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Revised ages of late Holocene tephras in Beppu Bay, central Kyushu, southwest Japan

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ABSTRACT

In this study, we revised eruptive ages, especially the Aso and Yufu volcanoes, central Kyushu, by analyzing a sediment core of southwestern Beppu Bay, southwest Japan, where undisturbed sediments are continuously deposited in a dysoxic basin. We identified two ash-fall layers in the sequence covering the last ca. 3000 years by using the refractive index of volcanic glasses and other parameters. These layers were likely correlated with N2 ash of the Aso volcano and Yufu-dake 1 ash (Yf1) of the Yufu volcano on the basis of the refractive indices of volcanic glasses, heavy mineral compositions, special distribution, and facies. According to high precision age models, the eruptive ages (68.2% probability range) of these tephras were 1470–1490 and 2010–2100 cal yr BP, respectively, and concordant with reported ages of previous research. These precise ages of tephras improve linking or dating in the various environments, and contribute to investigation of environmental changes or sedimentary process from source to sink.

1. Introduction

Convergent margins generally dominate the global flux of volcaniclastic and clastic material synchronically deposits in accumulation spaces within and adjacent to volcanic arcs (Manville et al., 2009). Therefore, tephras potentially are unique “key beds” for linking, dating, and synchronizing geological or paleoenvironmental sequences or events (Lowe, 2011; Ikehara, 2015) and hence the accurate ages of such tephras are critically important for Quaternary studies. The dating of tephras deposited within 60 kyr is dominated by the radiocarbon method on enclosing or encapsulated material (Lowe, 2011; Alloway et al., 2013). However, it can be difficult to estimate the precise age from the enclosing material in the case of terrestrial sediments because of the slow deposition rates or significant biological disturbance. In contrast, sediments deposited in marine or lacustrine environments have relatively rapid deposition rates. The precise age of even small-scale eruptions can be estimated from the enclosing material in the sediment when the disturbance is small, and such a precise age potentially contributes to the stratigraphic correlation between different depositional environments.

In this study, we focus on Beppu Bay (Fig. 1A), where undisturbed sediments are continuously deposited in the dysoxic strike-slip basin associated with the subduction of the Philippine Sea Plate (Kuwae et al., 2013; Noda, 2013). Active Holocene volcanoes, such as Aso, Kuju, Yufu, and Tsurumi-Garan, are distributed close to populated cities in this region. Several eruptive ages have been reported for these volcanoes (e.g., Kobayashi, 1984; Ono et al., 1995; Umeda et al., 1996; Kamata and Kobayashi, 1997; Miyabuchi and Watanabe, 1997; Okuno et al., 1999; Furusawa and Umeda, 2000; Fujisawa et al., 2002). However, different ages with large age uncertainties have been estimated mainly from enclosing terrestrial carbons buried in soils (paleosols) in volcanic ash sequences in these studies. Hence, we revise the eruption ages, especially for the Aso and Yufu volcanoes, by identifying the tephras in a well-dated

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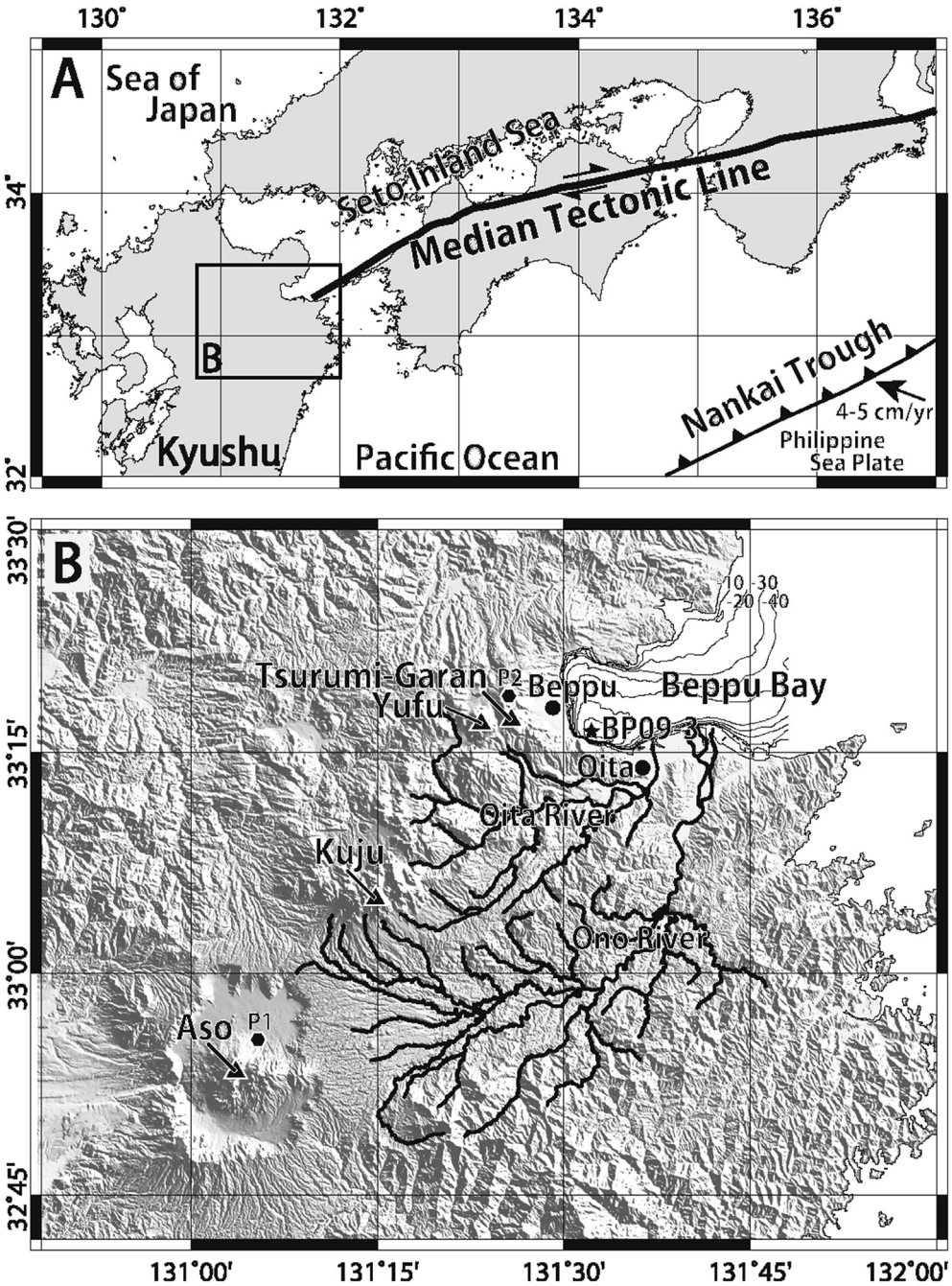

Fig. 1. Location of Beppu Bay in central Kyuhsu of southwestern Japan. A: Tectonic setting of southwestern Japan based on Itoh et al. (2014b). Beppu Bay is located at the western end of an arc-bisecting dextral fault of the Median Tectonic Line (MTL). The bay has been dominated by pull-apart stress from the younger stage of 1.5 Ma to the present. Sediment was therefore continuously deposited and recorded the eruptive history near the bay. B: Shaded-relief map of the Beppu Bay area based on the 10-m resolution digital elevation model (DEM) of the Geospatial Information Authority of Japan. The solid triangles, circles, star, and hexagons show the active Holocene volcanoes, heavy populated cities of Beppu and Oita, the BP09-3 core drilling site, and sampling sites of proximal samples, respectively. The solid lines indicate the major channels of the Oita and Ono rivers, which feed into the bay.

marine sediment sequence covering the past ~3000 years in Beppu Bay.

2. Regional setting

Beppu Bay is located at the western end of an arc-bisecting dextral fault of the Median Tectonic Line (MTL). According to Itoh et al. (1998, 2014b), the formation of the bay can be divided into two stages. The younger stage (1.5 Ma to the present), particularly from 0.7 Ma to the present, is dominated by posterior pull-apart stress. As a result, sediment was continuously deposited in the bay during the Holocene. Beppu Bay, which has a maximum depth of 72 m and a shallow 52 m deep drainage mouth, is located at the western end of the Seto Island Sea (Fig. 1A). Active volcanoes beginning in the middle–late Pleistocene and Holocene, such as Aso, Kuju, Yufu, and Tsurumi-Garan, are distributed in this region (Fig. 1B). Clastics including ejecta from these volcanoes, such as ash-fall and volcaniclastic turbidites, are rapidly deposited at an

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