Deep seismic reflection line 10GA-CP1

(Pilbara Craton, Capricorn Orogen)

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Location

Maps: Mount Bruce (SF 50-11), Turee Creek (SF 50-15)

Zone: MGA Zone 50

End coordinates: 505312E 7388790N to 574151E 7512403N

Length: 180 km

Scale of interpretation: 1:250 000

Type of modelling: 2D forward modelling of gravity and magnetics and 2D magnetotelluric (MT) inversion of a profile.

This south-southeast to north-northwest-oriented section is coincident with deep reflection seismic line 10GA-CP1 (Johnson et al., 2011, 2013) that transects the Hamersley and Fortescue Basins of the Pilbara Craton and the Ashburton Basin of the Capricorn Orogen (Fig. 1).

Tectonic units

Archean granite–greenstones of the Rocklea Inlier form basement to the Paleoproterozoic Hamersley and Fortescue Basins of the Pilbara Craton (Thorne et al., 2011a). The middle to lower crust along the northern part of the transect comprises the unexposed Carlathunda Seismic Province (Korsch et al., 2011). Volcano-sedimentary rocks of the Fortescue Group (Blake et al., 2004) and distal marine sedimentary rocks of the Hamersley Group (Thorne and Trendall, 2001) overlie the Archean granite–greenstones. The southern margin of the Hamersley and Fortescue Basins is unconformably overlain by siliciclastic sedimentary rocks of the Turee Creek and Ashburton Basins that consist of the Turee and Shingle Creek Group and the Wyloo Group, respectively. The Fortescue and Hammersley Groups are interpreted to underlie the Turee Creek and Ashburton Basins (Thorne et al., 2011b). The Bandee Seismic Province forms the middle crust of the Capricorn Orogen at the southern end of the transect.

Structure

The Hardey and Turner Synclines and the Rocklea Inlier form the main regional-scale structures within the Pilbara Craton. These structures formed during the 2215–2154 Ma Ophthalmia Orogeny (Rasmussen et al., 2005) and affected rocks of the Shingle Creek Group and older deposits. Rocks in the overlying Ashburton Basin were deformed during the 1820–1770 Ma Capricorn Orogeny (Thorne and Seymour, 1991; Sheppard et al., 2010).

Three major trans-crustal faults were imaged in the section. The Baring Downs Fault, which at depth forms the boundary between the Bandee and Carlathunda Seismic Provinces, dips steeply to the northeast. The Nanjilgardy Fault is also a steep, north–east-dipping structure, but is interpreted to be a transpressive flower structure at the surface. In the shallow crust, the Soda Well Fault dips steeply to the northeast, but the angle shallows at depth.

Geophysical data

A gravity profile was extracted from the Geological Survey of Western Australia gravity merged grid of Western Australia (GSWA, 2013a), with points sampled every 440 m (Fig. 2b). Additional gravity points had been taken along the seismic line in addition to the statewide 2.5 km coverage. Topographic data were taken from the Shuttle Radar Topography Mission (SRTM) at the same points. Magnetic data were taken from the State 80 m merged map (GSWA, 2013b).

MT data were also collected along this profile at 5 km spacing for broadband instruments (200 – 0.005 Hz) and 15 km spacing for long-period instruments (0.1 – 0.0001 Hz).

Forward modelling

All modelling was performed in Modelvision v.11.0 software. The starting model was taken from the interpretation of seismic line 11GA-CP1 and modified so that the calculated potential field anomalies fitted the observed anomalies better without significantly changing the seismic form lines.

Forward modelling results

Values for density and magnetic susceptibility used in the modelling are listed in Table 1.

The northern end of the line is dominated by high-amplitude, short-wavelength magnetic anomalies (Fig. 2b), and high-amplitude gravity anomalies (Fig. 2d), which can be associated with banded iron-formation (BIF) of the Hamersley Group in the Turner Syncline. A significant amount of remanence is associated with the Hamersley

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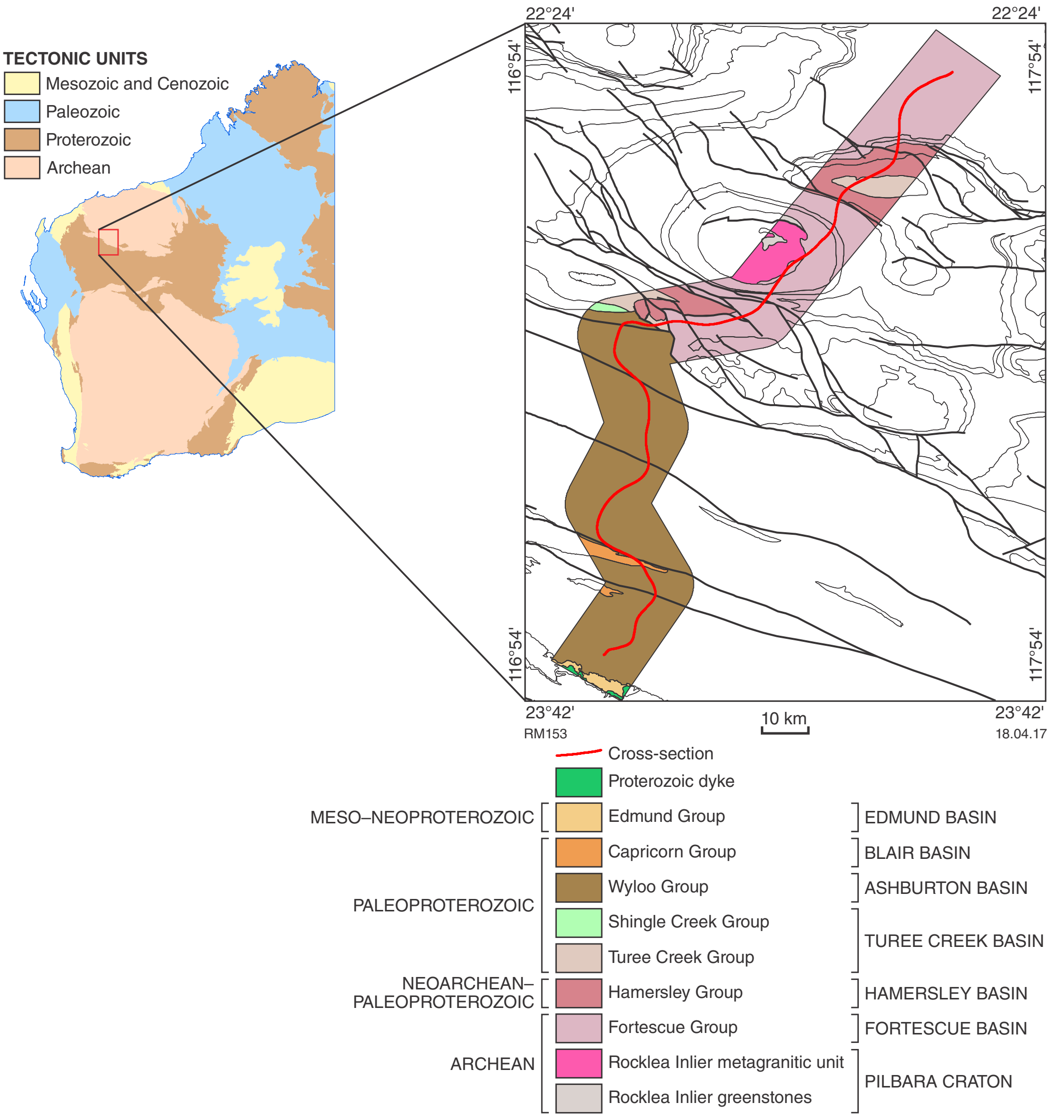

Figure 1. Simplified 1:500 000 interpreted bedrock geology map of the Hamersley and Fortescue Basins (Pilbara Craton) and the Ashburton Basin (Capricorn Orogen) showing location of cross-section A–B

Table 1. Summary of the physical properties used in the gravity model of the seismic line 10GA-CP1. The colour column refers to colours used in Figure 2a

Colour	*Modelled unit*	*Rock type*	*Density (g/cm³)*	*Magnetic susceptibility (SI)*
	Upper Wyloo Group	Sedimentary siliciclastic	2.67	
	Lower Wyloo Group	Sedimentary siliciclastic	2.70 – 2.80	
	Turee Creek Group	Sedimentary siliciclastic	2.80	
	Hamersley Group	Sandstone and BIF	3.20	0.10 – 0.20
	Fortescue Group	Mafic rocks	2.85 – 2.90	
	Pilbara granite–greenstones	Granites with greenstones	2.58 – 2.70	
	Carlathunda Seismic Province	Lower crust	2.90	
	Bandee Seismic Province	Middle crust	2.80	0.05
	Lower Bandee Seismic Province	Lower crust	2.90	
	Upper mantle	Mantle	3.20	

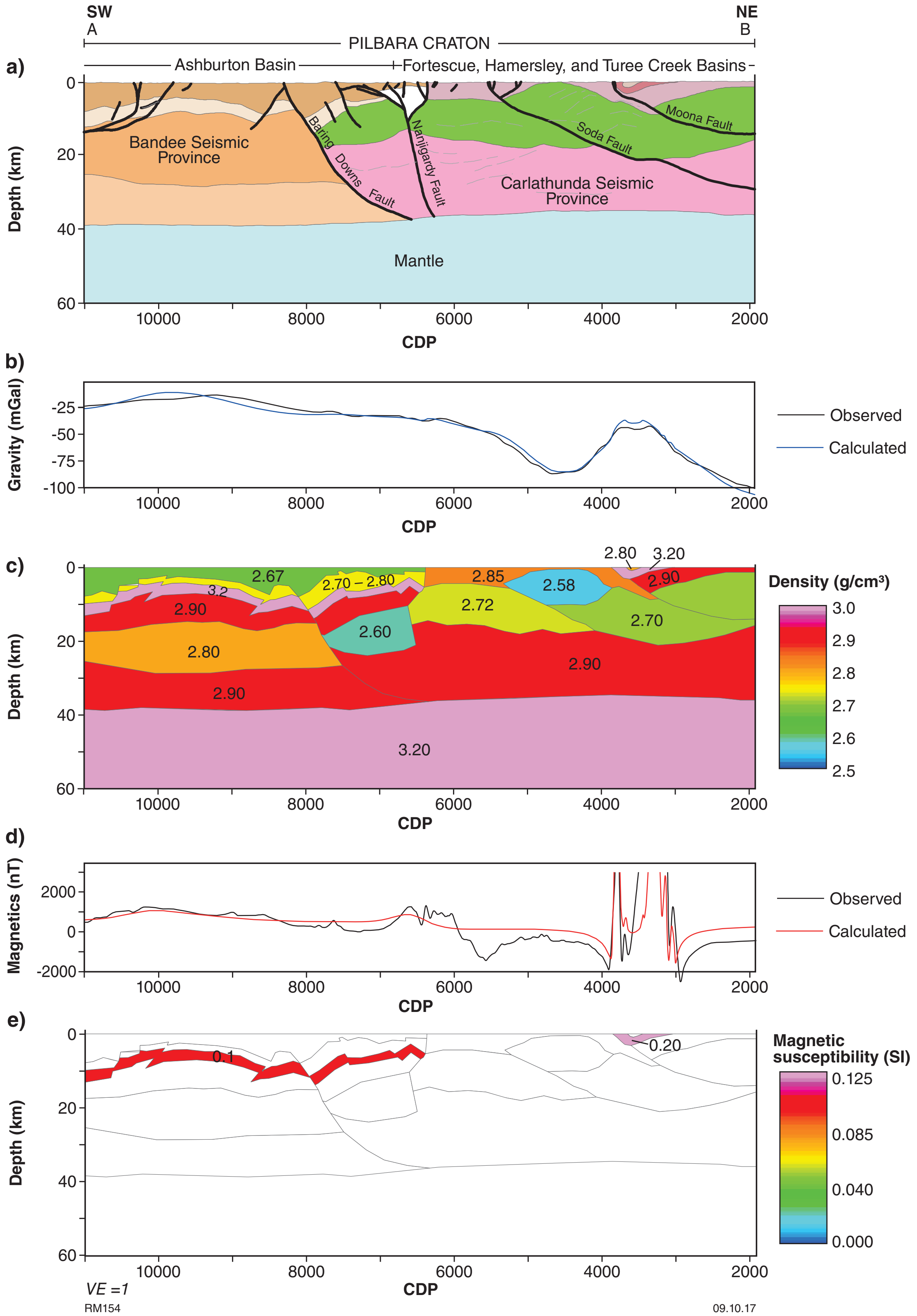

Figure 2. **Profiles of the seismic line 10GA-CP1 showing: a) lithological section from the interpretation of seismic data; b) observed and calculated gravity anomaly profile with error line; c) section of density per lithology; d) observed and calculated gravity anomaly profile with error line; e) section of magnetic susceptibility per lithology**

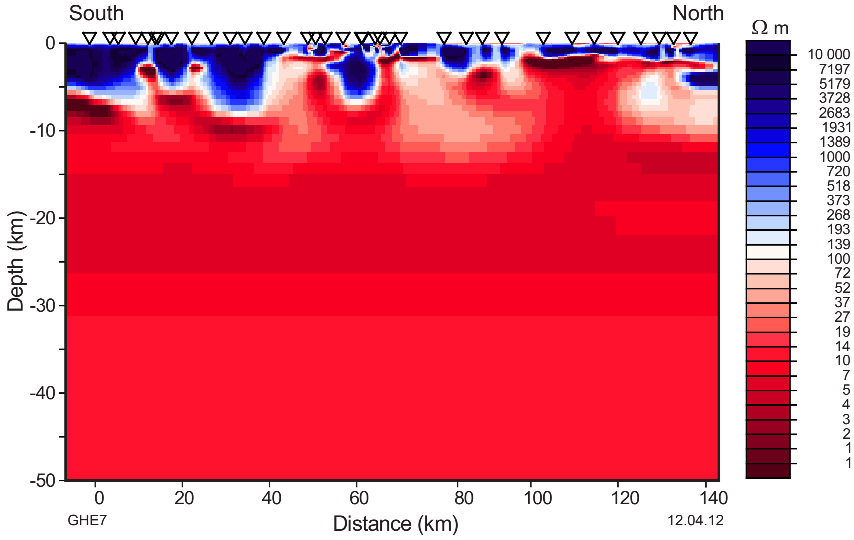

Figure 3. 2D resistivity section for line 10GA-CP1. The bandwidth of the inversion was 200 – 0.1 Hz. The profile orientation was taken to be 30°E of geographic north (with geological strike perpendicular to the profile)

Group, and hence the signals are far stronger than have been modelled (Guo et al., 2011).

The Fortescue Group is dominated by mafic volcanic and volcaniclastic rocks and has a much smoother magnetic signature.

The strong magnetic signal in the region of the Nanjilgardy Fault are from BIF within the Hardey Syncline, but are off-section to this line and were therefore not modelled.

The Ashburton Basin is modelled as a gentle dome (Fig. 2a) with a strong magnetic signature, which appears to be truncated at the Baring Downs Fault. This also appears to be the boundary between higher density rocks in the south compared to the relative low gravity at the northern end. These high-density rocks could have originated in the Bandee Seismic Province, but an alternative model would place layers of Hamersley and Fortescue Groups underlying the Ashburton Basin. The addition of the Hamersley Group gives a better fit to the regional magnetic anomaly (Goodwin, 2011).

MT inversions

Modelling and inversion of the MT data was done using the WinGLink software, which utilizes the 2D inversion code of Rodi and Mackie (2001). More details on the data processing can be found in Heinson et al. (2011).

Inversion results

The final plot of the MT along the profile of 10GA-CP1 (Fig. 3) (Heinson et al., 2011) is the simplest model which fits the observed MT responses. Only the broadband responses were used in the inversions. The resistivity structure appears fairly uniform. It consists of a thin conductive sedimentary layer at the top, underlain by a very resistive layer 2–10 km thick, which thickens at the southern end of the profile. This is underlain by a very conductive (~1 Ω) region. Below this region, the model cannot be resolved as the conductive layer does not allow the current to flow any deeper. This fact also prevents any structures within the basins to be imaged. During the processing, many responses showed evidence of 3D structure and possible anisotropic conduction which was not modelled here.

Long-period data were not modelled due to the low quality and 3D features.

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