地 震 研 究 所 彙 報
Bull. Earthq. Res. Inst.
Univ. Tokyo
Vol. 81 (2006) pp. 291-294

Deep Drilling at the Arc-arc Collision Zone in the Yamakita Area, Central Honshu, Japan

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Abstract

We carried out borehole drilling in the Yamakita area near an active fault of the arc-arc collision zone in the western part of Kanagawa Prefecture. Slime and core samples were obtained. The borehole geology was established by examined them using petrographic analyses and geophysical logging data. We found that the southwestern slope of Mt. Maruyama was down-faulted from the northern slope of the mountain by an unknown fault. After drilling was completed, the borehole was established as a Hi-net seismic observation station. Data are collected by the Hi-net observation system and made available through the INTERNET.

Key words : borehole drilling, Mt. Maruyama, Hinata thrust, Hi-net

1. Introduction

A collision boundary of 2 island-arc systems, namely, Izu-Ogasawara and Honshu arcs, is located at the southwestern part of the Kanto region, central Honshu, Japan. Many active faults such as the Kozu-Matsuda Fault are distributed in the collision zone. It is important to obtain the detailed geologic structure of the active-fault system for estimating seismogenic risk in the Kanto region. The 1923 Kanto earthquake occurred at the upper boundary of the subducting Philippine Sea slab beneath the southern part of the Kanto region. The seismic velocity structure at a shallow depth in the collision zone is a key to earthquake disaster mitigation in the Kanto region.

We carried out borehole drilling in the Yamakita area near an active fault of the arc-arc collision zone in the western part of Kanagawa Prefecture (Fig. 1). Slime and core samples were obtained. The borehole geology was established by examined them using petrographic analyses and geophysical logging data. After drilling was completed, the borehole was established as a Hi-net seismic observation station.

2. Geological Setting

The Yamakita-Minami drilling site (35.3551°N, 139.0942°E, 152 m in altitude) is located on the southwestern slope of Mt. Maruyama in the Ashigara Mountains (Figs. 1, 2). The Ashigara Mountains are located between 2 major Quaternary thrust systems ; namely, the Kan'nawa and Kozu-Matsuda fault systems. The Hinata Thrust is an active fault of the Kozu-Matsuda fault system, and is located at the topographic boundary between Mt. Maruyama and the Ashigara Plain (Soh, 1995).

The Ashigara Mountains are mainly composed

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of Plio-Pleistocene trough-fill deposits called Ashigara Group (Amano *et al.,* 1986). The Ashigara Group is unconformably overlain by Pleistocene Hakone old somma (OS) and terrace deposits. Mt. Maruyama crops out mainly as the Neishi Formation of the lowest part of the Ashigara Group, which consists of pyroclastic rocks and mudstone. The Neishi Formation is thought to thrust up to the southward OS deposits through the low-angle Hinata Thrust beneath Mt. Maruyama.

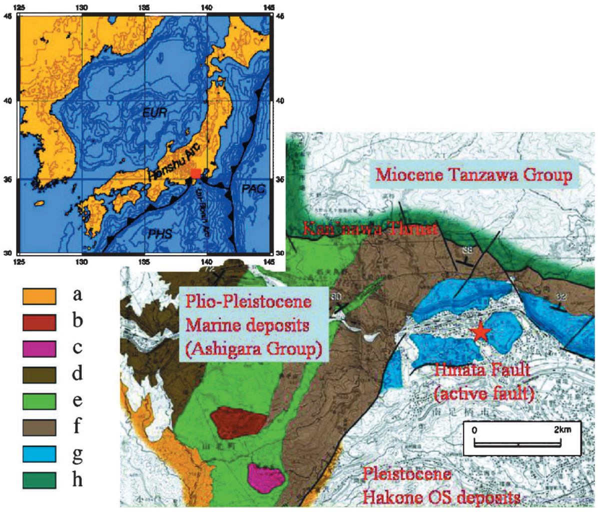

Fig. 1. Map showing the geologic setting of the Yamakita-Minami drilling site (red star). a : Pleistocene Hakone OS deposits, b : Pleistocene andestic rocks, c : Pleistocene quartz diorite, d-g : Pliocene-Pleistocene Ashigara Group, h : Miocene Tanzawa Group. The geologic map is partly modified after Amano *et al.* (1986).

Fig. 2. Photograph of borehole drilling at Yamakita-Minami.

3. Borehole Geology

At the present drilling site, whole core samples down to 1076.6 m and 4 deeper spot-core samples from a total depth of 2035.4 m were recovered. Geophysical logging and VSP methods were conducted at the present borehole.

The core samples are mainly composed of volcanic breccia, lapilli tuff, lava flow, and subordinate conglomerate, sandstone, mudstone (Fig. 3). With respect to logging and VSP data, the present borehole geology is divided into 8 units as follows in descending order (Fig. 4) :

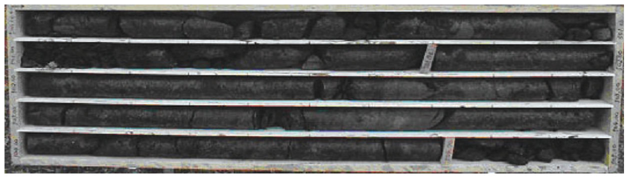

Fig. 3. Core sample from 500 to 505 m in depth (volcanic breccia of the Unit D).

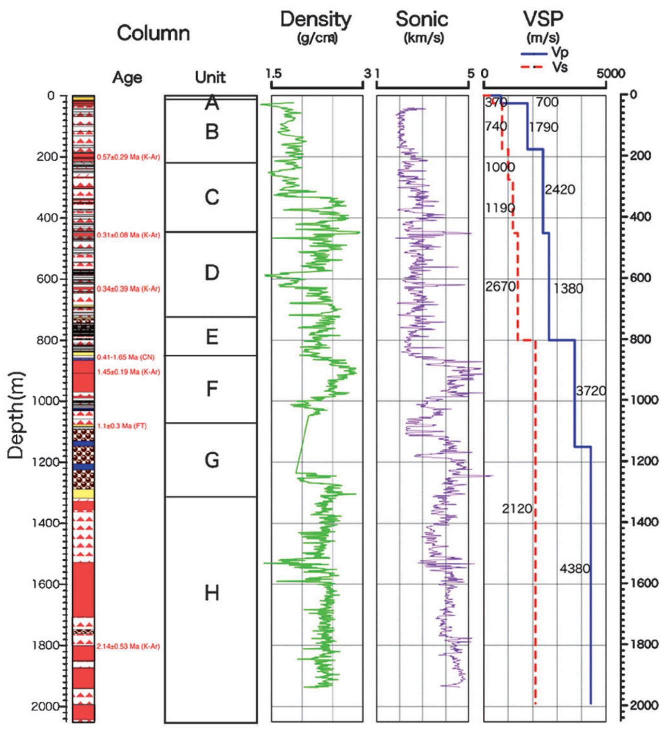

Fig. 4. Profile of the Yamakita-Minami borehole.

- Unit A (0–13.5 m in depth interval) : brown weathered tephra with scoria.
- Unit B (13.5–221 m) : volcanic breccia and lava composed of olivine basalt.
- Unit C (221–445 m) : volcanic breccia and lava composed of olivine bearing 2 pyroxene basaltic andesite.
- Unit D (445–721 m) : volcanic breccia and lava composed of olivine basalt.

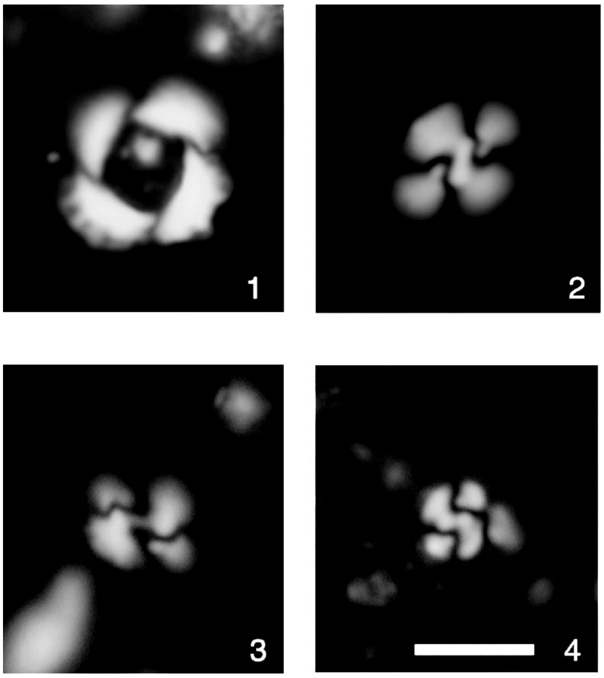

Fig. 5. Calcareous nannofossils from the Yamakita-Minami borehole. 1 : *Pseudoemiliania lacunosa* (838.0 m in depth), 2 : *Gephyrocapsa caribbeanica* (838 m), 3 : *Gephyrocapsa oceanica* (830.75 m), 4 : *Gephyrocapsa* sp. (830.75 m). Scale bar = 3 micrometers.

- Unit E (721–855 m) : subrounded cobblestone, sandy lapillistone and very coarse-grained sandstone with shell fragments and microfossils.
- Unit F (855–1076 m) : lava, volcanic breccia and lapilli tuff composed of 2 pyroxene andesite.
- Unit G (1076–1315 m) : altered tuffaceous conglomerate intercalating sandstone and mudstone.
- Unit H (1315–2035.4 m) : altered andesitic lava and volcanic breccia.

Potassium-Argon and fission track ages were obtained from 6 horizons of core samples (Fig. 4). Coarse-grained sandstone at 830.75 m in depth yields calcareous nannofossils, and is correlated with the zones from CN13b to CN14a (1.65 to 0.41 Ma) of Okada and Bukry (1980) (Fig. 5). According to these dating and petrographic data, the geologic units are stratigraphically identified (Fig. 4). Unit A is correlated with late Pleistocene tephras that erupted from Fuji Volcano. Units B, C, and D are classified into Hakone Volcano OS deposits. Units E, F, G, and H are interpreted to be Plio- Pleistocene basement rocks of Hakone Volcano.

The northern slope of Mt. Maruyama exposes the Plio-Pleistocene marine deposit Neishi Formation of the Ashigara Group. At the present borehole geology of the southwestern slope, however, the Pleistocene terrestrial OS deposits are distributed from 13.5 m to 721 m in depth. With respect to the elevation of the present drilling site, it is suggested that the southwestern slope of Mt. Maruyama should be down-faulted from the northern slope of the mountain by an unknown fault. The assumed displacement of this unknown fault is at least 500 m. Assuming that the age at the base of the OS deposits

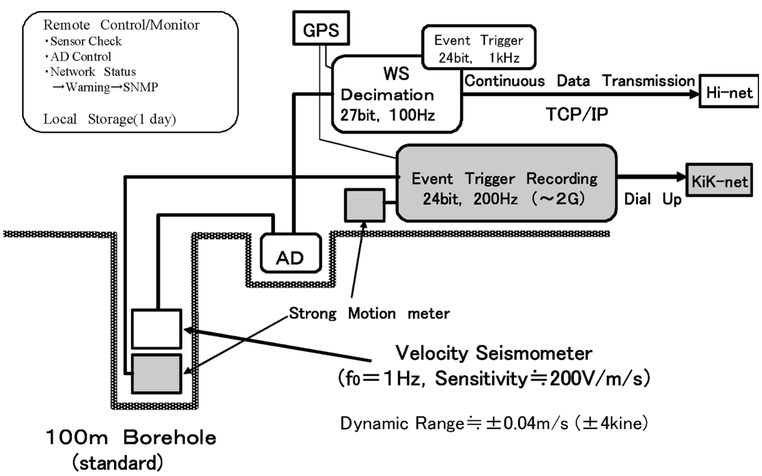

Fig. 6. Hi-net seismic observation station.

is about 0.5 Ma, the average displacement rate of the newly-suggested fault should be more than 1 mm/year.

4. Installed Seismometers

After drilling was completed, seismometers of Hi-net specifications were installed at the bottom and the surface of the borehole (Fig. 6). Data are distributed by the Hi-net seismic observation system and made accessible through the INTERNET (Okada *et al.,* 2004). Using these data, it became possible to obtain the seismic structures around the borehole, such as 3-dimensional seismic velocity and Q structures by a seismic tomography method.

5. Conclusion

- Drilling in the Yamakita area at western part of the Kanagawa Prefecture, we obtained the seismic and geological profile along the borehole.
- Examining core samples and slime using petrographic analyses and geophysical logging data, we found that the southwestern slope of Mt. Maruyama is down-faulted from the northern slope of the mountain by an unknown fault.
- The borehole was established as a Hi-net seismic observation station after drilling was competed.

Acknowledgments

This workshop is sponsored by the Special Project for Earthquake Disaster Mitigation in Urban Areas from the Ministry of Education, Culture, Sports, Science and Technology of Japan. GMT software (Wessel and Smith, 1991) is used to draw some of the figures.

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(Received November 29, 2005)
(Accepted April 19, 2006)