Volc., Seis., 1990, Vol. 8(6), pp. 850-868
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Printed in the United Kingdom

VOLCANIC ASH ON BERING ISLAND (COMMANDER ISLANDS) AND KAMCHATKAN HOLOCENE ERUPTIONS

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(Received September 2, 1985)

Twelve volcanic ash horizons ranging in composition from andesitic-basaltic to liparitic-dacitic have been investigated on Bering Island (Commander Islands) in peat of Holocene age. This is the finest portion of the widely dispersed tephra associated with the powerful explosive eruptions of Kamchatkan volcanoes (Shiveluch, Kizimen and Karymskii) some 300-450 km from Bering Island. The tephra horizons are 0.5-7 cm thick. Their major components are volcanic glass, plagioclase and green hornblende. Study of these ashes gives some idea of the eruptions of the above-mentioned Kamchatkan volcanoes, which occurred 1400-1500, 3000, 3300, 3500, 4000, 7200-7500, 7700, 9-9200, and 9200-9500 years ago. Palynologic research has revealed climatic fluctuations synchronous with the Early Holocene flurry of explosive volcanic activity.

In the north of Bering Island (Commander Islands) there are 12 horizons of volcanic ash, the subject of our study, in a peat bog of Holocene age. The one and only reference to the presence of volcanic ash in sections on the Commander Islands has been made by I. V. Melekestsev [14].

The main aims of this research were: (1) to study the composition of the volcanic ash on the Commander Islands; (2) to estab-

lish the possible centers of eruption; (3) to determine the age of the volcanic ash on the basis of ^{14}C dating and palynologic data; to establish the correlation in time between the maximum outbreaks of acid volcanic activity and climatic fluctuations.

The peat bog investigated on Bering Island is located in alluvial river terrace deposits of the Bol'shaya Rakushechnaya River. The age of the peat bog is put at 10,000 years on the basis of radiocarbon datings obtained for the base of the section. Volcanic ash is clearly recorded in the section of the peat bog; the layers, which have no visible traces of redeposition, are between 0.5 and 7 cm thick.

Radiocarbon dates for peat samples are given on Fig. 1. When a single date is given it was obtained from the sum of alkaline extracts of the humic matter of the peat and it reflects the mean age of the sample. Where there was sufficient organic matter alkaline extracts of humus acids from the same sample were separately dated. In that case the extreme ages are applied to the section.

Characteristics of the volcanic ash

The position of the ash in the section of the peat bog is shown on Fig. 1. All the ash is light in color, and no coarser than fine-grained sand. In terms of SiO_2 content (see the Table) it is classified as andesitic-basaltic, andesitic, andesitic-dacitic, dacitic and liparitic.

The last manifestations of volcanic activity on the Commander Islands came to an end in the Pliocene-Early Pleistocene [11], which rules out local origin for the Holocene ash on Bering Island. It is somewhat improbable that the Aleutians were the source of supply for the ash on Bering Island. The distance from Bering to the nearest volcanoes that were active in the Holocene, namely Kiska, Segula, Cerberus and Little Sitkin on the Rat Islands (Aleutians) is 1000-1200 km. Ash could be transported for such great distances only by jet streams in the upper troposphere and lower stratosphere, but the prevailing direction of movement of the air masses at such

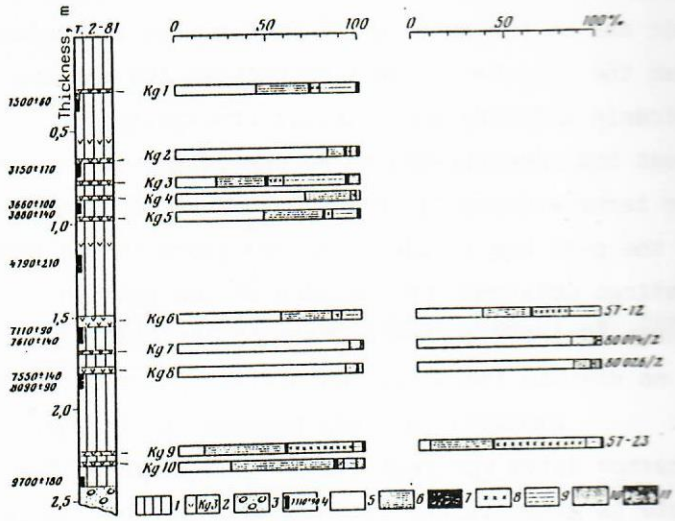

Fig. 1. Position of volcanic ash in a peat section of Bering Island, radiocarbon dates and quantitative mineral composition of the ash: 1 - peat, 2 - ash horizons and their indices, 3 - alluvial deposits, 4 - radiocarbon dates (years ago), 5-11 - composition of ash (size category 0.1-0.063 mm) on Bering Island (pts 2-81), at Kamaki (pt 57), Zhupanovo (pt 80026) and in the Lake Kronotskoe region (pt 80014): 5 - volcanic glass, 6 - plagioclase, 7 - ore minerals, 8 - rock fragments, 9 - green hornblende, 10 - pyroxenes, 11 - brown hornblende.

Chemical analyses of volcanic ash on Bering Island and of the ash horizons of Kamchatkan volcanoes with which comparison is made

Oxide	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	68,98	55,04	64,98	61,27	64,65	73,98	72,06	57,09	54,00	71,70	67,67	72,23
TiO_2	0,48	0,66	0,61	0,61	0,56	0,28	0,56	0,78	0,69	0,37	0,43	0,36
Al_2O_3	15,83	19,35	18,72	17,69	17,94	14,69	15,17	18,52	20,62	14,55	17,17	14,41
Fe_2O_3	0,54	1,69	0,42	1,63	0,79	0,52	0,62	0,43	2,93	1,80	4,28	1,30
FeO	2,03	3,34	2,16	2,30	2,96	1,14	1,69	3,58	3,31	1,73	1,16	1,67
MnO	0,06	0,21	0,19	0,12	0,13	0,09	0,06	0,12	0,14	0,08	0,08	0,08
MgO	1,82	6,26	2,27	4,05	2,09	0,33	0,61	4,55	4,99	0,81	1,15	0,70
CaO	3,86	8,66	6,10	6,69	6,33	2,67	2,53	8,24	8,37	2,30	2,00	2,12
Na_2O	4,32	3,87	3,54	4,20	3,49	4,29	4,07	3,66	4,16	3,79	3,21	4,30
K_2O	2,09	0,91	1,01	1,44	1,06	2,01	2,61	1,03	0,79	2,86	2,46	2,80

Note. 1-8 - Volcanic ash on Bering Island: (samples, 1 - KD-1; 2 - KD-2; 3 - KD-4; 4 - KD-5; 5 - KD-6; 6 - KD-7; 7 - KD-8; 8 - KD-9); 9 - volcanic ash at Kamaki (sample 57-12); 10-12 - filler of pumice deposits of the caldera of Karymskii Volcano, 12 km northeast of the volcano (10 - sample 5-1; 11 - sample 5-3; 12 - sample 5-2). Analyses carried out in the central chemical laboratory at the Institute of Volcanology, Far East Scientific Center, USSR Academy of Sciences. Analysts N. A. Solov'eva (2 - 4, 6, 8, 9), T. G. Osetrova (1, 5, 7), and G. P. Novoseletskaya (10-12). Chemical analyses converted to the anhydrous state.

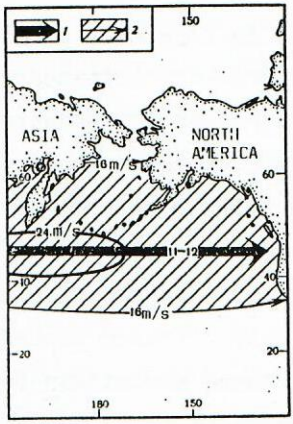

Fig. 2

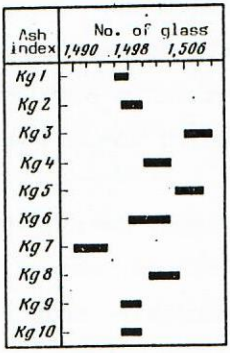

Fig. 4

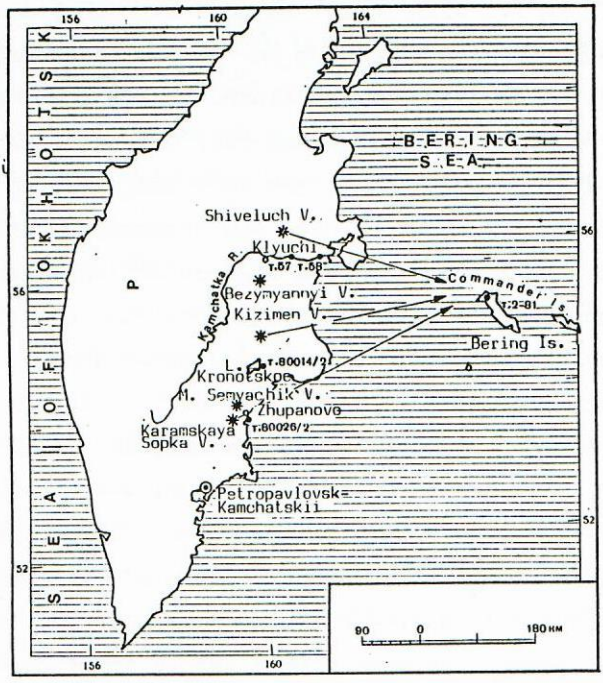

Fig. 3

Fig. 2. Direction of atmospheric jet streams in the north Pacific [2]: 1 - axis of the extratropical and subtropical jet stream. The figures inside the arrows indicate the height of the jet stream axis. 2 - lines of equal mean wind velocity (isotachs) at the level of the jet stream axis.

Fig. 3. Assumed directions of the arrival of tephra on Bering Island (indicated by arrows) and position of sections containing tephra layers.

Fig. 4. Refractive indices of volcanic glass for ash on Bering Is.

altitudes in this part of the Pacific is from west to east (Fig. 2), i.e. from the Kamchatka Peninsula towards the Commander Islands. The most probable assumption is that the ash is connected with eruptions of Kamchatkan volcanoes (Shiveluch, Bezymyannyi, Karymskii, and Kizimen), which are no more than 300-450 km from Bering Island (Fig. 3).

Only the finest part of the acid pyroclastics was deposited on the Commander Islands, namely the widely diffused tephra associated with powerful explosive eruptions of these Kamchatkan volcanoes in the Holocene. The volume of the tephra of these eruptions apparently exceeded 1 km^3. With lesser volumes of pyroclastics there was no appreciable deposition of ash on the Commander Islands. Thus, following the eruption of Shiveluch in 1964, which yielded 0.3 km^3 of tephra [8] (the axis of ash fall extended towards the Commander Islands), only 2.5 mm of ash were deposited on Bering Island [8], and all traces of it have now disappeared from the cover of soil and pyroclastics in the peat bogs of Bering Island.

Ash horizon KD-1[1] is 2 cm thick and consists of grayish-straw colored aleuropelite with traces of fine-grained sand. It should be noted that size categories larger than 0.25 mm in all ashes of Bering Island are in fact accretional ash [12, 18], i.e. ellipsoidal aggregates consisting of ash particles measuring 0.125-0.063 mm (30%) fused together with particles <0.063 mm (70%). The presence of a large amount of organic remains in these accretional ashes, in this case functioning as a type of reinforcement, prompts the assumption that the aggregates were formed mainly after deposition from the air onto a surface that was covered with vegetation and extremely moist.

In terms of SiO_2 content (see the Table), and also of the refractive index of volcanic glass (N = 1.496-1.498) (Fig. 4) the KD-1 ash is liparitic-dacitic. The particles of volcanic glass are

[1] The index KD is applied to all ashes studied on the Commander Islands.