# A seismic model of the crust through the Broken Hill Block and Tasman Line

*Jim H. Leven[1], Doug M. Finlayson[1], Andrew Owen[1], David Johnstone[1], & Barry J. Drummond[1]*

## Introduction

**Wide-angle seismic refraction profiling has helped to resolve crustal structure in the Broken Hill Block and across its eastern-bounding Darling Lineament (part of the Tasman Line, representing the Late Proterozoic continental rift margin in eastern Australia). The Australian Geodynamics Cooperative Research Centre undertook this work in 1997, primarily to determine whether the abundant amphibolites in the Broken Hill Block might have been sourced from a mid-crustal magma chamber. A secondary objective was to determine seismic wavespeeds in the crust; lower crust with high wavespeeds is typical in regions with I- (granodiorite) type intrusions, which are common in Proterozoic terranes in Australia but rare in the Broken Hill region.**

This work complements AGSO's recent (1996–97) deep seismic reflection profiling through the Broken Hill Block, and represents a further crustal geophysical contribution to the Broken Hill Exploration Initiative for the National Geoscience Mapping Accord. The reflection data show a prominent series of southeast-dipping events, interpreted as shear zones, some extending through the entire crust (Gibson et al. 1998: AGSO Record 1998/11). Within the eastern portion of the Broken Hill Block, the upper crustal shear zones have a listric character and appear to sole into a major detachment at around 10 km depth.

## Wide-angle seismic profiling

Eighty-six seismic group recorders (SGRs) on loan from the United States Geological Survey were deployed along a NW–SE-oriented profile extending over 350 km from the Olary Block (northwest) through the Broken Hill Block to the Murray–Darling Basin (Fig. 19). Station spacing varied from 2.5 km over the Broken Hill Block to 10 km near either end of the profile. Seismic signals were recorded digitally on tape drives in each instrument during pre-programmed time windows, and shots were fired within these time windows. The seismic signals were detected by 2-Hz geophones buried beside the SGR recorders.

Six shots were detonated during this program. Two 3000-kg shots (1 and 6) were positioned at either end of the profile to provide wide-angle data to offsets in excess of 300 km, and four intermediate, 1000-kg shots (2 to 5) were positioned along the profile to provide additional control on the mid-crustal seismic structure.

## The wide-angle seismic data

The recorded seismic events have been classified into five seismic phases (Fig. 20): Pg1(upper crustal refracted phase), Pg2 (lower crustal refracted phase), PcP (reflected phase from the mid-crustal boundary), PmP (reflected phase from the Moho), and Pn (Moho headwave phase).

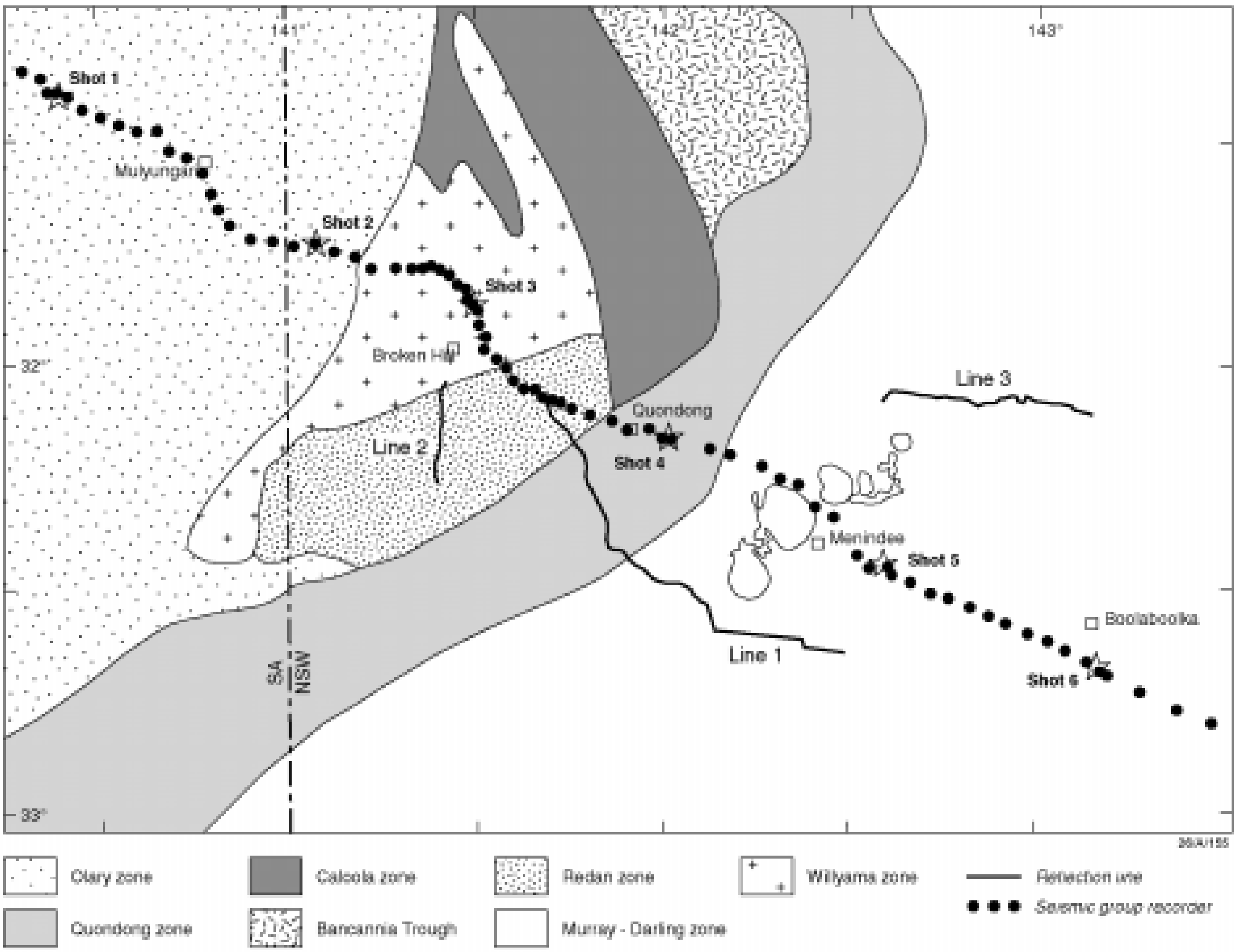


Fig. 19. Location of the Broken Hill wide-angle seismic profile.

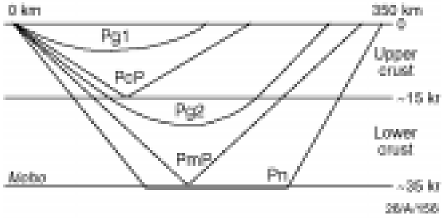


**Fig. 20. A simplified model showing the major wide-angle (refracted) raypaths.**

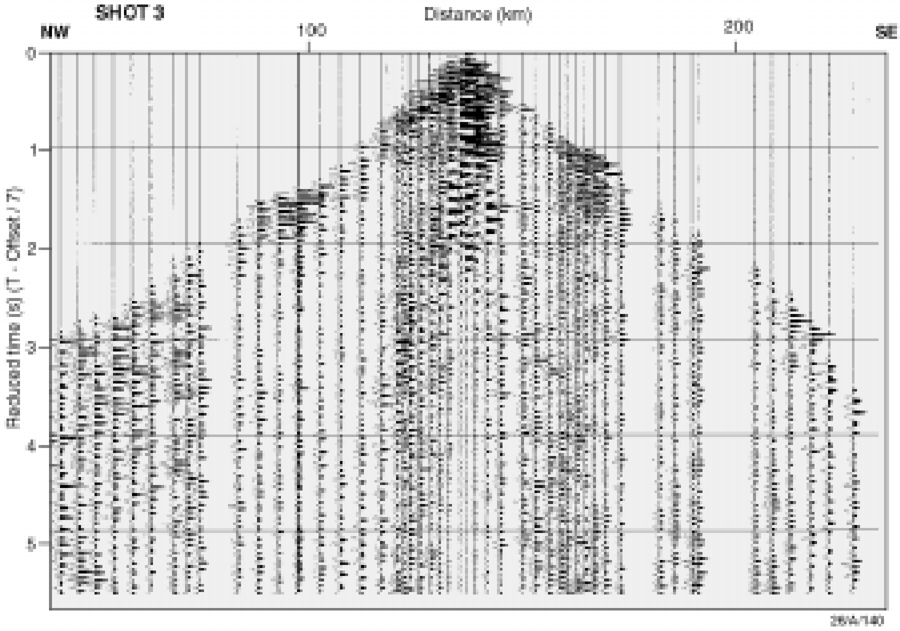


**Fig. 21. An example of the Pg1 arrivals from shot 3 detonated north of Broken Hill and recorded across the Broken Hill Block. These Pg1 arrivals show little delay time, indicating the presence of basement rocks with a P-velocity near 5.9 km/s near the surface.**

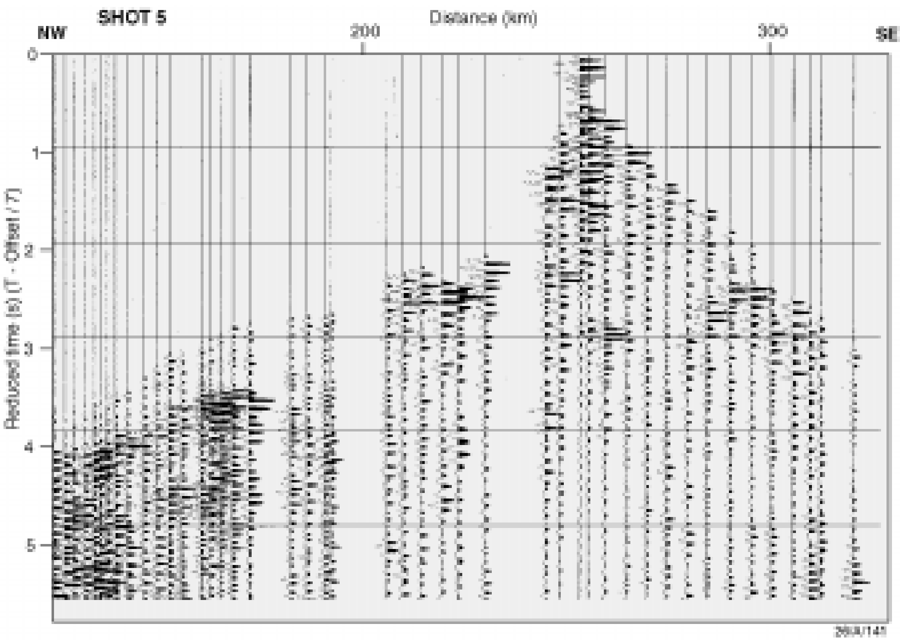


**Fig. 22. An example of the Broken Hill survey Pg1 arrivals from shot 5, detonated east of Menindee. These Pg1 arrivals show a significant delay time, indicating the presence of near-surface low-velocity rocks. The striking asymmetry of the Pg1 arrivals indicates rapidly changing geometry of this low-velocity zone, which corresponds to the Menindee Trough.**

The Pg1 phase for shot 3, detonated north of Broken Hill, has moderately symmetrical travel times about the shot (Fig. 21), and indicates basement P-wavespeed gradually increasing from 5.9 km/s beneath a thin weathering layer. The first arrivals from this shot provide no evidence for a marked variation in P-wavespeed in the upper crust beneath Broken Hill. In contrast, the Pg1 phase for shot 5 (Fig. 22), detonated near Menindee, evinces a delay-time of 600 ms and prominent asymmetry. Its first arrival times reflect a low-wavespeed near-surface layer, and a large variation in the thickness of this layer and/or upper crustal wavespeed either side of the shot.

Computing the observed arrival times of these various phases has enabled us to construct a P-wavespeed model of the crust along the profile (Fig. 23).

## The model

The model features:

- a two-layer crust:
  - upper layer with P-wavespeeds ranging from 5.9–6.4 km/s; and thickness, 20–30 km (thickest beneath the Broken Hill Block);
  - lower layer with P-wavespeeds ranging from 6.8–7.2 km/s; and moderately constant thickness, around 14 km;
- Moho depth ranges from 35 km on either side to 43 km beneath the Broken Hill

Block, and a sub-Moho P-wavespeed of 8.1 km/s;

- low seismic wavespeeds in the upper crust associated with and to the west of the Menindee and Blantyre Troughs, in the region of the Darling Lineament; and
- low lower-crustal P-wavespeeds; no evidence of an underplated lower crustal layer with P-wavespeeds above 7.5 km/s, and therefore no likely source region for I-type (granodiorite) magmas.

## Conclusions

The seismic model indicates a prominent thickening of the upper crust beneath Broken Hill, but no associated thickening of the lower crustal layer. Lower crustal P-wavespeeds are lower than world average beneath the Broken Hill Block. A region of low P-wavespeed extends into the basement beneath and to the west of the Menindee Trough.

[1] Australian Geodynamic Cooperative Research Centre (AGCRC) & Australian Geological Survey Organisation, GPO Box 378, Canberra, ACT 2601; tel. +61 2 6249 9275 (JHL); fax +61 2 6249 9972 (JHL); email Jim.Leven@agso. gov.au.

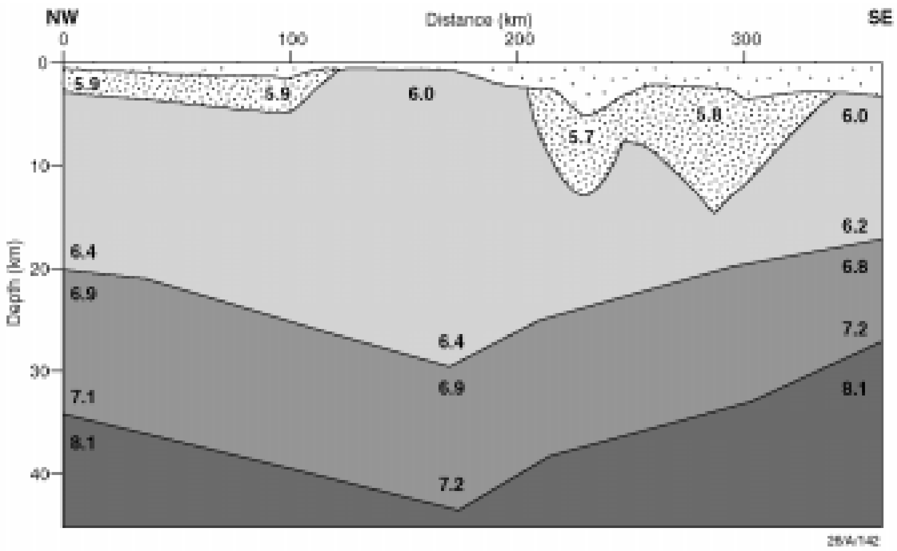


**Fig. 23. The P-wavespeed model derived from the seismic arrival times along the Broken Hill profile.**