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Structural framework of the Sumisu Rift, Izu-Ogasawara Arc

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Abstract : The Sumisu Rift is one of the back-arc rifts which extend discontinuously over 600km parallel to and immediately to the west of the volcanic chain of the northern Izu-Ogasawara Arc. The length and width of the Sumisu Rift are about 100km and 30 to 35km respectively. The rift is divided into two segments, namely the North Segment and the South Segment. They are bounded by the Intra Ridge. Both segments are occupied by basins which are covered by thick sediments.

The Sumisu Rift is bounded by normal faults at its western and eastern margins and many faults are developed in the rift. All of the faults runs in nearly N-S direction. Many faults in the rift are considered to be active. They indicate that the rift is being formed by the E-W extensional stress and is considered to be in the rifting stage now.

The normal faults are most active in the eastern part of the South Segment where the uppermost sediments are cut by normal faults, a volcanic mound composed of basaltic rocks is formed on the largest active fault, and high heat flow is measured. The rifting is inferred to be most active in the eastern part of the South Segment.

The Intra Ridge is composed of volcanic ridges and mounds. Major faults are continuous through the ridge from the North Segment to the South Segment and the volcanic ridges are nearly parallel to the faults. They indicate the simultaneous rifting and volcanic activity in the ridge.

The Sumisu Rift is asymmetrical in cross section. The trend of the asymmetry in the southern part of the rift is reverse relative to the northern and middle parts. The faults of the eastern boundary have greater displacements than those of the western boundary in the northern and middle parts of the rift, but faults of the western boundary are greater than those of the eastern boundary in the southern part. Although the faults of the eastern and western boundaries are shifted eastward in the southern part of the rift, the faults in the eastern part of the rift are continuous through the rift.

1. Introduction

The Izu-Ogasawara Arc is an active island arc which has many volcanic islands and submarine volcanoes along the volcanic chain. The Izu-Ogasawara Trench where the Pacific Plate is subducted under the Izu-Ogasawara Arc defines the eastern boundary of the arc. The Shikoku Basin, a back-arc basin, formed in Miocene (KLEIN and KOBAYASHI, 1980), occupies the western side of the arc (Fig.1).

The Izu-Ogasawara Arc consists of several ridges and basins which are the Nishi-Shichito Ridge, back-arc depressions, the Shichito-Iwo Jima Ridge, fore-arc basins, and the Ogasawara Ridge from the west to the east. The Nishi-Shichito Ridge is composed of echelon ridges which are elongated in the NEE direction. The Zenisu Ridge, the northern end of the Nishi-Shichito Ridge, consists of Miocene to Pliocene altered volcanic rocks (ISSHIKI, 1980). Basalt dredged from the Nishi-Shichito Ridge to the west of the Sumi-

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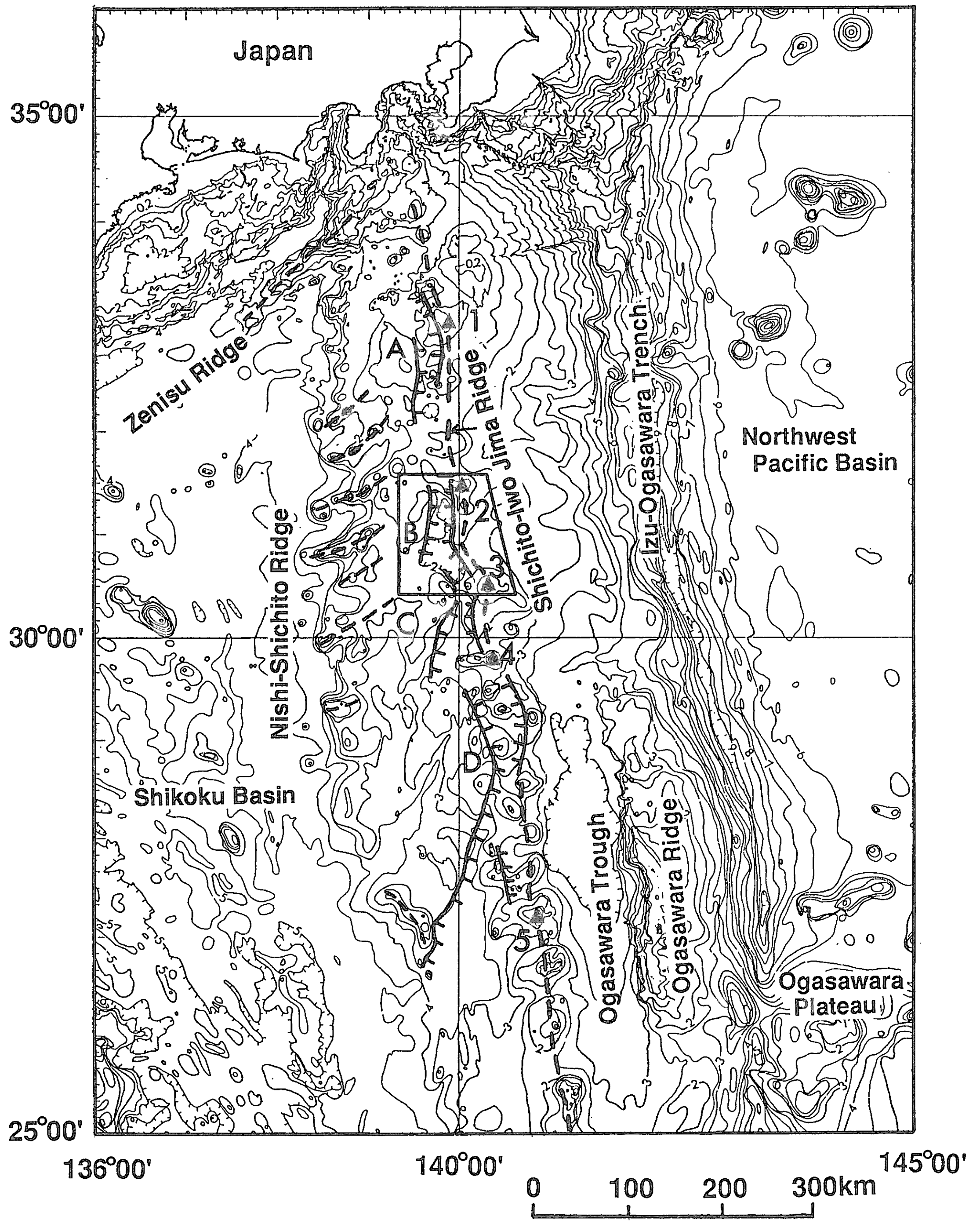


Fig. 1 Location of the Sumisu Rift. The study area is outlined by a rectangle. A : Hachijo Rift, B : Sumisu Rift, C : Torishima Rift, D : Nishinoshima Rift. 1 : Hachijo Jima, 2 : Sumisu Jima, 3 : Tori Shima, 4 : Sofu Gan, 5 : Nishi-no-Shima.

su Jima has the isotopic age of 2.2 ± 1.1 Ma (YUASA, 1985). This indicates that the Nishi-Shichito Ridge is composed mainly of the pre-Quaternary volcanic rocks.

The Shichito-Iwo Jima Ridge which consists of volcanic islands and submarine volcanoes is an active volcanic chain. Examples of recent large volcanic activity are the eruptions of the Tori Shima in 1939, the Myojin-Shō in 1952 and the Sumisu Jima in 1970 (SIMKIN *et al.*, 1981).

MURAKAMI and ISHIHARA (1985) found three calderas on the Shichito-Iwo Jima Ridge between the Hachijo Jima and the Tori Shima. They are the Aogashima Caldera, the North Beyonnaise Caldera and the Sumisu Caldera.

KARIG and MOORE (1975) indicated, based on a bathymetric chart and seismic profiles, that there are small basins on the back-arc side of the volcanic chain in the Izu-Ogasawara Arc. They concluded that the small basins were formed by the recent extension (along the basins), based on high heat flow values and the focal mechanism of earthquake showing the east-west extension.

TAMAKI *et al.* (1981) discussed the possibility of Quaternary back-arc spreading in the Izu-Ogasawara Arc based on bathymetric data, seismic profiles and dating of dredged rock. They found four depressions on the back-arc side of the volcanic chain between the Hachijo Jima and the Nishi-no-Shima, and called them "Back-Arc Depression". The depressions are named the Hachijo Depression, the Sumisu Depression, the Tori Shima Depression and the Nishinoshima Depression from the north (Fig.1). Basaltic pillow lavas which were too young to be dated by the K/Ar method were dredged from the ridge in the Sumisu Depression.

TAYLOR *et al.* (1984) surveyed the Nishinoshima Depression, the Torishima Depression and the Sumisu Depression using the seismic profiler and the wide range side scan sonar (SeaMARC II), and concluded that the back-arc depressions are grabens floored with ponded sediments and bounded by fault scarps. They called the depressions the back-arc rifts. I will use, in this paper, the term "back-arc rift" following TAYLOR *et al.* (1984).

Many observations by geophysical and geological methods have been carried out in the Sumisu Rift because of the high possibility of hydrothermal activity in the rift. The area was surveyed by R/V "Hakurei-maru" mainly during the GH80-4, GH84-2 and GH84-4 cruises (Fig.2). Single channel seismic profiling was carried out by using two air guns (120in^3 chambers with wave shape kits). The selected areas were surveyed by the deep-tow side scan sonar which has a survey range of 1000m.

This paper is an attempt to describe the geomorphology and geological structure of the Sumisu Rift and to clarify the process of the formation of the back-arc rift in the Izu-Ogasawara Arc.

2. Back-arc rifts

Four back-arc rifts between the Hachijo Jima and the Nishi-no-Shima are discontinuous (Fig.1). The boundaries between the Sumisu, Torishima and Nishinoshima Rifts are defined by volcanoes which extend westward from the volcanic chain. Relatively small volcanic mounds and basins extend for about 80km between the Hachijo Rift and the Sumisu Rift. Water depth of the four rifts increases southward, that is, they are 1000 to 1500m in the Hachijo Rift, 2000 to 2300m in the Sumisu Rift, 2800 to 3000m in the Torishima Rift and 3300 to 3800m in the Nishinoshima Rift.

The Hachijo Rift is about 130km long and extends from the west of the Hachijo Jima to the northwest of the Myojin-Shō. The rift is bounded by fault scarps at the western margin and bordered by volcanoes at the eastern end. The Hachijo Rift has a maximum width of 35km at the south of the Ao-ga-Shima.

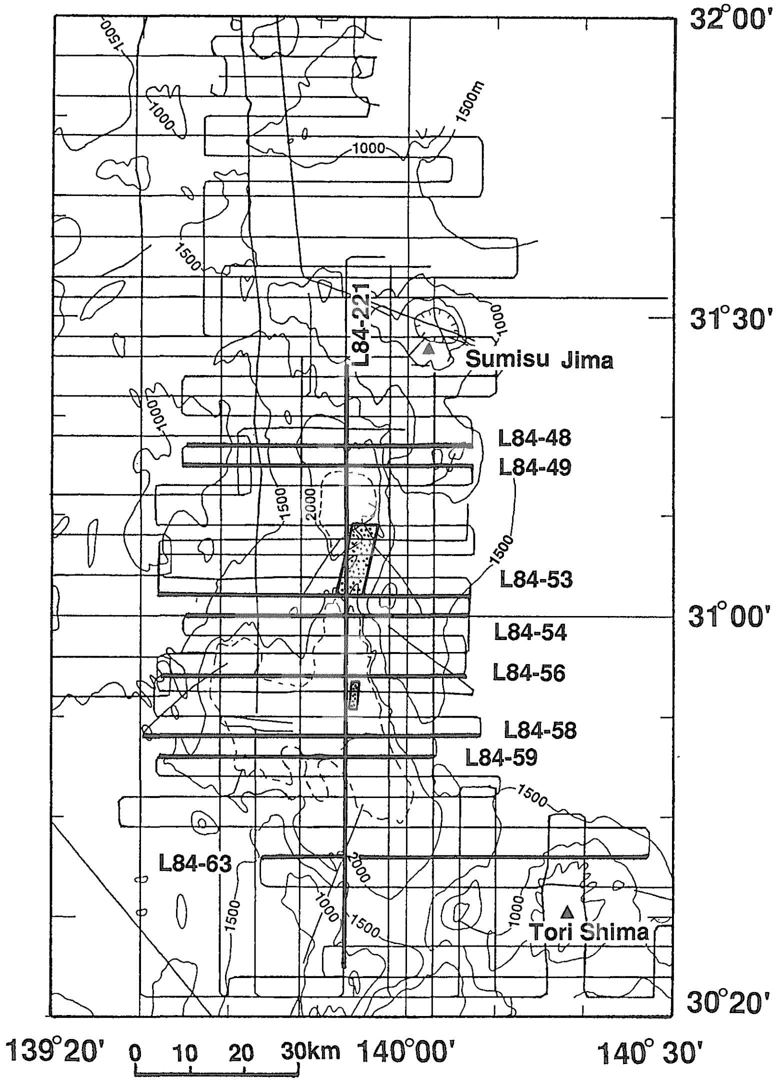


Fig. 2 Track lines of seismic profiling and 3.5 kHz SBP survey in the Sumisu Rift. The heavy lines indicate the location of seismic profiles shown in figures 5, 8, 9, 10, 11, 13, and 14. Rectangles show the surveyed areas by the deep-tow side scan sonar.

The Sumisu Rift is about 100km long. Its western and eastern boundaries are defined by fault scarps. The Sumisu Rift has a maximum width of 35km at an area northwest of the Tori Shima.

The Torishima Rift is about 100km long and extends from the southwest of the Tori Shima to the south of the Sofu Gan, a volcanic spine. The rift has a maximum width of 60km at an area to the west of the Sofu Gan. The rift is bounded by fault scarps at the western and eastern margins. The maximum heights of the western and eastern fault scarps are 1000m and 1350m respectively. Normal faults in the rift are west downthrown.

The Nishinoshima Rift is about 240km long and extends from the south end of the

Torishima Rift to the west of the Nishi-no-Shima. In the northern part of the Nishinoshima Rift, fault scarps bound its western and eastern ends. A seamount occupies a part of the eastern floor of the rift. The western scarp is continuous along the entire Nishinoshima Rift, while the eastern scarp does not extend southward beyond the latitude 28°40′N. The rift has a maximum width of 60km at the south of the Sofu Gan. The strike of the western scarp is N20°W in the northern part of the rift, but it changes to N20°E to the south of the latitude 28°40′N.

TAMAKI *et al.* (1981) stated that there are

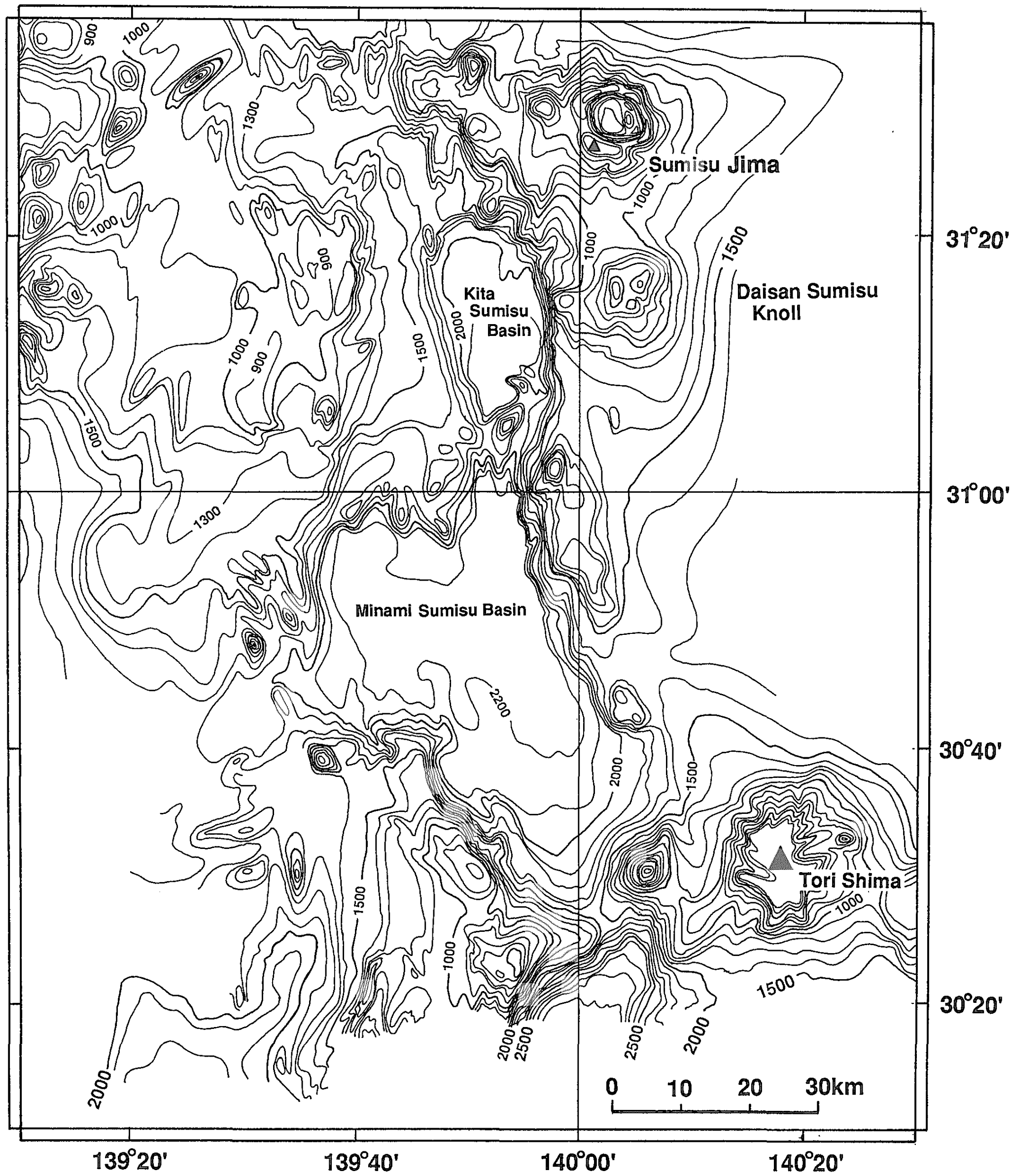


Fig. 3 Bathymetric contour map of the Sumisu Rift. Contour interval is 100 corrected meters.

no troughs on the back-arc side between the Nishi-no-Shima and the Mariana Trough. HONZA and TAMAKI (1985) postulated that this is the result of compressive stress by the collision of the Ogasawara Plateau. YAMAZAKI and MURAKAMI (1987), however, stated that relatively smaller troughs which are bounded by normal faults existed on the back-arc side between the Nishi-no-Shima and the Mariana Trough.

3. Sumisu Rift

The Sumisu Rift is located between the southwest of the Sumisu Jima and the west of the Tori Shima (Fig.3). The rift is a graben defined by fault scarps at its western and eastern boundaries. The scarps are normal faults which run in the nearly N-S direction and are called the West Scarp and the East Scarp. The basins called the Kita-Sumisu Basin (North-Sumisu Basin) and the Minami-Sumisu Basin (South-Sumisu Basin) (Hydrographic Department of Japan, 1987) are included in the rift (Figs.3 and 4). The Sumisu Rift is divided into two segments. They are the North Segment and the South Segment. They are bounded by the transverse volcanic ridge called the Intra Ridge. This ridge consists of volcanic ridges and mounds (Fig.3) and is occupied by strong reflection on sonograph of Sea MARC II. (BROWN and TAYLOR, 1988).

Fig.5 is a seismic profile crossing the Sumiisu Rift from the north to the south. The Kita-Sumisu Basin and the Minami-Sumisu Basin are buried by sediments. Basement has a opaque reflection characteristics and is inferred to be composed mainly of volcanic rocks. The reflection of the basement is not clear in the basin. Reflections are sometimes recognized in the basement, which indicates that a part of the basement are presumably composed of sedimentary rocks. The basin floor and the basement of the Minami-Sumisu Basin are deeper than those of the Kita-Sumisu Basin. The sediments in the Minami-Sumisu Basin are thicker than that in the Kita-Sumisu Basin. Thickness of sediment and depth of basement are shown by two way travel time in seconds.

The East and West Scarps consist of fault escarpments. They are continuous from the North Segment to the middle part of the South Segment but are laterally shifted eastward in the southern part of the South Segment (Fig.4).

Relatively smaller ridges and knolls occupy the area to the west of the northern and middle parts of the Sumisu Rift. The volcanic ridge is developed at the west of the southern part of the rift. The Shichito-Iwo Jima Ridge is occupied by volcanoes near the northern and southern ends of the rift but consists of the N-S elongated ridge between the volcanoes (Fig.3).

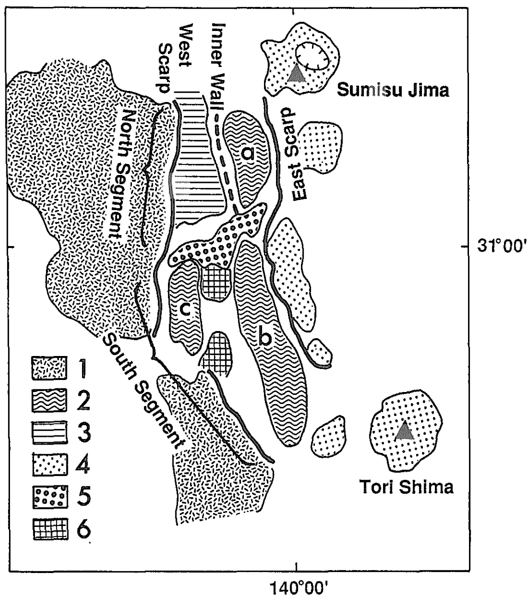


Fig. 4 Map showing the topographic features in the Sumisu Rift. 1 : ridge and knoll, 2 : basin, 3 : Upper Floor, 4 : high on the Shichito-Iwo Jima Ridge, 5 : Intra Ridge, 6 : Central Ridge, a : Kita-Sumisu Basin, b : East Sub-basin, c : West Sub-basin

3.1 North Segment of the Sumisu Rift

The North Segment is 35km long and 30km wide. The Kita-Sumisu Basin occupies the eastern part of the North Segment. The western part is occupied by the shallower floor which is called the Upper Floor. A slope (7° to 10°) called the Inner Wall bounds the Upper Floor and the Kita-Sumisu Basin (Figs.3 and 6).

The Kita-Sumisu Basin is 2000 to 2100m deep, and its length and width are 30km and 15km respectively (Figs.3 and 6). The depth of the basement of the basin is about 3.4 sec below sea level and buried by sediments of 0.7 to 0.9 sec in thickness (Figs.5 and 8-a, b). Volcanic rocks were intruded into the uppermost sediments in the basin, which indicates active volcanic activities (Fig.8-b). Chaotic reflection characteristics are found along the East Scarp of the northern part of the basin (Fig.8-a). They are inferred to be caused by slumping or sliding from the East Scarp.

The Inner Wall is a fault zone. The faults are east downthrown normal faults and cut sediments. Vertical displacement of each fault is 100 to 400m. The strike of the Inner Wall varies from N5°W to N10°W (Fig.7). The Upper Floor is 1400 to 1600m deep and 7 to 12km wide. The floor is covered by sediments of 0.1 to 0.3 sec in thickness.

The height of the East Scarp is 600 to 1500m above the basin floor and its average dip is 15°to 30°(Fig.6). The strike of the East Scarp is about N15°W. The scarp is cut by several submarine canyons (Fig.3) which drain sediments from the Sumisu Volcano into the Kita-Sumisu Basin (NISHIMURA and MURAKAMI, 1988). The height of the West Scarp is 400 to 550m above the Upper Floor and the inclination of the scarp is more gentle than that of the East Scarp. The strike of the West Scarp varies from N7°E to N14°E. The fault blocks in the West Scarp are tilted to the west (Fig.8-b).

3.2 South Segment of the Sumisu Rift

The South Segment is occupied by the Minami-Sumisu Basin. The length and width of the segment are about 60km and 30 to 35km respectively. The Minami-Sumisu Basin is divided into the East and West Sub-basins by the Central Ridge (Fig.4). The Central Ridge is recognized as topographic high at the northern and southern part of the basin. In the central part of the basin, the ridge submerges into the basin but is continuous as a structural high in the subbottom (Figs.9 and 10-a, b). The ridge is elongated in the N-S direction and its western and eastern margins are defined by the normal faults, which indicates that the Central Ridge is a horst.

The East Sub-basin is 12 to 15km wide and about 60km long. The sub-basin is 2200 to 2280m deep in the northern and middle parts, and it becomes shallow southward in the southern part (Fig.3). The basement is deepest in the eastern part of the East Sub-basin (Figs.9 and 10-a,b). The depth of the basement from sea level is 4.0 to 4.4 sec in the northern and middle parts and becomes shallow southward in the southern part. Thickness of sediments in the East Sub-basin is greater than that in the Kita-Sumisu Basin. Sediments attain a maximum thickness of 1.3 sec in the middle part of the sub-basin and becomes thin northward and southward.

Many of the faults in the sub-basin which cut the basement extend upward and cut the uppermost sediment. Vertical displasement increases toward the deeper horizon (Figs.10-a,b and 11). They indicate that these faults have been active during the deposition of the sediment. Most of the active faults are east downthrown except the fault near the East Scarp. The largest active fault is continuous for 40km (Fig.7) and has the greatest vertical displacement of 70m at the sea-bottom (Fig.11).

A elongated mound which is about 7km long and 0.7 to 1km wide was found on the

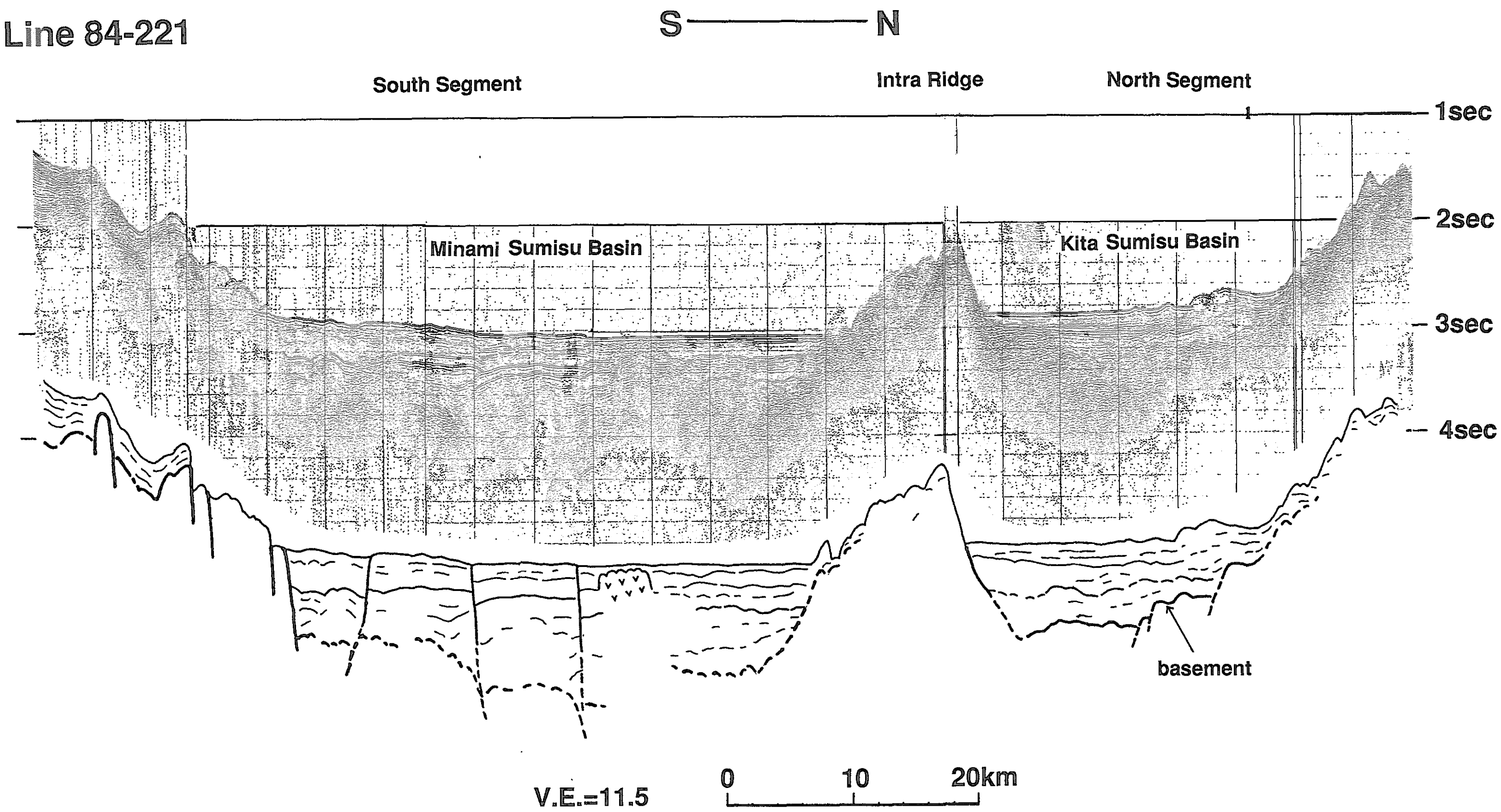


Fig. 5 Seismic profile traversing the Sumisu Rift in the N-S direction.

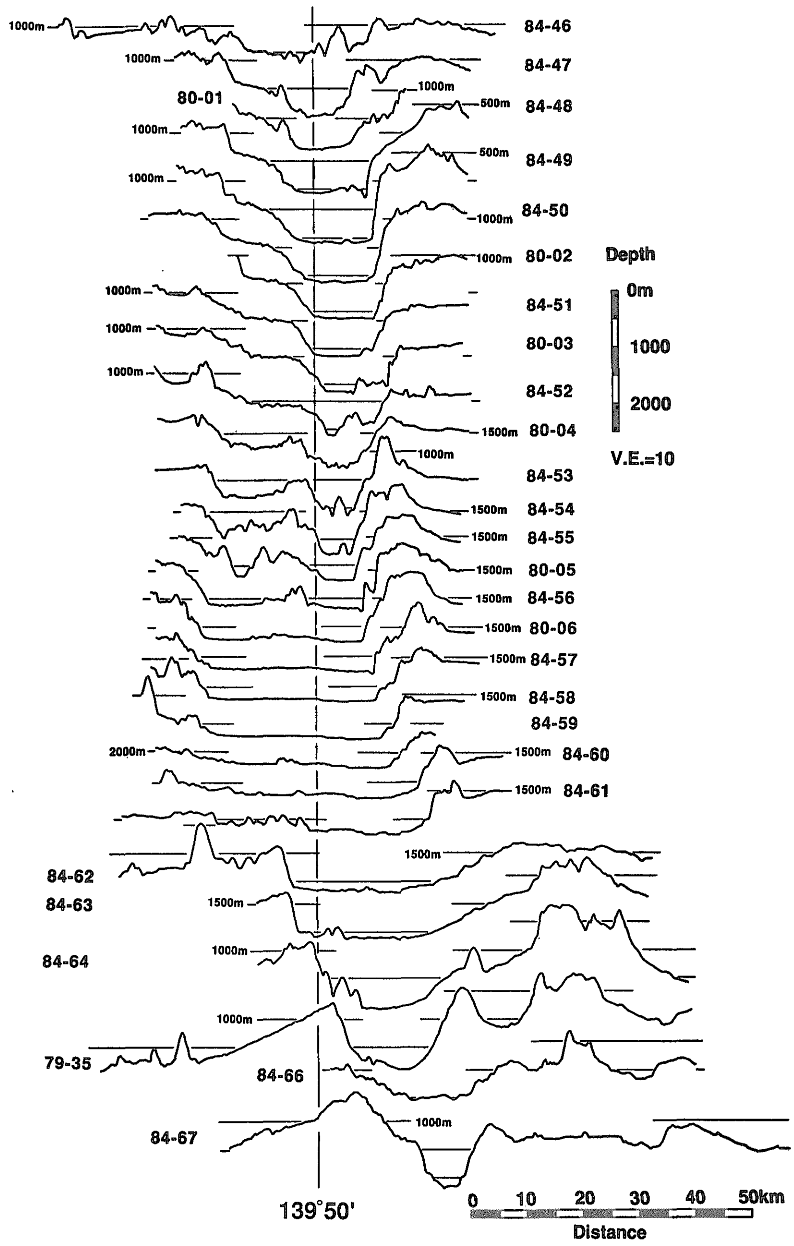


Fig. 6 Sea-bottom profiles across the Sumisu Rift.

northern part of the largest normal fault (Fig.12-a,b). The mound is 80 to 150m in height and its eastern slope is steeper than the western one. Basalts with a pillow structure was collected from the mound (YUASA, 1987). I believe that they erupted from the normal fault.

The West Sub-basin is 25km long and 8 to 11km wide. In the sub-basin, the sediments have a maximum thickness of 0.6 sec, and the basement is about 3.6 sec deep from sea level (Figs.9 and 10-a,b). Sediments are thinner

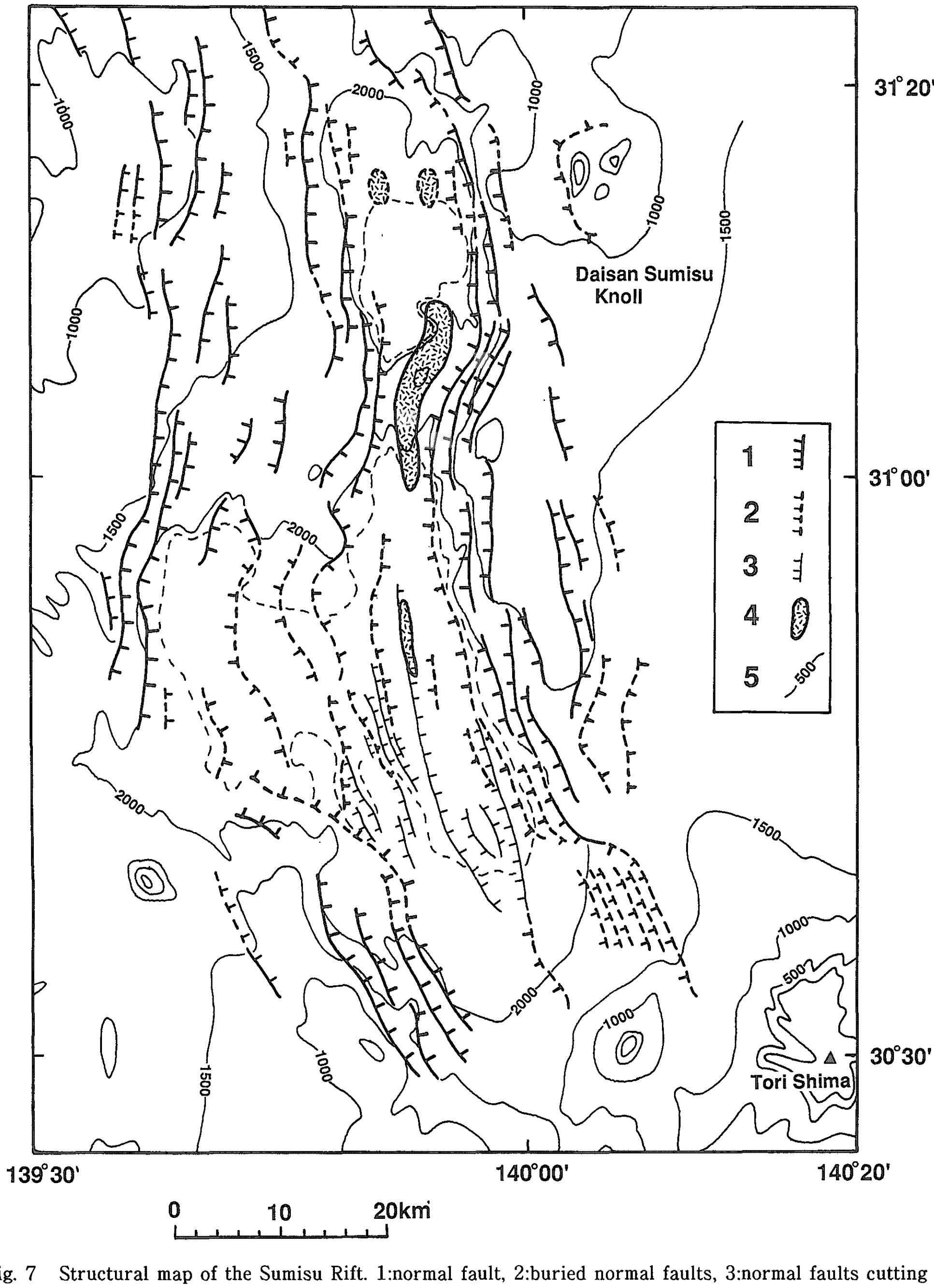
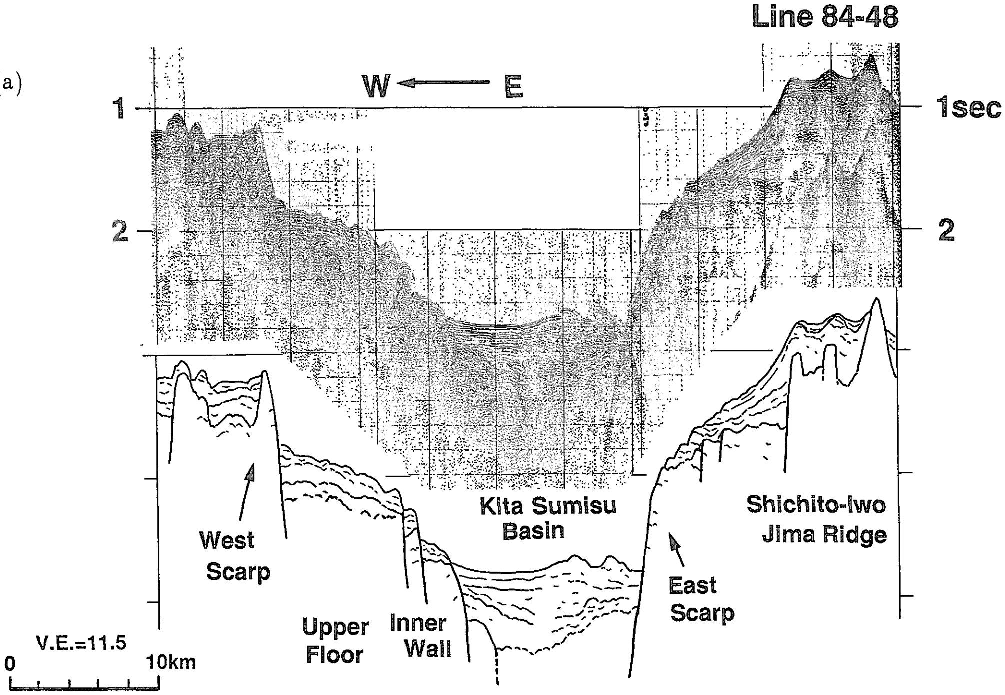


Fig. 7 Structural map of the Sumisu Rift. 1:normal fault, 2:buried normal faults, 3:normal faults cutting the uppermost sediments, 4:intruded volcanic rocks or elongated volcanic mound and ridge in the basin, 5:bathymetric contour (contour interval is 500m).

than that of the East Sub-basin, and the depth of the basement is also shallower than that of the East Sub-basin.

The East Scarp of the South Segment is continuous from the North Segment but disappears in the southern part. The strike of

(a)



(b)

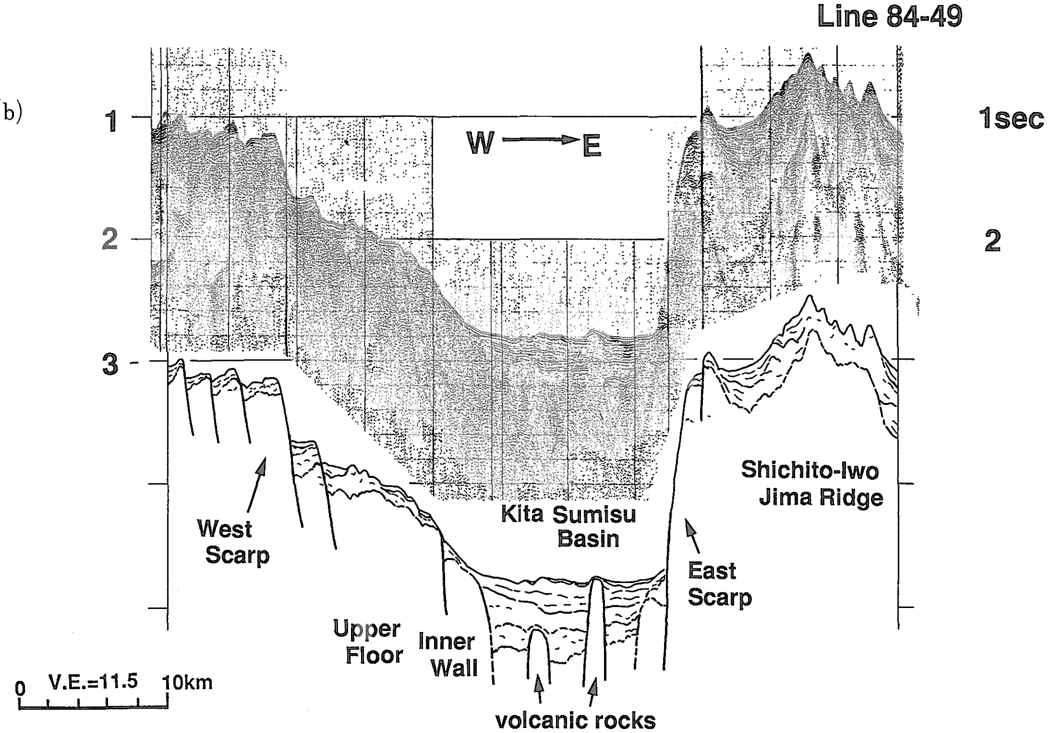


Fig. 8 Seismic profiles and their interpretation in the North Segment of the Sumisu Rift. a:Line 84-48, b:Line 84-49.

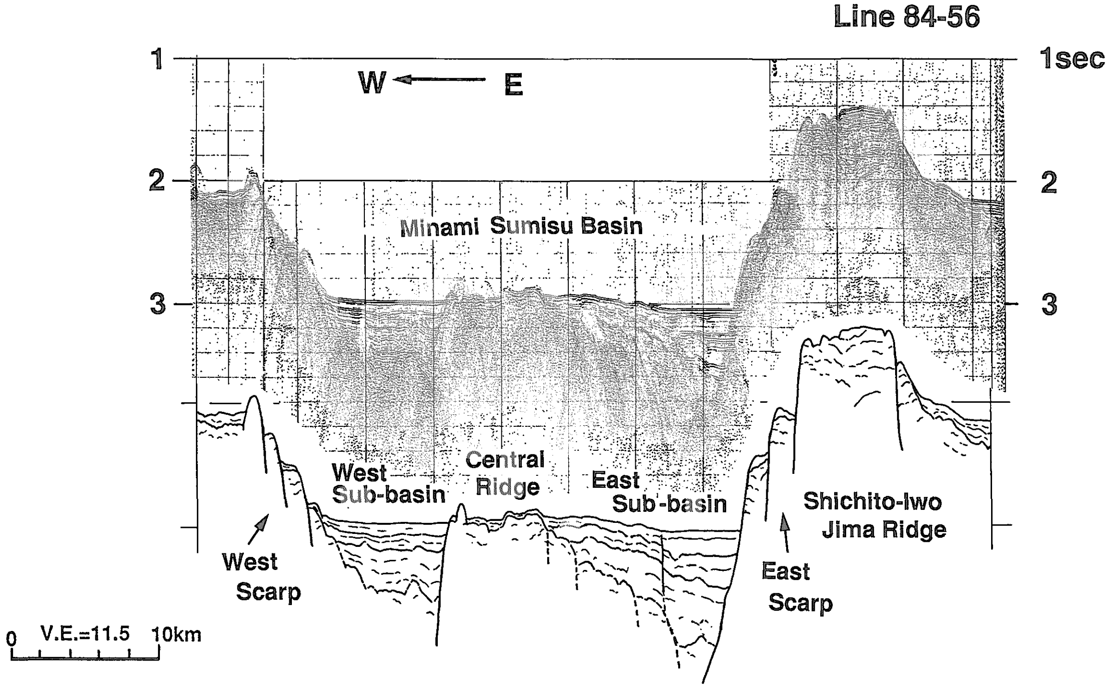


Fig. 9 Seismic profile and its interpretation in the northern part of the South Segment.

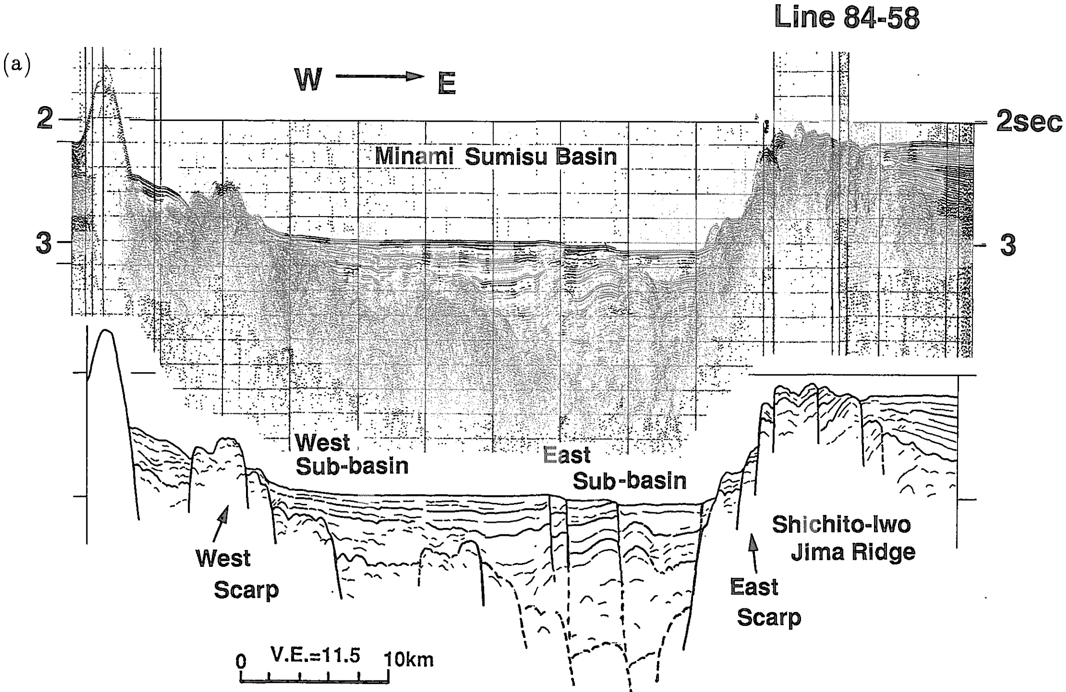


Fig. 10 Seismic profiles and their interpretation in the middle part of the South Segment. a : Line 84-58, b : Line 84-59.

(b)

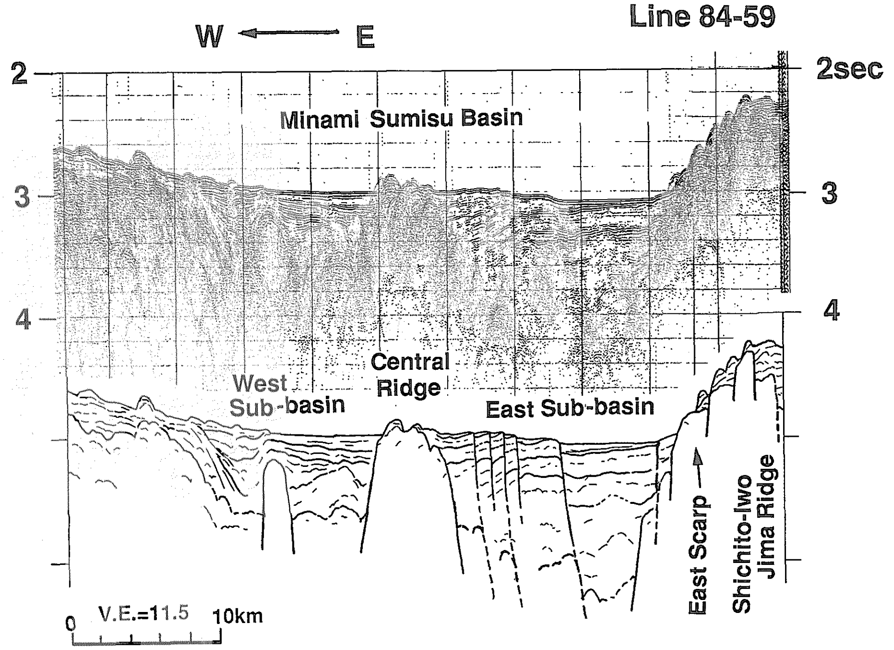


Fig. 10 continued

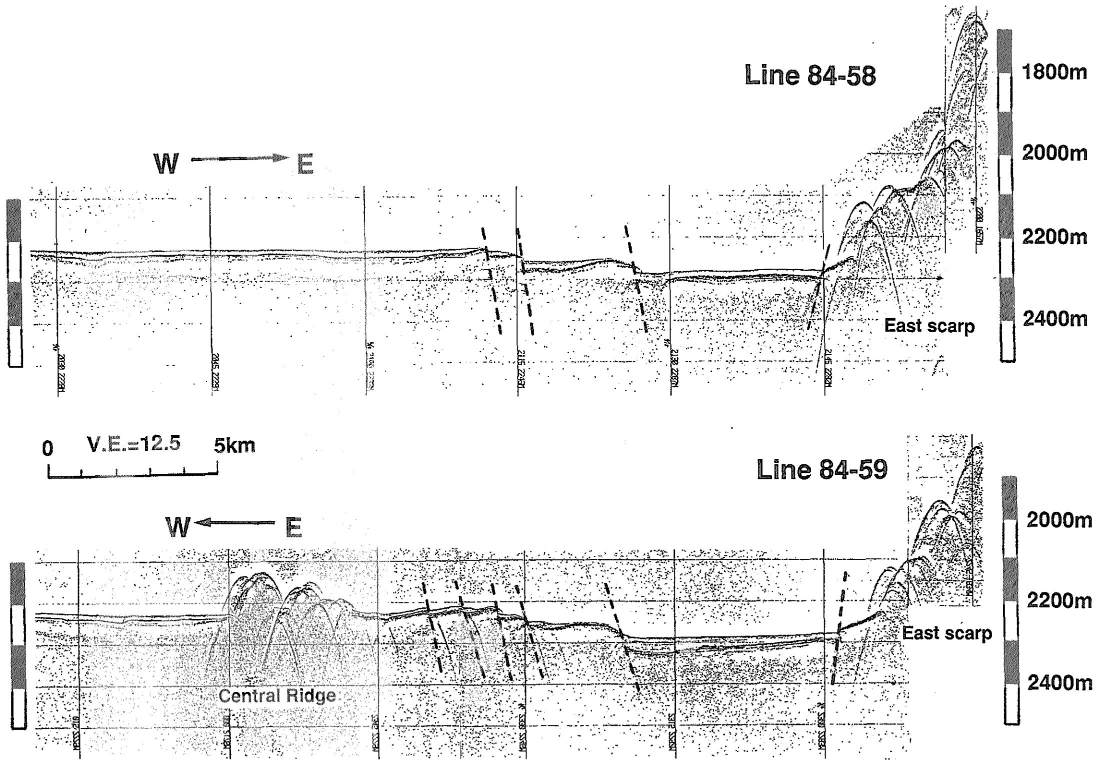


Fig. 11 Profiles of 3.5kHz SBP showing the active faults in the middle part of the South Segment.

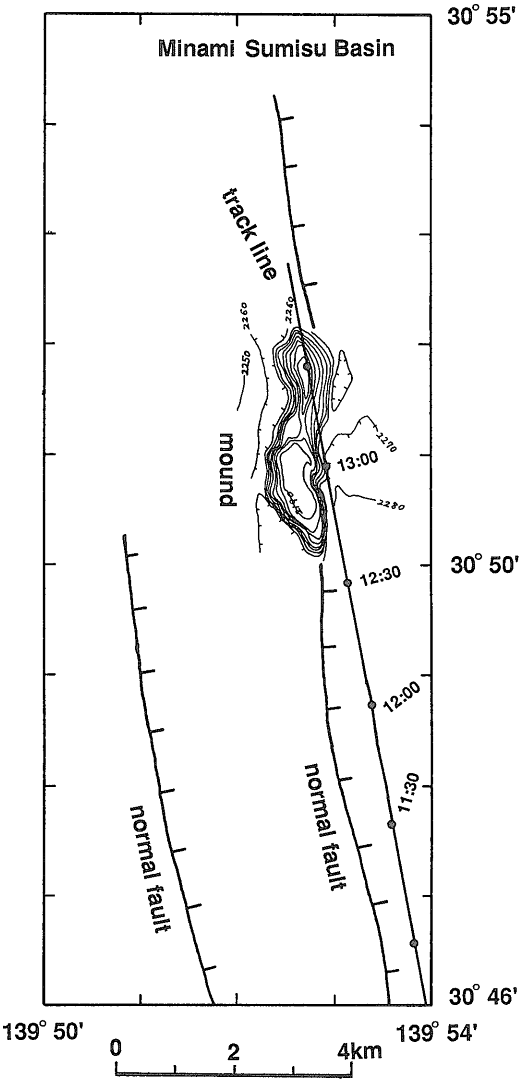


Fig. 12-a Detail map showing the relationship between the elongated mound and the active normal fault in the East Sub-basin of the South Segment. Contour interval is 10m.

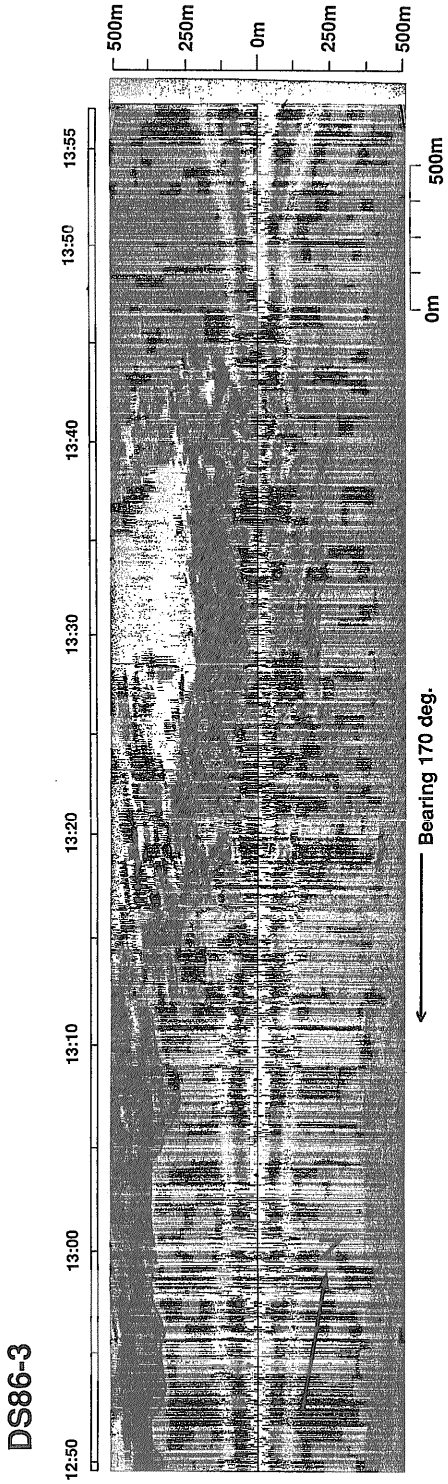


Fig. 12-b Sonograph of the elongated mound.

the East Scarp varies from N-S in the northern part to N20°W in the middle part (Fig.7). The scarp is 600 to 1200m in height from the basin floor and consists of stepped fault blocks descending to the basin (Fig.9). Average dip of the scarp is 6°to 12°, but individual escarpment is steeper (Figs.6 and 9). Vertical displacement of each fault in the scarp ranges from 250 to 410m (Figs.9 and 10-a,b), and total displacement of the basement is 1.9 to 2.3 sec. The basement in the scarp is covered by the sediments of 0.1 to 0.2 sec in thickness.

In the southern part, the eastern margin of the East Sub-basin is defined by gentle slope. The slope is continuous from the western flank of the Tori Shima (Fig.3) and covered by thick sediments (above 0.9 sec) which presumably consists of volcanic material from the Tori Shima volcano (Fig.13). Stepped faults are buried under the sediments and the maximum vertical displacement in the faults attains 0.3 sec (Fig.13). The faults run in the direction of nearly N25°W (Fig.7).

In the northern and middle parts, the strike of the West Scarp is about N10°E. Its height is 500 to 800m in the northern part but decreases to the south and disappears on Line 84-59 (Fig.6). The scarp consists of stepped faults descending to the basin and its average dip is about 10° on Line 84-56 (Fig.6). Vertical displacement of each fault in the scarp ranges from 200 to 400m. Total displacement of the basement is about 1.6 sec in the northern part (Fig.9).

In the southern part, the West Scarp is laterally shifted eastward. Its strike is about N30°W (Fig.7). The height of the West Scarp is about 1100m and its dip is 11° to 16°. The western part of the South Segment is cut by normal faults. Reflections in the sediments on the fault blocks tilt westward and the thickness in the sediment increases westward (Fig.13).

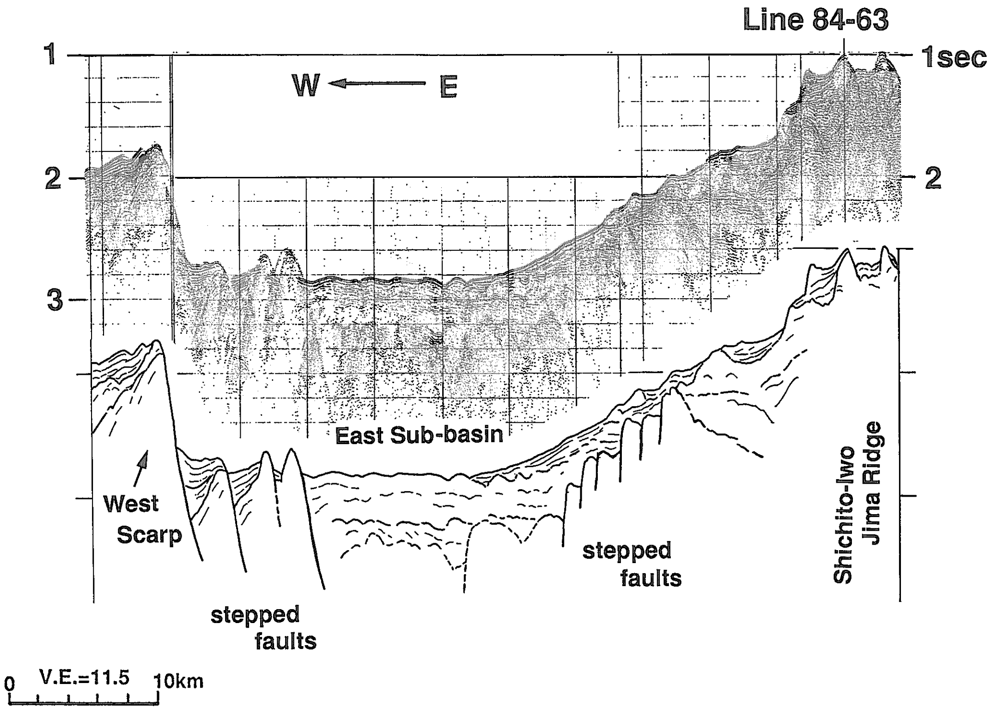
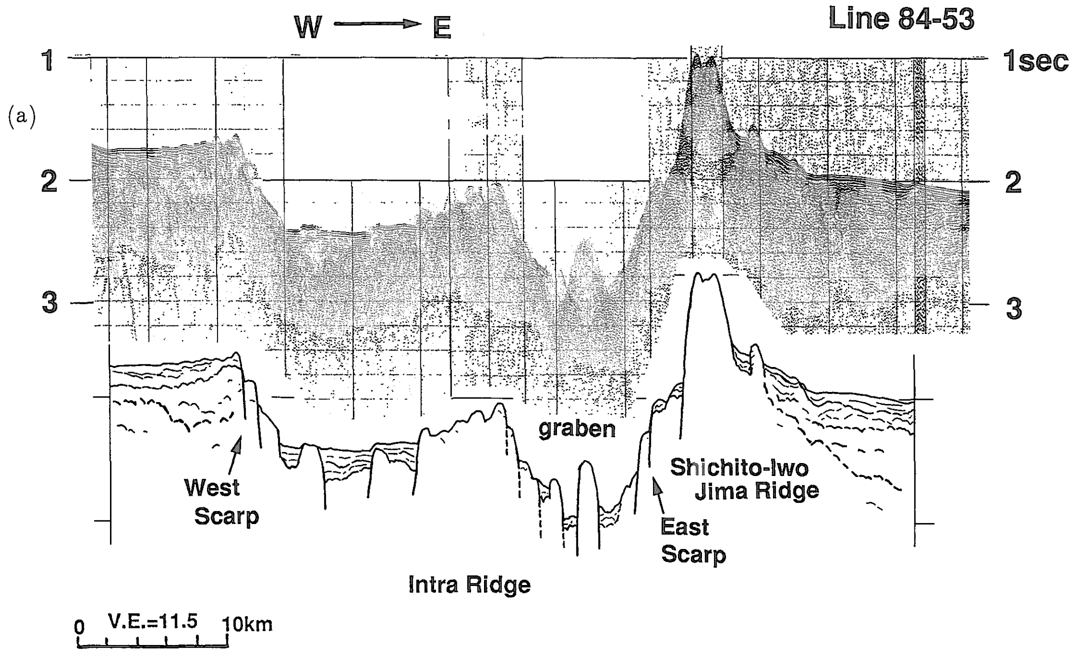


Fig. 13 Seismic profile and its interpretation in the southern part of the South Segment.



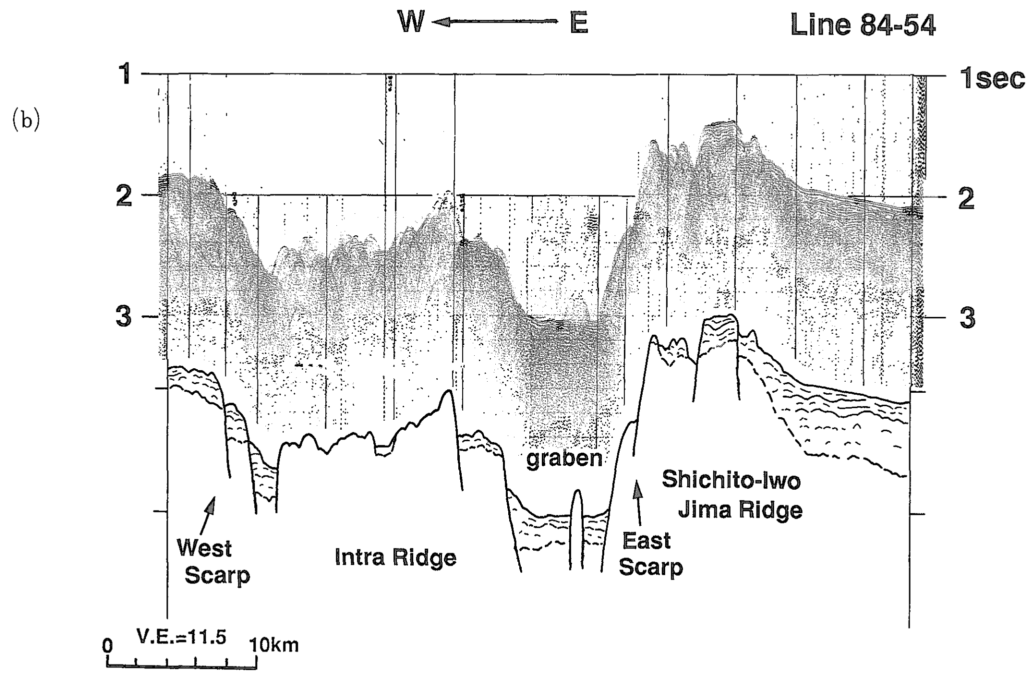


Fig. 14 Seismic profiles and their interpretation of the Intra Ridge in the Sumisu Rift. a:Line 84-53, b:Line 84-54.

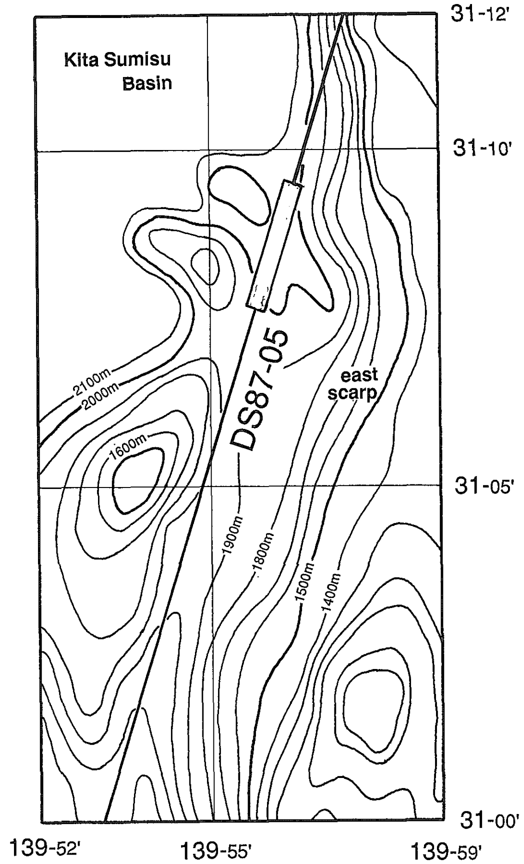


Fig. 15-a Track line of deep-tow side scan sonar in the graben on the Intra Ridge. A rectangle shows the location of the sonograph shown in Fig.15-b

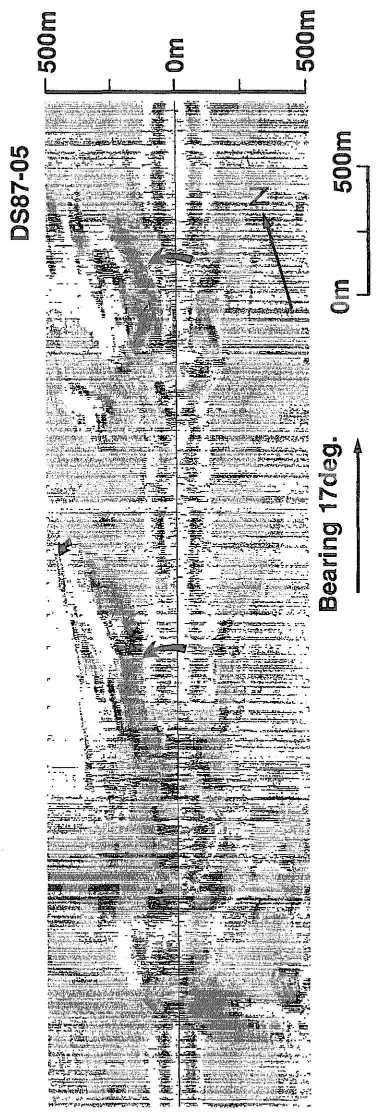


Fig. 15-b Sonograph in the graben of the Intra Ridge. Arrows show the volcanic ridge

3.3 Intra Ridge

The Intra Ridge trending N60°E consists of volcanic ridges and mounds. Figure 14-a is a seismic profile crossing the eastern part of the ridge in the E-W direction. The eastern part of the ridge is characterized by a graben structure which is continuous from the North Segment to the South Segment through the ridge (Fig.7).

The N-S elongated ridge which is composed of volcanic rocks lies in the graben. Sea floor observation by the deep-tow side scan sonar was carried out between the elongated ridge and the East Scarp in the graben (Fig.15-a). Mounds, trending approximately north, are recognized on the sonograph (Fig.15-b). This direction is very close to the general trend of the Sumisu Rift but is oblique to the direction of the Intra Ridge.

Figure 14-b is a seismic profile crossing the western part of the Intra Ridge in the E-W direction. The western part of the ridge is occupied by small mounds and the western end is bounded by faults in the West Scarp

which is also continuous from the North Segment to the South Segment.

4. Discussion

The Sumisu Rift is a graben and the other three rifts are also inferred to be grabens. The existence of the grabens strongly indicates that the Izu-Ogasawara Arc has been affected by the extensional stress.

Sediments in the Sumisu Rift onlap against the basement and the depo-center is nearly stable on the deepest area of basement. The sediments in the East Sub-basin are cut by active normal faults (Fig.16). The vertical displacement by the faults increase toward the deeper horizon. They suggest that the sediments have been accumulated and cut by the faults during the rifting. In the southern part of the South Segment, the sediments on the fault blocks in the West Scarp diverge and become thick toward the west, namely the direction of the tilting of the fault blocks. This indicates that the sediments have been accumulated during the growth of the faults by the rifting.

Although the normal faults in the Kita-Sumisu Basin were found to be not active, the volcanic rocks in the basin intrude into sediments and the sediments in the Inner Wall are cut by normal faults (Fig.16). These facts indicate the active rifting in the North Segment.

The heat flow in the Sumisu Rift ranges from 38 to 700mW/m². The very high heat flow and large variability of heat flow can be explained by intensive hydrothermal circulation (YAMAZAKI, 1988). The heat flow is highest in the East Sub-basin of the South Segment. This fact indicates that the rifting in this area is most active within this area.

The Intra Ridge is bounded by normal

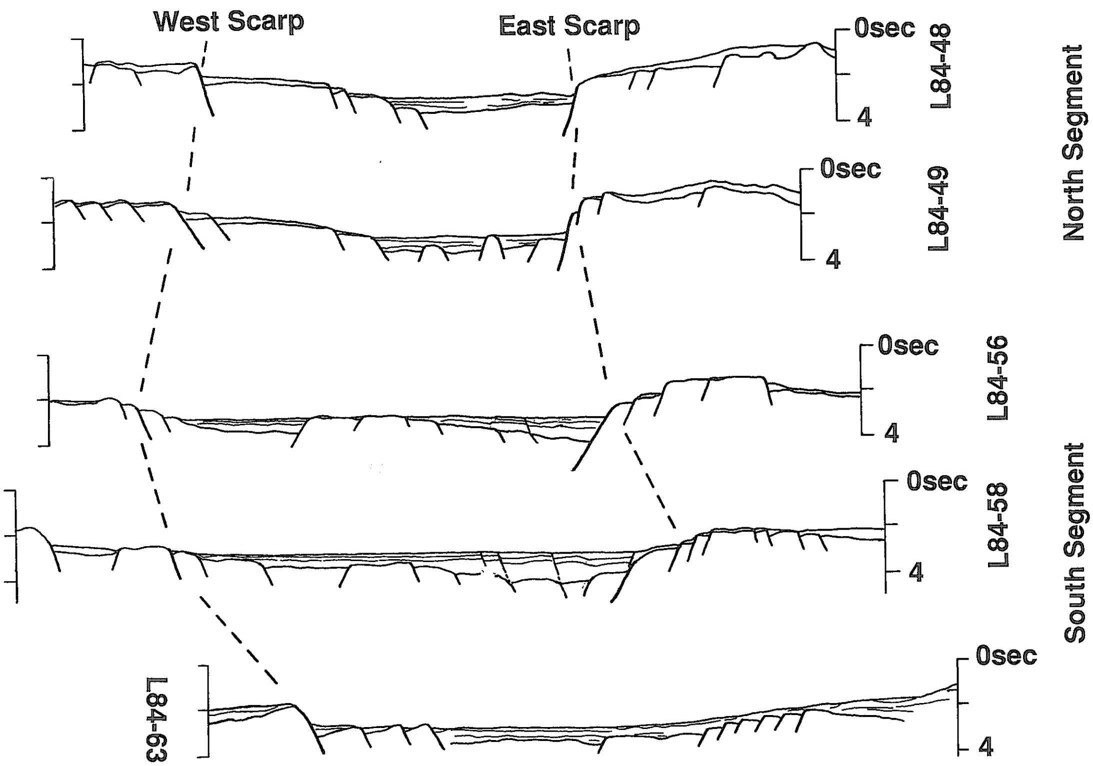


Fig. 16 Cross section of the Sumisu Rift. Vertical exaggeration is approximately 2.

faults at the West Scarp and the East Scarp, and a graben structure is formed in its eastern part. They are continuous from the North Segment to the South Segment. The directions of the faults and the elongated volcanic mounds in the ridge are nearly palallel to the general trend of the Sumisu Rift. They indicate that the rifting and volcanic activity are still active. The formation of the ridge is inferred to have started after the beginning of the rifting, because the ridge dose not extend over the East and West Scarps.

Although the lateral offset of the West Scarp in the South Segment may appear to be formed by a strike slip, the East Sub-basin and the normal faults in the sub-basin are continuous through the offset and no strike slip fault is found. It is believed that the Tori Shima volcano which is located just east of the southern part of the South Segment affects the structure of the rift.

In the North Segment and the northern and middle parts of the South Segment, the depth of the basement attains a maximum immediately to the west of the East Scarp, and the average height of the East Scarp is greater than that of the West Scarp (Fig.16). This shows that the Sumisu Rift forms an asymmetrical graben. In the southern part of the South Segment, the deepest part of the basement is continuous from the north and is located almost in the middle of the rift, but the West Scarp is clear and has a greater height than the eastern boundary of the segment (Fig.16). The southern part also has asymmetrical structure but has a reverse trend relative to the northern part (Fig.16).

Continental rifts typically have few tens of kilometers wide and are asymmetrical in cross section (Bosworth, 1985). This feature is similar to that of the Sumisu Rift. In the FAMOUS area on the Mid-Atlantic Ridge, segments of the rift valley bounded by transform faults are 40 to 45km long and 25 to 31km wide (Ramberg and Andel, 1977). Although the size of the Sumisu Rift is similar to one segment of the rift valley on the Mid-Atlantic Ridge, the cross section of the rift valley is approximately symmetrical.

The history of back-arc basin formation in the Mariana Arc was clarified by Hussong and Uyeda (1982) as follows based on the results of DSDP Leg. 60 ; (1) at the end of Miocene, the arc massif was built up by uplift and arc volcanism in a state of compressional stress, (2) the massif was rifted by the extensional stress during the latest Miocene, and (3) the back-arc basin was formed by spreading after the arc rifting. The Mariana Trough is a back-arc basin underlain by oceanic crust (Bibee, *et al.*, 1980) and its maximum width is about 200km (Karig, 1971). On the contrary, the Sumisu Rift is narrower than the Mariana Trough and no evidence is found that the rift is underlain by oceanic crust, but the normal faults are active. This indicates that the Sumisu Rift is presently in the rifting stage and will begin to spread in the future.

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References

Bibee, L.D., Shor, G. G., Jr. and Lu, R.S. (1980) Inter-arc spreading in the Mariana Trough. *Marine Geology*, vol.35, p.183 -197.

Bosworth, W. (1985) Geometry of propagating continental rifts. *Nature*, vol. 316, p.625-627.

Brown, G. and Taylor, B. (1988) Sea-floor mapping of the Sumisu Rift, Izn-Ogasawara

(Bonin) Island Arc. *Bull. Geol. Surv. Japan*, vol.39,p .23-38.

HONZA, E. and TAMAKI, K. (1985) The Bonin Arc, in NARIN, A. E. M., *et al.*, eds., *Ocean Basins and Margins*, vol. 7, Plenum, New York, p.459-502

HUSSONG, D. M. and UYEDA, S. (1982) Tectonic processes and the history of the Mariana Arc : A synthesis of the results of Deep Sea Drilling Project Leg 60, *in* HUSSONG, D. M., UYEDA, S., *et al.*, *Initial Reports of the Deep Sea Drilling Project*, 60, U. S. Government Printing Office, Washington, p.909-929.

Hydrographic Department of Japan (1987) *Bathymetric chart no.6527, Sumisu Sima, scale 1:200,000,* Maritime Safety Agency.

ISSHIKI, N. (1980) *Geology of the Mikura-jima Inamba-jima and Zenisu Districts*. Quadrangle Series, Scale 1 : 50,000. Geol. Surv Japan, 35p. (in Japanese with English abstract 3p.).

KARIG, D. E. (1971) Structural history of the Mariana Island Arc system. *Geol. Soc. America Bull.*, vol.82, p.323-344.

———— and MOORE, G. F. (1975) Tectonic complexities in the Bonin Arc System. *Tectonophysics*, vol.27, p.97-118.

KLEIN, G. deV. and KOBAYASHI, K. (1980) Geological summary of the North Philippine Sea, based on Deep Sea Drilling Project Leg 58 results, in KLEIN, G. deV., KOBAYASHI, K. *et al.*, *Initial Reports of the Deep Sea Drilling Project*, 58, U. S. Government Printing Office, Washington, p.951-961.

MURAKAMI, F. and ISHIHARA, T. (1985) Calderas found on the northern Ogasawara Arc. *Earth Monthly*, vol.7, p.638-646. (in Japanese).

NISHIMURA, A. and MURAKAMI, F. (1988) Sedimentation of the Sumisu Rift, Izu-Ogasawara Arc. *Bull. Geol. Surv. Japan*, vol.39 , p.39-61.

RAMBERG, I. B. and ANDEL, T. H. (1977) Morphology and tectonic evolution of the rift valley at lat. 36°30'N, Mid-Atlantic Ridge. *Geol. Soc. America Bull.*, vol. 88, p.577-586.

SIMKIN,T., SIEBRT, L., McCLELLAND, L., BRIDGE, D., NEWHALL, C. and LATTER, J. H. (1981) *Volcanoes of the World* (A regional directory, Gazetteer, and chronology of volcanism during the last 10,000 years). Pennsylvania, Smithsonian Institution, Hutchinson Ross, 232 pp.

TAMAKI, K., INOUE, E., YUASA, M., TANAHASHI, M. and HONZA, E. (1981) On the possibility of active back-arc spreading of Ogasawara Arc. *Earth Monthly*, vol.3, p.421-431.(in Japanese).

TAYLOR, B., FRYER, P. and HUSSONG, D. M. (1984) Rifting of the Bonin Arc. *EOS* (Am. Geophy. Union Trans.), vol.65, p.1006.

YAMAZAKI, T. (1988) Heat flow on the Sumisu Rift, Bonin Arc. *Bull. Geol. Surv. Japan*, vol.39, p.63-70

———— and MURAKAMI, F. (1987) Heat flow and structure in the back-arc area of the Izu-Ogasawara Arc. *Abstract with program of 1987 autumn meeting of the Seismological Society of Japan*, p.204.(in Japanese).

YUASA, M.(1985) Sofugan tectonic line, a new tectonic boundary separating northern and southern parts of the Ogasawara (Bonin) Arc, Northwest Pacific, in NASU, N., *et al.*, eds., *Formation of Actire Ocean Margins*, Terra, Tokyo, p.483-496.

———— (1987) Rocks dredged in GH86-1 and GH86-3 cruises of R/V Hakurei-maru, *in* NAKAO, S., YUASA, M., eds., *Submarine hydrothermal activity in the Izu-Ogasawara Arc* (1986 F. Y. Report), Geol. Surv. Japan, p.68-76. (in Japanese).

伊豆・小笠原弧，スミスリフトの地質構造について

村 上 文 敏

要　旨

伊豆・小笠原弧北部の火山列西側には，背弧リフトが600km 以上にわたって断続的に形成されている．スミスリフトは，その中の一つである．スミスリフトは南北に細長く，その長さ約 100km，幅 30-35km である．リフトは，北域と南域の２つの区域に分けられる．それらを分けるのは，ほぼN 60° E へのびるリフト内の海嶺である．両区域は，厚い堆積物によっておおわれた海盆からなる．

スミスリフトは，その東西両側を正断層群によって区切られ，またリフト内にも多くの正断層が発達する．これらの断層は，ほぼN-S 方向にのびる．リフト内の断層の多くは，活動的であると考えられる．これらのことは，リフトがE-W 方向への引っ張り応力によって形成され，そして現在リフティング期にあることを示す．

正断層は，南域東側において最も活動的である．ここでは，堆積層最上部まで正断層によって切られ，その中で規模の最も大きい活断層上に玄武岩からなる小丘が形成されている．また，高い地殻熱流量が測定されている．リフティングは，南域東側において最も活発であると推定される．

リフト内の海嶺は，火山性の海嶺と小丘からなる．主断層は，この海嶺を通り南域から北域まで連続であり，また火山性の海嶺は主断層にほぼ平行である．これらのことは，リフィテングとその海嶺における火成作用がほぼ同時期であることを示す．

スミスリフトは，東西断面において非対称である．リフト南部における非対称性は，中・北部と比較して逆の傾向を示す．すなわち，中・北部においてリフトの東縁断層は西縁断層より大きい落差を持つが，南部においては西縁断層の方が東縁断層より大きい落差を持つ．リフトの東西を区切る断層は，その南部において東へずれるが，リフト内の断層はリフト全体にわたって連続する．

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