Lithology Identification, Shale Volume Estimation and Formation Water Saturation of Fenchuganj Gas Field Using Wireline Log Data

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Abstract. This study has been undertaken with a view to interpreting and analyzing different types of logs, detecting hydrocarbon-bearing sand zone, identifying the lithology, estimating shale volume, and determining water saturation of the formation of the Fenchuganj gas field. Fenchuganj gas field is in the southern part of Bangladesh in the Sylhet division. It lies in the Surma basin and characterized as a water drive gas field. Gamma Ray (GR) log and Spontaneous Potential (SP) log analysis help to interpret the formation lithology. After interpreting lithology, the gamma-ray log and SP log were analyzed further, and the hydrocarbon-bearing zone was detected. From the analysis of different logs, for well 4, so many gas-bearing sand zones have been detected. These are the gas-bearing zones of fenchugonj well-4 determined from the composite log of this field. Water-bearing sand zones are between (1708-1714) m and the fully compacted shale zone is between (1920-1930) m. From the analysis of different logs, for well 5, so many gas-bearing sand zones have been detected. These are the gas-bearing zones of fenchugonj well-5 determined from the composite log of the field. Shale volume has been estimated from the gamma-ray log and from resistivity logs by the true resistivity method. In well 4, the calculated value of shale volume by Gamma Ray method and true Resistivity methods were respectively 15% and 6%, in well 5 these values were 7.25% and 7.64%. Formation water resistivity was determined from the formula and taken as 0.1 ohm-m and mud filtrate resistivity 0.76 ohm-m. For well-4 and for well-5 it was taken as 0.7 ohm-m (from the provided composite log of well 4 and 5). Formation true resistivity $R_t$ was estimated directly from the ILD log and true resistivity log. The average value of $R_t$ for well-5 was 33.75 ohm-m and for well-4 the value is 34.09 ohm-m. From the RFOC log, flushed zone resistivity $R_{xo}$ was calculated directly. Water saturation has been determined by three different techniques named Archie, Indonesia, and Simandoux method. For well 5, the value of average water saturation found from Archie, Indonesia, and Simandoux model was 8.5%, 22%, and 24.84%, and for well-4. The value of average water saturation was found as 7.3%, 18%, 20.51% respectively.
1. Introduction
In petroleum geology, reservoir is the most common element of petroleum system which can accumulate hydrocarbons (oil or gas). Reservoir rock is that place in which fluids can be stored and accumulated. The fluids might be water, oil, and gas. The most important geologic information is reservoir that is termed as a subsurface volume of rock. It has adequate porosity and permeability so that it can store hydrocarbon under presence of seals and traps. Migration of hydrocarbon form the source rock to porous and permeable rock occurred in conventional reservoir [1].

Integration of all available data to define the geometry, distribution of physical parameters, and flow properties of a petroleum reservoir is known as Reservoir Characterization. there are some physical properties of reservoir which is needed to characterize the reservoir. They are: Lithology, Porosity, Permeability, Compressibility, Fluid saturation, Capillary characteristics, Rock stress, Fluid rock interaction. Permeability is one of the flow properties [2]. In oil and gas industry, the most elementary methods for reservoir characterization well logging is used all over the world. To know about the petrophysical properties of the reservoir and detect the hydrocarbon bearing zone, evaluate the hydrocarbon volume well logging is used mostly. Well log data are routinely used for stratigraphic interpretation of the Earth’s subsurface. By using wireline log data, one can calculate: Shale Volume ($V_{sh}$), Water Saturation ($S_w$), Porosity ($\Phi$), and Permeability ($k$). Several steps are required to interpret wireline log data and analysis should not be done randomly because it might cause error in result. Basically, petrophysical properties (shale volume, water saturation, permeability, etc.) will be used in reservoir characterization which are mostly based on geology. The steps will be determination of petrophysical properties (shale volume, water saturation, permeability, etc.) of reservoir rock, evaluation of their nature and volume, at last its essential to estimate their economic feasibility [3].

Reserves are known as those quantities of petroleum resources which are economically feasible to recover commercially from the known accumulations soon from given data forward using the commercial methods under the regulations of the government and regulatory agencies. Thus, reserves must satisfy four criteria: it must be discovered, recoverable, commercial, and remaining. Proved reserves, possible reserves and probable reserves are the types of reserve. Proven reserves are the number of natural resources that a business fairly hopes to obtain from a structure that is formed using engineering and geological information collected by exploratory excavation and seismic testing. It should fulfil at odds 90% or more likelihood of regeneration. Probable stocks are those unproven resources that suggest that analysing geological and engineering information is more probable than unrecoverable. The likelihood of regeneration should be at least 50% or more of the expected amount plus likely stocks. Possible reserves are those unproved reserves which analysis of geological and engineering data suggests are less likely to be recoverable than probable reserves. Probability of recovery should be at least 10% or more of the sum of the estimated proved plus probable plus possible reserves [4]. Different approaches of reserve estimations are: Volumetric Estimate, Material Balance Estimate, Decline Curve and Reservoir Simulation. After discovery and at the early stage of production most commonly used method is volumetric method. The parameters needed for volumetric methods are: Area, Thickness, Porosity, Water saturation, Formation volume factor and Recovery factor.

Research was taken out in the Niger Delta to characterize hydrocarbon reservoirs using well registers to assess potential hydrocarbon, delineate hydrocarbon and water-bearing areas and petrophysical characteristics of interesting hydrocarbon reservoirs. The research used data from four composite well records consisting of the records of Gamma Ray, Resistivity, Neutron, and Density. Results from the research found that nine out of twenty-two concern areas (mud fields) were delineated and linked across to identify prospective hydrocarbon reservoirs. The outcome also shows an improvement in porosity with a rise in permeability. The petrophysical parameter assessed showed that porosity varies from (18-31%), air saturation (14-44%), hydrocarbon saturation (56-86%), permeability (138-10662) [5]. A research was conducted in order to classify the reservoirs in well-4 Rashidpur, Bangladesh, by quantitatively analysing petrophysical parameters in the gas field. The study identified 20 permeable areas. Four were gas-bearing zones among them, while the remainder were hot. In these areas, the hydrocarbon form may be a gas that shows relatively high resistivity, low neutron, and low-density
record responses than in the water areas. The average pore content in those areas ranged from 18-27% to 17-40% for water saturation and 60-82% for hydrocarbon saturation. Hydrocarbon is moved into the tank because the hydrocarbon mobility index indicates less than 0.70. The volume of average bulk was between 0.04 and 0.13. The lithology is fine to very fine grain sandstone with irreducible water saturation and all the calculated values confirms this. Zone-4 was shown to be comparatively highly thick, porous, moist, and permeable to other regions. [6]. From time-to-time Petro Bangla includes consultants in the carrying out of specific jobs and undertake studies to establish various gas fields on its behalf. Petro Bangla typically engages consultants in seismic surveying and interpreting, drilling, completion, work on, precision survey, reserve assessment etc., on the side of exploration and development. Some of these consultancy companies have performed studies on behalf of Petro Bangla to estimate and update the gas and reserves in place. BAPEX carried out research on the gas sector of Fenchuganj [7]. The objectives of this research are to interpret and analyse different types of logs, identify the lithology of the formation, and estimate shale volume and water saturation of the formation using log data.

2. Location and exploration of the field

Fenchuganj gas field is in southern part of Bangladesh and in Sylhet division. It lies in Surma basin and characterized in water drive gas field. It is in Fenchuganj upazila and about 40km south-east of Sylhet town. It is bounded by Longitude E 91º 53’–92º and Latitude N 24º 30’–24º 37’ and is 30 km long and 8 km wide. Fenchuganj gas field was discovered by Petro Bangla in 1988. This field is operated by Bangladesh Petroleum Exploration and Production Company Limited (BAPEX). The sequences of lithologies found in the region range from the age of Oligocene to Pliocene. It is an oval trough that is negative. It is an oval trough. In Lower Bokabil to Upper Bhuban formations in the late Miocene period, the gas bearing sands of the structure are found. Miocene sediments like alternating gray to dark gray clay and very fine to fine grained sandstone is found in the reservoir [8]. In Lower Bokabil to Upper Bhuban formations in the late Miocene period, the gas bearing sands of the structure are found. The seismic analysis reveals a major reverse fault of the Fenchuganj formation on the eastern flank. The line of the steep North Flank and the slightly south Flank is an asymmetrical antichange. The Fenchuganj sediments consist of a different proportion of shale and sandstone from Oligocene to the recent period. [9]. Fenchuganj gas fields' structural pattern in the whole region is smooth and uniform. The Fenchuganj structure's litho-stratigraphy is created based on good knowledge. The sequences of lithologies found in the region range from the age of Oligocene to Pliocene. This structure was a reverse fault with a trending axis of NNE-SSW. The number of dips on the eastern side ranges from 30°-35°; on the western side, the number varies from 20°-25° [9]. In Lower Bokabil to Upper Bhuban formations in the late Miocene period, the gas bearing sands of the structure are found. The seismic analysis reveals a major reverse fault of the Fenchuganj formation on the eastern flank. The line of the steep North Flank and the slightly south Flank is an asymmetrical antichange. The Fenchuganj sediments are composed of alternate shell and sandstones, which differ according to age. There has been no extensive research on the structural development of the region since this area has been discovered. The goal of this research is therefore to re-structure structural maps of the linkages between formations, to identify canal, fault and other structure, to delegate seismic disturbances and finally to interpret the results analysed to understand the structural development of the region [9].

In Bangladesh, most of the onshore part has been explored widely for natural gas, yet there is more possibility to explore the resource inland by remodelling and re-studying with modern techniques. Fenchuganj Gas Field is one of the producing gas fields located at north-eastern part of Bangladesh.
Five exploration wells (FNG-1, FNG-2, FNG-3, FNG-4 and FNG-5) have been drilled so far and two wells FNG-2 and FNG-3 are producing natural gas [10]. Figure 1 shows the discovered 26 gas fields of the country including 2 offshore ones and searching for other prospects both on offshore and onshore area. The total initial gas reserve in the 26 gas fields has been estimated at 27.12 Tcf (Proved and Probable) and 20.08 TCF (recoverable) of natural gas enough to meet our demand of energy.
consumption till 2019. Fenuganj is one of the most productive and prospective gas fields in Bangladesh and falls in gas block #14. Fenuganj gas field was discovered in 1988. First well #FNG-1 was drilled in 1960 down to 2439 m and abandoned as a dry hole. Later, January 21st, 1985 drilling of the well #FNG-2 started and reached TD on November 4, 1986. After producing 24 BSCF gas, the well #2 was suspended due to excessive water and sand production and the well was recompleted at lower zone. But due to much amount of water and well head pressure down (1020 psi), well #2 shut on July 21, 2013. The well #FNG-3 started on February 6, 2004 and completed as production well on May 14, 2004. Drilling of the well #FNG-4 started on November 2010 and was completed in May 2011 [10].

3. Methodology

3.1. Lithology identification and shale volume estimation

There are several reasons why it is important to know about the lithology of a zone (i.e., sandstone, limestone, or dolomite). The best logs for lithological purposes are those that are most influenced by rock properties and least influenced by fluid properties. The most useful of the commonly available logs are: Gamma Ray (GR) log and Spontaneous Potential (SP) log. Gamma Ray log can be used to calculate volume of shale in porous reservoirs. Shale is more radioactive than sand or carbonate. The volume of shale expressed as a decimal fraction or percentage is called V_sh. Calculation of the gamma ray index is the first step needed to determine the volume of shale from gamma ray log. The gamma ray log has several nonlinear empirical responses as well as linear response which have been expressed as equation (1) and (2). The nonlinear responses are based on geographic area or formation age.

Linear response (V_sh = I_GR) [11]:

\[ V_{sh} = I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \]  

Nonlinear response: Larionov (1969) for Tertiary rocks [11]:

\[ V_{sh} = 0.083(2^{3.7I_{GR}} - 1) \]  

Where, V_sh = shale volume, I_GR = Gamma Ray index, GR_log = Log value of Gamma Ray, GR_max = Maximum value of Gamma Ray of the formation and GR_min = Minimum value of Gamma Ray of the formation.

Spontaneous potential log, commonly called the self-potential log or SP log, is a measurement taken by oil industry well loggers to characterize rock formation properties. The log works by measuring small electric potentials (measured in millivolts) between depths in the borehole and a grounded electrode at the surface. A log of the natural difference in electrical potential, in millivolts, between an electrode in the borehole and a fixed reference electrode on the surface. The magnitude of the deflection depends mainly on the salinity. The difference between drilling mud and formation water and the clay content of the permeable bed. The spontaneous potential (SP) log is used to detect permeable beds from the formation [12].

3.2. Determination of water saturation

There are several methods to determine the water saturation and among these Archie, Simandoux and Indonesia method are most used, and these have been expressed in equation (3), (4) and (5) respectively.

Archie Formula:

Water saturation (Sw) of a reservoir’s uninvaded zone is calculated by Archie (1942) formula [11].
\[ S_w = \left( \frac{a \cdot R_{w}}{R_t \cdot \phi^m} \right)^{\frac{1}{m}} \]  

(3)

Simandoux Equation: [13]

\[ S_w = \left( \frac{0.4R_w}{\phi_e^2} \right) \cdot \left( \frac{V_{sh}}{R_{sh}} \right)^2 + \left( \frac{5\phi_e^2}{(R_w * R_t)} - \left( \frac{V_{sh}}{R_{sh}} \right) \right) \]  

(4)

Indonesia Method:

Water saturation for un-invaded zones [13],

\[ S_w = \left( \frac{1}{R_t} \right) \cdot \left[ \frac{V_{cl}^{(1-0.5\phi_e)}}{(R_{cl})^{0.5}} + \left( \frac{\phi_e^{0.5m}}{(aR_w)^{0.5}} \right) \right] \]  

(5)

Water saturation for flushed zones [13],

\[ S_{so} = \left( \frac{1}{R_{so}} \right) \cdot \left[ \frac{V_{cl}^{(1-0.5\phi_e)}}{(R_{cl})^{0.5}} + \left( \frac{\phi_e^{0.5m}}{(aR_{mf})^{0.5}} \right) \right] \]  

(6)

Where, \( S_w \) = Water saturation, \( R_w \) = Formation water resistivity, \( R_t \) = True resistivity of formation, \( \Phi \) = Porosity, \( m \) = cementation factor, \( n \) = saturation exponent, \( V_{sh} \) = Shale volume, \( V_{cl} \) = Clay volume, \( \Phi_e \) = Effective porosity, \( R_{so} \) = True resistivity of formation, \( R_{cl} \) = Clay zone resistivity, \( R_{so} \) = Flushed zone resistivity, \( R_{mf} \) = Mud filtrate resistivity.

4. Results and discussions

At first the analyzation of available log data takes place carefully to interpret lithology of the formation. In the formation there exist some gas bearing sand zone, some water bearing sand zone and fully compact shale zone. These zones are found from the log data. After detecting hydrocarbon bearing zones, different types of reservoir properties like shale volume, porosity, formation water resistivity, flushed zone resistivity, formation true resistivity, water saturation etc. Gamma Ray log, SP log, ILD log, sonic log, neutron log, density log etc. logs are used to determine the different types of reservoir properties.

4.1. Detection of lithology and hydrocarbon bearing zones

Gamma ray log and SP log analysis helps to interpret the formation lithology. After interpreting lithology, the gamma ray log and sp log were analyzed further and the hydrocarbon bearing zone was detected. When the value of GR log is low, resistivity log is high, neutron log is low and density log is low at the same time the zone is detected as hydrocarbon bearing zone. The relation between neutron log and density log helps to determine the hydrocarbon bearing zone easily and perfectly. From the analysis of different logs, for well 4, so many gas bearing sand zones has been detected. The gas bearing zones are found between (1585-1595) m, (1600-1610) m, (2409-2420) m, (2265-2270) m, (2295-2303) m, (2435-2450) m, (2465-2480) m, (3150-3155) m, (2955-2960) m. These are the gas bearing zones of...
fenchugonj well-4 determined from the composite log of this field. Water bearing sand zones are between (1708-1714) m and fully compacted shale zone is between (1920-1930) m. From the analysis of different logs, for well 5, so many gas bearing sand zones has been detected. The gas bearing zones are found between (2365-2385.5) m, (1820-1830) m, (1782-1803) m, (305-308) m, (336.5-338.5) m, (607.5-609.5) m. These are the gas bearing zone of fenchugonj well-5 determined from the composite log of the field.

4.2. Resistivity and shale volume calculation

Formation water resistivity was determined from formula and taken as 0.1ohm-m, for well-4 and for well-5 it was taken as 0.7 ohm-m (from the provided composite log of well 4 and 5). Formation true resistivity $R_t$ was estimated directly from ILD log and true resistivity log. The average value of $R_t$ for well-5 was 33.75 ohm-m and for well-4 the value is 34.09 ohm-m, from RFOC log, flushed zone resistivity $R_{xo}$ is calculated directly. Shale volume was calculated by using Gamma ray log values and True resistivity method. For well 4, the average shale volume calculated using Gamma ray log was 15.47% and the average shale volume estimated using true resistivity method 6.22%. For well 5 the average shale volume calculated using Gamma ray log was 7.25% and the average shale volume estimated using true resistivity method was 7.64%. Table 1 and table 2 show the shale volume calculation of well 4 zone (1600-1610) m and well 5 zone (2365-2385.5) m, by using gamma ray and true resistivity methods. These shale volume results are used to find one of the most important reservoir properties known as porosity on which the determination of water saturation also dependent.

| Well 4 | Vsh from Gamma Ray log | Vsh from True resistivity method |
|-------|------------------------|-------------------------------|
| Depth, m | Log values (API) | Calculated | Log values (ohm-m) | Calculated |
| | GRlog | GRmax | GRmin | Ish | Vsh (%) | Rt (max) | Rt | Relay | Vsh (%) |
| 1600 | 95 | 130.0 | 35.0 | 0.632 | 33.63 | 42 | 15.0 | 5 | 27.02 |
| 1601 | 78 | 130.0 | 35.0 | 0.453 | 18.20 | 42 | 30.0 | 5 | 7.87 |
| 1602 | 72 | 130.0 | 35.0 | 0.389 | 14.24 | 42 | 30.0 | 5 | 7.87 |
| 1603 | 66 | 130.0 | 35.0 | 0.326 | 10.87 | 42 | 33.0 | 5 | 7.87 |
| 1604 | 70 | 130.0 | 35.0 | 0.368 | 13.05 | 42 | 33.0 | 5 | 5.90 |
| 1605 | 75 | 130.0 | 35.0 | 0.316 | 10.36 | 42 | 42.0 | 5 | 0.00 |
| 1606 | 67 | 130.0 | 35.0 | 0.337 | 11.39 | 42 | 40.0 | 5 | 1.79 |
| 1607 | 68 | 130.0 | 35.0 | 0.347 | 11.93 | 42 | 38.0 | 5 | 2.99 |
| 1608 | 75 | 130.0 | 35.0 | 0.421 | 16.14 | 42 | 40.0 | 5 | 1.79 |
| 1609 | 72 | 130.0 | 35.0 | 0.389 | 14.24 | 42 | 40.0 | 5 | 1.79 |
| 1610 | 75 | 130.0 | 35.0 | 0.421 | 16.14 | 42 | 37.0 | 5 | 3.56 |
| Average | 73.00 | 0.40 | 15.47 | 34.09 | 6.22 |
### Table 2. Shale volume (Vsh) estimation of well 5 from GR and TR methods

| Well 5 | Vsh from Gamma Ray log | Vsh from True resistivity method |
|--------|-----------------------|---------------------------------|
|        | Depth (m) | Log values (API) | Calculated | Log values (ohm-m) | Calculated |
|        | GRlog | GRmax | GRmin | Ish | Vsh (%) | Rt (max) | Rt | Rclay | Vsh (%) |
| 2365   | 80 | 145.0 | 55.0 | 0.278 | 8.62 | 42 | 40.0 | 5 | 1.79 |
| 2366   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 33.0 | 5 | 5.90 |
| 2367   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 30.0 | 5 | 7.87 |
| 2368   | 65 | 145.0 | 55.0 | 0.111 | 2.74 | 42 | 30.0 | 5 | 7.87 |
| 2369   | 72 | 145.0 | 55.0 | 0.189 | 5.17 | 42 | 28.0 | 5 | 9.34 |
| 2370   | 66 | 145.0 | 55.0 | 0.122 | 3.06 | 42 | 27.0 | 5 | 10.14 |
| 2371   | 68 | 145.0 | 55.0 | 0.144 | 3.72 | 42 | 28.0 | 5 | 9.34 |
| 2372   | 65 | 145.0 | 55.0 | 0.111 | 2.74 | 42 | 28.0 | 5 | 9.34 |
| 2373   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 30.0 | 5 | 7.87 |
| 2374   | 67 | 145.0 | 55.0 | 0.133 | 3.38 | 42 | 33.0 | 5 | 5.90 |
| 2375   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 30.0 | 5 | 7.87 |
| 2376   | 68 | 145.0 | 55.0 | 0.144 | 3.72 | 42 | 40.0 | 5 | 1.79 |
| 2377   | 75 | 145.0 | 55.0 | 0.222 | 6.38 | 42 | 34.0 | 5 | 5.30 |
| 2378   | 82 | 145.0 | 55.0 | 0.300 | 9.62 | 42 | 27.0 | 5 | 10.14 |
| 2379   | 120 | 145.0 | 55.0 | 0.722 | 44.61 | 42 | 13.0 | 5 | 32.70 |
| 2380   | 102 | 145.0 | 55.0 | 0.522 | 23.38 | 42 | 30.0 | 5 | 7.87 |
| 2381   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 42.0 | 5 | 0.00 |
| 2382   | 63 | 145.0 | 55.0 | 0.089 | 2.13 | 42 | 42.0 | 5 | 0.00 |
| 2383   | 70 | 145.0 | 55.0 | 0.167 | 4.43 | 42 | 40.0 | 5 | 1.79 |
| 2384   | 67 | 145.0 | 55.0 | 0.133 | 3.38 | 42 | 35.0 | 5 | 4.71 |
| 2385.5 | 66 | 145.0 | 55.0 | 0.122 | 3.06 | 42 | 24.0 | 5 | 12.89 |

**Average**

|        | 73.62 | 0.21 | 7.25 | 7.64 |

#### 4.3. Water Saturation estimation

Water saturation was calculated using three different methods because from the proper analyzation, the water saturation of the zone can be analyzed effectively. Methods are archie, Indonesia and simandoux to determine the water saturation. From figure 2, we can see that at 1600 m the degradation of all the graph takes place simultaneously that means the water accumulation takes place in low quantity from this depth. Archies ranging from (6-13) %, Indonesia ranging from (15-30) % and Simandoux ranging from (17-36) %.
Figure 2. Depth vs water saturation calculated using Archie, Indonesia, Simandoux formula (well 4)

For well 5, from figure 3 the value of average water saturation found from archie, Indonesia and simandoux model were 8.5%, 22% and 24.84% and for well-4, The value of average water saturation was found as 7.3%, 18%, 20.51% respectively. Table 3 and table 4 show the water saturation estimation of well#4 zone (1600-1610) m and well#5 zone (2365-2385.5) m, by using Archie, Indonesia and Simandoux methods.

Figure 3. Depth vs water saturation calculated using Archie, Indonesia, Simandoux formula (well 5)
Table 3. Water saturation estimation by Archie, Indonesia and Simandoux method for well 4

| Depth (m) | Rt (ohm-m) | Shale volume (%) | Porosity (%) | S_w (%) (Archie) | S_w (%) (Indonesia) | S_w (%) (Simandoux) |
|-----------|------------|------------------|--------------|------------------|---------------------|---------------------|
| 1600      | 15         | 33.63            | 20.22        | 0.124            | 0.300025883         | 0.36043735         |
| 1601      | 30         | 18.20            | 21.13        | 0.085            | 0.205753857         | 0.244073591        |
| 1602      | 30         | 14.24            | 23.01        | 0.079            | 0.193799707         | 0.224227987        |
| 1603      | 30         | 10.87            | 26.88        | 0.070            | 0.173607344         | 0.192023191        |
| 1604      | 33         | 13.05            | 23.19        | 0.075            | 0.183748748         | 0.212110295        |
| 1605      | 42         | 10.36            | 25.91        | 0.061            | 0.150602297         | 0.168337876        |
| 1606      | 40         | 11.39            | 26.20        | 0.062            | 0.153083395         | 0.170541937        |
| 1607      | 38         | 11.93            | 26.90        | 0.062            | 0.15415073          | 0.170431268        |
| 1608      | 40         | 16.14            | 25.26        | 0.064            | 0.157102533         | 0.17682069         |
| 1609      | 40         | 14.24            | 25.80        | 0.063            | 0.154795822         | 0.173198376        |
| 1610      | 37         | 16.14            | 28.28        | 0.061            | 0.150747927         | 0.164254594        |

Table 4. Water saturation estimation by Archie, Indonesia and Simandoux method for well 5

| Depth (m) | Rt (ohm-m) | Shale volume (%) | Porosity (%) | S_w (%) (Archie) | S_w (%) (Indonesia) | S_w (%) (Simandoux) |
|-----------|------------|------------------|--------------|------------------|---------------------|---------------------|
| 2365      | 40         | 8.622715         | 18.21396     | 0.082146         | 0.20918706          | 0.245325537         |
| 2366      | 33         | 4.426625         | 21.82683     | 0.078677         | 0.20159023          | 0.225504018         |
| 2367      | 30         | 4.426625         | 21.38717     | 0.08382          | 0.21462849          | 0.24137467         |
| 2368      | 30         | 2.736589         | 21.52886     | 0.083395         | 0.21358546          | 0.23981585         |
| 2369      | 28         | 5.173009         | 20.52583     | 0.089552         | 0.22899739          | 0.260316396        |
| 2370      | 27         | 3.055612         | 21.58433     | 0.087732         | 0.22471174          | 0.252135623        |
| 2371      | 28         | 3.72159          | 22.8569      | 0.082434         | 0.21152072          | 0.233799071        |
| 2372      | 28         | 2.736589         | 22.7181      | 0.082821         | 0.21247525          | 0.23524243         |
| 2373      | 30         | 4.426625         | 21.7158      | 0.082842         | 0.21222704          | 0.237723136        |
| 2374      | 33         | 3.383857         | 21.69967     | 0.079032         | 0.2024615           | 0.226842693        |
| 2375      | 30         | 4.426625         | 20.55268     | 0.086429         | 0.22101947          | 0.25117183         |
| 2376      | 40         | 3.72159          | 22.38763     | 0.07008          | 0.17970494          | 0.199699825        |
| 2377      | 34         | 6.375457         | 23.0751      | 0.074262         | 0.1906082           | 0.210118348        |
| 2378      | 27         | 9.615189         | 19.02027     | 0.096705         | 0.24664374          | 0.285972127        |
| 2379      | 13         | 44.60505         | 14.67312     | 0.17019          | 0.42972172          | 0.532971986        |
| 2380      | 30         | 23.37634         | 17.84607     | 0.086356         | 0.24519046          | 0.288775666        |
| 2381      | 42         | 4.426625         | 23.466       | 0.065958         | 0.16937922          | 0.185922107        |
| 2382      | 42         | 2.125179         | 24.45081     | 0.063902         | 0.16430187          | 0.178467003        |
| 2383      | 40         | 4.426625         | 24.1401      | 0.066129         | 0.16996156          | 0.185196798        |
| 2384      | 35         | 3.383857         | 22.19251     | 0.075425         | 0.19335897          | 0.215374238        |
| 2385.5    | 24         | 3.055612         | 20.31366     | 0.097505         | 0.24924582          | 0.284158564        |
5. Conclusion
Determination of reservoir characteristics and assessment of reserves are very essential and essential to the decision making of a reservation. Estimation offers the trust that producing from a reservoir is economically feasible, whether it is capable of price or not. Estimation of a hydrocarbon reserve is a complex process because it involves integrating geologic and engineering data. In this study, hydrocarbon i.e., gas bearing zones have been detected using composite log interpretation and found between (1585-1595) m, (1600-1610) m, (2409-2420) m, (2265-2270) m, (2435-2450) m, (2465-2480) m, (3150-3155) m, and (2955-2960) m for well-4 and between (2365-2385.5) m, (1820-1830) m, (1782-1803) m, (305-308) m, (336.5-338.5) m, and (607.5-609.5) m for well-5. In this research different methods are used for estimating some of the reservoir properties of Fenchugonj gas field well -4 and well-5. The water saturation was estimated by three different models as Archie’s, Indonesia and Simandoux method, respectively. For well-4, the value of average water saturations found from Archie, Indonesia and Simandoux model were 7.3%, 18%, 20.51% respectively and for well-5 the value of average water saturations was found as 8.5%, 22% and 24.84% respectively. Results showed that the water saturation obtained from Archie’s formulae was lower than the value of Indonesia and Simandoux model.

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