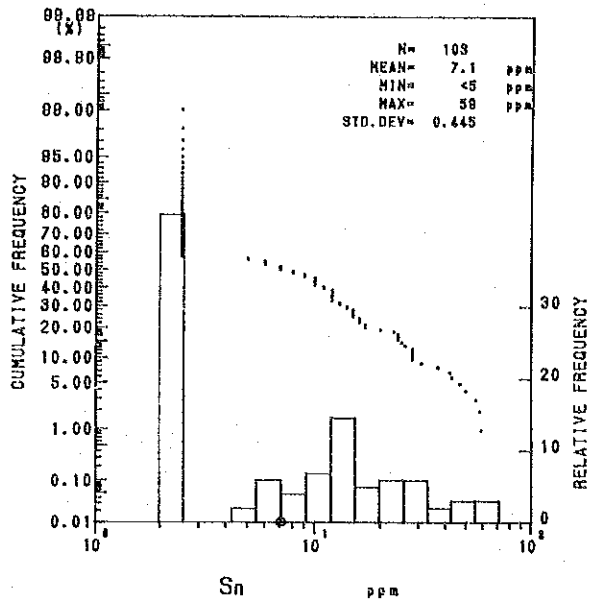
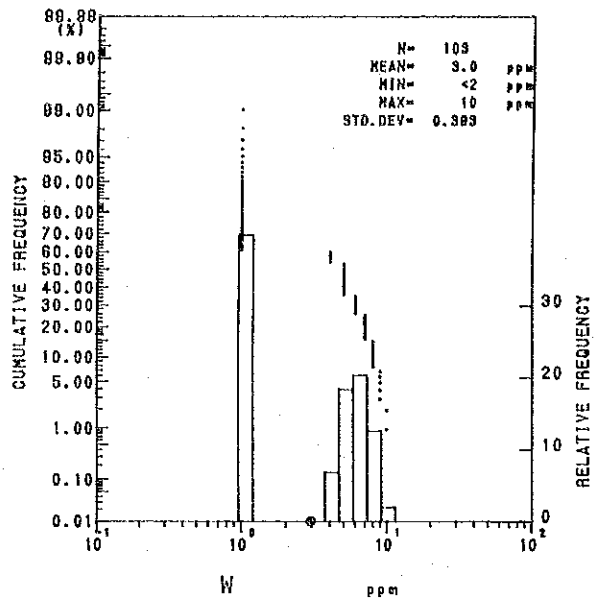
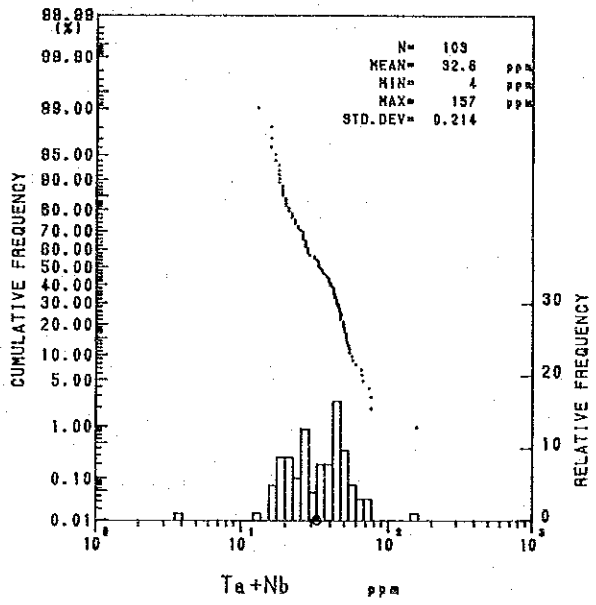
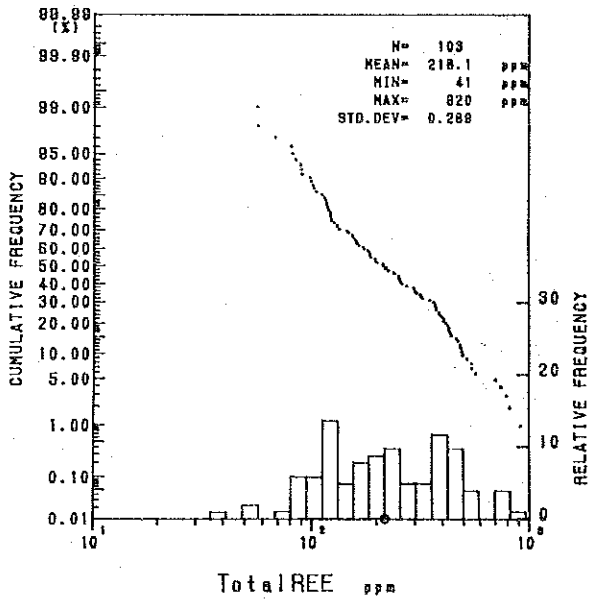








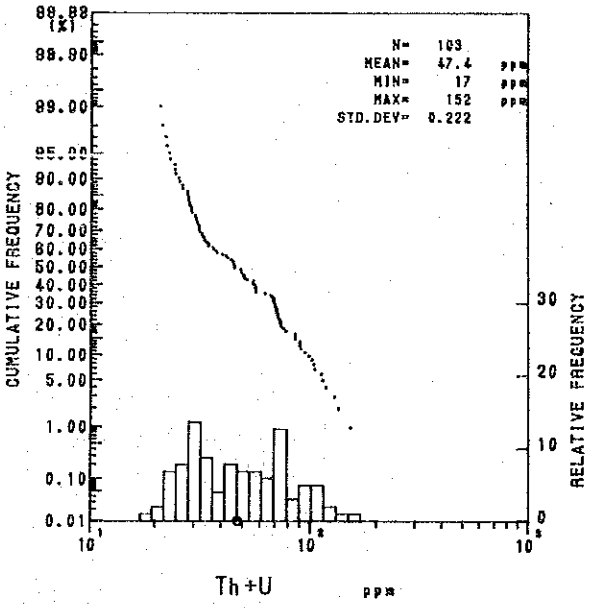


Fig. 14 Histograms and cumulative probability graphs of Area B-1

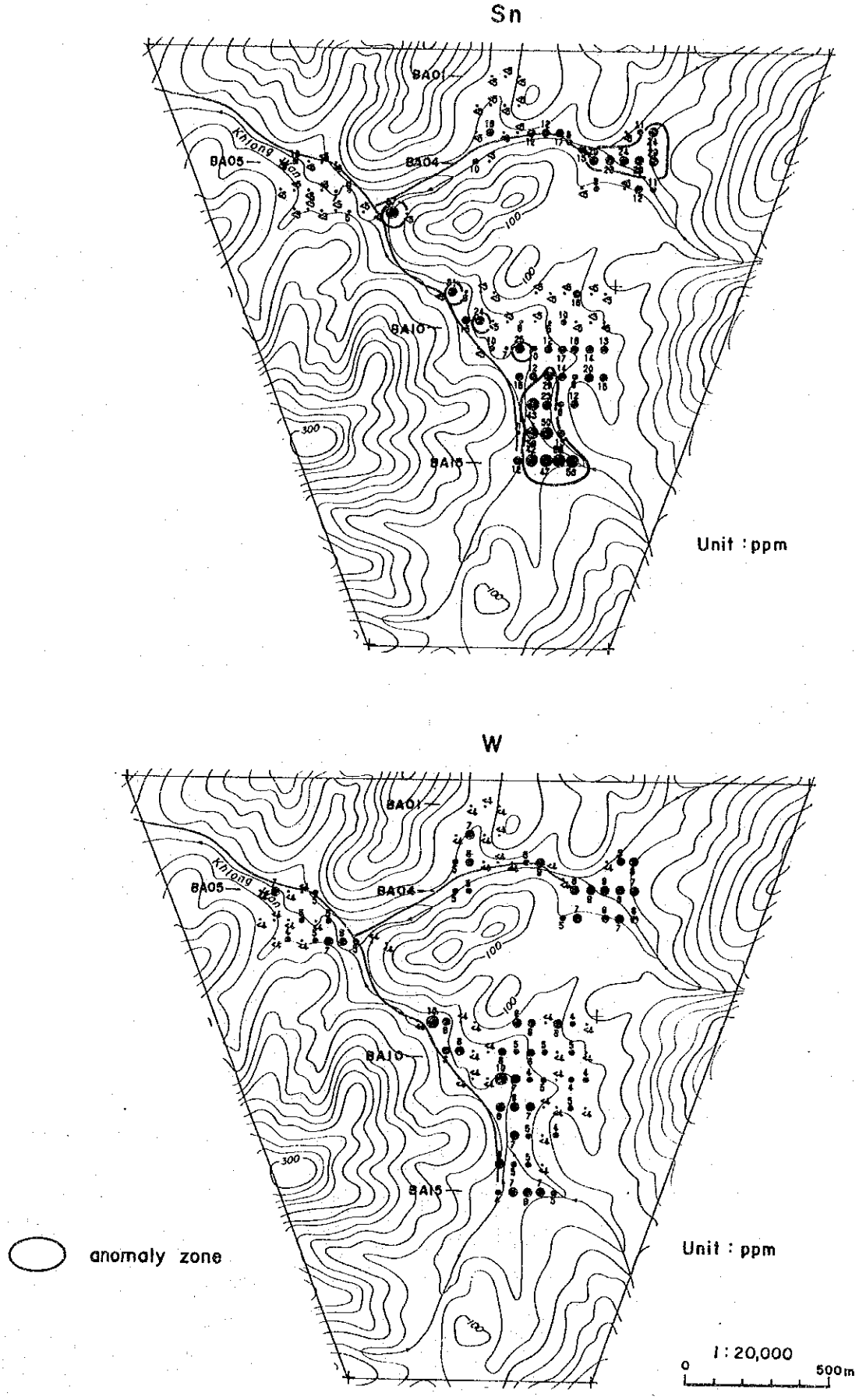


Fig. 15 Results of the geochemical survey of Area B-1 (1)

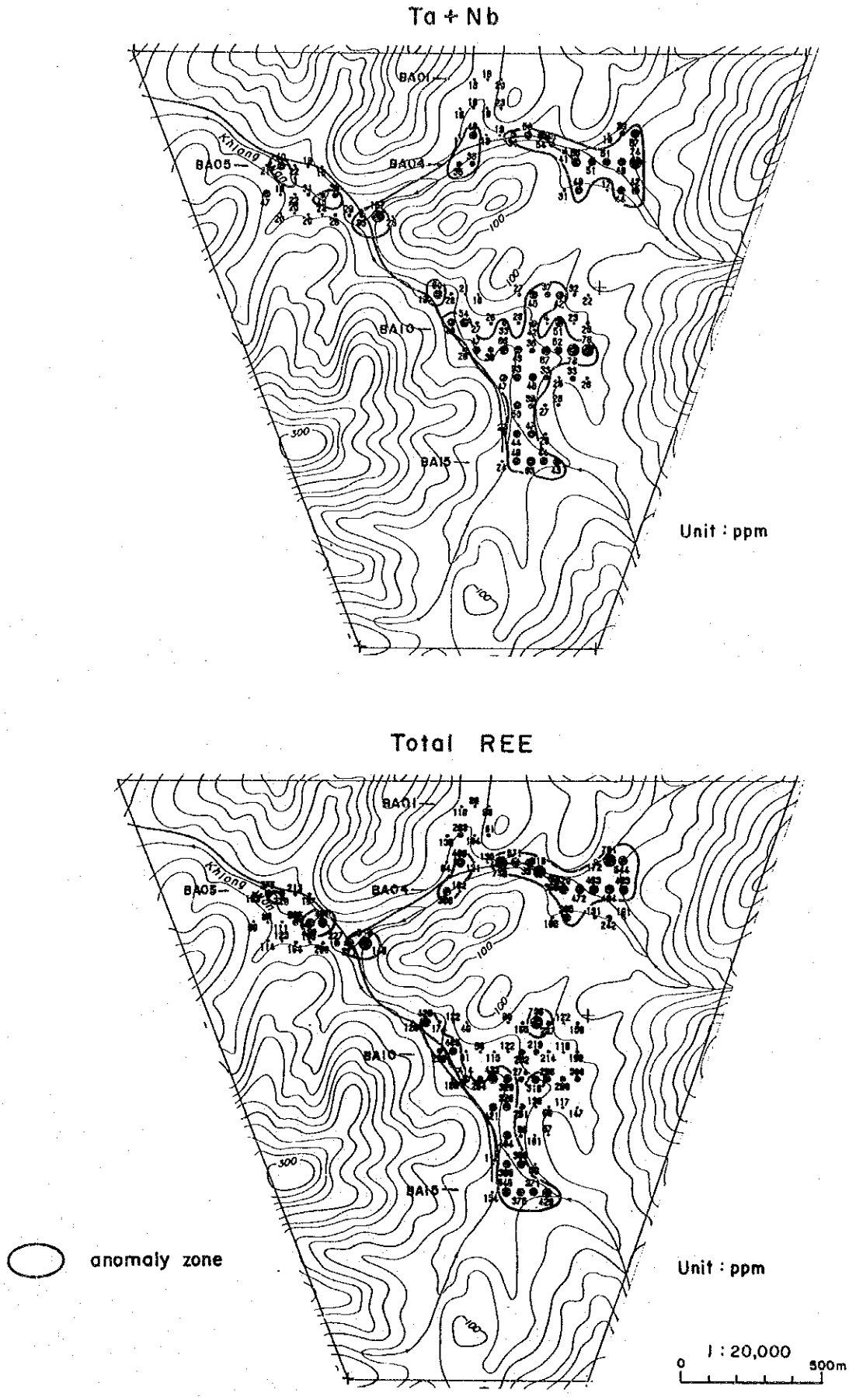


Fig. 15 Results of the geochemical survey of Area B-1 (2)

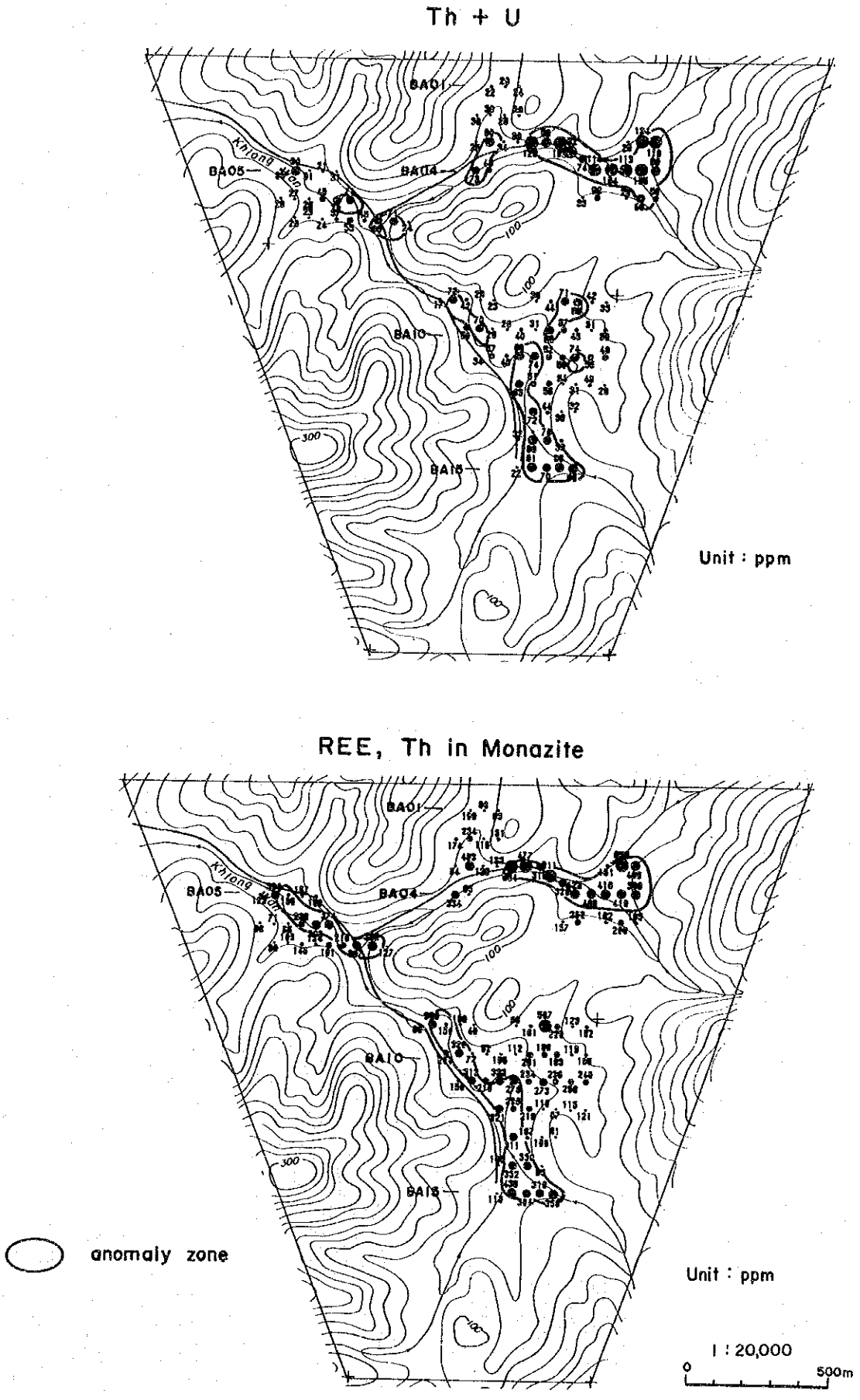


Fig. 15 Results of the geochemical survey of Area B-1 (3)

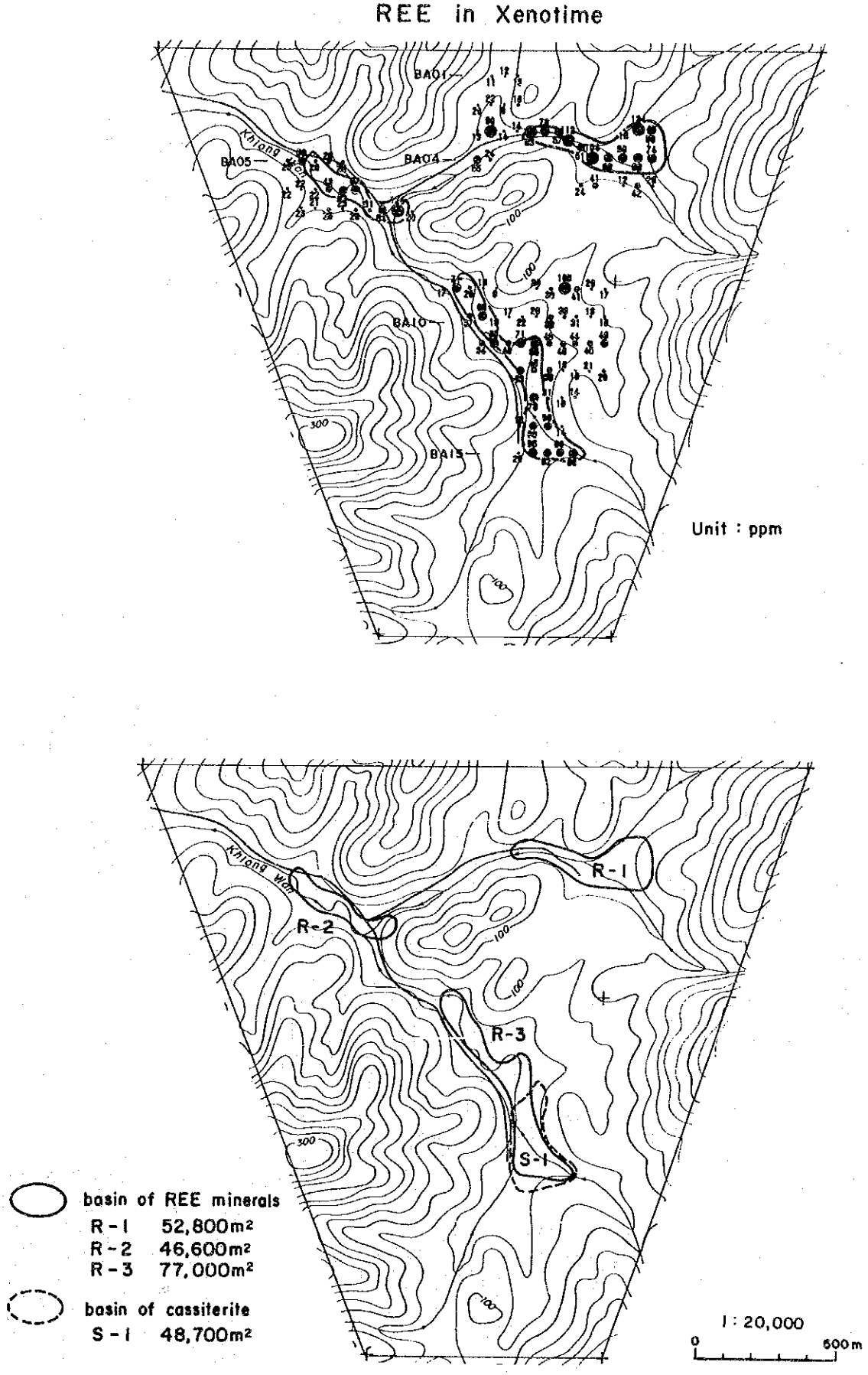


Fig. 15 Results of the geochemical survey of Area B-1 (4)

valley in the southern area.

The anomaly values of Th-U overlap with that of Total REE.

3-4-2 Heavy mineral samples

Four heavy mineral samples are collected from Area B-1. The samples from the south basin are more Sn and less REE, Th and U. Those of the west basin tend to be less Sn and much REE, Th and U. The result accords with soil geochemistry.

3-5 Discussion

The soil geochemical exploration reveals that the alluvial basins for placer deposits are on a small scale in this area; thereby much reserve can not be expected.

The elements of REE, thorium and uranium concentrate in the talus and terrace sediments, consisting of granite sand and gravel, in the north and the south of this area. The sediments in the north concentrate more than that in the south of this area. This may indicate that rare earth minerals in the alluvial basin have not been transported much.

The anomaly zones of tin coincide with fine sediments in the south of the survey area, and it is inferred that cassiterite has transported from southeast of the survey area. The reserve and grade are shown in Table 9.

Table 9 Reserves in Area B-1, B-2, B-3 and B-4

Area name B		Mineral name	Areas (m^2)	Ave. Thick (m)	Reserves (m^3)	Ave. contents (ppm)	Ave. Oregrade (kg/m^3)	Reserves of minerals (t)
B-1	R-1	monazite	52,800	2	105,600	300	0.771	81
		xenotime				68	0.170	17
	R-2	monazite	46,600	2	93,200	439	1.128	105
		xenotime				83	0.244	22
	R-3	monazite	77,000	2	154,000	315	0.809	124
		xenotime				63	0.185	28
	S-1	cassiterite	48,700	2	97,400	45	0.090	8
B-2	R-1	monazite	28,900	2	59,800	364	0.935	55
		xenotime				65	0.191	11
	R-2	monazite	71,400	2	142,800	250	0.642	91
		xenotime				65	0.191	27
	S-1	cassiterite	122,000	2	244,000	26	0.052	12
B-3	R-1 S-1	monazite	45,370	2	90,740	248	0.637	57
		xenotime				60	0.176	15
		cassiterite				49	0.098	8
	R-2	monazite	35,000	2	70,000	294	0.755	52
		xenotime				59	0.173	12
	S-2	cassiterite	31,000	2	62,000	52	0.104	3
	R-3-1	monazite	25,600	2	51,200	279	0.712	18
		xenotime				51	0.150	3
	R-3-2	monazite	33,300	2	66,600	280	0.719	23
		xenotime				63	0.185	6
	S-3	cassiterite	133,400	2	266,800	50	0.100	26
B-4	R-1 S-1	monazite	80,500	2	161,000	240	0.619	99
		xenotime				47	0.138	22
		cassiterite				43	0.086	13
	R-2 S-2	monazite	151,500	2	303,000	227	0.583	176
		xenotime				47	0.138	41
		cassiterite				47	0.094	28
Total		monazite	647,970	2	1,295,940	—	0.679	881
		xenotime				—	0.154	204
		cassiterite	612,470	2	1,224,940	—	0.082	101

Chapter 4 Area B-2

4-1 Location

Area B-2 is 10 kilometers northeast of Kra Buri Town. The center of the area is at latitude 10°26.5'N and longitude 98°52'E. The area was settled on an alluvial basin around Khlong (River) Phlu Yai, which is the upper stream of Khlong Sawa running westward from the center granite mass (Fig.16).

The river runs nearly in the E-W direction from the central granite mass, and small tributaries develop in a dendriform. The area ranges in altitude from 40 to 200 meters, and consists mainly of dissected hills except for slightly-steep mountains in the north of the area. An unpaved road branches from the Route 4 at Dong Sawa Village, and leads to Area B-2 through Area B-4. The distance of the roads from Kra Buri town is about 13 kilometers. It takes about 50 minutes by car, but it is difficult to get there after raining.

The anomalies of W, Nb, Ta and REE W were detected by the geochemical prospecting of stream sediments and soil samples.

4-2 Survey method

Soil samples were collected from each points designed by the rectangular grid method. The spacing between survey line is 100 meters, and the interval between sampling points 50 meters.
The number of soil samples is 114.

4-3 Geology

Area B-2 is underlain by Silurian-Devonian Kra Buri Formation, Carboniferous Matsi Formation, Cretaceous granite and the Quaternary (Fig.17).

Kra Buri Formation is distributed on the north of a NNE-SSW fault in the north of the survey area, and consists mainly of slate and pebble-bearing mudstone.

Matsi Formation is distributed in the center of the survey area, and consist of strongly weathered mudstone.

Cretaceous granite is distributed around Matsi Formation, but the intrusion has had no contact metamorphic effect on the surrounding sedimentary rocks. The granite consists of biotite granite and fine-grained two-mica granite. The biotite granite is composed mainly of microcline, orthoclase, quartz, plagioclase and biotite, with accessories zircon, apatite, sphene and ilmenite. The fine-grained two-mica granite is found on a small scale near the BB1313 point. It appears the marginal facies of the central granite mass. This two-mica granite is composed mainly of microcline, orthoclase, quartz, plagioclase, muscovite and biotite, with accessories zircon, tourmaline, and sphene.

The Quaternary is talus and fluvial sediments. Talus sediments are found in the east edge of the area, which consist of silt containing gravel of granite and quartz-veins. Fluvial sediments are distributed in narrow terraces along rivers, and consist of sand and silt.

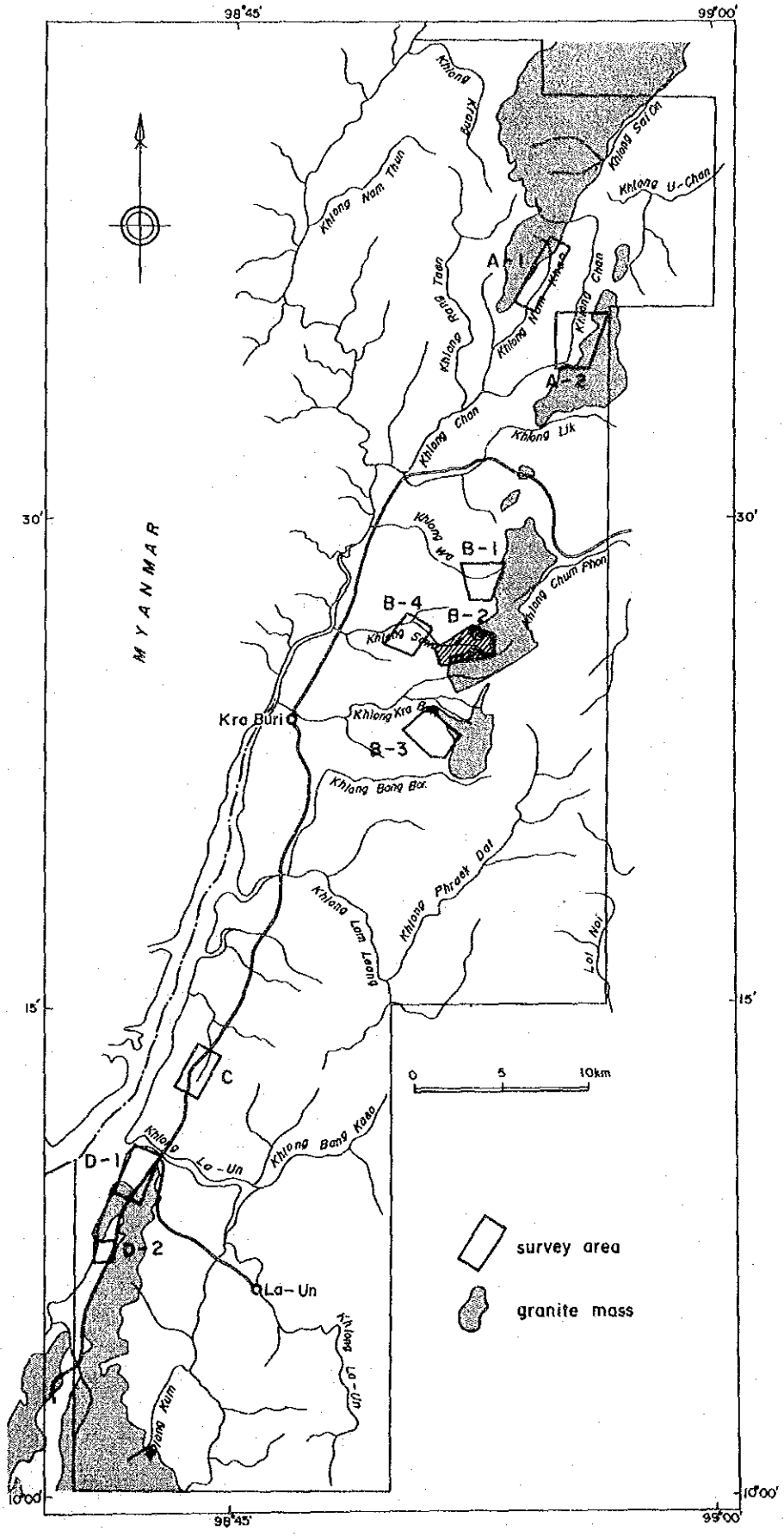


Fig. 16 Location map of Area B-2

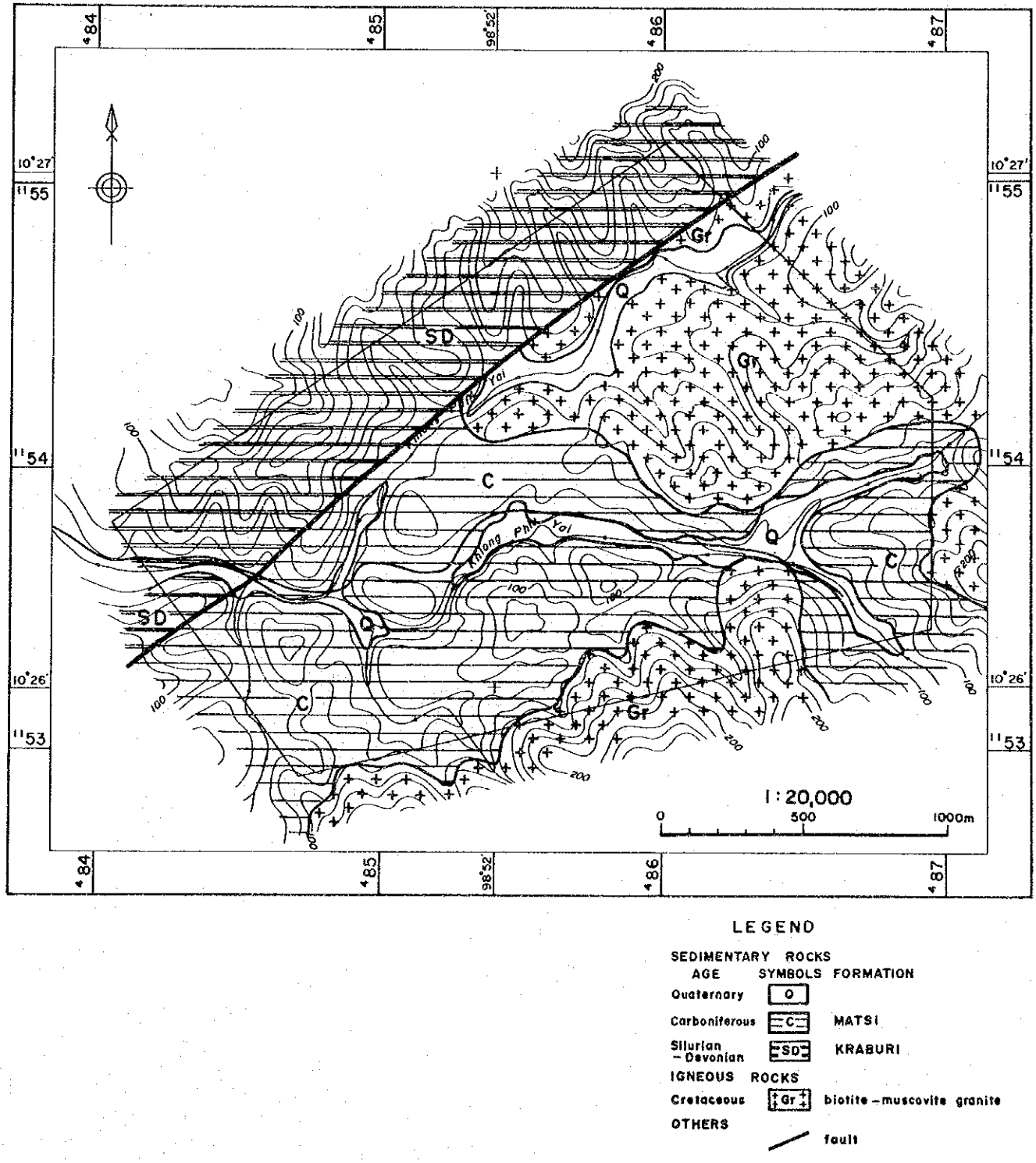


Fig. 17 Geologic map of Area B-2

4-4 Result of geochemical exploration

4-4-1 Soil samples

The range, mean value (M), standard deviation (σ) are shown in listed in Table 10. Fig.18 shows the histograms and cumulative probability graphs of the five elements' groups, i.e., Sn, W, Ta-Nb, Total REE and Th-U.

The Sn values shows a bimodal distribution except its below-detection-limit values. The threshold is taken at M+0.5σ (15ppm), which is the boundary of two populations. The threshold value of W is taken at M+0.5σ (11 ppm) in the same manner. The values of the Ta-Nb group and Total REE group also show bimodal distribution respectively. The threshold is determined to mean values (Ta-Nb; 34ppm, Total REE; 217 ppm), which are the boundaries of two populations.

The values of Th-U group are composed of three populations. The threshold is determined to M+0.25σ (61 ppm), which is one of skew points on the cumulative probability graph.

Table 10 Geochemical basic statistic quantities of Area B-2

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	38.0	<5.0	0.971	9.4	0.432
W	ppm	23.0	<2.0	0.806	6.4	0.422
Ta	ppm	7.0	1.0	0.423	2.7	0.335
Nb	ppm	65.0	<2.0	1.485	30.5	0.263
Ce	ppm	230.0	25.0	1.926	84.3	0.194
Eu	ppm	1.4	<0.2	-0.213	0.6	0.303
La	ppm	120.0	8.0	1.515	32.7	0.214
Nd	ppm	78.0	<5.0	1.316	20.7	0.248
Sm	ppm	16.0	1.3	0.641	4.4	0.239
Tb	ppm	3.7	<0.5	-0.071	0.8	0.312
Th	ppm	96.0	18.0	1.658	45.5	0.183
U	ppm	26.0	2.2	0.936	8.6	0.275
Y	ppm	188.0	<2.0	1.520	33.1	0.611
Gd	ppm	16.9	<0.5	0.612	4.1	0.342
Dy	ppm	18.0	3.0	0.854	7.1	0.197
Pr	ppm	20.0	<20.0	1.003	10.1	0.028
Yb	ppm	19.2	2.7	0.820	6.6	0.203
Lu	ppm	2.5	0.4	-0.048	0.9	0.194
Ta+Nb	ppm	71.0	1.0	1.528	33.7	0.264
T.REE	ppm	597.6	78.5	2.337	217.1	0.190
Th+U	ppm	122.0	20.7	1.738	54.6	0.192

The content distribution maps are shown in Fig.19 (1) to (4).

Generally, most anomaly values are found in the area around BB10-BB13 lines in the east of the survey section. The several anomaly values of Total REE, TH-U are also found in a narrow area near the BB08-BB09 lines in the west of the survey area.

The cluster of Sn anomaly values is recognized in the BB10-BB13 lines. The content in the east side of these lines tends to be higher than that in the west side. The east side is underlain by talus sediments, whereas the west side is by fluvial sediments.

Two anomalies of W are detected in the east of Area B-2. They are the east anomaly and the west anomaly. The east anomaly is smaller than the other, but the W content is high in the east anomaly.

The Ta-Nb anomalies almost overlap with that of Sn.

In the southwest of Area B-2, one of the anomaly of Total REE is distributed near the BB08-BB09

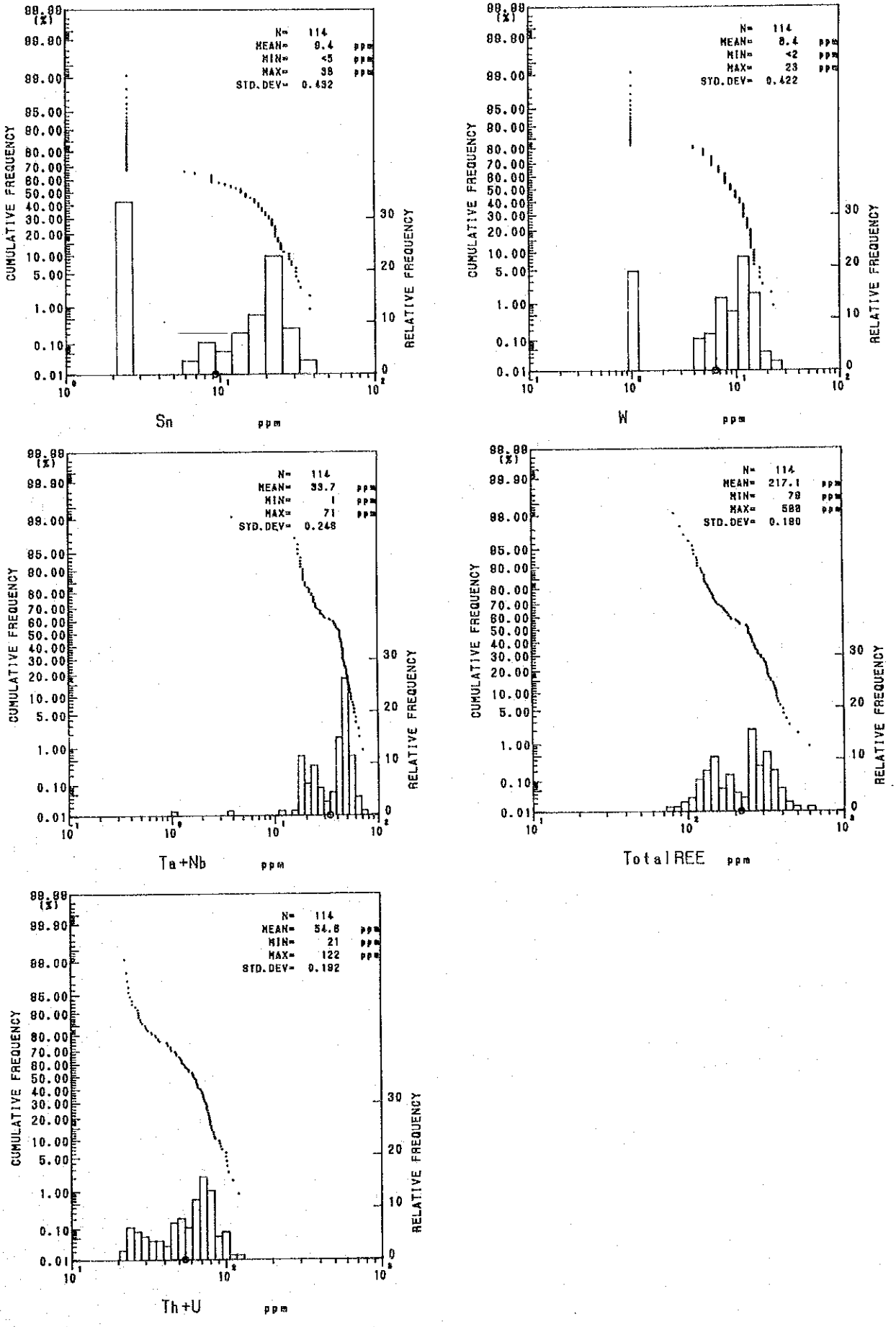


Fig. 18 Histograms and cumulative probability graphs of Area B-2

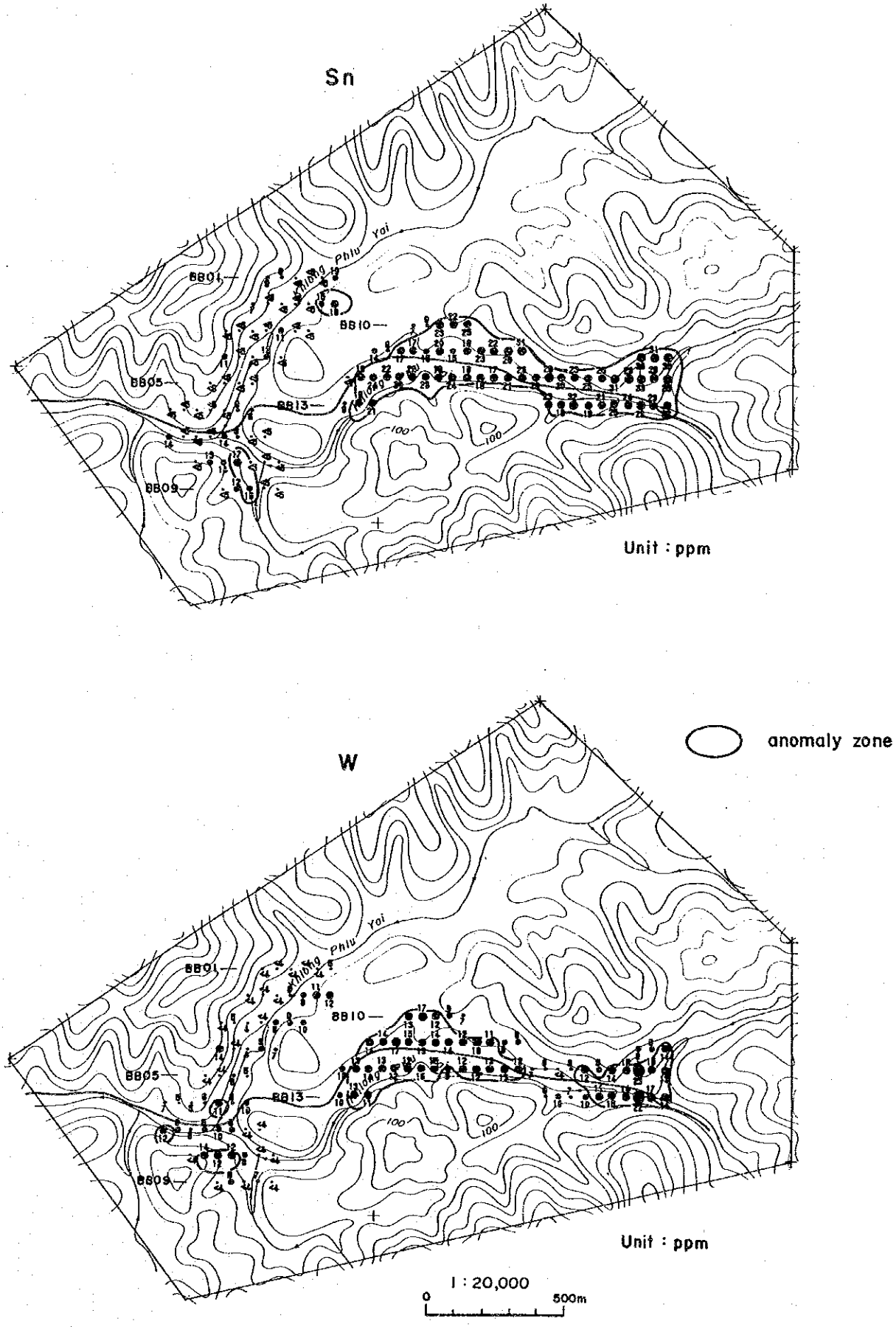


Fig. 19 Results of the geochemical survey of Area B-2 (1)

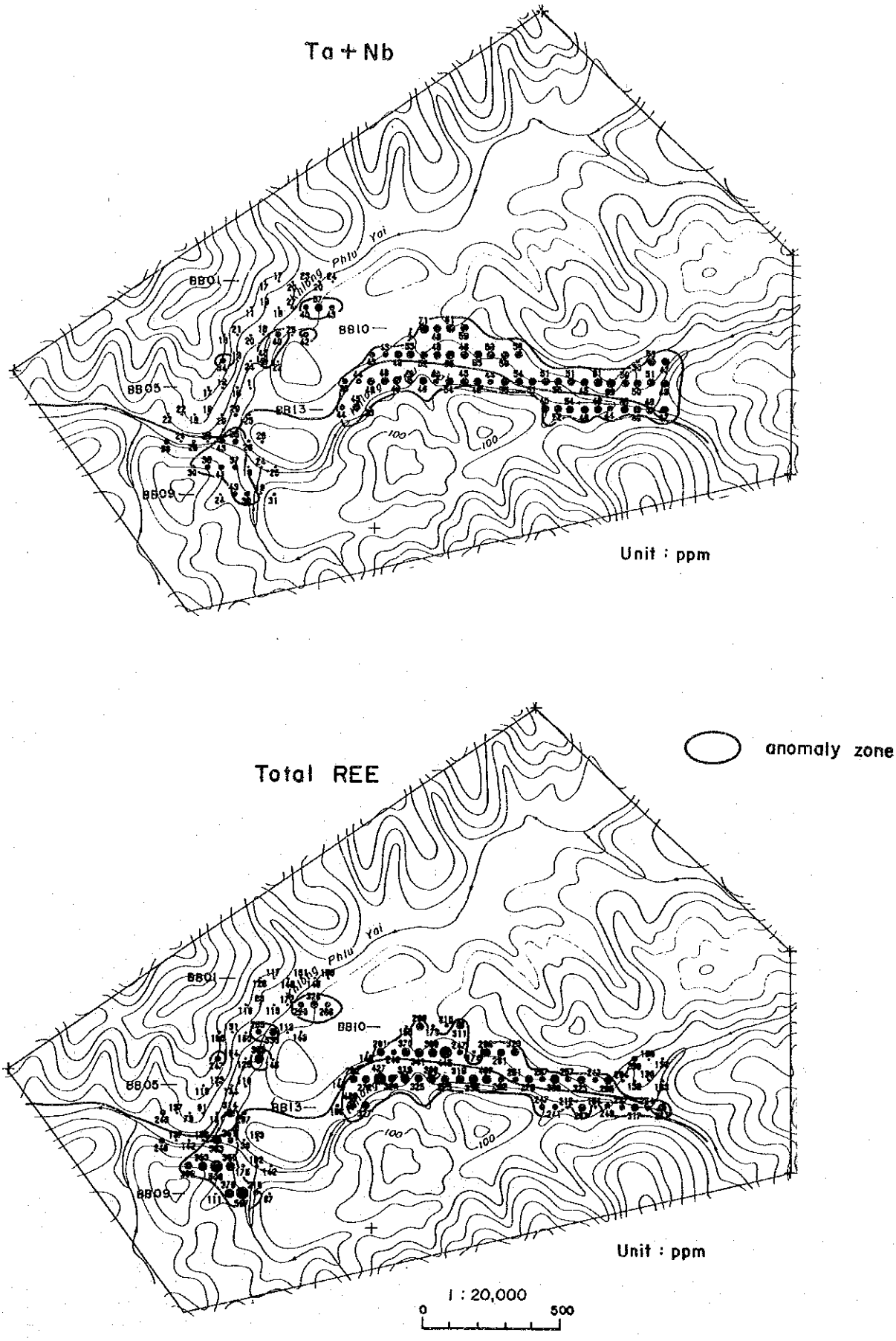
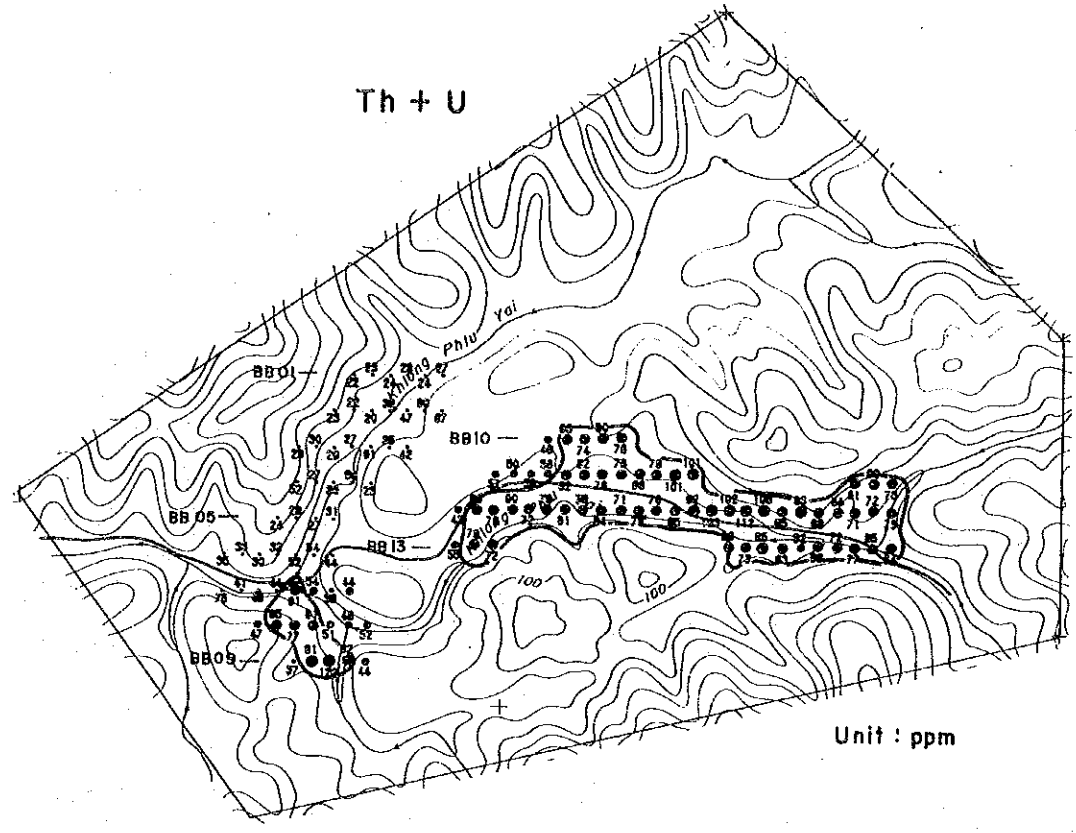


Fig. 19 Results of the geochemical survey of Area B-2 (2)



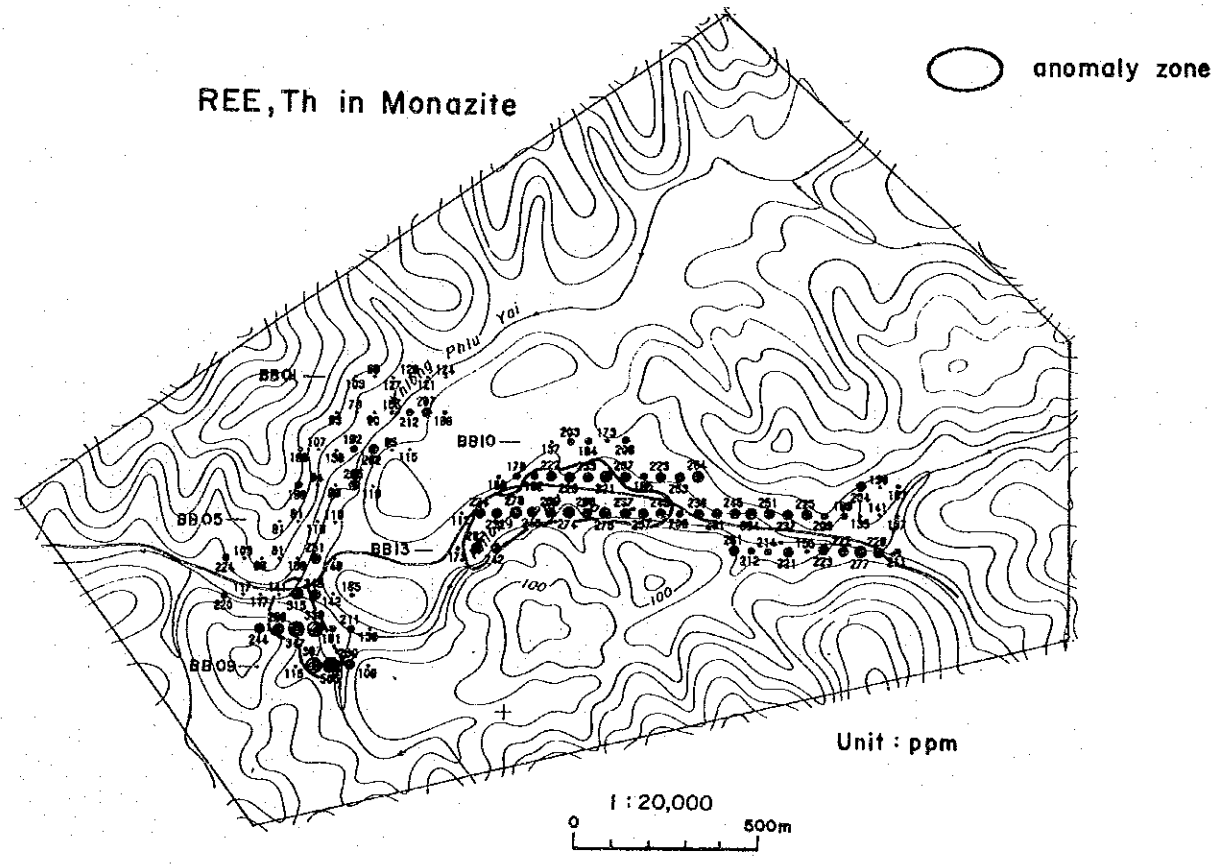


Fig. 19 Results of the geochemical survey of Area B-2 (3)

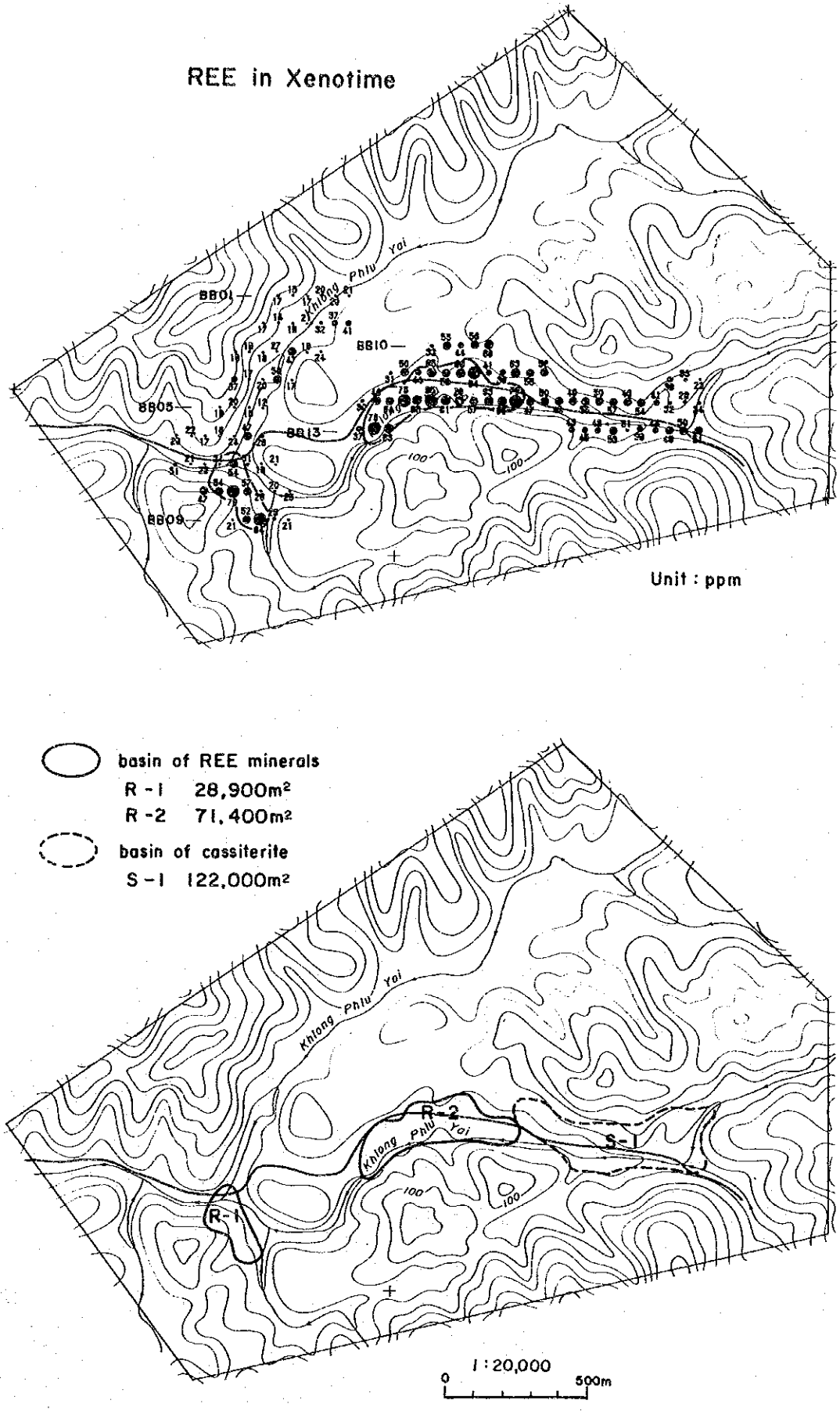


Fig. 19 Results of the geochemical survey of Area B-2 (4)

lines. The anomaly has high values, but is on a small scale. The other high values concentrate in the middle of Area B-2 in the west of the BB11-BB13 lines. They are on the fluvial sediments. On the other hand, the values on terrace sediments in the west are lower than the threshold.

The anomaly values of Th-U are distributed in the BB07-BB09 and BB10-BB13 lines. The anomaly values do not vary markedly, except that slightly higher values are observed in the center of the BB12 line.

4-4-2 Heavy mineral samples

Four samples of heavy minerals were collected. The samples on the eastern edge of the survey area tend to be more Sn and less REE. The samples in the western side of the BB09 and BB12 lines tend to be more REE and less Sn. These tendencies are in accord with the results of soil geochemistry.

4-5 Discussion

The geochemical exploration defined two alluvial basins of placer deposits; the southwest area around the BB07-BB09 lines and the east area around the BB10-BB13 lines. Though southwest basin contains rare earth minerals, its area is very small. The east basin contains both tin and rare earth minerals. The tin values are rather low in the western half of this basin; it may mean that the actual basin as a placer deposit is only the eastern half. The reserve and grade are shown in Table 9.

Chapter 5 Area B-3

5-1 Location

Area B-3 is 8 kilometers east of Kra Buri. The center of the area is at latitude 10°24'N and longitude 98°51'E. The area was settled along the tributaries of Khlong (River) Kra Buri running westward from the south of the central granite mass (Fig.20).

The bent system of tributaries is the S-N and the E-W direction. The area ranges in altitude from 60 to 240 meters. An alluvial basin is surrounded by relatively-gentle hills and mountains. This basin is topographically desirable to have a placer deposit because of its narrow exit.

An unpaved road leads from Kra Buri Town to Area B-3 along Khlong Kra Buri, and the distance is 10 kilometers, and it takes about 30 minutes by car.

The geochemical anomaly of Nb, Ta, REE, Th, U and Y from stream sediments and that of U, Y and W from soil sediments were detected by the first year geochemical prospecting.

5-2 Survey method

Soil samples were collected from each point designed by rectangular grid method. The spacing between survey lines is 100 meters, and the intervals between each sampling point 50 meters. The number of collected samples is 143.

5-3 Geology

Area B-3 is underlain by Carboniferous Matsi Formation, Cretaceous granite, and alluvium (Fig.21).

Matsi Formation is distributed in the mountains surrounding an alluvial basin, and consists of mudstone and siltstone.

An alluvial basin is distributed in a valley, and its exit is narrow. The sediments consist mainly of sand and gravel derived from the granite mass. A white clay layer is distributed in the lowest reaches of the river. Two old open mining pits remain on a small scale near the BC0402 and BC0810 points.

Cretaceous granite is coarse-grained equigranular biotite granite (adamellite), and is composed mainly of orthoclase, microcline, quartz, plagioclase and biotite, with accessories zircon, apatite, sphene and ilmenite. Allanite and cassiterite also occur in less abundance.

5-4 Result of geochemical exploration

5-4-1 Soil samples

The range, mean values (M) and standard deviations (σ)are shown in Table 11. Fig.22 shows the histograms and cumulative probability graphs of the five elements groups, namely, Sn, W, Ta-Nb, Total REE and Th-U.

The distributions of all the groups show multi-modal distribution. In this area, the thresholds were taken at M+0.5σ (Sn:46ppm, W:11ppm, Ta-Nb:42ppm, total REE:230ppm and Th-U:77ppm respectively) nearby the skew points of respective cumulative probability graphs.

The content distribution maps are shown in Fig.23 (1) to (4).

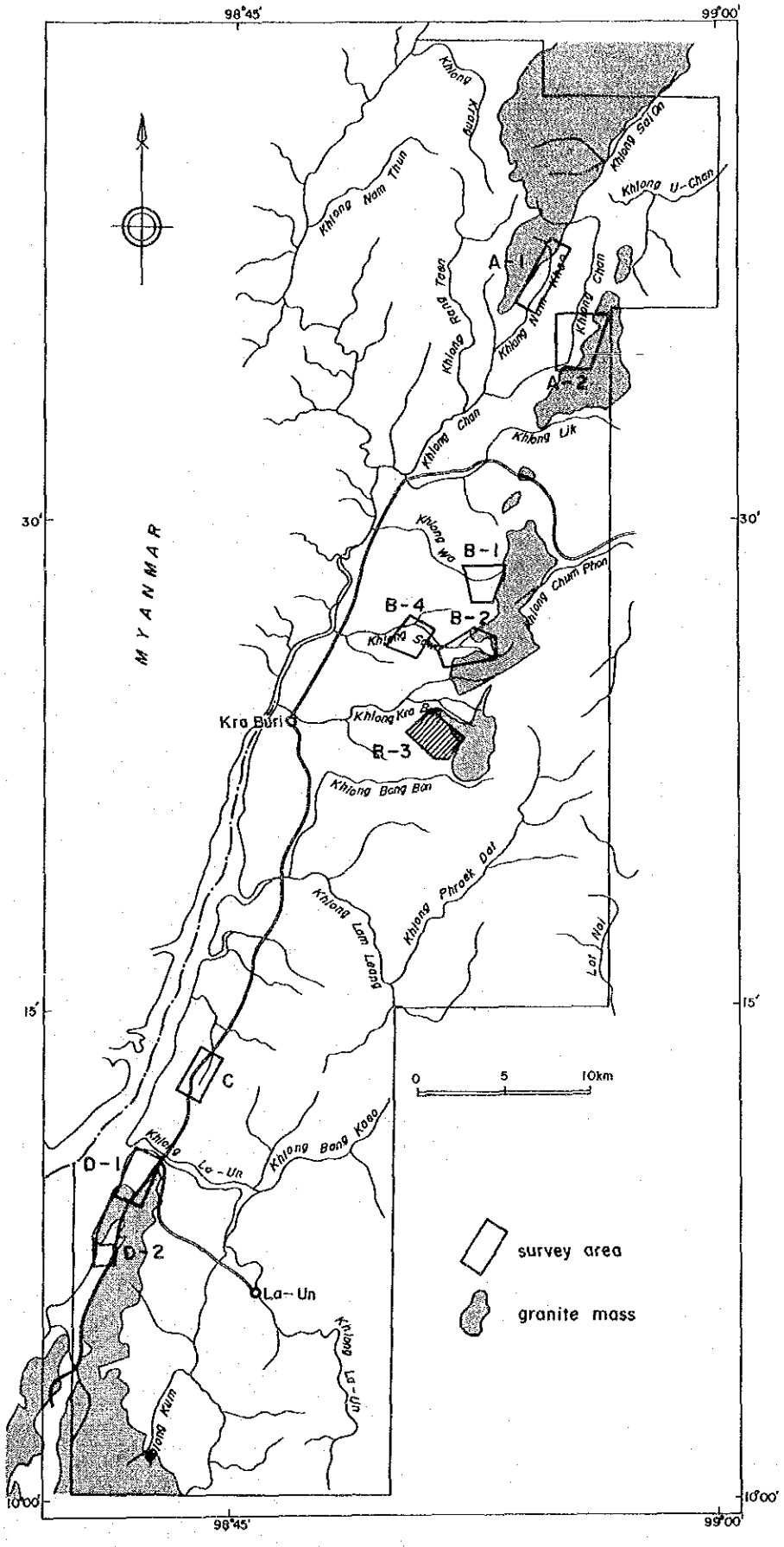


Fig. 20 Location map of Area B-3

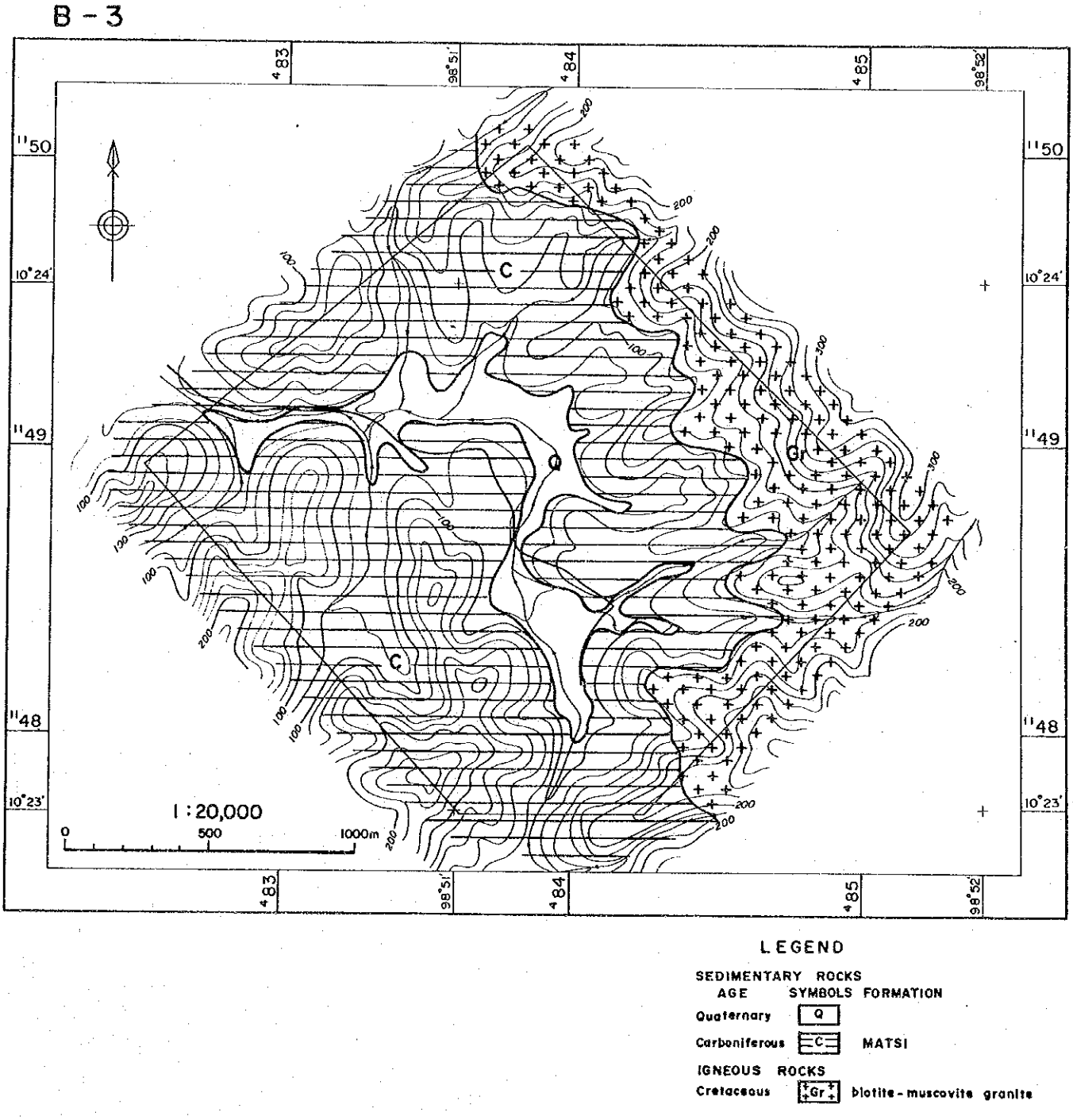


Fig. 21 Geologic map of Area B-3

Table 11 Geochemical basic statistic quantities of Area B-3

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	66.0	19.0	1.602	40.0	0.124
W	ppm	41.0	<2.0	0.863	7.3	0.343
Ta	ppm	8.0	<1.0	0.576	3.8	0.261
Nb	ppm	50.0	12.0	1.514	32.6	0.115
Ce	ppm	240.0	12.0	1.864	73.2	0.226
Eu	ppm	3.5	<0.2	-0.186	0.7	0.184
La	ppm	130.0	11.0	1.447	28.0	0.202
Nd	ppm	120.0	7.0	1.271	18.7	0.236
Sm	ppm	18.0	1.1	0.543	3.5	0.252
Tb	ppm	3.9	<0.5	-0.104	0.8	0.277
Th	ppm	140.0	15.0	1.713	51.6	0.181
U	ppm	35.0	2.7	0.999	10.0	0.249
Y	ppm	156.0	8.0	1.569	37.1	0.232
Gd	ppm	19.7	0.2	0.532	3.4	0.353
Dy	ppm	28.0	1.6	0.760	5.8	0.222
Pr	ppm	21.0	<20.0	1.004	10.1	0.037
Yb	ppm	20.1	2.1	0.770	5.9	0.207
Lu	ppm	2.8	0.3	-0.083	0.8	0.201
Ta+Nb	ppm	57.0	16.0	1.565	36.7	0.117
T.REE	ppm	617.9	62.6	2.266	184.4	0.193
Th+U	ppm	149.7	17.7	1.794	62.2	0.185

The Sn anomaly zones are distributed in three places; the exit of a basin on the west of the BC02-BC03 lines, the area around the inflection point of the main river on the east of the BC02-BC05 lines, and the vicinity of the main river and its tributaries in the southeast of the survey area. Old mining pits of cassiterite remain in the former two anomaly zones. The latest anomaly zone is the largest among them. The W anomaly zone almost overlaps with the Sn anomaly zones. High anomaly values are also found in the northeast area; the east part of the BC02-BC03 lines and the eastern edge of the BC06 line. It is inferred that the tungsten mineral has been derived from the northeast part of the survey area. The Ta+Nb anomaly zones also overlap with the Sn anomaly zones. The southeast one has higher anomaly values among them.

The anomaly values of Total REE are also distributed in the above-mentioned three Sn anomaly zones. However, the anomaly zone in the southeast is smaller than that of Sn.

The anomaly values of Th-U almost overlap with the anomaly zones of Total REE.

5-4-2 Heavy mineral samples

Five panned heavy mineral samples were collected in Area B-3. The heavy mineral samples shows high content of Sn and low REE content, compared with that of Area B-1 and B-2 around the central granite mass.

There is a large possibility of the placer deposits of cassiterite in Area B-3, but the scale of the deposits is smaller than that of the southwest of Area A-1.

5-5 Discussion

Area B-3 were assumed to have a large amount of fluvial sediments and talus sediments.

Only three small anomaly zones are detected by the result of geochemical exploration; thereby the reserve of a placer deposit is rather small scale in Area B-3.

The anomaly values of Ta-Nb and W are detected in the talus sediments and on the ridge or slope in the east of the survey area, whereas those of Sn and Total REE are detected only the areas along valleys.

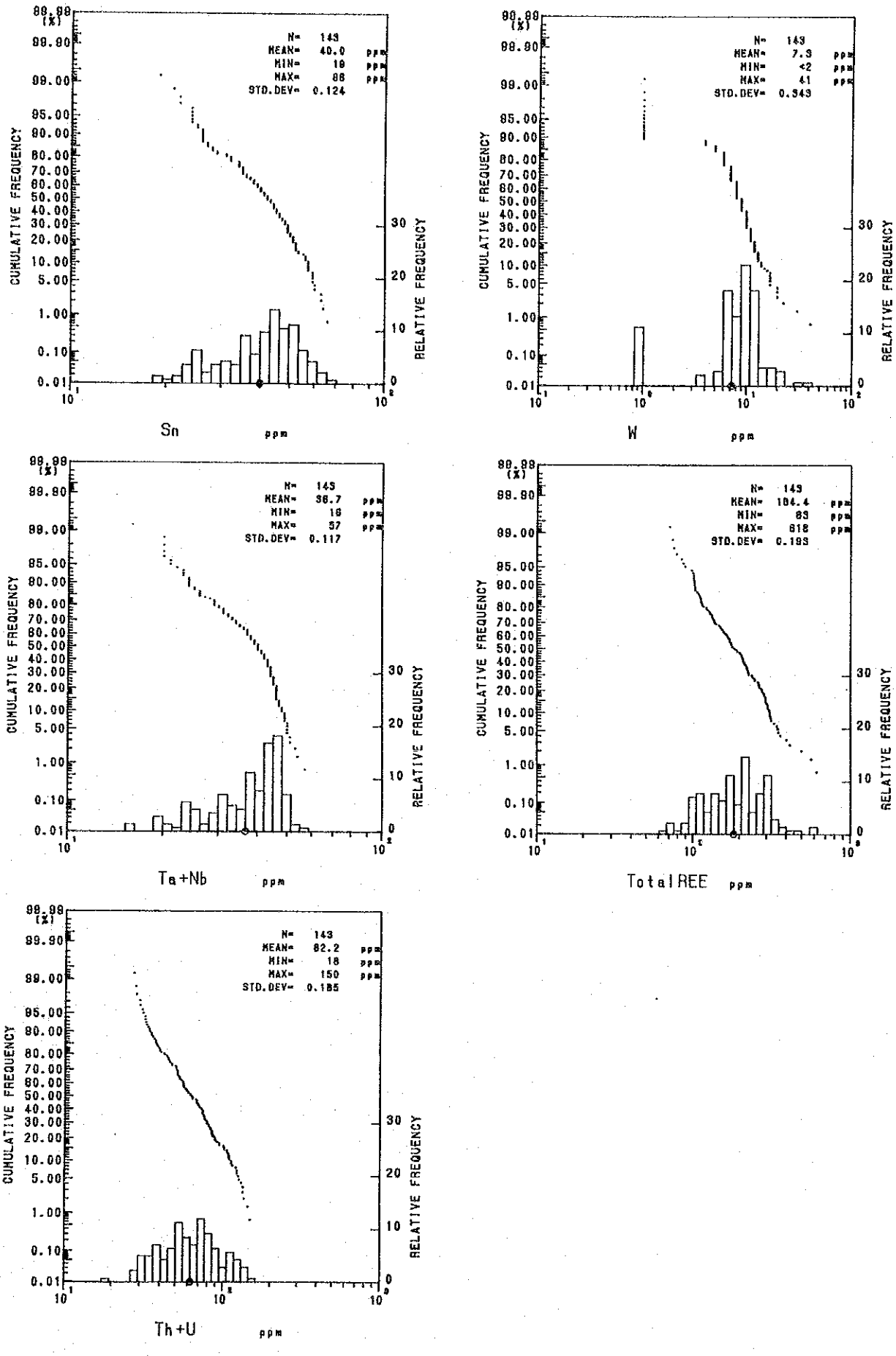


Fig. 22 Histograms and cumulative probability graphs of Area B-3

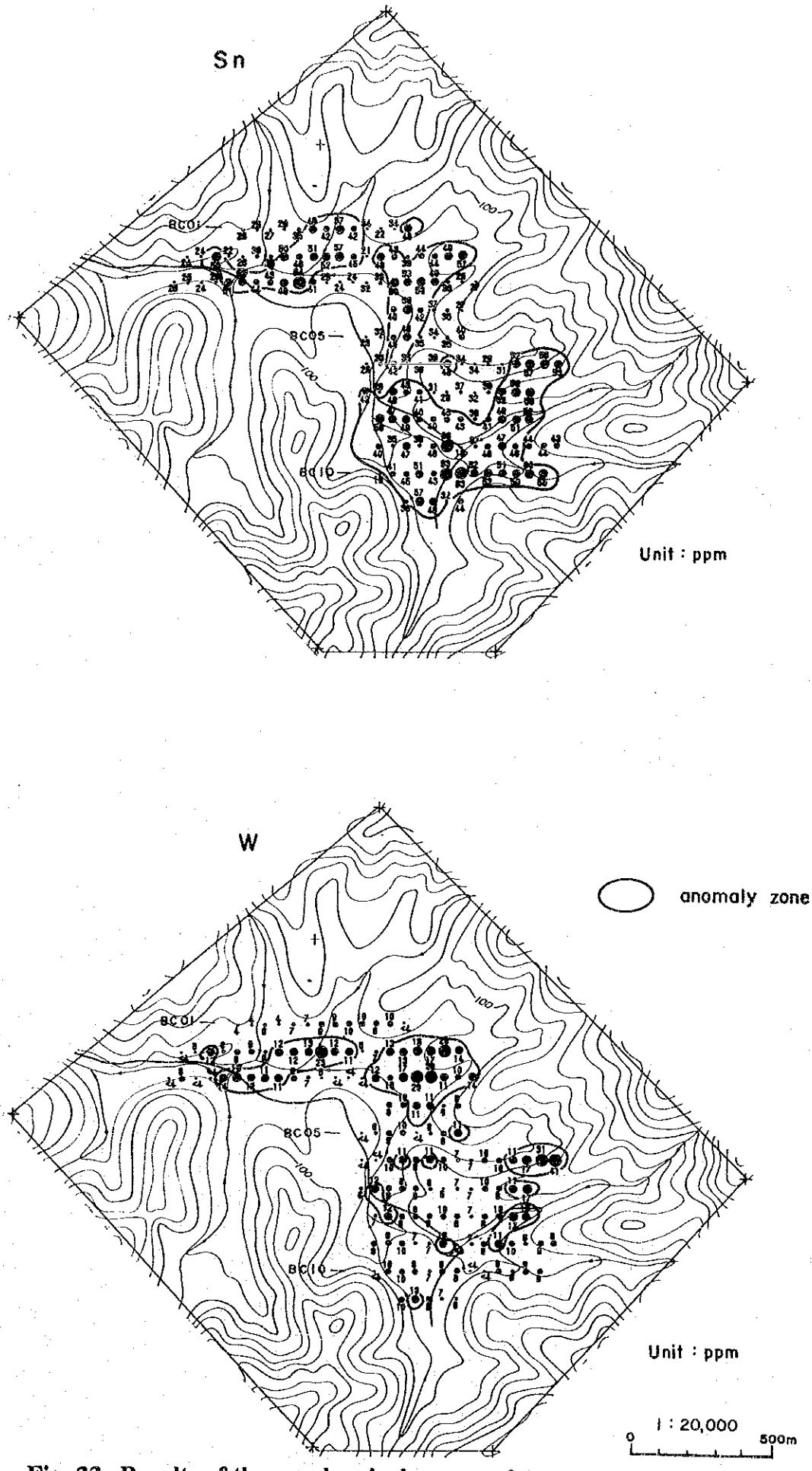
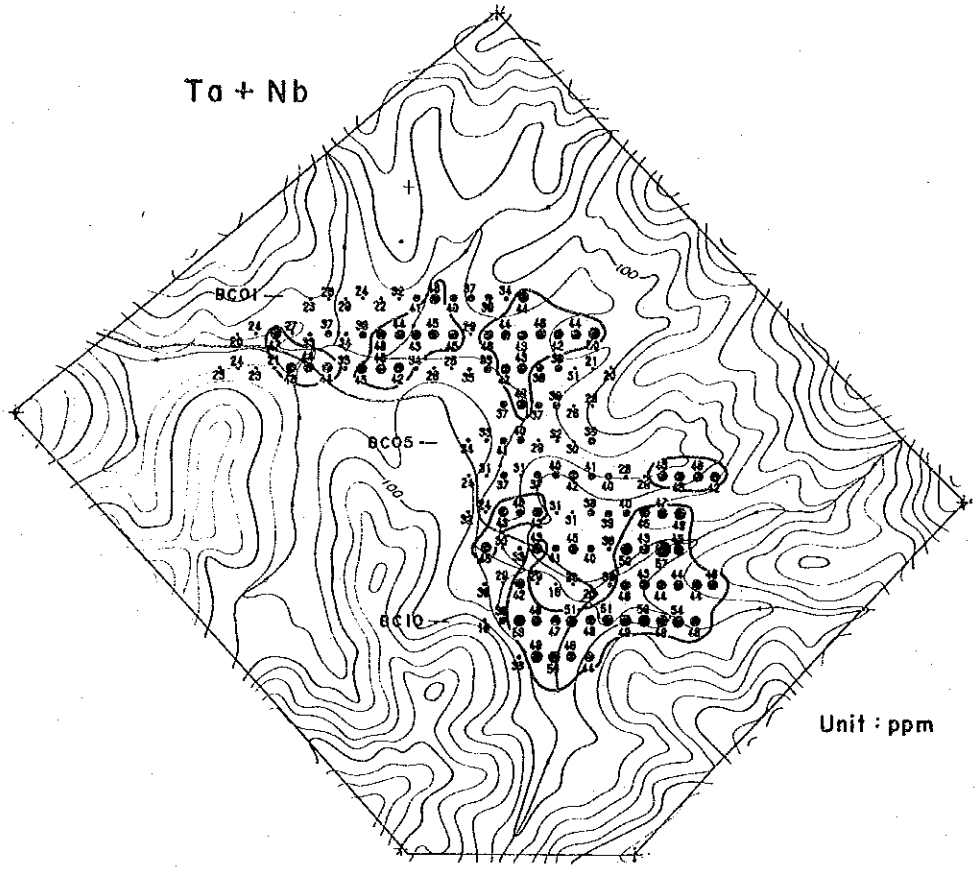


Fig. 23 Results of the geochemical survey of Area B-3 (1)



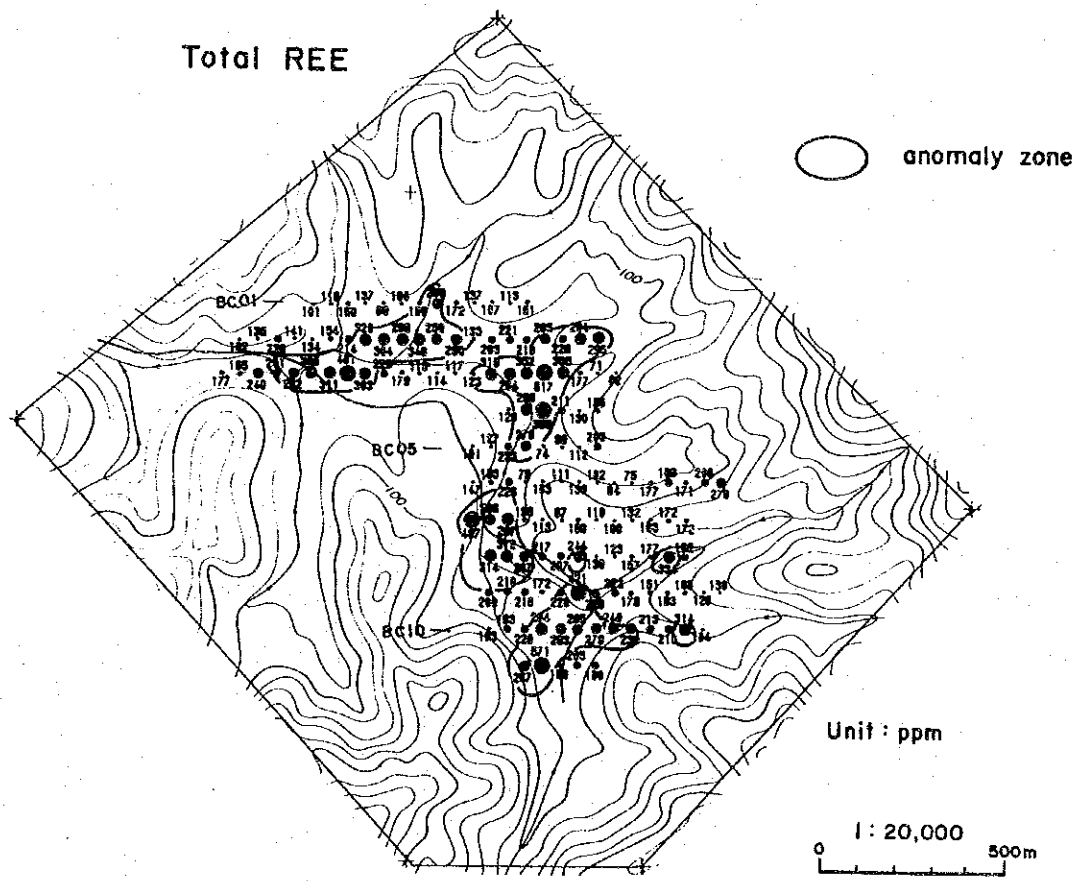


Fig. 23 Results of the geochemical survey of Area B-3 (2)

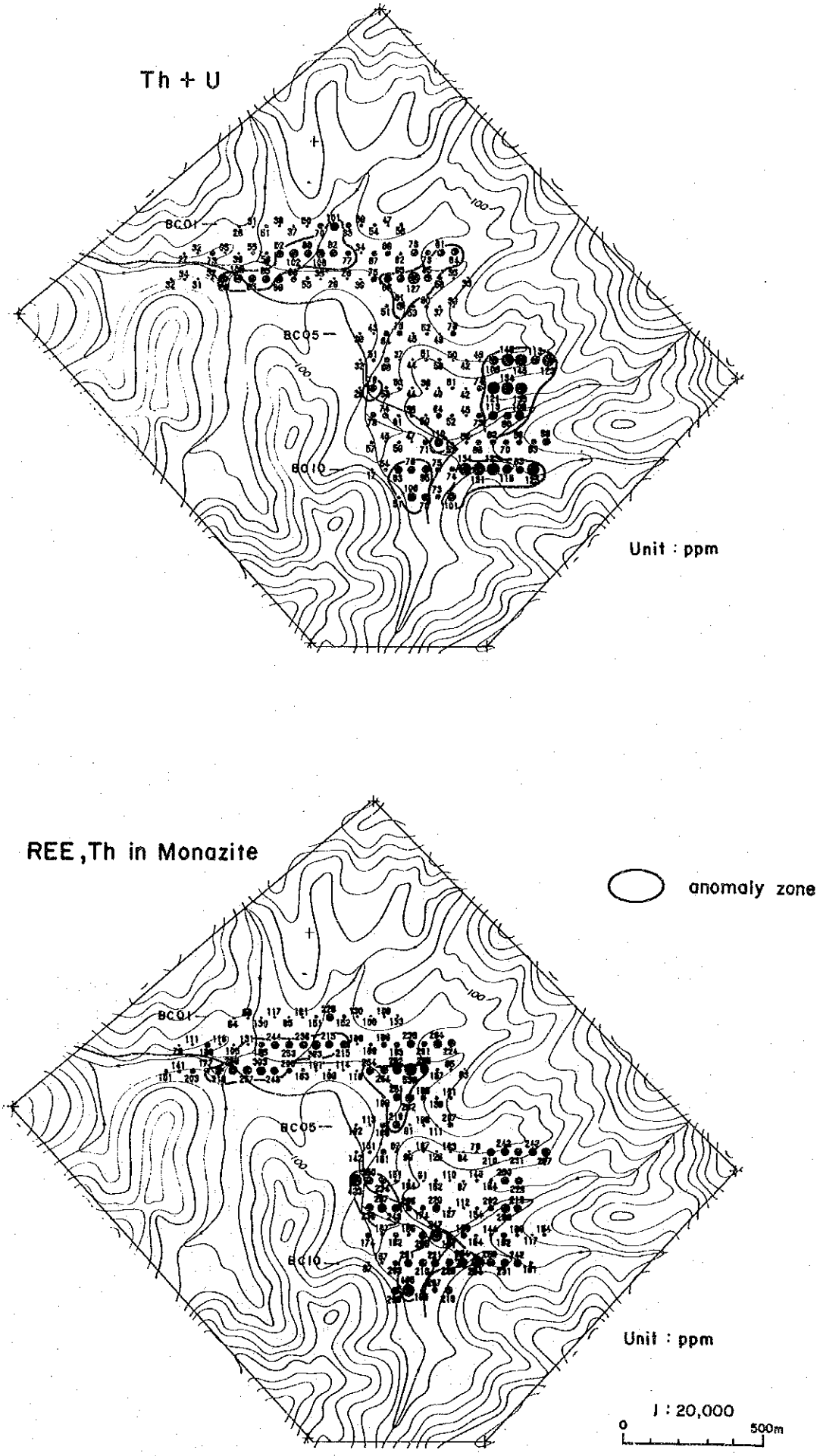


Fig. 23 Results of the geochemical survey of Area B-3 (3)

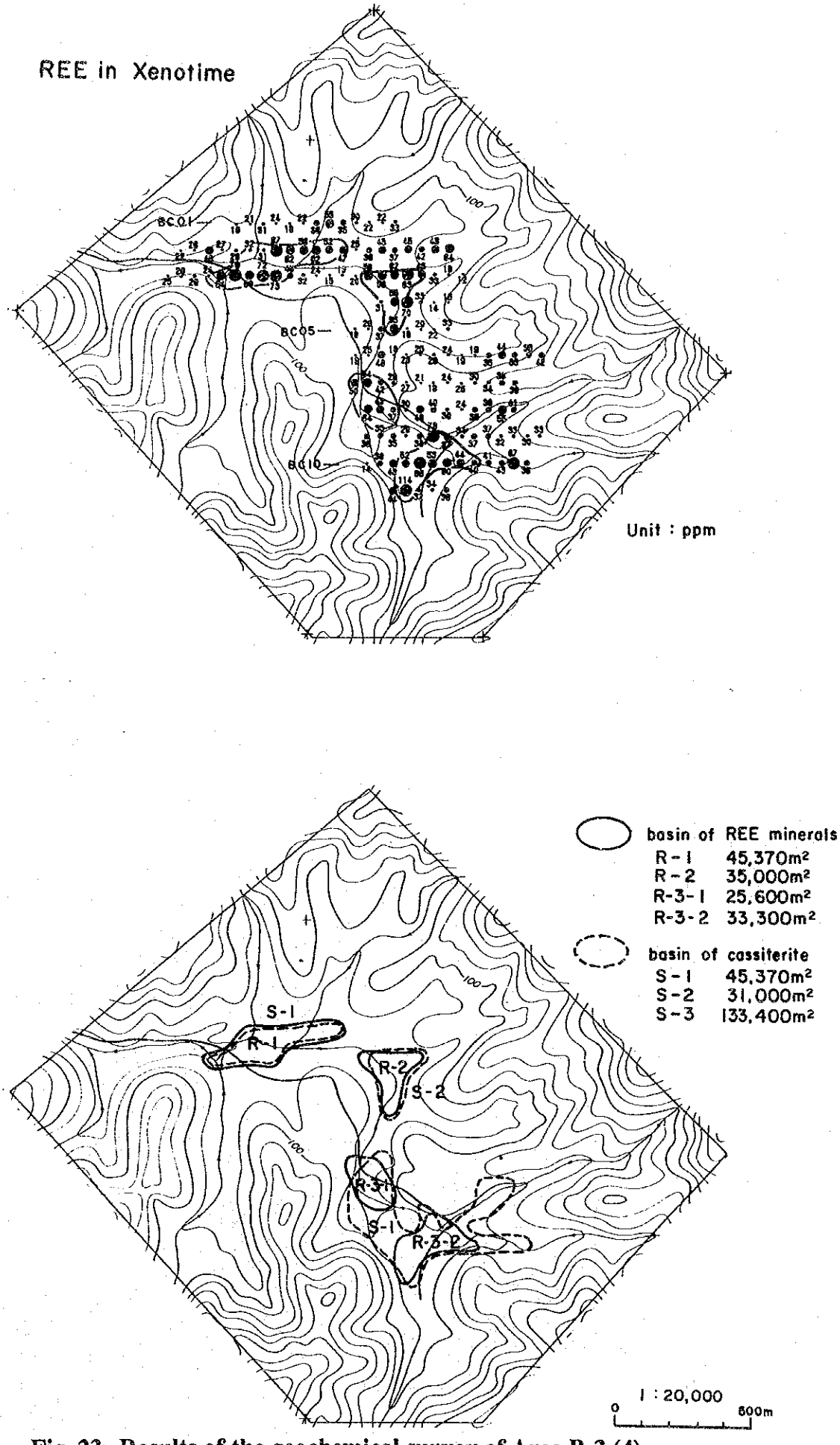


Fig. 23 Results of the geochemical survey of Area B-3 (4)

Therefore, most cassiterite and rare earth minerals are inferred to have been transported and accumulated on low land.

It is peculiar in the nine survey areas that anomaly of tin and rare earth elements overlap each other in Area B-3. It is inferred to be due to a closed alluvial basin.

The reserve and grade are given in Table 9.

Chapter 6 Area B-4

6-1 Location

Area B-4 is about 9 kilometers northeast of Kra Buri Town. The center of the area is at latitude 10°26.5'N and longitude 98°50.5'E. The area covers Khlong (River) Sawa and its tributary (Fig.24).

Khlong Sawa runs nearly westward in the north of the area, while its tributary in the south run west-northwestward. The area ranges in altitude from 30 to 150 meters, and consists of a large alluvial basin surrounded with gentle hills. The rivers meander through the area.

In the first year survey, the geochemical anomaly of Sn and REE was detected from stream sediments samples.

6-2 Survey method

Soil samples were collected from each point designed by rectangular grid method. The spacing between survey lines is 100 meters, and the intervals between each sampling point 50 meters. The number of collected samples is 147.

6-3 Geology

Area B-4 is underlain by Carboniferous Matsi Formation and the Quaternary (Fig.25).

Matsi Formation forms gentle hills, and consists of strongly weathered mudstone and siltstone.

Alluvium is distributed only in lowland along rivers. Terrace sediments consisting of clay, sand and gravel are found along Khlong Sawa, especially thick on the east end of the BD03-BD04 lines. The area of the tributary is alluvial lowland used as rice paddies, where a thick white clay layer is found.

6-4 Result of geochemical prospecting

6-4-1 Soil samples

The range, mean value (M) and standard deviations (σ) are listed in Table 12. Fig.26 shows the histograms and cumulative probability graphs of the five groups, namely Sn, W, Ta-Nb, Total REE and Th-U.

The four groups except W show nearly bimodal distribution. Their respective thresholds were determined to be M+0.5σ (Sn:37ppm, Ta-Nb:30ppm, Total REE:225ppm, Th-U:38ppm). The threshold of W was determined to be M+0.75σ (12ppm) in consideration of the skew point of its cumulative probability graph. The content distribution maps are shown in Fig.27 (1) to (4).

The anomaly values of all the groups almost overlap each other. Anomaly zones are distributed on the eastern side of the BD03-BD04 lines and around the DB11 line. The anomaly zones continue to the down stream along Khlong Sawa. These anomaly zones cover terrace sediments. Anomaly values are scattered around the BD05-BD10 lines in the basin of the tributary, though most samples in this area show lower than their respective threshold values.

The content of Total REE and Th-U in this area tends to be relatively lower than those in the other areas.

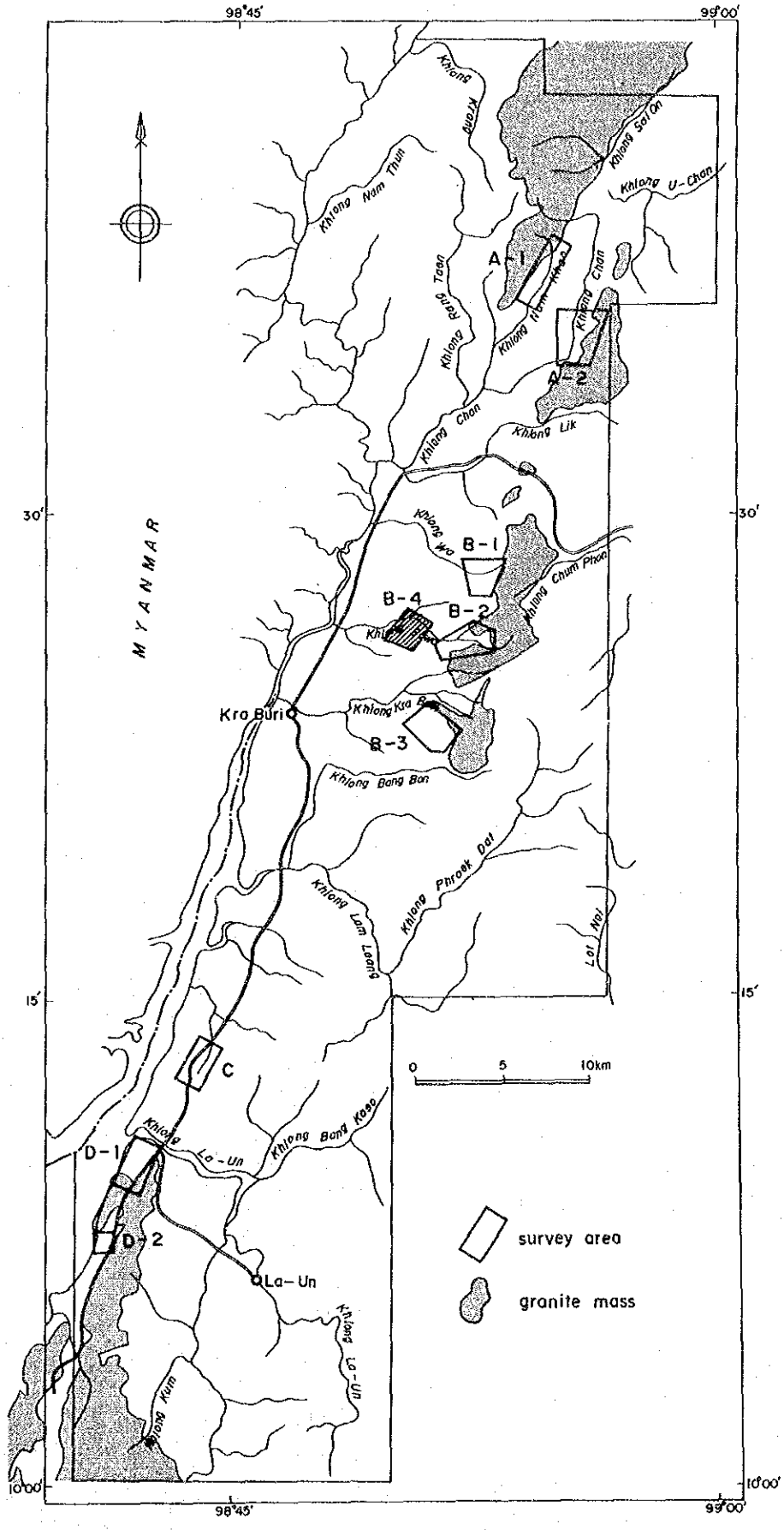


Fig. 24 Location map of Area B-4

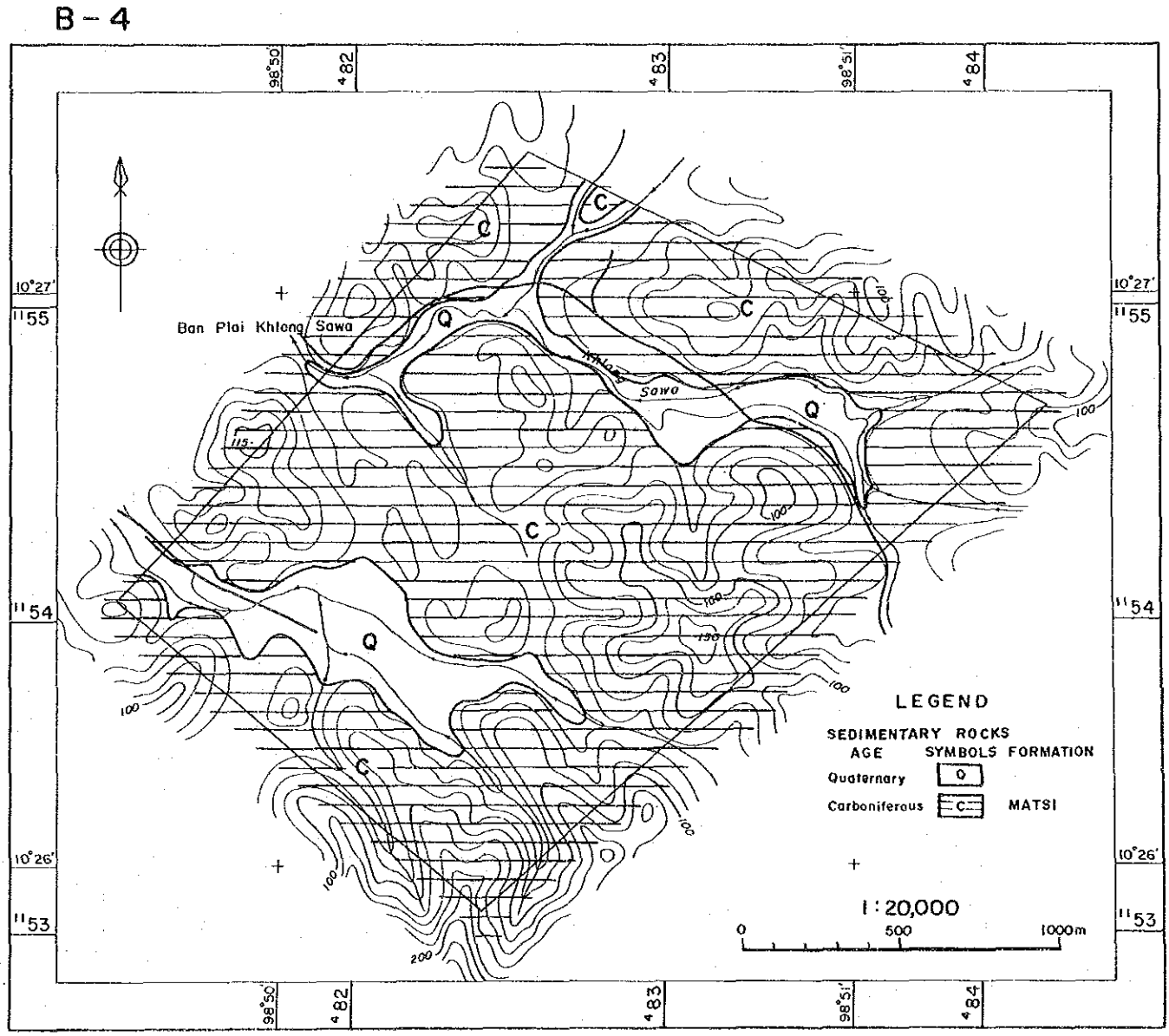


Fig. 25 Geologic map of Area B-4

Table 12 Geochemical basic statistic quantities of Area B-4

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	62.0	17.0	1.500	31.6	0.142
W	ppm	43.0	<2.0	0.799	6.3	0.383
Ta	ppm	6.0	<1.0	0.115	1.3	0.366
Nb	ppm	41.0	<2.0	1.347	22.3	0.165
Ce	ppm	240.0	3.0	1.794	62.2	0.274
Eu	ppm	2.0	<0.2	-0.198	0.6	0.236
La	ppm	72.0	5.0	1.470	29.5	0.252
Nd	ppm	55.0	<5.0	1.280	19.0	0.328
Sm	ppm	10.0	0.7	0.540	3.5	0.261
Tb	ppm	2.5	<5.0	-0.231	0.6	0.325
Th	ppm	54.0	9.0	1.397	24.9	0.203
U	ppm	18.0	<0.5	0.595	3.9	0.384
Y	ppm	92.0	16.0	1.584	38.4	0.178
Gd	ppm	14.3	0.2	0.627	4.2	0.336
Dy	ppm	15.5	3.0	0.786	6.1	0.180
Pr	ppm	<20.0	<20.0	------	----	------
Yb	ppm	10.8	2.4	0.654	4.5	0.184
Lu	ppm	1.5	0.4	-0.161	0.7	0.167
Ta+Nb	ppm	45.0	1.0	1.374	23.7	0.176
T.REE	ppm	391.6	50.2	2.245	176.0	0.213
Th+U	ppm	68.0	10.4	1.468	29.4	0.221

6-4-2 Heavy mineral samples

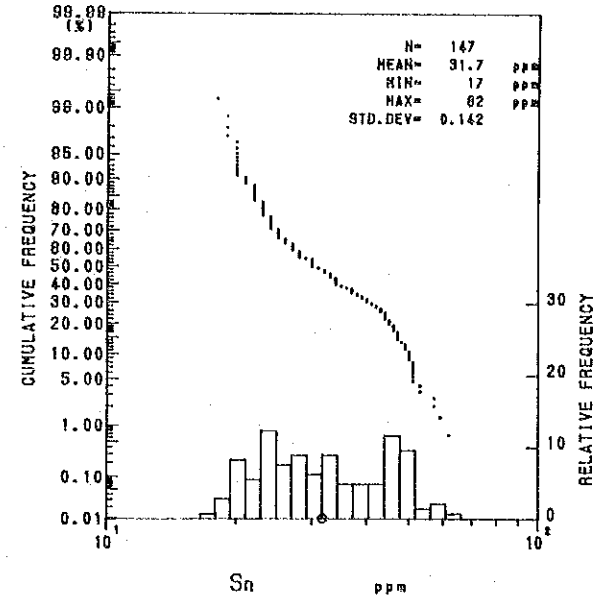
Four heavy mineral samples were collected from places along Khlong Sawa. The highest Sn content is detected at a downstream of the east bank of Khlong Sawa, where the most superior anomaly values are also recognized from soil samples. The contents of REE, Th and U tend to increase toward the lower reaches of the river.

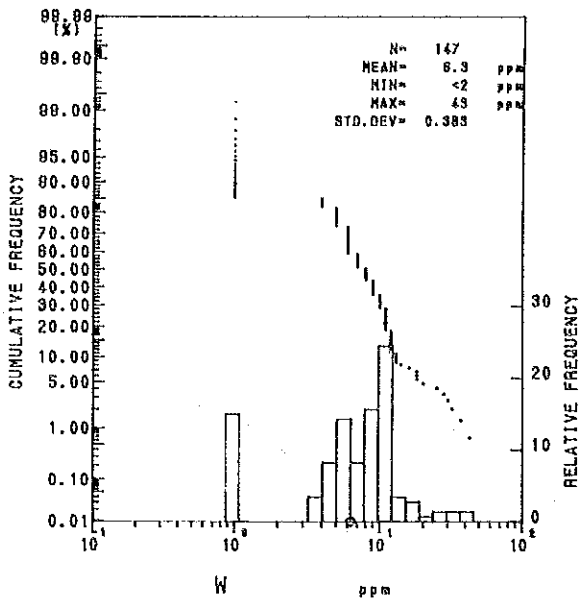
6-5 Discussion

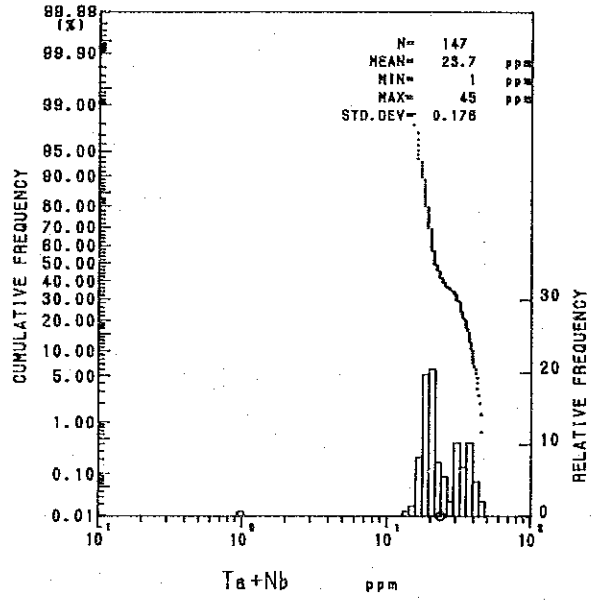
Two alluvial basins of placer deposits, the east basin and the west basin, are distributed in terrace sediments along Khlong Sawa. The sediments have accumulated thickly in the east basin, whereas the sediments are narrowly distributed along the river in the west basin. These basins are the biggest of all in Area B-1 to B-4, and contain much heavy minerals. The reserve of the largest basin is estimated at lower than 300 thousand m^3.

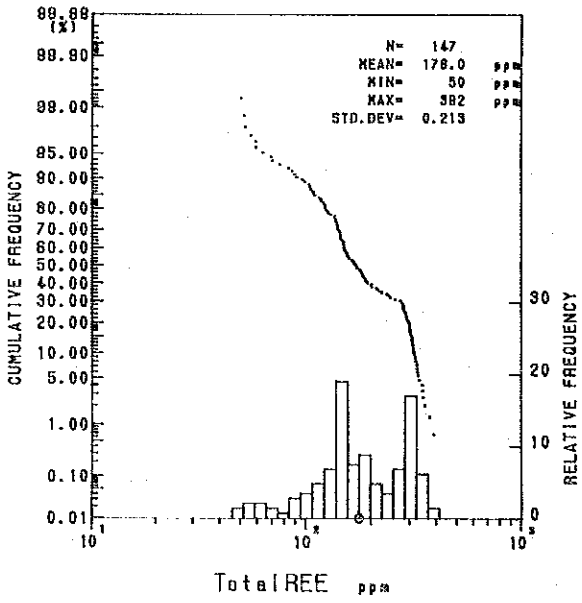
The south area of the tributary around the BD05-BD10 lines also consists of a flat basin. Most parts of this basin are used as rice paddies, and white clay has thickly accumulated. It is impossible to evaluate accurately this basin because of the no data about the thickness of a white clay bed. The anomaly values are scattered in this basin; thereby the potential of placer deposits is inferred to exist in the south of Area B-4.

The reserve and grade are shown in Table 9.









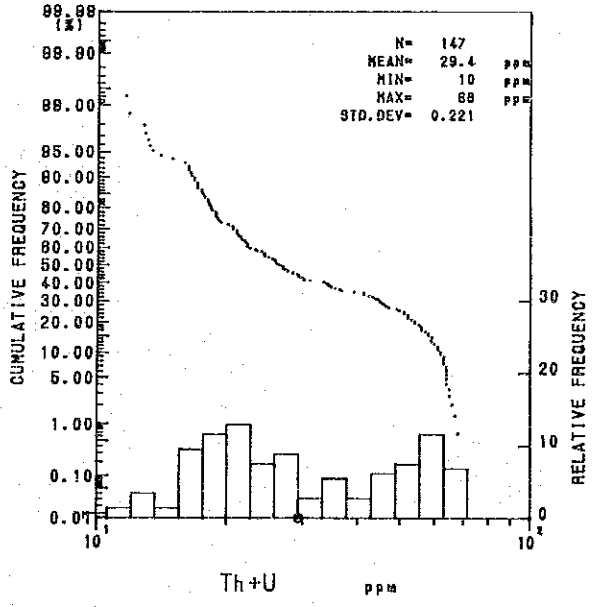


Fig. 26 Histograms and cumulative probability graphs of Area B-4

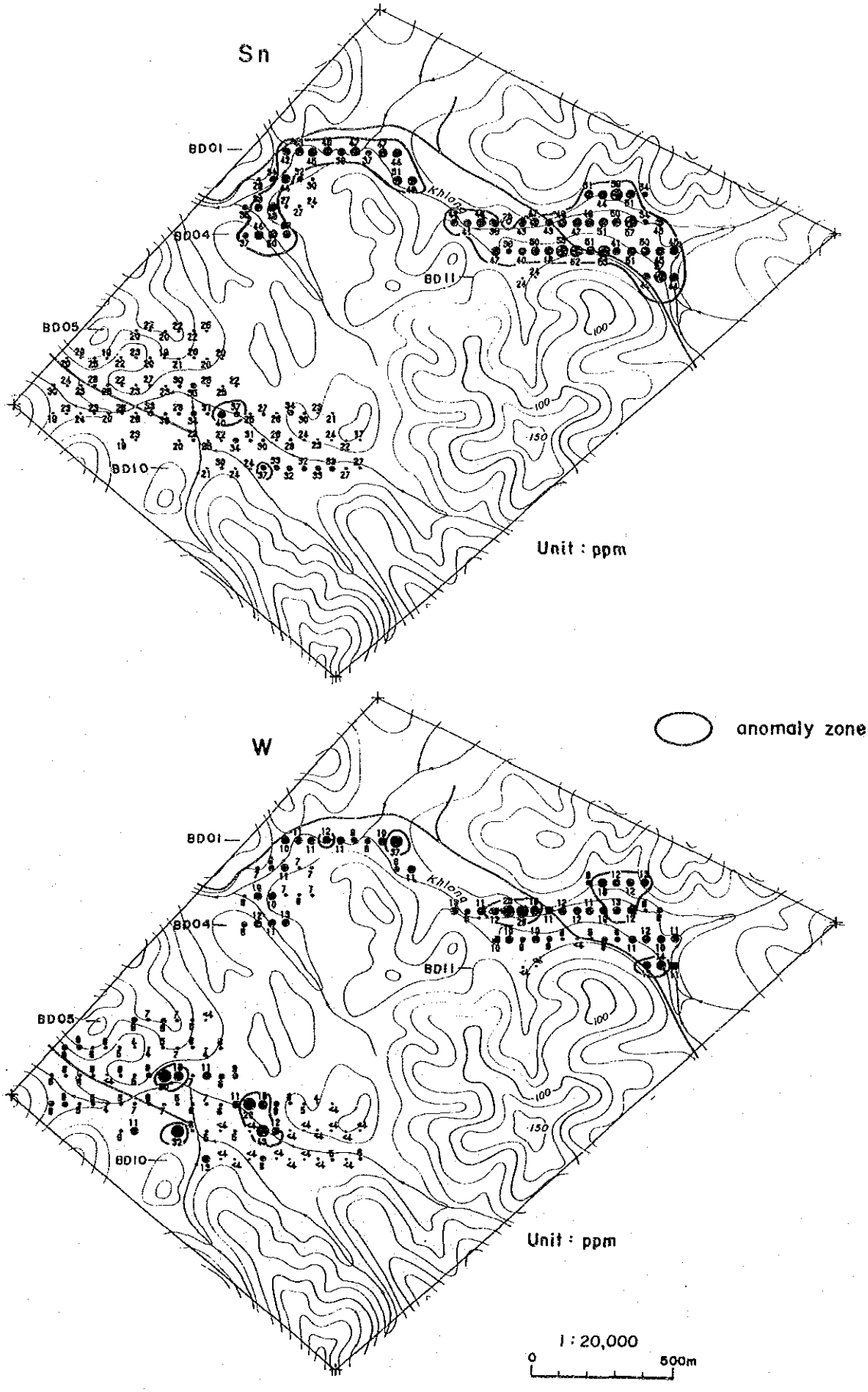


Fig. 27 Results of the geochemical survey of Area B-4 (1)

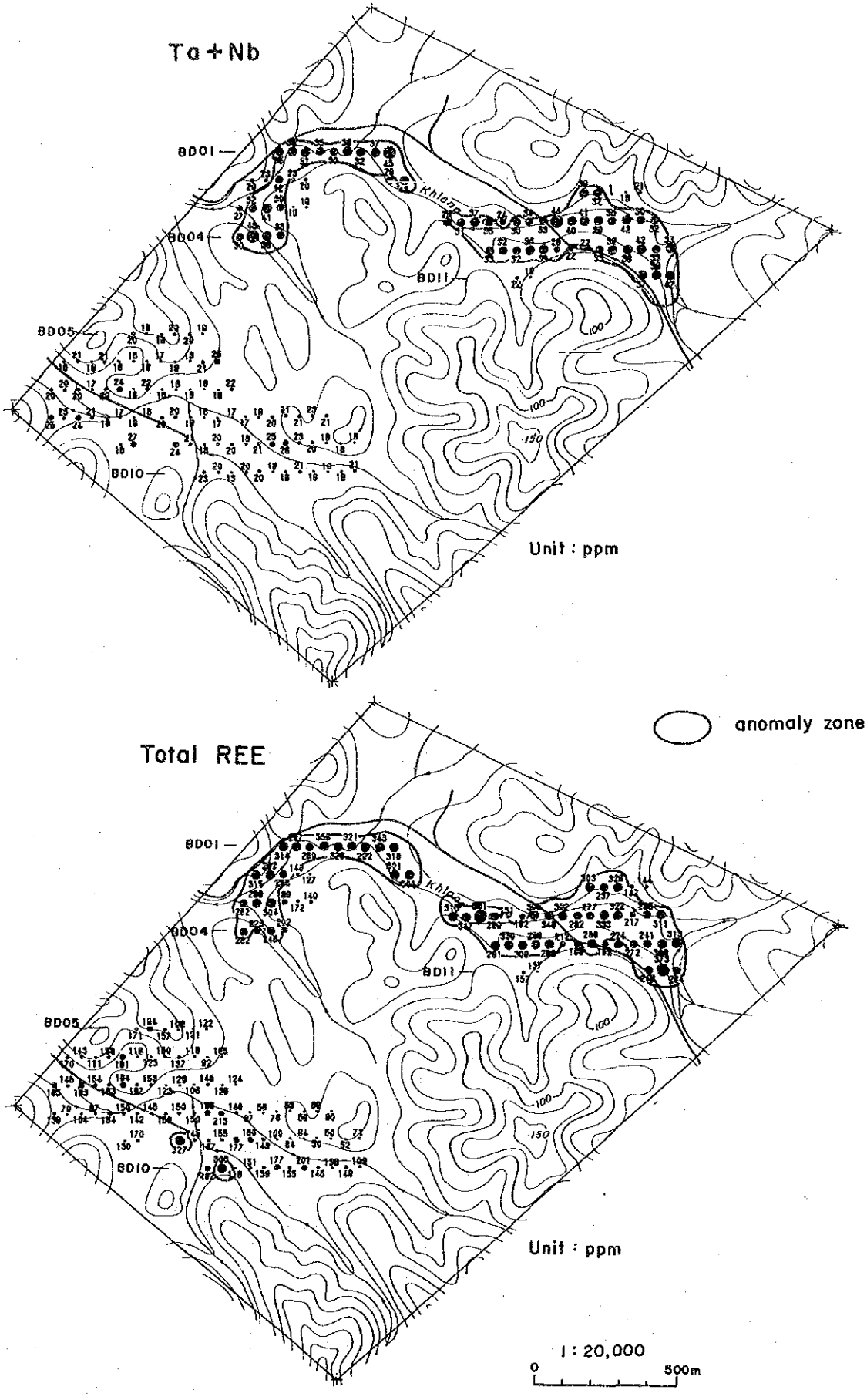


Fig. 27 Results of the geochemical survey of Area B-4 (2)

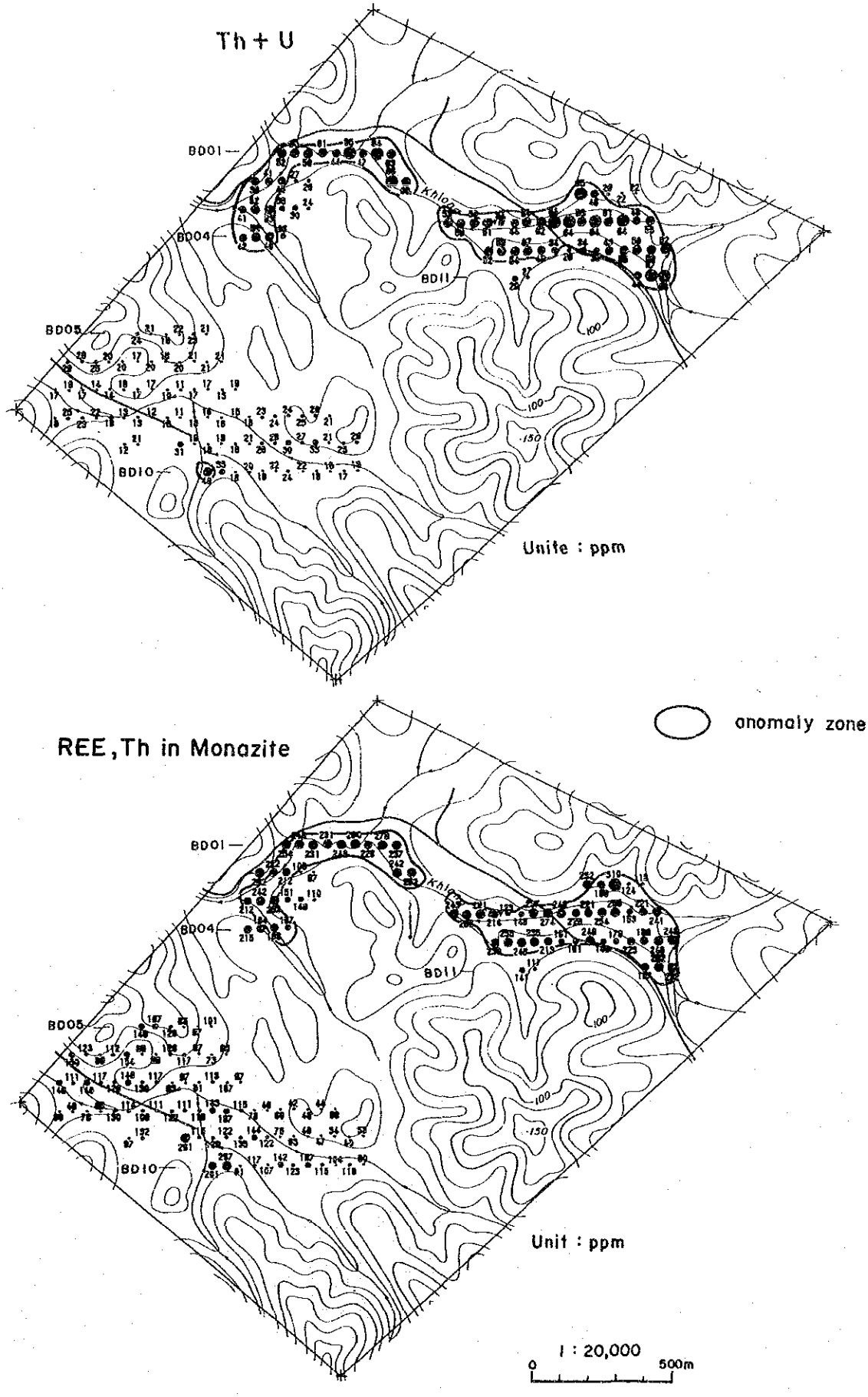


Fig. 27 Results of the geochemical survey of Area B-4 (3)

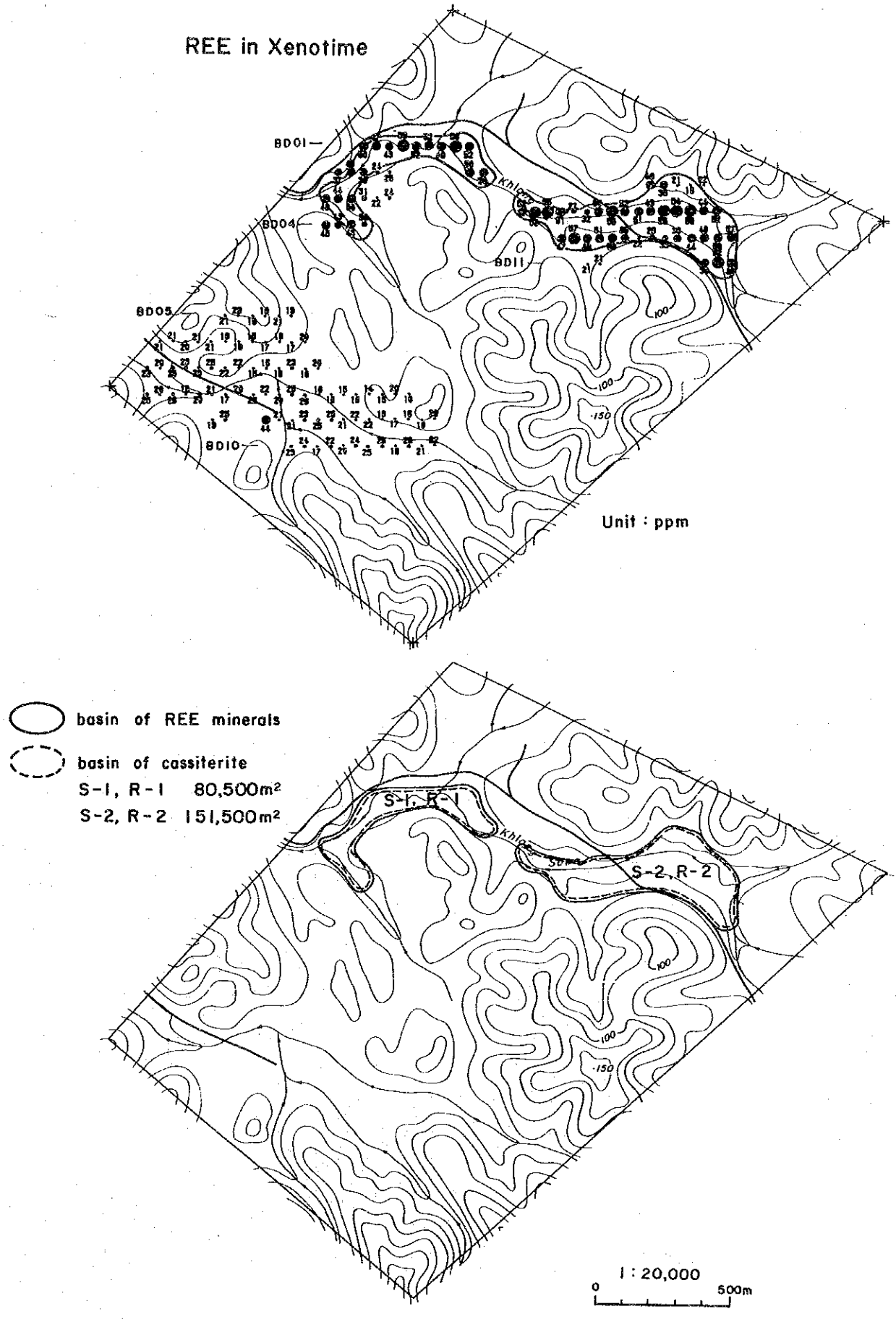


Fig. 27 Results of the geochemical survey of Area B-4 (4)

Chapter 7 Area C

7-1 Location

Area C is about 22 kilometers south-southeast of Kra Buri Town on the northern edge of Khao (Mt.) Fachi Silicified Zone. The center of the area is at latitude 10°13.5'N and longitude 98°44'E. The area covers Khao Fachi silicified zone and an alluvial basin on the east of the silicified zone (Fig.28).

Khlong (River) Bang Yai Lang runs nearly northward in the area, and its tributary runs northwestward and joints the main river in the area. The area consists of steep mountains in the west, gentle hills in the east, and the alluvial basin in the north.

The Route 4 passes longitudinally through the area. The distance of the road from Kra Buri Town is 25 kilometers, and it takes about 30 minutes by car.

The geochemical anomaly of Sn, Nb, Ta, REE, Th, U and Y was detected from stream sediments by the first year geochemical prospecting.

7-2 Survey method

The geochemical anomaly of tin and rare earth elements is inferred to cause of the Khao Fachi silicified zone in Area C. This survey was conducted to evaluate the potential of primary deposit in the silicified zone, and to clarify the transportation mechanism of heavy minerals from the silicified zone to an alluvial basin. Soil samples were collected from each point designed by a rectangular grid method. The spacing between survey lines is 100 meters, and the intervals between each sampling point 50 meters. The number of collected samples is 362.

7-3 Geology

Area C is underlain by Carboniferous Matsi Formation, Khao Fachi Silicified Zone, and the Quaternary (Fig.29).

Non-silicified Matsi Formation forms hills in the eastern half of the area, and consists of strongly weathered mudstone and sandstone.

Khao Fachi Silicified Zone forms steep ridges in the west of the area. The rocks in this zone have been subjected to weak to medium silicification and white argillization. The original rocks of this zone have been mudstone and sandstone of Matsi Formation. The foliation is common in the silicified rock, and trends N-S or N10°W and dips 80 to 90°W. The network quartz veins, ranging in width from several to some ten centimeters, mainly trend N20°E and dip 80°N. They cut the foliation. They are not observed megascopically any mineralizations.

Alluvium has thickly accumulated in the basin of Khlong Bang Yai Lang between the CA01-CA12 lines. The alluvium near the CA0713 point consists, from above to downward, surface soil about 1.5 meters, kaolinite clay bed about 1 meter, and sand and gravel bed. The area south of the CA12 line is steep valleys. Fluvial sediments are narrowly distributed along these valleys, and consist mainly of white clay.

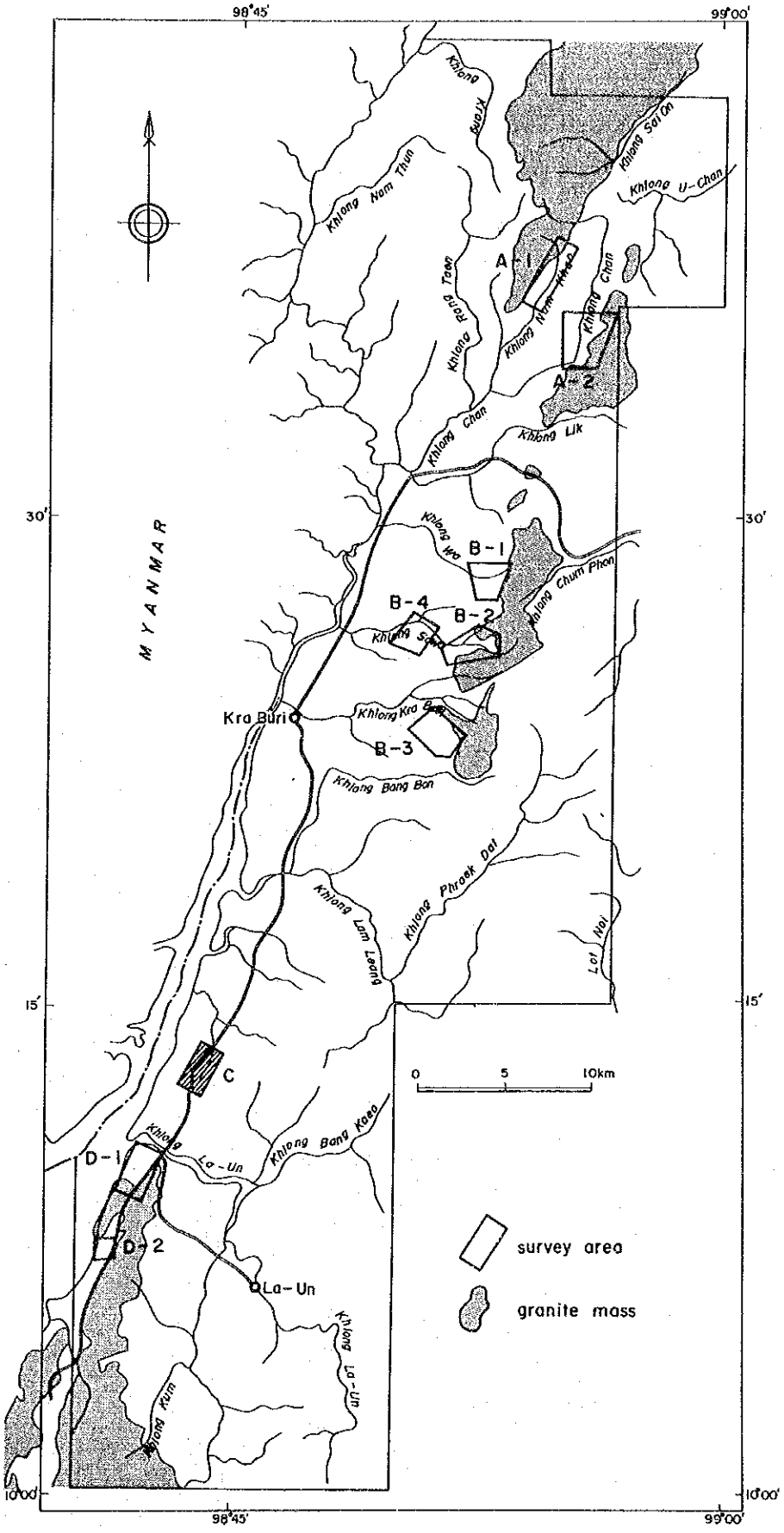


Fig. 28 Location map of Area C

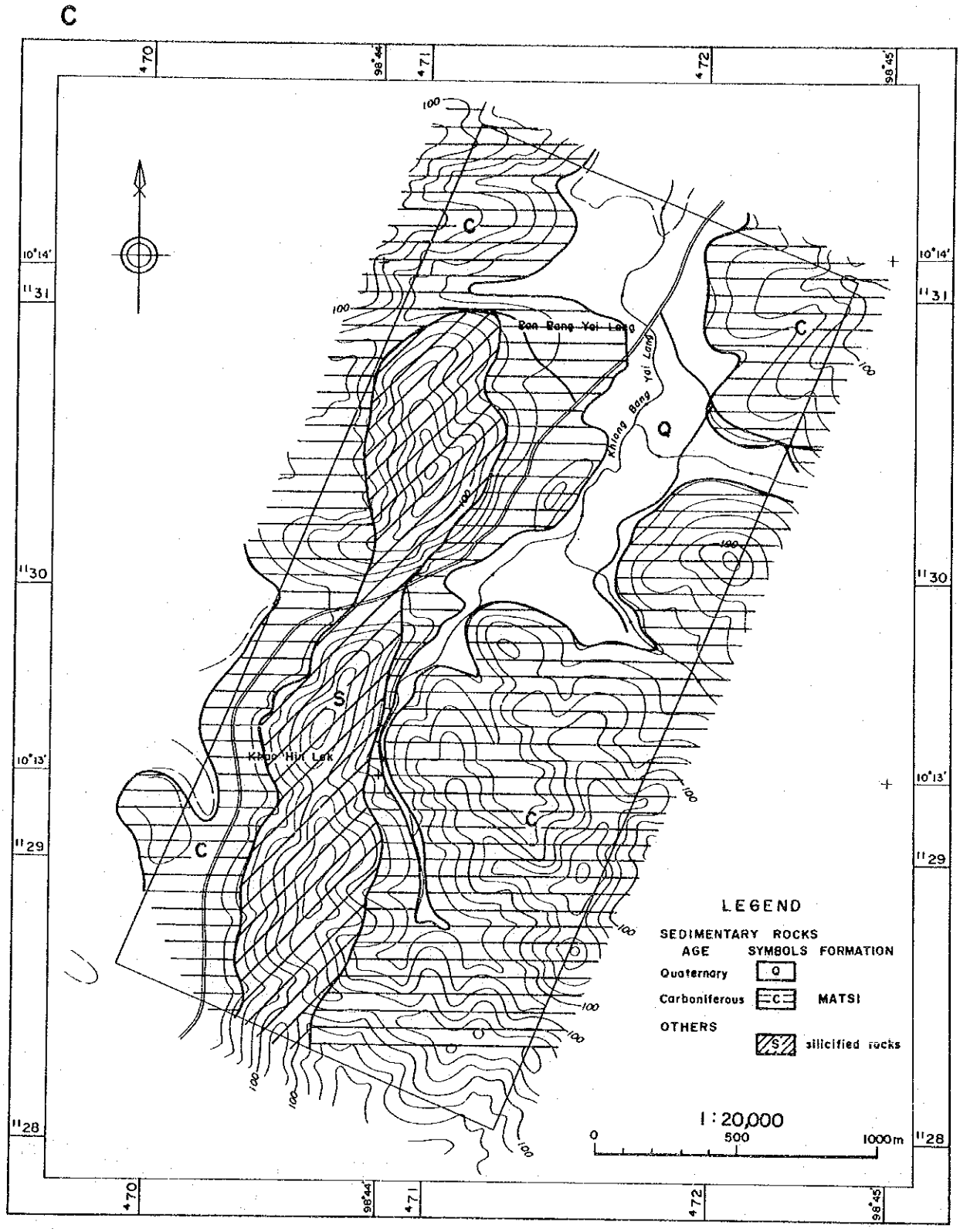


Fig. 29 Geologic map of Area C

7-4 Result of geochemical prospecting

7-4-1 Soil samples

The range, mean values (M) and standard deviations (σ) are listed in Table 13. Fig.30 shows the histograms and cumulative probability graphs of the five elements groups, namely, Sn, W, Ta-Nb, Total REE and Th-U.

The thresholds of all the groups were determined to be Sn:23ppm (M+0.75σ), W:17ppm (M+1.5σ), Ta-Nb:25ppm (M+0.75σ), Total REE:173ppm (M+0.25σ) and Th-U:26ppm (M+0.5σ) respectively based on the histograms and cumulative probability graphs.

Table 13 Geochemical basic statistic quantities of Area C

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	57.0	<5.0	1.149	14.1	0.284
W	ppm	32.0	<2.0	0.462	2.9	0.526
Ta	ppm	11.0	<1.0	0.025	1.1	0.299
Nb	ppm	39.0	11.0	1.326	21.2	0.075
Ce	ppm	200.0	15.0	1.858	72.0	0.144
Eu	ppm	6.0	<0.2	-0.099	0.8	0.185
La	ppm	86.0	9.0	1.470	29.5	0.181
Nd	ppm	58.0	<5.0	1.274	18.8	0.228
Sm	ppm	13.0	1.0	0.553	3.6	0.175
Tb	ppm	5.6	<0.5	-0.361	0.4	0.270
Th	ppm	41.0	9.0	1.325	21.1	0.101
U	ppm	6.8	<0.5	0.292	2.0	0.286
Y	ppm	53.0	9.0	1.477	30.0	0.116
Gd	ppm	12.0	0.5	0.579	3.8	0.229
Dy	ppm	11.1	0.8	0.717	5.2	0.129
Pr	ppm	29.0	<20.0	1.005	10.1	0.044
Yb	ppm	7.2	1.3	0.557	3.6	0.093
Lu	ppm	0.9	0.2	-0.228	0.5	0.089
Ta+Nb	ppm	42.0	11.0	1.348	22.3	0.081
T.REE	ppm	367.9	57.5	2.238	173.0	0.121
Th+U	ppm	45.3	10.4	1.369	23.4	0.095

The content distribution maps are shown in Fig.31 (1) to (4).

The Sn anomaly values are distributed around the mountains north of the Route 4 in the northwest part of Area C, and tend to disperse toward an alluvial basin east of the road. High Sn content samples concentrate near Bang Yai Lang Village on the northeast of mountains.

The W anomaly values are found around the mountains, but do not be detected to the east of the road.

The anomaly values of Ta-Nb almost overlap with the Sn anomaly values in the north of the survey area, except other two anomaly zones are found; a small anomaly zone in the silicified zone to the south of the road, and the small anomaly zone in the southernmost part of the survey area which overlaps with the anomaly zone of Total REE.

A strong anomaly zone of Total REE is detected in the mountains southernmost of Area C, and the anomaly values are also found on the other side of its ridge. This anomaly zone is inferred to extend to the further east area. Weak anomaly zones of Total REE are detected along ridges and along Khlong Bang Yai Lang from the northeast to the middle in Area C.

The Th-U content in Area C tends to be lower than that in other areas. No marked anomaly is detected. The tendency of Th-U content distribution is similar to that of Total REE in the survey area.

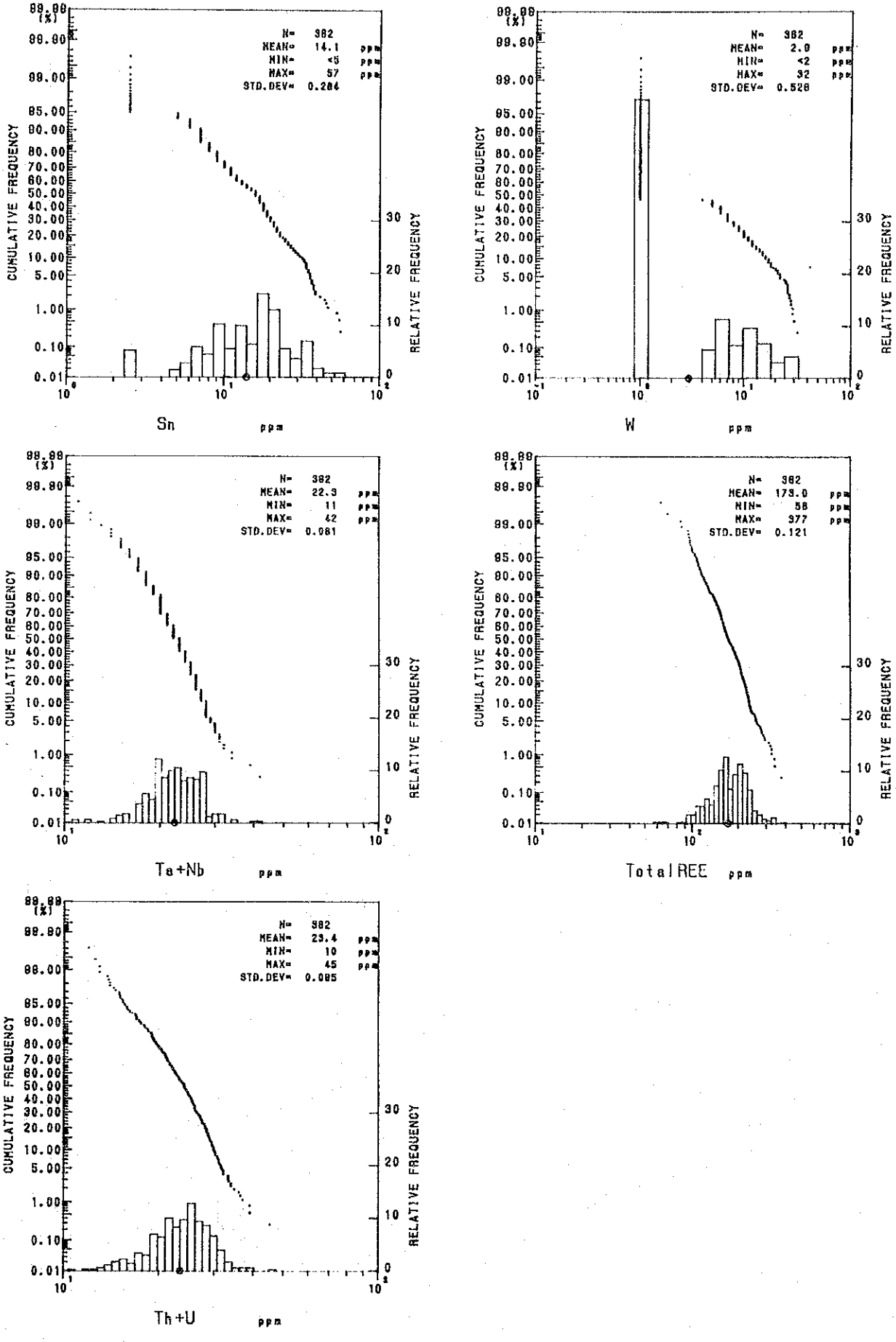


Fig. 30 Histograms and cumulative probability graphs of Area C

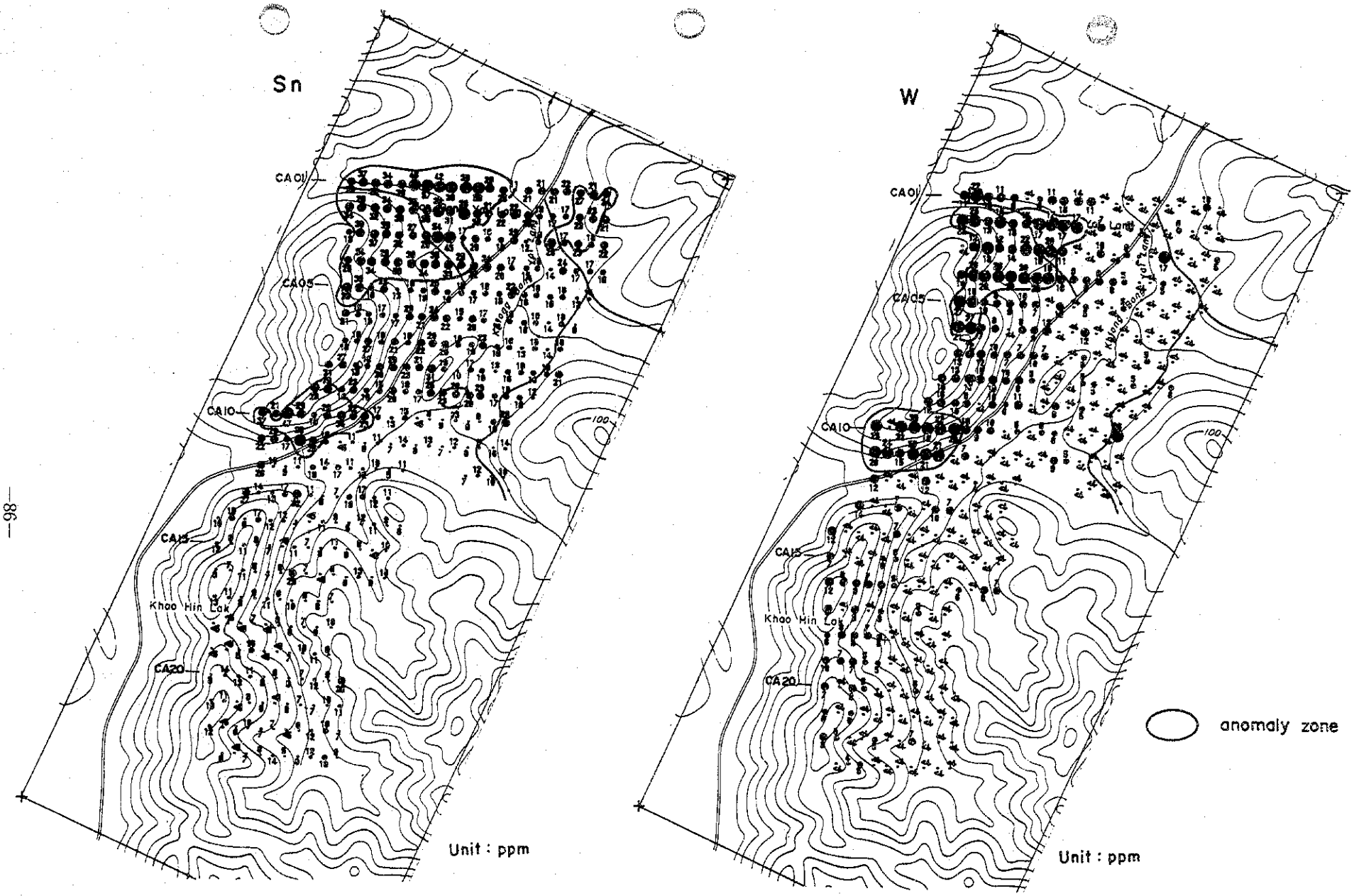


Fig. 31 Results of the geochemical survey of Area C (1)

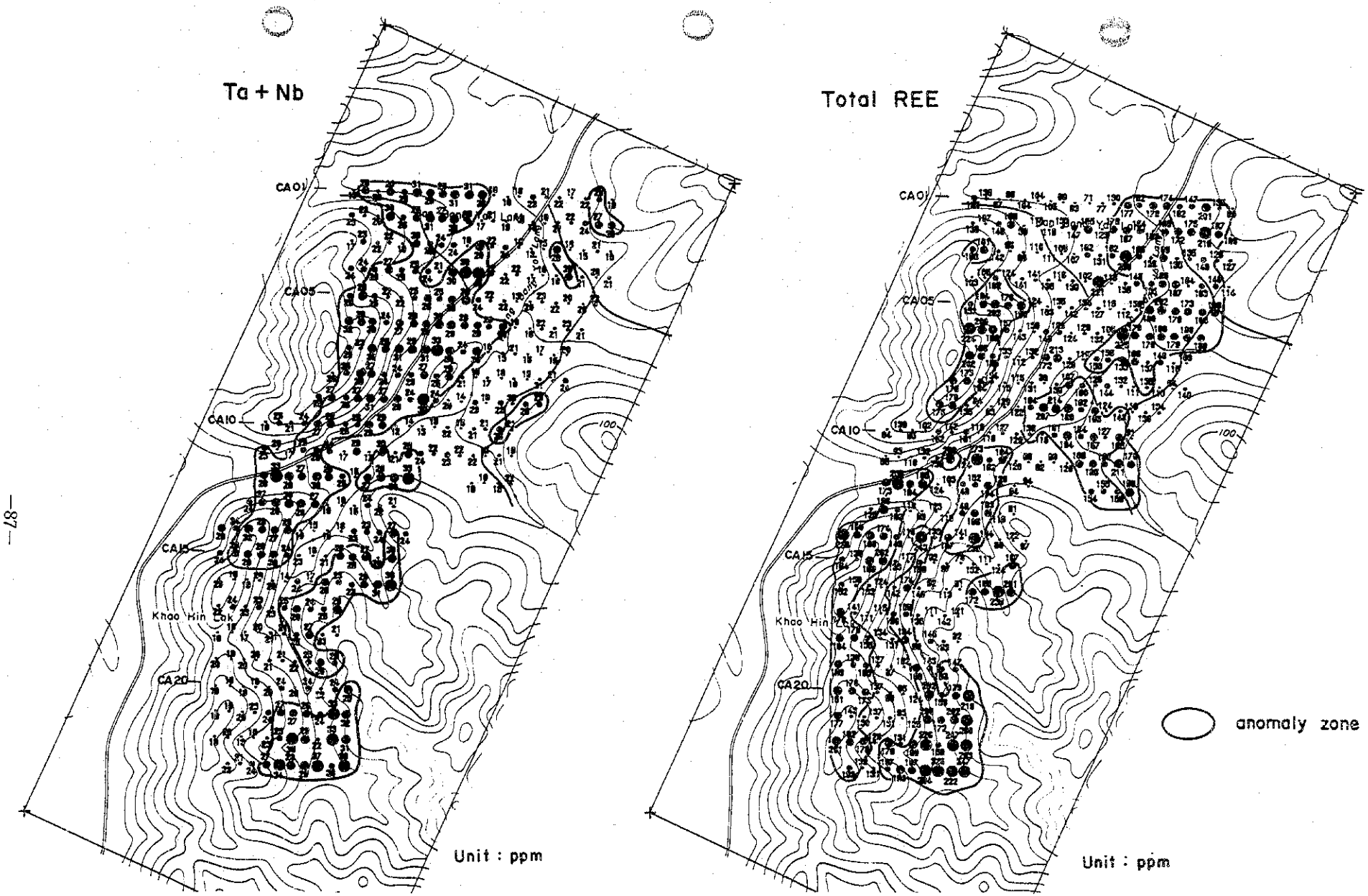


Fig. 31 Results of the geochemical survey of Area C (2)

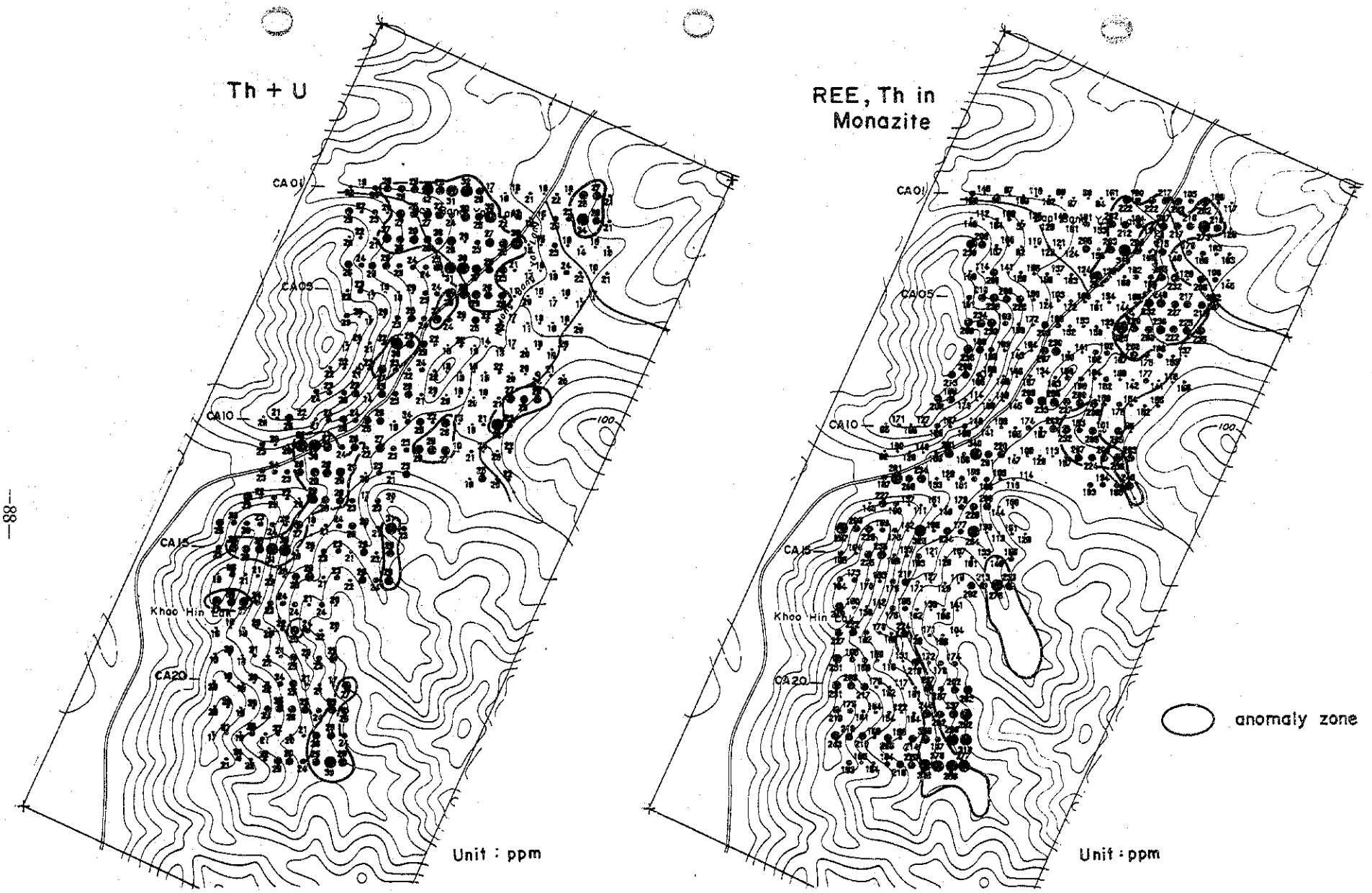


Fig. 31 Results of the geochemical survey of Area C (3)

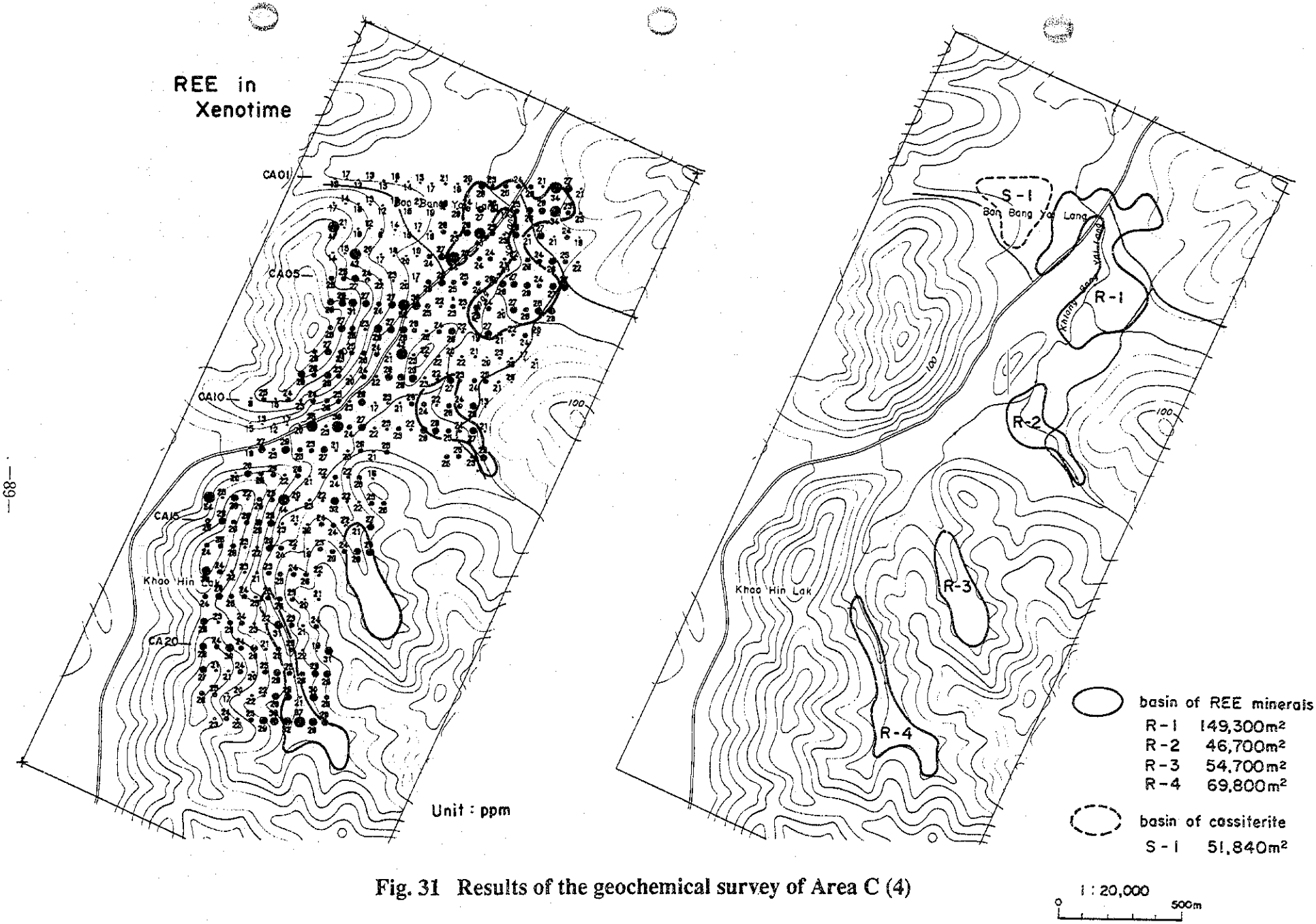


Fig. 31 Results of the geochemical survey of Area C (4)

7-4-2 Heavy mineral samples

Samples of heavy minerals were collected from sand and gravel bed in the alluvial basin along Khlong Bang Yai Lang between the CA01-CA11 lines. Since sediments along the river, from above to downward, consist of surface soil, kaolinite clay, and sand and gravel bed; sand and gravel bed is the lowest layer in this alluvial basin.

The Sn content of heavy mineral samples is high near the CA07-CA11 lines, though its amount is small. There are no anomaly values of soil samples along this river, but it is inferred that tin concentrates at the bottom of the alluvial basin.

7-5 Discussion

A tin anomaly zone is distributed on a slope of the northwest mountains; these tin anomalies are inferred to have been supplied from the silicified rocks in the northwest mountains. The reserve and grade are calculated only in this slope, though soil and weathered material are relatively thin. The reserve of cassiterite is 100 thousand m^3 (Table 14).

Another target of a placer tin deposit is inferred to be a basin extending from near Bang Yai Lang Village to the north. But rice paddies spread in this basin on the north of the CA01 line; thereby the extension of the basin was not confirmed in this survey, though the analysis of heavy mineral samples indicates the potential of placer tin deposits at the base of the basin in and around Bang Yai Lang.

The high anomaly zone of rare earth elements is detected in the southernmost part of Area C. This anomaly zone have no association with the distribution of silicified rocks. Anomaly values increase eastward in this zone, and are also recognized on the other side of the ridge. Thereby they may indicate that rare earth minerals are derived from the mountains to the southeast of Area C. There is a large possibility that an unknown granite mass intrudes southeast of Area C.

Another anomaly zone of rare earth elements is widely distributed in the northeast. It means the existence of a certain amount of rare earth deposits, though the grade is low. The reserve of rare earth minerals is 640 thousand m^3 (Table 14).

Table 14 Reserves in Area C

Area name		Mineral name	Areas (m^2)	Ave. Thick (m)	Reserves (m^3)	Ave. Contents (ppm)	Ave. Oregrade (kg/m^3)	Reserves of Minerals (t)
C	R-1	monazite	149,300	2	298,600	228	0.586	174
		xenotime				26	0.076	22
	R-2	monazite	46,700	2	93,400	218	0.560	52
		xenotime				25	0.073	6
	R-3	monazite	54,700	2	109,400	228	0.586	64
		xenotime				27	0.079	8
	R-4	monazite	69,800	2	139,600	261	0.670	93
		xenotime				27	0.079	11
	S-1	cassiterite	51,840	2	103,680	44	0.088	9

Total	monazite	320,500	2	641,000	–	0.845	383
	xenotime				–	0.235	47
	cassiterite	51,840	2	103,680	–	0.104	9

Chapter 8 Area D-1

8-1 Location

Area D-1 is about 30 kilometers south-southeast of Kra Buri Town. The center of the area is at latitude 10°10'N and longitude 98°42'E. It takes about 35 minutes to get there through the Route 4 by car. The area covers the northern portion of the southern granite mass and a wide mangrove zone extending to the northwest from the granite (Fig.32).

The mangrove zone is distributed in and around the confluence of Mae Nam Kra Buri and Khlong La-Un. There is a network of meandering creeks, varying in size, in the mangrove zone.

The mountains in the southeast of the survey area extend straight in the NNE-SSW direction and form relatively steep slopes. There is no big river from the mountains except Khlong Sai Dean running north-northwestward to the south of Area D-1.

Gentle slopes are found in the area between the mountains and the mangrove zone on the south of the DA12 survey line.

The anomalies of Ta, Nb, REE, U, Y and Th were detected from stream sediments and heavy mineral samples by the first year geochemical prospecting.

8-2 Survey method

In the area between the granite mass and the mangrove zone, the intervals between sampling points are decided to be 50 meters, to evaluate the mechanism of transportation and sedimentation of useful heavy minerals. The number of collected samples is 359.

8-3 Geology

Area D-1 is underlain by Cretaceous granite and the Quaternary (Fig. 33).

The granite consists of coarse-grained equigranular two-mica granite often containing mega-crystals of potassium feldspar. The rock is composed mainly of microcline, orthoclase, quartz, plagioclase, biotite and muscovite, with accessories zircon, apatite, sphene and ilmenite. This granite has been subjected to mylonitization. Allanite is often observed in the mylonitized lamella. Strongly sheared and silicified rock crops out on the north of the granite mass. The cement of the brecciated part is composed of quartz, chlorite, sericite and euhedral pyrite. An argillized granite is found on gentle hills in the south, whose plagioclase is completely replaced by kaolinite.

A mangrove mud covers widely in the mangrove zone and overlies the granite sand and partly kaolinite clay bed. The area lacking a mangrove mud is near the border between a slope and the mangrove zone, ranging in width from 20 to 30 meters. The mangrove mud is about 1 meter thick at a distance of 100 to 150 meters from the border of the slopes, and increase the thickness toward Mae Nam Kra Buri.

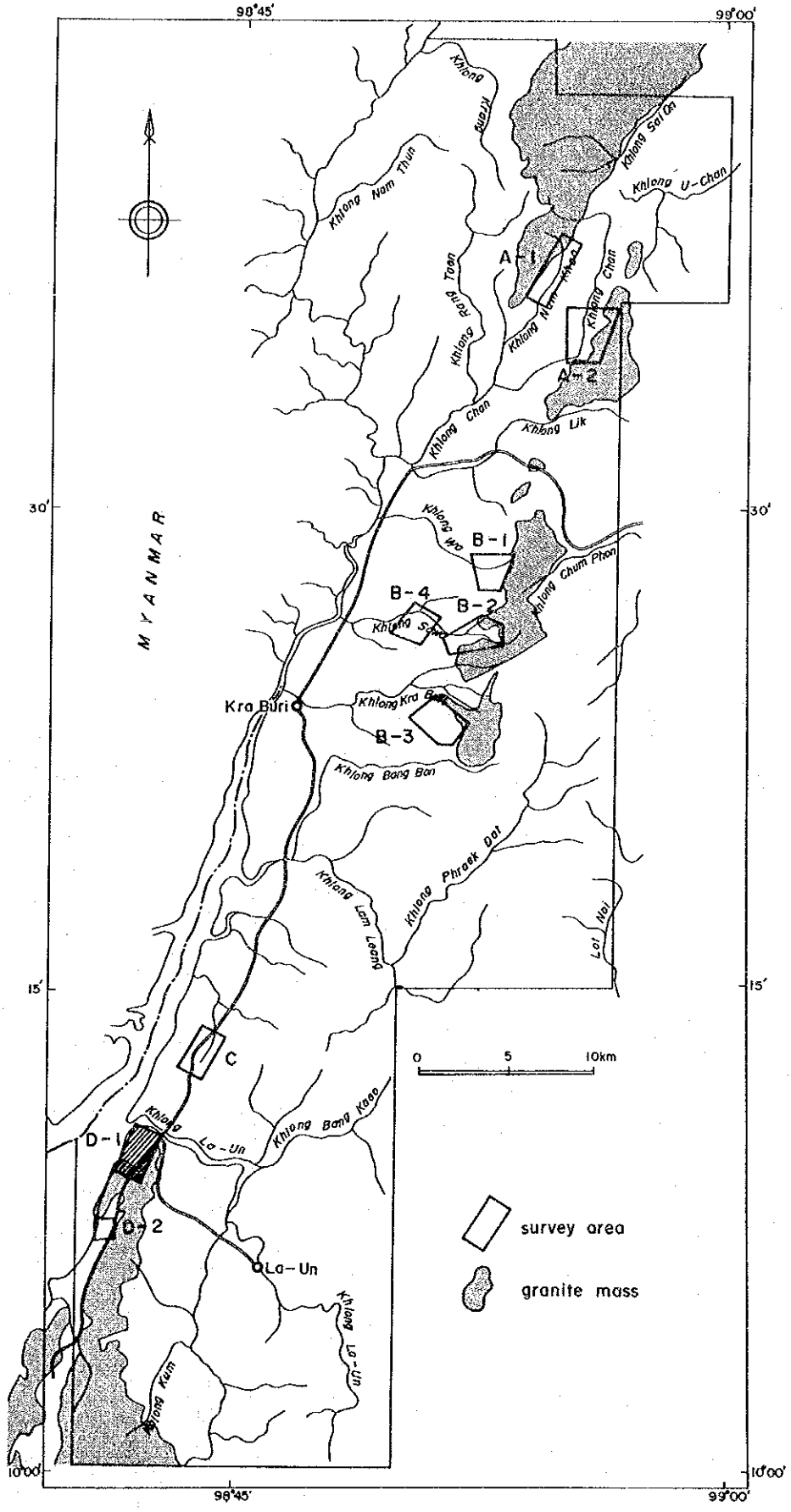


Fig. 32 Location map of Area D-1

D

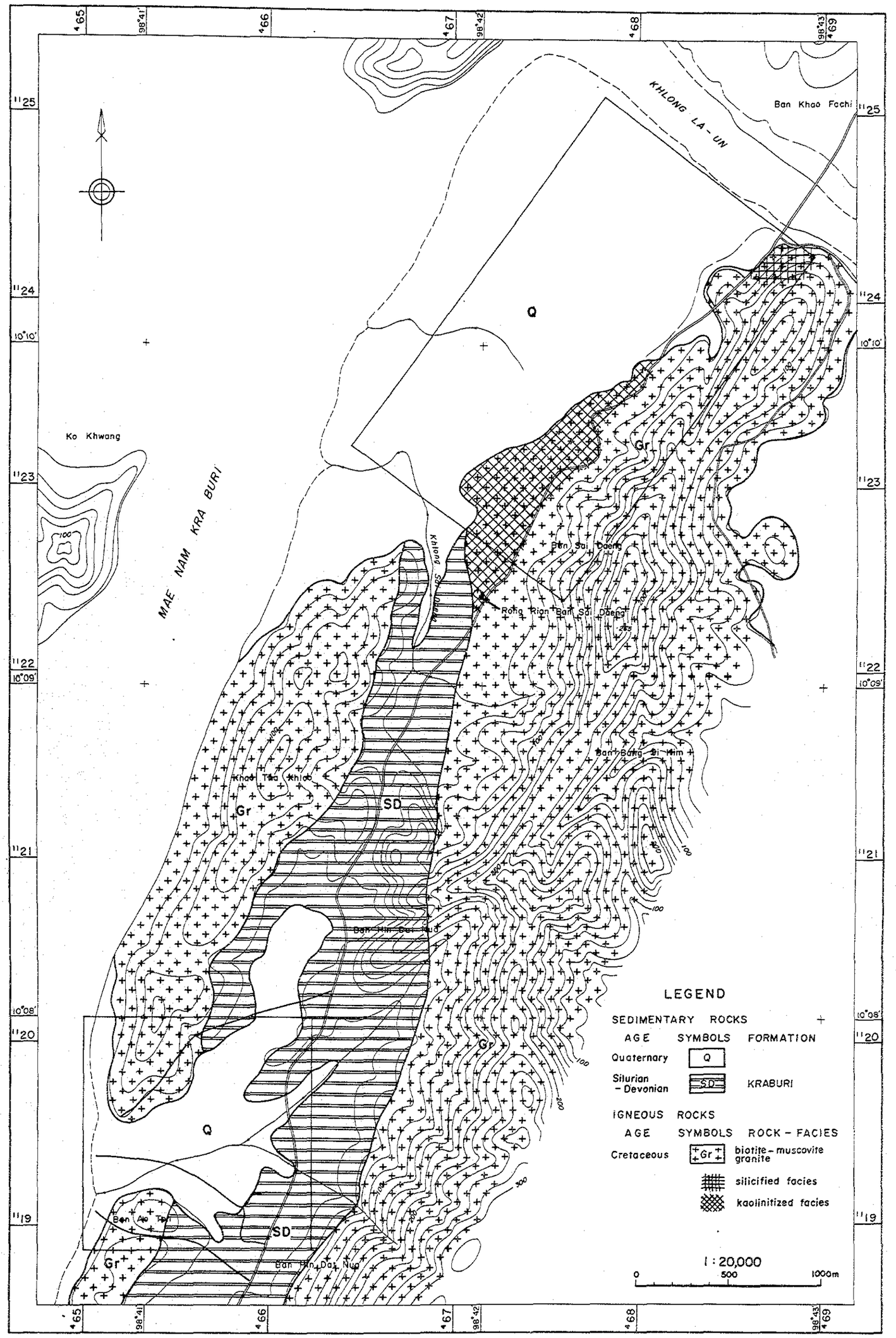


Fig. 33 Geologic map of Area D-1 and D-2

8-4 Result of geochemical prospecting

8-4-1 Soil samples

The range, mean value (M) and standard deviation (σ) for each element are listed in Table 15. Fig.34 shows the histograms and cumulative probability graphs of the five groups, namely Sn, W, Ta-Nb, Total REE, Th-U.

The four groups except W show clear bimodal distribution in Fig.34.

The thresholds of all the groups were determined to be Sn:31ppm (M+0.25σ), W:7ppm (M+0.75σ), Ta-Nb:54ppm (M+0.5σ), Total REE:477ppm (M+0.5σ) and Th-U:109ppm (M+0.5σ) respectively based on the histograms and cumulative probability graphs.

Table 15 Geochemical basic statistic quantities of Area D-1

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	111.0	<5.0	1.418	26.2	0.264
W	ppm	16.0	<2.0	0.491	3.1	0.454
Ta	ppm	12.0	<1.0	0.463	2.9	0.335
Nb	ppm	126.0	2.0	1.596	39.4	0.208
Ce	ppm	630.0	65.0	2.234	171.2	0.259
Eu	ppm	2.6	<0.2	-0.105	0.8	0.247
La	ppm	310.0	32.0	1.899	79.2	0.198
Nd	ppm	190.0	18.0	1.718	52.2	0.198
Sm	ppm	32.0	3.7	0.968	9.3	0.195
Tb	ppm	3.6	<0.5	-0.122	0.8	0.325
Th	ppm	260.0	20.0	1.820	66.0	0.344
U	ppm	20.0	4.5	0.924	8.4	0.126
Y	ppm	121.0	12.0	1.566	36.8	0.130
Gd	ppm	30.6	1.8	0.838	6.9	0.188
Dy	ppm	23.8	2.6	0.847	7.0	0.124
Pr	ppm	58.0	<20.0	1.021	10.5	0.101
Yb	ppm	9.9	1.2	0.567	3.7	0.126
Lu	ppm	1.4	<0.1	-0.317	0.5	0.156
Ta+Nb	ppm	138.0	2.0	1.629	42.6	0.209
T.REE	ppm	1047.2	171.6	2.581	380.7	0.196
Th+U	ppm	296.6	26.7	1.881	76.1	0.313

The content distribution maps are shown in Fig.35 (1) to (4).

Most Sn anomaly values area distributed in the granite area, and specially high anomaly values are found in the silicified granite in the north of the mass; thereby these facts indicate that the granite mass has caused tin anomalies in soil samples, and tin has concentrated in the granite mass during the process of silicification. On the contrary, the argillized granite shows a low Sn content in the south of the survey area.

In the mangrove zone, the soil samples are not variable in the Sn content and few samples show low content. The anomaly values are scattered in the mangrove area, and they were collected from the deeper part, e.g., a bottom of a creek. The DA1006 sample with the highest Sn content, was also collected at a depth of 2 meters near the bottom of a large creek. The Sn content tends to increase downward. The high Sn values are also observed in the area, where a mangrove mud is absent, along the valleys on the east of the DA10-DA11 lines.

All the W values are low and the maximum value is only 16 ppm. The distribution of relative high values overlaps with the silicified zone in the north of the granite mass.

The anomaly zones of Ta-Nb, Total REE and Th-U are the same shape as the granite mass, and

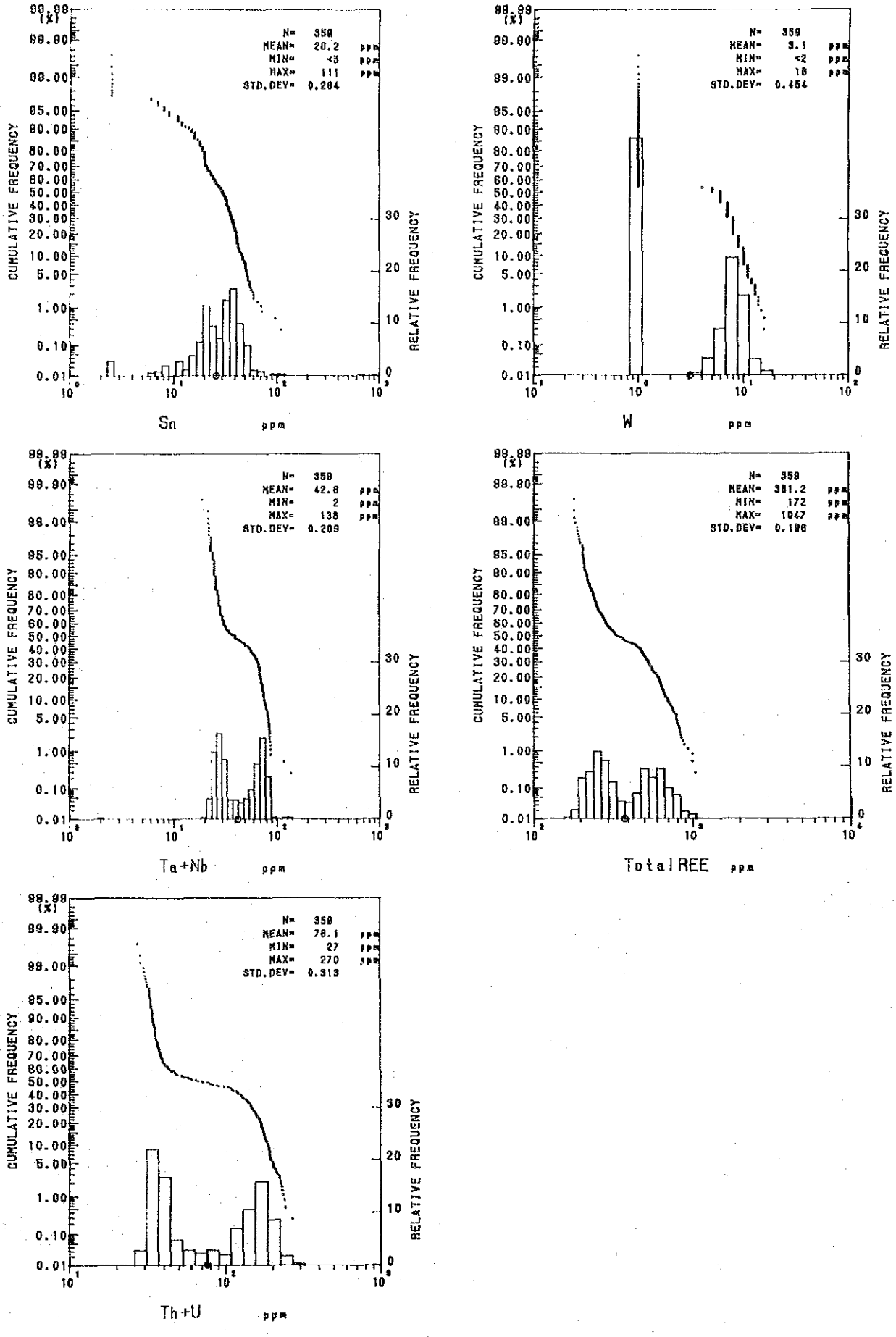


Fig. 34 Histograms and cumulative probability graphs of Area D-1

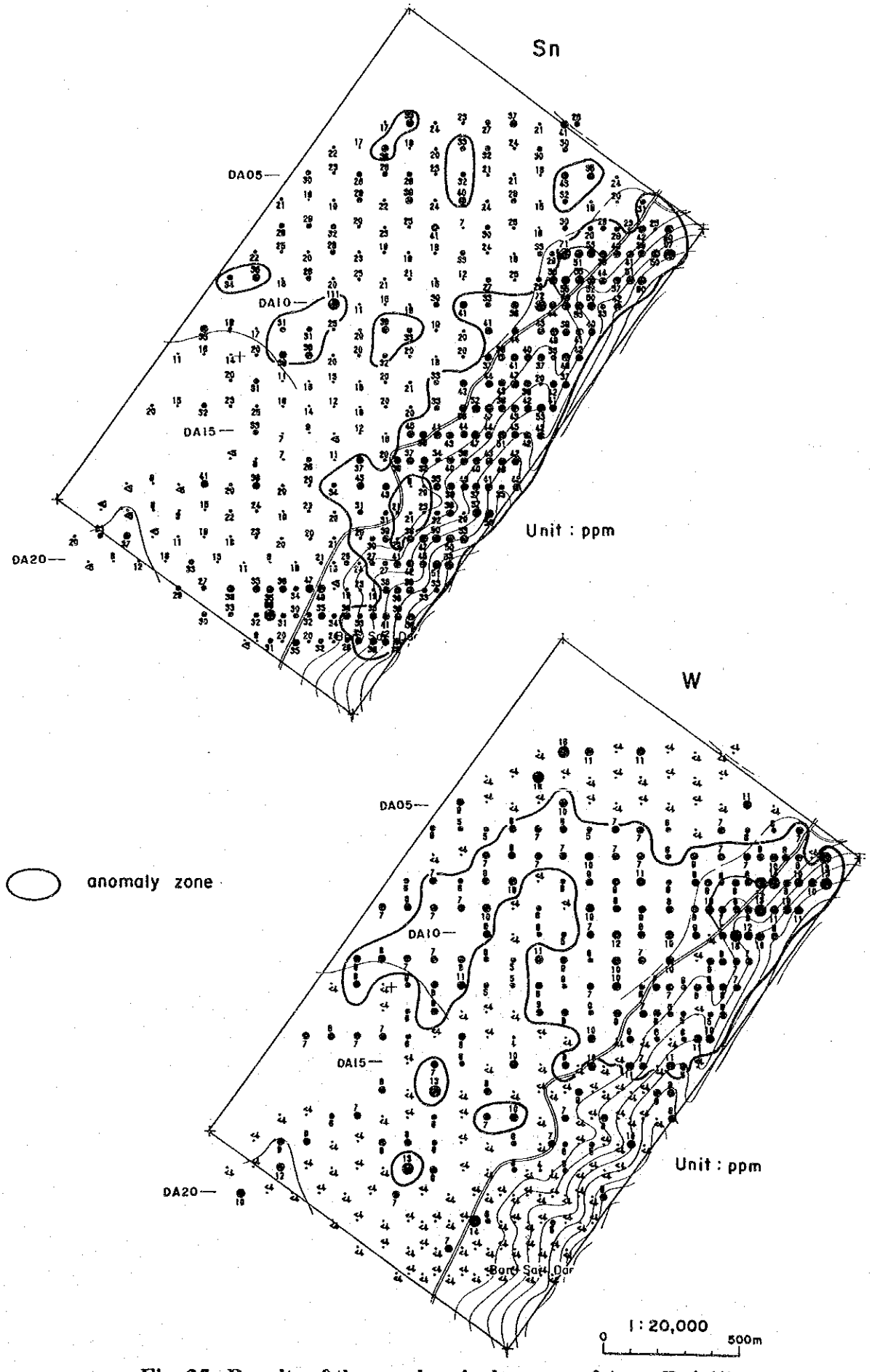


Fig. 35 Results of the geochemical survey of Area D-1 (1)

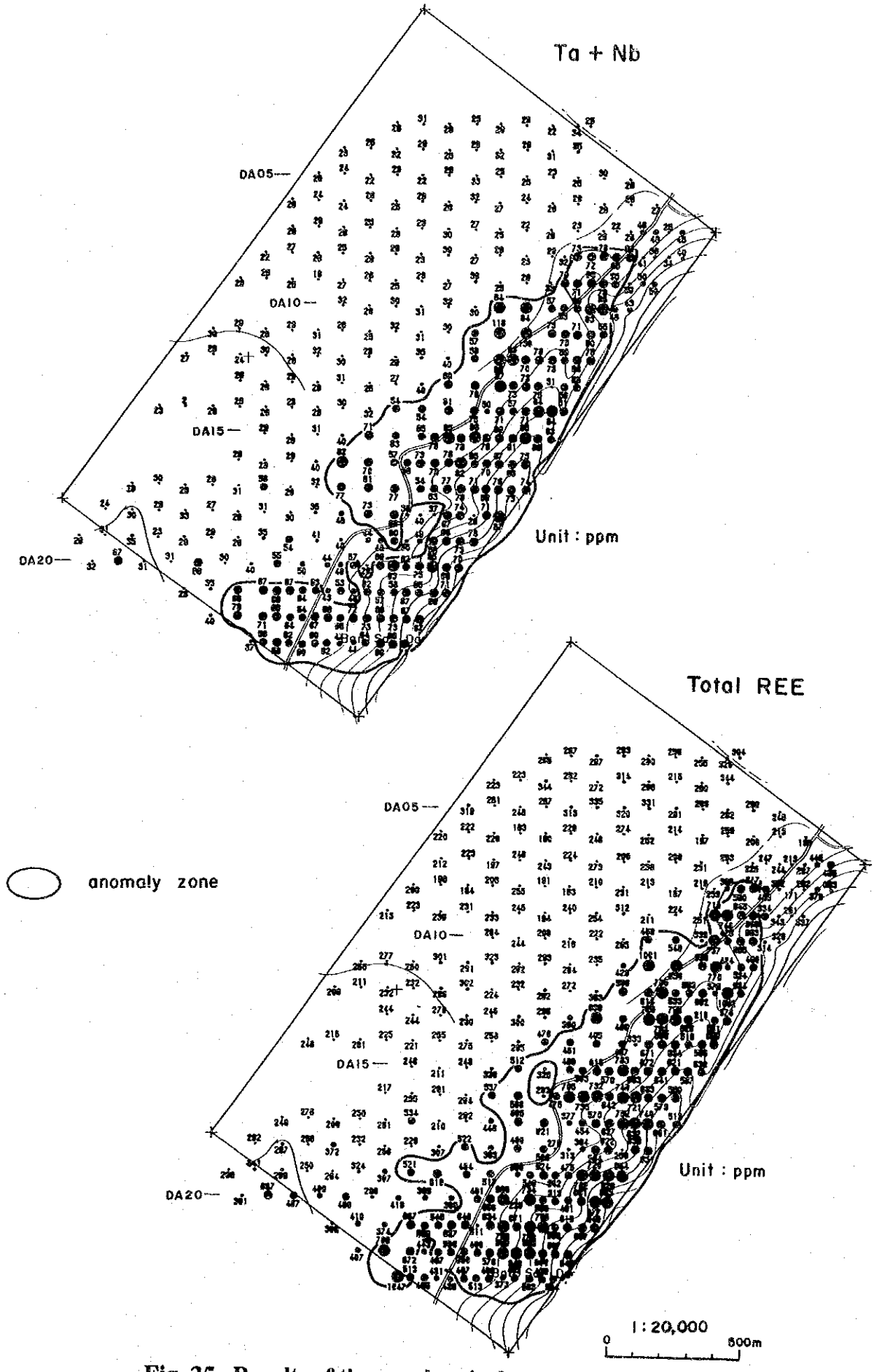


Fig. 35 Results of the geochemical survey of Area D-1 (2)

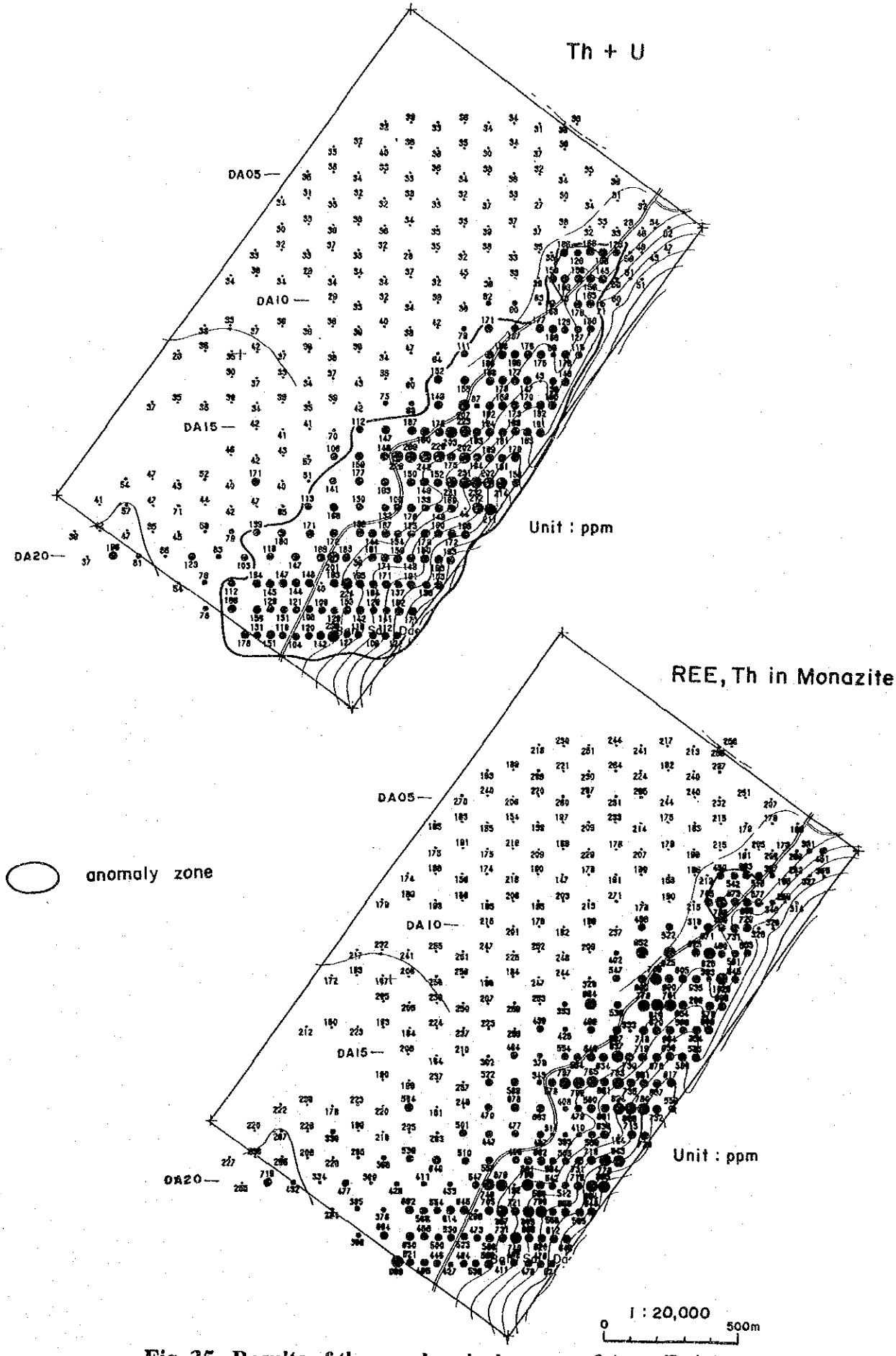


Fig. 35 Results of the geochemical survey of Area D-1 (3)

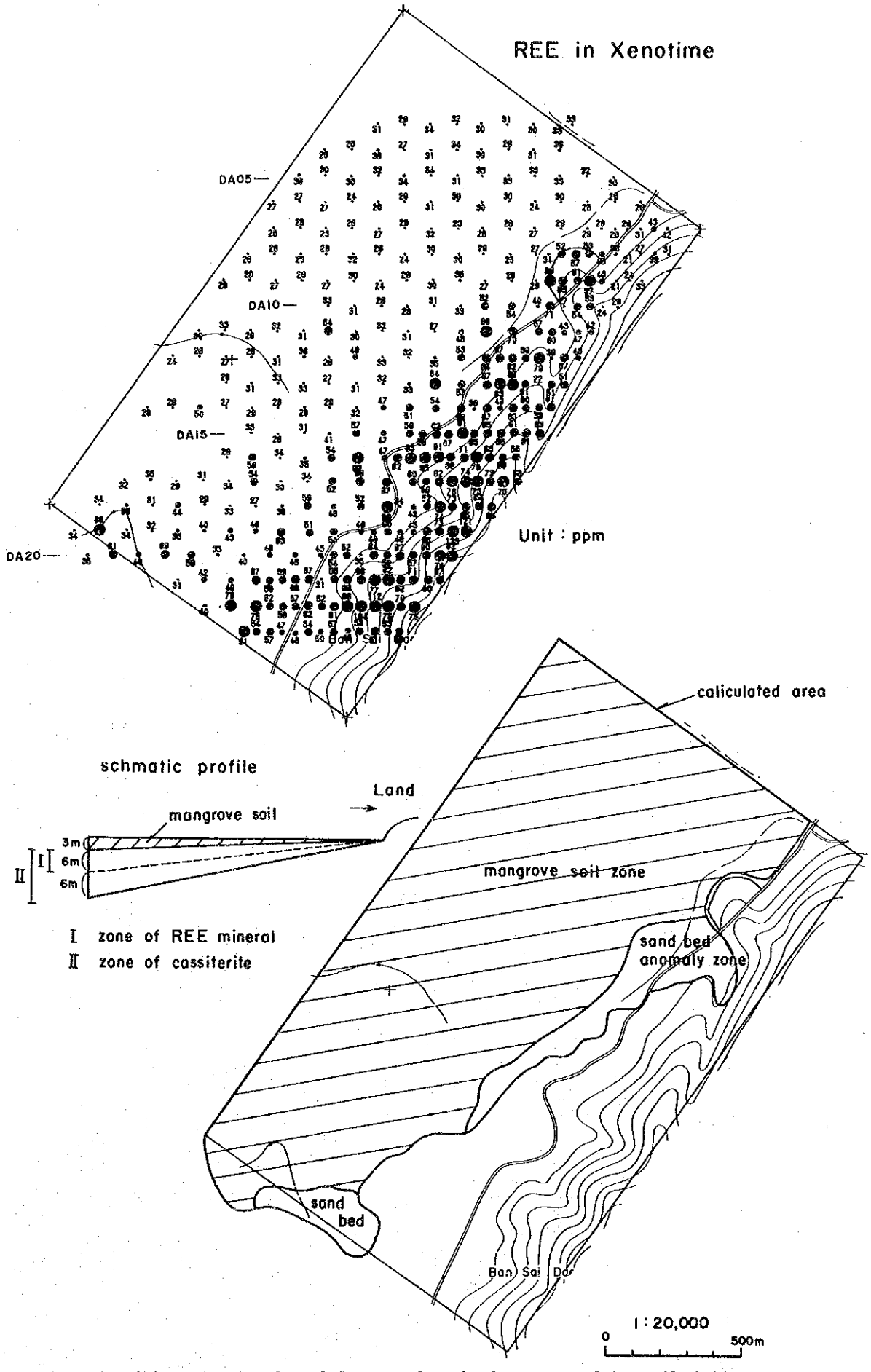


Fig. 35 Results of the geochemical survey of Area D-1 (4)

almost overlap each other. But only few high anomaly values are found in the silicified zone contrary to the Sn values and only lower anomaly values are distributed in an argillized granite; thereby the content of these elements in the silicified or argillized rock tends to be lower than that of the center of granite mass. High anomaly values are distributed in slopes and foot of the mountains rather than ridge. Other anomaly zone overlaps with the area around the DA10-DA17 lines, where the sand bed exposes on the gentle slope between the mountains and alluvial flatland and a mangrove mud is absent. Some of the anomaly values are higher than those in the granite area; thereby it is inferred that these elements concentrate in the alluvium. Samples with a high Th-U content are distributed near the DA15-DA17 lines in the center of the survey area, and their distribution is different a little from that of Total REE and Ta-Nb.

8-4-2 Heavy mineral samples

Six samples of heavy minerals were collected from a sand bed. The amount of monazite is remarkably large, and the amount of heavy minerals follows that in Area A-2. The contents of rare earth elements, thorium and uranium are the highest among all the survey areas, but the content of tin is the lowest.

The distribution of tin content is contrary to that of rare earth elements content. The content of rare earth elements tends to increase southward, whereas that of tin tends to decrease.

8-5 Discussion

Most geochemical anomaly values fall in with the distribution of granite. These anomaly values are almost homogeneous except for thorium and uranium having especially high anomaly values.

In the silicified zone, tin anomaly values are slightly higher than those of the other portion of the granite, whereas the anomaly values of other elements groups show lower, almost a half of the average values.

In the argillized granite, all the elements groups show lower values than those in un-altered granite; thereby there is little possibility of the adsorption-type rare earth deposit.

Topographically, the content of pathfinder elements in a slope and foot is slightly higher than those in a ridge. Some samples in the sand bed area with a lack of mangrove soil show higher content values than the samples in the mountains. These facts indicate that heavy minerals have been transported toward a mangrove zone and accumulated there, resulting of the erosion of the granite.

In the mangrove area, tin anomalies are sporadically found. Some anomaly values of the elements groups except tin are recognized in the area covered by a mangrove mud, though anomaly values of those groups are mostly distributed in the sand bed area between mountains and the mangrove area. These anomaly samples in the mangrove area were collected from the deeper part, e.g., the bottom of a creek; thereby there is a large possibility that a placer deposit exists below a mangrove mud.

The reserve was calculated in Area D-1. The total thickness of an alluvial basin was determined to be 15 meters by assuming the incline of the base of an alluvial basin 1° and the total extension of an alluvial basin 850 meters from the border between a land and the mangrove zone. The reserve excludes a very fine-grained mangrove mud of the uppermost of an alluvium, assumed ranging up to 3 meters thick from surface to downward in the western edge of Area D-1. It is assumed that the upper portion of the sand bed contains rare earth minerals and the content of REE is a mean value of soil samples, and the lower

portion contains only cassiterite and the content is 111 ppm obtained from the bottom of a creek (Fig.34 (4)).

The reserve of rare earth ore is estimated at 7.5 million m^3 (at a monazite content of 1.480kg/m^3 and a xenotime content of 0.167kg/m^3) and that of tin ore at 14.55 million m^3 (at a cassiterite content of 0.222kg/m^3). This reserve is the largest in this program (Table 16).

Table 16 Reserves in Area D-1 and D-2

Area name	Mineral name	Areas (m^2)	Depth (m)	Reserves (m^3)	Ave. contents (ppm)	Ave. Oregrade (kg/m^3)	Reserves of minerals (t)
D-1	monazite	2,350,000	3 - 9	7,500,000	576	1.480	11,100
	xenotime				57	0.167	1,252
	cassiterite		3 -15	14,550,000	111	0.222	3,230
Area name	Mineral name	Areas (m^2)	Ave. Thick (m)	Reserves (m^3)	Ave. contents (ppm)	Ave. Oregrade (kg/m^3)	Reserves of minerals (t)
D-2	monazite	651,500	2.5	1,628,750	282	0.742	1208
	xenotime				40	0.117	190
	cassiterite				26	0.052	84

Chapter 9 Area D-2

9-1 Location

Area D-2 is about 35 kilometers south of Kra Buri Town, and the west of the Route 4. The area is south of Area D-1. It takes about 40 minutes to get there by car (Fig.36).

The area consists of a mangrove zone, which is an alluvial basin surrounded by hills. The rivers run west-southwestward in the center and at the foot of the northern hills. Much creeks form a network in a mangrove zone. This alluvial basin is topographically desirable to have a placer deposit because of its narrow exit.

The geochemical anomaly of Nb, REE, Th and Y from stream sediments and that of Ta, Nb, REE, Th, U and Y from soil samples were detected by the first year geochemical prospecting.

9-2 Survey method

Since the main target area is the mangrove zone, where the heavy minerals have been dispersed horizontally somewhat and their contents do not vary, the interval between sampling points are decided to be 100 meters and spacing between survey lines 100 meters. The number of collected soil samples is 91.

9-3 Geology

Area D-2 is underlain by Silurian-Devonian Kra Buri Formation of the Tanaosi Group, Cretaceous granite and the Quaternary (Fig.33).

Kra Buri Formation is surrounded by a granite, and consists mainly of strongly-weathered mudstone. The west contact of granite mass is metamorphosed to amphibolite.

Cretaceous granite consists of medium or coarse grained equigranular two-mica granite, and is foliation conspicuously. The rock is composed mainly of microcline, orthoclase, quartz, plagioclase, biotite and muscovite, with accessories zircon, apatite, sphene and ilmenite.

A mangrove mud covers widely in the mangrove zone and overlies the coarse sand bed. The area lacking a mangrove mud is on the west of the Route 4, ranging in width from 200 to 300 meters. The mangrove mud is only ranging from 1 to 2 meters thick even on the western edge of the survey area.

9-4 Result of geochemical prospecting

9-4-1 Soil samples

The range, mean value (M) and standard deviation (σ) for each element are listed in Table 17. Fig.37 shows the histograms and cumulative probability graphs of the five groups, namely Sn, W, Ta-Nb, Total REE, Th-U.

The four groups except W show clear bimodal distribution in Fig.37.

The thresholds of all the groups were determined to be Sn:30ppm (M+0.25σ), W:8ppm (M+0.75σ), Ta-Nb:35ppm (M+0.5σ), Total REE:309ppm (M+0.5σ) and Th-U:62ppm (M+0.5σ) respectively based on the histograms and cumulative probability graphs.

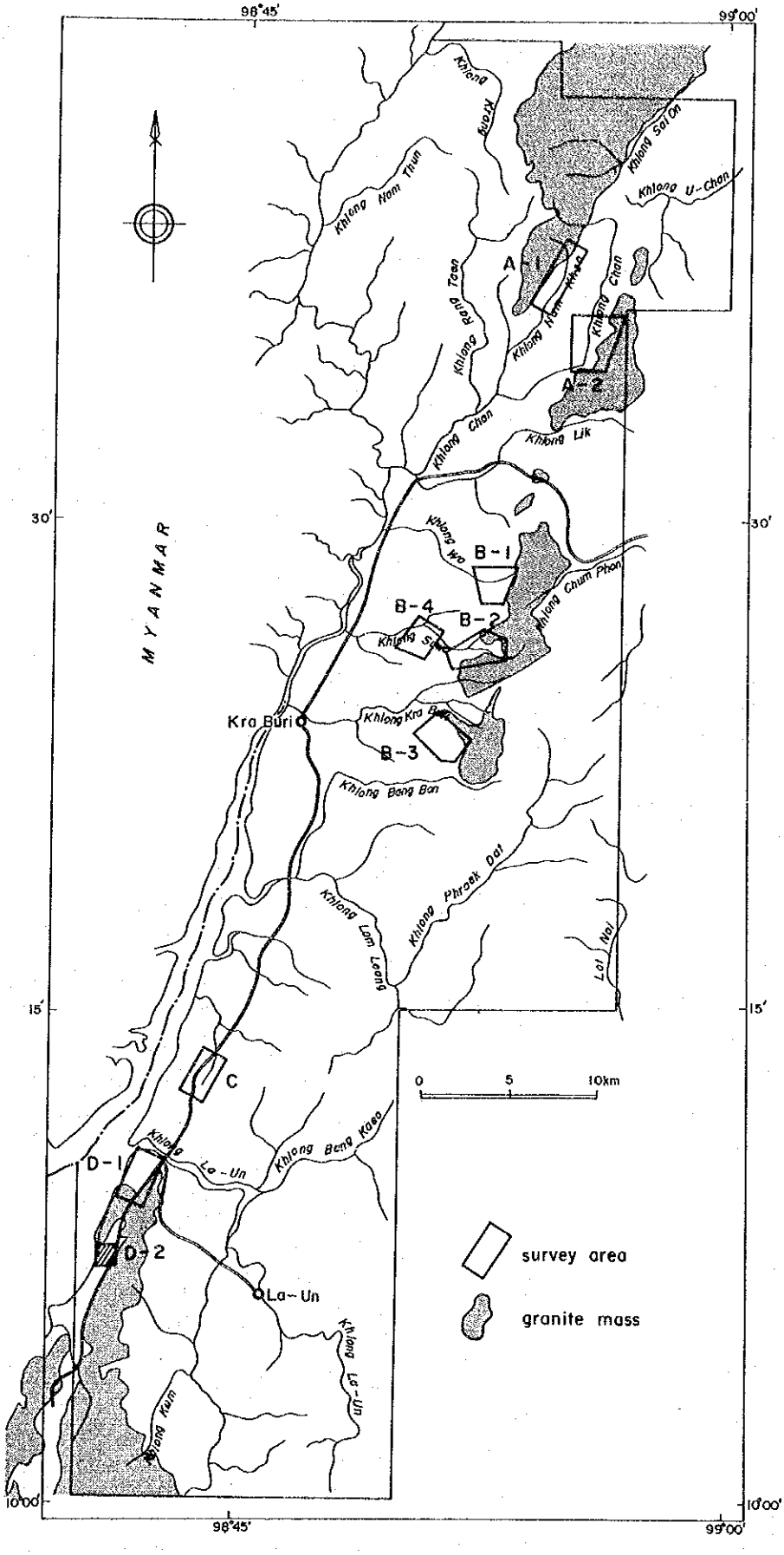


Fig. 36 Location map of Area D-2

Table 17 Geochemical basic statistic quantities of Area D-2

Element	Unit	Max.	Min.	Average	av.ant-log.	Std.Dev.
Sn	ppm	58.0	<5.0	1.350	22.4	0.251
W	ppm	40.0	<2.0	0.613	4.1	0.458
Ta	ppm	6.0	<1.0	0.362	2.3	0.357
Nb	ppm	76.0	21.0	1.564	36.7	0.103
Ce	ppm	410.0	49.0	2.062	115.3	0.177
Eu	ppm	2.0	<0.2	-0.123	0.8	0.196
La	ppm	240.0	29.0	1.780	60.3	0.160
Nd	ppm	180.0	15.0	1.599	39.7	0.181
Sm	ppm	26.0	2.8	0.824	6.7	0.157
Tb	ppm	2.2	<0.5	-0.004	1.0	0.184
Th	ppm	200.0	16.0	1.667	46.5	0.222
U	ppm	19.0	1.8	0.899	7.9	0.150
Y	ppm	61.0	10.0	1.541	34.8	0.146
Gd	ppm	24.9	2.0	0.857	7.2	0.164
Dy	ppm	15.3	2.6	0.855	7.2	0.132
Pr	ppm	25.0	<20.0	1.009	10.2	0.057
Yb	ppm	7.4	1.3	0.573	3.7	0.142
Lu	ppm	1.1	0.2	-0.250	0.6	0.157
Ta+Nb	ppm	81.0	21.0	1.595	39.4	0.106
T.REE	ppm	960.8	138.9	2.454	284.4	0.141
Th+U	ppm	209.7	19.6	1.742	55.3	0.200

The content distribution maps are shown in Fig.38 (1) to (2).

Most anomaly values of Sn and W are found in the south of the survey area, and no anomaly values are detected along valleys in the north.

The anomaly values of Ta-Nb are detected in the east of the survey area and near hills. No anomaly values are distributed in the area covered by mangrove mud from the central part to the western part of the survey area.

The anomaly values of Total REE and Th-U are detected in the northeast and the southwest of the alluvial basin and granite in the northwest of the survey area.

9-4-2 Heavy mineral samples

Eight samples of heavy minerals were collected from mainly the sand bed. The sand bed shows relatively high heavy minerals content. Several samples are rich in monazite.

The distribution of elements content is harmonious with the distribution of their content in soil samples.

9-5 Discussion

Soil samples in Area D-2 are not much variable in composition. A few high anomaly values are found in all the elements groups in and around the area lacking a mangrove mud, though the distributions of Sn and Ta-Nb anomaly are different from those of Total REE and Th-U anomaly. No anomalous values of all the elements are detected in the area covered a mangrove mud.

The reserve can be calculated in an alluvial basin, because there is a large possibility of the existence of a placer deposit below a mangrove mud. The average thickness of a placer deposit was assumed to be about 2.5 meters, which was the thickness from the surface of a mangrove mud to the bottom of a creek. The reserve was estimated at 1,600 thousand m^3 (Table 16).

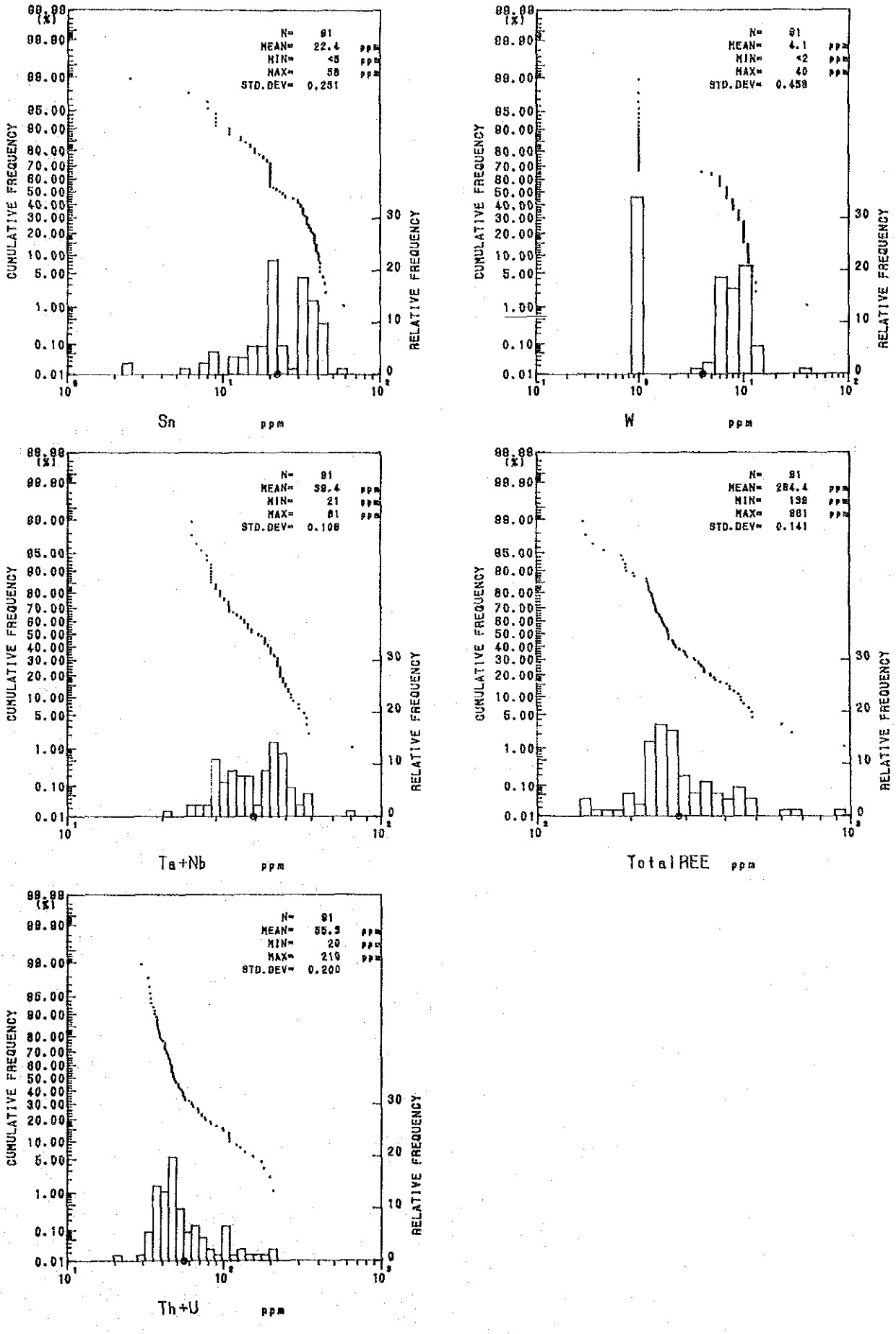


Fig. 37 Histograms and cumulative probability graphs of Area D-2

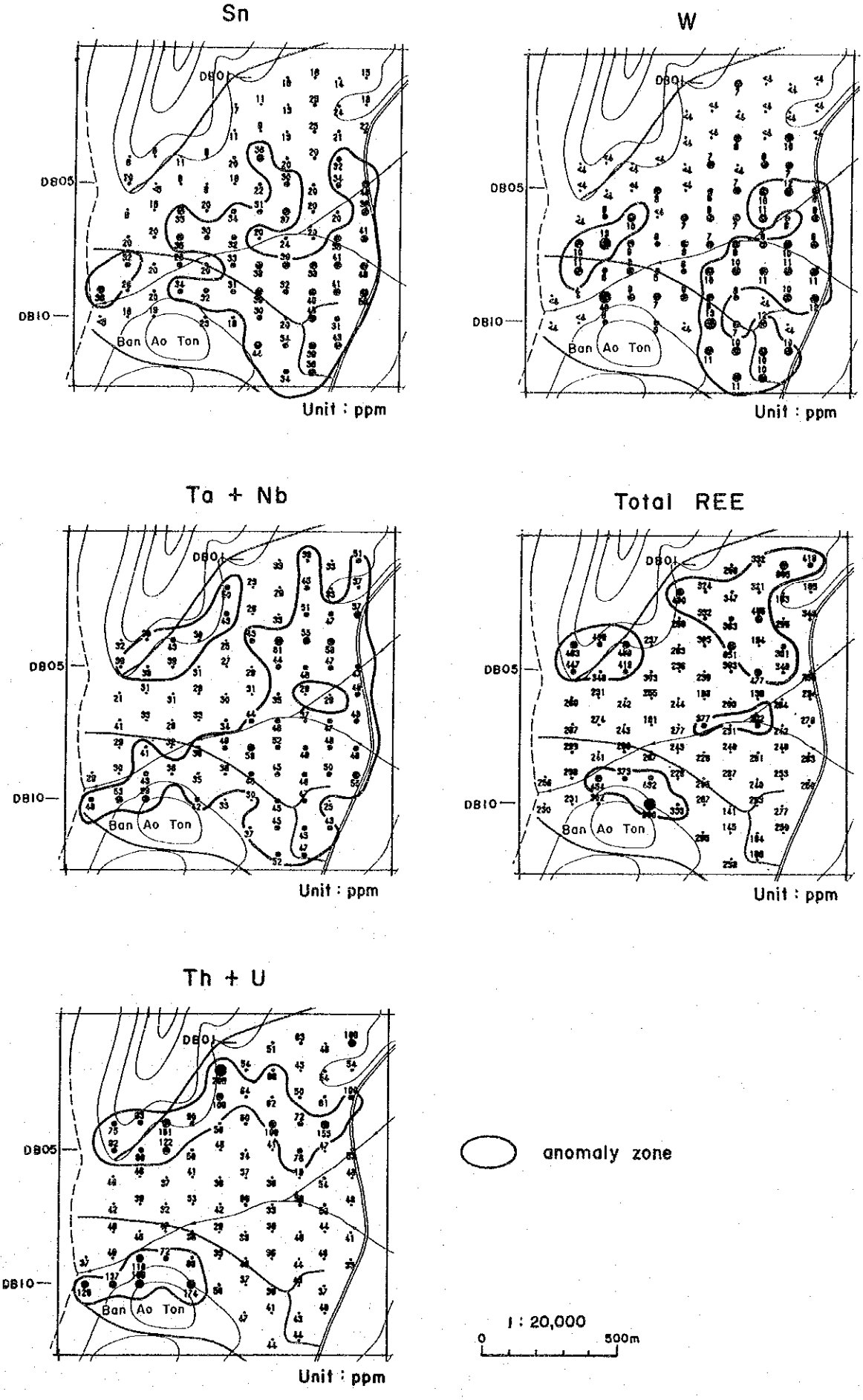
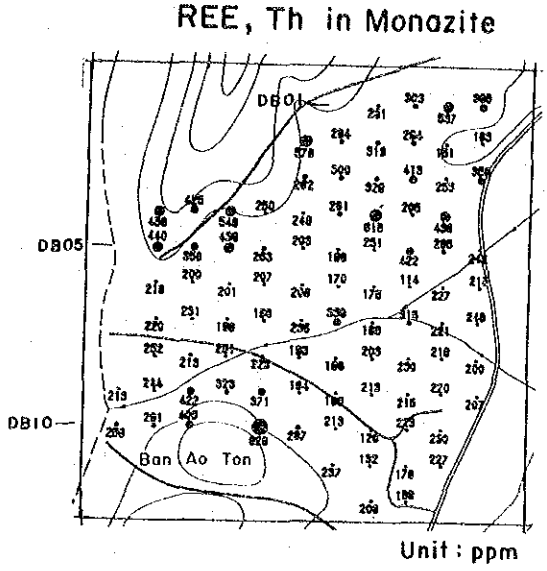
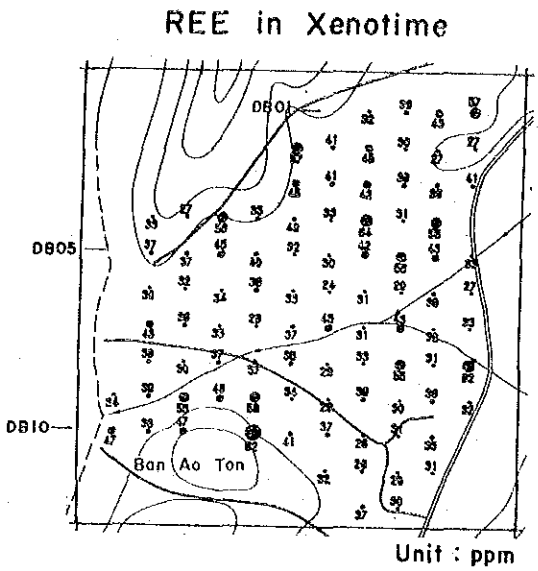
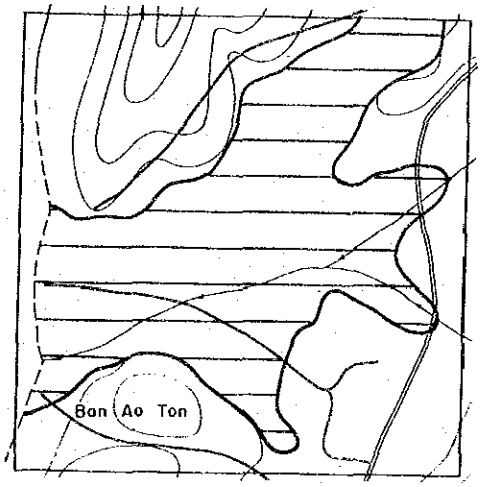


Fig. 38 Results of the geochemical survey of Area D-2 (1)







assumed basin of cassiterite and REE minerals

651,500 m²

1 : 20,000

0 500m

Fig. 38 Results of the geochemical survey of Area D-2 (2)

Chapter 10 Comprehensive Discussion

The potential for mineral deposits and the relationship between granite and mineral deposits in the Kra Buri Area are discussed here.

The first year program revealed that the geochemical anomalies of rare earth elements were detected in and around the granite masses, and old workings of placer tin deposits were close to the granite masses; thereby it suggests that these anomalies have a close association with a granite mass and heavy minerals, such as cassiterite, monazite and xenotime, have been transported from the granite masses to alluvium such as talus and fluvial sediments resulting of the weathering and erosion of the granite masses.

The purpose of the second year program is mainly to delineate the extension of alluvial basins containing placer deposits, also to evaluate the possibility of primary deposits and adsorption-type rare earth deposits; thereby in this program the detailed soil geochemical prospecting was conducted in this program in nine areas which were selected from the anomaly zones detected by the first year geochemical prospecting of stream sediments.

In Area A-2 and D-1, soil samples from the granite areas show high trace element content, which reflects high trace elements content of the granite masses. Trace element contents also vary with the granite facies.

In Area A-2, the argillized granite in the north and the south margin of the granite masses is rich in tin and tungsten and poor in rare earth elements, whereas a massive two-mica granite containing megacrystals of potassium feldspar is poor in tin and tungsten and rich in rare earth elements. Though the elements content of soil samples corresponds nearly with that of granites, soil samples from slopes and lowland along valleys show higher content; thereby the heavy minerals have been transported from the granite mass to lower places and concentrated there.

In Area D-2, the granite mass contains silicified part and argillized part as its marginal facies. Silicified granite is more tin and tungsten and less rare earth element. An argillized granite is less tin and less rare earth element than the massive two-mica granite.

The relationship between tin content and rare earth elements' content in each granite mass shows a negative correlation in Fig.39.

The relationship between the differentiation index (D.I.) and trace elements content, as shown in Fig.40, indicates that high differentiated facies are rich in tin while low differentiated facies rich in rare earth element. This suggests that the crystallization of cassiterite and rare earth minerals occurs in the different stages of differentiation; rare earth minerals such as monazite and xenotime crystallize in the early stages of differentiation, whereas cassiterite crystallizes at more differentiated granite such as muscovite granite, tourmaline granite, greisen, pegmatite vein and quartz vein. The reasons are as follows;

1) In Area A-2, soil samples in the argillized granite after muscovite granite are rich in Sn and W, whereas soil samples in the non-altered massive two-mica granite are rich in rare earth elements.

2) As shown in Area A-1, much tin is typically contained in fluvial and talus sediments consisting mainly of clay with gravel derived from quartz veins, whereas rare earth elements are contained in fluvial and talus sediments consisting of sand and gravel derived from the granite masses.

3) On the basis of the geochemical prospecting of stream sediment in the first year program, only tin and tungsten anomalies were detected in the hornfels area in the east of the central granite mass where quartz veins are observed in hornfels, whereas strong rare earth elements anomalies and weak tin anomalies were detected along valleys in the west of the central granite mass where granite crops out.

The schematic model of crystallization of cassiterite and rare earth minerals and the generation of placer deposits is shown in Fig.41. Each stage is explained as follows;

1) After granite melt intruded into sedimentary rocks, rare earth minerals crystallize at the main granite facies in the early stage of crystallization differentiation. Residual liquid moves to the upper margin of the granite mass, and it forms the differentiated granite facies such as muscovite granite, tourmaline granite and greisen. Also pegmatites and quartz veins are formed in wall rock. Tin and tungsten concentrate in residual liquid, then cassiterite and walframite and/or scheelite are crystallized when the differentiated facies are produced.

2) When the area starts to be uplifted, marginal facies such as pegmatites and greisen are eroded to produce sediments. Heavy minerals such as cassiterite are transported to an alluvial basin.

3) Further erosion causes the exposure of the main granite facies. Finally monazite and xenotime are transported to an alluvial basin.

The stage between second and third is applicable to the alluvial basin in the south of Area A-1. The third stage is applicable to the alluvial basin in the north of Area A-1. In the east of the central granite mass, tin and tungsten geochemical anomalies are inferred to be derived from quartz veins related with a concealed granite.

The reserves and grades of placer deposits are decided by heavy minerals content of sources, i.e., the tin and rare earth content of each granite mass though the scale and form of alluvial basins are also important.

Fig.30 shows that the southern mass and the northern west mass contain more tin and rare earth elements; thereby they are the sources of large placer deposits in Area A-1 and D-1. The northern east mass and the central mass tend to contain relatively less tin and rare earth elements.

The southern granite mass varies in composition. On the basis of the first year geochemical prospecting of stream sediments, strong tin anomalies and no rare earth elements anomalies were detected in the east, whereas weak tin anomalies and strong rare earth elements anomalies were detected in the northwest. Also strong tin and rare earth elements anomalies are found in the southwest. In harmony with these facts, the composition of granite has much tin and less rare earth element in the east, less tin and much rare earth element in the northwest. The intermediate composition between both of them shows in the southwest.

In the central mass, which is divided into three rock bodies, the southern rock body has a high tin content in comparison with the northern and middle rock bodies. A placer deposit and heavy mineral samples in Area B-3, adjoining the southern mass, show a high tin content in comparison with those of Area B-1 and B-2.

Fig.40 suggests that a granite containing tin at 25 ppm or above has a potential for placer tin deposits, and a granite containing rare earth elements at 300 ppm and above has a potential for placer rare earth deposit.

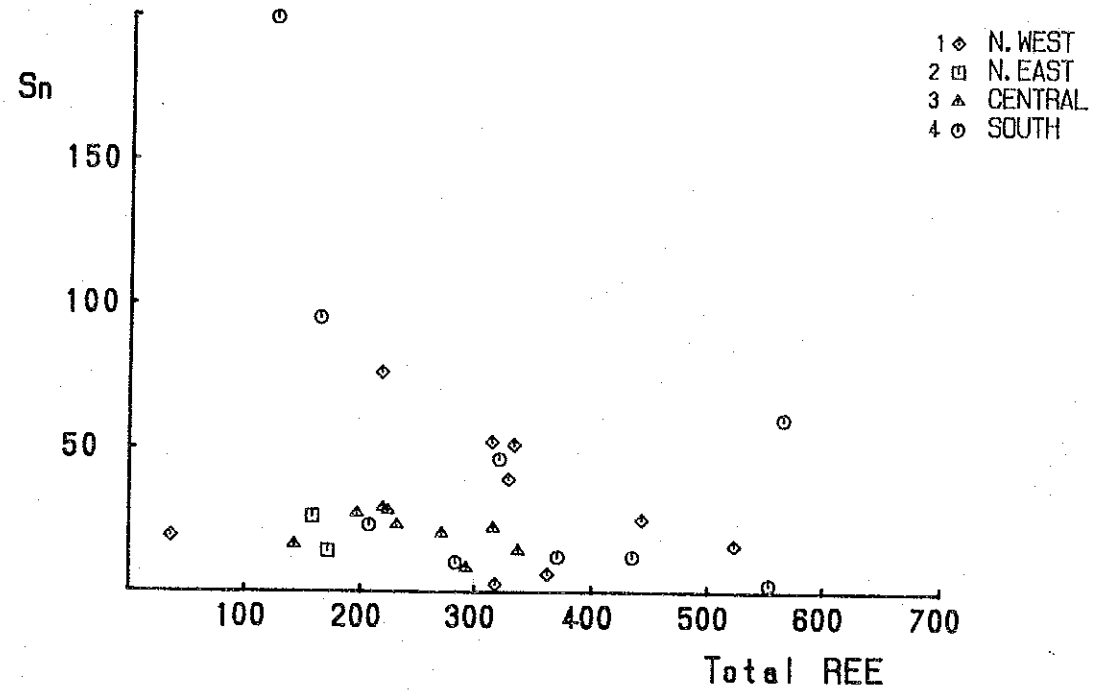


Fig. 39 Sn-Total REE diagram

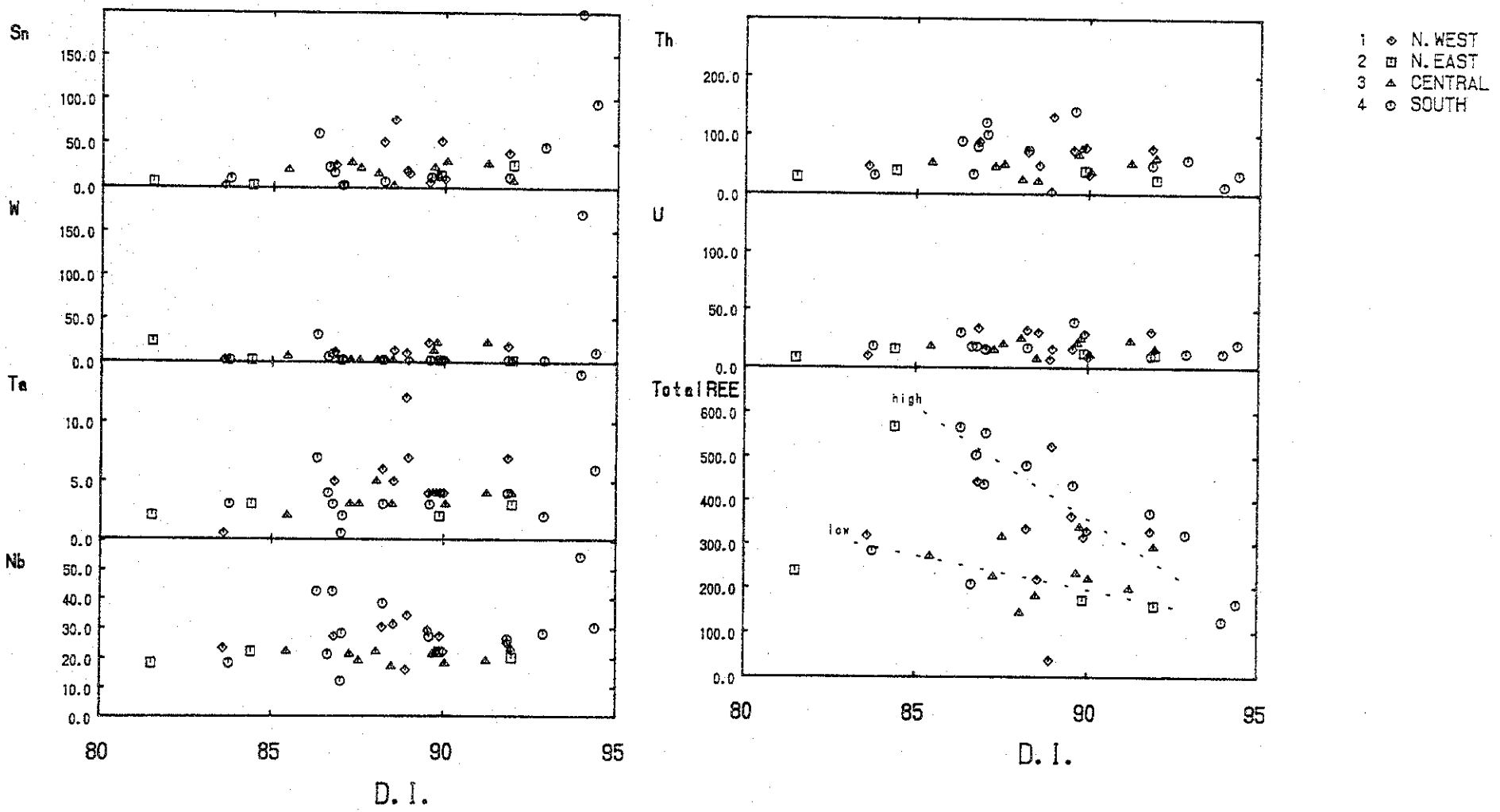
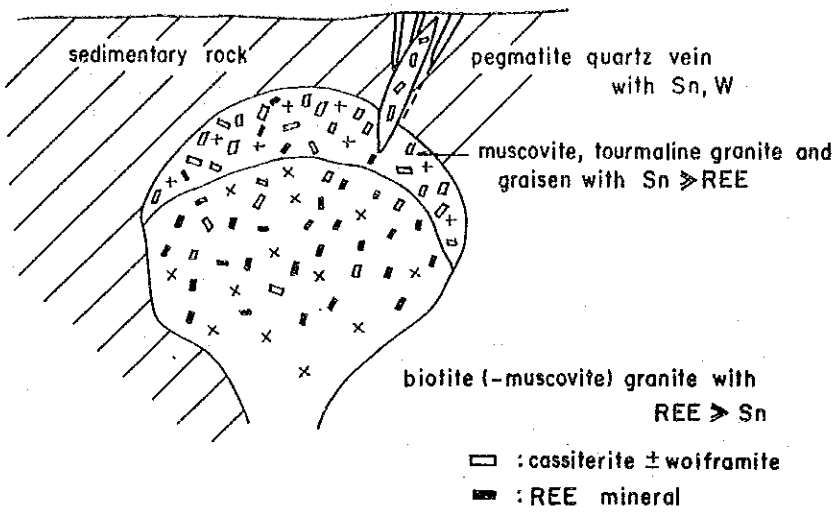
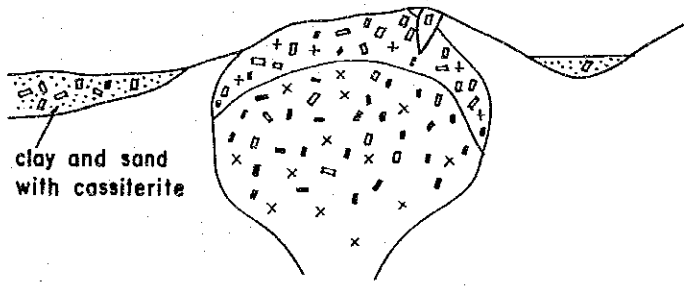


Fig. 40 Variation diagram of minor elements

1) Intrusion and differentiation of granite



2) Erosion of upper level



3) Erosion of deeper level

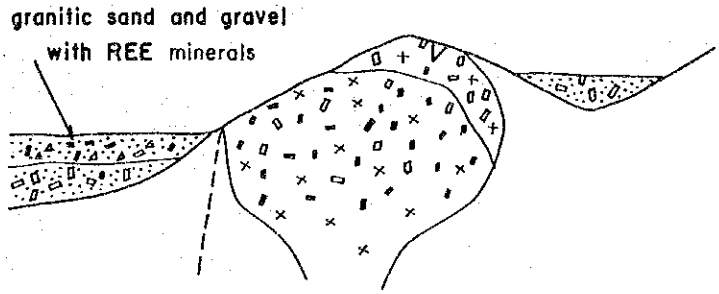


Fig. 41 Schematic cross-section relating mineralization of cassiterite and rare earth minerals

PART III CONCLUSION AND RECOMMENDATION

Chapter 1 Conclusion

The purpose of this program is mainly to delineate the extension of alluvial basins containing placer deposits, also to evaluate the possibility of primary deposits and adsorption-type rare earth deposits; thereby the detailed soil geochemical prospecting was conducted in this program for nine areas which were selected from the anomaly zones detected by the first year geochemical prospecting of stream sediments.

On the basis of the interpretation of geochemical data and geological evidence, it has been made clear that the pathfinder elements are separated into two groups, namely, tin group (Sn, W, Ta, Nb) and rare earth group (REE, Th, U). The geochemistry of these two groups shows the different geochemical characteristics in the granite masses. The anomaly areas of the tin group elements are found in the extremely high differentiated part that sits in the uppermost part of the granite masses, whereas those of the rare earth group in the low differentiated part under the uppermost part. It is inferred that the crystallization of rare earth minerals occurred at the earlier differentiation stage than that of tin and tungsten minerals.

The potential of tin deposits and rare earth deposits are evaluated as follows;

(1) In Area A-1, anomaly zones are distributed in four places such as the northern, central, southeastern and southwestern parts of this area. They overlap with the distribution of talus deposits and alluvial sediments. The reserves of cassiterite and rare earth minerals are estimated at 1.31 million m^3 (at a cassiterite content of 0.116kg/m^3) and 2.20 million m^3 (at a monazite content of 1.315kg/m^3 and a xenotime content of 0.236kg/m^3) respectively.

(2) In Area A-2, an adsorption-type rare earth deposit was expected to exist because of the distribution of argillized granite. Rare earth contents of non-argillized granite are higher than those of argillized facies; thereby this area has a very low potential of adsorption-type deposits. The geochemical anomalies indicate a small placer deposit reserving less than 300 thousand m^3.

(3) In Area B-1 to B-4, alluvial basins lie narrowly along rivers surrounded by mountains and hills. The reserves in area B-1 to B-4 are estimated at 60 to 300 thousand m^3 respectively. Ore grade is also low.

(4) In Area C, the geochemical anomaly of tin is caused by silicified rocks in the northwest. The anomaly of rare earth elements is found in the southeast. The reserves of cassiterite and rare earth minerals are estimated at more than 100 thousand m^3 and about 600 thousand m^3 respectively, but they are low grade.

(5) In Area D-1, mangrove mud covers widely in the west. Though markedly anomaly values are not found in a mangrove mud, some anomalies are detected from the samples of the edge of eastern mountains and the bottom of creeks in a mangrove area. It is inferred that the potential for placer deposits exists below a mangrove mud. The reserve of rare earth ore is estimated at 7.5 million m^3 (a monazite content of 1.480kg/m^3 and a xenotime content of 0.167kg/m^3) and that of tin ore at 14.55 million m^3 (at a cassiterite content of 0.222kg/m^3). These reserves are the largest in this program.

(6) In Area D-2, mangrove mud covers widely. It is also inferred that a placer deposit exists under mangrove mud in this area. The reserve is estimated to be 1.6 million m^3, but it is low grade.