REGULARITIES IN THE DYNAMICS OF THE KLYUCHEVSKOY VOLCANO ERUPTIONS

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In 1984 a summit effusive-explosive eruption occurred at Klyuchevskoy. Visual observations of the eruption resulted in identifying certain regularities in the eruptive activity of the volcano. The regularities consisted in alternation of intervals of large explosions ($_{max}$ 1-1.5 hrs, height of bomb outburst is 600-800 m) with those of small explosions ($_{min}$ 4-4.5 hrs, height of bomb outburst is 150-200 m). Periodicity revealed in the explosive activity $_{max+\ min}$ 5-6hrs existed for a long time in the course of eruption.

To single out periodicities typical of Klyuchevskoy eruptions we analysed data on the eruptive activity of the volcano for the last 50 years. The analysis of the data enabled us to distinguish the following periodicities: 1-8 min, 12-15min, for single bomb outbursts; 30-50 min for series of stronger ejections; 1.5-7.00 hrs for fountaining; and half diurnal, diurnal and monthly periodicities have been identified in the fumarolic stage of activity(Fig. 1).

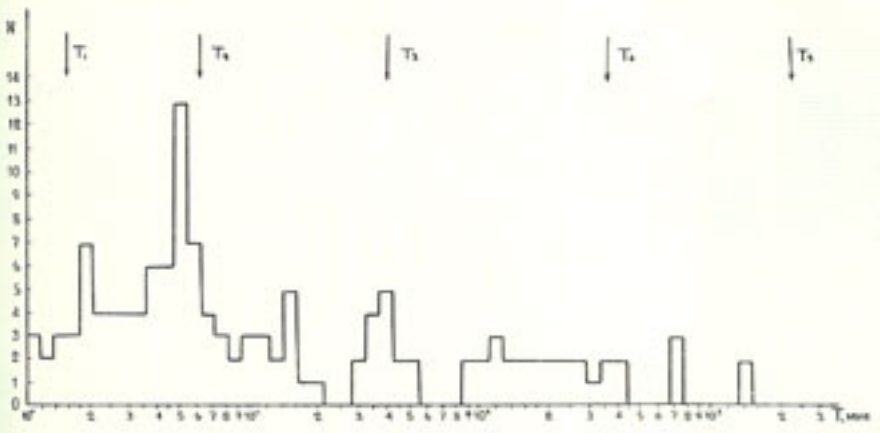


Fig. 1. Distribution of the observed periods in the eruptive activity of Klyuchevskoy from 1932 till 1978. N- the number of references on these periods. Arrows indicate principal periods distinguished from seismological data during the 1983 and 1984 eruptions.

Visual observations are, as a rule, fragmentary and subjective, and therefore can not be statistically processed. To identify and study periodicities one has to run a continuous record on the variations of the parameter under study. Among geophysical fields volcanic tremor reflects the volcanic process most distinctly. Volcanic tremor is continuously recorded at the seismic stations located in the region of Klyuchevskoy (Fig. 2).

The data on volcanic tremor during summit eruptions in 1983 and 1984 have been statistically processed. The procedure chosen was due to the necessity of studying a wide range of frequencies and due to requirements of equidistant counting. Thus, from July 19 till August 27, 1984 the measurements of the maximum amplitude of volcanic tremor (A_{max}) have been made at a 15-min step. As a result, a 6624-point long sequence has been obtained. For ten 4-hour intervals A_{max} was measured at a 1-min step (the length of each sequence is 240 points), for ten 1-hour intervals A_{max} was measured at a 10-s step (the length of each sequence is 360 points). Similar procedure was also employed to obtain data on the 1983 eruption (Fig. 3).

All sequences obtained were processed on a computer with a program developed for analysis of temporal sequences. Auto- and cross-correlational functions were calculated. Spectral estimates have been made by method of maximum entropy. The comparison between data on volcanic tremor and visual observations of the 1983-1984 eruptions has shown that variations in the level of volcanic tremor distinctly reflect the variations in the eruptive activity of Klyuchevskoy.

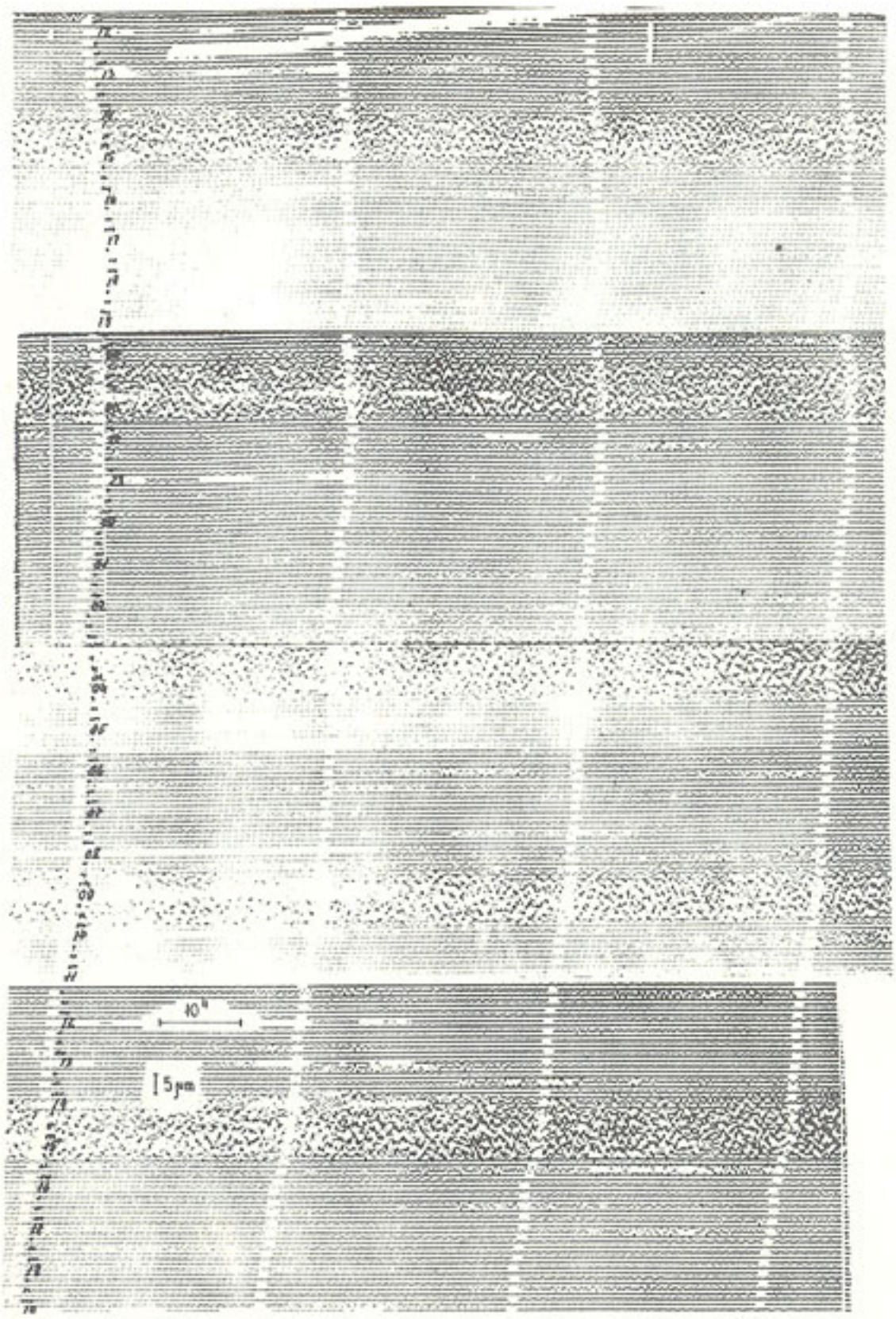
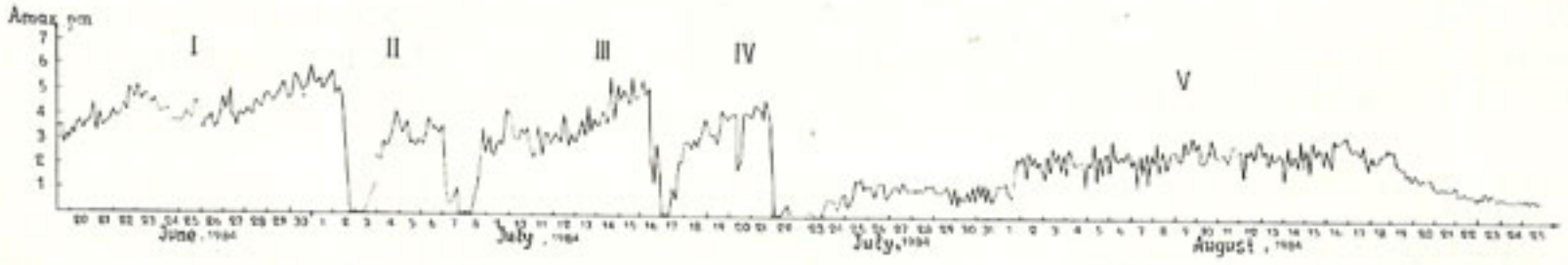


Fig. 2. Selected fragments of seismograms recorded at the seismic station Apakhonchich from 11 hrs 37 min on July 30 till 19 hrs 00 min on July 31, 1984. The 4-hour pulsations of the volcanic tremor amplitude can be distinctly seen.

Fig. 3. Temporal variations in the maximum amplitude of volcanic tremor from June 19 till August 25, 1984.

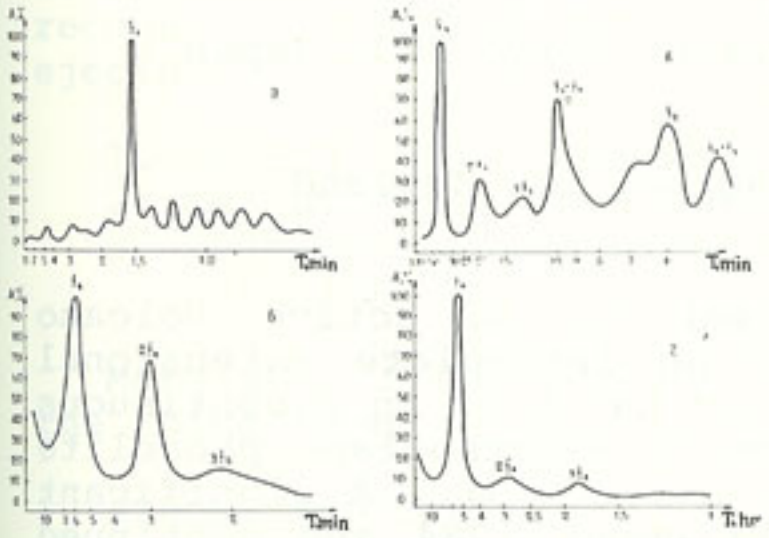


Based on this study the following conclusions can be drawn:
1. A discrete set of frequencies of the envelope shape of volcanic tremor exists within the range of 5.5×10^{-6}-2.5×10^{-2}Hz. This set consists of 5 basic frequencies: 1.1×10^{-2}Hz (T_1=1 min 34 s); 2.5×10^{-3}Hz (T_2=6 min 10 s); 4.2×10^{-4}Hz (T_3=40 min); 5.1×10^{-5}Hz (T_4=5 hrs 30 min); 7.7×10^{-6}Hz (T_5=36 hrs) and superposition of their harmonics (Figs. 4 a-e; 5 a-b).

2. Volcanic tremor frequencies obtained have been maintained for at least 1 year and 7 months, the basic frequencies are characteristic of the eruptive activity of Klyuchevskoy over the last 50 years since 1932 (see Fig. 1).

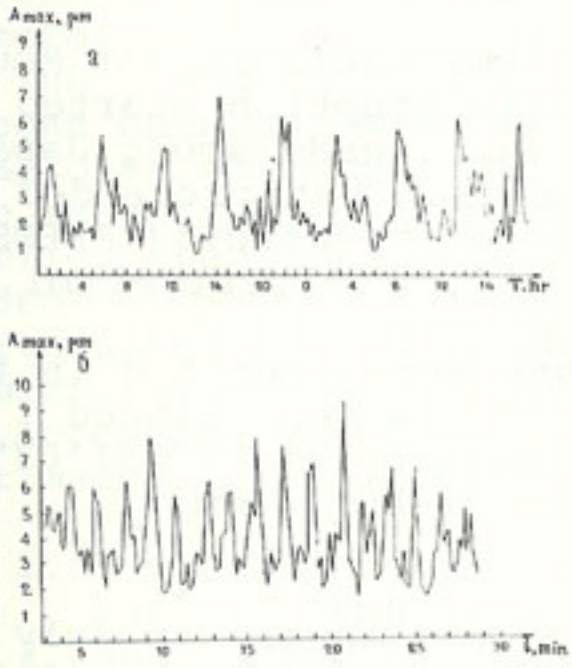
3. Based on distinct correlation it is suggested that lunar-solar tide deformational processes influenced the dynamics of the 1983 and 1984 Klyuchevskoy eruptions (Fig. 6).

Fig. 4 a-e. Resonance spectra of the envelope shape of volcanic tremor for the following intervals of time:



a) 03-04 hrs, Jul23, 1984
b) 01-02 hrs, Aug 23, 1984
c) 15-19 hrs, Jun 25, 1984
d) 00 hrs, Aug 14-01 hr, Aug 16, 1984
e) Jun 19- Jul 2, 1984

Fig. 5 a-b. Variations in volcanic tremor amplitude for time intervals:

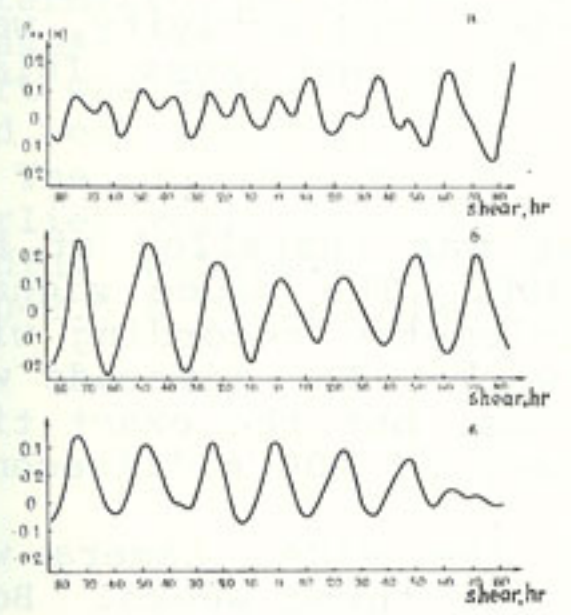


a) 00 hrs, Aug 14-20 hrs, Aug 15, 1984 (at a 15-min step)

b) 03 hrs 03 min - 03 hrs 29 min, Jul 23, 1984 (at a 10-min step)

The pulsations of the volcanic tremor amplitude with periods of 5 hrs 30 min and 1 min 34 s are expressed well.

Fig. 6 a-c. Cross-correlograms of corrections for tidal variations in gravity and related values of envelope shape of volcanic tremor for time intervals:



a) 13 hrs, Jun 19-01 hr, Jul 1, 1984

b) 02 hrs, Jul 9 -01 hr, Jul 16, 1984

c) 02 hrs, Aug 1 -01 hr, Aug 12, 1984