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GEOLOGY

The First Data on Isotopic Age of Anyui Volcano (Chukotka)

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Abstract—The age of the Anyui volcano (Chukotka) has been determined for the first time with the use of the K–Ar method; it is 0.248 ± 0.030 Ma. The absence of glacial impact traces on volcanic deposits allows us to suppose the absence of glaciations in the continental areas of West Chukotka during the last 250 ka.

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The Anyui Volcano (67°10′27″ N, 165°50′08″ E, 1054 m) is situated in the basin of Big Anyui River, a tributary of the Monni River; it pierces the northern slope of the Vulcannaya Mount (1585 m), which is one of the tops of the South Anyui Ridge. The volcano is also referred to as Monni, Molodykh, and Ustieva volcano. The first mention about it was made by E.K. Ustiev [12], whose expedition studied the entire lava flow (58 km) up to the scoria cone and described this object in detail, which is unique for Chukotka. On the basis of the good morphological preservation, absence of glacial treatment traces, and absence of glacial impacts in the lava flow and cone, Ustiev supposed that the volcano was formed several hundreds years ago. The majority of researchers had analogous thoughts concerning the age of volcano, or refer it to Holocene at least (for instance, [1]). As evidence, the words of local inhabitants that the flow smoked in their lifetime are presented [3]. V.A. Ignat'ev and V.I. Sizykh [4–6, 9], based on the correlation with glacial forms, placed the age of the volcano as Late Sartan. A.A. Surnin et al. [10, 11] mention that the ages of Balagan-Tas and Ustieva volcanoes range from 0.2 to 0.4 Ma; however, these works do not contain primary data of isotopic dating and do not give any links to them. Thus, at present, the age of the Anyui volcano has been assessed only by indirect signs, while isotopic datings are absent.

In August 2009, we visited the Anyui volcano for the purpose of determination of its age. The studies were carried out near the scoria cone, and lava flows were investigated at distances up to 7 km from the cone.

The lava field is mostly not turf-covered. Primary morphostructures of the flow are well preserved, and glazed lava icicles also appeared in ideal preservation. There were no substantial traces of glacial impacts, but traces of frost erosion of rocks are common. The scoria cone is of special interest: nowadays, it is composed of dense caked agglutinates of near-vent facies, mostly of a bricky red color. Coverage with mostly black granular scoriae, typical for young (Holocene) cones, is almost completely absent. Nevertheless, scoriae (tephra) are absent in the flow proper and in adjacent mounts and streams, which signifies the relatively old age of the eruption. The rim of the cone is reinforced by the packet of interlayering of thin beds of lavas and pyroclastic material.

"Ballistic outburst products" [12], which are often mentioned in almost all works and are preserved in the best way on the bedrock slope of the Vulcannaya Mount to the west of the cone, are either a side vent or a fragment of the primary cone, which rested against the slope in the past. Additionally, the absolute elevations of the "outburst products" and the upper (eastern) rim of the crater are identical. The size of the primary cone might be visibly larger than the remaining building. For the primary cone, the following minimal parameters can be assumed: $H \geq 150$ m, $D = 500–600$ m, $d \leq 300$ m, and $h = 80–100$ m, where H is the height of the cone, D is the diameter of the base, d is the diameter of the crater, and h is the depth of the crater. In this case, the volume of the cone might be 0.011 km^3. The parameters of the cone of Anyui Volcano are very close to those for the southern part of the Large Tolbachik fissure eruption in 1975–1976, whose volume was 0.012 km^3 [2]. With the ballistic outburst products, scoria block fragments, and tephra taken into account, the total volume of pyroclastic material for the southern part is estimated at 0.031–0.048 km^3 [2]. It is permissible to suppose that the summarized effect of the explosive phase for Anyui Volcano might be analogous

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Results of K–Ar dating for lavas of Anyui Volcano

No. lab.	No. sample	K, mass %	$^{40}Ar_{rad}$, $nm^3/g \pm \sigma$	$^{40}Ar_{atm}$ in sample, %	Age, Ma $\pm \sigma$
31	0909/1	1.42	0.0000130 ± 33	97.2	0.236 ± 0.065
			0.0000132 ± 18	94.5	0.238 ± 0.040
			0.0000138 ± 18	94.2	0.249 ± 0.040
55	0913/1	1.08	0.0000098 ± 53	98.7	0.234 ± 0.130
			0.0000085 ± 38	98.4	0.228 ± 0.110
56	0914/1	1.74	0.0000185 ± 15	90.5	0.273 ± 0.030
			0.0000173 ± 15	91.0	0.255 ± 0.030
58	0916/2	1.65	0.0000159 ± 23	95.0	0.248 ± 0.045
			0.0000173 ± 22	94.2	0.270 ± 0.040

(0.03–0.05 km^3). Tephra associated with the eruption was propagated up to tens of kilometers from the eruption center.

Beyond the lava field, several sections were made to find buried pyroclastic material, but it was not found anywhere. At a distance of 5 km from the scoria cone, in the base of continuous peat of 1–6 meters thick, the radiocarbon date of 4880 ± 60 BP (GIN-14105) was yielded; it unambiguously signified the absence of eruptions for the last five years.

Assuming the Pleistocene age of the eruption, we tried to obtain a series of K–Ar dates for the volcano. The lava samples from earlier (samples 0914/1 and 0916/2) and later (samples 0909/1 and 0913/1) portions of the lava field were taken near the scoria cone at distances ranging from 0.2 to 7 km. The lavas are represented by high-potassium Pl–Ol basalts; the share of inclusions varies from 10 to 20%; an aphyric structure is typical only for the sample 0913/1. The results of measurements are given in the table.

Measurement of the radiogenic argon content was done from test charges of 160–190 mg on the MI 1201IG mass-spectrometric complex via the method of isotopic dilution with the use of a ^{38}Ar monoisotope. Melting of samples was carried out at 1500°C. Purification of gas was made in the ethanol-cooled trap at –121°C and further in a sequence of two Ti–Zr–Al getters. Errors for determination of teh radiogenic carbon content and sample age were calculated based on the technique presented in [13] with their maximal values taken into account. The potassium content was measured on an atomic absorber AAS-3 (Geologic Institute, Russian Academy of Sciences, analyst I.V. Kislova) with an error less than 1%. The validity of the obtained results was controlled by convergence of the repeated measurements of samples and by reproducibility of analyses of standard specimens. In age calculations, the following constants were used: $\lambda_e = 0.581 \times 10^{-10}$ $year^{-1}$, $\lambda_\beta = 4.962 \times 10^{-10}$ $year^{-1}$, $^{40}K/K = 1.167 \times 10^{-4}$ [15].

On the basis of the obtained dates, the age of Anyui Volcano can be assumed at 0.248 ± 0.030 Ma. An interesting note is that the isotopic date for lavas of the Balagan-Tas volcano (Yakutia), yielded by the Ar–Ar method is 0.266 ± 0.030 Ma [7]. Both these volcanoes have a similar degree of preservation of scoria cones.

The formation of Anyui Volcano (~250 ka BP) is chronologically close to the boundary of MIS 7 and 8 [14]. Paleogeographic data of the column from Lake El'gygytgyn (280 km northeast of the volcano) signify that cooling of MIS 8, analogous to the later deeper coolings (MIS 2, 4, 6), were characterized by a dry or even arid climate [8]. Thus, the absence of traces of substantial glacial impact on volcanic deposits can be interpreted as the absence of large glaciers within the studied territory for the last 250 ka at least.

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