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QUALITATIVE WELL LOG INTERPRETATION OF SOME EARLY CRETACEOUS FORMATIONS IN SIDI ABDEL RAHMAN AREA

BY

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ABSTRACT

Well log is considered as an indirect method to differentiate between formations differing in their properties (resistivity, radioactivity, etc.) in a section. to establish their boundaries and depth of occurrence and to determine their lithologies.

In this work, two correlation charts were drawn using well logging data to trace lateral continuity of strata and to assure that the boundaries of rock units are in their correct positions. Consequently, a type composite sonic and deep resistivity log of the study well was established.

Many histograms were also constructed to check log quality and to show changes in formation characteristics using different available logging data.

INTRODUCTION

The study area lies between Sidi Abdel Rahman and Kanayis Gulf in the extreme north central part of the Western Desert (Fig. 1). It has an area of about 2500 Km^2 and bounded by longitudes 28° 00' and 28° 50' E and latitudes 30° 20' and 31° 00' N Six wells named Almaz-I, Abu Subeiha-IX, Fadda-I, Dahab-IX, Washka-IX and Ganayen-IX have been drilled in the study area by WEPCO and Shell Winning Companies. Their well logs have been interpreted qualitatively to study some formations called Alamein, Dahab and Kharita of Early Cretaceous time. This study gives a general idea about the physical characteristics of each formation and its continuity in both vertical and horizontal directions, which may be useful for understanding the petrophysical and lithological variation in the study formations.

Generally, the lower Cretaceous sediments in the northern part of the Western Desert are characterized by non-marine and deltaic facies in the south grading to marine, shallow marine and lagoonal facies in the north [2] .

The Mamura Formation represents the beginning of the Lower Cretaceous Series in the study area, its thickness is 35 ft in Almaz-I well and reaches 155 ft in Fadda-I well. It is composed of limestone which is considered a survival of the Upper Jurassic Masajid Formation.

A thick sequence of sandstone and shale with carbonate streaks named Alam El Bueib Formation represents a great part of the lower Cretaceous Series. In the upper part of this unit, shale is the predominant lithology. This sequence has a thickness of 3986 ft in Abu Subeiha-IX well, 3823 ft in Fadda-I well, 3026 ft in Almaz-I well and more than 819 ft in Washka-IX well, where drilling was stopped inside this formation in the last three wells.

The Alamein Formation is a distinct unit of Aptian age overlying the previous sequence. It consists of carbonate rocks and repesented in all the studied wells with a thickness ranging from 305 ft in Dahab-IX well to 245 ft in Abu Subeiha-IX well. The upper part of Aptian sequence is Dahab Formation which consists of interbedded shale and sandstone with some carbonate streaks. It has a thickness ranging from 454 ft in Fadda-I wel to 374 ft in Ganayen-IX well.

The Kharita Formation is of Albian age and represents the upper part of the Lower Cretaceous section. It consists of sandstone with shale intercalations and varies in thickness between 1267 ft in Almaz-I well and 1100 ft in Dahab-IX well.

The Upper Cretaceous sequence is represented by limestones and shales with frequent marine fossils [1,2, 4,5,6,13]. However, this section was divided into three rock units named Bahariya, Abu Roash and Khoman Formations respectively from base to top.

Tectonically, the northern part of Western Desert belongs to the unstable shelf area which lies between the stable shelf in the south and miogeosynclinal basinal area in the north [3,10, 14, 15]. It has a thick sedimentary section overlying a high basement relief (due to block faulting) and was affected by a minor compressional folding.

Among the tectonic movements which affected the sedimentation processes, is the Alpine movement. This movement continued throughout all Mesozoic time in the form of pulses that reached its maximum at the end of the Cretaceous and caused the formation of many folds having a ENE-WSW (Syrian Arc) trend, [7].

WELL LOGGING RESPONSES

The logging data recorded in drill holes constitute data sets in which each observation is identified by its position in vertical sequence [9]. The different well logs can be used qualitatively to delineate the different types of rocks depending on their responses, which may change laterally in the same formation or vertically with depth.

Each log should respond to some properties of strata. This response is affected by the matrix composition, porosity percentage and fluid type. The responses of the available logs and their indication to a certain rock type can be illustrated briefly as follows :

a) Gamma ray log

The clay minerals formed during the decomposition of igneous rocks have very high absorption and ion exchange capacities. They are therefore able to absorb the heavy radioactive elements released during the composition of other minerals, and to hold those originally contained in the feldspars and mica from which the clays are derived. This process results in unusually heavy concentration of radioactive elements in shales compared to sandstones or carbonates [12]. Accordingly, the gamma ray log, which is a measure of the natural radioactivity of a formation, is essential for differentiating the shaly from clean formations where the natural gamma ray increases by increment of shale content in the formation. The clean formations usually have a very low level of radioactivity unless radioactive contaminations are present [15].

b) Spontaneous potential (SP) log

The SP curve is a continuous recording versus depth of the potential difference between a movable electrode in the borehole and a fixed (zero) potential surface electrode. The difference of potential depends on the relative salinities of the formation water, mud filtrate and the permeability of the formation. On the SP log, the reading oposite shale beds tend to follow a straight line called shale base line, but opposite permeable formations, this curve shows deflection from the shale base line. This deflection could be postive or negative depending on the relative salinities and its absolute value increases by increment of permeability and difference in salinities.

c) Caliper log

This log is a measure of the hole diameter, and may help in the delineation of the rock types, where in front of permeable beds (sandstones), the hole diameter could be less than bit size as a result of mud cake accumulation.In front of shale beds, the shale collapse makes the hole diameter to exceed the bit size, this causes other logs to be more affected by the mud.

d) Sonic log

The sonic log is a continuous record versus depth of the specific time repuired for a compressional wave to traverse a given distance of formation immediately adjacent to the borehole. However, each lithology is characterized by a certain interval transit time which is short in carbonates and longer in sandstone and shale. This transit time is directly proportional to the primary porosity of the formation and does not respond to the secondary porosity.

e) Neutron log

The log responds primarily to the amount of hydrogen present in the formation. In clean formations, whose pore spaces are liquid-filled (water or oil), the log reflects the amount of liquid-filled porosity but in shaly formations the log readings increase as a result of the presence of bound water associated with shale.

f) Formation density log

This log is a continous record of variations in the density of the lithologic column cut by the borehole. It is a good indicator for both lithologic and porosity. Lithologically, dolomite has high bulk density followed by limestone then sandston and shale. As a porosity indicator, the log shows low readings in front of porous beds or gas filled pore spaces.

g) Resistivity log

The resistivity logs of shallow and deep investigations depends on the specific resistance and temprature of the formation, the amount and salinity of connate water, in addition to the mud type in the borehole. Electrically, carbonate rocks are characterized by high resistivity values while sandstone and shale have low resistivity ones. As a fluid indicator, hydrocarbon zones give high resistivity values but on the contrary, water zones give low resistivity values.

CORRELATION OF WELL LOGS

One of the first uses of well logs is correlation of equivalent strata from one well to the next one. This correlation is useful to trace the formation continuity from one well to another and to know whether or not the well is within a given major geological structure.

Two correlation charts between the studied wells were drawn using the bottom of Alamein Formation as a datum. In the first one (Fig. 2), sonic logs have been used as a basis for correlation [8], in addition to gamma ray logs which help in detecting the shaly horizons and their continuity in different wells. Each geologic unit has its characteristic sonic and gamma ray responses which are extended through the different wells except for Bahariya Formation in Dahab-IX well where the curve shape becomes more regular and the fluctuation is limited to the upper part of the curve indicating change in lithology of the formation (sandy facies). The most diagonestic unit is Alamein Formation which is extended with nearly equal thickness all over the study area and attains low gamma ray and sonic log values.

Abdine and Deibis [2] mentioned that lithlolgic and electric log correlations were used to determine the approximate limits of the Lower Cenomanian-Albian sequence in the northern part of Western Desert. In the study area, the second correlation chart is based on the deep resistivity and spontaneous potential logs (Fig. 3). The SP log has been used instead of gamma ray in this chart.

It should be taken into account that the difference in salinity of the drilling mud from well to another gives change in the magnitude of the SP curve and the resistivity of the invaded zone [11]. In the studied wells, the logs still have the distinctive responses for each geologic unit except for Abu Subeiha-IX well where the SP curve is featurless perhaps due to the slight difference between mud filtrate and formation water.

By examining the different logs vertically and horizontally in the both two correlation charts, the boundaries of each formation could be delineated and also, a type composite sonic and deep resistivity log was constructed which may be useful in recognizing the study formations in any other wells of the area.

Fig. 4 represents the type composite sonic and deep resistivity log of the study formations collected from the study wells. The typical sonic log is compiled from Fadda-I and Washka-IX wells. It could be informally divided into four sonic log units according to the variation of their responses both in magnitude and shape. It is obvious that each geologic unit is characterized by a certain sonic response. Alamein, Dahab, Kharita and Bahariya Formation are represented by the sonic units S1 , S2, S3, and S4 respectively.

Unit S1 has a diagonestic range of reading (45-55 msec/ft) which indicates a unique lithology (dolomite). Unit S2 has a wide range of readings (50-120 msec/ft) expressing the occurrerce of variaties of litholgies alternating between carbonate, sandstone and shale. Unit S3 has a nearly steady curve shape and the readings range from 75 to 85 msec/ft indicating sandstone lithology with some shale intercalations in the lower part of the unit which has a wider range of values, and finally unit S4 has a very wide range (50-140 msec.ft) indicating the presence of different types of lithologies, from carbonates to shales. The curve shape of the units S2 and S4 is diagonstic by its fluctuation. This indicates the occurrence of different lithologies as relatively thin beds or intercalations of carbonates and shales with some sandstones.

The second curve is the type deep resistivity log which was compiled from the same wells. This type log is composed of three units only, whereas Bahariya Formation is not represented due to lack of resistivity logs of this interval in some wells. These units are denoted by R1, R2 and R3 from bottom to top corresponding to Alamein, Dahab and Kharita Formations respectively.

Unit R1 has the highest resistivity values which range from 10-80 ohm due to the presence of carbonate rocks (mostly dolomite). Unit R2 has a wide range of values (0.5-20 ohm.m) indicating the occurrence of different lithologies and unit R3 has the lowest resistivities with an average value of 0.4 ohm.m indicating sandstone lithology with minor occurrence of shale and carbonate rocks (higher resistivity values) in the lower part of the unit.

It is obvious that both the sonic and resistivity curves have the same significance in determining the specific curve shape and character of the previously mentioned geologic units. They both also give a general idea about the lithology and its distribution in these units.

STATISTICAL STUDY OF LOGGING RESPONSES USING HISTOGRAMS

Correlation between histograms for a certain logging responses is carried out to clarify the similarity, in shape and position of logging data frequencies [15] and to trace the change in lithology with the variation in logging responses.

With the available logs of the three formations in six wells, 135 histograms have been constructed. The following is a description and interpretation of the logging data trend.

a) Gamma ray histograms (Fig. 5)

Alamein Formation is characterized by the individual frequency distribution of a very low radioactivity values with slight occurrence of high values.

The histograms in Dahab Formation show biomodal frequency except in Almaz-I and Dahab - IX wells which have unimodal histograms with mode of low radioactivity at the first well and high radioactivity at the second one. This points to the presence of clean lithologies and shale in different proporation, but shale is prevailing in Dahab-IX well.

In Kharita Formation, all histograms, except that of Dahab-IX, are unimodal with a mode of low radioactivity indicating a clean formation tendency with minor occurrence of shale. In Dahab-IX well, the biomodal frequency distribution indicates an increment of shale content.

b) Spontaneous potential histograms (Fig. 6)

It is observed that the SP values have different ranges in the studied wells. This may be due to the variation in salinity from well to another. When the differnce in salinity is small, the log quality becomes less in distinand R3 from bottom to top corresponding to Alamein, Dahab and Kharita Formations respectively.

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In Dahab Formation, a bimodal frequency distribution is present in Fadda-I, Abu Subeiha-IX and Almaz-I wells, while the other histograms have polymodal frequencies indicating the irregularity in borehole diameter. This irreqularity may be due to the occurrence of shale with other lithologies.

In Kharita Formation, only four histograms were constructed due to lack of caliper logs in Ganayen-IX and Washka-IX wells. A unimodal frequency distribution is observed with the mode of values close to the bit size except in Fadda-I well where the caliper readings are lower than bit size. This indicates the occurrence of high permeability zones. These histograms verify of other logging responses to formation lithologies, but in Dahab-IX, enlarging of hole diameter in some zones indicating that the log responses to be affected by the drilling mud.

d) Sonic histograms (Fig. 8)

In Alamein Formation, a unimodal frequency distribution is cleary evident with the mode of very low interval transit time values indicatiog carbonate lithology.

In Dahab Formation, the histograms in all wells (except Fadda-I well) show a bimodal frequency with some changes in position and shapes of the prevailing modes. This indicates that there is no predominance of certain lithology. In fadda-I well, a unimodal frequency with range of data distribution is prevailing. The mode of the most frequent distribution is between 75-85 msec/ft indicating that sandstone is predominant.

The sonic frequency distribution in Kharita Formation is unimodal with mode ranging between 80-85 msec/ft in all wells (except in Dahab-IX well where the mode is ranging between 70-80 msec/ft). This mode is more likely to indicate sandstone lithology, with lower porosity in Dahab-IX well.

e) Bulk density histograms (Fig. 9)

The Alamein Formation histograms are unimodal with the mode ranging between 2.65-2.85 gm/cc (except in Washka-IX and Dahab-IX wells, where the mode is between 2.7-2.9 gm/cc.). These histograms indicate that dolomite lithology of high bulk density is predominant.

The Dahab Formation histograms are unimodal in Washka-IX well, bimodal in Fadda-I well and polymodal in other wells with wide range of data distribution indicating no predominance of certain lithology.

The Kharita Formation histograms are unimodal with mode lying between 2.30-2.35 gm/cc (except in Dahab-IX well, where the mode is less frequent and lying between 2.45-2..50 gm/cc.). These histograms indicate sandstone lithology, with minor occurence of other lithologies in Dahab-IX well.

f) Neutron histograms (Fig. 10)

The histograms of the studied intervals in Ganayen-IX and Washka-IX wells, in addition to Kharita Formation in Dahab-IX well, are absent due to lack of neutron porosity data.

However, a unimodal frequency distribution with mode ranging between 0-10% is shown in Alamein Formation, while the histograms of Dahab Formation show wide distribution ranging from very low porosity values (carbonate rocks) to very high ones (shale). The Kharita Formation histograms show a unimodal frequency distribution with the mode of moderate porosity values ranging between 20-25%.

g) Resistivity histograms (Figs. 11 & 12)

Alamein Formation has histograms with highest resistivities indicating carbonate rocks. Moreover, the deep resistivity show slight tendency to higher values than the shallow resistivity ones. This may be due to the occurrence of hydrocarbons in some zones.

The Dahab Formation histograms exhibit high resistivity values, but smaller than the carbonate rock resistivities of minor occurrence.

Kharita Formation has a clear unimodal frequency of deep and shallow resistivities with the mode of very low resistivity values. This could indicate the occurrence of water-filled porous rocks.

SUMMARY AND CONCLUSIONS

The well logs of six wells drilled in the area between Sidi Abdel Rahman and Kanayis Gulf in the northern part of Western Desert were interpreted qualitatively to study Alamein, Dahab and Kharita Formations of the Early Cretaceous age. The interpretation is based upon well log correlation and statistical study of the available logging responses.

Two correlation charts were constructed using electric logs in the first chart and both gamma ray and sonic in the second one. The logs were matched horizontally and vertically to follow log characteristics in each formation, consequently a type composite sonic and deep resistivity log was established. It was found that both sonic and resistivity logs have the same significance in determining the specific curve shape and the character of the three formations. The type log is useful for determining the bounderies of those formations in any other wells drilled in the area.

Alamein Formation has the lowest sonic readings (45-55 μ-sec/ft) and highest resistivity values (10 - 80 ohm. m). The curves of Dahab Formation are characterized by its fluctuation; wide ranges of sonic values (50 - 120 μ sec/ft) and resistivity ones (0.5 - 20 ohm.m). Kharita Formation has a nearly steady curves of both sonic (75 - 85 μ sec/ft) and resistivity (about 0.4 ohm.m).

Generally, the histograms of different logging responses in Alamein Formation show a unimodal frequency distribution with most of the modes of very narrow ranges " one bar type " indicating the predominance of dolomitic lithology (low sonic and neutron porosity values and high bulk density and resistivity ones). The higher deep resistivity values of this formation than those of shallow resistivity in some zones indicate a probable hydrocarbon occurrence.

The Dahab Formation histograms are quite irregular with wide ranges covering different indications of the most common lithologies (sandstone, shale, and carbonate rocks).

This show the hybrid occurences of all these lithologies in proportion varying from well to another, but the shale is more abundant in Dahab -IX well. Correlation of gamma ray, SP, Caliper and resistivity logs indicates that shale has a rather high resistivity.

The different histograms of Kharita Formation have a unimodal frequency distribution with minor frequencies. This indicates the predominance of clean lithology (low radioactivity and SP). This lithology is mostly sandstone due to the moderate values of sonic, bulk density and neutron porosity. The fluid content is most probably water as indicated by electric logs (no big difference between shallow and deep resistivities). In Dahab-IX well, this formation tends to be shaly.

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Delta J.Sci. (12) (1) 1988

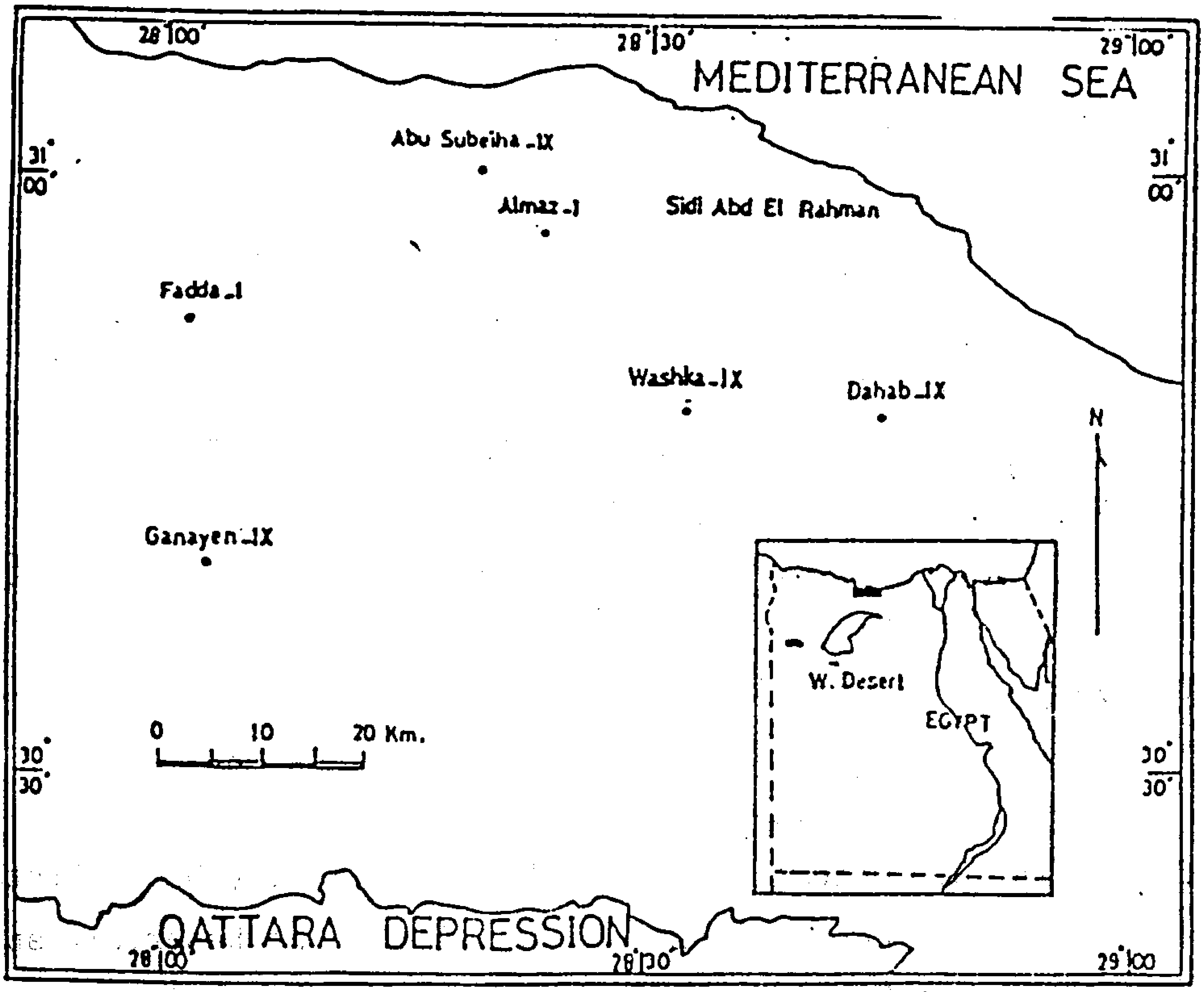

Fig.1 Location map of the study area showing distribution of the studied wells.

Delta J.Sci. (12) (1) 1988

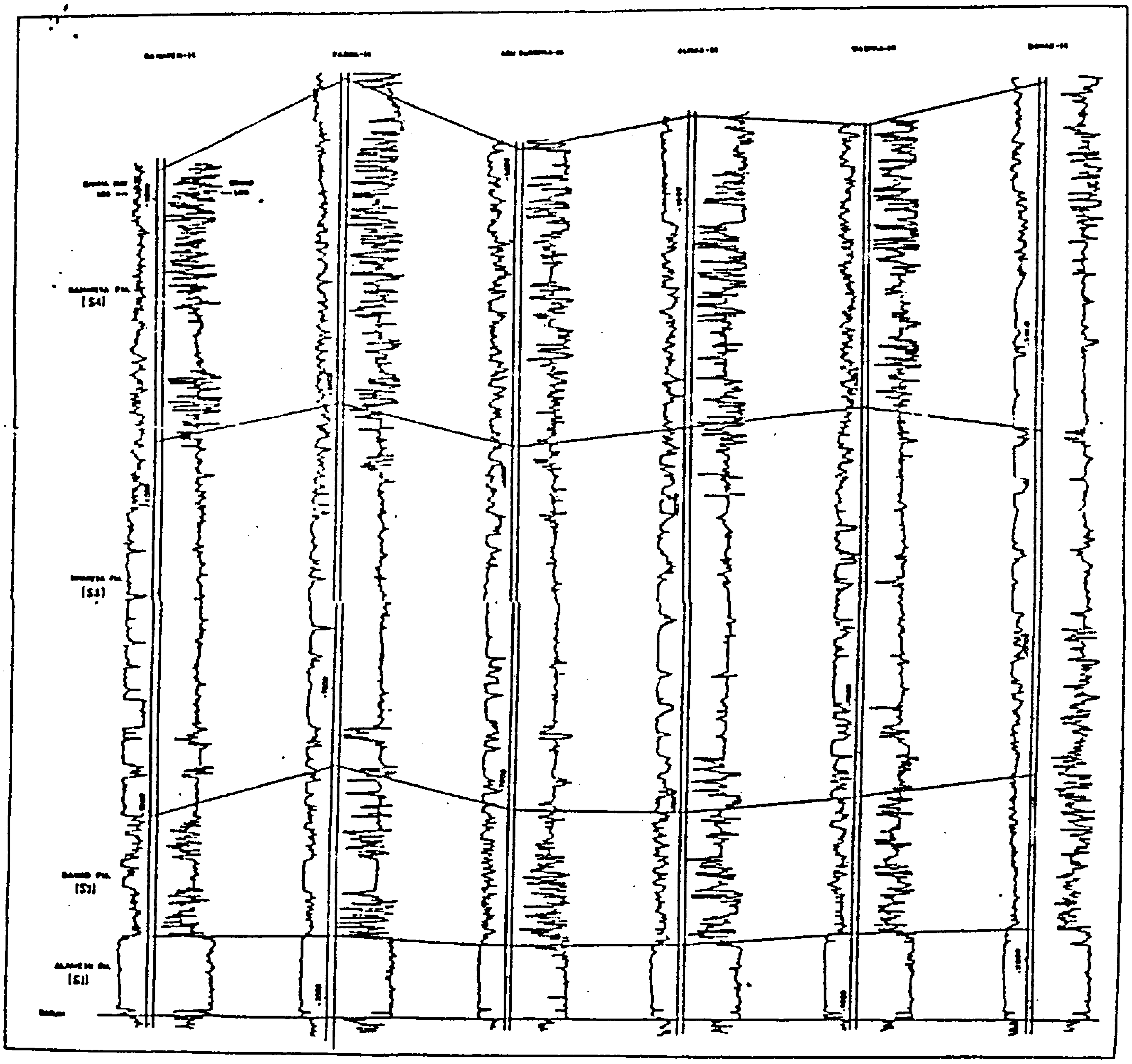

Fig.2 Correlation of gamma ray and sonic logs of the studied formations.

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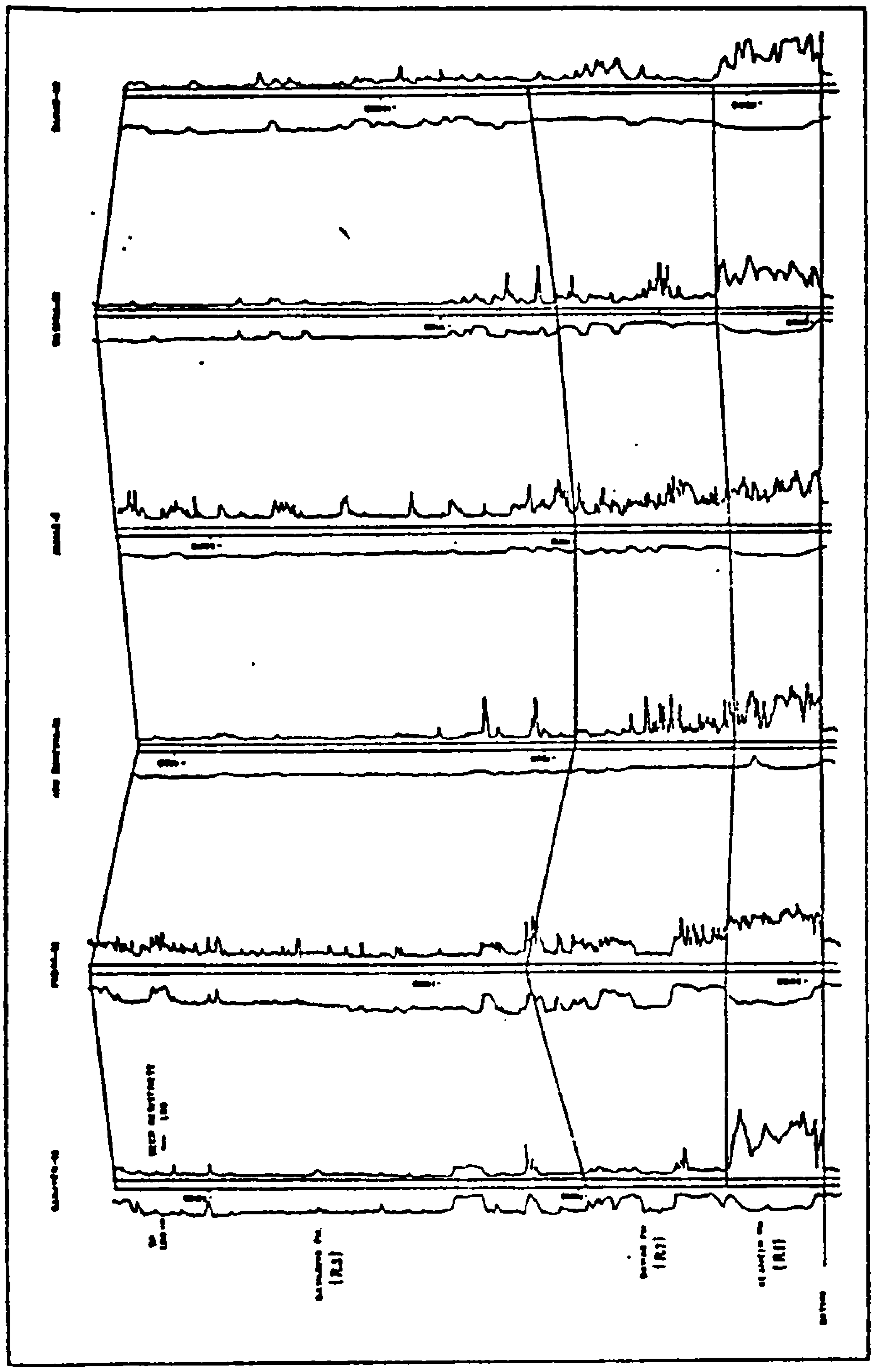

Fig.3 Correlation of SP and deep resistivity logs of the studied formations.

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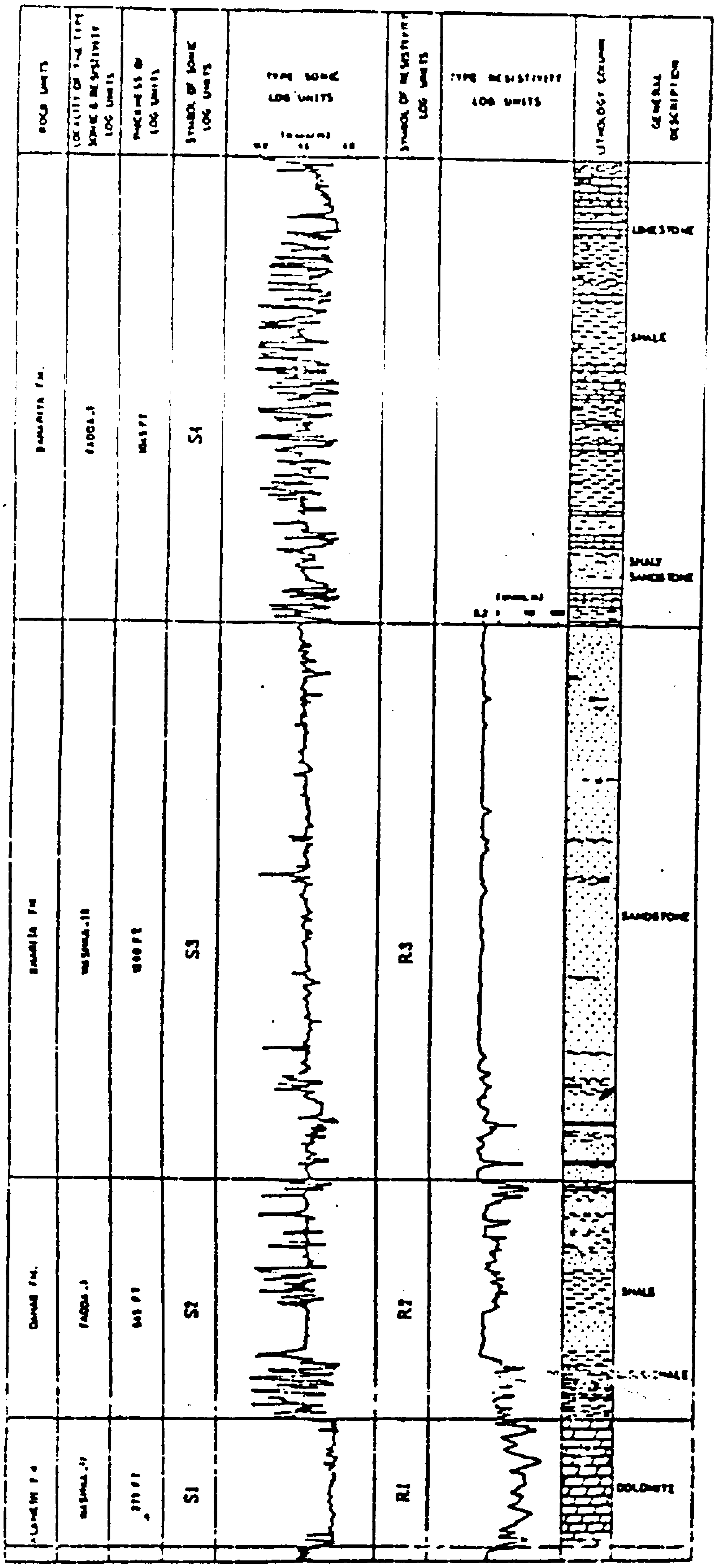

Fig.4 Type composite sonic and deep resistivity logs of the studied formations.

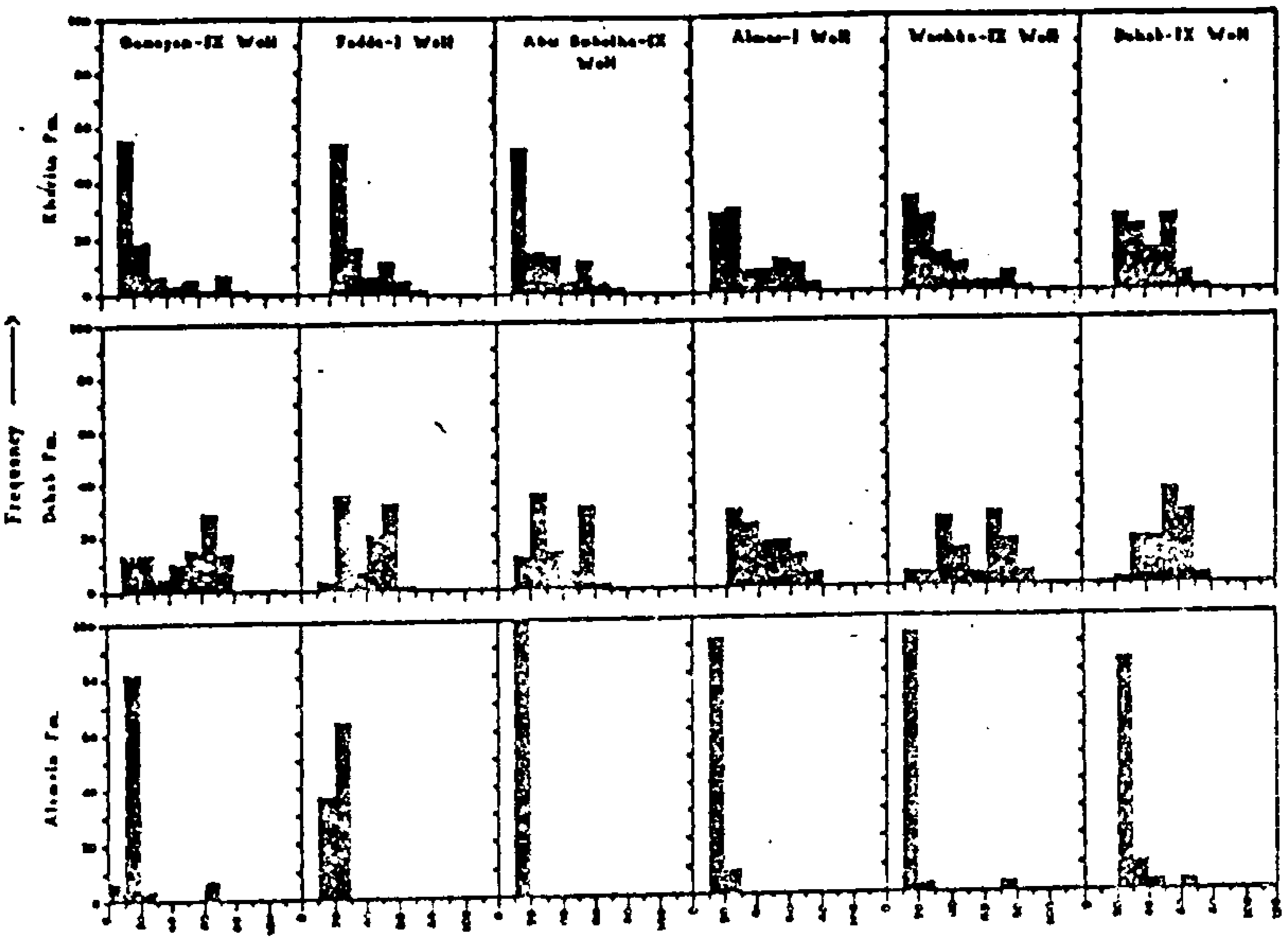

Fig.5 Gamma ray histograms of some wells in the studied formations.

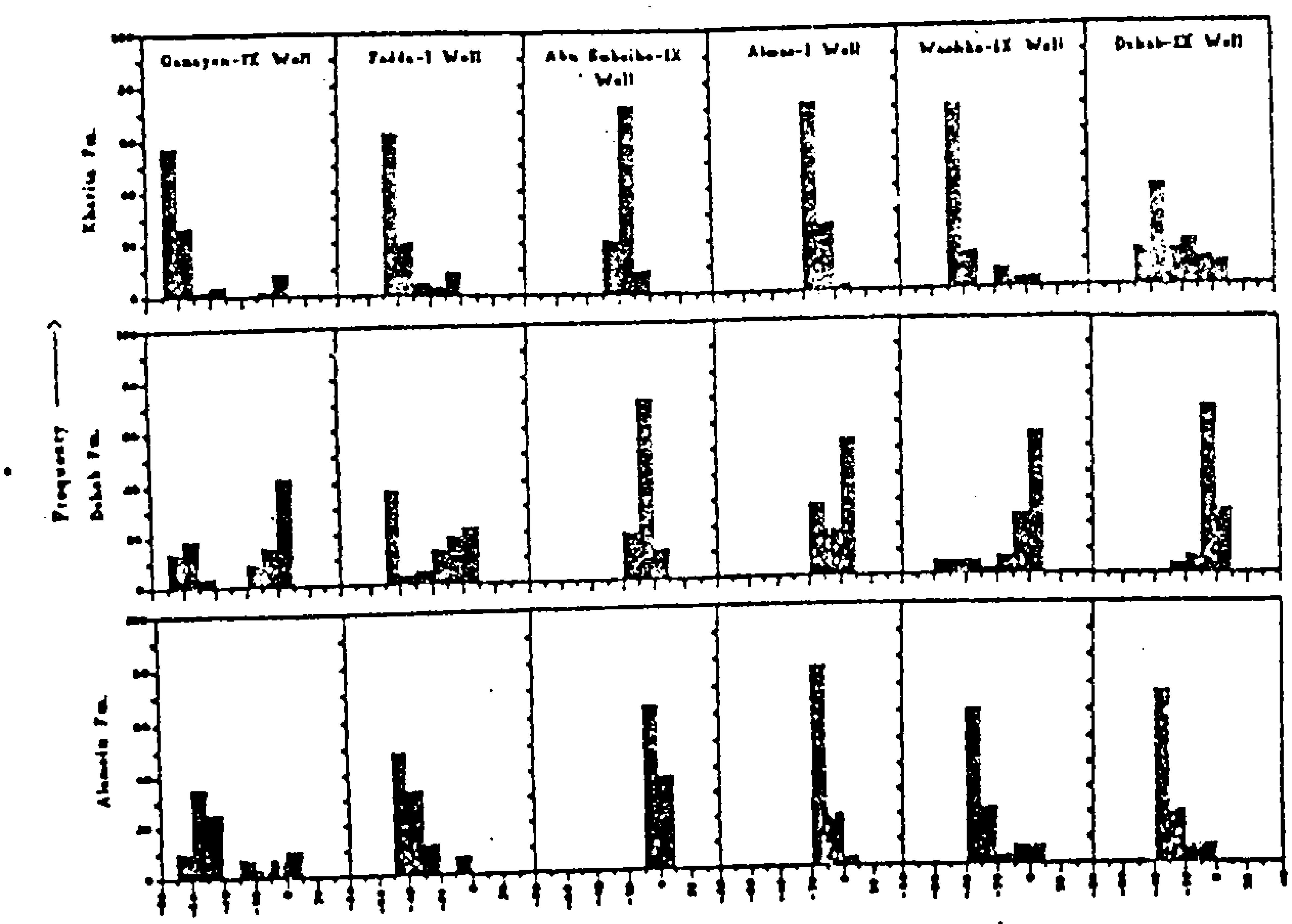

Fig.6 Spontaneous potential Histograms of some wells in the studied formations.

Delta J.Sci. (12) (1)1988

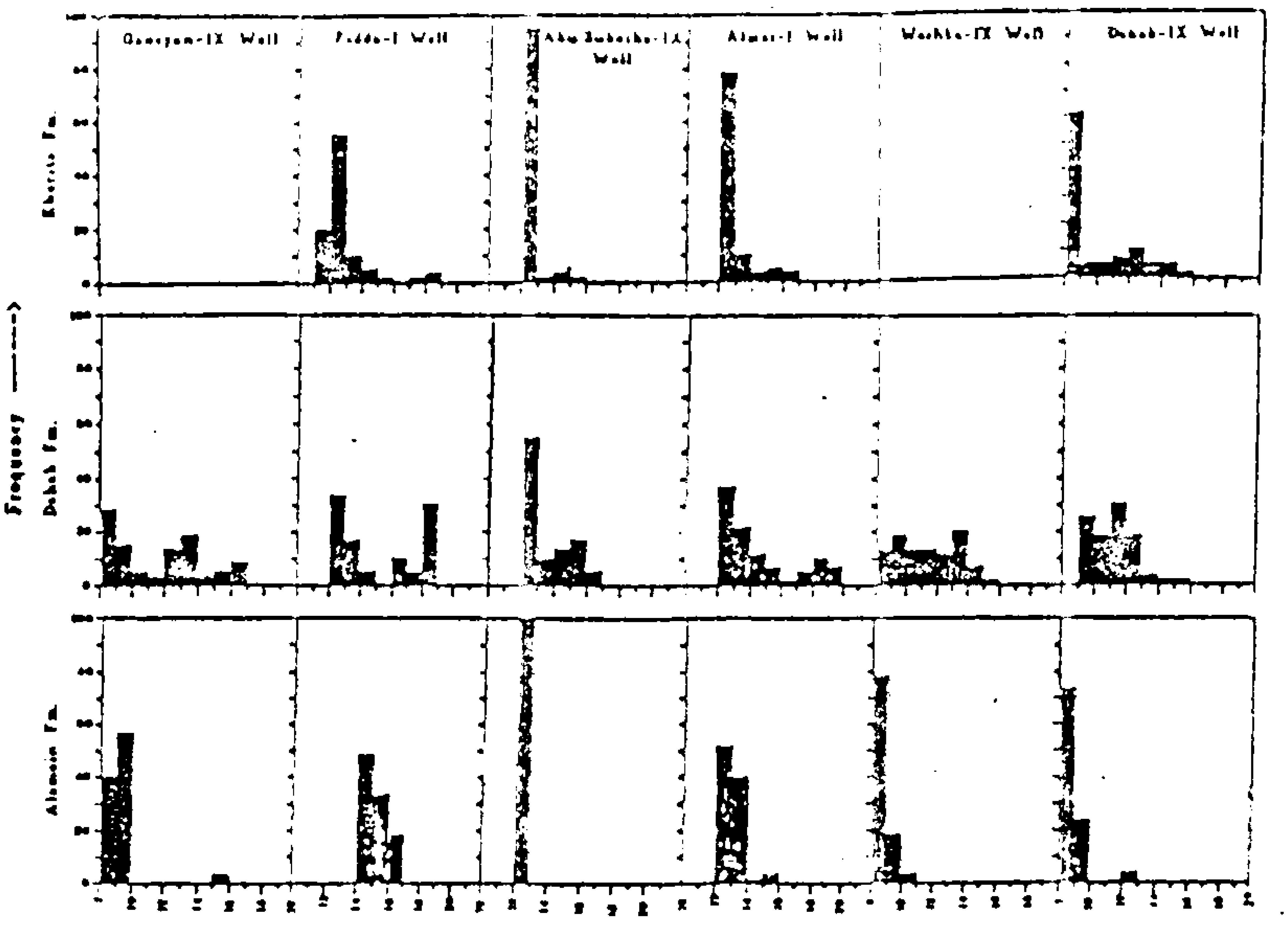

Fig.7 Caliper Histograms of some wells in the studied formations.

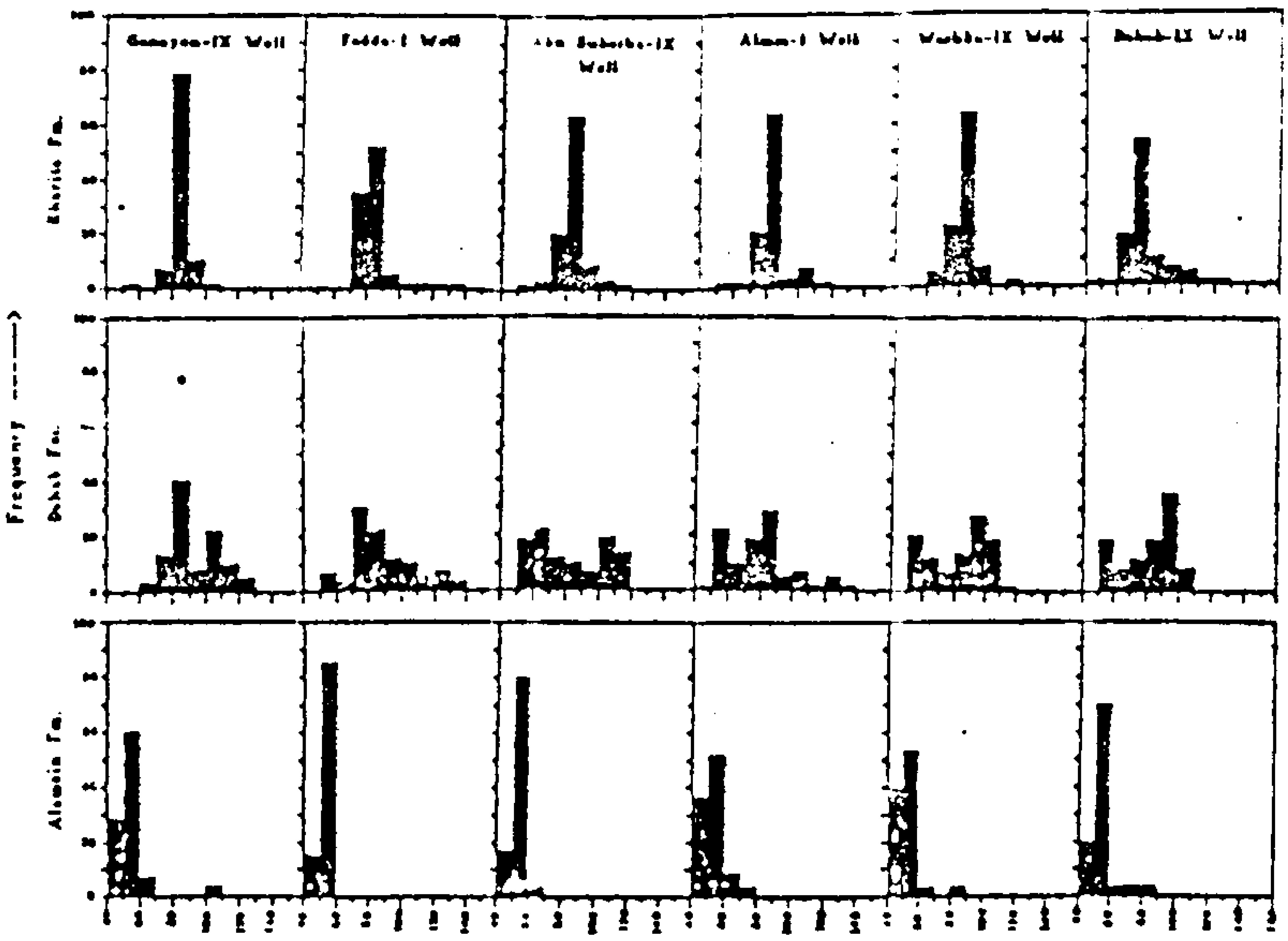

Fig.8 Sonic Histograms of some wells in the studied formations.

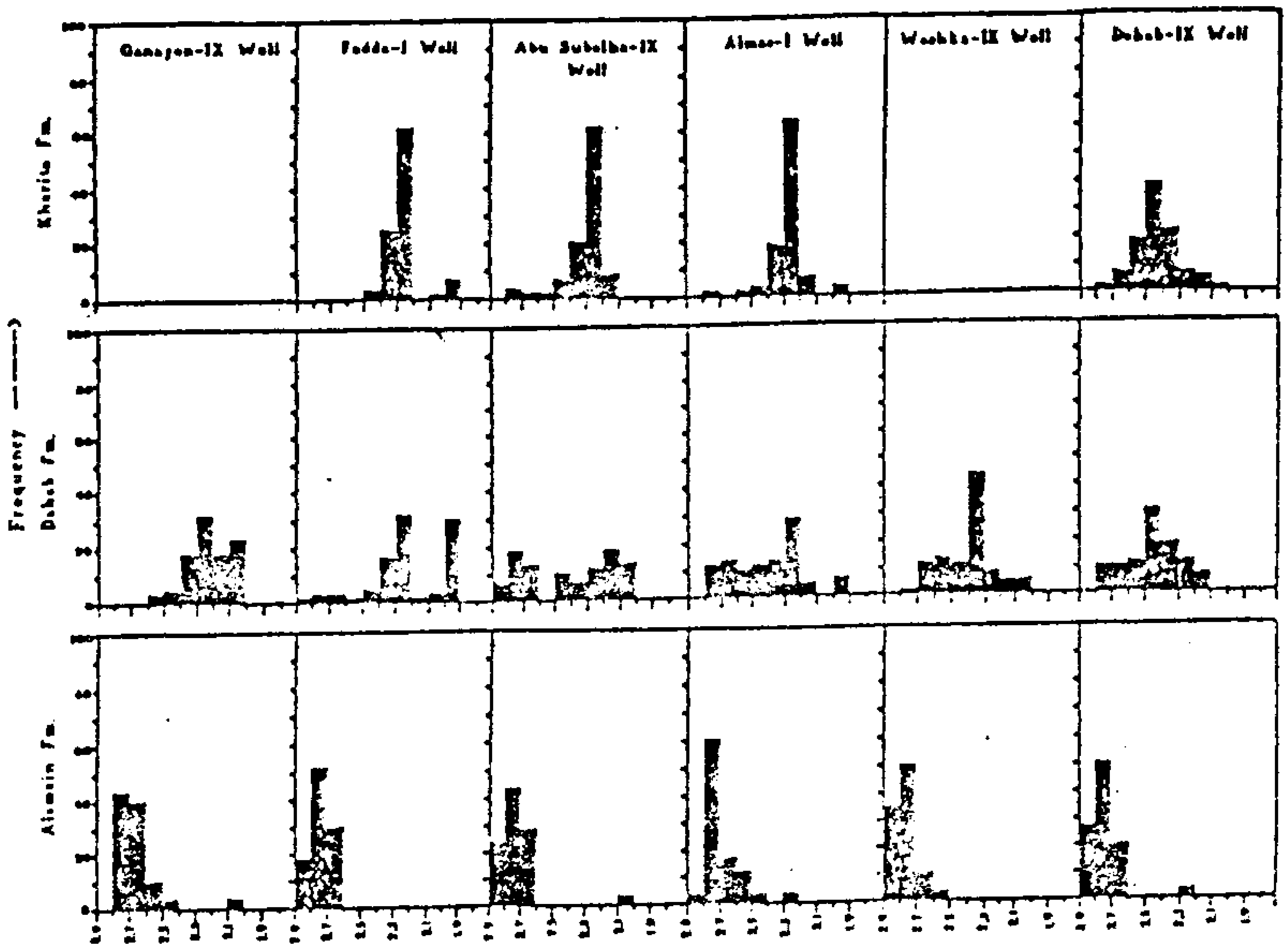

Fig.9 Bulk density histograms of some wells in the studied formations.

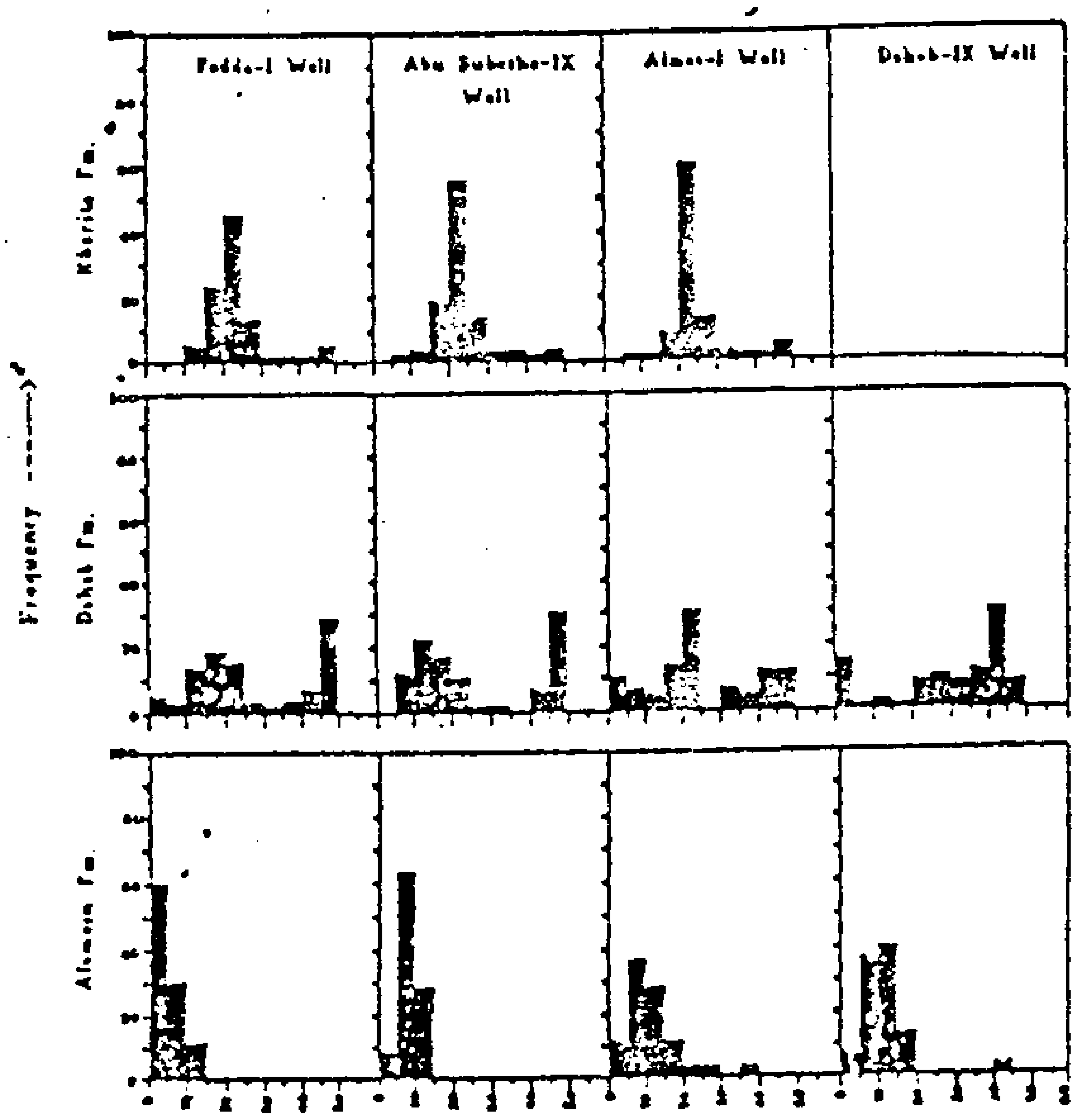

Fig.10 Neutron histograms of some wells in the studied formations.

Delta J.Sci. (12) (1) 1988

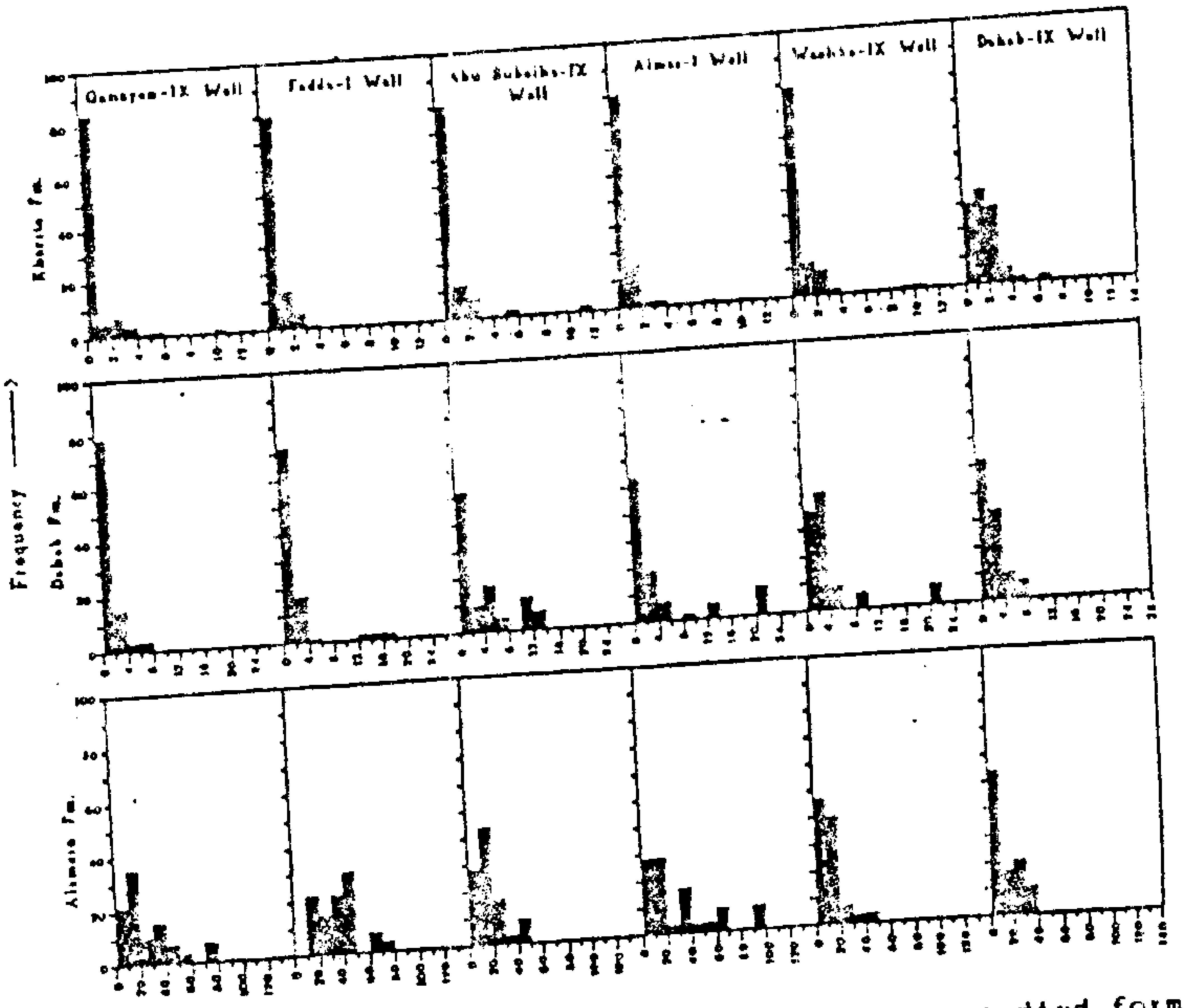

Fig.11 Deep resistivity histograms of some wells in the studied formations.

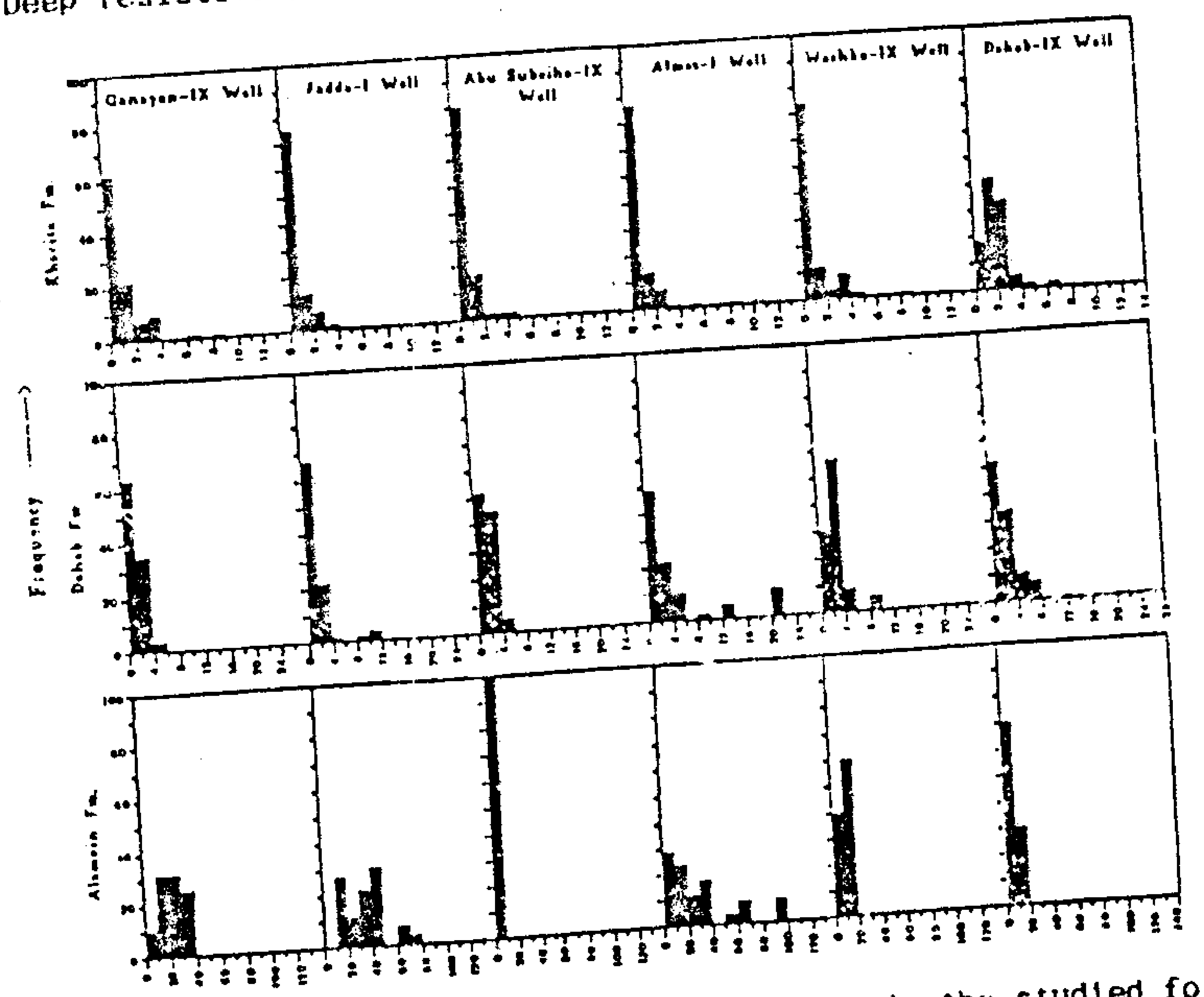

Fig.12 Shallow resistivity histograms of some wells in the studied formations.

غسير كيفى لتسجيلات الابار لبعض تكاوين العصر الطباشيرى السفلى فى منطقه سيدى عبد الرحمن

الدكتور / نادر حسنى الجندى ـ والسيد / عز الدين على صالح
كلية العلوم ـ جامعة طنطا

يهدف فى هذا البحث الى تحليل كيفى لمجموعة تسجيلات الابار لدراسة الخواص الفيزيقيه لثلاث تكوينات جيولوجيه تنتمى الى العصر الطباشيرى السفلى فى شمال الصحراء الغربيه فى منطقه سيدى عبد الرحمن وهذه التكاوين الجيولوجيه هى العلمين ودهب وخريطه ٠

وتم من خلال مضاهات تسجيلات الابار للمنطقة المدروسة باستخدام الطرق الكهربية مرة وباستخدام كلا من الطرق الاشعاعية والموجات الصوتية مرة اخرى لنفس التكاوين استنتاج أن الشكل العام لكل تكوين جيولوجى له خواصه الفيزيقية المميزة مما ساعد على وضع تسجيل نموذجى للصفات الفزيقية لهذه التكاوين باستخدام المقاومه الكهربيه والموجات الصوتية التى يمكن بها التعرف والاستدلال على الحدود الفاصلة بين كل تكوين على حده فى المناطق المجاوره٠

كما تم ايضا التعرف على الاتجاهات الصخريه فى كل تكوين بالتمثيل البيانى (هستوجرام) للقياسات الفيزيائيه المختلفه مثل المقاومه الكهربيه والكثافه والموجات الصوتيه والنشاط الاشعاعى وغيرها الى استنتاج السحنه الصخريه المميزه لكل تكوين ومدى تغيرها من بئر الى آخر واستنباط مبدئى لاحتماليه تواجد البترول فيه٠ وعلى أى حال وجد أن السحنه الكربونيه مميزه لتكوين العلمين بينما الشحنه الطفليه مميزه لتكوين دهب والسحنه الرمليه مميزه لتكوين خريطه٠