

Calculation Improvement of the Clay Content in the Hydrocarbon Formation Rocks

Sudad H. Al-Obaidi*

Department of Petroleum Engineering, Hayat University, Kurdistan, Iraq

Abstract

Natural radioactivity of reservoir rocks of oil and gas in East Baghdad field is due to not only their content of clay material, but also the existence of uranium located in the skeleton of rocks. In connection with this, for the shale content determination of reservoir rocks, it is necessary to exclude the uranium contribution from the overall intensity of the gamma radiation. The paper presents the results of a research, using the data of spectral (standard) gamma ray logs-SGR, in which more accurate determination of the shaliness (clay content) in the productive zones of the Zubair section of East Baghdad field (In Iraq) is proposed. With the help of a computer program, a formula that allows us to remove the effect of uranium, which affects the readings of gamma ray logging, is obtained.

Keywords: Uranium, clay content, gamma ray, CGR, SGR

***Author for Correspondence** E-mail: sudad.hameed@koyauniversity.org

INTRODUCTION

As indicators of the clay content and shale in the formation rocks, unsealed by a well, many types of logging can be used, in particular, the spontaneous potential (SP), density, neutron, and gamma ray logging.

Gamma ray tools record naturally occurring gamma rays in the formations adjacent to the wellbore. This nuclear measurement indicates the radioactive content of the formation rocks. Effective in any environment, gamma ray tools are the standard devices that are used for the correlation of logs in cased and open holes.

One of the most effective gamma ray log tools, based on the measurements of the natural radioactivity of the formation rocks, was proposed in 1980. Its readings are analysed from the point of view of determining the nature and quantity of radioactive elements [1]. The tool can be considered as an improved indicator of clay content of the formation rocks. This logging device detects the presence of uranium U, thorium Th and potassium K in rocks, and subjected to determine the volumes of these radioactive minerals.

After calculation of the content of uranium, thorium and potassium by the method of

weighted least squares the total gamma intensity of the radiation can be represented as a linear combination of the intensities of radiation of each of these elements.

Since, the presence of clay affects the results of the determination of petrophysical parameters of formation rocks, such as saturation and porosity, it is necessary to introduce relevant corrections to the clay content [2]. Different bulk clay volumes for many intervals of Zubair section was determined using two different gamma ray logs data (spectral gamma ray log, SGR and corrected gamma ray, CGR). The CGR log is the log at which the effect of uranium is excluded from the overall gamma ray intensity of the formation rocks.

CALCULATION OF SHALE VOLUME (CLAY CONTENT)

The interpretation data of gamma ray logs could be used as a single indicator of clay content of the formation rocks based on the following basic relationship [3]:

$$V_{sh} = \frac{I_{\gamma} - I_{\gamma(\min)}}{I_{\gamma(\max)} - I_{\gamma(\min)}} \quad (1)$$

Where;

$I_{\gamma(\min)}$, Minimum intensity of the radioactivity that corresponds to the clean formation rocks.

$I_{\gamma(\max)}$, Maximum intensity of the radioactivity that corresponds to the formation of net clays.

I_{γ} , The intensity of the natural radioactivity of the formation rocks studied.

In practice, there are two types of logging curves of gamma ray (GR) logs. The first corresponds to a standard curve of GR, where GR indications are represented as a linear combination of the radioactivity of potassium, thorium and uranium, in accordance with the following equation:

$$I_{\gamma} = AI_{TH} + BI_U + CI_K \quad (2)$$

Where, A, B and C are coefficients obtained from the calibration of the logging tool. This calibration takes into account the intensity of thorium radioactivity, I_{Th} , the intensity of uranium radioactivity, I_U and the intensity of potassium radioactivity, I_K .

The second type is the corrected gamma ray log CGR, where the proportion of uranium is excluded from the total gamma activities of the formation rocks. The CGR log represents a linear combination of gamma ray activities, only thorium and potassium, of the formation rocks:

$$I_{\gamma corr.} = AI_{TH} + CI_K \quad (3)$$

Since, the existence of uranium is associated most with radioactive materials of the formation rocks other than those found in clay [1], such as organic sediments, then the data of CGR log can significantly reduce the distorting effect of slit and organics on the assessment of the shale in the reservoir rocks.

Therefore, CGR log is considered to be a good indicator of clay content. To determine the shale volume of the formation rocks using the data of the CGR log, Eq. (1) is used.

Due to the fact that CGR log is not always available in well logging complex due to its high cost, the data of SGR log is undertaken for sand bodies in wells where CGR log is recorded (EB-55, EB-56, EB-77, EB-79), at the same sand bodies depths of wells (EB-18 and EB-15) where the CGR is not recorded, are used in a regression program together with data of the CGR log data.

This regression program has been developed to give a linear relationship to determine the

values of I_{γ} corrected, using the data of standard GR log, as shown in Figure 1.

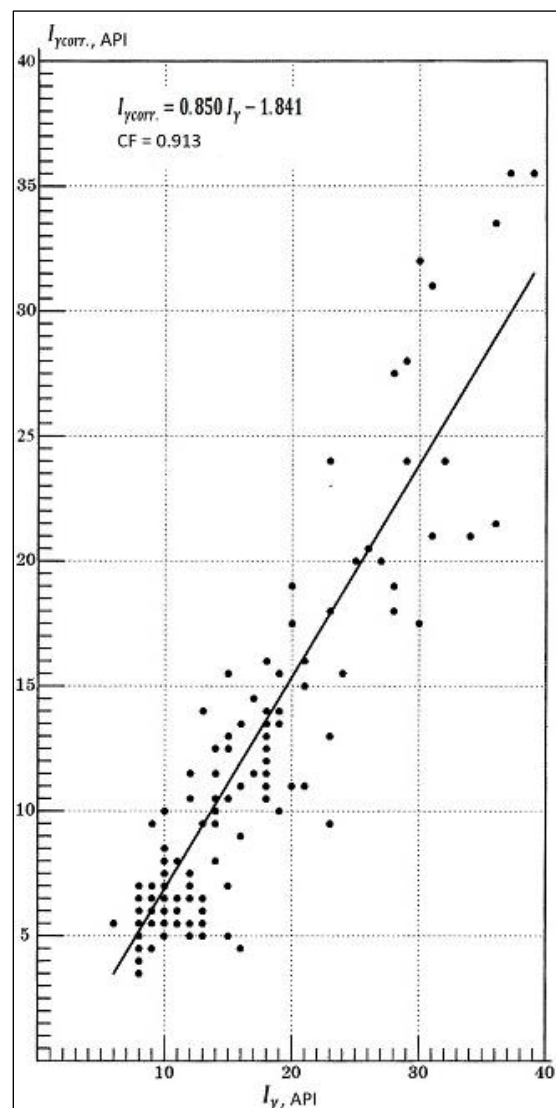


Fig. 1: Dependence of $I(\gamma_{corr})=f(I_{\gamma})$ for Sandstone Intervals of Zubair Formation.

In this Figure 1, the data of standard gamma ray log and corrected gamma ray log are plotted to obtain a single fundamental equation, which can be further applied to each interval of Zubair section;

$$I_{\gamma corr.} = 0.850 I_{\gamma} - 1.841 \quad (4)$$

Since the clay content coefficient that is calculated according to any separately used well logging method, often turns out to be overestimated, in practice, the clay content of the formation rocks is recommended to be calculated by several methods of well logging [4]. Thus, for an amendment to the clay content calculated according to the data of well log-

ging, which consequently affects the values of the petrophysical parameters of the formation rocks, the lowest estimated values of clay content are used [5].

To determine the effectiveness of the proposed method (Eq. (4)), the shale volumes of formation rocks calculated by the proposed method are compared with the values obtained, using other methods such as a cross-plot method of Neutron log-Density log; standard (spectral) gamma ray log (SGR) (Table 1). The comparison of the clay content volumes obtained using the proposed method with those values obtained by other methods, clearly shows that the proposed method gives the lowest values.

Table 1: Comparison of V_{sh} Calculated by Proposed Method and V_{sh} Calculated by Cross-Plot (Neutron and Density Logs) and SGR Log Methods.

Depth (m)	$V_{sh}, \%$ Proposed Method	$V_{sh}, \%$ Spectral GR Log Method	$V_{sh}, \%$ Cross-Plot Method
3019	18	23.3	19
3022	8	11.5	10
3028	13.6	18.1	14
3045	18	23.3	18.8
3110	12	16.2	14
3115	6	9.2	7
3136	6	9.2	7.5
3155	12	16.2	13
3163	24	30.4	25.5
3169	6	9.2	7.3
3177	18	23.3	18
3181	6	9.2	7.1
3189	6	9.2	6
3197	0	2.1	5
3217	6	9.2	6.5
3258	0	2.1	0
3270	6	9.2	6.8
3289	6	9.2	7.5
3305	18	23.3	20

CONCLUSIONS

As a result, it is found that the proposed method, in which the excluding of uranium effect from the overall intensity of the gamma radiation, gives a better estimation of clay content of formation rocks than the original method which takes into account the presence of the uranium component.

As a consequence, this will lead to a more accurate determination for the petrophysical parameters of the formation rocks, such as saturation and porosity, and consequently to more accurate hydrocarbons reserve estimation.

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