Mendeleev volcano has a long and very complex history of development. Three volcanic edifices were built and then destroyed during the succession of alternating cone-building and caldera-forming events, which produced a remarkable complex of three nested calderas with sizes of 6x9 km (oldest caldera), 3x3.5 km, and 1x1 km (youngest caldera). The decrease of the caldera size with time may indicate the gradual decrease of volcanic activity and, perhaps, is related to the length of the formation of this volcano-tectonic structure. The detailed sequence and scales of events is still difficult to reconstruct due to a poor exposure of the volcano and the absence of detailed tephra-chronological studies for the Pleistocene-Holocene events in the Kuriles.

Based on the results of our 1999-2003 field works we can confidently characterize three stages of the eruptive activity at Mendeleev. The earliest indications of its eruptive activity are represented by 8-m-thick lava flows of basaltic andesites overlain by the middle-Pleistocene marine sediments. The sediments underlying lavas were accumulated in the open bay with a river run-off. The Thalassiosira nidulans var. nidulus zone with an age ranging from 230 to 200 thousand years ago was determined using diatoms. Marine deposits of the lower sub-unit of the Golovninskaya suite formed in the transgressive phase of late Pliocene (diatom zone Pyxidicula zabelinae with an age range of 2.3-1.95 Ma) are located at the base of the cross-section.

A 1-2-m-thick marking horizon represented by two bands of scoriae of basaltic andesite is located in the middle of cross-section. The analysis of a charred wood immediately beneath the lower band and at the contact with pumice layer yielded a radiocarbon age of 36200 ± 500 yr. ago (GIN-11870) and 36400 ± 400 yr. ago (GIN-11871).

A very large sub-aerial eruption occurred during the formation of the youngest 1x1 km caldera. It was followed by the growth of extrusive dome (2550 ± 40 yr. ago, GIN-8964). The extrusive activity continued for several centuries, as indicated by two dated 2-3-cm-thick layers of a coarse volcanogenic material with ages of ca. 1500 and 2100 yr. ago, respectively, found in the vicinity of Yuzhno-Kurilsk.

The extrusive activity was followed by the formation of explosion funnels along the ring faults outlining the extrusive dome and by the development of active fumarolic fields.

The North-Eastern and North-Western fumarolic fields are currently the most active.

The North-Eastern fumarolic field consists of at least three overlapping explosion funnels, through which energy discharges as volcanic gases and thermal solutions. In 1880 a weak phreatic eruption (Milne, 1896) took place in the North-Eastern fumarolic field. In 1901 a “thunder” (Ôtchet komissii..., 1901) was heard at the volcano. In 1946 local settlers heard a roar of hot gases and steams emitted by the volcano from the North-Eastern fumarolic field. In February-April, 1977 a swarm of earthquakes (more than 200) with a focal depth larger than 20 km occurred beneath the Mendeleev volcano. The earthquakes were most likely triggered by changes of a stress field in the upper crust in response to the drilling at the geothermal field Goryachy Plyazh. It is possible that the activization of the magma source of the volcano was caused by this activity. A short increase of fumarolic activity in the North-Eastern field was observed in late August, 1977 as harmonic emissions of steam-and-gas plumes up to the height of 150-200 m (Sovremennye protsessy..., 1980). In April-June, 1987 a swarm (about 80) of supposedly volcanic earthquakes was observed. In May, 1987 a small steam-gas emissions occurred in the North-Eastern field. A small temperature increase and mass flux variations of fumaroles and thermal hot springs was observed prior to this event. When the fumarolic activity decreased to the previous level, the temperature of fumaroles and hot springs decreased too (temperature decrease varied from 1-2° to 7-10°).
In August 15, 1978 the temperature of the Spokoiny fumarole in the North-Western field increased up to 113°C, which was accompanied by appearance of melted sulphur. In 1984 the temperature of the same fumarole was 111°C. In 1984 the temperature of the Revushchaya fumarole reached 130°C forming a flow of molten sulphur. In September 3, 1987 the temperature decreased again to 111°C. In 1990 the activity in the North-Western fumarolic field increased again, which was indicated by sulphur melting on the upper basic fumarole and also by the appearance of a new thermal source and an increase of temperatures of other thermal hot springs for approximately 2°C. Swarms of earthquakes with focal depth less than 20 km were observed in summer 2000.

The temperature measurements of fumaroles of the Mendeleev volcano in 2000-2003 showed an apparent decrease of activity. The temperatures in the North-Eastern field did not exceed 100°C. The maximum temperature in the North-Western field was recorded at the Revushchya fumarole (109.6° in August, 2000, 106.3°C in September, 2001, and 101.0°C in September, 2002). Similarly, the temperature measurements of hot springs (Kisly and Doktorsky) indicated either a stable regime (Kisly) or a temperature decrease for 0.5-2°C as compared to 1999 (Nizhnedoktorsky hot springs).

Study of the deep structure beneath Mendeleev suggested the presence of a system of near-surface and deep magma sources. The shallow magma source with a diameter of about 2 km is located immediately beneath volcano at a depth of 4.5 km (Zlobin et al., 1997). A deep magma chamber is situated at a depth of 30-60 km.

The results of our geological study and the continuous monitoring of fumaroles and hot springs indicate that the significant variations of the volcanic activity at Mendeleev are unlikely in the nearest future. At present and in the nearest future the energy discharge of the magma source will probably continue to be through emission of steam-gas jets and thermal waters. Phreatic and hydrothermal explosions, as well as effusions of sulphur flows are possible in some fumarolic fields, particularly in the North-Eastern and in the North-Western. The areas possibly affected by volcanic activity will be local, within the boundaries of fumarole fields and valleys of Kedrovy, Kisly, Lechebny, Chetverikov streams. The populated areas beyond the 2-km zone are not hazardous.

Our conclusions are based on the analysis of all available information; however, we cannot completely exclude the beginning of a new cycle of volcanic activity due to a fresh magma input from the deep magma source.

The mitigation of volcano hazard in the area requires the development of regular volcano monitoring and particularly:
- installation of a permanent seismic network,
- detailed geological study of previous eruptive episodes at Mendeleev, and
- development of volcano monitoring techniques based on temporal variations of composition and temperature of fumaroles and hot springs.

References