

The study area is located in central Kyushu Island, around the west and central side of Aso caldera, southwest Japan (Fig. 1). Mount Aso is one of the largest active volcanoes on the Earth, with a caldera area of ~380 km². Activity initiated at the Aso volcanic cluster ~0.3 Myr ago with a large eruption that generated extensive pyroclastic flows. Four subsequent large, explosive eruptions resulted in the formation of Aso caldera (Ono and Watanabe 1985; Okubo and Shibuya 1993). Pyroclastic flows and volcanic ash from the caldera-forming eruption sequence covered a wide region of central Kyushu, including the study area. The basement rocks of the study area are mainly composed of Paleozoic metamorphic rocks, non- or weakly metamorphic eugeosynclinal rocks, Mesozoic granitic rocks, and marine sediments (Ono and Watanabe 1985).

In the southwest part of Aso caldera, the Hinagu–Futagawa fault zone, composed of the NNE–SSW- to NE–SW-striking Hinagu fault and NE–SW- to ENE–WSW-striking Futagawa fault, extends for ~81 km (Fig. 1b). Previous studies have shown that both the Hinagu and Futagawa faults are currently active, with recurrence intervals for large earthquakes of 3600–11,000 years for the Hinagu fault and 2600–8100 years for the Futagawa fault. The most recent event on the Hinagu fault occurred between 1200–1600 years BP, whereas the most recent large event on the Futagawa fault occurred 2200 years BP (Headquarters for Earthquake Research Promotion 2016). However, trench investigations occurred that were conducted after the 2016 Kumamoto earthquake reveal that: (1) prior to the 2016 earthquake, at least two morphogenic earthquakes occurred in the past ~2000 years on the Hinagu Fault, and four events in the past 4000–5000 years on the Futagawa Fault, suggesting an average late Holocene recurrence interval of 1000 years for morphogenic earthquakes within the HFFZ; and (2) the most recent event occurred in the period between AD ~850 and

AD ~1150 AD; and (3) The penultimate morphogenic event took place in the period between AD ~80 and AD ~200 AD (Lin et al. 2017). The 2016 Kumamoto earthquake occurred in the jog area between the Hinagu and Futagawa faults, ~30 km southwest of Aso caldera (Fig. 1b; Japan Meteorological Agency 2016; Geospatial Information Authority of Japan 2016). Historical and instrumental records show that >10 large earthquakes ($M \geq 6.0$) have occurred in the study area (Headquarters for Earthquake Research Promotion 2016). Seismic and geological data show that the Hinagu–Futagawa fault zone is currently active, and its earthquakes frequently cause severe damage, as exemplified by the 2016 Kumamoto main shock (Headquarters for Earthquake Research Promotion 2016).

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