Breathing New Life into the Gippsland Basin

Nigel Mudge, CGG, Australia, discusses how a new reprocessing project offers unique exploration opportunities.

The Gippsland Basin in south-eastern Australia is located approximately 200 km east of the city of Melbourne, and remains one of Australia's most prolific oil and gas provinces. The major fields were discovered in the early 1960s, using images from a coarse 20 km (12 mile) grid of 2D seismic data commissioned by BHP, then a steel and mining company. Ever since, the region has seen limited 2D and 3D seismic coverage. There are still extensive areas where no 3D surveys have yet been acquired. Where they do exist, they are not recent, with an average age of 15 years.

While many may see the Gippsland Basin as a mature area, the province remains significantly underexplored. Unlike other mature basins, production in this area shows an immature creaming

curve, with no kicks due to the usual 'step-change' events such as the application of 3D seismic or exploration of the deep water. This is because there was historically no interest in further exploration after the major fields had been discovered.

With infrastructure already in place, CGG wanted to know if there was more to be discovered by reprocessing existing data sets with the latest high-end technologies and whether the possible uplift could be demonstrated, especially where key elements of the imaging remained difficult to de-risk. Additionally, it was hoped that key areas could be identified in order to improve survey design (cable length, orientation, broadband, sampling regime, etc.) for future seismic data acquisition.

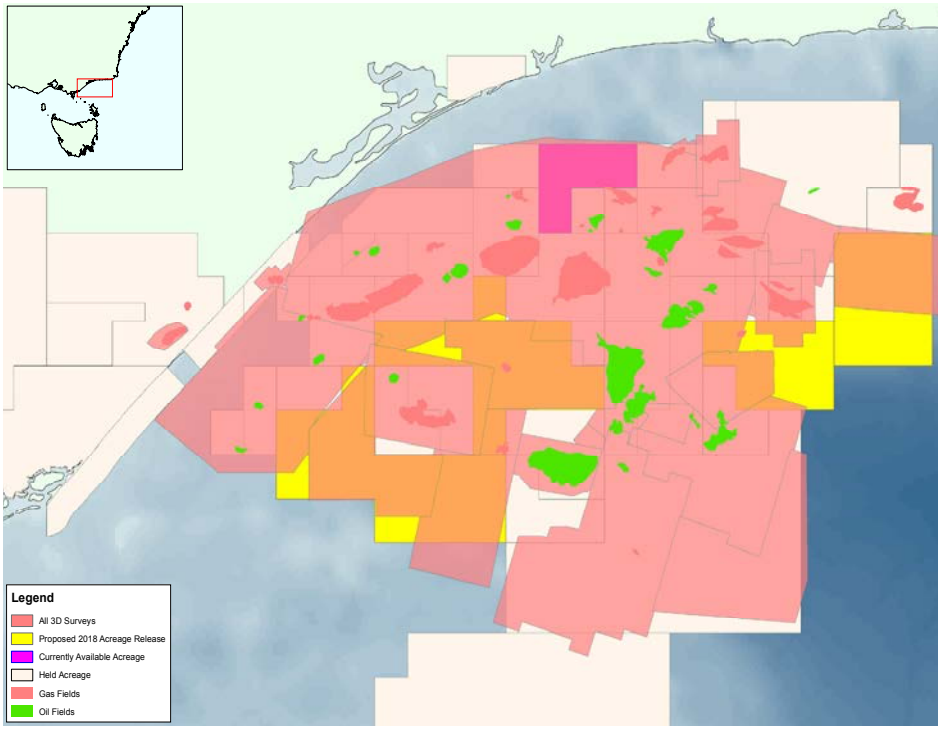

Figure 1. *Map of 3D seismic surveys in the Gippsland Basin that will contribute to CGG's Gippsland ReGeneration reprocessing project. Image courtesy of CGG Multi-Client & New Ventures.*

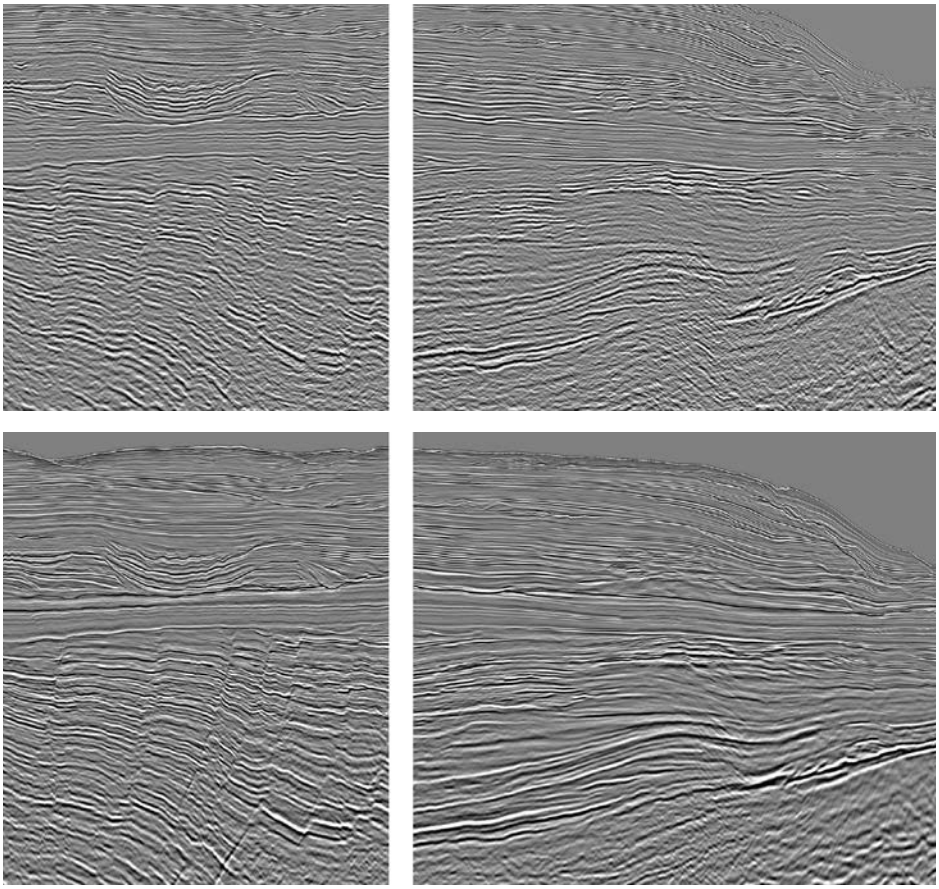

Figure 2. *Example showing data reprocessing uplift. The displays are a crossline (top left) and inline (top right) of the legacy data. New reprocessing crossline (bottom left) and inline (bottom right) show significant improvement in many areas. Image courtesy of CGG Multi-Client & New Ventures.*

CCG has conducted data processing in the Gippsland Basin for many years, the most recent significant programme being performed during 2009 - 2014 using the most up-to-date tools and algorithms available at the time. However, the recent evolution of broadband data acquisition and imaging has led to a step-change in processing algorithms. This evolution enables the application of new bandwidth-enhancing techniques on older data in order to significantly improve image quality.

One area in particular that has historically proved challenging to image is the shelf break, where oil companies, both major and independent, have taken acreage and performed acquisition, processing, reprocessing and test drilling campaigns, with little success. Mis-ties of seismic-to-well markers of over 180 m have been observed with little correlation between subsurface geology and seismic imaging. Acreage in this shelf break area has been taken up and relinquished many times.

Geography

These imaging challenges can be characterised by two distinct but linked geographical areas, driven by the geology and seafloor topography.

Firstly, the north-western platform area lies in water depths of less than 200 m. This area has a characteristically hard seabed, causing extensive multiple generation and data contamination with mode conversions and other high levels of coherent energy. This, in combination with shallow high-velocity carbonate channels and highly absorbing and scattering coal reflectors, made obtaining a good seismic image a challenging exercise. Previous processing in this area has generally been focused on the most obvious top latrobe (principal target horizon) structures.

Further east in the basin, a very rugose seabed shelf-break area combined with complex velocity

variations, associated again with high-velocity carbonate channels, causes intense structural imaging issues and large historical mis-ties between seismic and well data. In addition, no previous direct hydrocarbon indicator (DHI) techniques such as amplitude versus offset (AVO) studies have been possible. Complex raypaths have not enabled sufficiently reliable imaging to allow such analysis to be performed up to now, as remnant multiples contaminated near offsets and residual coherent noise dominated far traces.

Reprocessing the data

With recent advances in data processing techniques and algorithms, the aforementioned areas have been identified as prime examples of where advanced technologies and approaches could make a fundamental difference. Working under a multi-client business model, CGG has been able to combine the large amount of public-domain historical knowledge of the basin with its own processing experience and expertise in the region to capitalise on recent advances in data processing.

CGG Multi-Client & New Ventures (MCNV) began the Gippsland ReGeneration project by analysing and reprocessing a small test area over the block VIC/P70 in late 2016. The results of this indicated the uplift that could be expected from a larger 3D reprocessing effort. A fully funded pilot area of 450 km² was selected as a final proof-of-concept and the data delivered in Q4 2017.

Following this, the reprocessing of additional data sets was initiated. Six major 3D surveys totaling over 8000 km² were selected as the primary areas of focus and as being key to providing a regional image of the uplifts obtained from reprocessing. More data has since been added to extend the product (Figure 1), and further surveys will be incorporated until eventually all 3D surveys in the area (~15 000 km²) have been reprocessed. This reprocessing is revealing new potential deep-reservoir targets and extensively improving understanding of the basin.

Both CGG's Perth and Singapore subsurface imaging centers are investing significant time and effort into delivering this basin-wide reprocessing product. By selecting suitable surveys and using all available data overlaps, imaging issues relating to the presence of azimuthal anisotropy in the velocity model building can be resolved. Overlapping surveys also provide additional subsurface coverage to maximise illumination of the targets.

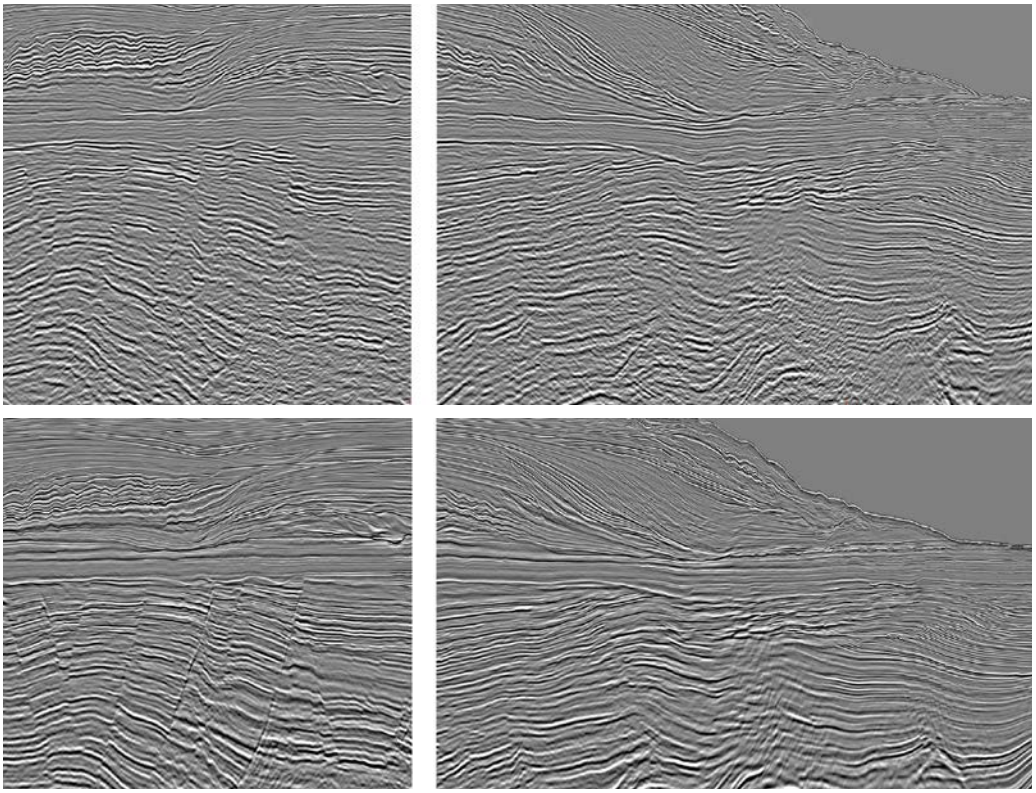

Figure 3. *Another example showing data reprocessing uplift. The displays are a crossline (top left) and inline (top right) of the legacy data. New reprocessing crossline (bottom left) and inline (bottom right). Image courtesy of CGG Multi-Client & New Ventures.*

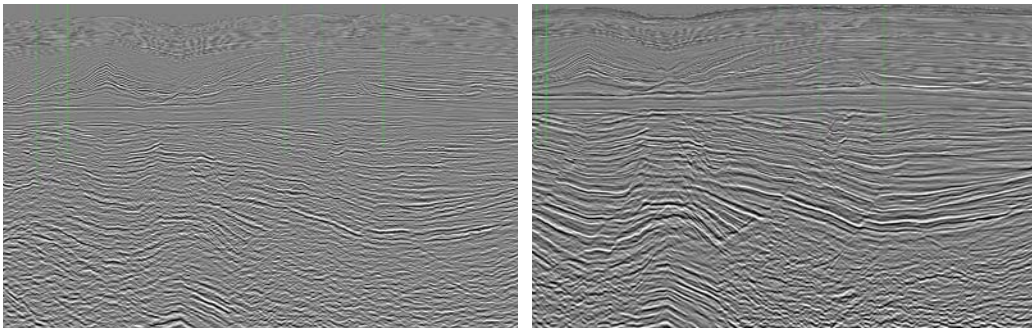

Figure 4. *Random line through various wells. Legacy processing (left). New reprocessing (right). Well ties are considerably improved with the new reprocessing. Images courtesy of CGG Multi-Client & New Ventures.*

Overcoming imaging challenges

The regeneration of this basin via data reprocessing can be categorised into a few key steps, each helping to unlock the imaging in the basin:

- Broadband data processing: joint source and receiver deghosting with designature extend the bandwidth to both high and low frequencies to deliver a step-change in resolution.
- Sophisticated noise attenuation improves the signal-noise ratio for clearer images.
- Advanced demultiple algorithms and their application and combination clarify structures and reduce confusion.
- Hybrid FWI/tomography including anisotropy for

improved velocity model building.

- Advanced imaging algorithms, such as Q Least-squares Kirchhoff depth migration that compensates for absorption losses and illumination effects, deliver improved fault definition and deep structural imaging while mitigating artifacts and noise.

The imaging improvements delivered by the combination of these elements are clearly demonstrated in Figures 2 - 4, which show improved seismic resolution and fault imaging compared to the legacy data. The data has broader frequency content, reduced levels of coherent and scattered noise and subsequent improvements in signal-to-noise ratio. Non-geological undulations in the structure are reduced, and deeper fault plane imaging significantly enhanced. As a result, relative amplitudes are better preserved, which along with correct ray-pathing from PSDM imaging, allow AVO analysis and enhanced confidence in any DHI's seen. With advanced demultiple techniques and modelling of complex amplitude absorption features, the data areas on the north-western platform are now showing mappable structural features below the strong coal reflectors. This deeper view is new to the basin and will encourage existing acreage holders to consider further production from previously only suspected deeper targets.

The Gippsland ReGeneration project has led to the delivery of a high-quality reprocessing product that is coming to market and a licensee has already taken its first new acreage in the basin in a decade, on the strength of preliminary results from this newly reprocessed data.

Furthermore, the Australian Government recently published its proposed 2018 offshore petroleum acreage release areas for the Gippsland Basin. Several of the 2018 bid blocks are now covered by our high-end reprocessing, which will improve understanding of the area and help the industry rejuvenate this basin. In addition, a projected shortfall in Australia's East Coast gas supplies caused by export commitments from newly online LNG plants (in other parts of the vast Australian continent) makes positive prospectivity insights into this established basin even more timely. By delivering a basin-wide reprocessing product, covering held and open acreage, we are shedding new light onto the remaining potential of this prolific basin. There has previously never been a consistent, let alone high-quality, basin-wide data set to allow a full understanding of the basin model, petroleum system, missed potential and new plays. Final products for the first phase of 8000 km² will be released in mid-2018 and will overcome the known imaging issues, enabling the industry to breathe new life into this basin.

Conclusion

Enhanced data sets will also bring new information to guide any future acquisition work. For example, in previously misunderstood and ignored acreage for which no 3D surveys yet exist, new seismic acquisition could potentially reveal significant attractive drilling targets, close to the existing infrastructure and market. Even where 3D surveys do exist, there is potential for modern seismic surveys combined with advanced imaging to deliver improved images, as, unlike the north-west shelf of Australia, there has been no broadband acquisition nor use of cables longer than 6 km, nor nodes. New data could also be acquired and processed in conjunction with existing surveys to provide multi-azimuth coverage to improve illumination and significantly reduce exploration and development uncertainty.

The Gippsland ReGeneration project is delivering a new platform for revitalising hydrocarbon production in this important region, potentially filling the significant projected gap in gas supplies, both by increasing the performance of existing fields and through the discovery and development of new opportunities.