

TEPHROCHRONOLOGICAL RESEARCH IN KALMAR PROJECT AND ITS  
IMPLICATIONS TO THE TEMPORAL AND COMPOSITIONAL EVOLUTION OF  
VOLCANISM IN KAMCHATKA

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About 3000 new glass analyses obtained at the IFM-GEOMAR under Phase 1 of the KALMAR Project characterize tephra samples collected from the Kamchatka and Magadan on-land outcrops, Pacific ODP core 883 (Detroit Seamount), and Elgygytgyn Lake core (Chukotka). This extensive and novel database permits geochemical fingerprinting of tephra layers associated with the largest Holocene and Pleistocene eruptions of the Kamchatka volcanoes on multicomponent criteria and has a suite of tephrochronological implications:

- (1) Compositional variability of glasses from the volcanoes all over Kamchatka reveals certain spatial patterns, which ensure identification of the source volcanic zone for distal tephra and provide constraints on the origin of Kamchatka silicic melts (Kuvikas et al., *this volume*).
- (2) Long-distance (in certain cases - transmarine) correlations of individual tephra layers permit evaluation of eruptive volumes and areas of ash dispersal for a number of large explosive eruptions.
- (3) Identified tephra marker layers link various depositional successions (soil-pyroclastic sequence, peat, eolian sands, deep-sea and lake sediments, etc.) that permits direct comparison of paleoclimatic and other records.
- (4) Once dated, a marker tephra layer serves as an isochron and provides age constraints for distal bracketing deposits.

In addition, analyses of proximal tephra permitted detection of compositional variations within the eruptive history of an individual volcano (Portnyagin et al., Kuvikas et al., *this volume*).

Highlights of the initial analysis of the new tephra data base include first ever recognition of a Kamchatka tephra in the ODP core 883; high-resolution dating of organic-free (undatable by <sup>14</sup>C) tephra sequence from Klyuchevskoy volcano; documentation of early Holocene Shiveluch volcano tephra differing in composition from earlier known for this volcano.

We have analyzed glass shards found in the ODP core 883 at the levels dated at 32.5-39.8 ky. Most of the shards from the 37.1-39.8 ky levels exhibit relatively low SiO<sub>2</sub> and high K contents as well as other features typical for Gorely volcano evolved magmas. Proximal Gorely caldera pumice has shown glass compositions identical to those from the submarine ash. Highest concentration of the glass shards is observed at 39.4 ky-level that likely provides the most reasonable age for the caldera-forming eruption, previously estimated to be in a wide range from 33 to ~40 <sup>14</sup>C ka BP (Braitseva et al., 1995, Bull Volcanol). In addition, the same 39.4 ky level has the highest concentration of the ice rafted debris that is interpreted as

a glacial advance accompanied by production of icebergs (Bigg et al., 2008, EPSL). Scatter of Gorely glass shards within the marine sediments accumulated during 2.7 ky probably is related to various ways of tephra transport to the site (by eruptive cloud or by icebergs) and/or peculiarities of ash sedimentation in water-saturated ooze.

Glass shards deposited at the levels dated at 32.5-34.3 ky differ dramatically from Gorely tephra and have both mafic and silicic glass in each of the samples, which all fit into the trend transitional between low- and medium-K compositions. These and other geochemical features likely indicate a source in South Kamchatka (proto-Kurile Lake or Prizrak calderas). This preliminary identification should be confirmed by studies of proximal pyroclastic deposits.

Evolution of Klyuchevskoy volcano magmas has been studied based on a 12-m thick tephra sequence sampled ~15 km northeast of the volcano summit. Analyses of glass shards from 32 light-colored dominantly silicic marker tephra layers intercalated with dark-gray Klyuchevskoy cinders has permitted correlation of most of these layers to regional <sup>14</sup>C dated marker tephras that has allowed us to time Klyuchevskoy samples with an accuracy of 50-100 years. This high-resolution dating helped us to reveal millennial-scale compositional variations of Klyuchevskoy magmas (Portnyagin et al., *this volume*). In addition, it has provided time constraints for major eruptions from Ushkovsky volcano (Krashenninikov et al., *this volume*).

Eleven markers from the Klyuchevskoy section directly link this section with the Uzon area, ~250 km to the south; at least eight markers - with the Dvuh'yurtochny Lake area (where the cores were taken in 2007), and thirteen - with the Ust'-Kamchatsk area (lake cores obtained in 2008). These and many other correlations permit direct comparison of the Holocene records from different areas.

Geochemical study of Shiveluch, the most productive andesitic volcano in Kamchatka, located above the edge of the Pacific slab has proved unique nature of its melts and allowed us to identify main stages in their evolution (Gorbach et al., *this volume*). Proximal Shiveluch tephra is dominated by pumice lapilli of medium-K andesite composition. Two different mafic tephras, of high-K high-Mg basalt and medium-K high-Mg basalt composition were erupted during the peaks of Shiveluch activity 3.6 and 7.6 <sup>14</sup>C ka BP indicating changes in its magma supply system (Volynets et al., 1997, Petrology). New analyses of glass from proximal and distal pumice tephra from Shiveluch have allowed us to document one more compositional deviation in its eruptive history: during an early Holocene period of enhanced activity Shiveluch produced at least four pumice tephras compositionally shifted to high-K mafic andesites. In addition, this study helped to identify Shiveluch as a source of some widely spread tephra layers, e.g. enigmatic "lower yellow" marker in the Eastern Kamchatka. These correlations permit re-evaluation of eruptive volumes and magnitude of large Shiveluch eruptions.

The new tephra database can be used for long-distance correlations with deep-sea cores and to Greenland ice cores, and is ready for use during the current paleoclimate research based on lake cores and in the course of the following KALMAR marine studies.