

Investigations of tsunami deposits on Kamchatka and Kuril Islands, Russia

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ABSTRACT: Tectonic activity along the Kuril-Kamchatka subduction zone expressed in earthquakes and volcanic eruptions. Great subduction-zone earthquakes can produce catastrophic tsunamis and large-scale coseismic deformation on the nearby coast. Prediction and estimation of earthquake-related hazards can be realized only on the basis of a long history of great and large earthquakes and their attendant tsunamis. Therefore, to understand recurrence intervals of such earthquakes, we have carried out paleotsunami studies as well as studies of recent historical earthquakes and tsunamis in this region..

For nearly 15 years, our team of geoscientists has been collecting data on historical and pre-historical tsunami deposits in Kamchatka and the Kuril Islands. Short historical observations in eastern Kamchatka (since about 1730 A.D.) include many large and several great earthquakes. In the time frame of our campaign alone, there have been three large tsunamis generated at the Kuril-Kamchatka subduction zone (Kronotsky 1997; Central Kuriles 2006 & 2007). Many studied localities have traces of historical events, and we can use these data from historical earthquakes and their tsunami deposits as benchmarks for pre-historic events. As a result of our studies, we have reconstructed key events in coastal evolution during the Holocene and determined the ages and distributions of strong paleoearthquakes for different sites along the Kurile-Kamchatka coastlines.

Specific methods of these investigations include: 1) application of tephrochronology and tephrostratigraphy to dating and correlation of various types of coastal deposits and landforms; 2) study of paleotsunami deposits in order to determine their ages and recurrence rates and to estimate the magnitude of large tsunamis and tsunamigenic earthquakes along the Kurile-Kamchatka subduction zone and north of that zone during Holocene time; 3) analysis of the geologic structure, age, and modern and paleo-topography of marine terraces and beach ridges in order to determine the direction and scale of coseismic deformation as well as cumulative seismotectonic effects; 4) Application of ground penetrating radar (GPR) (down to 25 m) – to study thicknesses of sedimentary deposits covering shoreline angles of marine terraces; to identify buried erosional

scarps on Holocene marine terraces; and to locate other stratified and unconformable structures.

During our paleoseismological investigations focusing on the subduction zone along Kamchatka and the northern Kurils, we have correlated, compared and analyzed data from multiple historical and prehistorical tsunami deposits [Pinegina et al., 2001, 2003]. Based on these results, we have identified the most disastrous tsunamis as well as other large events (Fig 1).

The two strongest historical tsunamis on Kamchatka and the northern Kurils occurred in 1952 A.D. ($M_w \sim 9.0$) and 1737 A.D. Our tsunami-deposit data allow us to conclude that the magnitudes of these two earthquakes were comparable and that their sources approximately coincide spatially.

Along southern Kamchatka and the northern Kurils we have established that in the last ~1500 years, at least three to four very strong tsunamis in addition to 1952 and 1737, or 1 event per 230-280 years on average. Based on the record, we suggest that all these events were produced by interplate earthquakes with $M_w > 8-8.5$. We interpret yet other tsunami-deposits layers that we cannot correlate between coastal sites as generated by smaller ruptures, teletsunamis, and possibly even landslides.

In Kuril Islands, paleoseismological data from expeditions in 2006, 2007 and 2008 have shown that the previously quiet central Kurils are seismically very active, comparable to other parts of the Kuril - Kamchatka subduction-zone system. Earthquakes and tsunamis of 2006 and 2007 [MacInnes et al., 2009a,b] gave us a unique opportunity to compare their height, inundation and deposits with the same parameters of

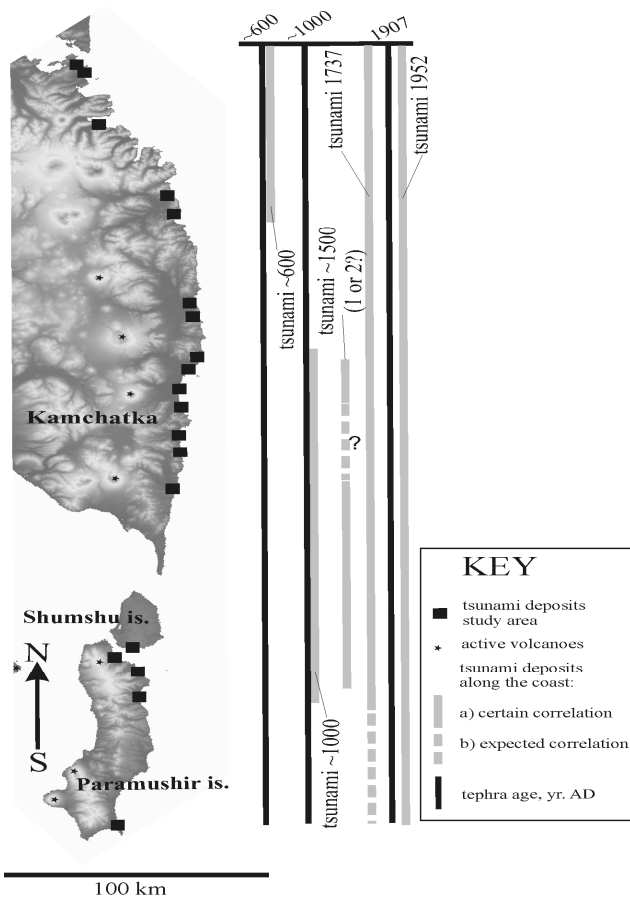


Figure 1. Tsunami deposits from the biggest events for the last ~1000-1500 years, from Petropavlovsk in the north to Paramushir Island in the south.

ancient tsunamis. According to our preliminary data for the late Holocene, strong tsunamis, with intensity comparable to or larger than the 2006 tsunami, have occurred on the central Kurils every 200-250 years. These tsunamis would be generated by earthquakes of $M_w \geq 8$.

During 1998-2003 for several field seasons we turned to the northern terminus of the Kuril-Kamchatka subduction zone, where the Aleutian-Komandorsky chain collides with Kamchatka, and north of that to the southern Komandorsky Basin in the southwestern Bering Sea. First we examined geological evidence for the 1969 Ozernoi earthquake and tsunami [Bourgeois et al., 2006; Martin et al., 2008], which were generated north of the modern subduction zone. Then we used these data as well as data on other historical tsunamis as a guide for analyzing more than 4000 years of paleoseismic record in the southwestern Bering Sea. In this area we have documented evidence for 12-15 tsunamis during about 4500 years. Based on tsunami runup (4-8 m) and tsunami inundation (≤ 300 -400 m), we think that these events were

produced by earthquakes with $M_w \sim 7.5 \pm 0.5$. Possibly, they are underwater analogues of Olytorskiy earthquake with $M_w = 7.6$ on April 20, 2006 in Koryakia, Russia (Pinegina, 2007). The southwestern Bering Sea margin is thus quite tsunamigenic, albeit at a somewhat slower rate and lesser magnitude than the Kuril-Kamchatka subduction zone. Future destructive events should be expected in this regio.

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