Andesite Crystallization in the Upper Parts of Volcanic Canals

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Abstract

Constant observations of the eruption process of Bezymianny volcano and an incessant control of the properties and volume of ejected products enabled us to reconstruct cristallization conditions of the magma in the top parts of the volcanic vent assumedly to a depth of 6-8 km.

Substantial changes in the mineralogy and petrography of lavas have been recorded during the thirteen years of the activity of the volcano.

Hornblende andesites of the first portions of eruptions were replaced by bipyroxene andesites, in which the second generation of phenocrysts had appeared - subphenocrysts. The content of subphenocrysts was progressively increasing with a simultaneous drop in the amount of glass to nearly one half of the former amount.

In the process of eruption the chemical composition of rocks did not change: a high viscosity of the melt prevented a differentiation in the upper parts of the magmatic column.

A relative permanence of the composition and amount of phenocrysts of plagioclase and pyroxene throughout all the eruption stages indicates that already at a depth of 7-8 km the melt contains intratelluric phenocrysts.

The appearance in lavas of the last eruption stage of phenocrysts belonging to the 2nd generation despite an unchanged chemical composition, indicates their cristallization in subsurface conditions in the interval of 5-10 years.

Process of eruption

On October, 1955 a new eruptive cycle began in the history of Bezymianny volcano. The eruption continues up to this time. The following main stages can be outlined in the thirteen-year long period of activity of this volcano.

1. Renewal of activity. Beginning with October 1955 up to March 1958 eruptions of a Vulcanian type took place. The top part of the volcanic cone consisting of andesite lavas flows of the last eruptions

was ruined by strong explosions. An open crater was formed with a diameter of about 250 m; in the south-eastern part of the volcano an extrusive dome became pushed out, which was formed before the core of the volcanic cone. About 0.4 cubic km of juvenile ash was ejected during this period.

2. Paroxysm. One of the largest eruptions of historical times took place on March 30, 1956. A direct explosion with a kinetic energy of 1.2×10^{24} erg destroyed the core of the volcano and ejected about 1 cubic km of its rocks to a distance up to 25 km. The deposits of the directed explosion were represented by a resurgent (0.8 cu. km) and juvenile (0.2 cu. km) material. About 0.4 cubic km of juvenile ash formed a tremendous eruptive cloud. The final event of this eruption was the formation of a pyroclastic flow; the volume of its deposits came to 1 cubic km.

3. The formation of the extrusive dome began immediately after the paroxysm of the eruption. At first the squeezing out of the lava proceeded quietly. Then, beginning with 1959, when the dome reached a cristal size, its further growth was compensated by Merapi-type eruptions. During ten years the volume of the dome and of the associated deposits of incandescent lavas and ash came to 0.5 cu. km.

Changes in the Mineralogical, Petrographic and Physical Properties of Lavas in the Process of the Eruption

Substantial changes were recorded in the mineralogy and petrography of lavas in the process of the eruption. It is difficult to judge about the properties and composition of the first portions of the melt, which have been ejected in the form of ash. Generally speaking, by its chemism and mineralogy it was close to the lavas of the pyroclastic flow of March 30-th. The latter were represented by hornblende andesites. Up to 65 % of the rock consisted of a ground mass, 35 % being phenocrysts of plagioclase, hornblende and pyroxene.

The insignificant volume of extrusive lavas that formed the first blocks of the dome, differed from the andesitic pyroclastic flow only by the colour of the hornblende, which was brown in the dome and green in the pyroclastic flow. The texture of the rock remained the same. Andesites of the subsequent portions of the extrusive dome were characterized by a complete absence of hornblende. The main rock-forming dark-coloured minerals were already pyroxenes. Essential changes took also place in the microtexture of the rocks. A second generation of inset-subphenocrysts appeared in the lavas of the 1961 eruption. During subsequent years the content of subphenocrysts of plagioclase and pyroxene in the andesites of the new blocks in the dome gradually increased: in 1965 the amount of phenocrysts of 2nd generation pyroxenes came to 19 %. Simultaneously the amount of glass dropped nearly by half. The character of the groundmass also changed: the glass became clearer, the number of microlites and crystallites obviously decreased.

In the process of eruption a regularly lesser porosity was recorded in andesites, along with a higher temperature of the lavas. The nature of eruptions and the character of subsequently formed blocks of the dome indicate a lesser viscosity of the lavas. In this connection worth a notice is a change in the composition of volatiles. While during the first years of the dome formation chlorine was predominant among the volatile components now the role of fluorine sharply increased (from 30 mg/l in 1962 to 1050 mg/l in 1965 in condensates of the dome). In the last portions of lavas from the dome there has been a substantial increase in the amount of apatite and a newly appeared accessory pyrite.

Crystallization Conditions in the Volcanic Vent

The most probable shape of a volcanic vent seems to be a cylinder and the area of its cross section can be estimated at 0.3 sq. km. Of approximately the same cross section was the floor of the crater after the explosion of 1956 and such is at the present time the monolithic base of the dome. Of a large cross section are the roots of the extrusions on Sheveluch volcano deeply exposed after the catastrophic explosion of 1964. Consequently, if the area of the cross section in the vent is assumed to be 0.3 sq. km, the entire volume of juvenile material supplied to the surface during Besymianny eruption, occupied before the eruption the top 8 km of the magmatic column. A reliable proof of this is a change in the composition of xenoliths evacuated by Bezymianny lavas throughout the last decade. At first these have been sandy siliceous rocks of the upper levels of the basement, and beginning with 1965 xenoliths of deeper Miocene macroporphyric pyroxene basalts began to appear.

During the lengthy period of repose of the volcano crystallization condition in the volcanic vent varied at different levels. The melt of the upper part of the magmatic column (from the surface to a depth of 5-6 km) was crystallizing under conditions of a high partial oxygen pressure. This portion of the melt during the first year of eruption produced about 2 cubic km of horneblende andesites. At a depth over 6 km the hornblende was already absent. Here dark-coloured minerals were crystallizing as pyroxenes of the 1st generation.

During the eruption the ascent of the melt to the surface has not been regular and even. The gas-saturated and relatively low-temperature magma of the top levels in the vent was thrown out virtually instantaneously during the paroxysm of March 30, 1956. The melt, which up to this time was crystallizing at a depth of 6-8 km got into near-surface conditions. Its first portions formed the first block of the dome. These were still hornblende andesites. A further advance of the melt towards the surface became drastically slowed up. For this reason the next portions of the melt during 5-10 years quietly crystallized at a small depth.

This time interval has not been sufficient for the accumulation of such an amount of volatiles that would cause the formation of hornblende. However, the delay in the ascent of the melt contributed to the crystallization of the 2nd generation of plagioclase and pyroxene phenocrysts. Their number was correspondingly 20 % and 15 %. The blocks of the dome squeezed out during 1960-1966 were represented by bipyroxene andesites. Beginning with 1965 the extrusive process intensified and the lavas ascending to the surface became less and less viscous and of a higher temperature.

The chemical composition of rocks did not change during the eruption. A high viscosity of the melt prevented differentiation in the top parts of the magmatic column.

Conclusions

1. In the vent of Bezymianny volcano the crystallization of the hornblende took place only in its upper parts at a temperature over 900° (TSCHELISCHEV, 1965) under conditions of a high partial oxygen pressure.

2. The relative persistence of the composition and amount of phenocrysts of plagioclase and pyroxene throughout all the stages of the eruption indicates that at a depth up to 7-8 km the melt already contains intratelluric phenocrysts.

3. The appearance in the lavas of the last stage of eruption of phenocrysts of the 2nd generation with an unchanging chemical composition of the rocks, shows that they were crystallized under near-surface conditions during 5-10 years.

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