predictive mineral discovery CRC - PIRSA-CGGP Numerical Modelling Project Update #2

Regional Thermal-Fluid-Flow Modelling: Predictive Targeting Outcomes

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Predictive Targeting Outcomes:

- Rocks within ~200 vertical metres of the base of the (Gawler Range Volcanics) "seal" are potentially the most prospective. Arguably, all significant mineralisation in the region resides (at least in part) within this zone immediately below the GRV (Tarcoola, Glenloth, Earea Dam, Tunkillia, Nuckulla Hill, Barnes, Menninnie Dam, Weednanna and, potentially, the deposits of the Olympic Dam IOCG province to the NE of the current GRV outcrop).
- Reactive rock types, as defined by the geochemical modelling (mafics and carbonaceous sediments), in close proximity to the base of the GRV, also add to the prospectivity.
- Significant steep structures intersecting or abutting the base of the GRV increase the probability of mineralisation as they provide a focussed deep fluid source to the base of the GRV and potentially provide a zone for this deep hot fluid to mix with the cooler lateral fluid flow beneath the GRV.
- Damage zones in the lower GRV are also potential mineralisation hosts (especially when hosted by more mafic units of the Lower GRV, as they are an ideal geochemical trap for Au fluids). These damage zones may be triggered by intersecting faults/ shear zones or localised fluid overpressure (from blind structures or shallow level Hiltaba intrusives etc.).
- Segments of major steep faults proximal to Hiltaba intrusions may be sites of more vigorous up-flow and mineral precipitation.

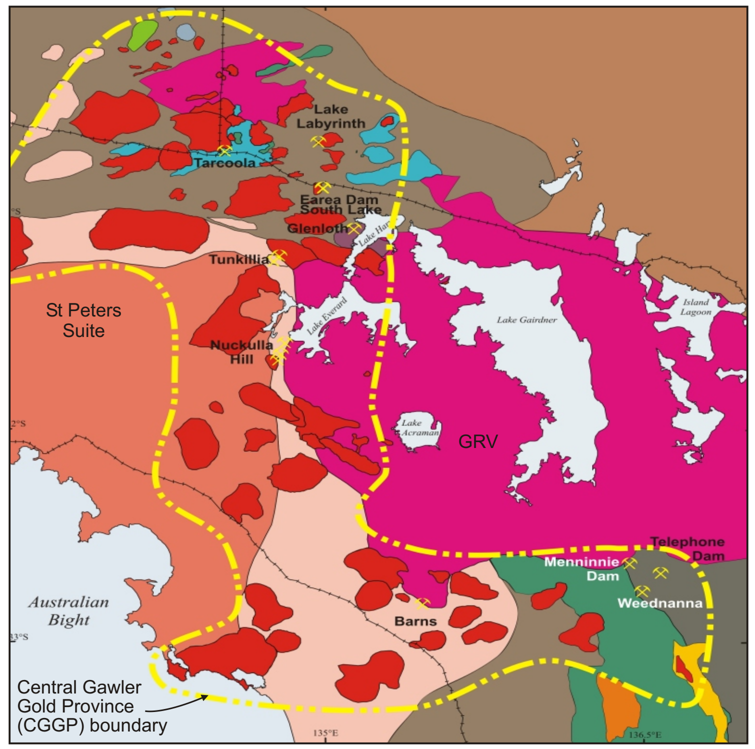
Aim of thermal-fluid-flow modelling:

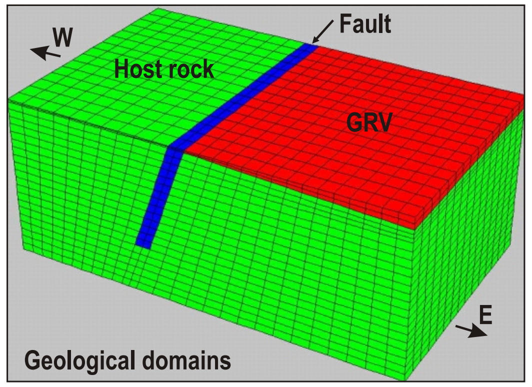
Large scale 3D coupled thermal-fluid-flow modelling was undertaken in order to:

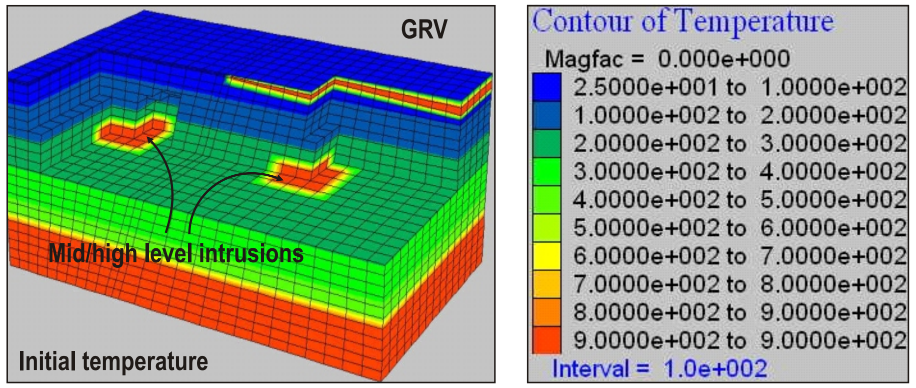
- understand the impact of the Gawler Range Volcanics/Hiltaba thermal event (igneous and volcanic) on regional thermally driven fluid flow.
- identify fluid pathways, and where thermally driven fluids are likely to focus.
- identify where the high thermal gradients are, and how they interact with fluid flow.
- provide temperature gradient and fluid pathway inputs for regional geochemical modelling.

Initial model conditions and assumptions:

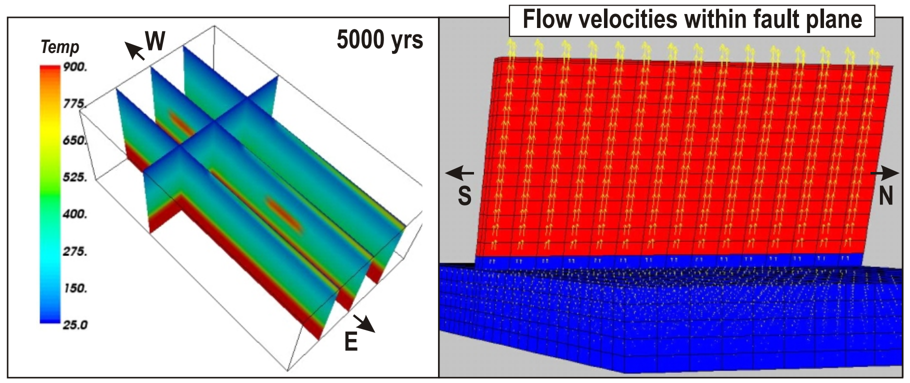
- Initial geothermal gradient of 30 C/km throughout model.
- A steeply dipping high permeability fault zone (representative of the Yarlbrinda Shear Zone, or similar).
- Intermediate permeability host rocks with a generic granitic rheology.
- The model is instantaneously overprinted by 900 C GRV extrusive blanket with very low permeability, and a 5km thick, 900 C, slab across the base of the model to represent the Hiltaba/GRV thermal source.
- The model is initially fluid saturated, and no additional fluids are added.
- There is no deformation therefore, fluid flow is driven solely by thermal expansion of the pore fluid over a period of 1Ma following the emplacement of the hot slab and overlying volcanics.

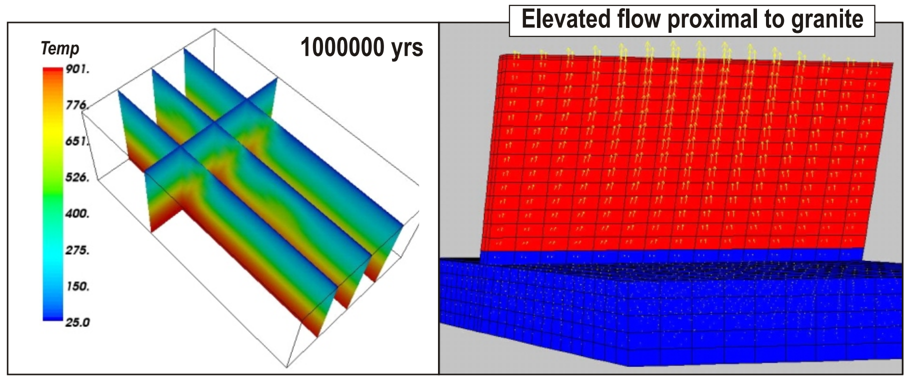






- High level Hiltaba-aged intrusives proximal to the base of the GRV could also provide a mechanical, thermal and/or fluid pressure anomaly to localise mineralisation.
- High level Hiltaba-aged intrusives proximal to steep shear zones/faults can locally perturb the flow field within the fault increasing up-flow within the fault proximal to the hot intrusion. These areas of increased up-flow within the fault can have a positive impact on mineral precipitation. If the intrusive is big enough it may trigger convection within the fault. Either of the above may explain, or help to predict, periodicity of alteration and/or mineralisation along major faults such as the Yarlbrinda Shear Zone.





- There is no reason why the prospective area for gold dominant deposits and therefore the delineation of the CGGP should not extend Eastwards under the GRV, the challenge now being how to use the predictive modelling in conjunction with geophysical interpretation and forward modelling to generate valid targets below the thinner portions of the GRV.

The predictive targeting outcomes presented in this report result from numerical modelling/simulation of complex mechanical/fluid-flow/chemical/thermal systems. The modelling process utilises both empirical data and geological interpretations as a basis for model construction and some intrinsic assumptions are required by the process. Every effort has been made to simulate these processes as accurately as possible based on the available geological interpretations and data, however, it must be noted that changes to numerical model inputs following further data acquisition or variations in geological interpretation may result in different modelling outcomes.

More information:

https:/pmd-twiki.arrc.csiro.au/twiki/bin/view/PIRSA/WebHome

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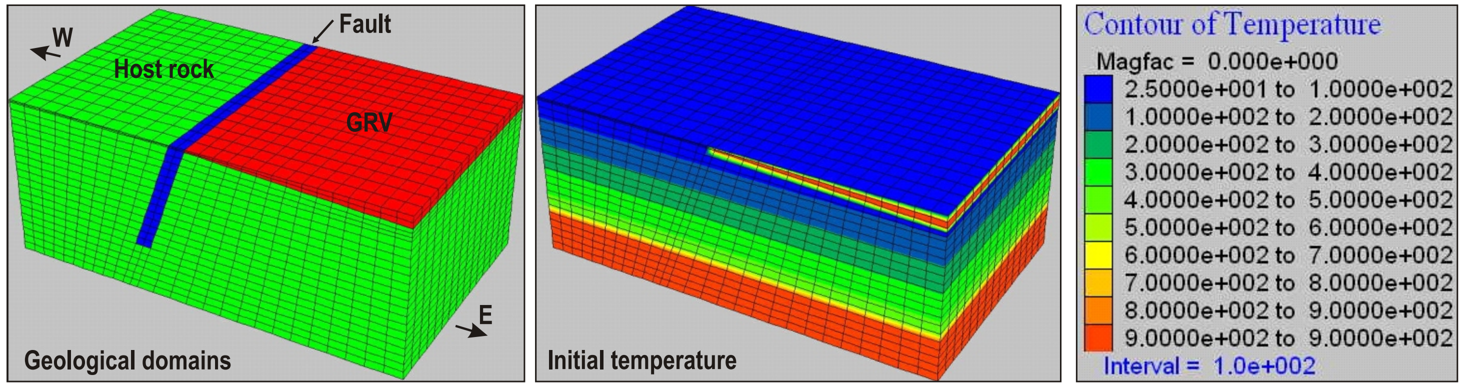
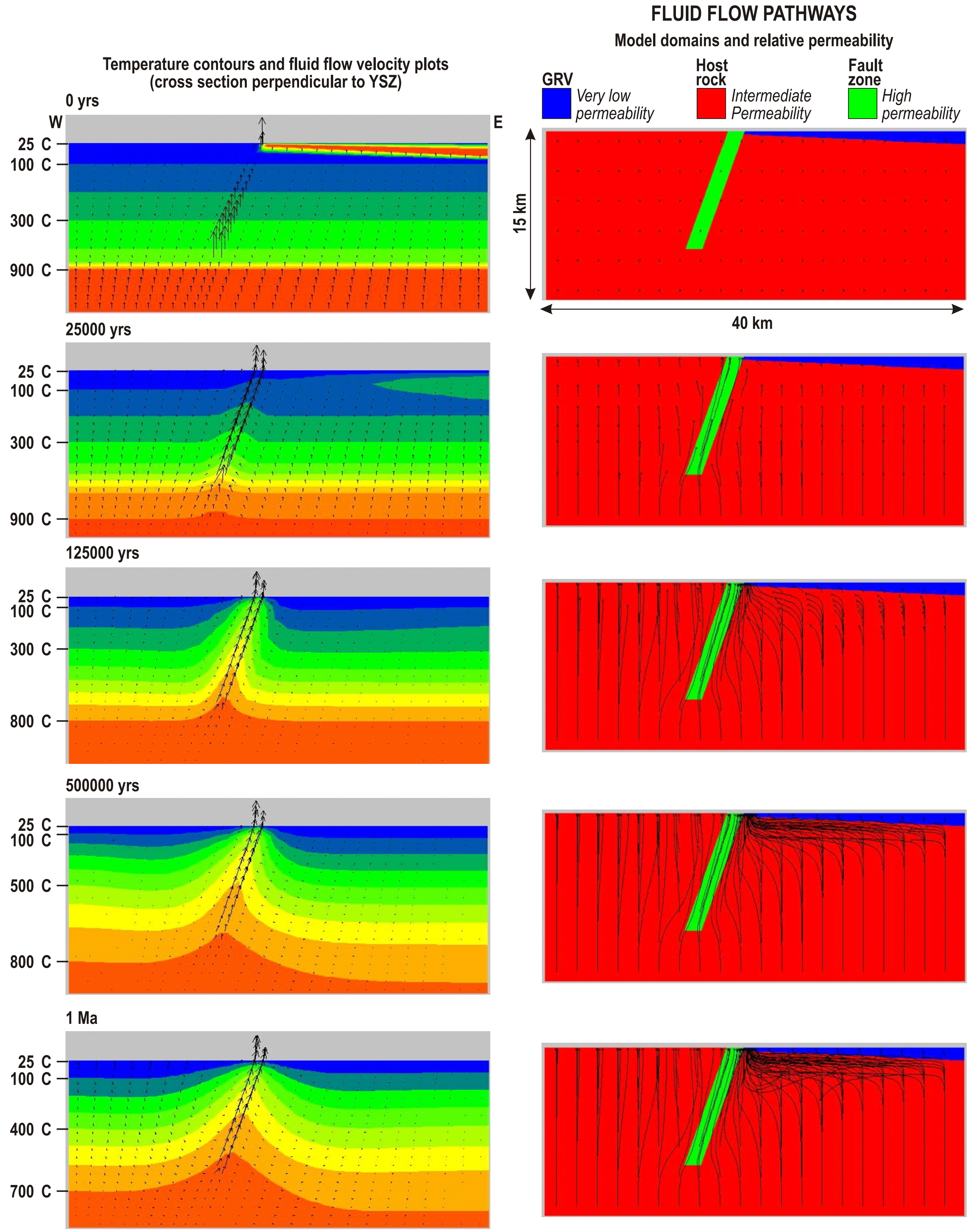


Results: (see time slice cross sections opposite).

- The GRV forms an impermeable blanket that forces focussed lateral flow in the rocks immediately beneath the GRV.
- This lateral flow seeks to escape from under the GRV either via potentially through-going structures (such as the Yarlbrinda Shear Zone), or by flowing towards the margins of the GRV sequence. In either case significant fluid focusing is predicted by the simulations.
- The thermal impact of the thin (<2km) GRV blanket is negligible.
  - The temperature anomaly in the GRV erodes to equilibrate with the regional geothermal gradient within 50,000 yrs. Most of the GRV cools by >400 C in the first 5000 yrs.
  - The initial high temperature of the GRV extrusive suite has no noticeable impact on fluid flow in the underlying rocks.
  - The GRV do not act as a thermal blanket for the underlying rocks, rather, over time, the geothermal gradient beneath the GRV is slightly lower than that of the rocks without a blanket of GRV.
- The slab of hot material at the base of the model takes >50,000 yrs to have a significant impact on the regional geothermal gradient and regional fluid flow patterns.
  - The permeable fault focuses rapid up-flow of hot fluids, sourced from deeper in the crust. These fluids undergo rapid cooling as they approach the surface.
  - The less permeable country rock exhibits a slower up-flow pattern, as a result, the infiltrating fluid geochemistry will most likely be rock buffered. This may provide a dissolution source for ore minerals, particularly if hot fluids pass through mafic rock sequences.
  - After ~100,000 yrs there is a significant fluid flow anomaly which develops beneath the GRV to the east of the fault. This is attributed to the very low permeability of the GRV which forces fluids to flow laterally in order to escape from under the GRV.
  - This focussed lateral flow remains essentially isothermal and isobaric until it reaches the fault, where it focuses even further into the fault/shear zone, potentially mixes with the flux of hotter fluid coming up the fault/shear zone, and again drops pressure as it flows upwards.
  - While the two fluids would originally have had the same composition, the fluids that have passed relatively slowly through the wall-rock have become rock buffered and may have dissolved significant quantities of ore minerals into the fluid, while the fluids channelled through the fault/shear zone would be less rock buffered and probably maintain some resemblance to their original source fluid geochemistry. Thus, the mixing zone of two such fluids might result in some significant geochemical gradients potentially promoting mineral precipitation.
- The laterally extensive very low permeability blanket created by the GRV is critical to the focussing of thermally driven regional fluid flow.
  - The lower GRV is visibly deformed and locally altered in outcrop and contains mafic units (identified as ideal gold traps for the Hiltaba Gold Fluids by the geochemical modelling) .
  - If deformation or locally over pressured fluids have ruptured the lower GRV (especially mafic units) there is significant potential for gold (and other) mineralisation in the lower GRV.
  - Topography on the basal contact of the GRV may also result in preferred flow paths immediately below the contact. Such topography is indicated in the Olympic Dam Seismic line to the NE.



Cross sections through model at various time steps