Using onshore sediment cores to reconstruct the ages of oceanic intraplate earthquakes in Beppu Bay

*Masaki Yamada[1], Shigehiro Fujino[2], Takashi Chiba[2], Catherine Chagué-Goff[3,4]

1.Graduate School of Life and Environmental Science, University of Tsukuba, 2.Faculty of Life and Environmental Science, University of Tsukuba, 3.School of Biological, Earth and Environmental Sciences, UNSW Australia, 4.Australian Nuclear Science and Technology Organisation

Historical written records document the devastation of the coasts of Beppu Bay, eastern Kyushu, Japan, by a tsunami associated with an oceanic intraplate earthquake in AD 1596 (*M*=6.9, Hatori, 1985). Results of acoustic and coring surveys conducted in the bay (e.g., Shimazaki et al., 2000; Ooita Prefecture, 2002), show that east part of the Beppu Bay–Hijiu active faults has been active five times since the deposition of the K-Ah tephra (7170–7300 cal. yr BP, Smith et al., 2013). However, the accurate timing of these fault ruptures is yet to be determined. It is also not known whether each prehistorical earthquake triggered a tsunami or not. The aim of this study is to establish a detailed chronology of tsunamigenic earthquakes that occurred in Beppu Bay in prehistorical ages using data from onshore sediment cores obtained from a coastal marsh located on the south coast of the bay. In order to identify prehistorical tsunami deposits, sediment cores were analyzed for grain size, diatom and geochemistry (using an ITRAX core scanner) combined with the observation of sedimentary facies. Radiocarbon analysis of plant material taken from the organic-rich mud immediately above and below the assumed prehistorical tsunami deposits was also undertaken.

At site OEJa-02 (170 m from the shoreline), the sedimentary sequence between 2.0–7.8 m depth is mainly composed of organic-rich mud. Plant material obtained from the uppermost (2.15–2.17 m depth) and lowermost (7.79–7.80 m depth) parts of this section returned ages of 2760–2860 cal. yr BP and 7670–7790 cal. yr BP, respectively. Two tephra layers at 4.30–4.33 m and 5.30–6.50 m depth were identified as the Danbaru scoria (DS) and the Kikai-Akahoya tephra (K-Ah), respectively, based on refraction indexes of volcanic glass. Three sand layers were observed in the sedimentary sequence. Two are thin sand units above the 5700-year-old DS and which are dated to 3330–3450 cal. yr BP and 4400–4530 cal. yr BP, while there is another 6500-year-old sand layer between the DS and K-Ah tephras. Immediately beneath the K-Ah layer, there is a 4 cm thick graded unit composed of pebbles to coarse sand. All sand units exhibit sharp upper and lower contacts with the surrounding muds, suggesting that they were deposited by a sudden event. They are characterized by higher magnetic susceptibility associated with higher counts of titanium (Ti) and iron (Fe), as well as silicon (Si), potassium (K), calcium (Ca), vanadium (V), chromium (Cr), manganese (Mn), strontium (Sr), and barium (Ba) than in the overlying and underlying organic-rich muds. Principal component analysis of the ITRAX results suggests that the sand grains were transported from different environments. Moreover, as the marine benthic diatom *Rhaphoneis* sp. occurred in the sand layers, but not in the surrounding muds, the sand units appear to have, at least partly, a marine source.

The sedimentary record since the K-Ah tephra includes at least three probable prehistorical tsunami deposits from 3300–3450, 4400–4530, and 6500 years ago. Based on the submarine cores obtained from Beppu Bay, the last five fault ruptures are estimated to have occurred 1700–2200, 3600–4600, 5300–6000, and 5800–7300 years ago in addition to the AD 1596 earthquake (Headquarters for Earthquake Research Promotion, 2005). Bearing in mind that the record preserved in the sediment cores at our study site does not include the last 2760–2860 years, the number of past tsunami deposits reported here show some agreement with the results of the offshore seabed research (e.g., Ooita Prefecture, 2002; Headquarters for Earthquake Research Promotion, 2005).

Keywords: Tsunami deposit, Submarine active fault, Beppu Bay, Radiocarbon dating, Diatom, Geochemistry

