CHAPTER 2

STUDY AREAS

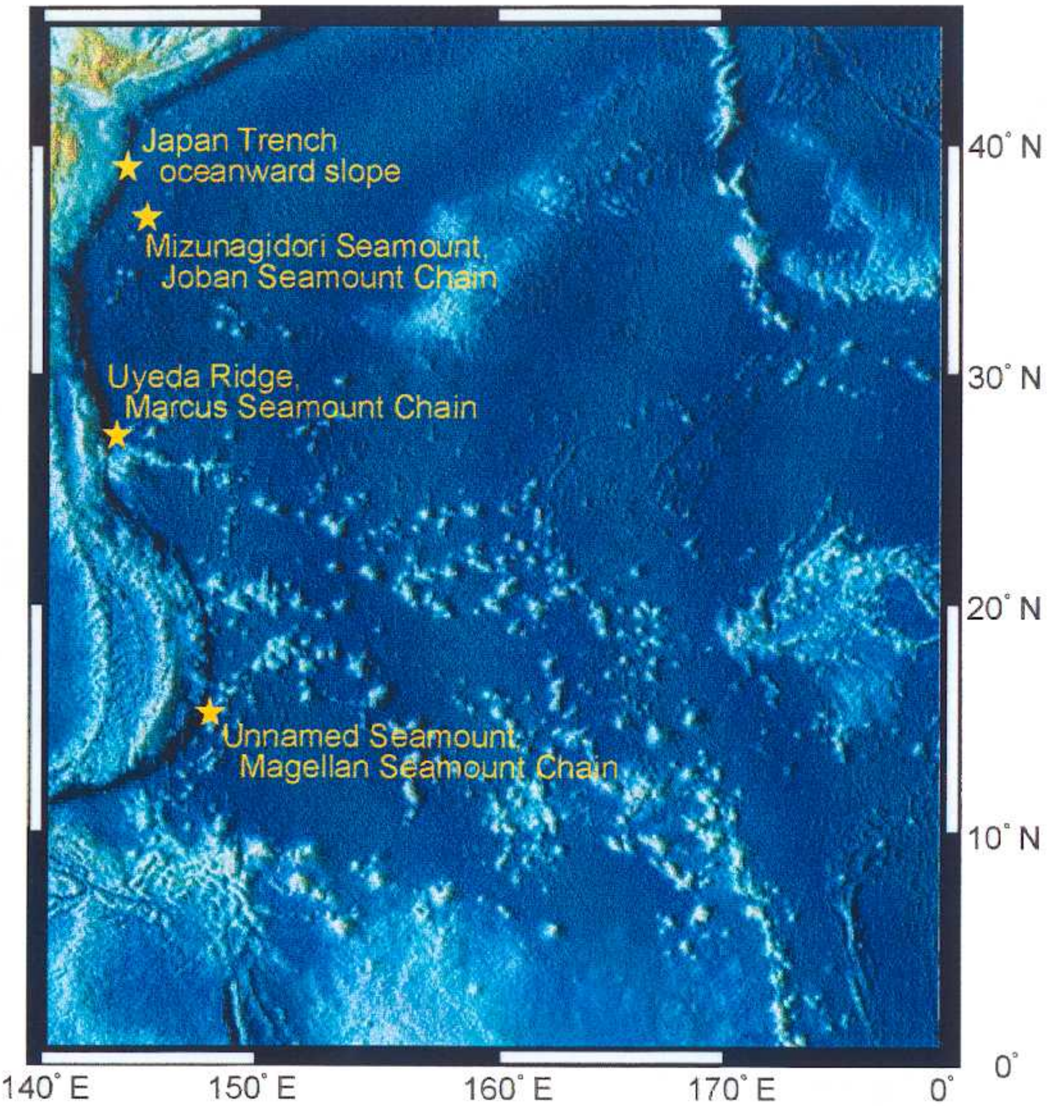

Figure 2.1 Sampling site in the WPSP.

2-1 Sampling Site

Seamounts in the WPSP at present have been carried into oceanic trenches at the western margins of the Pacific Plate and dislocated by normal faulting caused by horizontal extension due to the plate subduction at the trench oceanward slope. The samples used in this thesis were collected from such seamounts, which are expected to be the Cretaceous volcanic edifices (Appendix A, Figure 2.1).

2-2 Japan Trench Oceanward Slope

During the *KAIKO* mission of KR97-11 cruise by ROV *KAIKO* of Japan Marine Science and Technology Center (JAMSTEC), we found continuous outcrops of alkaline pillow basalt and collected two samples at the oceanward slope toe of the northern Japan Trench ($39^{O}23.1173'$ N, $144^{O}15.6582'$ E) of approximately 7300 to 7400 meters depth. These were exposed at the normal fault scarp on the down-going Pacific Plate of Late Cretaceous age (Figure 2.2). Normal faults are mostly parallel to the trench direction, N-S, with some exceptional NNW or NNE ones, due to the warping of the Pacific Plate (Kobayashi *et al.*, 1998). Many horst and graben structures of 10 km horizontal range with 100 m to 500 m scale vertical displacement are developed (Ogawa *et al.*, 1996a) (Figure 2.3).

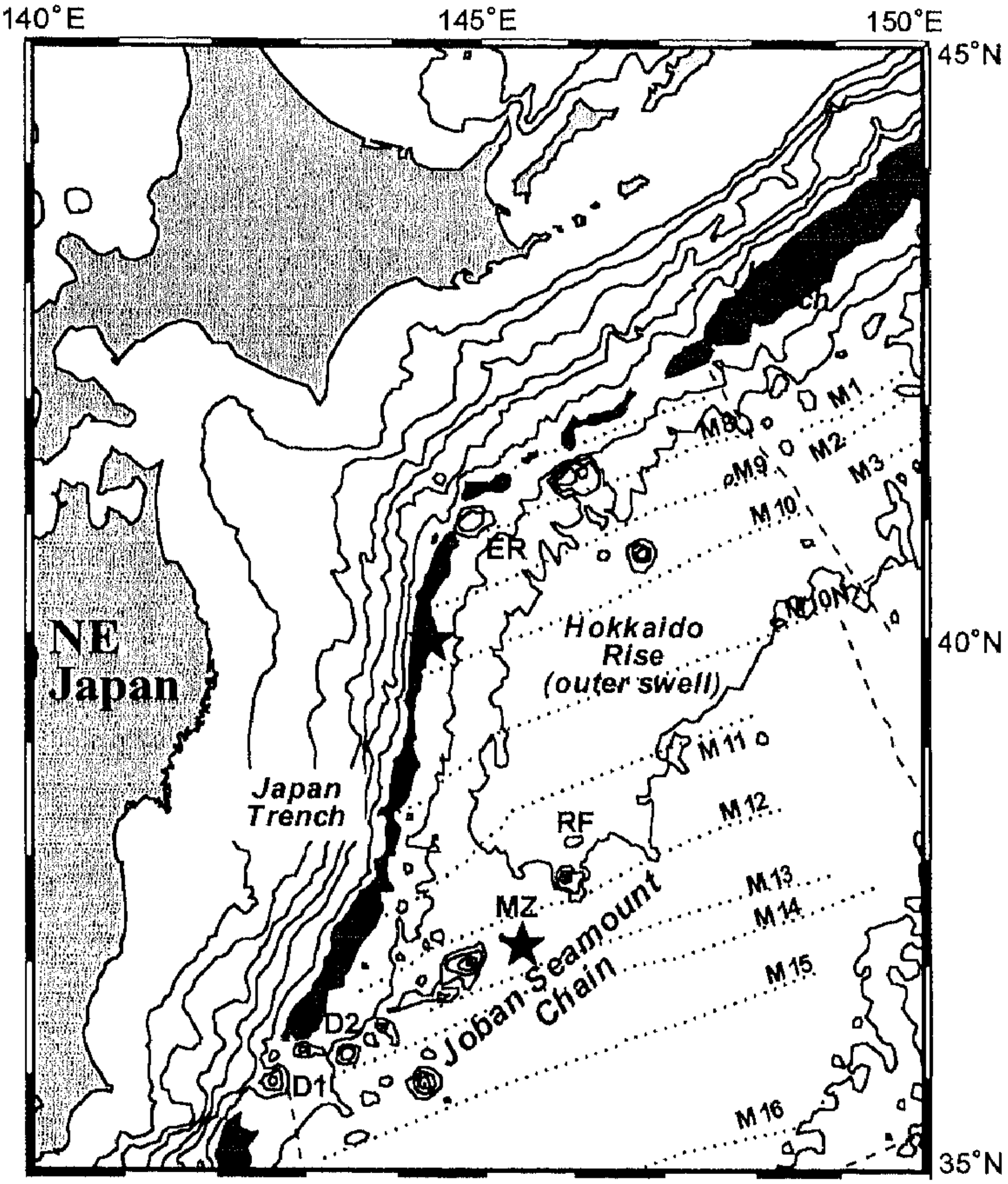

Figure 2.2 Bathymetric map around the Japan Trench. Dotted lines are magnetic lineations, and broken lines are fracture zones. Asterisks are study sites (Japan Trench oceanward slope and Mizunagidori Seamount). Seamount symboles and their radiometric ages are as follows, D1: Daiichi-Kashima Seamount (120 Ma Ar-Ar age; Takigami *et al.*, 1992), D2: Daini-Kashima Seamount (81 Ma K-Ar age; Ozima *et al.*, 1970), MZ: Mizunagidori Seamount (this study; see next chapter 2-3), Ryofu Seamount (70-72 Ma K-Ar age; Ozima *et al.*, 1970) and ER: Erimo Seamount (104 Ma Ar-Ar age; Takigami *et al.*, 1989).

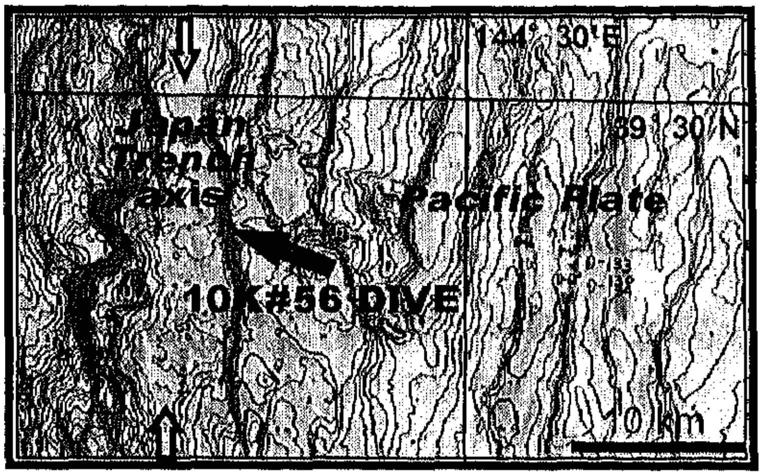

Figure 2.3 Seabeam map around the 10K#56 dive site in the Japan Trench oceanward slope.

Alkaline pillow basalt and hyaloclastite outcrops are continued from 7325 to 7355 m depths. The bathymetry near the Japan Trench oceanward slope does not show any large edifice for a seamount (Figure 2.3). There are rather many seamounts and guyots just off the Japan Trench, as the Joban Seamount Chain (Figure 2.2) (Masalu *et al.*, 1997; Nakanishi *et al.*, 1998 etc.). The representative 120 Ma Daiichi-Kashima Seamount and 104 Ma Erimo Seamount are studied (Takigami *et al.*, 1989). In paticular, Joban Seamount Chain may be the products of Cretaceous hotspot origin because of the straight line as a hotspot trace (see chapters 2-3 and 4).

However, as noted later, the origin of the alkali-basalts from the Japan Trench oceaward slope have no link with these Cretaceous seamounts.

2-3 Joban Seamount Chain

The Joban Seamout Chain is a good collinear chain of the azimuth of the SW to NE and is composed of main 10 seamounts; those are the Daiichi-Kashima, Katori, Daini-Kashima, Daisan-Kashima, Daiyon-Kashima, Hitachi, Iwaki, Mizunagidori, Soma and Ryofu Seamounts from the SW. The Daigo-Kashima Seamount is SE off the Joban Seamount Chain (Figure 2.4). Topographic characters of the Joban Seamount Chain (Figure 2.5) are as follws:

- Sizes of all seamounts of less 50 km in diameter are clearly smaller than the others in the WPSP seamounts.
- The Daiichi-Kashima, Hitachi and Iwaki Seamounts are guyots, whereas the other seamounts are peaked.
- Spatial gaps between the Hitachi and Daiyon-Kashima Seamounts and between the Mizunagidori and Soma Seamounts divide these seamounts into three groups.
- The Iwaki and Mizunagidori Seamounts in the middle group do not have a concentric topography, whereas the other seamounts are well concentric.
- Very samll seamounts, the Harumi and Yayoi Knoll (Kobayashi *et al.*, 1992), are on the gap between the Soma and Mizunagidori Seamounts side by side.

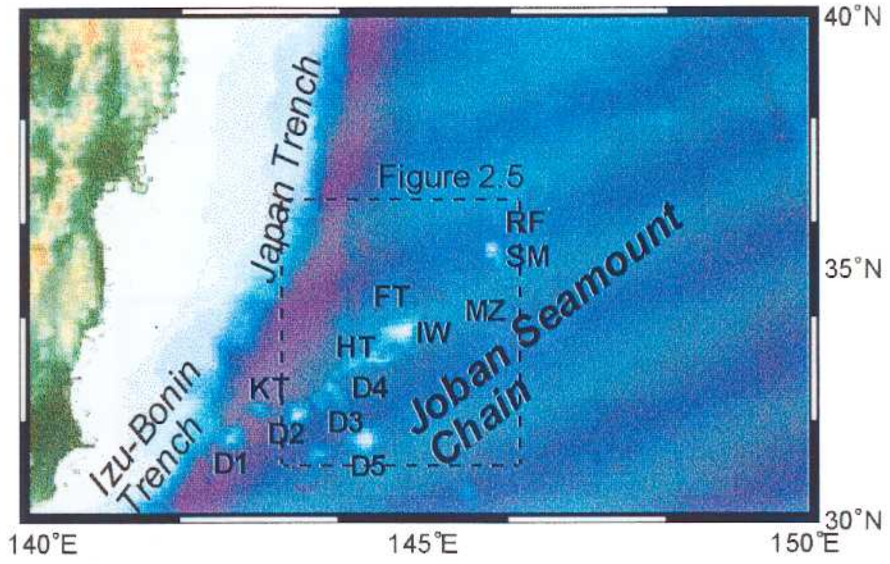

Figure 2.4 Bathymetric map of the Joban Seamount Chain. Seamount symboles are as follows, KT: Katori Seamount, D3: Daisan-Kashima Seamount, D5: Daigo-Kashima Seamount, D4: Daiyon-Kashima Seamount, HT: Hitachi Seamount, IW: Iwaki Seamount, FT: Futaba Seamount and SM: Soma Seamount. Others symbols, D1, D2, MZ and RF, are the same as Figure 2.2.

During the Japan-France *KAIKO* Project in 1985, a deep-sea submersible, *Nautile*, surveyed the Daiich-Kashima Seamount and found the limestone on the top above volcanic rocks (Kobayashi *et al.*, 1987), and some volcanic rocks from the Daiichi-Kashima Seamount are dated that the Ar-Ar plateau ages of the trachy andesite and olivine basalt are 120.4±2.7 and 118±10 Ma, respectively (Takigami *et al.*, 1989). Although the Daini-Kashima and Ryofu Seamounts have been dated as the K-Ar age being 81 Ma and 70 to 72 Ma were obtained, respectively (Ozima *et al.*, 1970; Kaneoka *et al.*, 1971), in this thesis, these ages by the K-Ar method should not be adopted as mentioned previously (see chapters 1-6 and 3-3).

In this thesis, the samples dredged from the top of the Mizunagidori Seamount during KH92-3 cruise of the R.V. *Hakuho-Maru* by Ocean Research Institute, University of Tokyo, at the 37°07' N, 145°20' E to 37°09' N, 145°17' E, and approximately 2800 to 2300 meters depth, are used.

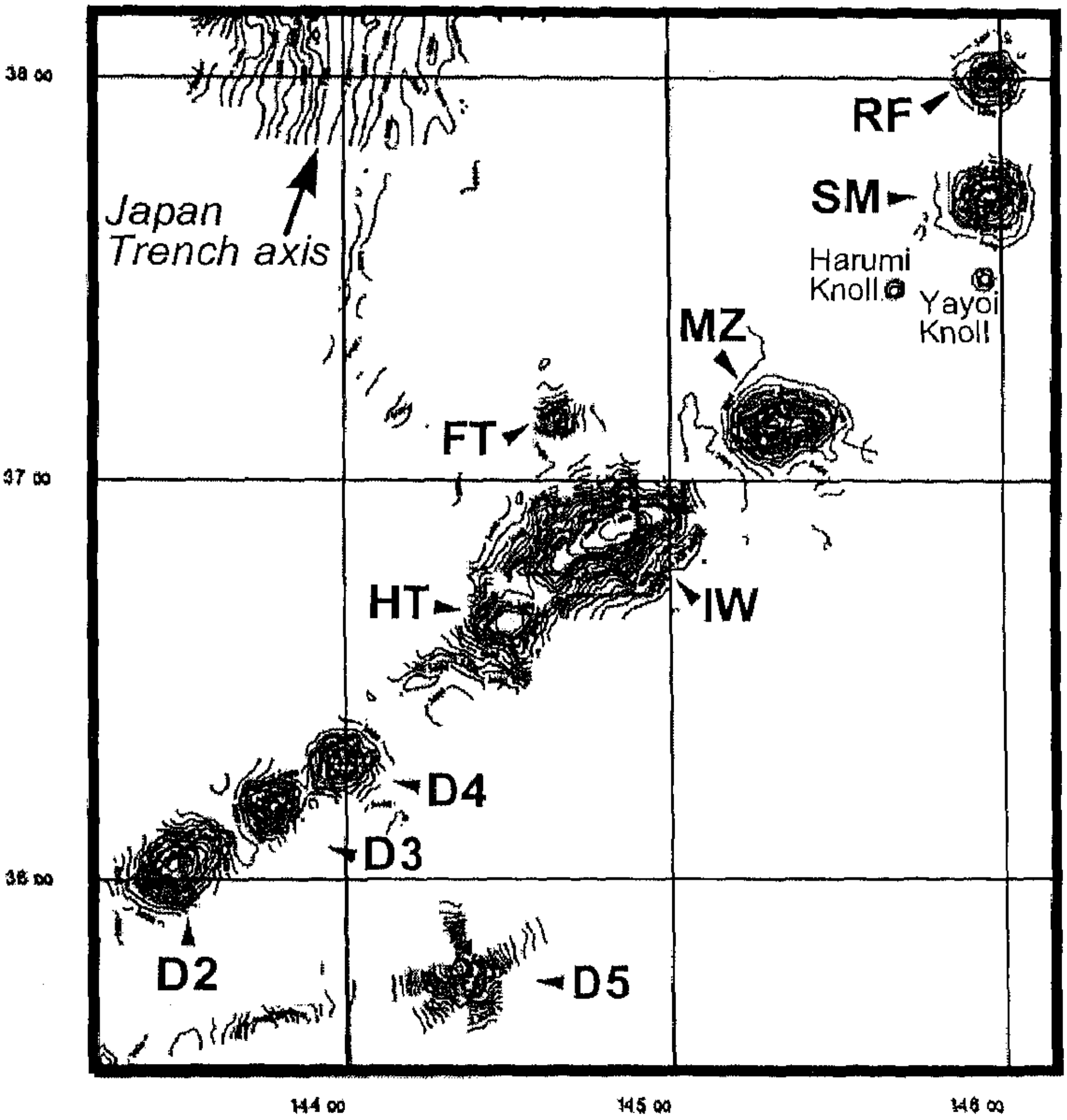

Figure 2.5 Topographic map of Joban seamount Chain after Kobayashi (1992). After Kobayashi (1992).

2-4 Uyeda Ridge in Marcus-Wake Seamount Chain

Uyeda Ridge

The Uyeda Ridge is located around 27°20'N and 144°E at the western tip of the Marcus Seamounts Chain (Figure 2.6), and is approximately 148 km long, 18 km wide in average and 36 km at its greatest width. As this topography is very peculiar compared with many other seamounts in the WPSP (Figure 2.7), the origin of the Uyeda Ridge is thought to be part of an extinct remnant spreading center or to be a product of some magma leakage (Smoot and Heffner, 1986; Kobayashi, 1990).

At the southern neighbor of the Uyeda Ridge, the Michelson Ridge including the Ogasawara Plateau characterizes the peculiar topography in the WPSP. It is over 550 km long on an azimuth of 275° and is composed of four guyots of irregular shape (Figure 2.6). Smoot (1983) suggested that the Ogasawara Plateau corresponds to the western Michelson Ridge jammed into the trench. Shiba (1979) reported the mid-Cretaceous limestones from the Yabe Guyot (Shiba, 1979), or the Smoot Guyot (Smoot, 1983) of an alias, in the Michelson Ridge. However no radiometric ages have ever been known from intra-plate volcanic edifices around this area.

The western part of the Uyeda Ridge is dislocated by two large N-S trending normal faults caused by horizontal extension due to the plate subduction at the trench oceanward slope (Figure 2.7). The samples were dredged from this western tip of the Uyeda Ridge during KH87-3 cruise of R.V. *Hakuho-Maru* by Ocean Research Institute, University of Tokyo, at the 27°08' N to 27°10' N, 143°27' E, and 6129 to 5869 meters depth.

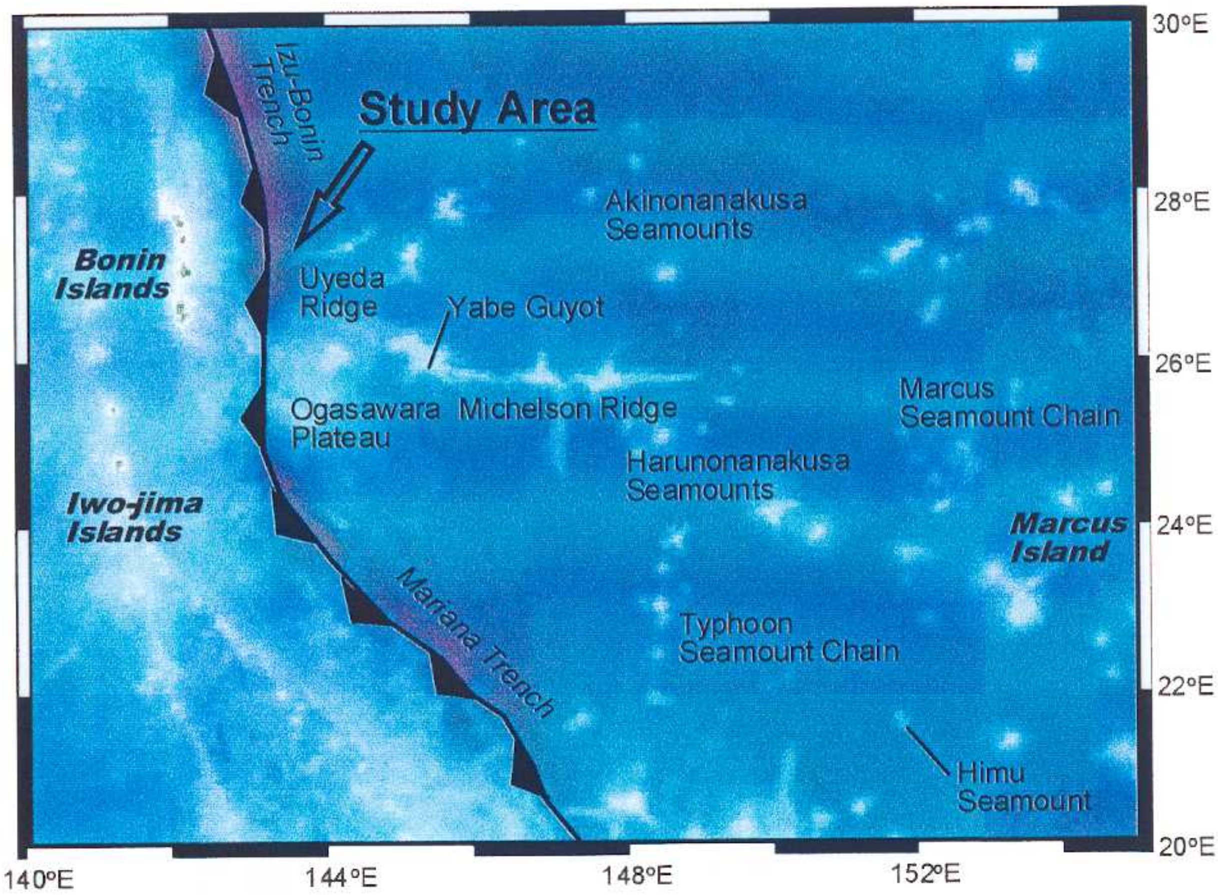

Figure 2.6 Bathymetric map around the Uyeda Ridge.

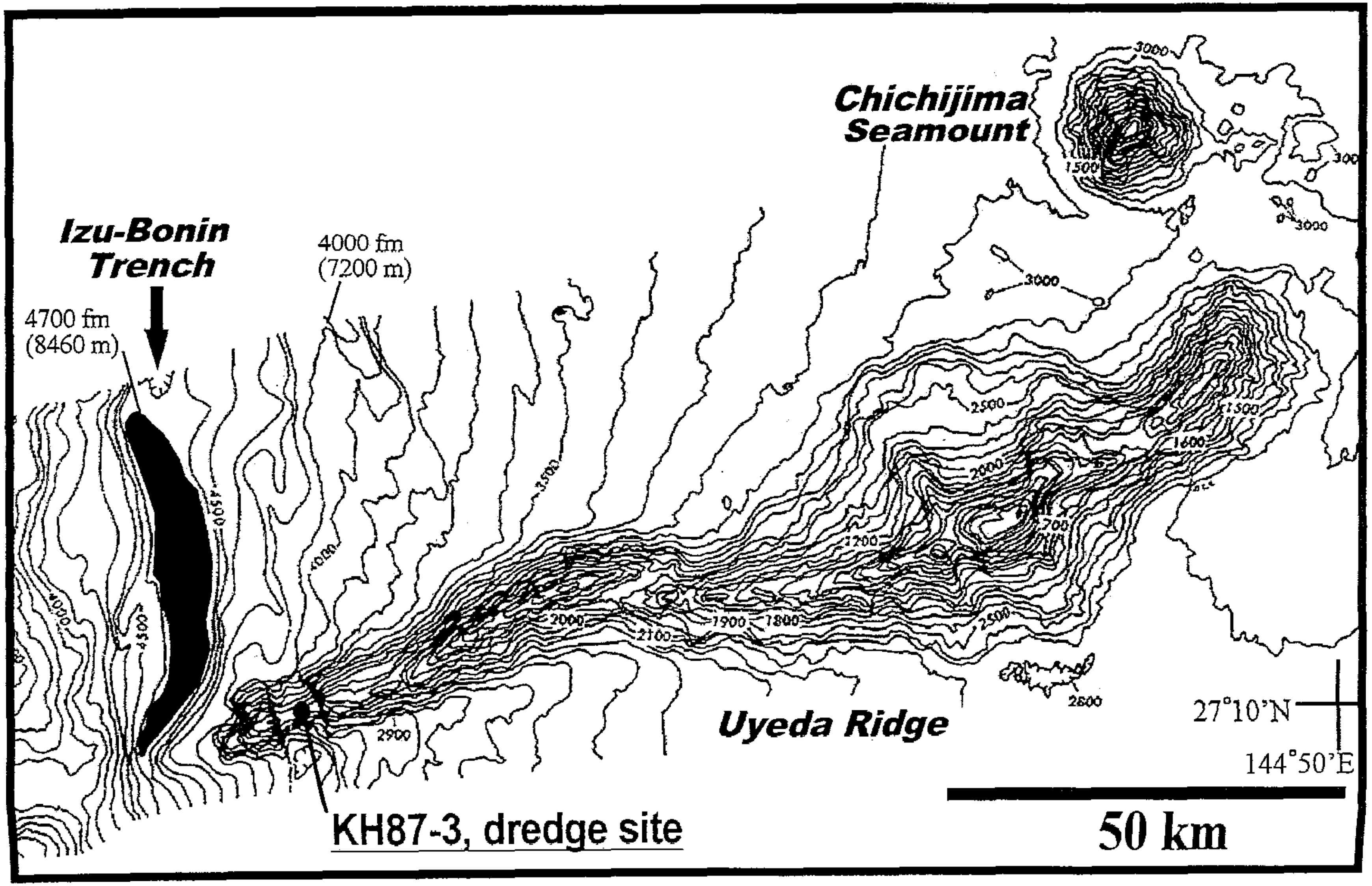

Figure 2.7 The Uyeda Ridge. The contour interval is 100 fm.

Marcus-Wake Seamount Chain

The Marcus-Wake Seamount Chain distributes as a seamount trail of the WSW azimuth from the Uyeda Ridge to ENE and has two islands, the Marcus and Wake Islands. The western Wake Seamount Chain has broader NS-width than the eastern Marshall Seamount Chain, and may be crossed by some seamount chains of various trends. In the Eastern Marcus Seamount Chain, the Wake Seamount Chain, some Ar-Ar ages of 80 to 98 Ma are reported by Winterer *et al.* (1993) (Figure 1.6).

2-5 Magellan Seamount Chain

The Fukunaga seamount at the western tip of the Magellan Seamount Chain is now subducted to the Mariana Trench (Figure 2.8) at around 15°29' N and 147°50' E, and is at least 35 km in diameter and approximately 3000 m in altitude from the abyssal plain. This is dislocated by normal faults caused by horizontal extension due to the plate subduction at the trench oceanward slope (Figure 2.9) (Ogawa *et al.*, 1994). The faulting produced many steep cliffs composed of volcanic rocks and pelagic sedimentary rocks (Figure 2.10). Two volcanic rock and four sedimentary rock samples were collected from these cliffs during the 181st dive of JAMSTEC submersible *Shinkai 6500* on October 4th, 1993, at approximately 6000 to 6400 m depth (Figure 2.10).

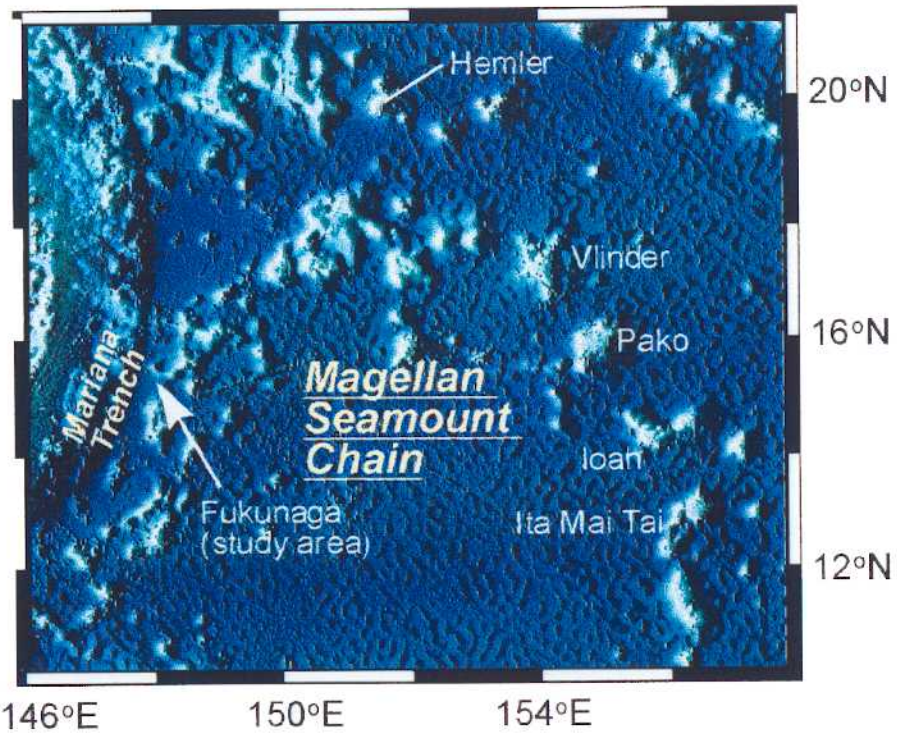

Figure 2.8 Bthymetric map around the Mariana Trench and Fukunaga Seamount.

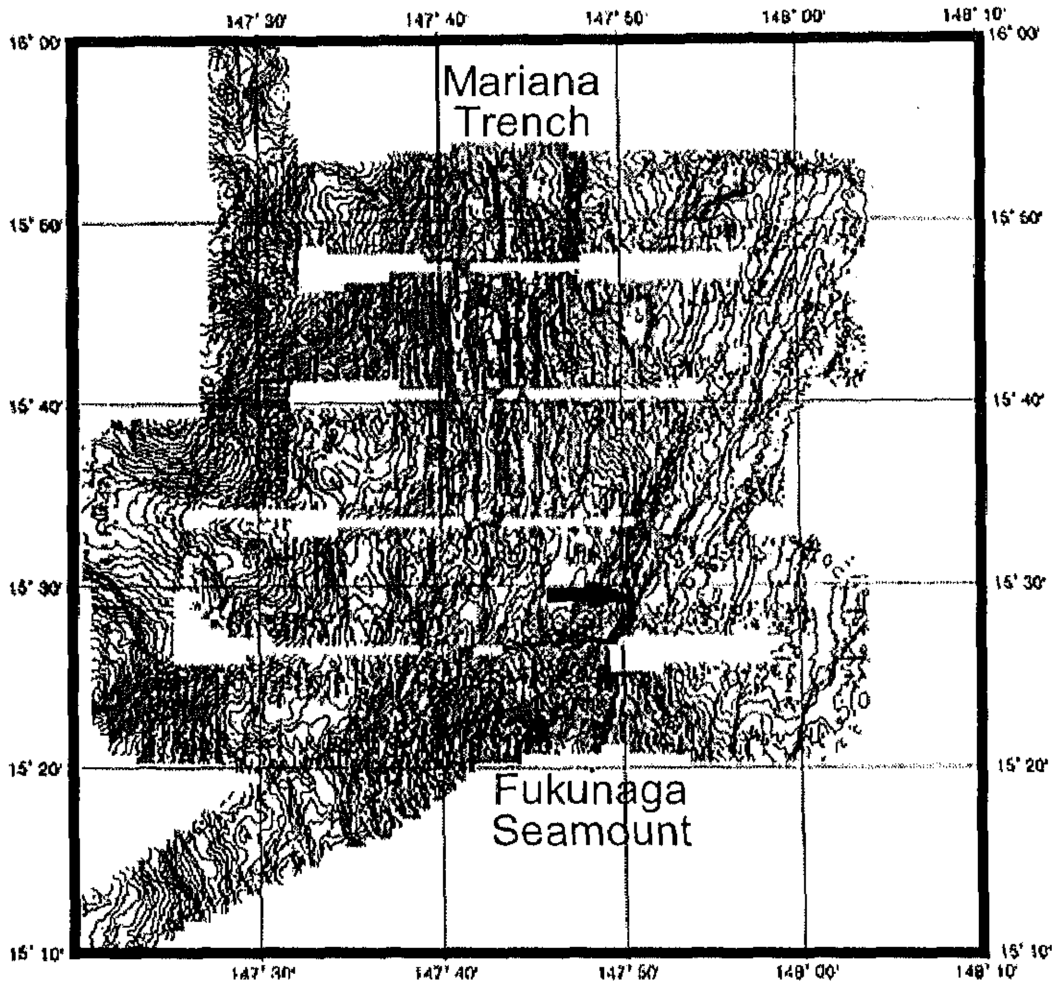

Figure 2.9 Multi-narrowbeam map of the study area. An arrow shows the sampling site. Contour interval is 100 m. Adopted from Ogawa *et al.* (1994).

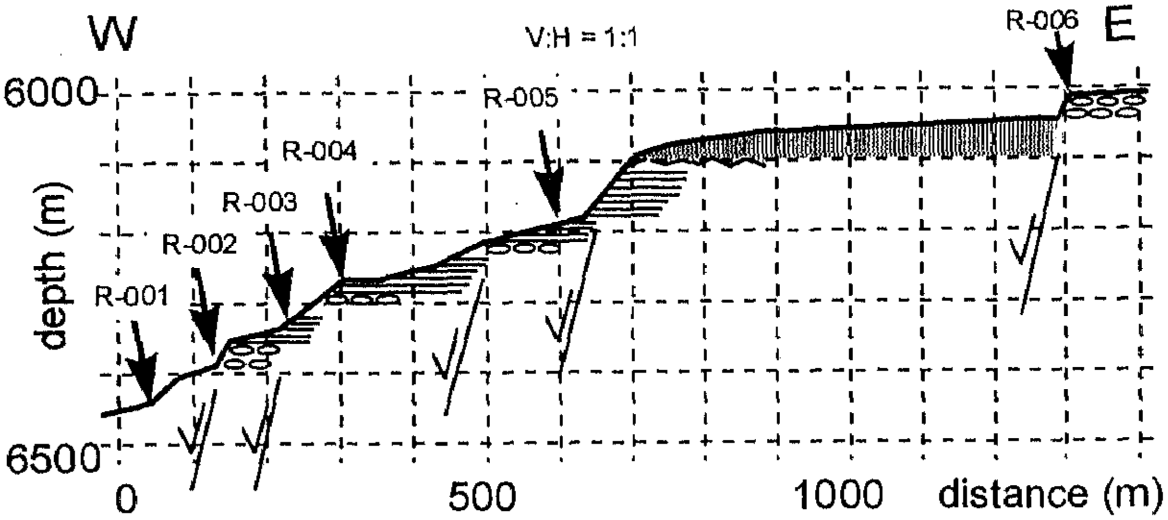

Figure 2.10 W-E cross section of dive 181. Symbols of rock types are ellipses (lava), lines (chert) and dots (clay). Some normal faults inferred on the bottom of the cliff are also shown. Samples dated in this study are R-002, R-003 and R-006.

As mentioned above, age distribution of seamounts in the Magellan Seamount Chain and neighboring seamounts chains, the Marshall-Gilbert Seamount Chain and the Marcus-Wake Seamounts Chain, are also complicated (see chapter 1.6). Among them, there are some Early Cretaceous seamounts (e.g. Himu and Hemler Seamounts (Smith *et al.*, 1989); Ita Mai Tai Seamount (Koppers *et al.*, 1998); Look Seamount (Lincoln *et al.*, 1993)) within dominant Late Cretaceous ones (Figures 1.6 and 2.8). Lincoln *et al.* (1993) show possible seamount rejuvenation by passing over the other hotspots later from the gap between the Early and Late Cretaceous fossil ages of some seamounts in the Marshall-Gilbert Seamount Chain. Although Koppers *et al.* (1998) reported a NNW-SSE hotspot track of 100 to 88 Ma Vlinder, Pako and Ioah guyots in the

Magellan Seamount Chain, the southernmost Ita Mai Tai guyot shows disharmonically 120 Ma Ar-Ar age (Figure 1.3). In this study, the Magellan Seamount Chain is mainly shown as the western NE to SW seamount trail belonging to the Fukunaga Seamount and is not the NW to SE chain in Koppers *et al.* (1998).