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Holocene geohazard events on the southern Izu Peninsula, central Japan

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ABSTRACT

Faunal compositions and ^{14}C ages of emerged sessile assemblages at four sites in the southern part of Izu Peninsula, central Japan, indicate that co-seismic uplift occurred at 1256–950 BC, AD 1000–1270, AD 1430–1660, and AD 1506–1815. The data suggest that the stress field in the southern part of Izu Peninsula changed to its current north–south compression at ca. 3100 BP, and that the recurrence intervals for uplift-inducing earthquakes have become shorter during the last 1000 years. The main faults responsible for this seismicity appear to be located offshore from the south part of Izu Peninsula. This study also examined a 1-cm-thick scoria layer deposited between 6940 and 6810 cal BP in the south part of Izu Peninsula. The layer, which had not been previously examined petrographically, consists of scoria grains derived from Izu-Oshima volcano located 40 km east of the study area, rather than from volcanoes located on Izu Peninsula itself.

1. Introduction

The Japan islands are located at the boundaries of the Eurasian, North American, Pacific and Philippine Sea plates (Fig. 1a). Consequently, large earthquakes, tsunamis, and extensive volcanic activity have occurred in this region as a result of a long history of plate collision, which has caused frequent catastrophic events in the region. Most recently, a magnitude 9.0 earthquake occurred on 11 March 2011 in the Japan Trench off northeast Japan, causing a mega-tsunami that resulted in ~20,000 deaths. Numerous studies have since re-examined the available geologic evidence for large historical earthquakes and tsunamis in the region; these include events in the area of the Suruga, Nankai, and Sagami troughs, located off southwest and central (e.g., Abe and Shirai, 2013; Fujiwara et al., 2013; Kitamura et al., 2013a, b; Kitamura and Kobayashi, 2014a, b). The Philippine Sea (PHS) plate is subducting beneath the Eurasian plate in both the Suruga and Nankai troughs, as well as beneath the North American plate in the Sagami Trough (Fig. 1). The AD 1854 Ansei-Tokai earthquake (M 8.4) and the AD 1923 great Kanto earthquake (M 7.9) occurred in the Suruga Trough and Sagami Trough, respectively (Fig. 1a, b), within the past 200 years.

Izu Peninsula, located at the northeastern edge of the Suruga Trough and the northwest edge of the Sagami Trough, occupies the northern tip of the PHS plate (Fig. 1a, b). Its northern margin represents a collision zone with central Japan, which is located on the Eurasian and North American plates (Sugimura, 1972; Somervill, 1978; Nakamura and Shimazaki, 1981).

The region's many active faults and the resulting seismicity indicate that active deformation is occurring on the Izu Peninsula (Sagiya, 1999). For example, the Tanna and Irozaki faults caused the AD 1930 North Izu earthquake (M 7.3) and the AD 1974 Off-Izu Peninsula earthquake (M 6.9), respectively (Fig. 1b). Izu Peninsula has experienced large earthquakes, tsunami and volcanic activity in the past, and is known to be tectonically active. For example, the coastal areas of the peninsula were attacked by large tsunamis generated by the AD 1854 Ansei-Tokai earthquake and the AD 1923 great Kanto earthquake (Usami, 1975; Hatori, 1976) (Fig. 1b). More than 100 monogenetic volcanoes are found within an area measuring 40 × 30 km, which covers the eastern part of Izu

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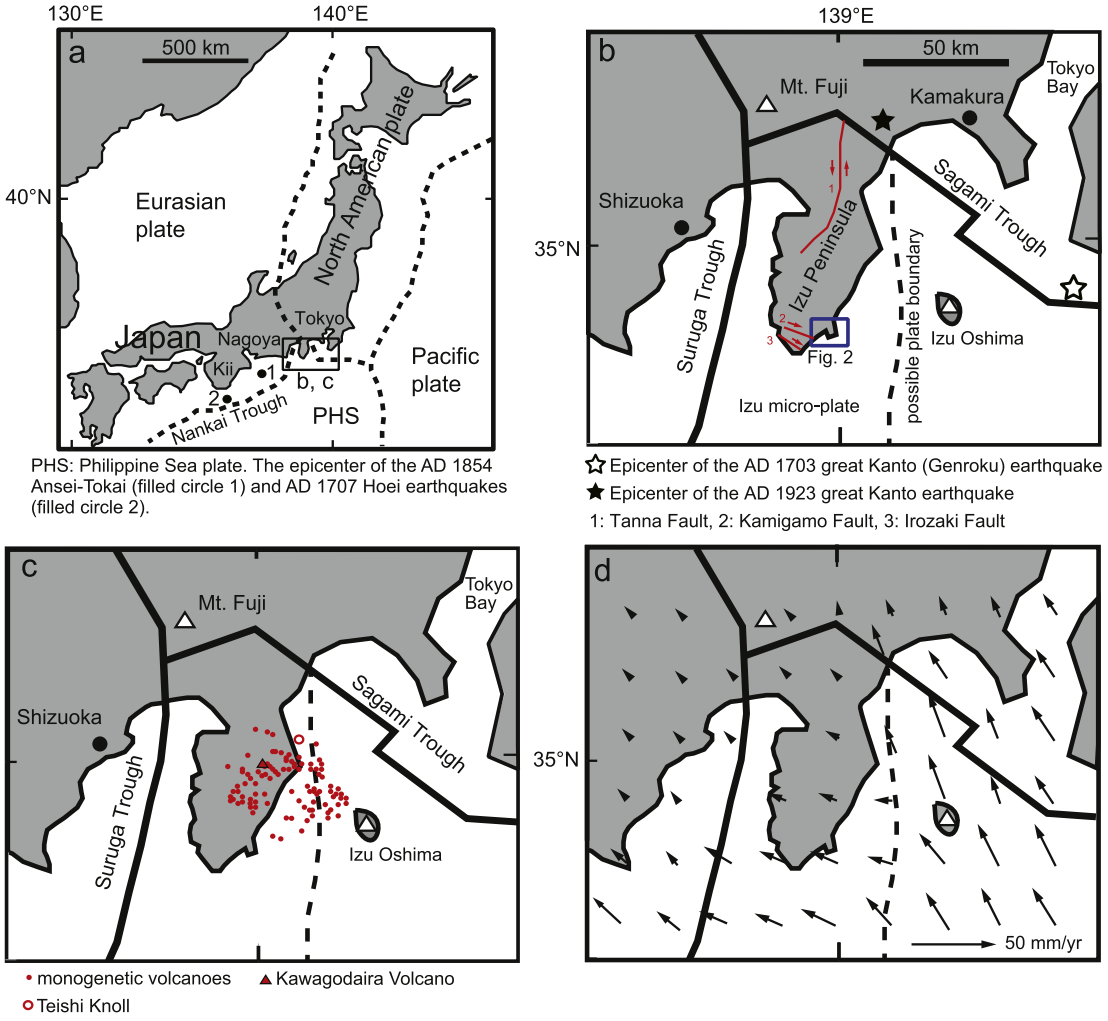

Fig. 1. Locality maps. (a) Japan Islands, showing plate boundaries, the location of Izu Peninsular, and epicenteral locations of the AD 1854 Ansei-Tokai and AD 1923 great Kanto earthquakes. (b) Locations of key active faults on Izu Peninsular. Possible plate boundary is after Nishimura et al. (2007). (c) Locations of monogenetic volcanoes on Izu Peninsular (Koyama and Umino, 1991; Notsu et al., 2014). (d) Arrows indicate the approximate directions of the sum of rigid block rotation and elastic deformation parts of the velocity field of the Kanto region predicted by the Euler pole of the best fit model in the central Japan block (CJP)-fixed reference frame (Nishimura et al., 2007).

Peninsula and the western part of Sagami Trough (Hamuro, 1985) (Fig. 1c); this area has been named the "Izu–Tobu Volcanoes" by the Japan Meteorological Agency (2005). The Teishi Knoll submarine volcano, which erupted on 1989, belongs to this group (Oshima et al., 1990, 1991). Similarity, the Kawagodaira Volcano erupted between 1210 and 1187 cal BC (95.4% confidence level) (Tani et al., 2013), resulting in pyroclastic flows in the surrounding area. The fine pumice from this volcano is widely distributed in the central and western parts of the Japanese mainland (Hamuro, 1977; Ikeya et al., 1990; Shimada, 2000).

Recent geodetic studies have proposed that the Izu microplate, which includes Izu Peninsular, moves separately from the rest of the PHS plate (Sagiya, 1999; Heki and Miyazaki, 2001; Nishimura et al., 2007), indicating that the Izu microplate is a region of concentrated deformation between Izu Peninsula and the main part of the PHS plate (Fig. 1d). Sagiya (1999) interpreted this tectonic movement as crustal deformation that is partitioned into left-lateral motion along a possible plate boundary located east of Izu Peninsula (the left-lateral Izu-Oshima Kinkai earthquake (M 6.5) occurred in this region in 1990; Abe and Okada, 1993) (Fig. 1b) and along the Zenisu Ridge, which is part of the suspected plate boundary (Nakanishi et al., 1994).

In this paper, we start by reviewing previous studies that have detailed Holocene geohazard events in the southern part of Izu Peninsula. We then provide new information on geohazard events, such as the co-seismic uplift history and volcanic activity in the area from middle–late Holocene. Co-seismic uplift history is reconstructed by faunal analysis and dating of emerged sessile assemblages. This method is commonly used in temperate areas (e.g., Shishikura et al., 2008; Iryu et al., 2009; Castilla et al., 2010; Scicchitano et al., 2011; Melnick et al., 2012). These data are also important to understand the evolution of the collision zone.

2. Study area

2.1. Crustal movements

Fukutomi (1935) reported abrupt uplifts of the southern end of Izu Peninsula based on emerged sessile assemblages. Ota et al. (1986) and Taguchi (1993) proposed that the area was subsiding up until 3000 BP. Ota et al. (1986) obtained non-calibrated ^{14}C ages of emerged shell fossils at Bentenjima, Shimoda, on the southern Izu Peninsular (Fig. 2); however, shell fossils can no longer be found at this site by human activities. The authors also obtained ^{14}C ages