Dispersion of Rayleigh waves from the inter-station measurements in Borborema province, NE Brazil.

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Abstract

The Borborema Province is located in Northeast Brazil and had its internal structure investigated by different geophysical methods (gravity, magnetic, seismic, etc). In this work we studied the behavior of the S wave velocity with depth in the Province crust, using dispersion characteristics of surface waves. The dispersion curves are calculated using the inter-station method with two or three stations. This method allows to estimate S wave velocity in the region between the stations. The events arriving are located mainly at the edges of the South American, Nazca and North America plates. The inversions of dispersions were performed with Rayleigh waves. We used the knowledge of the depth of Moho under the stations as a constraint in the inversion. Our results shown that S waves velocities are similar in the profiles, there is a observation that the Moho is at a depth of about 33 km in the profiles with two stations and in the profile that passes through the Potiguar basin we observed a lower velocities.

Introduction

The Borborema province is a geological structural domain and is situated in the Northern region of Northeast Brazil. Many geophysical methods such a tomography surface waves (Vilar 2004), potential methods (Castro et al. 1998; Oliveira, 2008) and receptor function (Novo Barbosa, 2008) has been used to investigate the internal structure of the province and therefore characterize the geology and tectonic evolution of each region.

In this paper, we estimated the behavior of the S wave velocity with depth in the region of the province. For this, we use the dispersion of surface waves between two and three stations (inter-station method). The dispersion curve shows the group or phase velocity of the waves at a certain period range. So, we invert curves and obtain the profile of the S wave velocity with depth. Surface waves are sensitive to variation of the S wave in depth because for a small pertubation of the S wave, there are a big pertubation in the group velocities. Observing the layers where the S wave changes velocities, we can identify the lateral variations in the route studied. In this paper, we describe the methodology first, then we shown the data and conclusions.

Surface waves dispersion

The wave dispersion occurs when different components frequency propagate with different velocities. The dispersion of surface waves is characterized by long periods of the waves that reach at a greater depth and short periods that reaches at shallower depth. The waves with periods different are sensitive to structures to the different depth. we can determine the phase velocities or the group velocities for a given number of periods of the surface waves of two ways: *i*) using the registry in an unique station, knowing the source characteristics and *ii*) using two or more stations (inter-station). in this paper we use the inter-station approach, in this case for surface waves observed $u(x,t)$ in two or three stations in the positions x_1 and x_2 (Snoke & James, 1997; Meijian An, 2004;Darbyshire, 2005;) the phase diference (ϕ) between the stations are:

$$\Delta\phi(\omega) = \phi_2(\omega) - \phi_1(\omega) \pm 2n\pi \quad (1)$$

$2n\pi$ is the phase ambiguity. Provided that the dependence with the distances x of each sinusoidal component is e^{ikx}, the phase change in the propagation from x_1 to x_2 :(figure 1, in this case x_1 or x_2 can be any of the stations).

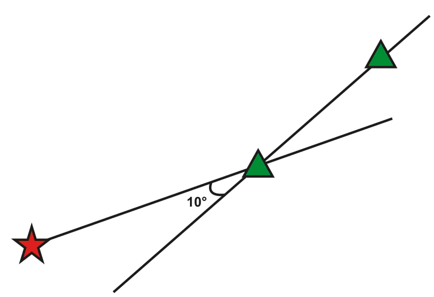

Figure 1: stations aligned with event. Green triangle are the stations in the position x_1 or x_2 and the star is the event.

$$\Delta\phi(\omega) = k(x_2 - x_1) = \frac{\omega}{c(\omega)}(x_2 - x_1) \quad (2)$$

So, the phase velocity $c(\omega)$ between two stations can be express by:

$$c(\omega) = \frac{\omega(x_2 - x_1)}{\phi_2 - \phi_1 \pm 2n\pi} \quad (3)$$

Therefore, we use the inter-stations way because we need to know only the phase on the each station. The dispersion curves of surface waves inter-station is calculated using the Multiple Filter Technique (Multiple Filter Technique, MFT) (Dziewonski et al, 1969), this technique studying variations in the amplitude of a signal in terms of velocity and wave period. Soon after we do a cross-correlation between seismograms of each station (pair of stations). The Gaussian function can be write like (Dziewonski et al., 1969; Herrin & Goforth, 1977).

$$H_n(\omega) = e^{-\alpha\left(\frac{\omega-\omega_n}{\omega_n}\right)^2} \quad (4)$$

ω_n is the central frequence of the filter and α is a parameter width of the filter (Bhattacharya, 1983). To perform the inversion of the dispersion of waves of surface, we used the computer program *Surf96* (Herrmann & Ammon, 2002). This work was performed using the smoothness constraint, assuming that the velocity between the layer varies smoothly. We used also knowledge of the thickness of the moho estimated by the receptor function method.

Data

The teleseismic events that we used in this paper were recorded by broadband stations, from the Milênio project(Estudos Geofísicos e Tectônicos na Província Borborema - CNPq). We also use the RCBR (installed through of agreement between the USGS (U.S Geological Survey) and UFRN). The data selected spanned from 2007 to 2011. We used 10 events with magnitude equal or greater 5.0 M_w and until 40 km of the depth (figure 2). The figure 3 shows the area between each three stations used in the paper.

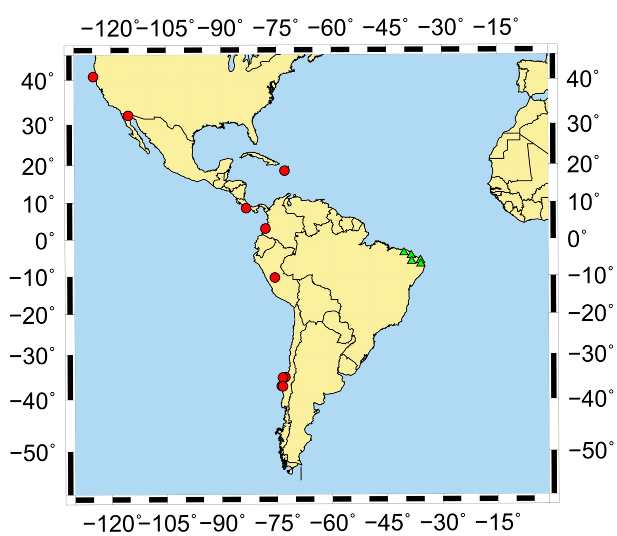

Figure 2: Map with the BB stations and the ten events used in this paper.

Discussion and Conclusions

The medium profiles of the S wave velocity are represented by figure 4 (two stations) and figure 5 (three stations). We use some periods higher than 150s, so in some profiles with two stations we can estimate the moho discontinuity. All the profiles has similar S wave velocities. When we using dispersion curves in three stations, we don't have stations aligned with the events. When we using dispersion curves in two stations, we have stations aligned with the

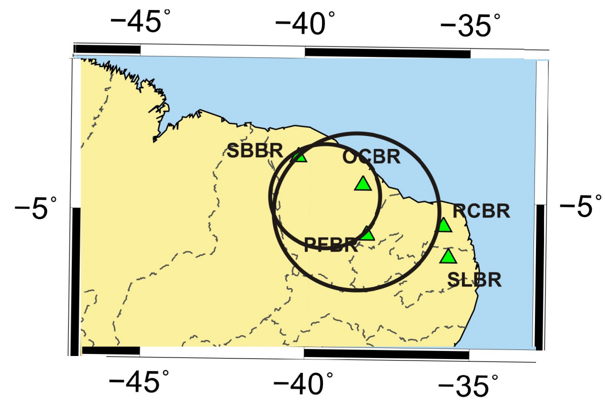

Figure 3: circles indicate the region between each 3 stations used in this paper, in the Borborema province.

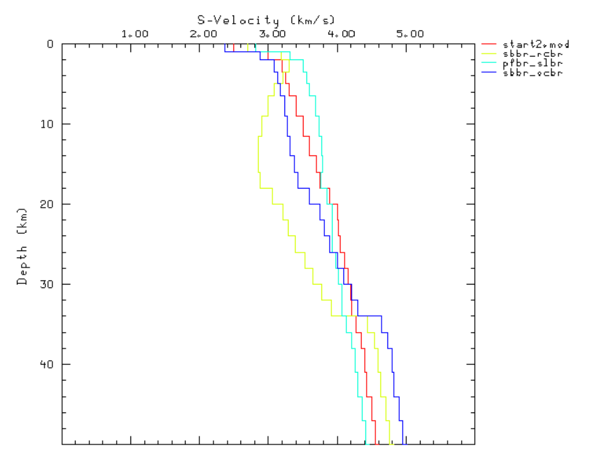

Figure 4: curves processed with two stations.

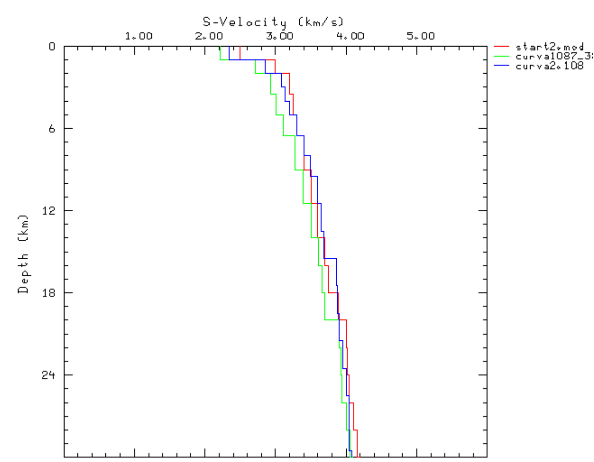

Figure 5: curves processed with three stations.

events and in this case we observed that the moho is at a depth of about 33 km in the profiles. So in two stations the profiles were clearer than with three stations. in both cases with two or three stations, we observed a higher layer 2-3 km to the S wave velocity lower, indicating a possible fractured layer.The velocities of the profiles are within the expected range of S velocity in the crust, except for some values of the profile SBBR-RCBR. In the profile we observed a low velocity layer due to Basin Potiguar that is in the medium of the stations (figure 6). we integrate our results with those of Function of the receiver. Estimates of the receptor function (Novo Barbosa, 2008) shown that under the OCBR and RCBR stations the crust is thicker than others stations used in this paper. In ours profiles there is a velocities low in those stations where the crust is thick. So our results agree with receptor function method.

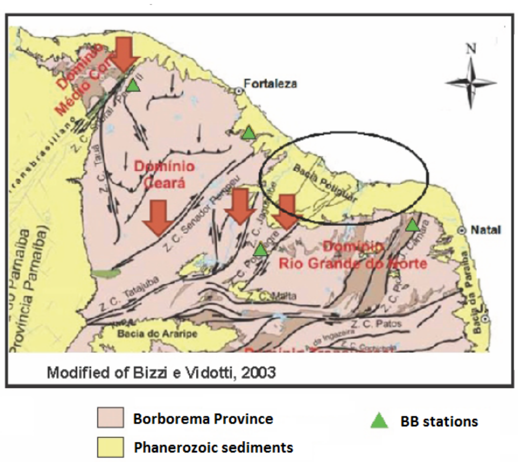

Figure 6: Potiguar Basin is in the middle of the staions

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