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Geochronology of the Upper Precambrian of the Siberian Platform, Uchur-Maja Region

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ABSTRACT

Based on absolute age determinations on glauconites from the sedimentary cover and magmatic rocks cutting these sediments, a geochronological scheme of the Upper Precambrian was elaborated for the Uchur-Maja region located within the Aldan Schield. It can be demonstrated that the formation of the Siberian Platform began at an earlier time than the formation of the Russian platform. In addition, the large discontinuities in sedimentation occurred earlier on the Siberian platform than on the Russian platform.

Being involved in the problem of ascertaining the main boundaries of sedimentary formations of the Upper Precambrian, the present authors have undertaken, from a geochronological point of view, a detailed review of the Upper Precambrian areas within the USSR, both on platforms and geosynclines. Systematic geochronological investigations have been carried out for many years over several extended regions of the Earth's crust within the Russian and Siberian platforms as well as on the Ural and Enisei geosynclines.

In this paper the results obtained by the authors on the eastern part of the Siberian platform between the rivers Uchur and Maja are summarized. Here, in the eastern outskirts of the Aldan shield, and farther to the east in the Maja trough on the folded and metamorphosed Lower Proterozoic-Archean basement, slightly altered sedimentary and sedimentary-volcanogenic strata occur; the age succession and completeness of these sections are recognized by all geologists who have studied this region (see NUZHNOV and YARMOLYUK, 1959 and 1968; GAMALEYA, 1968; GAMALEYA, LOSEV and POPOV, 1964; GAMALEYA and ZABRODIN, 1967; STAVTSEV, 1967; ZABRODIN, 1966).

In the first region, the nearest one to the Aldan shield and occupying the interstream (or divide) area between the rivers Uchur and Aim, the section begins with sandy-carbonate deposits of the Gonamian and Omakhtin suites of the Uchurian series changing upwards into the sandy-aleuritic Ennin suite of the Majan series which, in its turn, is unconformably overlain by the Yudomian suite of the Vendean.

In the second, more southern region covering the Ulkan trough, the most ancient section of the Upper Precambrian is outcropping below the eroded formation described above. Here, on a folded and deeply eroded basement, composed of gneisses and migmatites of the Batomgian and Dzheltulin series with an absolute age of 2100–2300 m.y., terrigenous, prevailingly sandy-aleurolitic rocks intercalated with

the effusives of the Ulkanian and Ujanian series and reaching a thickness of 2.5–3 km are found.

In the third region which is located in the basin of the river Maja, to the east and north-east of the above described area, the section of the Upper Precambrian is completed upwards. Here the entire sequence of Majan series is exposed, represented by an alternation of carbonate and terrigenous rocks of the Ujanian series, predominantly formed of sands and sandstones. This Precambrian section is overlain by sandy-carbonate rocks of the Yudomian suite of the Vendean complex.

The central part of the Uchur depression is occupied by the Ulkan pluton – a complexly built multiphase granite massif. According to the data (GAMALEYA, 1968) the Lower Ulkanian rocks are cut by this intrusion; its earliest phase is associated with the Pre-Uiyan time. Within the Ulkan trough and zones of faults bordering the Aldan shield in the South-East and East, the sheet bodies and dykes of basic rocks are found, which are almost unknown above the Ennin suite (not taking into account Mesozoic intrusions which are widely developed here). A typical feature in the geological structure of the region is the presence of alkaline and ultrabasic ring-shaped intrusions among which the Ingili massif is of highest interest for geochronology, as it cuts the deposits of the Upper Precambrian and is, in turn, unconformably overlain by the sands of the Yudomian suite.

A distinctive feature of the Uchur-Maja region is the presence of glauconite rocks in every suite of the Precambrian. The first determinations of the absolute age for some glauconites from the Uchur-Maja region were carried out by POLEVAYA and KAZAKOV (1960, 1961), dating the Rifean (Upper Precambrian) age of the old sedimentary formations in the Siberian Platform. Of great importance for the understanding of the geochronology of the Aldan shield were the investigations of TUGARINOV et al. (1965, 1966) and TUGARINOV (1968). In fact, it was the first geochronological scheme created for the whole Precambrian of the given region. The following stage became then possible – the elaboration of a geochronological scheme for the sedimentary Precambrian cover of the Siberian platform.

The authors of this paper have collected and analysed K/Ar samples of glauconites and magmatic rocks having a definite chemical allocation and characterizing the main development stages of the sedimentary cover in the Uchur-Maja region.

The absolute age of isolated monomineralic fractions of glauconite and magmatic rocks was determined by the K/Ar method with isotopic control and using the decay constants $\lambda_\kappa = 0{,}557 \cdot 10^{-10}$ years^{-1} and $\lambda_\beta = 4{,}72 \cdot 10^{-1}$ years^{-1}. The potassium content was analysed by the method of flame photometry.

We shall begin the review of obtained geochronological data with the western part of the region adjoining the slope of the Aldan shield, in accordance with the geological description given above.

According to the obtained glauconite dates the time of sedimentation of the Gonamian series from the river Uchur was assumed at 1570 m.y.; for the Omakhtinian series it is 1400 m.y., and for the Enninian series 1200 m.y. (see Table 1). From these ages we can see that, in general terms, the Uchurian series corresponds to the Lower Rifean in the stratotypic Uralian section. In the Ulkan depression the glauconite from the lower part of the Elgeteian suite of the Ulkanian series has given an absolute age

of 1750 m.y. This date characterizes one of the most ancient glauconite horizons within the territory of the USSR. When comparing these absolute age figures with the dates obtained by POLEVAYA by the K/Ar method for quartz porphyries of the same series – 1615 m.y., and zircons by the Pb/U method – 1840 m.y. – obtained by TUGARINOV, a rather good agreement between the figures can be seen. Pessimistic conclusions about inevitable Ar losses in glauconite are therefore refuted.

From the ribeckite pegmatites of the Ulkan pluton, which represent the last phase of this pluton's emplacement, we have determined the absolute age of a monomineral riebeckite fraction, which proved to be 1640 m.y. This is in full agreement with STAVTSEV's (1967) and GAMALEYA's (1967) ideas about the time of formation of the pluton being associated with the period of the Pre-Ujanian hiatus. Obviously, the zircon date of 1140 m.y. reported by TUGARINOV from the field of granites of the Ulkan pluton, must be assigned to the small dykes of granitoids cutting both the Ulkan pluton proper and the metamorphic strata of the basement.

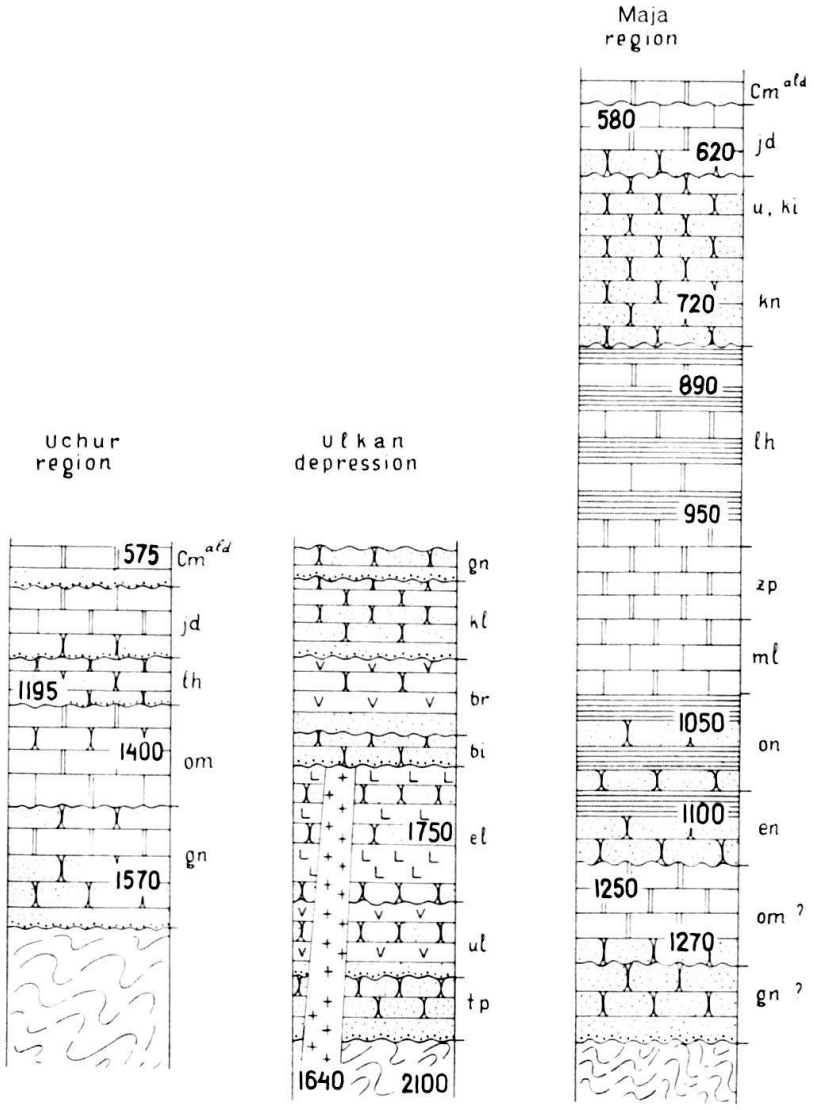

Fig. 1. Schematic lithological-geochronological section of Uchur-Maja region of the Siberian Platform.

Absolute age determinations of sills, diabases, gabbro-diabases and porphyrites over the Ulkan depression show at least three phases of intrusion. The first one is the Postgonamian to Pre-Enninian phase with an absolute age of 1280–1250 m.y. The second is the Post-Ennian with an absolute age of 1160–1075 m.y., and the third one is dated at 900 m.y.

Thus, on the basis of studying the absolute age of rocks of the Ulkanian series, we can infer that this series belongs to the Pre-Rifean formations and is the most ancient stratum of the sedimentary cover in the Siberian Platform – with an absolute age of 1900–1600 m.y. According to the recent scale of absolute geochronology the Ulkanian series belongs to the Middle Proterozoic.

In the Maja region we have geochronologically assessed a problematic sandstone stratum unconformably overlying the redcoloured strata. Lithologically it represents one and the same cycle of sedimentation with the overlying Ennianian and Omninian suites. Its absolute age is 1270–1250 m.y. and we believe it to correspond with the lower parts of the Majan series. Hence, in the Maja region, the Nadomakhtin section is more complete than in the western sections along the Uchur river.

The upper horizons of the Majan series are characterized by the dates obtained on glauconite from the base (950 m.y.), and the roof (890 m.y.) of its upper most member – the Lakhandinian suite. Proceeding from the existing absolute time-scale for the late Precambrian, the Majan series up to the Lakhandinian suite must certainly be Middle Rifean, and the Lakhandinian suite itself must be considered as Upper Rifean.

The determination of the absolute age of glauconites from the Ujanian series showing 720 m.y., indicates its Upper Rifean age.

The absolute age of the Yudomian series may be well determined from the age of biotite from the Ingili intrusion, as well as by direct determinations on glauconites from the sediments. The resulting age lies in the range of 675–580 m.y.

An important piece of evidence for the geochronology of the boundary between the Cambrian and Precambrian is the age determination on glauconite from the Nemakit-Daldynian horizon of the Kotuikan river in the Anabar shield. This horizon lies below the Sunnaginian one and is characterized by its fauna and the mottled suite of the Lower Cambrian; it has recently been dated by worms and by problematical remains. The Nemakite-Daldynian horizon and the Starorechenskiy suite of the Vendean complex form together a single series of sediments. The Nemakite-Daldynian horizon, despite its being deprived of skeletal fossils, is, according to most valid arguments of a number of investigators, the top horizon of the Precambrian (see ROZANOV, 1964, and MISSARZHEVSKY (1967). The obtained glauconite date (580 m.y.) may presently characterize the upper boundary of the Upper Precambrian dated by the methods of geochronology. Glauconite from the lower parts of the faunistically proved Lower Cambrian of the Udokanian region, Kalar depression, has been dated at 570 m.y.

Thus, as exemplified by the deposits of the Siberian platform, the geochronological boundary between the Cambrian and the Precambrian is definitively established at 570 ± 10 m.y.

Taking into account that the absolute age of glauconite from the Upper Yudomian subsuite, at the base of which there is an unconformity, proved to be equal to

580 m.y., it may be assumed that the Nemakite-Daldynian horizon is stratigraphically an analogue of the Upper Yudomian subsuite.

Summarizing our geochronological scheme of the sedimentary, non-metamorphosed cover of the Uchur-Maja region in the eastern part of the Siberian platform (Fig. 2), it may be stated that we have here actually the most complete section of the Middle and Upper Proterozoic ranging from 1900 to 570 m.y.

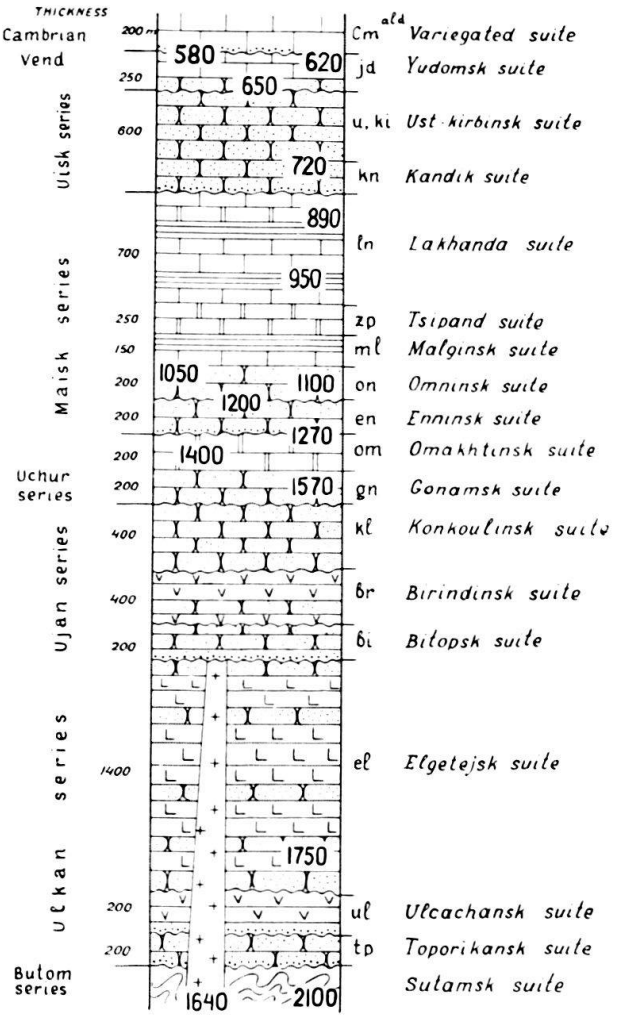

Fig. 2. Combined schematic lithological-geochronological section of the Uchur-Maja region of the Siberian Platform.

When we had clarified the general scheme of geochronology of the Siberian platform's sedimentary cover, we tried to compare it with the geochronologically described section of the sedimentary cover of the Russian platform in its more complete eastern part.

Of great interest was the question of whether the two largest platforms of the European-Asiatic continent had been formed synchronously or their development proceeded at different times.

In our earlier papers we have shown that the formation of the Russian platform began in its eastern parts (Volga-Ural region) in the Lower Rifean, which in the ab-

solute chronology corresponds to 1500–1530 m.y. (KAZAKOV et al., 1967). The Russian Platform took its start after the end of the Late Karelian folding on a basement composed by Archean, Lower and Middle Proterozoic strata, with the youngest absolute age values of 1750–1900 m.y.

The largest breaks in sedimentation during the Late Precambrian in the Russian Platform are the following ones: at the base of the sedimentary cover (1500–1530 m.y.) corresponding to the beginning of the Nizhnebavlin series; the discontinuity at the base of the Serdob series (1000 m.y.); the discontinuity at the base of the Pachelm series (680 m.y.), and the discontinuity at the base of the Volyn series (620 m.y.). There is a less marked discontinuity at the level of 1360–1310 m.y., at the base of the Serafimov suite. In the western and north-western parts of the Russian Platform this discontinuity becomes more distinct and corresponds to the base of the Byelorussian series and the Iotnian-Salmian series of the north-eastern shore of the Ladoga lake.

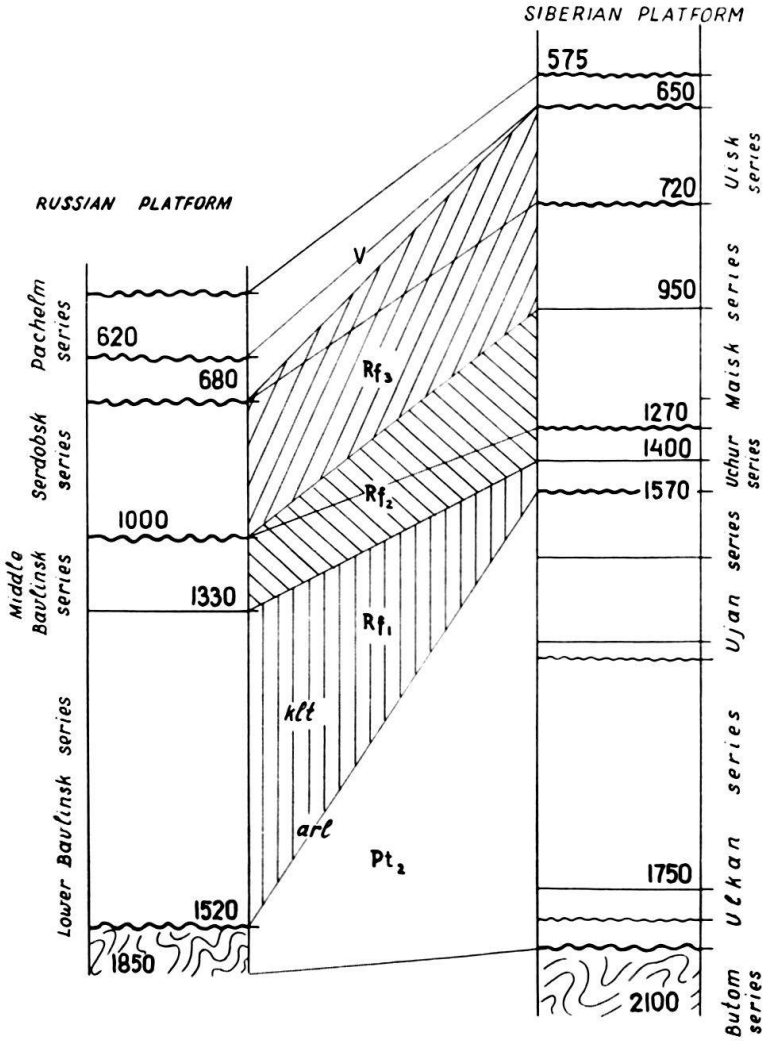

Fig. 3. Correlation scheme for the precambrian combined section of the Russian and Siberian Platforms based on geochronological data. Rf_1, Rf_2, Rf_3 = Lower, Middle and Upper Rifean.

We have compared the *most important* breaks in sedimentation corresponding to the *most important* tectonic stages in the Russian and Siberian platforms, beginning from the most ancient discontinuity in the roof of the basement (Fig. 3).

The scheme distinctly shows that the Siberian Platform has started its life earlier than the Russian Platform. At the time when the most ancient sedimentary cover began to develop on the Siberian platform, miogeosynclinal conditions of sedimentation still persisted in troughs framing the shield and the uplifts of the Russian platform; the platform had not yet become consolidated.

The following large discontinuity on the Siberian platform is confined to the base of the Uchurian series of the Lower Rifean with an absolute age of 1570–1600 m.y. On the Russian platform the Nizhnebavlinian series began its formation 1500–1530 m.y. ago.

The deposition of Majan series on the Siberian platform began 1270–1250 m.y. ago and the Serdobian series, following the Nizhnebavlinian series on the Russian platform, began to develop about 1000 m.y. ago.

The deposition of the Ujanian series began from the time of 720–750 m.y. and the Pachelmian series, which follows the Serdobian series of the Russian platform, began to form 680 m.y. ago.

The Yudomian suite on the Siberian platform began to develop some 660–650 m.y. ago and the Volynian series of the Russian platform, succeeding the Pachelmian series, were deposited some 620 m.y. ago.

Thus the earlier beginning of deposition on the Siberian platform, when compared with the Russian platform, was a general planetary process of successive shift of the main phases of tectogenesis from east to west during the Late Precambrian period within the Atlantic segment of the Earth Crust. All the largest breaks in sedimentation on the Siberian platform in the Late Precambrian, which serve as basis for the boundaries of the series to be traced, occur earlier than the corresponding events on the Russian platform.

Separate smaller discontinuities may be noted at almost all levels of the Upper Precambrian suites within the platform discussed. They show that the Earth's crust keenly reacted upon all tectonic disturbances, which were characterized by a different intensity in different areas.

On the basis of given analysis of geochronological data, it is not possible to agree with the opinion of investigators advocating the strict synchronism of the formation of Precambrian platforms of the continents. Considering the formation of platforms in large time intervals, one naturally may come to the conclusion that they were formed simultaneously. Yet, the accumulated geochronological data prove that platforms, in particular the Russian and the Siberian ones, differ in their time of formation, if analysed in detail.

In future, extensive geochronological investigations have to be carried out for comparing the time of formation of the large Precambrian platforms, as well as of the geosynclines, all over the European and Asiatic continents of the Laurasian block and the continents of Gondwanaland.

Table 1. Results of analysis of sedimentary and magmatogenic rocks and minerals of the Uchur-Maja region

No. of the sample		Sampling place, geological age, author	K %	Ar 10^{-5} cm^3/g	Age 10^6 years
		Glauconites			
1	Sample 1820/2	Right bank of the R. Ulkachan, middle course. Elgetei suite. Yu. N. Gamaleya's sample	3.30	35.6	1740
2	Sample 212/259	R. Uchur above the mouth of the R. Onne. Gonam suite. S. V. Nuzhnov's sample	5.62	51.9	1570
3	Sample 369/4	R. Bolshoi Aim, 3 km above the R. Dyondorukha	5.6	43.8	1400
4	Sample 8/12	Left bank of the R. Chumikan, below the mouth of the R. Bereya. Problematic Ennin or Gonam suite V. R. Alexeev's sample	4.32	29.7	1270
5	Sample 272	R. Tanyagda, left tributary of the R. Chimikana. Problematic Ennin or Gonam suite V. R. Alexeev's sample	5.89	39.5	1250
6	Sample 246/270	R. Uchur, below the mouth of the R. Gonam. Ennin suite S. V. Nuzhnov's sample	6.70	42.24	1195
7	Sample 2053/5	Ennin suite S. P. Krasilnikov's sample	2.75	17.9	1170
8	Sample 120[b]	Ennin suite Terentyev's sample	5.22	31.4	1150
9	Sample 34/3	Left bank of the R. Omnya, Ennin suite, upper strata S. P. Krasilnikov's sample	3.19	18.0	1100
10	Sample 1659	Right bank of the R. Batomgi, 30 km above the mouth. Problematic Ennin suite Agentov's sample	6.50	36.5	1100
11	Sample 67–63/55	R. Maja, opposite the mouth of the R. Maimakan. Omninsk suite, lower strata S. V. Nuzhnov's sample	2.25	11.9	1050
12	Sample 11/1	Brook Namnchi, left tributary of the R. Chelasin. Omninsk suite, basement V. R. Alexeev's sample	4.81	25.0	1030
13	Sample 1540/26	R. Maja below the settlem. Nelkan. Lakhandin suite Kallimulin's sample	1.28	5.82	950

Table 1. (1. Continuation).

No. of the sample		Sampling place, geological age, author	K %	Ar 10^{-5} cm^3/g	Age 10^6 years
14	Sample 48	R. Maja above the mouth of the R. Bolshoi Kandyk. Lakhandin suite E. A. Baskov's sample	5.62	2.42	890
15	Sample Sh-129/65	R. Aldan, right bank, 10 km above the mouth of the R. Belaya, middle course, Nizhneyudomsk subsuite B. A. Komara's sample	4.60	13.3	650
16	Sample m-143	R. Belaya opposite the mouth of the R. Tary-Inakh, middle part of the Nizhneyudomsk subsuite B. A. Komara's sample	5.75	16.9	635
17	Sample 1561/7	Near-mouth part of the R. Severny Ui at the inflow into the R. Maya. Variagated suite, Yudomsk suite R. N. Kallimulin's sample	5.37	15.0	620
18	Sample 200/65	Right bank of the R. Aldan, 10 km above the mouth of the R. Belaya Variagated suite?, Yudomsk suite V. A. Komara's sample	5.46	15.2	620
19	Sample M-188	R. Aldan, 10 km above the mouth of the R. Belaya V. A. Komara's sample	5.21	15.8	670
20	Sample 2307/12	Region Ingili, Yudomsk suite, upper subsuite M. Ya. Popov's sample	5.46	13.91	580
21	Sample M-418/12	R. Kotuikan, Anabar anteclise Nemakite-Daldynsk horizon V. V. Missarzhevsky's sample	5.17	13.1	580
22	Sample 125/1	Ridge Udokan. Kalarsk depression, R. Chikanda basin, lower strata of the lower Cambrian N. V. Pokrovskaya's sample	5.09	13.0	570
23	Sample 501/3	Left bank of the R. Yudoma, 31 km from the mouth Kandyk suite S. V. Nevolin's sample	5.04	16.7	720
24	Sample 171/2	R. Bereya, left tributary of the R. Chumikana V. R. Alexeev's sample	4.39	12.3	625
25	Sample 50[a]	R. Ichas V. R. Alexeev's sample	3.41	10.5	620

Table 1. (2. Continuation).

No. of the sample		Sampling place, geological age, author	K %	Ar 10^{-5} cm^3/g	Age 10^6 years
		Magmatic rocks			
1	Sample 3388/2	Confluence of the Rivers Ulkan-Uchur, olivine diabase, post gonamic, preennin V. E. ZABRODIN's sample	1.50	10.4	1280
2	Sample 1402/5	Confluence of the Rivers Ulkan-Uchur, diabasic porphyrite, sill in upper strata of the Elgetei suite YU. N. GAMALEYA's sample	1.05	7.20	1270
3	Sample 5015/8	Upper course of the R. Ulkan, left bank; gabbrodiabase breaks through quartz porphyries of the Elgetei suite YU. N. GAMALEYA's sample	0.65	4.50	1250
4	Sample 1408	Right tributary of the R. Uchur, brook Bezymyanny (effusive?), diabase, lower strata of the Elgetei suite YU. N. GAMALEYA's sample	2.55	16.20	1200
5	Sample 1355	Right tributary of the R. Uchur, brook Bezymyanny, diabasic porphyrite, sill cutting upper strata of the Elgetei suite YU. N. GAMALEYA's sample	1.03	6.12	1140
6	Sample 3587A	Left bank of the R. Ulkan, eastwards of the Ulkan pluton, diabasic porphyrite, lower strata of the Elgetei suite YU. N. GAMALEYA's sample	2.41	13.2	1075
7	Sample 3388/1	Confluence of the Rivers Ulkan-Uchur, northwards of the Ulkan pluton, diabasic porphyrite, postganamic, possibly postennin V. E. ZABRODIN's sample	1.04	4.54	900
8	Sample 3516/4	R. Nichvagan, right tributary of the R. Uchur southwards of the Ulkan pluton, diabasic porphyrite sill in upper strata of the Elgetei suite YU. N. GAMALEYA's sample	1.68	7.3	900
9	Sample R-1	Ulkan massif. Riebeckitic pegmatite, youngest phase of magmatism. Riebeckite YU. N. GAMALEYA's sample	1.36	12.5	1640

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