Supplemental Material

Characterising the cover across South Australia: A simple passive-seismic method for estimating sedimentary thickness

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This document contains the caption for Table **S1** and figures (**S1-S7**).

Table S1: Table contains the Psb phase arrival information and the receiver function estimated basement depth. In total, it contains the 231 seismic stations with at least 10 individual receiver functions that passed the quality control. Columns represent – Network, Station, Latitude (North), Longitude (East), Number of receiver functions, Psb arrival (seconds), Receiver function estimated basement depth (m).

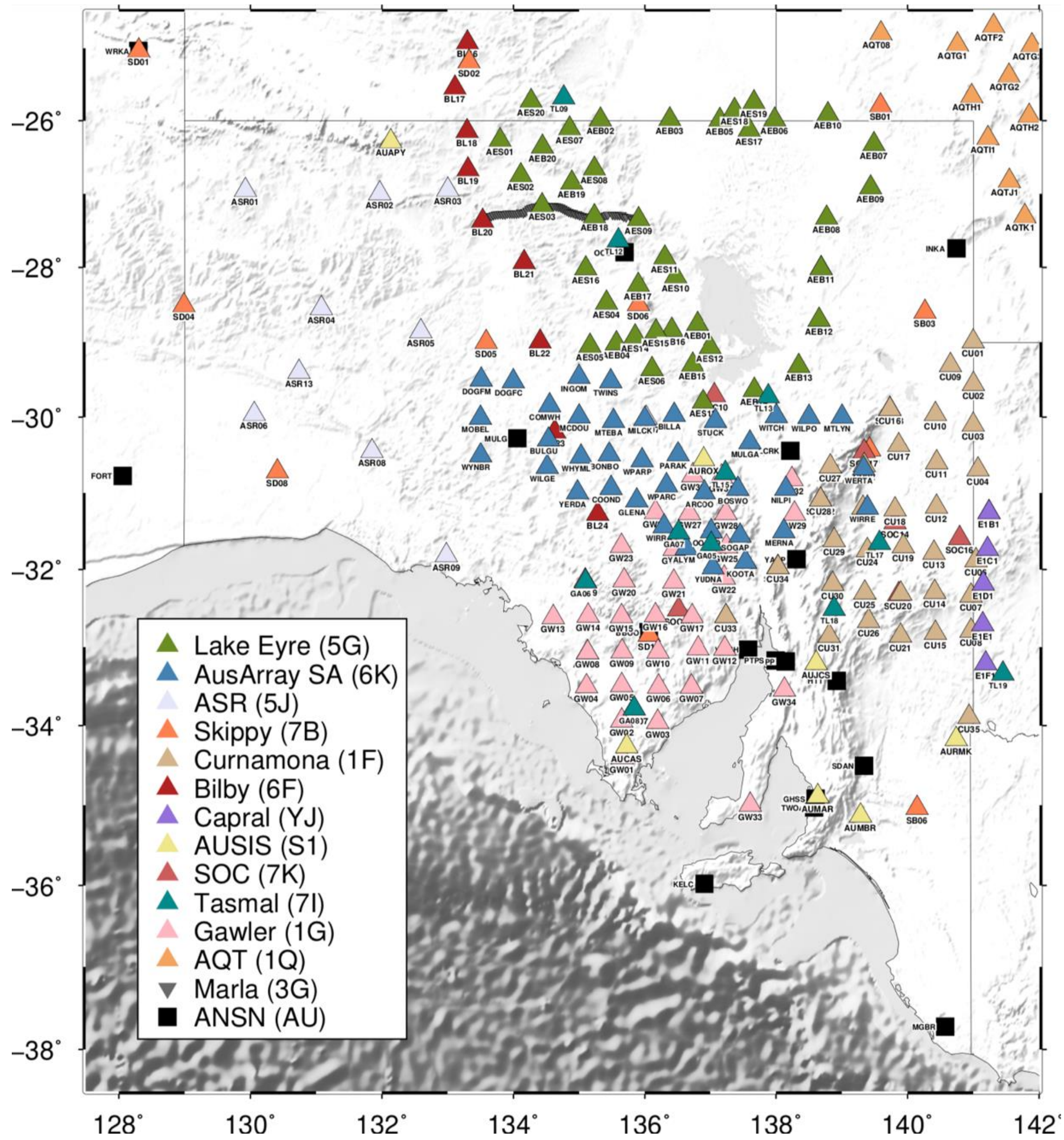

Figure S1. Map of all the seismic stations (243) used in this study. Stations are coloured by the seismic networks, according to the legend. See Data and Resources Section for more information.

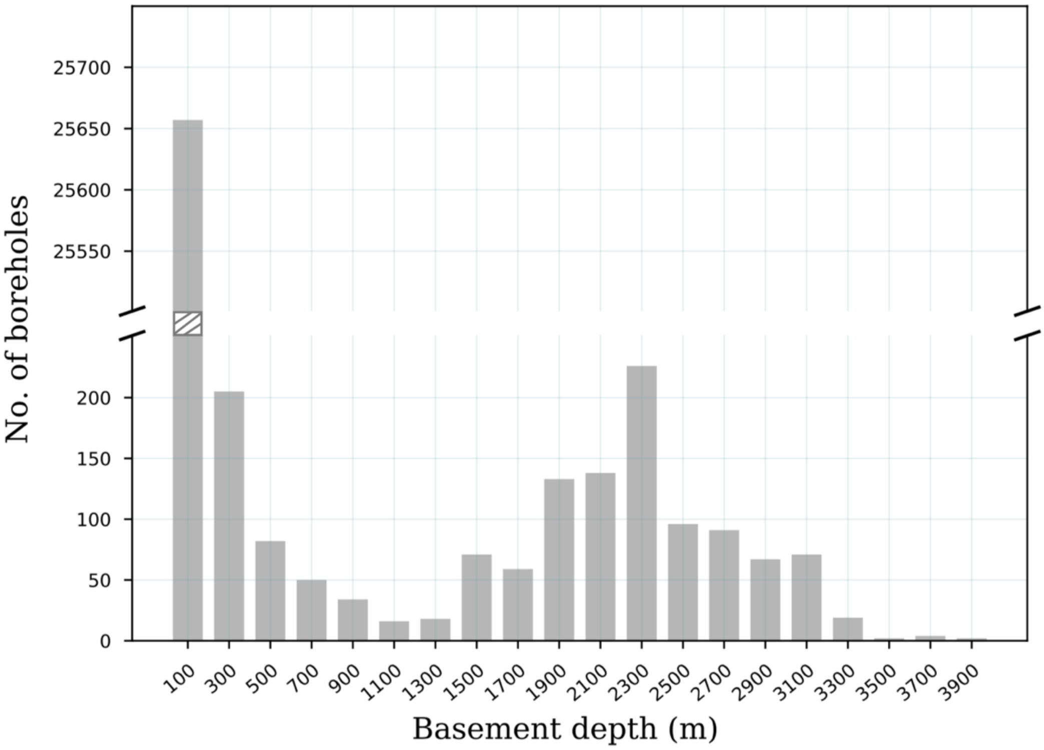

Figure S2. Histogram depicting the variation in the borehole depths in South Australia (see Data Availability Section for details). Out of 27,100 boreholes, more than 25,657 were drilled in places with less than 200 m of sediments. The parallel bars on the y-axis represent a change in scale along the y-axis.

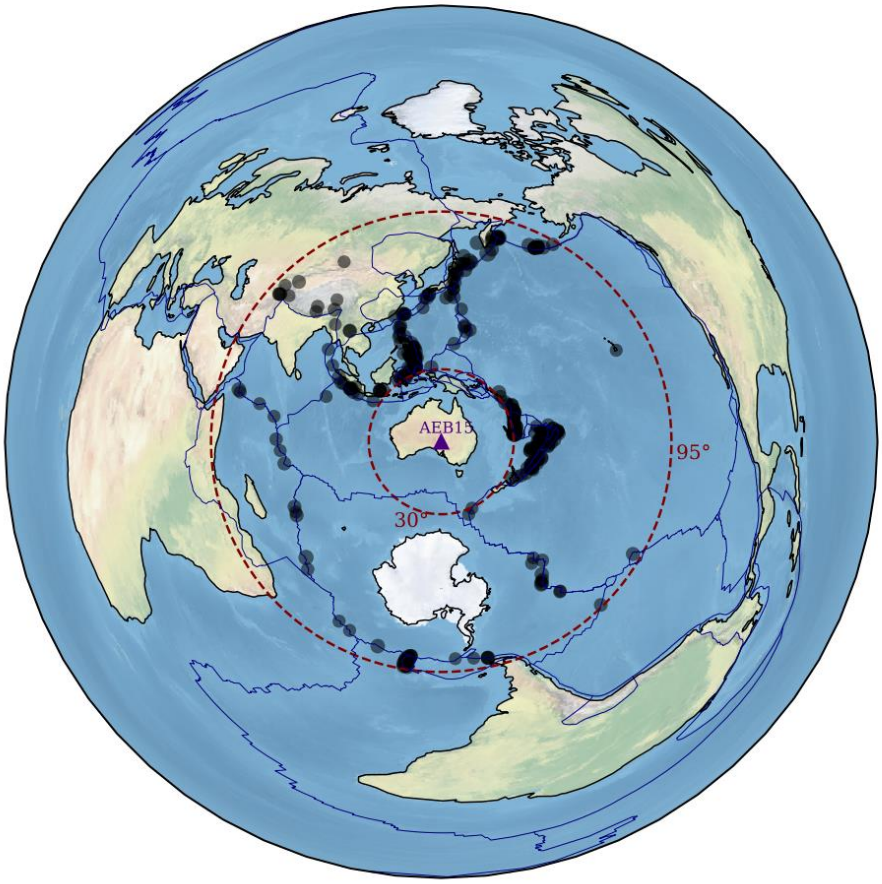

Figure S3. Earthquakes (black circles) available for receiver function analysis for a typical station AEB15 (Lake Eyre seismic array). The dashed red circles represent the epicentral distance between which the earthquakes were sought. In total, 246 earthquakes of Mw > 5.5 were available.

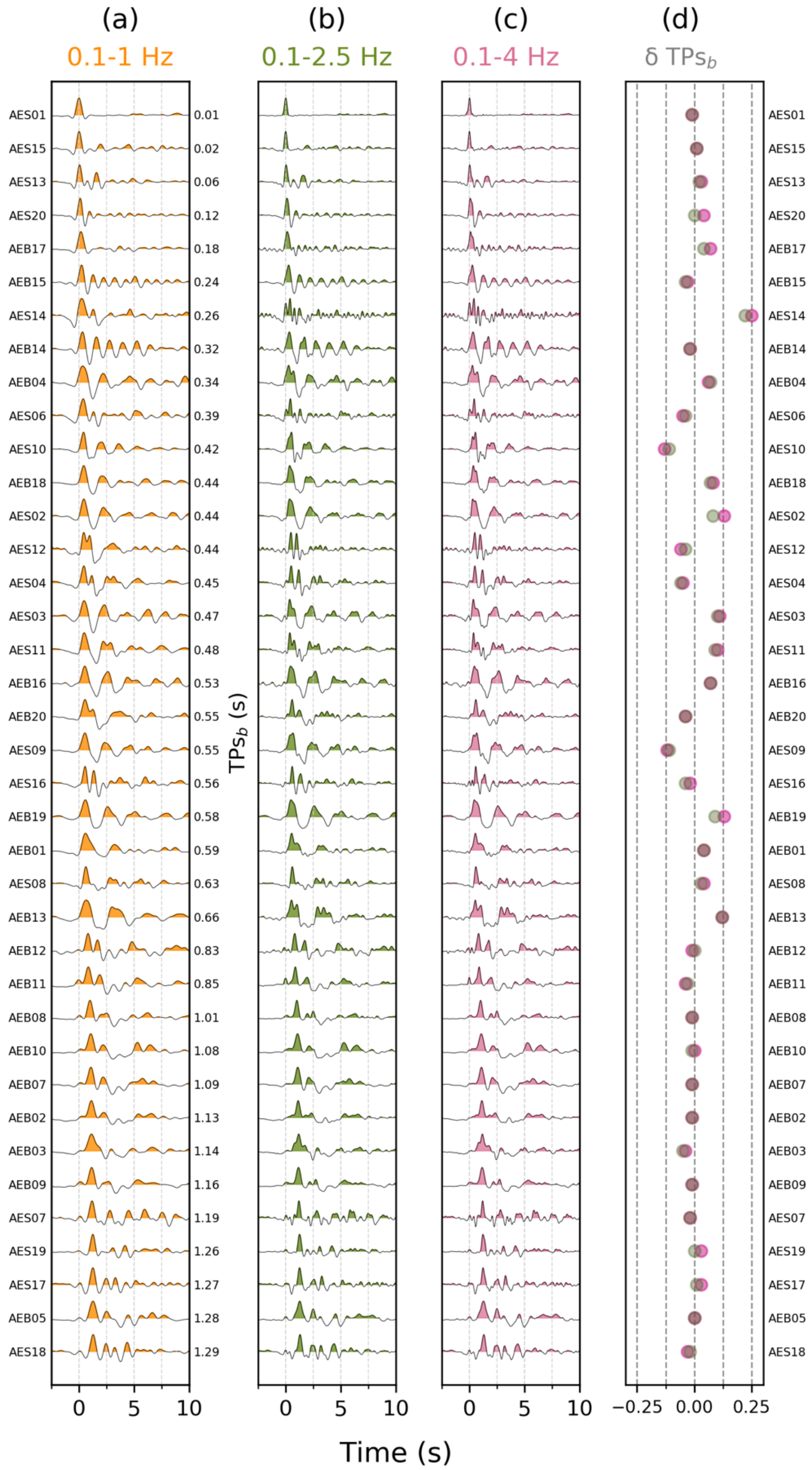

Figure S4. Receiver functions for stations from the Lake Eyre seismic array calculated using three different frequency bands (a-c). RF (a-c) are arranged by increasing TPsb values, as listed on the right hand side of sub-figure (a). (d) Coloured circles represent the differential TPsb time between the higher frequency RF from (b) in green or (c) in pink with the original RF calculated in the lower frequency band 0.1-1 Hz as shown in (a).

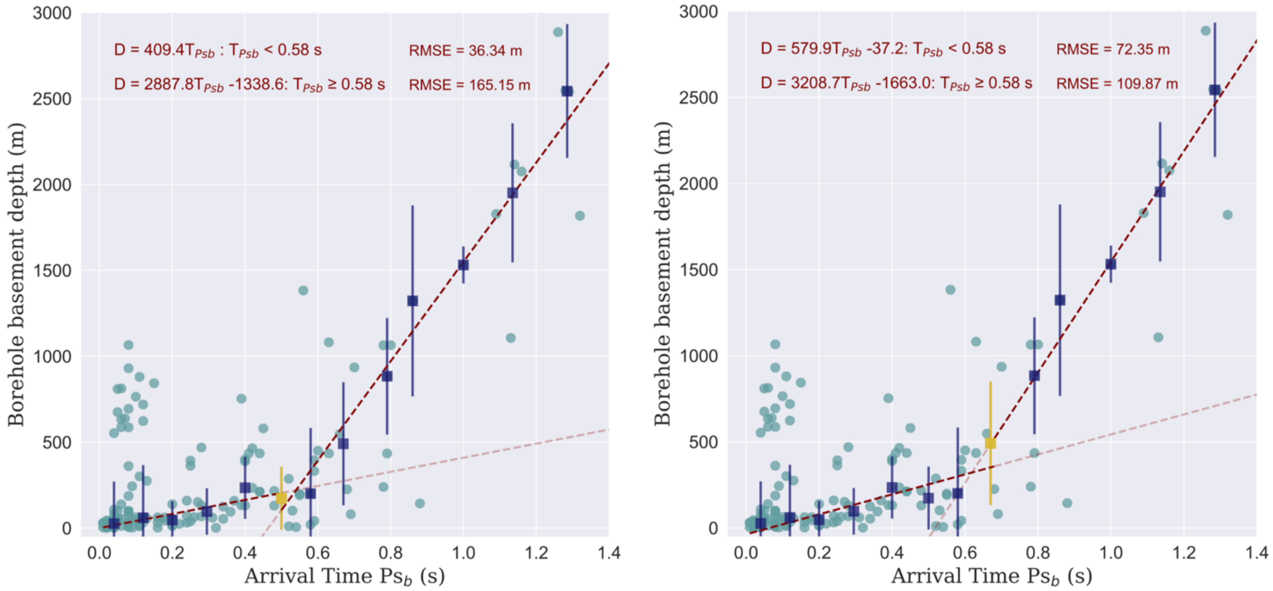

Figure S5. Statistical comparison of the receiver function estimated TPsb and borehole basement depth beneath 200 seismic stations, plotted as turquoise circles. Dark blue squares are the binned median values for every 0.09 s, with solid blue lines representative of the standard deviation. The yellow squares (left 0.5 s; right 0.68 s) denote the point of inflection in the data, about which two linear equations (maroon dotted lines) are regressed. When a different inflection point is chosen, as shown here, then the root mean square error (RMSE) increases compared to Figure 6.

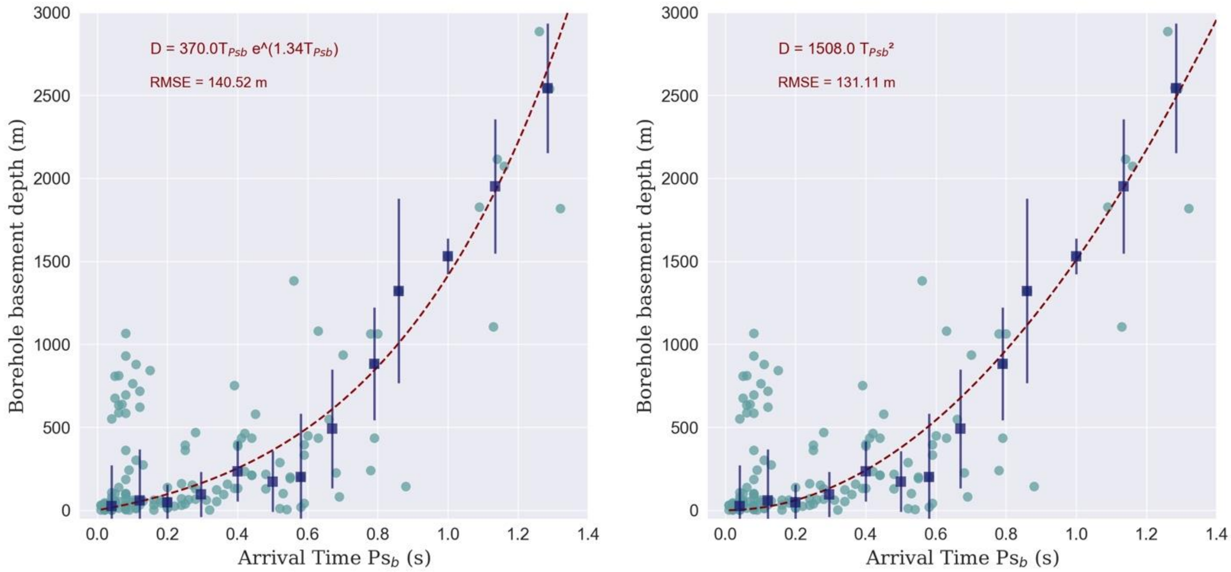

Figure S6. Same as Figure S5, except data is regressed to an exponential (left) and quadratic (right) relation between basement depth and TPsb. In both cases the RMSE is larger than the best fitting linear relations (Figure 6).

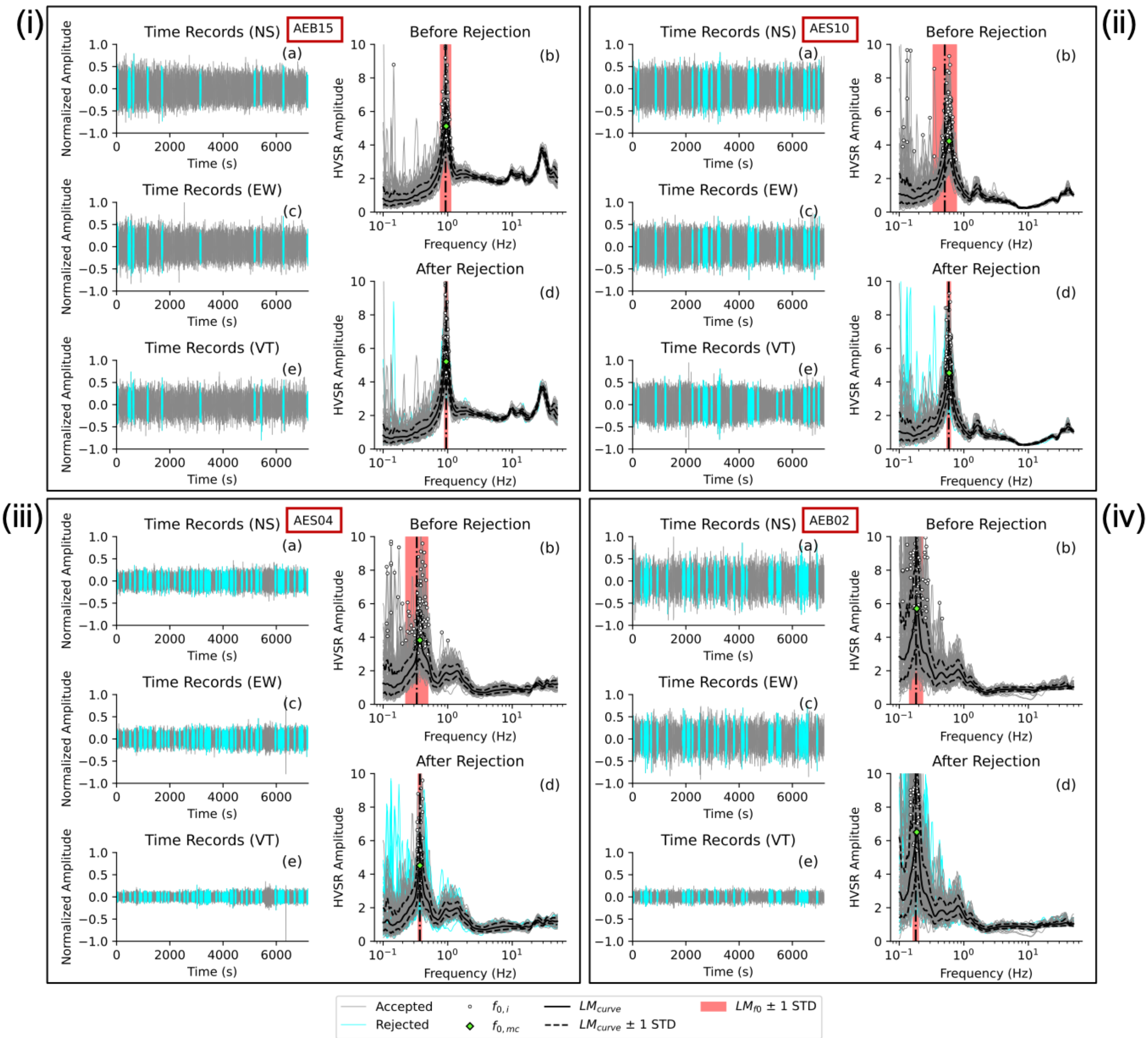

Figure S7. Examples of HVSR analysis to estimate fundamental site frequency (f_0) shown for four Lake Eyre array stations – AEB15 (i), AES10 (ii), AES04 (iii), and AEB02 (iv) - in increasing order of sediment thickness, using hvsrpy python package (Vantassel, 2020). For each station: (a,c,e) 2-hour long three-component seismically quiescent time records are chosen, with cyan windows indicating the rejected parts, according to a frequency-domain window-rejection algorithm (Cox et al., 2020). HVSR curves before (b) and after rejection (d), where white circles are the $f_{0,i}$ values for each 60 sec time window and the green diamond represents the lognormal (LM) median of the $f_{0,i}$ values. The LM f_0 (standard deviation) for the stations AEB15, AES10, AES04, and AEB02 were found to be 0.95 Hz (0.05), 0.59 hz (0.06), 0.37 Hz (0.05), and 0.18 Hz (0.04) respectively. For further clarification of the methodology, we refer the reader to Cox et al. (2020).

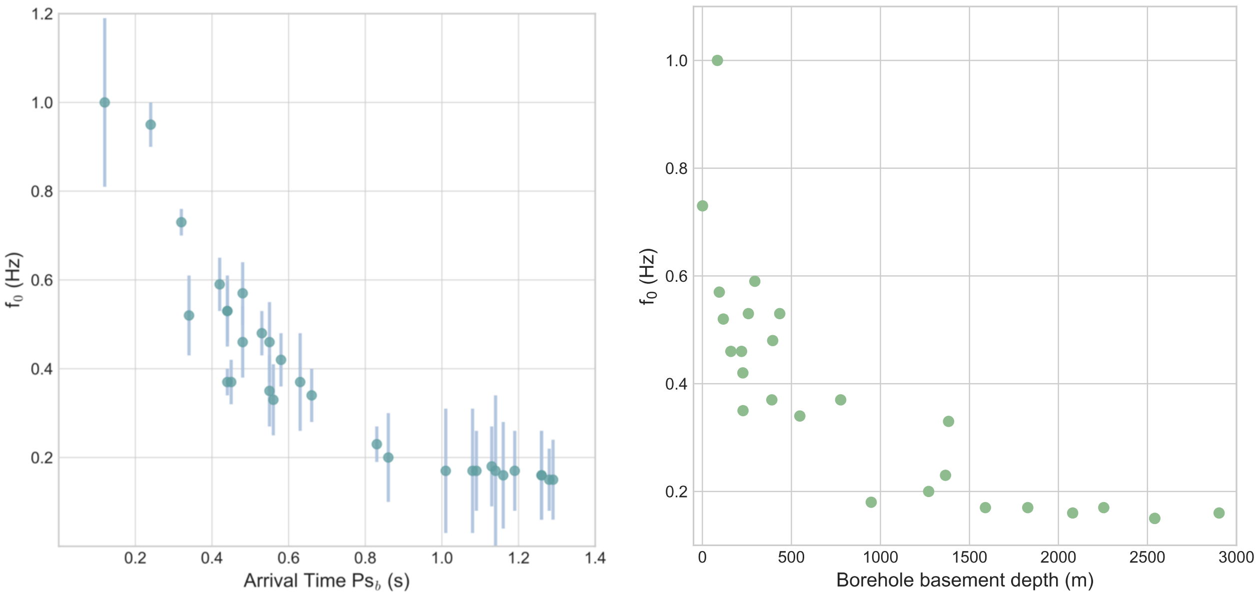

Figure S8. a) Comparison of HVSR obtained site fundamental frequency (f_0) and Ps_b time from receiver functions for Lake Eyre array stations (plotted as circles). The site fundamental frequency is calculated using ambient seismic noise (Fig. S7) following the methodology of Cox et al. (2020). The vertical bars represent the standard deviation in f_0 for each seismic station. b) Fundamental frequency (f_0) for stations plotted against the borehole basement depth obtained using the Inverse Distance Weighting. As expected, the fundamental frequency decreases as the sediment thickness increases, as indicated by both the Psb arrival time (a) and borehole basement depth (b).

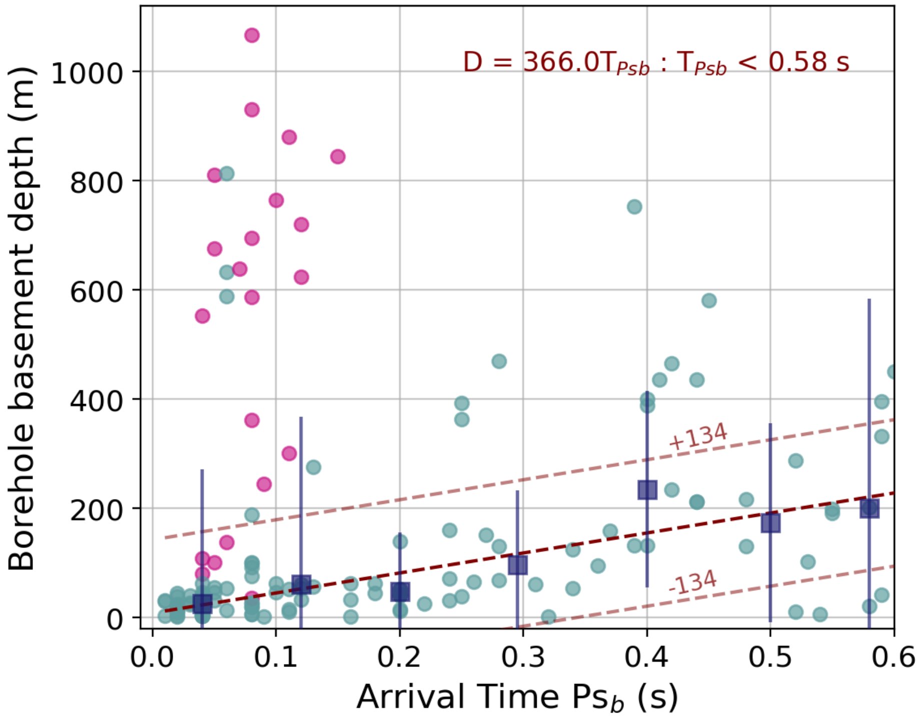

Figure S9. Same as Figure 6 in the main text but for TPsb < 0.6s. The dark red dashed line is the regressed line with the equation shown on the top right. The light red dashed lines are plotted ± 134m of the equation, representing the average standard deviation of the binned data points (i.e. the average size of the error bars over this range).

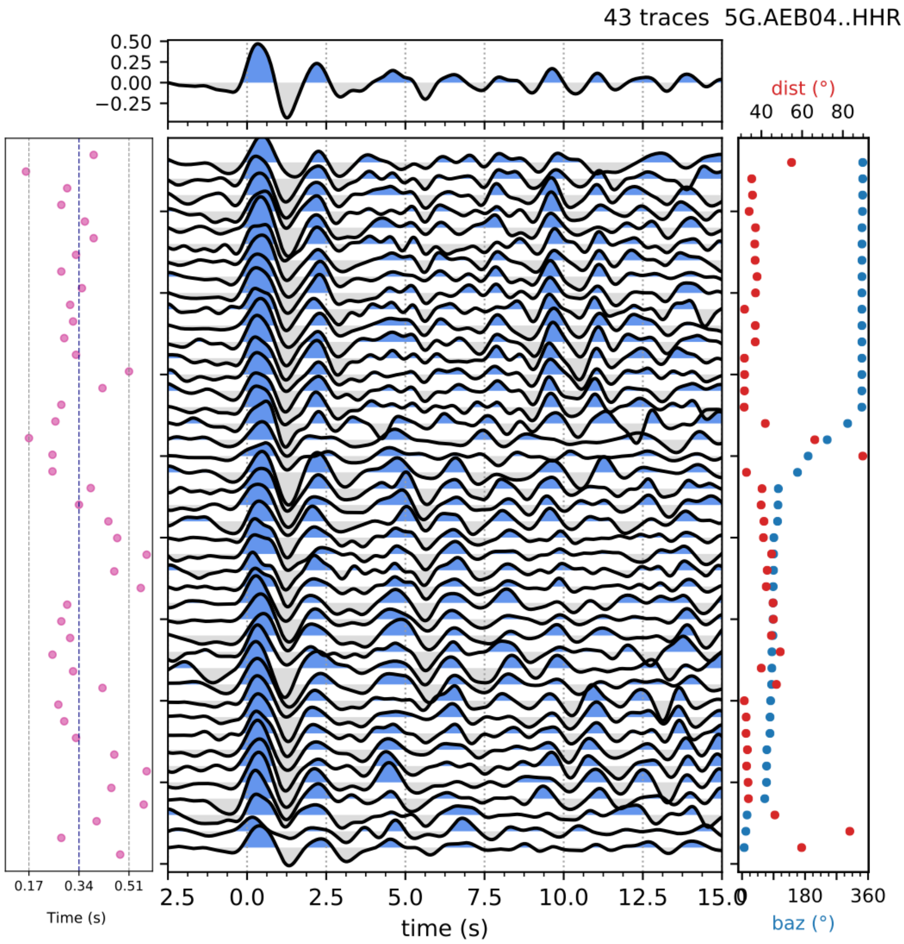

Figure S10. Receiver functions for station AEB04 which displayed some of the largest backazimuthal variations. The right panel provides epicentral distance (red dots) and backazimuth (blue dots) values for each receiver function. The left panel shows the TPsb picks from individual traces centered around 0.34 sec - Psb arrival time in the stack.

Reference

Cox, B. R., Cheng, T., Vantassel, J. P., & Manuel, L., 2020. A statistical representation and frequency-domain window-rejection algorithm for single-station hvsr measurements, Geophysical Journal International, 221(3), 2170–2183.

Vantassel, J., 2020. jpvantassel/hvsrpy: v0. 2.1 (version v0. 2.1). zenodo.