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GEOLOGY

Reasons for the Outbreak of Microphytoplankton Productivity in the Late Oligocene Turtas Lake–Sea, Western Siberia

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Abstract—Palynological (dinocysts) and geochemical data were compared for the first time for Paleogene sediments of borehole no. 8 (settlement of Russkaya Polyana, Omsk oblast). The layers with a concentrated amount of dinocysts of the genus *Pseudokomewuia* (20.5% of the palynocomplex) are characterized by higher contents of Fe, P, Ti, Nb, Ta, and W. The microphytoplankton bloom (an analog of the present-day red tides) in the late Oligocene Turtas Lake–Sea was probably caused by a greater contribution of nutrient substances from the continent during the transgression of this basin. Comparative analysis of the geochemical features of marine and continental Paleogene sediments from borehole no. 8 showed that the Turtas basin was either freshwater or had brackish water.

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The Turtas Lake–Sea occupied a significant part of the territory of the West Siberian plate in the Late Oligocene [9]. The sediments of this paleobasin are characterized by the presence of dinocysts of the genus *Pseudokomewuia*, which were found for the first time in the Upper Oligocene Zhuravka Formation (the southern and southeastern part of the West Siberian plate) [5, 6]. At present, dinocysts of this genus are known from 18 occurrences of the plate (Fig. 1). They were also found in the Upper Oligocene Turtas Formation (the southeastern and central part of the plate) [1, 7]. Most fossil and present dinocyst taxons are marine; thus, the findings of *Pseudokomewuia* forced us to reopen the problem of the genesis of the Turtas Lake–Sea. Previously, it had been suggested that it could have been brackish water or even marine because of the typical layering of sediments, greenish color, and presence of glauconite [9]. The dinocyst findings still impede from a final conclusion on the genesis of this intracontinental basin, because the data on ecological features of the representatives of the genus *Pseudokomewuia* are ambiguous. The species of this genus occur in both freshwater lacustrine [10] and lagoonal conditions with lower salinity [11, 12].

The findings of *Pseudokomewuia* in Siberian sections provide the possibility to specify the ecological conditions for this genus and to reveal the reasons for bloom of this microalgae group in the late Oligocene. With this aim, we compared the palynological and geochemical data for 29 samples collected from the drill core of borehole no. 8 (settlement of Russkaya Polyana, Omsk oblast). The samples were taken from formations with proven marine genesis (Talitskaya (*tl*), Lyulinvor (*ll*), Tavda (*tv*)), as well as from the continental Isilkul (*is*), Novomikhailovka (*nm*), Zhuravka (*zr*), Ambrosimovka (*ab*), and Beshcheul (*bs*) formations. Most samples were collected from the Upper Oligocene Zhuravka Formation (Fig. 2). The geochemical samples of continental formations were taken from intervals that have previously been described well by palynological and magnetostratigraphic data [3].

The rocks were crushed to a powder and fused up to glass condition using an Ir heater [15]. The contents of major and trace elements were analyzed on a Jeol JXA 8200 SuberProbe microprobe at the Max Planck Institute for Chemistry (Mainz, Germany) [13]. Some trace elements were determined by laser ablation inductively coupled mass spectrometry (LA-ICP-MS) on an ELEMENT-2 mass spectrometer (Thermo Scientific, Great Britain) equipped with a UP-213 solid-state laser (New Wave Research, Great Britain) using basalt glass KL-2G and NIST 612 as standards and Ca as a normalized element [14]. The typical laser beam was 60–80 μm, and the ablation time was 60–80 s. The analytical error estimated from standard reproduction was less than 5 (2σ) and 10 rel. % for contents of >1 and ~0.1 ppm, respectively.

The chemical composition of marine and continental samples is significantly distinct in contents of (ppm) Ba (122–357 vs. 192–2243), Ta (0.3–1.1 vs.

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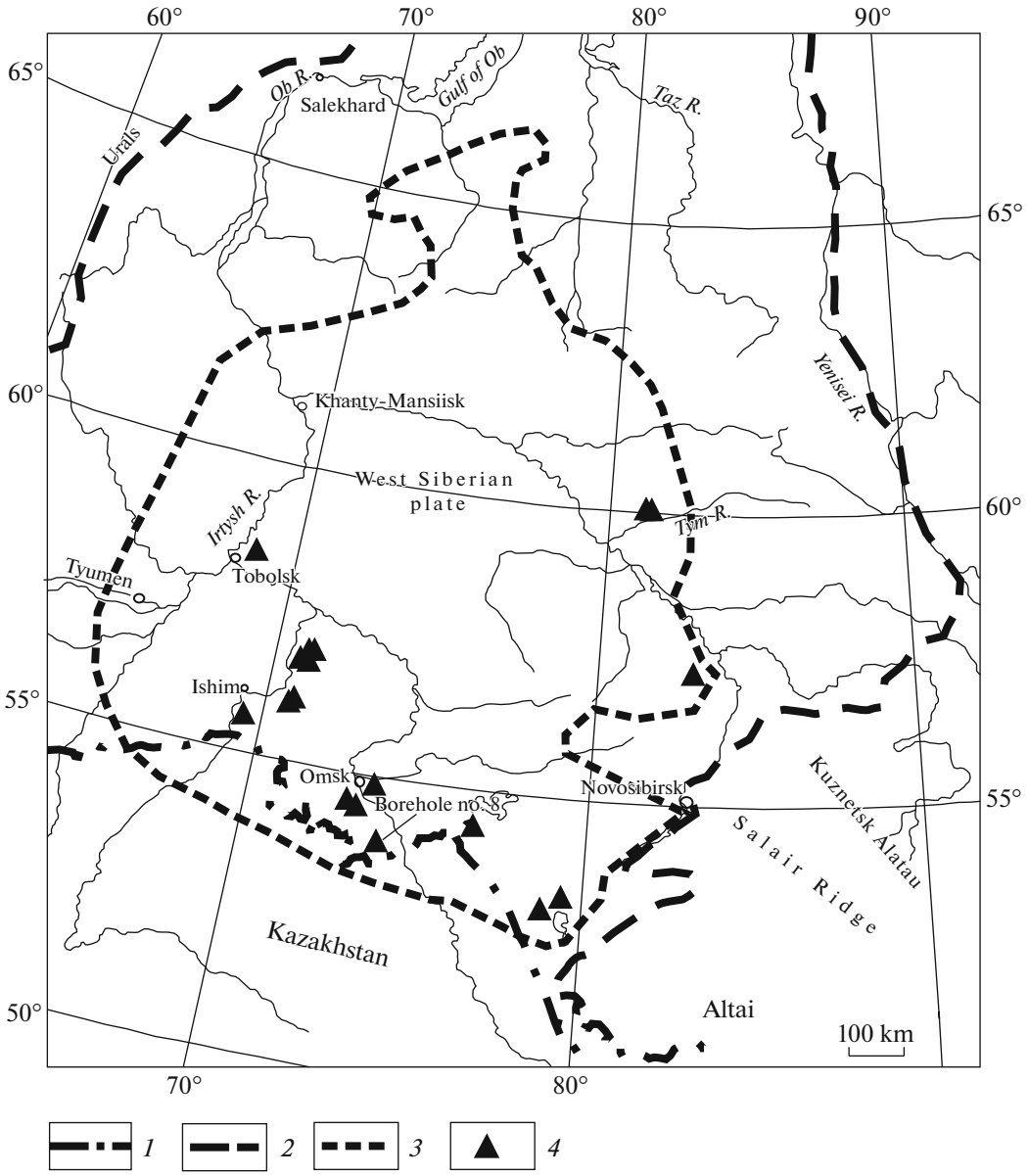

Fig. 1. Scheme of West Siberian plate. *1–3*, Boundaries of (*1*) Russia, (*2*) the West Siberian plate and its mountainous framework, (*3*) the Late Oligocene Turtas Lake–Sea; (*4*) position of boreholes with dinocyst findings [1, 4, 5].

1.3–6), Zr (42–277 vs. 70–2820), Ti (1028–7202 vs. 7202–22071), and V (197–411 vs. 73–149), respectively. The Na_2O content of marine sediments is 0.8–1.1 wt % in contrast to 1.1–2.2 wt % Na_2O of continental sediments. The MgO/Sr ratio of marine and continental samples reliably reflects the degree of paleosalinity: the high MgO content combined with low Sr content is evidence of high paleosalinity and vice versa. The MgO content of marine formations is insignificantly higher, on average, than that of continental formations: 1.1–2.4 and 0.2–1.9 wt % MgO, respectively. At the same time, the Sr content is notably distinct: 99–174 and 150–574 ppm, respectively.

A sample from a depth of 58.6–58.7 m (Zhuravka Formation) is distinct from other samples of the section by its high Fe, P, Ti, Nb, Ta, and W contents, as well as maximum amounts of dinocysts (20.5% of palinocomplex) (Fig. 2).

Indirectly, comparison of the chemical composition of marine and continental rocks exposed by borehole no. 8 is indicative of the unlikely normal salinity of the late Oligocene Turtas Lake–Sea. A marine genesis of the Zhuravka Formation is also not supported by biomarkers of organic matter [3]. The basin was most likely freshwater or brackish. It may have been affected by marine basins to the south through the Turgai Strait, although this connection still lacks evi-

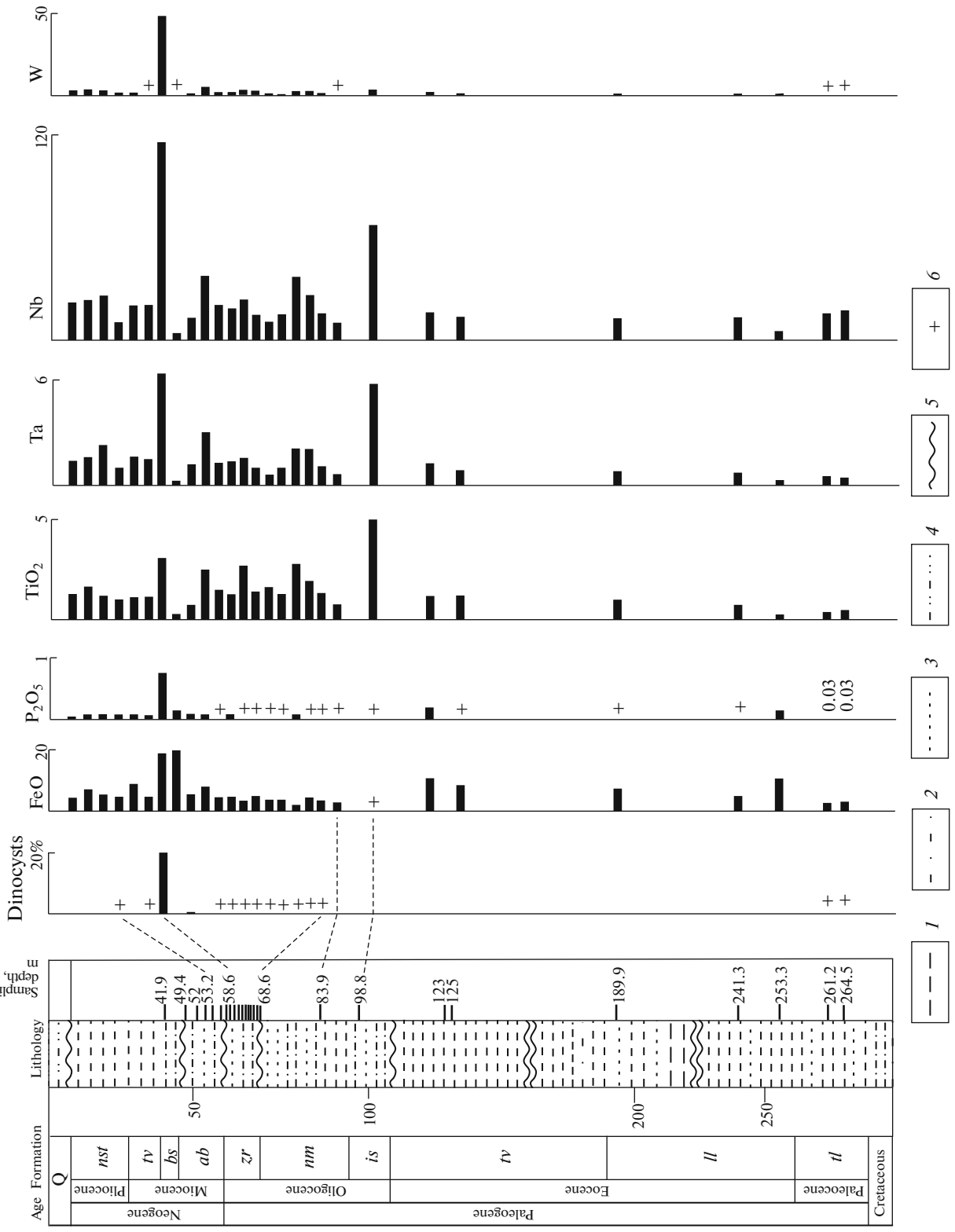

Fig. 2. Comparison of palynological (dinocysts) and geochemical data for borehole no. 8. *1*, Clay; *2*, silt; *3*, sand; *4*, loam; *5*, hiatus; *6*, content of <1 (<0.1 for P_2O_5). Concentration of dinocysts (%) and major (Fe, P, Ti) and trace (Ta, Na, W) elements (wt. % and ppm, respectively).

dence: no typical marine dinocyst species have been found in western Siberia and there are no data on findings of dinocysts of the genus *Pseudokomewuia* in the Oligocene of the East European platform and Sarmatian and Turan cratons.

The maximum concentration of dinocysts in the Zhuravka Formation of borehole no. 8 correlates with a high content of Fe, which is a key element of photosynthesis. The higher Fe content may be evidence of anoxic sedimentation conditions. The P contents are related to the higher bioproductivity of the paleobasin. The high concentrations of Ti, Nb, Ta, and W indicate an increased contribution of terrigenous material [8].

As known, the present-day red tides are caused by human environmental pollution, when the basin is poisoned by a great amount of chemicals, which provide nutrient conditions for plankton. In the geological record, such events occurred as a result of sharp eustatic oscillations of the basin level [2]. Thus, the dinocyst blossom of the Turtas Lake–Sea could have been caused by the higher contribution of terrigenous material, as well as nutrient substances, which are necessary for life activity of plankton. This could have resulted from coastal erosion and, probably, was caused by an increased level of the basin. Only one interval with a maximum amount of dinocysts was revealed in the studied sections of the Turtas and Zhuravka formations [7]. In the Turtas Formation, it is confined to the intermediate part, whereas, in the Zhuravka Formation, which is abundant in the southern and southeastern parts of the valley, it typically occurs at the bottom of the straton. This formation was probably formed later, when the Turtas Lake–Sea moved to the southern and southeastern parts of the basin as a result of transgression [7]. It can be suggested that the microphytoplankton bloom was synchronous for the entire area of the paleobasin, which allows us to use this event for intraregional correlation of sections.

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