Sedimentary Thickness Across Australia From Passive Seismic Methods

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1) Introduction

Finding new mineral deposits hidden beneath the sedimentary cover of Australia is a national priority. A fundamental first step in finding new deposits is to characterise the depth of sedimentary cover. Excellent constraints on the sedimentary thickness can be obtained from borehole drilling or active seismic surveys. However, these approaches are expensive and impractical in the remote regions of Australia. Using receiver functions (RFs), specifically the delay time of the P-to-S converted phase generated at the interface of the sedimentary basement, relative to the direct-P arrival, we can obtain a first order estimate of the thickness of sedimentary cover for a vast array of seismic stations across Australia.

2) Method

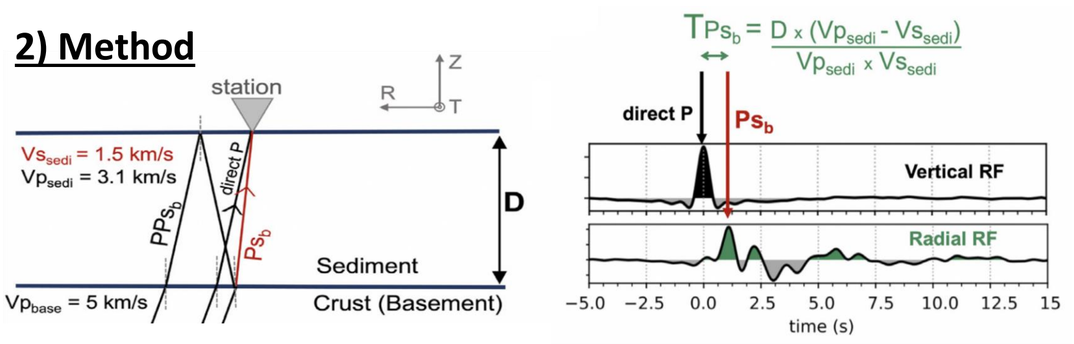


Figure 1: (left) Schematic diagram showing the P-to-S conversion of seismic waves at the crust-sediment interface. (right) Illustrative vertical and radial receiver functions, showing the delay caused by energy conversion at the crust-sediment interface. (Reproduced from Agrawal et al 2022.)

3) Results

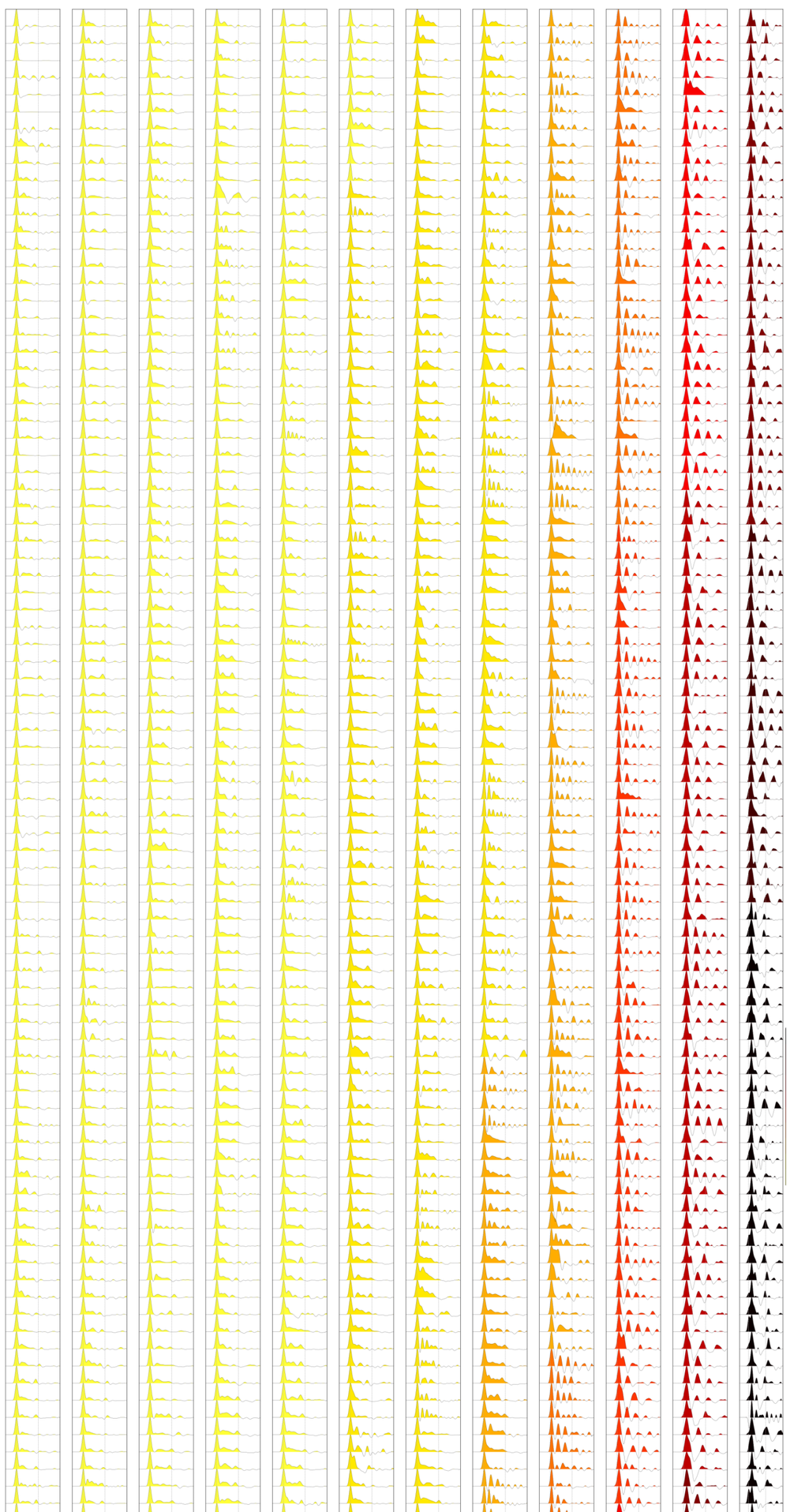


Figure 3: Stacked receiver functions for 1450 seismic stations across Australia, coloured by delay time of the sediment basement converted phase. Times given relative to the P-arrival onset.

Figure 2: Forward modelling of receiver functions (right top) and their autocorrelations (right middle) for models with varying sedimentary thickness (left). In this model, sedimentary v_s is 1 km s^{-1}. The delay time of the first P arrival varies linearly (as expected) with thickness but can only be detected for thicknesses > 300m. The two-way traveltime of shear waves is also difficult to constrain when sediments are thin, but then shows an approximately linear relationship with sediment thickness.

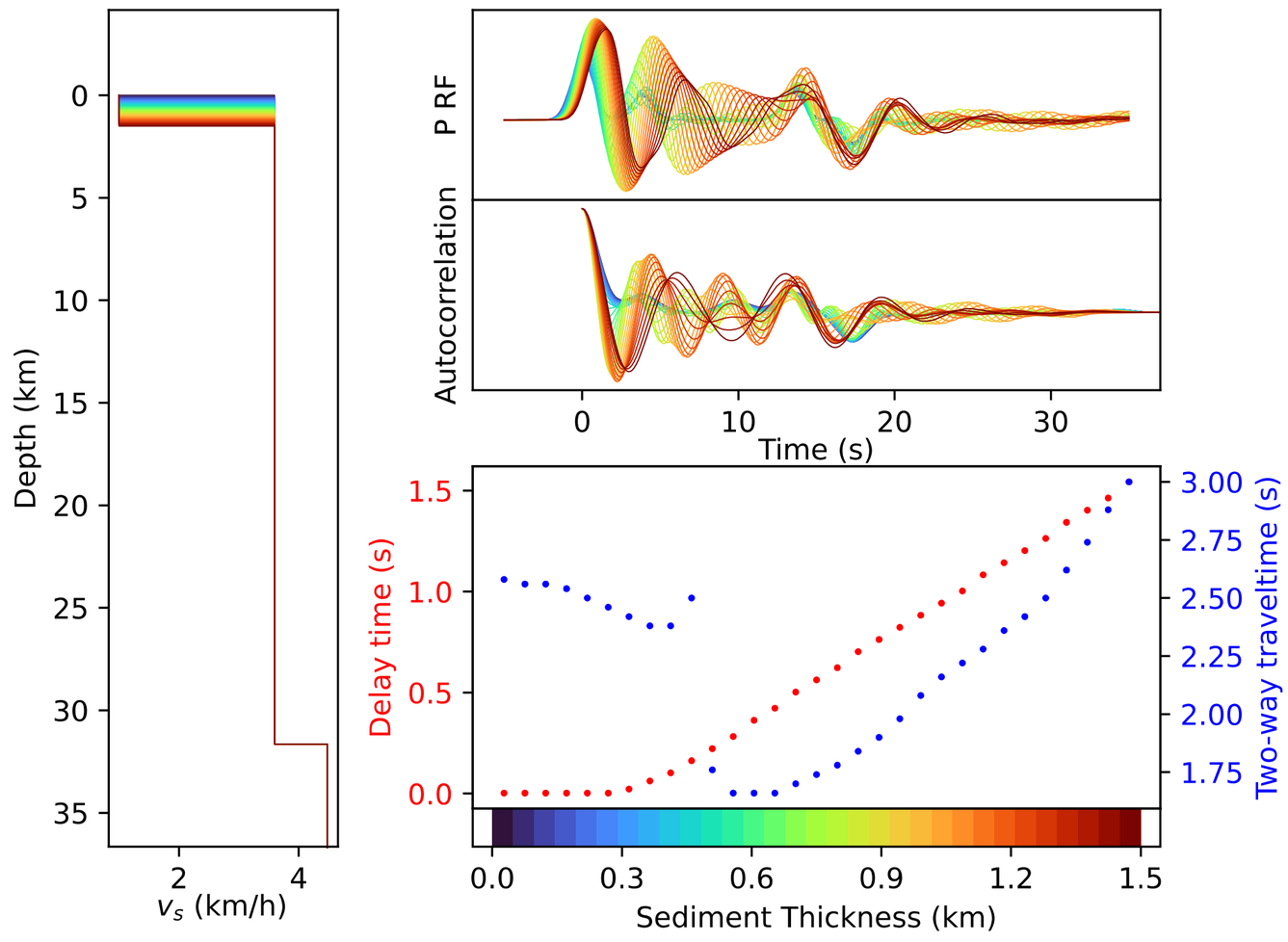
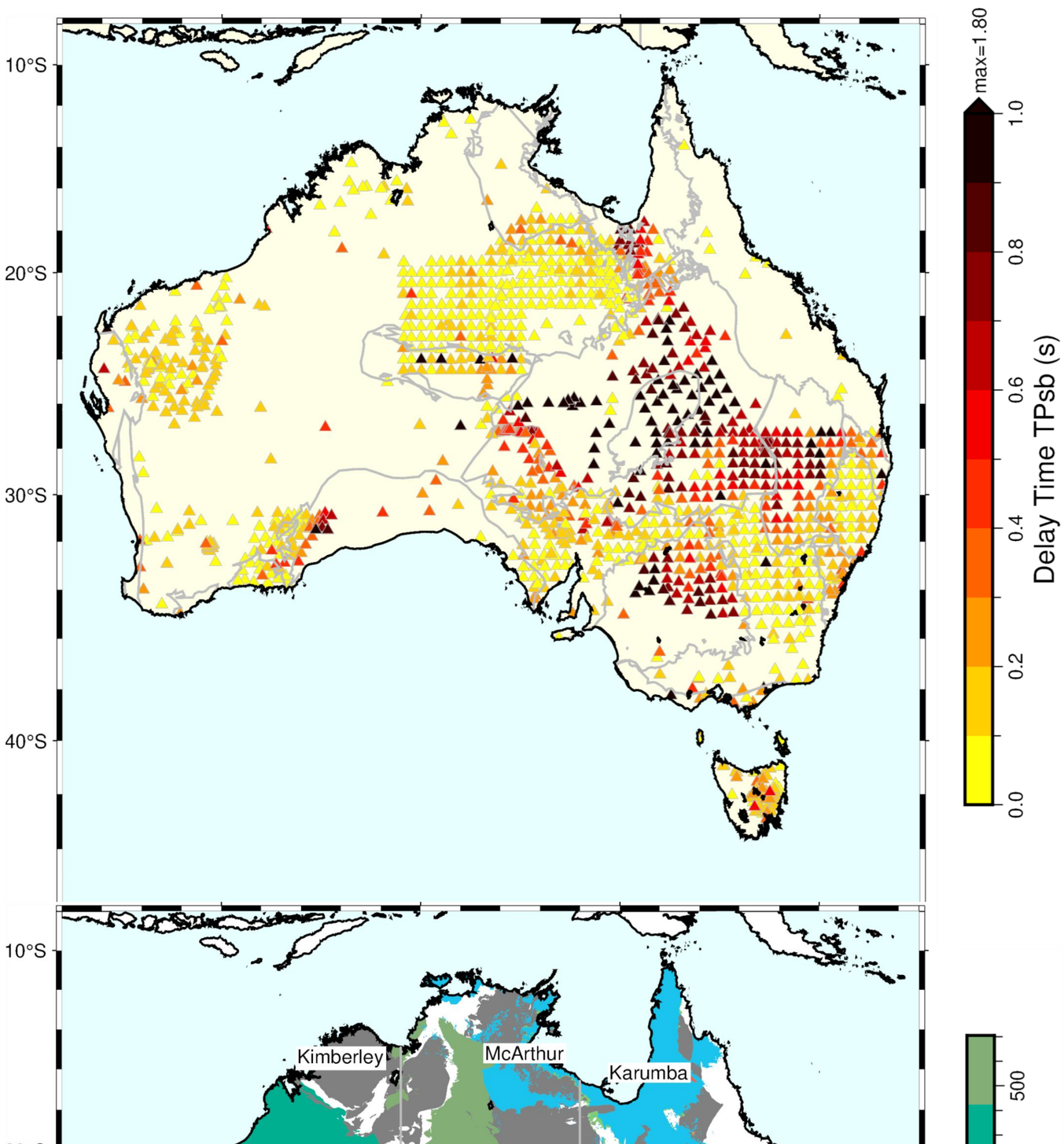


Figure 4: (bottom) Geological map of Australia showing the major sedimentary basins, coloured by age. (top) Delay times of the sediment basement converted phase across Australia. Grey lines outline the major sedimentary basins.



4) Conclusions

Form the receiver function delay times we identify many features, such as the relatively young Cenozoic Eucla and Murray Basins, despite many reverberations in the less consolidated sedimentary layers of the seismic phases. From a comparison with measurements of sedimentary thickness from local boreholes, we expect to obtain a straightforward predictive relationship between the delay time and the sediment thickness.

References
Shubham Agrawal, Caroline M Eakin, John O'Donnell, Characterizing the cover across South Australia: a simple passive-seismic method for estimating sedimentary thickness, *Geophysical Journal International*, Volume 231, Issue 3, December 2022, Pages 1850–1864,