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Estimation of Internal Friction Angle for The Third Section in Zubair Oil Field: A Comparison Study

Ali Khaleel Faraj [1,] Hassan Abdul Hadi Abdul Hussein[2] and Ali Nahi Abed Al-Hasnawi[3]*

[1]Petroleum Technology Department, University of Technology-Iraq, Baghdad-Iraq
[2]Petroleum Department, College of Engineering, University of Baghdad, Iraq
[3]Drilling Branch, Petroleum Engineer, Islamic Azad University, Tehran - Iran

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Corresponding Author:
Ali Khaleel Faraj
150103@uotechnology.edu.iq

Abstract

The One important rock mechanical property in geomechanical investigations is internal friction angle. In order to predict wellbore failure and construct a geomechanical earth model, friction angle is essential. It is usual to estimate the internal friction angle using core tests, but this approach requires more cores and is expensive. Instead, several empirical correlations were found to estimate the internal friction angle from logs data. The goal of this study was to determine the most accurate approach for estimating internal friction angle from log data and to demonstrate how clay volume and porosity influenced this estimate.This property is estimated using three different correlations built within Techlog 2015 software depend on neutron, density, and gamma ray logs data. The findings demonstrate that Weingarten and Perkins Weal correlation is used, especially when water production is actually occurring. The gamma ray technique does not accurately match the core data since it only employs the gamma ray log. With effective porosity and clay volume used as input data for the Plumb Clay Volume and Porosity correlation, the findings demonstrate an excellent match with the core data. The frictional angle exhibits minimal values in the Tanuma formation and at various depths as a result of a decrease in effective porosity and an increase in shale volume. The results showed that for determining frictional angle, the Plumb correlation approach was the most accurate.

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1. Introduction

In geomechanics analyses, which consider a rock's reaction to environmental stresses brought on by human activity utilizing solid mechanics and geology ideas, internal friction angle is one of the important rock mechanical features, [1]. Analysis of rock deformation issues encountered in the oil industry requires the estimation of rock strength parameters using geophysical measurements, [2,3,4,]. Identification of the composition and component elements controlling rock failure is required for the computation of rock mechanical strength properties, [5,6].

Internal friction angle is one of rock mechanical strength properties refers to soil quality and rock hardness, [7]. This angle is a key factor in calculating rock failure, is defined as the rock's resistance to shear failure. The angle of friction is generally depicted on the Mohr-coulomb criteria plot as the angle of inclination with respect to the normal stress, [8,9,10]. The mechanical characteristics of rocks are influenced by both internal and external influences. Confining pressure, strain rate, and external temperature are the three most significant external factors, [11,12,13]. Porosity, particle size, mineralogy, and the kind of cement are crucial internal factors, [14,15,16]. Internal factors and rock failure in relationship to each other since previous research did not take into consideration the impacts of both clay and porosity, rocks have poor physical characteristics. For instance, research without clay demonstrates the link between porosity and the mechanical characteristics of rocks, [17,18,19].

For the Zubair oil field, Techlog 2015 software may be used to calculate internal friction angle using several methods. Zubair is one of Iraq's largest oil fields. This field, which may be shown in Fig. (1) below, is about 20 kilometers southwest of Basra. It was discovered in 1949, and construction work started in 1951. According to the tectonic zones of Iraq, the Zubair oilfield, which is a portion of the quasiplatform foreland of the Arabian plate, is located in the sagging pelvis of the Mesopotamian zone, [20]. The geological column in this field and the segment that is important to our investigation are shown in Fig. (2). This study objective was to identify the best method for predicting internal friction angle based on log data and show how porosity and clay volume affected this estimate.

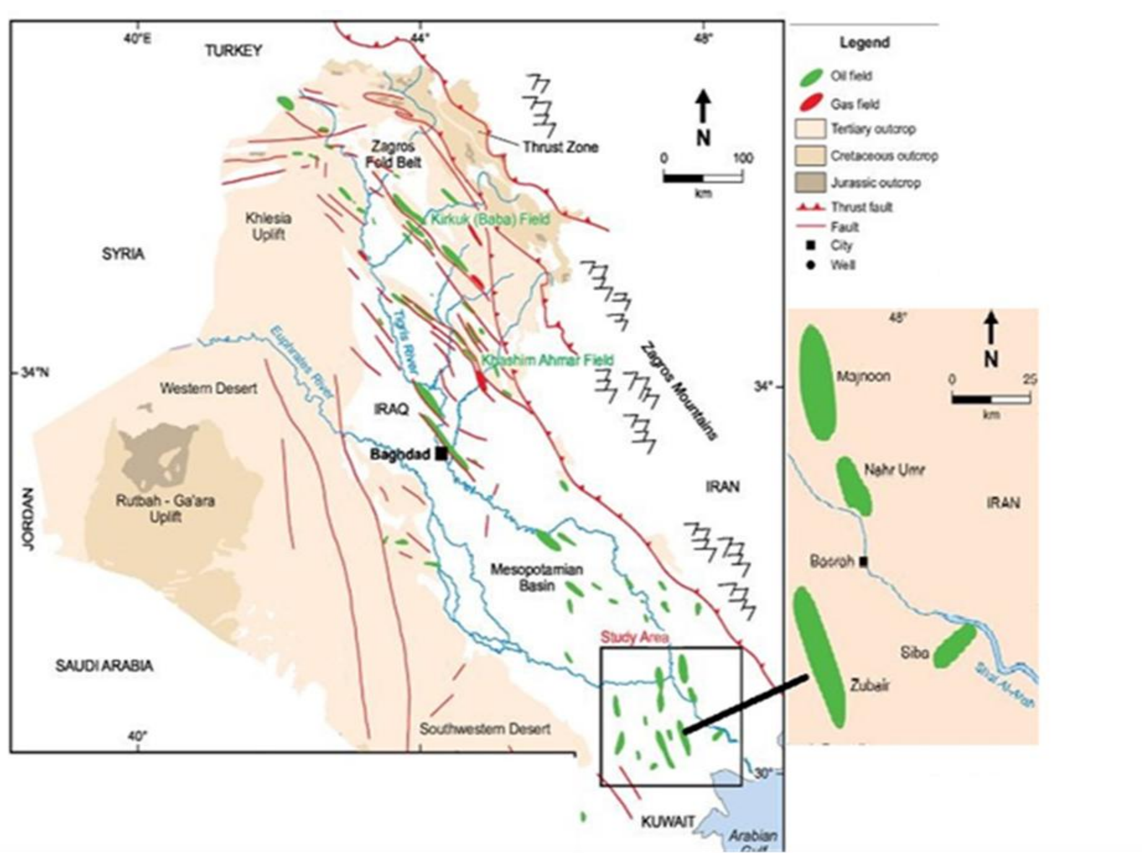

Figure 1: Zubair oil field location [21].

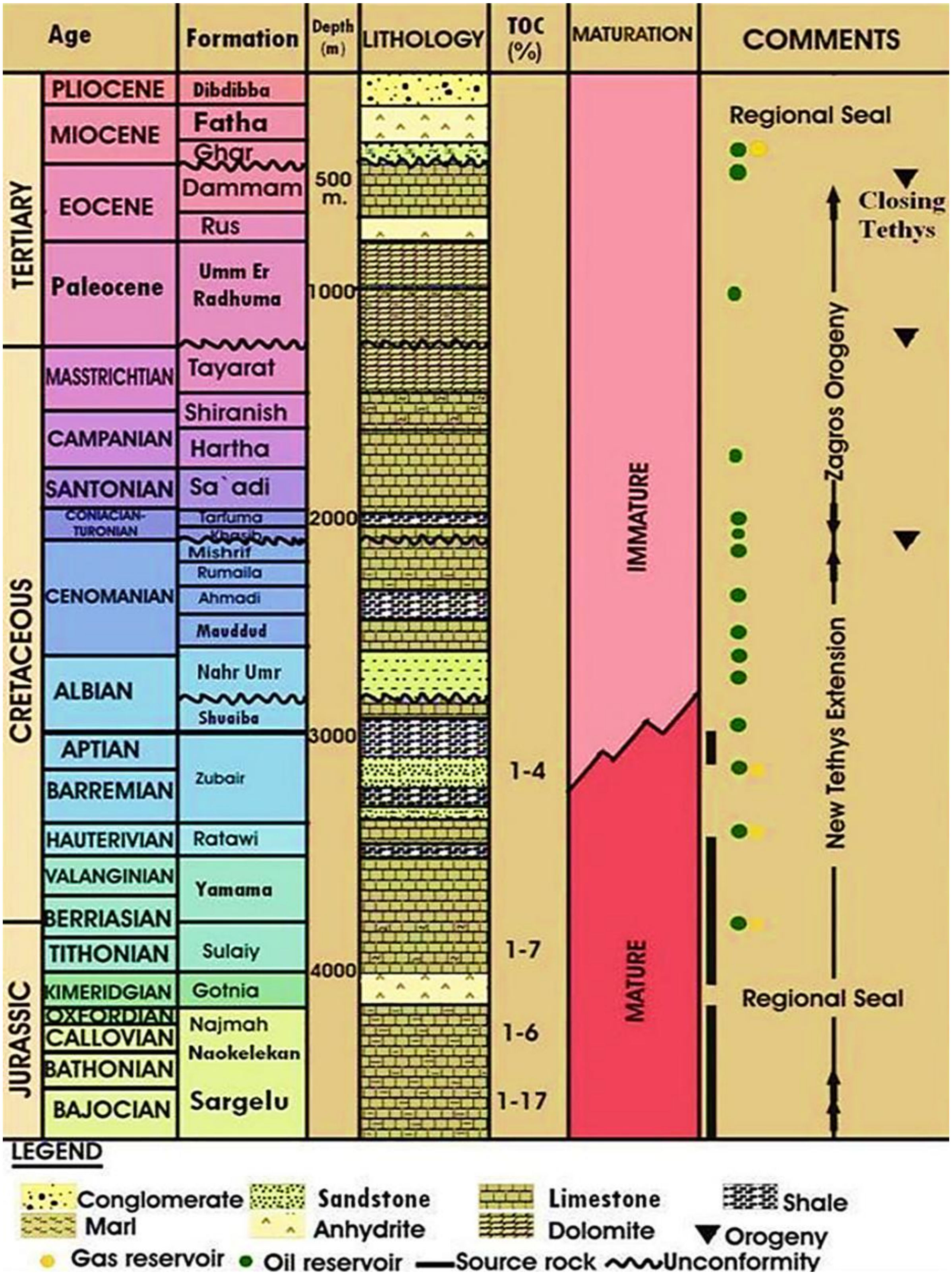

Figure 2: Zubair oil field's geological column, [22].

2. Methodology

Due to the high cost and length of time for estimating this data, the variability of required data was the most common issue encountered while estimating the internal friction angle. Data were gathered from the ZA-2 well, which has two domes, in the Zubair oil field (Shuaiba and Al-Hamar). The drilled well, which pierced six levels, took Section 12.25 into account (Sadi, Tanuma, Khasib, Mishrif, Rumulla, and Ahmadi). As illustrated in Fig. (3) below, the data were gathered through logs such as the gamma-ray, density, and Neutron log. While the three correlations listed below were utilized to estimate the internal friction angle from the log data, friction angle may be computed directly from core laboratory tests.

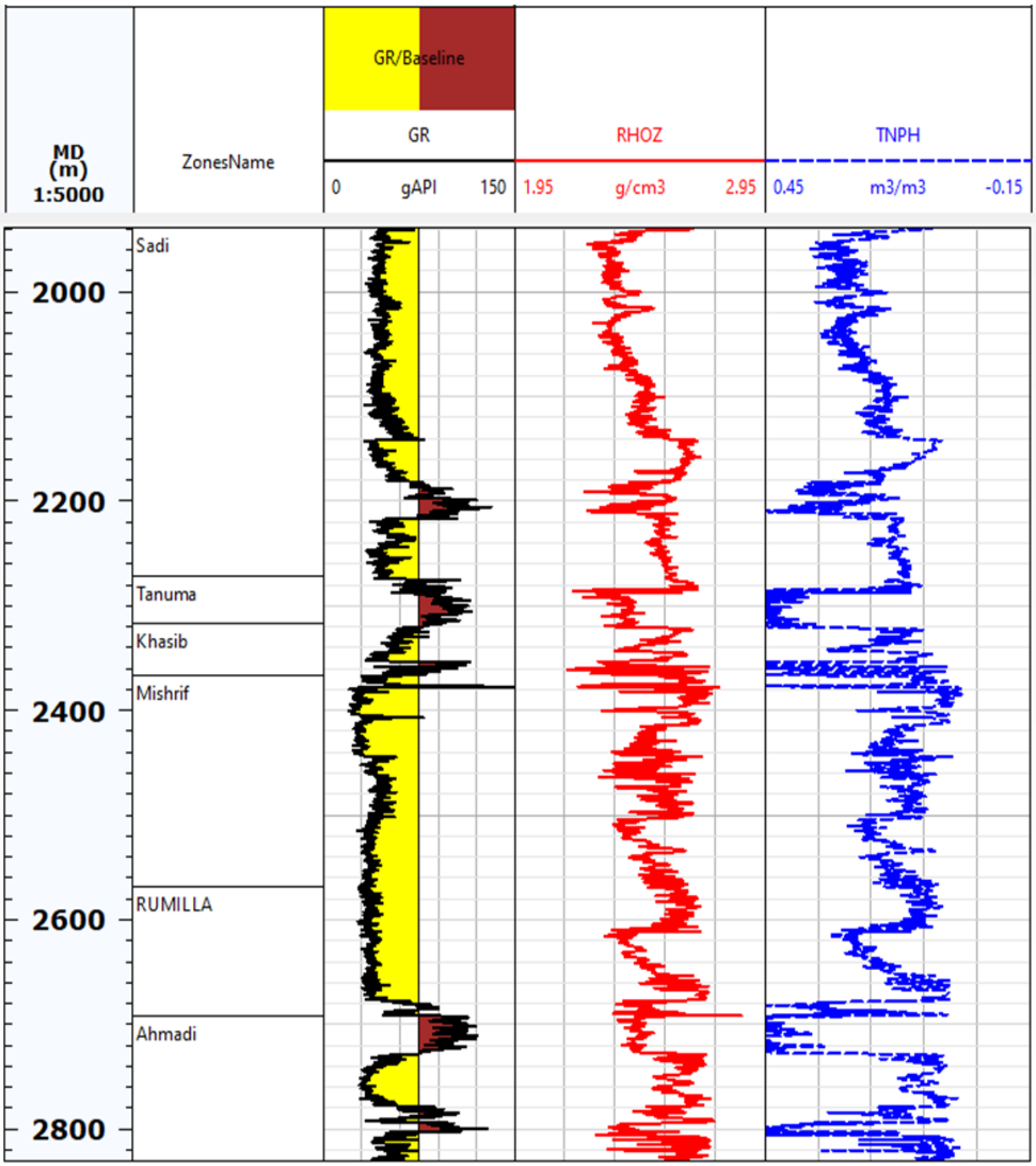

Figure 3: Data using for this study from well ZA-2 in Zubair oil field.

2.1. Weingarten and Perkins Weal Sand Porosity Correlation

This method, developed in 1995 to estimate the production of sand in gas wells, proved that frictional angle could be computed from total porosity log data. Total Porosity and the frictional angle had the opposite relationships, [23].

$$\phi = 57.8 - 1.05\theta \qquad (1)$$

Where ϕ is frictional angle and Θ is the total porosity.

2.2. Gamma ray log

With a linear connection, this approach translates Gamma Ray to Friction Angle. A cutoff is applied, GR 120 gAPI is translated to FANG 20 dega with default settings, while GR 40 gAPI is translated to FANG 35 dega, [24].

$$\phi = \tan^{-1}\left(\frac{78-0.4\,GR}{60}\right) \qquad (2)$$

2.3. Plumb Clay Volume and porosity Correlation

The equation was created by Plumb and may be used to calculate the friction angle utilizing log tools (neutron, density, and gamma-ray, [25].

$$\phi = 26.5 - 37.4(1 - \mathrm{NPHI} - V_{shale}) + 62.1(1 - \mathrm{NPHI} - V\_shale)^2 \qquad (3)$$

Where φ is the friction angle, NPHI is the porosity from neutron porosity log or effective porosity, V shale is the volume of shale represented by equation (4).

$$V_{shale} = \frac{GR - GR_{min}}{GR_{max} - GR_{min}} \qquad (4)$$

Where GR is gamma ray log, GR_{max} and GR_{min} is the maximum and minimum values of gamma ray log.

3. Results and Discussion

Figure (4) illustrates the internal friction angle estimate using Weingarten and Perkins Weal Sand Porosity Correlation in the fourth track (FANG-SND-WPM) with red color; the internal friction angle calculated using this approach exhibits a good match with the core data points in blue circles. The total porosity (PHIT-ND), which is shown by the third track in the same image, was estimated using neutron log and density data for this correlation. According to Figure. (5) The internal friction angle estimate using Gamma Ray Correlation is shown in the fourth track (FANG-from Gr) with a red color. The internal friction angle calculated using this approach exhibits a poor match with the core data point in blue circles. The gamma ray log used as the input data for this association is shown by the third track in the same picture. Figure (6) illustrates the internal friction angle estimate using Plumb Clay Volume and Porosity Correlation in the fifth track (FANG-PPC) with red color, friction angle by this approach demonstrate a good match with core data point in blue circles. Shale volume (VSH-GR) is shown in the fourth track in the same figure, whereas the third track in the same figure is the effective porosity log (PHIE-ND) utilized as input data for this correlation.

The Weingarten and Perkins Weal correlation shows that this approach is utilized, particularly when there is water production, and that there are times when the frictional angle is less than zero, which causes a decrease in the effective cohesive strength of the rock and the formation of sand. The gamma ray approach just uses the gamma ray log and does not match the core data correctly. The results show an excellent fit between the core data and the final approach, which employs effective porosity and clay volume as input data. Due to decreasing in the effective porosity and increasing shale volume, the frictional angle shows minimum values in the Tanuma formation and at various depths.

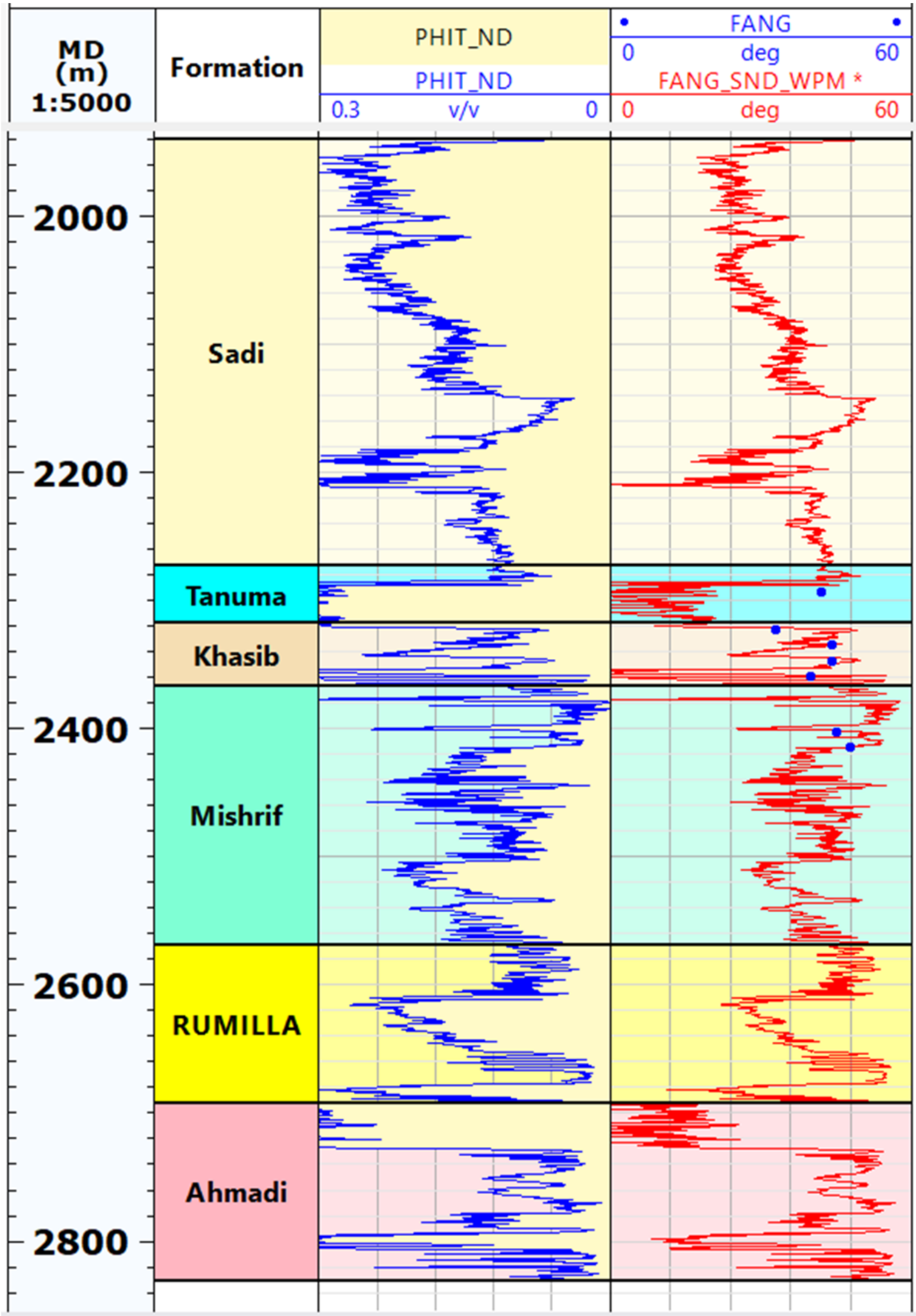

Figure 4: Internal friction angle by Weingarten and Perkins Weal Sand Porosity Correlation.

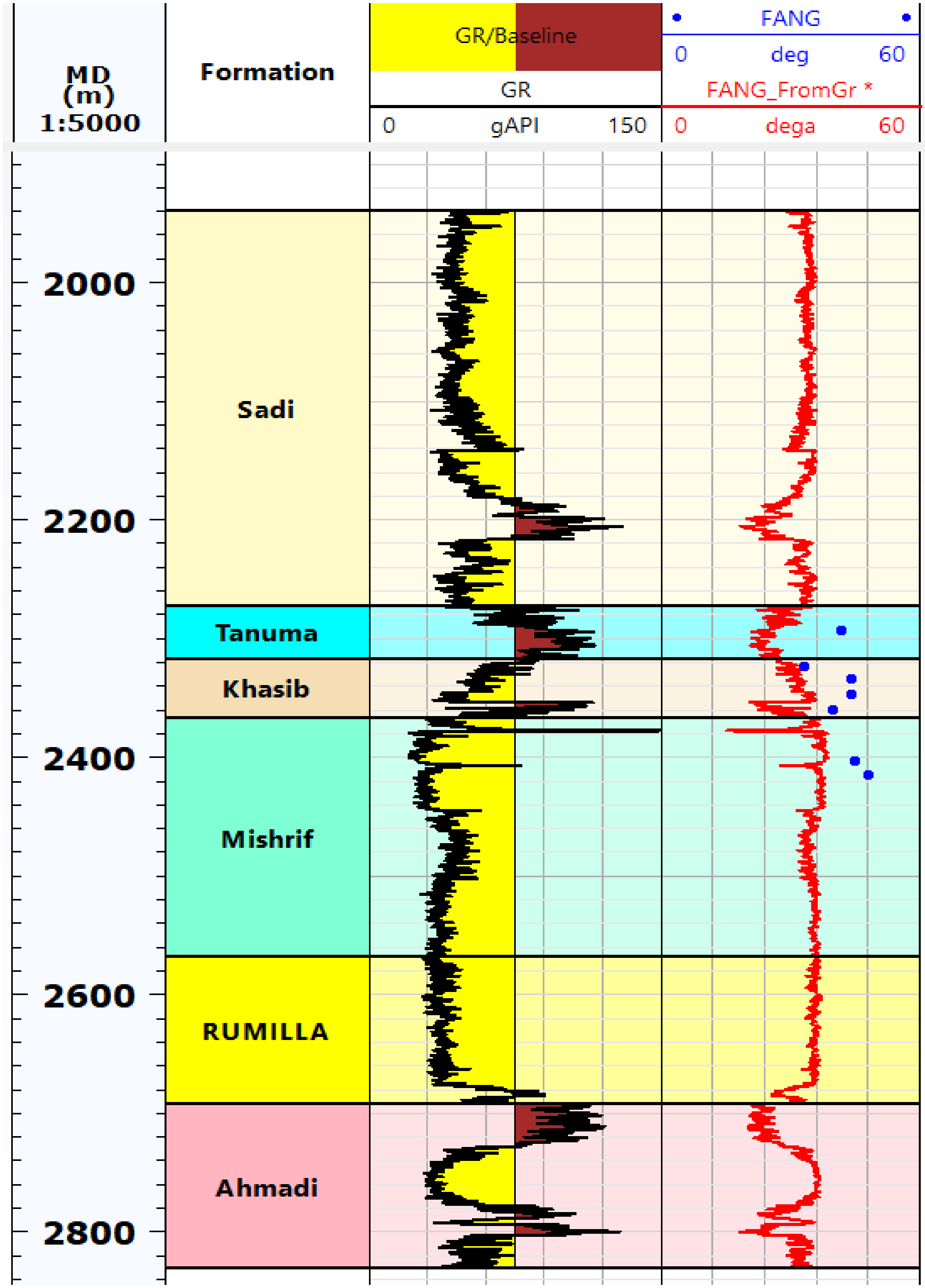

Figure 5: Internal friction angle by Gamma ray log.

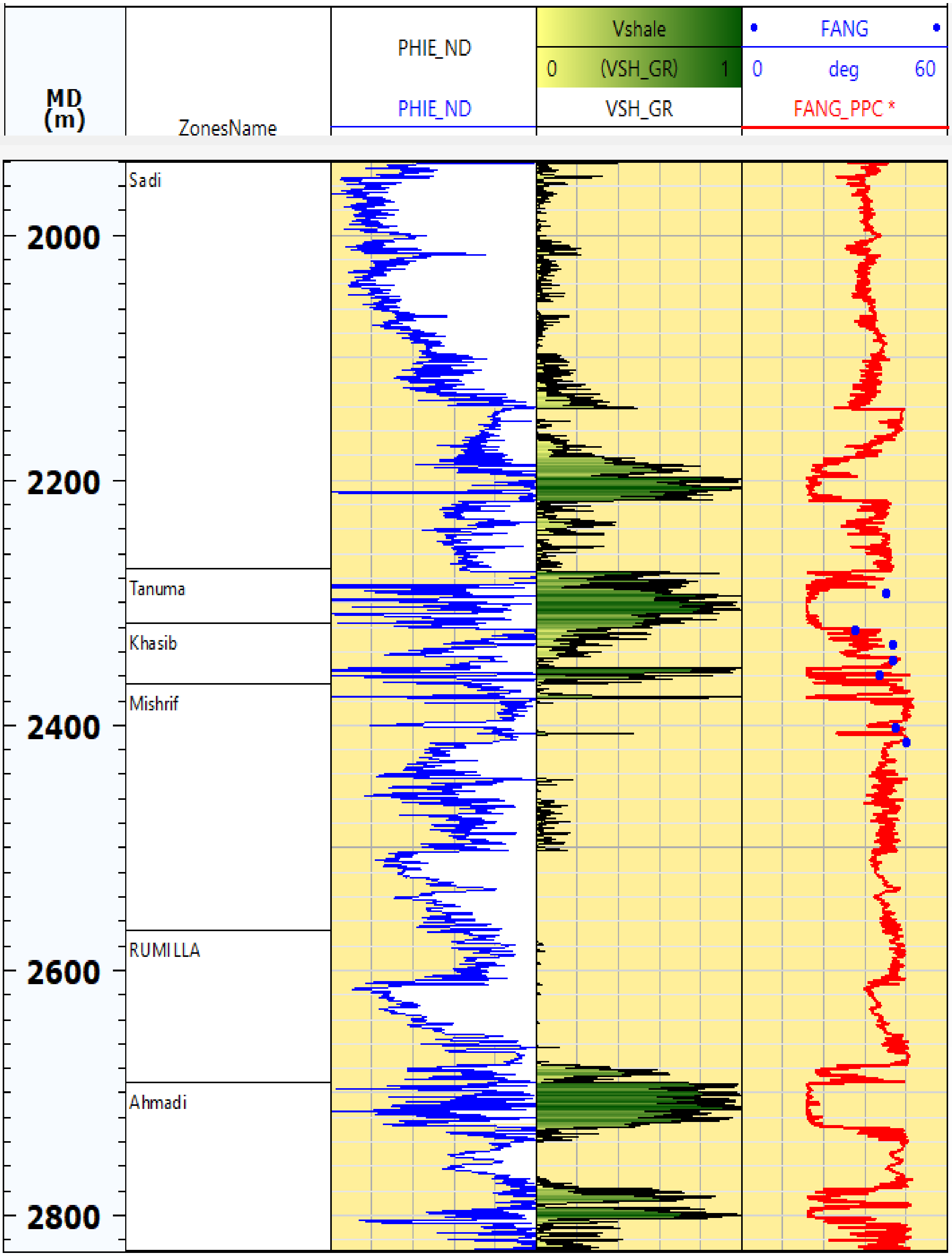

Figure 6: internal friction angle by Plumb Clay Volume and porosity Correlation.

4. Conclusion

The following conclusions may be made based on the findings from the previous section:

- According to the Weingarten and Perkins Weal correlation, which demonstrates that some depths have friction angles that are less than zero, this approach utilized, especially when there is water production.
- According to the Weingarten and Perkins Weal correlation, the relationship between the total porosity and internal friction angle is totally opposite.
- The effective porosity and friction angle are directly correlated; when effective porosity increased with lowering shale volume, friction angle increased as well based on Plumb Clay Volume and porosity Correlation.
- Results demonstrated that the Plumb correlation method was the most accurate method for estimating frictional angle.

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