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Linkages among tectonism, earthquakes, magma genesis and eruption in volcanic arcs, with a special focus on hazards posed by arc volcanism and great earthquakes

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SCIENTIFIC PROGRAM & ABSTRACTS

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MAJOR AND VOLATILE ELEMENTS IN GLASSES OF LARGE EXPLOSIVE ERUPTIONS IN KAMCHATKA CORRELATE WITH DEPTH TO SUBDUCTING PLATE

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There were at least 40 large (>1 km^3 of tephra) and numerous smaller explosive eruptions in Kamchatka during the Holocene. Tephras of strong eruptions have wide distribution and serve as time-markers in stratigraphic research. In previous studies, tephras of various volcanic centers were recognized based on K_2O content in bulk samples (Braitseva et al., 1997) and in volcanic glass (Ponomareva et al., 2004). In this study we attempted to assess multi-component systematics of volcanic glass from major Kamchatka tephras. These results are used for 1) fingerprinting of tephra from different sources; 2) comparison of silicic magmas across and along the volcanic arc, and 3) understanding the processes governing generation of silicic melts in Kamchatka.

Within the framework of the German-Russian project KALMAR, we have analyzed 94 samples of volcanic glass from major Kamchatka tephras. The analyses were obtained at the IFM-GEOMAR (Kiel, Germany) with the JEOL JXA 8200 microprobe using a single analytical protocol (15 keV accelerating voltage, 6 nA current, and 5 micron beam size). Smithsonian Institution glass standards (Jarosevich, 1980) were used for reference. High-sensitivity (H-type) crystals were used for analysis of volatiles and low concentration elements (Ca, Fe, Mg in silicic glasses), which significantly improved the analytical precision for these elements compared to conventional analyses. As a result we have obtained a new self-consistent database of ~2500 high-quality glass analyses of known source and age. Here we report some pilot results from the analysis of this database.

There is large compositional variability of volcanic glasses from different volcanic zones and volcanic centers in Kamchatka. Some spatial geochemical trends are, however, evident from our database. For example, mean glass compositions from different volcanoes demonstrate an increase in K_2O contents, and a decrease in FeO, MgO, CaO contents and Cl/K ratio from the volcanic front toward the rear-arc, i.e. with increasing depth to the subducting plate (Fig. 1). With regard to the increasing concentrations of incompatible elements (e.g., K) and decreasing Cl/K from the volcanic front to the rear-arc, the trends of silicic melts are qualitatively similar to those reported for mafic rocks and primitive melt inclusions in olivine (e.g., Volynets, 1994; Portnyagin et al., 2007) yet absolute concentrations of K_2O are higher in silicic melts and Cl/K ratios are lower. This suggests that crystal fractionation of mantle basaltic melts is the main mechanism of silicic melts generation in Kamchatka while assimilation of crustal rocks plays a relatively minor role. Reconciling the spatial geochemical zoning evident from our data and massive crustal assimilation involved in the origin of silicic melts (e.g., Bindeman et al., 2004) requires re-melting of rocks formed within the same volcanic center.

At first glance, most of volcanoes in Kamchatka produced tephras with glass compositions plotting along single fractionation trends. Clear exceptions from this pattern are Ksudach, Khangar, Shiveluch and Bezymianny volcanoes. Significant variability of glasses from individual volcanoes can be related to variable extent of crustal assimilation, compositional heterogeneity of parental melts and different conditions of crystallization. For example, glass from minor Bezymianny tephra erupted on October 14, 2007 differs dramatically from that found in the pumice from the 2400 yr BP large eruption by having lower Al_2O_3 and higher K_2O, FeO and TiO_2 at given SiO_2 content. We suggest that these compositional peculiarities reflect low (near-surface) pressure conditions of magma fractionation in recent years (probably after 1956) that promoted frequent weak eruptions rather than the larger ones driven by high water pressure in deeper magma chamber.

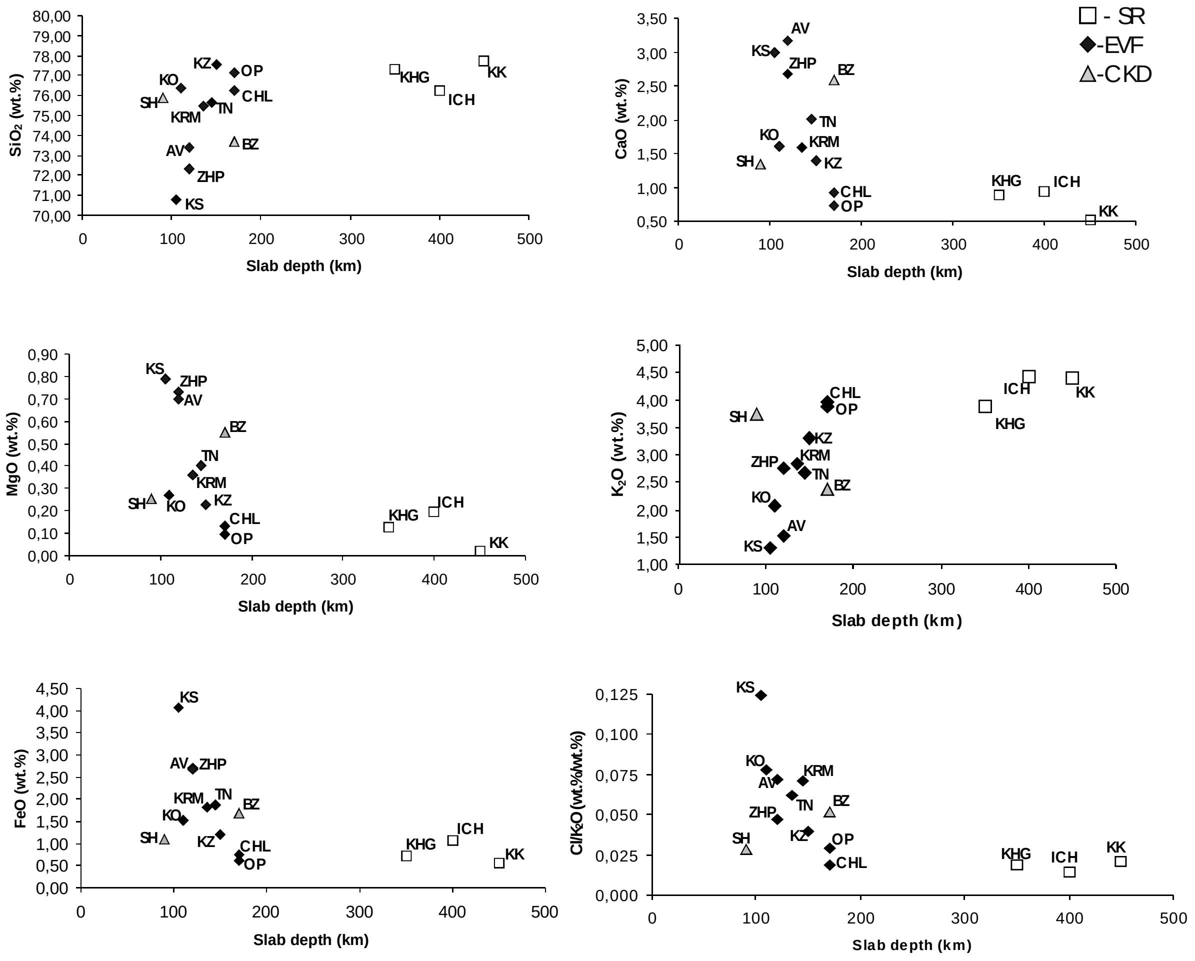

Fig.1. Across-arc variations of major elements in volcanic glass. Symbols are labeled as follows: “SR” – Sredinny Range, “EVF” – Eastern Volcanic Front, “CKD” – Central Kamchatka Depression. Abbreviations for volcanoes: KO – Kurile Lake Caldera, AV – Avachinsky, KS – Ksudach, KRM – Karymskaya Caldera, ICH – Ichinsky, KHG – Khangar, KZ – Kizimen, OP – Opala, BZ – Bezymianny, SH – Shiveluch, TN-Taunshits, ZHP – Zhupanovsky volcano, CHL – Chasha Lake, KK – Kekuknaisky volcano.

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