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Seismic Energy Attenuation in Miocene Succession in the Area East Gharib, Gulf of Suez, Egypt

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ABSTRACT. The attenuation of seismic energy in Miocene succession has been investigated in a deep borehole of East Gharib, Gulf of Suez. This has been done through the spectral analysis of the available successive downgoing waves of vertical seismic profiling. The related amplitude spectra of Miocene succession are then treated in order to differentiate the individual and cumulative attenuations of seismic energy in this thick succession (9100 ft). It has been found that the seismic energy has attenuation values of 0.53 db/100Hz. 100ft and 0.75 db/100Hz. 100ft in the upper and lower parts of Miocene succession, respectively. These attenuations can be attributed to the cyclic nature of the evaporitic upper part of succession, and to the existence of low velocity sandstones which are repeated alternatively with shales in its lower part. Comparison of the results obtained from this work with those from similar studies in the surrounding area at Ras Budran, further north, shows that the Miocene succession has approximately the same attenuation characteristics all over the central part of the Gulf of Suez.

Introduction

The poor quality of the useful deep seismic reflections from the pre-Miocene oil reservoirs represents generally the common problem of seismic prospecting in the Gulf of Suez. This problem could be attributed to the overlying Miocene sequence of highly attenuating character, as well as to the complex structural patterns in the area (Tagland 1978).

Hassan (1984) and Hassan *et al.* (1984) investigated intensively the attenuation problems of seismic energy in the Miocene sequence through the examinations of the transmission loss and the frequency dependent loss using borehole data in the area North July Oil Field. They concluded that the increase of the transmission loss in

such a sequence is mainly due to its cyclic nature. Tagland (1978) obtained the general rate of decay as 0.74 db/Hz for both the Miocene and pre-Miocene formations in Ras Budran Oil Field, while Sakr (1985) and Sakr *et al.* (1987) in their studies deduced a higher energy decay rate of about 0.84 db/Hz for the Miocene formations only.

The present study deals with the estimation of individual (every 100 ft) and cumulative attenuations of a stratigraphic zone having a thickness of 9100 ft. This zone (Fig. 1) ranges in age from middle Lower Miocene to most Upper Miocene in a borehole located east of Gharib, Gulf of Suez (Fig. 2).

AGE		FORMATION	THICKNESS (Feet)	LITHOLOGY	DESCRIPTION
Pliocene - Pleistocene			3300		Gravel, sand, marl and shale.
MIOCENE	Upper ?		9100		Limestone.
	Middle	Zeit			Evaporites.
		South Gharib			Evaporites with some shales and sandstones.
		Belayim			
	Lower	Kareem			Globigerina marls and shales with sandstones.
		Rudeis			
		Nukhul			Basal conglomerate and sandstone.
Oligocene		Abu Zabal			Basalt in northern area.

FIG. 1. Generalized Miocene stratigraphic column in East Gharib area, Gulf of suez (after Barakat 1982).

Method

Attenuation of seismic energy through its journey in the earth is a function of both lithology and distance traveled. The distance traveled can readily be shown by scaling the data in proportion to the distance traveled from the source. The lithological factors affect mainly the frequency content of the seismic energy, and the earth acts as a high cut filter (Anstey 1977). The mechanism of this energy loss is frequency selective, introducing a greater loss at higher frequencies than at lower frequencies. Generally, the attenuation of seismic energy can be expressed as spectral ratios, which are obtained from the successive downgoing waveforms of the vertical seismic profiling (Fig. 3) throughout the concerned zone.

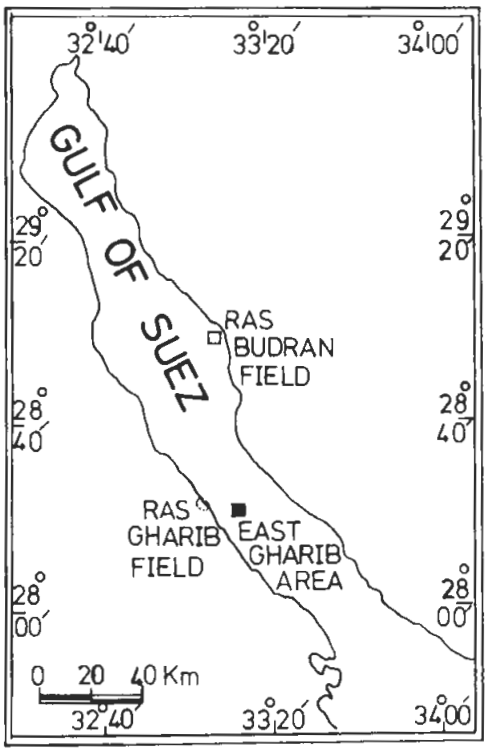

FIG. 2. Location map showing east Gharib area, Gulf of Suez, Egypt.

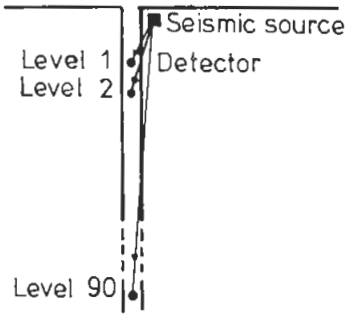

FIG. 3. Schematic of vertical seismic profiling survey.

Theoretically, this problem can be simplified as follows: The amplitude spectrum of the reference downgoing wave ($D_1(f)$), when multiplied by the earthresponse spectrum ($A(f)$) of a certain zone, would change it into a deeper one ($D_2(f)$), as:

$$D_1(f) \times A(f) = D_2(f) \tag{1}$$

In time domain, equation (1) can be written as :

$$d_1(t) \times a(t) = d_2(t) \tag{2}$$

Where $D_1(f)$ is the Fourier Transform of $d_1(t)$, $A(f)$ is the Fourier Transform of $a(t)$, and $D_2(f)$ is the Fourier Transform of $d_2(t)$

Accordingly, the spectrum of the earthresponse is then given by:

$$A(f) = D_2(f) / D_1(f) \tag{3}$$

The earthresponse $a(t)$ which is considered as the attenuation of such zone, can be directly obtained from the spectrum of earthresponse by using the inverse Fourier Transform technique.

Results and Discussion

Figure 4 shows examples of amplitude spectra for seismic records at some successive levels, taken into consideration that the Miocene sequence is divided to 90 levels, each of 100 ft thick. The spectral analysis are applied to detected seismic trace after removal of the source signature (Designature). This process extracts the useful seismic wavelet after the source wavelet for each shot. This designature technique is done by convolving the detected seismic trace with the source signature inverse operator.

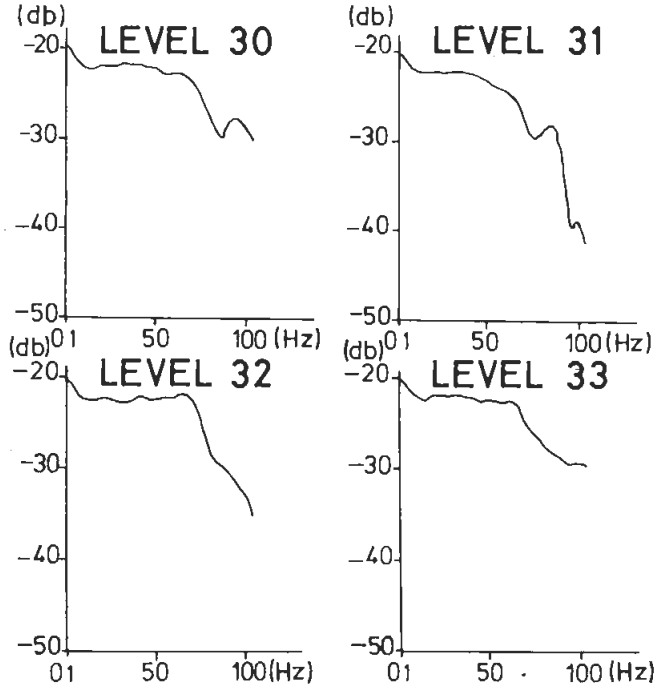

FIG. 4. Examples of amplitude spectra for seismic records at some successive levels.

The spectral densities were based on a 100 m sec window commencing 20 m sec before the first trough. Data within this selected time window, were chosen to include the direct arrival wave at each level and then were analysed using the Fourier Transform technique (Berson 1959 and Berson *et al.*, 1962) to produce such amplitude-frequency graphs.

Two types of spectral ratios were analysed, and accordingly two resultant attenuation relations were obtained :

1. Incremental spectral ratios fulfill to illustrate the spectral ratios between the adjacent levels which represent, in this case, the individual attenuations of seismic energy between these adjacent levels (Fig. 5).

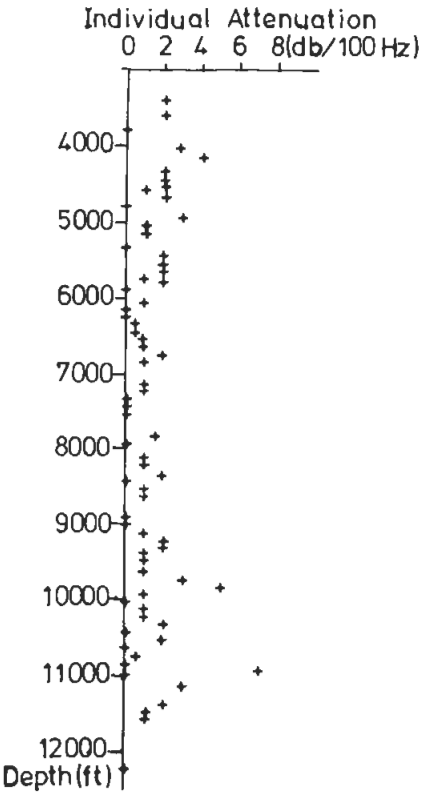

Fig. 5. Individual attenuations of seismic energy in Miocene succession.

2. Cumulative spectral ratios were performed using a fixed reference downgoing wave, and accordingly the cumulative attenuations with respect to this reference level can be demonstrated (Fig. 6). In the present study, level 16 at 4600 ft (within Zeit formation) was selected as a fixed reference downgoing wave in order to avoid the noisy situations present within the shallower levels.

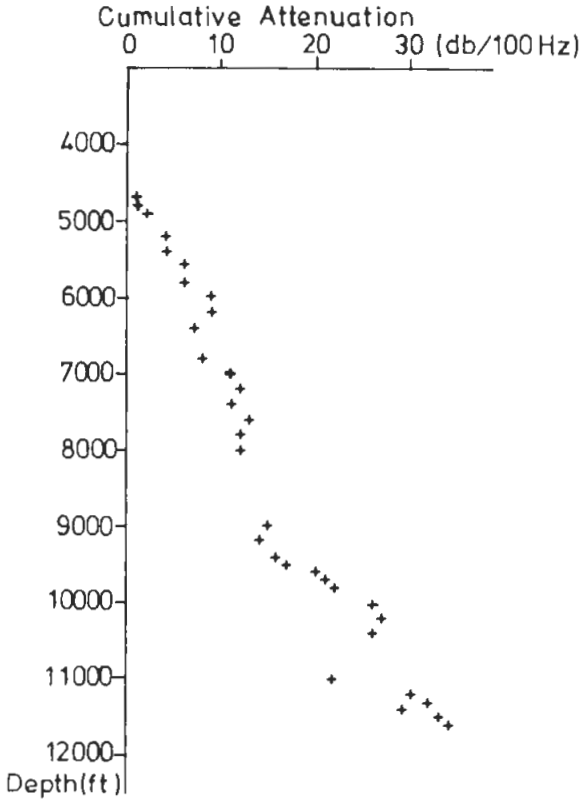

FIG. 6. Cumulative attenuations of seismic energy in Miocene succession.

Figure 5 illustrates that the range of individual seismic energy decay falls between 0 db/100Hz. 100ft and an extremely high value 3.5 db/100Hz. 100ft with the mean value 0.64 db/100Hz. 100ft. The relatively high individual attenuation values observed in the upper part of Miocene succession up to the Top of Kareem formation (0.53 db/100Hz. 100ft) can be attributed to the cyclic nature of Miocene evaporitic sequence. This evaporitic sequence is formed essentially by alternating layers of high velocity anhydrite and relatively low velocity shale. The above mentioned conclusion is similar to the result obtained by O'Doherty and Anstey (1971). In this study, it was noticed that the transmission loss of such a cyclic zone lowers uniformly the amplitude of all frequencies in the seismic wave. The high individual attenuation values in the lower part of Miocene succession (0.75 db/100Hz. 100ft) can be explained by the existence of relatively low velocity sandstones, which are repeated alternatively with shales. These highly porous sandstones may be considered as significant oil traps in the presence of normal faults and tilted blocks (Mostafa 1976).

The cumulative attenuation of seismic energy as a function of depth has also been utilized to define the responses of different formations in the Miocene succession as shown in Fig. 6. It can be observed that the decaying rate of seismic energy through a zone located between the reference level (within Zeit Formation) and Top Kareem (4400 ft) is 14 db/100Hz with an attenuation gradient of 0.318 db/100Hz. 100ft. This result is lower than the value 0.53 db/100Hz. 100 ft obtained from the analysis of individual attenuation. On the other hand, the attenuation gradient in Kareem and Rudeis Formations reaches a distinct high value of 0.80 db/100Hz. 100ft, which shows an obvious harmony with the value of 0.75 db/100Hz. 100ft obtained from the analysis of individual attenuation.

Moreover, the comparison of the results obtained from this work with those of similar studies by Tagland (1978), Sakr (1985) and Sakr *et al.* (1987) in Ras Budran, further north, illustrates that the Miocene succession has approximately the uniform attenuation characteristic (0.78 db/100Hz. 100ft) all over the central part of the Gulf of Suez.

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اضمحـــلال الطاقـــة السيزميـــة في تتابـــع الميوســـين بمنطقـــة شرق غارب خليـــج السويس ، مصـــر

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مستخلص . يشتمـل هذا البحث على دراسـة اضمحـلال الـطاقة السيزمية في تتابع الميوسين بإحـدى الابار العميقة بمنطقة شرق غارب بخليج السويس . وقد تمت هذه الدراسة من خلال التحليل الطيفي للموجات السيزمية النازلة المتتابعة للبروفيلات السيزمية الرأسية والتي أُجريت في البئر . ولقد عولجت السَّعات الطيفية المناظرة للتتابع الميوسيني حتى يمكن اشتقـاق الاضمحـلال الجـزئي والاضمحلال التجميعي للطاقة السيزمية في هذا التتابع السميك (٩١٠٠ قدم) . وقد وجد أن للطاقة السيزمية قيمًا اضمحلالية هى ٠,٥٣ ديسيبل / ١٠٠ هرتز . ١٠٠ قدم و ٠,٧٥ ديسيبل / ١٠٠ هرتز . ١٠٠ قدم للجزءين العلوي والسفـلي لهذا التتابع ، على الترتيب . وقد أرجع هذا الاضمحلال إلى الطبيعة الدورية لمتبخرات الجزء العلوي من التتابع ، وكذلك إلى وجود الصخور الرملية المنخفضة السرعة والتي تتكرر تبادليا مع الطفل في جزء التتابع السفلي . وقد أظهرت المضاهاة بين نتائج هذه الدراسة والدراسات المماثلة التي أُجريت على المناطق المجاورة برأس بدران ، إلى الشرق من منطقة البحث ، أن تتابع الميوسين له تقريبا نفس الخواص الاضمحلالية على طول الجزء الأوسط من خليج السويس .