MAJOR MAGMATIC ACTIVITY AS A KEY TO PREDICTING LARGE EARTHQUAKES ALONG THE SAGAMI TROUGH, JAPAN

By

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Major magmatic activity as a key to predicting large earthquakes along the Sagami Trough, Japan

MIHARA-YAMA is a basaltic stratovolcano on Oshima, an island lying about 20 km off the coast of Izu Peninsula in central Japan (Fig. 1). I attempt here to show that the magmatic activity of Mihara-yama could be used to predict large earthquakes along the Sagami Trough. There is apparently a causal relationship between eruptions of Mihara-yama and the earthquakes.

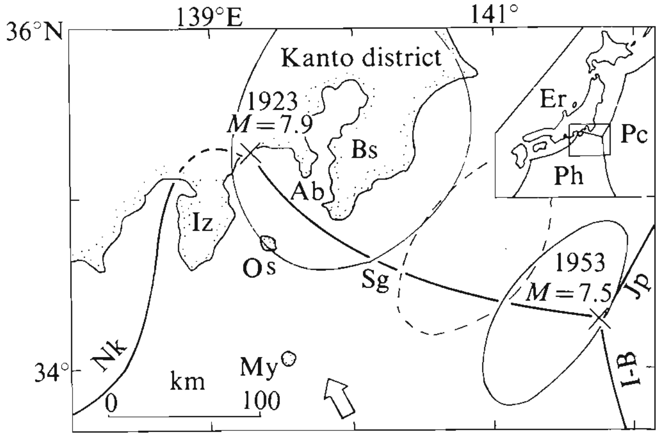

Fig. 1 Large earthquakes that have occurred along the Sagami Trough during this century. The aftershock area is enclosed within the solid line, and the seismicity gap is enclosed within the broken line (see ref. 6). ×, Epicentre of the large earthquake; arrow, direction of slip of the northern Philippine Sea Plate[3]; Sg, Sagami Trough; Nk, Nankai Trough; Jp, Japan Trench; I–B, Izu–Bonin Trench; Os, Oshima; My, Miyakejima; Ab, Aburatsubo; Bs, Boso Peninsula; Iz, Izu Pensinula. Inset: Ph, Philippine Sea Plate; Pc, Pacific Plate; Er, Eurasian Plate.

The floor of the summit crater of Mihara-yama rose approximately 400 m before the Great Kanto Earthquake of 1923 ($M=7.9$) and the Bosooki Earthquake of 1953 ($M=7.5$), (see ref. 1). Both earthquakes occurred along the Sagami Trough, which extends from the Japan Trench, 180 km south-east of the Boso Peninsula, through Sagami Bay to the city of Odawara on the coast (Fig. 1).

The Sagami Trough forms a border between the Philippine Sea Plate and the Eurasian Plate (ref. 2 and Fig. 1). It is a right-lateral fault with an underthrusting component[3] indicating subduction of the Philippine Sea Plate. Stress between the two plates causes seismic activity along the trough. I have noticed that subsidence of the southern Kanto district around Aburatsubo occurs concurrently with a north-westerly movement of the Philippine Sea Plate. Marked drops in the altitude of the area were recorded before the earthquakes of 1923 and 1953. Further, on both occasions, as the land mass dropped, the floor of Mihara-yama's summit crater rose as much as 400 m, and the volcano erupted.

The earthquakes occurred almost concurrently. The crater's floor fell when the Aburatsubo area rose again after the earthquakes (Fig. 2). It has been suggested that the magma is squeezed up by the compressional crustal strain[1]. I conclude therefore, that the increased compressional crustal stress along the trough forces a downward movement of the Aburatsubo area and squeezes up the magma beneath Mihara-yama, and that, consequently, large earthquakes occur to release strain along the trough. Such activity is regarded as one contributing factor to a major eruption and earthquake.

Mihara-yama's volcanic activity is apparently related to that of Miyakejima, a volcanic island about 80 km south of Oshima. When crustal stress builds up along the trough, Miyakejima begins a cycle of activity of volcanic earthquakes with three frequency maxima, erupting during the second maximum (Fig. 3). Volcanic earthquakes result as stress concentrates beneath the smaller volcano. The stress, though not strong enough to trigger a major eruption of Mihara-yama, does stimulate activity beneath it. In fact, when Miyakejima erupts, a minor eruption occurs on Mihara-yama. When Mihara-yama erupts, all volcanic

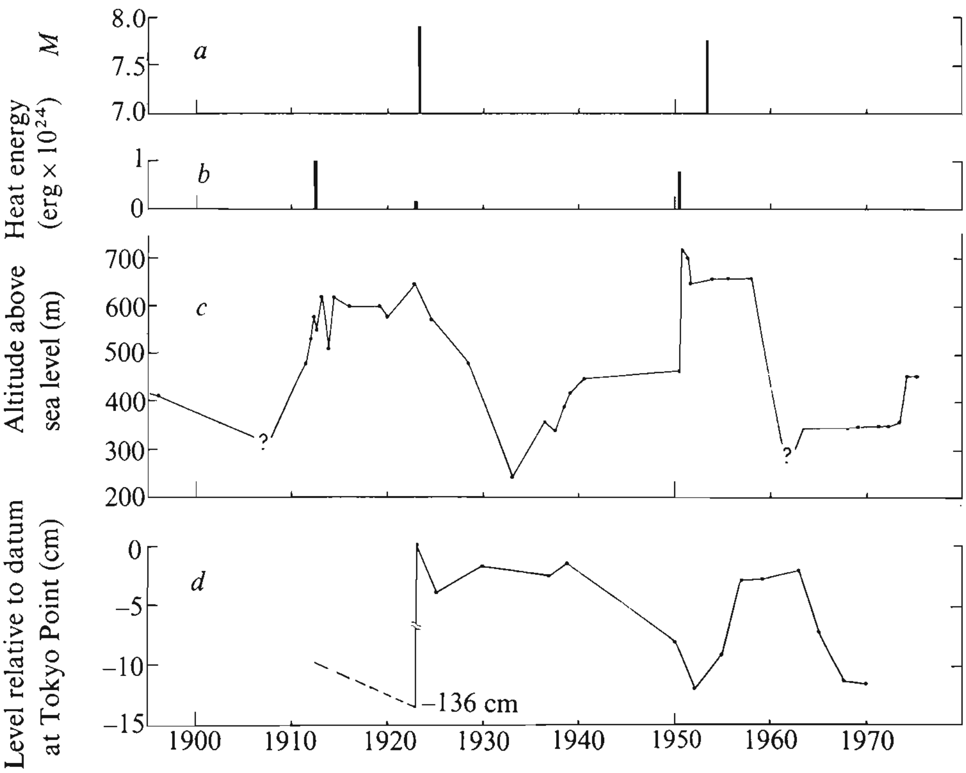

Fig. 2 Relationship between large eruptions, changes in level of floor of summit crater of Mihara-yama, and large earthquakes that have occurred along the Sagami Trough. *a*, Record of large earthquakes along the Sagami Trough (used magnitude data were officially determined by the Japan Meteorological Agency); *b*, heat energy discharged by large eruptions of Mihara-yama[1]; *c*, changes in levels of floor of the summit crater of Mihara-yama (ordinate shows the height above sea level; levelling data to 1958 from refs 7 and 8, after 1958, collected by author); *d*, changes in level at Aburatsubo (solid line measured with precise levelling relative to datum at Tokyo Point[9], and the broken line was deduced from tidal data[10]).

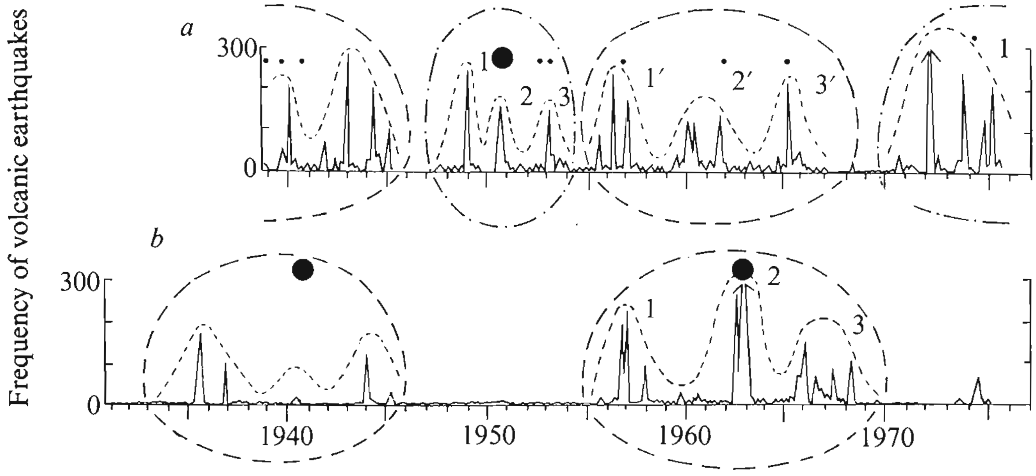

Fig. 3 Relationship between volcanic earthquakes and eruptions in Oshima (*a*) and Miyakejima (*b*) (data from the Japan Meteorological Agency). ●, Eruption points (large dots represent large eruptions; smaller dots represent smaller eruptions which ejected essential magmatic materials). Portions enclosed in the regular broken line, active stages of Miyakejima (*b*). Correlative activity at Oshima (*a*), (relative to datum at Miyakejima) is also enclosed in a regular broken line. Portions enclosed in the irregular broken line (—–—–·—–—), show active stage of Mihara-yama, Oshima. 1, 2, 3 and 1′, 2′, 3′, maxima of frequency of volcanic earthquakes in respective stages.

activity on Miyakejima stops. This implies that strain is first released on Miyakejima, and then accumulates under Mihara-yama. This is a major contributing factor in causing Mihara-yama to enter the active stage. Miyakejima last erupted in 1962. Mihara-yama began its first maximum in 1970; it will probably end sometime in 1975 (Fig. 3).

During the past 200 yr, four large eruptions have occurred on Miyakejima, followed by large eruptions on Mihara-yama at intervals ranging from 2 to 17 yr after activity was first noted on Miyakejima. Large earthquakes followed the eruptions of Mihara-yama within 3–11 yr (ref. 4). Since Miyakejima erupted in 1962, and since Mihara-yama has almost completed its first maximum, we can safely assume that it will erupt sometime between 1975 and 1979. In fact, in 1974 I observed a 100-m elevation of the floor of Mihara-yama's summit crater (ref. 5 and Fig. 2*c*).

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1 Nakamura, K., *Bull. volcan. Soc. Japan*, **16**, 63–71 (1971).
2 Sugimura, A., *Kagaku*, **42**, 192–202 (1972).
3 Kanamori, H., and Ando, M., *Publs 50th Anniversary of the Great Kanto Earthquake, 1923*, 89–101 (Earthquake Research Institute, University of Tokyo, 1973).
4 Kimura, M., *J. Geogr.*, **82**, 171–188 (1973).
5 Kimura, M., and Toyoda, J., *Bull. volcan. Soc. Japan*, **19**, 65–78 (1975).
6 Nagumo, S., *Publs 50th Anniversary of the Great Kanto Earthquake, 1923*, 273–291 (Earthquake Research Institute, University of Tokyo, 1973).
7 Tsuya, H., Okada, A., and Watanabe, T., *Bull Earthq. Res. Inst., Tokyo Univ.*, **34**, 33–59 (1956).
8 Kizawa, T., and Tanaka, Y., *Pap. Meteorol. Geophys.*, **23**, 411–428 (1972).
9 Fujita, N., *Rep. coord. Comm. Earthquake Prediction*, **5**, 36–37 (1971).
10 Imamura, A., *Publs Imp. Earthq. invest. Comm.*, **25**, 1–143 (1930).

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