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Fluvial Reservoir Architecture Modeling and Remaining Oil Analysis

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Abstract

Most of the mature oil fields in east China are in a stage of high water cut. For these oil fields, the reservoir characterization and remaining oil study need fine scale geological models. A study of reservoir architecture can provide such a fine model. In this paper, we focus on the architecture modeling of fluvial reservoir. Fluvial architecture contains hierarchical bounding surface and architecture elements. This architecture model provides information to analyze the reservoir heterogeneity caused by hierarchical bounding surfaces. Previous architecture studies were conducted on outcrop and modern river deposits. We use the 7th block of Gudong oil field in China as an example to analyze the subsurface reservoir architecture and distribution of remaining oil.

Gudong oil field has been exploited for 30 years. A total of 1070 wells have been drilled and the well space is 150mx150m. Data are abundant and includes core data, horizontal wells, logging data, production data and surveillance data, all of which are used for the reservoir architecture study.

We use the method of "fitting geological model" for the architecture study. Using results of outcrop and modern river deposit studies and paloe-environment analysis, we build the geological patterns of meandering and braided rivers. Based on our analysis, the geological pattern of internal point bar has the following characteristics: (1) parallel-inclined lateral accretion intercalation; (2) 200m width of single lateral accretion body; (3) 3~5 degree dig angle of lateral accretion surface. Our study also shows that the geological pattern of the internal mid-channel bar, which is confirmed by the production information and pair wells data, is asymmetrical intercalation and 2~5 degree dip angle of intercalation surface. Guided by geological patterns, we establish the internal architecture models of $Ng52^2$ layer and Ng64 layer in this study area.

Using the internal point bar and mid-channel bar models, we analyze remaining oil and establish different remaining oil distribution patterns. Our analysis shows that the matching relationship between intercalations and perforated intervals is the main factor that influences remaining oil distribution of a sand body. This provides a new way to find remaining oil in a mature oil field.

Introduction

Gudong Oilfield is one of biggest oilfields of Bohai Bay basin in east China (Fig.1). We use the 7^{th} Block of Gudong oil field for the study. The study area is about $14km^2$. The number of wells is about 1070, among them there are 13 cored wells and 8 horizontal wells. Well space is 150mx150m. The study is implemented on $Ng52^2$ layer and Ng64 layer. $Ng52^2$ layer is a meandering river deposit. Ng64 layer is a braided river deposit. Average sand thickness is about 10m. Reservoir porosity is about 32%. Average permeability is about $1612\times10^{-3}\mu m^2$. Production data and surveillance data are very rich. With 30 years of development, the reservoir is extensively water-flooded and the water cut is about 95%. The oil recovery is less than 40%. The conventional reservoir characterization based on microfacies study has difficulty in finding remaining oil distribution because its large scale study covers the internal heterogeneity of a sand body. Therefore a more fine and detail reservoir model is needed. We carry out the architecture modeling study to provide the model.

In this paper, we first talk about the architecture modeling of meandering river point bar and braided river mid-channel bar in the study area. Then we use this model to analyze the remaining oil distribution.

Many aspects of fluvial architecture studies about outcrops and modern river deposits have been reported, such as, architecture elements and lithofacies, bounding surfaces, internal pattern of point bar, the constructing process of point bar, hydrodynamic condition of mid-channel bar and braided channel deposit, types and internal architecture of mid-channel bar, and dimension of fluvial channel. These studies provide a geological basis for the architecture of subsurface fluvial reservoir. Also some subsurface reservoir architecture studies, which include architecture element recognizing in wells, profile architecture study, and architecture analysis using horizontal wells, have also been reported.

Remaining oil studies on fluvial reservoir mainly focused on large scale microfacies, structure or micro-structure and micro-scale lithology. In this paper we introduce the systemic process of architecture study and remaining oil analysis. We