

Structure of the crust and upper mantle beneath the Bransfield Strait (Antarctica) using P receiver functions



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The Bransfield Strait is a rift basin located between the Antarctic Peninsula (AP) and the South Shetland Islands (SSI), where ongoing slab rollback of the Phoenix plate under the Antarctic and Shetland plates is causing back-arc spreading. We use teleseismic P-wave receiver functions to study the crustal and upper mantle structure of the region. Data is obtained from twelve seismic stations belonging to three networks: CCV, DCP, LVN (Instituto Andaluz de Geofísica – Universidad de Granada); ESPZ, JUBA (Antarctic Seismographic Argentinian Italian network); DECP, ELEF, FREI, LOWI, OHIG, PRAT and SPPT (Seismic Experiment in Patagonia and Antarctica). DCP and DECP are treated as a single station. Receiver functions are calculated with the time-domain iterative deconvolution method by Ligorria & Ammon (1999).

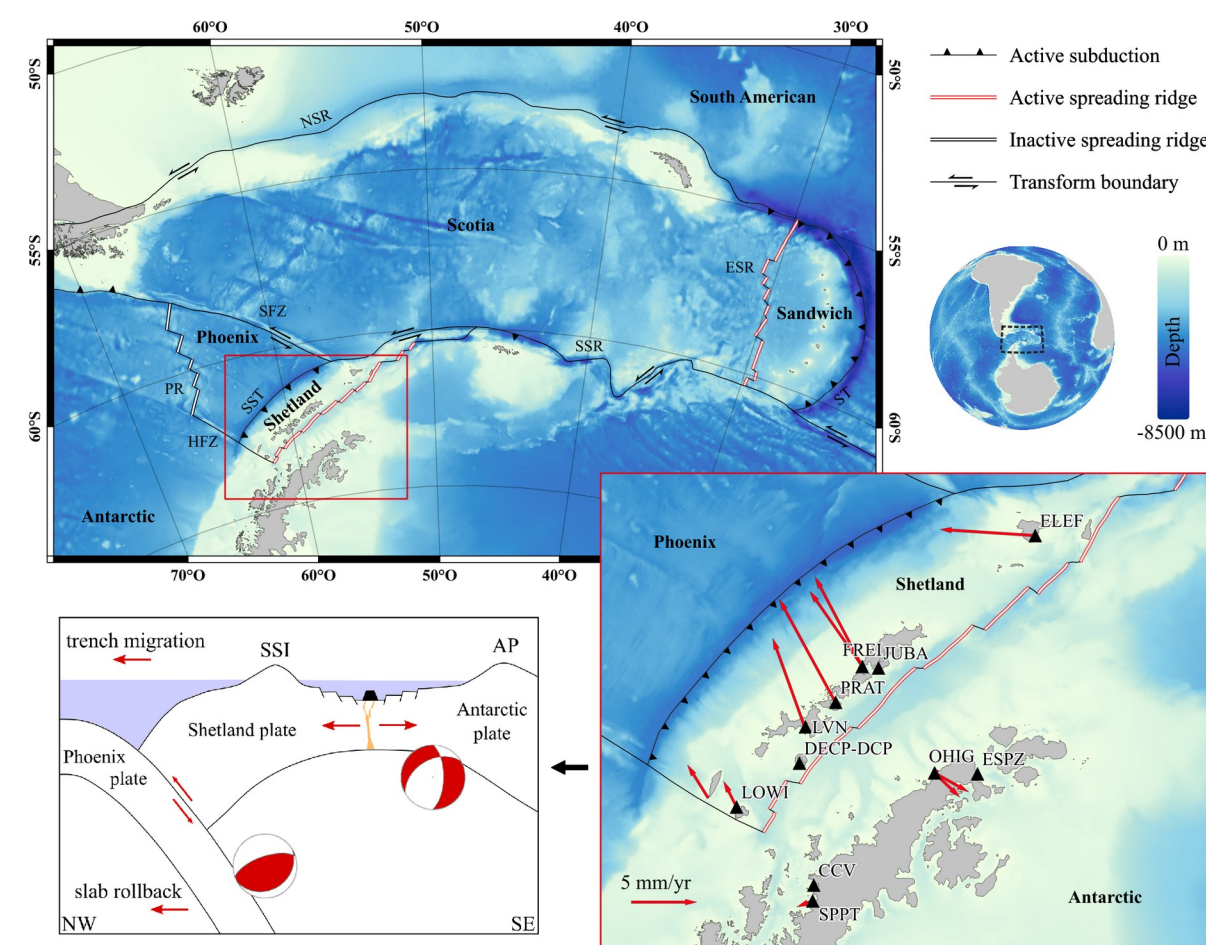


Figure 1. Tectonic setting of the Bransfield Strait and location of the seismic stations (ETOPO1 relief). Beach ball plots from Robertson Maurice et al. (2003); horizontal ground motion data from Taylor et al. (2008).

Conclusions

Our results reveal a highly heterogeneous crust in the SSI, achieving a minimum crustal thickness of 15 km in Deception Island. High V_p/V_s (>1.95) may indicate the presence of melts and/or a heavily fractured medium. The AP displays much more heterogeneous characteristics, averaging a crustal thickness of 34 km and a V_p/V_s ratio of 1.77. The spatial distribution of H - κ reflects the asymmetrical geometry of the rift basin, with the SSI being affected by extension to a greater extent.

In the SSI, we interpret the deepest converted wave (Ph_{3s}, at 70-90 km) as the oceanic Moho of the Phoenix slab. Ph_{2s} (45-70 km) indicates the presence of a Low Velocity Zone (LVZ) in the mantle wedge that could act as the source of melts, favored by slab devolatilization. Melts may then ascend and get trapped beneath the crust, producing an underplating layer (Ph_{1s}, at 35-45 km). The AP lacks both the slab and the underplating layer, even though we also identify a LVZ (Ph_{2s}). This suggests widespread partial melting of the upper mantle below the basin.

The MTZ thickness analysis reveals it is clearly thickened below the AP, and thus that the Phoenix slab subducts steeply. The traces also show a delay relative to the theoretical P_{410s} and P_{660s} arrivals, providing further evidence for the LVZ.

Crustal thickness (H) and V_p/V_s (κ)

Crustal thickness and V_p/V_s estimates are obtained with the H - κ stacking technique by Zhu & Kanamori (2000). H - κ results also allow us to estimate the arrival times of the multiples of P_{ms} (the converted wave at the Moho discontinuity), therefore making easier the identification of other converted phases beneath the crust.

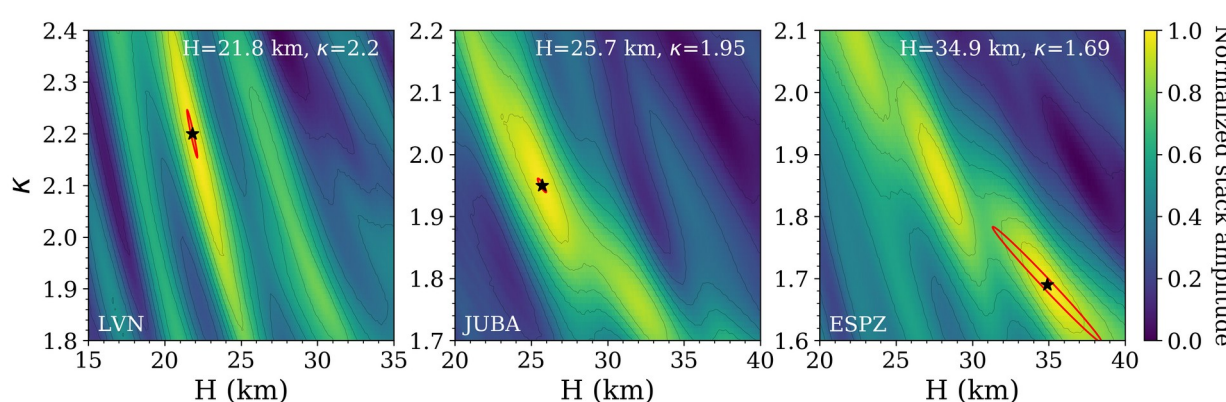


Figure 2. H - κ stacking examples. Red ellipses indicate the standard error.

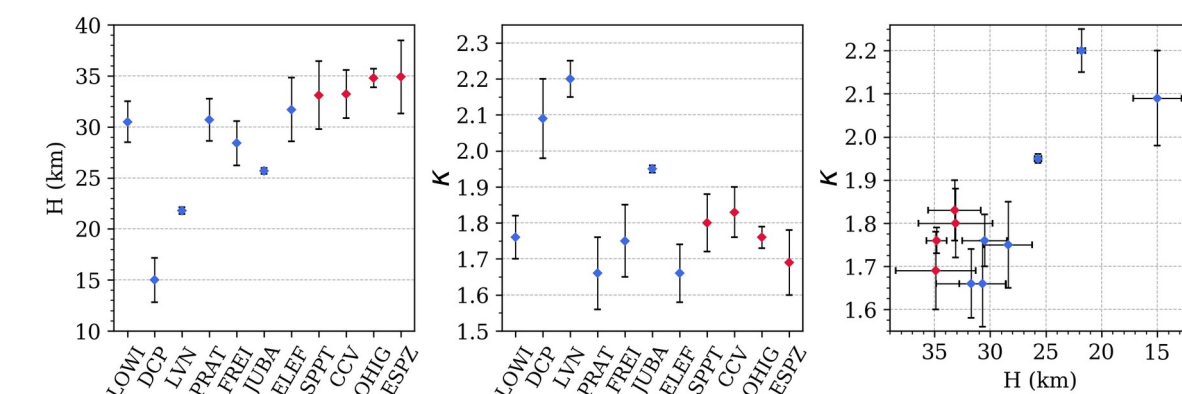


Figure 3. H - κ results with standard error. Stations in the SSB are shown in blue, whereas stations in the AP are shown in red.

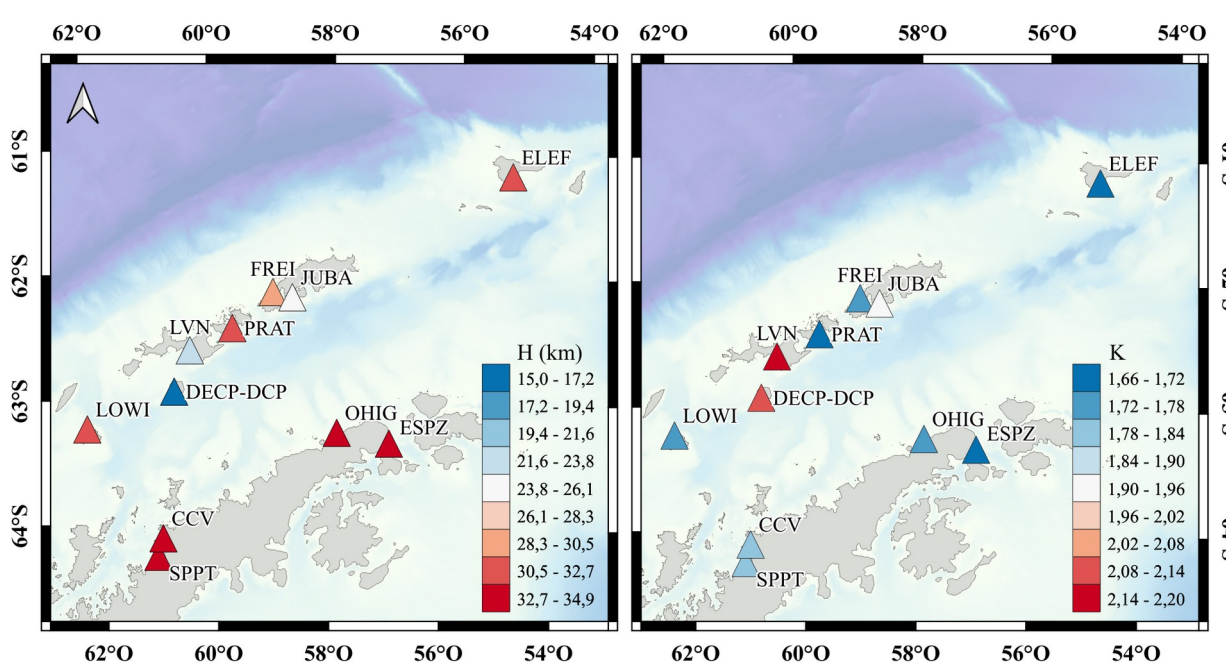


Figure 4. Spatial distribution of H and κ in the Bransfield Strait.

Ligorria, J., Ammon, C., 1999. Iterative deconvolution and receiver-function estimation. *Bulletin of the Seismological Society of America* 89 (5), 1395–1400.
Robertson Maurice, S. D., Wiens, D. A., Shore, P. J., Vera, E., Dorman, L. M., 2003. Seismicity and tectonics of the South Shetland Islands and Bransfield Strait from a regional broadband seismograph deployment. *Journal of Geophysical Research: Solid Earth* 108 (B10).
Taylor, F. W., Bevis, M. G., Dalziel, I. W. D., Smalley, R., Frohlich, C., Kendrick, E., Foster, J., Phillips, D., Gudipati, K., 2008. Kinematics and segmentation of the South Shetland Islands-Bransfield basin system, northern Antarctic Peninsula. *Geochimica et Geophysica*, Geosystems 9 (4), n/a–n/a.
Zhu, L., Kanamori, H., 2000. Moho depth variation in southern California from teleseismic receiver functions. *Journal of Geophysical Research: Solid Earth* 105 (B2), 2969–2980.

Upper mantle and Mantle Transition Zone (MTZ)

Three converted waves are identified and interpreted as discontinuities in the upper mantle: Ph_{1s}, Ph_{2s} and Ph_{3s}. The MTZ is analyzed using a grid stacking approach.

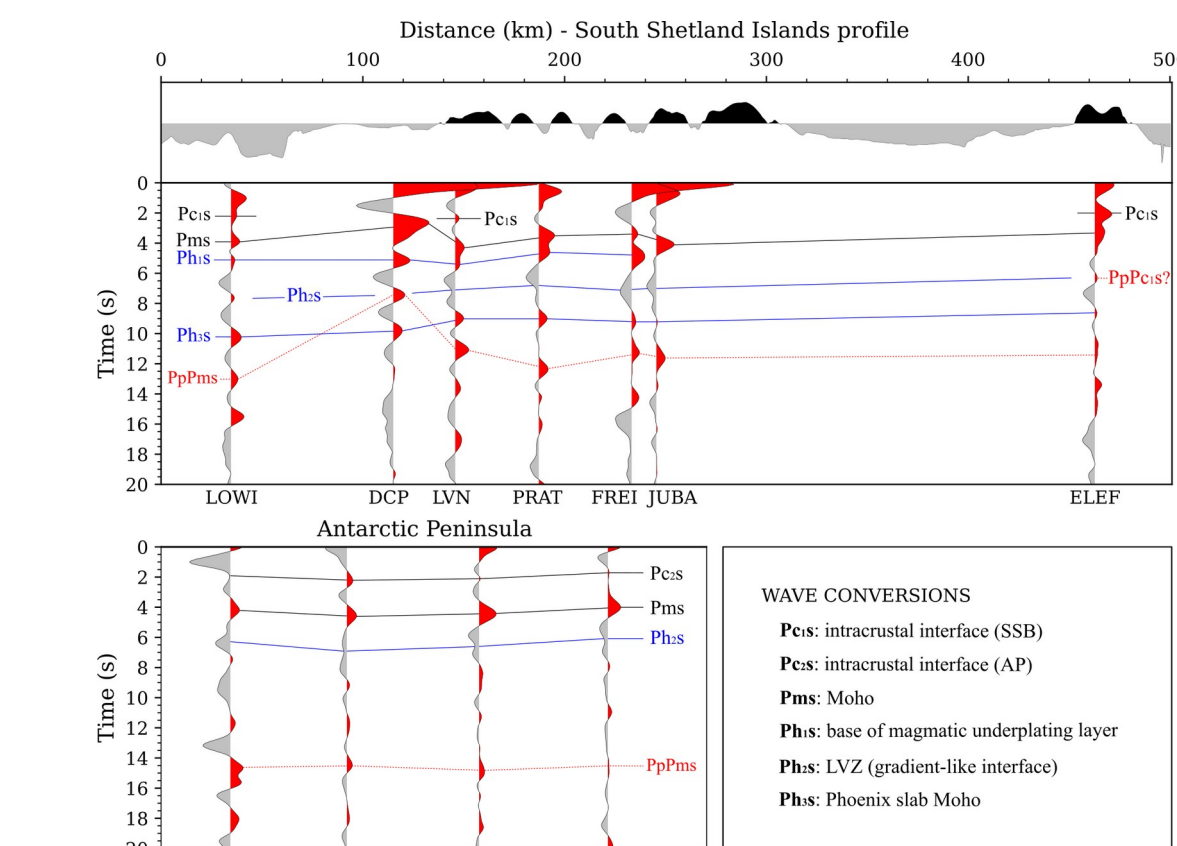


Figure 5. Receiver function stacks (Q component) and their interpretation. Solid lines connect the pulses interpreted as converted phases (black is for crust and blue is for mantle). Dashed red lines connect multiples.

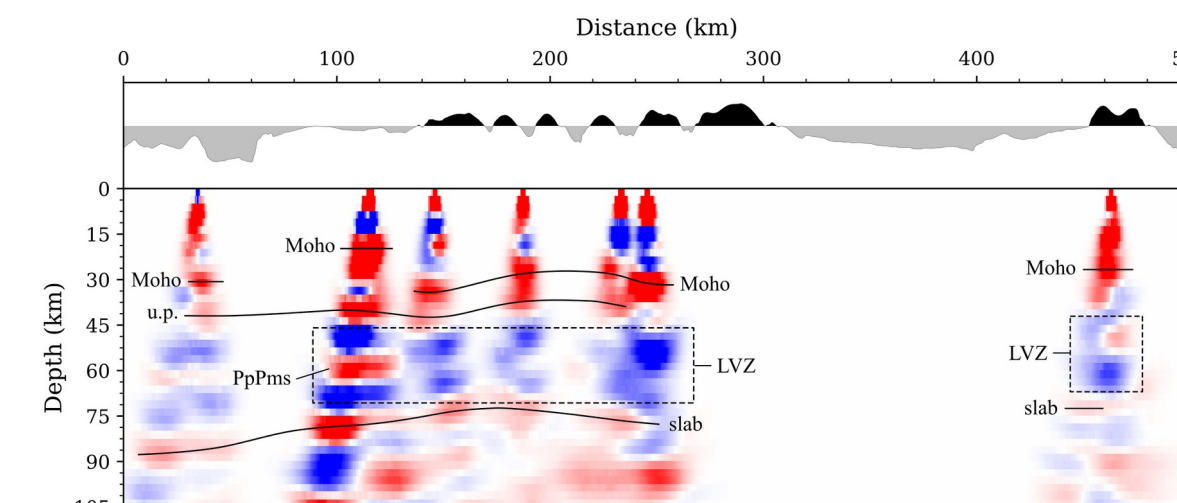


Figure 6. Common-conversion point stacking profile of the SSI and interpretation.

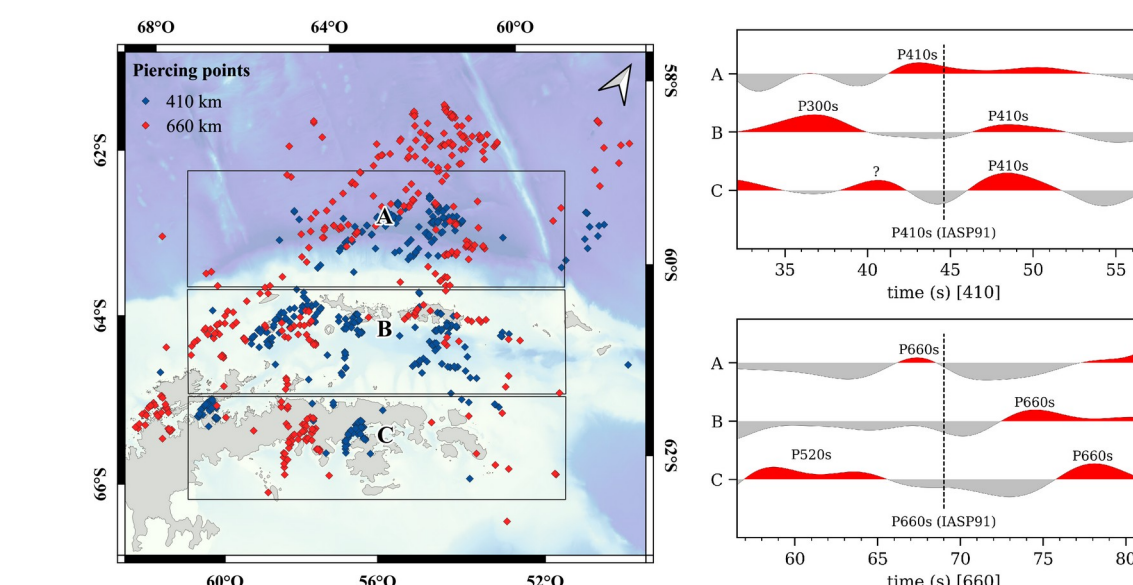


Figure 7. Left: piercing points at 410 km and 660 km alongside the three stacking cells. Right: summation traces by cell and discontinuity.