Calculation Pore Pressure Utilized Two Methods / Case Study of Zubair Oil Field.

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Abstract: Pore or formation pressure calculation is crucial to petroleum industry. There is currently no widely accepted approach for pore pressure estimation in carbonate reservoirs, and the results are still far from satisfactory. In this study, discussion two approaches called Eaton Slowness and Bowers Original method utilizing in prediction pore pressure. The concerned data (logs, calibration data, drilling, and mud report) and these data were utilized in Techlog 2015 software.
Pore pressure in the Tanuma formation is around 4650 psi according to the Eaton data, compared to 3100 psi for the Bowers technique. Eaton's hypothetical mud weight at a certain depth was greater than the actual mud weight, however bowers' results showed that it was lower than the actual mud utilized for this well. When the results of two methods compared against mud weight and the pressure tests are both yield agreeable.
Even with improved knowledge, the characteristics for reservoir formations may be was the impact of porous systems on velocities and numerous correlation aspects are still poorly understood. The Bowers method of pore pressure computation is substantially more accurate than the Eaton method.

Key word: Pore pressure, Bowers method, Eaton method, Zubair oil field.

1.Introduction

The fluid inside the pore spaces or the porous media called pore pressure, [(Aadnoy and Looyeh, 2011), (Sayers, 2006)]. Petroleum industry at many levels (exploration, drilling, and production) depends heavily on accurate formation Pressure prediction. In the drilling plans, as well as in the geomechanical and geological investigations, pore pressure is an important factor, [(Zoback.,2007); (Dutta.,2022)]. Carbonate formations contain over 60% of a total world oil reserves. However, the considerable variety that carbonate rocks exhibit at various scales causes significant uncertainty in PP estimation and presents difficulties for oil and gas exploration.

Normal pore pressure is one of two types of pore pressure (hydro-pressure) A typical pore pressure is around 0.465 psi/ft, which is equivalent to the hydrostatic pressure of a whole column of formation. The second type of pp is abnormal pore pressure (geo-pressure). This is present in areas without direct fluid movement to nearby areas. Such zones have impermeable borders, which prohibit the fluid from moving and trap it, causing it to absorb a significant amount of the overburden stress. Pore pressure during abnormal development is between 0.8 and 1 psi/ft, (Aadnoy and Looyeh, 2011). The primary process and source of abnormal PP in clastic sedimentary rocks is disequilibrium compaction, (Chen and Guan, 2000). Rocks compacted differently produce varied densities and porosities, these variations may be seen in the logs of velocity (or transit time), and other properties. The calculation of abnormal formation pressure is based on these differences, (Chopra and Huffman, 2006).

In general, pore pressure calculation is based on log density and sonic wave log data also. We will concentrate on the Eaton Slowness Method and Bowers Original Method in this study for section 12.25“of the Zubair oil field.

1.1. Area of Study

Zubair oil field was discovered in 1949 and construction began in 1951 which was one of Iraq's biggest oil fields. This field located approximately 20 kilometers southwest of Basra, as depicted in Figure.1. The dense sequence of Cretaceous carbonates that make up the geological column of the Zubair oilfield, which is rich in

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numerous and significant hydrocarbon accumulations, are depicted in Figure 1. The Zubair and Mishrif formations are the main hydrocarbon-prone and oil-producing reservoirs in the Iraqi field, (Deng et al., 2018).

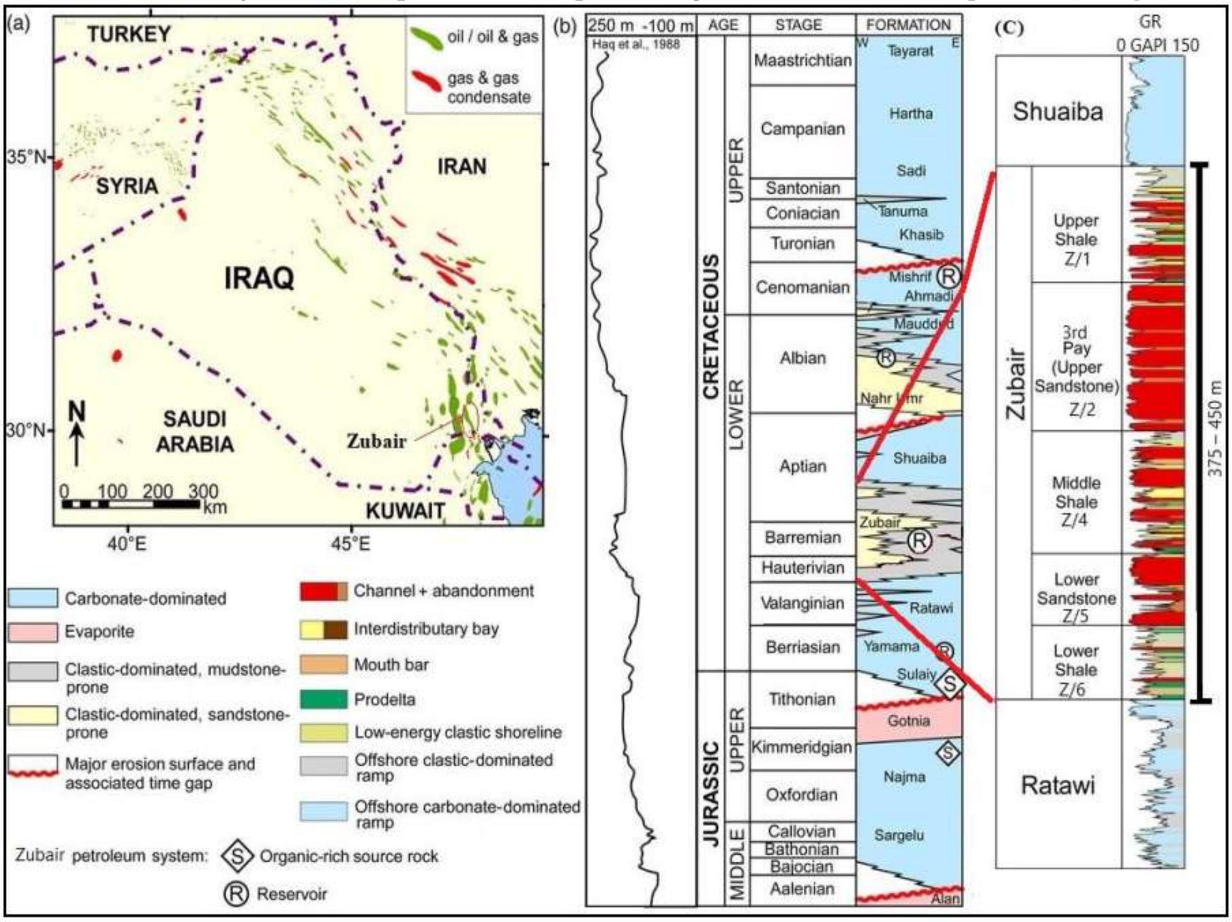

Figure 1. Geological column and map location, (Al-Jafar and Al-Jaberi, 2019).

2. Methodology

The variety of necessary data is the most frequent problem. The Zubair oil field's ZA-2 production well, which has two domes, was used to collect data (Shuaiba and Al-Hamar). Section 12.25" was taken into consideration in the drilled wells because of drilling challenges like drilling mud loss and wellbore instability, which is penetrated six layers (Sadi, Tanuma, Khasib, Mishrif, Rumulla, and Ahmadi).

In carbonate reservoirs, there are still no commonly used approaches for predicting formation pressure. Nearly all of the current theories and methodologies are based on shale characteristics. There are different kinds of pore pressure prediction techniques. The direct calculation approach comes first. Those types of cross-plots and overlay are the most basic and traditional ways of representing physical quantities in pore pressure, (Pennebaker, 1968) and (Fillippone, 1982).

Effective stress law of Terzaghi and Biot supports the basic other theory for predicting formation pressure, (Terzaghi, 1943). According to this theory, pore pressure in the formation is determined by total stress (or overburden stress) and effective stress as show in Fig.2 below, (Zhang, 2011).

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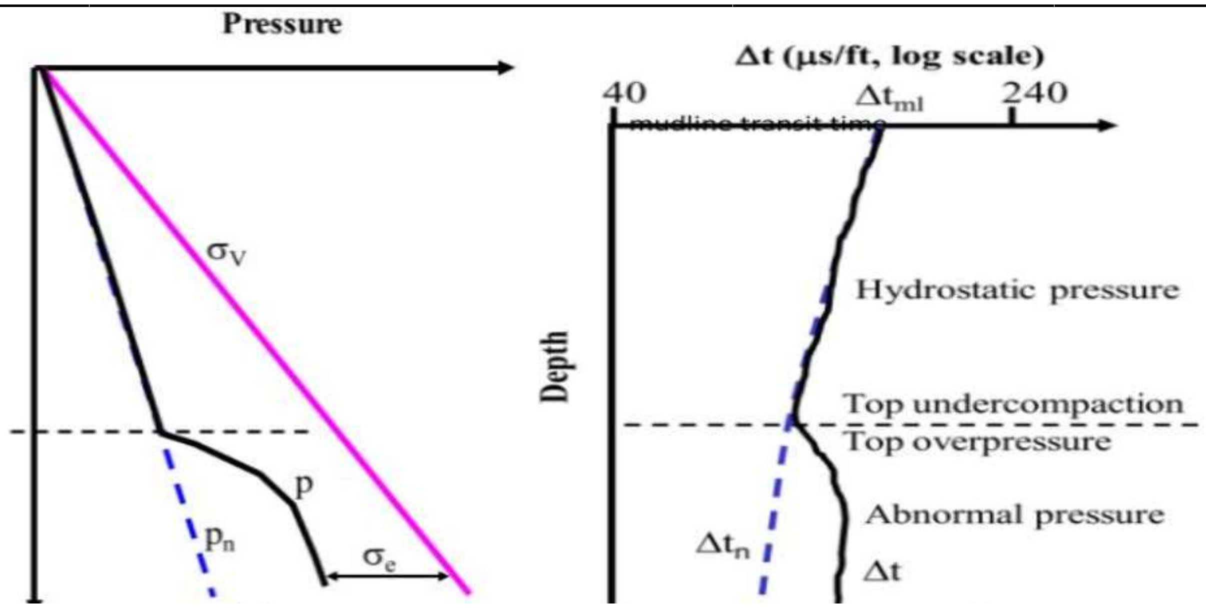

Figure 2. Formation pressure estimation diagram depend on effective and total stress, (Schlumberger, 2015).

2.1 Indirect Method

The two approaches that are most frequently used for calculating pore pressure from acoustic log data are the Eaton slowness approach and Bowers' original method. Eaton Slowness approach was the first method created in 1975 to detect pore pressure, initially using logs of resistivity data. Later, it was improved to identify the number of pores under pressure using sonic logs data as show in Eq.1, (Eaton, B.A., 1975).

$$\frac{p}{D} = \frac{\sigma v}{D} - \left[\frac{\sigma v}{D} - \left({}^{P}/_{D}\right)_n\right]((\Delta\, tn)/(\Delta\, to))^3 \qquad (1)$$

P/D is formation pressure gradient , σv /D gradient of vertical stress, normal or hydrostatic gradient, $\Delta\, tn$ compressional slowness time in shales at normal pressure and $\Delta\, to$ compressional slowness time from the sonic log.

In 1995, Glenn L. Bowers created a brand-new technique for calculating the pressure inside formation generated by liquid expanding and compression processes. Contrary to other methods, fluid expansion can enhance pore pressure more quickly than overburden stress, but under compaction cannot reduce effective stress. This technique shows how to determine effective stress from sonic velocity data as show in Eq.2 and predict pore pressure from these measurements, (Bowers, 1995).

$$v = 5000 + A\sigma_e^B \qquad (2)$$

Where v is velocity (ft./s) from sonic log data, A and B are fitting parameters while σ is effective stress (psi). Pore pressure can calculation depend on effective stress and vertical stress using Eq.3 below, (Terzaghi, 1943).

$$\sigma_e = \sigma_V - \propto .\mathrm{Pp} \qquad (3)$$

Where σe is effective stress (psi), Pp is the pressure inside formation in (psi), α effective stress parameter and σv is vertical stress in psi unit. Either empirical regional relations, (Traugott, 1997) or may be utilized the density logging data, provided by the formula in Eq. 4 below can be used to estimate the overburden pressure in a satisfactory way, (Dutta, 2002; Chen and Guan, 2000).

$$\sigma_V = \int_0^z \rho\,(z)\; g\; dz \qquad (4)$$

3. Outcome and Discussion

In the results of the Eaton method shown in Fig. 3 below, the second track referred to formation in this section, the third track, termed "shale-flag," was a calculation of the volume of shale that was then used as an input value for a calculation of the pore pressure, and the fourth track, labeled "compressional slowness logs," was sonic logs data used. As you can see, at some depth the mud weight in red color was higher than the actual mud. This is illogical given the claim in the final drilling reports for this well that there is no kick or blow out in the well, which is factually incorrect. The fifth track in black was the real mud weight utilized in this well,

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and red color was the mud weight calculation by this method. This method predicts the pore pressure in the Tanuma formation to be about 4650 psi while the hydrostatic pressure is about 3033 psi, which may not be accurate. The sixth track contained vertical stress, hydrostatic pressure, pore pressure prediction, and repeat formation testing.

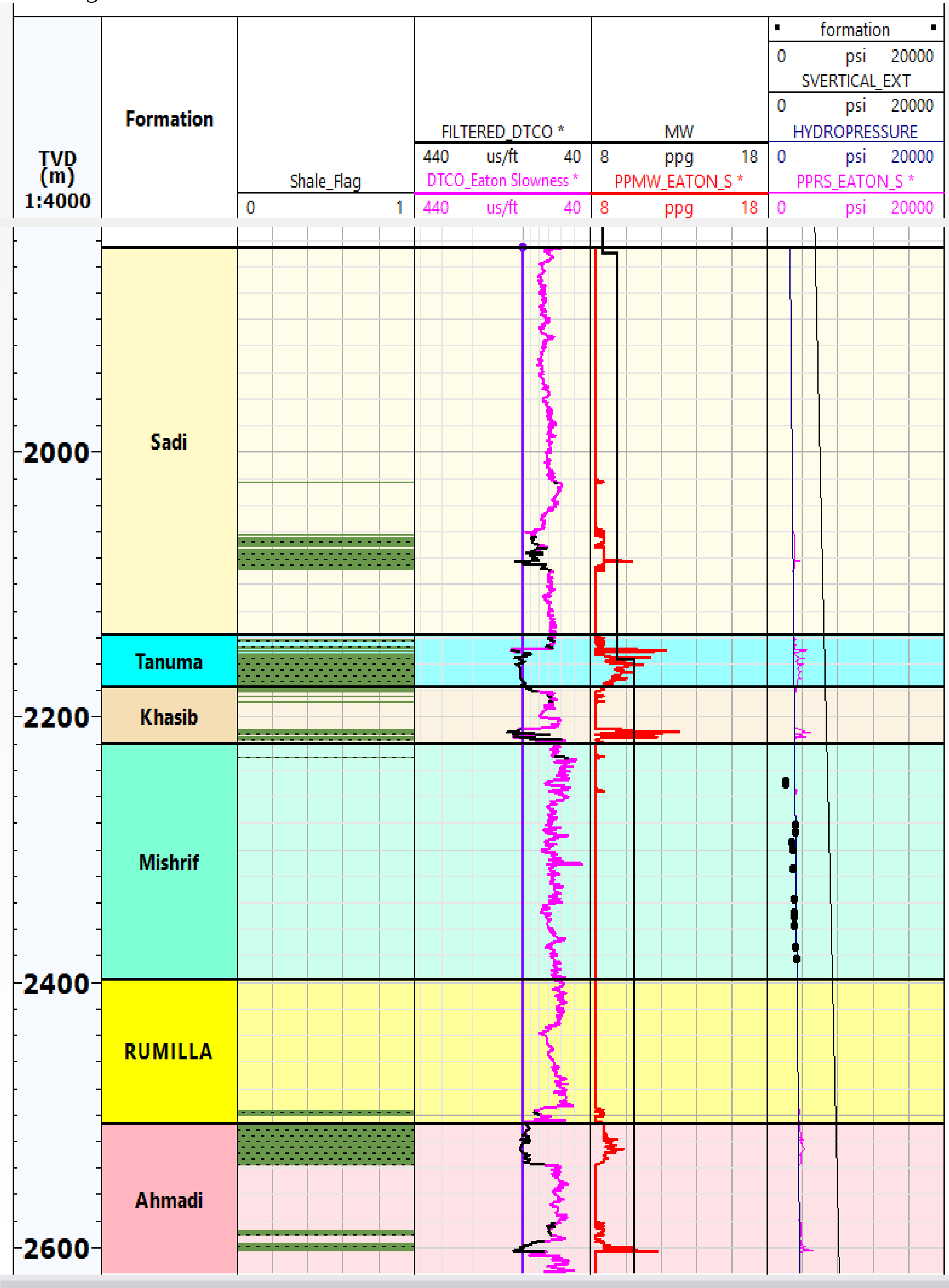

Figure 3. Formation pressure calculation using Eaton method.

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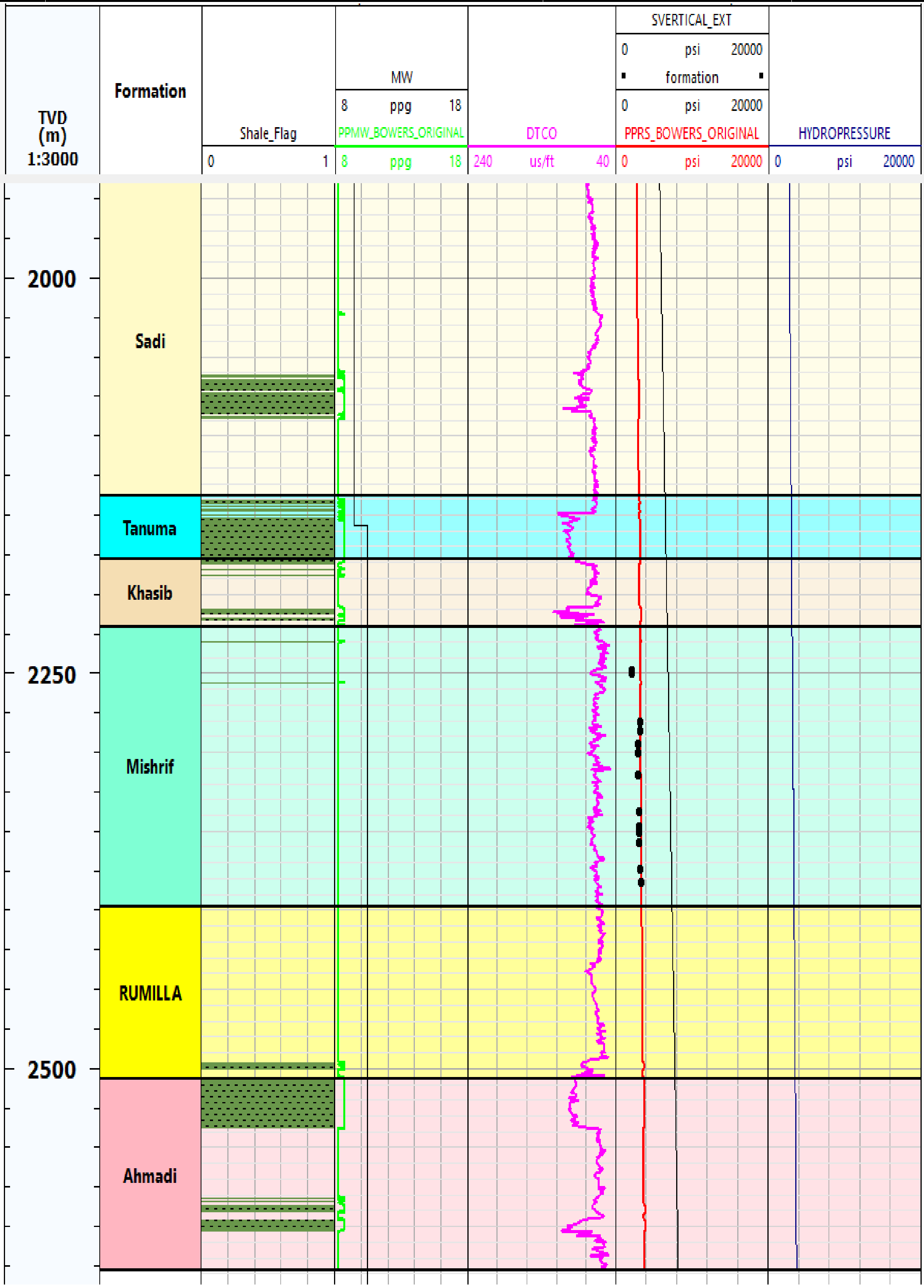

Figure 4. Pore pressure using Bowers method.

It is possible to say that the Bowers technique findings displayed in Fig. 4 above are accurate because the fourth track PPMW-BOWERS-ORIGINAL mud computed by this approach in green color is shown to be less than the real mud used for this well in black color. The sixth track had pore pressure in red, which was well matched with the results of the black circle repeat formation test. This approach yielded a pore pressure measurement in Tanuma of about 3100 psi, which is close to hydrostatic.

4.Conclusion

- The pore pressure forecast for the carbonate reservoir is not yet fully resolved at this time. One of the solutions to this problem is a more effective rock physics model, although scientific research is moving slowly in this direction.
- Contrast between real mud weight and the outcomes of repeat formation tests, both of these two approaches produce satisfactory outcomes.
- Forecast outcome of the Bowers' approach is considerably better than the Eaton's method.
- The impact of porous system on velocities and the various correlation features are still far from good understood in terms of the physical characteristics of carbonate rocks in prediction pore pressure.

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