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THE STUDY OF COMPACTION USING SEISMIC VELOCITY ANALYSES IN EAST - BAGHDAD OIL FIELD (MID - IRAQ)

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دراسة التضاغط باستخدام تحاليل السرع الزلزالية في حقل نفط شرق بغداد – وسط العراق

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الدراسة الحالية تتعلق بالحصـول على معادلات تجريبية تربط زمن المسار (T) وزمن المرور (T.T) مـع العمق (Z) والتي يعبر عنها بالصيغ التالية :

$$T = BZ^N + A, \quad \log T.T. = -s \log Z + H$$

ولهذا الغرض فقـد تم اختيار (128) موقع على شبكة الخطوط الـزلزالية التي تغطي حقل شرق بغداد حيث أجريت فيها تحاليل الصرع لغرض الحصول على العلاقات آنفة الذكر ، هذا وان المعادلات التجريبية التي تم الحصول عليها تمثل قيم فترتين جيولوجيتين وهما تكاوين الحقبة الحديثة والحقبة المتوسطة . من هذه المعادلات فقد تم استخلاص قيم العاملين N و S وتم تمثيلهم على أربعة خرائط كنتورية للفترتين أعلاه ثم فسرت هذه الخرائط بدلالة حالة التضاغط .

Key Words : Compaction, Velocity, Analysis, Seismic exploration, Porosity, Time, Depth.

ABSTRACT

The present study deals with estimation of empirical equations relating travel time (T) and transit time (T.T) with depth (Z) which are expressed in the forms :

$$T = BZ^N + A, \quad \log T.T. = -s \log Z + H$$

For this aim, (128) velocity analyses locations situated at seismic lines grid covering East oil field, were choosen to deduce the above relations.

The estimated equations relate the data point sets of two geologic intervals which consequently represent Cenozoic and Mesozoic formations. Of these, two parameters N and S were deduced, plotted and presented in four contour maps for the above intervals, and then interprated in function of compaction state.

INTRODUCTION

The relations of travel time (T) of seismic waves and depth (Z), and seismic velocity (V) - depth (Z) were the object of study and discussion since the fifties, where many relations covering many rock typs and different measurement conditions (insitu-laboratory), are estimated.

The relations between T, interval volocity (IV) or its reciprocal transit time (T.T) may be expressed as follows:

$$T = BZ^N + A \quad .... (1) \quad [1]$$

$$IV = CZ^M \quad .... (2) \quad [2]$$

$$\log T.T = - s \log Z + H \quad .... (3) \quad [3]$$

Where :

A is the intercept for the linear relation $T\text{-}Z^N$, meanwhile
B is the slope of this relation.
N is the exponent.
C is the slope of the linear relation between IV and Z^5
S is the slope of the logarithmic relation
H is the intercept.

These parameters are studied and interprated in terms of compaction state and related factors. The parameter M is considered to be nearly constant equal to 1/6, while the parameter N is a variable, [1].

In a recent investigation carried out in the Mesopotamian basin [4] it was indicated that the parameters A, N, and C increased with increasing consolidation, while B, H, and S were inversely related to it, Moreover, these parameters are of varied sensibility to detect the presence of intercalated low velocity layer in a given sequence [5].

MATERIAL AND METHODS

In the actual study 128 points were choosen on 26 seismic line grids covering the northern part of the East-Baghdad field, Mid-Iraq. (Fig - 1).

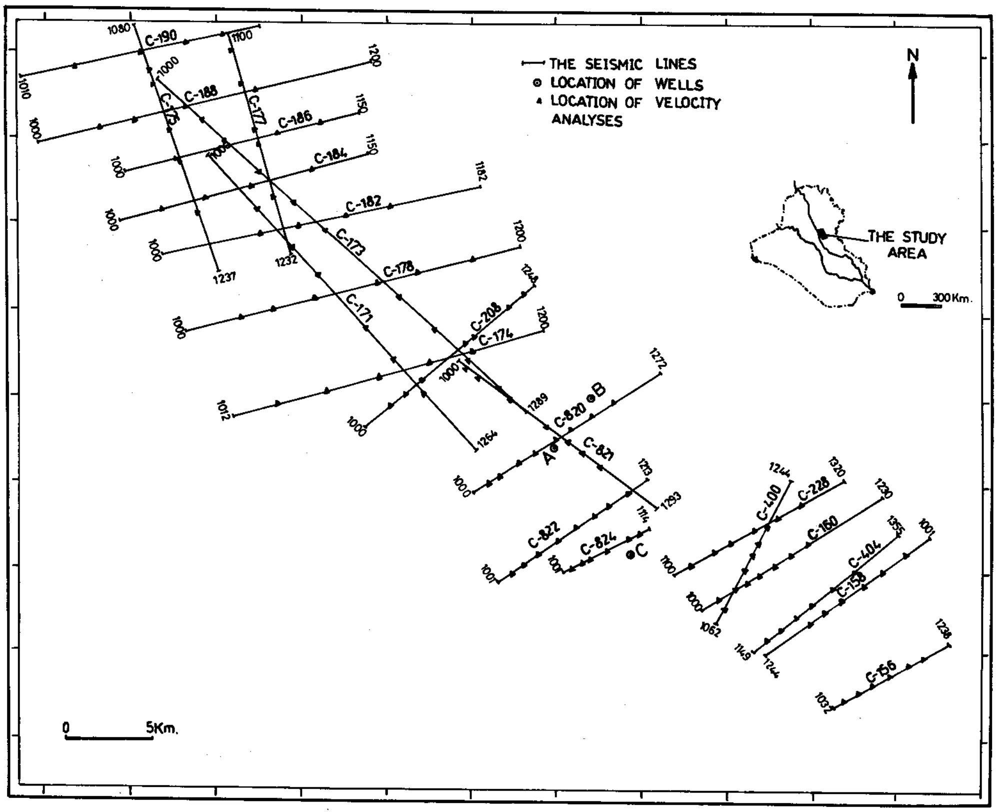

Fig. 1 : Map for the Study Area.

At each point a velocity analysis display was obtained during the processing of sciismic data. Normally, the velocity data obtained from these analyses contribute to the enhancement of seismic signal (Primary reflection) to noise ratio in summed gathers. In addition, the best two-way time (2T) versus the root mean square velocity (Vrms) curve is utilized for calculating the interval velocity (IV), average velocity (AV), and depth (Z), by using Dix equations [6].

For the aim of finding the empirical relations between T, IV or T.T and Z, the 2T versus Vrms curve was divided at each analyazed point into two segments S1 and S2 which consequently correspond to the Cenozoic and Mesozoic Formations. On this curve picking was made up at a constant interval of 100 millisecond starting from zero time till the end time of interest. For S1 the picking process is carried out between one-way time 0 and 650 msec., meanwhile for S2 it ranged between 650 and 1200 msec.

The next step included the using of Dix equations to calculate the parameters IV, AV, and Z for each picked samples. It followed that for each segmet S1 and S2 there were a number of values of the calculated parameters which will be included in the estimation of functional relationships.

1 - TIME VERSUS DEPTH RELATION :

Equation -1 which relates travel time (T) to the depth (Z) raised to power N, is used to estimate the T vs. Z relation at each segment, i.e. S1 and S2, for all the analyzed locations in the area. A number of least-square "best-fits" between the dependent variable (T) and the independent variable (Z) are computed for various values of N. The best value of N is that for which the scatter about the theoretical curve is least. An example of the plots, which relates this exponent, represented at x-axis, with standard deviation (SD) values presented at y-axis are demonstrated in Fig-2. The suitable N to be choosen is that which corresponds to the inflection point of the N vs. SD curve, where a minimum SD value is shown.

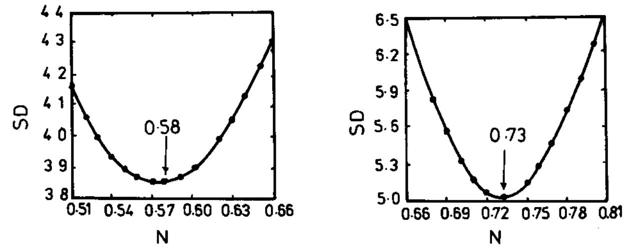

Fig. 2 : Determination of the best N for the set of time and depth data, at one anoloyzed poit, for the two segments S_1 and S_2. The best N is indicated by the minimum standard deviation (SD).

In the area under investigation, 256 empirical equations were estimated for both S1 and S2, where the values of N for all studied locations are listed at two base maps for the two analyzed segments, and followed by contouring process. (Figures 3,5).

2 - TRANSIT TIME VERSUS DEPTH RELATION :

In the same manner, equation (3) which relates the logarithims of both transit time (T.T) and depth (Z) is used to catimate the T. T VS. Z relation at each segment, i.e. S1 and S2, for all the analysed locations in the area. Simple regression analysis was used to estimate the best-fits between the dependent variable (log. T.T) and the independent variable (log Z), where 256 empirical relations were deduced.

Moreover, the values of the slops (S) are listed at two base maps for the two analyzed S1 and S2 and followed contouring process. (Figures 4,6).

RESULTS

1 - CONTOUR MAP OF N-VALUES FOR S1 :

Examination of (Fig-3) indicates the following anomalies :

a - A negative anomaly extended in the diroction NW-SE of 29.5 km long and width of 12.5 km, with a minimum contour line value of N = 0.30. This is located at the lower part of the area, where the minimum values found to the east of well-C, and between lines C-160. Also one small positive anomaly of N = 0.60 is sited at the profile C- 400 in the middle of the negative long anomaly.

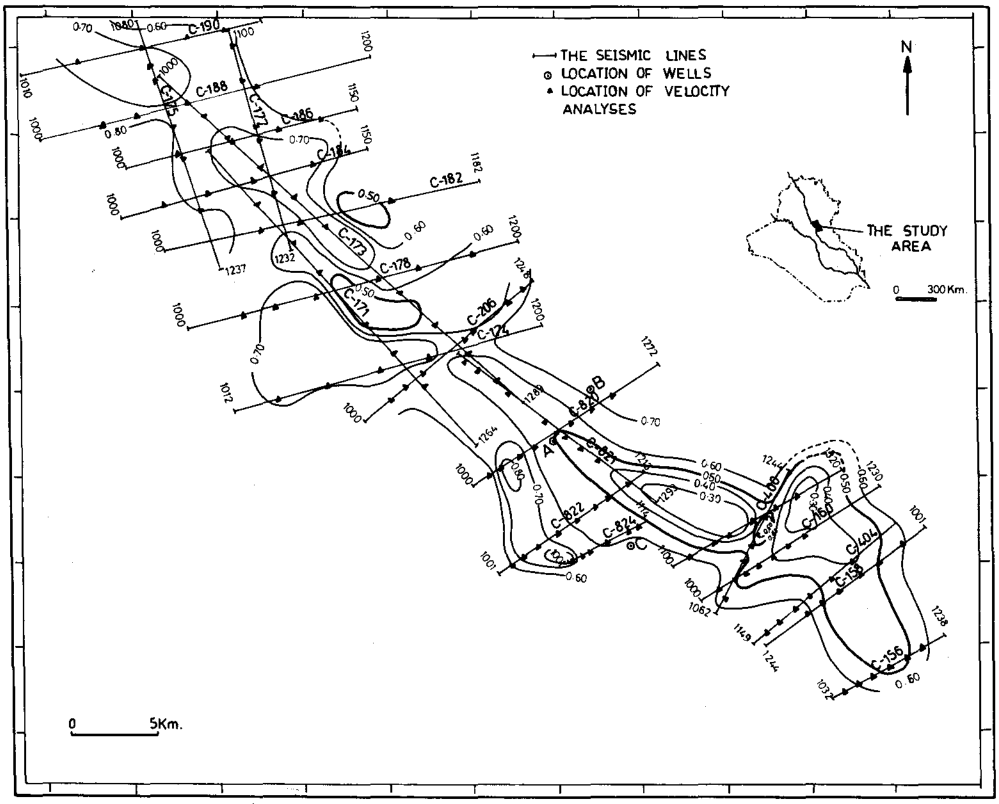

Fig. 3 : The "N" Values Contour Map for the Cenozoic era in the Study Area.

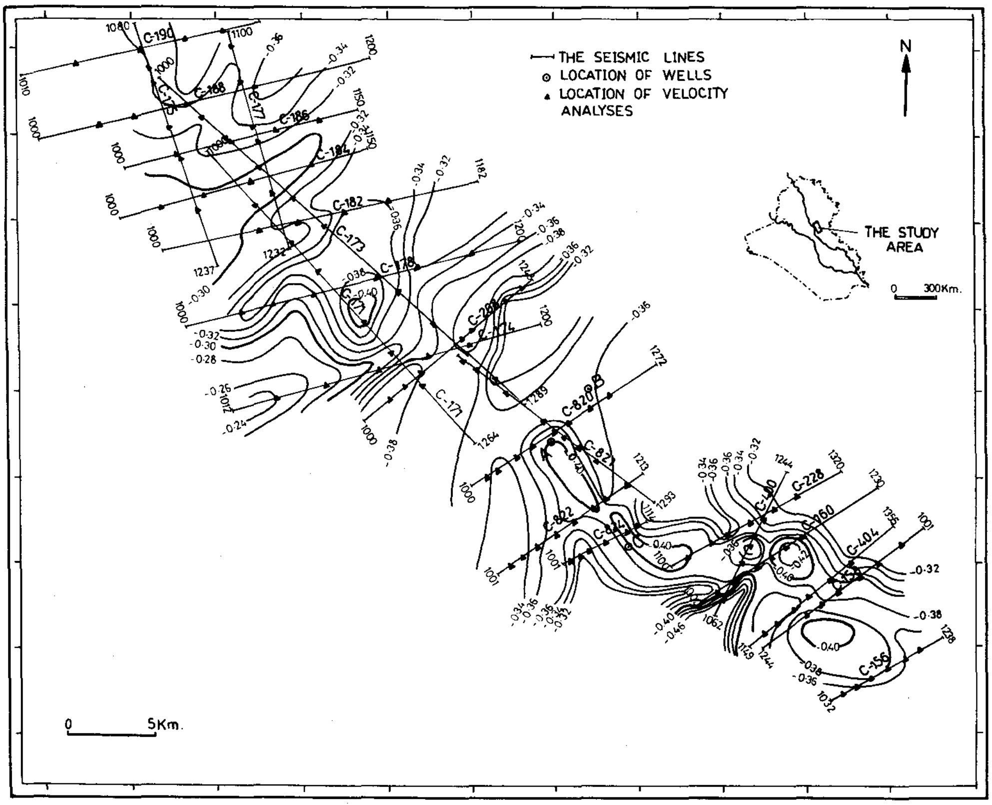

Fig. 4 : The "n" Values Contour Map for the Cenozoic Era In The Study Area.

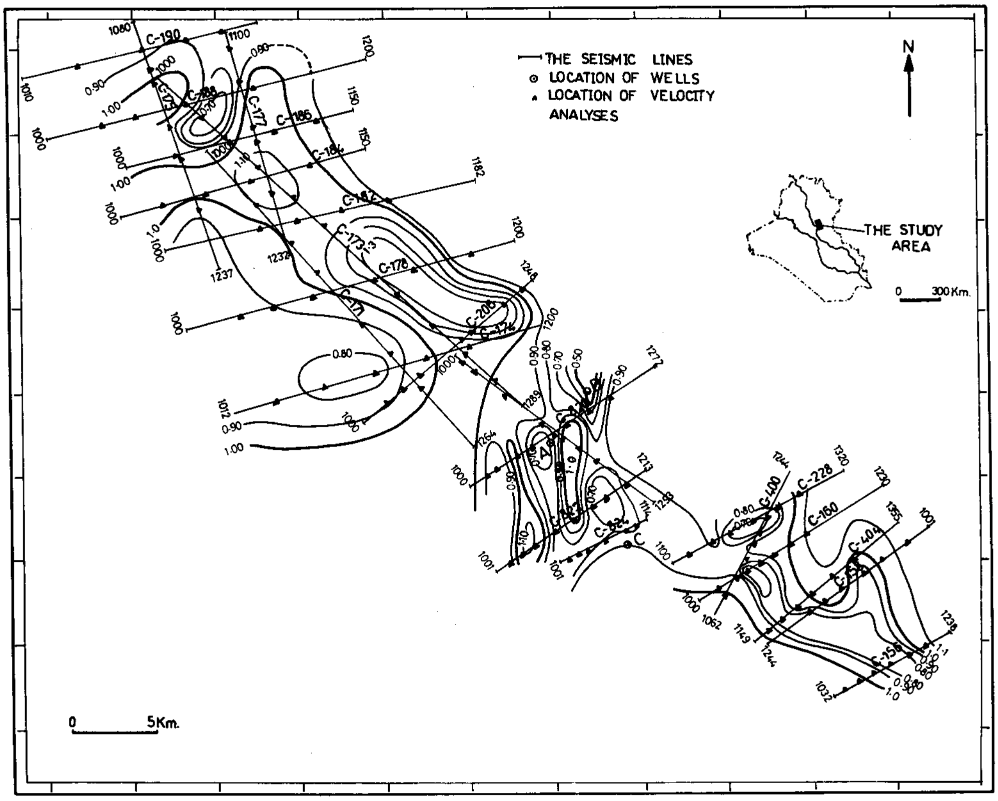

Fig. 5 : The "N" Values Contour Map The Mesozoic Era In The Study Area.

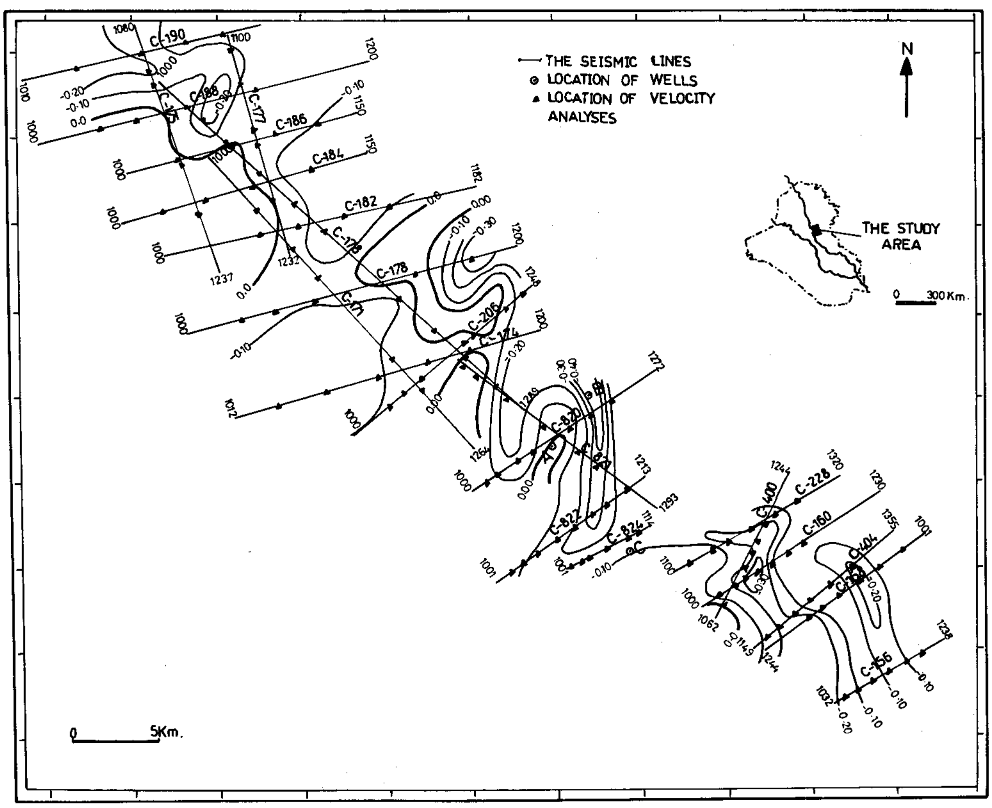

Fig. 6 : The "N" Values Contour Map for the Mesozoic Era In The Study Area.

b - Two small negative anormlies of 2 and 5 km long are located at lines C-182 and C-171.

c - One positive anomaly of N = 0.80 is located between lines C- 824 and C - 820.

d - A positive anomaly about 20 km long which has N = 0.70, is extended in the NW-SE direction, and is located between C-190 and C-178.

A general look on this map gives an indication that N decreases in the direction of the crest of the structure at the lower middle part of the area, meanwhile at the northern part of the area, it seems that it increases from east to west.

2 - CONTOUR MAP OF S-VALUES FOR S1 :

The map of s-value as shown in Fig-4 shows the following anomalies :

a - A long negative anomaly is found at the lower and middle part of the area, located between lines C-156 and C- 820 to the south of well - B, of lengh equal to 30 km and width of 6 km. Its minimum contour line value is (-0.40).

At the profile C- 400, where it intersects the above anomaly, a positive and small anomaly of S = 0.32 and 5 km length exists which divides the biggest negative anomaly into small ones.

b - One anomaly directed N-S (12 km long an 6.5 km wide) limited between the lines C-174 and C-182, has a minimum contour line value of S = - 0.40.

c - Another anomaly directed NE=SW of more than 10 km length and extend along the line C-184, has a s-value equal to -0.30.

In general, the s-value is shown to decrease in going from trough to the crest of the structure at the lower and middle parts of the area, whereas it increases in the northern part of the area.

3 - CONTOUR MAP OF N-VALUE FOR S2 :

Fig - 5 shows the following anomalies :

a - A negative anomaly is located at the southern part of the area which is oriented SE-NW, about 20 km long 8 km wide, a minimum value of 0.70 is observed. This anomaly is limited to the south by the profile C-156 and to the north by the profile C- 821.

b - Small anamalies are located around well - A and around well-B of N = 0.70 and N = 0.50 respectively. Also, another negative one is shown along the profile C-174 and 5 km long which has N = 0.80.

At the northern parts, and more exactly between lines C-186 and C-188, there is a negative anomaly which is oriented NE-SW, of N = 0.70.

c - A positive long anomaly extends in the same direction of the structure, i. e. SE-NW, oof about 25 km long 11 km wide and has a maximum N equal to 1.3.

d - Another positive anomaly of N = 1.0 oriented in the N - S direction 11 km long and 2 km wide and is located between profiles C- 822 and C- 820.

In general the N-values of segment S2 ranged between 0.5 and 1.3 which are greater than those of segment S1 where N ranged between 0.30 and 0.80.

Moreover, in the southern middle part of the area the value of N is generally descreased in the crest direction of the structure. At the northern part of the area a reversed behavior is observed, where the values of N increased in the direction of structure.

4 - CONTOUR MAP OF S-VALUES FOR S2 :

Examination of the S-contour map as shown in Fig - 6 shows the following anomalies :

a - At the southern part two elongated anomalies extended in the NW-SE direction. The first one is 15 km long and 5 km wide and is located to the south of well-C. Its minimum contour line is equal to -0.30. The second one is 11 km long and 2.5 km wide, and is located between lines C-160 and C-156. Its minimum contour line is equal to - 0.20.

b - In the central part of the area two anomalies extend in the N-S direction, The first is 12.5 km long and 2.5 km wide it has a minimum value equal to - 0.40 around well-B, while the second anomaly of S + 0 is found around well-A. Also one anomaly of S = - 0.30, 6.5 km long and 5.5 km wide, extends in the NE-SW direction crossing the profile C-178.

c - To the north a negative anomaly of S= - 0.20 of more than 10 km in length and 5 km wide is found between the profiles G-190 and C-186.

Generally, the S-values of segment S2 ranged between 0 and - 0.40, while the map of S1 shows that S ranged between - 0.24 and - 0.40. Also the map of Fig-6 indicates that most of the negative anomalies are located along the axis of the structure.

DISCUSSION

The deduced maps have revealed that most of the negative anomalies (lowering of N and values) are located along the crest of the structure of NW-SE direction, especially in the lower and middle parts of the field. This is interpreted in terms of increasing porosity and hydrocarbons accumulations, where many wells are drilled, especially in the southern part.

The increasing of N and S values in the northern part along the structure is attributed to decreasing of depth in this part where the beds are generally rised in going from south and east, to the north and west. This shallowness leads to a decreasing of thickness of cenozoic deposits, decreasing of pore pressure which causes the increasing of N and S. [5].

To investigate the relation between N and porosity P for the interval Tamuma-Abmadi situated at the second S2, one porosity map for this interval prepared by Al-Jubory, 1992 [7] was utilized.

By using least-square fit to data points, the following equation is given :

$$N = 0.057\ P + 2.11$$

$$SD = 0.183,\ R = 0.26$$

The negative sign indicates a reverse relation between (N) and (P.) (Fig - 7). Also the weak relation betwwn them indicates that many parmeters, besides porosity, may affect the N-values such as thickness, depth of burial, pore pressure, and fractures. On the other hand, the mutual relations between N and S, for the two segments, is of great importance because S is widly studied, discussed, and became well-known parameter in terms of geology. Consequently, the regression analysis for the data set, of S1 and S2 are as follows :

For S1, S =0. 186 N-0.462, SD=0.031, R = 0.68
For S2, S =0.566 N=0.619, SD=0.055, R = 0.89

These equations which are presented in Fig-8 indicated direct and good match between and S.

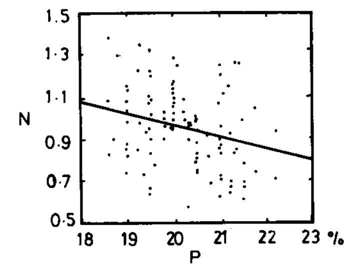

Fig. 7 : N Versus the porosity (P) for the intervel Tonumo - Ahmadi, at the second segment S_2

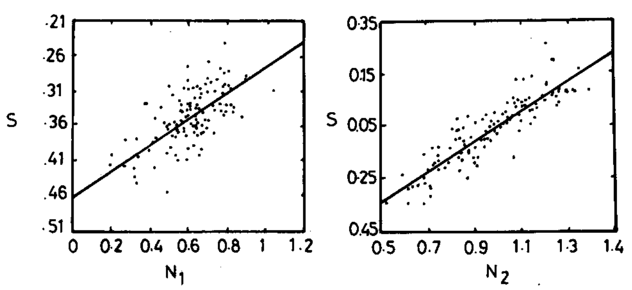

Fig. 8 : 8 : Plots of S versus N for the two segments S_1 and S_2

In addition, the maps of N show that, for cenozoic Formations S1, the values of N ranged between 0.30 and 0.80, while its values for Mesozoic Formations S2 ranged between 0.50 and 1.30. Also, the maps of S for S1 ranged between - 0.24 and -0.40 while, its values for S2 ranged between 0 and -0.40.

The Cenozoic Formations are mostly a sequence of clastic and carbonate rocks, whereas the mesozoic Formations are mostly composed of carbonate roks. It follows that the more consolidated rocks have higher values of N and S, whereas the presence of overpressured zones, high porosity, fracture, and hydrocabon accumulations are effective parmeters in reducing N and S.

CONCLUSIONS

In view of the results mentioned and discussions in this study, the following major conclusions can be made.

1 - The parameters N and S, defined in the time-depth and transit time-depth relations, which are related to the compaction state of a given geologic interval, decrease in most parts of the crest of the anticlinal structure of the studied area.

This behavior is interpreted in terms of increasing prosity and hydrocarbon accumulations in the middle and lower parts of the field. At the northern part a reversed behavior is shown where N and S increase at the crest. This increasing is related to the depth of burried formations and decreasing thickness.

2 - The weak match between N and porosity gives an indication that not only the porosity has an effective role in lowering the values of N, but other factors may also effect the value of N like pore pressure, fractures, depth and thickness of burial, and lithology.

Moreover, the high correlation coefficient obtained for the relation between N and S indicates the validity and usefulness of using N as a new d iagnostic paremeter in the compaction study, because S is widely used and a well-known parameter.

Finally, for the future work it is necessary to divide each time-depth curve into a number of segments (corresponing to geologic layers), where each segment has time-depth and velocity-depth equations, and therefore characteristic parameters.

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