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FREQUENCY ANALYSIS AND ARGAND DIAGRAMS OF THE FIRST EVENTS ON REFRACTION SEISMOGRAMS

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ABSRACT *Amplitude spectra of the first break cycles of the refracted P and S waves were analyzed to determine a relationship among the maximum frequencies and corner frequencies of the first break one cycle periods of the refracted waves and their Argand Diagrams. More than 20 seismic P and S refraction seismograms were analyzed. The maximum first break frequencies (dominant frequencies) and the corner frequencies of the first break one cycle periods of the refracted waves were formed groups for each branch of the time-distance curves. Their Argand diagrams represented some similarities and made groups.*

INTRODUCTION

The seismic refraction data are the variation with time of the amplitudes of various geophone outputs. The paths and the travel times of the waves depend upon the physical properties of the rocks and the attitude of the beds. The objective of interpretation of the seismic refraction data is to deduce information about the rocks, especially about the thicknesses and velocities of the beds from the observed first arrivals times. However, due to the refracted seismic waves are the results of the superposition of many sinusoidal waves differing in frequency, amplitude and phase variations in the frequencies, phases and refraction times from place to place on the surface, usually indicate structural features in the strata below. In some cases, background noise may swamp the early part of the seismic signal and the amplitudes of both the signal and noise vary and a phase picked as a first event on one trace may not be identical to the phase picked on another. In this condition the interpretation of the refraction seismograms become very subjective and need additional attributes. This study describes a relationship among the maximum and corner frequencies of the first break one cycle periods of the refracted waves and their Argand diagrams.

THEORY and METHOD

More than 20 seismic refraction data were collected in different place and rock types. The offsets and the geophone intervals have been varied between 1m and 5m. The data were recorded using RAS24 and Geometrics model seismic refraction recording instruments with 12 P and S wave geophones. The signals were enhanced to increase S/N ration. The collected data were processed using seismic refraction interpretation software program (SIP). In the first stage, the seismic refraction data were interpreted and their time-distance curves were determined (Kurtuluş, 2002; Sobeslavsky,et.al.,1995; Hatherly 1982). In the second stage, the first break one cycle periods of the traces on the seismogram were digitized and their amplitude spectra were obtained using Fast Fourier Technique (FFT) (Ziemer et al., 1998; Kurtuluş et al.2004). The peak and the corner frequencies were determined from the amplitude spectra. In the third stage, the Argand diagrams of the first break one cycle period of the traces were obtained by drawing the real and imaginary components as axis and ordinate respectively.

APPLICATIONS OF THE METHOD

P WAVE

The P wave seismic refraction data (Fig-1) were interpreted using the seismic refraction interpretation software program (SIP).

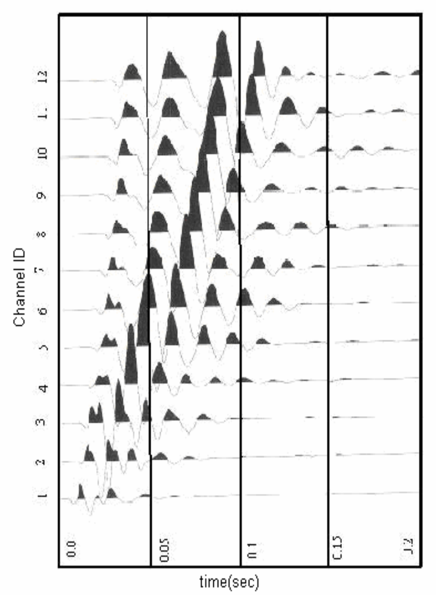

Figure-1. Seismic refraction record (#1). Recorded length 0.2 sec., sample interval 0.5 msec. PreAmp Gain 24 dB.

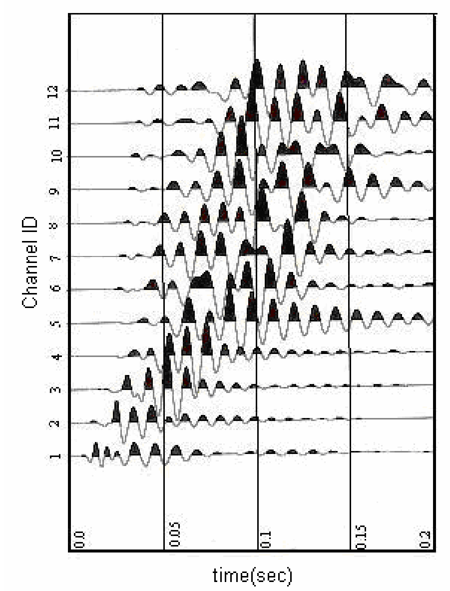

Figure-2. Seismic refraction record (#2). Recorded length 0.2 sec, sample interval 0.5msec PreAmp Gain 24 dB. Offset is 2m and geophone interval is 1m.

Three layers were detected under the ground. The velocities of these layers are V_1=283m/s V_2=439.5m/s and V_3=480.5m/s. The thicknesses of the first and the second layers are 0.53m and 2.189m. The first breaks one cycle periods of the refracted waves were sampled with the sampling interval 0.5 msec and their amplitude spectra were obtained using the FFT technique. The peak frequencies were handled drawing a perpendicular from the maximum peak to the frequency axis.

The maximum peak frequencies of the first break one cycle period of the first channel traces on all the seismograms could not be determined because of irregular amplitude variations in their spectra. The peak frequencies of the traces on the seismograms were formed three groups corresponding to time –distance curves of all the seismograms determined. The corner frequencies were determined drawing the high and low frequency envelopes of the amplitude spectra of the first break one cycle periods. The maximum and corner frequencies of the first break one cycle periods of the refracted waves related to the first, second and third layers have almost the same frequencies in their groups (Table-1).The Argand diagrams of the first break one cycle periods were shown in Fig-3. It can be observed from the figure that the energies and their shapes of the Argand diagrams related to the first break one cycle periods of the first, second and the third branches of the time-distance curves show different characters.

Energy densities of the Argand diagrams related to the first branch of the time-distance curves show weak closures at the center. The energy densities of the Argand Diagrams at the center gradually increase for second and third branches and the shape of the Argand Diagrams resample to each other for each individual branch(Fig-3 (a)). The little change on the shape of Argand Diagrams indicates the lithologic irregularities in the layers.

Table-1. The maximum frequencies and the corner frequencies of the first one cycle periods of the refracted waves (P-S wave) on #1 and #2 records.

Traces **P-WAVE**	Stright line segments	Max freq.(Hz)	Corner Freq. (Hz)	Traces **S-WAVE**	Stright line segments	Max freq.(Hz)	Corner Freq. (Hz)
1		--	--	1		--	-
2	1.th line	88.2	94.1	2	1.th line	128	110
3	Segment	88.2	94.1	3	segment	128	110
				4		128	110
4		64.7	58.8	5		117	100
5	2.th line	64.7	58.8	6	2.th line	117	110
6	Segment	64.7	58.8	7	segment	117	100
		64.7	58.8	8		117	100
				9		117	100
7		52.9	52.94	10	3.th line	88.2	80
8		52.9	52.94	11	segment	94.1	80
9	3.th line	52.9	52.94	12		52.9	80
10	Segment	52.9	52.94				
11		52.9	52.94				
12		52.9	52.94				

S WAVE

The S wave seismic refraction seismogram recorded in different place than that of the seismogram #1 Fig.-2.

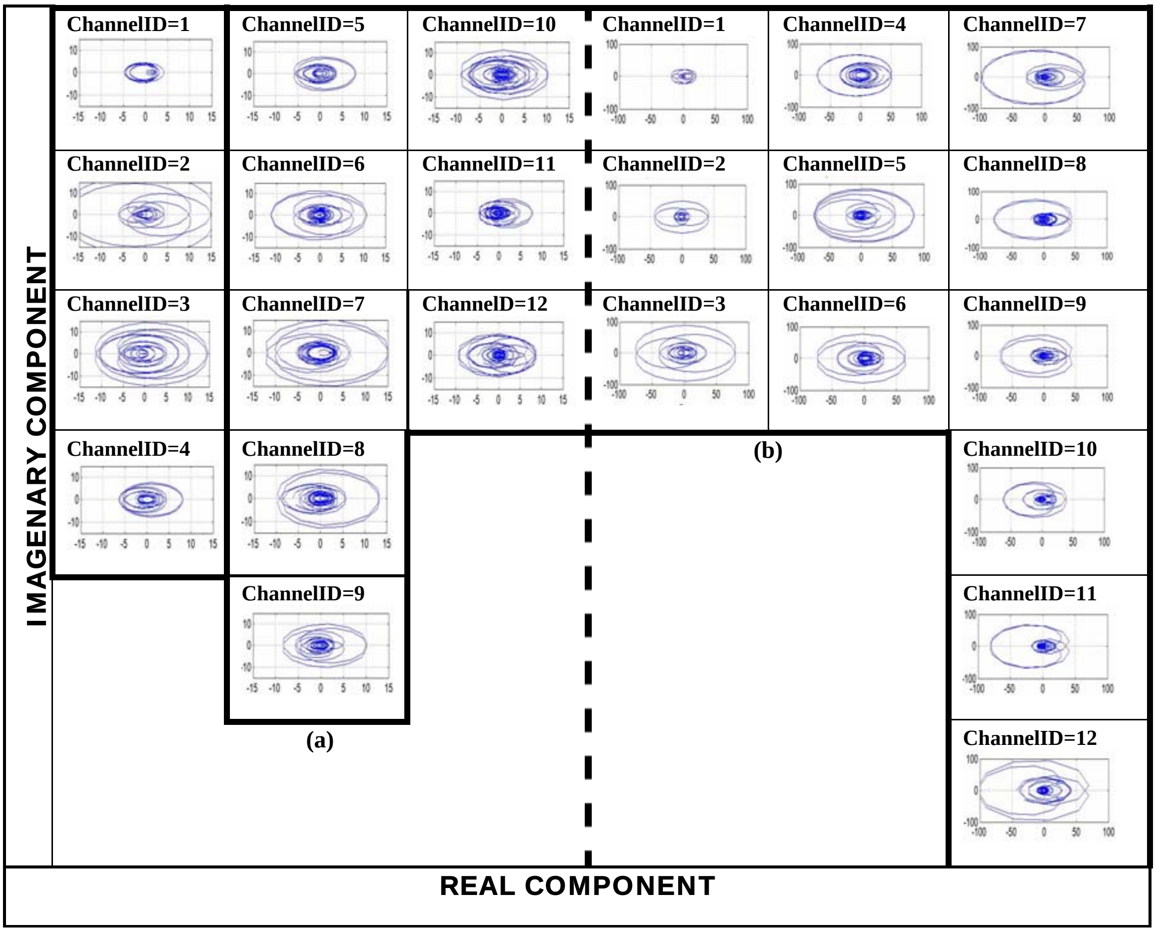

Figure-3. The Argand diagrams of the first break one cycle periods of traces corresponding to the three branches of the time-distance curves of the seismogram #1(a) and #2(b).

The Argand diagrams of the first break one cycle of the refracted wave traces on the record #2 are given in Fig-3(b).

Three layers were determined from the interpretation of the record # 2. The velocities of the layers are 275m/s, 390m/s and 560m/s. The maximum and the corner frequencies related to the first, second and third branches of the time-distance curves have almost the same frequencies and are given in Table 1.

The energy densities of the Argand diagrams of the traces related to the first branch of the time-distance curves of the record #2 are weak at the center and the shapes of the contours resemble more or less to each other whereas the energy densities of the Argand diagrams of the traces related to the second branch of the time-distance curves are more stronger than that of the previous branch and the contours have almost the same shape and the Argand diagrams of the traces related to the third branch of the time distance curves have the strongest energy densities at the center and similar contours of the same shape.

RESULT and DISCUSSION

The frequency analysis of the traces on more than twenty 12-chanel seismic refraction records were concluded and the Argand diagrams of the traces were examined in this study. It has been realized from the study that the maximum peak frequencies, corner frequencies and the Argand diagrams of the traces related to the same refracted surfaces were gathered together. The only point in question resulted from the frequency analysis of the first break one cycle periods of the first channel traces on the seismograms because of their irregular amplitude variations. For that reason their maximum peak frequency values and corner frequencies could not be detected. The small variations observed on the Argand diagrams represent lithologic changes in the area.

The study indicated that when the identification of the first events (first breaks) of the traces on the refraction records are not distinguishable, the analysis of the first break one cycle periods of the refracted traces and the examination of their Argand diagrams provide additional information in determining the time-distance curves of the refraction records and owing to figure out the velocities of the layers more accurately.

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