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CRUSTAL AND UPPER MANTLE STRUCTURE OF THE AMAZON REGION FROM RECEIVER FUNCTIONS

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Abstract

We show here the results of the receiver function analysis from the data obtained by three seismic broadband stations installed in March 1997 north of Manaus, Brazil, and operated until September, 1998. Each station was equipped with a Guralp 40T sensor (flat response between 30s and 50Hz) and a Reftek 7206 DAS recording continuously at 20 samples per second. Together with the IRIS station Pitinga (PTGA), these stations formed a diamond shaped network of 60 x 200 km extension.

Between March 1997 and January 1998, more than 110 teleseismic events with good azimuthal coverage were recorded which could be used to analyze the crustal and upper mantle structure using the receiver function method. In addition, 15 events with SKS and SKKS phases of sufficient quality could be used to study shear wave anisotropy in this region.

RECEIVER FUNCTION ANALYSIS

Figure 1 shows the receiver functions (Q-components) for a M=6.5 event recorded at all four stations. As can be seen from comparison with the expected phases for a single layered crustal model (Figure 2), individual converted phases can clearly be identified. For the three northernmost stations (PTGA, NEBL, JABU) we commonly observe the Moho conversion Ps as the strongest signal on the Q-component. For station PTGA the Ps signal is generally more complex than for stations to the sedimentary cover of the Amazon basin.

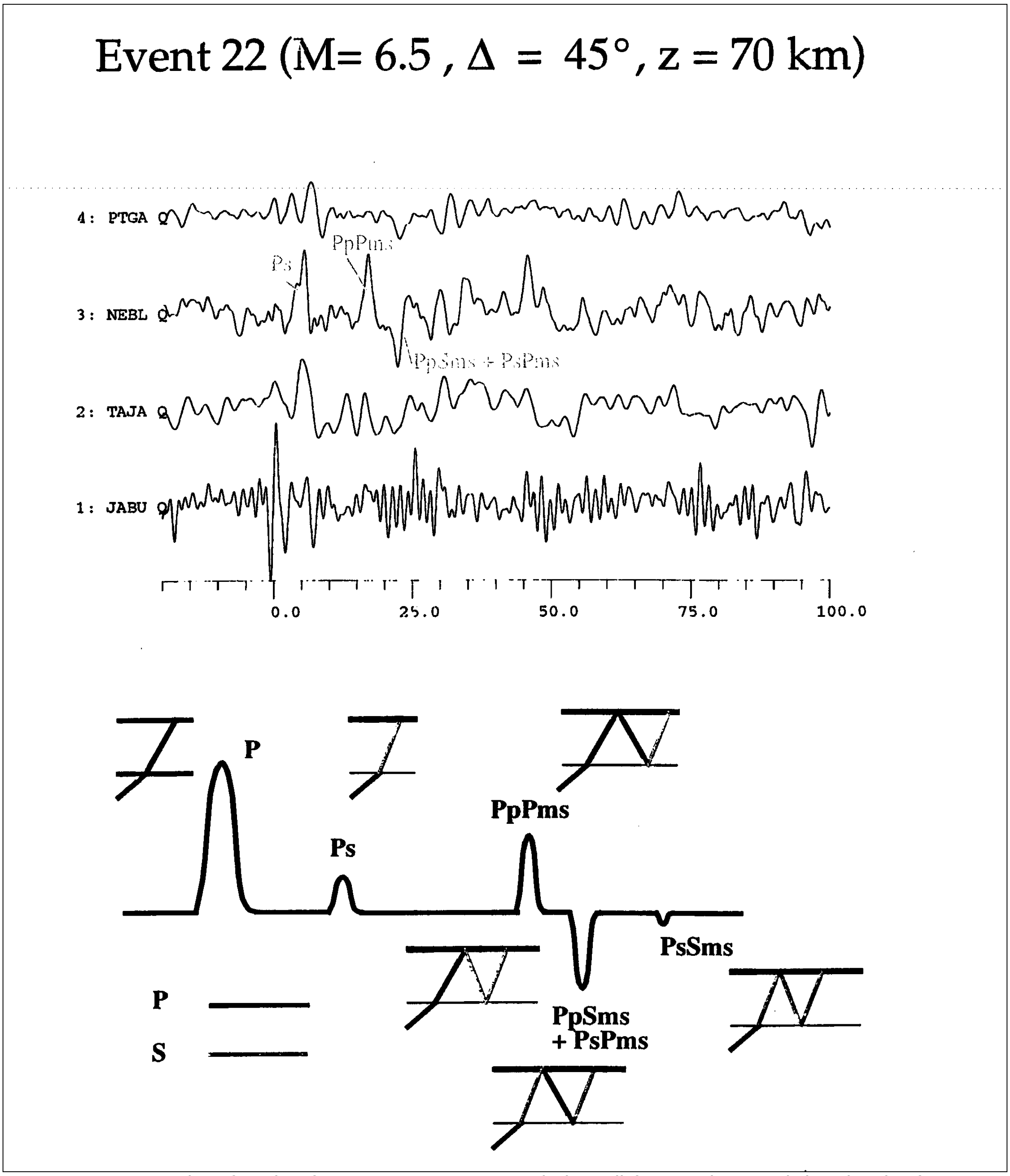

Figure 1 Q component receiver function for a M=6.5 event recorded at all four stations and the sketch of converted phases in a single layered crust.

In individual cases, the data quality is good enough to obtain a velocity-depth model from waveform inversion (heavy solid line in the left panel of Figure 2). In the right panel of Figure 2, the dashed waveforms (two botton traces) correspond to the observed Q-trace of the receiver function at Neblina (NEBL). The starting velocity model was a halfspace model with vs = 3.5 km/s (thin solid line in the left panel on Figure 2). The heavy solid line in the middle panel on the right of Figure 2 shows the synthetic receiver function corresponding to the resulting velocity model. As a measure of resolution, the uppermost trace in the right panel shows the L-trace of the receiver function after deconvolution.

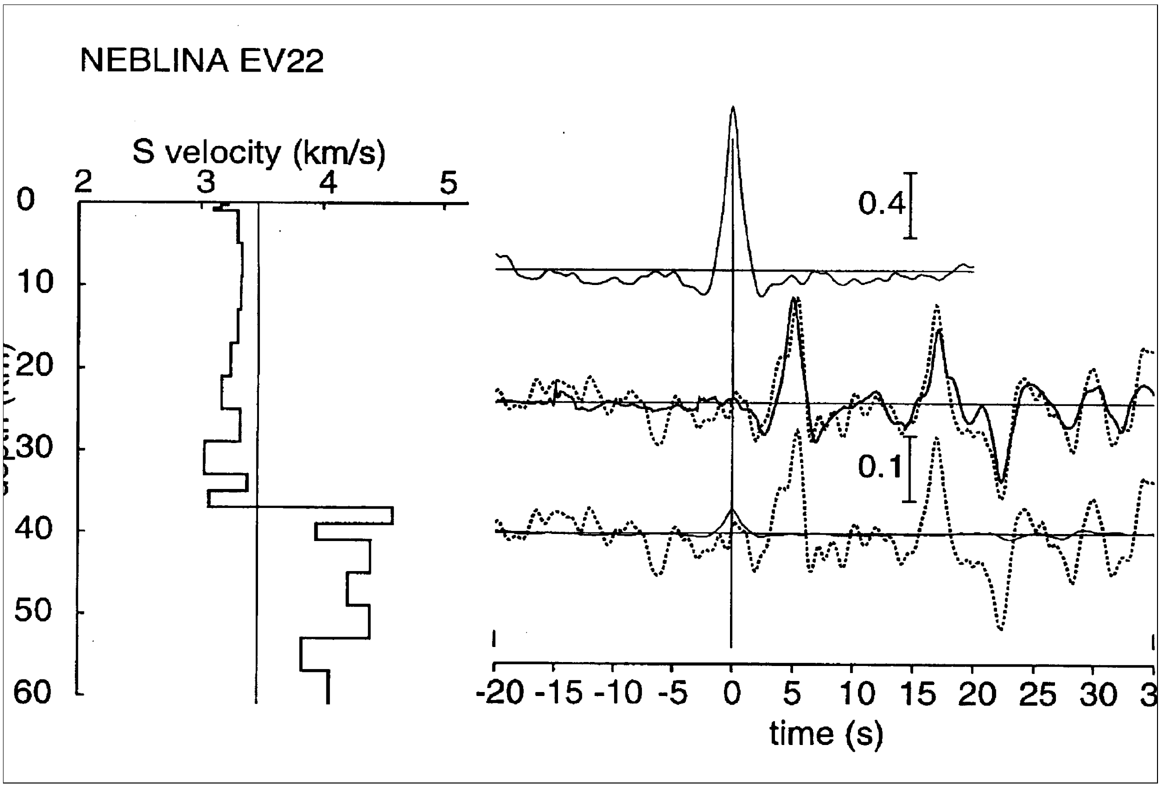

Figure 2 Receiver function inversion for the shear wave velocity distribution at station Neblina.

The Q traces of the receiver functions of all the stations show azimuthally dependent variations of the Ps arrival time, potentially indicating Moho topography.

MOHO STRUCTURE IMAGING

For each station-event pair, Fresnel zone images of the Moho conversion piercing points have been determined by two point ray tracing. For the ray tracing, the IASP91 model has been modified to accomodate the crustal velocity structure obtained from the receiver function waveform inversion shown in Figure 2. In addition, for station JABU, a sediment coverage of 500 km has been assumed based on geological evidence. The resulting piercing point Fresnel zone disks were then plotted for each station considered, based on the Moho depth for each case. This allowed us to generate a map of the Moho topography around each station.

UPPER MANTLE DISCONTINUITIES

From the subset of teleseismic events recorded at epicentral distancies larger than 35 degrees, receiver function stacks (after moveout correction) were calculated to determine the conversion depths of Upper Mantle discontinuities (Figure 3). Clear conversion signals from discontinuities at 414 and 659 km depth were detected (Figure 3).

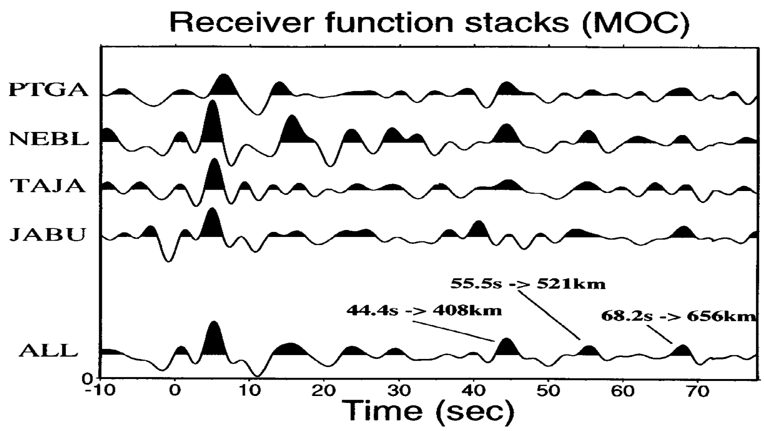

Figure 3 Upper Mantle conversions in stacked receiver functions. The uppermost 4 traces show station based stacks (after moveout correction), the botton trace shows the overall stack. Minimum epicentral distance > 35 degrees.

SHEAR WAVE ANISOTROPY

From the existing data set, splitting times and fast directions of SKS and SKKS waves recorded in a distance range of roughly 90-125 degrees were determined for a total of 15 events with good S/N ratio. Figure 4 shows a data example for an event from the Kermadec Islands.

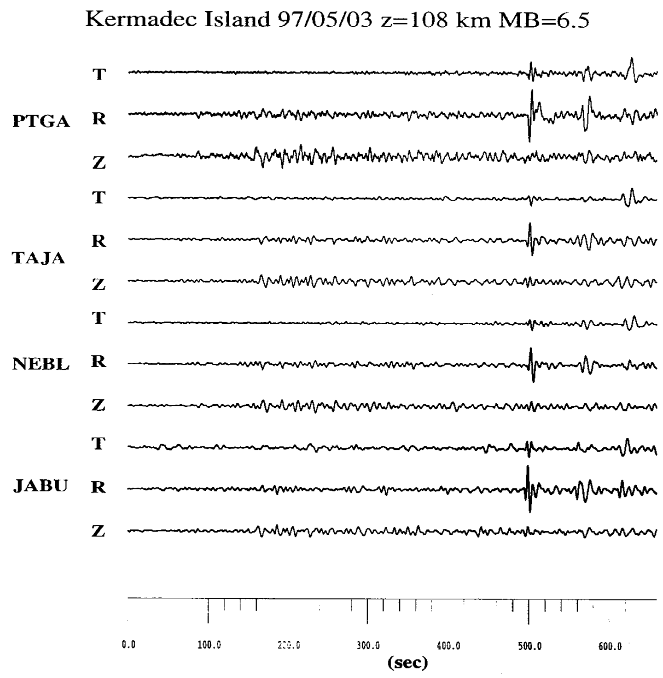

Figure 4 Data example for a SKS event (Kermadec Island 97/05/03 z=108 km MB = 6.5)

The set of observed splitting parameters determined from all stations show consistent results, although good azimuthal coverage is only obtained for the IRIS station PTGA. For a backazimuthal range between 40 and 245 degrees, here the distribution of splitting times and fast directions can be explained by a single layer with axial symmetric anisotropy and a fast direction of 110 degrees. For a backazimuth of 325 degrees, however, several events with good S/N ratio have been observed which shwo perfectly linear polarization. This situation would be consistent with either a different orientation of the fast direction or isotropy, but is inconsistent with the splitting parameters obtained under a back-azimuthal range of 40 to 245 degrees. Based on the argument that the Fresnel zones of SKS waves reaching the station PTGA from NW and SW have to be separated to enable the corresponding waves to catch completely different splitting parameters, we estimated a minimum depth of roughly 200 km for the anisotropic region.

CONCLUSIONS

A) **RECEIVER FUNCTIONS**

CRUSTAL STRUCTURE

- PTGA: crystalline, complex; Moho = 50 km
- NEBL, TAJA: crystalline, simple; Moho = 40 km
- JABU: sedimentary, Conrad?; Moho > 40 km

MANTLE STRUCTURE

- UM-discontinuities at 414 km and 659 km (IASP91)

B) **SKS ANISOTROPY**

- Back-Azimuth 40-245 degrees: simple axial symmetric anisotropy (fast direction at 110 degrees).
- Back-Azimuth 325 degrees: Linear polarisation.

=> Origin of anisotropy deeper than ~ 200 km.