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The First U–Pb SHRIMP Dating of Zircons from Capitanian (Middle Permian) Deposits of the Omolon Massif (Northeast Russia)

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Abstract—The U–Pb dating of zircons from two samples taken in the stratotype sections of the Middle Permian Gizhiga Formation in the Omolon Massif has been carried out for the first time. Weighted average ages of 266 ± 2 and 265 ± 3 Ma taking the error into account are consistent with the Capitanian age calculated previously by paleontological determination. The observed detrital zircon population has made it possible to identify a few source areas in the Omolon Basin. Pre-Permian zircons are related to erosion of basement deposits of the Omolon Massif and the Middle Paleozoic volcanic rocks of the Kedon Group, while the Permian zircon population is due to the tuff supply from the Okhotsk-Taigonos volcanic arc.

Keywords: Regional Stratigraphic Scale, Permian, U–Pb SHRIMP dating of zircons, Omolon Massif, Northeast Russia

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INTRODUCTION

Correlation of the Permian deposits of the Northeast Russia with the International Stratigraphic Scale (ISS) and, moreover, with the General Stratigraphic Scale (GSS) used in Russia has always been a challenging problem [4, 11]. In particular, this is the case of the Middle Permian top and the entire Upper Permian, which are completely devoid of the orthostratigraphic fauna groups such as fusulinids and conodonts that the ISS is based on. Recently, advanced precision U–Pb zircon dating methods such as SHRIMP and IDTIMS have come into use in the studied region to date the Permian rocks [5–7, 10]

However, all these works related to zircon dating were carried out outside the stratotype area of the Regional Stratigraphic Scale (RSS). Therefore, the dating of zircons from tuffaceous rocks, synchronous to sedimentation, in the stratotype area is a very important and urgent object in terms of regional stratigraphic units. This paper reports the first SHRIMP dating results for zircons from two reference sections of the Gizhiga Formation and the cognominal regional horizon of the Omolon Massif: it are stratotype in the Vodopadnyi Creek and parastratotype in the Russkaya–Omolonskaya River. These sections were fully studied by traditional biostratigraphy and lithology methods at the end of the last century [9].

THE STRATIGRAPHY OF THE GIZHIGA FORMATION IN THE VODOPADNYI CREEK AND RUSSKAYA–OMOLONSKAYA RIVER SECTIONS AND THE POSITIONS OF THE SAMPLES

The Gizhiga Formation has a similar structure in the Vodopadnyi Creek and Russkaya–Omolonskaya River sections (Fig. 1). Its characteristic features include abundant pyroclastics and foreign scattered gravel–pebble–boulder material. All these features are less evident in the Russkaya–Omolonskaya River section than in the even-aged Vodopadnyi deposits [9].

In the Russkaya–Omolonskaya River section, the Formation (Fig. 2a) is 55-m thick, the contact with the underlying the Omolon Formation is sharp, with negligible erosion traces [9], whereas the contact with the Khivach Formation is gradual. The Gizhiga Formation rocks are composed of the following deposits from bottom to top [9]:

(1) Green tuffites are silty in dimension, massive, with platy cleavage, chloritized, and rubbly. Rare gravel–pebble-size inclusions occur as felsic, and more rarely, intermediate and basic effusive rocks. Faunistic remains include brachiopods *Rhynchopora lobjaensis* (Tolmatchew), *Cancrinelloides obrutschewi* (Licharew), and *Neospirifer invisus* Zavodovsky; bivalves *Maitaia* cf. *bella* Biakov, *Merismopteria* ex gr.

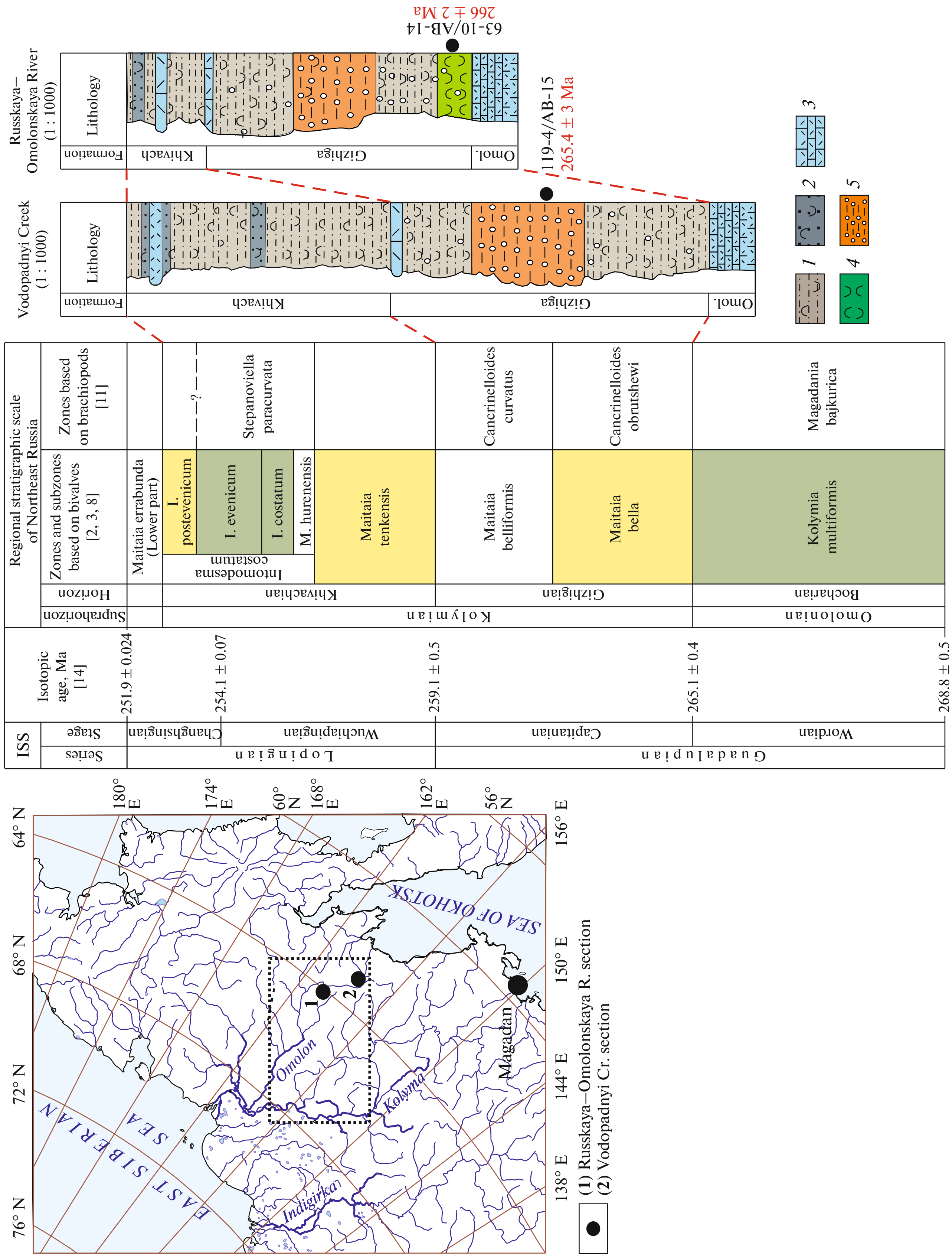

Fig. 1. The location of the studied sections in the Northeast Russia and stratigraphic position of the samples. (*1*) Tuff siltstone, (*2*) tuff sandstone, (*3*) Kolymic limestone, (*4*) tuffite, (*5*) diamictite.

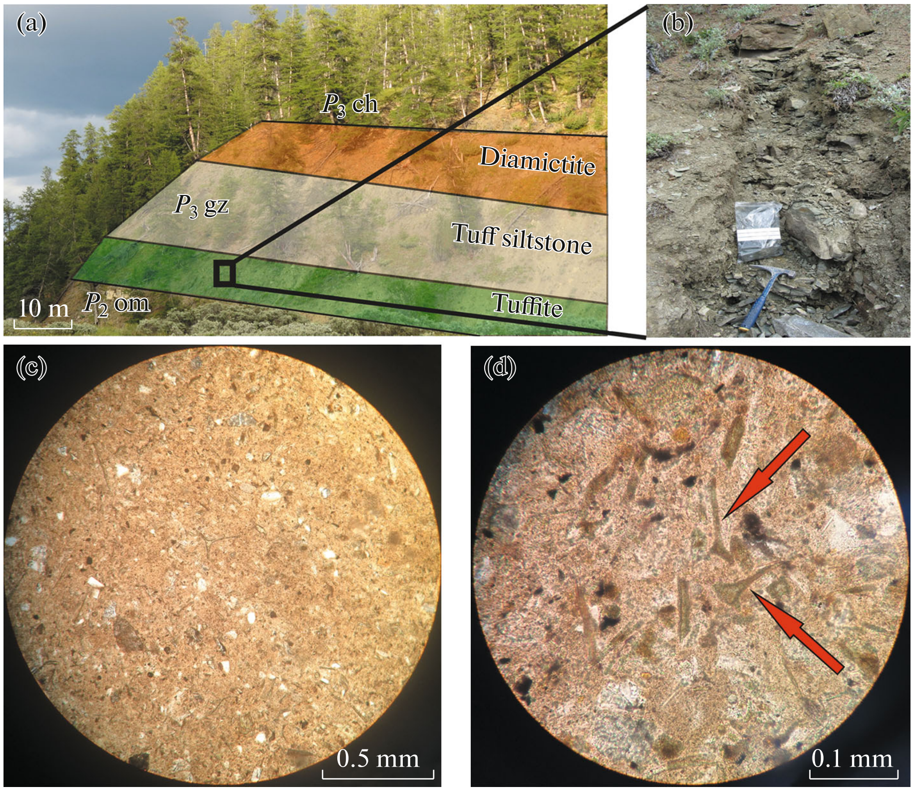

Fig. 2. The stratigraphic position and petrography of sample 63-10/AB-14. (a) Outcrop of the Gizhiga Formation in the Russkaya–Omolonskaya River section, (b) the green tuffite member that sample 63-10/AB-14 was taken from, (c) general microscopic view of the rock, (d) ash angular grains in tuffite. (P_2om) Omolon Formation; (P_3gz) Gizhiga Formation; (P_3ch) Khivach Formation.

macroptera (Morris), *Pachymyonia elata* Popow, and *Streblopteria* ex gr. *englehardti* (Etheridge et Dun). Sample 63-10/AB-14 was taken in the middle part of this member to date zircons; the thickness is 8 m.

(2) Greenish gray tuff siltstones are sandy–silty in dimension, irregular, rubbly, with a scattered gravel–pebble material, similar in composition to those found in member 1; the thickness is 10 m.

(3) Gray diamictites are rubbly, and the rock groundmass is clayey–sandy in dimension. Scattered inclusions of gravel–pebble–boulder dimension are similar to those described in members 1 and 2 and compose up to 30% of the rock. Diamictites contain brachiopods *Cancrinelloides curvatus* Tolmatchew and *Tumarinia tsaregradskyi* Zavodovsky; the thickness is 21 m.

(4) Greenish gray tuff siltstones are massive, calcareous, and contain gravel–pebble material. Deposits contain brachiopods *Cancrinelloides curvatus* Tolmatchew, *Tumarinia tsaregradskyi* Zavodovsky, *Brachythyrina turusica* Tschernjak; bivalves *Maitaia bella* Biakov, *Fasciculiconcha* sp. nov., and *Streblopteria englehardti* (Etheridge et Dun); the thickness is 15 m.

(5) Brownish gray tuff limestones are sandy–silty in dimension, massive, and tough; the thickness is 1 m.

In the Vodopadnyi Creek section, the Gizhiga Formation (Fig. 3a) is 66 m thick, and the contact between the underlying the Omolon and overlying the Khivach Formations is gradual. The Formation is composed of the following deposits from bottom to top [9]:

(1) Gray tuff siltstones are clay–sandy in dimension, lumpy; the rocks are loose, rubbly. Minor randomly oriented gravel–pebble–boulder material of various roundness is similar in composition to that found in the Russkaya–Omolonskaya River section. Faunistic remains: brachiopods *Neospirifer* cf. *invisus* Zavodovsky and *Cancrinelloides* sp. indet; the thickness is 23 m.

(2) Gray diamictites are clay–sandy in dimension in the groundmass, massive, low-calcareous, rubbly, with shell-like cleavage. Inclusions of gravel–pebble–boulder dimension are well-rounded and occur chaotically; the predominant fraction is from 0.5 to 5 cm. Brachiopod shells found in diamictites include *Cancrinelloides curvatus* Tolmatchew, *Penzhinaella tsaregradskyi* Zavodovsky, *Neospirifer crassiconchialis* Zavodovsky, *Brachythyrina sibirica* Tschemjak, and

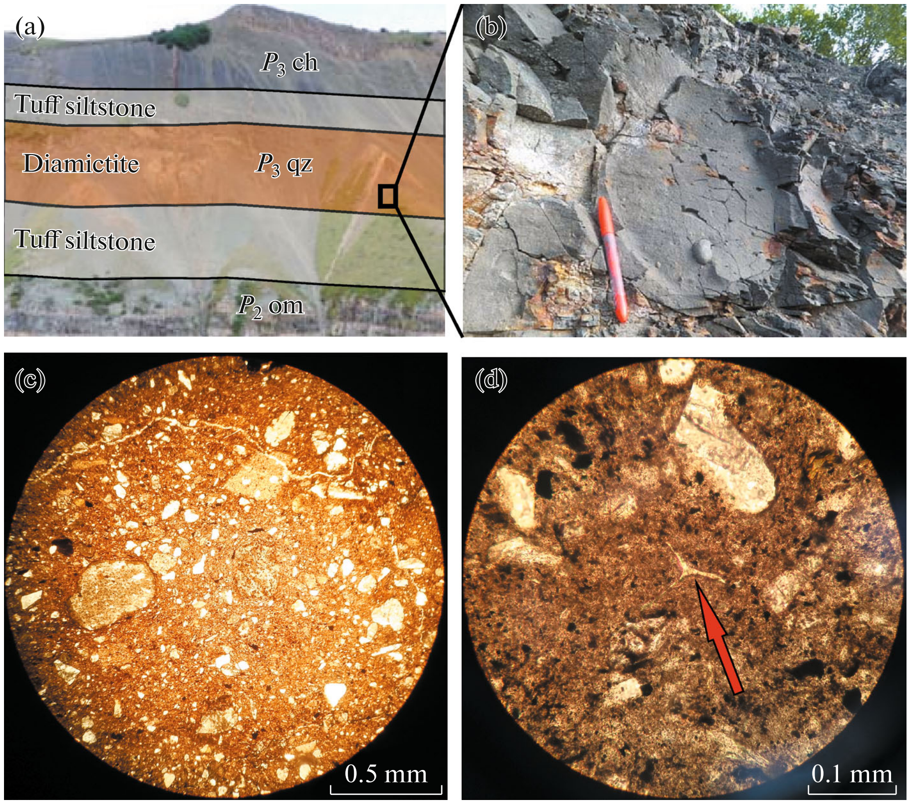

Fig. 3. The stratigraphic position and petrography of sample 119-4/AB-15. (a) Outcrop of the Gizhiga Formation in the Vodopadnyi Creek section, (b) diamictite with pebble-size inclusions, which sample 119-4/AB-15 was taken from, (c) general microscopic view of the rock, (d) ash angular grain in diamictite. (P_2om) Omolon Formation; (P_3gz) Gizhiga Formation; (P_3ch) Khivach Formation.

Actinoconchus planosulcatus (Phillips). Sample 119-4/AB-15 was taken from this member to date zircons; the thickness is 27 m.

(3) Gray tuff siltstones are clay–sandy in dimension, lumpy or layered, calcareous, with rare inclusions of gravel–pebble dimension. The brachiopod shell layers are composed of *Cancrinelloides curvatus* Tolmatchew, *Penzhinaella tsaregradskyi* Zavodovsky, and *Neospirifer crassiconchialis* Zavodovsky; bivalves include *Maitaia bella* Biakov, *M. belliformis* Biakov, *Streblopteria englehardti* (Etheridge et Dun), *Permophorus costatus* Brown, and *Myonia* aff. *komiensis* (Maslennikov); the thickness is 16 m.

ZIRCON IDENTIFICATION AND DATING METHOD

To determine the U–Pb age of the deposits, samples weighing 1.5–2 kg were taken from the most promising rock varieties. The sampling was focused on their probable tuff origin and the absence of large inclusions of scattered material in diamictites. The heavy fraction was recovered after crushing and sieving the samples using magnetic separation and heavy (bromoform) liquid. The final selection of zircon grains was carried out manually under a binocular microscope.

U–Pb dating was conducted at the Center for Isotope Research, Karpinsky Russian Geological Research Institute (St. Petersburg), with the SHRIMP-II ion microprobe. Hand-selected zircon grains, together with grains of TEMORA and 91500 zircon standards, were implanted in epoxy resin and half-ground. Optical and cathodoluminescent images that reflect the internal structure of zircons obtained with the CamScan MX 2500 scanning microscop, were used to select the dating points within the grain. The SHRIMP-II U–Pb ratio was measured according to L.S. Williams [15]. The error of single analyses (ratios and ages) was given at the two-sigma level. Concordia plotting was carried out using the ISOPLOT/EXX version 3.75 [13].

Due to the fact that young zircons (younger than 1 Ga) are characterized by a low ^{207}Pb signal [12], and the determination error of the ^{207}Pb/^{206}Pb age, in this case, is higher than 2%, the ^{206}Pb/^{238}U ratio was used for values of less than 1 Ga, and ^{207}Pb/^{206}Pb was used for ages of more than 1 Ga. In this regard, two different formulas were used to calculate the discordance: for an age of more than 1 Ga: D = 100* (Age

(^{207}Pb/^{206}Pb)/Age (^{206}Pb/^{238}U) – 1)); for an age of less than 1 Ga: D = 100*(Age (^{207}Pb/^{235}U)/Age (^{206}Pb/^{238}U) – 1)). The selection criterion for concordant dates was the discordance range (D) from –10 to 10%.

DESCRIPTION OF THE SAMPLES AND THE ZIRCONS IDENTIFIED IN THEM

Sample 63-10/AB-14 (Fig. 2b) (63°39′25″ N and 159°00′42″ E) occurs as greenish gray crystalline vitroclastic (ash) massive silty tuffite. Thin sections are dominated by ungraded, clayey–sericite material with a finely dispersed impurity of feldspar and quartz and numerous ash angular grains (Fig. 2c), composing up to 70% of the rock, with a fraction size of 0.025–0.01 mm (Fig. 2d). Fragmental rock particles are elongated and isometric, with average grading and degree of angular roundness. The allotygenic part is composed of feldspar and quartz clystalloclasts with a grain size from 0.005 to 0.4 mm (15% of the rock) and moderate effusive 0.1–0.7-mm rock lithoclasts with a glassy and hyalopilitic structure (10% of the rock).

Ten zircon grains were extracted from tuffite (Fig. 4). Grain 10.1 (Table 1) was excluded from consideration, because its discordance value is 51%. The other studied grains can be subdivided into three groups: the first group (Precambrian) includes four grains in the age range from 2656 ± 14 to 1845 ± 14 Ma; the crystal size is from 150 to 263 μm. The grains are poorly rounded, often broken off, elongated prismatic, with abrasion traces and vague oscillatory zoning. The contents are as follows (ppm): 159–2022 U; 50–306 Th; and 0.16–0.33 Th/U.

The second group (Carboniferous) includes two grains in the age range of 325 ± 2.2 and 324 ± 2.9 Ma; the crystal size is from 110 to 223 μm; the grains are poorly rounded, short-prismatic, with oscillatory zoning. The contents are as follows (ppm): 181–597 U, 45–340 Th, and 0.26–0.59 Th/U. The third group (Permian) includes four grains in the age range from 287.7 ± 2.5 to 265 ± 1.5 Ma; the crystal size is from 160 to 260 μm; the crystals are euhedral individuals with fine oscillatory zoning. The contents are as follows (ppm): 131–590 U, 84–989 Th, and 0.61–2.78 Th/U. The zircons are devoid of abrasion traces due to their insite nature. The most ancient grain from the Permian population (1.1) is excluded from further consideration, because it is obviously older than the estimated age of the Formation.

The remaining three grains from this population (Fig. 4a) form a cluster with a weighted average ^{206}Pb/^{238}U age of 266 ± 2 Ma, MSWD of 0.98, and a probability of 0.40 (Fig. 5).

Sample 119-4/AB-15, which we took in the Vodopadnyi Creek section (63°05′15″ N and 159°18′55″ E), is composed of dark gray diamictite (Fig. 3b); it is low-calcareous, crushed, with shell-like cleavage. The rock is crystallolithoclastic massive. Scattered inclusions of gravel and pebble dimension compose 25% of the rock (Fig. 1). In the thin section, the diamictite groundmass (Fig. 3c) is composed of poorly graded sericite–quartz–feldspar–clay material with a grain size of 0.005–0.025 mm (more than 50% of the rock). Angular ash particles are observed in the groundmass (Fig. 3d). Fragmented particles are characterized by elongated, acute-angled and isometric shape, poor grading and rounding, often, by angularity. Allotygenic components include crystalloclasts of feldspar, quartz, and, rarely, plagioclase with fragments ranging in size from 0.05 to 0.7 mm (up to 20% of the rock). Lithoclasts occur as intermediate–basic effusive rocks with felsic, porphyritic, and hyalopilitic structures; fragments are 0.2–2 mm in size (about 20% of the rock).

Twenty zircon grains were identified in diamictite; three of them (3.1, 12.1, 16.1, and 2.1) did not fit the discordant date selection criteria and therefore were not used. The other studied grains can be subdivided into two groups: the first (pre-Permian) group includes five grains. Four of them are dated from 2332 ± 11 to 1805 ± 25 Ma. These grains are 100–180 μm in size, have a vague zoning, broken off, poorly rounded, and predominantly short-prismatic. The contents are as follows (ppm): 148–309 U, 60–159 Th, and 0.27–0.53 Th/U. One grain of Carboniferous age (334 ± 1.8 Ma) is characterized by a size of 139 μm, vague zoning, short-prismatic shape, and contents (ppm) of 576 U, 19 Th, and 0.03 Th/U.

The second group (Permian) includes twelve grains in the age range from 284.2 ± 1.5 to 263.2 ± 3.7 Ma. The grains are 90–300 μm in size, zoned; some grains are marked by fine oscillatory zoning; they are euhedral, both long- and short-prismatic, occasionally with corrosion traces. The contents are as follows (ppm): 72–584 U, 63–901 Th, and 0.65–2.03 Th/U.

The sample age was estimated using three youngest zircons (Fig. 4) which were characterized by euhedral shape and fine oscillatory zoning without abrasion traces. Hence, the weighted average ^{206}Pb/^{238}U age for these three young grains was 265 ± 3 Ma at MSWD of 0.13 and a probability of 0.88 (Fig. 5).

DISCUSSION AND CONCLUSIONS

In terms of the faunistic data [2, 3, 11], the Gizhiga Formation and the corresponding cognominal regional horizon correlate with the ISS Capitanian, whose lower boundary is currently estimated at 265.1 ± 0.4 Ma [14]. The Capitanian is the uppermost stage of the middle (Guadalupian) section of the Permian system, whereas its analogue in GSS, the Severodvinian stage, is considered as the lower stage of the Upper Permian [4, 11].

The weighted average ^{206}Pb/^{238}U age of 266 ± 2 Ma that we obtained for tuffite from the lower part of the

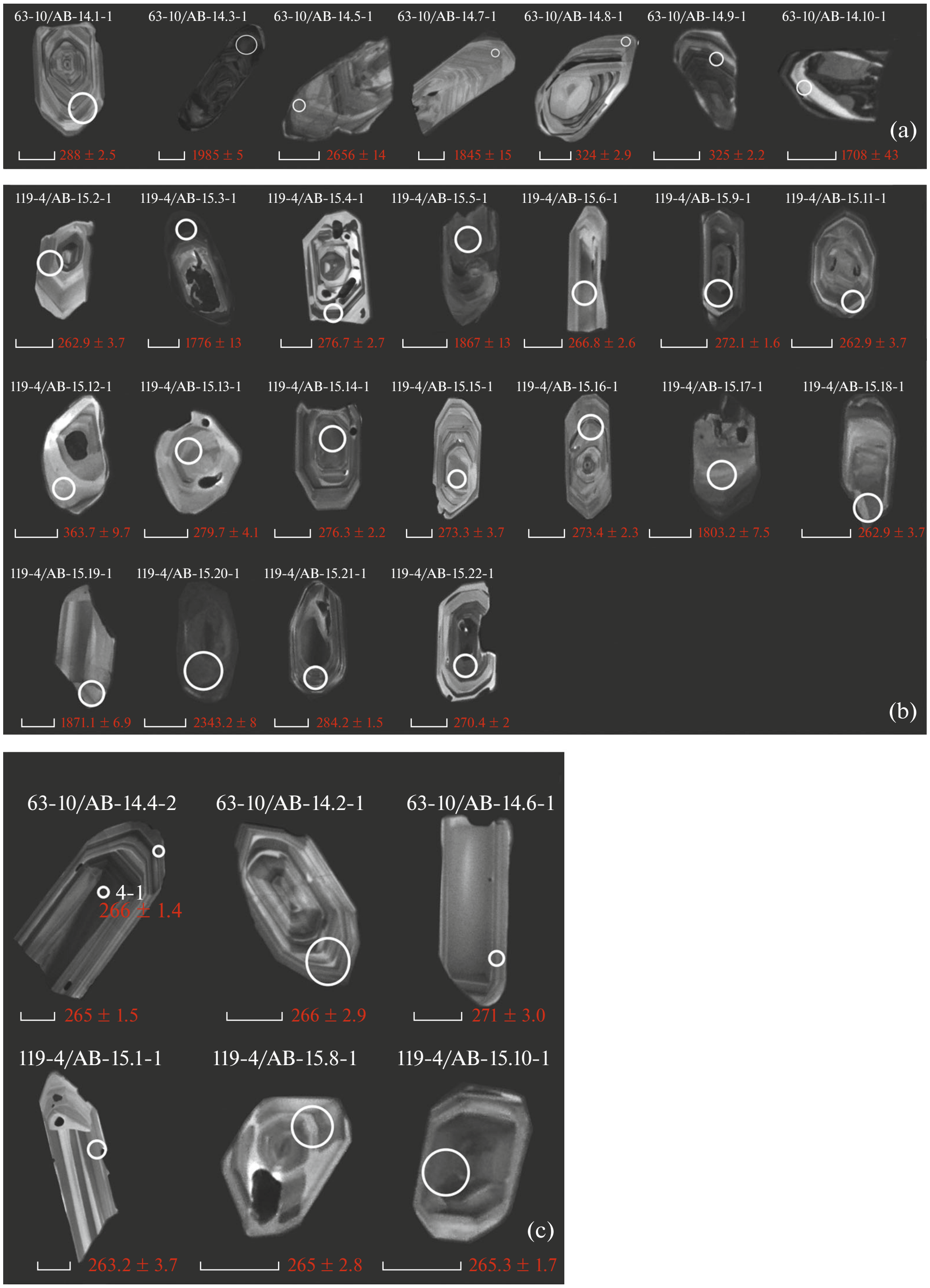

Fig. 4. Cathodoluminescent images of zircons from the Gizhiga Formation. The point numbers correspond to the numbers in Table 1. (a) Zircon grains from sample 63-10/AB-14, (b) zircon grains from sample 119-4/AB-15. Scale bar: 50 μm; (c) zircon grains used to calculate a weighted average age for the above-mentioned samples. Scale bar: 100 μm.

Formation in the Russkaya–Omolonskaya River section, taking the error into account, corresponds, according to the last version of the ISS [13], to the boundary between the middle part of the Wordian and the lower part of the Capitanian. The youngest dating (grain 4.2) of 265 ± 1.5 Ma, taking the error into account, approximately determines the lower boundary of the Capitanian and is consistent with the stratigraphic position of the sample in the lower part of the Gizhiga Formation.

The weighted average $^{206}Pb/^{238}U$ age of diamictite from the middle part of the Formation along the

Table 1. The U–Pb analysis of zircons from tuffite (sample 63-10/AB-14) and diamictite (sample 119-4/AB-15) of the Gizhiga Formation.

Grain number	% $^{206}Pb_c$	ppm U	ppm Th	$^{232}Th/^{238}U$	ppm $^{206}Pb^*$	Age, Ma (1) $^{206}Pb/^{238}U$		Age, Ma (1) $^{207}Pb/^{235}U$		Age, Ma (1) $^{207}Pb/^{206}Pb$		D, %	(1) $^{238}U/^{206}Pb$	±%	(1) $^{207}Pb^*/^{206}Pb^*$	±%	(1) $^{207}Pb^*/^{235}U$	±%	(1) $^{206}Pb^*/^{238}U$	±%	Error
Tuffite (sample 63-10/AB-14, 159.011667, 63.656944), lower part of the Gizhiga Formation (Russkaya–Omolonskaya R.)																					
Weighted average concordant age 266± 2 Ma, MSWD = 0.98, $p = 0.40$, $N = 11$																					
4.2	0.31	483	743	1.5914	17.500	265	1.5	265	7	–	–	0	23.83	0.58	0.0515	3.10	0.2983	3.20	0.04197	0.58	0.180
4.1	0.11	590	989	1.7312	21.400	266	1.4	261	5	–	–	–2	23.78	0.53	0.0505	2.20	0.2928	2.20	0.04205	0.53	0.238
2.1	0.88	142	84	0.6149	5.180	266	2.9	266	21	–	–	0	23.70	1.10	0.0515	8.90	0.3000	8.90	0.04220	1.10	0.126
6.1	0.48	131	351	2.7776	4.840	271	3.0	277	15	–	–	2	23.32	1.10	0.0532	6.10	0.3140	6.20	0.04287	1.10	0.182
1.1	0.00	168	182	1.1194	6.590	288	2.5	283	8	–	–	–1	21.91	0.88	0.0511	3.20	0.3220	3.30	0.04564	0.88	0.266
8.1	1.06	181	45	0.2597	8.090	324	2.9	329	17	–	–	2	19.39	0.93	0.0539	5.80	0.3830	5.90	0.05156	0.93	0.158
9.1	2.17	597	340	0.5873	27.100	325	2.2	340	16	–	–	5	19.33	0.70	0.0559	5.60	0.3980	5.60	0.05172	0.70	0.125
10.1*	2.46	329	106	0.3328	55.500	1131	6.3	–	–	1708	43	51	5.21	0.61	0.1047	2.30	2.7670	2.40	0.19180	0.61	0.255
7.1	0.06	180	82	0.4720	50.900	1828	9.7	–	–	1845	15	1	3.05	0.61	0.1128	0.84	5.0970	1.00	0.32780	0.61	0.584
3.1	0.03	2022	306	0.1563	572.000	1834	4.0	–	–	1985	5	8	3.04	0.25	0.12194	0.30	5.5310	0.39	0.32900	0.25	0.640
5.1	0.01	159	50	0.3276	68.000	2607	14.0	–	–	2656	14	2	2.01	0.63	0.1804	0.82	12.3900	1.00	0.49830	0.63	0.610
Diamictite (sample 119-4/AB-15, 159.315278, 63.0875), middle part of the Gizhiga Formation (Vodopadnyi Cr.)																					
Weighted average concordant age 265.4 ± 3 Ma, MSWD = 0.13, $p = 0.13$, $N = 22$																					
2.1*	0.92	73	52	0.7429	2.63	262.9	3.7	226	24	–	–	–14	24.02	1.4	0.0433	12	0.2490	12.00	0.04163	1.40	0.116
1.1	0.92	72	63	0.9099	2.59	263.2	3.7	247	24	–	–	–6	23.99	1.4	0.0478	11	0.2750	11.00	0.04168	1.40	0.128
8.1	0.00	119	234	2.0336	4.29	265	2.8	287	13	–	–	8	23.83	1.1	0.0564	5.20	0.3260	5.30	0.04196	1.10	0.202
10.1	0.00	351	485	1.4276	12.7	265.3	1.7	274	7	–	–	3	23.8	0.64	0.0535	2.70	0.3101	2.80	0.04202	0.64	0.227
6.1	0.00	143	156	1.1251	5.21	266.8	2.6	288	11	–	–	8	23.66	0.98	0.0563	4.10	0.3280	4.20	0.04226	0.98	0.231
22.1	0.25	364	281	0.7967	13.4	270.4	2.0	270	9	–	–	0	23.35	0.75	0.0516	3.60	0.3050	3.70	0.04283	0.75	0.205
9.1	–0.19	562	722	1.3266	20.8	272.1	1.6	283	8	–	–	4	23.19	0.61	0.0542	3.10	0.3220	3.20	0.04312	0.61	0.192
15.1	0.00	72	68	0.9775	2.67	273.1	3.7	287	16	–	–	5	23.11	1.4	0.0546	6.10	0.3260	6.20	0.04328	1.40	0.224
16.1*	–0.46	231	338	1.5124	8.56	273.4	2.3	306	16	–	–	12	23.08	0.87	0.0588	6	0.3510	6.00	0.04333	0.87	0.143
11.1	–0.30	349	218	0.6460	13	274	1.8	280	11	–	–	2	23.03	0.68	0.0531	4.50	0.3180	4.60	0.04342	0.68	0.148
14.1	0.00	222	315	1.4691	8.35	276.3	2.2	283	9	–	–	2	22.83	0.8	0.0532	3.40	0.3210	3.50	0.04379	0.80	0.227
4.1	0.00	165	120	0.7494	6.22	276.7	2.7	271	10	–	–	–2	22.81	1	0.0505	3.90	0.3060	4.00	0.04385	1.00	0.254
13.1	0.00	80	135	1.7599	3.03	279.7	4.1	300	15	–	–	7	22.55	1.5	0.0562	5.60	0.3440	5.80	0.04434	1.50	0.257
21.1	0.26	584	901	1.5944	22.7	284.2	1.5	300	8	–	–	6	22.19	0.54	0.0554	3.10	0.3440	3.20	0.04507	0.54	0.171
18.1	0.39	576	19	0.0335	26.4	334	1.8	351	11	–	–	5	18.8	0.57	0.0563	3.60	0.4130	3.60	0.05318	0.57	0.156
12.1*	0.00	14	1	0.0929	0.674	363.7	9.7	417	38	–	–	15	17.23	2.7	0.0635	11	0.5080	11.00	0.05800	2.70	0.242
3.1*	0.7	1168.9	511.4	0.5	280	1572.6	3.2	–	–	1776	13.0	12.9	3.6155	0.23	0.10857	0.7	4.1	0.7	0.3	0.2	0.3
17.1	0.22	148	60	0.4195	41.2	1803.2	7.5	–	–	1805	25	0	3.097	0.48	0.1104	1.40	4.9110	1.40	0.32280	0.48	0.330
5.1	0.00	309	159	0.5308	88.9	1863.7	5.2	–	–	1867	13	0	2.9829	0.32	0.11415	0.72	5.2760	0.79	0.33520	0.32	0.408
19.1	0.00	190	60	0.3279	55	1871.1	6.9	–	–	1858	18	–1	2.969	0.43	0.1136	0.99	5.2740	1.10	0.33680	0.43	0.396
20.1	0.00	241	62	0.2658	90.6	2343.2	8.0	–	–	2332	11	0	2.2813	0.41	0.1488	0.66	8.9930	0.78	0.43830	0.41	0.522

(MSWD) standard deviation, (p) concordance probability. (1δ) Errors of single analyses. ($^{206}Pb_c$ and $^{206}Pb^*$) normal and radiogenic lead. (1) Corrected for normal lead using measured ^{204}Pb. The calibration error of TEMORA standard is 0.52% (not included in errors of single analyses). Analyses were carried out with SHRIMP-II in the Karpinsky Russian Geological Research Institute (St. Petersburg). (*), Grains that do not meet the selection criteria for concordant dates (a concordance range of –10 to 10%).

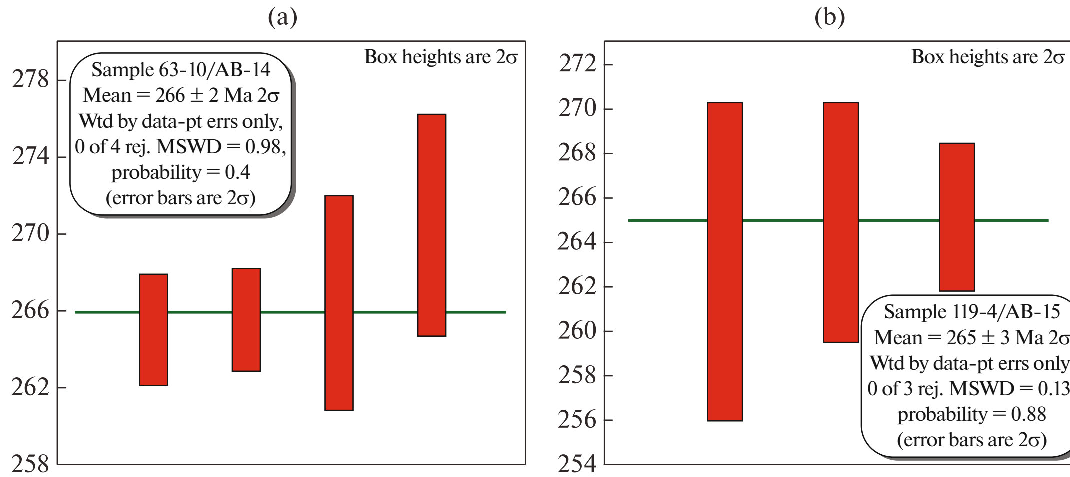

Fig. 5. The estimated weighted average age of (a) sample 63-10/AB-14 from the lower part of the Gizhiga Formation and (b) sample 119-4/AB-15 from the middle part of the Gizhiga Formation.

Vodopadnyi Creek section estimated at 265 ± 3 Ma, taking the error into account, is indicative of the range from the middle part of the Wordian to the upper part of the Capitanian. The youngest grain (1.1) of the dated Permian population is 263.2 ± 3.7 Ma, corresponding to the middle part of the ISS Capitanian and agreeing with the stratigraphic position of the dated sample.

Despite the fact that the number of detrital zircons studied is small, it can be noted that both samples contain Neoarchean, Paleoproterozoic, Carboniferous, Lower and Middle Permian grains, which make it possible to suggest their possible sources. An acute-angular form of scattered fragments in the rock is indicative of a relatively close material source area. The most ancient age range (Neoarchean–Paleoproterozoic) suggests the erosion of the Omolon Massif basement rocks. The Carboniferous detrital zircons may be evidence for erosion of the Kedonian Group (Middle Devonian–Early Carboniferous) volcanic rocks. Numerous Permian grains, including the apparently insite Middle Permian zircons, were likely brought from a nearby source. Obviously, this source is the Okhotsk–Taigonos volcanic arc reconstructed to the southeast (in modern coordinates) of the Omolon Massif [1].

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