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Correlation of tsunami deposits based on temporal change in coastal environment, eastern Hokkaido

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Because Hokkaido and the Kuril Islands lack an extensive historical record, geologic studies of paleotsunami deposits are the most reliable method of estimating the frequency and magnitude of past tsunami events in this area.

Eight sand layers in 3000 years of coastal deposition on the eastern coast of Hokkaido provide the best evidence for frequency and magnitude of the tsunami hazard faced by this area. However, correlation of these sand layers from one location to the next, or even within one location, is difficult?the regional tephra stratigraphy provides poor resolution for the time of interest, and radiocarbon also often fails to provide adequate resolution. Here we couple mineralogical analysis of the deposits with high-resolution granulometry to provide another tool for correlation on this coast.

Paleotsunami deposits are often correlated based on thickness, depositional structures, tephrochronology, and radiometric dates. In this area, however, the depositional environment (a hummocky marsh) creates microtopography that makes both thickness and depositional structures unusable for large-scale correlation. The available marker tephas in the area are: Tarumae-a tephra (Ta-a, AD1739), Komagatake-c2 tephra (Ko-c2, AD1694), Tarumae-b tephra (Ta-b, AD1667), Baekdu-san Tomakomai tephra (B-Tm, ˜1000 yr BP), and Tarumae-c tephra (Ta-c, ca. 2700 yr BP). These are insufficient for chronology before the 17th century. Equally, with approximately one layer every 350-400 years, even radiocarbon often cannot provide adequate resolution to be used for correlation of these sand units.

In this study we attempt to correlate sand layers using particle size distribution, diatom assemblages, and the chemical composition of volcanic glass and orthopyroxene. Particle size distributions vary with layer and subunit depending on hydraulic conditions and on source material. Sand layer composition also varies with source material. In particular, pumice and orthopyroxene can be used to infer different source areas on this coastline. Diatom assemblages can also be used to help explain the source of the sand.

We sampled sand layers in two marshes, near Urahoro and Nemuro, using a Geoslicer. Particle size distribution within each layer was measured with a Retsch Camsizer. Minerals and diatoms were identified under a light microscope. Major element composition of volcanic glass and orthopyroxene was determined with an EDS.

Near Urahoro, eight tsunami layers (U-1 to U-8) occur between Ta-b and Ta-c. Four layers (U-1, U-2, U-5, and U-8) can be correlated by their particle size distribution. Depositional structures vary greatly in the area, probably because of microtopography. U-1 is distinguishable from others by the presence of orthopyroxene, possibly suggesting that U-1 was deposited during a different season. Sand samples taken from inland sites contain more pumice fragments than samples from seaward sites, suggesting density separation during transport.

In Nemuro, one tsunami layer (N-1) occurs above Ta-a, and seven layers (N-2 to N-8) between Ko-c2 and Ta-c. Tsunami layers contain 90% freshwater diatoms and 5-10% brackish, indicating that the tsunami waters originated from the diatom-poor sea and flowed through brackish and freshwater areas. Younger layers contain more marine and brackish diatoms, suggesting land subsidence or coastal erosion.

Precise particle size distributions and compositional analysis strengthen the correlations of tsunami layers. Grain materials and diatom assemblages enable interpretation of tsunami deposit source and the geological and hydrological setting at the time of the tsunami.

Keywords: Tsunami deposits, correlation, particle size distribution, grain materials, Kuril Trench