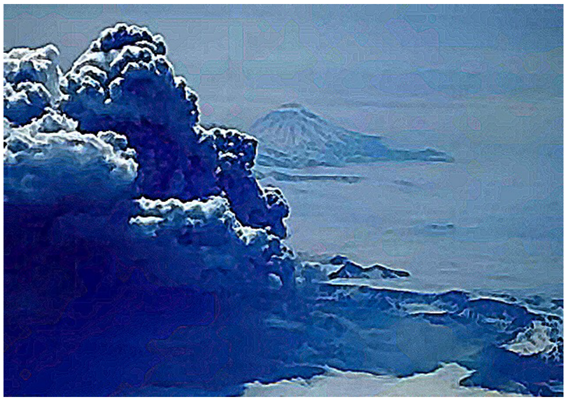
6th Biennial Workshop on Japan-Kamchatka-Alaska Subduction Processes (JKASP-2009)



Mitigating natural hazards in active arc environments

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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GEODYNAMICAL CONDITIONS AT THE NORTH OF THE KAMCHATKA SUBDUCTION ZONE: GEOCHEMICAL EVIDENCE

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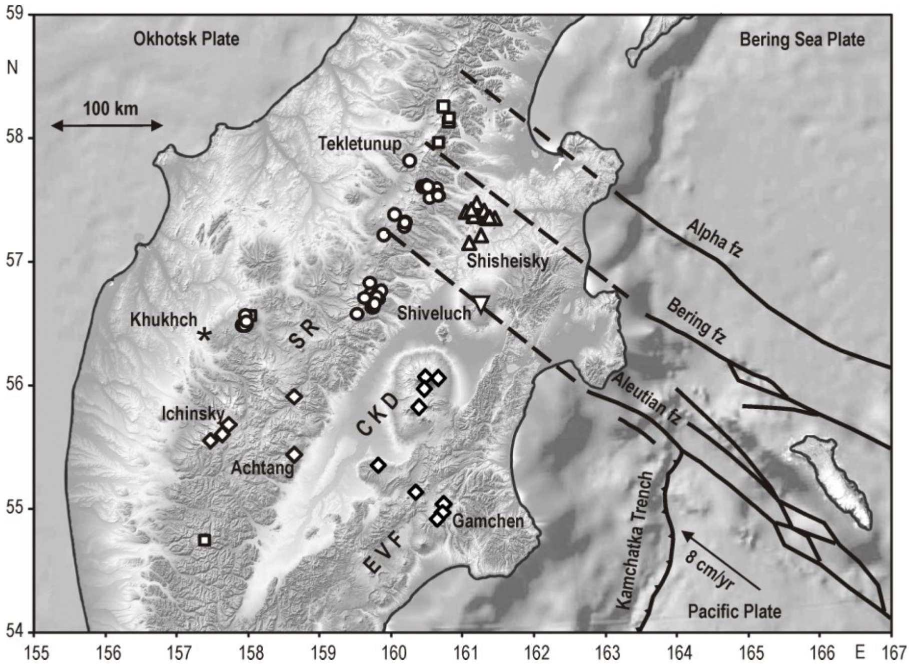
The results of this report are based on two transects which were carried out through Kamchatka peninsula during the last decade: (1) a SE-NW cross-arc transect and (2) a SW-NE Sredinny Range (SR) along-arc transect. These data together with the first Ar-Ar dating offer an opportunity to study the geochemical feature distribution of the volcanic rocks in space and time.

The cross-arc transect (Fig. 1, Churikova et al., 2001, 2007), extending from the Gamchen Volcano in the Eastern Volcanic Front (EVF) through the Central Kamchatka Depression (CKD) to Ichinsky Volcano in the SR, is based only on Quaternary rocks; it showed a continuous geochemical zonation from the arc front to the back arc of the present subduction zone, including strong and gradual increases in LILE, LREE, and HFSE in whole rocks. The transect along the SR back arc (Volynets et al., this meeting) from the Achtang lava field to Tekletunup Volcano (Fig. 1) comprises two age groups, each uniform in geochemical features. Late Miocene-Pliocene rocks (3.05-6.19 Ma) represent voluminous plateau lavas of depleted basalts with low HFSE and HREE. Fluid-mobile elements are enriched; enrichment patterns are in fact similar to typical arc front lavas. The younger group of Quaternary rocks (<1 Ma) is represented by monogenetic cones and stratovolcanoes that combine the typical LILE/HFSE-enrichment of a subduction setting with enrichment in all incompatible elements.

Geological and geophysical studies (Legler, 1977; Avdeiko et al., 2007) suggest that in Eocene-Miocene time the present back arc represented the active volcanic front of the Proto-Kamchatka subduction zone. Later, the Kamchatka arc system was modified by a step-by-step accretion of the Kronotsky terranes from south to north. The time of that accretion and the outward southeast 200 km shift of the subduction zone to the presently active EVF is estimated to have occurred from 40 to 2 Ma (Alexeiev et al., 2006; Lander & Shapiro, 2007).

Our data can help to better constrain the timing of this event. We argue that the systematic change in SR rock geochemistry with time is the result of this arc shift, and has been facilitated by a massive slab roll-back event. In this scenario, the SR plateau lavas represent the volcanic front until as recently as 3 Ma; the area west of the Miocene Sredinny arc front constituted the back arc region at that time. Volcanic rocks of that region (Mt. Khukhch: 3.78 Ma, Fig. 1) are indeed characterized by the absence of an arc signature; some even exhibit true within-plate trace element patterns (Perepelov et al. 2006). The younger Quaternary rocks at SR are the present back arc lavas of the recent subduction zone. Both the systematic across-arc geochemical zonation from the contemporary arc front to the back arc and the uniform geochemistry of young volcanic rocks along the SR show that the volcanism of the whole region is explained by only one mechanism – subduction of the Pacific Plate below Kamchatka. A trend is documented from fluid-dominated melting in the EVF, through the upwelling of a strongly fluid-fluxed mantle below the CKD (Dorendorf et al. 2000), to melting of a fluid-enriched mantle aided by strong upwelling and decompression in the SR back arc region.

SR magmatism has continued to be active up to the Holocene, even though seismic data today do not signal a downgoing plate below this region. Geophysical studies have shown that the



depth of Kamchatka seismicity decreases from south to north. Kirby et al. (1996) showed that the absence of seismicity does not mean the absence of a plate, because at temperatures higher than 600-700°C seismicity is lost. Davaille & Lees (2004) argued that the seismicity of the subducted Pacific slab is gradually decreasing to the north as result of its heating.

Yogodzinski et al. (2001) argued that the edge of the Pacific Plate is traced below Shiveluch Volcano while Portnyagin et al. (2005) show that the slab edge may be traced somewhat further north at the Shisheisky complex (Fig. 1). We argue that the northern edge of the Pacific Plate is represented by a wide (150 km) boundary as a set of transform faults that can be projected on Kamchatka's surface from the morphology of the downgoing oceanic plate (Fig. 1). At the depth where fluid release is possible, this edge is marked by the termination of Holocene volcanoes on the surface. The absence of young volcanism to the north of the on-land projection of the Alpha fault, then, marks the plate boundary at depth (Fig. 1). The movements of the melts across the vector of subduction and small scale convection motions could be strong at the slab edge (Davaille and Lees, 2004) and thus magmatism will show a diffuse image of the slab edge. However, this slab edge is weak at best at the volcanic front, probably due to the fact that the slab edge has not been sufficiently heated at this position (Davaille & Lees, 2004).

Fig. 1. Tectonic sketch map of the region, where three plates are joined based on Seliverstov (1998). Relative motion of the Pacific and Bering Sea plates produces the system of transform fault zones Aleutian, Bering, and Alpha. Dashed lines show the extension of these transform zones under the Okhotsk Plate. Data sources for Quaternary volcanism: upturned triangle – Shiveluch (Yogodzinski et al, 2001), triangles – Shisheisky complex (Portnyagin et al., 2005), squares – data from Pevzner & Volynets (2006), rhombs – cross-arc transect from Churikova et al. (2001), circles – SR long-arc transect from Volynets et al. (this meeting), star – from Perepelov et al. (2006).

REFERENCES: Alexeiev et al., 2006: *Int J Earth Sci (Geol Rundsch),* **95**, 977-993; Avdeiko et al., 2007: *Geophysical Monograph Series*, **172**, 37-55; Churikova et al., 2001: *J Petrol*, **42** (8), 1567-1593; Churikova et al., 2007: *Contrib Mineral Petr*, **154** (2), 217-239; Davaille & Lees, 2004: *Earth Planet Sci Lett*, **226**, 293-304; Dorendorf et al., 2000: *Earth Planet Sci Lett,* **175**, 69-86; Kirby et al., 1996: *Rev Geophys,* **34**, 261-306; Lander & Shapiro, 2007: *Geophysical Monograph Series*, **172**, 57-64; Legler, 1977: *Moscow, Oceanology Institute AS USSR*, 137-169; Perepelov et al., 2006: *Doklady Earth Sciences, Geochemistry*, **409 (**5), 765-768; Portnyagin et al., 2005: *Geology*, **33** (1), 25-28; Seliverstov, 1998: *Moscow, Nauchnij mir,* 164 p.; Yogodzinski et al., 2001: *Nature*, **409**, 500-504.