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Reservoir quality assessment by petrographic and petrophysical analyses in Kupe Gas Field, Southern Taranaki Basin, New Zealand

S.M. Talha Qadri; Md. Aminul Islam and M.R. Shalaby*
Department of Physical and Geological Science, Faculty of Science, Universiti Brunei Darussalam

Summary

Present study evaluates the Farewell Formation which is an important reservoir of the Kupe Field, located in the southern Taranaki Basin, New Zealand. It includes petrographical and well log analyses coupled with impact of diagenesis on the reservoir quality of Kupe Field. The petrographical study was carried out on Kupe South–1, Kupe South–2, Kupe South–3, Kupe South–4 and Kupe South–5 wells by considering datasets and designing cross plots between different petrographical parameters e.g. grain size, porosity, permeability and the total cement concentrations etc. The study indicates that Farewell sandstone are ranging from Feldspathic arenite to Lithic arenite. Detrital mineralogy is dominated by quartz and feldspar. The total porosity within the Farewell Formation ranged between 10.29–26.2% while the permeability ranged between 0.43–1376 mD, thus showing good to very good reservoir quality. Petrophysical analyses from Kupe–1, Kupe South–2, Kupe South–5 and Kupe South–7 wells helped to double check the parameters which play a vital role in determining the reservoir quality i.e. volume of shale, total and effective porosities, water and hydrocarbon saturations, presence of net pay zones. The low volume of shale ranged between 11.4–28.9%, while total and effective porosities ranged between 18–32.8% and 16–26% respectively. Water saturation was observed between 23.9–45.3% while the hydrocarbon saturation was observed between 54.7–76.1%. Presence of nine pay zones with significant hydrocarbon saturations reconfirmed the Farewell Formation as a good to very good reservoir.

Theory / Method / Workflow

MBIE–New Zealand provided 66 cores based petrographical and petrophysical data points of Farewell Formation from the Kupe South–1, Kupe South–2, Kupe South–3, Kupe South–4 and Kupe South–5 wells. Reservoir quality was evaluated by the relationships between certain parameters e.g. porosity, permeability, cement and authigenic clay (total cement content). The statistical analysis of the provided data points helped to understand the control of these parameters on the reservoir quality. Moreover, the petrophysical analyses from well log data of Kupe–1, Kupe South–2, Kupe South–5 and Kupe South–7

wells helped to determine the reservoir quality by estimating the vertical distribution of various petrophysical parameters. The porosity is evaluated by using sonic, density, neutron and their combination. A 10% porosity cut–off was used to identify more promising sand zones from the less porous and permeable sand intervals (El-Din et al., 2013). The neutron porosity was calculated based on response given by the neutron tool while Wyllie equation (Wyllie, 1963) was used to calculate the sonic and density porosity. Shale volume content is an important petrophysical parameter to assess the reservoir quality. Low shale volume content within the pore spaces indicates the possibility of a good reservoir quality. In addition to shale concentration, it is also important to identify the type of shale distribution throughout the reservoir formation. The type of shale distribution was identified by using neutron porosity versus density porosity cross plot. A 50% shale cut off was also applied to differentiate between shale rich and sand rich intervals within the reservoir formation. Net pay is evaluated by applying 50% water saturation cut off, which helped to identify the hydrocarbon zones and estimated net/gross thickness in the present study.

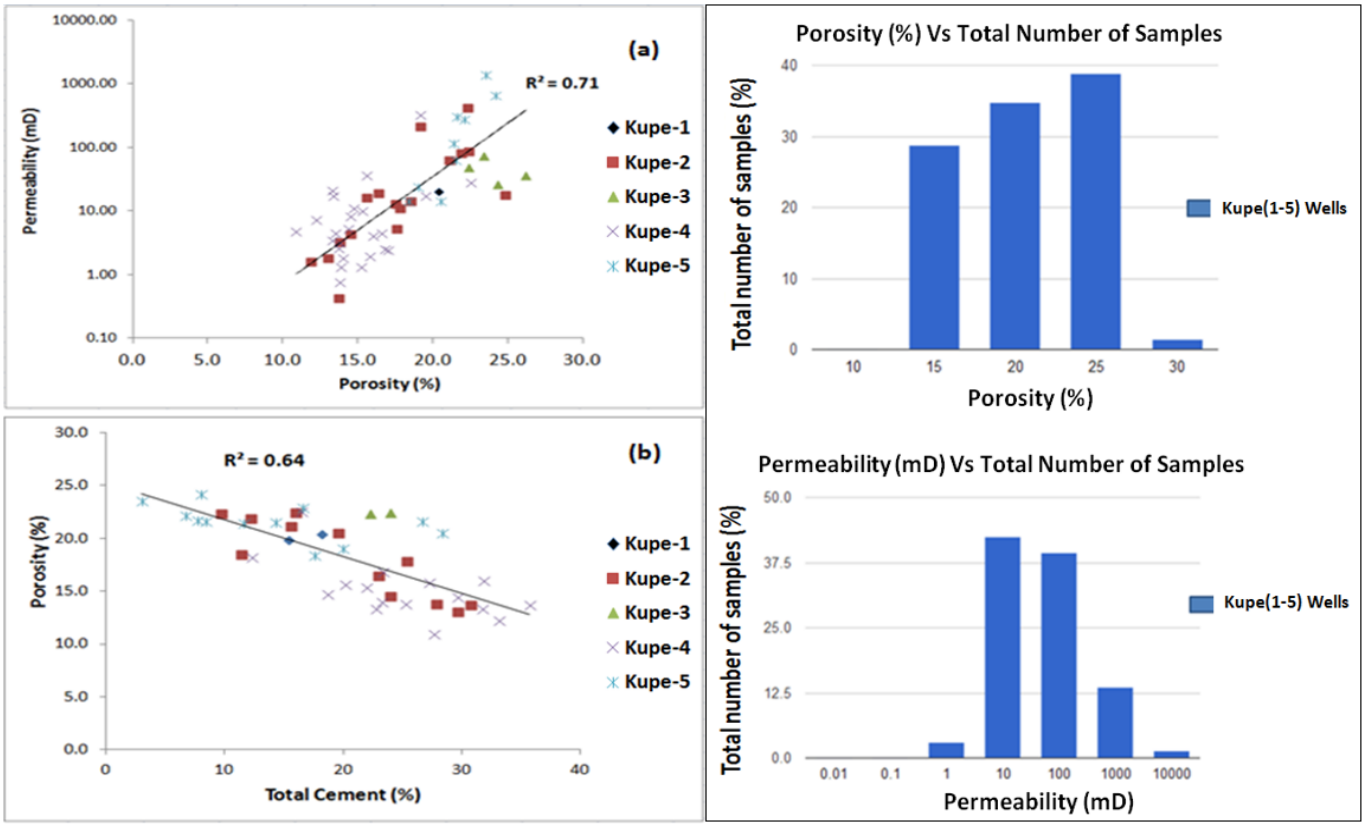

Figure 1: Graphical relationships between porosity with permeability and total cement (at left); Histogram showing porosity and permeability w.r.t total number of analyzed samples (at right).

Results, Observations, Conclusions

Farewell Formation in the Kupe Gas Field is mainly composed of fine to very coarse-grained sandstone with intercalation of shale and carbonates. Detrital mineralogy of the Farewell sandstones is mainly arkosic arenite to lithic arenite. Carbonate and authigenic clay are the most common diagenetic minerals found in the studied samples of Farewell sandstone Formation. The clay content lies between 3% and 35% of the total cement concentration while the carbonate cement exhibits a variable distribution ranging between 0.2% and 18% of the overall cement within the analyzed samples. Reservoir quality is also evaluated by establishing statistical relationships between various parameters e.g. gran size, porosity, permeability and total cement contents etc. In the study area, porosity varies from 10.9–26.2% while permeability range between 0.43 and1376 mD within studied wells. The reservoir classification devised by Levorsen based on porosity and permeability (Levorsen, 1967) indicates Farewell Formation as a very good reservoir. A strong positive correlation (r^2 = 0.71) is observed between porosity and permeability. This explains that the formation has ability to store and transmit the fluids and can act as a good reservoir. An inverse correlation (r^2 = 0.64) is observed between porosity and total cement. It means that due to cementation of different types within the pore spaces has reduced the porosity and impeded the reservoir character of the formation.

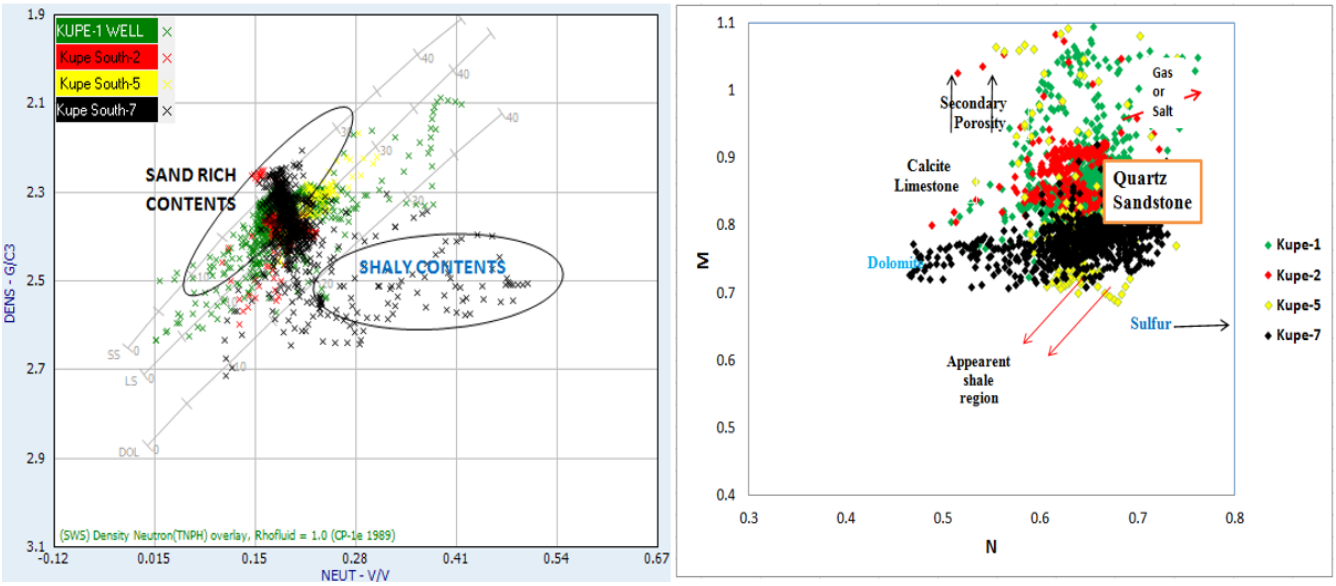

Figure 2. Neutron versus density cross plot and M-N cross plots indicating the lithological and mineralogical composition of the reservoir formation

Qualitative petrophysical analysis was conducted to identify the lithological and mineralogical composition of the reservoir formation, using neutron versus density logs and M-N cross plots. The neutron versus density cross plot shows that the Farewell Formation within the analyzed wells of Kupe Gas Field, mainly

comprises clean to shaly sandstone, carbonates and shale. The M–N cross plot indicates that most of the data points represents sandstone as the dominant lithology within the reservoir formation. The data points represent sandstone as the dominant lithology within the reservoir formation. The data sets also reveal the presence of carbonate and shale. Petrophysical properties such as shale volume, porosity, water saturation and hydrocarbon saturation were evaluated by well log analysis conducted on Kupe–1, Kupe South–2, Kupe South–5 and Kupe South–7 to double check the reservoir quality of the Kupe Field. The type of shale distribution was identified by Neutron porosity versus density -porosity cross plot. The data points from the studied wells mostly revealed the dispersed nature of shale distribution. That is why Kupe–1, Kupe South–2, Kupe South–5 and Kupe South–7 wells were subjected to dual water saturation model for precise calculations of hydrocarbon. The total porosity type was determined by using the neutron–density porosity versus sonic porosity cross plots. Most of the data points within the cross plot indicate the presence of intergranular and secondary porosities. These findings agree to the results inferred from petrographical and diagenetic analyses. After applying 10% porosity cut off the total porosity observed for the studied wells ranged between 18–32.8% while the effective porosity estimated for the studied wells ranged between 16–26%. To differentiate between net pay and non-pay (water saturated) zones a water saturation cut-off 50% was used. After applying the cut–off, it was observed that water saturation exhibited by Farewell sandstones ranges between 23.9–45.3%. Integrating results obtained from petrographical and petrophysical data sets indicate the Farewell Formation as a good reservoir.

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References

Wyllie MRJ (1963). The Fundamentals of Well Log Interpretations. Academic Press, New York.

Levorsen AI (1967) Geology of Petroleum, W.H. Freeman Company, San Francisco, USA.

El–Din ES, Mesbah MA, Kassab MA, Mohammed IF, Cheadle BA (2013) Assessment of petrophysical parameters of clastics using well logs: The Upper Miocene in El–Wastani gas field, onshore nile Delta, Egypt. Petrol.Explot. Develop.40(4), 488–494.