Physical and chemical properties of volcanic ashes of different ages (Kamchatka)

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Soil-pyroclastic cover that spreads on the most part of the territory of Kamchatka Peninsula consists of tephra horizonts and buried soils. Ashes of the greatest eruptions form clear marker layer that can be observed within large areas. The strata between ash marker layers are also generated from pyroclastic materials and include both the products from less great or remote eruptions and secondary redeposited ashes [1]. This paper presents the results of the study of physical and chemical properties of volcanic ashes, which are both markers and unidentified tephra.
The following methods were applied within our research:

- granulometric composition was carried out using the pipette method [2];
- mineral composition of ashes was determined using infrared absorption spectroscopy with FSM-1201 IR-spectrometer (LOMO, Russia) over the range from 400 to 4000 cm^{-1} at room temperature [11];
- chemical analysis of volcanic glasses was carried out with Jeol JSM-6480LV microprobe complex (All laboratory analyses were carried out by V.O. Yapaskurt and E.V. Guseva, faculty of Geology, Moscow State University);
- phase composition of moisture and freezing temperature were determined by contact and cryoscopic methods combination [4];
- thermal conductivity was determined using I type regular method (α-calorimeter) [4].

The analyzed ash samples were collected in the Kluchevskaya volcano group and in Kamchatka river valley, the sampling places are situated at the attitudes from 190 to 1630 m a.s.l. Most of the ashes are Holocene, except the sample collected from lake diatom clay sediments of steep bank “Polovinka” whose age is determined as second half of early Pleistocene (Q^2_1). The sample is a white vitroclastic ash with acid composition.

Volcanic ashes are referred to very fine sands by granulometric composition [3]. According to silicon dioxide the volcanic glass of our samples belongs to three types: andesite, basaltic and rhyolite. IR-spectra data indicates that in Kamchatka amorphous allophane is associated with andesitic and basaltic glass whereas opal with rhyolitic glass (allophane is hydrous aluminium silicate clay mineral, opal is hydrated silicon dioxide) [10].

The following experimental results were obtained.

Phase composition of water. For the first time there were obtained the experimental data concerning phase composition of water (the content of ice, unfrozen water and steam) in frozen volcanic ashes [5]. The main characteristic of phase composition of water is the dependence of unfrozen water content on temperature which was carried out for the range of temperature from 0 to -15°C; the changes in unfrozen water content at the temperature below -3°C are insignificant. It was established that unfrozen water content in the frozen volcanic ashes is changed from 0 to 11% under the temperature of thermal conductivity determination (-10 °C). The presence of unfrozen water content is presumably connected with volcanic glass transformation and clay minerals (allophane etc) occurrence that have large surface area [6, 9].

Thermal conductivity. The thermal conductivities of volcanic ashes for thawed and frozen states were obtained in the wide range of humidity and density. While density (ρ_d) and humidity (W) are changing from 0.7 to 1.65 g/sm^3 and from 10 to 80 % respectively the thermal conductivity (λ) increases from 0.37 to 1.0 W/(m·K) in a thawed state and from 0.41 to 1.27 W/(m·K) in a frozen state [7, 8]. In spite of the fact that volcanic ashes are very close to sedimentary fine sands, they have completely different thermal properties. The thermal conductivity for sedimentary rocks is higher than for volcanic deposits in both frozen and thawed states. This discrepancy might be explained by different reasons, for example, distinctions between thermal

conductivities of mineral skeleton (thermal conductivity of quartz and amorphous glass are distinguished in 3-4 times) or the particle shapes. The ash particles have compound and polyhedral shape. Most of particles, especially volcanic glasses are defined as fragments of complex overlapping of gas bubbles. That's why the conductivity process becomes more complicated in volcanic deposits.

Salinity. The analysis of salinity showed that according to GOST 25100-95 [3] all investigated ashes, excepting the sample from steep bank "Polovinka", are unsalted, their the total soluble salt content is about 0.02-0.03%. The ash sample from steep bank is highly salted. The chemical analysis of aqueous extract shows that the amount of salt is 1.815% by substance weight and the main component of chemical composition is sulfate (SO_4^{2-} content is 1.242% by substance weight). Also very low pH = 3.4 was observed.

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