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Investigation of pore types distribution in lateral and vertical directions using rock physics modeling in wells of an Iranian carbonate reservoir

Maryam Sadat Mirkamali[1], Abdolrahim Javaherian[2*], Hossein Hassani[3], Mohammad Reza Saberi[4], Seyed Abolfazl Hosseini[5] and Sajjad Zabihi Sarallah[6]

1- Ph.D. student, Department of Petroleum Engineering, Amirkabir University of Technology, Tehran, Iran
2- Professor, Department of Petroleum Engineering, Amirkabir University of Technology, Tehran, Iran.
3- Associate Professor, Department of Mining and Metallurgical Engineering, Amirkabir University of Technology, Tehran, Iran
4- GeoSoftware, The Hague Area, 2591 XR Den Haag, The Netherlands
5- Dana Energy Company, Tehran, Iran
6- Geophysics Department, Exploration Directorate, National Iranian Oil Company, Tehran.

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Corresponding author: agholami@ut.ac.ir

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Extended abstract

Summary

Different depositional environments and their subsequent diagenetic processes usually result in various rock textures with complex pore structure in carbonate rocks. This study considers Fahliyan carbonate formation in an Iranian oil field within the Abadan plain to quantify pore shapes using a rock physics model. In this modeling, the aspect ratios of different pore shapes and their volume fractions are calculated using differential effective medium theory, taking into account the pore shape effect on the elastic moduli estimation. Different pore shapes together with their aspect ratios and volume fractions are quantified using differential effective medium theory, and then, it is used further to predict elastics logs by Xu-Payne modeling. The results indicate that two pore types of reference pores and stiff pores can be characterized as the main pores in Fahliyan carbonate formation. This conclusion is confirmed by formation micro imager (FMI) log and core information.

Introduction

Carbonate rocks are considered as one of the primary host rocks for the hydrocarbon reserves worldwide and account for a significant portion of the world hydrocarbon production. These reservoirs are generally complex and difficult to model because of their heterogeneity and pore shape variability (Xu and Payne, 2009). Variable pore shapes of given mineral composition and fluid type can cause scattering of the velocity versus porosity cross-plot (Anselmetti and Eberli, 1999), and carbonates exhibit a wide variation in their pore shapes. Rock physics models are successfully used for seismic reservoir characterization by providing accurate quantitative relationships between geophysical observations and reservoir properties. The inclusion-based models incorporate the pore shape into modeling steps using idealized inclusions with different aspect ratios to account for mechanical interaction between the pores (Mavko et al., 2009). Pore spaces are generally characterized by their aspect ratios and corresponding volume fractions. Pore aspect ratio is presented to introduce the stiffness or softness of carbonate pore systems in estimating their elastic properties. Kumar and Han (2005) considered the pore shape effect to estimate the average aspect ratio of the different pore shapes and their volume fractions in carbonate rocks. Following the work of Kumar and Han (2005), Xu and Payne (2009) extended Xu-White (1995) model by introducing four different pore systems. Xu-Payne model divides pore space into clay-related pores, reference pores, micro-cracks, and stiff pores (Xu and Payne, 2009).

Methodology and Approaches

This paper uses a pore-type inversion algorithm to determine the pore aspect ratios and volume fractions based on total porosity and measured velocity. Then, the obtained pore geometries are used in the Xu and Payne (2009) model to predict P-and S-wave velocities. The field data have been taken from an oil carbonate reservoir in the Fahliyan Formation. The procedure is to obtain the best match between the measured and the modeled P-wave velocity using differential effective medium modeling by optimizing the input parameters. This algorithm is applied to our carbonate data set from sample to sample, independent of each other, leading to depth varying pore aspect ratios and their volume fractions.

Results and Conclusions

For the given field, we have observed that reference pores are the dominant constituents of the pore spaces, while stiff pores and cracks are the next constituents of the pore system for the layer around both wells in the Fahliyan Formation. The geological reports and core information confirm the results. For the intervals with missing data and washed-out zones, applying the rock physics modeling resulted in a successful replacement of the poor-quality data.