USING NEW GEOPHYSICAL DATA TO CONSTRAIN THE LITHOSPHERIC RELATIONSHIP BETWEEN THE GAWLER CRATON AND MUSGRAVE PROVINCE

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Introduction & Aim

- The location of the boundary between the Gawler Craton and Musgrave Province is currently inferred from magnetic and gravity anomalies, yet the nature of this boundary is poorly understood. Thick overlying Arckaringa and Officer Basin sediments restrict outcropping basement, and the number of basement-intersecting drill holes across the northern Gawler is limited. This region is critical to identifying the lithospheric relationship between the adjacent terranes, providing insights into the mechanism of Australian Proterozoic assembly.
- This study presents 15 new heat flow estimates from the Nawa Domain of the Northern Gawler Craton and one new value from the Musgrave Province with the aim of characterising changes in basement lithology corresponding to changes in observed heat flow.
- This new dataset provides data to a region with no published heat flow data to date. This data will contribute a substantial addition of heat flow values into the Australian continental heat flow dataset.
- These new heat flow values are also complemented by a magnetotelluric dataset transecting the study region. This dataset allows for the imaging of resistive and conductive bodies beneath the crust to a depth of 300 km.

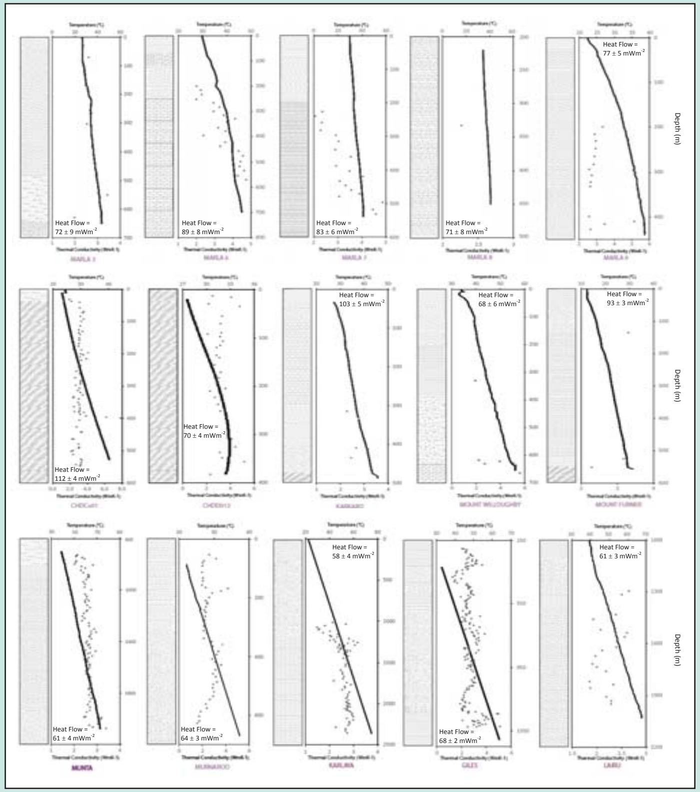

Figure 1: Temperature and thermal conductivity plots for each well included in this dataset

First row: Marla wells (north of Middle Bore Fault);
Middle row: Gawler Craton wells (south of Middle Bore Fault) and Musgrave Province well (CHDD013);
Last row: Wells in the west of the study area, overlying Officer Basin sediments.

Methods

- Heat flow is calculated from the following equation:

$$Q_d = \lambda \times [\partial T \partial z]_d$$

Heat Flow (Q_d), Thermal Conductivity (λ), Thermal Gradient ($[\partial T \partial z]_d$)

- Heat flow is the product of thermal conductivities of lithologies and the thermal gradient at depth; thermal gradients are sourced as single value Bottom Hole Temperature (BHT) extrapolated to determine gradient, or from continuous temperature logs.
- Thermal conductivities of lithologies firstly requires loaned samples of core from the South Australian Drill Core Reference Library. These core samples correspond to the same well from which the temperature data was obtained. Core samples are scanned using a Thermal Optical Scanner, which applies a heat source to the core sample and measures its response, giving a single representative value of thermal conductivity per sample of core.

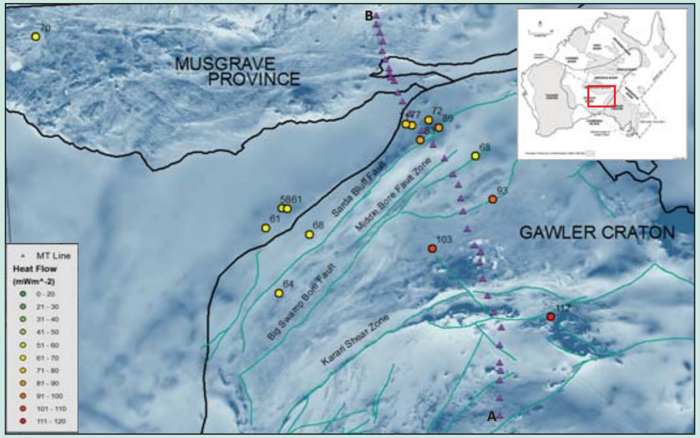

Figure 2: Heat flow values overlying a total magnetic intensity image of the study region. A clear transition is observable between above average heat flow exhibited by the Marla wells north of the Big Swamp Bore Fault, moving south into high heat flow values exhibited by wells overlying Neoarchean core. Purple triangles correspond to survey locations of the accompanying Magnetotelluric transect of the region. (Total Magnetic Intensity image modified after (Petrie et al. 2007); inset displaying location of study region (Modified after Morton & Drexel (1997))

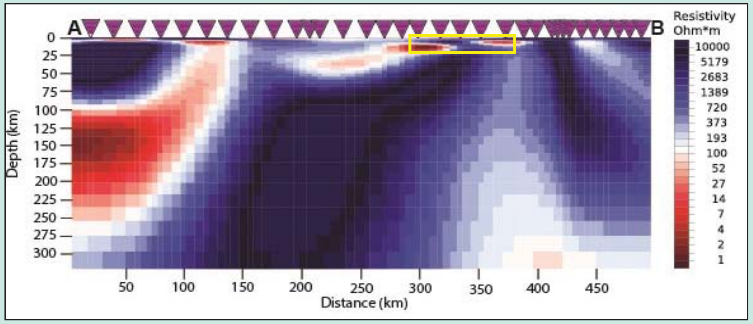

Figure 3: Magnetotelluric subsurface cross section produced from data collected across 33 stations spanning the study region. The highlighted area between the two conductive bodies (yellow box) corresponds to the region of transitioning heat flow shown in Figure 2.

Results

- Heat flow values range from continental average (58-68 mWm^{-2}; Giles-1, Murnaroo-1, Munta-1, Karlaya-1 and Lairu-1) in the west of the study region, to above average in the northern Marla Region (68-89 mWm^{-2}; Marla-3, Marla-6, Marla-7, Marla-8, Marla-9 and Mount Willoughby-1), transitioning to high heat flow in the south of the study region (93-112 mWm^{-2}; Karkaro-1, CHDCu001 and Mount Furner).
- The first heat flow value overlying known Musgrave Basement was calculated at 70 mWm^{-2} (CHDD013)

Well	Heat Flow (measured thermal conductivity) (mWm^{-2})	Heat Flow (thermal conductivity proxies) (mWm^{-2})	BHT recorded in well		
Giles 1	68 ± 2	76 ± 15	36 °C	@	482 m
Murnaroo 1	64 ± 3	69 ± 19	26 °C	@	247 m
Munta 1	61 ± 4	64 ± 12	72 °C	@	2078 m
Karlaya 1	58 ± 4	45 ± 8	76 °C	@	2366 m
Lairu 1	61 ± 3	75 ± 16	67 °C	@	2029 m
Marla 3	-	72 ± 9	43 °C	@	650 m
Marla 6	89 ± 8	89 ± 21	46 °C	@	698 m
Marla 7	83 ± 6	67 ± 8	41 °C	@	543 m
Marla 8	-	71 ± 8	46 °C	@	446 m
Marla 9	77 ± 5	73 ± 15	43 °C	@	435 m
Karkaro 1	103 ± 5	N/A	45.5 °C	@	482 m
Mount Willoughby 1	68 ± 6	N/A	55 °C	@	639 m
CHDCu001	112 ± 4	N/A	40 °C	@	528 m
Mount Furner	93 ± 3	N/A	31 °C	@	555 m
CHDD013	70 ± 4	N/A	32.5 °C	@	382 m

- Magnetotelluric data reveal a region of resistive crust located between two conductive bodies, corresponding to the location where heat flow values transition from above average (68-89 mWm^{-2}) to high (93-112 mWm^{-2})

Discussion

- Three zones of heat flow are present in this dataset (Figure 2); values of 58-64 mWm^{-2} are observed in the west overlying thick Officer Basin sediments, above continental average values of 68-89 mWm^{-2} are observed in the north and values of 93-112 mWm^{-2} overlie Neoarchean Gawler basement in the south.
- It is possible that this transition from above average heat flow in the north to high in the south are indicative of a change in underlying basement lithology, as a result of crossing the boundary from Musgrave crust in the north to Gawler crust in the south.
- Magnetotellurics supports this suggestion, with a region of resistive crust between two conductive bodies corresponding to the same region in which heat flow transition occurs.
- Based on available seismic reflection profiling from this region (GOMA seismic line; Korsch et al. 2008), the transition from Musgrave Province into Gawler Craton crust likely corresponds to a structural feature such as the Box Hole Creek Fault or Big Swamp Bore Fault.

Conclusions & Further Work

- There are a number of reasons that may explain a change in heat flow signatures and resistivity signals, however the most likely explanation is **a change in the nature of basement lithology.**
- The nature and location of the boundary between the Musgrave Province and Gawler Craton is currently poorly understood; the new heat flow and magnetotelluric datasets presented in the study suggest that it most likely corresponds to a structural feature located within the transitional heat flow zone.
- To allow higher resolution delineation of this boundary and to further constrain the thermal characteristics of the crust in this region, further work collecting more robust temperature and thermal conductivity datasets is necessary to allow for additional heat flow estimates overlying the transitional zone identified in this study.