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Integrated reservoir characterization for fractured reservoir using static and dynamic data

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Abstract: For the successful characterization of the fractured reservoir, it is inevitable to describe fracture properties more precisely. Although the deterministic features, of mega-trend faults can be relatively definite, the background features of minor fractures are not easily analysed in spite of the various data of these features. In this study, two different methods, statistical and fractal methods, are used to construct the minor fracture system over the entire field. After completing these tasks, with the identified deterministic features and background features, total fracture system for fractured reservoir is constructed and updated with the aid of dynamic data obtained from well test.

1. Introduction

The fractured basement reservoirs, in a macroscopic view, can contain structural features ranging from small size fractures to large size fractures that serve different functions of fluid storage and fluid transmission. For successful characterization of the fractured reservoir, the major regions of fluid storage and fracture systems should be identified. Typically, the fracture network model includes at least two types of features: major features that can be analyzed deterministically and minor features that one can only described stochastically.

Deterministic Features: Deterministic features are major conduits or storage fractures that are already known their location. The interpretation of these major fractures can be supplied from different sources: (1) the seismic analysis of fractured reservoir (2) the structural modelling data. And the result can also be modified by using well test data.

Background Features: Minor fractures, that have very small conduit contribution to the reservoir, are also the main storage in fractured reservoir, and can be identified by FMI at wellbores. Generally, in fractured reservoir, there are three different kinds of open fractures that can conduct reservoir fluid: (1) vuggy fractures, (2) continuous fractures, and (3) discontinuous fractures. Although using various types of analysis method, it is difficult to identify the intensity or the distribution of these micro-fracture sets.

2. Determination of Background Features

The minor fractures can be identified but local at wellbores, so these features can only be analyzed by stochastic method, such as statistical method or fractal method.

Statistical Method: It is assumed in this method that the location of fracture center and the fracture orientation will be controlled by some statistical functions such as Poisson's distribution function and Fisher distribution function which is affected by fracture intensity and fracture termination etc. The fracture size data is also identified using the data obtained statistically, such as fracture trace length, stereological data.

Fractal Method: Since the fractal behavior was observed in natural fracture patterns, and fractal geometry could provide a quantification of the size scaling for the complex fracture system, the quantification of complex structure of fracture networks have become an important part in modeling fluid flow in fractured reservoirs. Fractal analysis of fracture system consists of the estimation of a non-integer number, fractal dimension, which is related to fracture geometry. Typically, box-counting technique is applied to measure the fractal dimension of the fracture networks (Fig. 1). After determination of fractal dimension of outcrops, the fractal fracture system in unknown part of reservoir can also be constructed.

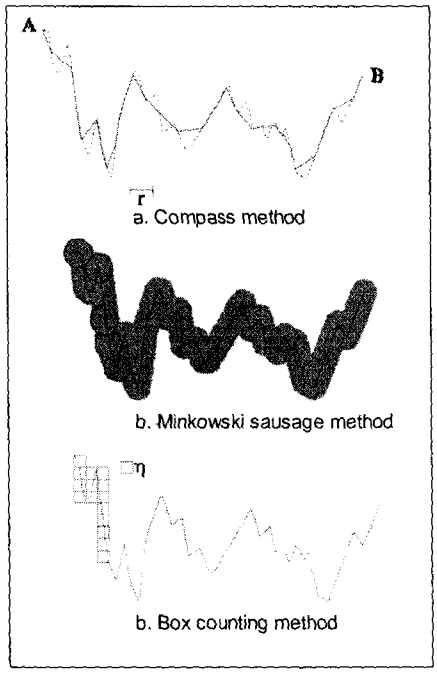

Fig. 1. The determination of fractal dimension.

3. Integration of Dynamic Data

The dual-porosity and dual-permeability reservoir models, which assume that the fractured reservoir is composed of homogeneous fracture system, can generally be used as a reservoir model. But in the case of large fractures, the hydraulically fractured well model would be applied because the dominating fracture in the fractured basement is similar to the hydraulically induced fracture system. And various hydraulically fractured models are presented according to the fracture conductivity and its size. The dynamic data obtained form these well model can present the dominant fracture system in the reservoir, and average permeability value within the radius of investigation. And, in the well test processes, the pressure-time data can be matched with the obtained dominant-minor fracture system, and hence these fractured reservoir system can be updated more precisely.

4. Application to Field Case

The data of the fractured reservoir, which has been known as fractured basement reservoir, are used to conduct this study. The fractured basement reservoirs, in a macroscopic view, can be classified as two types: the first type has no dominative fracture, so the reservoir fluid flow is mainly governed by small size fractures, and the second type contains large scale fractures, so these fractures are the main flow conduits in the reservoir. Hence, specification of fracture system is the most important task to characterize these types of reservoirs. To identify the trace length and fractal dimension, 3 types of different outcrop data (Fig. 2) are applied, and to determine the fracture intensity and fracture average dip and dip angle, 3 sets of FMI data at different wellbores are used. The deterministic features, such as faults and large fractures, were determined by seismic analysis data. By utilizing above data, the fracture system of the fractured reservoir has been constructed. After completing these, the well test analysis results, which are very complex case of fractured reservoir, have been matched with the fracture system, and the constructed fracture system has been also updated.

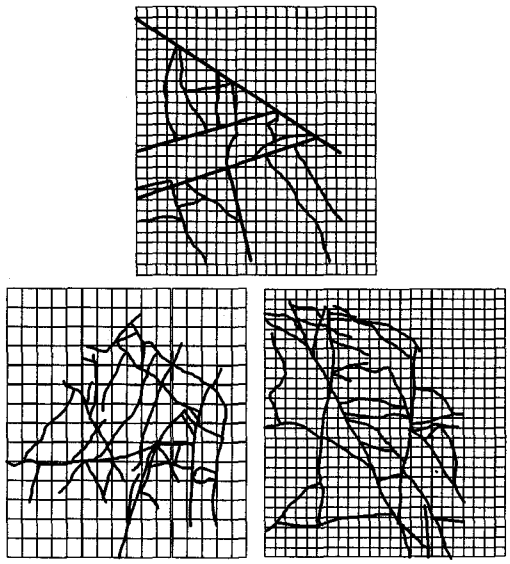

Fig. 2. Three different kinds of outcrop data obtained from the fractured reservoir.

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