Using Modified d-exponent Method and Equivalent Depth to predict Abnormal pressure zones in oil wells in Amara Oilfield (Southeast Iraq).

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ABSTRACT:

Reduction in drilling problems particularly those associated with drilling costs can be achieved, to a certain degree, by an early determination of abnormal permeability pressures The prediction of these pressures and fractures degree can be used to define the limit of protective curtain of the drilling boreholes for petroleum purposes.

In the present study, two boreholes (A1 and A2) have been selected from Amara oil field, southern Iraq to define the regions of abnormal pressure by using two methods.

These methods are the modified d-exponent method and equivalent depth method. These methods are depending on acoustic logging data. Both of them gave coincident results and this may reflect the good accuracy of these methods in determining zones of abnormal pressures using acoustic or sonic logging data.

استخدام طريقة (الاس – d) المطورة وطريقة العمق المكافيء للتنبؤ بأنطقة الضغوط غير الاعتيادية في ابار نفطية في حقل العمارة النفطي (جنوب – شرق العراق)

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المستخلص:

ان تقليل مشاكل الحفر وبالاخص كلفة الحفر الى حد كبير يمكن الوصول اليه بالتحديد المبكر للضغوط المسامية غير الاعتيادية، وان التنبؤ بهذه الضغوط وبتدرجات التشقق يساعد في تعيين حدود استعمال البطانات الواقية وحماية عملية حفر الابار النفطية .

تم في هذه الدراسة اختيار بئرين من احد حقول ميسان جنوب العراق لتحديد مناطق الضغط غير الاعتيادي باستخدام طريقتين من طرق تحديد هذه الضغوط وهما طريقة الاس - d- المعدلة Modified d-exponent method وطريقة العمق المكافيء Equivalent depth method وهي من الطرق المعتمدة على معلومات المجسات الصوتية ، لقد وجد ان الطريقتين قد اعطت تطابقاً في نتائجها وهذا يعكس دقة تطبيق الطريقتين في تحديد مناطق الضغوط غير الاعتيادية.

Introduction:

The abnormal pressure beds are considered as closed hydraulic systems with pressure seals that prevent the complete connection of the bed liquid. The abnormal pressures may be found in the rock beds near the surface (hundreds of feet at the subsurface) and at depths more than 20000 feet [1].

Generally, abnormal pressures are always found in massive shale and silt beds or in massive evaporates and carbonate sections in addition to the faults and other structures [2].

Abnormal pressures in (180) sedimentary basins have been determined and most of the gas and petroleum generated in these basins were found in the abnormal pressure sections of the fluid [3].

The presence of abnormal pressures is resulted from many reasons and factors which are related to geological, physical, geochemical and mechanical variables. It has been found that the structure of the reservoirs, rate of sedimentation, tectonic activities and formation compaction are representing some of the reasons that form these abnormal pressures [3, 4].

There are other reasons which lead to the formation of abnormal pressures in the bedded rocks from them are effect of hot water, accumulation of cementing materials in the beds, escape of water from shale beds and diffusion [5, 6, 7].

The knowledge of pressure distribution in a certain area will surely decrease the problems associated with all geophysical operations, drilling operations and petroleum engineering. Therefore, the dangerous problems which face the field work groups are the location of abnormal pressures. This problem may be correlated with Cretaceous geological period which has a direct relation with subsurface geological structures of the area.

In general, the abnormal pressures (above or below the normal gradient) have been found in many producing hydrocarbon and depleted reservoirs. Unless the region of these pressures is still unknown in perfect way, but their presence can be attributed to compaction effects, tectonic activities, differential densities and fluids migration [8,9].

Stratigraphic and Tectonic Setting of Amara Field:

Amara oil field lays on the unstable shelf at the Mesopotamian basin according to the tectonic zones of Iraq [10]. This setting has a direct effect on structural style, fracture intensity and depositional setting. Amara structure consists of a single anticline with axis trending northwest- southeast (Fig.1).

Mishrif Formation (Cenomanian-early Turonian) in Amara oil field consists of porous limestone, chalky limestone, compact limestone and shale with chert at the bottom of Formation.

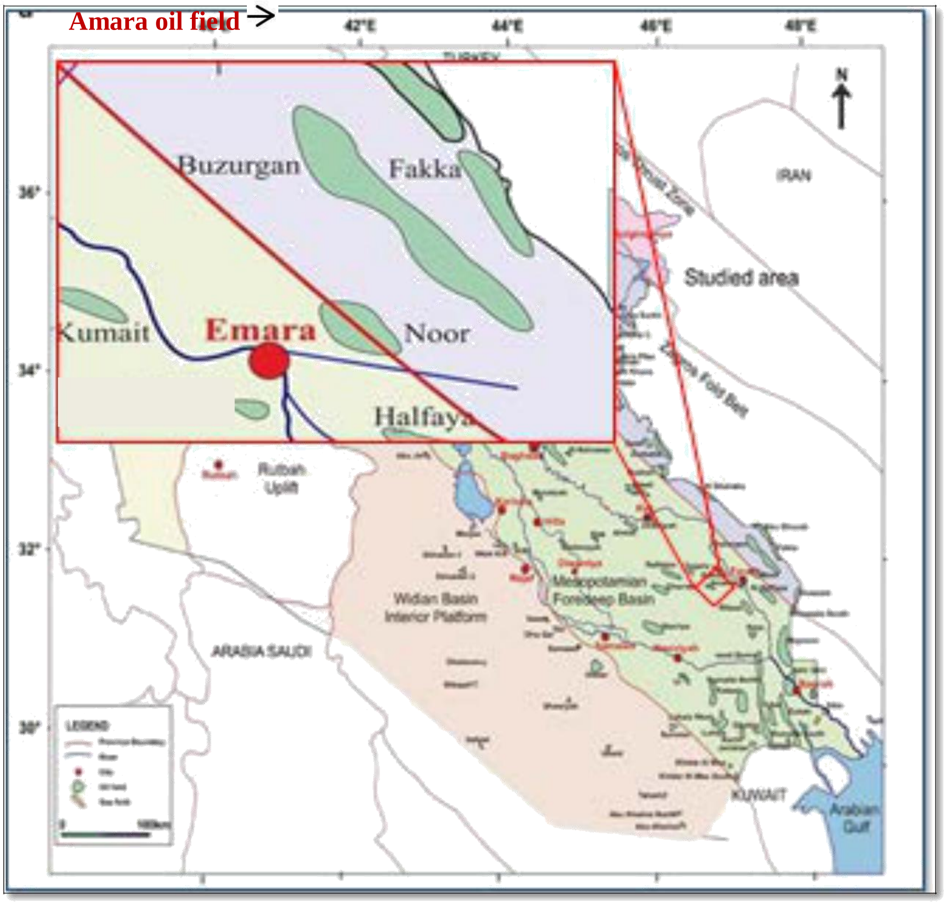

Figure (1) Location map of Amara oil field (modified from [11]) .

The lower boundary of Mishrif Formation represents the change from basinal Rumaila Formation to shallow open marine facies. It is a conformable surface [12]. The upper boundary of Mishrif Formation is with Khassib Formation, and this boundary is truncated by unconformity surface separating the middle from late Cretaceous [13].

Mishrif Formation is considered to be an overall progradational marine shelf sequence. Following the deposition of the transgressive shales and limetones of Ahmidi and Rumaila Formations, rudist reefs and other related buildups represented the deposition of the Mishrif Formation. Mishrif Formation reservoir of the Mesopotamian basin accommodates more than one-third of the proven Iraqi reserves within rudist-bearing stratigraphic units [12].

The Late Cenomanian to Early Turonian was a period of generally favorable condition world-wide for high organic productivity and the eustacy was the major element controlling the growth, development and location of built-up [14]. Mishrif Formation is composed of two major sedimentary cycles abruptly terminated by the unconformity which separates Mishrif Formation from the overlying Khassib Formation [12].

Prediction Methods of Abnormal Pressures:

There are many methods that have been used all over the world to predict abnormal pressure, from them are seismic data method, method based on drilling data, method based on sonic log data, shale density method, temperature measurement method and the presence of gas in mud method [15,16, 17].

Most of the above methods are divided into sub-methods that are differ in using certain variables, for example, the method based on different drilling data, including penetration rate, weight applied on the bit, rotation speed, borehole volume and weight of the drilling mud. The data used in a certain method can be used with other variables in other methods.

In this paper two methods are used to predict the zones of abnormal pressures. The first method used is modified d-exponent method, which takes the weight of drilling liquids in consideration and the second method used is the equivalent depth method. It is one of the methods which depends on sonic log information. In this method a graph between the transit times through shale and the depth is drawn.

The use of these two methods are depending on the available information from the two well present in the studied area, namely A1 and A2.

Results:

The modified d-exponent method in relation with depth is used in this paper to determine the beginning or the top of the abnormal pressure bed, or the transition from the bed of normal pressure to that of abnormal pressure.

The use of this method is clearer in application than the normal d-exponent method, due to the effect of weight increment of the used drilling mud during the drilling of the abnormal pressure zone. Figures (2&3) show drawings of modified d-exponent values against depth.

In these Figures, the deviations of d values from the normal trend line are to the left. These deviations from the normal trend line indicate the presence of zones with abnormal pressures. The consideration of mud weight effect used in drilling operation is necessary to increase the efficiency of this method in compaction with normal d-exponent method.

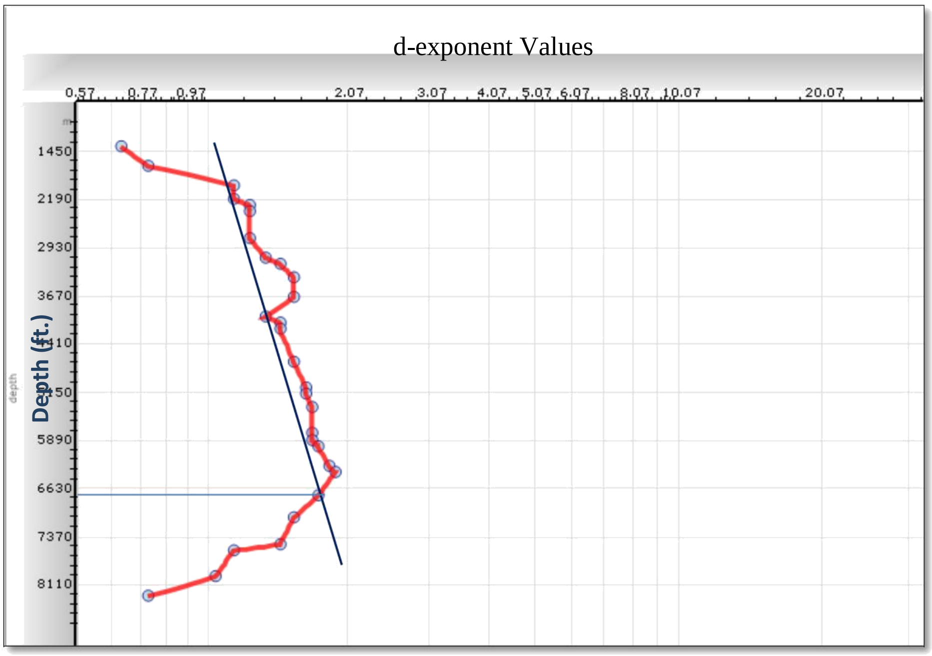

Figure (2) Modified d-exponent method to determine abnormal pressure depth in well (A1).

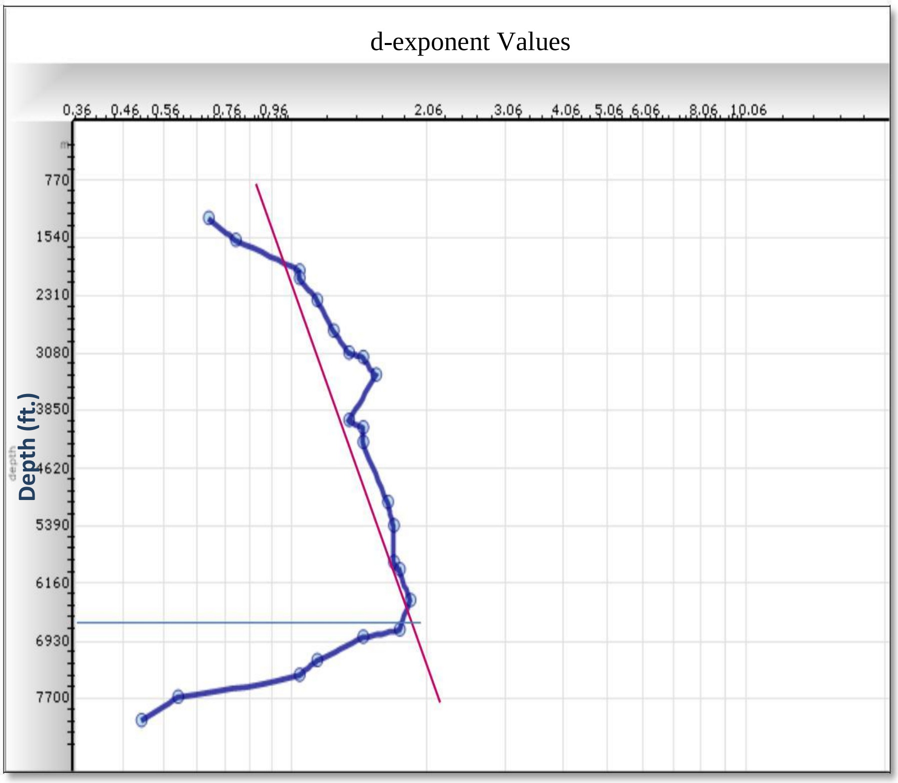

Figure (3) Modified d-exponent method to determine abnormal pressure depth in well (A2).

The method used is:

$$dc = d\frac{MWh}{MW} \text{............ (1)}$$

Where:

dc= modified d-exponent.

MWh= normal pressure gradient of drilled area in (lb/gal).

MW= weight of drilling mud or the gradient of used pressure (lb/gal).

(d) can be measured from the following relation (2):

$$d = \frac{\log(\frac{-ROP}{GON}}{\log(\frac{12W}{10^6\ Dh})} \text{........... (2)}$$

In the second method the measurements of the transit times (Δt) are used to predict the zones of abnormal pressure depending on the well-known geological information which state that, zones of abnormal pressures are less compacted and since sonic log is affected by porosity of the bed and its fluid content, so the measurements are decreased in front of these zones.

The used equation, which represents a straight line when it is drawn on a semi-log paper, is written as:

$$\Delta t = \Delta t_o e^{-cD} \text{.......... (3)}$$

Where:

Δt= transit time through shale in (microsecond/ft.) Δt_o= transit time at the surface in (microsecond/ft.) c= slope of the normal compaction line in (1/ft.)

D= depth in feet.

This equation has been applied on the data obtained from the two studied wells, and Fig.(4) and Fig.(5) show normal compaction lines of both wells respectively. Both figures show the amount of deviation from normal compaction lines to the left direction, which indicate the beginning of the abnormal pressure zone at a depth of (6770) ft. for the first well (A1) and a depth of (6750)ft. for the second well (A2).

These results coincide to a high degree with the results of the previous method which depends on drilling parameters.

Conclusion

Since the both used methods, modified d-exponent method and equivalent depth method, reached approximately to the same results about the expected depths of the abnormal pressure zone in wells A1 and A2, this may encourage us to use a large numbers of wells in future studies. If both methods still giving approximately similar results, as in this case, then depending on only one of them will be enough to predict reliable results in predicting the abnormal pressure zone in a certain oilfield.

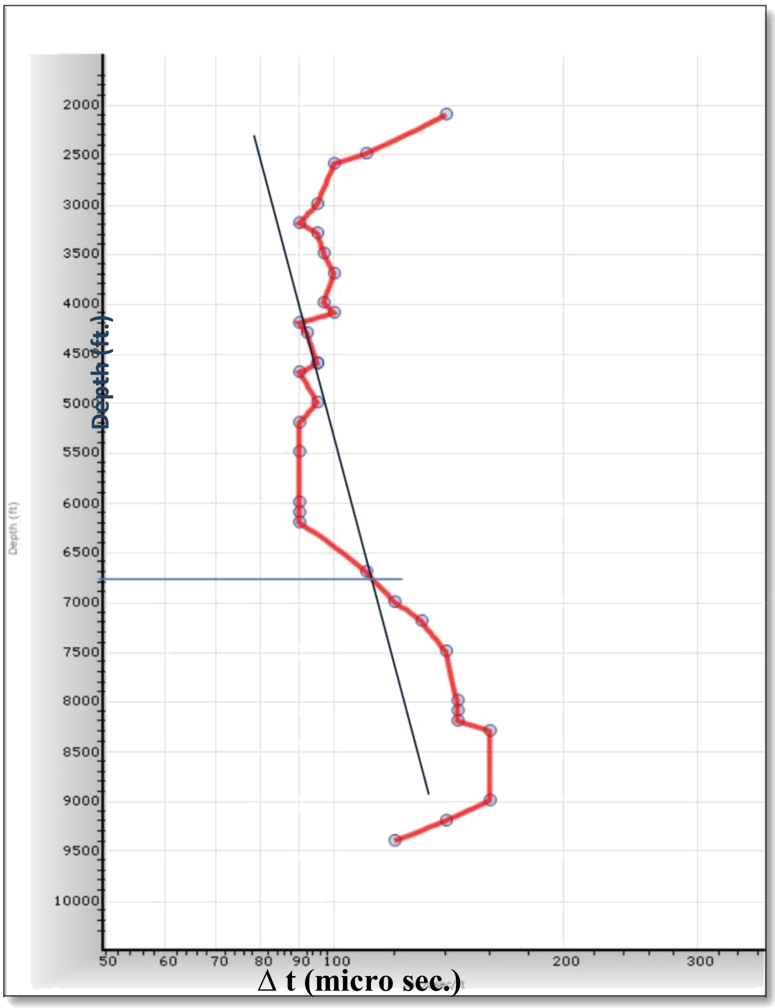

Figure (4) Prediction of abnormal pressure depth using transit time (Δt) in well A1.

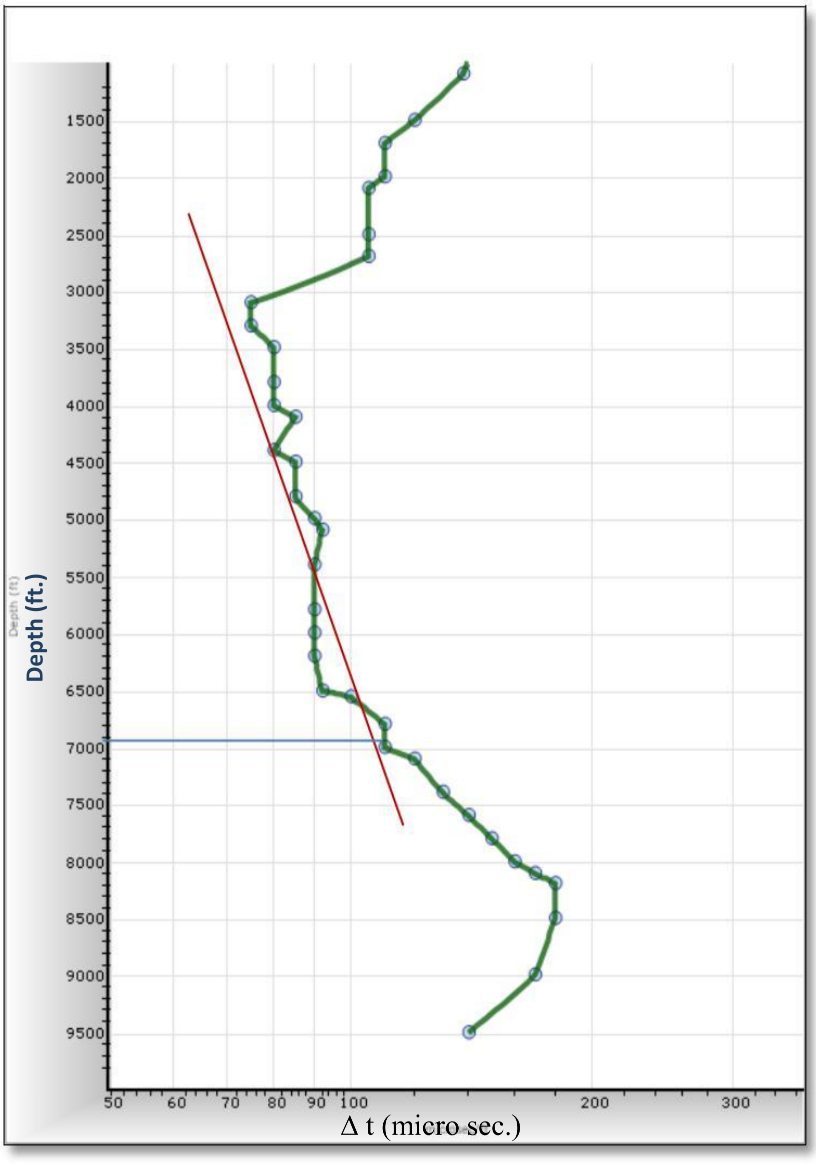

Figure (5) Prediction of abnormal pressure depth using transit time(Δt

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