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High resolution record of Quaternary explosive volcanism recorded in fluvio-lacustrine sediments of the Uwa basin, southwest Japan

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ABSTRACT

The identification of widespread tephras is important, not only for understanding volcanic processes but also for age estimation and establishing stratigraphic relationships. Many widespread tephras have been erupted from six active and buried caldera volcanoes in the SW Japan-Ryukyu volcanic arcs. To reconstruct high-resolution tephrostratigraphy, we analyzed core UT from the Uwa basin on western Shikoku Island and correlated the tephras in the core with the proximal source deposits that we sampled. This 120 m-long core composed of fluvio-lacustrine deposits, spanning the middle Pleistocene to Holocene. We recognized and characterized 52 visible tephra and tephric sediment layers in the core on the basis of their stratigraphy, the petrographic features and the major-element composition of glass shards. We successfully correlated 15 tephras with the following previously identified widespread tephras, mainly from volcanoes on Kyushu: Kikai-Akahoya (7.3 ka), Aira-Tn (29 ka), Aso-4 (87 ka), Kikai-Tozurahara (95 ka), Aso-ABCD (100 ka), Ata (105-110 ka), Aso-3 (112.7 ka, calculated in this study), Aso-2 (140 ka), Ata-Toihama (240 ka), Aso-1 (250-270 ka), Tky-Ng1 (290-300 ka), Kakuto (330-340 ka), Oda (420-450 ka), Hiwaki (570-580 ka), and Yufugawa (600 ka). Above 50 m depth, all known widespread tephras from Kyushu younger than 350 ky were included in the sequence that has a fairly constant sedimentation rate of about 0.14 mm/yr. This high-resolution tephrostratigraphy was correlated with those of regional long-core records from the Lake Biwa in the central Japan and offshore of Shikoku that contributes to establish onshore-onshore and onshore-offshore correlations in southwest Japan. In the sediments, each of the following tephras from caldera-forming eruptions, Aso-4, Aso-ABCD, Ata, Aso-3, Aso-2 and Aso-1 occurred above multiple, compositionally similar tephra layers erupted from the same volcano over a long time period. This high-resolution record is therefore an important contribution to the correlation of regional stratigraphy and reconstruction of both the long-term eruptive history and the magma evolution of volcanoes in the SW Japan and -Ryukyu volcanic arcs.

1. Introduction

In Japan, explosive volcanic eruptions often produce large ash plumes, which may be widely dispersed by the prevailing westerly winds and deposited in downwind regions as widespread tephras. Along the southwest Japan and -Ryukyu volcanic arcs, one of the most active volcanic regions in the world, four currently active caldera volcanoes (Aso, Aira, Ata, and Kikai Fig. 1a) and two dormant caldera volcanoes (Kakuto-Kobayashi, and Shishimuta) erupted catastrophically (i.e., eruptions with a volcanic explosivity index, VEI, of 6–7) many times in the past, forming calderas and producing widespread tephras (Machida and Arai, 2003). To assess the risk associated with such catastrophic volcanic hazards and elucidate magmatic processes over long periods, a comprehensive record of explosive volcanism and recurrence rates provided by tephra sequences preserved in Quaternary deposits is useful. Tephra sequences are often preserved in oceanic and lacustrine sediments downwind of volcanic regions. For example, a

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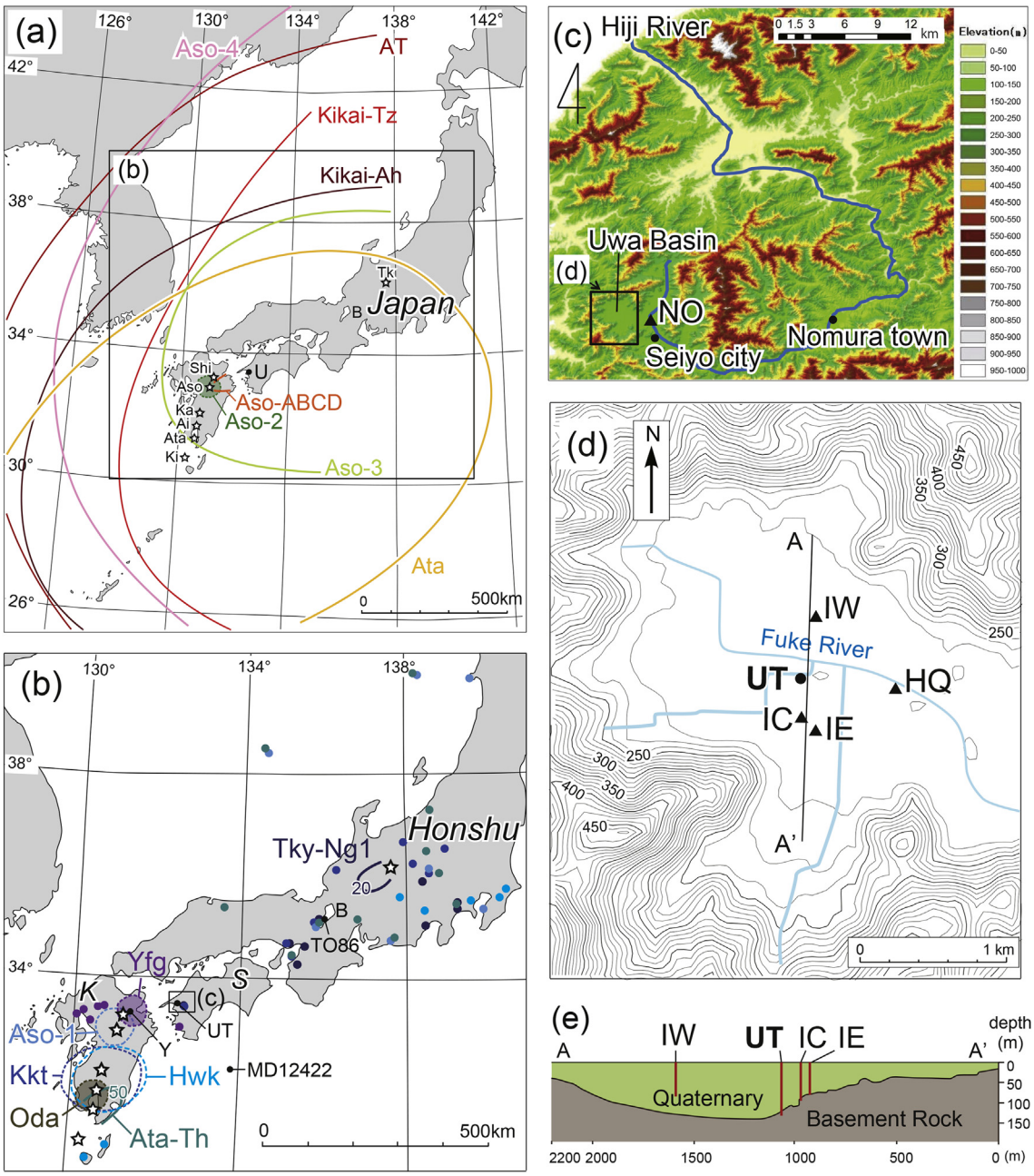

Fig. 1. Dispersal of widespread tephras deposited (a) since 200 ka and (b) during 600–200 ka and correlated with core UT tephra layers in this study. In (a) and (b), the data of K-Ah, AT, Aso-4, Aso-ABCD, Ata, Aso-3, Ata-Th, and Tky-Ng1, taken from Machida and Arai (2003), are indicated by solid lines, where the colors correspond to the type color used for the tephra names. Dispersals of Aso-2, Aso-1, Oda, Hwk, and Yfg have not been published; localities where these tephras are reported by Machida and Arai (2003) are indicated by closed circles, where the colors correspond to the type color used for the tephra name. The distributions of Aso-1, Kkt, and Hwk ignimbrites, taken from Machida and Arai (2003), are indicated by dashed lines. The distributions of Aso-2, Oda and Yfg ignimbrites, estimated from Ono and Watanabe (1983), Sato et al. (2000) and Shimoyama et al. (2012) are indicated by shaded areas surrounded by dashed lines. Stars indicate the locations of the calderas (Shihimuta, Shi; Aso; Kakuto, Ka; Aira, Ai; Ata; Kikai, Ki; Takayama, Tk) that produced the widespread tephras studied here. In (b), the navy and green contours indicate the 20 cm isopach of Tky-Ng1, and 50 cm isopach of Ata-Th. The locations of core UT, TO86 and MD012422 sites are shown. K, Kyushu; S, Shikoku; B, Lake Biwa; U, Uwa basin; Y, Yufu basin. (c) Topographic map showing the location of the Uwa basin in the upper part of the Hiji River catchment and the Nagaosa (NO) coring site. (d) Topographic map of the Uwa basin showing the locations of the IC, IE, Iwaki (IW), UT HQ, coring sites. (e) Schematic cross section along line A–A′ (location shown in (d)) through the central Uwa basin modified from Group of the Seated Ground Water in Uwa-town (2007) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

sedimentary succession from Lake Biwa has been used to establish a middle Pleistocene to Holocene tephrostratigraphy for Japan (Yoshikawa and Inouchi, 1991; Nagahashi et al., 2004), that has been used for dating and correlating the tephrostratigraphy (Machida and Arai, 2003) and paleoenvironmental record (e.g. Kuwae et al., 2002).

The Uwa basin in western Shikoku (Fig. 1), by virtue of the relatively short distance of the core site from Kyushu Island volcanoes (60–250 km), are likely to record not only coarse-grained and/or thick tephra deposits representing explosive and/or large volume eruptive events but also thinner and/or finer-grained tephra representing less explosive and/or lesser volume eruptions. In fact, many tephras have been previously reported from late Quaternary deposits in cores from the Uwa basin (e.g. Kawamura

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