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Distribution of organic matter in rocks of the Bazhenov horizon (*West Siberia*)

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Abstract

We studied the distribution of organic carbon in rocks of the Bazhenov horizon, a unique object of predominantly biogenic sedimentation in the West Siberian sedimentary basin. The contents of organic carbon in the rocks were determined using the data from 4094 core analyses and core-log relationships derived from 48,500 radioactive- and electrical-log measurements. For the Bazhenov and Tutleima Formations, both approaches gave the same results. The average content of organic carbon in the rocks is 7.7%. These data were used to compile a detailed map of the distribution of organic carbon contents in sedimentary rocks of the basin. It was shown that the average organic carbon content in the rocks increases from 2–4% on the periphery of the basin to 10–12% in its central, deepest part. The distribution of C_{org} values in the basin is highly asymmetric. The highest C_{org} values are observed in the southwestern part of the basin interior, where beds with >10% C_{org} range in thickness from 5 to 12–15 m. In sections, the highest C_{org} values are observed in their middle and upper parts, composed predominantly of silicites and mixtites enriched in biogenic silica.

Keywords: Bazhenov horizon; organic matter; West Siberia

Introduction

The presence of high levels of organic carbon in the Upper Jurassic intervals of Mesozoic sections of the West Siberian sedimentary basin was first reported as far back as 1958–1959 (Chernikov and Zapivalov, 1958; Gurari, 1959; Nikonov, 1959; Sverchkov, 1958). These intervals were used in the USSR as the basis for studying the distribution patterns of organic carbon in ancient sedimentary basins. The map of organic carbon values of Upper Jurassic rocks (formerly known as the Maryanovka Formation) was first published in 1959 (Gurari, 1959). In 1962–1964, mapping of organic carbon on the basis of more extensive factual material was undertaken by F.G. Gurari, N.P. Zapivalov, A.E. Kontorovich, I.I. Nesterov, A.S. Fomichev, etc. In these years, Strakhov (1962) wrote that the study of the spatial patterns of organic carbon in modern and ancient sedimentary basins should be a major aim of sedimentary geochemistry.

Mapping of organic carbon distributions in sedimentary rocks of West Siberia was initially based on available core data alone. The combination of nuclear logging and core-log correlation was first proposed by Pluman (1971) in an attempt to estimate organic carbon content in rocks of the Bazhenov Formation of West Siberia, which had the potential to greatly increase the observation density in the resultant maps. In the 1980s, building on the approach described in Pluman (1971), similar methods were proposed by F.G. Gurari and V.I. Moskvin (Gurari et al., 1988), and later by Kontorovich (2002). Empirical core-log relationships were developed by these authors based on averages of using averages of the parameter estimates for the Bazhenov Formation derived from each well. In this study, the concentrations of organic carbon (C_{org}) were determined in the Volgian–Berriasian section at each 0.5-m interval using the following core–log relationship:

$$C_{org} = a \cdot \log_{10}(GL) + b \cdot \log_{10}(LL) + c,$$

where a, b, c are the parameters estimated from laboratory determinations of C_{org} content in core and measurements of the natural radioactivity and subsurface electrical resistivity

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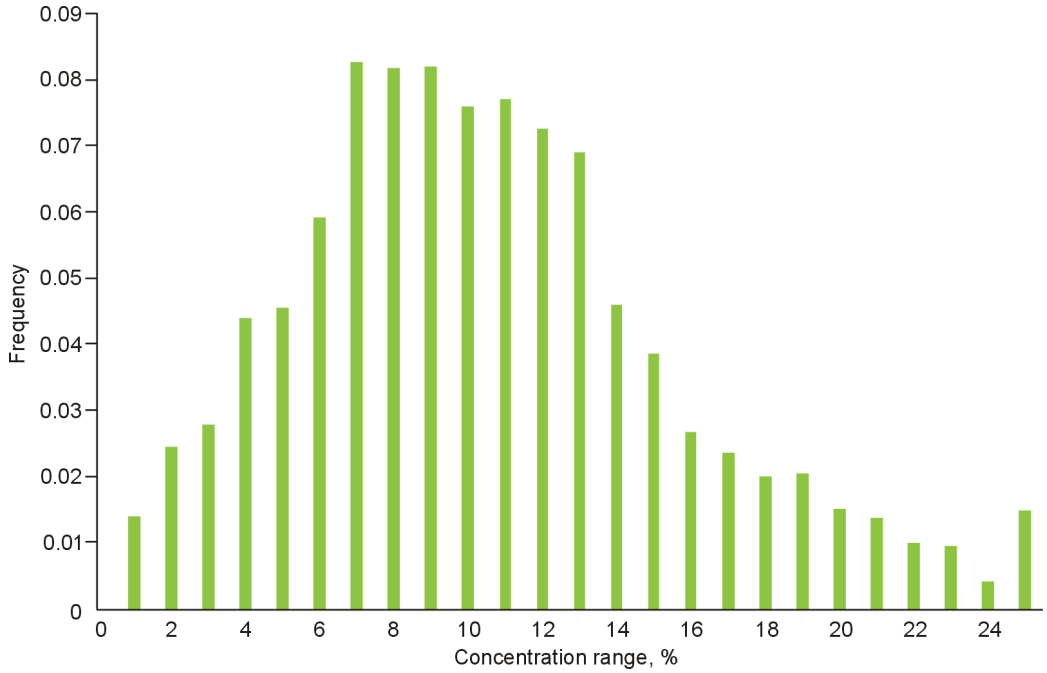

Fig. 1. Histogram of organic carbon (C_{org}) concentrations in rocks of the Bazhenov and Tutleima (lower unit) Formations (derived from core): wells—232, analyses—4094, $C_{org\ av}$ = 7.7. Here and in Figs. 2–4, the beginning of each concentration range is shown on the *x*-axis.

from gamma-ray logs and lateral logs. The three constants *a, b, c* are different from each other for different facies regions.

The results of our study show that the present-day organic carbon content ranges from 1–2 to 25% in the central part of the West Siberian basin (Bazhenov and Tutleima (lower unit) Formations). The C_{org} values for these rocks often range from 7 to 13%, with an average of 7.7% based on 4094 analyses (Fig. 1). In the eastern part of the basin (Golchikha, Yanovstan, and Maryanovka Formations), C_{org} values vary from a few tenths of percent to 6–7%, ranging most often from 1 to 3%, with an average of 1.9% based on 376 analyses (Fig. 2).

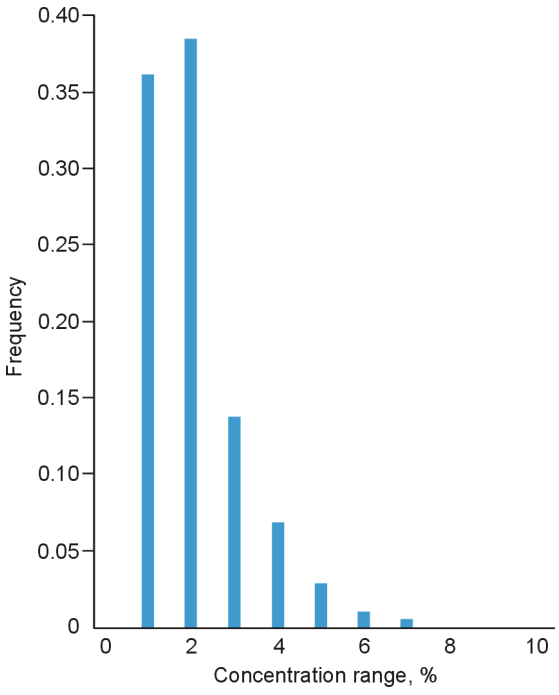

Fig. 2. Histogram of organic carbon (C_{org}) concentrations in rocks of the Golchikha, Yanovstan, and Maryanovka Formations (derived from core): wells—38, analyses—376, $C_{org\ av}$ = 1.9.

The core–log correlation was developed using nuclear logs from more than 870 wells drilled in the central part of the West Siberian basin. The results were used to determine the C_{org} content across the Bazhenov horizon for all of the cored wells. The C_{org} values in each well were determined at 48,500 points. These estimates were fairly consistent with the average organic carbon content (7.6%) for the Bazhenov and Tutleima (lower unit) Formations (Fig. 3).

The analysis of log data for the southern and western (southern portion) parts of the basin (Maryanovka, Mulym'ya, and Danilov Formations) was used to measure C_{org} in these wells at more than 4700 points. The processing of these data gave the average C_{org} value of 3.2% (Fig. 4).

It should taken into account that a positive correlation can often be observed between uranium and organic carbon content and between the U log and organic carbon values if the latter show a range between 2–4 and 15–20%. Therefore, no core–log relationships were established for the norther regions of the West Siberian basin where C_{org} values are rarely higher than 5–6% and the maps for these regions were built on the basis of analytical data alone.

Kontorovich et al. (2016) proposed a new classification of rocks of the Bazhenov Formation and showed that kerogen is a major rock-forming component. It was also shown that siliceous rocks usually contain >10% kerogen: