SEDIMENT DISTRIBUTION OF CONTINENTAL MARGIN OF THE SOUTHERN BRAZIL BASIN IN THE SOUTHWEST ATLANTIC OCEAN

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ABSTRACT

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The present analysis is an approach to use the seismic attributes to extract the geologic information of the Southern Brazil Basin, located on a passive continental margin in the south-west Atlantic, near the Rio Grande Rise. Attributes are computed seismic sections of NGDC data of the area. The implemented amplitude and frequency attributes images of seismic sections have been tried to use for the characterization with the geology of the area. The attributes images reveal that discontinuous sequences are better readable than that of the seismic sections. Remarked sequences are drawn as to be the indication of the continuing process of deposition of the area. The recent depositional overview is found as: terigeneous fluxes are higher at the beginning region of line 29A on the middle continental rise using characterization with frequency anomaly of the frequency attributes images. Deposition is little higher at shallow depths according to the slope of the oceanic crust but ends with all most straight and horizontal manner. Geologic compositions are seemed as almost uniform particularly in the deeper region.

Key words: Sediment distribution, Seismic attributes and Atlantic Ocean

INTRODUCTION

The Southern Brazil Basin (SBB) is located on a passive continental margin in the south-west Atlantic. It is bounded by two E-W a seismic ridges, the Rio Grande Rise- to the south and the Vitoria-Trindade Seamounts to the north. North of the Sao Tome, the continental shelf is narrow (50 km off Vitoria), except for two wide banks north of the Vitoria-Trindade Seamounts resulting from an accumulation of sediments between the coast and volcanic seamounts (Gamboa and Rabinowitz, 1984; Fainstein and Summerhayes, 1982). The width of the continental slope never exceeds 50 km. In contrast, south of the Cape Sao Tome, the continental shelf and slope are much wider, especially in the area of the Sao Paulo Plateau, extending from 2000 to 3500m depth (Butler, 1970). Most striking morphological feature of the Southern Brazil Basin is the scarcity of cross-margin channels. The Columbia Channel, south of the Vitoria-Trindade Seamounts, is the most important path allowing terrigenous material to reach the deep areas of the basin. Terrigenous supply to the Southern Brazil Basin is weak, because the rivers draining the continent in the area are not important. Very few major channels cross the margin, and the contribution of gravitational processes to the sedimentation in the deep areas of the basin is almost nonexistent. Moreover, numerous authors have underlined the major role played by deep- sea currents in the transport and distribution of sediments (Melguen and Thiede, 1974, 1975; Chamley, 1975; Damuth and Hayes, 1977; Melguen et al., 1978; Jones and Robinson, 1982; Jones, 1984). Consequently, the Rio Grande Rise and the deep southern Brazil Basin, swept by anarctic bottom water (AABW) and almost free of proximal continental supply, are key zones to study the imprint of deep-sea currents on the sedimentation (Johnson et al., 1976, 1977; Ledbetter, 1979; Richardson et al*.,* 1987; Mezerais et al*.*, 1993; Masse et al*.,* 1994). However, the characteristics of Quaternary deposits in the southern Brazil Basin itself are still poorly known. Several authors have analyzed the microphysiography of the deposits on a wide scale (Damuth and Hayes, 1977) or the morphostructural character of the basin through seismic lines and drill-hole data (Barker et al*.,* 1983), but there is little information on the recent sedimentary cover.

This paper attempts to study recent depositional overview of the area (Figure 1) from the seismic lines with the application of attributes analysis. Amplitude, phase and frequency attributes analysis can play important roles to study on sedimentology. Computation of complex attributes is basically a transformation that splits apart the amplitude, phase and frequency information into separate displays. Frequency attribute is the instantaneous frequency of a time signal or an way of time frequency representation. SINFIT (Hardy et al. 2003), AOK (Steeghs and Drijkoningen, 2001), STFT (Chakraborty and Okaya, 1995), Zero-crossing, Complex trace analysis (Taner et al. 1979) etc. are the present techniques to implement time frequency representation of signals. Using complex trace analysis (Rahman et al. 2007, 2006 and 2005) has shown time frequency representations of various seismic sections. Therefore this work is an effort to study the geological constituents of the mid Atlantic seismic profiles with time frequency analysis along with other attributes analysis applying the tool made by Rahman *et al.* (2006).

DATA AND METHODOLOGY

Data

The National Geophysical Data Center (NGDC), located in Boulder, Colorado, is a part of the US Department of Commerce (USDOC), National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data and Information Service (NESDIS). NGDC is one of three NOAA National Data Centers (NNDC). NGDC's mission with regard to Marine Geology and Geophysics (MGG) is data management in the broadest sense, playing a role in the nation's research into the environment and providing data to a wide group of users. NGDC's mandate includes responsibility for long-term archival, and dissemination of marine geological and geophysical data collected with National Science Foundation and other US government funds. NGDC compiles marine geological and geophysical data from both national and international sources through cooperative programs and exchange agreements, including through the World Data Center system. NGDC is responsible for compilation, documentation, quality control, archival, and dissemination of marine geological and geophysical data as well as geological and geophysical data from the Great Lakes.

The data has been used in this research of the Southern Brazil Basin is located on a passive continental margin in the south-west Atlantic near latitude 26^0 S and longitude 38^0 W (Figure 1). The data were collected by the University of Texas Institute for Geophysics of Research Vessel FRED M. MOORE in July 1979 as part of its Southwest Atlantic IPOD (International Phase of Ocean Drilling) Site Survey. Data were gathered to define the geologic and geophysical setting for proposed IPOD drilling sites. The data were recorded with a sample rate of 2ms. Navigation used was transit satellite with dead reckoning for the ships heading and speed. The streamer used was a 6-channel streamer (group interval 100 m) with 2 sonobuoy traces recording to a DFS 4 (low filter=8Hz; high filter=62Hz). Source to near trace offset was 263 m. The seismic source for these was three Bolt air guns with a volume of 4500 cu. in. of air compressed to approximately 450 psi. The source depth was 10 m.

These data were jointly incorporated to obtain information on the structure and stratigraphy of the area. There are twenty-three (23) 2-D seismic reflection sections of the study area. Only two seismic sections (line-29A, line-29B) have been analyzed in this article.

METHODOLOGY

The real seismic trace, $u(t)$ can he expressed in terms of a time-dependent amplitude $A(t)$ and a time-dependent phase $\theta(t)$ as (Rahman, 2006 and Taner et al. 1979)

$$u(t) = A(t)\cos\theta(t) \qquad 1$$

The quadrature trace $u^*(t)$ can be written as

$$u^*(t) = A(t)\sin\theta(t) \qquad 2$$

and the complex trace $U(t)$ is

$$U(t) = u(t) + ju^*(t) \qquad 3$$

$$= A(t)e^{j\theta(t)}$$

On other hand, quadrature trace $u^*(t)$ can be obtained from real seismic trace $u(t)$ using Hilbert transform as:

$$u^*(t) = \frac{j}{\pi} \times \int \frac{s(\tau)}{t-\tau} d\tau \qquad 4$$

Now $u(t)$ and $u^*(t)$ are known, therefore the solution for $A(t)$ and $\theta(t)$ can be given below as:

$$A(t) = \sqrt{u^2(t) + u^{*2}(t)} = |U(t)| \qquad 5$$

and

$$\theta(t) = \tan^{-1}(u^*(t)/u(t)) \qquad 6$$

$A(t)$ is called the reflection strength and $\theta(t)$ is called the instantaneous phase (Bracewell, 1965). The rate of change of time-dependent phase gives a time-dependent frequency

$$\frac{d\theta(t)}{dt} = \omega(t) \quad (7)$$

This can be expressed as

$$\omega(t) = \int_{-\infty}^{\infty} d(\tau)\theta(t-\tau)d\tau \quad (8)$$

i.e. $$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} d(\tau)\theta(t-\tau)d\tau \quad (9)$$

The attributes computations of synthetic test signals are given in the following section.

Attributes Analysis for Test Signal

A test time signal is produced with varying amplitude and frequency in the defined time scale as shown in Fig. 2(a). Using the above mathematics Eqns. (1-9) amplitude, phase and frequency attributes are computed. The test signal, the computed amplitude, phase and frequency attributes are shown in Figs. 2(a-d) respectively. It is found accurate attributes estimation. Another test signal and its attributes computation made by Rahman, et al. (2007) with the same mathematics are also shown in Fig. 3(a-d). Justified tools are then applied to seismic profiles of line-29A and line-29B in the following section.

Attributes Analysis of the Seismic Profiles of SBB

Reflection seismic profiles (Figs. 4 -5) of the Southern Brazil Basin (SBB) located on a passive continental margin in south-west Atlantic ocean have been used in this research. Computed amplitude and frequency attributes of the seismic profiles of line-29A and line 29B are shown in Figs. 6-9.

RESULT AND DISCUSSION

Geology Interpretation Using Attributes Analysis

Fig. 4 shows reflection seismic profile of line-29A traveling in NW-SE direction. This profile is indicated that there are two moderate reflection layers respectively at 6 and 7 sec. The first layer at 6 sec is not continuous while the layer at 7 sec is found almost continuous and straight. Geology of the SBB is said (Masse et al. 1994, 1996) that below 4000 m depths, the terrigenous flux is clearly higher than on the middle continental rise (line-29A). This is due to the deposition of fine-grained terrigenous material, transported from the Argentine Basin by the western boundary current. Moreover, the sedimentation rate shows lateral variations depending on the morphological and hydrological contexts.

Fig. 5 shows reflection seismic profile of line-29B running in NW-SE direction. The structural information from the seismic profile is not clearly understood. The composition below 6.5 sec. seems to have uniform formation. Geology of the SBB is said (Masse et al. 1994, 1996) again that on the middle continental rise (line-29B), the deposits show a strong pelagic character. The terrigenous input is almost entirely trapped higher on the margin at Sao Paulo Plateau. Consequently, intermediate depths (roughly 3000-4000 m) are characterized by the lowest values of the sediment flux.

Fig. 6 represents the amplitude attribute image of the seismic section of line-29A. This image shows a discontinuous reflection layer at time 6 sec only and sediment structures are seemed all most uniform formation. Exceptions are marked at the end of the section (165-180 km) with different amplitude sequences.

Frequency attributes image of the same profile of line-29A shown in Fig. 7 gives better information than that of amplitude attributes and raw seismic images, especially about the layer at 6 sec. This layer is almost continuous throughout the section. Interesting event observed from the analysis as: near NW side, from 0-70 km within the time depth 6-7 sec. the frequency anomalies are approximately 30-35 Hz and a very narrow frequency anomaly of 30-35 Hz at 6 sec throughout the remain section (60-180 km). In addition little less similar type frequency distributions (30-35 Hz) are observed upto 8 sec, while below 8 sec frequency attributes are almost similar.

From the amplitude and frequency attributes analyses the following interpretation have been drawn as: there is only one reflector at 4000 m (6 sec in the time scale) depth and structure of the two layers are not very different according to constituents. Reflector can be said as very light interface. In the present analysis, terrigenous material are characterized with the frequency anomaly of 30-35 Hz, which is indicated that terrigenous flux is higher at a portion 0-60 km of the line 29A in between 6 and 7 sec rather than whole on the middle continental rise. A very thin terrigenous flux is appeared throughout the section at the beginning of the oceanic crust and at a depth 4000 m (6 sec). Below 8 sec, constituent of the oceanic crust is found all most uniform properties. The deposition of fine-grained terrigenous material, transported from the Argentine Basin by the western boundary current is well agreed and is confined at the region beginning of the profile 29A of the study area.

Amplitude attributes image shown in Figure 8 of seismic line-29B provides important information about sediment structure of the basin. Little higher amplitude sequences are observed at 6-7 sec in 78-140 km region from the NW side. An anticline structure is also observed at around 100-120 km in between 6 and 7.5 sec.

Figure 9 represents the frequency attribute image of the profile of line-29B. Frequency anomalies are seemed here all most uniform up to 6.5 or 7 sec of 30-35 Hz. Below 7 sec another uniform wide region with frequency anomalies less than 25 Hz. At the same time, this difference again in frequency anomaly of analyzed section does not seem two distinct layers. Depositional overview of the region can be explained as a moderate pelagic character and terrigenous input trapped higher at the beginning of the line-29 B i.e. on the margin of Sao Paulo Plateau.

Frequency attributes analysis for the both the sections has shown depositional rate is little higher at the beginning of the profiles according to the slope of the oceanic crust but the depths covered for the terrigenous flux up to 6.5 or 7 sec or roughly 3000-4000 m are almost straight and horizontal. Seismic profile line-29B laid in the southern part of the Brazil basin, is located in an area protected from direct terrigenous input by the Sao Paulo Plateau. From the attributes analysis image, continuous and thick reflectors are not found. Discontinuous sequences (Figure 7 and 9) observed in the amplitude and frequency attributes are thought to be the indication of the slow continuing process of deposition. Seismic line-29A was also laid in the north-west of the contourite-fan, is located in a field of stationary sediment waves, covering the lower continental rise on the path of Antarctic bottom water (AABW). Amplitude attributes (Figure 5) does not reflect any meaningful anomalies all over the section and it is found approximately a uniform formation. While the frequency attributes section (Figure 7) shows uniform formation is being mixed other constituents. Mixing rate is little higher near north-west side in 0-70 km.

Sedimentological analysis made by Masse et al. (1996) has shown that the deposits consist almost exclusively of very fine-grained silty-clayey muds. Carbonate contents are very low; they never exceed 25% of the bulk sediment, and are mostly less than 5%. Frequency attributes analysis is also indicating the same message as carbonate contents are almost less than 5% according to mixing rates in frequency attributes image.

CONCLUSION

The distribution of sediment fluxes in the Southern Brazil Basin is known as a bathymetric trend. This pattern is the consequence of the existence of two distinct sediment sources: the Brazilian continental areas and the Argentine Basin. On the continental slope and upper continental rise, close to the continent, terrigenous and carbonate fluxes are high and variable. The attributes analysis made in this article is an addition to study sediment fluxes in the middle continental rise. Characterizing frequency anomaly in frequency attribute images depositional overview of the region has been studied. Terrigenous materials have been analyzed and shown little higher on the margin of Sao Paulo Plateau.

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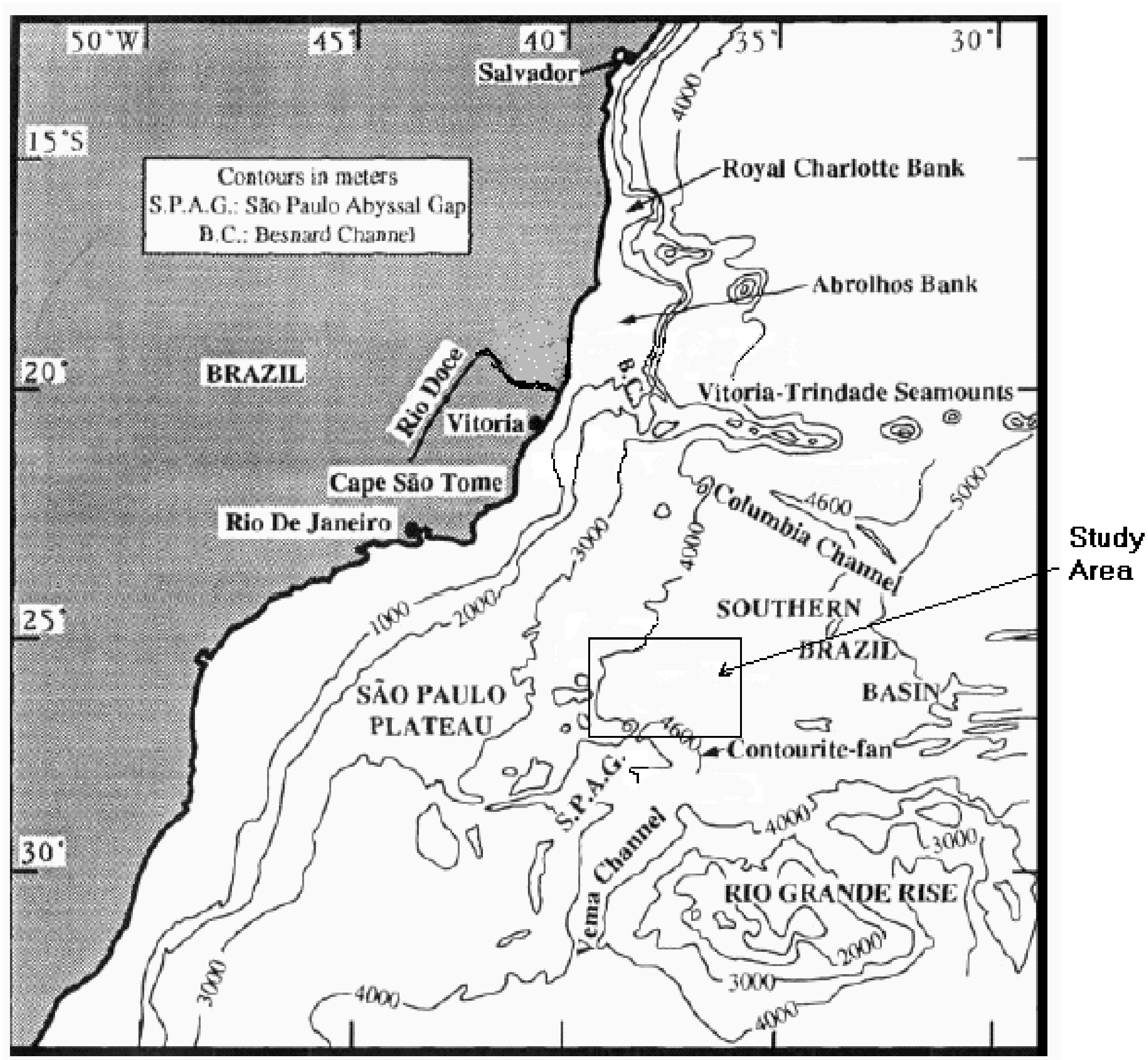

Figure 1. Bathymetry of the Southern Brazil Basin and rectangle indicates the location of the study area.

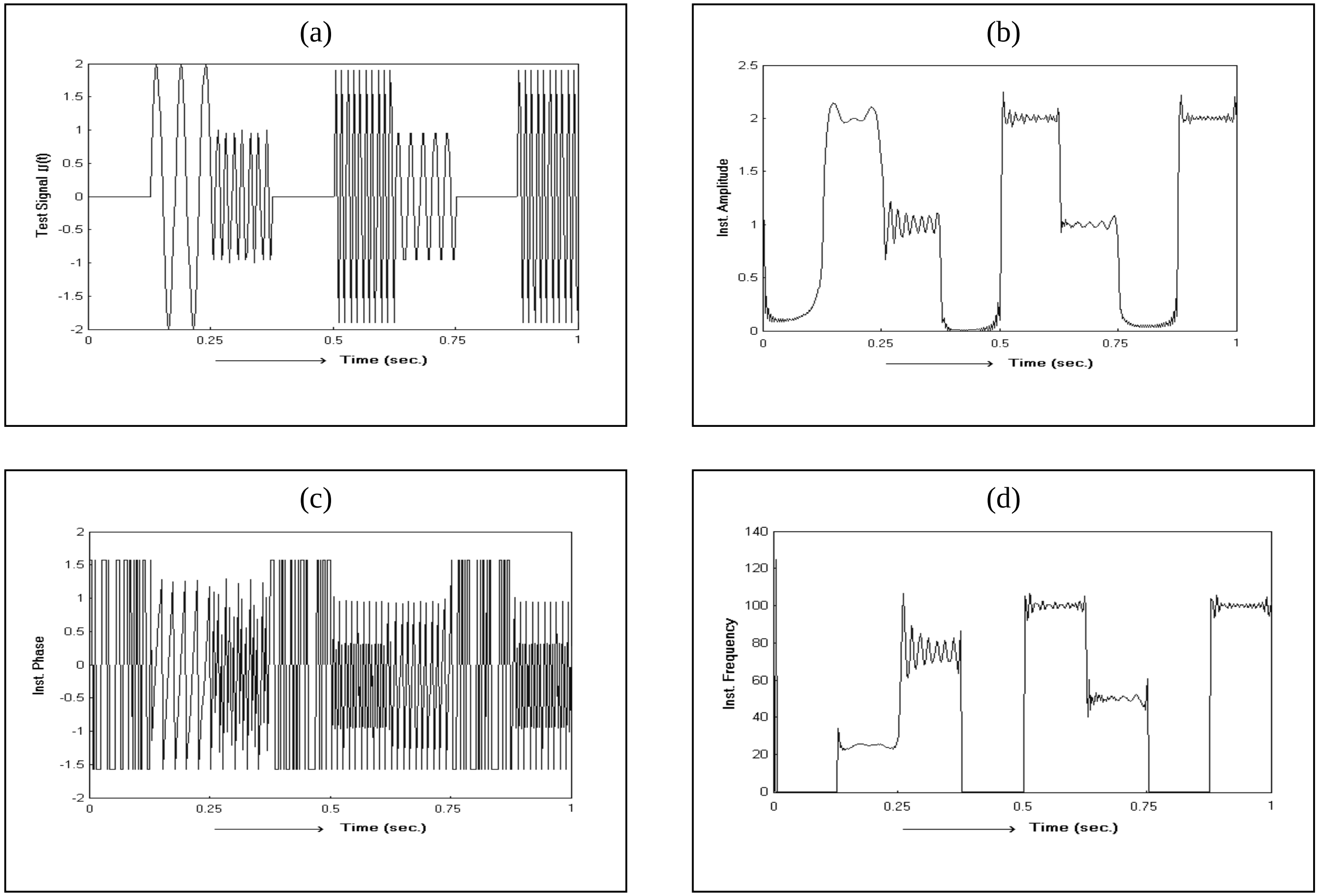

Figure 2 .a) Test time signal with frequency 25Hz, 75Hz, 100Hz, 50Hz and 100Hz respectively in the time span 0.125-0.25 sec., 0.25-0.375 sec., 0.5-0. 625 sec., .625-.75and 0.825-1.0 sec along with amplitude variation, b) amplitude attribute, c) phase attribute and d) frequency attribute of test signal, (a).

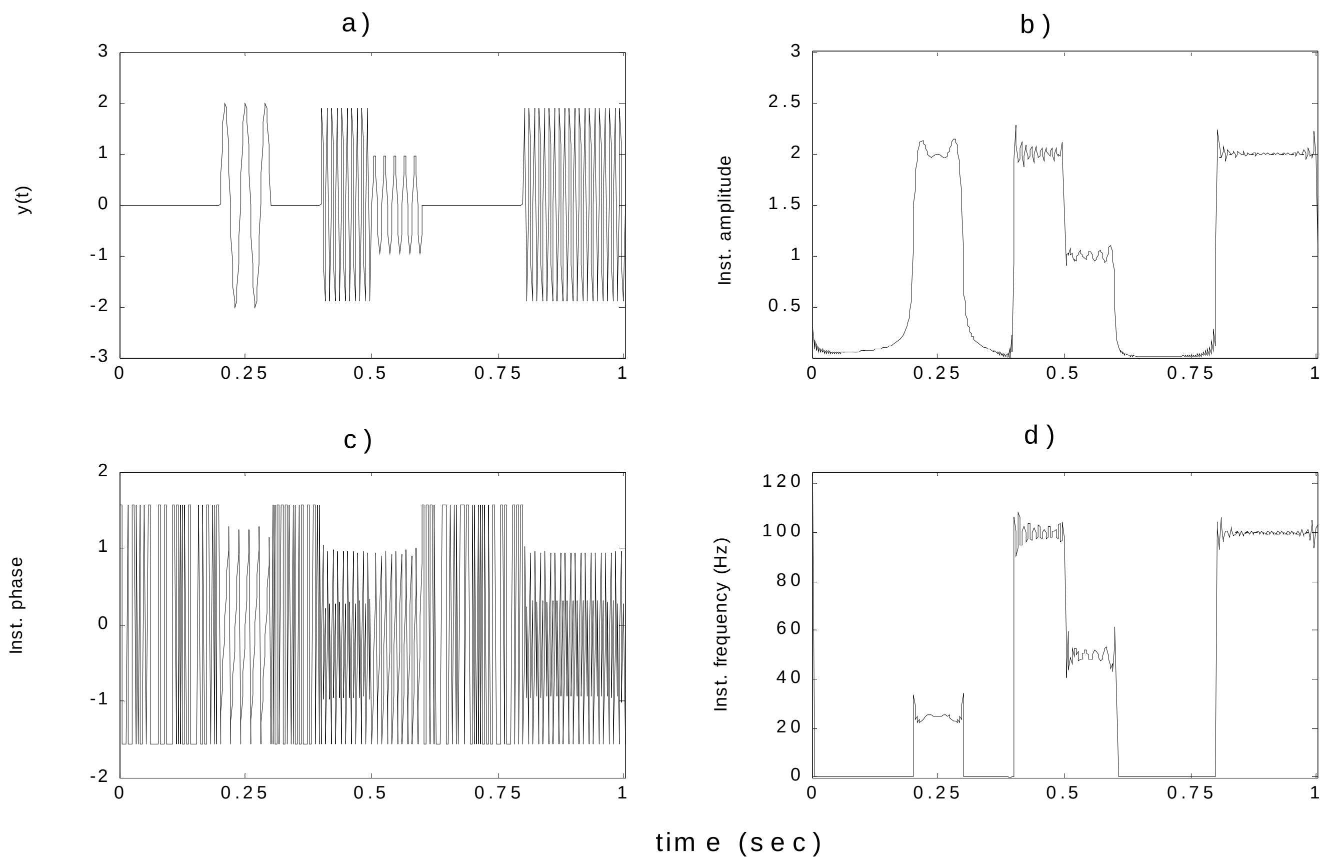

Figure 3. a) Test time signal, frequency 25 Hz, 100 Hz, 50 Hz and 100 Hz respectively in the time span 0.2-0.3 sec., 0.4-0.5 sec., 0.5-0.6 sec. and 0.8-1.0 sec and half amplitude in the time span 0.5-0.6 sec. b) amplitude attribute, c) phase attribute and d) frequency attribute of the test signal (a)

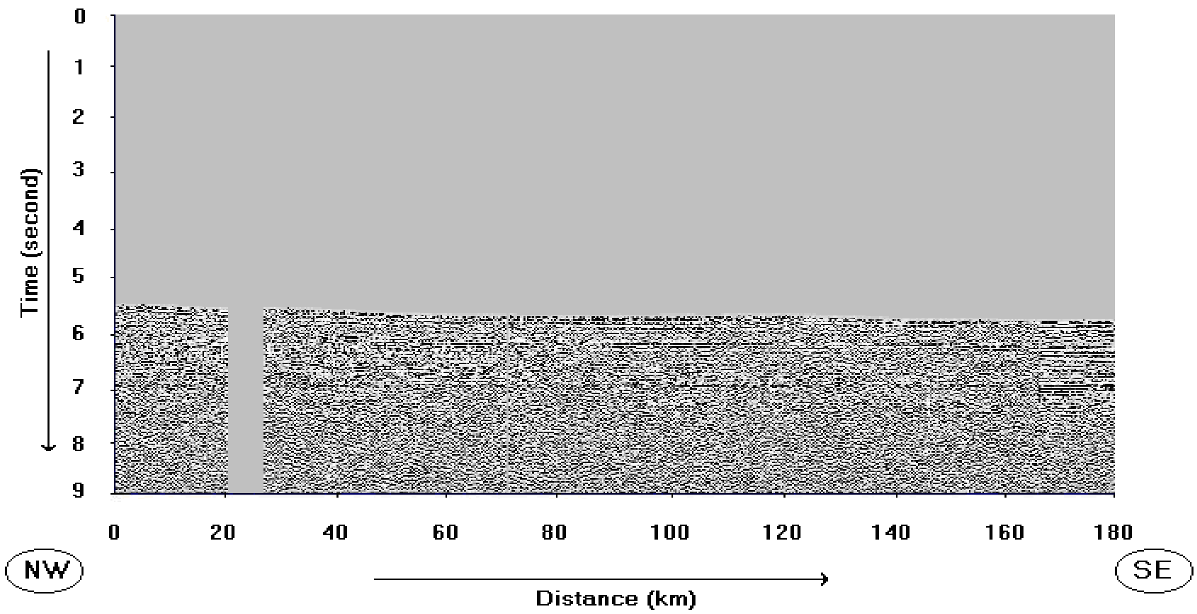

Figure 4. Reflection seismic profile of line 29A moves towards NW-SE direction.

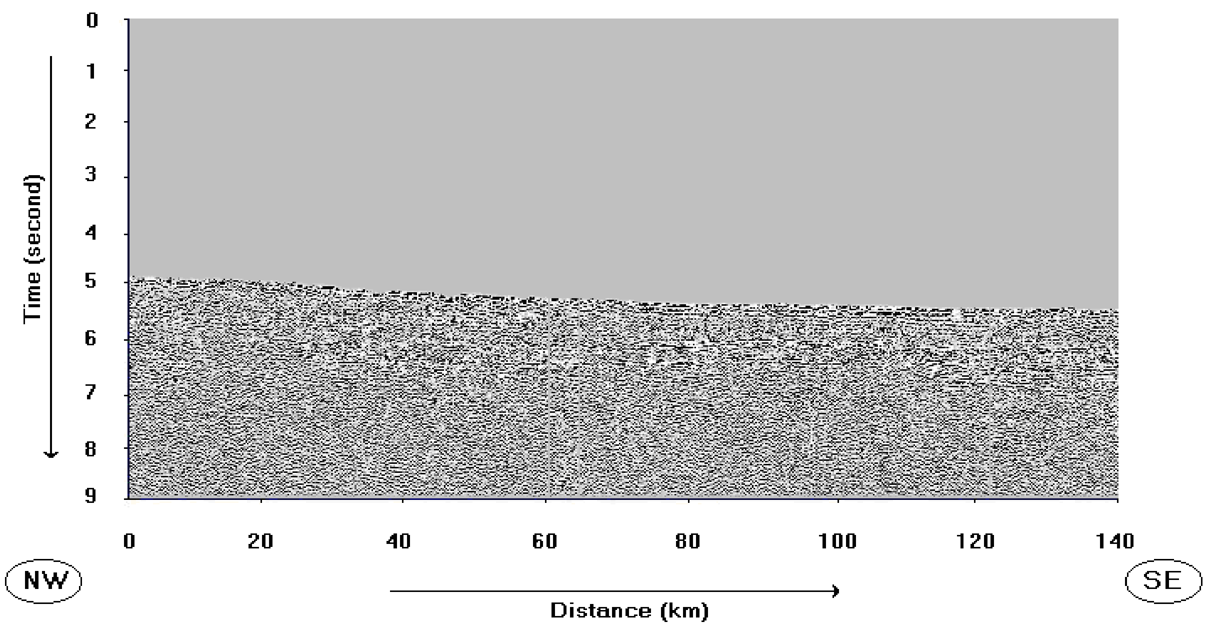

Figure 5. Reflection seismic profile of line 29B moves towards NW-SE direction

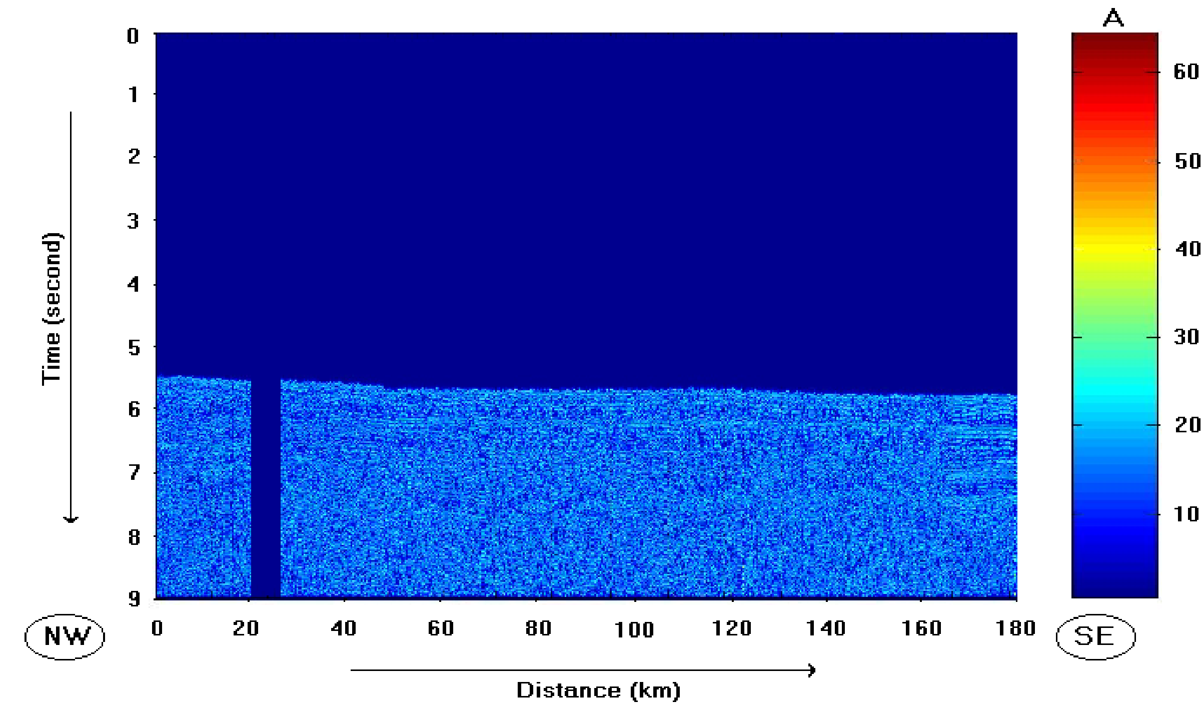

Figure 6. Amplitude attributes of seismic Line 29A

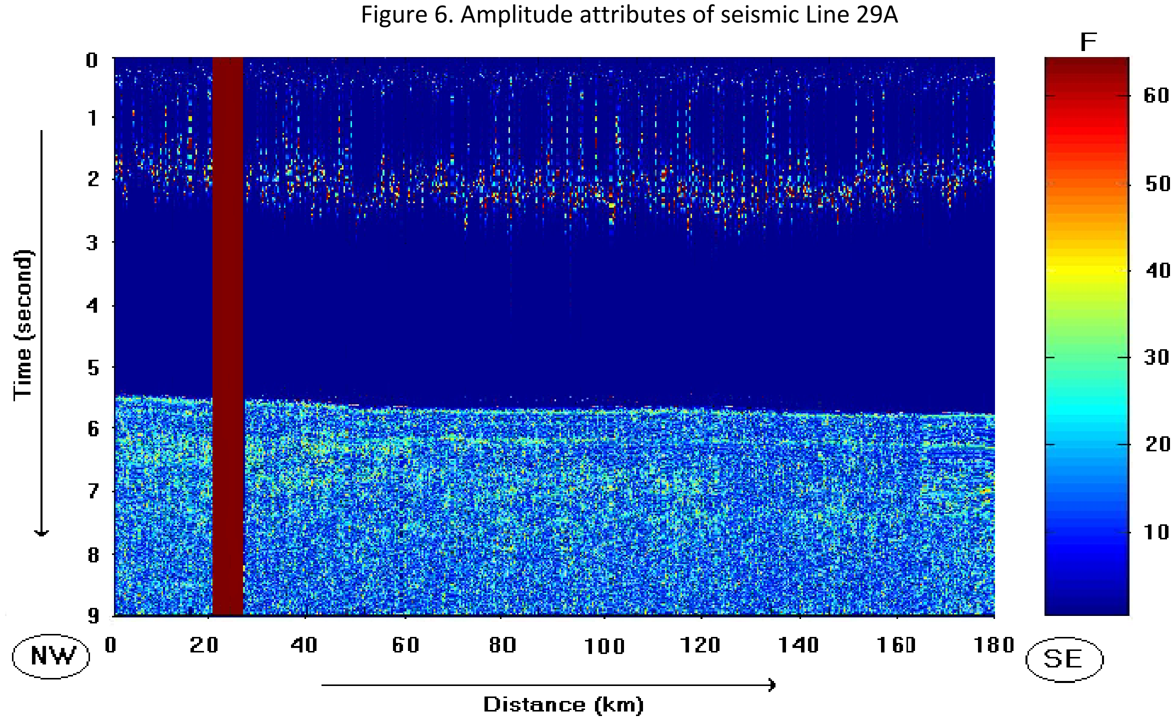

Figure 7. Frequency attributes of seismic line 29A

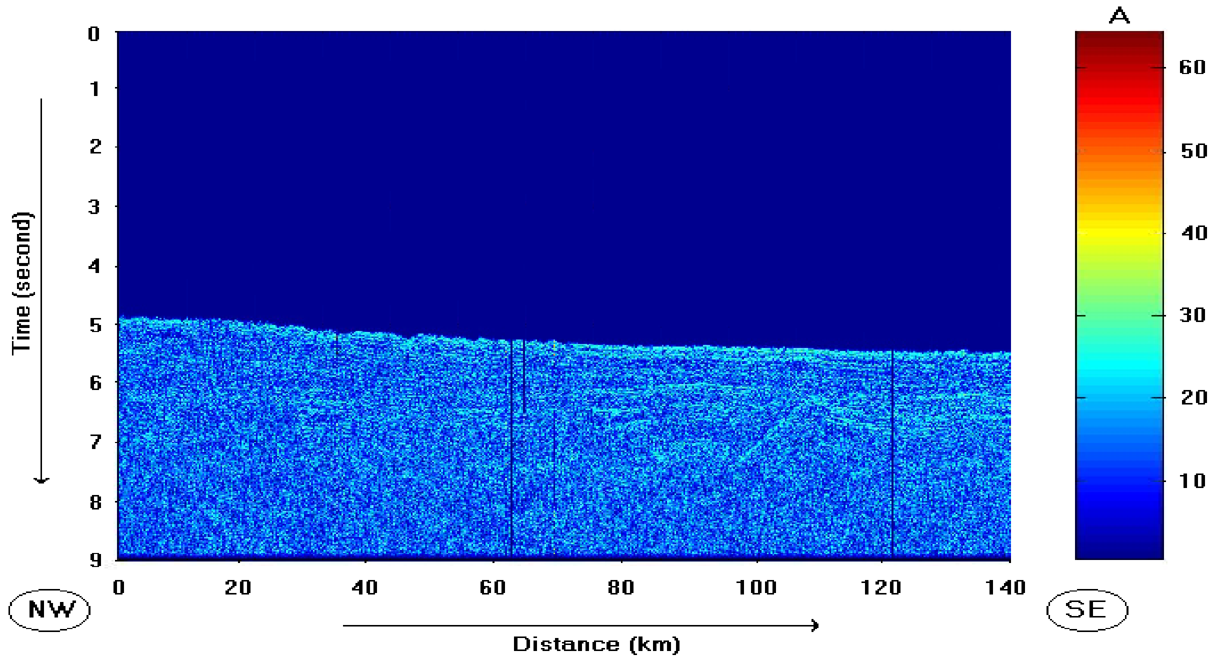

Figure 8. Amplitude attributes of seismic section line 29B.

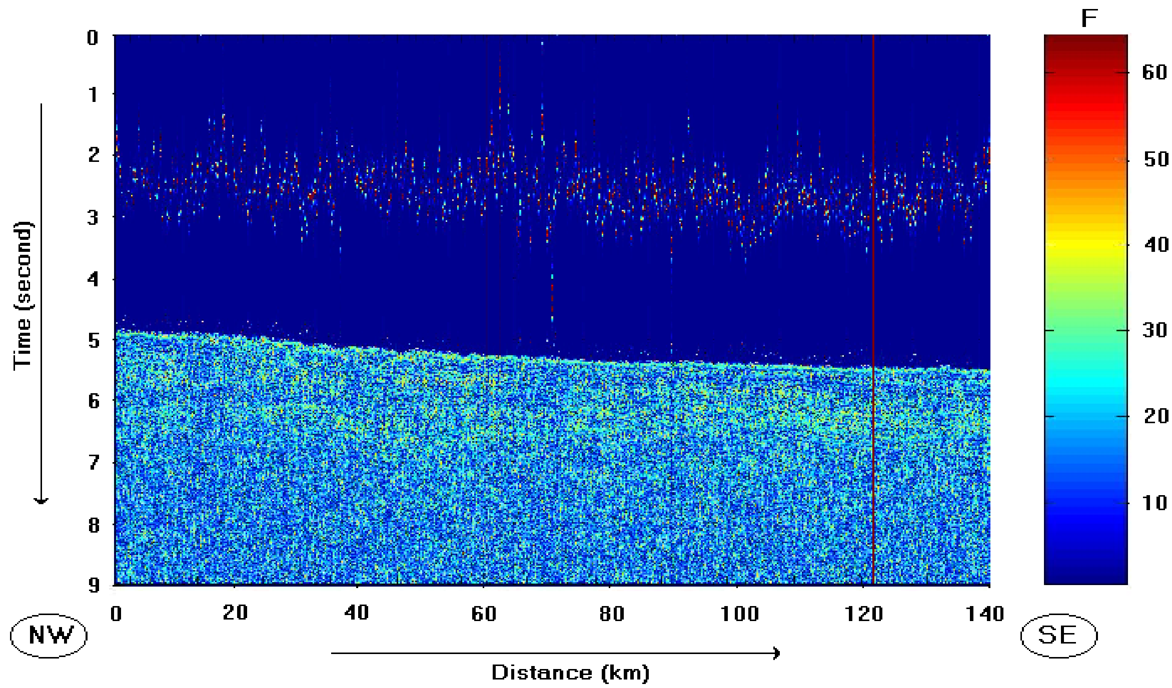

Figure 9. Frequency attributes of seismic section line 29B.

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