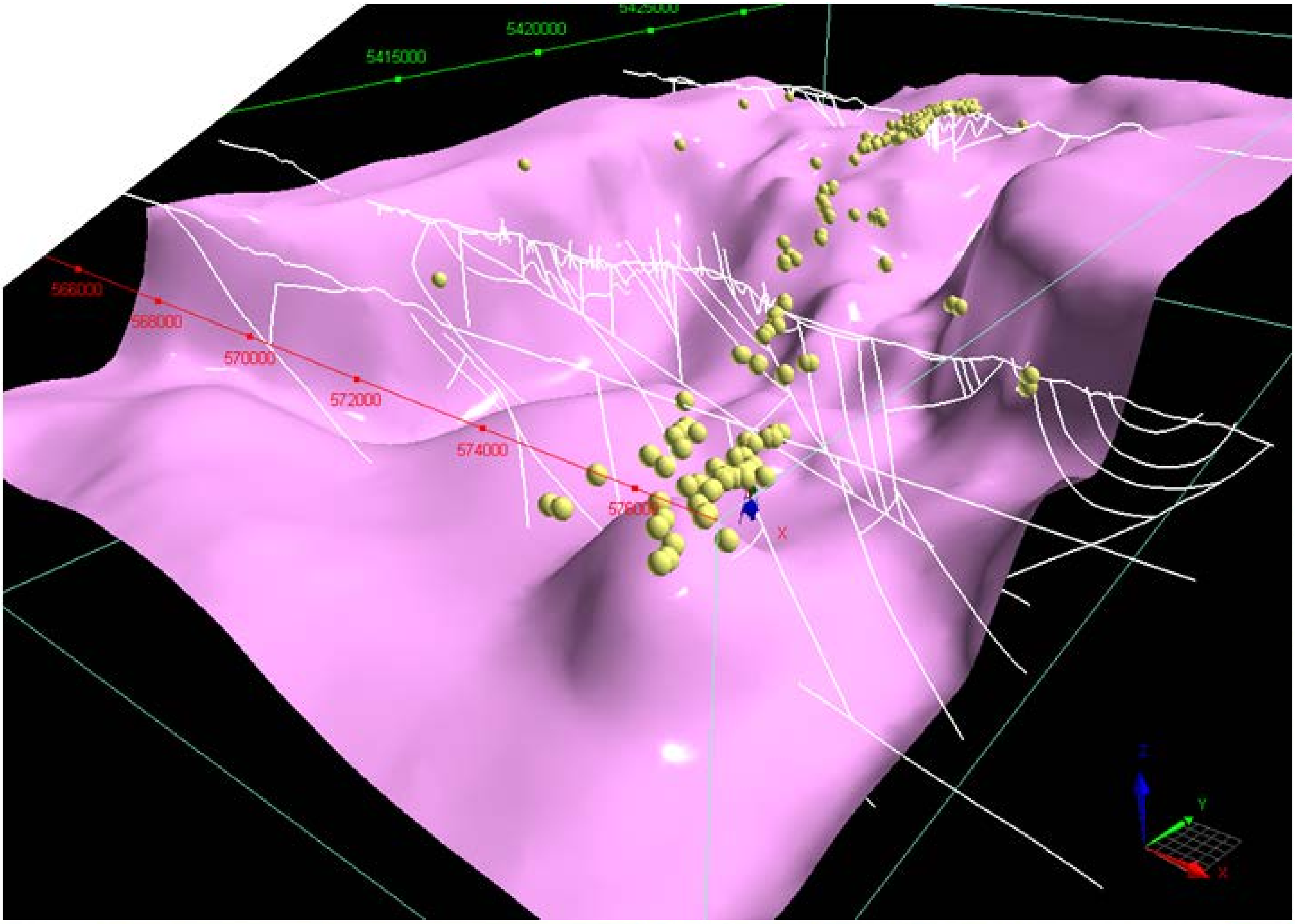
# ALBERTON-MATHINNA 3D MODEL: EXPLANATORY NOTES

# MINERAL RESOURCES TASMANIA REPORT UR2018-3





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# Abstract

Mineral Resources Tasmania (MRT) has developed a high resolution 3D model of the Alberton-Mathinna "Gold Corridor", northeast Tasmania. The geological model expresses a new structural synthesis based on mapping and multiple cross sections by MRT staff. The model is constrained by 3D geophysical modelling using MRT's gravity and magnetic survey data coupled with drilling and rock physical property databases. Statistically generated sensitivity characterisation is incorporated into 3D model products as a step towards estimating confidence in the spatial variability of geological objects at depth. Joint inversion results show that calculated gravity and magnetic responses are in good agreement with observations. A product of statistical sensitivity modelling is a new granitoid surface, which is significantly more detailed when compared to previous versions. This fusion of geological and geophysical information with measures of model sensitivity is a significantly more sophisticated addition to MRT's suite of public pre-competitive geoscience products, with the aim of further reducing exploration risk.

# Data delivery and visualisation

The model is being distributed primarily as a Geoscience ANALYST project and is described here as such. Geoscience ANALYST is visualisation and communication software for GoCAD® 3D models, made freely available by Mira Geoscience (http://www.mirageoscience.com/). All major components of the 3D modelling process from sections to geophysical inversion results are obtainable in their original formats. Metadata for these contents is given below.

All spatial objects within the model are referenced to the Map Grid of Australia zone 55 and the Australian Height Datum.

# Model contents

## Cross sections

Line work was digitised from interpretations by Michael Vicary on 15 east-west sections spaced 2 kilometres apart. All lines correspond to mapped or inferred faults.

## Drill holes

Collar and hole geometry for the 75 holes recorded on open file for the model area in MRT's drilling database. Attributed with downhole information such gold assays, physical properties (density and magnetic susceptibility, in units of t/m3 and SI x 10-5 respectively) and stratigraphic unit or lithology intersected where available, however this is not the case for most holes.

# Golden Gate Mine

Reefs, faults and mine workings produced by Tamar Gold Ltd from historic data for the New Golden Gate and Tasman Consols workings (Murphy 2011).

# Granitoid models

Granitoid models indicating evolution in understanding of 3D geometry of regional Devonian granitoid intrusions. The surfaces are thus an undifferentiated amalgamation of all Blue Tier and Scottsdale Batholith plutons.

- **2004 granitoid surface:** extracted from Statewide 3D model (Murphy et al 2004).
- **2011 granitoid surface:** Interpolation from structure contours produced by revised 2D geophysical interpretation (Leaman 2012) and slightly modified by M Duffett.
- **2018 granitoid surface:** Interpolated probability threshold surface developed by this study (see below).

# Input - 3D Geological Modelling

- **Faults:** Surfaces interpreted from surface mapping and cross sections. Identified as either normal or thrust.
- **Geology Reference Model – Surfaces:** Boundaries of geological units in the initial model, subsequently refined by geophysical inversion (see '3D Geophysical Modelling'). Lone Star Siltstone, Pyengana Granodiorite, Russells Road Granite, Sideling Sandstone and Tombstone Creek Granite all correspond to stratigraphic units identified in 1:25,000 scale mapping. However, the Pyengana Granodiorite is subdivided into magnetic and non-magnetic phases (following Roach 1994) and it should be noted that the Russells Road Granite contains both granitic (sensu stricto) and monzonitic phases. Undifferentiated granitic Blue Tier Batholith occupies much of the lower portion of the reference model. A magnetic unit previously inferred to exist at depth from gravity and magnetic modelling (Roach 1994) remains unassigned to a stratigraphic unit. Its properties and situation are consistent with either an igneous intrusion similar to the magnetic Pyengana Granodiorite, magnetic material introduced into Mathinna Supergroup rocks by processes associated with contact metamorphism (known to occur elsewhere in the region), or some combination of both.
- **Geology Reference Model - Voxet:** 3D voxet grid representation of the geology reference model, indicating unit volumes derived directly from the reference model surfaces. Geological units in the voxet (attribute 'lithologies') thus correspond to those of the surfaces, except that the Lone Star Siltstone and Sideling Sandstone have been combined as Mathinna_Supergroup, as their physical properties are very similar. Used for subsequent geophysical modelling (see below). Lithology 0 is an artefact of surface-voxet translation and should be disregarded.

# Output - 3D Geophysical Modelling

- **Calculated datasets**
  - *Calculated gravity response 250m:* 2D grid of the gravity response (mGal) computed from final model iteration of the joint inversion, upward continued to 250 metres
  - *Calculated TMI response 500m:* 2D grid of the magnetic response (nT) computed from final model iteration of the joint inversion, upward continued to 500 metres.

- **Observed datasets**
    - *Observed ResBouguer gravity:* 2D grid of isostatic residual complete Bouguer gravity anomaly (mGal), i.e. simple Bouguer anomaly corrected for the effects of surface and Moho topography (Duffett 2018). No upward continuation.
    - *Observed TMI response:* 2D grid of total magnetic intensity, from MRT data (200 metre line spacing). No upward continuation.
    - *Observed gravity response 250m:* 2D grid of isostatic residual complete Bouguer gravity anomaly (mGal) upward continued to 250 m.
    - *Observed TMI response 500m:* 2D grid of total magnetic intensity (nT) upward continued to 500 m.

Upward continuations were performed mainly to attenuate unwanted responses from shallow sources (differential weathering and similar 'geological noise', remanent magnetisation of Cenozoic basalts) that were impractical to account for at the scale of the modelling.

- **Sensitivity statistics:** 3D sectional representation of summary statistics for 1.4 billion inversion iterations. The suite of statistical sensitivity products made available for model interrogation include the following
    - *Entropy,* records the volatility of a particular voxel during the inversion. A value of zero indicates low volatility and 1 high volatility.
    - *Mean density,* derived from the accumulated accepted inversion proposals/models
    - *Mean susceptibility,* derived from the accumulated accepted inversion proposals/models
    - *Most probable threshold,* which records the most often assigned lithology to a particular voxel location for a user defined threshold value over the iteration range specified (i.e., ~2.6 million acceptable models). 99% was the threshold set in GeoModeller for this study. Null voxels are those that failed to meet this threshold for any one unit, thus indicating uncertainty in the model at these locations.
    - *Probability of individual unit lithology,* the probability of finding an individual geological unit with the whole model space which varies between 0% (black voxels) and 100% (white voxels).
- **Vector overlays**
    - 25k geology polygons: vector file of individual lithological units, extracted from MRT's 1:25,000 seamless geological map coverage
    - 25k lines geology and faults: vector file of lithological boundaries and faults, extracted from MRT's 1:25,000 seamless geological map coverage
    - Tenements: vector file of exploration licence areas, extracted from MRT register 20 July 2018
- **Digital elevation model (DEM):** Surface topography in the Alberton-Mathinna model area. Extracted from MRT's statewide digital elevation model and resampled to 100 metre cells.
- **25K Geology –** image extracted from published MRT 1:25,000 mapping
- **Gold deposits –** locations extracted from MRT mineral occurrence database.

# Geophysical modelling methodology - summary

Mineral Resources Tasmania (MRT) has developed a geophysical inversion workflow to image complex terranes in 3D (Bombardieri et al 2018, in preparation). The first model to be released using this workflow is a 3D model of the Alberton-Mathinna goldfields located in north-east Tasmania. The Alberton-Mathinna area has historically been one of the most gold-rich in the State, with total production exceeding 330,000 ounces. Virtually all of this has been within a NNW-oriented linear trend known as the 'gold corridor' encompassing the eponymous townships, but the macroscopic details of structural or other controls on the primary quartz vein-hosted mineralisation are not well understood.

The Alberton- Mathinna 3D model was constructed in GoCAD® Mira Geoscience as a synthesis of all previous work and relied heavily on the structural interpretation by MRT staff as part of the TasExplore initiative. The model dimensions are 33 x 18 km and a depth of 5 km encompassing the Alberton and Mathinna goldfields. Model elements include Cambrian allochthonous mafic-ultramafic complexes, Silurian-Devonian Mathinna Supergroup sediments, Devonian intrusives, Carboniferous to Permo-Triassic sedimentary units, Jurassic dolerite and Cenozoic basalts. The level of geological detail incorporated into the model is dictated by likely bulk physical property contrast as well as tectonic, stratigraphic and practical modelling considerations.

The workflow incorporates geological information in the form of cross-sections representing structural interpretations and petro-physical data in the form of unit rock property density and susceptibility measurements. A "reference model" comprising surfaces representing the various lithologies and fault architecture is first constructed. This model is then discretised in preparation for forward and inverse modelling using GoCAD's potential field module (VPmg code; Fullagar et al., 2008). Geological information (cross sections) is used to constrain geophysical inversion and reduce uncertainty. The 3D model derived to this point (which itself has undergone deterministic geophysical validation) is a 'best estimate' synthesis that is consistent with observed gravity and magnetic data. However, as is well known with potential fields, this solution is not unique.

3D GeoModellerTM is employed to explore the range of similarly plausible possible models. The stochastic exploration algorithm takes a Monte Carlo approach, generating a sequence of linked models starting with the reference model making small "random" changes to the lithological boundaries and physical properties. Model sensitivity is quantified by measuring the evolution of geological bodies via changes to their volume. The commonality and shape ratio probability functions are the two methods used to perform geological tests on proposed cell perturbation or volume change. The commonality constraint aims to preserve a cells original lithology by limiting the degree to which it can vary. This constraint is controlled by a Weibull distribution with a scale parameter ranging from 0.5 (loose) to 0.05 (tight). In contrast, the shape ratio aims to preserve the shape of the original lithology. It is defined as the shape of the lithological unit in the proposed model divided by the shape of the lithological unit in the reference model. The constraint is controlled by a log normal distribution with the scale parameter (i.e., standard deviation) ranging from 0.5 (loose) to 0.05 (tight) (McInerney et al. 2013).

For the Alberton-Mathinna joint inversion case, tightly constrained scale parameters (0.05) were used for geological boundary tests. Tight constraints have an impact on the rate of convergence for the joint inversion process by reducing the number of geological acceptances. This in turn reduces the number of geophysical acceptances (McInerney et al. 2013). For each iteration, if the geological boundary change is accepted then the geophysical response of the adjusted model (constrained by petrophysical information enforced by statistical distribution laws) is calculated. This model response is assessed and the proposal is accepted or rejected depending on whether the misfit is improved or maintained below an acceptable threshold.

Another parameter used in the inversion is the probability of property change parameter which is set as a ratio. In default mode the ratio is 50/50 meaning there's an equal split between changes made to lithological boundaries and changes to petrophysical properties of the unit. For the Alberton-Mathinna inversion run a ratio of 99/1 was used with the goal of controlling acceptable levels of geology-boundary variation (McInerney et al. 2013).

Upon completion of the joint inversion run GeoModellerTM carries out an analysis of the ensemble of models that reproduced the observations to an acceptable degree (McInerney et al. 2013). In total 18 million acceptable models were made available for sensitivity metrics. Of these, 2.64 million consisted of geological unit boundary changes.

One example of sensitivity generated metrics includes a probability threshold surface representation of an amalgamation of individual granitoid plutons. The new 2018 granitoid surface shows significant increase in 3D surface detail compared to previous models. It must be remembered, however, that the emergent details depend primarily on the assumption of consistent density contrast between granite (low) and Mathinna Supergroup country rock (high). The possibility of contributions to local negative gravity anomalies from unmodelled deep weathering, alteration or other processes resulting in rock density reduction is recognised. Among the new features to emerge is a cupola in the vicinity (~1.6km) of the Mathinna goldfield. In relation to the Ringarooma United deposit located within the Alberton goldfield, modelling shows that the fault network architecture underpinning the deposit was intruded by granite to a depth of ~400 metres. While studies show ore-forming solutions for both deposits were most likely metamorphic in origin (Bottrill et al. (1992), a second gold event involving magmatic fluids (i.e., granite related) may also be considered.

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