



Tsunamigenic volcanic landslides of Kurile-Kamchatka arc

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The most voluminous landslides on Earth occur on volcanoes; when such a landslide enters a sea it generates strong tsunami. The goal of our study was to determine parameters of tsunamigenic volcanic landslides in Kurile-Kamchatka arc, which is one of the most active volcanic regions of the world. We have conducted investigation of air and space images of the area supplemented by field works on several selected volcanoes. This allowed us to identify in the area more than 40 cases of large scale volcanic tsunamigenic landslides of Late Pleistocene – Holocene age. At Kurile Islands the tsunami-generating landslides were found at active (33 cases) as well as extinct (7 cases) volcanoes. Widths of most of the landslide scars (30 cases) range from 0.5 to 2 km indicating volumes of the landslides of approximately 1 cub.km. Three largest scars are from 3 to 4 km across (volcanoes Milne, Sinarka and Stokap); they were formed by landslides having volumes of approximately 5 cub.km. At least 3 volcanoes (Harimkotan, Ekarma, and Mendeleev) experienced multiple (3 or more) landslides. In the scars of most of the volcanic landslides in Kuriles, rocks with high degree of hydrothermal alteration are exposed; the related landslide deposits contain large proportion of clay. This suggests that hydrothermal alteration weakened rocks composing the volcanic edifices and played leading role in gravitational destabilization of the volcanoes.

Two large scale volcanic landslides occurred at Kuriles in historical time (since early 17-th century). The landslide on Sinarka volcano in 1878 destroyed village of Ainu people. The landslide on Harimkotan occurred in 1933 in the beginning of strong explosive eruption of the volcano (Miyatake, 1934). The landslide with the volume 0.4 cub.km entered Pacific Ocean along the shore line of 8 km long and generated tsunami up to 20 m high; 2 victims were reported on nearby Onekotan Island. Subaerial part of the landslide deposit forms a broad hummocky fan (max thickness 10-20m; length 7 km; area 20 sq.km). Multiple (>4) deposits of prehistoric volcanic landslides spreading offshore were discovered on the island. That is the evidence that tsunamigenic landslides, similar with the 1933 event, repeatedly occurred in the history of Harimkotan volcano. Youngest of them occurred 1100 and 2000 C14 BP.

In contrast to volcanoes of Kurile Islands the volcanoes of Kamchatka peninsula are situated far away from the ocean. There is only one clear case of tsunamigenic volcanic landslide that occurred at Avachinsky volcano. The landslide with the volume exceeding 10 cub.km traveled the distance more than 24 km and entered Avachinsky Bay along the shore line of 5 km long. Thickness of the landslide deposit in modern sea cliff reaches 50 m. Radiocarbon dating of sea sediments from the base of the landslide gave the age 16550+/-110 BP (Raphael Paris, personal communication).