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FULL LENGTH ARTICLE

Flow-units verification, using statistical zonation and application of Stratigraphic Modified Lorenz Plot in Tabnak gas field

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Abstract The relationship between two main reservoir parameters being porosity and permeability, in the carbonate rocks is very complex and obscure. To get a better understanding on flow behavior, the relationship of porosity and permeability of reservoir units, reservoir zonation and flow units were defined. The significance of dividing the sedimentary intervals into flow units reflects groups of rocks that have similar geologic, physical properties and depositional environment that affect fluid flow. Variations in rock properties result from depositional, diagenetic and post-depositional changes. A flow unit is a volume of a reservoir rock that is continuous laterally and vertically and has similar averages of those rock properties that affect fluid flow. Different methods exist for the zonation of reservoirs based on petrophysical data and well logs; among them are: Permeability–Porosity cross plot, Pickett and Soder and Gill methods. In this study, the flow units are determined in Tabnak gas field in South of Iran based on Testerman Zonation Technique and Stratigraphic Modified Lorenz Plot (SMLP) methods. For determining these units, conflation of petrophysical data and comparing porosity and permeability of cores are done for verification three wells. By comparing flow-units derived from two methods, it was realized that in permeable zones they have a relatively valid correlation.

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1. Introduction

Accurate reservoir characterization requires the integration of core and log data to understand the variation in hydraulic properties such as porosity, permeability and capillary pressure. The concept of hydraulic flow units has widely been used

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in reservoir characterization and permeability prediction studies [1–7]. In fact the definition of hydraulic flow units allowed a better petrophysical characterization and description of the field and can be used as inputs for construction of reservoir model.

Numerous studies have been conducted on this topic and the results show an improved reservoir characterization by classifying reservoir rock into HUs. Gardner and Albrechtsons [8] observed a significant improvement in the reservoir description through the refinement of permeability model using HU concept. Svirsky et al. [5] were able to resolve the challenges in Siberian Oil field using the concept of hydraulic flow units (HUs). Guo et al. [9] showed that hydraulic flow concept proved to be an effective technique for rock-typing in clastic reservoirs in South America. Shenawi et al. [10] developed generalized porosity–permeability transforms based on hydraulic unit technique with excellent accuracy for carbonate reservoirs in Saudi Arabia. Orodu et al. [11] expressed a satisfactory estimation of permeability from HUs, considering high reservoir heterogeneity, availability of less number of cored wells and poor well log response correlation to permeability. Shahvar et al. [7] observed an enhanced prediction of relative permeability by discretizing reservoir rock based on hydraulic flow units for a carbonate reservoir in Iran. Recently, Nooruddin and Hossain [12] developed a porosity–permeability model employing new parameters with conventional Kozeny–Carman model. They used 30,000 data points of an existing Middle East field. The results show an excellent agreement with the data.

Considering the aim, selected scale and available data there are different ways for determination of flow-units. In this study, the methods used determine flow-units by method of statistical zonation [13] and Stratigraphic Modified Lorenz Plot [14] and comparing these two methods is done for three wells in Tabnak gas field in South of Iran.

This article presents a statistical zonation technique developed by Testerman [13] to identify and describe porous and permeable zones in a reservoir, and for determining which ones are likely to be continuous between adjacent wells. Also another method is Stratigraphic Modified Lorenz Plot [14]. Stratigraphic Modified Lorenz Plot (SMLP) is a plot of percent flow capacity versus percent.

Storage capacity is ordered in stratigraphic sequence. If the data are continuous (smoothed), they should be constructed using every sample available.

2. Description of the field

Tabnak gas field has been discovered in 1963 and is the biggest onshore sweet gas field in Iran which found a significant importance because of the sweetness of its gas and capability of ready release of its gas into global pipeline. This field is placed in south of Iran, in south-west of Lamerd, in east side of Asalouyeh anticline. Dashtak, Kangaan, and upper Dalaan stratas are in this hydrocarbon containing field. Fig. 1 shows position of Tabnak gas field.

3. Data and methodology

Cores from three drilled wells in subsurface stratas of Tabnak gas field have been used in this study, and for specifying

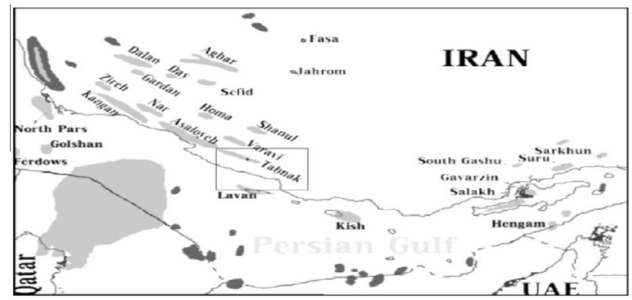

Figure 1 Tabnak gas field position [15].

flow-units the Testerman statistical zonation is used. For statistical zonation, description of a quantitative and variable reservoir is essential. According to this point that transportation and fluid production is a function of permeability, for introduction of fluid flow-units this petrophysical term should be used [16]. Also in a supplementary study and for evaluating accuracy of statistical zonation, the Stratigraphic Modified Lorenz Plot (SMLP) was used. The used data in this method are usual core analysis (porosity and permeability).

4. Statistical zonation technique

A statistical zonation technique has been successfully used to detect significant differences between samples. The object in the problem of zonation is to detect the existence of distinct vertical sections or flow units within the permeability profile of each well in the reservoir. The reservoir zonation technique is a two-step operation.

1. Permeability data from the top to bottom of the strata of a single well are divided into two zones. These zones are selected such that the variation of permeability within the zones is minimized and maximized between zones. Statistical Eq. (1) used to zone the permeability data is:

$$B = \frac{1}{L-1}\left[\sum_{i=1}^{l} m_i\left(\bar{k}_{l.} - \bar{k}_{..}\right)^2\right] \quad (1)$$

The variance within any zone, W, is computed from:

$$W = \frac{1}{N-1}\left[\sum_{i=1}^{L}\sum_{j=1}^{m_i}\left(\bar{k}_{l.} - \bar{k}_{..}\right)^2\right] \quad (2)$$

Zonation index, R, is

$$R = \frac{B-W}{W} \quad (3)$$

The zonation of individual wells is a multi-step procedure:

(a) First, the permeability data, in their original order of depth, are divided into all possible combinations of two zones. Then, Eqs. (1)–(3), are used to calculate for each of these possible two zone combinations. The zonation index calculated from Eq. (3) is the criterion used to indicate the best division. R, which ranges between 0 and 1, indicates how closely the division corresponds to homogeneous zones. The closer R is to 1, the more homogeneous are the zones. The larger R value denotes the best division into two zones, is retained for comparison with other indices. Any negative values of R are replaced by zero in order to conform to the definition of R.

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