Moho depth estimative at Balbina lake area, Amazonas, Brazil

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Abstract

The crustal thickness at Balbina lake area was estimated using the receiver function technique. From April to September 2002 and during all the year 2003 24 teleseismic events were recorded by a broadband seismic station (BALB). The receiver functions of these data yield a preliminary value of 37 km for the Moho depth.

Introduction

The Balbina Reservoir belongs to Eletronorte hydroelectric power company and is located at Amazonas State, Brazil. It's volume is of 17,5 km^3 and the dam has 42 m high, and the triggered seismicity started 2,5 years after the start of impoundment of the lake (1987). The broadband seismic station BALB was installed at the area in April 1998, equipped with a Guralp 40T sensor and a Reftek data logger sampling continuously at 100 samples per second. The Balbina Lake is located at the Amazonian Craton, between the geochronological provinces Amazonia Central (2.5 Ga) and Ventuari-Tapajós (1.95-1.8 Ga). The first comprise Paleoproterozoic felsic to intermediate volcanic rocks and granitoids, and the later granite-gnaisses (Tassinari & Macambira, 2004).

Method

Developed by Langston (1977, 1979), the Receiver Function method (RF) is widely used to investigate crustal and mantle structure (Owens *et al*., 1987; Ammon *et al.*, 1990). Teleseismic P waves contain information related to the source, near-source structure, propagation effects through the mantle, and local structure surrounding the recording site. This P wave incident on the base of the crust generates a converted shear waves (Ps), which have their dominant amplitude on the radial component while P have almost all energy on the vertical component. The converted phases are isolated from source and propagation effects through the mantle, and near-source structure by deconvolving the vertical from the radial component of the P waveform to produce a time series called a receiver function. In our study we select teleseismic events with magnitudes of 4.5 m_b or grater for epicentral distances between 17° and 50°, and magnitudes of 5.0 m_b or grater for distances between 50° and 105°. The time period for this search is from April to September 2002 and all the year 2003. Only the waveforms with clear P wave onset were selected to perform the FRs. The deconvolution of temporal series was performed in the frequency domain (Owens *et al*., 1984; Ammon *et al*., 1990) with a low-pass gaussian filter $[\exp(-(\omega^2/4a^2))]$ with parameter a=3, and using the water level method of Clayton & Wiggins (1976) of 0.001 and gauss parameter c=3 (França, 2003). A specific time window, ranging 30-90 seconds, was chosen for each event to produce the best receiver function with the lowest noise before the arrival of the "direct P-wave". The final data set is composed of 24 events (Table 1). Figure 1 shows the azimuth distribution for the data set used in this study.

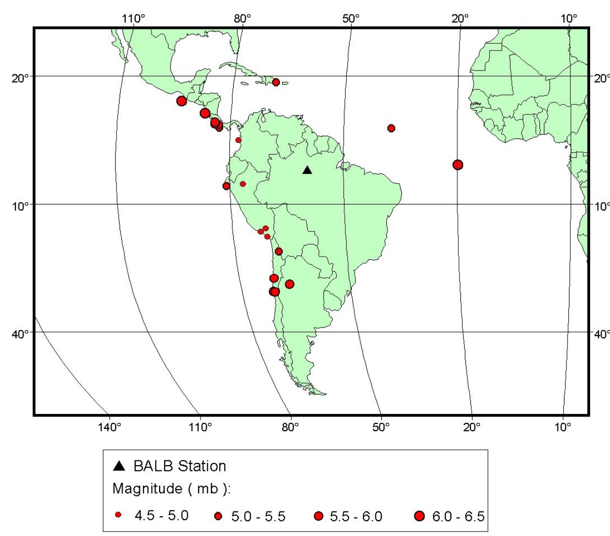

Figure 1 – Distribution of the events used for the receiver function analysis.

For each event of the list the water level was changed to 0.005 and 0.01 when performing the receiver function. Comparing the receiver function waveforms for each water level value, we choose the best one.

Results

The Moho depth was calculated for a crustal P velocity of 6,0 km/s and a Vp/Vs ratio of 1.80 following Krüeger *et al.* (2002) analysis for a region very close to this study area (IRIS station PTGA). The Receiver Function method allows us to stack signals with near azimuth and distance to enhance the signal to noise ratio. Therefore, we perform a stacking of individual RF waveforms with event azimuth and ray parameter (p) ranging 10° and 0.2 s/°, respectively. Figures 2 to 5 shows the stacking of 4 groups of events. The first group has 5 events with azimuth ranging from 214° to 220° and ray parameter p between 10,8 s/° and 10,9 s/°. The stack signal shows a clear Ps near 5.5 seconds with a good match between the 5 events (Figure 2). It is quite difficult to identify the multiple fases (PpPms and PpSms+PsPms). We cannot show the Ps fases for the second group as the maximum amplitude before the "direct P" pulse. The Ps for this event group is also weak on the stacked waveform (Figure 3). However, we find a peak near 5.5 seconds that was interpreted as the Ps fase. One can see from Figure 4 that the RF seismogram of event 17 of Table 1 doesn't match with the other ones.

Table 1 – Selected teleseismic events and event groups used in RF analysis for BALB station; p is the ray parameter and H is the crustal thickness.

N	Date	m_b	Dist (º)	B-Az (º)	p (s/º)	TPs-TP (s)	H (km)
1	2002/218	5.1	17.4	258,3	11.00	6.07	**40**
2	2003/362	4.5	17.9	219.5	10.90	5.44	**36**
3	2002/238	4.8	19.4	215.3	10.90	5.58	**37**
4	2002/259	5.1	19.4	221.0	10.80	5.56	**37**
5	2003/309	5.7	19.5	290.4	10.90	5.60	**37**
6	2003/154	5.4	19.9	219.2	10.80	5.58	**37**
7	2003/051	5.3	20.0	214.1	10.80	5.56	**37**
8	2002/131	5.7	20.7	245.1	10.80	5.56	**37**
9	2002/158	5.1	20.9	300.4	10.70	5.51	**36**
10	2002/241	5.2	21.0	203.5	10.60	5.74	**38**
11	2002/111	5.0	21.7	259.2	10.70	5.41	**36**
12	2003/359	5.0	22.2	336.0	10.40	5.28	**35**
13	2002/153	4.8	23.9	66.5	9.13	6.10	**42**
14	2002/213	5.1	25.2	292.5	9.08	5.31	**36**
15	2003/359	6.1	25.5	294.0	9.07	5.34	**36**
16	2002/167	5.4	26.7	293.6	9.00	5.40	**37**
17	2002/272	5.1	26.9	294.1	8.99	6.24	**43**
18	2002/108	6.2	27.6	201.8	8.93	5.52	**38**
19	2002/148	6.1	27.7	193.5	8.94	5.05	**35**
20	2003/309	4.9	30.2	293.1	8.82	5.59	**38**
21	2003/171	6.4	30.6	200.5	8.81	5.40	**37**
22	2002/169	6.0	30.7	199.7	8.80	5.42	**37**
23	2002/213	4.6	37.0	296.3	8.48	5.30	**37**
24	2003/313	5.5	39.8	89.1	8.31	4.90	**34**
Group 1					10.85	5.61	**37**
Group 2					10.80	5.63	**37**
Group 3					9.04	5.42	**37**
Group 4					8.87	5.44	**37**
Mean crustal thickness							**37**

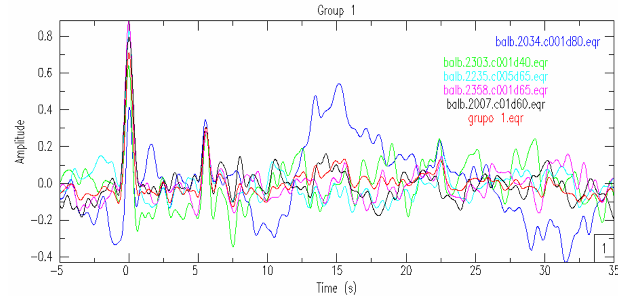

Figure 2 – Stacking (red) of events 2 (blue), 3 (green), 4 (cyan), 6 (magenta) and 7 (black) of Table 1. Backazimuth range from 214° to 221° and p from 10,8 s/° to 10,9 s/°.

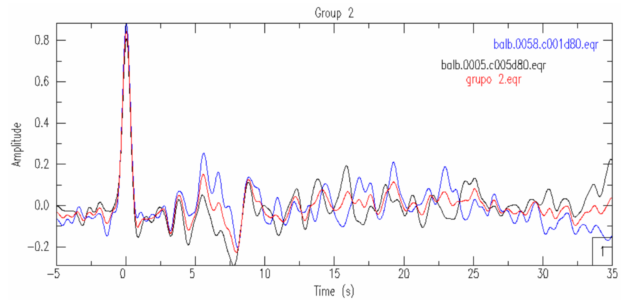

Figure 3 – Stacking (red) of events 5 (blue) and 9 (black) of Table 1. Backazimuth range from 290° to 300° and p from 10.7 s/° to 10.9 s/°.

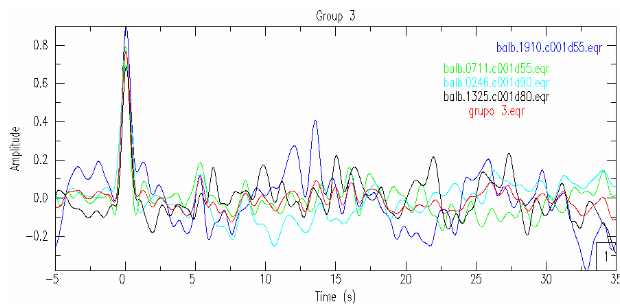

Figure 4 – Stacking (red) of events 14 (blue), 15 (green), 16 (cyan) and 17 (black) of Table 1. Backazimuth range from 292° to 294° and p from 8.99 s/° to 9.08 s/°.

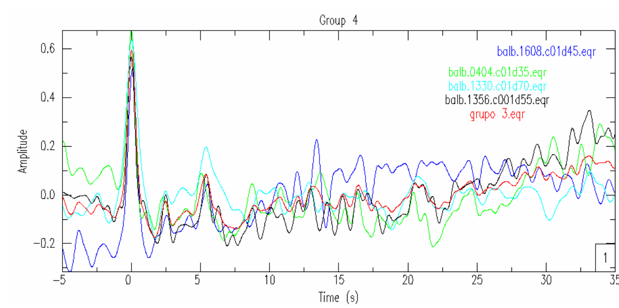

Figure 5 – Stacking (red) of events 18 (blue), 19 (green), 21 (cyan) and 22 (black) of Table 1. Backazimuth range from 193° to 202° and p from 8.80 s/° to 9.94 s/°.

The RF waveform of this event shows a little peak that match with the other events Ps peak. The RF stacking seismogram of the last group (Figure 5) have a good Ps peak match between the events.

Discussions and Conclusion

Almost all events whose waveforms were used to perform the RF in this study (event numbers 1 up to 19 of Table 1) have distance below 30°. At these distances, the Ps amplitude is affected by the mantle triplication. We believe that this triplication effect was responsible by the little anomalous Moho depths estimated from events 1, 13 and 17 of Table 1 (3, 5 and 6 km above the mean). However, most of the values obtained show consistent with the mean crustal thickness, mainly the stacked waveforms from the event groups. We also perform estimates of Moho depth for Vp=6.0 km/s and Vp/Vs ratio of 1.75 (H=40 km), Vp=6,2 and Vp/Vs ratios of 1.75 (H=40 km) and 1.80 (H=38 km), and all of these results agree with Krüger *et al.* (2002) for the region, that indicates a crustal thickness varying from 38 to 48 km from south to north in a distance range of about 150 km. The 24 receiver function waveforms don't show clear peaks for the multiples, what difficult to constrain the final result. Although this study is preliminary the results obtained for crustal thickness at Balbina Reservoir area is in good agreement with other research at the area (Krüger *et al*., 2002), which found a Moho depth of 38 km.

Acknowledgments

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