

THE ESTIMATION OF SEISMIC VELOCITIES AND THE ATTENUATION
 COEFFICIENT Q FROM SEISMIC TRACE ANALYSIS.
 APPLICATION IN A MARINE SEDIMENTARY BASIN

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ABSTRACT

Two different models have been proposed for the crustal structure of the N. Aegean through based on the available geophysical data mainly gravity, magnetics and refraction seismics.

Additional physical properties of rock units can be derived from reflection seismology, i.e. compressional waves velocity V_p and quality factor Q.

The average velocity V_p of ophiolites, granites and Neogene sediments, that comprise the surface geology, (fig.1) is a very characteristic physical property that differentiates these rock types and as such has been used in this study.

Regarding the attenuation parameters no previous work has been carried out in this area.

Thus, its use as further

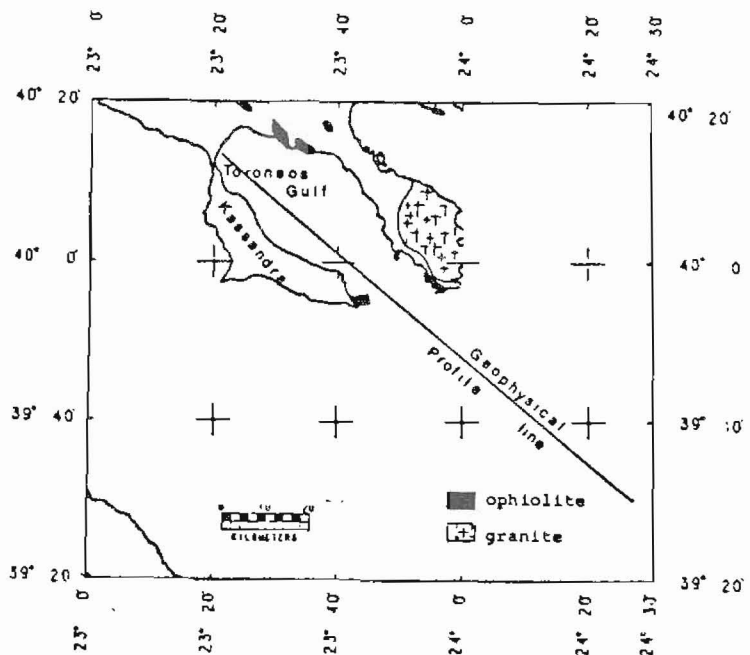


Fig.1 - Location map

evidence in distinguishing ophiolites from granites is investigated.

INTRODUCTION - EXPLORATION REVIEW

The N. Sporades basin of the N. Aegean trough has been studied by many research teams who have presented two different crustal models.

Makris (1977), Kiriakidis (1984), Brooks and Kiriakidis (1986), Ginzburg et al (1987) have interpreted the gravity and magnetic field in the area in terms of a crust having a thickness of about 26-30 km with massive ophiolitic bodies thrust on it.

Data from long refraction lines have also been used in their interpretation. However Le Pichon et al (1984), Christodoulou and Hatzfeld (1988) who also studied the crust in the area under investigation concluded that the crust is much thinner (15km) and has been intruded by hot material. The former based their study in gravity, magnetic, short refraction lines and also a few heat flow measurements while the latter on earthquake residual travel times. Rokka et al (1983) presented supporting evidence for upcmcd hot material in the area of N. Sporades based on earthquake epicenter locations.

Recently Kiriakidis (1989) accumulated all available gravity, magnetic, seismic and borehole data in N. Greece and presented a Bouguer map corrected for water and sediment thickness. The 3-D magnetic and gravity interpretation of the geophysical anomalies situated in the N. Aegean trough showed that the area is characterized by normal crust incorporating thick (up to 6 km) ultramafic bodies.

SEISMIC VELOCITIES AND Q ESTIMATION

The combined analysis of seismic velocities and the quality factor Q can be directly correlated with the tectonics and the lithology of the earth's crust (Mokhtar et al, 1989).

The spectral decay method was applied to reflection seismic traces for the Q factor estimation.

The marine seismic data from the Toroneos Gulf were provided by DEP EKY SA. The whole data processing was carried out in DEP EKY's computer center using software from Western Geophysical Company.

The seismic data were processed in a relative amplitude preservation mode. The seismic velocities were calculated by using the conventional techniques of processing (Johnston, 1983) and performing one analysis every 3 km.

Consecutively, the stacked seismic traces were used for the Q factor estimation. The location of each analysis was determined by the quality of the data and their geologic interpretation and finally a mean density of one analysis every 3.5 km was obtained.

Spectra from stacked traces spanning an area of 1-2 km were averaged to provide a smoothed spectrum for each analysis position. An example of such an averaged spectrum

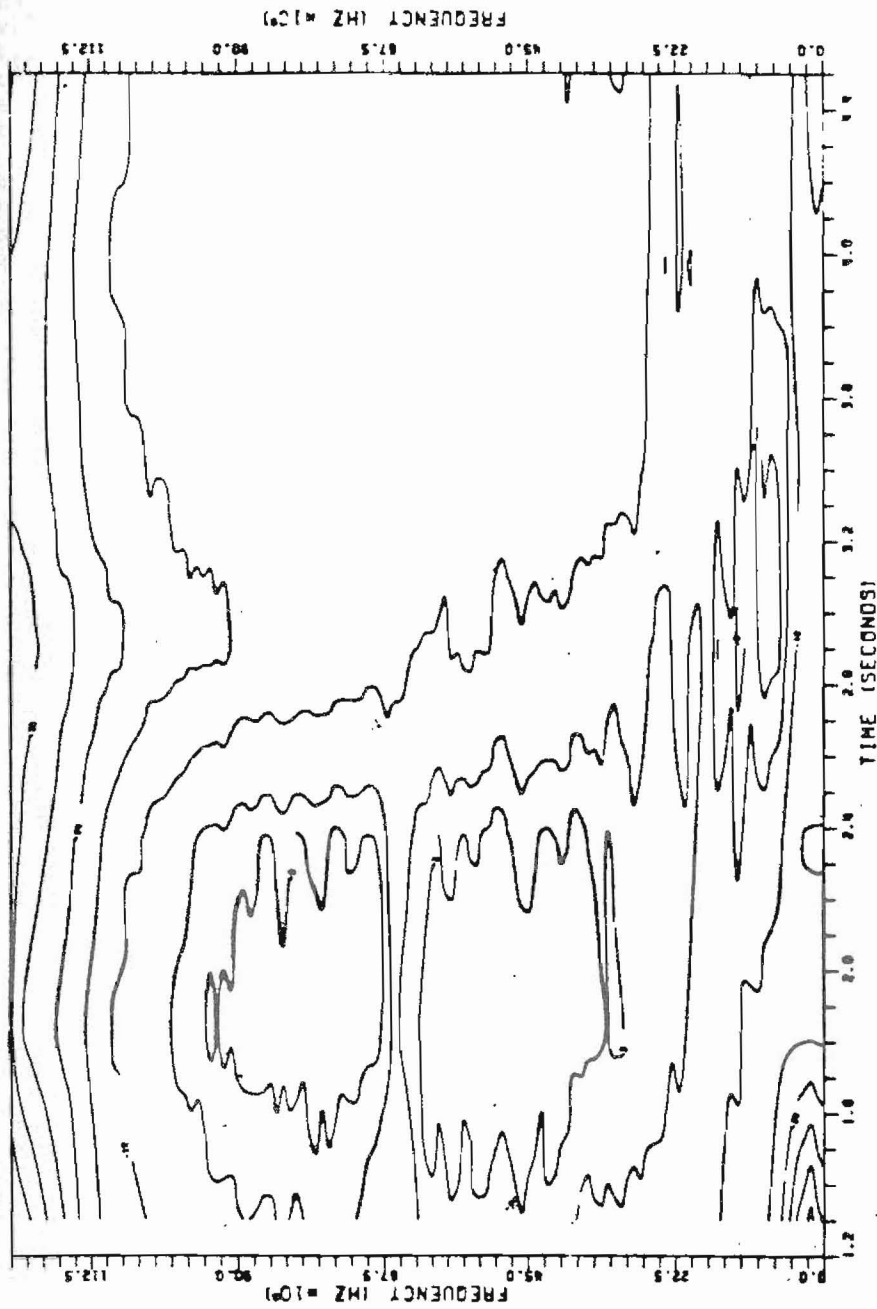


Fig. 2
 -TV Q ESTIMATE
 WINDOW LENGTH = 1000 (MS) WINDOW ADVANCE = 500 (MS) STARTING TIME = 1300 (MS)
 CONTOURS ARE OF AMPLITUDE SPECTRA IN DB FROM THE MAXIMUM VALUE

is shown in fig. 2. Windows having a length of 1.0 sec two-way time with overlap of 500 ms were analyzed and the Q-value estimated was attributed to the centre of each window. The spatial distribution of centres is presented in fig. 3. A total of 130 values were obtained. Fig. 7 is the final smoothed contoured map of the Q distribution.

Fig. 3 DISTRIBUTION OF Q ANALYSIS CENTRES



The frequency range used for the Q estimation is included between 12.5-50 Hz, that is 0.1 to 0.4 the Nyquist frequency. It is well known that this range of signal frequency is representative for this kind of seismic exploration while the Q is practically frequency-independent (Unknown, 1988).

The model for attenuation is given by the relation :

$$A(t) = \exp(-\pi t f/Q) \text{ (Norris et al, 1984)}$$

Calculating the slope (in db/Hz) of a straight line fitted to the values of the amplitude plotted on a logarithmic scale, we derive the Q value as :

$$Q = 27.3 t/\text{slope}$$

Obviously the so derived Q estimations are strongly dependent on the shooting and recording parameters on the S/N ratio and on the processing techniques applied. However, if all the above factors are kept constant throughout the survey, the Q values can differentiate areas possessing relatively medium or low attenuation properties.

ANALYSIS OF THE GEOPHYSICAL DATA

The rock units comprising the surface geology in the nearby Axios and Serbomacedonia geologic zones have the known geophysical properties (Makris and Muller 1977, Phillipopoulos 1983, Kiriakidis 1984, Filbrandt 1986, Kiriakidis, in press) that are presented on table I.

TABLE I.

ROCK TYPE / PHYSICAL PROPERTIES	DENSITY Tm^{-3}	MAGNETIC VECTOR INTENSITY (Am^{-1}) DECLINATION INCLINATION	SEISMIC VELOCITY $KmSEC^{-1}$
OPHIOLITE	3.0 - 3.1	19×10^{-3} 20° 60°	>6.8
GRANITE	2.6	NEGLECTIBLE	5.5 - 6.0
MEOGENE SEDIMENTS	2.15 - 2.35	NONE	2.0 - 3.5

It is obvious from the above table that the seismic velocity, density and the magnetization are distinct properties differentiating the granitic from the ophiolitic rocks. More specifically the granitic rocks have a seismic velocity of about 5.8 kmsec a density of 2.6 Tm and

negligible magnetic properties. To the contrary ophiolites have a seismic velocity of > 6.8 kmsec, a density of $3.0 - 3.1$ Tm and significant magnetization.

The magnetic and the gravity values along a parallel to the seismic profile line and also the seismic interval velocity data and the Q estimation are presented in Figs. 4 to 7 respectively.

Based on the seismic velocity, gravity and magnetic values observed we have identified six distinct areas along the profile line that possess geophysical anomalies. These areas together with the geophysical properties are tabulated in table II. In this table + we also include the Q estimation for each one of the areas A to F.

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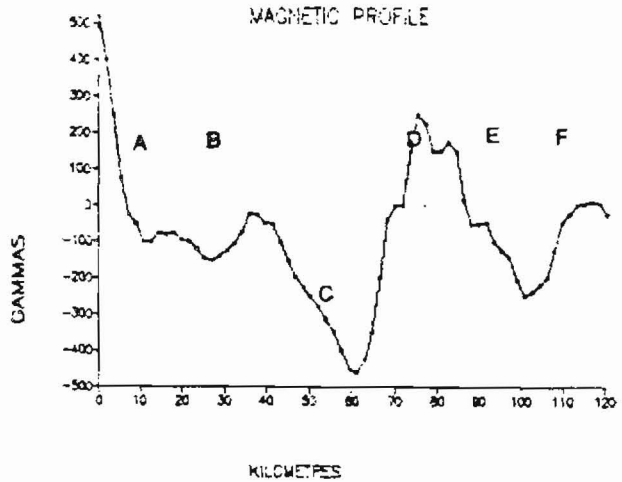


Fig. 4

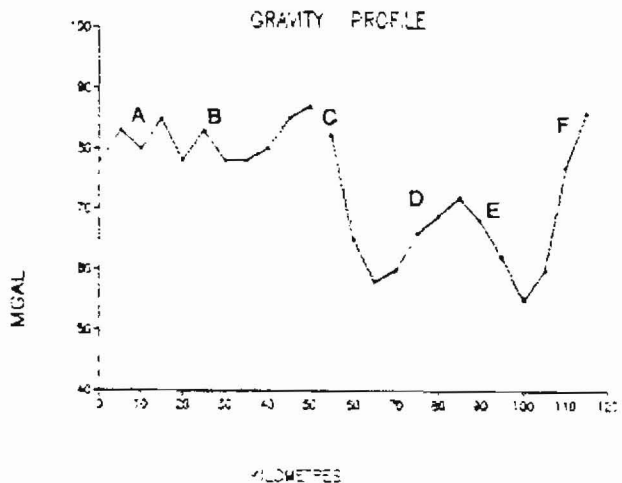


Fig. 5

INTERPRETATION

In Area A which is known to be occupied by ophiolitic rocks, (Kiriakidis 1984, Filbrandt 1986, Kiriakidis 1988, DEP-EKY Commercial borehole data) the interval velocity contour of 7.5 kmsec is only 5 km below surface and it is occupied by high magnetic values and a medium Q value of 2000. To the contrary in area B the 7.5 km/sec contour is located at least 3 km below surface and no magnetic disturbance is observed in the area. However the Q value is characteristically high (>9000). This area is very close to the Sithonia granite and taking into account the physical

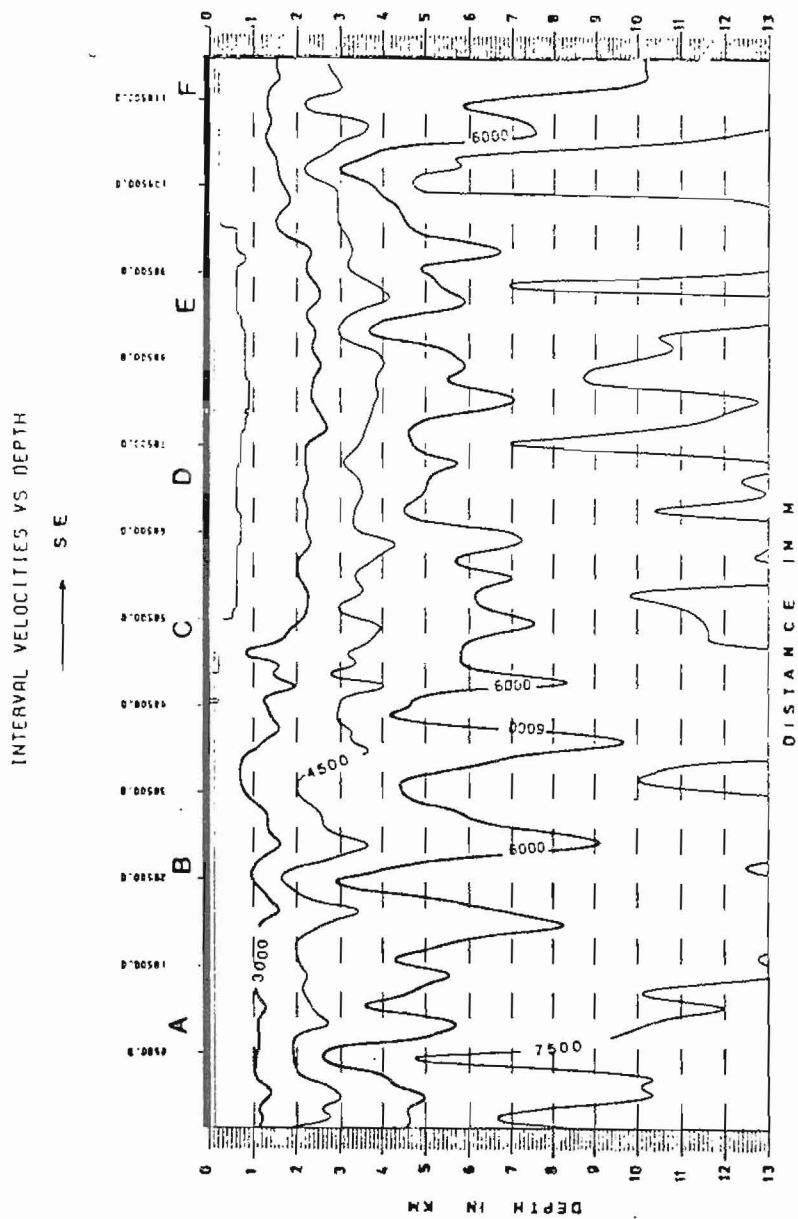
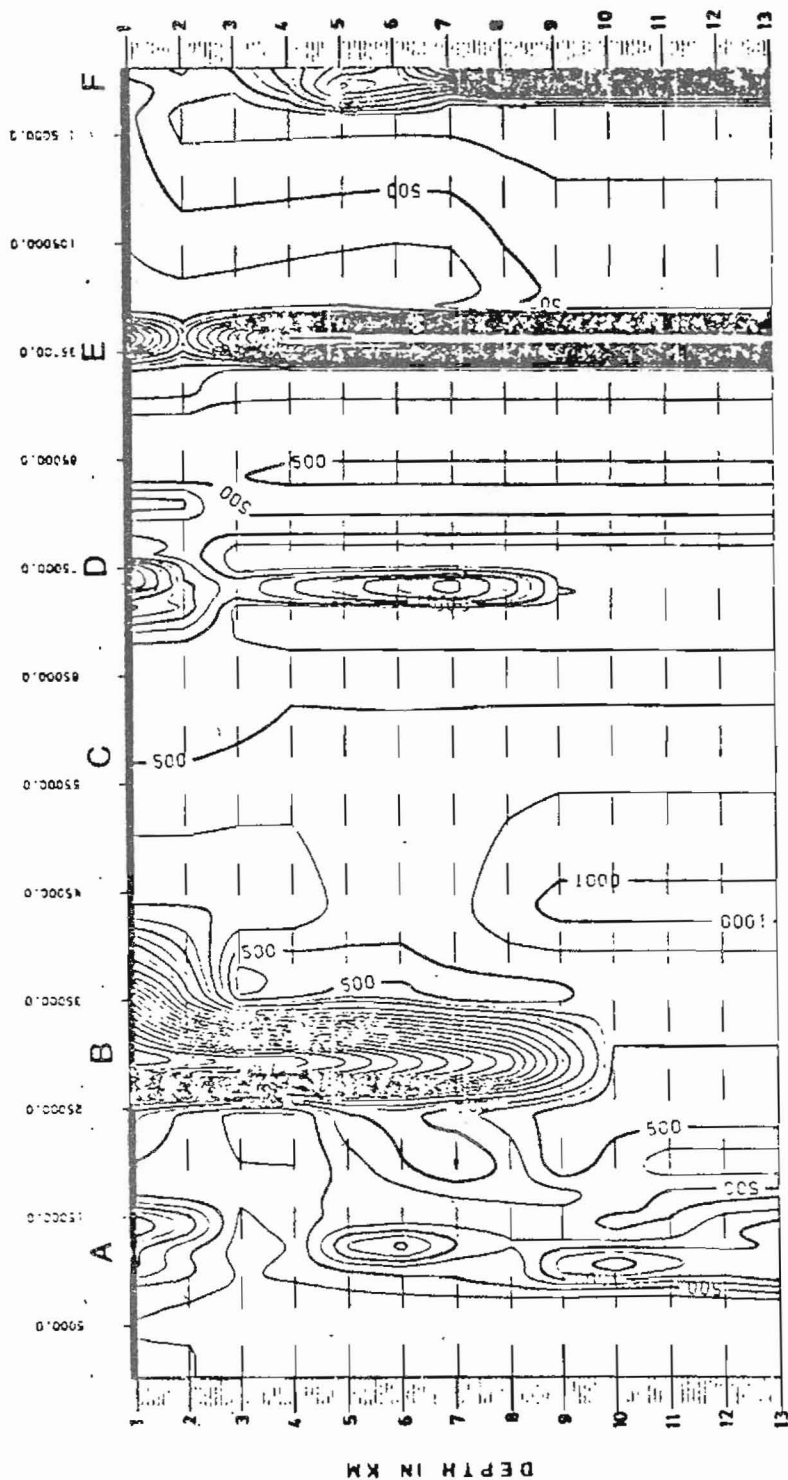


FIG. 6.

0 FACTOR VS. DEPTH

SE



properties of the rock units in Serbomacedonian zone presented previously and the interpreted seismic section we conclude that area B is occupied by granitic rocks. Using areas A and B as guides we can correlate areas C to F with geologic units. Area C is interpreted to be occupied by a thick sequence of Neogene sediments accumulated in a local basin (6 kmsec contour located at 6 km depth). The geophysical properties of area D are similar to those of area A thus it is concluded that

ophiolitic rocks underly the Neogene sediments in a depth of about 6 km. This is in very good agreement with the gravity and magnetic modelling conducted by Kiriakidis (1988).

In Area E the 7.5 kmsec contour lies 7 km below surface and a high Q value of 9000 has been estimated. This in conjunction with the fact that no positive magnetic anomaly is observed is indicative of a granitic type rock situated below the Neogene sediments. The radioactive elements of this rock type could contribute towards an anomalously high heat flow in the area (Le Pichon et al 1984).

Finally area F is occupied by geophysical anomalies that could be attributed to ophiolitic rocks although Q value estimation indicate that it is occupied by granitic rocks.

CONCLUSIONS

This study has shown that :

A. The quality factor Q, as estimated by the spectral analysis method obviously can be used as an additional evidence for distinguishing rock types in this area.

B. Regarding the crustal structure of the N. Sporades area it is evident that the geophysical anomalies investigated are caused by ophiolitic rocks resting on top of the crystalline basement and granitic intrusions. This conclusion supports the crustal model proposed by Makris (1979), Kiriakidis (1984), Brooks and Kiriakidis (1987), Ginzburg et al (1987) and Kiriakidis (1988).

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