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FACUL TY OF MINERAL TECHNOLOGY 2nd INTERNATIONAL CONFERENCE ON EARTH SCIENCE, MINERAL AND ENERGY 2019 ART E H N S O C E IE C N N C E E R , E M F I N N O E C R L A A L N AN O I D T A E N N R E E R T G N Y I Co-Host:

Well Log Analysis and Geochemical 3 Data to Identify Source Rock and Hydrocarbon Reservoir: Northeast Java Basin Study Case

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Abstract. 3 Comprehensive characterizarion methods are carried out to determine accurate source rock and reservoir identification. Geochemical data has become a critical part of recent unconventional exploration and development. However, due to high cost of geological core extraction and analysis, geophysical wireline logging tools have become the primary source of downhole measurement of geomechanical properties. This study covers an integrated approach at defining geochemical report derived from geological core extraction and analysis and its relationship with geophysical wireline logs of 5 (five) wells at Northeast Java Basin. Geophysical wireline logs can be utilized to identify reservoir and source rock intervals in the early stage of well drilling. However, the well logs that directly measure the hidrogen content of the kerogen do no exist. Consequently, it is utilized for source rock evaluations and calculation of Total Organic Carbon (TOC) which are most commonly include sonic, density, gamma ray, neutron, and resistivity. The Van Krevelen diagram has been applied to all 5 (five) wells that indicates 2 (two) of them have potential gas – kerogen type III/IV with 13 marginally mature to mature source rock. The integration of well logs and geochemical data greatly improves the accuracy and understanding of the controls of reservoir quality and source rock. It can be used for further step of knowing basin potential and its prospect level.

Keywords : well log analysis, geochemical data, Total Organic Carbon, Northeast Java Basin

INTRODUCTION Petroleum is generated from organic-rich sediments (source rocks) containing organic matter originating from biological materials [1]. Source rock is one of the main elements of a hydrocarbon system. Therefore, to identify a region of hydrocarbon, it is necessary to investigate the source rock and its characteristics first [2]. Thermal maturity is the primary factor that determines whether a source rock can produce oil, gas, or condensate [3]. The study of source rocks is an important step towards accurate assessment of the hydrocarbon source potential of sedimentary rocks. The determination of the most favorable petroleum exploration targets depends on the geochemistry of source rocks and knowledge on the generation, migration and accumulation processes combined with the geophysical and geological features of the sedimentary basin under evaluation [4]. In order to evaluate the source rocks various laboratory methods are used. Among these techniques, Rock–Eval pyrolysis has been widely used in the industry as a standard method in petroleum exploration [3]. Petrophysical parameters are the most useful characteristics of reservoir for development and production of the drill well and estimation of reserves in any oil and gas field [5]. Reservoir rocks, which are porous and permeable sedimentary rocks containing water, oil or gas in their pore spaces, were identified using the gamma and the porosity (neutron-density) logs. Common reservoir rocks are sandstones and carbonate. Sandstone reservoirs exhibit very low radioactivity, because of low concentrations of radioactive elements [6]. Integration between gamma-ray (GR), resistivity, neutron (NPHI), and density log can differentiated a hydrocarbon and non-hydrocarbon bearing zone(s) within reservoir [7]. The East Java Basin is a basin that still produces oil and gas in Indonesia, one of the oil and gas fields is Kangean Block. Based on Mudjiono and Sayana, the North East Java Basin is controlled by two fault systems, that is, the horizontal fault system trending northeastsouthwest and east-west direction. This basin is formed by several main structural elements from south to north, namely: Kendeng Zone - The Madura Strait is elongated in the east-west direction which is characterized by a fold structure, normal faults and many upward faults. South Rembang Zone and Randublatung which are negative zones with east-west trending structural patterns characterized by folds. There is a dome structure that is associated with a fault structure. The North Rembang Zone and North Madura, the anticlinorium structure that was elevated and eroded in Pliocene-Plistocene associated with a horizontal fault system drifted in a continuous northeast-southwest direction to South Kalimantan [8]. The Petroleum System is a component that must be owned to allow the accumulation and accumulation of an oil in a basin, including the East Java Basin, which is a hydrocarbon producer [9]. The petroleum system consists of important components, source rock in the North East Java Basin originates from shale derived from marginal marine, deltaic, and lacustrine environments. The Ngimbang Formation, mainly originating from the Central Deep Basin with kerogen types II and III so as to produce oil and gas [10]. Deep sea shale at the bottom of the Kujung Formation are also potential as source rock. Reservoirs are rocks with porosity and permeability that are good for storing and flowing hydrocarbons. The main reservoirs in this basin are the carbonate rocks of the Ngimbang Formation and the Kujung Formation as well as the siliciclastic reservoir of the Ngimbang Formation, Tuban Formation and the Ngrayong Formation. Hydrocarbon migration divided into primary migration is the transfer of hydrocarbon fluid from the host rock to reservoir rock and secondary migration is the movement of fluid in the reservoir through the trap. Stone hoods have a role as nonpermeable insulation such as claystone. The rock seals in this basin are shale of the Ngimbang Formation, Tuban Formation, Wonocolo Formation, and Lida Formation. Tuban shale is a covering rock that has a thickness of 500 - 1500 m the North East Java Basin [11]. The types of traps in all East Java petroleum systems generally have similarities. This is due to tectonic evolution that occurs in all sedimentary basins along the southern boundary of the Sunda palace so that the type of geological structure and trap mechanism become relatively similar. The structure traps that developed in the form of anticlines and faults and stratigraphic traps were found when the sandstone unit rested (onlap) and covered part of the bedrock height [9]. The aim of this study is to examine geochemical and petrophysical characteristics of Kangean Block for better understanding the petroleum play.

MATERIALS AND METHODS Well-logging Method: Well logging in oil industry has its own meaning; log means “record against depth of any of the characteristics of the rock formations traversed by a measuring apparatus in the well bore”. The value of the measurement is plotted continuously against depth in the well [12]. The types of logging used are gamma ray log, log density, neutron log, resistivity log, and sonic log. Qualitative interpretation in this study uses gamma ray logs to identify permeable zones, if a low gamma-ray log value identifies a permeable zone due to the presence of natural radioactive elements not concentrated in zones with low permeability but concentrated in zones with high permeability such as clay or shale. Next, look at the cross-over NPHI curve or Neutron Porosity Hydrogen Index against the RHOB or bulk density curve which is overlaid with a range of opposite curves so that the interpretation process is easier to see cross-over [13]. Reservoir Characterization: In doing this there are several parameters used, namely shale volume (Vsh), porosity, water resistivity (Rw), water saturation (Sw) and permeability (k) where the parameters are related to each other [14]. This study uses the calculation of Sw from the Archie method, the parameters used are Rw, resistivity values read by LLD or ILD curves, effective porosity (Phie) values, and provision values, namely cementation factor values according to target zone lithology if the limestone is 2 and sandstone is valued at 2.15, the value of the factor is according to the target zone lithology if the limestone is 1 and the sandstone is 0.62, and the general saturation exponent value is 2. The Simandoux method, the parameter used is Rw, Vsh, the resistivity value that results from reading the LLD or ILD curve, the Phie value, and the solid shale resistivity value from the reading of the maximum gamma ray curve or shale. This method is very good in calculating Sw in formations that have high water salinity and only densely covers high salinity zones. The Indonesian method, the parameter used is Rw, Vsh, the resistivity value reads the LLD or ILD curve, Phie value, and shale resistivity value. The high content of clay ranges from 30-70% which is often found in oil reservoirs in Indonesia and this calculation is very good in calculating Sw in formations containing low salinity. In this method, the relationship of conductivity between Rt and Sw is the result of clay conductivity, formation water and other conductivity caused by interactions between the two conductivity [15]. RESULTS AND DISCUSSION Petrophysical Analysis : on 5 wells that have a log data record that is quite complete, namely well AR-1 with MD depth of 10,0105 ft, BL-1 well with a depth of 13,700 ft. BT-1 well with a depth of 4279 ft, BG-1 well with a depth of 2530 meter, and TG-1 well with a depth of 7444 ft. To conduct a petrophysical analysis the author divides 2 stages, namely qualitative interpretation and quantitative interpretation until the calculation of permeability. Qualitatively, the 4 wells have a reservoir zone, that is, in the TG-1 well at 2300-2350 ft (Figure 1) with a thickness of 50 ft, limestone lithology has a gamma ray range value of 23.28 - 31.1 API, resistivity range value 1.32 - 91.35 ohm.m, the RHOB range value is 1.85 2.00 g/cc, and the NPHI range value is 0.15 - 0.42 v/v. BT-1 well has a reservoir zone 12 at a depth of 3150-3288 ft in Figure 2 with a thickness of 138 ft, limestone lithology has a gamma ray range value of 10.57 - 37.34 API, resistivity range value 0.95 - 8.97 ohm.m, RHOB range value 1.56 - 1.99 g/cc, and NPHI range value 0.13 - 0.46 v/v. In the AR-1 well has a reservoir zone 12 at a depth of 3055-3157 ft in Figure 3 has a ray gamma range value of 30.40 - 53.19 API, resistivity range value 0.53 - 0.93 ohm.m, RHOB range value 1.68 - 2.04 g/cc, and range value NPHI 0.37 - 0.51 v/v. In BL-1 well has a reservoir zone at a depth of 7100-7315 ft in Figure 4 gamma ray range values 84.98–108.17 API, resistivity range values 1.21 - 2.07 ohm.m, RHOB range values 1.7 - 2.30 g/cc, and NPHI range values 0.23 - 0.60 v/v. Figure 1. Reservoir zone in TG-1 wells at depth of 2300-2350 ft Figure 2. Zone A in the layout of the BL-1 well at depth of 7100-7315 ft

Figure 3. Reservoir zone in BT-1 well at depth of 3150-3288 ft Figure 4. Zone A in the layout of the AR-1 well at depth of 3055-3157 ft Quantitatively, in the reservoir zone carried out is a petrophysical analysis, from the petrophysical analysis performed calculations and produce parameters in reservoir characterization in this study are 17 Shale Volume (Vsh), Effective Porosity (ϕ), Water Resistivity (Rw), Water Saturation (Sw) and Permeability (K) of 4 wells (Table 1-4).

Table 1. Results Calculation of TG-1 WELL NAME DEPTH (FT) ZONE THICK NESS

LITHOLO GY FORMATI ON Vsh (%) PHIE (%) Sw (%) K (mD) TG-1 23002350 A 50 Sandstone Mundu 34.053 17.098 12.90 325.936 Table 2. Results Calculation of AR-1 WELL NAME DEPTH (FT) ZONE THICK NESS LITHOLOG Y FORMA TION Vsh (%) PHIE (%) Sw (%) K (mD) AR-1 30553157 A 102 Limestone Mundu 22.01 29.24 0.4869 604877.314 Table 3. Results Calculation of BL-1 WELL NAME DEPTH (FT) ZONE THICK NESS LITHOLO GY FORMA TION Vsh (%) PHIE (%) Sw (%) K (mD) BL-1 71007315 C 215 Limestone Upper Cepu 48.69 31.074 48.04 1361.343034 Table 4. Results Calculation of BT-1 WELL NAME DEPTH (FT) ZONE THICK NESS LITHOLO GY FORMA TION Vsh (%) PHIE (%) Sw (%) K (mD) BT-1 31503288 A 138 Limestone Mundu 23.298 28.915 2.155 613039.061 Geochemical 1 analysis, in this study using Rock Eval Pyrolysis (REP) is an analysis of hydrocarbon components in source rock by means of gradual heating of the host rock samples in an oxygen-free state where the programmed temperature is inert (Table 5). From the heating, the solid separates free organic components and components that are still bound in the host rock. 1 The results of the REP analysis are populated with several parameters, namely the values of S1, S2, S3, Tmax and combinations, namely PY, PI and HI (Table 6). Table 5. Ro values on 5 wells in the Kangean block Well Name Depth (Ft) Ro (Ohm.m) BG-1 2200 0.67 TG-1 4000 0.21 BT-1 - AR-1 5720 0.31 BL-1 7600 0.41 Table 6. Results of REP analysis on 5 wells in the Kangean block Well Name Depth (Ft) S1 (mgHC/gRk) S2 (mgHC/gRk) S3 (mgCO2/gRk) Tmax (degC) PY PI HI (mgHC/gTOC) BG-1 2200 4.22 2.21 1.28 361 2114.2 0.998 329.69 TG-1 4000 0.028 0.627 0.162 435 0.655 0.0427 120.58 BT-1 - - - - - - - -
AR-1 5720 0.2 2.23 - 420 2.43 0.0823 128.16 BL-1 7600 0.07 1.63 - 435 1.7 0.0412 206.329 CONCLUSIONS Reservoir layers in 5 wells in Kangean block are break down into some conclusions. TG-1 well in Zone A with lithology limestone and sandstone, indicated gas reservoir and oil reservoir. BT-1 well in Zones A and B with Limestone and Sandstone lithology, indicated gas reservoir layers, oil reservoirs and water reservoirs. The AR-1 well in Zones A and C with lithology limestone and Sandstone, indicated a gas reservoir layer. BL-1 well in Zone A with lithology limestone, which is indicated by a gas reservoir layer.

Source Rock Layer on 5 wells in Kangean block vary into different depths, BG-1 well at 2200 feet with core TOC 1.01 and TOC Log 0.8, Tmax 361 degC and Hydrogen Index 329.69 mgHC/gTOC which are in the category of kerogen type III rock. The TG-1 well was at depth 4000 feet with core TOC values 0.52 and TOC Log 0.22, Tmax 435 degC and Hydrogen Index 120.58 mgHC/gTOC were included in the category of kerogen type IV rock IV. AR-1 well at depth 5270 feet with 1.74 of TOC Core values and TOC Log 1.65, Tmax 420 degC and Hydrogen Index 128.16 mgHC/gTOC which are included in the kerogen type II and III source rock categories. The maturation level of the reservoir zone hydrocarbons in the Kangean block is immature in BG-1 well but mature wells in TG-1 and AR-1 wells. REFERENCES 1. K. E. Peters and M. R. Cassa, "Applied Source Rock Geochemistry," AAPG Mem. 60, no. AAPG Special Publications, pp. 93–120, 1994. 2. M. M. El Nady, N. M. Lotfy, F. S. Ramadan, and M. M. Hammad, "Evaluation of organic matters, hydrocarbon potential and thermal maturity of source rocks based on geochemical and statistical methods : Case study of source rocks in Ras Gharib oilfield , central Gulf of Suez , Egypt," Egypt. J. Pet., vol. 24, no. 2, pp. 203–211, 2015. 3. M. M. El Nady and M. M. Hammad, "Organic richness , kerogen types and maturity in the shales of the Dakhla and Duwi formations in Abu Tartur area , Western Desert , Egypt : Implication of Rock – Eval pyrolysis," Egypt. J. Pet., vol. 24, no. 4, pp. 423–428, 2015. 4. A. Devi, S. Boruah, and G. B. Gilfellon, "Geochemical Characterization of Source Rock from the North Bank Area , Upper Assam Basin," J. Geol. Soc. INDIA, vol. 89, no. April, pp. 429–434, 2017. 5. M. A. Habib, M. T. Islam, and M. R. Mita, "Interpretation of wireline log data for reservoir characterization of the Rashidpur Gas Field, Bengal Basin, Bangladesh," IOSR J. Appl. Geol. Geophys., vol. 1, no. 4, pp. 47–54, 2013. 6. A. S. Mjili and G. D. Mulibo, "Petrophysical Analysis of Reservoirs Rocks at Mchungwa Well in Block 7 Offshore , Tanzania : Geological Implication on the Reservoir Quality," Open J. Geol., vol. 2018, pp. 764–780, 2018. 7. J. O. Amigun, B. Olisa, and O. O. Fadeyi, "Petrophysical analysis of well logs for reservoir evaluation : A case study of ' Laja ' Oil Field , Niger Delta," J. Pet. Gas Explor. Res., vol. 2, no. 10, pp. 181–187, 2012. 8. C. Aprilana et al., "New Prespective

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