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Lithology and Mineralogy Estimation from Matrix Density Utilizing Wireline Logs in Glauconitic Sandstone, Blackfoot Area, Alberta

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Summary

The purpose of the work conducts to estimate lithological and mineralogical properties of the Glauconitic sandstone formation within Western Canadian Sedimentary Basin, Blackfoot area, Alberta, Canada. Three wells, named 2, 3 and 4 were chosen in order to quantify parameters needed to evaluate contents of rocks in the study wells. The area we have studied consists in general of sandstone, shale and minerals such as siderite and pyrite.

We use wireline logs to estimate the lithology and mineralogy for the study formation. Data includes gamma ray logs, neutron logs and density logs. In addition, cores along with special core analysis data were used to delineate and define different lithology, porosities and bulk densities at various depth points for the three wells within the study area.

Results from the log data demonstrate that sandstone is less dense than shale, and the matrix densities are higher than bulk densities. Matrix densities lie in the range between 2.4 g/cm^3 and 3.4 g/cm^3 with an average of 2.72 g/cm^3 for the three wells. A reasonable estimation for lithology compare to conventional lithological and mineralogical standards of the Glauconitic sandstone formation is obtained.

The significance of the study is that the techniques used in the work can assist to identify the content of rocks even with the lack of core data, and to estimate the petrophysical properties such as porosity, permeability and fluid content. The results consequently can be used to evaluate the reservoir and to analyze the basin.

Introduction

The Blackfoot Field is located about 15 km southeast of the town of Strathmore, south-eastern Alberta in Canada. The target formation within the Blackfoot area is a Lower Cretaceous, Glauconitic Sand Formation. In the Blackfoot area, the glauconitic sandstone is encountered at a depth of about 1550 m and the valley-fill sediments are up to 45 m thick.

The Glauconitic sandstone in this area is composed of a complex incised-valley system, which has eroded into regional Glauconitic deposits, removed the Ostracod Formation, and locally cut as deep as the Detrital Formation. It is subdivided into three phases of valley invasion. The three incised valleys are of different sand quality.

The upper and lower incised valleys are the main reservoirs, the lower and upper members are made up of quartz sandstone, while the middle member is tight lithic sandstone. The lithic inside valley sand deposits are non-reservoir quality and act as permeability barrier between upper and lower incised valleys.

The Glauconitic consists of very fine to medium grained quartz sandstone in the eastern part, and quartz sandstone mixed with somewhat coarser lithic or sub-lithic sandstone in the western part of Alberta, and some siderite spherules are present in places. Interstitial clay and calcareous cement vary (Glass, 1997). The facies are composed of quartz and chert-rich sand with average porosity of 20% and average permeability of 750mD.

The aim of this study is to identify and establish the lithological and mineralogical contents of rocks, and in the estimation of petrophysical parameters such as porosity, permeability and fluid content. The results of this work can be used in reservoir and basin analysis.

Theory and/or Method

For the purpose of this work, gamma-ray, neutron and density logs were used to determine the lithologic components of the formation in the area of study, as well as the porosity and matrix densities. Composite logs containing gamma ray, neutron and density logs for three different wells were digitized at one meter depth intervals to obtain the raw well data for the determination of the parameters of interest. Lithologies are determined from core data and it was established that the rock matrix consists mainly of sandstone, shale with carbonaceous materials and siderite.

The gamma ray has been used as one of the independent shale indicators in the evaluation of glauconitic sandstone formation. The gamma ray logs are usually used to discriminate the shale from reservoir rock. The neutron/density combination was used to compute for porosity as shown by equation (1) below (Bassiouni, 1994).

$\rho b=\rho ma(\rho ma-\rho f)f(\varnothing N)$ **(1)** Where $\varnothing N$ is the apparent porosity, ρf is the density of the fluid filling the pores, ρb is the bulk density of formation.

We then resolve equation (1) to obtain density of the matrix ρma, this is given as:

$\rho ma=(\rho b-\varnothing\rho f)/(1-\varnothing)$ **(2)** Where $\varnothing$ is the true porosity.

For normally encountered formations, the value to be used for matrix density is generally between 2.65 g/cm^3 and 2.87 g/cm^3, depending on lithology. For values of fluid density, it is necessary to know the type of fluid in the pores. The fluid density for hydrocarbon ranges from 0.2 to 0.8 g/cm^3. Salt-saturated water (NaCl) density may be as high as 1.2 g/cm^3, and with the presence of $CaCl_2$, values even as great as 1.4 g/cm^3 may occur.

The impact of the uncertainty in fluid density can be illustrated. For example, if the saturating brine is a dense (1.4 g/cm^3) with calcite matrix, then the porosity corresponding to the measured density of 2.5 g/cm^3 is 16%. On the other hand if the saturating fluid is low density (0.6 g/cm^3) then the calculated porosity would be about 10%. It is fortunate that the uncertainty that can be tolerated in ρf is much greater than that for ρma.

Equation (1) is used to compute for the matrix densities at different depths, saturated with different fluids (fresh water =1.0 g/cm^3, salt water = 1.1 g/cm^3, and oil = 0.9 g/cm^3) by substituting the appropriate values of the parameters in the equation. The three study wells (2, 3 and 4) are computed and the values presented by Tables 3, 4 and 5 respectively.

Examples

The digitized logs and the computed values are obtained for the three wells (2, 3 and 4) showing the selected depth intervals, GR values, porosities, bulk densities and the matrix densities for the Glauconitic formation saturated with different fluids. For the three wells, the relationship between the parameters shows that the shale from gamma ray is denser than sandstone. It is also evident that matrix densities are higher than the bulk densities.

Graphical presentation of the plots of bulk densities against matrix densities shows bulk densities being lesser than matrix densities in all the wells at various depths (Figure 1). Ranges and averages of variation in percentage for matrix density from bulk density through the entire logged depth within the formation of the study wells that are saturated with different fluids are shown in Table 1.

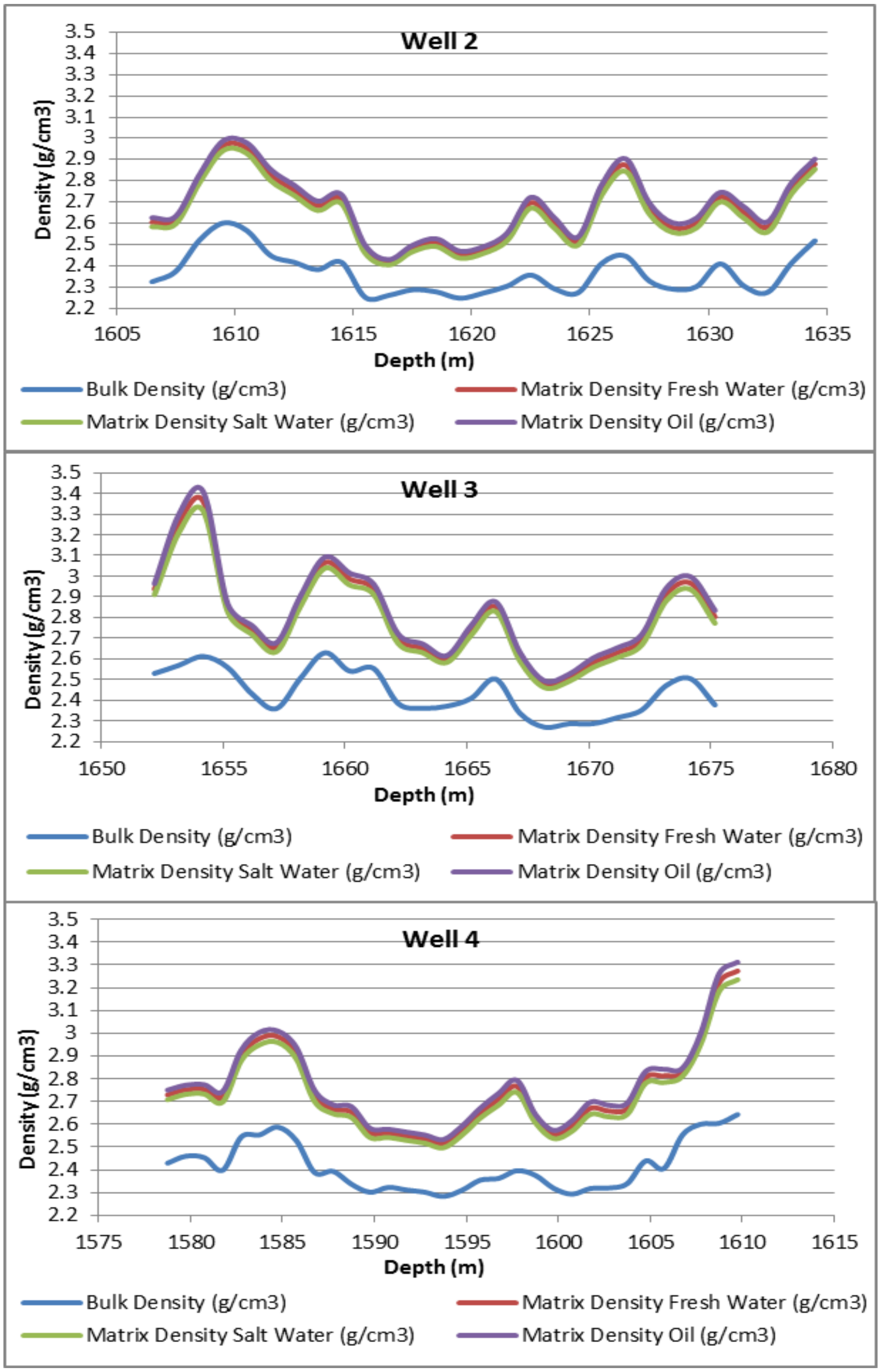

Figure 1: Plot of densities of Glauconitic formation with different fluid saturation versus bulk density for all study wells

Table 1: Variation of average matrix densities from average bulk densities of different fluids for the three wells

Well	Statistics (%)		Fluid		
			Fresh Water	Salt Water	Oil
2	Average		11.16	10.43	11.87
	Range	Max	16.11	15.12	17.08
		Min	5.86	5.44	6.28
3	Average		13.16	12.37	13.93
	Range	Max	26.72	25.29	28.13
		Min	7.39	6.87	7.90
4	Average		11.84	11.10	12.57
	Range	Max	22.66	21.43	23.87
		Min	8.49	7.90	9.08

Conclusions

The Glauconitic sandstone reservoir in these wells is heterogeneous, such as in this case, where a combination of clean sandstone and lithic sandstone is presented. The wire-line logging data obtained was analyzed and computed values confirmed the lithologic sequence of the Glauconitic Sandstone Formation, which is quartz sandstone, glauconitic, siderite and calcareous cement.

The bulk densities of all three wells are lower than matrix densities. Also, the shale is denser than sandstone, and the type of the formation's fluid significantly influences the value of the bulk density. From Tables 3, 4 and 5 the range of matrix densities have a range from 2.40 gm/cm^3 to 3.40 gm/cm^3, which correlates to the density ranges of the matrix range for sandstone, shale and calcareous cement with the mineral constitute of siderite and pyrite.

Through the use of the selected wells, it is hoped that a more precise determining of other unknown petrophysical parameters such as porosity, permeability, fluid contents etc. In addition, this work could aid in the identification of reservoir for economic benefit.

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