Estimation of Compaction Parameters from Sonic Logs Data at Jambur Area North of Iraq

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Abstract

The present paper deals with estimation of compaction parameters from the empirical relationships relating time and velocity of the propagated sonic waves with depth. For this aim two geologic intervals were chosen at Jambur area, the first one is limited between the top of Fatha formation (M. Miocene) and base of Jeribe formation (L. Miocene) while the second one is limited between the base of Jeribe formation and the top of Qamchuqa formation (Albian – M. Cretaceous). Sonic logs data revealed the existence of two Low Velocity Layers (LVL) in these intervals. They correspond to porous saliferous and seepage beds in the first interval. and to the highly fractured and oil bearing carbonate bed in the second interval.
Sonic logs data of 7 oil wells were analyzed and used to compute 77 empirical exponential relations for bath intervals. Of these, the compaction parameters were deduced and interpreted in terms of many parameters like the depth below the top of the interval and the thickness of the LVL.
The results indicate the importance of using compaction parameters in the estimation of depth and thickness variations of (LVL).

الخلاصة

يتعلق البحث الحالي بتعيين عوامل التضاغط المشتقة من معادلات تجريبية تربط الزمن والسرعة الطولية بدلالة العمق. لهذا الغرض تم اختيار فترتين جيولوجيتين في منطقة جمبور الأولى تقع بين أعلى تكوين الفتحة (المايوسين الأوسط) واسفل تكوين الجريبي (المايوسين الأسفل) في حين الثانية محصورة بين اسفل الجريبي وأعلى تكوين قمجوقة (الكرتياسي الأوسط) وقد بينت معلومات المجسات الصوتية في الآبار تواجد طبقتين ذواتا سرعة قليلة (LVL) في هاتين الفترتين حيث إن هاتين الطبقتين هما طبقة مسامية ملحية وناضجة في الفترة الأولى وطبقة جيرية ذات تكسرات حاملة للنفط في الفترة الثانية .
وقد تم التعامل مع معلومات الجس الصوتي لسبعة آبار نفطية حيث تم حساب 77معادلة تجريبية وأُسية لكلا الفترتين. ومن هذه المعادلات تم استخراج عوامل التضاغط وتم تفسيرها بدلالة عدة عوامل مثل العمق تحت السطح العلوي للفترة وكذلك سماكة طبقة السرعة القليلة بينت النتائج أهمية استخدام عوامل التضاغط في تقييم التغيرات التي تحصل في عمق وسماكة الطبقة ذات السرعة القليلة .

Key Words
Sonic Logs, empirical relations, compaction Parameters, LVL.

Introduction

Many types of empirical relations relating time of wave propagation (T), interval velocity (IV) and average velocity (AV) in function of depth (Z), were established by many others like Faust, 1951 [1], wyrobek, 1959 [2], Gassmen, 1959 [3], Acheson, 1959,1963, 1981, [4-6],

Pennebaker, 1968 [7]. The deduced empirical equations were derived using seismic, sonic and ultrasonic data and applied to different types of lithology at a number of basins in the world.
In the present work the following equations will be used:

$$T = A + B Z^{N} \qquad (1) \qquad [4\text{-}6]$$

$$AV = D Z^{U} \qquad (2) \qquad [4\text{-}6]$$

$$IV = C Z^{M} \qquad (3) \qquad [1]$$

The parameters N, U, M, A, D, and C were previously utilized to describe the pressure and compaction state and other related factors at a given section, change of lithology, presence of fractures, time-depth conversion …etc.
In a recent investigation [8] a low seismic velocity layer (LVL) was introduced into a hypothetical model consisting of a succession of layers which have defined seismic interval velocities. For this model the empirical relations were established and their parameters were examined as function of variation in the thickness of (LVL).It was shown that these parameters are greatly affected by LVL in different manners, and so they can be used to detect the presence of LVL in a given section.
In a complementary study [9,10] one hypothetical seismic model has been assumed, where one LVL is included in this model. Two tests were made up to detect the effect, produced by changing the depth (Z_1) and thickness (ΔH) values, on the behavior of seismic compaction parameters (N, U, M, …) of the empirical equations (1-3). The behavior of these parameters are well illustrated in Fig-1 .
On the other hand, due to the close connection between the presence of oil in fractured or porous bed and the lowering of seismic interval velocity Jambur oil field was chosen for the present study. This field is located to the SE of Kirkuk City.The structure is an oil bearing anticline. Seven oil Wells (A, B, C, D, E, F, &G) located at the axis of the structure were chosen for the present study. (Fig-2).
These wells are the source of geologic data, i.e., the stratigraphic sequence, lithology, presence of porous and fractured rocks, and fluid contents. Based on these data the geologic section presented in Fig-3, was divided into two intervals.
1/ the first interval (H_1-H_2) is limited between the top of Fatha Formation (H_1), (M. Miocene), and the bottom of Jeribe Formation (H_2), (L. Miocene). The lithology of this interval is mainly composed of massive anhydrite and clastic rocks with limestone at the lower part.
2/ The second interval (H_2-H_3) is located between the bottom of Jeribe (H_2) and top of Qamchuqa formation (H_3), Albian-(M. Cetaceouse). The lithology is mainly marly limestone and some part of the interval is highly fractured.
The second interval data is obtained from the wells (C, D, E, &F) while those of the first interval is from all wells. Each interval will be separately treated.

Method

Using the records of sonic logs of the wells, and making a picking process by the digitizer, is the first step in the actual work. The intervals are determined on these records and sampling process is made up at a regular small interval of (2m). The picked values represent the transit times as function of depth. These were later converted into velocity logs like average velocity Which are used in the present study. Average velocity log is presented as curve relating the average velocity values (AV) to the depth (Z) of the investigation at the studied well. The (AV - Z) curves for all wells were picked using interval length of (50m) which is sufficient enough for the statistical analysis to deduce the empirical relations for the intervals (H_1-H_2) and (H_3-H_4). Each one of these geologic intervals will be separately treated, so that the relations time (T) - depth (Z), average velocity (AV) - depth (Z), and interval velocity (IV) - depth (Z) are established and examined in terms of the parameters of the empirical equations.
Using statistical regression analysis, the (T - Z), (AV - Z), and (IV - Z) relations are estimated, and the correlation coefficient (R) and the standard deviation (SD) are calculated. The depth (Z) is raised to the power values (N, U, &M) and plotted on the x-axis, and travel time (T) is plotted on Y- axis . The computation is made for various (N, U, &M) values, and the best value of (N, U, &M) is that which give least scatter about the curve. Fig–4 illustrates the test which is made up at one of the studied wells, where the best (N, U, &M) chosen for them are those, which having a minimum standard deviation. In tables-1A and 1B all the equations and their parameters

with the statistical parameters (R & SD) are listed. One can notice the high values of (R) for (T – Z^N) relation which are higher than (R) values of (AV – Z^U) and the (R) values of the later relation are higher than that of the values of (IV – Z^M) relation. This relation suggests a higher correlation between transit time and depth than that between velocity and depth.

Table - 1A : Time, velocity and depth empirical relations for the first interval of the studied wells (A, B, C, D, E, F, &G).

Well	Logarithmic relation	R	SD	Exponential relations	R	SD
A	InT=-0.58+0.92InZ InAV=7.5+0.83InZ InIV=0.17+1.07InZ InTT=12.5-1.07InZ	0.997 0.997 0.76 0.76	0.007(m/s) 0.007(m/s) 0.123(m/s) 0.123(µs/ft)	$T=122689Z^{0.004}-125881$ $AV=1932.9\ Z^{0.08}$ $IV=0.33\ Z^{1.24}$	0.999 0.820 0.798	2.51(ms.) 145(m/s) 476(m/s)
B	InT=0.60+0.923InZ InAV=7.5+0.76InZ InIV=6.7+0.24 InZ InTT=3.31-0.16 InZ	0.999 0.907 0.26 0.19	0.005(m/s) 0.005(m/s) 0.099(m/s) 0.122(µs/ft)	$T=0.71\ Z^{1.17} + 99.7$ $AV=1686Z^{0.08}$ V.High value of (M)	0.999 0.907 0.158	2.04(ms) 164(m/s) 3945(m/s)
C	InT=-2.1+1.1 InZ InAV= 9-0.098 InZ InIV=8.5-0.036InZ InTT=4.1+0.04 InZ	0.999 0.922 0.51 0.51	0.007(ms) 0.007(ms) 0.126(m/s) 0.126(µs/ft)	$T=1.22\ Z^{0.82} – 116$ V.High value of (u) V.High value of (M)	0.999	2.98(ms)
D	InT=0.16+0.81 InZ InAV=6.75+0.19InZ InIV=2.5+1.47 InZ InTT=15.2-1.47InZ	0.998 0.973 0.798 0.798	0.003(ms) 0.003(m/s) 0.115(m/s) 0.115(µs/ft)	$T=53362\ Z^{0.007} – 55714$ $AV=817\ Z^{0.19}$ $IV=0.054\ Z^{1.52}$	0.999 0.972 0.777	1.43(ms) 58(m/s) 46(m/s)
E	InT= -0.57+0.9 InZ InAV=7.48+0.95InZ InIV=-10.6+2.6InZ InTT= 23.3-2.6 InZ	0.997 0.851 0.598 0.598	0.011(ms) 0.011(m/s) 0.668(m/s) 0.668(µs/ft)	$T=956\ Z^{0.13} – 2055$ $AV=1755.7\ Z^{0.1}$ $IV=37\ Z^{0.66}$	0.999 0.852 0.744	1.97(ms) 39(m/s) 453(m/s)
F	InT=-0.68+0.92InZ InAV=7.6+0.84InZ InIV=5.6+0.38 InZ InTT=7- 0.77 InZ	0.999 0.96 0.63 0.629	0.005(ms) 0.005(m/s) 0.109(m/s) 0.109(µs/ft)	$T=1.69\ Z^{0.77} – 624$ $AV=1789\ Z^{0.09}$ $IV=222\ Z^{0.44}$	0.999 0.95 0.656	2.2(ms) 220(m/s) 449(m/s)
G	InT=0.42+0.78 InZ InAV=6.48+0.22InZ InIV= -2.9+1.5 InZ InTT=15.5-1.54InZ	0.996 0.959 0.846 0.846	0.003(ms) 0.008(m/s) 0.12(m/s) 0.12(µs/ft)	$T=89389\ Z^{0.09} – 91569$ $AV=632\ Z^{0.22}$ $IV=0.03\ Z^{1.58}$	0.996 0.959 0.862	2.36(ms) 381(m/s) 479(m/s)

Table – 1B: Time, velocity and depth empirical relations for the second interval of the studied wells (C, D, E, &F).

Well	Logarithmic relation	R	SD	Exponential relations	R	SD
C	InT= -0.71+0.91 InZ InAV= 7.6+0.09 InZ InIV= 6.6+0.24 InZ InTT= 6-0.24 InZ	0.999 0.98 0.29 0.29	0.002(ms) 0.003(ms) 0.095(m/s) 0.095(μs/ft)	$T=1.71\ Z^{0.77} - 103$ $AV=2065\ Z^{0.09}$ $IV=530\ Z^{0.28}$	0.999 0.977 0.329	1.4(ms) 36(m/s) 462(m/s)
D	InT= 0.16+0.81 InZ InAV= 6.7+0.2 InZ InIV= 6.69+228 InZ InTT= 5.93-0.23 InZ	0.998 0.995 0.26 0.26	0.003(ms) 0.002(m/s) 0.099(m/s) 0.099(μs/ft)	$T= 0.82\ Z^{0.85} - 36$ $AV=771\ Z^{0.2}$ $IV=586\ Z^{0.27}$	0.999 0.995 0.298	1.43(ms) 45(m/s) 484(m/s)
E	InT= -0.4+0.88 InZ InAV= 7.3+1.2 InZ InIV=-17.51+3.4 InZ InTT= 30-3.4 InZ	0.999 0.968 0.499 0.499	0.084(ms) 0.004(m/s) 0.781(m/s) 0.781(μs/ft)	$T=56\ Z^{0.4} - 643$ $AV=1544\ Z^{0.12}$ $IV=62\ Z^{0.56}$	0.999 0.968 0.611	1.68(ms) 102(m/s) 433(m/s)
F	InT= -0.69+0.91 InZ InAV= 7.6+0.09 InZ InIV= 6.2+0.28 InZ InTT= 6.38-0.28 InZ	0.999 0.966 0.29 0.289	0.003(ms) 0.003(m/s) 0.125(m/s) 0.125(μs/ft)	$T=13.5\ Z^{0.55} - 355$ $AV=1826\ Z^{0.09}$ $IV=330\ Z^{0.34}$	0.999 0.965 0.328	1.35(ms) 205(m/s) 580(m/s)

Well	Depth in (m) H_1	Depth (m) H_2	Depth (m) H_3	(LVL) depth range (m)	Z_1 (m)	ΔH (m)	AV range (m/s)	N	U	M
A	1400	2300	/	1400 – 2000	100	600	3329 – 3338	0.004	0.08	1024
B	1200	2100	/	1350 – 1850	200	450	3181 – 3225	1.17	0.08	High value
C (1)	1000	1900	/	1100 – 1700	200	500	4130 – 3940	0.82	High value	High value
D (1)	1400	1880	/	1600 – 1700	200	100	3370 - 3388	0.007	0.19	1.52
E (1)	950	1650	/	950 – 1300	0	350	3443 – 3455	0.13	0.10	0.66
F (1)	1000	1650	/	1000 – 1450	100	350	3550 – 3600	0.77	0.09	0.41
G	1200	1800	/	1350 - 1500	150	450	3125 – 3144	0.09	0.22	1.58
C (2)	/	1900	2900	2100 – 2600	175	500	4087 – 4134	0.77	0.09	0.28
D (2)	/	1900	2700	1800 – 2300	200	470	3350 – 3500	0.85	0.20	0.27
E (2)	/	1700	2600	1800 – 2200	125	400	3669 – 3763	0.40	0.12	0.56
F (2)	/	1650	2500	1800 - 2300	150	500	3783 - 3838	0.55	0.09	0.34

Table-2: Data related to the (LVL) of the first and second intervals of the studied wells

Interpretation of Velocity Data

Velocity data deduced from sonic logs, are plotted with depth, then examined as function of lithology and related petrophysical properties. An example concerning the well (A) is treated here and shown in Fig-5.

The examination of the (AV – Z) curve reveals that (AV) values are nearly constant at the upper part of the first interval ($H_1 – H_2$) which is ranged in depth between 1400 and 2000m and having (AV) values ranging (3329 – 3338) m/s. The constancy of (AV) values means that the (IV) values at this depth is less than the (IV) of the overlying horizons as clarified by observing the (IV – Z) curve. This indicates that the upper red bed, seepage bed, and saliferous beds of Fath'a Formation represent a low velocity layer (LVL) relative to the adjacent upper and lower beds. These lower beds represent the transition zone between Fath'a and the underlying Jeribe Formation, which is a gradual change of lithology from anhydrite and silts to limestone.

In the second interval ($H_2 – H_3$), a general increase in (AV) with depth can be observed for the Formations Dhiban and Sergagni. Dhiban Formation is composed of anhydrite while Sergagni Formation is composed of marly limestone and anhydrite. This is followed by constant (AV) with depth corresponding to Jadala, Aaliji and upper part of Shiranish Formations. The (AV) value then increases again at the lower part of Shiranish and Kometan Formations.

In the same manner, the velocity curves of other wells were examined which show nearly the same phenomena for both intervals. Details of these (LVL) concerning their depth, thicknesses, velocities, and the values of (N, U, &M) are listed in table-2. It shows obviously the constancy of the (AV) values at the zones of (LVL) relative to the general behavior of velocity as function of depth with the exception of the decreasing values of (AV) at the first interval of well-C.

Interpretation of Seismic Compaction Parameters

The parameters (N, U, &M), which are listed in table-2, describes the relations (T – Z), (AV – Z) and (IV – Z) for the intervals ($H_1 – H_2$) and ($H_2 – H_3$) at the studied wells. These parameters will be interpreted in terms of the available data presented at the same table. It is obvious that the (LVL) in the first interval corresponds to brine bearing saliferous porous beds and seepage bed, while the (LVL) of the second interval corresponds to oil bearing fractured limestone. The (LVL) thickness values (ΔH) and their depths (Z_1) from the top of the investigated interval (listed in table-2) ,shows differences from one well to another, the variations of (ΔH) and (Z_1) values in addition to (IV) are highly affected the parameters (N, U, &M) as it is shown in Fig-1 where their behavior are illustrated. Based on this variation , correlation can be done to estimate the relative variations in the thicknesses and depths from one location to another. To facilitate the interpretation process, the following table was used, where the values of all parameters are classified into three groups.

Table-3: Classification of the parameters (N, U, &M)

Parameters	Low	Interm.	High
N	0 – 0.3	0.3 – 0.6	> 0.6
U	0 – 0.1	0.1 – 0.15	> 0.15
M	0 – 0.3	0.3 – 0.6	> 0.6

The first interval (H1 – H2)

Well-A: (ΔH=600m, Z_1=100m, N=0.004, U=0.08, M=1.24).With reference to Fig-1, it appears that lowering of (N & U) and augmentation of (M) is due to the shallow depth (Z_1) of (LVL), where Z_1=100m, and that (LVL) occupies the shallow and intermediate parts of the interval. Fig-1 reveals that (N) increases and (M) decreases with the increasing of (ΔH),but it seems that the depth plays more important role than the thickness. The reduction of (N) value and increasing of (M) is also due to low consolidation of the clastic rocks, whereas in contrast the high value of (U) accompanies such rock type.

Well-B: (ΔH=450m, Z_1=200m, N=1.17, U=0.08, M= very high value)

The high value of (N) and low value of (U), which is associated with high (ΔH) and the location of (LVL) at the middle and lower parts of the interval, is identical to their behavior in term of (ΔH) and (Z_1) given in Fig-1. The abnormal high value of (M) is mainly due to the rapid variation of the decreased (IV) with depth, which gives a negative slope of (AV – Z) curve. This cause is more effective than the effect of (ΔH) & (Z_1) where it is expected that high (ΔH) associated with the location of (LVL) at the middle of interval will produce low value of (M).

Well-C: (ΔH=500m, Z_1=100m, N=0.82, U & M have very high values)

The high value of (N) is mainly due to the location of the (LVL) at the middle part of the interval and to its high thickness. (M) & (U) have very high values which is attributed to the rapid variation in the (IV) and (AV) value with depth. Obviously table-2 shows the decreasing of velocity values from 4130 to 3940 m/sec at the corresponding depth 1200 and 1700m. In contrary, the high values of (ΔH) and (Z_1) means low (U) and (M) values, so it may be worth to say that these effects are overcomed by the decreasing of the velocity with depth.

Well-D: (ΔH=100m, Z_1=200m, N=0.007, U=0.19, M=1.52)

Low value of (N), and high values of (U) and (M) are due to the low (ΔH) value and to the location of (LVL) at the central part of the interval (H_1 – H_2).

Well-E: (ΔH=350m, Z_1=0, N=0.13, U=0.10, M=0.66)

Low value of (N), intermediate values of (U) and (M) are attributed to the high (ΔH) value and to the shallowness of (LVL) where (Z_1=0).

Well-G: (ΔH=150m, Z_1=150m, N=0.004, U=0.22, M=1.58)

Low value of (N), and high values of (U) and (M) are because of the combined effects of the location of (LVL) at shallow depth (Z_1), low (ΔH) value, and the less consolidation of the clastic rocks.

Well-F: (ΔH=350m, Z_1=100m, N=0.77, U=0.09, M=0.41)

The high value of (ΔH) and the location of (LVL) at the middle part of the section causes the high value of (N), low value of (U) and moderate value of (M). According to Fig-1 (M) is decreased with increasing of (ΔH) values and increased at shallow and moderate depths.

From the above results, it was generally seen that the increasing of (ΔH) will cause the increasing of (N) values and decreasing of (U) & (M) values which are coincidence with their behavior given in Fig-1. One exception was seen at Well-A, ΔH=600m, the low values of (N) and (U) and high value of (M) are attributed to the shallowness of the (LVL) and the constancy of (AV) values with depth. The same observation was seen at Well-E where ΔH=350m. Moreover, similar values was shown for (N) and (M) at the Wells-(A), (D), &(G), where the thickness (ΔH) values at the Wells-(D) & (G) are low. The value of (U) at Well-(A) is clearly indicates the presence of thick (LVL) whereas high (U) values at Wells-(D) & (G) are indication of small thicknesses.

The comparison between Wells-(E) & (F) indicates that for both wells, (ΔH) value equal to 350m but the depth (Z_1) equals to 0 and 100m respectively. This increment of (Z_1) causes the increasing of (N) values and decreasing of (U) & (M) values.

At Well (B), we have seen that, ΔH=450m and Z_1=200m, which cause high value of (N=1.17) and low value of (U=0.08), meanwhile the Well (C) which has (ΔH) value equal to 500m and Z_1=100m, gives a low value of (N), and higher values of (U) & (M). This was interpreted in terms of decreasing of (AV) with depth and that the rocks of (LVL) at Well (C) are less compacted than those of Well (B).

Another comparison was done between the parameters values (N, U, &M) at the studied Wells to know if there is a match in function of the structural depth. Examination of the data reported in table-2 indicates the presence of very weak correlation.

The second interval (H_2 – H_3)

Well-C: (ΔH=500m, Z_1=175m, N=0.77, U=0.09, M=0.28)

The moderate to high value of (N) and low values of (U) & (M) are due to high thickness and depth values of (LVL), in addition to the high consolidation of the limestone.

Well-D: (ΔH=470m, Z_1=200m, N=0.85, U=0.20, M=0.24)

The high value of (N) and low value of (M) are in accordance with the high thickness (ΔH) and the location of the (LVL) in the central part of the interval. The parameter (U) has an exceptional moderate value, which means that it was not greatly affected by the thickness and depth of (LVL). This may be interpreted in terms of the constancy of (AV) in function of depth besides its low values (AV=3350 to 3500 m/s).

Well-E: (ΔH=400m, Z_1=125m, N=0.4, U=0.12, M=0.56)

The moderate value of (N), low to moderate value of (U) and high value of (M) are attributed to the combined effects of high thickness (ΔH) and shallow depth of (Z_1) of (LVL), in addition to the hydrocarbons saturation of the fractured limestone.

Well-F: (ΔH=500m, Z_1=150m, N=0.55, U=0.09, M=0.34)
The applicability of Fig-1 necessitate that (N) value is supposed to be high, due to the high value of (ΔH) and its location in term of (Z_1). But, the given value of (N) here considered to be moderate because of the accumulations of hydrocarbons at the fractured limestone layer.

Low value of (U) and moderate value of (M) are also accepted at the present case, where the high value of (ΔH) reduces (M) values which are balanced by the effect of saturation with hydrocarbons.

Conclusions

Results of the present work can be summarized as follows:

1. The presence of (LVL) in the given intervals has greatly affected the compaction parameters (N, U, &M) which have different sensitivities. These effects are interpreted in terms of the thickness (ΔH), lithology and consolidation and depth (Z_1) to top of the (LVL), in addition to the behavior of velocity with depth.
2. The behavior of the parameter (N) of the relation (T - Z) shows the following characters:
   a. Low value of (N) means a low velocity at shallow depth.
   b. The non-consolidated rocks show a low value of (N), while the consolidated rocks like the carbonate has a high value. This property will be decreased when these rocks are fractured, or when they are highly porous saturated with fluids.
   c. (N) value decreases when (LVL) is located at shallow depth (Z_1) and then increased at intermediate and greater depths.
   d. (N) increases with increasing of thickness (ΔH) of (LVL).
3. The parameter (U) of the relation (AV – Z) behaves as follows:
   a. (U) decreases with the increasing of the thickness (ΔH) of (LVL).
   b. (U) shows a low value when the (LVL) is located at the central part of the interval, while it increases at the shallow and deep parts of the interval.
4. The parameter (M) of the relation (IV – Z) indicates the following characters:
   a. Low values of (M) with increasing of the thickness of (LVL).
   b. High value of (M) at shallow depth, and then decreases at intermediate and deep parts of the interval.
   c. Increased values of (M) accompanied the non-consolidated rocks and fractured solid rocks.
   d. Very high values of (M) and (U) mean a negative gradient of the (IV – Z) and (AV – Z) curves.
5. There is no relation between the studied parameters and the structural depths; therefore, a better picture will be obtained when larger area with a given structure is studied.

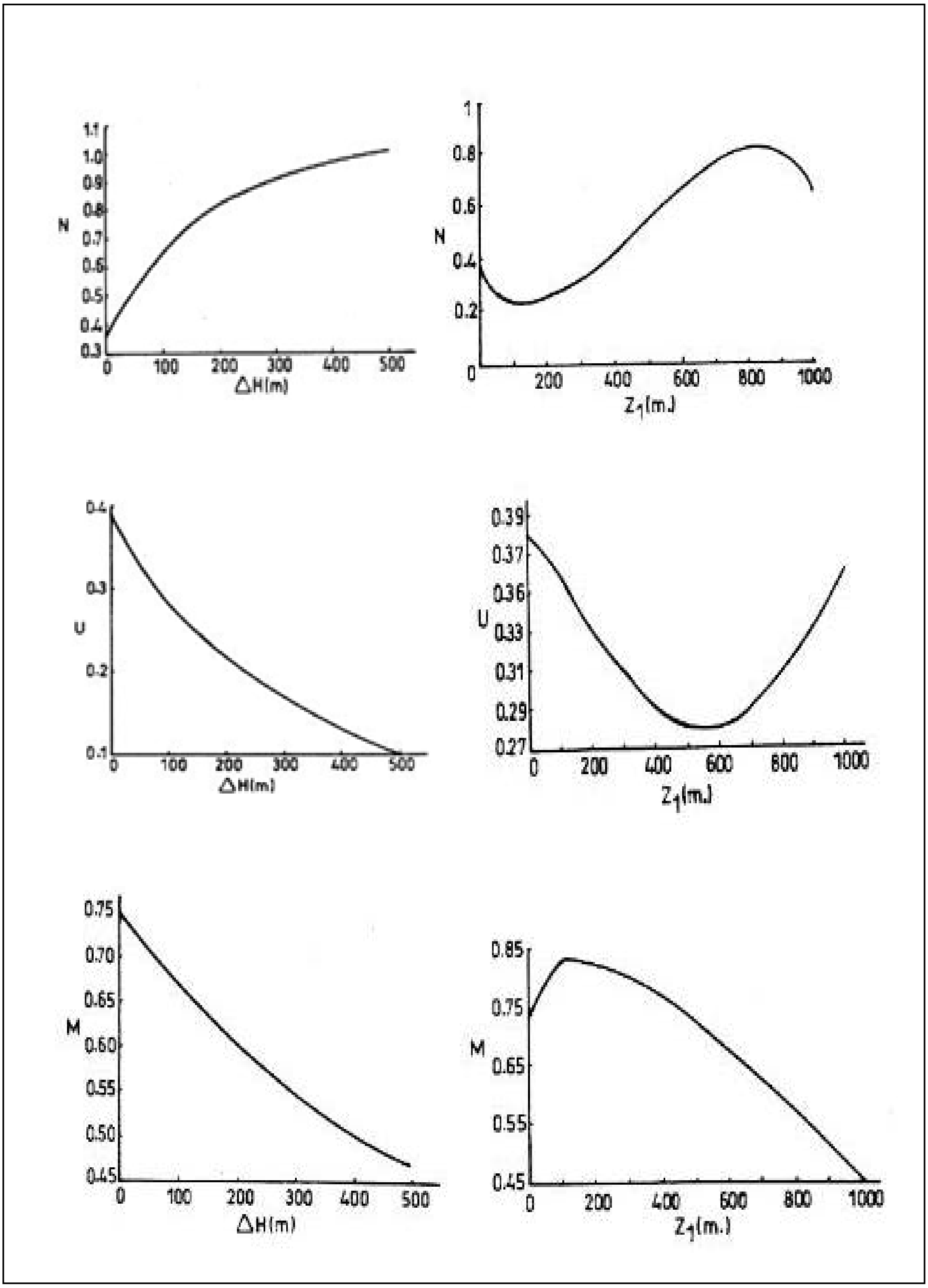

Fig. (1): Plots of the parameters (N, U, and M) versus the depth (Z_1) to the top of the (LVL) and it thickness (ΔH)

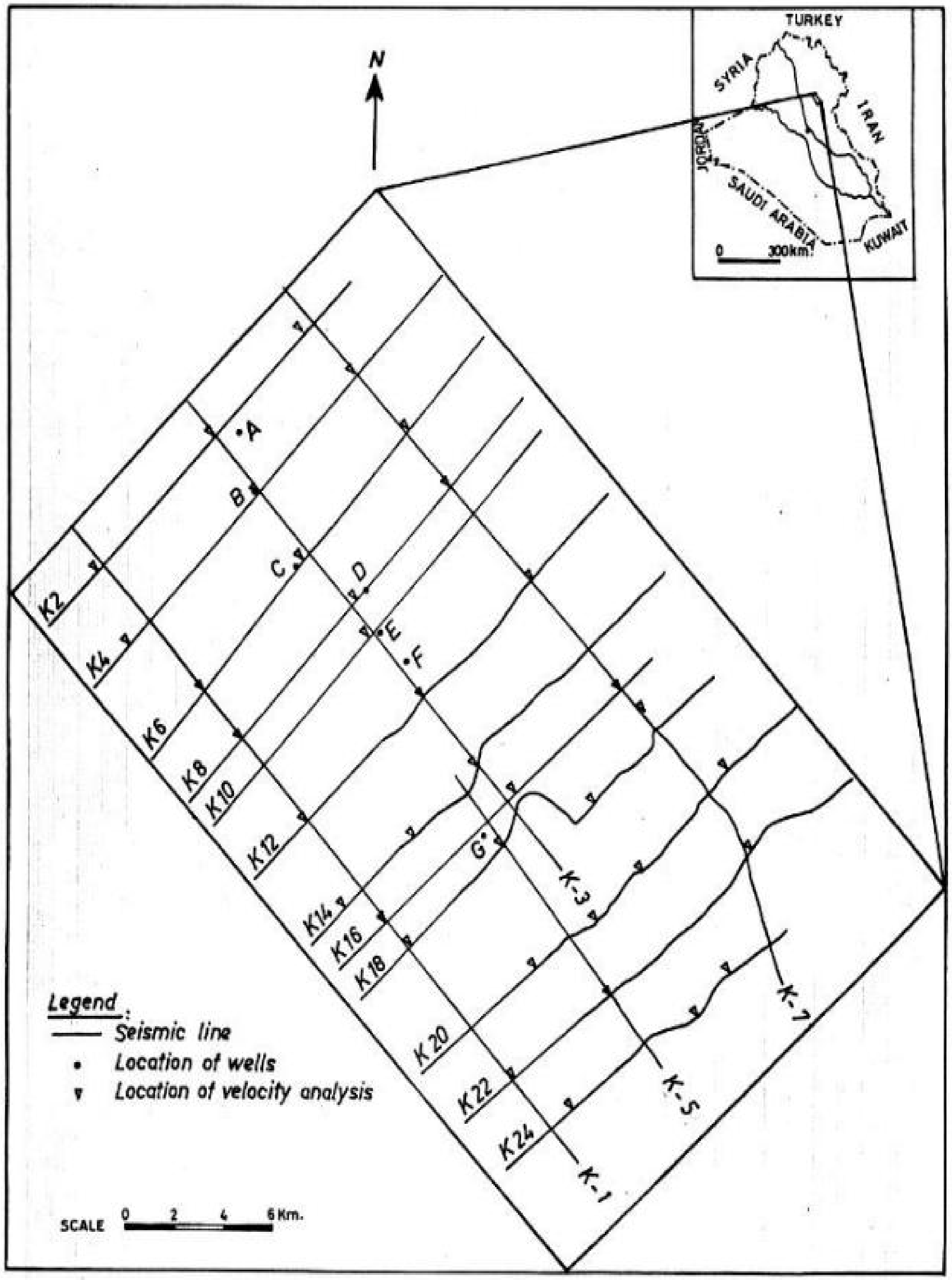

Fig. (2): Location of the studied wells at jambur area

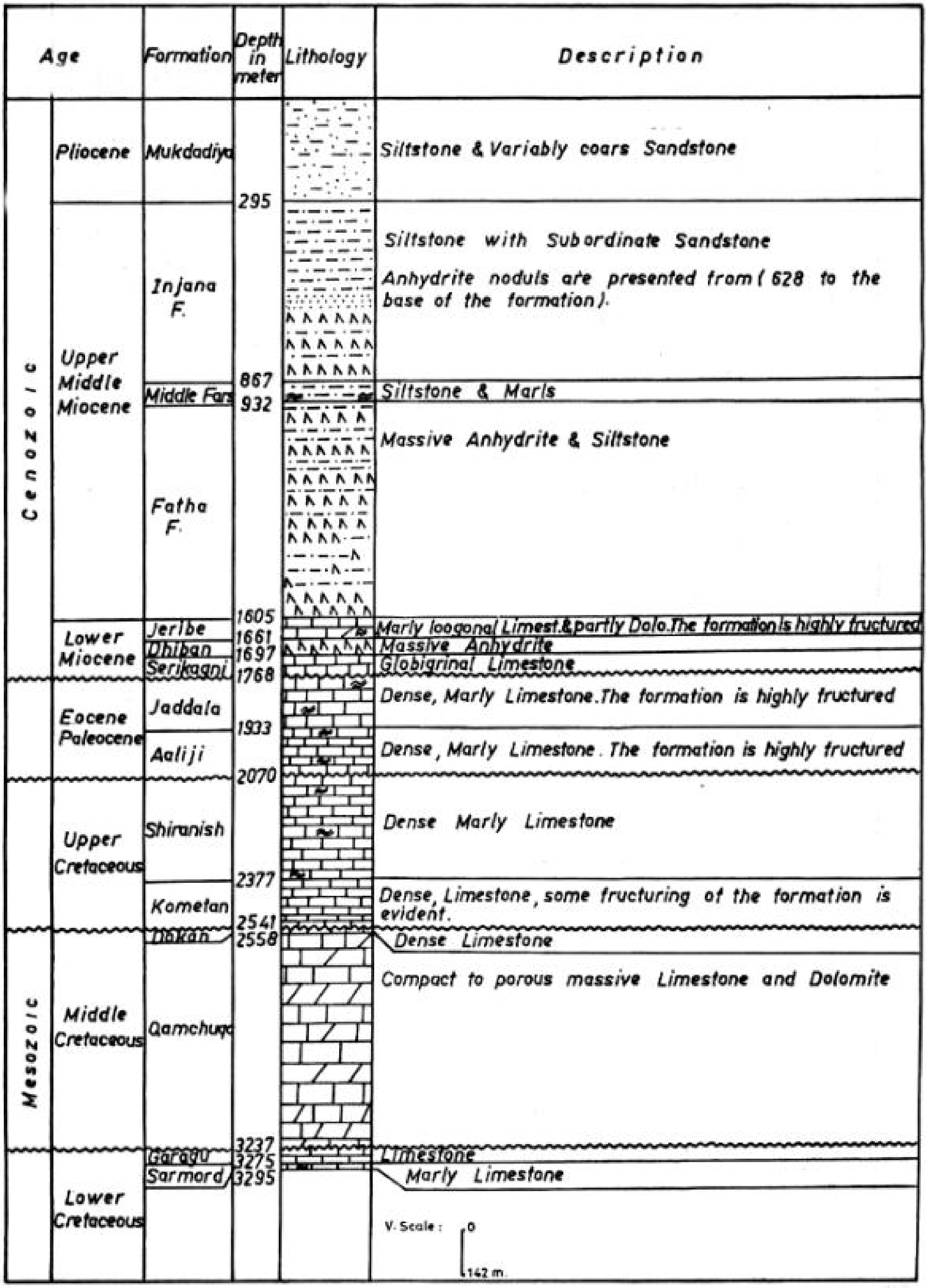

Fig. (3): Stratigraphic section of one of the studied wells

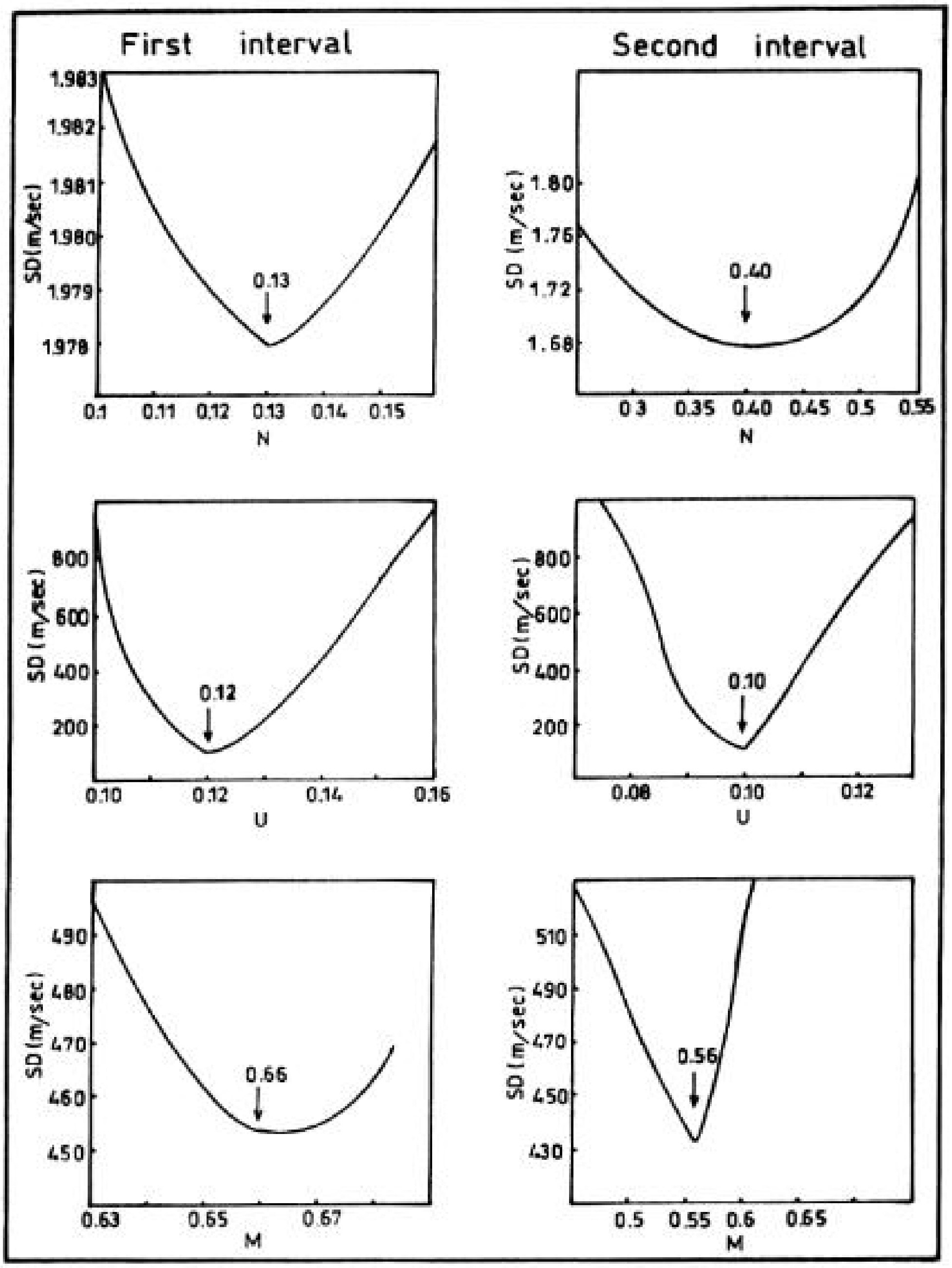

Fig. (4): Determination of the best (N, U, and M) for the sets of time, average velocity, and interval velocity in function of depth data, at the analyzed well for both intervals. The best parameter is indicated by the minimum standard deviation (SD).

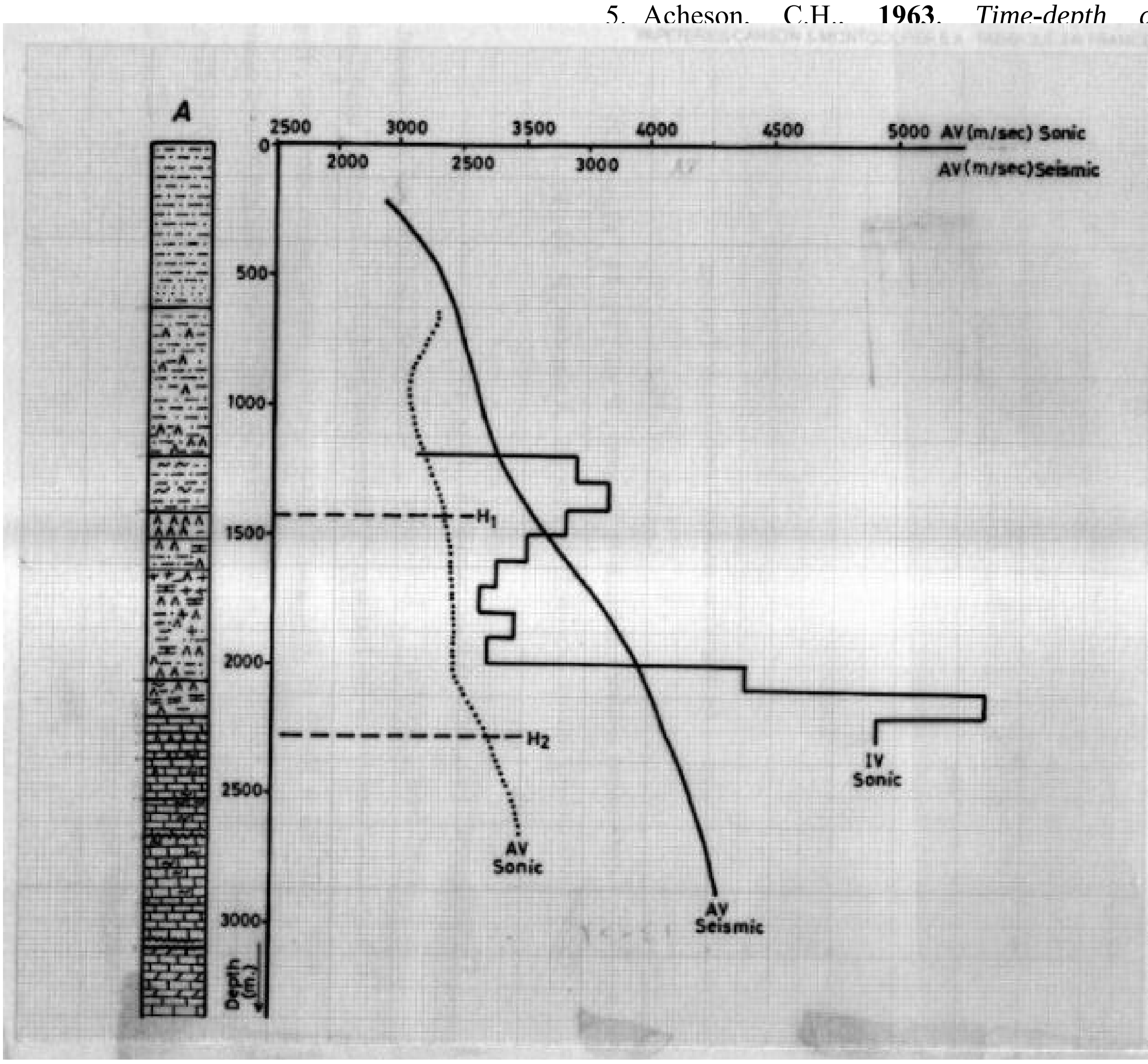

Fig. (5): Plot of average velocity and interval velocity versus the depth at well-A.

References

1. Faust, L.Y., **1951**, *Seismic velocity as a function of depth and geologic time*, Geophysics, v.16, p.(195-206).
2. Wyrobek, S.M., **1959,** *Well velocity determinations in the English Triassic, Permian and carboniferous*, Geophysics, v.7, p.(218-230).
3. Gassman, F., **1959,** *Elastic Waves through a packing of spheres*, Geophysics, v.16, p.(271-288).
4. Acheson, C.H., **1959,** *The correction of seismic time maps for lateral variation in velocity beneath the low velocity layer*, Geophysics, v.24, p.(706-724).
5. Acheson, C.H., **1963**, *Time-depth and* ... *da*,
6. cheson, C.H., **1981,** *Time-depth and velocity-depth relations in Sedimentary basins*, Geophysics, v.46, p.(707-716).
7. Pennebaker, E.S., **1968,** *Seismic data indicate depth magnitude of abnormal pressures*, world oil, p.(73-78), June.
8. Al-Mukhtar, K., **1995,** *The influence of seismic (LVL) on the behavior of the time-depth and velocity-depth relations*, Iraqi Jour. Of Science, v.36, N.3, p.(881-894).
9. Al-Mukhtar, K., & Al-Bahadily, H., **2008,** *The influence of depth and thickness of seismic (LVL) on the behavior of seismic compaction parameters*, in press.

10. Al-Bahadily, H.A., **1997,** *The use of seismic velocity data for the study of stratigraphic variations at Jambur area*, M. Sc. Thesis presented to Baghdad Univ., unpublished.