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Pressure prediction methodologies in South Caspian Basin (Bulla field)

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Abstract

The regularities of distribution of pressure values in the southern basin of the Caspian Sea water area were investigated, and the possible calculation methodology of Overburden pressure, pore and hydraulic fracturing pressures was optimized. Pressure values were obtained by several methods. The calculated pressure results were compared and the differences were investigated.

Keywords: *Pressure prediction, pressure profile, wellbore stability, hydraulic,* analogical, petrophisical, basin modelling, extrapolation etc.
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Introduction

Genearally Bulla field is very comlpicated place for drilling operation in a world. Therefore we use several method for pressure prediction. In general practice, there are several methods of predicting pressure values, which are used in different situations.

1.Analogical method

2.Petrophisical method

3.Basin modelling method

In areas wich is tehere are rich logging data, in this condition petrophysical method is more convinient, in cases of where well test and drilled well data are rich, a similar method is used. Since the basin model of the South Caspian water area requires relatively deeper research, the article will only talk about analogical and petrophysical methods.

Petrophisical metod

Overburden pressure prediction's methodologies

Overburden stress, or vertical stress (lithostatic stress), is caused by the weight of the overlying formations. If the overlying formations have an average density of a, then overburden stress (Sv) can be calculated by:

$$S_v = \int_0^z \rho \, gzDz \qquad (1)$$

Sv – overburden stress [Pa],

ρ – density [kg/m^3],

g – gravitational acceleration constant [m/s^2],

z – depth [m].

Overburden pressure values is input parameters in formation pressure calculation, after this operation pore pressure can be calculate. Sv and Pore pressure are input parameters for formation hydraulic fracturing pressure calculation, the calculation of pressure values starts with overburden(lithostatic) pressure calculation first. Overburden pressure is calculated using geophysical measurement results of density or sonic, seismic velocity etc. Initially, the methods of calculating overburden pressure by petrophysical method are given below.

Extrapolation Method: Density is extrapolated up to mud line using the following geometric fit.

Amoco: The average bulk density below the sea floor is estimated by an empirical equation obtained from statistical data from the Gulf of Mexico.

Gardner: Bulk density is modeled from sonic log and seismic data is required.

Miller: Miller density is calculated from porosity.

Wendt non-acoustic: The synthetic density is calculated with acoustic slowness and formation temperature.

Traugott: This is an empirical model of decreasing porosity with depth originally developed by David Scott and Martin Traugott (Amoco, 1988), from an exponential fit of Gulf Coast Miocene sediment density data compiled by Classen, 1966.

Average Density Input: In this mode, you can create a density curve which has a constant value along depth.

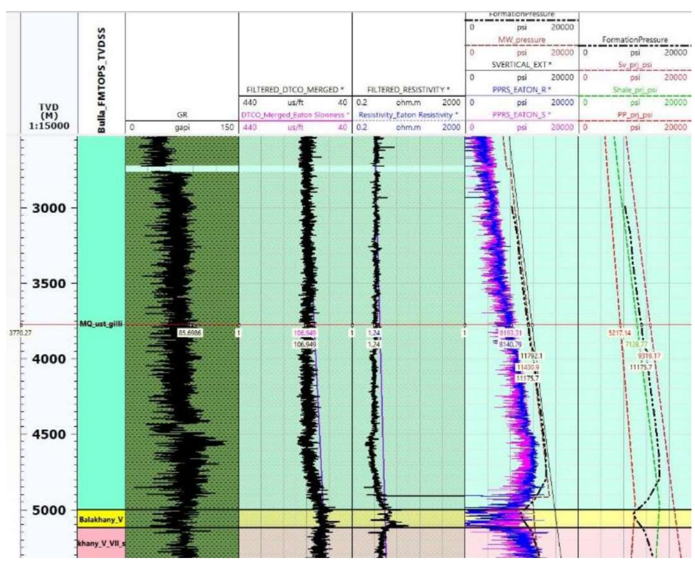

Figure 1. Comparison between different pressure prediction methodologies in Bulla field.

There is no any information about seismic velocity, connectivity, tectonic complication such a fault and fold, OWC, OGC contacts, oil and gas migration path etc. Due to limited information about field based on well tops data 3D structural model and map view was made, correlation with offset wells carried out (based on GR, RT data), PPFG plot was prepared each plan wells etc.

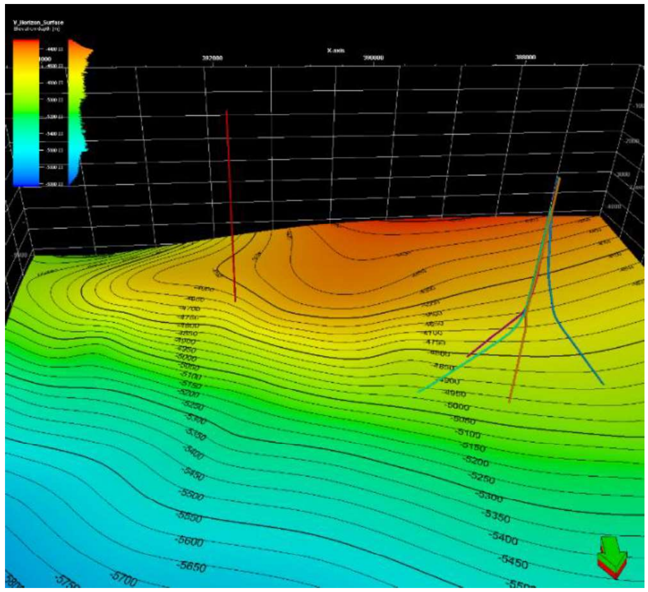

Figure 2. 3D Structural model of Bulla field.

1. Pore pressure prediction's methodologies

Pore pressure is the pressure of the fluids contained within the pore space of a rock in the reservoir, commonly expressed as the density of fluid. In the absence of any other processes (compression, compaction), the pore pressure is simply equal to the weight of the overlying fluid, in the same way that the total vertical stress is equal to the weight of the overlying fluid and rock. This pressure is often referred to as the hydrostatic pressure. The normal hydrostatic pressure gradient for freshwater is 0.433 psi/ft (1.42 psi/m) and 0.465 psi/ft (1.52 psi/m) for water with 100,000 ppm total dissolved solids

Most pore pressure methods are based on effective stress approach ruled out by Terzaghi's law. The differences are in the way those stresses are derived from logs. The effective stress principle states that all measurable effects of a change in stress such as compaction and variation in elastic wave velocities are functions only of the effective stress.

Eaton Slowness: calculates PP from compressional slowness

$$PP=S_v-(S_v-PP_n)(\Delta t/ \Delta t_{ng})^n \qquad \text{Eaton sonic method} \qquad (2)$$

Eaton Resistivity: calculates PP from Resistivity log

$$PP=S_v-(S_v-PP_n)(R/R_{ng})^n \qquad \text{Eaton RT method} \qquad (3)$$

Eaton D-Exponent: calculates PP from drilling exponent curve

Bowers Original: calculates PP from compressional slowness or velocity based on Bowers method original formula

Bowers: calculates PP with compressional slowness or velocity based on Bowers method

Traugott resistivity: calculates PP from Traugott resistivity trendline based on Eaton method

Traugott slowness: calculates PP with compressional slowness or velocity based on Traugott method

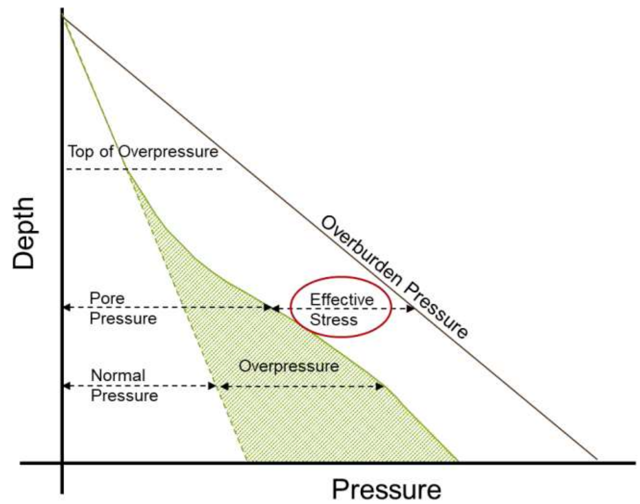

Figure 3. General veiw of Sv, effective stress and pore pressure

Methods for petrophysical estimation of PP:

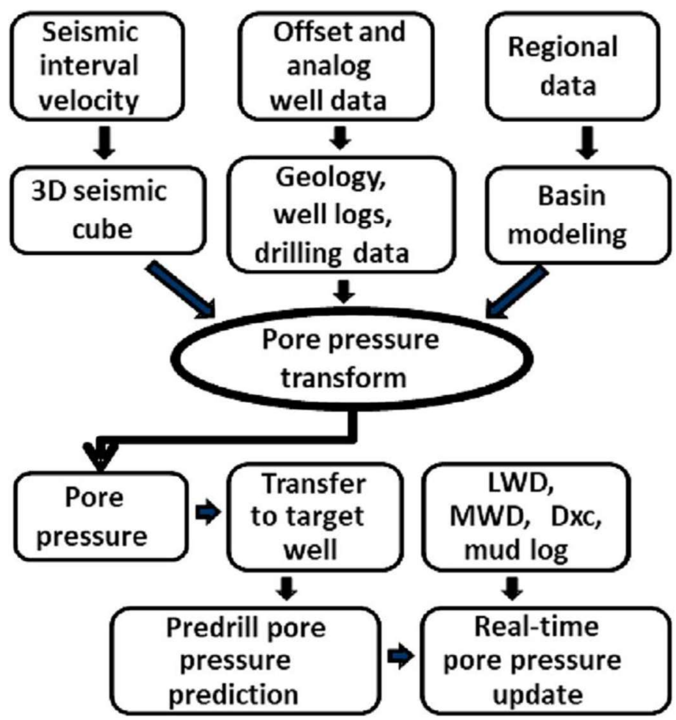

Figure 4. Schematic workflow for pore pressure analyses (Applied petroleum geomechanics J.J. Zhang).

2. Analogical method

Where use transpose method one wich is called structural adjustment and transpose method two that's is gradient method. This methods are very useable for pressure prediction. If we have a offset wells data such a (MDT, XPT), drilling data (such as ROP, WOB, RPM, flow rate etc), registered drilling events (gain, gas kick, tight hole, overpull and other WBS events), properties of drill cuttings from samples collected at the shale shaker, caving data (splintery, tabular, angular etc), measure gas levels from well, estimate a lithological column while drilling etc pressure value can be predictable. First and foremost structural adjustment have to carried out, after this procedure pressure adjustment calculatable. Via this way pressure prediction is prepared. This version is about pore pressure prediction method. Formation fracture pressure predcitions also calculatable via this way. If has a drilling events (loss), well test data (FIT, LOT, XLOT) ets min SFG can be take to equal ECD data on the loss point and after with backcalculation method k nod and Poisson ratio can be calculate. Poisson ratio and k nod are geological parameter and this parametrs are spesifhic parametr to formation. As a result if it has a drilling events or formations tesyt data of each formation, fracture pressure value can be calculate.

3. Fracture pressure prediction methodologies

Fracture pressure is very crucial parameter for drilling operation. FG calculation method has been noticed below. Calculating fracture pressure on the basis of offset well data is a widespread method, events (total loss, seepage) in offset wells, welltest results, are used for application of this method. For understanding Shmin, SFG expressions firstly must be aware of rock preporties and rock mechanics. Based on the general Hooke's law and assuming uniaxial strain, which means we set $\varepsilon_x=\varepsilon_y=0$ in Hooke's law we get a simple relationship based on Poisson's ratio, but often referred to as k-nod, k_o, or the earth coefficient at rest. Using the k_o from laboratory tests in the shallow sections gives often good results, but with depth the relationship tends to deviate from the measure values.This is often explained with temperature, tectonics and diagnetic processes in the rocks, this is often presented in form as a tectonic component in addition to the k_o value.

$$k_o=\frac{\sigma h}{\sigma v}=\frac{\nu}{1-\nu} \quad (4)$$

σ_h – Horizontal stress

σ_v – Vertical stress

ν – Poisson ratio

$$\sigma_e = Sv-\alpha x PP \quad (5)$$

σ_e – Effective stress

α – Biot coffisient

$$\alpha=1-\frac{Kdry}{Kmatrix} \quad (6)$$

$$S_h=PP+k_0(Sv-PP)+S_{tectonics} \quad (7)$$

Although there are no any UCS, TCS, TCTR core data we can calculate fracture pressure from loss points and bad FIT experience via above formula. Pressure prediction has been made in Bulla field for arbitrary well via transpose method one (structural adjusment). PP line has been selected from MDT points, wbs and gain events have been taken for absence MDT points. While SFG line calculation loss points and bad FIT results have been selected. In order to calculate the formation pressure at the points that do not have an actual value and are important to calculate, at two consecutive depths, the gradient of the remaining pressure value between the actual pressure values was calculated and extrapolated by depth.

S_h- Horizontal stress

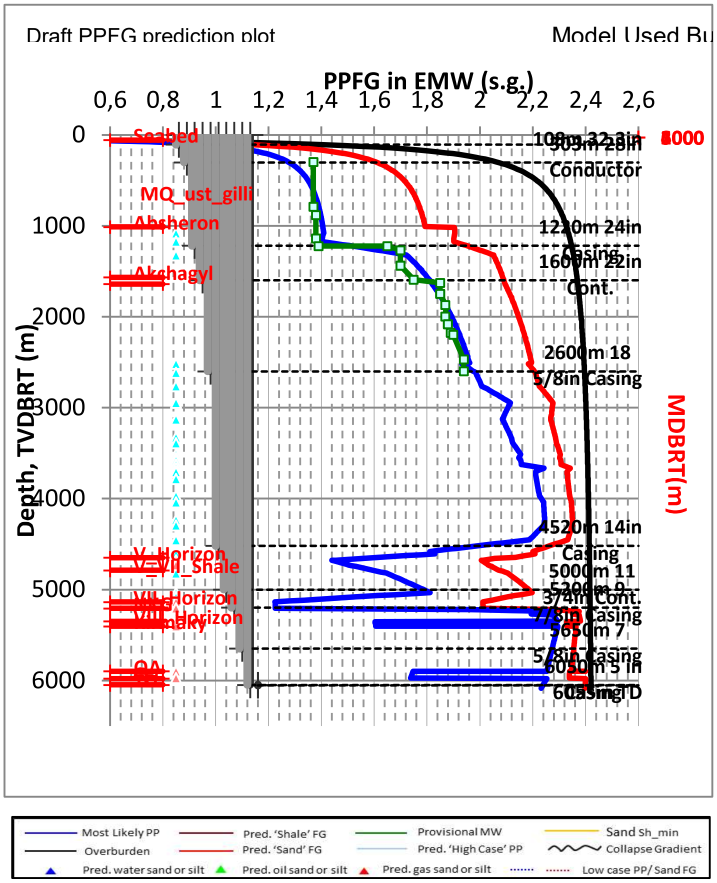

Figure 5. Pressure prediction overview by Saleh Orujov (Analoghical method)

Conflict of Interest

The authors declare that they have no conflict of interest in relation to this research.

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