Georgina Basin 3D Geological Model

Supplementary model building method report

CSIRO

Data gathering and compilation

The 3D geological model build was an ambitious component of the Stage 2 project. The Southern Georgina Basin comprises a very large greenfields exploration area, more than 70 000 km^2 in extent, with extremely limited and patchy geological data upon which to base the 3D geological model. To optimise the quality and detail of the final model, a range of existing datasets were compiled and a number of new datasets and derivative data types were generated.

- The NTGS solid geology map for the Southern Georgina Basin was imported and spatially registered in GoCAD and used as the initial control for all further data integration.
- Existing drill hole logs (for historical hydrocarbon exploration holes) were sourced from the NTGS and provided to CSIRO by Bruce Groenewald. Most of these logs were in paper format only, some were poorly or incorrectly located (a NTGS data error) which made incorporation into the 3D model a very time consuming task requiring intensive quality control checking and numerous revisions as more data became available at various times during the modelling process.
- Drill holes that were logged (overview logs) and photographed by Yanhua Zhang, Bruce Groenewald and Warren Potma, on two separate field trips, were used to constrain the stratigraphic columns and provide distinguishing lithological and rheological properties which were used as the basis for grouping/splitting units prior to building the 3D geological model.
- These drill hole logs were combined with existing logs to constrain the conversion and interpretation of the various seismic lines and potential field datasets (including the derivative worm data). The 3D model provides the integrated down hole lithology groupings in spatially referenced digital format.
- A significant amount of data and pre-existing interpretations were sourced from the SEEBASE report (SRK) and the NTGS report entitled Geology and resource potential of the southern Georgina Basin". Many of the derivative products provided in the SEEBASE report had significant spatial location errors, with products such as the depth to basement DTM not being internally consistent with either the drill hole logs or the seismic data. There were also numerous drill hole location errors in the NTGS data. These errors had to be deciphered and corrected before any of this data could be incorporated into the new model.
- The NTGS 400m line-spaced aeromagnetic dataset was reprocessed by Mincor's consultants and provided as a total magnetic intensity (reduced to pole) ER Mapper grid which CSIRO used to calculate the WORMS, which were imported directly into GoCAD to help constrain the location and dip of major structures within the 3D model. The worms were also provided to Barry Murphy to generate his derivative interpretation products (which are described in detail in a separate report, and were also integrated into the 3D model). A workshop was held where Barry Murphy's interpretations as well as the seismic and raw WORMS were interrogated to decide which faults were significant enough to be included in the regional 3D geological model.
- Mincor also undertook a major detailed gravity survey on a 2 km square grid over their tenement packages, with infill to the existing Arunta survey conducted to the south by the NTGS so that the two detailed surveys could be stitched together seamlessly. This provided an excellent dataset for the calculation of the gravity WORMS, which were also incorporated directly into the 3D model, with further detailed interpretation and derivative products provided by Barry Murphy for integration into the 3D model.
- The historic seismic lines proved very difficult to obtain from the NTGS. Initially only 3-4 lines were available from the NTGS (sourced by Bruce Groenewald) and these were only available in paper format and PDF as two-way time images, and reliable spatial co-ordinates for the line end points were also not available (initially). Without depth converted images or

constraining petrophysical data it was nearly impossible to incorporate and use this data in the 3D model. It took approximately 8-10 weeks before the majority of seismic lines were sourced from the NTGS, and the X,Y corner points of the lines were known with any certainty, however the Z (vertical) spatial control was still a problem. Eventually several of the seismic line datasets were provided in digital SegY format, in which, while the resolution of the data was not as good as the PDF's, the location data was better. It took a further week of QC and data integration before the seismic line data were confidently co-located with the drill hole and other geological datasets in 3D. Once this was done a decision was made (with Mincor) to use the drill holes to manually constrain the two-way time to depth conversion of the seismic data, rather than go to the time and expense of reprocessing the original seismic data, assuming the original data could ever be located. It must be noted that while this manual stretching (and double checking via approximating the (unknown) petrophysical properties of the units is reasonably accurate it lacks the precision of reprocessing the original data, thus accuracy errors of +/- tens of metres on the scale of the seismic sections are to be expected. For the sake of this model however, this error was deemed to be acceptable to Mincor.

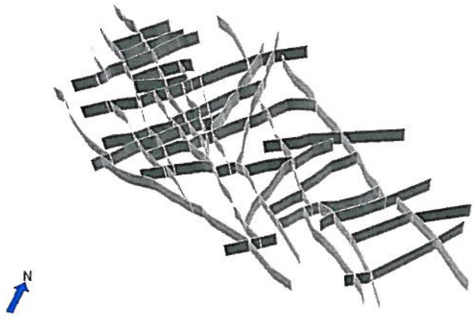
- Throughout the data compilation phase described above, Bruce Groenewald was compiling a series of cross sections through the southern Georgina Basin utilising the drill hole data and SEEBASE surfaces as a starting-point from which to refine a series of more detailed 2D geological interpretations. These cross sections also formed a critical input into the 3D geological model build and were the basis for resolving some of the 3D geological interpretation issues that arise when generating a 3D geological model for a very large region with sparse data.

Building the 3D geological Model

All of the available data was imported into and spatially registered in GoCAD (a 3D geological modelling and GIS package). Regular meetings and workshops (every week or two) were held at CSIRO with Bruce Groenewald and other representatives of Mincor throughout the data compilation, importing and interpretation process.

- Where the data was available in digital format it was directly imported into GoCAD (with some requirement for grid conversions etc).
- Some drill hole data required conversion from paper logs to digital format (completed by CSIRO), and most needed significant spatial QC before it could be used reliably.
- The SEEBASE datasets (including the flawed depth to basement model) were imported into GoCAD and required significant and ongoing debugging and modification before these could be used in the final 3D geological model.
- The magnetic and gravity WORMS were imported directly into GoCAD and used to interpret the location and dip/dip direction of major faults
- The various seismic line data were imported as spatially registered PDF's as they became available, and once constrained (see notes above), were manually located and stretched to approximate the depth conversion from 2-way time. The seismic lines were interpreted, in 3D, constrained by drill hole logs and informed by the WORM interpretations as well as the Mincor cross section interpretations (which were also imported and registered in GoCAD once they were complete).
- Barry Murphy's derivative WORM products and interpretations were used (in conjunction with other datasets) to interpret and rank the most important structures, and to decide which structures should be included in the 3D geological model.
- The 3D fault architecture was constructed first. This provided a framework upon which the stratigraphic variations could be interpreted using 3D Geomodeller software. This software enables geological surfaces (such as lithological contacts) to be automatically modelled

based on a set of geological rules, and subsequently reiterated rapidly as new data becomes available. This software, and model building methodology, significantly reduces the 3D geological model building time and allows for rapid automatic revision of the geological model when new data becomes available, rather than the traditional manual rebuilding of models which often takes as long to complete as the original model build.



- The subsequent 3D stratigraphic contact surfaces were then exported back to GoCAD where the surface intersections were cleaned up and the final model with all supporting data was delivered.
- The 3D geological model was also provided as a 3D PDF, and all model surfaces were provided separately in DXF format to enable them to be easily imported into other 3D modelling packages as required by the client

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