3D Mapping of NSW Project: Sydney–Gunnedah Basin

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SUMMARY

The Geological Survey of NSW (GSNSW) has created a 3D geological model of the Sydney–Gunnedah Basin that includes best available geological mapping and new 3D modelling.

The onshore Sydney Basin comprises the southern section of the Permo-Triassic Sydney–Gunnedah–Bowen system, which overlies the Lachlan Orogen and Late Carboniferous volcaniclastic rocks. The Hunter–Bowen Orogeny formed the adjacent New England Orogen and resulted in uplift and erosion that deposited Jurassic sedimentary sequences of the Surat Basin over large parts of the Gunnedah Basin.

Model generation followed GSNSW's map development workflow, developed as part of the larger project: 3D Mapping of NSW.

The integrated Sydney–Gunnedah Basin 3D model was developed with the aim of advancing the understanding of the geological and structural setting of the region. This will inform areas of investigation such as coal and hydrocarbon prospectivity, groundwater management and exploration, and environmental and land use decision making.

Key words: Sydney, Gunnedah, NSW, seamless, 3D.

INTRODUCTION

The Geological Survey of NSW (GSNSW) is using its geological databases to create a digital Seamless Geology Map of NSW. This is integrated with subsurface information such as drillhole logs and seismic data to generate 3D models in areas of geological interest. A statewide depth-to-basement model, with consolidated and unconsolidated cover, has been completed and provides a framework for more detailed models of specific basins and orogens (Figure 1). The Sydney–Gunnedah Basin model includes best available geological mapping from the NSW Seamless Geology Project (Figure 2) and new 3D modelling (Figure 3).

The onshore Sydney Basin comprises the southern section of the Permo-Triassic Sydney–Gunnedah–Bowen system. This basin system initiated in a back-arc extensional setting during the Permian, and was followed by thermal subsidence and subsequent foreland basin down-warping. The onshore Sydney Basin contains up to 6000 m of Permo-Triassic clastic sedimentary rocks and overlies the Lachlan Orogen and Late Carboniferous volcaniclastic rocks. To the north of the Liverpool Ranges, the Gunnedah Basin extends the basin system, containing alluvial and deltaic sequences. The Hunter–Bowen Orogeny formed the adjacent New England Orogen and resulted in uplift and erosion that deposited Jurassic sedimentary sequences of the Surat Basin over large parts of the Gunnedah Basin.

The purpose of this model of the Sydney–Gunnedah Basin was to produce a foundation for exploration of the basin. This model was generated as part of a work programme to create a statewide unified geological model, using the NSW 3D geological framework and seamless geology (Colquhoun *et al*. 2015), which provides an internally consistent database of best available surface mapping data. The model consists of major lithological surfaces representing stratigraphic boundaries (pre-Permian Basement, Permian and Triassic) and regional faults that exert major control over the regional architecture.

Using the base model established by the statewide depth-to-basement model (Figure 1), the aim of the 3D geological model for the Sydney–Gunnedah Basin was to provide insights into the sub-surface geology of the region and add detail to the consolidated cover volume, while updating the basement in the modelled area. Also, it aimed to highlight regional and basin-scale features, and to understand the geometry of geological structures under cover and stratigraphic evolution of major formations in areas with limited information, delivering a geological framework for future detailed modelling as new data becomes available. An important outcome was the validation of interpretations and correlations from the seamless geology (Phillips *et al*. in review) and seismic reflection profiles, so that the structural–stratigraphic relationships remain consistent. This led to a better understanding of the lateral heterogeneity in depositional environments and formation thicknesses across the different regions of the Sydney–Gunnedah Basin, and recognised gaps in our understanding of the regional scale structural–stratigraphic architecture of the Basin.

Table 1: Correlative/equivalent surfaces between the Sydney and Gunnedah basin models.

Sydney Basin surfaces/tops	Gunnedah Basin surfaces/tops
Wianamatta Group	Napperby Formation
Hawkesbury Sandstone	Digby Formation
Triassic-Permian Boundary	Black Jack Group
Singleton/Nea Correlatives	Clare Sandstone
Singleton/Black Jack Correlatives	Hoskissons Coal Seam
Maitland/Millie Group	Watermark Formation
Greta/Bellata Group	Porcupine Formation
Pebbley Beach/Rutherford Formation	Maules Creek Formation
Basement	Boggabri Volcanics/Werrie Basalt/Metasediments

METHOD AND RESULTS

Model generation followed our map development workflow (Robinson 2016), as part of the larger project: 3D Mapping of NSW. Constraining data sets include the seamless geology, 235 petroleum wells, >20,000 coal boreholes and SRTM topography data. Nine surfaces were modelled (Table 1) in each basin separately and joined in SKUA for final output. Paradigm®'s SKUA and ARANZ Geo's Leapfrog Geo were used to model the Sydney and Gunnedah regions separately, with a final model collated in SKUA.

The Sydney Basin SKUA model has a surface resolution of 1 km and was generated with SKUA's structure and stratigraphy workflow. Surfaces were snapped to petroleum well and seamless geology but not to interpreted horizon and fault data, nor to inputs from other studies.

The Gunnedah Basin Leapfrog model has a 1 km adaptive mesh resolution and was produced with the geological model process. Surfaces were snapped to petroleum well and seamless geology but not to interpreted horizon and fault data. Final output surfaces were produced from the tops of output volumes to ensure correct stratigraphic relationships.

CONCLUSIONS

The Sydney–Gunnedah Basin model delivered by this project has a strike length of ca. 700 km, a maximum width of ca. 320 km and extends to a maximum depth of ca. 15 km. The basin is bound by the crustal scale Hunter–Mooki fault to the east and Lachlan Fold Belt (or Orogen) to the west. Having been compressed in the basin's early stages, sediment-folding events are generally light and the trend of fold axes is generally SSE–NNW. The detailed examination of stratigraphic relationships during modelling has allowed recognition of the major transgression and regression events.

A previous version of the model was produced internally for the Office of Water and comprises the Sydney catchment area. The Sydney Catchment 3D Model has been demonstrated to be an effective tool for assessment of environmental factors, and assisted in the assessment and management of water resources.

The integrated Sydney–Gunnedah Basin 3D model was developed with the aim of advancing the understanding of the geological and structural setting of the region. More specifically, the model highlights the distinct changes in sea levels and depositional environments, alongside the structural architecture and fault movements that will inform areas of investigation such as coal and hydrocarbon prospectivity, groundwater management and exploration, as well as environmental and land-use decision making.

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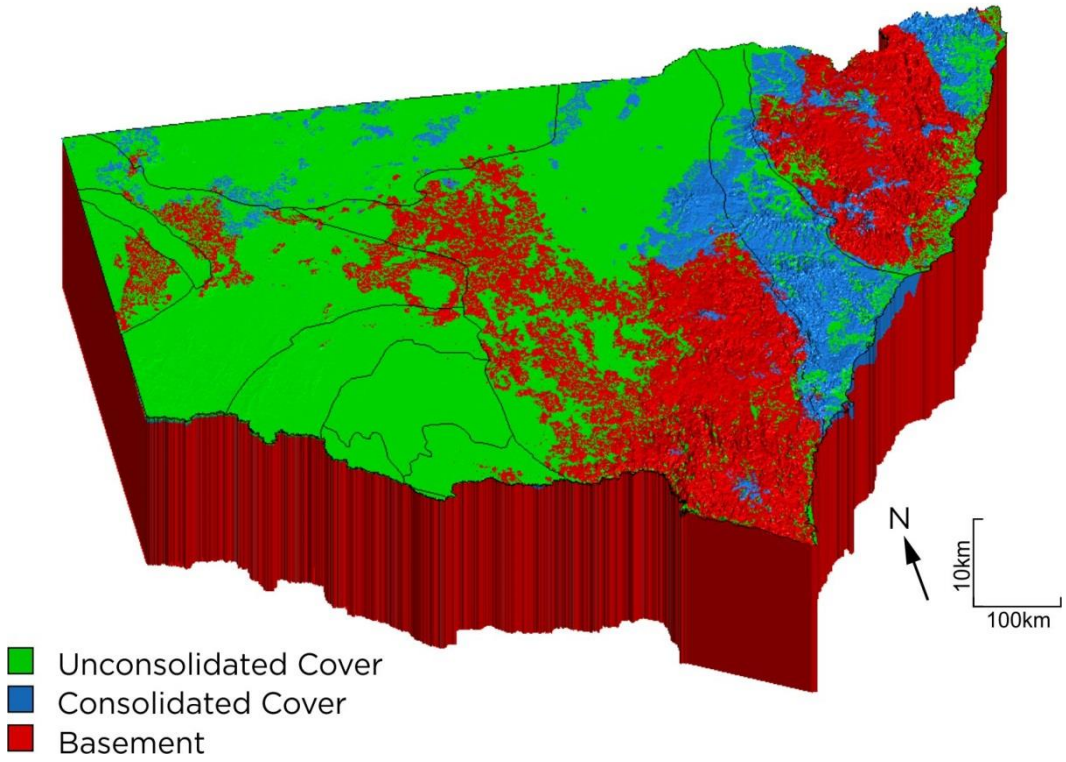

Figure 1: Statewide depth-to-basement model (basement = red, consolidated cover = blue, unconsolidated cover = green) (Robinson 2017).

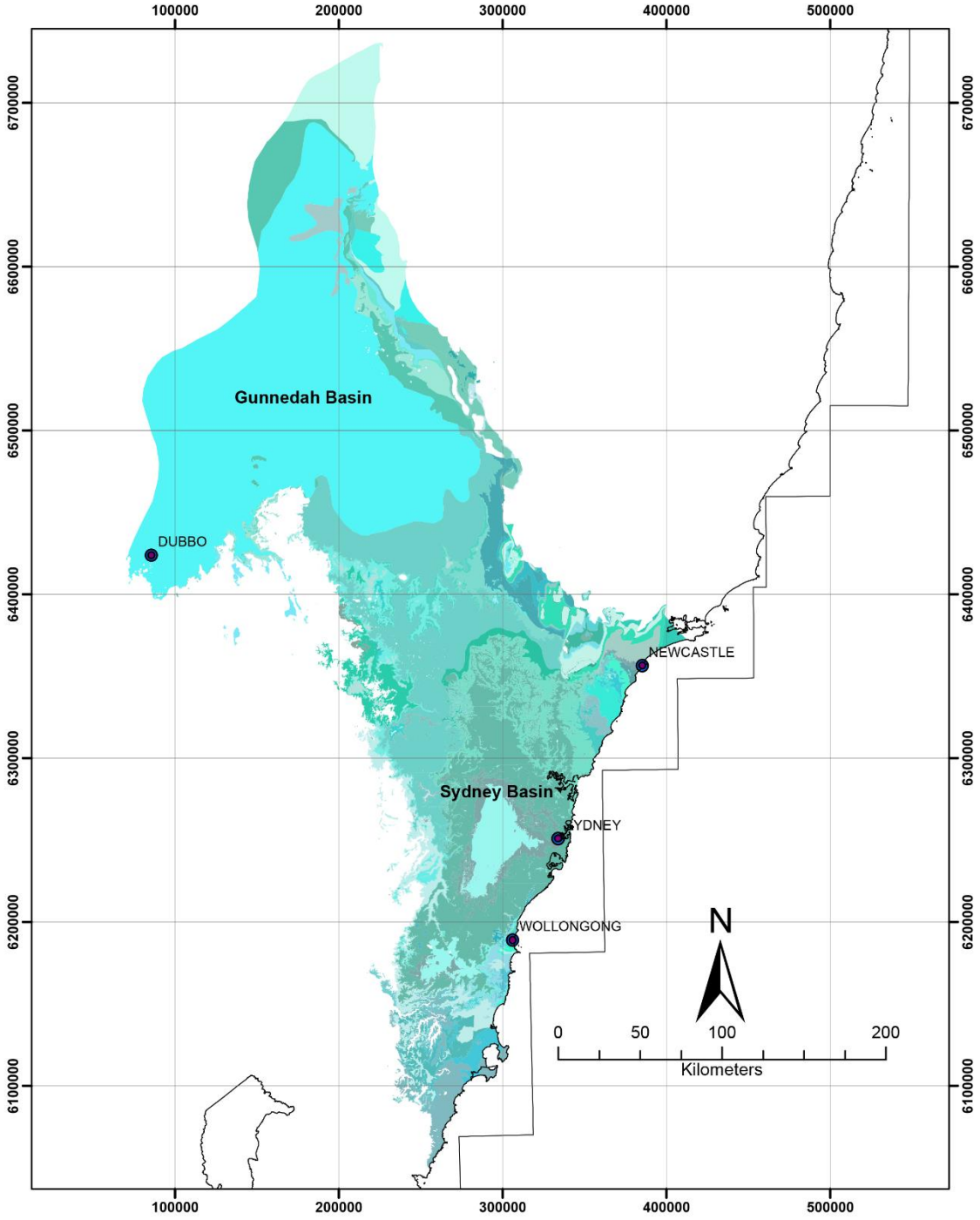

Figure 2: Location and extent of the Sydney–Gunnedah Basin 3D Geological Model. The map is an extract of the GSNSW Seamless Geology Zone 56 map (Colquhoun *et al*. 2015) with overlying cover removed. The 3D model is directly based on this map.

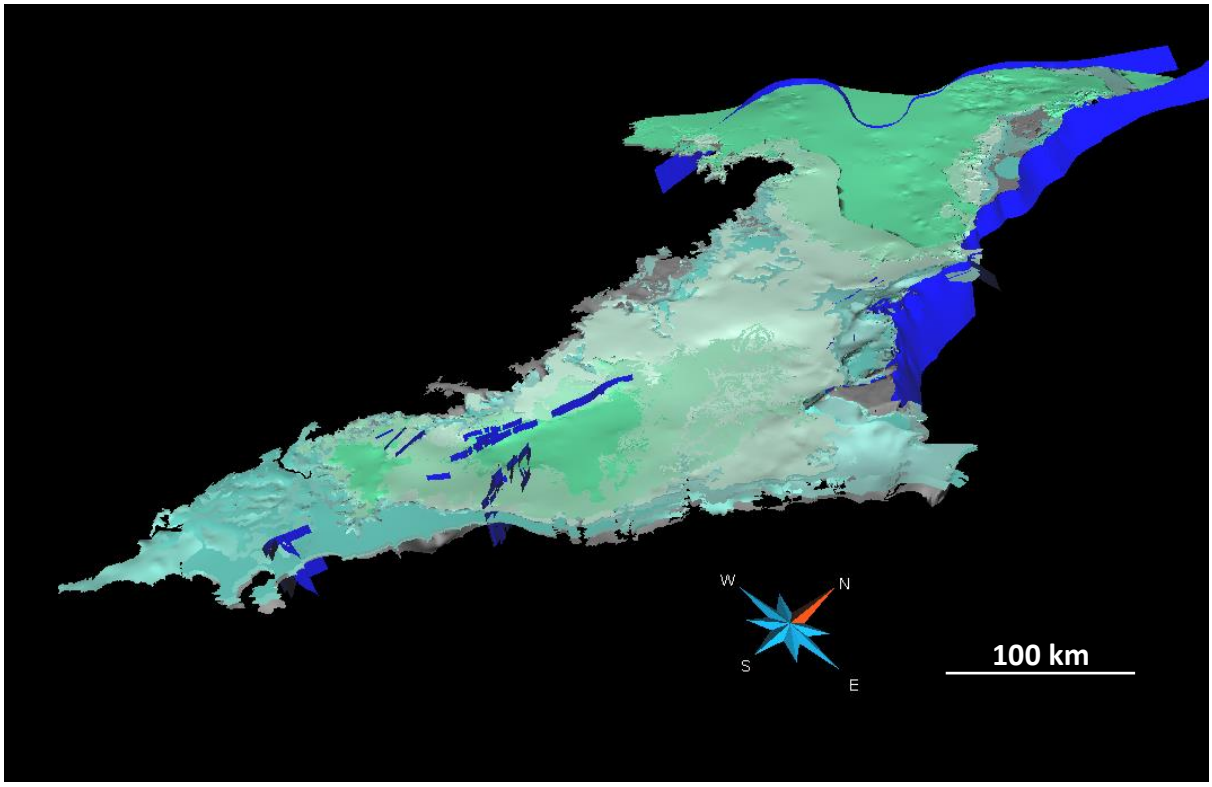

Figure 3: Integrated Sydney–Gunnedah Basin Model.