Better tools for interpolating 3D surfaces and thin bodies: Modelling auriferous reefs in the Bendigo Goldfields

Helen Gibson[1], Gabi Courrioux[2], Ray Seikel[1], Desmond FitzGerald[1]

[1]Intrepid Geophysics, Melbourne, [2]BRGM, Orleans, France

Abstract

3D geology modelling can assist explorers and producers of reef-gold deposits. This industry experiences challenges relating to the nuggety-nature of gold mineralisation, and to the fault-disruptured nature of auriferous reefs.

Predicting continuity of mineralised quartz veins and fault networks away from mapped and sampled zones is now more rigorous using *3D GeoModeller* which offers highly appropriate interpolators for predicting 3D surfaces. Interpolation in *3D GeoModeller* is based on potential field theory, and combines anisotropic kriging for better representing reality when it comes to interpolating thin and irregular, curvilinear bodies such as quartz veins and dykes.

The software

GeoModeller is a software tool for building complex, steady state 3D geology models, now developed and commercialised in Melbourne, Australia - in cooperation with BRGM, France.

Features of the geological editor:

- Intuitive interface (for geoscientists ... start with a stratigraphic pile ...)
- Imports diverse data (maps, sections, drill holes, GIS, seismic, xyz, ...)
- Employs rule-based modelling (honours stratigraphic relationships & fault network rules)
- Adds / revises data, and will rapidly re-compute and re-build the model
- Runs on a standard PC
- Flexible export options for modelled surfaces, shapes & data

…and to refine geology models using geophysics
Advanced capabilities include:

- Forward modelling magnetic & gravity responses direct from 3D geology
- Litho-constrained geophysical inversion

3D Interpolation methods

Interpolation of 3D surfaces is based on potential field theory – highly appropriate, because natural geological boundaries, fault surfaces and fold axial planes are all analogous to iso-potential surfaces of one or more scalar (potential) fields.

Contact data (from boundaries or faults) are treated as points along an iso-potential surface. Coupled orientation data (dip & dip directions) are treated as gradients of that potential field (Fig. 1)

Co-kriging these two related variables enables realistic 3D iso-surfaces to be computed, and:

- honours all data in 3D
- orientation data don't need to be on the geology contact
- allows orientation data to guide interpolators

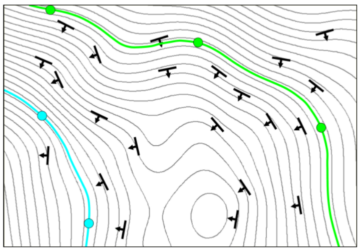


Fig 1: Iso-potential surfaces passing through 2 different groups of contact data (green and blue). The interpolator predicts geological surfaces in 3D which honour the contact data, whilst also accounting for the orientation data both above and below the contact.

Additionally, *GeoModeller* employs *anisotropic kriging* – which allows for anisotropic spatial covariance of contacts and orientation data. One benefit of this is to ensure that thin curvilinear bodies (e.g. veins in Fig 3) can remain coherent, when observations confirm this behaviour – rather than break into local shapes clustered around data points.

The geologist is still required to predict the continuity of quartz veins, and then to designate the finite extents of veins (in *GeoModeller*) where appropriate to the geological interpretation. The modeller is in control!

The Bendigo Goldfields

- Comprise intensely folded and faulted Ordovician sandstones, siltstones and mudstones (Figure 2).
- Minor folds can feature fold hinge lines with strongly varying plunges, creating dome-like structures which sometime host mineralised quartz saddle reefs.
- Historically, some of the richest zones of quartz vein-hosted gold mineralization were found in reefs located in the cores of anticlines or domes.

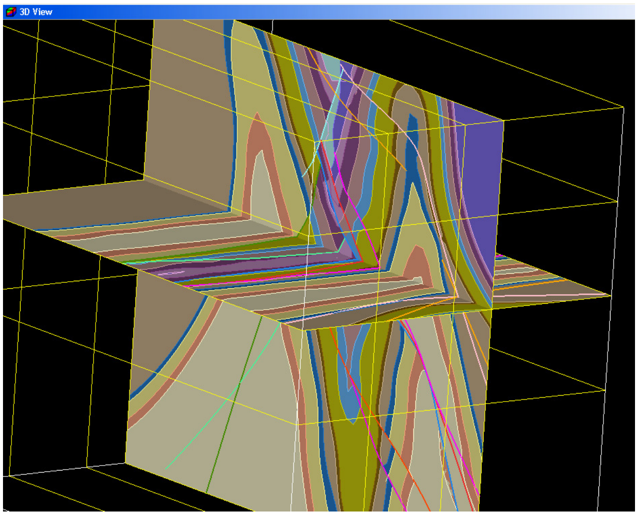
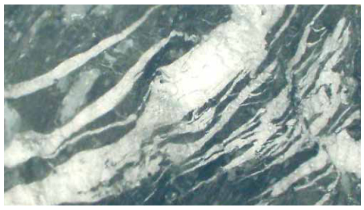


Fig 2: Rendered image from part of the Bendigo Goldfields geological model (Intrepid Geophysics, 2006). All represented faults and geological boundaries are consistent with and constrained by, the geological data that is geo-located in 3D (not shown, but including: geology contacts, bedding orientations, fault contacts, fault plane orientations and fold axial planes).

- Saddle reefs are often displaced by strike-slip faulting making it difficult to accurately predict the position of any extensions or offsets of the reefs.
- Therefore, verification and visualisation of the structural complexity of the geology in 3D - constrained by as much high-quality data as possible - is key to successful gold exploration.

Fig 3: Photograph of a spur reef with abundant quartz.



Key Points

- Bendigo Goldfields' geology is complex, presenting challenges for realistic prediction of geological units and structures in 3D space.
- Challenges are being addressed by building steady state 3D geological models
- *GeoModeller* uses primary geological observations, stratigraphic relationships and sophisticated 3D interpolator methods to build realistic 3D models.
- Two *GeoModeller* models have been built for the Bendigo Goldfields: one at mine-scale (by Intrepid Geophysics) and one at 1:250,000 scale (by Department of Primary Industry's Rediscover Victoria program).
- *GeoModeller* models can be efficiently updated as new data becomes available with progressive drilling, sampling and mining.

References

Gibson, H. Courrioux, G., Fraser, R. and Rawling, T., 2010. Modelling the Bendigo gold province: Better tools for interpolating 3D surfaces and thin bodies. Abstracts No. 97. GSA. Proceedings of the Specialist Group in Tectonics and Structural Geology, Conference 2010. 1-5 February 2010, Port Macquarie, NSW.

Williams, B., Skladzien, P. B. and Rawling, T. J., 2008. Bendigo Zone 1: 250,000 scale serial sections and accompanying notes. GeoScience Victoria 3D Victoria Report 1. DPI, Australia.