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RESEARCH ARTICLE

Diversity, stratigraphy and ecology of diatoms and plant pollen in the Miocene-Pliocene sediments of the Vitim Plateau (Baikal region, Russia)

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Abstract

We performed lithogeochemical and biostratigraphical studies of the core from the hole 8182 in the Northern paleovalley of Vitim Plateau. According to lithogeochemical characteristics of the sediments in the section, 5 members were found out. Three lower ones characterize the Dzhilinda suite, two upper ones – the Khoygot stratum. The analysis of biodiversity and fossil diatom algae distribution in the core resulted in revealing of 137 species and varieties of diatom algae related to 50 genera. Four diatom zones (DZ) were established by appearing or disappearing of index species. Ecological and geographic analysis showed domination of planktonic, indifferent, cosmopolite species. Palynological analysis revealed three pollen members with reconstruction of vegetation of forest type reflecting the vector of cooling and climate change from moderately warm one in Middle-Late Miocene to moderately cool in Early Pliocene.

Keywords
Diatom, Miocene, Palynological analysis, Pliocene, Vitim Plateau

Introduction

The Vitim Plateau is situated eastward from the Baikal Rift Zone (Fig. 1). During Mezozoic and Cenozoic, sedimentary and volcanogenic-sedimentary members accumulated there. Geological survey and drilling resulted in marking of the boundaries of three main paleovalleys (Northern, Central and Southern ones) buried by basalts (Luchinin et al. 1992; Rasskazov et al. 2000, 2007; Rasskazov and Chuvashova 2018). Volcanogenic-sedimentary rocks of Dzhilinda suite of Middle-Upper Miocene with lavas age range of 16-9 My and ones of Khoygot stratum of Upper Miocene-Pliocene with lavas age range of 5.0-2.8 My were revealed within these paleovalleys (Rasskazov et al. 2007; Chuvashova et al. 2019). Diatoms and terrestrial plants pollen are available in these deposits.

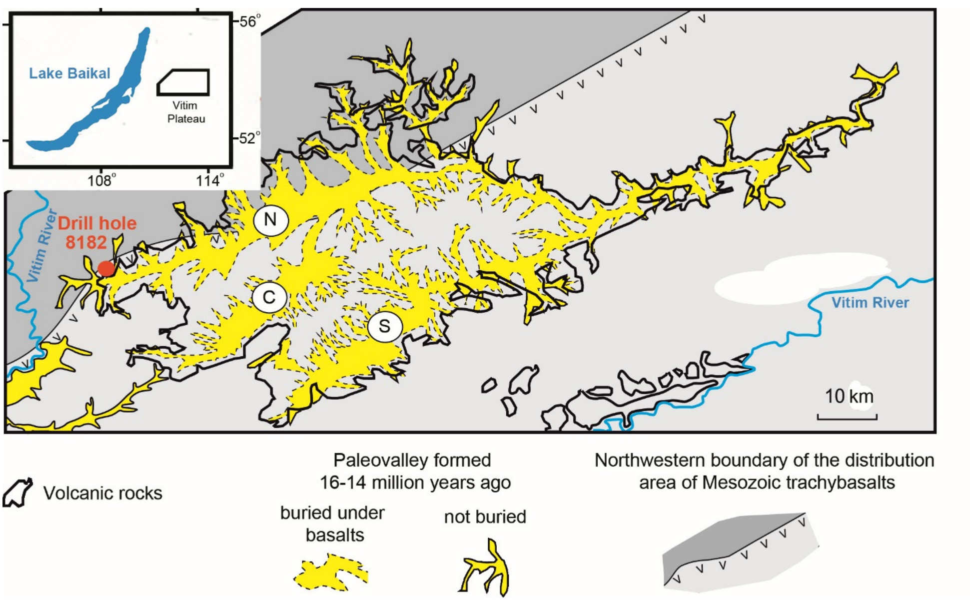

Figure 1. Geological setting of the Vitim Plateau and location of the 8182 drill hole. The scheme shows the paleo-valleys: Northern (N), Central (C) and Southern (S) ones.

While studying the diatom flora from three main paleovalleys on Vitim Plateau (Rasskazov et al. 2001, 2007; Chernyaeva et al. 2007) it was shown that Miocene lacustrine sediments in Northern and Southern paleovalleys differ by diatoms species composition. According to the data of the above cited authors, miocene diatom member of the Southern paleovalley is represented by ancient species *Aulacoseira praegranulata* var. *praeislandica* (Jouse) Moisseeva, *Actinocyclus tubulosus*

Khursevich, *A.* aff. *tunkaensis* Khursevich, *A. gorbunovii* (Sheshukova) Moisseeva et Sheshukova, *A. krasskei* (Krasske) Bradbury et Krebs (=*Coscinodiscus miocaenicus* Krasske), *Lobodiscus sibericus* (Tscheremissinova) Lupikina et Khursevich, *Pseudo-aulacosira moisseeviae* (Lupikina) Lupikina et Khursevich and *Alveolophora tscheremissinovae* Khursevich (Rasskazov et al. 2001, 2007; Chernyaeva et al. 2007). The detailed analysis of diatoms from the hole 7236 of the Southern paleovalley by scanning electronic microscopy (SEM) allowed us first for the region to determine the species *Aulacoseira spiralis* (Ehrenberg) Houk et Klee (Usoltseva et al. 2008), to widen the diagnoses for *A. gorbunovii*, *A. krasskei* and to describe new species *A. vitimicus* Usoltseva et Khursevich, *A. intermedius* Usoltseva et Khursevich and *Lobodiscus peculiaris* Usoltseva et Khursevich (Usoltseva et al. 2010).

Studies of fossil diatom algae in the Northern paleovalley was performed since 1970 (Endrikhinsky and Cheremisinova 1970). The authors found more than 50 taxa. Planktonic dominants among them were *Alveolophora jouseana* (Moiseeva) Moiseeva and different *Aulacoseira*. Species of *Actinocyclus* were represented by single specimens of *A. krasskei* and *Actinocyclus* sp. Later, A.I. Moiseeva determined 15 diatoms taxa, among which A. jouseana, some ancient taxa of *Aulacoseira* and *A. gorbunovii* (Moiseeva 1984) dominated. More detailed studies of diatoms in the Northern paleovalley were performed by G.P. Chernyaeva (Rasskazov et al. 2007; Chernyaeva et al. 2007). The studied cores from the holes 4053, 4119, 4124 and 3696 were characterized by homotypic composition consisting of more than 50 specific and intraspecific taxa. Dominant species were representatives of the planktonic genera *Alveolophora* (*A. areolata* (Moisseeva) Moisseeva, *A. jouseana* and *A. tscheremissinovae*), *Aulacoseira* (*A. baicalensis* (Wislouch) Simonsen, *A. praegranulata* var. *praeislandica* (Jouse) Moisseeva), *Actinocyclus* (*A. tuncaensis* and *A. krasskei*), *Concentrodiscus variabilis* Khursevich et Chernyaeva and species of the littoral genus *Tetracyclus*. It is shown that this diatom member developed under the conditions of a deep-water mountain lake of oligotrophic type with a littoral zone.

The analysis of spores and pollen of terrestrial plants from Vitim Plateau allowed to establish 11 palynological members (PU) of Paleogene and Neogene age (Rasskazov et al. 2007). Palynological member of the deposits from Oligocene-Early Miocene (PU III-IV) suggested expansion of polydominant coniferous-broadleaved forests with relicts of vegetation of Eocene and not numerous representatives of Turgay flora. Palynological members of Middle Miocene-Lower Pliocene (PU V-VIII) characterized the degradation of Turgay flora. Layers with spores and pollen of Pliocene (PU IX-XII) are obtained from the volcanogenic-sedimentary Northern paleovalley and suggest establishment and development of boreal flora.

The aim of this work was to study taxonomic composition, stratigraphy and ecology of diatoms, spores and pollen in the core 8182 from the Northern paleovalley of Vitim Plateau to justify the age of deposits and to reconstruct the paleoenvironment of diatoms and terrestrial vegetation habitat.

Materials and methods

Lithogeochemical Analysis

We studied a core from the hole 8182 sampled in the western part of the Northern paleovalley of Vitim Plateau. The core thickness was 105 m. During lithological studies, we determined facial peculiarities of the deposits by their color, composition, structure and texture features, character of debris material, mineral inclusions, inclusions of organic material (detritus), contacts between the layers, as well as by variation of these features in the section.

The contents of petrogenic oxides were determined in the Analytical Center of IEC of RAS SB by classic methods of "wet lab". Sample drying at the temperature of 105 ℃ eliminated hygroscopic water (H_2O-), the ignition at the temperature of 950 ℃-other volatile components (loss on ignition (LOI). Using high temperature heating, we extracted from sedimentary rocks constitutional water of minerals (including clayey ones) and annealed detritus organic material (Sizykh 1985; Ryashchenko and Ukhova 2008; Rasskazov et al. 2012). For sedimentary rocks, we calculated the Chemical Index of Alteration, $CIA=100\times Al_2O_3/(Al_2O_3+CaO+Na_2O+K_2O$ (Nesbitt and Young 1982 (calculated in mass %)) and ratio Fe_2O_3/FeO (Rasskazov et al. 2016).

Sedimentary sequence and Geochemical proxies of the Core 8182

We determined in the hole 8182 the deposits of two stratons: one of Dzhilinda suite and one of Khoygot stratum with revealed 5 sedimentary-volcanogenic members (Fig. 2). Basanites of the sectin base correlate with rocks similar by composition from the section of Lake Mukhal with K-Ar-dating of 13-12 My (Rasskazov et al. 2000).

Member 1 (interval of 102-89 m) is represented by aleurolite, grey, dark grey and black with inclusions of black organic material. Vivianite inclusions occurred at the depths of 94 and 99 m. A layer of fine-grained dark grey sand occurred in the upper part.

Member 2 (interval of 89-68 m) is divided into two layers. The lower one in the interval of 89-75 m, consists of aleurolite, dark grey, cream colored, somewhere with a yellow tint (limonitized). The depths interval of 85-86 m is represented by a layer of aleurosandstone of grey color. The upper layer (75-68 m) is represented by homogenous aleurolite, immensely light, light grey. There were inclusions of vivianite grains, it maximal accumulation was observed in the depths interval of 82-78 m.

Member 3 (interval of 68-50 m) consists of homogenous aleurolite, grey, somewhere with greenish tint, light (with diatoms). There were somewhere in this member inclusions of vivianite and detritus.

Member 4 (interval of 50-42 m) included different lithological types of deposits. The lower part of the member consists of dark grey aleurosandstone without diatoms. The upper part, in the depths interval of 45-42 m, is represented by grey aleurolite with diatoms and inclusions of vivianite.

Member 5 (interval of 42-19 m) is characterized by alternation of aleurosandstones and sandstones, fine-grained or consertal, grey, light grey. The member contains a large amount of biotite small grains and single inclusions of quartz grains. There is on the depth of 24-25 m a basalt interbed similar by its composition with basalts crowning the section of the Sirinikta R. with K–Ar-dating of 4.4 My (Rasskazov et al. 2000).

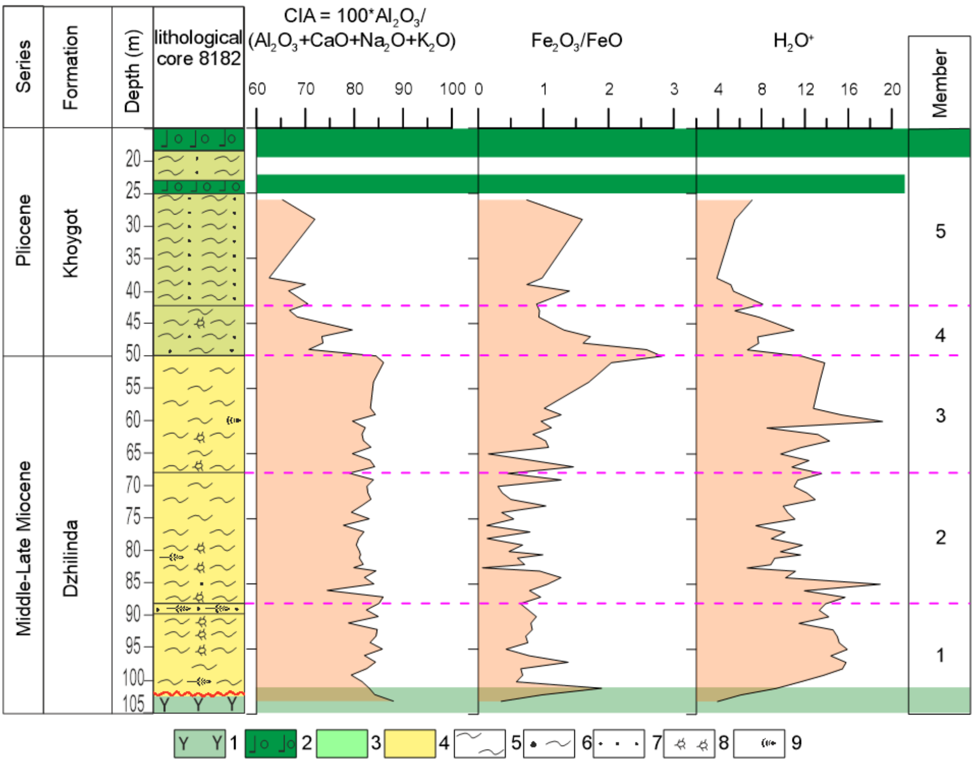

Figure 2. Change of sediment compositions and facies in the core 8182. In cores, deep variations in the chemical index of alteration (CIA) are determined, oxidation of iron (Fe_2O_3/FeO) and loss on ignition (LOI). Lithological and stratigraphic characteristics: **1** – basanite (12 My); **2** – basalt (4.4 My); **3** – Khoygot stratum (Pliocene); **4** – Upper Dzhilinda subsuite (Middle-Upper Miocene); **5** – aleurolite; **6** – aleurosandstone; **7** –sandstone; **8** – vivianite; **9** – detritus; **10** – boundary of stratigraphic unconformity.

Specificity of the lithogeochemical composition at different levels of the Late Miocene to Early Pliocene section is considered as an indicator of paleoclimatic change. At transition from Dzhilinda suite deposits to Khoygot stratum ones, there is an abrupt increase of iron oxidation (increase of Fe_2O_3/FeO), and values of CIA and content of LOI decreased gradually with small amplitude oscillations.

In the deposits of Dzhilinda suite (members 1-3), the values of CIA proxy (Nesbitt and Young 1982) were mainly in the interval of 77.82-88.0. With increase of CIA, the contents of LOI increased from 3.9 to 19.1 mass %, this is due to alternation of interbeds with different saturation with diatom algae, clay and vegetal detritus. Taking into account average content of H_2O in clays (ca. 10 mass %), higher LOI values can suggest presence of organic material. In the unique sample from the middle part of the member 2 (depth of 86 m), the value decreases up to 74.4 at LOI contents of 11.9 mass %) due to the increase of the role of sand component (Fig. 2).

Sedimentary deposits of Khoygot suite (members 4 and 5) are characterized by CIA values of 62.6-73.6 at LOI contents from 3.9 to 8.1 mass %, except the sample from the depth of 46 m with higher CIA (79.6) and LOI (11.0 mass %) contents (Fig. 2). Compared to deposits of Dzhilinda suite, the deposits of Khoygot stratum manifest decrease of LOI content, i.e., combined H_2O, included into clayey minerals and decrease of organic material amount.

In the deposits of the hole 8182, the values of ratio Fe_2O_3/FeO (Fig. 2) did not increase 1.8. The most oxidized rock (Fe_2O_3/FeO = 2.0-2.8) occurs only in a low thickness zone of surface oxidation without features of development of bedded oxidation zones in transitional intervals from member 3 to member 4 (depth of 51-49 m). Probably, during sedimentation pause, oxidation occurred in the near-surface zone, in the transitional layer from Miocene to Pliocene.

In the same way, parameters of CIA, LOI and ratio Fe_2O_3/FeO decreased and increased in the bottom sedimets of Lake Baikal Academician Ridge (Kashik and Lomonosova 2006), Tankhoy tectonic step (Hamoud et al. 2019; 2021), Barguzin valley (Rasskazov et al. 2016) and Tunka Depression (Hassan et al. 2020).

Diatom Analysis

For diatom analysis, 22 samples were taken from the core. Preparation of samples for light microscopy and quantitative accounting was carried out according to the method described in (Grachev et al, 1998). Cleaned valves were dried on cover slips and mounted in Naphrax (Naphrax Ltd., United Kingdom, refractive index = 1.74) and counted using an Axiovert 200 ZEISS LM (Carl Zeiss, Jena, Germany) light microscopy equipped with a Pixera Penguin 600CL camera.

For scanning electron microscopy (SEM) observations, sediment samples were cleaned in 30% H_2O_2 solution at 75 °C for 3 h, rinsed three times with deionised water, then centrifuged and rinsed several times in 0.1 % sodium diphosphate anhydrous with distilled water to remove clay particles. A cleaned slurry was then mounted on a brass stub and coated with gold using a SDC 004 (BALZERS) ion sputter for 150 seconds at 10–15 mA. The stub was analysed using a SEM Quanta 200 (FEI Company, USA) at 21.5 kV and 10 mm working distance.

All SEM pictures were mounted using Adobe Photoshop CS4 Portable (Adobe Inc., San Jose, CA, USA). The Venn diagram was constructed using a resource http://bioinformatics.psb.ugent.be/webtools/Venn/. Morphological identification of taxa was carried out using the literature (Zabelina et al. 1951; Glezer et al. 1974; Krammer and Lange-Bertalot. 1986; 1991; Houk 2003; Houk and Klee 2007; Kozyrenko et al. 2008; Kuz'min et al. 2009; Usoltseva and Tsoy 2010; Kulikovskiy et al. 2012; Titova et al. 2021).

All determinations were done taking into account recent taxonomic changes listed in AlgaeBase (https://www.algaebase.org/). Ecological-geographic analyses were performed according to the articles (Getsen et al. 1978; Sládeček 1986; Van Dam et al. 1994; Barinova et al. 1996; 2000; 2006; Loseva et al. 2004; Stenina et al. 2017; 2019).

Spore-pollen Analysis

Sedimentary deposits age was found out by the results of palynological analysis providing determination of layers relative age by the dynamics of vegetation and climate conditions on the territory. Spore-pollen analysis was done by a standard method (Berglund and Ralska-Jasiewiczowa, 1986). Palynological macerate was examined using a light microscope Zeiss Axiolab with increase by 400 x and 630 x times. Spores and pollen volumes of vegetation groups and of each taxon were calculated from their total amount (not less than 500 members) in a spore-ponnen spectrum. On the spore-pollen diagram, horizontal axes without percentage show pollen and spores content <5%.

In order to specify the effect of sedimentation paleoclimatic conditions onto the peculiarities of spore-pollen spectra distribution, we performed a factor analysis using a sofrware Statistica 12 by method of main components without rotations. The graphs are made using softwares Grafer 13 and Corel Draw 16. Phototables are made using Adobe Photoshop CS4.

Result

Biodiversity and stratigraphy of Diatom flora. We studied species diversity and distribution of diatom algae in the core from the hole 8182. The diatoms were found in the depths interval of 98.0-20.0 m (Fig. 3). The species composition is represented by 137 species, among them 20 planktonic, 23 littoral-planktonic and 94 benthic taxa. The species list and their ecological and geographic characteristics are presented in the Table 1. The analysis of dominant species distribution in the core, appearing and disappearing of marker species resulted in revealing of 4 local diatom zones (DZ). Planktonic diatoms dominated in the whole core but their composition varied.

The Figure 4 shows difference of species structure in the core and diatoms abundance in different diatom zones.

DZ 1 is established in the depths interval of 98–88 m. Total diatoms abundance varied from 19.3 to 82.5 millions frustules/g. Leading role belonged to planktonic diatoms of two genera *Alveolophora* and *Aulacoseira*. Mass species was *Aulacoseira canadensis* (Hustedt) Simonsen (Figs 3–5). Its fraction was 11.0-89.5 % from total abundance of all frustules. Its maximal amount (82.5 millions frustules/g) was found out at the depth of 95 m. Accessory species was *Aulacoseira pusilla* (F. Meister) Tuji et Houki. *Alveolophora jouseana* (Moisseeva) Moisseeva was found out only in the lower part of the core (95-98 m) as much as 1.3-3.2 millions frustules/g. *Actinocyclus krasskei* occurred in small amounts (0.38 millions frustules/g) only at the depth of 95 m.

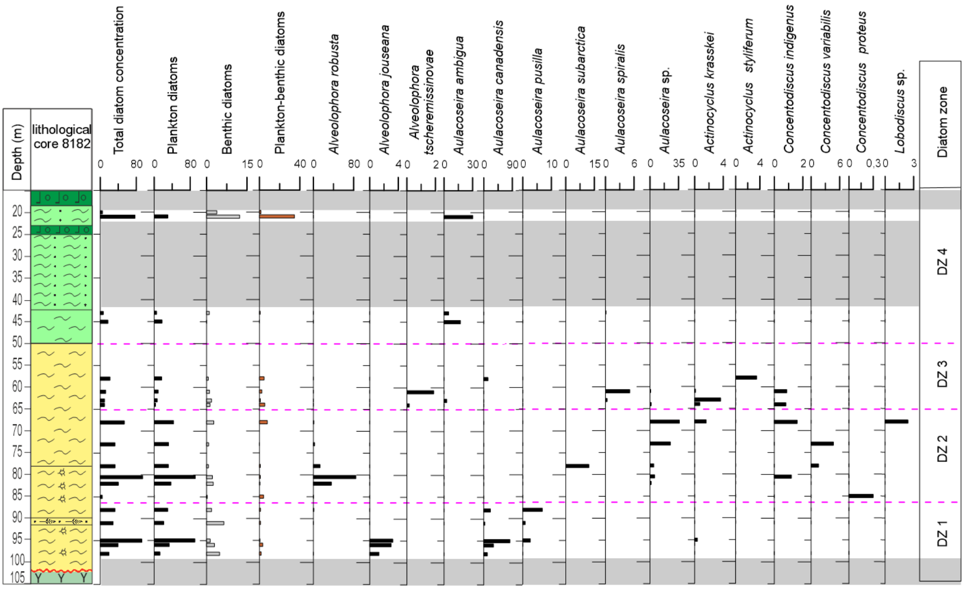

Figure 3. Distribution of planktonic diatoms in lacustrine sediments of the hole 8182 on Vitim Plateau. Along the x axis – millioms frustules/g.

The fraction of benthic-planktonic species was 0.4-8.5 %. There were among them *Melosira undulata* (Ehrenberg) Kützing, *Ellerbeckia kochii* (Pantocsek) Moisseeva, *Gomphonema intricatum* Kützing, *Gomphonema acuminatum* Ehrenberg, *Staurosira subsalina* (Hustedt) Lange-Bertalot, *S. venter* (Ehrenberg) Cleve et Möller, *Staurosirella martyi* (Héribaud) Morales et Manoylov, *Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot, *Pseudostaurosira brevistriata* (Grunow) Williams et Round, *Navicula cryptocephala* Kützing, *Tabellaria fenestrata* (Lyngbye) Kützing and *Tetracyclus emarginatus* (Ehrenberg) Smith.

Benthic species were represented (1.3-6.4 %) by *Amphora ovalis* (Kützing) Kützing, *Caloneis silicula* (Ehrenb.) Cleve, *Cymbella affinis* Kützing, *C. helvetica* Kützing, *C. subleptoceros* Krammer, *C. turgidula* Grunow, *Cymbopleura acuta* (AWFSchmidt) Krammer, *C. cuspidata* (Kützing) Krammer, *C. reinhardtii* (Grunow) Krammer), *Diploneis oblongella* (Naegeli) Cleve-Euler, *Eolimna aboensis* (Cleve) Genkal, *Eunotia arcus* Ehrenberg, *E. diadema* Ehrenberg, *E. minor* (Kützing) Grunow, *E. soleirolii*

(Kützing) Rabenh, *E. curtagrunowii* Nörpel-Schempp et Lange-Bertalot, *E. polyglyphis* (Grunow), *Epithemia sorex* Kützing, *E. zebra* var. *saxonica* (Kützing) Grunow, *Paraplaconeis placentula* (Ehrenberg) Kulikovskiy et Lange-Bertalot, *P. infirma* Krammer), *Pinnularia isostauron* Grunow, *P. obscura* Krasske, *P. brevicostata* Cleve, *P. interrupta* Smith, *P. microstauron* (Ehrenberg) Cleve, *P. phoenicenteron* f. *rostrata* A. Cleve, *P. subrostrata* (Cleve) Cleve, *Gomphonema parvulum* (Kützing) Kützing, *Placoneis gastrum* (Ehrenberg) Mereschkowsky, *P. elginensis* (Gregory) Cox, *Pseudostaurosira polonica* (Witak et Lange-Bertalot) Morales et Edlund, *Planothidium dubium* (Grunow) Round et Bukhtiyarova, *Skabitschewskia peragalloi* (Brun et Herib) Kulik. et Lange- Bertalot, *S. oestrupii* (Cleve) Kulikovskiy et Lange-Bertalot, *Sellaphora laevissima* (Kütz.) Mann, *Staurosira binodis* (Ehrenberg) Lange-Bertalot, *S. obtusa* Lagerstedt, *Navicula radiosa* Kützing, *N. oppugnata* Hustedt, *Reimeria sinuata* (W. Gregory) Kociolek et Stoermer, *Tetracyclus japonicus* (Petit) Tempère et Peragallo, *T. ellipticus* (Ehrenberg) Grunow, *T. glans* (Ehrenberg) Mills, *T. rupestris* (Kützing) Grunow, *T. strumosus* (Ehrenberg) Williams.

Major part of benthic species occur in water bodies nowadays. Extant taxa were the species *Tetracyclus japonicus*, *T. ellipticus*, *T. rupestris* and *T. strumosus*.

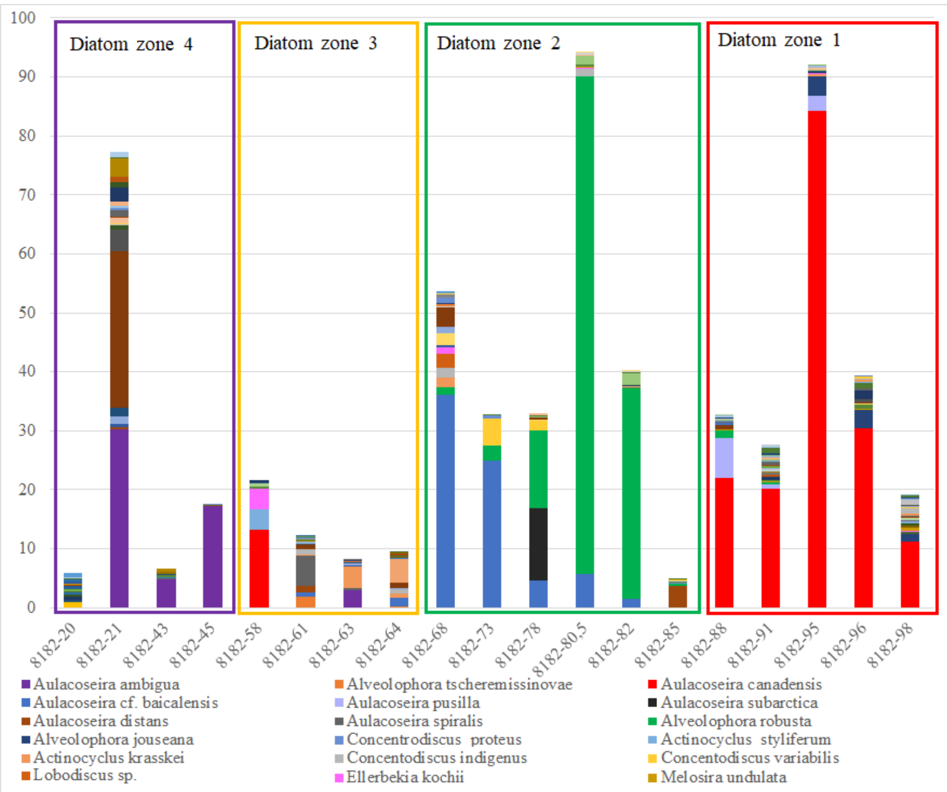

Figure 4. Diatoms species structure in lacustrine sediments of the hole 8182 on Vitim Plateau. Along the x axis – millions frustules/g.

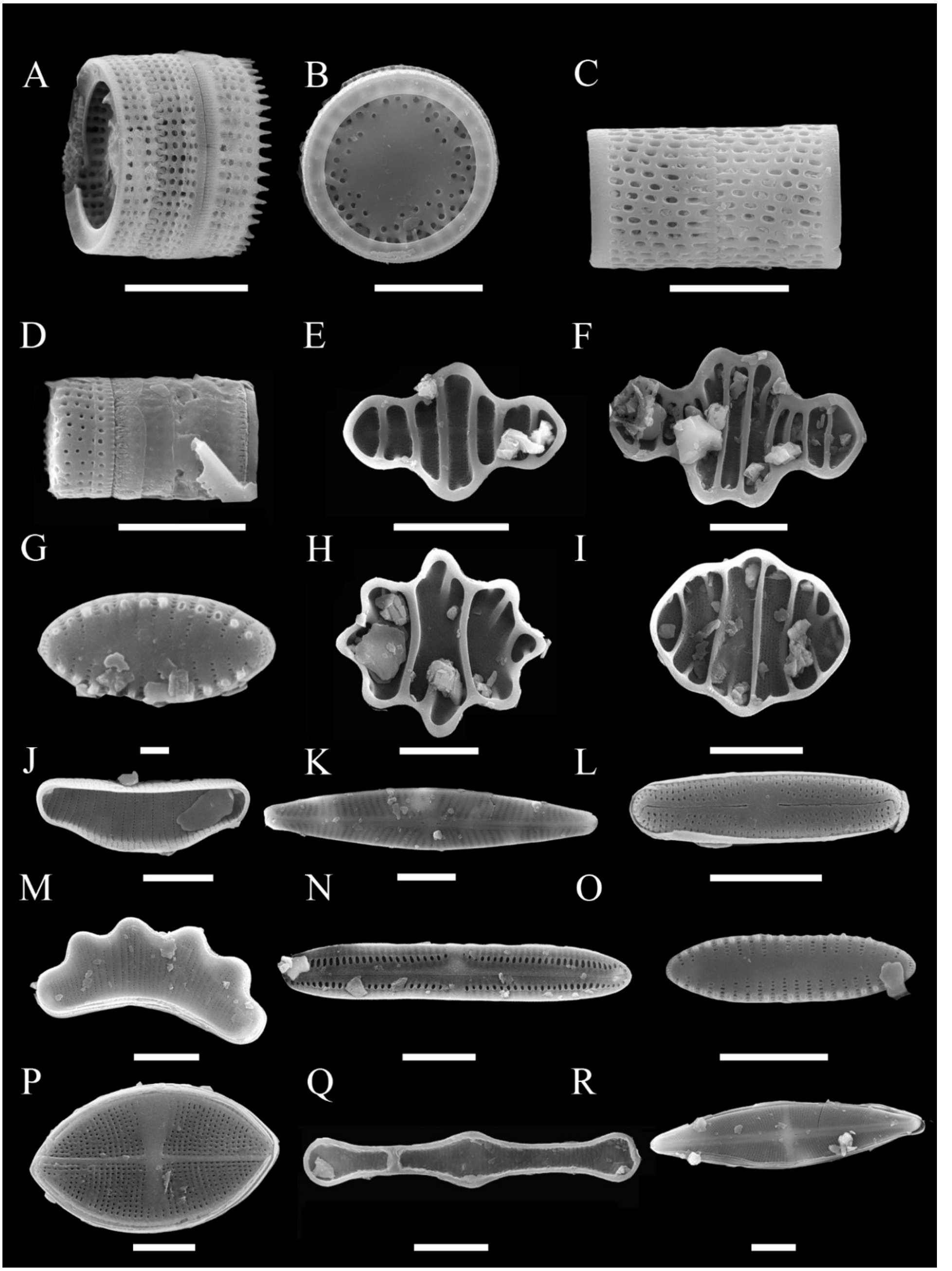

Figure 5. Some diatoms of diatom zone 1 of the 8182 core from Vitim Plateau. **A**, **B** –*Alveolophora jouseana*, **C** – *Aulacoseira canadensis*, **D** – *Aulacoseira pusilla*, **E** – *Tetracyclus glans*, **F** – *Tetracyclus emarginatus*, **G** – *Staurosira subsalina*, **H** – *Tetracyclus japonicus*, **I** – *Tetracyclus strumosus*, **J** – *Eunotia inflata*, **K** – *Navicula radiosa*, **L** – *Genkalia digituloides*, **M** – *Eunotia robusta* var. *tetraedon*, **N** – *Pinnularia* sp., **O** – *Staurosira subsalina*, **P** – *Gololobia obliqua*, **Q** – *Tabellaria fenestrata*, **R** – *Stauroneis phoenicenteron*. Scale bars: 10 μm (A–C, E, F, H, I, K, N, Q, R), 5 μm (D, J, L, M, O, P) and 1 μm (G).

DZ 2 is established in the interval of 85–68 m. Diatoms concentration in this zone was maximal. The frustules abundance varied from 4.8 to 94.2 millions frustules/g. Planktonic genera were very diverse (Figs 3, 4, 6). Besides *Alveolophora* and *Aulacoseira* representatives of extant genera *Actinocyclus*, *Concentrodiscus* and *Lobodiscus* appeared. In the lower part of the zone (85–78 m), dominant species was *Alveolophora robusta* (Khursevich) Usoltseva et Khursevich (6.2–89.7 %), and in the upper one (75–65 m) – *Aulacoseira* sp. 1 (67.5–75.9 %). There were small amounts of *Aulacoseira subarctica* (O. Müller) Haworth, *Actinocyclus krasskei*, *Concentrodiscus indigenus* Khursevich et Fedenya, *C. variabilis* Khursevich et Chernyaeva, *C. proteus* Khursevich et Fedenya, *Mesodictyopsis insolita* Khursevich et Fedenya, *M. peculiaris* Khursevich, Iwashita, Kociolek et Fedenya, *Ulnaria capitata* (Ehrenberg) Compère and *Lobodiscus* sp.

Benthic–planktonic diatoms occurred in small aounts (up to 14.8 %). At the horizon of 85 m, they reached up to 82.1 % (3.9 million frustules/g). They are represented by *Aulacoseira distans* (Ehrenberg) Simonsen, *Ellerbeckia kochii*, *Melosira undulata*, *Aneumastus tusculus* (Ehrenberg) Mann et Stickle, *Cavinula pseudoscutiformis* (Hustedt) Mann et Stickle, *Gomphonema intricatum*, *G. acuminatum*, *Planothidium lanceolatum*, *Pseudostaurosira brevistriata*, *Nitzschia amphibia* Grunow, *Nitzschia palea* (Kützing) Smith, *Odontidium hyemale* (Roth) Kützing, *Staurosira subsalina*, *Staurosirella martyi* and *Tabellaria fenestrata*.

The fraction of benthic diatoms was 2.0–6.1 % of total amount. They were represented by *Altana cingens* (Skvortsov) Kulikovskiy, *Cymbella helvetica*, *C. subleptoceros* Krammer, *C. tumida* (Brébisson) Van Heurck, *Didymosphenia geminata* (Lyngbye) Schmidt, *Encyonema gracile* Rabenhorst, *Encyonema minutum* (Hilse) Mann, *E. perpusillum* (Cleve) Mann, *E. neogracile* Krammer, *Gomphonema parvulum*, *Gomphosphenia grovei* var. *lingulata* (Hustedt) Lange-Bertalot, *Eolimna aboensis*, *Epithemia turgida* (Ehrenberg) Kützing, *E. turgida* var. *granulata* (Ehrenberg) Brun, *Eunotia robusta* var. *tetraedon* (Ehrenberg) Ralfs, *E. polydentula* Hustedt, *E. polyglyphis*, *Navicula cari* Ehrenberg, *Nitzschia fonticola* (Grunow) Grunow, *N. dissipata* (Kützing) Rabenhorst, *N. palea* (Kützing) Smith, *Karayevia laterostrata* (Hustedt) Bukhtiyarova, *K. kolbei* (Hudtedt) Bukhtiyarova, *Planothidium dubium*, *Skabitschewskia circumradians* Kulikovskiy et Lange-Bertalot, *S. oestrupii*, *Pseudostaurosira polonica*, *Staurosirella oldenburgioides* (Lange-Bertalot) Morales, García et Maidana, *S. martyi*, *Rhopalodia gibba* (Ehrenberg) Müller, *Tetracyclus celaton* Okuno, *T. ellipticus*, *T. glans* and *T. rupestris*.

Extant taxa were *Gomphosphenia grovei* var. *lingulata*, *Tetracyclus celaton*, *T. ellipticus*, *T. ellipticus*, *T. glans* and *T. rupestris*.

DZ 3 is established in the interval of 64–58 m according to disappearing of the species *Alveophora robusta* and appearing of *Alveolophora tscheremissinovae* Khursevich (Fig. 7). Total diatoms abundance increased upward from 9.5 to 21.8 millions frustules/g. Planktonic diatoms *Aulacoseira spiralis* (Ehrenberg) Houk et Klee, *A. ambigua* (Grunow) Simonsen, *A. canadensis*, *Actinocyclus krasskei*, *A. styliferum* Khursevich et Fedenya, *Concentrodiscus indigenus*, *Concentrodiscus subabnormis* Khursevich et Fedenya and *Concentrodiscus* sp. dominated. Their fraction was 33.0–76.5 % of total abundance. There was single *Actinocyclus immemoratus* Khursevich et Fedenya.

Benthic-planktonic diatoms were represented by *Aulacoseira distans*, *Ellerbekia kochii*, *Cavinula cocconeiformis* (Gregory ex Greville) Mann et Stickle, *C. pseudoscutiformis*, *Gomphonema intricatum*, *Pseudostaurosira brevistriata*, *Stauroneis anceps* Ehrenberg, *Staurosira construens* Ehrenberg, *S. venter*, *S. subsalina* and *Staurosirella martyi*. Their fraction was 9.0–53.9 % of total abundance.

Benthic diatoms occurred in small amounts (2.7–18.9 %). There were among them *Altana woronichinii* (Jasnitsky) Kulikovskiy et Lange–Bertalot, *Cavinula scutelloides* (Smith) Lange-Bertalot, *Encyonema minutum*, *E. gracile*, *E. muelleri* (Hustedt) Mann, *E. silesiacum* (Bleisch) Mann, *Eolimna aboensis* (Cleve) Genkal, *E. polyglyphis*, *Fragilaria* sp., *Fallacia pygmaea* (Kützing) Stickle et Mann, *Genkalia* sp., *Gomphosphenia groove* var. *lingulata*, *Paraplaconeis placentula*, *Pinnularia microstauron* (Ehrenberg) Cleve, *Pinnularia* sp., *Placoneis elginensis*, *P. gastrum*, *P. zula* Kulikovskiy, *Pinnularia* sp. 1, *Pinnularia* sp. 2, *Punctastriata lancettula* (Schumann) Hamilton et Siver, *Navicula schonfeldii* Hustedt, *Grunowia tabellaria* (Grunow) Rabenhorst, *Sellaphora pupula* (Kützing) Mereschkovsky, *Skabitschewskia oestrupii*, *Stauroneis* sp., *Staurosira binodis*, *S. pinnata* (Ehrenberg) Williams et Round, *Staurosirella pinnata* (Ehrenberg) Williams et Round, *Tetracyclus glans*, *T. ellipticus* and *T. japonicus* (Petit) Tempère et Peragallo.

DZ 4 is established in the interval of 45–20 m (Fig. 8). In the sample from 45 m, planktonic diatoms amount was 17.3 millions frustules/g. The dominant species was *Aulacoseira ambigua*. Its fraction was 99 % of total diatoms abundance. Diatoms were not found in the interval of 42–25 m. Higher (21 m upward), the diatoms frustules abundance reached 77 millions frustules/g. In this zone, there were maximal values of abundance of benthic-planktonic (13 millions frustules/g) and benthic diatoms (38 millions frustules/g). There were no extant species in this zone.

Benthic-planktonic species were represented by *Aulacoseira distans*, *Ellerbekia kochii*, *Cavinula pseudoscutiformis*, *Gomphonema intricatum*, *Pseudostaurosira brevistriata*, *Pinnularia viridis* (Nitzsch) Ehrenberg, *Staurosira construens*, *S. subsalina*, *S. venter*, *Staurosirella martyi*, *Tabellaria fenestrata* and *Tetracyclus emarginatus*.

Such benthic species occurred as *Amphora* sp., *A. pediculus* (Kützing) Grunow, *Cymbopleura cuspidata* (Kützing) Krammer, *C. problematica* (Van Landingham) Krammer, *C. solea* (Brébisson) Smith, *Cymbella* sp., *C. subleptoceros*, *Didymosphenia geminata*, *Eunotia curtagrunowii*, *E. ewa* Lange-Bertalot et Witkowski, *Eunotia* sp., *E. minor*, *E. arcus*, *Gomphonema parvulum* (Kützing) Kützing, *Hantzschia* cf. *amphioxys* var. *vivax* Grunow, *Luticola mutica* (Kutzing) Mann, *Genkalia digituloides* (Lange-Bertalot) Lange-Bertalot et Kulikovskiy, *Genkalia digitulus* (Hustedt) Lange-Bertalot et Kulikovskiy, *Genkalia similis* Kulikovskiy, Lange-Bertalot et Metzeltin, *Pinnularia* sp., *P. microstauron*, *P. major* (Kützing) Rabenhorst, *P. interrupta*, *Placoneis gastrum*, *P. elginensis*, *P. anglophila* (Lange-Bertalot) Lange-Bertalot, *P. viridis* (Nitzsch) Ehrenberg, *Stauroneis javanica* (Grunow) Cleve, *S. phoenicenteron* (Nitzsch) Ehrenberg, *Staurosirella pinnata*, *Stauroforma* sp., *Tetracyclus japonicus*, *T. glans* and *T. strumosus*.

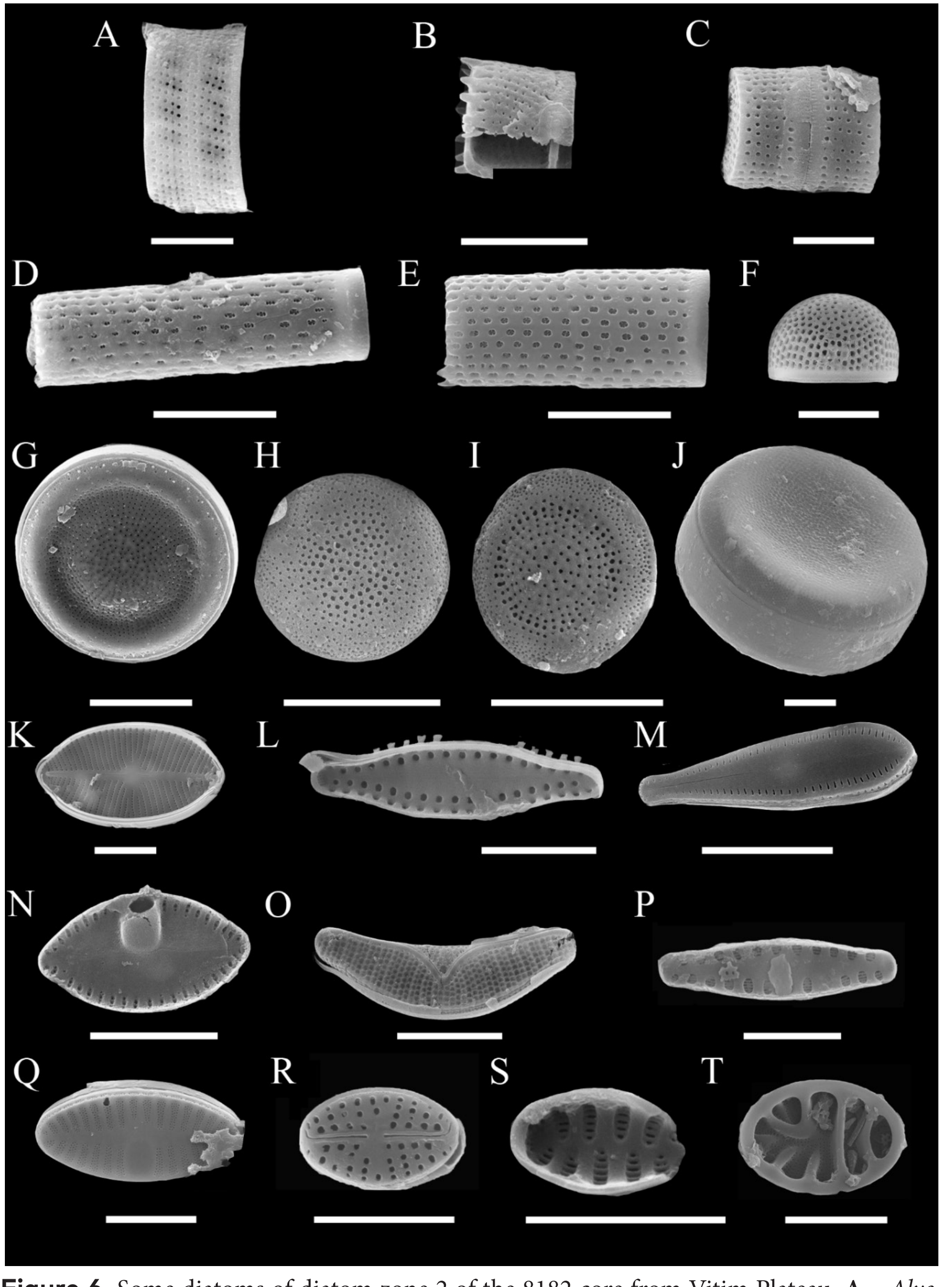

Figure 6. Some diatoms of diatom zone 2 of the 8182 core from Vitim Plateau. **A** – *Alveolophora robusta*, **B** – *Aulacoseira subarctica*, **C** – *Aulacoseira distans*, **D**, **E** –*Aulacoseira* sp. 1, **F** – *Aulacoseira auxospora*, **G** – *Concentrodiscus variabilis*, **H** – *Concentrodiscus proteus*, **I** – *Concentrodiscus indigenus*, **J** – *Lobodiscus* sp., **K** – *Placoneis ruppeliana*, **L** – *Pseudostaurosira brevistriata*, **M** – *Gomphosphenia grovei* var. *lingulata*, **N** – *Skabitschewskia oestrupii*, **O** – *Epithemia turgida*, **P** – *Punctastriata lancettula*, **Q** – *Planothidium lanceolatum*, **R** – *Eolimna aboensis*, **S** – *Staurosirella pinnata*, **T** – *Tetracyclus ellipticus*. Scale bars: 10 µm (A–K, M, O, P, R, T), 5 µm (L, N, Q, S).

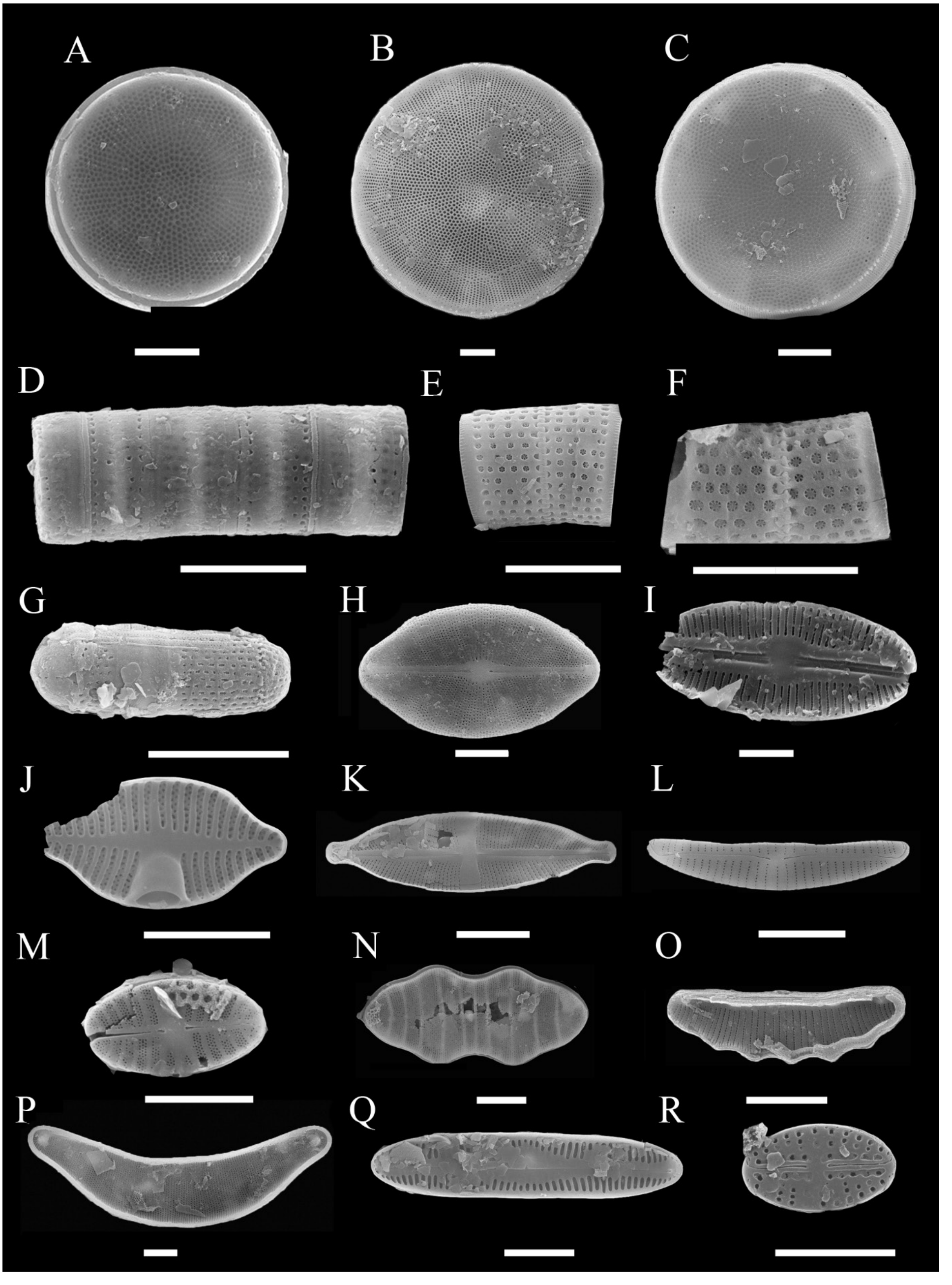

Figure 7. Some diatoms of diatom zone 3 of the 8182 core from Vitim Plateau. **A** – *Actinocyclus krasskei*, **B** – *Actinocyclus styliferum*, **C** – *Actinocyclus immemoratus*, **D** – *Alveolophora tscheremissinovae*, **E** – *Aulacoseira spiralis*, **F** – *Aulacoseira* sp. 2, **G** – resting spora of *Aulacoseira*, **H** – *Cavinula cocconeiformis*, **I** – *Diploneis* sp., **J** – *Planothidium rostratum*, **K** –*Stauroneis* cf. *anceps*, **L** – *Encyonema gracile*, **M** – *Planothidium frequentissimum*, **N** – *Tetracyclus celaton*, **O** – *Eunotia polyglyphis*, **P** – *Amphorotia clevei*, **Q** – *Pinnularia microstauron*, **R** – *Eolimna aboensis*. Scale bars: 10 µm (A–H, K–Q), 5 µm (I, J, R).

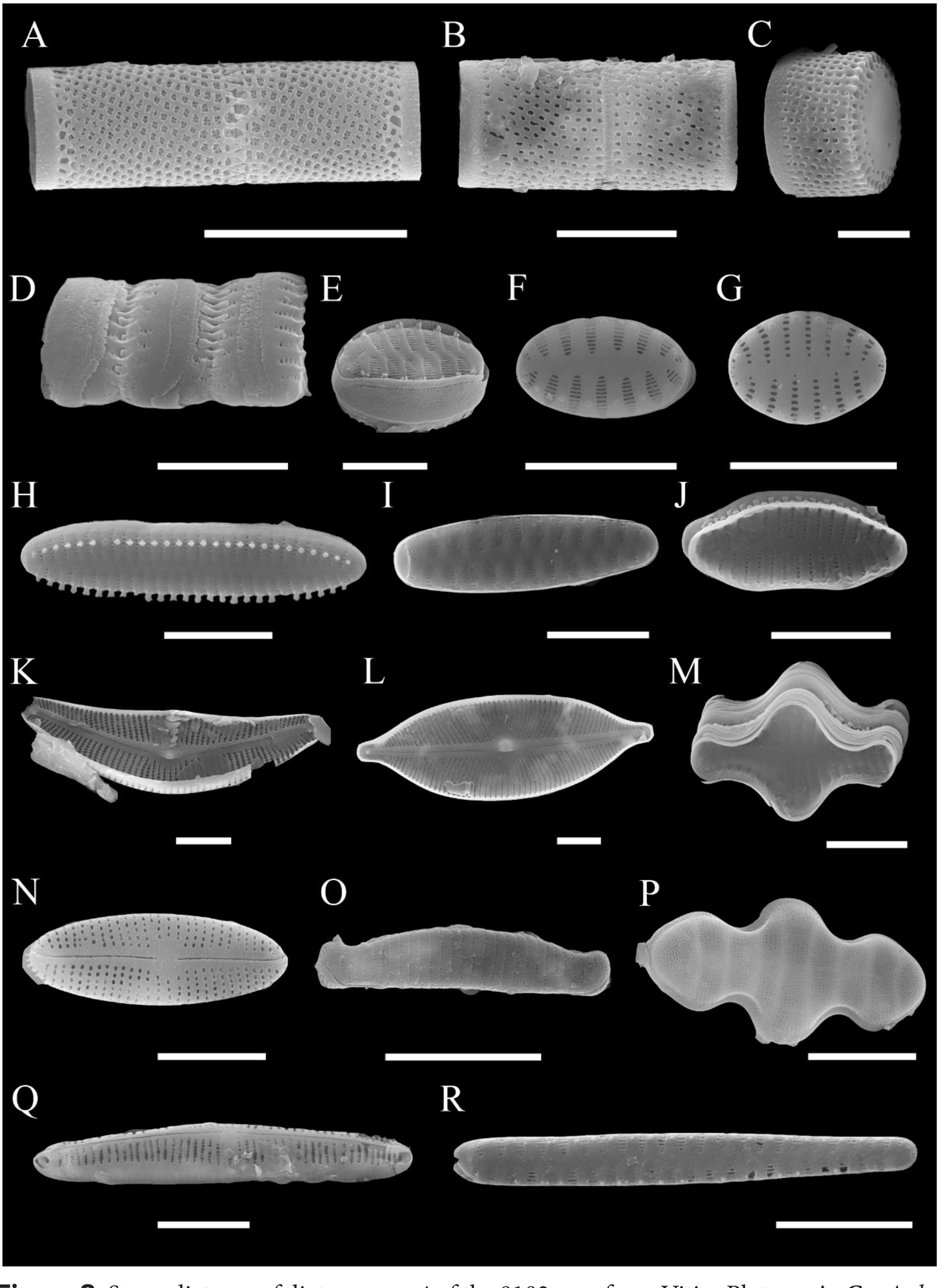

Figure 8. Some diatoms of diatom zone 4 of the 8182 core from Vitim Plateau. **A–C** – *Aulacoseira ambigua*, **D** – *Staurosira subsalina*, **E**, **F** – *Staurosirella pinnata*, **G** – *Staurosira venter*, **H**, **J** – *Staurosira subsalina*, **I** – *Staurosirella martyi*, **K** – *Cymbella* cf. *cistula*, **L** – *Cymbopleura cuspidata*, **M** – *Staurosira construens*, **N** – *Genkalia digitulus*, **O** – *Eunotia neocompacta*, **P** – *Tetracyclus glans*, **Q** – *Navicula* sp., **R** – *Staurosirella* sp. Scale bars: 10 μm (A, B, K, L, O–Q), 5 μm (C–J, M, N, R).

The comparison of taxonomic composition of planktonic, centric littoral-planktonic and benthic diatoms from different diatom zones is presented on the Figures 9 and 10. The Venn diagram suggests that maximal amount of unique planktonic species (4) was in the diatom zones 1 and 2 (Fig. 9). Two species were common on the diatoms zones 1-2, as well as two species in the diatom zones 2 and 3. One species occurred in three zones 1-3. The diatom zone 4 differed from other ones and had only two common species with the diatom zone 3 and one common species (*Aulacoseira distans*) with the diatom zones 2 and 3. There were no species characteristic for all four zones among planktonic diatoms.

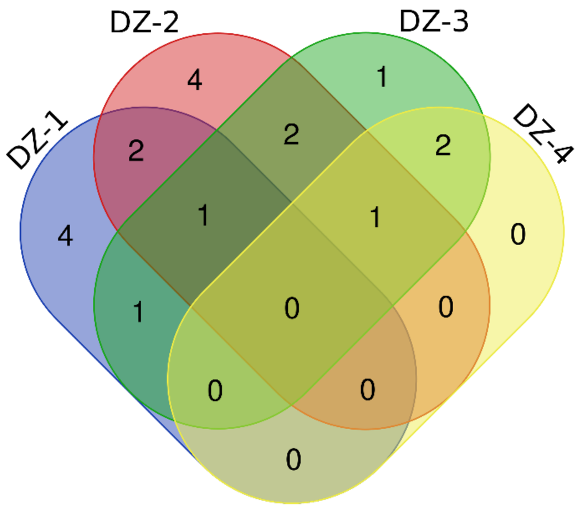

Figure 9. Venn diagram illustrating the amount of common planktonic diatoms species in different diatom zones (DZ) in the core 8182 from Vitim Plateau.

Among benthic diatoms, 18 species occurred in all diatom zones (Fig. 10). Unique (characteristique only for this zone) in DZ 1 were 28 species, in DZ 2 –16 species, in DZ 3 – 12 species and in DZ 4 – 13 species. A large amount of benthic species suggests a well developed littoral zone.

The comparison of species composition of planktonic diatoms of the studied core 8182 with data for other holes (4053 and 4119) from Vitim Plateau Northern paleovalley (Rasskazov et al. 2007) showed that they are comparable and have the same age range. Five common species for all the cores were revealed (Fig. 11). The core 8182 showed greater diversity of planktonic diatoms (11 species). There are in the core 4053 as much as 5 unique species, in the core 4119-1 species.

The comparison with other known for the Baikal region ancient diatoms from Lake Baikal (Kuz'min et al. 2009), Barguzin valley (Hassan et al. 2019; Usoltseva et al. 2019, 2020) and Tunka valley (Cheremisinova 1973; Hassan et al. 2020) showed that deposits from DZ 1–3 in the core 8182 from Vitim Plateau are related to Middle-Late Miocene, from DZ 4-to Early Pliocene.

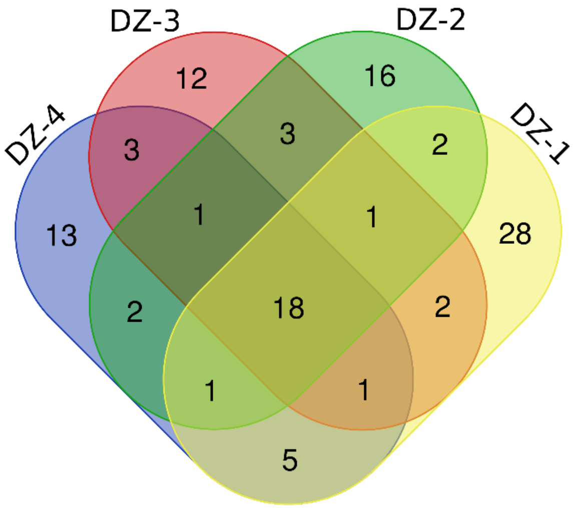

Figure 10. Venn diagram illustrating the amount of common benthic diatoms species in different diatom zones (DZ) in the core 8182 from Vitim Plateau.

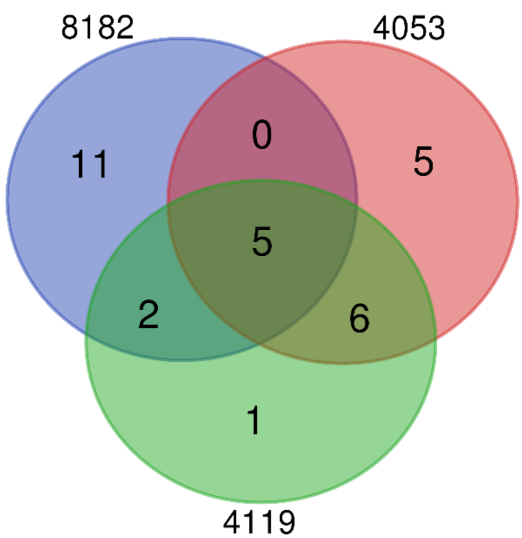

Figure 11. Venn diagram illustrating the amount of common planktonic diatoms species in the cores from the holes 8182, 4053 and 4119 on Vitim Plateau.

It is interesting to notice that species *Concentrodiscus* and *Mesodictyopsis* described from Lake Baikal Upper miocene were found out in the deposits of the Northern paleovalley for the first tiime, this fact suggests inheritance of elements of Baikalian flora from more ancient Miocene flora from Vitim Plateau. It is known that during Miocene, the Baikal Region was a wide plain covered with lakes and swamps connected with each other by channels, creeks, rivers (Nevesskaya et al. 1987; Rasskazov et al. 2007). Therefore, no wonder that numerous diatoms species found in Middle-Upper Miocene deposits in Trans-Baikal occur as well in Upper Miocene deposits from Lake Baikal (Kuz'min et al. 2006). In the end of Miocene, especially at the time interval of 7-5 MY BP, ancient Lake Baikal extended and considerably deepened in the area of modern underwater Academician Ridge, where the hole BDP-98 was staked (The Baikal Drilling 1998). During that period, the composition of Baikalian diatoms considerably renewed thanks to evolutional appearing and intensive speciation of Mesodictyopsis (Khursevich et al. 2004), which became extinct in the beginning of Pliocene (Kuz'min et al. 2009).

Ecological Analysis of Diatom Flora. Ecological and geographic characteristics are known only for recent species (Table 1). They have narrow optima and tolerances for many environmental variables (e.g., pH of the water, salinity, habitat, nutrient availability, water depth, saprobity, etc.) that make them exceptionally useful in quantifying environmental characteristics within a high degree of certainty (Zalat and Servant-Vildary 2005, 2007; Barinova et al. 2006; Stenina et al. 2017, 2019).

We revealed in the core from the hole 8182 both fossil and recent diatoms species. The fraction of extant taxa was 15 % in the diatom zone 1, 22% in the diatom zone 2, 18 % in the diatom zone 3 and 6.5 % in the diatom zone 4. These were mainly representatives of planktonic genera *Alveolophora*, *Aulacoseira*, *Actinocyclus*, *Concentrodiscus* and *Lobodiscus*. Among benthic species, there were such extant ones as *Gomphosphenia grovei* var. *lingulata* and representatives of the genus *Tetracyclus*.

Table 1. Diatoms taxonomic composition and their ecological and geographic characteristics

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
								Phylum Bacillariophyta Class Coscinodiscophyceae Order Aulacoseirales Family Aulacoseiraceae							
1	*Aulacoseira ambigua* (Grunow) Simonsen	-	-	+	+	P	-	st-str	sp	α-β	i	6-8.5	alf	k	R
2	*A. canadensis* (Hustedt) Simonsen	+	-	+	-	P	-	-	-	-	-	-	-	-	F
3	*A. distans* (Ehrenberg) Simonsen	-	+	+	+	P-B	cool	-	sp	x-o	i	6.9	acf	b	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
4	*A. pusilla* (F. Meister) A. Tuji et A. Houki	+	-	-	-	P	-	-	-	-	i	-	alf	b	R
5	*A. spiralis* (Ehrenberg) Houk et Klee	-	-	+	-	P	-	-	-	-	-	-	-	-	P
6	*A. subarctica* (O. Müller) E.Y. Haworth	-	+	-	-	P	-	st-str	-	α-β	i	7.3	alb	a, k	R
7	*Alveolophora jouseana* (Moiseeva) Moiseeva	+	-	-	+	P	-	-	-	-	-	-	-	-	F
8	*A. robusta* (Khursevich) Usoltseva et Khursevich	+	+	-	-	P	-	-	-	-	-	-	-	-	F
9	*A. tscheremissinovae* Khursevich	-	-	+	-	P	-	-	-	-	-	-	-	-	F
	Order Coscinodiscales Family Hemidiscaceae														
10	*Actinocyclus immemoratus* Khursevich et Fedenya	-	-	+	-	P	-	-	-	-	-	-	-	-	F
11	*A. krasskei* Bradbury et Krebs	+	+	+	-	P	-	-	-	-	-	-	-	-	F
12	*A. styliferum* Khursevich et Fedenya	-	-	+	-	P	-	-	-	-	-	-	-	-	F
	Family Lobodiscaceae														
13	*Lobodiscus* sp.	-	+	-	-	P	-	-	-	-	-	-	-	-	F
	Order Melosirales Family Melosiraceae														
14	*Melosira undulata* (Ehrenberg) Kützing	+	+	-	-	P-B	temp	-	-	o-α	i	-	alb	k	R
	Order Paraliales Family Radialiplicataceae														
15	*Ellerbeckia kochii* (Pantocsek) Moiseeva	+	+	+	+	P-B	temp	-	-	-	-	-	-	b	F

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
	Class Bacillariophyceae Subclass Bacillariophycidae Order Thalassiosirales Family Stephanodiscaceae														
16	*Concentrodiscus indigenus* Khursevich et Fedenya	-	+	+	-	P	-	-	-	-	-	-	-	-	F
17	*C. proteus* Khursevich et Fedenya	-	+	-	-	P	-	-	-	-	-	-	-	-	F
18	*C. subabnormis* Khursevich et Fedenya	-	-	+	-	P	-	-	-	-	-	-	-	-	F
19	*C. variabilis* Khursevich et Chernyaeva	-	+	-	-	P	-	-	-	-	-	-	-	-	F
20	*Concentrodiscus* sp.	-	+	-	-	P	-	-	-	-	-	-	-	-	F
21	*Mesodictyopsis insolita* Khursevich & Fedenya	-	+	-	-	P	-	-	-	-	-	-	-	-	F
22	*M. peculiaris* Khursevich, T. Iwashita, Kociolek et Fedenya	+	+	-	-	P	-	-	-	-	-	-	-	-	F
	Order Bacillariales Family Bacillariaceae														
23	*Grunowia tabellaria* (Grunow) Rabenhorst	-	-	+	-	B	-	-	-	o-β	i	-	alf	k	R
24	*Hantzschia amphioxys* var. *vivax* Grunow	-	-	-	+	B	-	-	-	-	hl	-	alb	k	R
25	*Nitzschia amphibia* Grunow	-	+	-	-	P-B	temp	-	sp	o	i	4-9	alf	k	R
26	*N. fonticola* (Grunow) Grunow	-	+	-	-	B	-	-	-	o-β	i	7.7	alf	k	R
27	*N. dissipata* (Kützing) Rabenhorst	-	+	-	-	B	-	st-str	sx	x	i	7.8	alf	k	R
28	*N. palea* (Kützing) W. Smith	-	+	-	-	P-B	temp	-	sp	o-x	i	7-9	ind	k	R
29	*Tryblionella angustata* W. Smith	-	-	-	+	P	-	st	sx	x-β	i	7.7	alf	k	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
						Order Achnanthales Family Achnanthidiaceae									
30	*Achnanthidium pusillum* (Grunow) Czarnecki	-	+	-	-	B	-	-	sx	o	-	-	-	-	R
31	*Karayevia kolbei* (Hudtedt) Bukhtiyarova	-	+	-	-	-	-	-	-	-	-	-	-	-	R
32	*K. laterostrata* (Hustedt) Bukhtiyarova	-	+	-	-	B	-	str	sx	x-o	i	7.6	ind	a-a	R
33	*Planothidium dubium* (Grunow) Round et Bukhtiyarova	+	+	-	-	B	-	sx	-	-	i	-	alf	-	R
34	*P. lanceolatum* (Brébisson ex Kützing) Lange-Bertalot	+	+	-	-	P-B	warm	st-str	sx	x-o	i	7.5-8.1	alf	k	R
35	*Skabitschewskia oestrupii* (A. Cleve) Kulikovskiy et Lange-Bertalot	+	+	+	-	B	-	-	-	o	i	-	ind	a-a	R
36	*S. peragalloi* (Brun et Heribaud) Kulikovskiy et Lange- Bertalot	+	-	-	-	B	-	-	-	-	-	-	-	-	R
37	*S. circumradians* Kulikovskiy et Lange-Bertalot	-	+	-	-	B	-	-	-	-	-	-	-	-	R
						Order Cocconeidales Family Cocconeidaceae									
38	*Cocconeis placentula* Ehrenberg	+	-	-	+	P-B	temp	st-str	es	o-β	i	5.5-9	alf	k	R
						Order Cymbellales Family Cymbellaceae									
39	*Cymbella affinis* Kützing	+	-	-	-	B	temp	st-str	sx	β-o	i	-	alf	k	R
40	*C. subleptoceros* Krammer	-	+	-	+	B	-	-	-	-	-	-	-	-	R
41	*C. helvetica* Kützing	+	+	-	-	B	-	-	-	o-α	i	-	alf	k	R
42	*C. tumida* (Brébisson) Van Heurck	-	+	-	+	B	temp	-	sx	x	i	6.8-9	alf	k	R

№	Taxon	Diatom Zone						Ecological and geographic characteristics							
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
43	*C. turgidula* Grunow	+	-	-	-	B	-	st-str	es	-	-	-	ind	k	F
44	*Cymbopleura acuta* (Schmidt) Krammer	+	-	-	-	B	-	-	-	-	i	-	-	b	R
45	*C. cuspidata* (Kützing) Krammer	-	-	-	+	B	temp	-	-	o-α	i	6.7	ind	k	R
46	*C. naviculiformis* (Auerswald ex Heiberg) Krammer	-	-	-	+	B	-	-	es	o	i	-	ind	b	R
47	*C. problematica* (Van Landingham) Krammer	-	-	-	+	B	-	-	-	-	i	-	ind	b	R
48	*C. reinhardtii* (Grunow) Krammer	+	-	-	-	B	-	-	-	-	-	-	-	k	R
49	*Didymosphenia geminata* (Lyngbye) Mart. Schmidt	-	+	-	+	B	-	st-str	sx	x	i	-	ind	a-a	R
50	*Paraplaconeis placentula* (Ehrenberg) Kulikovskiy et Lange-Bertalot	+	-	+	-	B	temp	-	sx	x-β	i	-	alf	k	R
51	*Placoneis anglophila* (Lange-Bertalot) Lange-Bertalot	-	-	-	+	B	-	-	-	-	-	-	-	Ha	R
52	*P. elginensis* (W. Gregory) E.J. Cox	+	-	+	+	B	-	-	sx	x-o	i	-	ind	k	R
53	*P. gastrum* (Ehrenberg) Mereschkowsky	+	-	+	+	B	-	-	sx	x-o	i	-	ind	k	R
54	*P. zula* Kulikovskiy, Lange-Bertalot et Metzeltin	-	-	+	-	B	-	-	-	-	-	-	-	-	R
	Family Gomphonemataceae														
55	*Encyonema gracile* Rabenhorst	-	+	+	-	B	-	-	sx	β	hb	-	ind	a-a	R
56	*E. minutum* (Hilse) D.G. Mann	-	+	+	-	B	-	st-str	es	o-β	oh	6.2	ind	k	R
57	*E. perpusillum* (A. Cleve) D.G. Mann	-	+	-	-	B	-	-	-	-	hb	-	acf	b	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
58	*E. silesiacum* (Bleisch) D.G. Mann	-	-	+	-	B	-	st-str	sx	x-	i	6.2-7.7	ind	k	R
59	*E. muelleri* (Hustedt) D.G. Mann	-	-	+	-	B	term	-	-	-	i	7-9	alb	-	R
60	*E. neogracile* Krammer	-	+	-	-	B	-	-	-	-	-	-	-	-	R
61	*Gomphonema acuminatum* Ehrenberg	+	+	-	-	P-B	-	-	-	x-β	i	-	alf	k	R
62	*G. intricatum* Kützing	+	+	+	+	P-B	-	-	-	x-o	-	-	ind	k	R
63	*G. parvulum* (Kützing) Kützing	+	+	-	+	B	temp	str	es	x	i	4.5	ind	k	R
64	*Reimeria sinuata* (W. Gregory) Kociolek et Stoermer	+	-	-	-	B	-	st	sx	-	i	-	ind	k	R
	Family Rhoicospheniaceae														
65	*Gomphosphenia grovei* var. *lingulata* (Hustedt) Lange-Bertalot	-	+	+	-	B	str	es	β-α	i	-	-	-	k	F
	Order Eunotiales Family Eunotiaceae														
66	*Eunotia arcus* Ehrenberg	+	-	-	+	B	-	-	-	x-β	i	-	acf	k	R
67	*E. curtagrunowii* Nörpel-Schempp et Lange-Bertalot	+	-	-	+	B	-	-	-	-	-	-	acf	k	R
68	*E. diadema* Ehrenberg	+	-	-	-	B	-	-	-	-	-	-	acf	-	-
69	*E. ewa* Lange-Bertalot et Witkowski	-	-	-	+	B	-	-	-	-	-	-	-	-	R
70	*E. faba* Ehrenberg	+	-	-	-	B	temp	st	sx	o	i	5-9	alf	k	F
71	*E. minor* (Kützing) Grunow	+	-	-	+	B	-	-	es	x	i	5.2	acf	k	R
72	*E. neocompacta* S. Mayama	-	-	-	+	B	-	-	-	-	i	-	-	k	R
73	*E. polydentula* Hustedt	-	+	-	-	B	-	-	-	x-β	hb	-	acf	k	R
74	*E. polyglyphis* Grunow	+	-	-	-	B	-	-	-	-	-	-	acf	-	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
75	*E. robusta* var. *tetraedon* (Ehrenberg) Ralfs	-	+	-	-	B	-	-	-	o-α	hb	-	acf	a-a	R
76	*E. soleirolii* (Kützing) Rabenhorst	+	-	-	-	B	-	-	-	-	-	-	acf	-	R
	Order Fragilariales Family Fragilariaceae														
77	*Odontidium hyemale* (Roth) Kützing	-	+	-	-	P-B	cool	st-str	sx	β-o	hb	6.5-7.5	ind	k	R
78	*Punctastriata lancettula* (Schumann) P.B. Hamilton et Siver	-	-	+	-	B	cool	-	es	o	i	7.8	alb	b	R
	Family Staurosiraceae														
79	*Pseudostaurosira brevistriata* (Grunow) D.M. Williams et Round	+	+	+	+	P-B	-	st-str	-	x-o	i	7.2	alf	k	R
80	*Pseudostaurosira polonica* (M. Witak et Lange-Bertalot) E.A. Morales et M.B. Edlund	+	+	-	-	B	-	-	-	-	-	-	-	-	R
81	*Staurosira binodis* (Ehrenberg) Lange-Bertalot	+	-	+	-	B	-	-	-	o-β	i	-	alf	k	R
82	*S. construens* Ehrenberg	-	-	+	+	P-B	temp	st-str	sx	o	i	5.5-9	alf	k	R
83	*S. subsalina* (Hustedt) Lange-Bertalot	+	+	+	+	P-B	-	st	es	o	hl	-	alf	k	R
84	*S. venter* (Ehrenberg) Cleve et J.D. Möller	+	-	+	+	P-B	warm	st-str	sx	β	i	5.5-9	alf	k	R
85	*Staurosirella martyi* (Héribaud) E. Morales et K.M. Manoylov	+	+	+	+	P-B	-	st-str	es	o-α	i	7.5-9	alf	k	R
86	*S. oldenburgioides* (Lange-Bertalot) E. Morales, M.L. García et Maidana	-	+	-	-	B	-	-	-	-	-	-	-	-	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
87	*S. pinnata* (Ehrenberg) D.M. Williams et Round	-	-	+	+	B	temp	st-str	es	β-α	hl	6.2-9.3	alf	k	R
	Order Licmophorales Family Ulnariaceae														
88	*Ulnaria acus* (Kützing) Aboal	-	-	-	+	P	-	st-str	es	o-α	i	-	alb	k	R
89	*U. capitata* (Ehrenberg) Compère	+	+	-	-	P	-	-	-	o-β	-	-	-	-	R
	Order Mastogloiales Family Mastogloiaceae														
90	*Aneumastus tusculus* (Ehrenberg) D.G. Mann et A.J. Stickle	-	+	-	-	P-B	-	-	-	o-x	i	-	alf	k	R
	Order Naviculales Family Cavinulaceae														
91	*Cavinula cocconeiformis* (W. Gregory ex Greville) D.G. Mann et A.J. Stickle	-	-	+	-	P-B	-	str	es	o	i	6.9	ind	a-a	R
92	*C. pseudoscutiformis* (Hustedt) D.G. Mann et Stickle	-	+	+	+	P-B	-	st-str	sx	o	i	6.7	ind	a-a	R
93	*C. scutelloides* (W. Smith) Lange-Bertalot	-	-	+	-	B	-	-	-	o-β	-	-	-	-	R
	Family Diadesmidaceae														
94	*Luticola mutica* (Kützing) D.G. Mann	-	-	-	+	B	-	st-str	sp	o	i	-	ind	k	R
	Family Diploneidaceae														
95	*Diploneis oblongella* (Naegeli) Cleve-Euler	+	-	-	-	B	-	-	sx	o-α	i	-	alf	k	R
	Family Naviculaceae														
96	*Altana cingens* (Skvortsov) Kulikovskiy, Metzeltin et Lange-Bertalot	-	+	-	-	B	-	-	-	-	i	-	-	r	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
97	*A. woronichinii* (Jasnitsky) Kulikovskiy et Lange-Bertalot	-	-	+	-	B	-	es	-	-	i	-	ind	b	R
98	*Caloneis silicula* (Ehrenberg) Cleve	+	-	-	-	B	-	st	sp	x	i	6.3-9	alf	k	R
99	*Genkalia digituloides* (Lange-Bertalot) Lange-Bertalot et Kulikovskiy	-	-	-	+	B	-	-	-	o	i	-	ind	k	R
100	*G. digitulus* (Hustedt) Lange-Bertalot et Kulikovskiy	-	-	-	+	B	-	-	-	-	-	-	acf	-	R
101	*G. similis* Kulikovskiy, Lange-Bertalot et Metzeltin	-	-	-	+	B	-	-	-	-	-	-	-	-	R
102	*Navicula cryptocephala* Kützing	+	-	-	-	P-B	-	-	-	x	i	-	alf	k	R
103	*N. cari* Ehrenberg	+	+	-	-	B	-	-	es	β	i	-	ind	k	R
104	*N. oppugnata* Hustedt	+	-	-	-	B	-	-	sx	o-β	i	-	-	k	R
105	*N. radiosa* Kützing	+	-	-	-	B	temp	st-str	es	o	i	5-9	ind	k	R
	Family Pinnulariaceae														
106	*Pinnularia brevicostata* Cleve	-	+	+	+	B	-	-	es	β-α	hl	-	alf	k	R
107	*P. infirma* Krammer	+	-	-	-	B	-	-	-	o	-	-	-	-	R
108	*P. isostauron* (Ehrenberg) Cleve	+	-	-	-	B	-	-	-	o	i	-	ind	a-a	R
109	*P. interrupta* W. Smith	+	-	-	+	B	-	-	sp	β-o	i	5.6	acf	k	R
110	*P. major* (Kützing) Rabenhorst	-	-	-	+	B	temp	st-str	-	x	i	-	ind	k	R
111	*P. microstauron* (Ehrenberg) Cleve	+	-	-	+	B	temp	-	sp	x	i	-	ind	k	R
112	*P. obscura* Krasske	+	-	-	-	B	-	ae	-	-	-	-	-	-	R
113	*P. phoenicenteron* f. *rostrata* Cleve	+	-	-	-	B	-	-	-	-	-	-	-	-	R
114	*P. subrostrata* (Cleve) Cleve	+	-	-	-	B	-	-	sx	-	-	-	-	-	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
115	*P. viridis* (Nitzsch) Ehrenberg	-	-	-	+	P-B	temp	-	es	o-x	i	7.1	ind	k	R
	Family Sellaphoraceae														
116	*Eolimna aboensis* (Cleve) Genkal	+	+	+	-	B	-	-	-	-	i	-	ind	a-a	R
117	*Sellaphora laevissima* (Kützing) D.G. Mann	+	-	-	-	B	-	-	-	-	i	6.8	ind	-	R
118	*S. pupula* (Kützing) Mereschkovsky	-	-	+	-	B	eterm	st	sp	o-x	hl	5.2-9	ind	k	R
	Family Stauroneidaceae														
119	*Stauroneis anceps* Ehrenberg	-	-	+	-	P-B	-	-	-	x	i	-	ind	k	R
120	*S. phoenicenteron* (Nitzsch) Ehrenberg	-	-	-	+	B	temp	-	es	x-o	i	7.3	ind	k	R
121	*S. javanica* (Grunow) Cleve	-	-	-	+	B	-	-	-	-	-	-	acf	-	R
122	*S. obtusa* Lagerstedt	+	-	-	-	B	-	ae	-	-	-	-	-	-	R
	Order Rhopalodiales Family Rhopalodiaceae														
123	*Epithemia sorex* Kützing	+	-	-	-	B	temp	st	sx	o-α	i	5-9	alf	k	R
124	*E. turgida* (Ehrenberg) Kütz.	-	+	-	-	B	temp	st	sx	o	i	5-9	alf	k	R
125	*E. turgida* var. *granulata* (Ehrenberg) Brun	-	+	-	-	B	-	st	-	-	hl	-	ind	b	R
126	*E. zebra* var. *saxonica* (Kützing) Grunow	+	-	-	-	B	temp	-	-	β-o	i	4.8-9	alb	k	R
127	*Rhopalodia gibba* (Ehrenberg) O. Müller	-	+	-	-	B	temp	-	es	x-o	i	6.2-9	alb	k	R
	Order Tabellariales Family Tabellariaceae														
128	*Tabellaria fenestrata* (Lyngbye) Kützing	+	+	-	+	P-B	-	-	-	x	-	-	ind	k	R
129	*Tetracyclus celaton* Okuno	-	+	-	-	-	-	-	-	-	-	-	-	-	R

№	Taxon	Diatom Zone				Ecological and geographic characteristics									
		1	2	3	4	Hab	T	R	S1	S2	Sa1	pH	A	Geo	Fossil / Recent
130	*T. japonicus* (Petit) Tempère et H. Peragallo	+	-	-	+	-	-	-	-	-	-	-	-	-	F
131	*T. ellipticus* (Ehrenberg) Grunow	+	+	+	-	B	-	-	-	-	-	-	-	-	F
132	*T. emarginatus* (Ehrenberg) W. Smith	+	-	-	+	P-B	cool	st-str	-	-	i	-	acf	a-a	F
133	*T. glans* (Ehrenberg) F.W. Mills	+	+	+	+	B	-	-	o	-	i	-	acf	a-a	R
134	*T. rupestris* (Kützing) Grunow	+	+	-	-	B	cool	ae	x-β	-	i	-	-	a-a	F
135	*T. strumosus* (Ehrenberg) D.W. Williams	+	-	-	+	-	-	-	-	-	-	-	-	-	F
	Order Thalassiophysales Family Catenulaceae														
136	*Amphora ovalis* (Kützing) Kützing	+	-	-	-	B	temp	st-str	sx	α-β	i	6.2-9	alf	k	R
137	*A. pediculus* (Kützing) Grunow	-	-	-	+	B	temp	st	es	o-α	i	-	alf	k	R

(+) a taxon is present; (-) a taxon is absent. Habitat (Hab): P – planktonic; B – benthic, P-B – planktonic-benthic. Temperature (T): cool – psychrophilic, temp/or indifferent–temperate and/or indifferent, eterm–eurythermal. Reophility (R): st – stagnant, str – running, st-str – stagnant-running and/or indifferent; Saprobity (S1): Group of Watanabe indicators: sx – saproxene, sp – saprophile, es – erisaprob; Saprobity (S2): Pantlet-Bucca self-purification zones by Sládeček: x–0.0 – xenosaprobes, x-o–0.4 – xeno-oligosaprobiont, o-x–0.6 – oligo-xenosaprobiont, x-b–0.8 – xeno-betamesosaprobiont, o–1.0 – oligosaprobiont, o-b-1.4 – oligo-betamesosaprobiont, χ -α-1.55 – xeno-alohamesosaprobiont, b-o–1.6 – beta-oligosaprobiont, o-a-1.8 – oligo-alphamesosaprobiont, b–2.0 – betamesosaprobiont; Salinity (S): mh – mesohalob, oh – oligohalob, i – indifferent oligohalob, hl – oligohalob-halophile, hb – oligohalob-halophobe; pH intervals; A (groups of acidulation indicators): ind – indifferent and/or neutrophilic, alf – alkaliphilic, alb – alkalibiont, acf – acidophilic; Geo – preferable geographic zone: Ha – Holarctic, Pt – Paleotropic, k – cosmopolite, b – boreal, a-a – Arctic-Alpine; fossil extant (F) and alive, recent (R). The table is formed according to (Getsen et al. 1978; Sládeček 1986; Van Dam et al. 1994; Barinova et al. 1996; Barinova et al., 2000, 2006; Loseva et al 2004; Stenina et al. 2017, 2019).

On the base of the analysis of ecological and geographic characteristics, we made a diagram of distribution of species amount (%) along the core by ecological groups (Fig. 12).

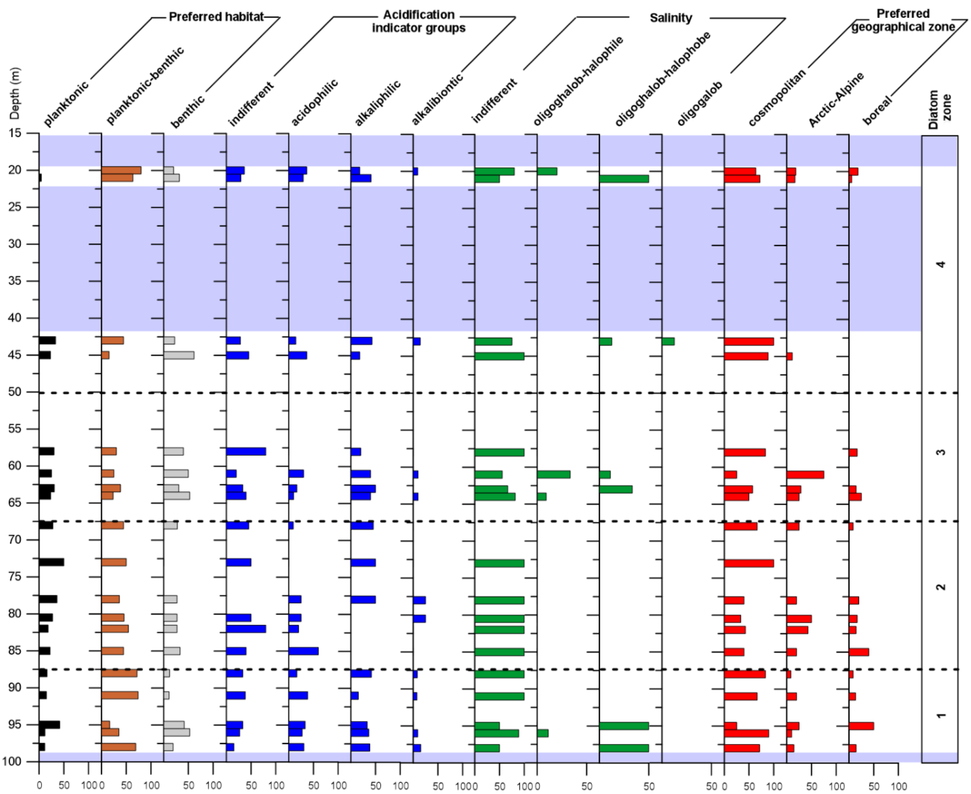

Figure 12. Diagram illustrating the different diatom ecological groups in the core 8182. Along the axis x- %, along the axis y–core depth, m.

The habitat spectrum shows that mainly, the whole core was dominated by planktonic benthic and benthic diatom algae. Dominating by species amount, these diatoms have low quantitative proxies. Such ratio of species with quantitative dominance of planktonic diatoms is characteristic for deep water bodies.

By ratio to water pH, the content of alkaliphilic species was 25–100%, of indifferent ones 7–58 %, of acidophilic ones 6–67 % and of alkalibiont ones 4–50 %. Indifferent and alkaliphilic diatoms species dominated along the whole core. The amount of alkalibiont and acidophilic species was slightly less (Fig. 12). The expansion of these groups was more or less equal in all diatom zones.

By salinity ratio, indifferent taxa dominated, their fraction was from 50 to 100 %. Halophobic taxa occurred at some horizons of the diatom zones 1, 3 and 4, halophilic–only in the zones 3 and 4.

The analysis of biogeographic distribution of taxa showed abundant cosmopolite (33–92 %) and Arctic-Alpine forms (33–92 %) along the whole core. Boreal forms were less abundant (0–25 %) (Fig. 8).

In the whole, ecological and geographic analysis of diatoms showed dominance of benthic, indifferent, cosmopolite species. It is shown that during the period corresponding to sedimentation in the DZ 2 and 3 the water body was cooler as suggested by increase of Arctic-Alpine taxa.

Palynological complexes (PCs). In the section of deposits opened by the hole 8182 in the depths interval of 19–100 m, we studied 21 spore-pollen spectra and established among them three palynological complexes (Fig. 13).

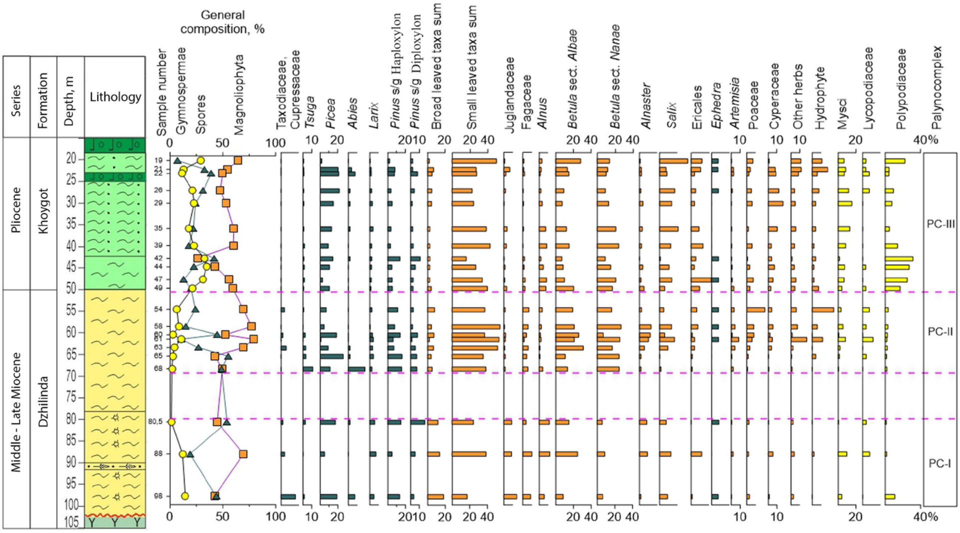

Figure 13. Spore and pollen diagram of sediments recorded in the 8182 well. On the diagram with common composition: triangles–Gymnospermae, squares–Magnoliophyta, circles–Spores.

Dzhilinda suite is characterized by two types of palynological complexes (PC-1, 2). PC-1 gives an idea on its lower part in the depths interval of 100-80 m (Fig. 9). It was dominated by pollen either of angiosperms (up to 69%) or gymnosperms (up to 54%). Dominant pollen belonged to *Picea*, *Pinus* s/g Haploxylon, *Betula* and *Alnus* (tree forms), dominant spores–to Polypodiaceae and *Sphagnum*. There was accompanying pollen of *Pinus* s/g Diploxylon, *Larix*, *Tsuga* spp., Fagaceae (*Quercus*, *Carpinus*, *Fagus*, *Castanea*), Juglandaceae (*Carya*, *Platycarya*, *Pterocarya*), *Corylus*, *Ulmus*, *Alnaster*, *Salix*, *Poaceae*, *Cyperaceae*, *Asteraceae*. There were single grains of pollen of *Podocarpus*, *Juniperus*, *Glyptostrobus*, Taxodiaceae, *Abies*, *Ilex*, *Ostrya*, *Tilia*, *Juglans*, *Hamamelis*, Ericaceae, Asteraceae, *Ephedra*, Chenopodiaceae, *Thalictrum*, Apiaceae, *Persicaria*, *Typha*, *Lycopodium*, *Riccia*, *Selaginella*. A considerable presence of pollen of families Pinaceae and Betulaceae (especially *Betula*), constantly present pollen of Taxodiaceae, pollengrains content of different species of broadleaf deciduous plants (in sum up to 14%), participation of pollen of *Ephedra* allow to suppose the similarity of this complex with the complex VII of the second half of

Middle Miocene obtained earlier according to the results of studies in a stratotypical area of the Dzhilinda R. (Rasskazov et al. 2007). The PC-1 differs from it by lesser participation of the spores of Polypodiaceae.

The established complex PC-I suggests a forest vegetation type consisting of broad-leaf-pine-spruce-birch forests with admixture of hemlock and very rare representatives of subtropical species of gymnosperms under the conditions of warm moderate climate. The climate was humid but cooler compared with time of climatic optimum still allowing to keep among vegetation a considerable diversity of broad-leaf deciduous plants. This PC allows to reconstruct palynoflora similar to one of Basheul' horizon of West Siberia (Volkova et al. 1986) and Mamontovogorsk horizon of North-East Siberia (Fradkina 1995) comprising still many representatives of Turgay flora on the background of increase of areas of boreal one.

PC-II is established in the depths interval of 70-50 m (Fig. 13). It dominated by pollen of angiosperms (in average 63%, among which pollen of tree birch *Betula* sect. *Albae* (maximally 30%) with a considerable fraction of shrubs pollen (up to 34%), among which in average 20% belonged to pollen of shrub birch *Betula* sect. *Nanae*. There was subdominant pollen of *Picea* (10%) and *Pinus* s/g Haploxylon (10%). There was accompanying pollen of *Larix*, *Tsuga*, *Quercus*, *Corylus*, Asteraceae, Poaceae, Cyperaceae, Polygonaceae, Ericaceae and spores of *Sphagnum*, Polypodiaceae. There was single but constant pollen of *Larix*, *Tsuga*. There were sporadic grains of psychrophilic plants: *Carya*, *Pterocarya*, *Myrica*, *Carpinus*, *Ilex*, *Glyptostrobus*, Taxodiaceae, pollen of diverse grasses: *Artemisia*, Ranunculaceae, Chenopodiaceae, Fabaceae, Apiaceae, Rosaceae, Valerianaceae, Caryophyllaceae, *Ephedra*, *Typha*, *Persicarya*, *Sparganium*; spores *Bryales*, *Riccia*, *Leptochylus*, *Osmunda*, *Botrychium*, *Onoclea*, *Lygodium*, *Huperzia selago* L., *Lycopodium pungens* (Dsv.) LaPyl. ex Iljin. and *Selaginella sanquinolenta* (L.) Spring.

The complex composition allowed as well to reconstruct a forest vegetation type. Probably, during deposits accumulation, the watershed areas were covered with dark-coniferous forests with a small admixture of broad-leaf ones. Subtropical plants occurred as relicts and very rarely. Valleys were dominated by birch forests with a rich grass cover.

Dominants and subdominants of coniferous ans small-leaf boreal species, presence of mainly less thermophilic *Quercus* and *Corylus*, rare occurrence of subtropical plants or their absence allowed to compare the complex obtained with palynological complex VIII of Late Miocene from Vitim Plateau Upper Dzhilinda subsuite (Rasskazov et al. 2007). Sporadic presence in the spectra of rare pollen of the family Taxodiaceae, considerable amount of shrubs pollen and low content of pollen of thermophilic angiosperms allowed to compare the spectra obtained in the zone with the palynological complex characterizing Upper Miocene deposits of Khapcheranga horizon in North-East of Russia (Fradkina 1995).

The Khoygot suite is characterized by PC-III (Fig. 13), the spectra of which continued to be dominated by pollen of small-leaf plants (in average up to 32%)

with a high fraction of shrubs (in average 19%, maximum up to 28%). Grasses pollen amount in the spectra increased (in average up to 14%). Dominant and subdominant pollen belonged to *Betula* sect. *Albae*, *Betula* sect. *Nanae*, *Picea*, *Pinus* s/g Haploxylon, *P.* s/g Diploxylon, Polypodiaceae, *Sphagnum*. Accompanying pollen belonged to *Tsuga*, *Alnus*, Ericaceae, Poaceae, Cyperaceae. Other taxonomic varieties of xero-mesophitic motley grasses occurred sporadically like pollen of thermophilic broad-leaf (*Quercus*, *Corylus*, *Tilia*, *Acer*, *Juglans*, *Castanea*) plants. Pollen of the families Cupressaceae and Taxodiaceae disappeared from the spectra.

Lower part of the suite in the interval of 50-42 m contains abundantly spores of Polypodiaceae (maximum up to 29%). Dominance of birch pollen, considerable amount of shrubs pollen and of spores diversity of meso-xerophitic grasses pollen, absence of pollen of Cupressaceae and Taxodiaceae allow to reconstruct pine-spruce-birch forests with inclusion of hemlock and rare representatives of warm temperate trees species under the conditions of temperate climate.

Upward the section, in the interval of 42-19 m, maximal abundance in the spectra belonged to pollen of spruce (20%) and pollen of grasses (18%) with diverse taxonomy. Among them, sedge pollen dominated (20%), there were less pollen of ericales, wormwood, other Compositae, Poaceae, pigweeds. There was sporadically pollen of *Ephedra*, Ranunculaceae, *Thalictrum*, Polygonaceae, Rosaceae, *Sanquisorba*, Fabaceae, *Bupleurum*, Apiaceae, Valerianaceae, Onagraceae, Caryophyllaceae, Labiatae. Among aqueous species, we revealed pollen of *Typha* and *Persicaria*. Fraction of spores was 17%. Dominant among them were grains of *Sphagnum* (9%), Polypodiaceae (6%), rare ones were: *Botrychium* and psychrophilic *Selaginella sibirica* (Milde) Hieron. and *Meesia*. There were sporadically spores of *Lycopodium selago* L. growing in dark-coniferous humid mied woods and birch-motley grasses cenoses.

The comple composition allows to reconstruct birch-coniferous forests with inclusion of fir, larch, pine and hemlock and is similar to the palynological comple IX of Early Pliocene (Rasskazov et al. 2007) established from deposits of Khoygot stratum of the Dzhilinda R., which differs from the described one by presence of rare *Taxodiaceae pollen*.

Constant presence of larch and fir pollen in the deposits of Khoygot suite from the hole 8182, noticeable occurrence of shrubs pollen, considerable amount of spores of *Sphagnum* or Polypodiaceae, less of *Bryales*, *Lycopodium*, *Selaginella*, *Botrychium* and *Osmunda*, diversity of grasses systematic composition, absence of pollen of the family Taxodiaceae and rarely occurring pollen of thermophilic angiosperms allow to compare the obtained comple with PC Begunovsk horizon of Lower Pliocen in North-East Siberia (Fradkina 1995). At that time, under the conditions of climate cooling, shrub bushes of birch, alder, willow expanded widely.

Late Miocene and Pliocene Paleoclimatic Evolution. We included in treatment by factor analysis of spores and pollen data percentage of all taxa determined in the preparations (95 forms).

On the factor diagram, in coordinates of first and third factors (Fig. 14), plants taxa were distributed into three groups: groups 1 (PC-I) and 2 (PC-II) characterize

Middle Miocene and Upper Miocene lacustrine deposits; group 3 (PC-III) covers Low Pliocene alluvial-lacustrine deposits.

Taxa of PC-I are situated in the square III, except data for the sample from the depth of 98 m. This group is characterized by considerable content of pollen grains of broad-leaf plants. In the sample 80.5, like in two others, there is pollen of small-leaf angiosperms representatives, but its composition is more enriched with it, there for this sample is on an intermediate position.

This group characterizes flora of warm temperate climate with numerous representatives of Turgay flora on the background of in crease of area of boreal one. Composition of the sample 98 has a positive F3 value and differs from other ones by elevated amount of thermophilic coniferous plants suggesting warmer climatic conditions with larger participation of evergreen subtropical species.

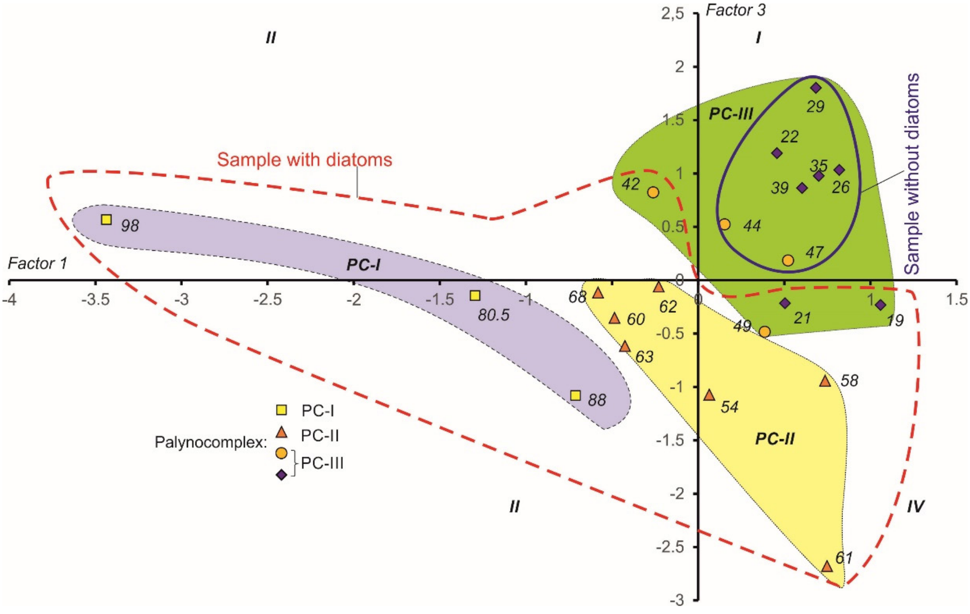

Figure 14. Factor diagram of spore-pollen spectra for sediments of the 8182 well (numbers show depths of sampling). Factor loadings are given in the text. Symbols as in Fig. 13.

Taxa of PC-II are in the squares III and IV, they are characterized by a considerable participation of boreal small-leaf plants. They are subdivided into 2 subgroups. First one (square III) differs from PC-I by lower content of pollen of most thermophilic species of broad-leaf plants Juglandaceae (*Platycarya*, *Pterocarya*). Taxa of the second subgroup, in difference with first one, have a strongly positive value of the factor 1, they do not comprise fir on the background of total species diversity of hemlock. From bottom to top along the section, we observe a common trend of increase of spores amount (from 1.6-4.2 for the subgroup 1) to (8.2 up to 34.4 % for the subgroup 2).

The group composition characterizes a moderately warm climate transitting gradually to moderately cool one, under the conditions of which thermophilic species of broad-leaf plents still occurred. Subtropical plants occurred as relicts and were extremely rare.

Taxa composition of PC-III has different values of first and third factors. They are situated in the squares I, II and IV. Major part of them is in the first square, their position is due to a high content of small-leaf plants species among them. In the whole, taxa from the square I characterize a temperately warm climate (23 species) with further empoverishment of composition of thermophilic flora (5 species).

The group composition allows to tell about climate cooling on the background of a wide expansion of shrubs species.

Palynological spectra of Miocene and Pliocene deposits are strongly divided by factor 1 and show a purposeful shifting towards Early Pliocene cooling found out at Tankhoy tectonic step (Hamoud et al. 2019; 2021), in Barguzin and Tunka valleys (Rasskazov et al. 2016; Hassan et al. 2019; 2020).

Comparison of distribution of core samples by the results of spore-pollen analysis on a factor diagram with data on distribution and concentration of diatom algae showed that increase of the values of the first factor showed a trend for decrease of paleo-lake depth from Middla-Late Miocene towards Early Pliocene.

Paleoenvironmental interpretations. The history of development of Late Cenozoic on Vitim Plateau counts two great paleogeographic stages: Middle-Late Miocene and Early Pliocene. An important role belongs to volcanic events 14, 12.1–9.2 and 5.0–2.9 My BP (Rasskazov et al. 2000; Rasskazov et al. 2007). These events were accompanied by activation of deep erosion and by filling of deep erosional cuts with sediments of Lower Dzhilinda subsuite.

Variations of volcanic rocks composition in the section of Dzhilinda suite are characterized in detail in the area of Lake Mukhal. The section characterizes volcanism in the second half of Middle Miocene and of first half of Late Miocene of Mukhal volcanic center. The same varieties of volcanic rocks occur in the sections of Dzhilinda suite of other volcanic centers of Vitim Plateau (Rasskazov et al. 2000; Rasskazov et al. 2007). In global aspect, this period is characterized by a concentrated crust extension in the area of shift-gapping Tsipa-Muyakan and gapping Barguzin-Severobaikalsk segments (Fig. 1). Accumulation of Upper Dzhilinda subsuite occurred in the interval of ≈11–6.5 My BP and finished in Late Miocene (6.5–7.5 My BP). The studied section of the hole 8182 characterizes the sedimentation situation taking place by Middle Miocene. After volcanism extinction ca. 12 My BP, the accumulated Middle Miocene sedimentary-volcanogenic stratum was divided by a deep erosion. The lake formed in Middle Miocene and still existed in Early Pliocene. The analysis of environmental composition of revealed complex of the first diatom zone suggests its dominance by planktonic species of the genera Aulacoseira, Alveolophora at non-considerable quantitative development of benthic and epiphytic forms. Such diatoms composition suggests sediments formation under the conditions of a deep-water lacustrine basin with a wide pelagic zone. Unusually high abundance of diatoms frustules of dominant planktonic species in the material from bottom to top from members 1–3 suggests that transgression of paleo-lake existed. We revealed at the depths of 85 and 64 m a maximal abundance of littoral forms of diatoms (53–82 %). It is very probable that the paleo-lake was not deep. The results of spore-pollen spectra analysis suggest that lacustrine sediments accumulated during Middle-Late Miocene under the conditions of moderately warm, humid climate.

Early Pliocene evolution of Khoygot paleovalley of Vitim Plateau in the deposits from members 4 and 5 was accompanied by decrease of diatoms productivity. At the same time, amount of planktonic diatoms and of broad-leaf species of terrestrial vegetation decreased. It suggest transition towards local shallow-water conditions of sedimentation at climate worsening.

Conclusion

We found in the core 8182 from Northern paleovalley of Vitim Plateau 137 diatom algae taxa (instead of 50 taxa known before). We did not find *Alveolophora areolata*, *Aulacoseira praegranulata* var. *praeislandica*, *Actinocyclus tuncaensis* described before in the deposits from other cores of Northern paleovalley. However, we revealed first for Vitim Plateau *Concentrodiscus proteus*, *C. indigenus*, *Mesodictyopsis insolita*, *M. peculiaris* characteristic for Lake Baikal Upper Miocene deposits suggesting a common character of flora of ancient Lake Baikal and of paleo-reservoir of Vitim Plateau in the end of Middle Miocene and in Late Miocene.

Diatoms distribution in the core 8182 suggests a non constant character of paleo-reservoir hydrological regime. According to diatoms ecology, the sediments corresponding to DZ 1–3 were accumulating in a deep water body with a wide littoral zone. Probably, during the last phase (DZ 4) of sedimentation, the parameters of paleo-reservoir changed abruptly – the paleolake depth decreased and the littoral zone increased.

The palynological analysis allowed to establish three palynological complexes with reconstruction of forest type of vegetation reflecting the vector of cooling and climate change from moderately warm in Middle-Late Miocene to moderately cool in Early Pliocene.

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