

## Chapter 3 Survey Results

### 3-1 Outline of the Survey Area

#### 3-1-1 Outline of the North Fiji Basin

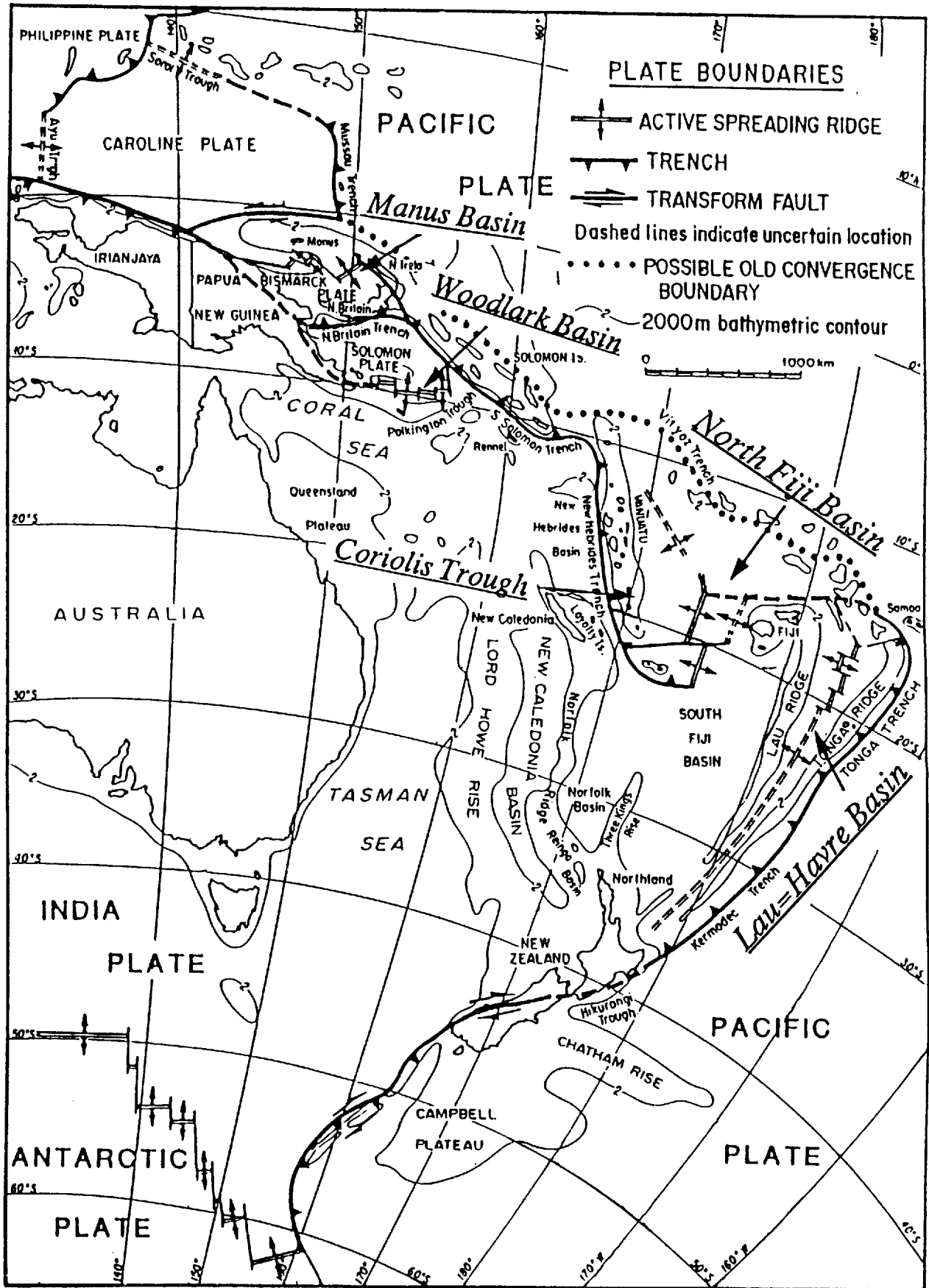
The north Fiji Basin is back-arc basin located east of Australia, approximately at 170° E (Figure 3-1-1-1). The southwest Pacific including the North Fiji Basin is called Melanesian Borderland constituting a boundary zone between the Pacific and India-Australia major plates. Complicated arc and back-arc systems with back-arc basin, namely from north to south, Manus Basin, Woodlark Basin, North Fiji Basin, and Lau-Havre Basin, occur along this zone (Coleman and Packham, 1976, Packham, 1982 Honza, 1991). The North Fiji Basin, which extends approximately 1,000km X 1,000km with average depth of 3,000m, is the largest among those Pliocene to Recent marginal seas and it is moving toward northwest as a part of the Pacific Plate (Doutch, 1981).

The study of the North Fiji Basin started at early 1970's by U.S. and France with focused efforts on the selected areas and large scale profiling across the basin. France, also, studied a part of the North Fiji Basin during the EVA (Evolution des Arcs insulaires) program, which was started in 1976.

The existence of an axial ridge was assumed by the partial mapping of an accreting ridge in the North Fiji Basin in 1985 by French SEAPSO (Sea Beam Pacifique Sud Ouest) program (Auzende et al. 1986). Based on the results of SEAPSO program, the North Fiji basin was intensively studied by STARMER project (Japan-France-SOPAC cooperative project) from 1987 to 1992. By STARMAR project a general view of the North Fiji Basin was clearly revealed with detailed mapping of the Central Spreading Ridge and, further, hydrothermal mineralization sites, White Lady sites and Pere Lachasie field, were found. The Hyfiflux project started in 1995 by German scientist found a new site of hydrothermal mineralization and it was named SO99 site.

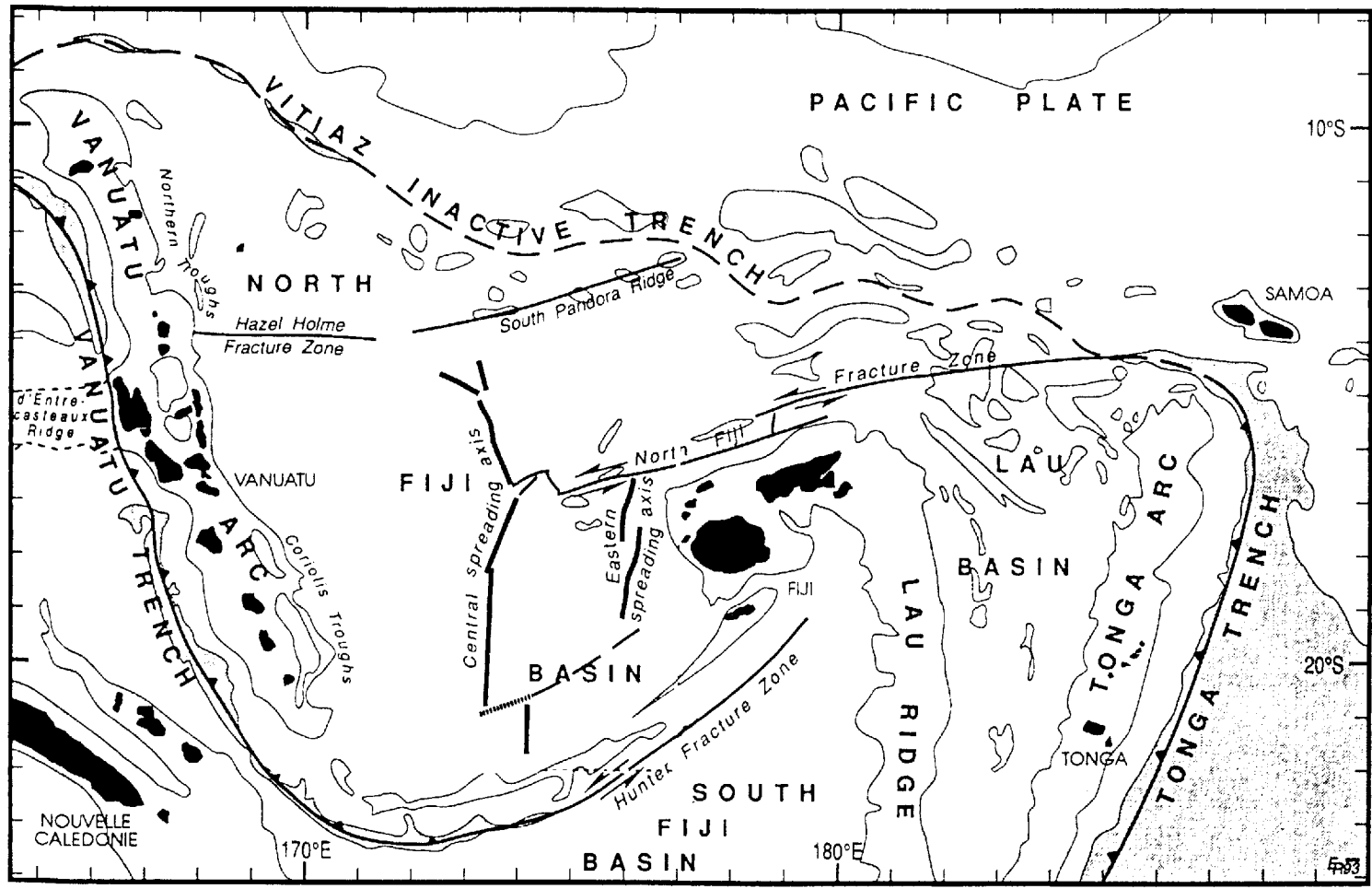
#### 3-1-2 Geology of the North Fiji Basin

The North Fiji Basin lies between the Vanuatu Arc (New Hebrides Arc) to the west and Fiji Platform to the east (Figure 3-1-2-1). The Vanuatu Arc with the Vanuatu Trench located in the west of it forms active arc-trench system starting from Paleogene with east dipping subduction zone, and the North Fiji Basin was formed as a back-arc basin of this arc-trench system (Carney and MacFarlane, 1982; Brocher, 1985). The Fiji Platform consisting of Paleogene to recent volcanic



After Packham(1982)

Figure 3-1-1-1 Outline of the Southwest Pacific Ocean



After Huchon et al., (1994)

Figure 3-1-2-1 Main Tectonics of the North Fiji Basin

rocks and limestone forms Fiji Island and extends further south to Lau Ridge. North and south of the North Fiji Basin are bounded by the Vitiiaz Trench and the Matthew-Hunter zone. The Vitiiaz trench is an inactive trench without active volcanism and seismicity (Brocker, 1985), while the Matthew-hunter zone consists of shallow ridges separating the shallow North Fiji Basin and the older and deeper South Fiji Basin.

Based on the results of the SEAPSO and the STARMER projects, the geology and tectonics of the North Fiji Basin are summarized as below.

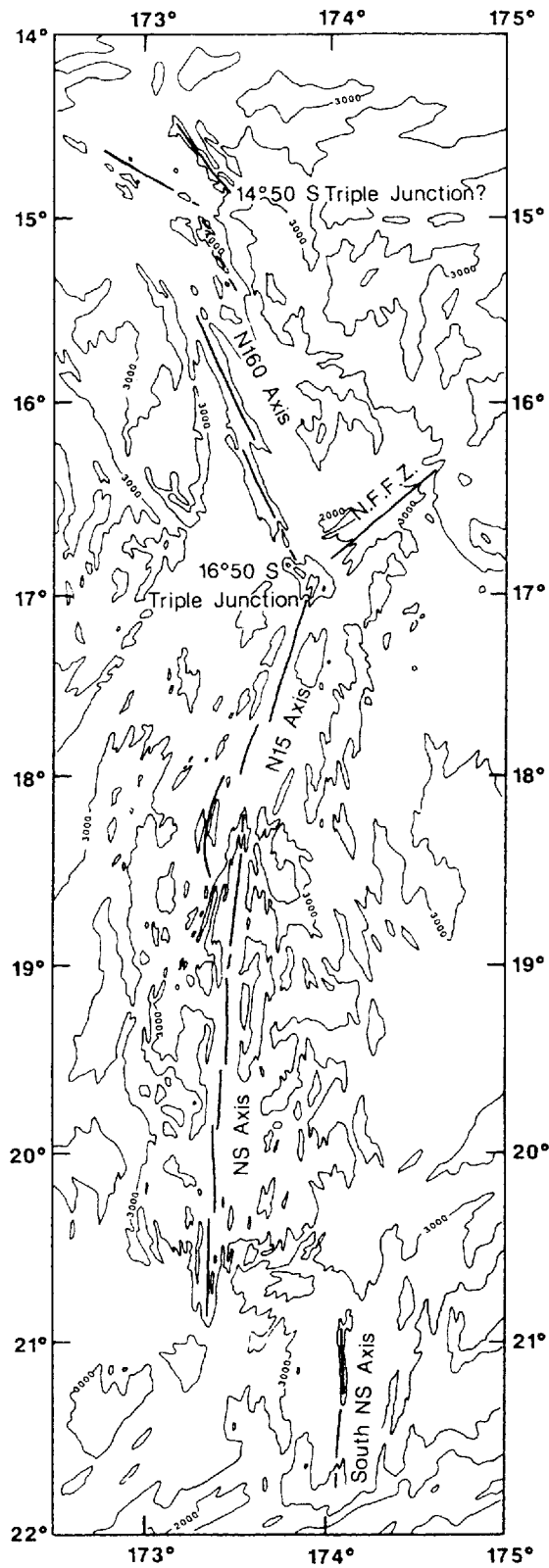
In the north of the North Fiji Basin, E-W to WSW-ENS trending Hazel Holme Ridge and South Pandora Ridge align from the Vanuatu arc to the Vitiiaz trench. The Central Spreading Ridge, the main spreading ridge of the North Fiji Basin, occupies slightly east of the North Fiji Basin and runs north to south starting from the above ridges to the Hunter Fracture zone. The area approximately at  $17^{\circ}$  on the Central Spreading Ridge is called the Triple Junction where the central Spreading Ridge and the North Fiji Fracture Zone meets. The North Fiji Fracture Zone, trending in WSW-ENE, is considered to be a lateral fault with sinistral movement (Louat and Pelletier, 1989), and it runs from the Triple Junction reaching to the Tonga Trench.

The Central Spreading Axis is 800m long, N-S trending spreading axis, and a detailed mapping of it conducted during STARMAR project (Auzende et al., 1990a, Monzier et al., 1991, Urabe et al., 1992) showed that it consisted of four separate fragment, namely, from south to north, the Southernmost segment, North-South segment,  $N15^{\circ}$  segment and  $N160^{\circ}$  segment (Figure 3-1-2-2). The magnetic lineations along the Central Spreading Ridge were confirmed for all the segments and spreading rate were estimated to be 50 to 82mm/yr (Auzende et al., 1990b, Huchon et al., 1994).

The followings are the evolution of the North Fiji Basin according to Auzende et al., (1988) and (1995).

The rifting of the North Fiji Basin was initiated at 12Ma by the splitting of the Vitiiaz-New Hebrides-Fiji-Lau-Tonga arcs. After the rifting, spreading along a NW-SE direction continued synchronous with the clockwise rotations of the New Hebrides arc and the anticlockwise rotation of the Fiji Platform. The outline of the fan-shaped North Fiji basin was formed during this period. The NW-SE spreading axis stopped at 7Ma and was replaced by an E-W trending spreading center from the northwestern tip of the basin to the north of the Fiji Platform. Around 3Ma, a triple junction was active between the E-W axis and the newly created N-S trending





After Anzende et al.,(1994)

Figure 3-1-2-2 Bathymetric Map around the Central Spreading Ridge

spreading center. Around 1.5Ma the opening along the E-W axis was reorganized by the development of the North Fiji Fracture Zone along the Fiji Platform up to N-S spreading axis, creating the Triple Junction at 16° 50'S.

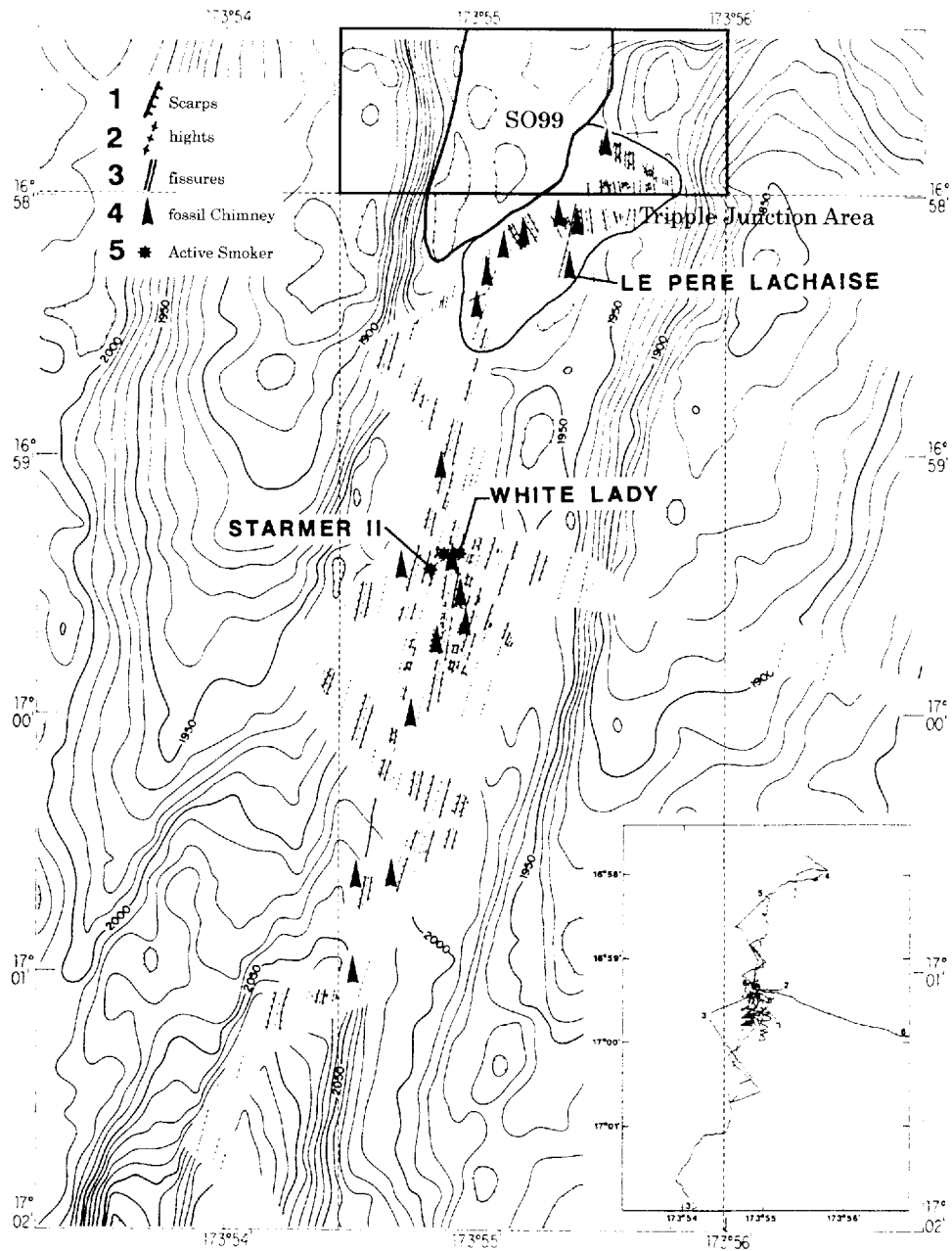
### 3-1-3 Geology and Mineralization of the Area Surrounding the Triple Junction

The Triple Junction, where N160° and N15° segments and the western tip of the North Fiji Fracture Zone meet, is located in the center of the North Fiji basin at 16° 50'S. The geology and mineralization of the area is summarized as below based on the results of the STARMER project (Auzende et al., 1991, Tanahashi et al., 1991, Lagabrielle, et al., 1994, Bendel et al., 1993).

The center of the Triple Junction is occupied by the volcanic hill with approximately 18km across dome shape, rising 500 to 600m above the surrounding sea bottom, and it is call as the Central Dome. A N-W trending graben of 0.5km to 2km wide, which is consider to be the extension of the axial graben of the N15° segment, runs over the top of the Central Dome. The graben is filled by basaltic pillow and sheet lavas, and floor of the graben is characterized by the occurrences of collapsed lava lake. From the Central Dome, the N160° segment extends toward NNW and V-shaped graben of 35km wide, which is considered to be the western tip of the North Fiji Fracture Zone, extends toward NE.

Inside the graben of the Central Dome, three sites of hydrothermal mineralization, White Lady, Pere Lachaise and SO99 sites, have been found (Figure 3-1-3-1). At White Lady site, located on the fault scarps in the 2km wide and 100 to 150m deep graben, anhydrite chimneys expelling shimmering 285°C water were found on the mound consisting of sulfides and oxides. The Pere Lachaise Site, located closer to the Triple Junction, north of the White Lady site, is characterized by the disappearance of the axial graben and increasing width of the domain. The site consists of several tens of inactive individual spires growing directly on basalt scattered over 2km × 2km surface. The SO99 site, located northwest of the Pere Lachaise Site, consists of hydrothermal mounds with inactive chimney scattering over the area of 500m × 600m. The sea floor observation of the site suggests chimney and basalt of younger generation compared with those of Pere Lachaise Site (Hallback et al., 1995, FU Berlin and partner, 1998).

The survey area of this year is as same as the Area1 of 1999 survey and it is located at the center of the North Fiji Basin including the Triple Junction of the Central Spreading Ridge. The topographic and magnetic surveys were conducted



After Gracia et al.,(1994)

Figure 3-1-3-1 Hydrothermal Activity of the Central Spreading Ridge

over the survey area of this year, while hydrothermal mineralization survey and environmental survey were conducted in a small area inside the axial valley of the Central Spreading Ridge. This area was named as the Triple Junction Area and it includes SO99 site and the western part of the Pere Lachaise site.

### 3-2 Topographic and Magnetic Surveys

#### 3-2-1 Topography of the Survey Area

The topographic survey of the survey area was conducted as the Area 1 during the 1999 program and the topographic survey of this year was subordinately conducted for the purpose of the magnetic survey. Consequently, no new topographic information was obtained by the topographic survey of this year. The bathymetric map of the survey area and the shaded map of a slightly enlarged scale covering the Triple Junction Area are shown in Figures 3-2-1-1 and 3-2-1-2.

The survey area is located covering the topographic high of the Triple Junction, where N15° segment and N160° segment of the Central Spreading Ridge and North Fiji Fracture Zone meet. The topographic high, called as Central Dome, is a volcanic dome located at northern end of the N15° segment.

The central Dome is approximately 900m high from the surrounding basin of 2,700m deep and it occupies an area of 20×12km at the contour line of 2,100m. The shallowest point of this egg-shaped dome is 1,860m and its northern slope is relatively steep, while southern slope is gentle. A 2km-wide valley, the Axial valley, extends in NNE-SSW direction cutting through the center of the Central dome, and two ridges, the Eastern and Western Ridges, exist on the both sides of the valley. The scarps of both side of the Axial Valley are steep and 40 to 60m high.

In the survey area, the water depth of the Axial Valley, extending to SSW direction from the Triple Junction, is shallower near the Triple Junction and becomes deeper reaching 2,230m. toward south. The valley floor forms step-wise terrace of two to three steps and the central part is the deepest.

The area northeast of the Central Dome forms a valley of 5km wide. The valley becomes deeper toward northwest and it is connected to the N160° segment of the Central Spreading Ridge. In northwest of the Central dome, a wide depression with a depth more than 2,400m occurs. This is considered to be the western tip of the North Fiji Fracture zone (Tanahashi et al., 1991).

The Triple Junction Area of the hydrothermal mineralization and environmental surveys occupies central north of the Central Dome. It includes the Axial Valley at center, the Western Ridge on the west and the scarp toward the



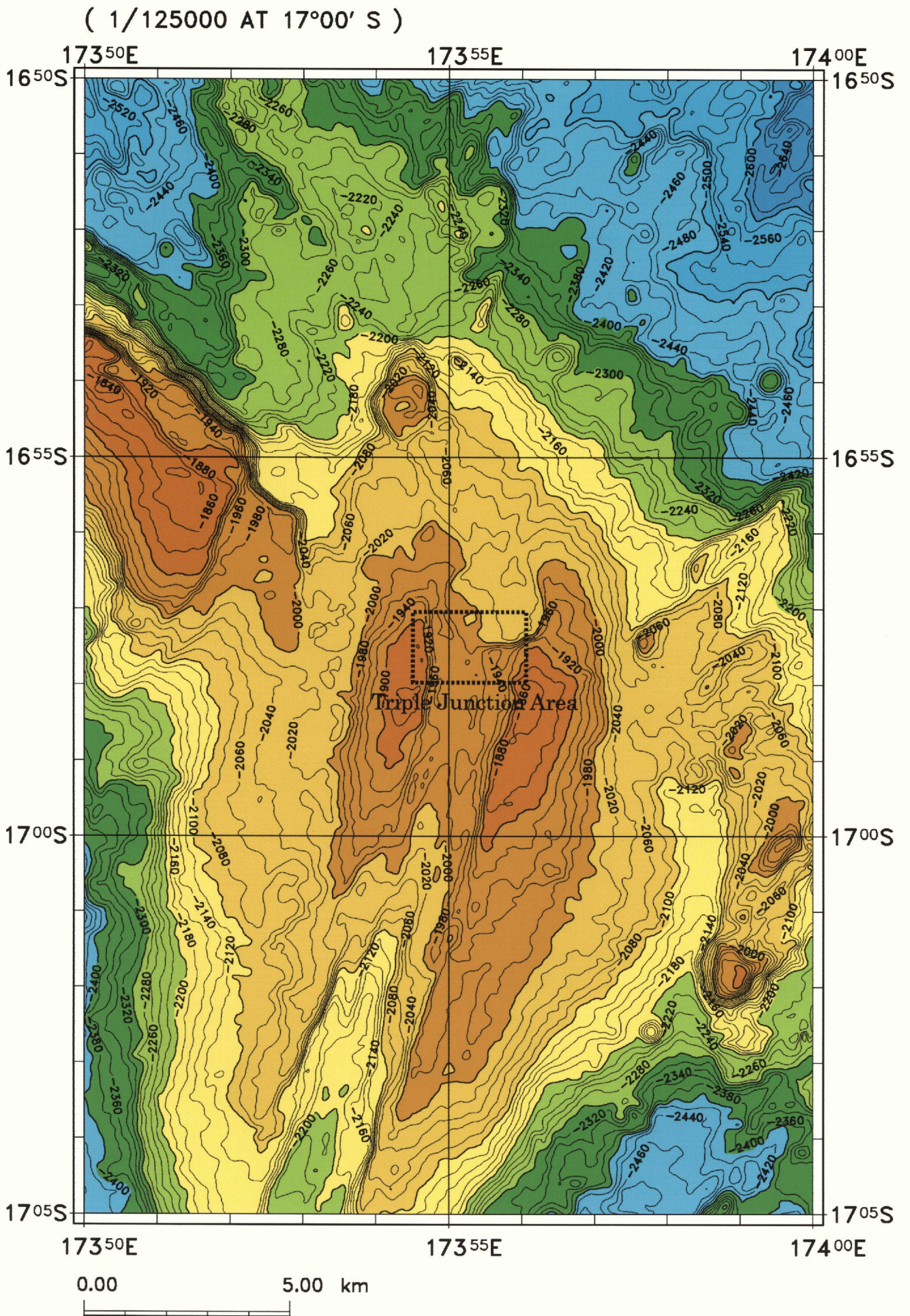


Figure 3-2-1-1 Bathymetric Map of the Survey Area



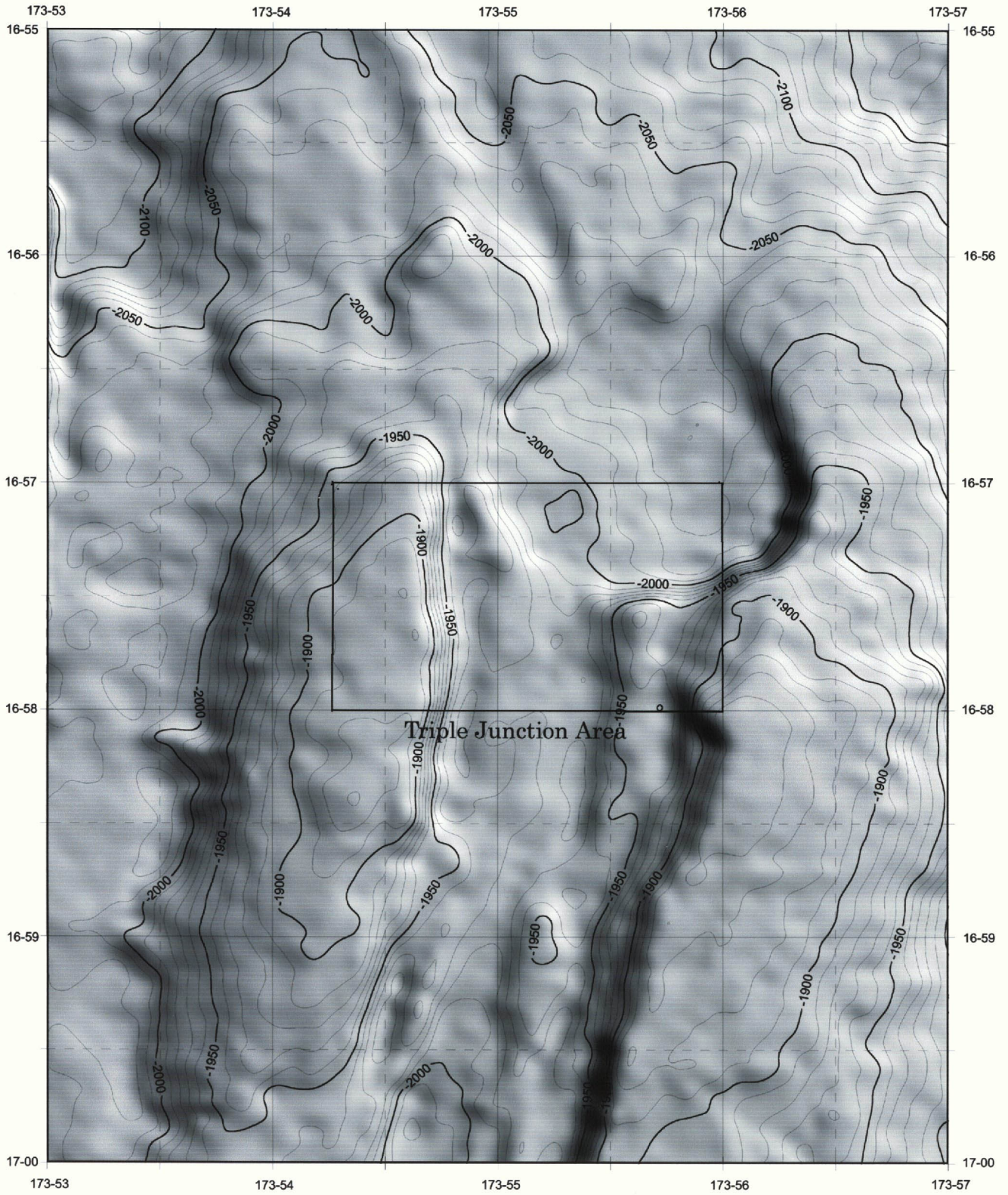


Figure 3-2-1-2 Shaded Map of the Triple Junction Area

Eastern Ridge on the east. The western part of the Axial Valley forms a gentle hill with a depth shallower than 1,970, while eastern part of the Axial Valley is relatively flat with depth of more than 1,970. A steep fault scarp of 70m high occurs between the Axial Valley and the Western Ridge. While, the slope between the Axial Valley and Eastern Ridge is relatively gentle with an appearance of intermediate terrace step on the slope. A 2,000 to 2,030m deep circular depression of 2km across, the Nodal Basin, occurs in the north of the Triple Junction Area.

### 3-2-2 Magnetic Survey

The result of the magnetic survey is shown in Figure 3-2-2-1, together with the bathymetric map of the survey area. Because the area covered by the magnetic survey of this year is not enough for a detail interpretation, only magnetic anomaly map is given on this report.

### 3-3 Hydrothermal Mineralization Survey

The hydrothermal mineralization survey in the Triple Junction Area was conducted mainly using the BMS. The target of the drilling was decided based on the results of the FDC survey of 1999 (JICA-MMAJ, 2000) and the cruise report of Hyfifluxn II Project as shown in Figure 3-3-1.

The videotapes of FDC in 1999 were reviewed in detail and ore showings were described (Table 3-3-1). All the ore showings studied from the FDC are located in the Axial Valley except one on the flat area on the top of the Western Ridge. In the axial valley, ore showing tend to be distributed in two separate areas bounded by 173° 55.2' line: one is over the gentle hill in the western part of the Axial Valley, the other is over the area from the flat valley floor to the foot of the Eastern Ridge in the eastern part of the area. These areas are named as the West Area and the East Area, respectively. According to the observation of FDC video, the ore showings of the area consist of hydrothermal mound extending 50 to 100m in one direction, uprising 5 to 10m from the surrounding sea floor. Reddish brown debris of chimney and fragments of sulfide ore are distributed on the mound. Inactive chimneys of 1 to 5m high are usually observed on the mound.

During the towing of BMS before and after the drilling operation, the sea floor observation was conducted by the high-resolution camera installed to the BMS. Based on the results of this observation together with FDC results, the search of new ore showings and the interpretation work of ore showings and geology of the area were conducted. On the days drilling operation was hampered by bad weather,



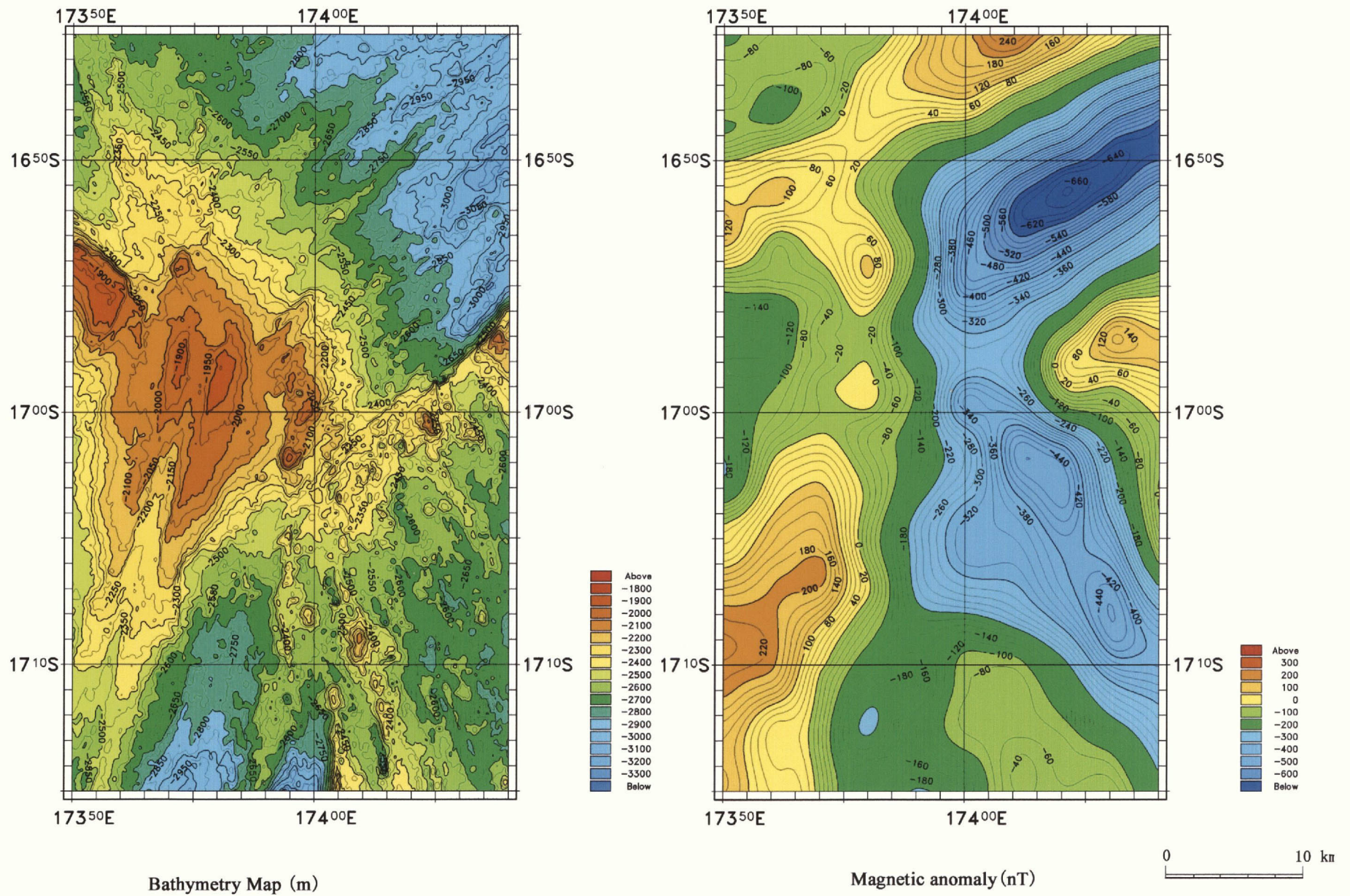


Figure 3-2-2-1 Bathymetric Map and Magnetic Anomaly Map



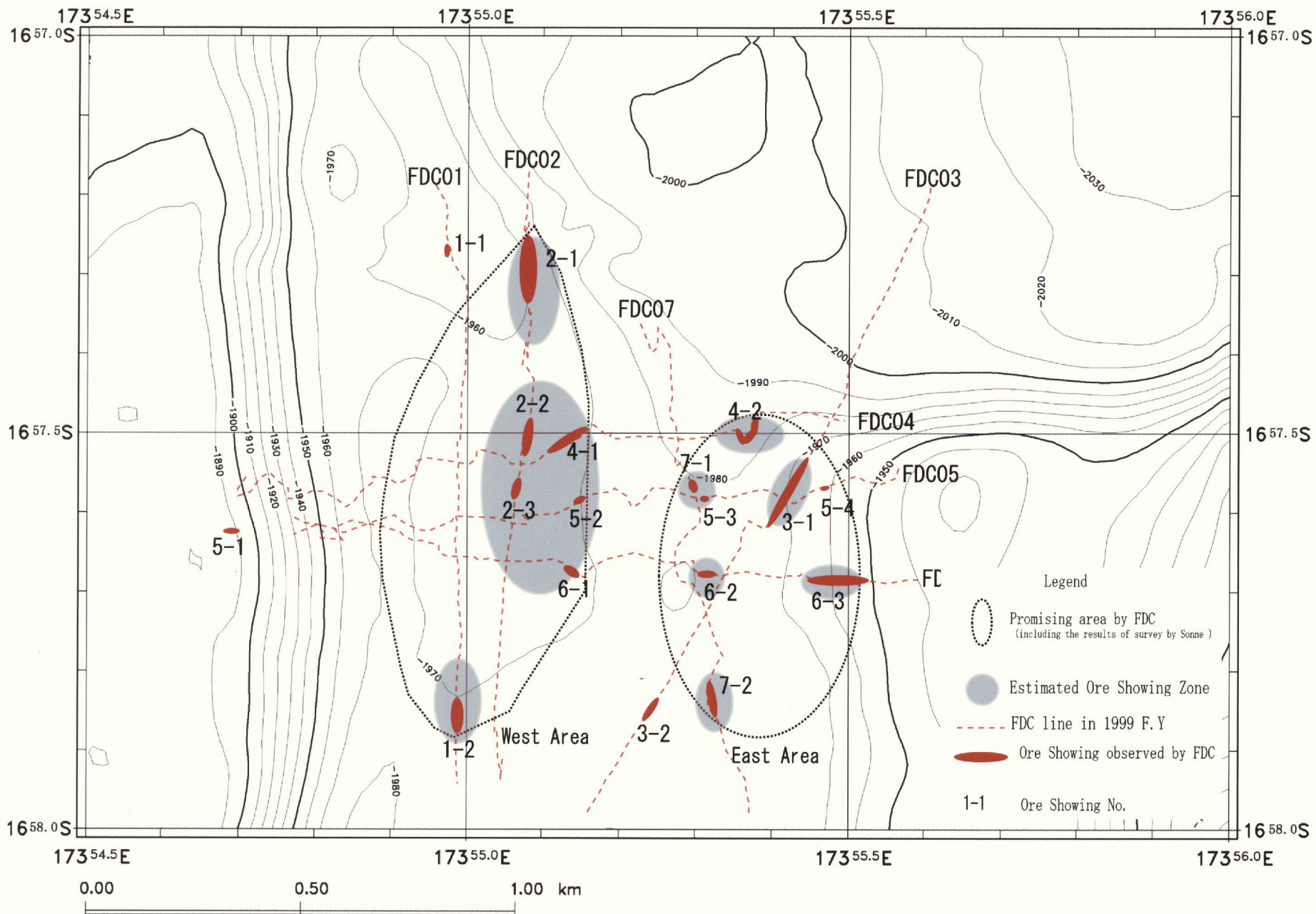


Figure 3-3-1 Promising Area

Table 3-3-1 Descriptions of Ore Showing Found by FDC of 1999FY (1/2)

West Area

No.	Area	Ore Showing by FDC	FDC Line	FDC passed ore showing at following time (GMT).	Location		Estimated Height	Descriptions
					latitude	longitude	Estimated Width	
1	West	1-1	99SFFDC01	21:43:30 21:44:00	16°57.280' S	173°54.960' E	5m	Mound rises 5m high from surrounding sea floor. Chimneys of 3m high are found on mound. Fragments, 0.5-1m across, consisting of chimney and sulfide ore are observed over sediments discolored to reddish brown. Beneath pillow lava dome, eastern margin of mound.
							15m	
2	West	1-2	99SFFDC01	22:25:30 22:27:55	16°57.840' S	173°54.965' E	5m	Forms dome structure of 5m high with gentle slop. Reddish brown to white color, cobble size debris of 10-30cm across, were accumulated on the mound. Reddish brown sediments with yellow and black patches were observed. No chimney was found.
							100m	
3	West	2-1	99SFFDC02	00:40:20 00:43:16	16°57.330' S	173°55.060' E	10m	Ore showing is composed of ridge to dome structure mound. Reddish brown fragments of chimney, sulfide ore and lava, 0.5-2.0m across, are accumulated on the mound. Sediments are discolored to reddish brown, and chimney was not found..
							100m	
4	West	2-2	99SFFDC02	00:53:45 00:56:25	16°57.500' S	173°55.065' E	5m	Reddish brown fragments, 0.5-3.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Sediments are discolored to reddish brown. A chimney of 2.0m high was observed..
							100m	
5	West	2-3	99SFFDC02	00:59:40 01:01:10	16°57.565' S	173°55.500' E	5m	Reddish brown fragments, more or less 1.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. A chimney of 1.0m high was observed.. FDC passed western ridge of mound.
							50m	
6	West	4-1	99SFFDC04	21:19:30 21:22:00	16°57.520' S	173°55.100' E	10m	Reddish brown fragments, 0.5-3.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sediments with white and yellowish brown patches are discolored to reddish brown. Chimneys of 1-2m high are scattered on mound. .
							100m	
7	West	5-2	99SFFDC05	23:57:12 23:58:00	16°57.605' S	173°55.115' E	10m	Reddish brown fragments, 0.5-2.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. Reddish brown sediments have white patches Chimneys of 3m high occur on the mound.
							50m	
8	West	6-1	99SFFDC06	02:45:30 02:47:00	16°57.680' S	173°55.120' E	10m	Partly observed by FDC It has an extension of more than 50m. Many chimneys of 5m high are found on mound. Reddish brown relics of chimney, 0.3-3m across are accumulated.
							50m+	

Western Ridge

No.	Area	Ore Showing by FDC	FDC Line	FDC passed ore showing at following time (GMT).	Location		Estimated Height	Descriptions
					latitude	longitude	Estimated width	
1		5-1	99SFFDC05	23:31:20 23:33:35	16°57.640' S	173°54.680' E	Unknown	It occurs on the flat top of the Western Ridge. Reddish brown fragments of chimney and lava, 0.2-5m across, are accumulated.
							100m	

Table 3-3-1 Descriptions of Ore Showing Observed by FDC of 1999FY (2/2)

East Area

No.	Area	Ore Showing by FDC	FDC Line	FDC passed ore showing at following time (GMT).	Location		Estimated Height	Descriptions
					latitude	longitude	Estimated width	
1	East	3-1	99SFFDC03	04:07:53 04:12:30	16°57.600' S	173°55.390' E	5m	Mound forms gentle dome structure. Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Chimneys of 2.0m high are scattered over mound. The eastern edge of mound was observed by FDC. Mound is partly covered by sediments. This suggests mound of older generation.
							100m	
2	East	3-2	99SFFDC03	04:24:50 04:26:20	16°57.820' S	173°55.250' E	10m	FDC crashed to mound and details are unknown. Reddish brown fragments, 0.5-3.0m across, consisting of relic of chimney and sulfide ore are distributed on the foot of the mound wall consisting of massive sulfide. Chimneys of 5m high occur.
							Unknown	
3	East	4-2	99SFFDC04	21:33:45 21:37:45	16°57.505' S	173°55.350' E	10m	Reddish brown fragments, 0.3-3.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. White and brownish yellow patches occur on reddish brown sediments. Chimneys of 1-3m high are distributed.
							100m	
4	East	5-3	99SFFDC05	00:07:17 00:08:00	16°57.595' S	173°55.290' E	10m	FDC crashed to mound of 10m high and extension is unknown. Fragments of chimney, 0.3-1.0m are distributed at foot of mound. Sediments were discolored to reddish brown.
							Unknown	
5	East	5-4	99SFFDC05	00:17:20 00:17:55	16°57.575' S	173°55.435' E	3 m	FDC passed at northern edge of mound. Fragments of chimney and sulfide ore, 0.2-1.0m across, are distributed. Sediments are discolored to reddish brown.
							30m	
6	East	6-2	99SFFDC06	02:55:50 02:57:10	16°57.685' S	173°55.305' E	5 m	FDC crashed to mound of 5m high and details are unknown. Chimneys of 5m high occur.
							Unknown	
7	East	6-3	99SFFDC06	03:03:26 03:07:25	16°57.690' S	173°55.460' E	10m	Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Reddish brown sediments have white patches Chimneys of 3-5m high occur on the mound.
							150m	
8	East	7-1	99SFFDC07	05:22:02 05:23:09	16°57.570' S	173°55.280' E	5 m	It forms a gentle dome structure and occurs at foot of scarp. Orange fragments, 0.1-0.3m across, consisting of relic of chimney and lava are distributed on mound. Sediments are discolored to orange color. Two chimneys of 1m high were observed. FDC passed at western edge of mound.
							50m	
9	East	7-2	99SFFDC07	05:38:43 05:41:40	16°57.845' S	173°55.305' E	10m	Reddish brown fragments, few m across, consisting of relic of chimney and lava are distributed on mound. Some of the lava fragments are not discolored. Sediments with white patches are discolored to reddish brown. A chimney of 3m high was observed.
							100m	

LC sampling obtaining the surface materials was conducted to understand the distribution of ore showings. The sampling locations of the BMS, LC and MC are shown in Figure 3-3-2.

### 3-3-1 Geology of the Area

The track lines of the sea floor observation by towing BMS were shown in the Figure 3-3-1-1. The geological map of the area, shown in Figure 3-3-1-2, was made based on the results of the sea floor observation by BMS and FDC. The typical photographs of the sea floor are given in Appendix 1.

The Axial Valley occupies the center of the Triple Junction Area, surrounded by the both scarps of Western and Eastern Ridges. The area is underlain by various types of basaltic lava, such as sheet lava, pillow lava, brecciated lava, lobate lava, lava lake and massive lava. On the geological map they are grouped in three units: sheet lava, pillow lava and massive lava.

The sheet lava extensively occurs covering the floors of the Axial Valley and the Nodal Basin of the Triple Junction Area. The sheet lava, generally, shows flat platy occurrence covered by thin sediments and it, sometimes, shows a lobate structure and lava lake. In central and central south parts of the area and in the Nodal Basin, collapsed lava lakes consisting of debris of platy lava of the surface and pillars are observed.

The pillow lava tends to occur in the higher location and it is found covering a gentle hill of the western part of the Axial Basin and in the area from the floor of the Axial Basin to scarp of the Eastern Ridge. On the floor of the Axial Basin, small domes of pillow lava rising few meters high from the sea floor of sheet lava, locally, occur along the fissures. Pillow structures are rounded, ellipsoidal and irregular shapes of 50 to 1m across and the lava with ropy structure, occasionally, occurs together with pillow lava.

The massive lava showing columnar joint occurs along the escarpments of the Western Ridge and the western side of gentle hill in the Axial Valley. The massive lava seems to be the lava of deeper horizon and have been exposed by the by fault movement.

The talus debris consisting of fragments of angular massive lava and pillow lava occurs extensively at the base of the escarpment of the Western Ridge.

The sediment cover in the Axial Valley is, generally, thin, more or less 10cm. A relative thick sediment cover, reaching nearly 1m, locally occurs in the area, on the top of the Western Ridge and on the gentle hill in the western part of the



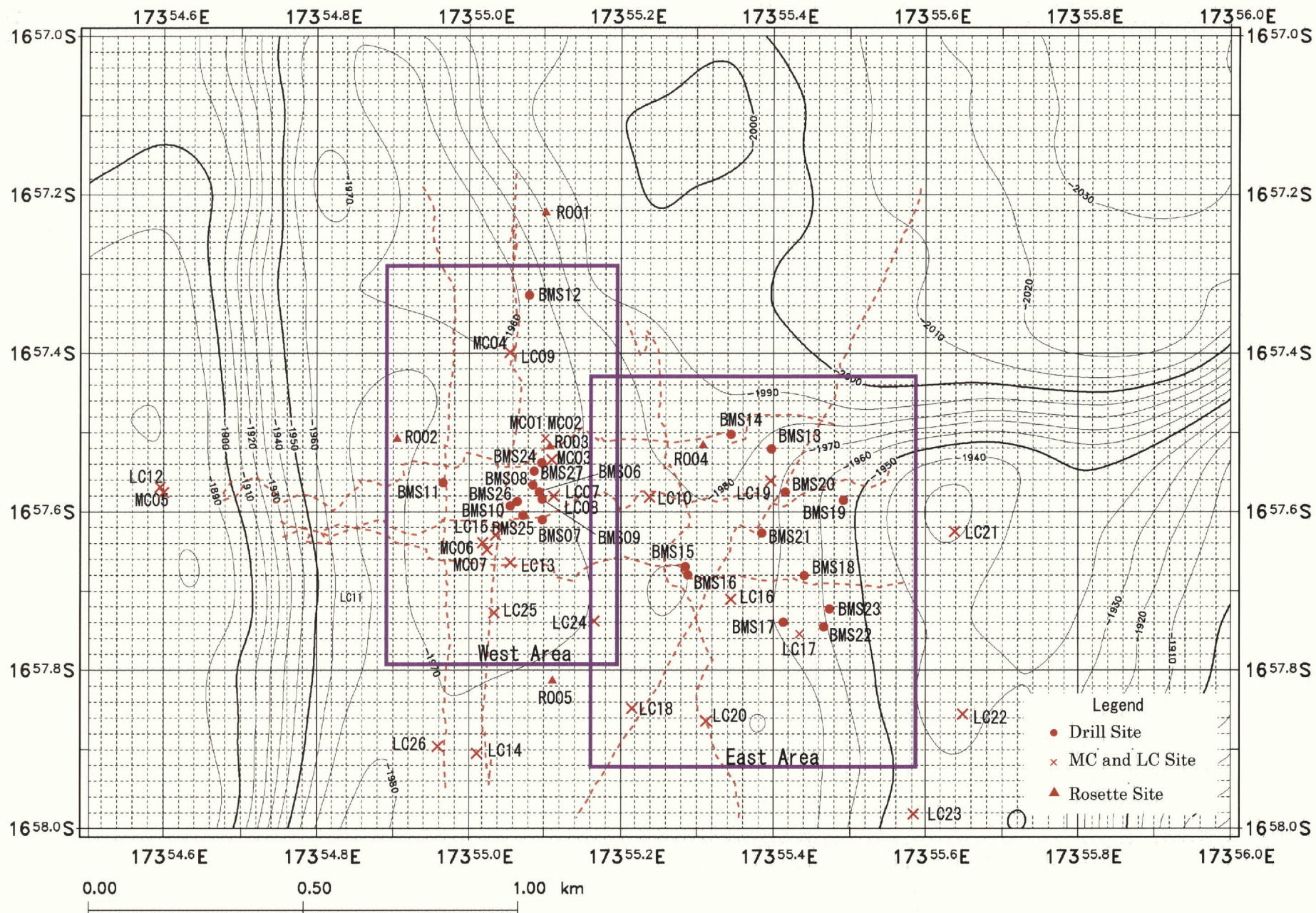


Figure 3-3-2 Location Map of Sampling Site



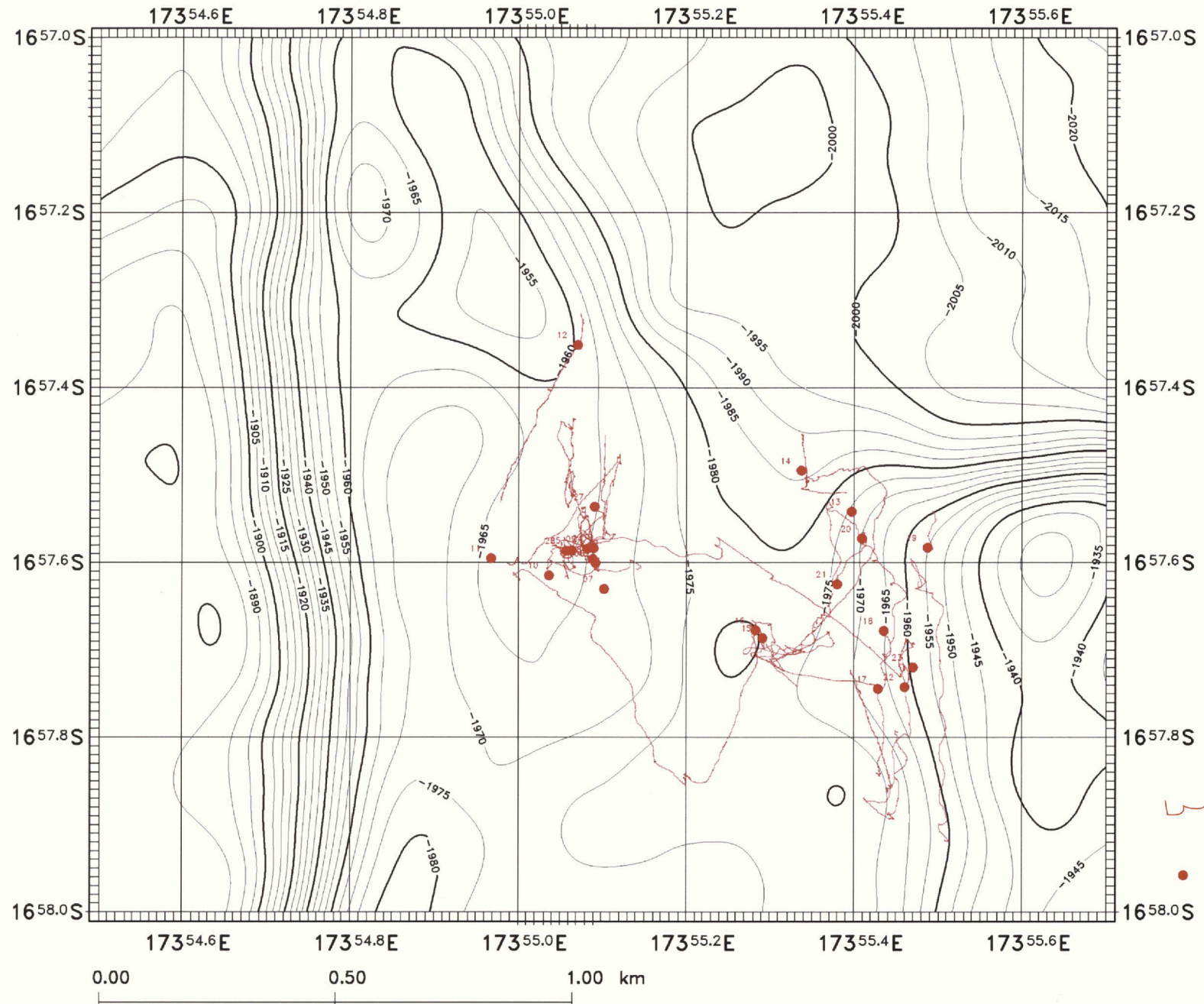


Figure 3-3-1-1 The Track Lines of the Seafloor Observation by Towing BMS

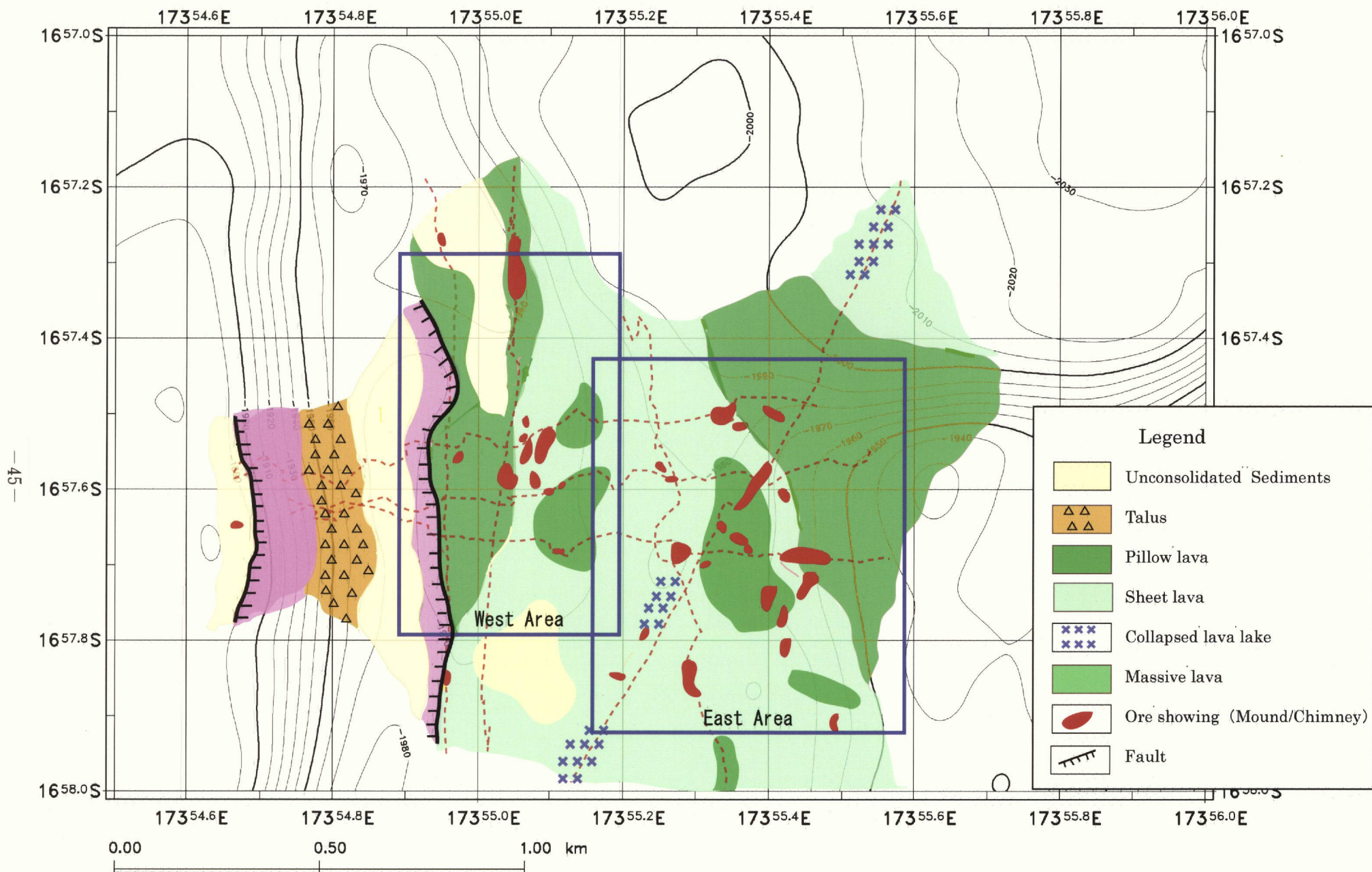


Figure 3-3-1-2 Geological Map of the Triple Junction Area

Axial Valley. The pillow lava tends to occur without sediments cover, while sheet lava, generally occurs with thin sediment cover. This may suggest a later eruption of the pillow lava after the emplacement sheet lava.

The many faults, fissures and small-scale horst/graben structures are observed on the floor of the Axial Valley. The majority of them align on N-S directions and rarely E-W trending ones are observed.

### 3-3-2 Ore Showings

The ore showings of the Triple Junction Area were described using the videotapes recorded by the high-resolution camera installed to the BMS. The locations of the ore showings are determined based on the towing track line of the BMS before and after the drilling operations. Since the track lines were drawn using the GPS at the stern of the vessel, some ambiguities remain for the location of BMS, especially, when the vessel makes turns. Considering this, the locations of the ore showings were determined. The height and extension of the ore showings were estimated from the video. For the extension of the ore showings in the most of the cases, it was estimated by only one traverse line of either FDC or BMS.

Through the sea floor observation by BMS, the ore showings found by the FDC of 1999 project were confirmed and some new ore showings were found. The distribution of the ore showings is shown in the geological map (Figure 3-3-1-2) and in the Bird's Eye View Map of Figure 3-3-2-1. As shown in these figures, the ore showings occur concentrated in two areas, the West Area and the East Area, separated by  $173^{\circ} 55.2'E$  line and they tend to occur on and near the boundary between sheet lava and pillow lava.

The distributions of the ore showings in the West Area and the East Area are shown in Figures 3-3-2-2 and 3-3-2-3, respectively, and the descriptions of them are given in Table 3-3-2-1. For the numbering of ore showings confirmed this year, W and E were used, respectively, for the West Area and the East Area.

The ore showing in the Triple Junction Area, typically, forms a hydrothermal mound rising from 5-10m high from the surrounding sea floor and inactive chimneys are found standing on mound. Because of the reddish brown discoloring of the fragments of chimney and sulfide ore accumulated on the mound, it is relatively easy to identify the hydrothermal mound by sea floor observation.

In the West Area, a total of 11 ore showings were identified by sea floor observations of FDC and BMS. The most of the ore showings of the West Area occur within a small area between  $16^{\circ} 57.5' E$  and  $16^{\circ} 57.6' E$  on the east side of the



Table 3-3-2-1 Description of Ore Showings 1/4

No	Area	Ore Showing	Showing Found by FDC	Location (Center of Ore Showing)		Estimated Height	Descriptions	Drill Hole No.
				latitude	longitude	Estimated Width		
1	West	W1	2-1	16°57.330' S	173°55.060' E	10m	Ore showing is composed of ridge to dome structure mound. Reddish brown fragments of chimney, sulfide ore and lava, 0.5-2.0m across, are accumulated on the mound. Sediments are discolored to reddish brown, and chimney was not found..	BMS12
						100m		
2	West		2-2	16°57.500' S	173°55.065' E	5m	Reddish brown fragments, 0.5-3.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Sediments are discolored to reddish brown. A chimney of 2.0m high was observed..	
						100m		
3	West	W2		16°57.525' S	173°55.055' E	5m	Partly observed and extends more than 20m. Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Sediments with white and yellowish brown patches are discolored to reddish brown. Few chimneys of 2-5m high were observed on mound.	
						20m+		
4	West	W3		16°57.565' S	173°55.180' E	10m	Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Sheets of massive sulfide ore are partly exposed on mound. Sediments with white patches are discolored to reddish brown. Few chimneys of 1-3m high were observed on mound.	BMS08 BMS24
						100m		
5	West	W4	4-1	16°57.545' S	173°55.105' E	10m	Reddish brown fragments, 0.5-3.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sediments with white and yellowish brown patches are discolored to reddish brown. Chimneys of 1-2m high are scattered on mound. .	BMS09 BMS27
						100m		
6	West	W5		16°57.560' S	173°54.980' E	unknown	Partly observed and extends more than 30m. Reddish brown fragments, 0.3-1.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Sediments are discolored to reddish brown. 8 chimneys of 3m high were observed on mound.	BMS11
						30m+		
7	West	W6	2-3	16°57.585' S	173°55.050' E	5m	Reddish brown fragments, more or less 0.3-2.0 m across, consisting of relic of chimney and sulfide ore are accumulated on mound. Sheets of massive sulfide ore are exposed. Sediments with white and reddish brown patches are discolored to reddish brown. Chimneys of 1-2m high were observed..	BMS10 BMS25 BMS26
						50m		
8	West	W7		16°57.590' S	173°55.085' E	5m	Partly observed and extends more than 20m. Reddish brown fragments, 0.2-2.0m across, consisting of relic of chimney, and sulfide ore are distributed on mound. Sediments with brownish yellow patches are discolored to reddish brown. Few chimneys of 2-3m high were observed on mound.	BMS06
						20m+		

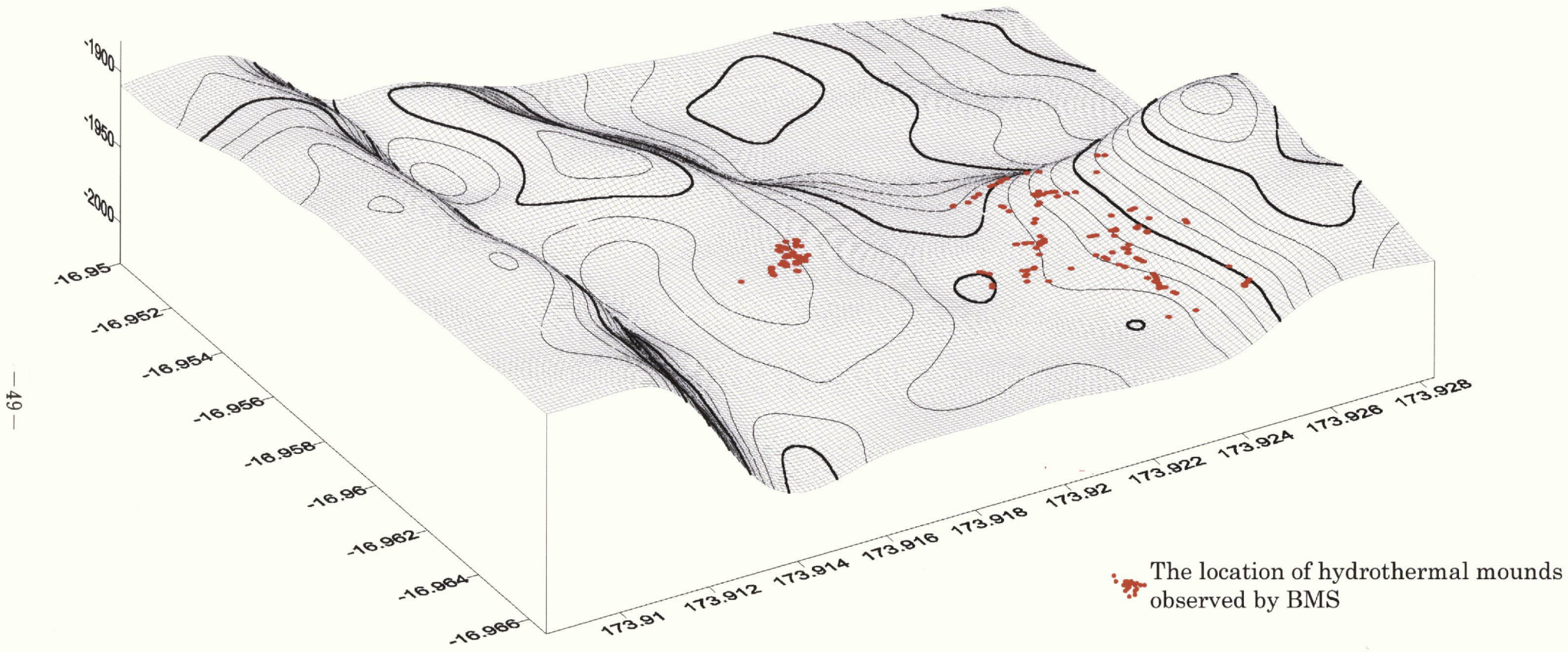


Figure 3-3-2-1 Bird's Eye View Map of the Triple Junction Area

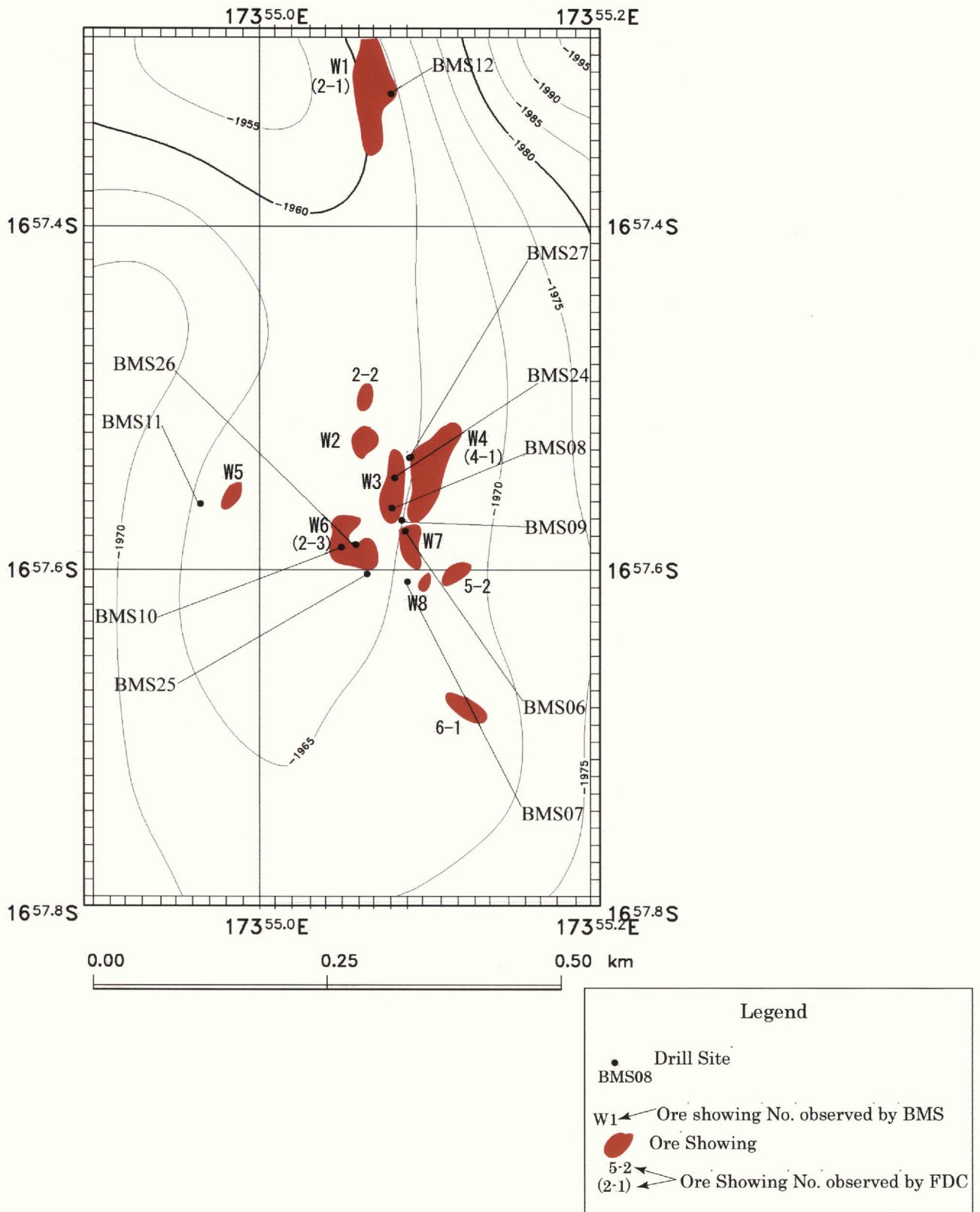


Figure 3-3-2-2 Distribution of the Ore Showing in the West Area

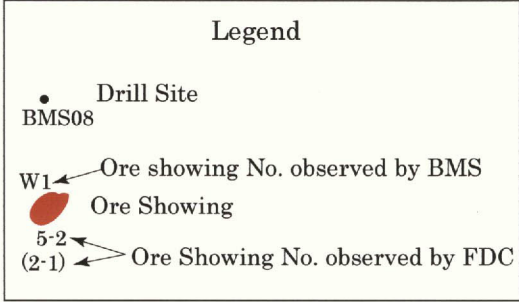
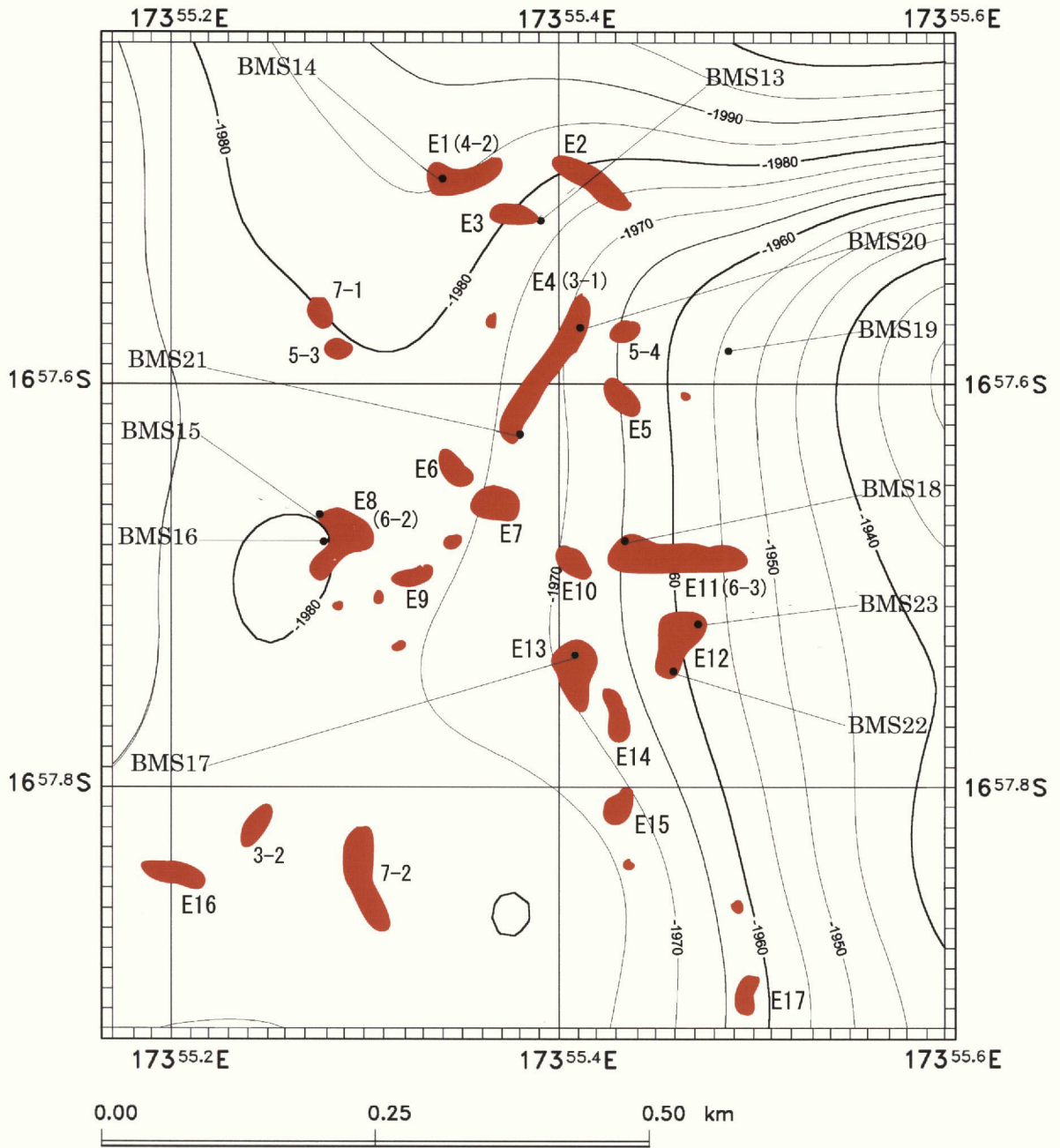


Figure 3-3-2-3 Distribution of the Ore Showing in the East Area

Table 3-3-2-1 Description of Ore Showings 2/4

No	Area	Ore Showing	Showing Found by FDC	Location (Center of Ore Showing)		Estimated Height	Descriptions	Drill Hole No.
				latitude	longitude	Estimated Width		
9	West	W8		16°57.610' S	1°73.551' E	unknown	Partly observed and extension and height are unknown. A chimney of 2m high was observed, surrounded by debris of chimney relic. Sediments is discolored to reddish brown.	BMS07
						unknown		
10	West		5-2	16°57.605' S	173°55.115' E	10m	Reddish brown fragments, 0.5-2.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. Reddish brown sediments have white patches Chimneys of 3m high occur on the mound.	
						50m		
11	West		6-1	16°57.680' S	173°55.120' E	10m	Partly observed by FDC It has an extension of more than 50m. Many chimneys of 5m high are found on mound. Reddish brown relics of chimney, 0.3-3m across are accumulated.	
						50m+		
12	East	E1	4-2	16°57.500' S	173°55.350' E	10m	Reddish brown fragments, 0.3-3.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. White and brownish yellow patches occur on reddish brown sediments. Chimneys of 1-3m high are distributed.	BMS14
						100m		
13	East	E2		16°57.500' S	173°55.420' E	10m	Forms gentle dome structure. Reddish brown fragments, 0.5-2.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. No chimney was observed.	
						150m		
14	East	E3		16°57.515' S	173°55.380' E	10m	Part of mound was observed. Reddish brown fragments, 0.2-1.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. No chimney was observed.	BMS13
						unknown		
15	East		7-1	16°57.565' S	173°55.275' E	5 m	It forms a gentle dome stricture and occurs at foot of scarp. Orange fragments, 0.1-0.3m across, consisting of relic of chimney and lava are distributed on mound. Sediments are discolored to orange color. Two chimneys of 1m high were observed. FDC passed at western edge of mound.	
						50m		
16	East		5-3	16°57.585' S	173°55.290' E	10m	FDC crashed to mound of 10m high and extension is unknown. Fragments of chimney, 0.3-1.0m are distributed at foot of mound. Sediments were discolored to reddish brown.	
						unknown		
17	East	E4	3-1	16°57.595' S	173°55.395' E	5m	Mound forms gentle dome stricture. Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Chimneys of 2.0m high are scattered over mound. The eastern edge of mound was observed by FDC. Mound is partly covered by sediments. This suggests mound of older generation.	BMS20 BMS21
						100m		

Table 3-3-2-1 Description of Ore Showings 3/4

No	Area	Ore Showing	Showing Found by FDC	Location (Center of Ore Showing)		Estimated Height	Descriptions	Drill Hole No.
				latitude	longitude	Estimated Width		
18	East		5-4	16°57.575' S	173°55.435' E	3 m	FDC passed at northern edge of mound. Fragments of chimney and sulfide ore, 0.2-1.0m across, are distributed. Sediments are discolored to reddish brown.	BMS19
						30m		
19	East	E5		16°57.610' S	173°55.435' E	5 m	Reddish brown fragments, 0.2-1.0m across, consisting of relic of chimney and sulfide ore are accumulated on mound. White patches occur on reddish brown sediments. Chimneys of 5m high occur.	
						50m		
20	East	E6		16°57.645' S	173°55.345' E	5 m	Reddish brown fragments, 0.2-1.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. The biggest relic of chimney reaches 5m across. White patches occur on reddish brown sediments. Chimneys of 50cm high are scattered on mound.	
						50m		
21	East	E7		16°57.660' S	173°55.370' E	2m+	Mound was partly observed.. Reddish brown fragments, 0.3- 2.0m across, consisting of relic of chimney and sulfide ore are distributed on mound. Sheets of massive sulfide ore are partly exposed. No chimney is observed.	
						50m+		
22	East	E8	6-2	16°57.680' S	173°55.295' E	5 m	Mound was partly observed.. Reddish brown fragments, 0.2- 1.0m across, consisting of relic of chimney are distributed over reddish brown sediments. Sheets of massive sulfide ore are partly exposed. Chimneys of 5.0m high are scattered over mound. Mound is partly covered by sediments without discoloring . This suggests the mound to be older generation.	BMS15 BMS16
						30m+		
23	East	E9		16°57.700' S	173°55.325' E	5 m	Reddish brown fragments, 0.2- 1.0m across, consisting of relic of chimney, sulfide ore and lava are distributed over reddish brown sediments. Collapsed chimneys of 2.0m high are observed. Mound is mostly covered by thin sediments without discoloring . This suggests the mound to be older generation.	
						100m		
24	East	E10		16°57.695' S	173°55.410' E	5m	Mound was partly observed.. Reddish brown fragments, 1.0m across, consisting of relic of chimney are accumulated on mound.	
						unknown		
25	East	E11	6-3	16°57.690' S	173°55.460' E	10m	Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Sheets of massive sulfide ore are partly exposed on the mound. Reddish brown sediments have white patches Chimneys of 3-5m high occur on eastern side of the mound.	BMS18
						150m		
26	East	E12		16°57.730' S	173°55.465' E	unknown	Mound was partly observed and details are unknown. Reddish brown fragments, 0.2- 1.0m across, consisting of relic of chimney and sulfide ore are distributed over reddish brown sediments with white patches. Sheets of massive sulfide ore are partly exposed.	BMS22 BMS23
						20m+		
27	East	E13		16°57.740' S	173°55.410' E	10m	Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Reddish brown sediments have white and brownish yellow patches. Chimneys of 3-5m high are scattered on mound.	BMS17
						30m+		



Table 3-3-2-1 Description of Ore Showings 4/4

No	Area	Ore Showing	Showing Found by FDC	Location (Center of Ore Showing)		Estimated Height	Descriptions	Drill Hole No.
				latitude	longitude	Estimated Width		
28	East	E14		16°57.765' S	173°55.435' E	5m	Forms gentle dome structure. Reddish brown fragments, 0.2-2.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Reddish brown sediments have white patches. A chimney of 50cm high was observed.	
						100m		
29	East	E15		16°57.815' S	173°55.435' E	5m	Forms gentle dome structure. Reddish brown fragments, 0.2-2.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Reddish brown sediments have white and brownish yellow patches. Chimneys are large, 5m high and 2-5m across.	
						50m		
30	East		3-2	16°57.820' S	173°55.250' E	10m	FDC crashed to mound and details are unknown. Reddish brown fragments, 0.5- 3.0m across, consisting of relic of chimney and sulfide ore are distributed on the foot of the mound wall consisting of massive sulfide. Chimneys of 5m high occur.	
						unknown		
31	East		7-2	16°57.845' S	173°55.305' E	10m	Reddish brown fragments, few m across, consisting of relic of chimney and lava are distributed on mound. Some of the lava fragments are not discolored. Sediments with white patches are discolored to reddish brown. A chimney of 3m high was observed.	
						100m		
32	East	E16		16°57.845' S	173°55.205' E	5m	Forms gentle dome structure. Reddish brown fragments, 0.3-1.0m across, consisting of relic of chimney, sulfide ore and lava are distributed on mound. Sediments are discolored to reddish brown. Many chimneys of 1-3m high occur.	
						100m		
33	East	E17		16°57.905' S	173°55.500' E	10m	Reddish brown fragments, 0.3-2.0m across, consisting of relic of chimney, sulfide ore and lava are accumulated on mound. Sediments with white patches are discolored to reddish brown. Chimneys of 3-5m high occur.	
						50m		

gentle hill extending in S-W direction. The Ore Showings W1 and 6·1 are located, respectively, north and south extensions of this area. Other than these, the Ore Showing W5 occurs on the west side of the gentle hill. Many chimneys were found by the Hyflux II project in the area close the Ore Showing W5. The details of the Ore Showing W5 were not obtained by the this survey, however, 8 chimneys of about 3m high and fragments of chimney and sulfide ore accumulated besides the chimneys were observed. Among these ore showings, the Ore Showings W1, W3 and W4 are large, extending more than 100m and rising 10m from the surrounding sea floor. In the Ore Showing W1, the mound forms gentle dome structure and reddish brown fragments of 0.5-2m across consisting of chimney relic, sulfide ore and basalt are accumulated on the mound. No chimney was observed in the Ore Showing W1. The Ore Showings W3 and W4 are similar. In there, reddish brown debris consisting of chimney relic, sulfide ore and lavas were distributed over the mound of approximately 10m high. At some places on the mound, sheets of massive sulfide with a rough surface are exposed, covered by reddish brown sediments with white and brownish yellow patches. Chimneys of 1-3m high are found on the mounds of both ore showings. The ore showings other than above, including ones partly observed, have an extension of more or less 50m with a height of 5-10m.

In the East Area, a total of 22 ore showings were identified by the sea floor observations of FDC and BMS. The ore showings in the East Area occur from the 1980m deep, flat floor of the Axial Valley, up to the area of 1950m contour line on the slop of the Eastern Ridge. The larger ore showings, with an extension of more than 100m and a height of 10m, tend to occur on the slop in the eastern part of the area. Among these ore showings in the East Area, E2 and E11 are the largest, extending perpendicular to the slop of the Eastern Ridge for 150m. In the Ore Showing E11, reddish brown debris consisting of chimney relic and fragments of sulfide ore and lavas, 0.3-2m across, were distributed over the mound of approximately 10m high. At some places on the mound, sheets of massive sulfide are exposed, covered by reddish brown sediments with white and brownish yellow patches. Reddish brown chimneys of 3-5m high are observed on the mound. The Ore Showing E2 with a mound of gentle dome structure shows a similar occurrence to the E11 and chimney was not found. Other than E2 and E11, Ore Showings E1, E4, E9, E14, 7·2, E16 have relatively large mound extending over the area of 100m, rising 5-10m from the surrounding sea floor. Among them, sheets of massive sulfide are exposed covered by reddish brown sediments on the mound of Ore Showing E1. While, the debris of chimney and ore fragments are covered by brown sediments