Keynote 2

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Explosive eruptions and ash dispersal patterns in the northwest Pacific

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Large explosive eruptions are among the extreme natural events and can produce hemispheric or even global catastrophic effects. One of the prerequisites of predicting future volcanic catastrophes is the understanding of sizes and recurrence times of past similar events. At the same time, the global record of large eruptions remains incomplete even for the last millennia and deteriorates deeper in time as many eruptions are yet to be identified. This is particularly true for remote North Pacific volcanic arcs potentially hazardous for the Northern Hemisphere. Both Alaska-Aleutian and Kurile-Kamchatka arcs are highly explosive, which is testified by many nested calderas and numerous tephra layers buried in sediments of the surrounding seas. Ash clouds from North Pacific eruptions repeatedly affected the whole Northern Hemisphere, dispersing ash as far as Greenland, Svalbard, and northern Europe (Jensen et al., 2013; Bourne et al., 2016; van der Bilt et al., 2017; Cook et al., 2018). At the same time, our knowledge about the number, age, and extent of tephras from these arcs is still fragmentary.

Since 2009, we have been systematically studying tephra from the Kurile-Kamchatka and, occasionally, Alaska-Aleutian arcs using electron microprobe and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Our main aim is to compile a record of large explosive eruptions from the Kurile-Kamchatka volcanic arc for the late Miocene-Pleistocene times. Our studies are based on (1) proximal pyroclastic deposits in Kamchatka and Kurile Islands; (2) tephra findings in the northeast Asian mainland; and (3) tephra and cryptotephra from marine sediments in the northwest Pacific and western Arctic oceans. In this presentation, we will discuss our published (Ponomareva et al., 2015; 2017, 2018; Derkachev et al., 2016) and new results.

In Kamchatka and Kurile Islands, Holocene tephra layers are ubiquitous, well preserved and form continuous sequences. They are routinely used for reconstructions of the volcanic histories as well as for paleoclimatic, paleoseismological and archaeological studies (e.g., Braitseva et al., 1997; Ponomareva et al., 2017; Pendea et al., 2016). Extensive database of glass compositions for the Holocene Kurile-Kamchatka tephras permits their successful identification in ultra-distal localities, e.g., in Greenland.

Pre-Holocene tephra sequences in the Kurile-Kamchatka arc are rare as they were mostly removed by glacial processes. As non-erosive marine environments provide better tephra archives than the terrestrial ones, in our attempt to obtain a late Miocene-Pleistocene tephra record we turned to the marine tephra sequences. North Pacific marine sediments contain numerous tephra layers. The sources of most of these tephras are however, not known. Most of proximal deposits are welded and preserve no volcanic glass, which hampers their comparison to distal tephra and thus assessment of tephra sources and dispersal areas. In order to geochemically characterize altered tuffs and correlate those to distal tephra, we use immobile trace elements concentrations and compositions of melt inclusions in minerals.

Our current research, funded by the Russian Science Foundation, is aimed at the reconstruction of the continuous record of tephra layers for the last 6 Myr based on the three sedimentary cores taken at the Detroit Seamount ~700 km downwind from Kamchatka. Geochemical correlations of tephra layers among the cores have permitted the construction of the summary tephra sequence that includes 109 individual layers. The age model for the sequence is based on the integration of the available age-depth models for the individual cores and additional isotopic dates for tephras and their proximal counterparts. The resulting database will serve as a reference for correlations of Kurile-Kamchatka tephras to their ultra-distal counterparts and provide a record of major explosive eruptions in the NW Pacific.

Our research on cryptotephra from the marine sediments in the Bering and Okhotsk seas and in the Arctic Ocean, over the distances of 600-1300 km from the volcanoes has demonstrated high background glass concentrations. This pattern attests to a significant input of volcanic material into marine sediments by currents or seasonal ice. Large amount of redeposited glasses may obscure the signal of primary, especially minor tephra falls, thus complicating tephrochronological studies in the area. At the same time, we were able to identify a number of cryptotephras including the 3.6 ka Aniakchak II tephra. The high concentration of the Aniakchak II glasses suggests that this tephra can be found still farther afield and serve as a major marker for the late Holocene sediments in the western Arctic Ocean.

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