Ronal Barcala Alvarez*), Sebastian Waszkiewicz)**

Total Organic Carbon determination using TOC Application in Geowin system - case studies from Poland and Cuba

*) UNESCO AGH fellow, Oil Cuban Union
**) Ph.D. student at the AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Department of Geophysics

Introduction

Total organic carbon (TOC) belongs to a group of geochemical indicators of the hydrocarbon generation potential in rocks. Unconventional hydrocarbon resources with TOC above 2%wt can be considered as a source rocks. Petrophysical base of TOC understanding is presented in figure 1.

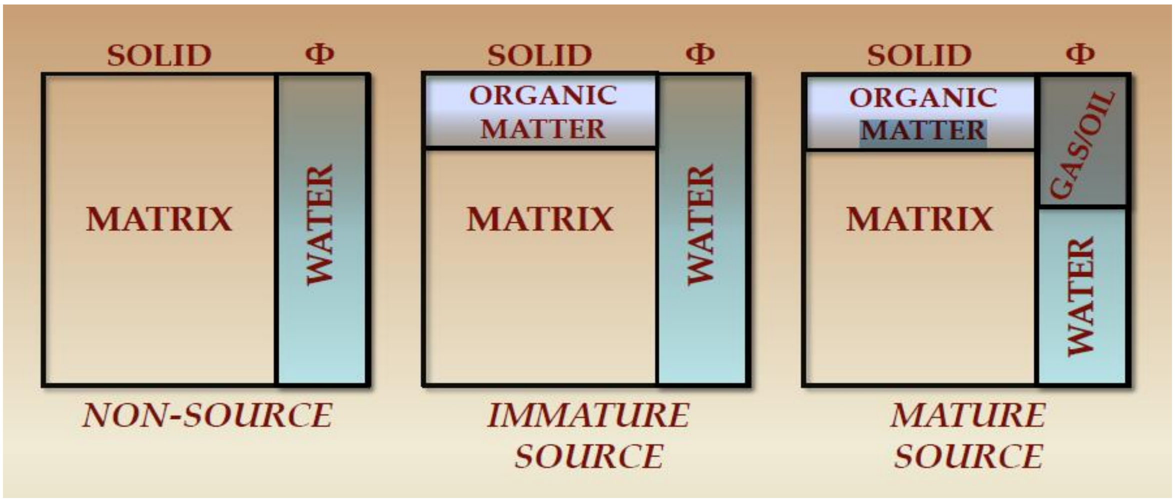

Fig. 1 Source rock composition (after Philippi (1968), Nixon (1973) and Meissner (1978) included in Bowman T. presentation, 2010)

Rock-Eval or other geochemical laboratory investigations are useful tools for TOC determination. Scientists, industry engineers and other practitioners use several TOC calculating methods basing on well logging data.

Methods and data sets

The frequently used is the method based on the combination/comparison of well logging traces in proper scale. This popular Passey et al. (1990) idea and it's modifications are based on the following curves: deep resistivity log (LLd or ILd), transit interval time from sonic log (DT), neutron porosity (NPHI) and bulk density (RHOB). Bowman …. (2010) method belongs to the same group of solutions. For each of the porosity related curves a synthetic curve from resistivity is calculated. This is made by plotting the resistivity logarithm vs. any of the porosity curves (Neutron, Acoustic or Density). Then, a regression line is selected. This one is a trend line representing clays with low content of organic matter. Difference between these synthetic curve and the original one, multiplied by the scale factor, represents the parameter Δ log R which is converted to TOC.

Another, also popular Schmoker (1979) method is based only on bulk density data. Volume of TOC and bulk density are combined by empirical formula:

$$TOC = \frac{a}{\rho_b} - b \qquad (1)$$

where: a and b are constants which should be calculated for a particular formations and ρ_b is bulk density.

To obtain TOC there are also considered empirical methods – statistical relationships. Among others there are used linear (2) and multidimensional (3) relations (Waszkiewicz 2018):

$$TOC = a(U - U/K) + b \qquad (2)$$

$$TOC = a_1 \cdot X_1 + a_2 \cdot X_2 + \cdots + a_n \cdot X_n + b \qquad (3),$$

where: U, K are uranium and thorium contents from spectral gamma ray log, X_1, X_2,…,X_n are logs selected by interpreter in the process of statistical approach to TOC determination, and a, $a_1, \dots, a_n, b$ are statistically evaluated constants.

The described methods were applied to well logging data from the Polish, Silurian and Ordovician shaly sediments in Baltic Basin, Poland (Kiersnowski and Dyrka, 2013) and the most productive Cuban oilfield of Cretaceous and Jurassic sediments located at N-NW of Hicacos peninsula (Tamayo, 2015).

Conclusions

Coefficients of determination describing the relationships between calculated and laboratory measured TOC values for empirical methods are bigger than for the Passey and Schmoker methods. Use of the empirical methods enables to devoid a subjective factor in comparison to the Passey method and locally determined coefficients in the Schmoker method. In the intervals of bigger TOC concentration determination coefficients are higher. Combining data for regression for several wells did not give appropriate results. The results depend on conditions like burial depth, type of kerogen.

In the case of Cuban data according to calibration, the Bowman method shows better results than Passey method. Calculated TOC curves well define source potential of rocks in close boreholes. Formations with high source potential show similar behavior from well to well.

Acknowledgments

Authors would like to thank PGNiG SA for Polish data sharing and support, and CUPET Company which provided the Cuban data.

References

Bowman T., 2010 - Direct Method for Determining Organic Shale Potential from Porosity and Resistivity Logs to Identify Possible Resource Plays. Search and Discovery Article #110128 (2010) Posted June 14, 2010, Adapted from oral presentation at session, Genesis of Shale Gas-Physicochemical and Geochemical Constraints Affecting Methane Adsorption and Desorption, at AAPG Annual Convention, New Orleans, LA, April 11-14, 2010

Kiersnowski H., Dyrka I. 2013, Ordovician-Silurian shale gas resources potential in Poland: Evaluation of Gas Resources Assessment Reports published to date and expected improvements for 2014 forthcoming Assessment. Przegląd Geologiczny, vol. 61, nr 11, s. 639–656

Meissner F.F., 1978 - Petroleum geology of the Bakken Formation, Williston Basin, North Dakota and Montana in Montana Geological Society, The Economic geology of the Williston Basin; Montana, North Dakota, South Dakota, Saskatchewan, Manitoba, p. 207-227

Nixon R.P., 1973 - Oil Source Beds in Cretaceous Mowry Shale of Northwestern Interior United States: AAPG Bulletin, v. 57/1, p. 136-157

Passey Q.R., S. Creaney, J.B. Kulla, F.J. Moretti, J.D. Stroud, 1990 - A practical model for organic richness from porosity and resistivity logs: AAPG Bulletin, vol. 74, p. 1777-1794

Philippi G. T., 1968, Essentials of the petroleum formation process are organic source material and a subsurface temperature controlled chemical reaction mechanism, in Advances in organic geochemistry: Oxford, Pergamon Press, p. 25-46

Schmoker J., 1979 - Determination of Organic Content of Appalachian Devonian Shales from Formation Density Log. AAPG Bulletin, vol. 63, pp. 1504-1537

Waszkiewicz S., Karczewski J, Krakowska P., Jarzyna J., 2018, Wyznaczanie całkowitej zawartości węgla organicznego TOC w skałach łupkowych z wykorzystaniem profilowań geofizyki otworowej na przykładzie danych z basenu bałtyckiego. Nafta-Gaz, vol. 74/11, s. 789-795

Tamayo, Y, 2015 - "Evaluación de las litofacies en el yacimiento Varadero Oeste mediante el uso de atributos sísmo estratigráficos, para determinar su continuidad lateral". Applied Geopyhsics Master Thesis, Library of Technological University of Havana "José Antonio Echeverría"