Korzhinskii M.A., Tkachenko S.I., Bocharnikov R.E., Shteinberg G.S. Peculiarities of the stationary degasing of the Kudryavyi Volcano within the period 1991-1999 years, phreatic eruption of 1999 year, its reasons and mechanism.

The Kudryavyi Volcano is one of volcanoes where, despite an absence of magmatic eruptions during 100 years, high-temperature (up to 900^{O}C) fumarole activity occurs [1]. This volcano is built of andesite-basalts. It is situated in the north of the Iturup Island (Southern Kuril Islands). Explorations during the period from 1990 to 1999 years on the high-temperature fumaroles "F-940" and "F-740" showed short-time and long-time variations of the fumarole activity. The long-time variations are reflected in gradual, after the maximum in 1992, decrease of temperature from 940 to 906^{O}C, depletion of the high-temperature gas in deuterium from –11 to 22 $^{O}/_{OO}$ and 1.5-2 time depletion in typical magmatic gaseous components, such as H_2, CO_2, sulfur, HCl, and HF with respect to water.

The short-time variations in the fumarole activity of different intensity were observed after meteoric precipitation. Slight and simultaneous oscillations of temperature, excess gas pressure, and, in less degree, of partial pressure of hydrogen were observed after raining of moderate intensity. The gas composition was practically constant (Fig. 1, left part). Intense oscillations of the excess gas pressure, partial pressure of hydrogen, significant changes in the gas composition toward the increase of concentration of typical magmatic components (H_2, CO_2, sulfur, HCl, and HF) with respect to water, as well as the phreatic eruption of 1999 year, were observed after abundant raining (Fig. 1, right part). As precipitation increased, the intrinsic seismisity of the volcano also increased (Fig. 1d). During the intense changes of the parameters of the fumarole gases, a change in the natural electric potential between high-temperature fumarole and atmosphere (Fig. 1d) was identified. Temperature of gases was practically constant.

In 7 October 1999 year, the eruption was registered in the Kudryavyi Volcano. It occurred in the central crater filled with loose crater deposits, where after the abundant precipitation water was stagnated. The duration of its active stage was more than an hour. During this stage, the periodical throwing out of the crater material at height 300-400 m occurred at 3-5 min. intervals. As a result, a new crater was formed with vertical walls of diameter 30-40 m and depth up to 35 m. In one of the walls at depth about 20 m, a fracture of 3*6 m^2 in size was exposed. Volcanic gas was emitted through this fracture. An absence of unaltered magmatic fragment in the eruption products allows considering of the eruption as the phreatic [2]. The eruption and results of investigation are described in detail in [3].

Discussion. According to [4], the observed long-time variations of parameters and composition of the fumarole gases within the period from 1991 to 1999 years are characteristic for immediately post-eruption period of the volcanic activity. This gives a basis to suggest that in the beginning of 90th, the magmatic chamber of the Kudryavyi Volcano was activated. This activation is probably caused by the ascending of a new portion of a melt.

Weak short-time oscillations of the parameters of the volcanic gases, observed after precipitation of moderate intensity, are assumed to be a result of localization of the emitted gas, and correspondingly, of a heat on a narrower area as a result of cooling and more intensive accumulation of sublimates in channels in low-temperature fumaroles and damming of the ways of cold filtration of meteoric waters. While the outcome and temperature of gas decreases in the peripheral low-temperature portions of the fumarole system, an increase of these parameters is observed in the central portions of the system.

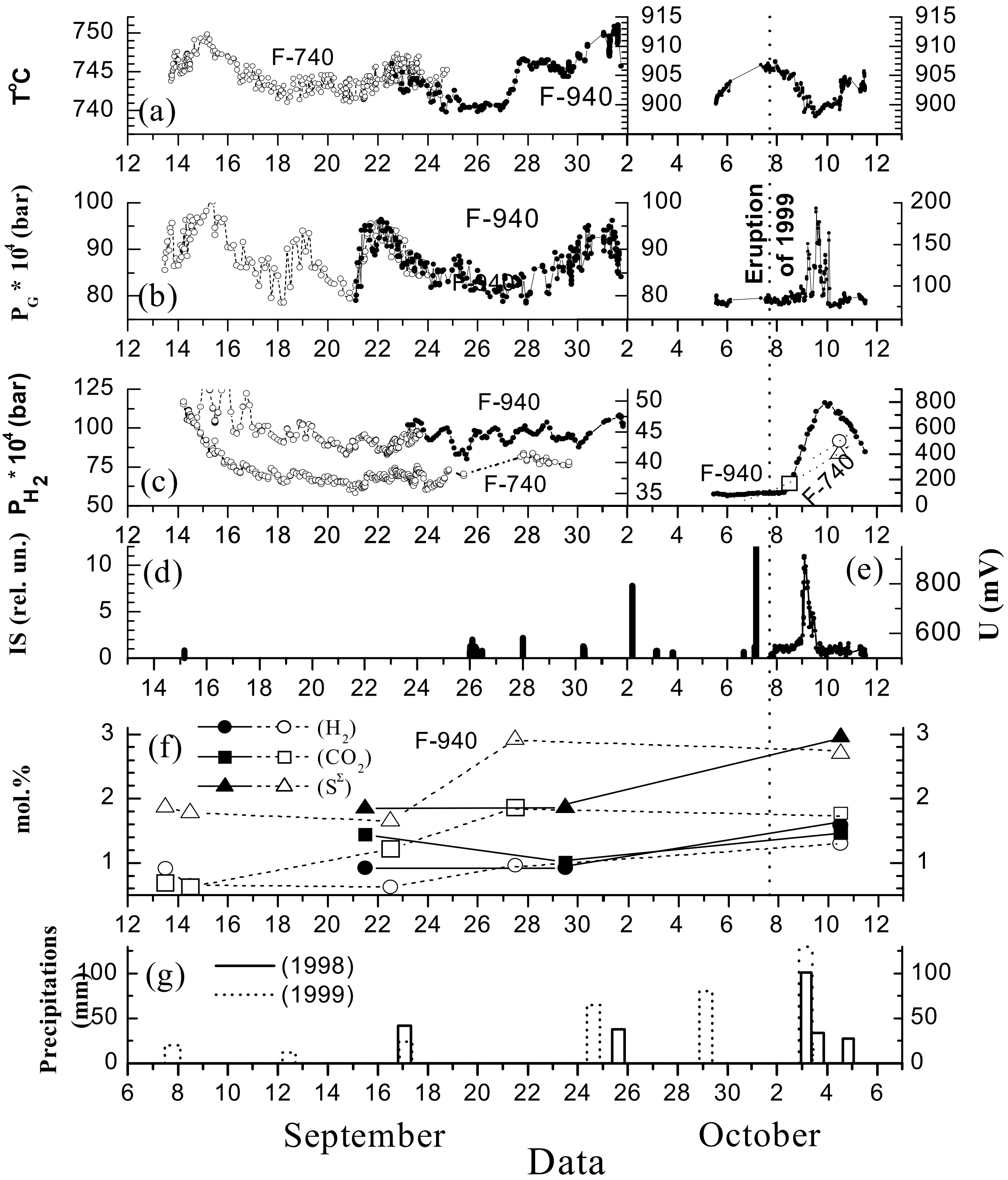

Fig. The results of measuring of the parameters of the high-temperature fumarole gases "F-940" and "F-740" in the Kudryavyi Volcano (filled circles – 1998 y., open circles – 1999 y.). a) temperature of gases; b) excess gas pressure; c) hydrogen partial pressure (values for the "F-740"are calculated from the measured f_{O2}); d) intrinsic seismity (data for 1999 y., 10 units correspond to ~1 unit of Richter scale); e) electrical potential between the "F-940" and atmosphere (data for 1998 y.); e) analytical concentrations of H_2O, CO_2, and $S^{\Sigma}_{(total)}$ in gas probes of the "F-940"; f) meteoric precipitations (time scale is displaced with respect to upper figures by 6 days).

The spontaneous periodical increase of the excess gas pressure, activation of seismisity of the volcano, including the phreatic eruption observed after abundant raining, can be a result of boiling of the meteoric waters during their penetration inside the volcanic body. In order to explain an increase of the content of typical magmatic components in gas after raining, the foloowing mechanisms are proposed.

1. Variations of the composition of the fumarole gas can be a consequence of re-distribution of actively and passively filtrating gases in favor of high-temperature gases. It should be admitted that during the passive gas filtration occurring through the wall of the volcano, the rate of filtration of gas components is higher than the rate of filtration of water. In this case, if the portion of the passive degassing decreases because of damming of the ways of the passive filtration, the concentration of gas components in the high-temperature actively filtrating gas must increase.

2. The observed variations of the gas composition could be a result of electrolytic reactions in the gas re-

sulted from changing in voltage of natural electric fields. Penetration of the meteoric waters mixed with the acid gas condensate into the volcanic body lowers a resistance between differently charged zones of the volcano. As a result, an electric circuit appears, electrolytic reaction proceed, which result in oxidation of solid phases and reduction of the gas components, including H_2O. Concentration of hydrogen and other reduced gases increases, whereas the water content decreases.

3. The observed variations in the gas composition can be a result of an increase of gas pressure over the melt resulted from the narrowing of the area of gas emitting. However, it should be admitted, that the degassed melt of the Kudryavyi Volcano is significantly depleted in volatile components. According to the Dixon's model [5], in order to produce the observed variations in the CO_2 concentration at an increase of the gas pressure over the melt by 2-4 bars, the water content in the degassed melt of the Kudryavyi Volcano should be just 0.1-0.2 wt. %.

4. Variations of the gas content can be a result of an increase of the rate of convection, and, correspondingly, the rate of decompression of the magmatic melt. This mechanism is based on the suggestion that the convection of the magmatic melt occurs within the Kudryavyi Volcano along the ascending and descending channels. The abundant precipitation and penetration of the meteoric waters inside the volcano results in cooling of the magma-driving channels. As a result, a viscosity and amount of crystalline substance increase. It results in decelerating of melt motion. In lower levels of the magmatic column, the melt pressure increases. As some critical value is achieved, the break of the "viscous cork" occurs. The rate of the melt convection increases, and the gas phase is enriched in more volatile components rather then water [6]. An influence of the meteoric waters on the magmatic system of the Kydryavyi Volcano can be effective because of imposition of its basement on the ancient volcanic body, composed of dacites. This ancient volcanic body serves as huge funnel, accumulating water.

The following mechanisms and causes for the eruption can be suggested. The heating of the volcano roof occurred after relatively long-time dry period. The level of boiling of the meteoric waters was displaced to the sub-surface horizons, and the thickness of above rocks decreased. Resulting from the regional earthquakes of magnitude of 3, new fractures were opened in the volcanic body. After abundant raining, resulted in formation of small lake in the central crater, water freely penetrated inside the volcano. An immediate interaction of water with hot rocks resulted in boiling. Then the excess gas pressure became larger than the solidity of the above loose rocks, the new crater was formed.

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