Sedimentary Characteristics, Origin and Model of Lacustrine Deepwater Gravity Flow Channels

A Case Study from Shahejie Formation in Huanghua Depression, East China

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Abstract—The Paleocene reservoir of Dagang Oilfield, which is one of the most important and complex fault-controlled lacustrine reservoirs in China, is located in the north depression of Bohai Basin. With forty years of exploration and development, most large oilfields in East China have generally entered the high water-cut stage. The original deep water lacustrine reservoirs in Dagang Oilfield have, however, experienced significant tectonic and diagenesis throughout its long geological history. These processes have greatly complicated the reservoir properties. Therefore, the fault-controlled deep water lacustrine reservoirs have become a new field of reservoir geology study in China, which is very important in getting a proper knowledge of remaining oil distribution and improving oil recovery rate.

Based on core observation and sedimentary facies analysis, reservoir characteristics of lower Es1 in T34 Block and the main geological factors influencing its physical properties are systematically studied by using a large number of rock thin sections, thin sections, porosity and permeability properties and mercury-injection data etc .It is held that the lower Es1reservoir belongs to mid to low porosity, low to extra-low permeability and fine throat reservoir. Reservoir properties of study area are dominated by diagenesis, and combination of sandstone and mudstone. Among them, carbonate cement, silica cement and clay mineral transformation are the main causes of the poor physical properties, while the corrosion produces substantial secondary porosity and provides favorable reservoir space. Authigenic kaolinite is the dissoluted product of feldspar and debris. Reservoir properties of vertical distribution are controlled by combination of sandstone and shale.

Keywords-reservoir property; controlling factors; lower member 1 of Shahejie Formation; T34 Block; Huanghua Depression

I. INTRODUCTION

T34, belonging to Dagang Oilfield, one of the most typical complex fault-block oilfields in China, is located in the north depression of Bohai Bay Basin(Fig .1).

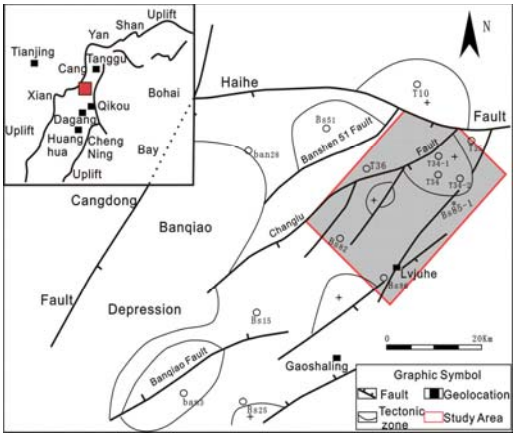

Figure 1. Tectonic zoning map of Changlu

With forty years of exploration and development, most large oilfields in East China have generally entered high water cut stage. However, deepwater reservoirs in Dagang Oilfield have experienced strong tectonic and diagenetic in the long geological period [1-9] (Fig .2), which made reservoir property complex, such as poor injection of injection wells, low recovery of oil wells, quick lateral phase transition of high-quality reservoir etc. Therefore, the deepwater fault-block reservoirs have become a new

field of reservoir geology study in China, which is very important in getting a proper knowledge of remaining oil distribution and improving oil recovery rate.

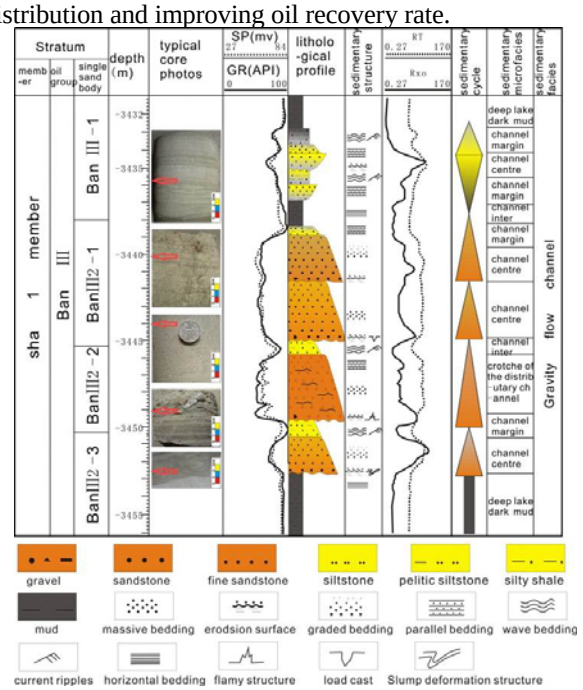

Figure 2. Core succession of gravity flow channel of Es1 from Well Tang34

II. RESERVOIR PROPERTIES

We describe a sedimentation pattern approach integrating core (Fig .3), well log and seismic data, to reveal the complex fault-controlled deep water lacustrine reservoirs in Dagang Oilfield. The fault- controlled reservoirs were identified on single wells. And the tectonic evolution history was reconstructed, thus the paleogeomorphology was rebuilt. During the Paleogene, tectonic activity on the Changlu fault that rapid subsidence and deep water environments evolved [10-19]. Then deep water lacustrine gravity flow channel sedimentary system was formed in study area with its supply from the north of Yanshan provenance systems and the northwest of the Cangxian uplift [20-25].

Figure 3. Drilling cores photos from gravity flow channel facies of the lower part of Member 1 of Shahejie Formation of Paleogene in T34 Block

The spatial distribution of the gravity flow channels were predicted with seismic attribute analysis and non-orthogonal wavelet transformation(Fig .4), as it showed an obvious correlation with fault- controlled reservoirs revealed by well data(Fig .5). Deposits in the deep water lacustrine gravity flow channels were divided into channel center microfacies, intersections of distributary channel, channel margin, channel inter and lake mud microfacies. Through the comprehensive analysis of sedimentation, diagenesis, seismic attribute and tectonic evolution history, the fault-controlled deep water lacustrine gravity flow channel sedimentation pattern was established eventually. Our method may be useful in characterizing similar fault-controlled deep water lacustrine reservoirs in other areas.

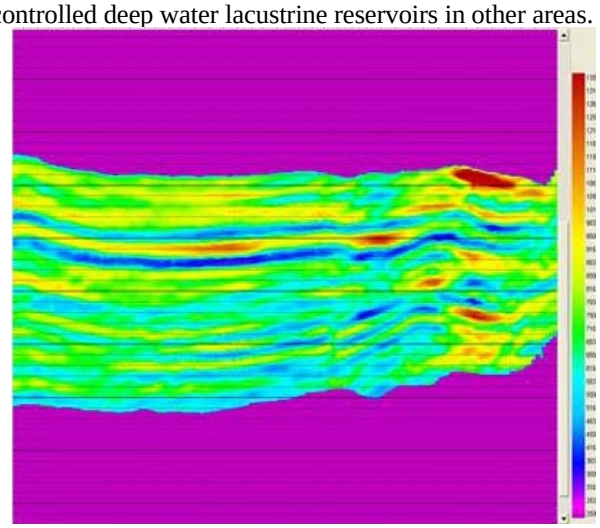

Figure 4. Reservoir inversion of gravity flow channels

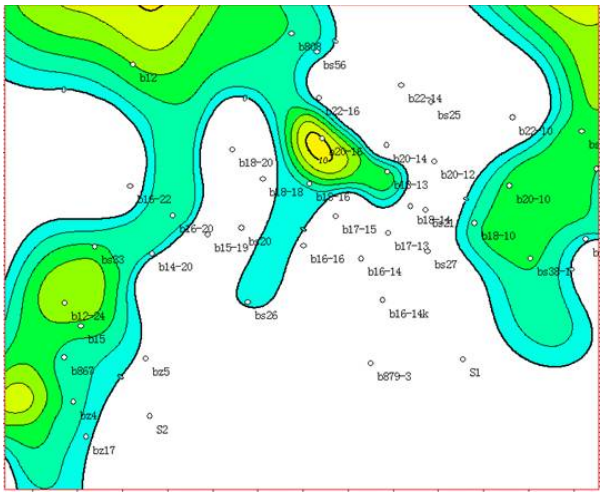

Figure 5. The spatial distribution of the gravity flow channels

Based on core observation and sedimentary facies analysis, the reservoir characteristics of lower Es1 in T34 Block and the main geological factors influencing its physical properties are systematically studied by using a large number of rock thin sections(Fig .6), thin sections, porosity and permeability properties and mercury-injection data etc (TABLE I).It is held that the lower Es1reservoir belongs to mid to low porosity, low to extra-low permeability and fine throat reservoir(Fig .7).

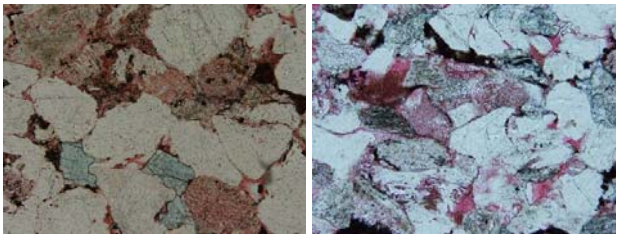

Figure 6. Rock thin sections of Tang34-1,3951.0m,10×, Tang34,3707.0m,20×

TABLE I. MERCURY-INJECTION DATA OF GRAVITY FLOW CHANNEL SANDBODY OF LOWER ES1 IN T34 BLOCK（AFTER MERCURY INJECTION DATA）

Well	depth/ m	Lithology	porosity/%	permeability/x10-3um2	expulsion pressure /MPa
Tang34	3435.87	middle-fine sandstone	19.81	10.3	0.1383
Tang34	3438.14	fine sandstone	17.67	0.3	0.9991
Tang34	3438.5	siltstone	14.13	0.3	1.0326
Tang34	3439.07	middle sandstone	20.72	41.2	0.1019
Tang34	3439.68	middle-fine sandstone	18.91	1	0.5368
Tang34	3441.39	middle-fine sandstone	18.77	0.7	0.5366
BS85-1	3064.21	fine sandstone	17.11	1.3	0.2908
BS85-1	3381.51	middle sandstone	18.45	10.5	0.1615
BS86	3018.5	fine sandstone	17.67	0.4	0.6919
BS86	3554.04	fine sandstone	15.95	4.4	0.3218
BS86	3557.36	middle sandstone	19.15	10.1	0.0981

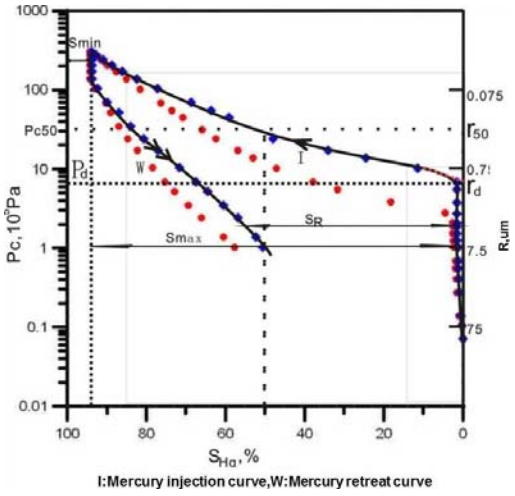

Figure 7. Pore structure features of gravity flow channel sandbody in T34 Block

III. CONTROLLING FACTORS

Reservoir properties of study area are dominated by diagenesis, and combination of sandstone and mudstone. Among them, carbonate cement, silica cement and clay mineral transformation are the main causes of the poor physical properties, while the corrosion produces substantial secondary porosity and provides favorable reservoir space [26-29]. Authigenic kaolinite is the dissoluted product of feldspar and debris. Reservoir properties of vertical distribution are controlled by combination of sandstone and shale.

IV. CONCLUSIONS

A. *Reservoir properties*

Gravity flow channel reservoir properties belong to medium porosity, low or extra low permeability, fine throat and uneven pore distribution .

B. *Controlling factors*

Corrosion of feldspar and cuttings produces substantial secondary porosity, cementation of calcite, dolomite and quartz contribute to destructive effects. Clay minerals have little influence on porosity, but have dramatic influence on permeability. Reservoir properties of vertical distribution are controlled by combination of sandstone and shale.

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