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SEISMIC RESOLVABLE FREQUENCY BAND FOR THE PRE-MIOCENE OIL TARGETS RAS BUDRAN, GULF OF SUEZ, EGYPT

By

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ABSTRACT

Seismic attenuation problem in Ras Budran area, Gulf of Suez was tackled by defining the resolvable frequency band. This band can transmit through the Miocene evaporitic cyclic section and hit pre-Miocene oil targets. This resolvable frequency band, which suffer minimum attenuation, was defined by using the area V.S.P. and its frequency-energy analysis. Also, the attenuation rates, through the Miocene evaporitic section, were defined. These results can serve for an accurate frequency processing of the surface seismic data. It helps to recognize the desired frequencies and to reject the other undesired frequencies. It also, guides in designing the source signature for a better picture at the target zones.

INTRODUCTION

This work aim to hit the main problem in the business of oil prospecting in the Gulf of Suez. How to treat with the area seismic limitations, where the seismic reflection method is the best powerful and reliable tool in oil prospecting and how to use the ground seismic response in improvement of the seismic data quality.

Ras Budran (Fig. 1) seismic data represents to some extents the common quality of the Gulf of Suez. The problem is well demonstrated in the poor quality of the pre-Miocene seismic reflections. Figure 2, is a sample seismic section, of northeast-southwest direction shows the poor quality of the pre-Miocene, oil target zone, seismic reflections (2.0-3.0 sec.). The Miocene evaporitic section (0.7-1.5

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sec.), of a good seismic quality, looks responsible for such pre-Miocene signal distortion. This is because, the Miocene evaporitic section is of cyclic nature, at which the transmission loss of seismic energy is enormous compared with that deeper thick bedded shales-sands-carbonates sequence of the pre-Miocene target zone (O'Doherty and Anstey, 1971). Miocene deposits play as a strong attenuator and act as a low-pass filter to the deep seismic reflections (Domenico, 1979). The Miocene deposits are composed essentially of interabedded anhydrite, salt and shale layers and their thickness varies in the area from a few hundreds to about 8000 feet.

In addition to this attenuation phenomenon, the Miocene section creats strong multiple families of different classes which effectively mask and distort the useful weak reflections of the complex pre-Miocene target zones.

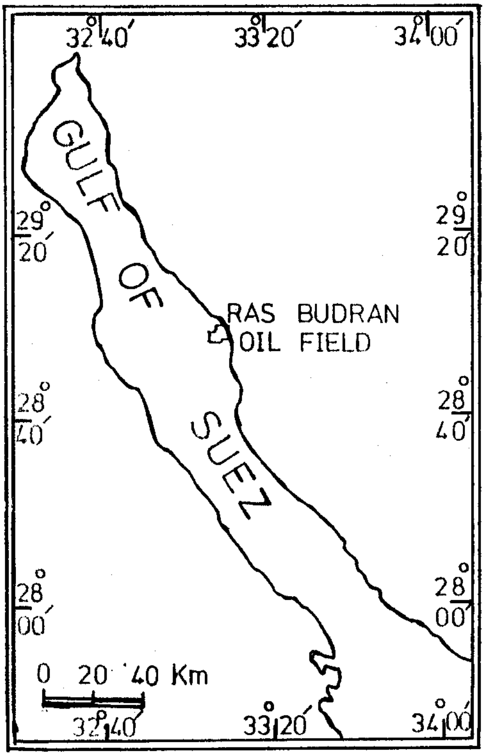

Fig. 1: Location map showing Ras Budran field, Gulf of Suez, Egypt.

In summary, the problem could be defined as a poor quality of deep seismic reflections related to the pre-Miocene targets in the Ras Budran in particular and Gulf of Suez in general. The overlying Miocene sediments creats severe seismic interpretation problems in mapping the structures at the pre-Miocene levels (Abdine, 1981).

In this study, the attenuation problem was tackled by defining the resolvable frequency band. This band can transmit through the Miocene evaporitic cyclic section and hit pre-Miocene oil targets.

DATA AND ANALYSIS

Data used to evaluate the earth seismic response in Ras Budran area are a collection of 3-D seismic surface data and the borehole geological-geophysical data.

The quality of this stacked migrated 3-D seismic data could be summarized as good quality to the Miocene reflectors and poor quality for the pre-Miocene reflectors (Fig. 2).

The borehole geophysical data are the vertical seismic profiling and the conventional sonic logs which were used to aid in seismic structural interpretation and to evaluate the vibrational characteristics of the evaporitic Miocene section. The borehole geological data and log measurements had provided the necessary information to define and evaluate the different rock units. Five boreholes act as control points in the area under study. These are RB-A1 well, EE 85-2 well, RB-B1 well, RB-C1 well and EE 85-7C well.

Frequency-energy analysis were carried out for all seismic records which are detected at check-shot levels for all the control wells. Frequency-energy analysis were done in terms of spectral power density and its relative attenuation in dB as a function of frequency components. Spectral power density analysis were applied to the detected seismic trace after removal of the source signature (Designature). This is to verify the geological signature on the seismic data. Through the deconvolution technique, designature was done by convolving the detected seismic trace with the source signature inverse operator. Figure 3 shows the spectral power density analysis for seismic records, detected at the mappable seismic reflector for the five wells in the area under study. The analysis was based on a 100 msec. window commencing 20 msec, before the first trough. A correction was applied to remove the effects of the field gain. However, no corrections were applied to compansate for change in the acoustic impedance between successive geophone position.

The energy source (gun pressure) remained constant at 1800 PSI through out the survey. Data within the selected time window is analysed using the Fourier and maximum entropy techniques to produce the power/frequency graphs. This window is chosen to include the direct arrival data at each geophone level which approximately correspond to the formation interfaces.

Attenuation of seismic waves as a function of depth were achieved in detailes through studying the attenuation per frequency components. From the power density spectra produced for each geophone level of interest, a series of frequency components (e.g. 5, 10, 20, 30, 40, 50, 60 Hz) were selected for graphical display of power attenuation against one-**way travel time** as a function of depth.

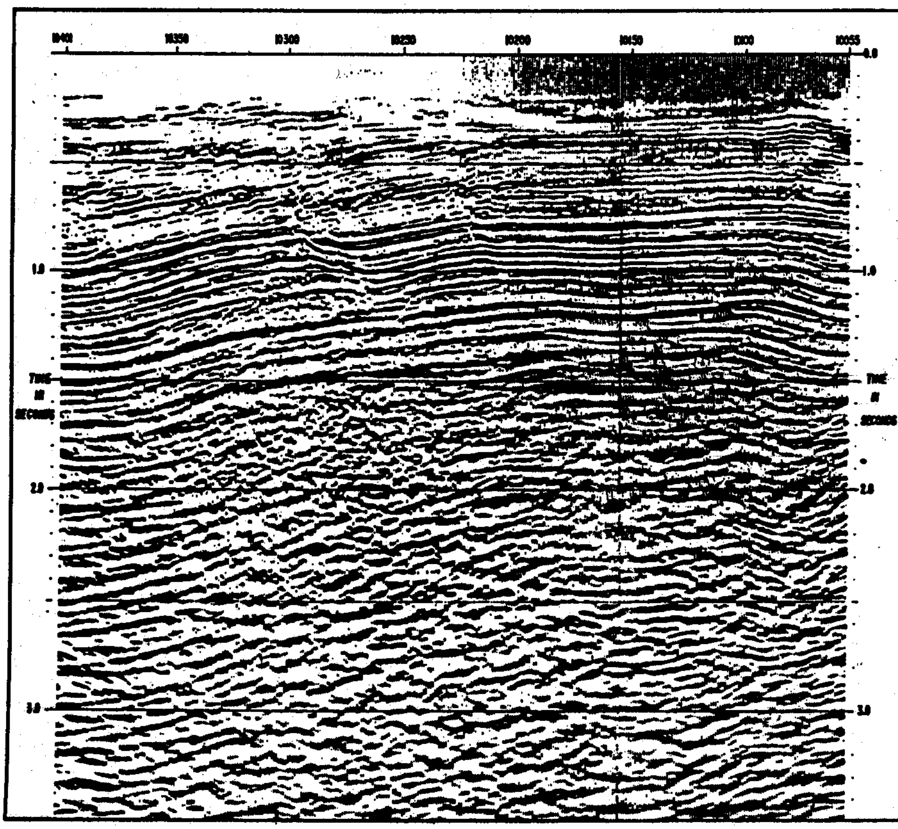

Fig. 2: Sample of seismic section.

INTERPRETATION AND DISCUSSION

The interpretation work was carried out in three stages, structural interpretation, configuration of vibrational characteristics and trend analysis. Structural interpretation of the area was achieved by integrating the available 3-D seismic data and both the geophysical-geological borehole data (Sakr, 1985). This stage was to identify the geological features and structural framework of the area.

Effective and resolvable frequencies to the base evaporitic section (Fig. 4) was mapped in terms of the predominant frequencies associated with the seismic wave fronts. This mapped frequency field demonstrates the earth frequency filtering behavior. It shows the frequencies which can penetrate through, as well as the frequencies which are attenuated through its journey to the horizon of interest.

Attenuation of seismic energy through the Miocene problematic section was investigated by mapping of the relative energy loss (dB) associated with the predominant frequencies travelled from the surface down to the base of the evaporitic cyclic section (Fig. 5). Figure 5 also shows the lateral configuration of the overburden attenuation characteristics. Moreover, the attenuation behavior was studied as a function of frequency component (5, 10, 20, 30, 40, 50, 60 Hz) against depth (one-way time). Figures 6, 7, 8, 9 and 10 show the rate of energy decay (dB) per second for each of the frequency component at the different well locations. Figure 11 illustrates the general trend (dB/cycle) for all frequencies, at each well.

Integrating the above mentioned analysis, it is recognized that the common effective resolvable frequency band within the Miocene mappable formations ranges from 37 Hz of 6 dB to 14 Hz of 84 dB. Consequently, this defined frequency band has the power to propagate through the Miocene problematic section. Therefore, this energy band should be used to resolve the structure at the deeper oil targets within the pre-Miocene.

Since the above analysis can be displayed either in terms of time or frequencies. The attenuation (dB) of seismic energy was interpreted for every frequency. Figure 11 shows this relations for all the control wells in Ras Budran area. The range of decay falls between 0.37 dB/cycle in EE 85-7C well and 1.323 dB/cycle in EE 85-2 well. The average decay rate within the Miocene evaporitic section is 0.84 dB/cycle. This means that 20 Hz energy at a depth of one second will suffer attenuation of 16.8 dB while 10 Hz will attenuate by 8.4 dB only.

These results agree well with the studies of O'Doherty and Anstey (1971), Schoenberger and Levin (1976) and Spencer (1977). According to them the classic transmission loss associated with a sort of cyclic section present in the Miocene evaporitic section, is enormous while the effect at low frequencies will be offset by the intrabed multiple effects. Tegland (1978) in his study of the well (KK 85-1) in

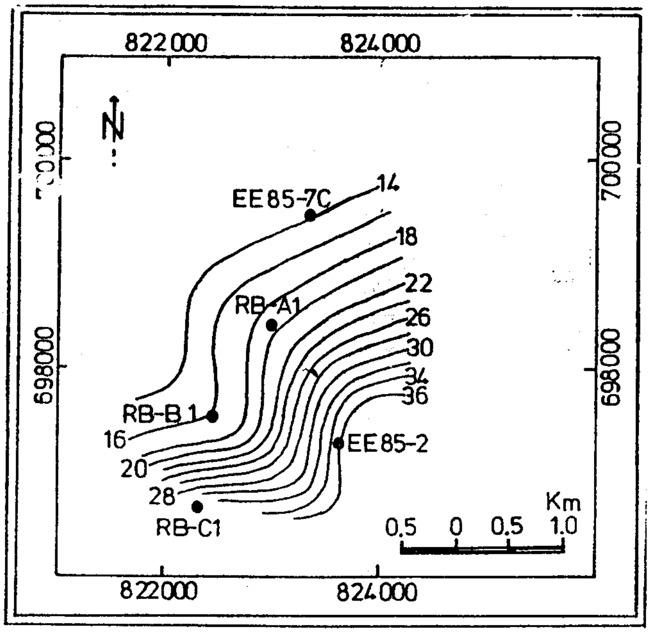

Fig. 4: Resolvable frequency map on Top Kareem formation of Ras Budran field, Gulf of Suez.

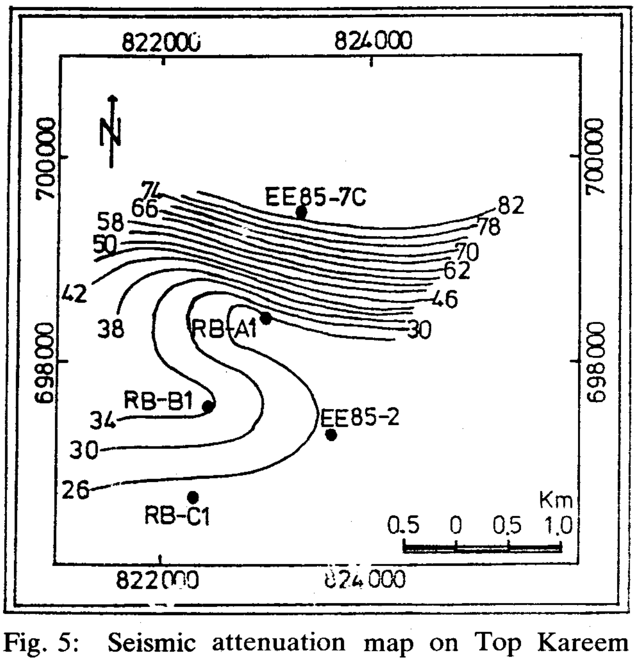

Fig. 5: Seismic attenuation map on Top Kareem formation of Ras Budran field, Gulf of Suez.

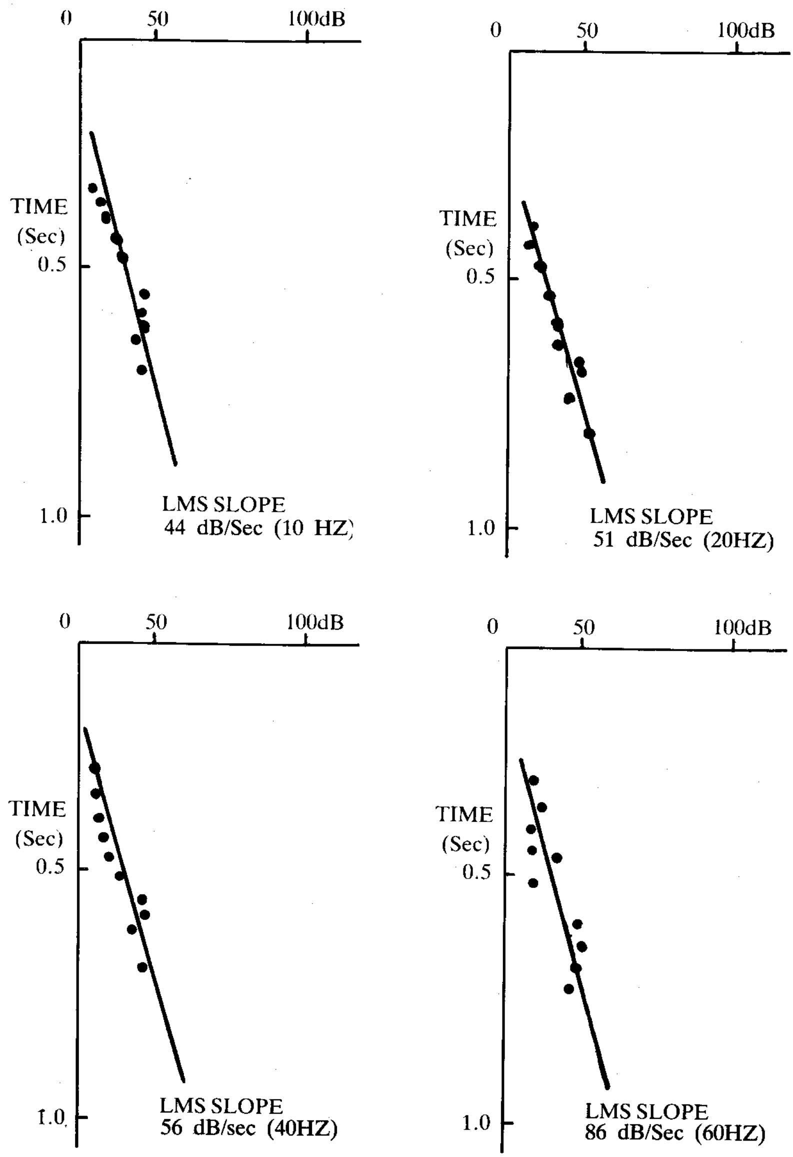

Fig. 6: Normalised attenuation analysis (dB/sec) at Well RB-A1.

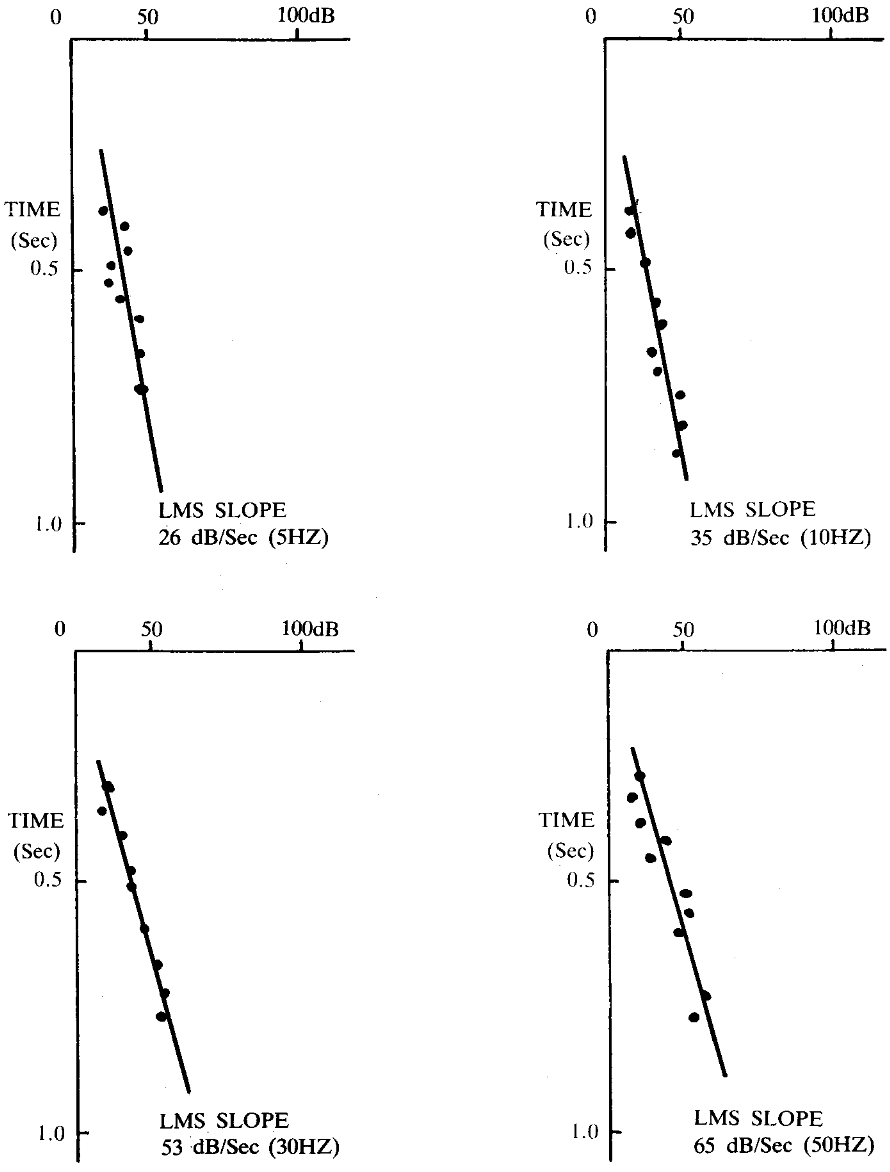

Fig. 7: Normalised attenuation analysis (dB/sec) at Well RB-B1.

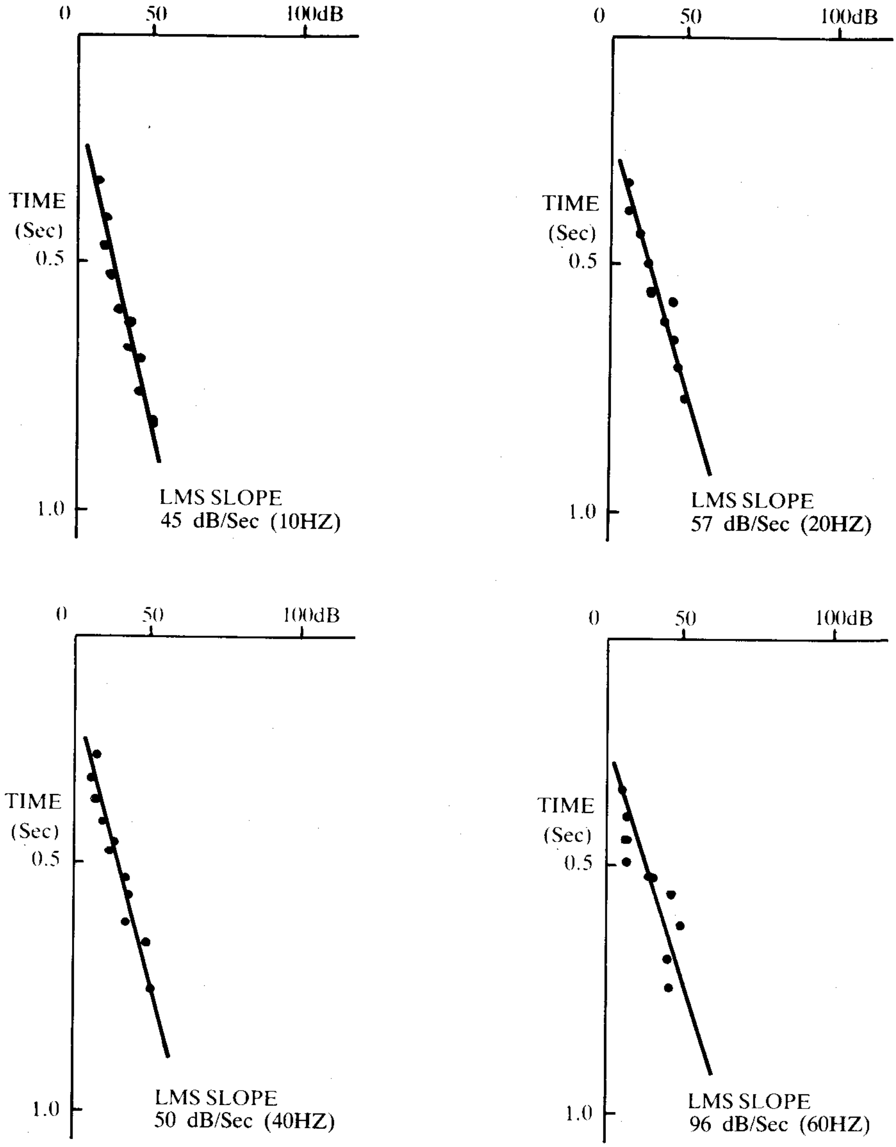

Fig. 8: Normalised attenuation analysis (dB/sec) at Well RB-C1.

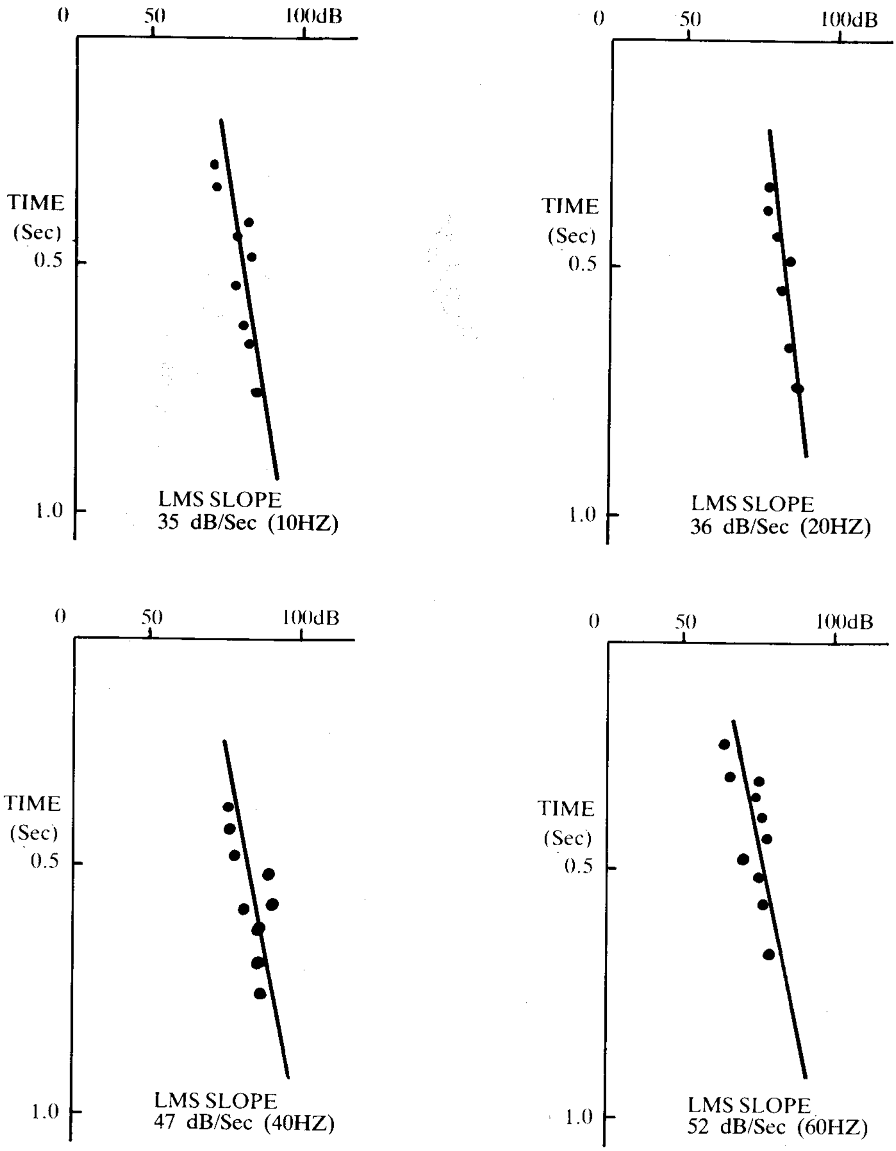

Fig. 10: Normalised attenuation analysis (dB/sec) at Well EE 85-7C.

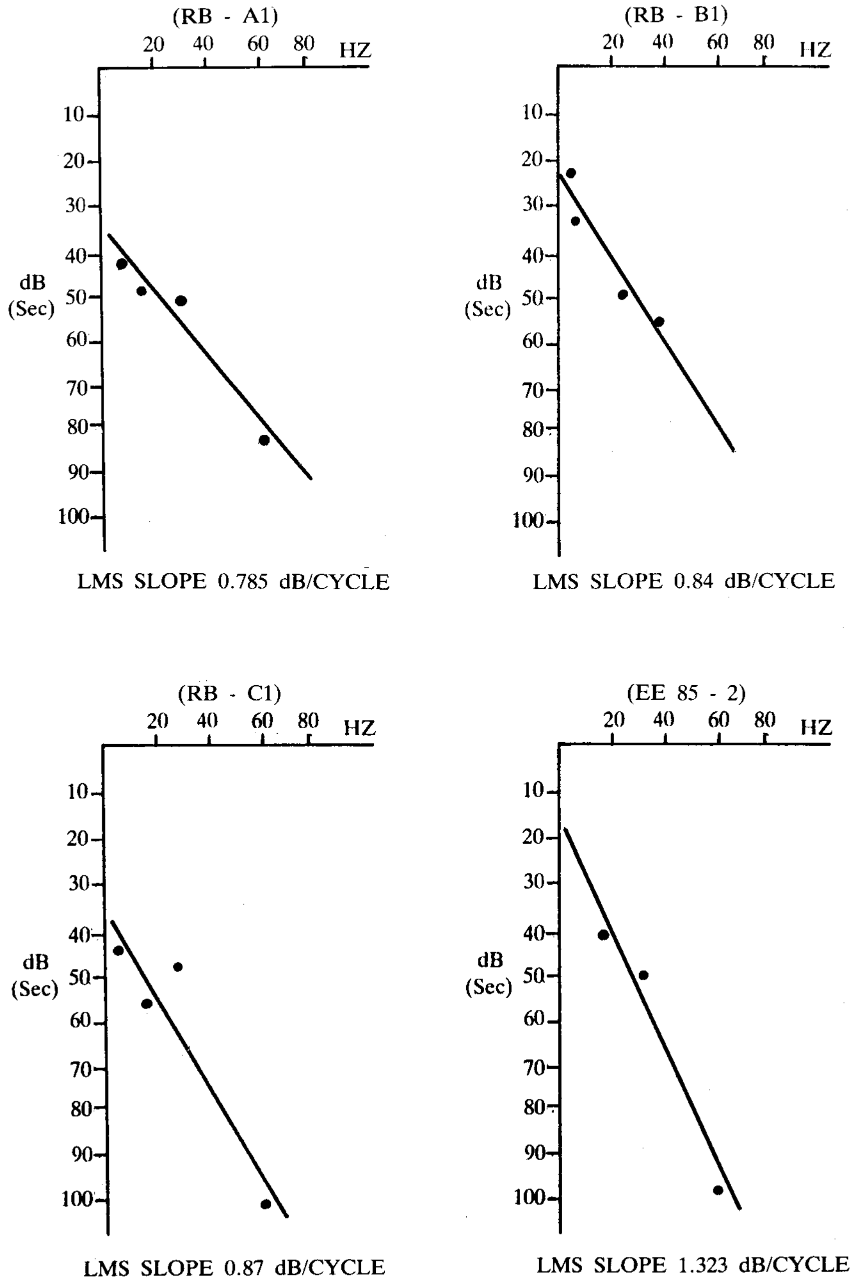

Fig. 11: Miocene attenuation analysis (dB/cycle).

the Gulf of Suez obtained the general rate of decay as 0.74 dB/cycle for both the Miocene and pre-Miocene formations.

The present study, on the other hand suggests a higher energy decay rate of 0.84 dB/cycle for the Miocene formation only. Apparently, the conclusion of Tegland would have been similar to the present study if he had studied the Miocene and pre-Miocene formations separately. As discussed in the preceding paragraph, the transmission losses in the evaporitic cyclic section of the Miocene are enormous whereas the transmission losses within the pre-Miocene section, characterized by thickly bedded shale-sand-carbonate sequence, are likely to be less severe.

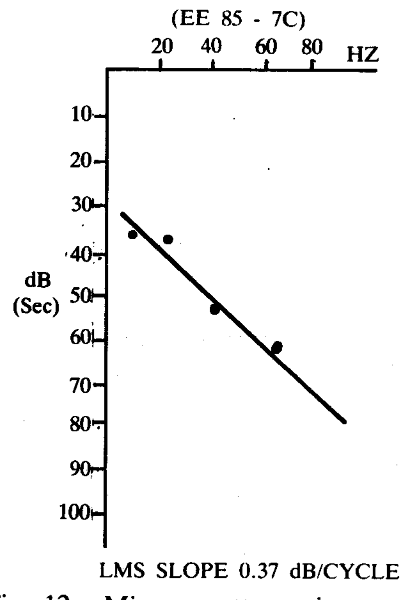

Fig. 12: Miocene attenuation analysis (dB/cycle).

CONCLUSIONS

Based on this study some conclusions were derived regarding the precise control of data collection and processing techniques for better seismic data quality. These conclusions are summarized as follows:-

1. The common effective resolvable frequency band ranges from 37 Hz to 14 Hz. This frequency band has the power to propagate deeper than the problematic section (Miocene evaporite) and to resolve the pre-Miocene oil target zone.

2. Attenuation analysis carried out for every frequency component as a function of depth/or time, shows that low frequencies (5-15 Hz) are much less attenuated than the higher frequencies. Also the plotted graphs of this analysis in terms of dB per cycle for Ras Budran area, shows a range of energy decay falls between 0.37 dB/cycle to 1.323 dB/cycle with average value of 0.84 dB/cycle. The difference between this value and that (0.74 dB/cycle) of Tegland's work (1978) can be attributed to the enormous transmission losses in the Miocene evaporite whereas the transmission losses is less severe within the pre-Miocene section as found by Tegland (1978).

3. In the phase of data acquisition, where the earth seismic response is not constant in three dimension (vertically and horizontally), the acquisition system should be offset-dependent system to precisely treat such variable conditions. The prevailing acquisition system are of fixed characteristics over the surveyed area. The offset-variable-dependent acquisition system means having a variable frequency characteristics source to meet the lateral variations of the earth frequency response. This will provide the useful effective resolvable frequencies which suffer the least attenuation during its journey through the earth.

   This could be achieved in marine seismic operations by using an offset controlled source array with a changeable fire power and also changeable pattern configuration. Furthermore, such offset-dependable technique could develop the concept of the beam steering technique (Dale, 1984) at which, the detectors subarray beam steering process is a plane wave stacking technique which removes the differential moveout and improve the resolution of seismic data by directing the subarray peak gain to the incident angle of seismic wave front.

4. In the phase of data processing, an offset-dependent true amplitude recovery treatment is suggested. The computed decay function can be serve for proper compensation in the relative amplitude strength processing, and thus yield a true picture of the lateral variations of the reflection horizons. The standard prevailing technique is to use the scaling techniques for each zone of interest, which destroys the stratigraphic features.

These conclusions should be considered for improving the seismic data quality in the Gulf of Suez environment and especially in the development process where the well data are available as in the case of Ras Budran oil field.

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حيز الترددات السيزمية المستنبط للنطاقات البترولية لصخور ما قبل الميوسين في رأس بدران - خليج السويس - مصر

محمد محمد عزت صقر - محمود عبد المنعم الحفناوي
و إجلال رفاعي

تتمثل المشاكل السيزمية بمنطقة خليج السويس في النوعية الفقيرة للانعكاسات السيزمية العميقة النافعة والتي ترتد من النطاقات البترولية لصخور ما قبل الميوسين - ويمكن إرجاع هذه المشاكل إلى عدة عوامل منها معاملات الانعكاسات السيزمية المتواضعة لصخور ما قبل الميوسين والاضمحلال القوي للطاقة السيزمية في القطاع الجيولوجي وكثرة متكررات الانعكاسات السيزمية وأخيراً إلى تعقيدات التراكيب الجيولوجية التحت سطحية - هذا بالاضافة إلى قدرتنا المحدودة - حتى الآن - على تحسين جمع ومعالجة البيانات السيزمية بواسطة إستخدام التقنية الحديثة .

ومن خلال دراسة إضمحلال الطاقة السيزمية فقد أمكن التوصل إلى حيز للترددات السيزمية والتي يمكنها المرور في متبخرات الميوسين وارتدادها من النطاقات البترولية لصخور ما قبل الميوسين بأقل اضمحلال ممكن ، وقد استنتج هذا الحيز من تحليل العلاقة (الترددات - الطاقة) والمستنتجة من البروفيلات السيزمية الرأسية . وكذلك أمكن توضيح التغييرات الجانبية لمعدلات الاضمحلال للطاقة السيزمية لقطاع متبخرات الميوسين .

عند أخذ هذه النتائج في الاعتبار للمعالجة الدقيقة للبيانات السيزمية خاصة في طور التنمية لحقول البترول ، حيث تتوافر نتائج الآبار الاستكشافية كما في رأس بدران فإنها تساعد على ادراك حيز الترددات السيزمية النافعة (١٤ - ٣٧ هرتز) والتخلص من ترددات الشوشرة ، وكذلك يمكن الاسترشاد بها عند تصميم مصدر سيزمي مناسب حتى نحصل على صورة واضحة للنطاقات البترولية المنشودة .