High-resolution regional-scale 3D inversion modelling using the National Computational Infrastructure

James Goodwin
Geophysicist
Geoscience Australia
james.goodwin@ga.gov.au

Dr Nicholas Williams
Senior Geophysicist
Ivanhoe Australia Ltd.
nickwi@ivancorp.net

Prof Doug Oldenburg
Director
University of British Columbia
Geophysical Inversion Facility
doug@eos.ubc.ca

SUMMARY

Large-scale high-resolution 3D inverse models have successfully been built for the Wallaby Plateau and Capricorn region of Western Australia using the National Computational Infrastructure supercomputer facility. This work highlights the benefit of using increased computing power to achieve higher grades of detail in 3D inversion modelling.

Key words: potential-field, 3D inversion, gravity, magnetics, supercomputing.

INTRODUCTION

3D inversion of potential-field data is a powerful technique for investigating subsurface geology. A common problem for any geophysicist performing 3D potential-field inversion is acquiring sufficient computational power to produce models that cover the area of interest at an appropriate resolution. Being limited by computing power often means that models are generally degraded in either their resolution or scale to ensure they are computed within available resources, in turn, limiting the resulting geologic interpretation. A collaborative arrangement between Geoscience Australia and the National Computational Infrastructure (NCI) hosted by the Australian National University has increased GA's capabilities to ensure that potential-field inversions are calculated at a resolution appropriate for the available national-scale gravity and magnetic data.

NCI maintain Australia's highest-performance supercomputer which consists of approximately 12,000 computer processor units each with 2.93 GHz of processing power (peak performance of 140 teraflops). For the geophysicist an essentially unlimited amount of computing power is provided meaning that 3D inversions and forward models are no longer limited by their detail and scale. The time taken to run models is also significantly reduced and there is now the ability to submit multiple jobs at one time. This allows for an iterative approach to be taken to geophysical modelling where the effects of different parameters on the final model can be investigated to achieve the best possible result. In particular, the University of British Columbia – Geophysical Inversion Facility (UBC-GIF) potential-field inverse codes GRAV3D and MAG3D have been parallelised by UBC-GIF for use on NCI.

METHOD

The magnetic and gravity inversion methods outlined by Li and Oldenburg (1996, 1998) have been used here. This method requires that an area larger than the desired volume (referred to as the regional model) be inverted for in order to account for the regional trend. To remove the regional trend a volume equal to the desired model volume (referred to as the local model) is set to '0' within the regional model. The resulting scooped out model is then forward-modelled to obtain the regional trend which is then subtracted from the original observed data. Once the regional trend is removed from the observed data a local scale inversion can be undertaken using the new observed dataset. At this stage constraints are added in the form of seismic interpretations and 3D geologic models to limit the ambiguity associated with inverse modelling.

3D INVERSION MODELLING PROJECTS

Wallaby Plateau

An example of the work that has been performed using NCI includes 3D gravity and magnetic inversions of the Wallaby Plateau (Figure 1) which cover a large volume (450 × 450 × 25 km) while still retaining detail (~5.06 million cells in the model). The Wallaby Plateau forms part of Australia's southwest margin and is an offshore area where little is known about the subsurface geology with current interpretations regarding the geology based on dredge samples and limited seismic reflection data. Both 3D density and susceptibility models covering the Wallaby Plateau were built to help define specific regions where further detailed analysis can be undertaken for the purpose of assessing the petroleum prospectivity of the area (Goodwin *et al.*, in prep).

The key findings from this work were that the modelling: (1) supported the idea that continental crust underlies portions of the plateau (2) aided with identifying areas of potential sedimentary basins (3) highlighted that the Wallaby-Zenith Fracture Zone (WZFZ) correlates well with a northeast dipping density contrast and (4) allowed for the extent of the plateau at depth and its relationship to surrounding abyssal plains to be analysed (Figure 2; Goodwin *et al.*, in prep).

Capricorn

Current 3D inversion modelling using NCI is focused on the Capricorn region of Western Australia where three seismic reflection lines (10GA-CP1, 10GA-CP2 and 10GA-CP3)

have recently been collected (Figure 1). Forward modelling of gravity and magnetic data along these seismic lines, and high-resolution (6.48 million cells) regional-scale (480 × 500 × 25 km) 3D inversion of the surrounding area, is aimed at providing insight into the crustal-scale architecture of the region. This modelling aids the interpretations of the seismic lines.

Yilgarn-Officer-Musgrave

Future high-resolution regional-scale 3D inversion models will continue to be built in areas that cover recently collected seismic reflection data, such as the Yilgarn-Officer-Musgrave (YOM) line (Figure 1) planned to commence in January 2012. The purpose of which is to investigate crustal-scale architecture and support the geologic interpretation of the seismic data.

CONCLUSION

The use of the NCI supercomputer has allowed for areas of potential-field data, typically too large and too detailed for any single computer to calculate, to be inverted using UBC-GIF. This process is currently supporting the interpretation of recently collected seismic data to build an understanding of crustal-scale architecture.

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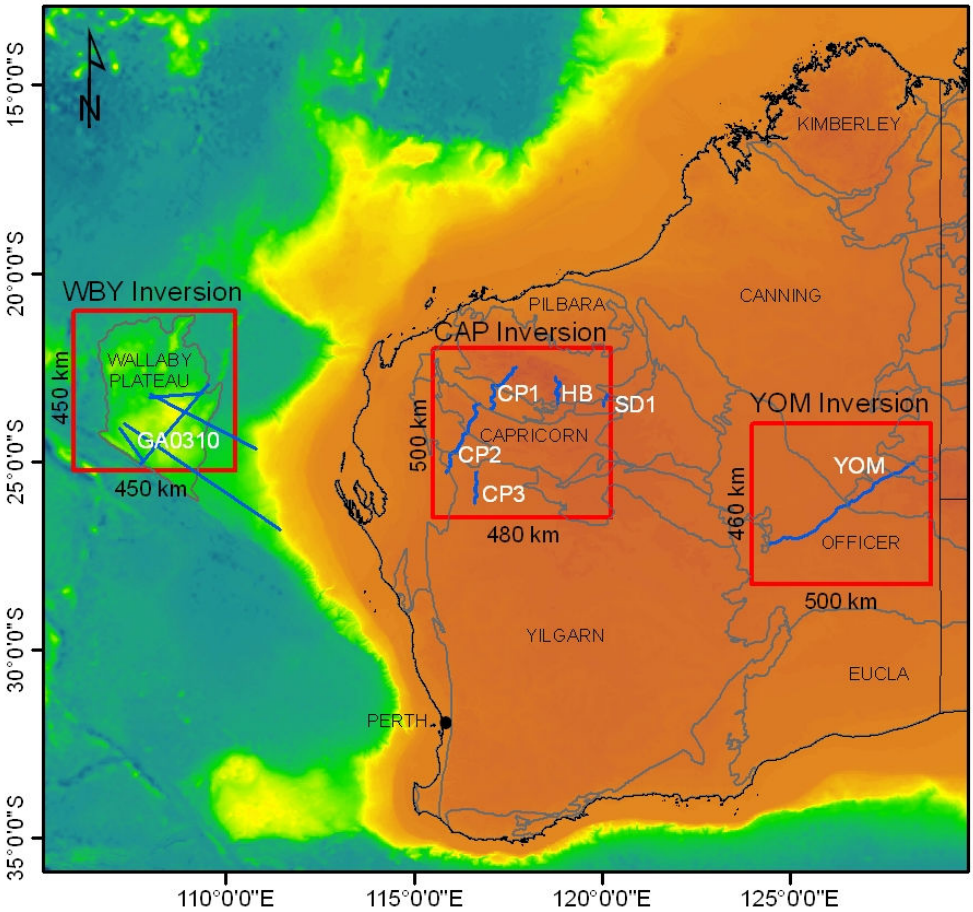

Figure 1: Locations of high-resolution regional-scale 3D gravity and magnetic inversion models. The approximate area covered by each model is shown (all of which extend to 25 km depth) while also highlighting the seismic lines used to constrain each model (blue lines). WBY = Wallaby Plateau inversion, CAP = Capricorn inversion, YOM = Yilgrarn-Officer-Musgrave inversion.

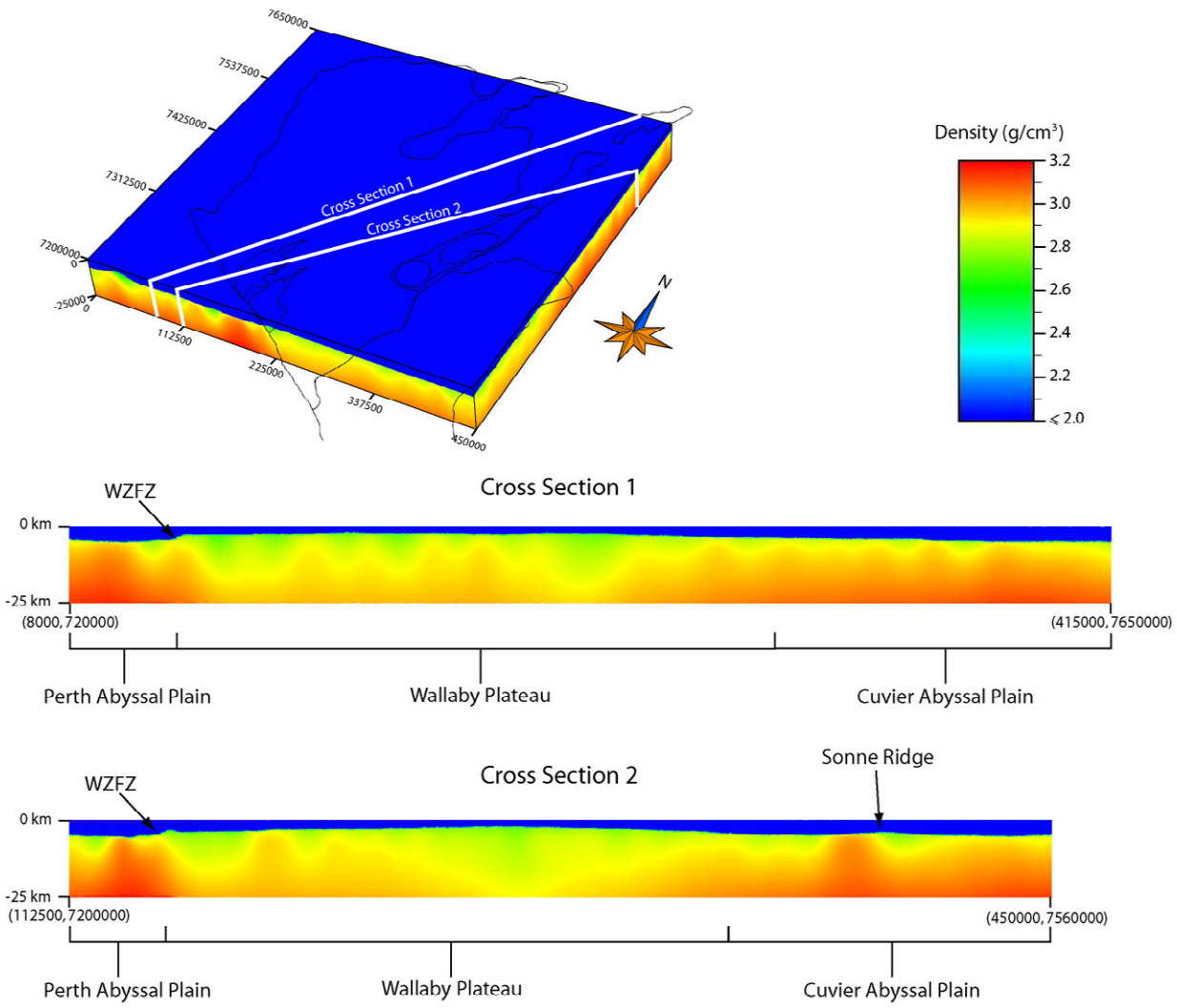

Figure 2: 3D density model of the Wallaby Plateau (outline shown on 3D model) highlighting the low density nature of the plateau itself making it distinct from the surrounding abyssal plains (a 1.5x vertical exaggeration has been applied). WZFZ = Wallaby-Zenith Fracture Zone.