3D Geological Structure of the Lower-Mid-Jurassic and Lower Cretaceous Reservoir Rocks, Stavropol Region, SW Russia: Case Study for Ozek-Suat Oil Field

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Introduction

Interest to Lower-Middle Jurassic and Lower Cretaceous sediments of the Stavropol Region is rather high due to their significant hydrocarbon reserves. This study is devoted to detail geological subdivision, stratification and correlation of Lower-Middle Jurassic and Lower Cretaceous sedimentary formations, and structural-tectonic and lithological modeling as well.

Theory and models

Ozek-Suat oil field is located within the Ozek-Suat prolific structural trend of the Peri-Kuma oil-producing district of the Eastern Fore-Caucasus petroleum province. In terms of tectonics, it belongs to the Near-Kuma uplifted zone. The Ozek-Suat uplift is a platform structure with gently dipping flanks and moderate amplitude. Despite of many years of accumulated experience in well-to-well correlation and fine stratification of the Jurassic sediments there are still some significant correlation problems. These difficulties are stipulated by objective reasons related to pre-early Cretaceous erosion of Jurassic sediments that is responsible for spotty distribution of Jurassic sandstones, variation of their thickness over the area and sedimentation conditions when older Jurassic sediments are onlapped to the Paleozoic uplift while younger Jurassic sediments overlap it. Upon analysis of structural forms it is revealed the following regularities: upward the section the depth of erosion is gradually increased from the south to north and area of sandstone beds occurrence is decreased. The least area is characteristic of V_{1-2} Jurassic reservoir that developed on the northern flank of the uplift. It is typically that Jurassic reservoirs V_6 , V_{3-5} and V_{1-2} in the apical part of uplift contact the above laid Lower Cretaceous reservoir $XIII_{2+3}$.

On the northern flank of the Ozek-Suat uplift the youngest Jurassic sediments of Plinsbachian stage are laid upon Triassic and Paleozoic rocks. Sediments of Toarcian stage are characterized by stratigraphic onlap to the Paleozoic uplift with gradual disappearing of lower sandstone members upward the slope. Reservoir VII is occurred inside this sequence and represented by lens-like beds of sandstones, gravelstones and siltstones. At the base of Aalenian stage, which is laid upon older Jurassic sediments or Paleozoic rocks with erosion, there is occurring everywhere a poorly sorted sandstone member with high content of gravel fraction confined to producing reservoir VI.

In the bottom part of Bajocian stage there is a producing reservoir V represented by series of gravel sandstones. This object can be easily traced over the vast area of the Eastern Fore-Caucasus region. In the most complete section it is represented by uniform series, however, at presence of clayey interlayers it can be tentatively subdivided onto 6 units. The upper and bottom of its parts are corresponded to some extent isolated reservoir units V_{1-2} and V_6, respectively, while the central part is presented by rather homogenous reservoir unit V_{3-5}. Unit V_6 is eroded on the south of the structure. The above laid unit V_{3-5} is characteristic of the highest thickness (effective thicknesses reaches 40 m) and smaller area of occurrence because it was subjected by transgression. In the crest and south-western part of the structure this unit is practically absent. The least areal development is characteristic of sandstone unit V_{1-2} that exists locally on the northeastern part of the structure.

Geological structure of the Cretaceous sediments is studied better than Jurassic ones. Lower Cretaceous sediments occur on Jurassic rocks with stratigraphic and angular unconformity. Structural forms in the Lower Cretaceous sediments are inherited from underlying ones, however they reveal more flat and loose contours, have bigger dimensions and separated onto the Northern and Southern cupolas.

As some peculiarity it should be noted 1.5-2 km of northward shift for structural contours upon the Lower Cretaceous sediments comparing with Jurassic ones.

Reservoir unit $XIII_{2+3}$ is developed over the whole region, however, in some places this sandstone is substituted by impermeable varieties. Its thickness is increased from north to south. Present day structural plan upon top of the bed shows up large arch of irregular form. From the west and east it is bounded by shallow but distinct depressions on the background of slight bedding dip to the south. In general, the uplift is stretched meridionally.

The crest of uplift is complicated by three cupolas: northern, central and southern ones that strike latitudinally. Northern cupola is a main one. The cupolas are separated by shallow saddles of 5m depth. Hypsometrical position of the northern and central cupolas is the same while southern one is of 10 m lower. Structural plans upon the Lower Cretaceous, Lower-Mid-Jurassic and pre-Jurassic sediments are not coincided. This feature is caused by active influence of tectonic movements between Jurassic and early Cretaceous that stipulated stratigraphic and angular unconformities.

Situated above the producing reservoir units $XIII_1$ is laid directly on $XIII_{2+3\ one}$ without a break. It ought to be mentioned that $XIII_1$ and $XIII_{2+3}$ units form a single reservoir with different producing horizons. However, they are different in term of stratigraphy. $XIII_{2+3}$ reservoir unit is of Valanginian age while $XIII_1$ belongs to Hauterivian stage. Regionally, both reservoirs units

manifest decreasing of their thickness to the north. Structural contours upon top of $XIII_1$ reservoir mimic main features of the underlain reservoir $XIII_{2+3}$.

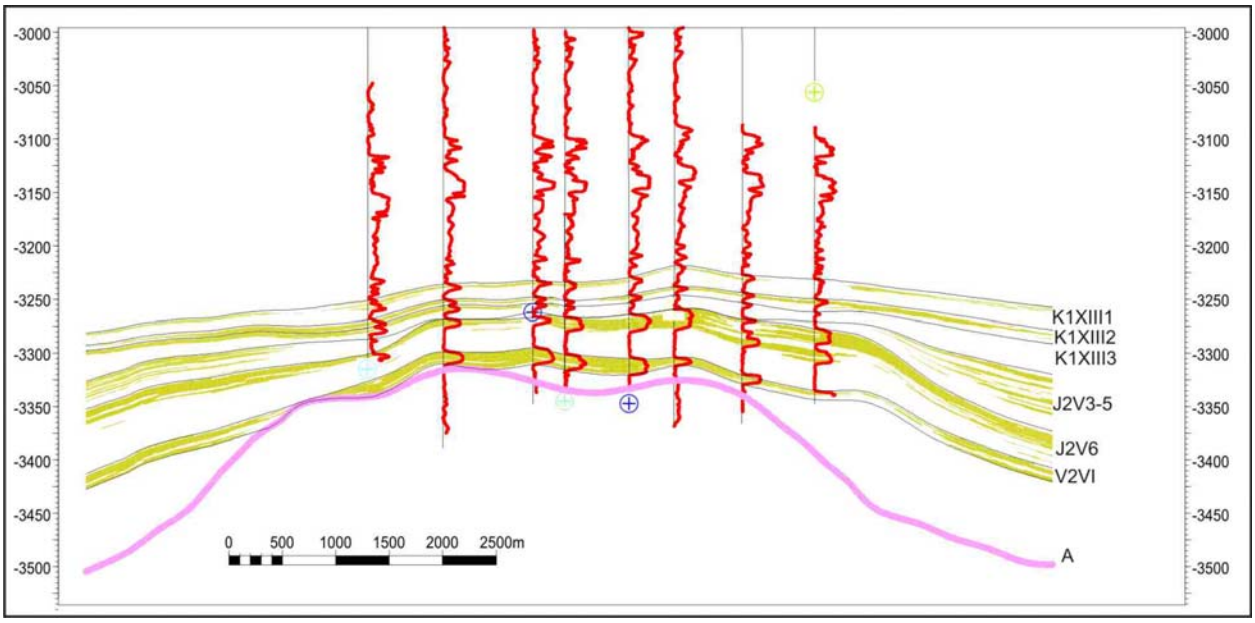

Figure 1 – W-E Geological section of Jurassic and Lower Cretaceous sediments upon results of 3D modeling

To study internal structure of these sediments it was conducted 3D geological modeling resulted in the set of improved structural-tectonic and lithological models for the Lower-Mid Jurassic and Lower Cretaceous sediments built using Petrel software package. Well-log and interpretation of 3D seismic data were put into this modeling. The seismic reference surfaces to compile structural and tectonic models were the top of pre-Jurassic rocks (horizon A), top of the Jurassic sediments (horizon J_2V) and horizon Kp related to the Lower Cretaceous sediments. Application of modern software for all stages this work has allowed adjusting stratification of Jurassic sediments by detail well-to-well correlation over the field. Regionally developed clay horizons were taken as correlative datum for this.

Conclusions

The detailed Lower-Mid-Jurassic and Lower Cretaceous sediments strata correlation of 150 well sections was executed. The concept of geological structures was revised. Structural surfaces were executed in accordance with new conceptual presentations.

The structural plan's positions were changed, that expanded deposit's areas, including on 10% of Jurassic sediments and on 30% of Cretaceous's. As a result of revision structural plans and interpretation of geophysical methods the original hydrocarbon's reserves were increased on 20% in Jurassic and on 60% in Cretaceous deposits. The residual hydrocarbon's reserves were calculated with using of detail geological model.

Improved geological models for the Jurassic and Lower Cretaceous sediments of Ozek-Suat oil field allow recognizing the most prospective zones to increase production, re-evaluate hydrocarbon reserves with higher accuracy and determine the strategy for further development of the field.

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