

# Influence of Erosion-karst Processes on Lithological Features of Productive Strata in Bobrikovian-Tournasian Oil Reservoir

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**Abstract.** Erosion-karst processes on the surface of Tournasian land, formed as a result of regression of Devonian-Tournasian Sea, led to both significant morphological transformation of Tournasian paleorelief and formation in the Late Radaevskian-Bobrikovian transgression of sand lenses with secondary clay-carbonate cement with a predominance of carbonate component. On the example of two adjacent wells it is shown that sandstones with abundant clay-carbonate cement during logging interpretation may be taken for carbonate reservoir rocks, if factors are not taken into account such as increased calcium in seawater of Radaevskian-Bobrikovian basin and carbon dioxide in the atmosphere of Lower Carboniferous. They led to the development of carbonate cement in Visean sandstone and secondary calcitization in Tournasian rocks.

**Keywords:** erosion-karst processes, incision, reservoir, oil saturation, correlation of sections, clay-carbonate cement, carbonate and clastic rocks.

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Karst processes are now widely distributed in that part of the earth's surface, which is composed of karst rocks - limestone, dolomite, gypsum (Gvozdetsky, 1954). Very peculiar landforms are the results of these processes. They can be observed in different geographical and climatic zones (Spain, Austria, the Crimea, China, Australia and others).

These corrosion processes had no less widespread occurrence in the past geological epochs. Underestimation of their role in creating sculptural forms of paleorelief and voids of karst rocks may lead to erroneous practical consequences.

An example of this is the comparison of the Lower Carboniferous sections from two wells (No. 2345 and 2507) on Zyuzevsky field. The wells are located 300 meters from each other in the central part of brachyanticline uplift of the III order on the roof of Tulsian horizon, which controls oil deposits in Tournasian carbonate reservoirs and Visean clastic rocks (sandstones, siltstones), and the Middle Carboniferous intervals – Bashkirian and Vereiskian sediments.

Modern forms of Tournasian surface in Zyuzevsky uplift, in our opinion, have been created as a result of erosion and karst processes on Tournasian land in Elkhovskian- Early Radayevskian time. Denudation and corrosion processes have also had a significant, albeit indirect impact on Radayevskian-Bobrikovian clastic rocks, filled post-Tournasian 'incisions' on the uplift, and Tulsian rocks overlapping Radayevskian-Bobrikovian strata. Excluding this factor, the interpretation of sections of neighboring wells by logging can be very different both on stratigraphic and lithological content as well as the nature of reservoirs saturation.

As concluded by logging, in the wells 2345 and 2507 the roof of the Tulsian horizon is close to absolute elevations – -1150.5 and -1156.2 m, respectively (Fig. 1). Well No. 2345 penetrated Visean incision: Radayevskian-Bobrikovian clastic rocks in its section lie on the eroded surface of Zavolzhsian horizon of the Upper Devonian Famennian tier, i.e. Tournasian deposits are denuded entirely in the area of

wells. Thickness of Visean complex is 78.6 m. The following oil-saturated reservoirs are marked in the well: Tulsian Stl-4 in the top of the horizon, Sbr-3, Sbr-2, which merges with the formation Sbr-1, and in incision – lenses of sandstones united in the Sbr-1 formation. Reservoirs are underlain and overlain by mudstone packs with thickness 2.5-15 m.

In well 2507 the roof of Tournasian deposits is conducted by logging at a depth of 1331.2 m (absolute mark – 1199 m) on the 'traditional' sign: decrease of gamma-ray values and increase of neutron gamma-ray values at the border 'clay-limestone' and indications of caliper log on this level. However, clay packs can be traced below the section in the intervals 1350.4-1354.4 m, 1362.6-1365.2 m, and 1367.4-1371.2 m, i.e. in Tournasian deposits. Marked between them carbonate interlayers have porosity of 23-23.8 %, 16.7-20 %, in the interval 1365.2-1367.4 m – 8.1%; The formation resistivity for these intervals is 8-16.8 ohmmeter. In terms of porosity they are highly porous reservoir rocks, in terms of resistivity – water-saturated rocks.

From the logging interpretation of two neighboring wells it follows that in the well 2345 the bottom of general oil-saturated interval is at an altitude -1224.4 m, while the roof of water-saturated interval in the well 2507 is at an altitude -1199 m, i.e. 25 m above.

Comparison of well logs suggests that their sections are correlated with each other quite well. In the well 2507 all reservoirs between clay packs are not the carbonate but sandstones on clay-calcareous cement, with a predominance of carbonate component over clay. The well 2507 penetrated the same Visean 'incision' which was penetrated by the well 2345. The thickness of Visean deposits is 84.2 m. Radaevskian-Bobrikovian clastic strata in the incision lies on the eroded surface of compacted limestone of Zavolzhsy horizon of the Upper Devonian Famennian tier. As in well No. 2345, Tournasian deposits in the well 2507 are completely eroded (Fig. 2).

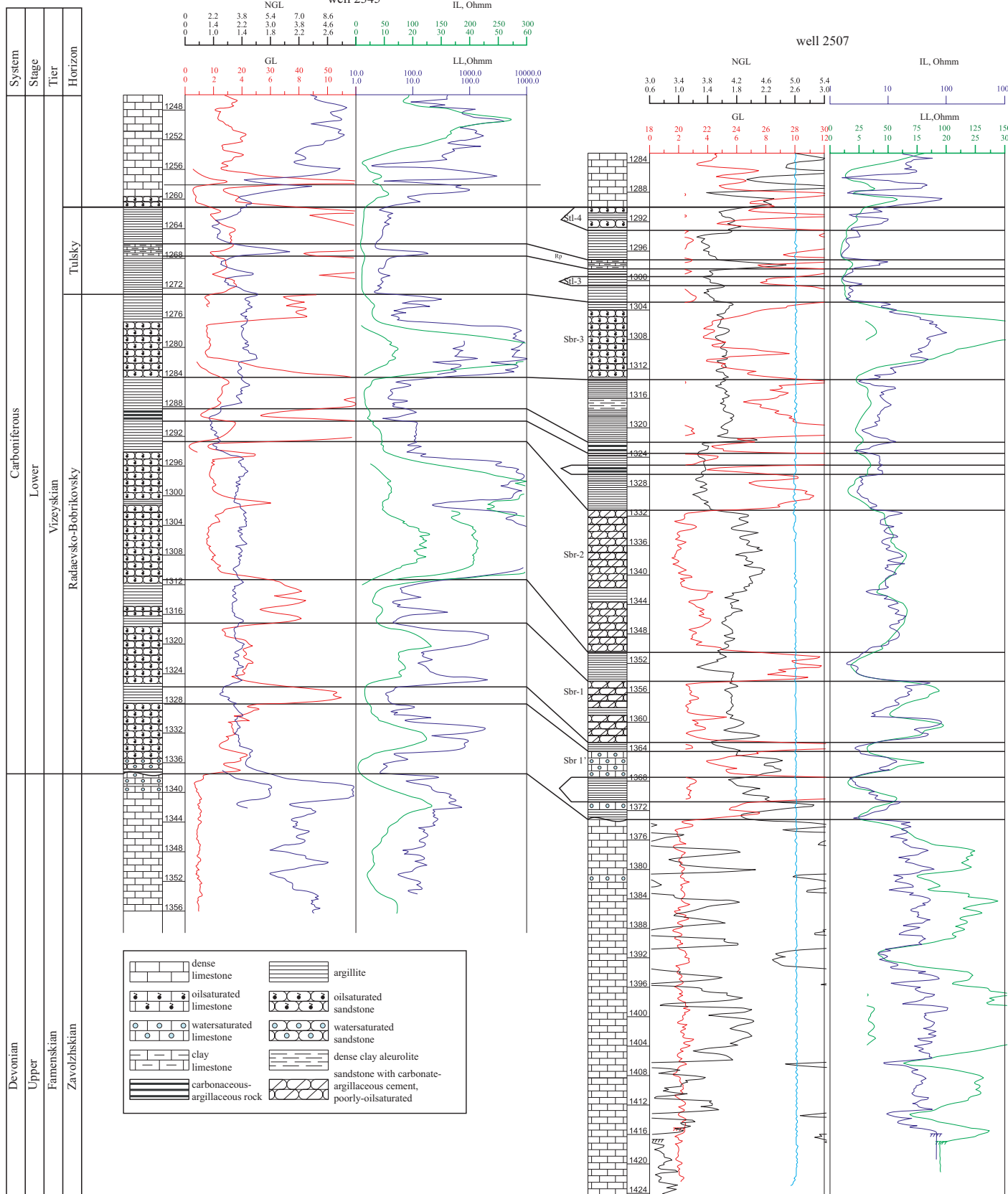


Fig. 1. Schematic comparison of the Lower Carboniferous deposits for wells No. 2345, 2507. Vertical scale 1:500.

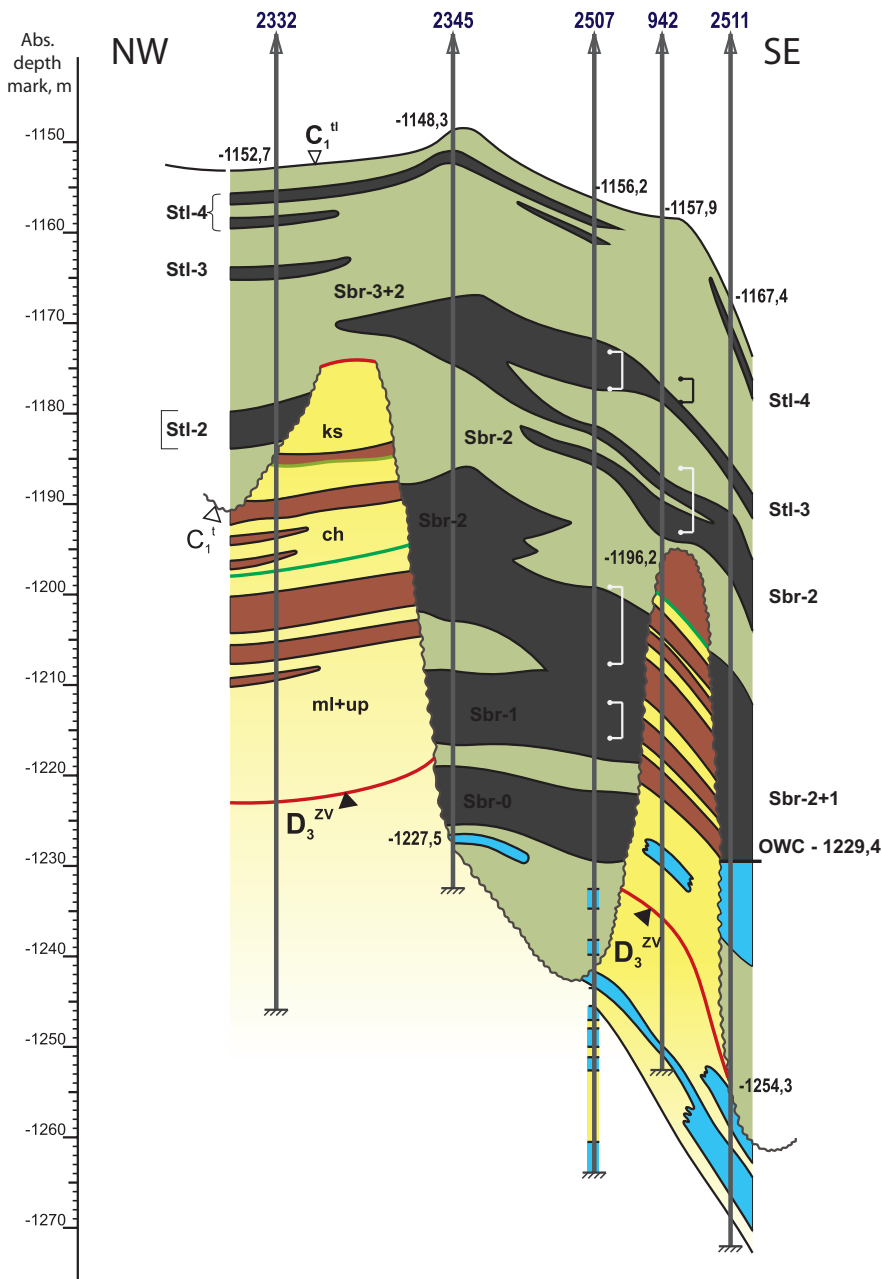


Fig. 2. Fragment of the schematic geological profile of the Lower Carboniferous productive deposits. Horizontal scale 1: 10,000, vertical scale 1:500.

Values of formation resistivity (8-12 ohmmeter) in general interval 1199-1229 m for carbonate reservoirs mean that they are water-saturated, values of 12-15 ohmmeter indicate their residual or weak oil saturation, whereas for sandstone this measure of oil saturation *ceteris paribus*.

Thus, in the section of well 2507 in the Visean clastic rocks there are reservoirs Stl-4, Sbr-3, Sbr-2, series of layers Sbr-1 that are oil-saturated as in neighboring wells on the profile (Fig. 2).

The relatively low value of permeability coefficient by logging – 5.7-91.9 mm<sup>2</sup> indirectly indicate on clay-calcareous nature of the cement sandstone in the well 2507. The carbonate component of sandstone cement is secondary in relation to the previously formed sand lenses.

Reservoirs Sbr-1, partly Sbr-2, with interbedded mudstones and filling ‘incisions’ were deposited in relatively shallow marine conditions established in the lower areas of the continent

as a result of the first cycle of sea transgression in Late Radayevskian-Bobrikovian. The waters of this sea contained a significant amount of dissolved calcium compounds transferred there with eroded and karst Tournaisian land, as well as water of Bobrikovian-Tuslkian basin, overlapped the entire surface of the east of the Russian Platform in the next cycle of marine transgression.

In addition, atmospheric water transferred to the sea basin contained a significant amount of carbon dioxide; frequent and heavy rains washed away destruction products from the Tournaisian surface, before it was overlapped by Bobrikovian-Tuslkian transgression. These destruction products were kind of weathering crust in the karst valleys and depressions. All this gave a peculiar litho-facies appearance to Visean clastic strata, especially in ‘incisions’.

The weathering crust consists of insoluble residue, fragments of native limestone rock (‘trash’), cemented with clay-silt precipitated mass. It is marked on the Tournaisian surface in a number of wells (No. 942, 2363, 2344 etc). In the well 2507, landslip limestone debris with porosity values of (8.1-8.3%) lie in a number of intervals 1365.4-1367.4 m and 1370.4-1372 m. The debris is underlain and overlain by mudstone packs. Similar intervals are found in other sections of wells (No. 2511).

Geological model construction of deposits at Zyuzeevsky uplift, which is complicated with ‘incisions’ of different directions and depths, lenses of sandstones in the Visean strata, should be based on the correlation of adjacent well sections. In turn, it must take into account the effect of erosion and karst processes on the reservoir properties of Visean sandstone and preserved by denudation Tournaisian rocks. It also should be based on the well testing data.

Thus, the formation of modern Tournaisian relief occurred in the regression of Tournaisian marine basin and subsequent Kosvinskian – Early Radayevskian break in sedimentation, established on the Russian Platform (Igolkina et al., 1977). This relief was created by the action of erosion and karst processes. Late Radayevskian – Bobrikovian and Tuslkian cycles of marine transgression led to the restoration of the marine environment and deposition of clastic rocks – Visean mudstones and sandstones. Features of physical and chemical composition of seawater, determined by lithology of destroyed surface, caused secondary calcitization and claying of both Visean sandstone and Tournaisian carbonate rocks.

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