Characterization of Flow Units in a Carbonate Reservoir: A Case Study

Peyman Mohammadmoradi, University of Calgary

Alireza Rahimzadeh, Petropars Ltd.

Summary

This paper summarizes a practical scheme for reservoir rock typing applied in a gas condensate field. A new formulation of rock typing is presented which demonstrates consistent flow unit classification for under consideration carbonate formations in compare with other conventional methods. Mercury injection test, CCAL and SCAL data and interpreted logs of the appraisal wells are used to validate the accuracy of the new classification method. Capillary pressure and relative permeability curves are then calculated for drainage and imbibition scenarios.

Introduction

Most challenging part of the basic reservoir studies is rock type definition to classify reservoir into distinct flow units. An integrated rock typing methodology guarantees proper saturation functions determination, consistent water saturation propagation with log data and reliable dynamic properties characterization. Numerous quantitative rock-typing procedures have been investigated in the literature; Winland method, RQI and Swi methods are used more frequently. Winland formula is the only approach which considers permeability and quality of reservoir is characterized by flow units which are controlled by hydrocarbon storage and flow capacity. Here, Winland equation is modified based on mercury injection (MICP) data then used to categorize core data (CCAL, SCAL) and extract saturation functions.

Theory

Porosity, permeability and pore size distribution characterize the rock texture while capillary pressure, relative permeability and wettability describe the rock-fluid interaction. Rock typing is thus a procedure by which several petrophysical parameters and dynamic measurements are integrated with geological facies (lithofacies) to estimate their flow behavior. Here a new statistical computer application is implemented to establish a correlation between permeability, porosity and pore throat size values based on an empirical correlation, validated by 133 sets of MICP data. Good consistency was observed between lithotypes and rock types to compromise the views of both geologists and reservoir engineers.

Examples

Rock type distribution for available core data based on new empirical correlation is presented in the following figure.
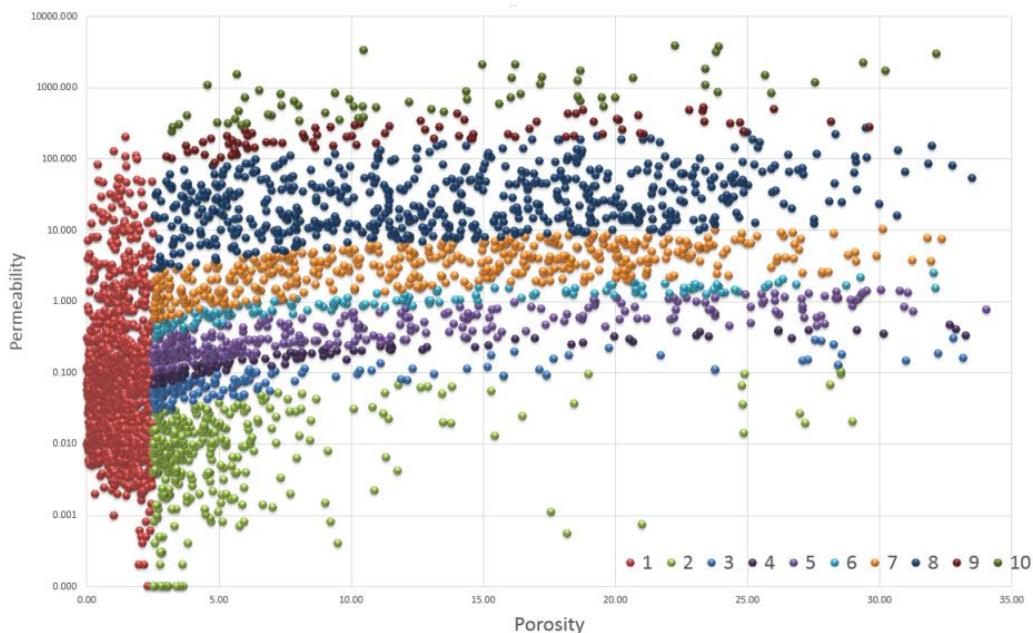

Figure 1 CCAL data classification based on presented approach

Capillary pressure and relative permeability curves are then calculated by averaging all experimental data available for each rock type.
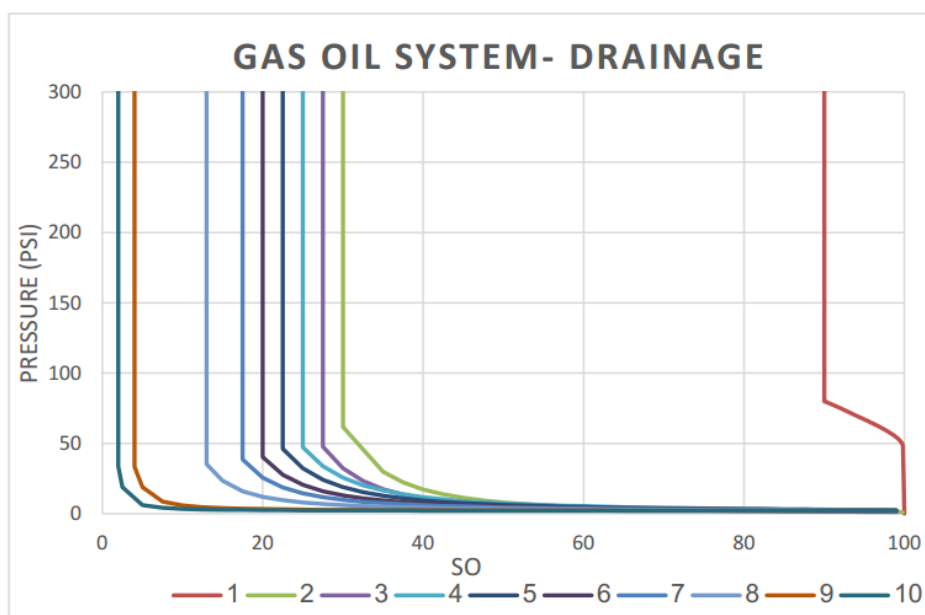

Figure 2 Drainage Capillary Pressure Curves (gas-oil system)

To validate the rock typing scheme, well saturation profile for appraisal well is produced and compared with log data. In figure below, a sample of decent match between produced dynamic saturation log and petrophysical interpreted saturation log is depicted.
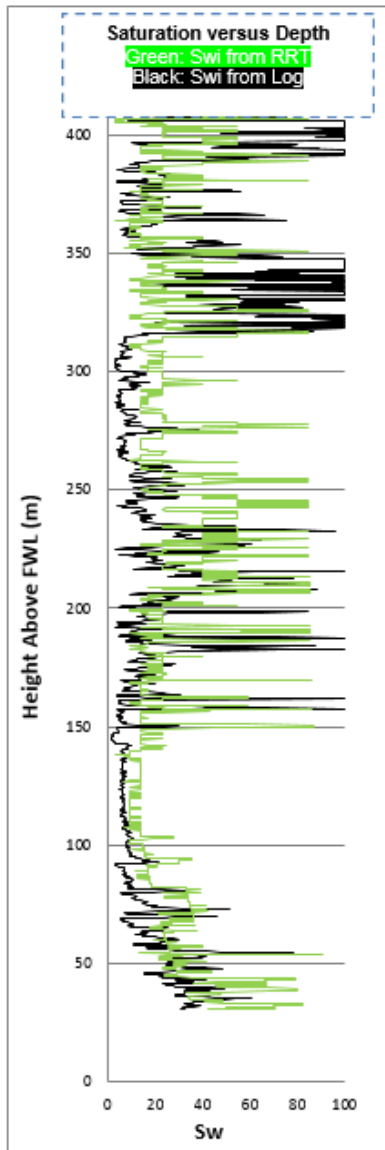
Figure 3 Water saturation log, petrophysical (Black) and derived saturation log based on rock types (Green)

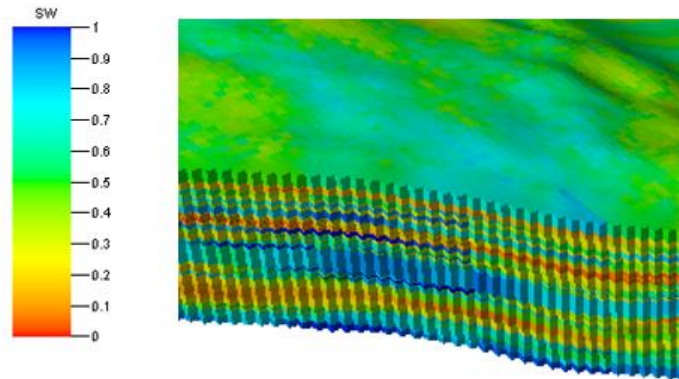Then water saturation is propagated through the model using porosity as secondary trend.

Figure 4 A snapshot of the water saturation model (Water saturation model is constructed based on rock type propagation)

Conclusions

One of the main challenges incorporated in the modeling of the under consideration field with four carbonate formations is appropriate method of reservoir rock typing to extract the saturation function curves appropriately. The results show that reservoir rock typing based on the new approach is a suitable technique for description of reservoir heterogeneity, recognition of reservoir units and identifying factors controlling reservoir quality of the under consideration field. The new formula for carbonate reservoir rock typing displayed perfect classification in regards to dynamic parameters such as capillary pressure and relative permeability.

References

[1] Chekani, M., & Kharrat, R. (2009, January 1). Reservoir Rock Typing in a Carbonate Reservoir—Cooperation of Core and Log Data: Case Study. Society of Petroleum Engineers. doi:10.2118/123703-MS

[2] Gomes, J. S., Ribeiro, M. T., Strohmenger, C. J., Naghban, S., & Kalam, M. Z. (2008, January 1). Carbonate Reservoir Rock Typing - The Link between Geology and SCAL. Society of Petroleum Engineers. doi:10.2118/118284-MS

[3] Skalinski, M., & Kenter, J. (2013, January 1). Carbonate Petrophysical Rock Typing - Integrating Geological Attributes and Petrophysical Properties While Linking With Dynamic Behavior. Society of Petrophysicists and Well-Log Analysts.