IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 06, Issue 01 (January. 2016), ||V3|| PP 29-34

Prediction technique of formation pressure

Wu Shangxin[1]

1. *Exploration and Development Research Institute of Daqing Oilfield Company Ltd, Daqing, Heilongjiang, China, 163318*

Abstract: Formation pressure is the basic data of oil exploration, development, design and construction, accurate prediction and control of formation pressure play a very important role in petroleum exploration and development, especially, it has great engineering value and economic significance to make accurate prediction of abnormal pressure layer.In this paper, a method of predicting formation pressure based on well logging data and seismic data is introduced.

***Key word**: pore pressure; well logging; seismic; abnormal pressure*

I. INTRODUCTION

Formation pore pressure (referred to as formation pressure) refers to the formation of pore fluid (oil, gas, water) with the pressure, is indispensable to the stability of borehole wall foundation parameters. In the early 1960s, to realize the importance of formation pore pressure in oil and gas wells .People began to explore the methods of estimate the value of formation pore pressure prediction research .This process has a history of 40 years. Currently used in advance, a lot of methods, detection of original formation pore pressure, the index of major geological analysis, the seismic method, dc method and logging method, etc. Geology analysis and seismic method are prediction before drilling, in deep strata with census district, without drilling data and well logging data to draw lessons from [4], which can be used to macro delimit the abnormal pressure zone, but has low accuracy; Dc index method to monitoring while drilling, the lithology of the judgment is not accurate, calculate stress values have also been affected. The logging data reflect the formation of the most detailed information, good continuity, high vertical resolution and reliability.

II. METHODS

2.1 Based on the depth of the balance method to calculate formation pressure：

The so-called "equivalent depth method" is in different depth with the same rock physical properties of the skeleton of the shale of sigma is equal to the effective stress [1]. Its basic basis is that, in a certain position with the same porosity of two similar clay or mudstone layer, its skeleton under compressive stress is equal, and has nothing to do with their buried depth. Equivalent depth method is suitable for the new exploration area, before the original formation pressure has not yet obtained the measured data, commonly used to calculate formation pore pressure. Equivalent depth method based on acoustic logging, it is to point to without considering the effects of temperature, if the normal trend line delta t value and the overpressure of one point on a point of delta t values are the same, is to reflect both the pore structure is the same as the degree of compaction, two equivalent resistance, and the measured value of overpressure the depth of the equivalent normal trend line at some point is the equivalent depth (Figure 1)。

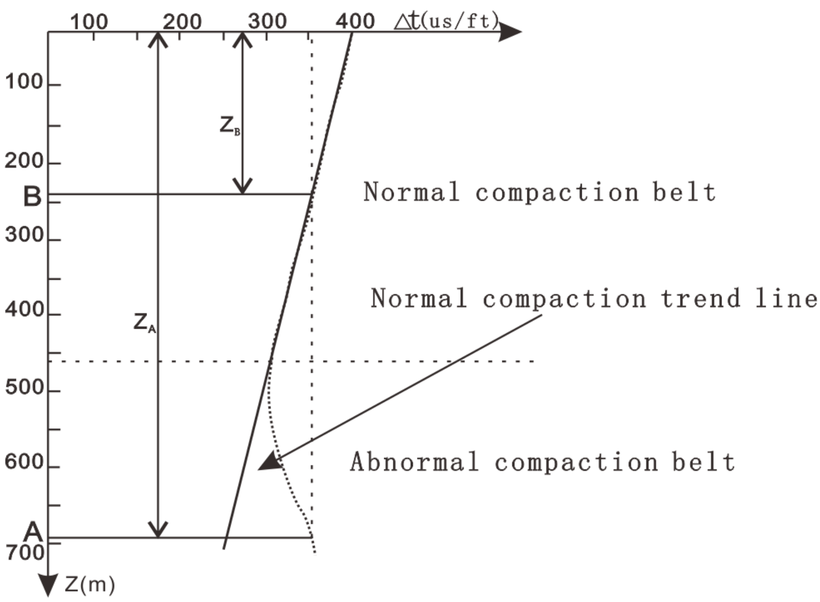

Fig. 1 Schematic diagram of compaction curve and equivalent depth

The △t value of point A and point B is same, The HB is the equivalent depth of HA。 Since point A、point B are equal effective, namely σA=σB, strata pore pressure Pe can be indicated by follow formula ：

$$P_e = P_e + (S_Z - S_e) = \rho_r gZ - (\rho_r - \rho_w)gZ_e (1.1)$$

If use the change of acoustic time said mudstone compaction law, there are ：

$$P_Z = \rho_r gZ + \frac{(\rho_r - \rho_w)g}{C} ln\frac{\Delta t}{\Delta t_0} \quad (1.2)$$

Type in :Z——Under compaction mudstone buried depth, m ;Z_e——Under compaction mudstone corresponding balance depth, m ; P_z——Under compaction mudstone of pore pressure and formation pressure, Pa ; P_e——Balance depth of hydrostatic pressure, Pa ; S_z——Static pressure of depth Z , Pa ; S_e——Balance depth of static pressure, Pa ; g——Acceleration of gravity, m/s ;ρ_r —— The average density of sedimentary rocks, kg/m; ρ_w —— Formation pore water density, kg/m ; Δt——Under compaction mudstone sonic time difference value, μs/m ; Δt_o——The surface acoustic time value, μs/m ; C——Normal compaction of mudstone compaction coefficient, m^{-1}。

Balance depth method is used to calculate according to the acoustic time difference data under compaction shale pore pressure of the specific steps are: (1) on the logging curve to read different buried depth of mudstone layer acoustic time value, make the curves of relationship between sonic move out and buried depth; (2) on the curves of relationship between sonic move out and buried depth to the normal compaction trend line, and the C value under the condition of normal compaction and delta values; (3) according toFormula (1.1) to calculate under-voltage pore pressure and abnormal pressure field layer。

2.2 Using logging data to estimate formation pressure

Assuming that overburden pressure for S, pore fluid pressure is P, the vertical stress is equal to the difference between the rock skeleton sigma [3]. That is:

$$\sigma = S - P \quad (2.1)$$

According to relevant data, the equations rock between porosity φ and the vertical stress of rock skeleton are as follows:

$$\emptyset = \emptyset_i e^{-k\sigma} \quad (2.2)$$

φfor mudstone porosity, φ_i for surface mudstone porosity, K is constant.

Take (1) into (2), and assume D is the depth of abnormal pressure, so porosity of D place is as follows:

$\emptyset_a = \emptyset_i eK(p - s)$ (2.3)

As we all know, the normal formation pressure of mudstone porosity index decreases with its buried depth increase.

$$\emptyset_n = \emptyset_i e^{-0.535D} \quad (2.4)$$

Type, : Φn for normally mudstone porosity of formation pressure.

According to (3) and (4) : $P_o = \frac{2.303}{K}\log\left(-\frac{\emptyset_a}{\emptyset_n}\right) + 0.465D$ (2.5)

Therefore, if we can calculate mudstone porosityφ_a in the depth D using logging data, we can determine the formation pressure.

2.3 Calculate formation pore pressure based on Eaton method

Eaton method is another kind of commonly used method to calculate formation pore pressure, it is a formation pressure model built according to the experience in the gulf of Mexico and well logging data [1]. The using premise of Eaton method is make the corresponding parameters of normal compaction trend line. The calculation equation is as follows:

$P_p = P_o - (P_o - P_w)(L/L')^x$(3.1)

Type: $P_o$is overlying strata pressure, MPa; $P_w$for hydrostatic column pressure, MPa; X is Eaton index; L、$L'$for the selected logging and drilling parameters, can for the acoustic time, resistivity, interval velocity, Dc index, etc., and meet the L/L'< 1. When the elected parameters increase with the depth, the L/L' indicates the ratio between measured parameter values and standard parameter values (normal parameters value corresponding to point depth), and vice versa. For example, when the selected parameter is resistivity, it increases with the depth.

2.4 Effective stress prediction of formation pore pressure based on the relation of velocity

Interval velocity is not only related to the formation pore pressure, but also related to other formation parameters, such as the lithology, porosity, etc. In this way, when the other influencing factors have not description or under the condition of appropriate assumptions, the results may produce larger errors. The errors include random errors and systematic errors, and the interval velocity is the average velocity between the two main reflect formation, the resolution is low, its will affect the accuracy of pressure prediction values and depth.

Calculation model of single point refers the corresponding relationship between interval velocity and formation pore pressure when calculating formation pore pressure using interval velocity, that is, a layer of speed points corresponding to a formation pore pressure, low speed has high calculate formation pore pressure, high speed has low calculate formation pore pressure, does not consider other factors, which affect the interval velocity and the logical relationship between the upper and lower strata. If the formation lithology is single and is given priority to with mudstone, then you can ignore the sandstone and other lithology sandwich. If the abnormal high pressure formation is given priority to with under compaction mechanism, single point algorithm has higher precision. Under the condition of this hypothesis, using the following model:

$$V_{int} = a + kP_e - be^{-dP_e} \qquad (4.1)$$

$$P_p = P_o - \alpha P_e + 9080665 \times \Delta C_p \times \frac{DEP}{1000} \qquad (4.2)$$

Type: V_{int} as seismic velocity,m/s ; a, k, b, das the empirical coefficient; P_o, P_e, P_p respectively for the overburden pressure, vertical effective stress and the formation pore pressure, MPa; α is Biot coefficient, generally take 0.15; ΔC_p for the formation pore pressure correction factor, generally take 0.35.

III. APPLICATION EXAMPLE

According to the basic principle of the equilibrium depth method, the calculation of the formation pressure of a single well is based to calculate the two parameters according to the normal compaction curve of the mudstone : The surface slowness values of delta Δt_0 and mudstone compaction correction coefficient C.

Take Qian 223well as an example to illustrate the process of calculating formation pressure by using acoustic time difference data.Figure 2 is the acoustic time difference curve of the Qian 223 well, from the figure can be seen above the depth of 1850m is the normal compaction section, so we can use above 1850 m formation mudstone sonic time difference curve fitting to calculate the surface mudstone sonic time difference value delta Δt_0 and mudstone compaction correction coefficient C.In normal compaction curve:

$$\Delta t = \Delta t_0 * e^{-CZ} \quad (5.1)$$

In figure 3, according to the formula (5.1) to fit properly compacted depth and acoustic time difference:

$$\Delta t = 552.68 * e^{0.0005z} \qquad (5.2)$$

So get Qian 223 well $\Delta t_0$is 552.68 mu s/m, C is 0.0005(Fic.3).

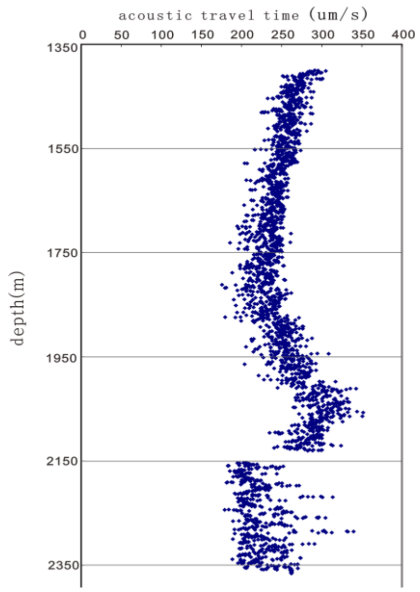

Figure 2 Qian 223 well mudstone sonic moveout and depth diagram

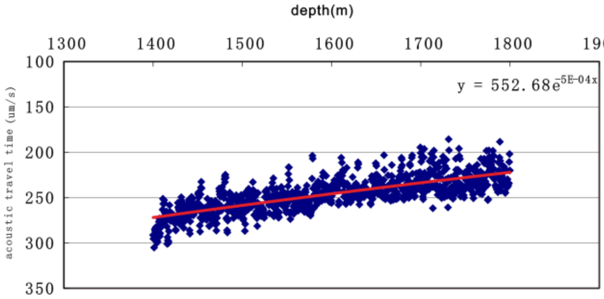

Figure 3 the mudstone sonic time difference curve fitting

We superimposedthe Qian 223 wells mudstone normal compaction trend line to acoustic time difference map, and can be seen on the graph (figure 4)the acoustic travel time of the well above 1850m was coincident with the normal mudstone compaction trend line, it shows that this part was normal compaction.At 1850m below the time difference of the sound wave was obviously deviated from the normal compaction trend line, it shows that the formation porosity was more than the normal compacted porosity, which belongs to the uncompaction layer.

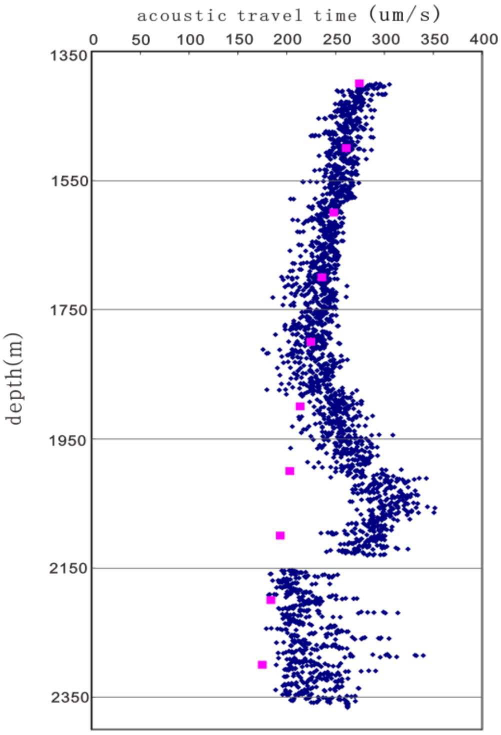

Figure 4. Relationship between acoustic travel time and normal compaction trend of Qian 223 well

For $\Delta t_0$and C, using a formula (1.2) to calculate the P_z, at last according to thepressure coefficient=P_z*100/ depth, the pressure coefficient of the super pressure can be obtained.
Thus, the peak value of abnormal pressure in the Qian 223 well is 14Mpa, depth is 2064.75 m,and its pressure coefficient is 1.6.

IV. CONCLUSION

There are many factors that can cause abnormal formation pressure, under normal circumstances, the abnormal formation pressure is not the result of single factor effect.Above all kinds of methods can be seen, that compared with the pre drilling seismic data to predict the formation pore pressure, and the method of monitoring formation pore pressure during drilling construction, logging data reflect stratigraphic information more detailed, and less affected by human factors and environmental factors, high precision,can accurately predict the formation pore pressure, continuous change with well depth can get continuous formation pore pressure profile.Based on the “Argillaceous sediments caused by unbalanced compaction formation under compaction and generate abnormal pressure” principle, using well logging data to predict the formation pore pressure also has its disadvantages, it is not applicable to other non-mudstone strata, because do not have access to more complex formation of continuous formation pore pressure longitudinal section; it is not applicable to abnormal formation pressure caused by other forming mechanisms except for the unbalanced compaction.

REFERENCES

[1] How to use well logging interval transit time curve to compute formation pressure. Wang yadong. Mud LoggingEngineering, 2005, 16(4): 59～61.

[2] Study on Logging Seismic Constraint Inversion to Predict StrataPressure in Mining Block. Zhang kai, Zou guangui. Coal Engineering, 2013, 12(5).

[3] Discussions on the traditional pore pressure evaluation methods by using well logging. Fan honghai. Petroleum Exploration and Development. 2003, 30(4):72~74.

[4] Difference of formation and evolution of overpressure of K1qn1 mudstone east and west of Daqing placanticline. Fu guang. 2008,32(5):1~4.