Petroleum Research

Petroleum Research 2018(April -May), Vol. 28, No. 98. 1-5

DOI: 10.22078/pr.2017.2717.2256

Considering the Importance of Calculating the Winland Method Coefficients in Carbonate Reservoirs, Case Study of Kangan and Dalan Formations, Central Persian Gulf

Vahid Tavakoli*, Hossain Rahimpour-Bonab and Mehdi Sahab Peyghambar Doust

School of Geology, University of Tehran, Tehran, Iran

Vtavakoli@ut.ac.ir

Received: March/28/2017 Accepted: October/09/2017

Abstract

In order to produce and develop hydrocarbon fields, understanding of the exact nature of the reservoirs is necessary. Various criteria have been taken into consideration in the zonation of reservoirs and reservoir intervals to separating net and non-pay intervals. Separating the reservoir based on rock type concept can fix the geological disadvantages of conventional zonation methods based on lithology or sedimentological facies. In this study, five rock types have been achieved in carbonate-evaporates of Kangan and Dalan formations from the standard Winland method with Winland's coefficients. Modified coefficients have been resulted in the determination of four rock types. Results have been showed that determining the rock types based on standard Winland method produces a huge error so that the pore sizes will be three times larger than the real values. Therefore, rock typing with new presented coefficients increases the precision of the calculations and better understanding of the reservoir nature. Integrating these data with thin section studies shows that dolomitization and dissolution are two important diagenetic processes that change reservoir properties in these determined rock types.

Keywords: Mercury Injection Capillary Pressure, Rock Types, Winland Method, Pore Throat Radius.

Introduction

Understanding of the exact nature of the reservoirs is crucial for hydrocarbon production and field development. Various criteria are taken into consideration in the zonation of reservoirs and reservoir intervals to separating net and non-pay intervals. Analyzing the reservoir based on rock type concept can fix the geological disadvantages of conventional zonation methods based on lithology or sedimentological facies [1, 2, 3, 4, 5, 6, 7]. Each of these rock types and their related calculating formula invented based on a dataset which vary from field to field. So, modifying the constants and coefficients is crucial for any reservoir study. This is more important in carbonate reservoirs with more heterogeneity. Winland (1972) introduced a relationship between pore throat sizes in 35 percent of mercury saturation in mercury injection capillary pressure tests (MICP) with porosity and permeability of the samples. The method tested in various fields and formations, and its reliability proved. It is obvious that the porosity and permeability coefficients as well as constant bias of the formula must be calculated for each formation. In spite of this importance, little have been made for calculating these coefficients for Iranian formations. This study calculates them in two of the main Iranian reservoirs, Kangan and Dalan formations in the central Persian Gulf Basin.

Methodology

The Permian–Triassic Kangan and Dalan formations are composed of carbonates (calcite and dolomite) and evaporite series deposited in a ramp depositional environment [8, 9, 10, 11, 12, 13]. They are the main host of the Iranian gas reservoirs. Dalan is divided into K4 and K3 and Kangan into K2 and K1 reservoir zones from bottom to top, respectively. A total of 29 samples from these formations analyzed by MICP test. Helium porosity and air permeability measured from 500 samples using Boyle's and Darcy's laws, respectively. A thin section prepared from a trim of each plug and studied by a polarizing microscope.

Results and Discussion

Facies studies under the microscope shows that samples are changed from mud to grain dominated carbonates as well as a few anhydrites. The lowest part of K4 unit is composed of grain-dominated, anhydrite cemented dolomitic facies. Grain-dominated facies are also dominant in upper part with limy lithology. The K3 unit is a mud-dominated unit terminated with Permian-Triassic boundary. The K2 and K1 units have been mainly dolomitized. Both grain and mud-dominated facies are present in these two units. The main diagenetic processes are dolomitization and dissolution, both enhanced reservoir properties.

A total of 29 Winland equations formed with unknown porosity, permeability and bias coefficients. The resulted coefficients are 0.38 for b (bias), 0.51 for permeability and 0.74 for porosity. The resulted R35 from both methods plotted against the laboratory measured values. The new equation is three times better than the standard Winland method. It should be noted that this is just because of the different studied cases. All 500 samples classified according to the new method. The limits are 0.1, 0.5, 2, 10 and larger than 10 microns of pore throat size in 35 percent saturation. The rock type (RT) one has

Petroleum Research, 2018(April -May), Vol. 28, No. 98

low porosity and permeability. It is composed of mud-dominated or anhydrite cemented samples. The RT2 has moderate porosity and permeability. The main facies are pack to grainstone. Presence of micrite in most samples caused moderate porosity and permeability. Grain-dominated facies are dominant in RT3 and RT4. They have high porosity and permeability. The main pore type is interparticle which is connected through the samples.

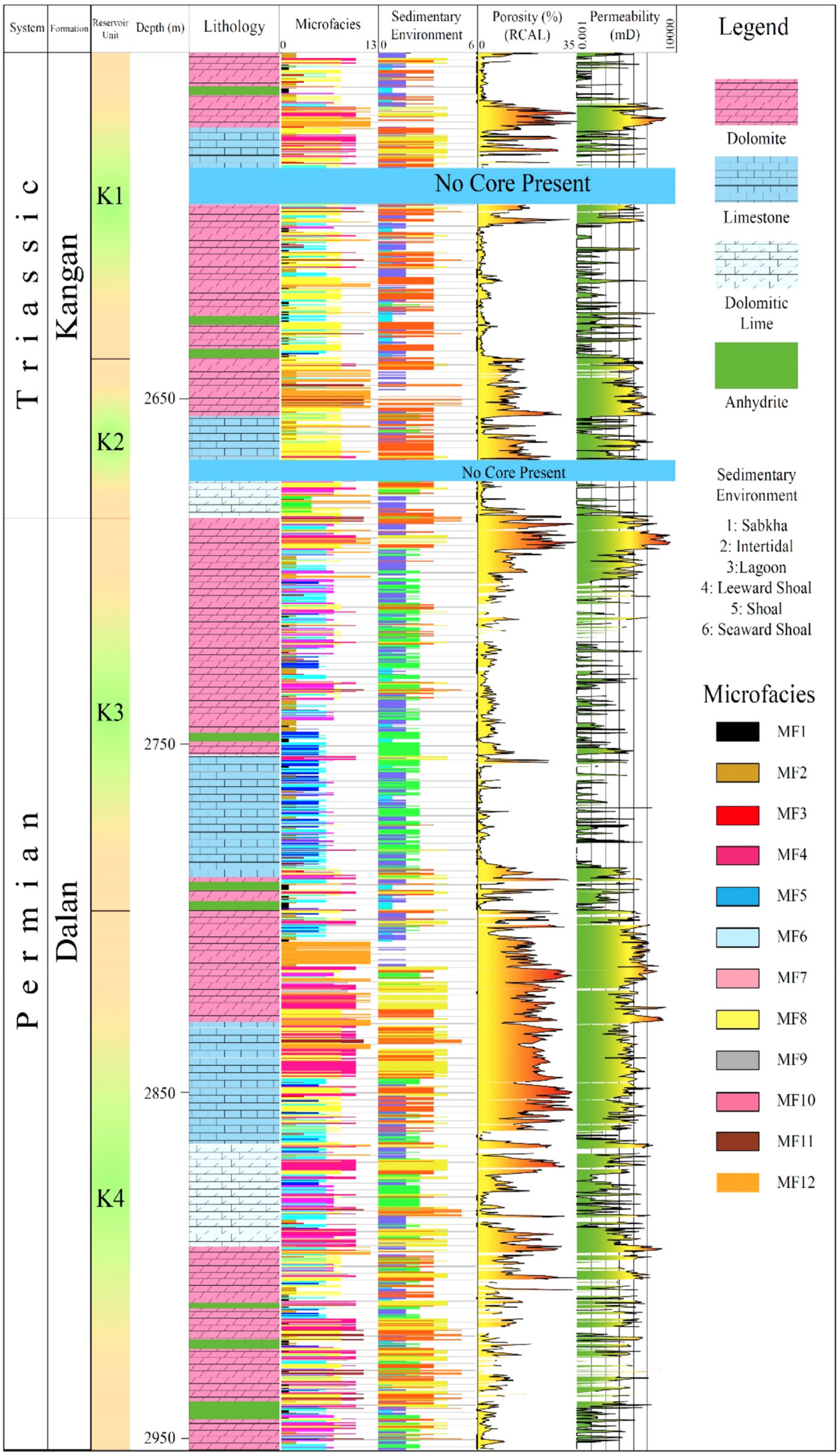

Figure 1: Lithological column with facies, porosity and permeability in studied well

Conclusions

Results showed that determining the rock types based on standard Winland method produces a huge error so that the pore sizes will be three times larger than the real values. Therefore, rock typing with new presented coefficients increases the precision of the calculations and better understanding of the reservoir nature. Integrating these data with thin section studies shows that dolomitization and dissolution are two important diagenetic processes that increase reservoir properties in these determined rock types. These coefficients should be determined in all Iranian reservoirs and for various methods of rock typing such as flow zone indicator, Lucia or Pitman methods.

References

[1]. Bear J., "Dynamics of Fluids in Porous Media" Elsevier, 1972.

[2]. Hear C.L., Ebanks W.J., Tye R.S. and Ranganatha V., "Geological Factors Influencing Reservoir Performance of the Hartzog Draw Field, Wyoming", J Petrol Sci Tech, Vol. 36, No. 8, pp.1335-1344, 1984.

[3]. Ebanks W.J., "The Flow Unit Concept-An Integrated Approach to Reservoir Description for Engineering Projects" AAPG Annual Convention 71, Los Angeles, California, pp.551-556, 1987.

[4]. Amaefule J.O., Altunbay M., Tiab D., Kersey, D.G. and Keelan, D.K., "Enhanced Reservoir Description: Using Core and Log Data to Identify Hydraulic (Flow) Units and Predict Permeability In Uncored Intervals/Wells." SPE Paper 26436 205-220, 1993.

[5]. Gunter G.W., Finneran J.M., Hartmann D.J. and Miller J.D., "Early Determination of Reservoir Flow Units Using an Integrated Petrophysical Method", SPE Annual Technical Conference and Exhibition, San Antonio, Texas: Paper SPE 38679, 1997.

[6]. Winland H.D., "Oil Accumulation in Response to Pore Size Changes. Weyburn Field, Saskatchewan."Amoco Production Research Report No. F72-G-25 197, 1972.

[7]. Pittman E.D., "Relationship of porosity and permeability to various parameters derived from mercury injection-capillary pressure curves for sandstone", AAPG Bull, Vol. 72, pp. 191-198, 1992.

[8]. Konert, G., Afifi, A.M., Al-Hajri, A., Droste, H., "Paleozoic Stratigraphy and Hydrocarbon Habitat of the Arabian Plate", AAPG, Memoir 74, Chapter 24, 2001.

[9]. Sharland, P., Archer, R., Casey, D., Davies, R., Hall, S., Heward, A., Horbury, A and Simmons, M., "A proposed sequence stratigraphy for the Phanerozoic succession of the Arabian Plate: Mesozoic and Cenozoic sequences", v. Special Publication No. 2: Bahrain, GeoArabia, 371 p, 2001.

[10]. Rahimpour-Bonab H., Asadi-Eskandar A., Sonei R., "Controls of Permian-Triassic Boundary over Reservoir Characteristics of South Pars Gas Field, Persian Gulf." Geol J, Vol. 44, pp.341-364, 2009.

[11]. Tavakoli V., Rahimpour-Bonab H., Esrafili-Dizaji B., "Diagenetic Controlled Reservoir Quality of South Pars Gas Field, an Integrated Approach." Comptes Rendus Geosc, Vol. 343, pp.55-71, 2011.

[12]. Aleali M., Rahimpour-Bonab H., Moussavi-Harami R. and Jahani D., "Environmental and Sequence Stratigraphic Implications of Anhydrite Textures: A Case from the Lower Triassic of the Central Persian Gulf." J Asian Ear Sci, Vol. 75, pp.110-125, 2013.

[13]. Mehrabi, H., Mansouri, M., Rahimpour-

Bonab, M., Tavakoli, V., Hassanzadeh, M., "Chemical compaction features as potential barriers in the Permian-Triassic reservoirs of Southern Iran", J Pet Sci Eng, Vol. 145, pp.95-113, 2016.