. For this reason, all samples within each given segy volume were normalised by a scaling factor. Scaling factors were calculated for individual volumes by finding the median value of RMS (Root Mean Square) values from all traces within a particular seg-y volume. This means, that a RMS value for every trace in the seg-y volume was found and then a median value of all these RMS values was chosen as a scaling factor. This process was repeated for every seg-y file.

Data Export, Gridding and Imaging

Sample values representing single time slice at every selected TWT level had to be exported from segy files to ASCII text files for later gridding and imaging. Text files from 3D files were exported individually, but for 2D data all lines were exported to a single file. Specific software was developed in-house for this purpose, which enabled generation of text files for all selected seg-y files for each chosen TWT in one operation.

The methodology used in this project for the preparation of composite time slices from 3D seg-y data can be summarized in the following steps:

1. Select 3D seg-y volumes
2. Scale all selected seg-y volumes to the common amplitude level
3. Extract trace coordinates and sample values related to chosen TWT level from all traces in a seg-y file and output them to ASCII text files.

4. Read grid data from every text file for each TWT level for each volume. No need for gridding, as text files already contain data arranged in grids.
5. Merge all 48 grid files representing one time slice.
6. Edit final grid to remove data generated outside areas of valid data defined by 3D data coverage.
7. Create final georeferenced tiff images representing time slice related to particular TWT.

The procedure described above is applied to every time slice for 3D dataset.
Every text file was used as input data in Petrosys' gridding module. For every chosen time slice level, 48 separate grids were generated from the 3D files. Gridding was not required for 3D data points, as they were already arranged in grids.
All these grids were then merged for a specific TWT level, using a blend option with feathering distance of 300 m. The final output grid was edited in order to remove portions of the grid outside areas covered by 3D surveys. Also holes within original surveys where no data was recorded had to be cut out from the final grid. The final grid was then processed using ER Mapper software to generate a georeferenced tiff image for each TWT level. The composite time slice showing only 3D data is shown in Figure 2.

Time slices were generated at 100 ms intervals between 1000 ms and 2900 ms to provide a practical and useful dataset for time slice presentation. Altogether, 20 separate time slices have been generated.

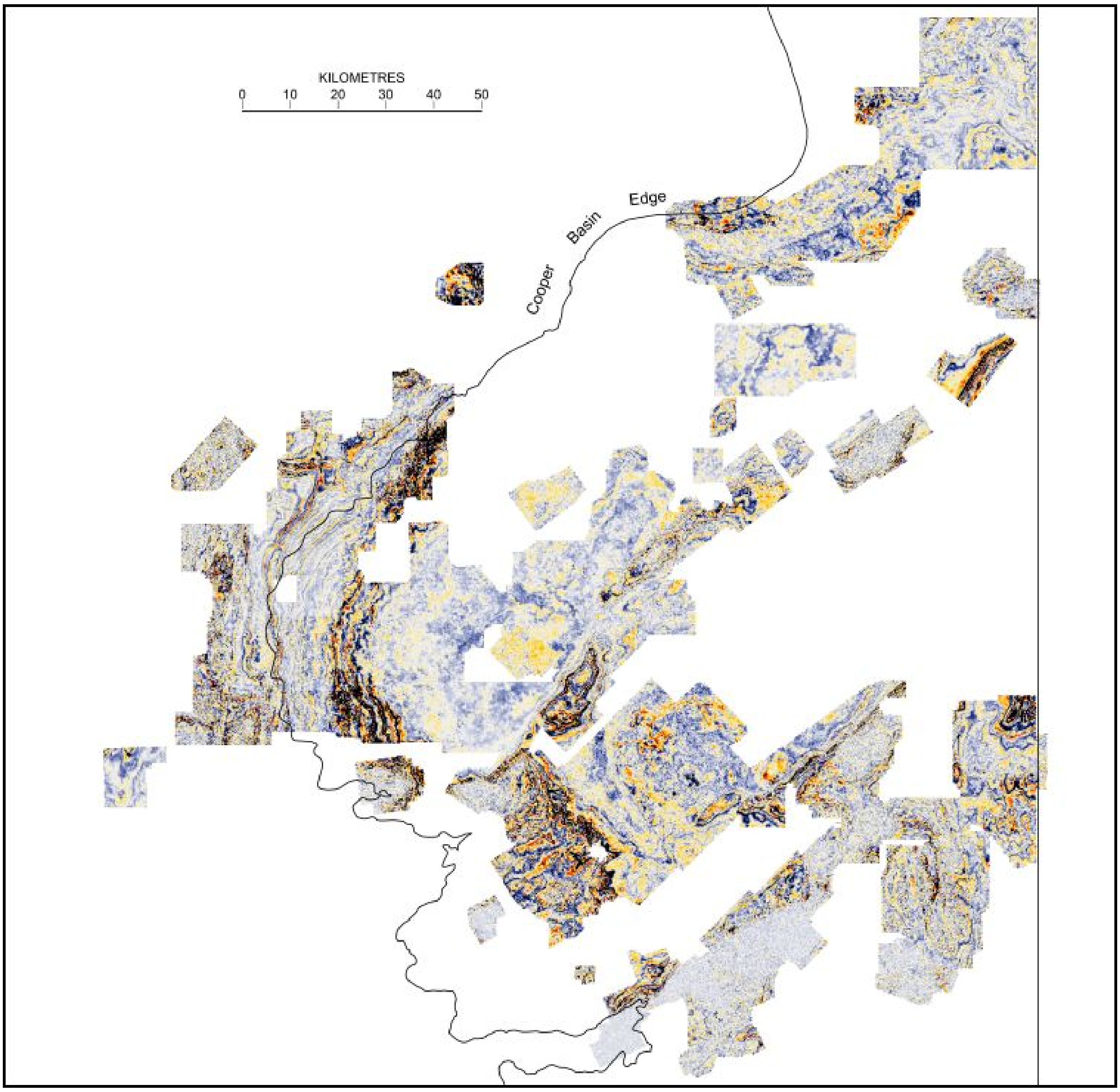

Figure 2 Composite time slice using only 3D data at 1700 ms TWT.

There are large portions of the Cooper Basin, which are not covered by 3D surveys and it was decided to attempt to infill the time slice gaps with 2D seismic data. The concept of presenting 2D lines in time slice form is based on the same principle as for 3D data, which is to show amplitude variation at a certain constant TWT level.

In the case of 2D data, gridding was done using a modified version of QuikGrid software (Coulthard, 2011). After an initial investigation Petrosys was considered not suitable for gridding the large (more than 3 million points) dataset containing all 2D points from the project area. QuikGrid software was found to be reliable and fast. The software and source code is freely available from the web (http://www.galiander.ca/quikgrid/) .The QuikGrid source code was adapted to develop a gridding application capable of handling our data and providing suitable output grids. Final images of 2D data time slices have been created in ER Mapper.

Of course, 2D data is just a line in the time slice view, so in order to make it visible, each 2D line was presented as a stripe of limited width. Although 2D time slices do not provide the same level of detail as 3D data, they nevertheless offer some clues in extending interpretation in areas not covered by 3D seismic. An example of composite time slice with 3D time slice superimposed on top of 2D time slice is shown in Figure 3. As expected the final image does present a range of resolution from 2D data 'strips' to older 3D data sets to more modern and detailed 3D datasets.

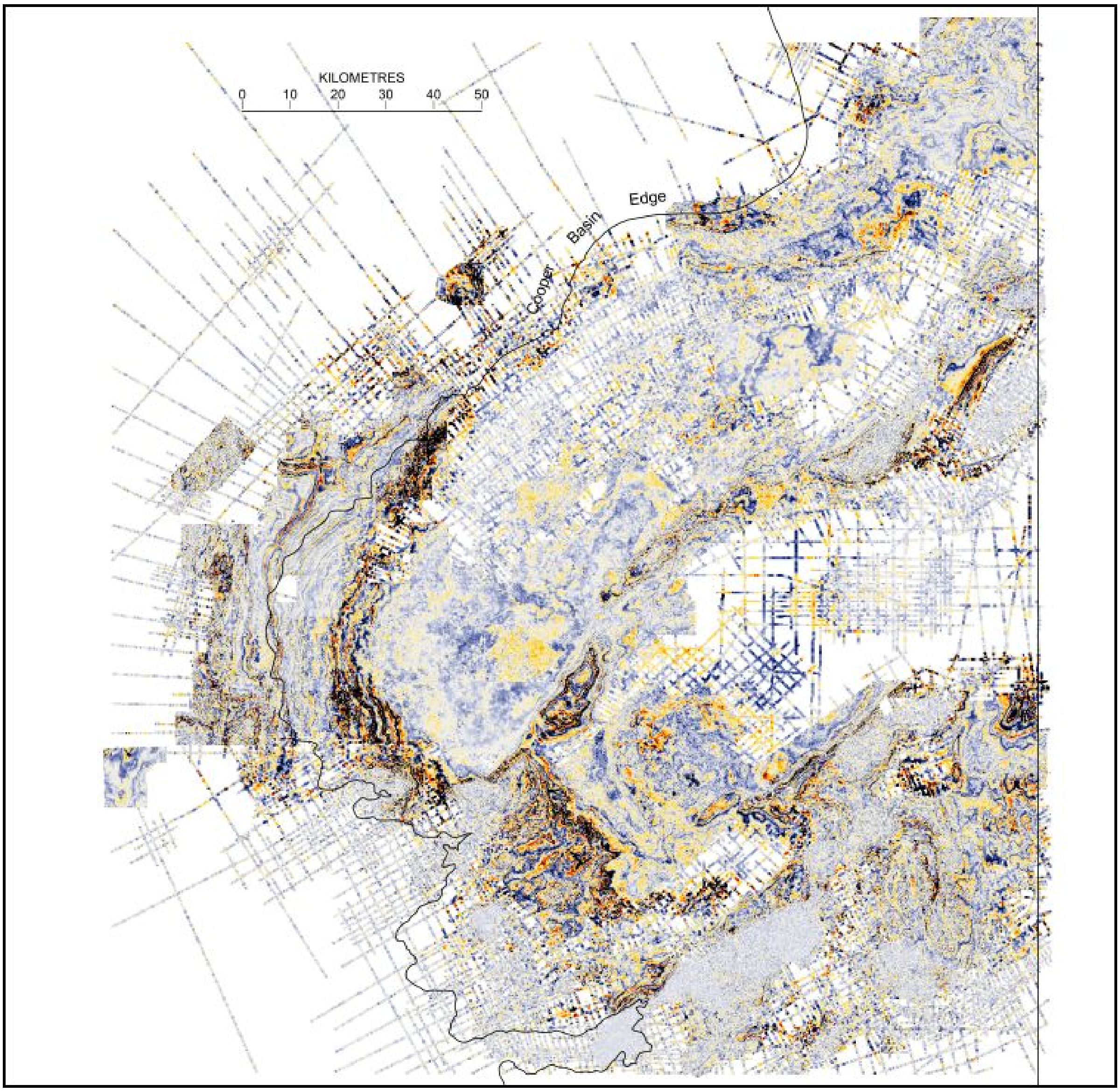

Figure 3. 3D time slice image overlaid on top of 2D time slice image at 1700 ms TWT.

CONCLUSIONS

The Department of State Development continues to utilise geotechnical data to stimulate investment in the State, focusing on practical, innovative and effective ways to reduce uncertainties. The final set of 20 time slice images prepared for the Cooper Basin in this project is now ready and available via the Department or its SARIG website. This data suite complements other value-added regional datasets covering the South Australian portion of the Cooper Basin such as regional seismic horizon and isopach maps, other geological maps, consolidated digital datasets and databases.

The purpose of this project was to create a series of composite time slice images covering the whole South Australian portion of the Cooper Basin. 20 separate time slice images have been created covering TWT (Two Way Time) range from 1000 milliseconds to 2900 milliseconds with 100 milliseconds interval between subsequent images. Composite time slices provide geoscientists with basin wide overview of structural setting and gives basis for a better understanding of the sedimentary deposition environment. The project developed a practical and efficient method of generating composite time slices from a large volume of data covering a large part of the Cooper Basin. All available open file seismic data from South Australian portion of the basin was utilized in the project.

Of the more than 80 3D seismic surveys recorded in the SA Cooper Basin, explorers have already combined a number of partially overlapping surveys into larger processed seismic SEG-Y volumes. This has broadened the extent of individual survey areas significantly, but not to the extent of basin-wide view ability. Several current Cooper Basin explorers have utilised this merging of seismic data to larger volumes in wider analysis of parts of the Cooper Basin, such as the Western Flank, a very productive oil province of the Basin. However, this project is the first to attempt to prepare Basin wide time slice coverage.

Although time slices from 2D data do not provide the same level of detail like 3D data, they nevertheless offer some clues in extending interpretation in areas not covered by 3D seismic. Final time slices obviously suffer from data inconsistencies and poor data quality in some areas. Misties between surveys and lines can be observed in many places and any potential user should be aware of it. In order to make final images more appealing feathering of 300 meters was used in merging of grids. This smoothed misties between some of 3D surveys, however original unsmoothed grids remain available if required.

The existing 3D seismic coverage of the basin is far from complete. Whilst there is reasonable overlapping of surveys in some areas to enable digital processing to merge the field data into 3D SEG-Y volumes, there are some portions of the basin without any 3D seismic coverage and smaller gaps between others that either preclude preparation of gridded time slices or degrade the time slice image through extrapolation/interpolation. 3D seismic surveys are recorded by explorers as time, focus, licences and funding allows. Hence there is always a tradeoff in coverage versus quality versus cost, and niceties such as consideration of future basin-wide compilations of data are generally not often on the radar as programs are undertaken.

The preparation of megasurvey seismic data volumes from either existing or new acquisition of data provides the ideal seismic dataset for imaging of basin-wide scale subsurface geology. This is commonly done offshore in prospective regions, such as the North West Shelf, usually by contractors on a non-exclusive basis. However, such processing of field data or acquisition of new data is expensive and requires substantive industry support to make such projects viable. The work done in this project does not require such expenditure and the time slices produced do have inherent gaps from past surveys. However, the project has delivered a composite suite of images that aims to assist analysis of the Cooper Basin, complementary to more detailed analysis of prospect scale volumes and broader scale review of wider spaced data, such as 2D seismic and wells.

It is not the intent of this paper to undertake such analysis, but rather, promote the methodology and an alternate and cost effective exploration tool. Our intention is to make images of time slices available through our departmental SARIG website, where they can be used in conjunction with other mapping products and datasets.

The set of final images and grids prepared to date is not a finished product. New data is coming in and this can be utilised to update the time slices in the future. Improvements can also be made in our procedure, especially in data preparation and final display presentation. Application of filtering and mistie adjustments (time and phase shifting) should improve data consistency across different surveys and hence provide better outcome.

REFERENCES

Coulthard, J., 2011, QuikGrid - 3D rendering of a surface represented by scattered data points: http://www.galiander.ca/quikgrid/ , viewed on 25 February 2016