Geophysical Research Abstracts
Vol. 19, EGU2017-7038-1, 2017
EGU General Assembly 2017

Frequent but hidden eruptions of Adatara and Bandai volcanoes during the last 50,000 years unraveled by volcanic damlake sediments, northeast Japan

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Adatara and Bandai volcanoes in the northeast Japan are very close to each other (∼18 km). Bandai volcano is well known for a large-scale debris avalanche following the phreatic eruption in AD1888 that took more than 400 fatalities. Eruptive history consists of at least 6 more debris avalanche events, 3 more phreatic eruptions, 6 lava flows, and 4 Vulcanian/sub-Plinian eruptions during the last 50,000 years revealed by subaerial proximal deposits. Whereas, the eruptive history of Adatara volcano comprises 6 Vulcanian and 5 phreatic eruptions during the last 10,000 years. The most recent eruption occurred in AD1899-1900.

The studied sedimentary core (INW2012) was drilled out from Lake Inawashiro-ko, the largest dammed lake in Japan, that was formed by the 50 ka Okinajima debris avalanche event at Bandai volcano. The lake is 94 m deep, and drilling site is located at the central part of the lake (∼90 m deep). In the 28 m long core sequence, in contrast to background lake sediments deposited under a deep offshore environment, very frequent (70) intercalations of event layers are recognized. Eight types of event layers can be recognized: 1) gray muddy layer (Gm), 2) gray sandy layer (Gs), 3) brown muddy layer (Bm), 4) brown sandy layer (Bs), 5) olive-gray muddy layer, 6) pale-brown sandy layer, and 7) yellow sandy layer, and 8) 2011 earthquake-induced turbidite, based on the characteristics of sedimentary facies, petrography, grainsize, mineral assemblages (XRD) and vertical variation of chemistry (micro-XRF). There are many tephra-fall layers but most of them are extra-basinal origin, i.e. of other volcanoes than Adatara and Bandai.

Gm is usually a few millimeters to centimeters thick, blue-gray color, homogenized, and finer than background sediments. Gs is accompanied with coarser subunits and thicker than Gm. Especially, Gm/Gs contain pyrite, sulfate minerals and smectite, and are characterized by high sulfur contents. Bm and Bs are 1 to 6 cm thick and are normally graded with a sharp erosive base. Fresh glass shards and organic material are commonly present.

The gray units (Gm/Gs) can be correlated with muddy lahars (cohesive debris flows/mudflows) in the Sukawa River catchment of Adatara volcano. High-sulfur contents indicate syn- or post-eruptive lahars in relation with phreatic eruptions or degradation of hydrothermally altered source rocks nearby the crater. The brown units (Bm/Bs) are thicker than those of gray units that suggest more proximal origin. The fresh glass shards and chemistry of those shards in brown units are unlikely to be reworking of pre-existing old tephra deposits, and therefore the events are attributed to magmatic eruption-fed density currents from Bandai.

Since depositional rates of background lake sediments are stable, the frequent eruption-related events both from Adatara and Bandai volcanoes can be well dated. These event deposits reveal unknown eruptive history of Adatara and Bandai as they were more active during the last 50,000 years than previously known. Appropriate evaluation for small-scale but high frequent eruptions and their risk assessments are necessary for Inawashiro Town (15,000 population) located at the foot/downstream of the volcanoes.