Chapter 4 Drilling

4-1 Outline of Survey

1) In Phase I, the purpose of drilling was as followings;

   A) to confirm the downward extension of two known weakly oxidized outcrops,

   B) to explore underneath of thick Pinosuk Gravels,

   C) to clarify the characteristics of IP.SIP anomalies, (hole MJM-8),

   Total ten drill holes (3,460.20 m) were allocated for these purposes.

2) In Phase II, the purpose of drilling was to confirm the extension of mineralization (hole MJM-8) in the N-S direction.

   Total three drill holes (1,103.70 m) were allocated for the purpose.

3) In Phase III, the purpose of drilling was to clarify the extension of mineralization, (namely, the Bambangan creek mineralized zone) in the south direction. Total five drill holes (1,507.10 m) were allocated.

The location of each hole is shown in Map II-6 and summary of result is listed in Table II-1.

4-2 Result of Survey

The geology and mineralization of each hole is as follows;

1. MJM-1 (340°, -50°, 350.30 m)

The hole was designed to confirm the continuation of mineralization towards depths. The mineralization of disseminated copper oxide minerals is distributed in sheared zone along the boundary between adamellite porphyry and serpentinite on the middle of the cliff along the Bambangan creek.

Geology of the hole is as follows;

From the surface to 40.8 m is hornfels and serpentinite, then garnet microdiorite to 263.3 m, which is suffered strong weathering, then turbidite layers of the Trusmadi Formation to the bottom of the hole. The turbidite consists of subangular to rounded pebble size siltstone and mudstone with the same matrix.

The alterations are rather weak. Carbonization, silicification and chloritization are common in garnet microdiorite. Prtially magnetic dots can be detected but pyrites are rare.

The argillization is more abundant than carbonization in turbidite.

Very rare fine pyrites in lenticular shape occurred at the depth of 298.9 m.

2. MJM-2 (70°, -50°, 351.00 m)

This hole was designed to check the downward extension of the mineralized zone of copper oxide which is located 700m north-northewest from MJM-1 on the western bank of upper stream of Bambangan creek.

The geology of the hole is as follows;

From surface to 69.04 m is biotite-hornfels then adamellite porphyry and from 93.20 m to 112.70 m is hornfels and then serpentinized peridotite to the bottom of the hole.

The alterations consist of silicification, carbonatization, serpentinization, biotitization, talc, chloritization etc. and pyritization is commonly observed in the peridotite.

The mineralization is pyrite-chalcopyrite dissemination (69.50-70.00m) in adamellite porphyry and weak pyrite dissemination in peridotite, having very rare chalcopyrite and molybdenite.

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
69.50 m - 70.00 m	(0.50 m)	0.12	1,820	4
142.80 m - 146.80 m	(4.00 m)	0.16	300	4
198.20 m - 209.20 m	(11.00 m)	0.10	140	35
212.50 m - 214.00 m	(1.50 m)	0.07	800	12
226.10 m - 233.60 m	(7.50 m)	0.23	170	13
299.80 m - 301.80 m	(4.00 m)	0.18	890	5
309.90 m - 313.00 m	(3.10 m)	0.09	520	3
322.20 m - 326.70 m	(4.50 m)	0.19	1,690	10

3. MJM-3 (20°, -50°, 300.50 m)

The purpose of MJM-3 was the same as MJM-1. It was drilled at the same site.

The geology of the hole is exactly the same as the geology in MJM-1 as follows;

From the surface to 31.6 m is in serpentinite zone , then encountering garnet-microdiorite and then the turbidite layers from 230.73 m to the bottom of the hole.

The alteration and mineralization is similar as those of MJM-1.

4. MJM-4 (30°, -50°, 351.00 m)

The adamellite porphyry has copper oxide mineralization in the exposure along west bank of Bambangan creek, however, it is very weak mineralized zone in the drill hole

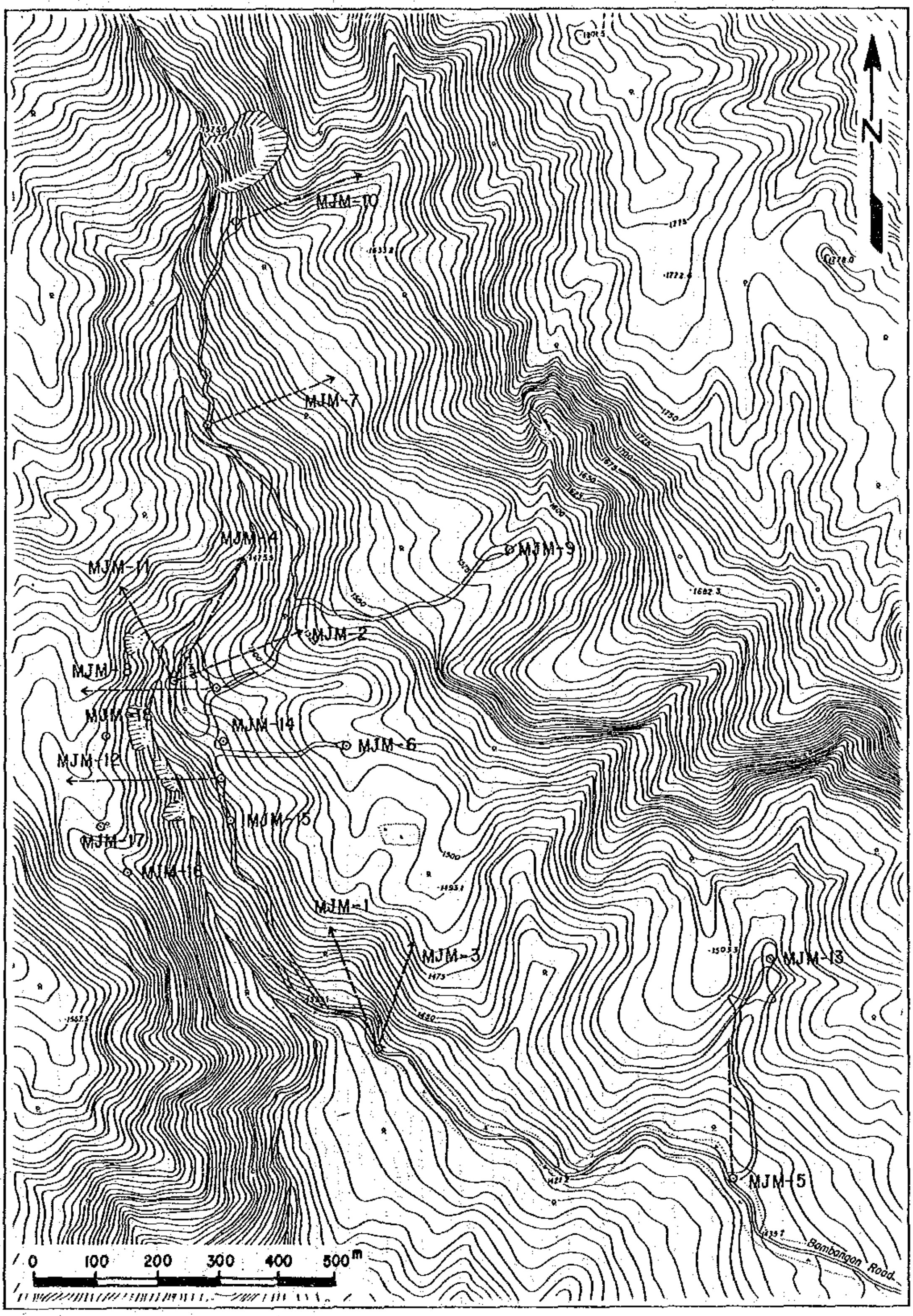


Fig. II-6 Location Map of Drill Holes

Table II-1 Summary of Results of Drilling Survey

Year	No. of Hole	Purpose	Drilling Period	Azimuth	Inclination	Length(m)	Core Length(m)	Core Recovery(%)	Mineralization
Phase I 1985	MJM-1	Downward Extension of Known Outcrop	Nov. 3, '85 ~ Dec. 7, '85	340°	-50°	350.30	319.30	97	No Mineralizations
	MJM-2	〃	Dec. 26, '85 ~ Jan. 23, '86	70°	-50°	351.00	331.40	99	Confirmation of Mineralized Zone (Cu 0.01% ~ 0.17%) in peridotite
	MJM-3	〃	Jan. 3, '86 ~ Jan. 22, '86	20°	-50°	300.50	277.70	99	No Mineralizations
	MJM-4	〃	Feb. 17, '86 ~ March 21, '86	30°	-50°	351.00	302.40	91	Confirmation of Mineralized Zone (Cu 0.04 ~ 0.07%) in peridotite
	MJM-5	Source of Origin of Known Geochemical Anomaly	Feb. 7, '86 ~ March 11, '86	0°	-50°	350.60	331.40	97	Local Pyrite Disseminations
	MJM-6	Mineralized Zone may be occurred underlying Pinosuk Gravels	March 25, '86 ~ April 9, '86	-	-90°	302.60	256.20	89	No Mineralizations
	MJM-7	〃	April 22, '86 ~ June 24, '86	70°	-50°	350.20	223.10	72	〃
	MJM-8	Confirmation of IP Anomaly (Bambangan Mineralized Zone)	July 12, '86 ~ July 26, '86	270°	-50°	351.00	291.60	88	Confirmation of Bambangan Mineralized Zone (Length of drilling 110m Cu 0.44%)
	MJM-9	Mineralized Zone may be occurred under Pinosuk Gravels	May 16, '86 ~ June 13, '86	-	-90°	401.10	307.50	79	Local Mineralized Zone (Cu 0.04% ~ 0.14%) in peridotite and hornfels
	MJM-10	〃	June 30, '86 ~ July 27, '86	70°	-50°	351.90	315.70	91	No Mineralizations
		Sub Total				3,460.20	2,956.30	89	
Phase II 1986	MJM-11	Northern Extension of Bambangan Mineralized Zone	Nov. 15, '86 ~ Dec. 1, '86	30°	-60°	351.00	313.00	93	Confirmation of Northern Extension of Bambangan Mineralized Zone (Cu 0.03 ~ 0.17%)
	MJM-12	Southern Extension of Bambangan Mineralized Zone	Oct. 1, '86 ~ Oct. 29, '86	270°	-50°	402.20	309.70	80	Confirmation of Southern Extension of Bambangan Mineralized Zone (Cu 51.3m Cu 0.34%)
	MJM-13	Mineralized Zone (Pyrite) may be occurred under Pinosuk Gravels	Oct. 23, '86 ~ Dec. 10, '86	-	-90°	350.50	278.10	83	No Mineralization
		Sub Total				1,103.70	900.80	85	
Phase III 1987	MJM-14	Southern Extension of Bambangan Mineralized zone	July 17, '87 ~ July 31, '87	-	-90°	301.00	220.20	75	Confirmation of Southern Extension of Bambangan Mineralized Zone (134m Cu 0.07%)
	MJM-15	〃	July 21, '87 ~ Aug. 8, '87	-	-90°	360.60	260.00	89	〃 (95m Cu 0.07%)
	MJM-16	〃	Sept. 11, '87 ~ Sept. 26, '87	-	-90°	304.00	252.30	85	〃 (53m Cu 0.03%)
	MJM-17	〃	Aug. 13, '87 ~ Aug. 25, '87	-	-90°	301.00	218.90	78	〃 (98m Cu 0.02%)
	MJM-18	〃	Aug. 11, '87 ~ Sept. 4, '87	-	-90°	300.50	226.30	79	〃 (96m Cu 0.06%)
		Sub Total				1,507.10	1,177.70	82	
Ground Total						6,071.00	5,034.80	83	

MJM-2.

So this hole was designed to confirm the mineralizion between above-mentioned exposure and hole MJM-2.

Geology of the hole is similar to that of MJM-2, as biotite-hornfels from surface to 121.20 m, then serpentinized peridotite to the bottom of the hole. No adamellite porphyry was encountered.

The alterations are as follows;

Weak silification is observed throughout of the hole, carbonization in some part, and remarkable serpentinization, talc, biotitization and chloritization, in peridotite. Weak pyritization is found in some part. Weak copper-molybdenum mineralization is also locally accompanied.

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
161.10 m - 162.60 m	(1.50 m)	0.21	690	116
163.30 m - 173.10 m	(9.80 m)	0.20	430	69
205.90 m - 222.90 m	(17.00 m)	0.06	620	120
322.70 m - 325.70 m	(3.00 m)	0.09	3,640	63

5. MJM-5 (0°, -50°, 331.40 m)

This hole was drilled in order to check the source of geochemical copper aromalies in soil which were detected by the OMRD, Sabah, BDH.

The Hole is occupied from the surface to the bottom by turbidute of the Trusmadi Formation.

The size of gravels is from those of more than one meter to less than few centimetres of sandstone and mudstone whose shapes are angular or subangular, while a matrix shows black-gray color and muddy-clayed compact facies.

Weak silicification, calcitization and argillization are common together with intermittent weak pyritization throughout of the hole.

Considerably strong pyrite disseminations give the following values without chalcopyrite.

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
21.50 m - 35.50 m	(14.00 m)	0.03	50	4
157.40 m - 179.00 m	(21.60 m)	0.02	50	3
335.809 m - 350.60 m	(14.80 m)	0.01	40	5

6. MJM-6 (-90°, 302.00 m)

The hole was designed to confirm the existence of minearalization under the Pinosuk Gravels.

The hole is of the Pinosuk Gravels from the surface to the depth of 161.30 m, and peridotite downwards.

The Pinosuk Gravels consist of angular - subangular gravels with one metre to less than thirty centimetres in size and accompanying sandy matrix.

The gravels are composed of various sedimentary rocks, igneous rocks and metamorphosed rocks, which are originally delivered from the surrounding area.

It can be divided into two layers, a loose layer (loose Pinosuk Gravels) which is distributed from surface to the depth of 60.80 m, being partially strongy weathered, and a solid and hard layer (solid Pinosuk Gravels) distributing to the bottom of the hole. However, any differences in the rock facies such as the kind of gravels and matrix can not be distinguished.

In the gravels, pyrite and chalcopyrite disemminations are found in places.

In the peridotite underneath the Pinosuk Gravels alterations such as sepentinization, silicification, carbonatization, talc, chloritization are commonly observed. Pyrite dissemination is also seen locally.

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
172.40 m - 177.40 m	(5.00 m)	0.00	210	9
227.40 m - 231.90 m	(4.50 m)	0.05	710	8

7. MJM-7 (709°, -50°, 350.20 m)

The purpose of hole was the same as that of MJM-6.

The geology was peridotite until 12.20 m from the surface and after a shear zone adamellite porphyry until 40.00 m, then gray-dark gray colored, compact hornfels throughout the hole.

Adamellite porphyry at the depth of 59.50 m with its width of 2.80 m and microdiorite at the depth of 233.10 m with its width of 11.47 m were encountered.

The alteration such as silicification, carbonatization and weak pyritization were observed throughout the hole.

The mineralizations in hornfels at the depth of 93.60 m and in biotite microdiorite which was mentioned above were observed as the strong dissemination of pyrite with very low grade of copper.

The result of the referenced analysis is as follows;

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
93.60 m - 96.80 m	(3.20 m)	0.0	250	3
233.10 m - 244.60 m	(11.50 m)	0.0	260	4

8. MJM-8 (270°, -50°, 351.00 m)

The hole was to confirm the characteristics of anomalies obtained by IP·SIP survey in Phase I.

The geology was, through the loose Pinosuk Gravels until the depth of 107.80 m, adamellite porphyry, then peridotite from 293.00 m to the bottom of the hole.

The upper part of the adamellite porphyry shows strong oxidation and bleaching with shearing and a little strong silicification. From depth of 180.00 m in the adamellite porphyry, silicification and pyritization develop, and after this zone the alteration becomes rather weak.

From the depth of around 207.30 m where a fault fractured zone was passed, a strong pyritized zone accompanying chalcopyrite dissemination was intersected.

The zone between the depth of 240.00 m and 260.90 m is strongly silicified and the mineralization of chalcopyrite dissemination and network are observed, showing the clear nature of a porphyry copper type. After this zone, the hole entered into the weakly mineralized zone with a small scaled zone of better copper grade.

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
107.80 m - 180.00 m	(72.20 m)	1.0	1,200	7.34
180.00 m - 291.10 m	(111.10 m)	0.2	4,400	59.3
291.10 m - 294.30 m	(3.20 m)	0.3	1,300	133.0

9. MJM-9 (-90°, 401.00 m)

The hole was designed the same purpose as MJM-7.

The geology was, after passing the thick Pinosuk Gravels until 270.70 m, peridotite, then through the sheared zone between 329.40 m and 335.10 m, the reddish brown-gray colored hornfels was encountered until the bottom of the hole.

The thickness of the Pinosuk Gravels occurring in this hole reaches more than 400 m if adding the exposed layers in the eastern steep cliff.

The Pinosuk Gravels as described in the clause of MJM-6 can be divided into two layers such as the loose Pinosuk Gravels until 48.30 m and then the solid Pinosuk Gravels.

The gravels and a matrix show the same rock facies as those in the other hole.

Serpentinization is commonly observed in peridotite. The hornfels portions are silicified between the depth of 383.90 m and the bottom of the hole.

The referenced chemical analyses were made for the mineralized zone bearing minor amount of chalcopyrite disseminations, as shown below;

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
291.90 m - 296.00 m	(4.10 m)	0.62	1,440	68
326.30 m - 327.80 m	(1.50 m)	0.52	940	7
335.10 m - 348.90 m	(13.80 m)	0.10	1,420	39
380.30 m - 395.80 m	(15.50 m)	0.04	670	9

10. MJM-10 (70°, -50°, 351.90 m)

The purpose of hole was the same as that of MJM-7.

The geology was the Pinosuk Gravels until 243.80 m and peridotite to the depth of 330.90 m, then entered into spilite and hornfels until the bottom.

The alterations of serpentinization, silicification, carbonatization and chloritization are observed in peridotite, however, their intensities are rather weak. Magnetite mineral is also detected throughout the hole.

The spilite and hornfels occur repeatedly in the bottom part of the hole after peridotite, with the alteration of silicification, chloritization and epidotization in part. The pyritization is very weak and local. No pyritization occurs in peridotite.

11. MJM-11 (30°, -60°, 351.00 m)

The purpose of hole was to confirm the extension of mineralization in north direction. The geology in the hole is as follow;

Surface -	20.10	loose Pinosuk Gravels
-	96.10	hornfels, generally oxidized with gossan
-	139.50	adamellite porphyry, generally oxidized with gossan
-	143.00	hornfels
-	146.00	adamellite porphyry dike
-	152.50	hornfels accompanied with weak to moderate oxidation
-	135.00	peridotite, partly serpentinized and fractured

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
42.60 m - 49.00 m	(6.40 m)	0.13	530	1.5
64.30 m - 75.70 m	(11.40 m)	0.09	340	2.6
88.20 m - 96.10 m	(7.90 m)	0.06	390	3.1
102.50 m - 113.90 m	(11.40 m)	0.13	630	5.2
122.50 m - 127.00 m	(4.50 m)	0.15	1,700	21.8
130.50 m - 132.00 m	(1.50 m)	0.15	520	18.0
138.50 m - 156.20 m	(17.70 m)	0.41	890	32.2

12. MJM-12 (270°, -50°, 402.20 m)

The purpose of hole was to confirm the extension of mineralization in south direction. Geology in the hole is as follows;

Surface -	136.20 m	Pinosuk Gravels, highly oxidized.
		hornfels, intruded by five dikes of
-	348.30 m	adamellite porphyry, 0.15 m to 2.10 m wide.
-	402.20 m	Fault fracture zone.

The fracture zone encountered at the bottom is considered to extend further below, possibly to more than 60 m wide.

In hornfels, 136.20 m below the surface immediately after the Pinosuk Gravels, there is an oxidized copper mineralized zone with gossan, where abundant fine crystals of native copper are scattered in the cracks, and streaks or veinlets, and other copper oxide minerals (mainly cuprite accompanied by tenorite and a small quantity of malachite) and secondary sulphide copper ores (mainly bornite accompanied with small quantities of chalcocite and covellite) are observed, with rarely recognizable fine grained chalcopyrite. These oxidized copper mineralized zone continues to the depth of 187.50 m, and after this point changes to the primary mineralized zone mainly consisting of chalcopyrite and pyrite, which becomes poor and disappears below 217.90 m

Zone	Depth	(Length)	Au g/t	Cu ppm	Mo ppm
Oxidized zone	136.20 m - 187.50 m	(51.30 m)	0.21	3,470	36
Primary zone	187.50 m - 217.90 m	(30.40 m)	0.06	1,660	29

13. MJM-13 (-90°, 350.00 m)

The purpose was to clarify the confinuation of pyrite impregnated zone in north side which was intersected by MJM-5.

Geology in the hole is as follows;

Surface - 94.20 m	Pinosuk Gravels
- 146.50 m	peridotite, serpentinized
- 202.75 m	garnet bearing microdiorite
- bottom	turbidite

A fault zone with 9.20 m width is found at the bottom of peridotite, and a fracture zone is also recognized in microdiorite at the depth of 188 m to 197 m (9 m in width). No copper mineralization was found in the hole.

The purpose of the following each hole, from MJM-14 MJM-18, is stated in the clause 3) of 4-1. Outline of Survey, in the same chapter.

14. MJM-14 (-90°, 301.00 m)

The geology of the hole is as follows;

9.00 - 77.10 m	Pinosuk Gravel
77.10 - 111.70 m	adamellite porphyry
111.70 - bottom	hornfels
(135.10 - 136.50 m	adamellite porphyry dike)

Fine native copper occurs in adamellite porphyry and in hornfels, and is restricted to the depth of 167.20 m in places, accompanied by disseminations and veinlets of pyrite, chalcopyrite and molybdenite in places. Dissemination of pyrite and chalcopyrite and/or veinlets of pyrite-chalcopyrite-quartz appears from the depth of 167.20 m. Mineralization is confined to adamellite porphyry and the hornfels.

The result of chemical analysis is as follows;

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
77.10 m - 111.70 m	(34.70 m)	0.07	1,448	16.7
(34.6 m, in adamellite porphyry)				
incl. 77.10 m - 98.10 m	(21.0 m)	0.08	1,724	4.0
(21.0 m oxide zone)				
111.70 m - 191.50 m	(79.80 m)	0.06	452	37.0
(79.8 m, in hornfels)				

15. MJM-15 (-90°, 300.60 m)

The geology of the hole is as follows;

10.90 - 114.40 m	Pinosuk Gravels
111.40 - 141.70 m	turbidite
141.70 - 213.50 m	adamellite porphyry
213.50 - bottom	peridotite

Prominent pyrite-chalcopyrite disseminations distributed in adamellite porphyry and hornfels, more intense in the former than the latter, and accompanying fine molybdenite crystals. Mineralization becomes very weak in peridotite, however, when compared with MJM-14 hole, it shows less copper mineralizations contrary to those of gold and molybdenum.

The result of chemical analysis is as follow:

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
141.70 m - 213.50 m (71.8 m, in hornfels and adamellite porphyry)	(71.80 m)	0.90	1,170	43.1
213.50 m - 223.50 m (10.0 m, in peridotite)	(10.00 m)	0.20	721	24.2

16. MJM-16 (-90°, 304.00 m)

The geology of the hole is as follows;

9.00 - 152.20 m	Pinosuk Gravels
152.20 - 250.10 m	hornfels
250.20 - bottom	peridotite

Specks of native copper crystals in places along fine cracks of hornfels accompanying with a weak pyrite dissemination between 152.20 m and 180.30 m, specks of molybdenite are rarely found between 163.90 m and 166.50 m.

Extremely poor mineralization with chalcopyrite and molybdenite in places, where observed between 180.30 m and 247.80 m accompanied by intermittent weak pyrite dissemination. Fine pyrite dispersions between 280.35 m and 283.10 m, specks of pyrite and molybdenite between 291.109 m and 291.50 m were only found without any intensive mineralization. It can be stated that the hole indicates the weakest mineralization among 5 drill holes in Phase III.

The result of chemical analysis is as follows;

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
152.20 m - 188.60 m (36.4 m in hornfels)	(36.40 m)	0.05	340	7

17. MJM-17 (-90°, 301.00 m)

The geology of the hole is as follows;

19.20 - 170.80 m	Pinosuk Gravels
170.80 - 269.30 m	hornfels
269.30 - bottom	peridotite

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
170.80 m - 220.40 m (49.6 m in hornfels)	(49.60 m)	0.03	175	2
220.40 m - 269.30 m (48.9 m, in hornfels)	(48.90 m)	0.04	310	3

18. MJM-18 (-90°, 300.50 m)

The geology of the hole is as follows;

15.00 - 95.20 m	Pinosuk Gravels
95.20 - 124.20 m	adamellite porphyry
124.20 - bottom	hornfels
(174.30 - 189.60 m	strongly serpentinized peridotite)

Disseminations of pyrite and chalcopyrite were detected between 108.20 m and 148.80 m in both rocks such as adamellite porphyry and hornfels.

Other than this zone, pyrite dissemination is observed intermittently down to the depth of 276.4 m.

Remarkable mineralization occurs between 118.40 m and 129.50 m including the boundary zone of adamellite porphyry and hornfels, however, the grade of copper is visually most likely to be less than these of MJM-14 and MJM-15.

The result of chemical analysis is as follows;

Depth	(Length)	Au g/t	Cu ppm	Mo ppm
108.20 m - 124.20 m	(16.00 m)	ND	957	24
(16.0 m in adamellite porphyry)				
124.20 m - 174.00 m	(49.80 m)	0.02	503	69
(49.8 m, in hornfels)				
189.60 m - 215.50 m	(25.90 m)	ND	259	15
(25.9 m in hornfels)				

The results of whole drilling were summarized as follows:

1) The purposes of drilling of eighteen holes are divided into the following three groups. (As already stated in (4-1, 1)) in the same order of A), B) and C).

A) group : to confirm the extension and/or characteristics of known outcrops or geochemical anomalies toward depths.

MJM-1 ~ MJM-5 (5 holes)

B) group : to confirm the occurrence of mineralized zone underlying the Pinosuk Gravels

MJM-6, MJM-7, MJM-9, MJM-10 and MJM-13 (5 holes)

C) group : to clarify the occurrence, size and assay grade of the IP anomalous zone, the Bambangan mineralized zone

MJM-8m MJM-11m MJM-12 and MJM-14 MJM-18 (8 holes)

2) The results in each group are summarized as follows:

A) group:

A weakly pyritized zones (maximum width was 22 m) accompanying a few chalcopyrite specks were found locally in the holes of MJM-2 and MJM-4 and MJM-5. However, no clear evidence between outcrops and the zones. It shows that the mineralization is rather weak and local.

B) group:

A weakly pyritized zones (1.40 m - 15.50 m in width, Cu 0.07 - 0.14%) were found in hornfels and peridotite in the holes of MJM-7 and MJM-9.

No further drilling is necessary for this purpose because no encouraging results were gotten from the holes other than MJM-7 and MJM-9.

C) group:

The hole of MJM-8 was allocated for clarifying the IP.SIP anomaly (F.E. 3 - 4 %) detected on the west bank of the Bambangan creek. The drilling confirmed the mineralized zone (depth 180 m - 291.10 m, average grade Cu 0.44%, Au 0.2 g/t, Mo 59 ppm). From the result of this survey, one additional hole in north side (MJM-11) to confirm the extension to north and six additional holes in south side (MJM-12, MJM-14 - MJM-18) were allocated (Fig.II-7). As the result of the survey, it was clarified that the mineralized zone is extended to the south direction rather than those extending to north direction.

3) As the results of eight holes survey for the mineralized zone in the Bambangan area, it was verified that the mineralized zone is,
   i) a porphyry copper type consisting of disseminated/stringers as a network shape in hornfels, peridotite and adamellite porphyry which intrudes along the Bambangan creek.
   ii) bearing the oxidized zone in upper portion containing native copper, cuprite, tenorite and chalcocite.
4) The extension of mineralized zone is about 400 m in N-S direction and 200-250 m in E-W direction and the thickness is about 90 m in central part of the zone. The average grades of seven holes (excluding MJM-11) are Cu 0.14%, Au 0.07 g/t and Mo 31 ppm with thickness of 91.40 m which are very lower than those in the Mamut (Cu 0.56%, Au 0.6 g/t).
5) The mineralized zone are covered by thick Pinosuk Gravels (thickness is 70 m - 170 m).
6) As above mentioned result, the Bambangan creek mineralized zone has a low potential for development. However, it is suggested that some mineralized zone, which may be similar to the Bambangan's, could be occurred in some places underneath of the Pinosuk Gravels.

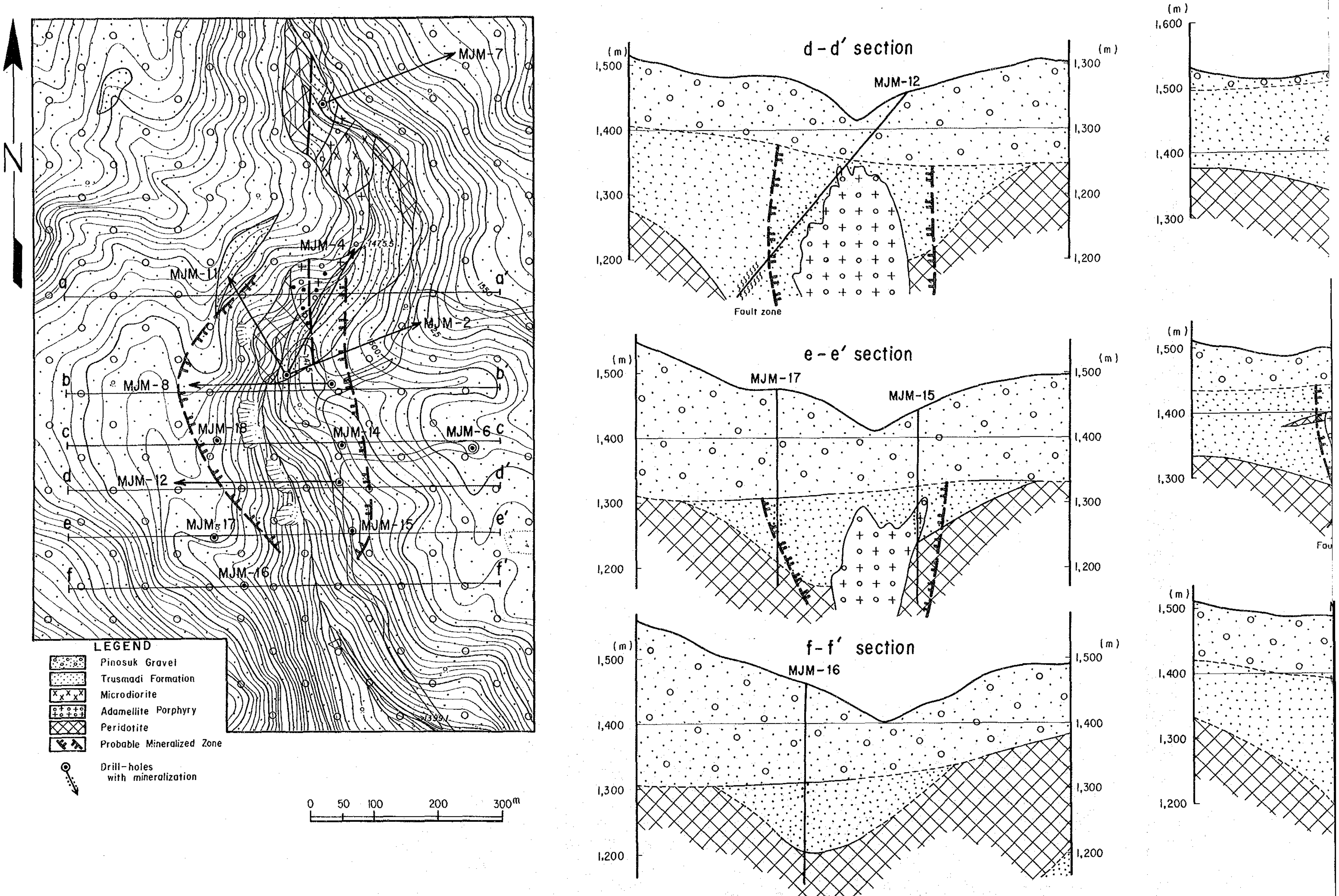


Fig. II-7 Geological Map of Drilling Survey Area and Profiles

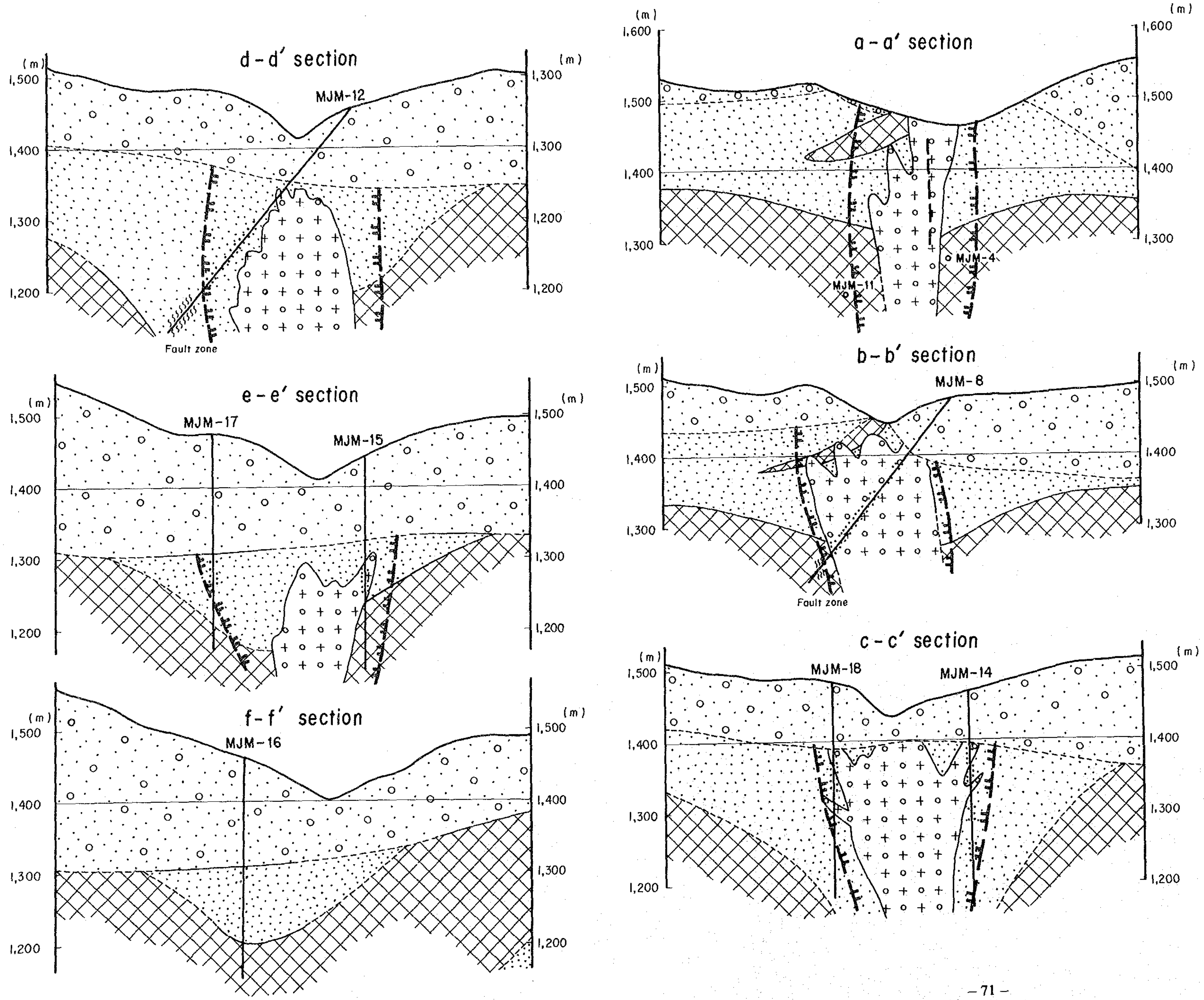


Fig. II-7 Geological Map of Drilling Survey Area and Profiles

PART III MANKADAU (B, b) AREA

Chapter 1 Geology

1-1 Outline of Geology

Based on the result of geological surveys in Phase I and Phase II, the geological map (Fig. III-1), stratigraphic section (Fig. III-2) have been compiled.

The sedimentary rocks consist of hornfels of unknown age, the Chert-Spilite Formation and the Quaternary alluvial deposit. The intrusives are peridotite, adamellite and pegmatite. Peridotite intruded in the Cretaceous age and emplaced in the last stage of the Miocene period. Adamellite and pegmatite intruded in the last stage of the plutonism formed Kinabalu mountain mass.

1-2 Geology

1-2-1 Sedimentary Rocks

(1) Hornfels (Unknown Age)

The rock distributes in the northwestern area. The thickness is more than 200 m. It mainly consists of gray to pale gray, medium to fine-grained massive hornfels derived from sandy rock. The rock is very hard and characterized by sharp fracture. It grades into pale gray quartzite in the southwestern part of the area. It shows a rhythmical alternating beds with interbedded dark gray mudstone in the upper reaches of Sasapan creek. It is locally intercalated with bluish gray massive basalt lava. A pillow structure and amygdaloidal texture are observed in basalt. However, the basalt is not mappable because of too small in size. The hornfels is resistant to the weathering, often forming steep cliffs and water falls.

Stratigraphical Relation: It is generally bordered by thrust with overlying peridotite. In the lower reaches of Sasapan creek, it is unconformably covered by the Chert-Spilite Formation.

(2) Chert-Spilite formation

It distributes in the central to the southeastern part of the survey area (surrounding area of the peridotite intrusives).

Thickness is more than 200 m.

The formation is divided into the following three members from its lithologic characteristics.

(Upper) Alternating beds of sandstone and mudstone

(Middle) Massive sandstone

(Lower) Spilitic basalt lava

Spilitic Basalt Lava

It is harmoniously distributed with the peridotite which extends in the central to the southeastern part of the survey area, especially widely on the northern side of the intrusive. It directly covers the peridotite in the central part of the area. The thickness is assumed to reach up to about 200 m.

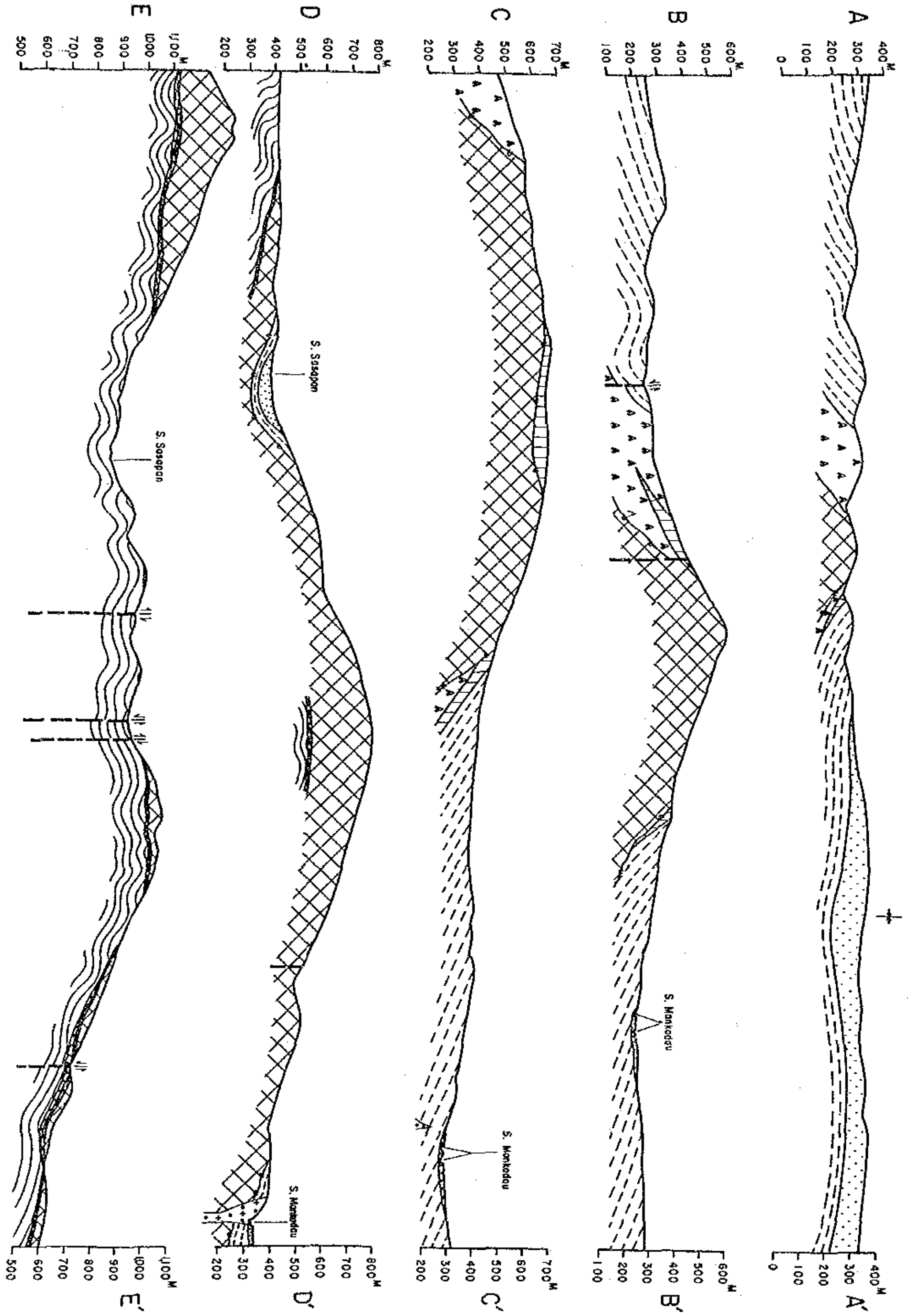
The member mainly consists of spilitic basalt lava, partly interbedded with brownish gray or greenish gray mudstone, sandstone and reddish brown chert.

The spilitic basalt lava is greeninsh gray in general, sometimes brownish gray in color. A pillow structure is common, accompanied with small quantities of hyaloclastite. The rock shows an intersertal texture, in which two millimetres long prismatic laths of plagioclase are observed. An amygdaloidal texture is commonly observed and the amygdaloids are filled with calcite or zeolite. The basalt samples collected from the Mankadau area were chemically analyzed.

The values of Al_2O_3 are high and the values of K_2O are low in all samples, which show similar values to those of basalt of an oceanic crust type.

From these facts, the basalt in the Mankadau area belongs to the tholeiite series from its chemical composition and it is likely to be distinguished to an extrusive rock in the ophiolite sequence or the similar one related to the sequence.

The rock locally grades into massive coarse-grained facies of dolerite. The intercalated mudstone is mainly distributed on the southern side of the peridotite intrusive in the eastern part of the area, and it is distributed stratigraphically in the horizon of the bottom of spilitic basalt laval. The rock is weakly bedded, interbedded with lenses of sandstone and shale. Further it is intercalated with sandstone and chert, both of which form thin layers with about 10 metres in thickness. The rock facies of the sandstone resembles to the massive sandstone in the upper sequence, to be mentioned later, and it is medium to fine-grained, massive and hard, containing "concretion" of the same source. Chert is well bedded and hard, and characterized by sharp fracture and abundant radiolaria.



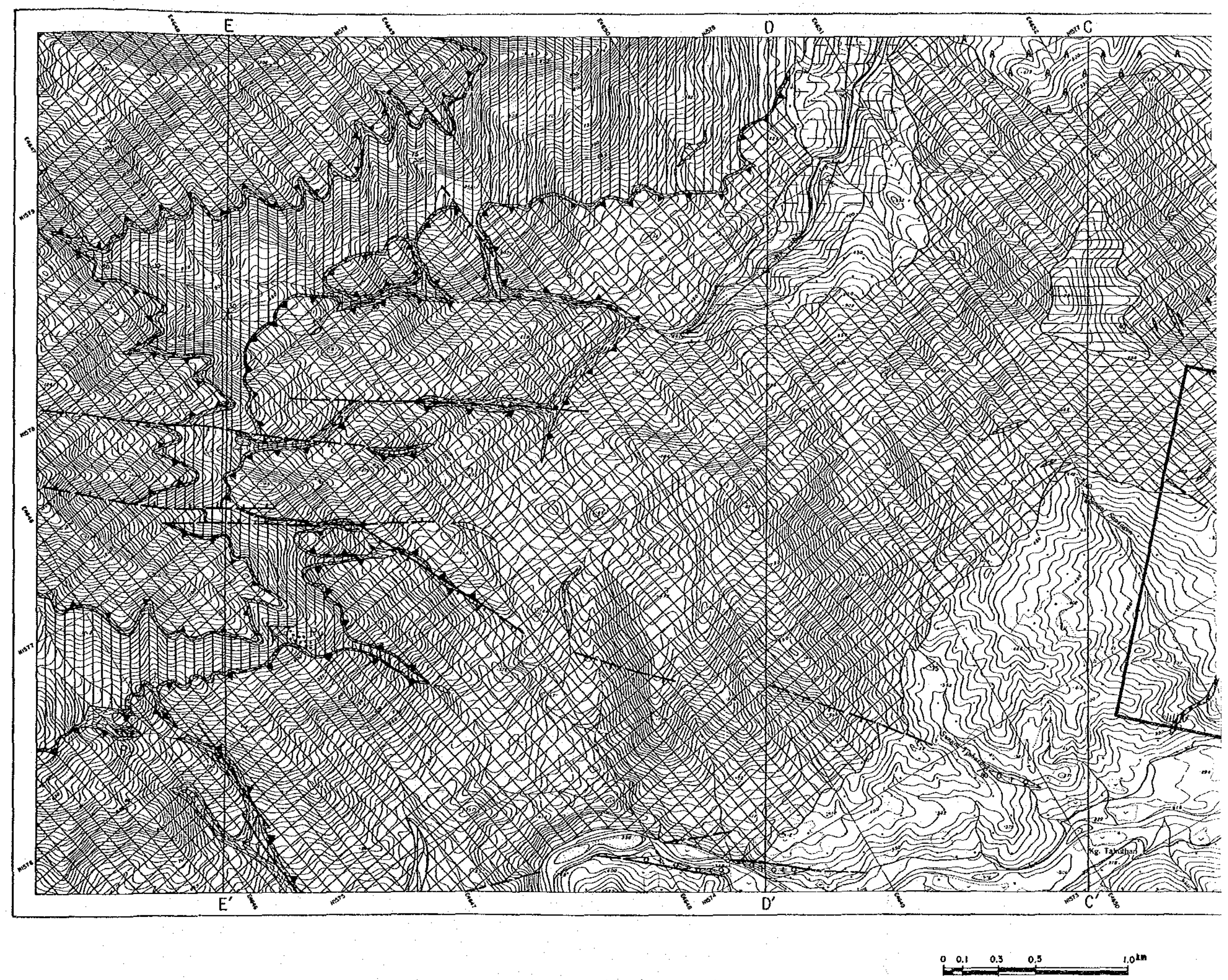
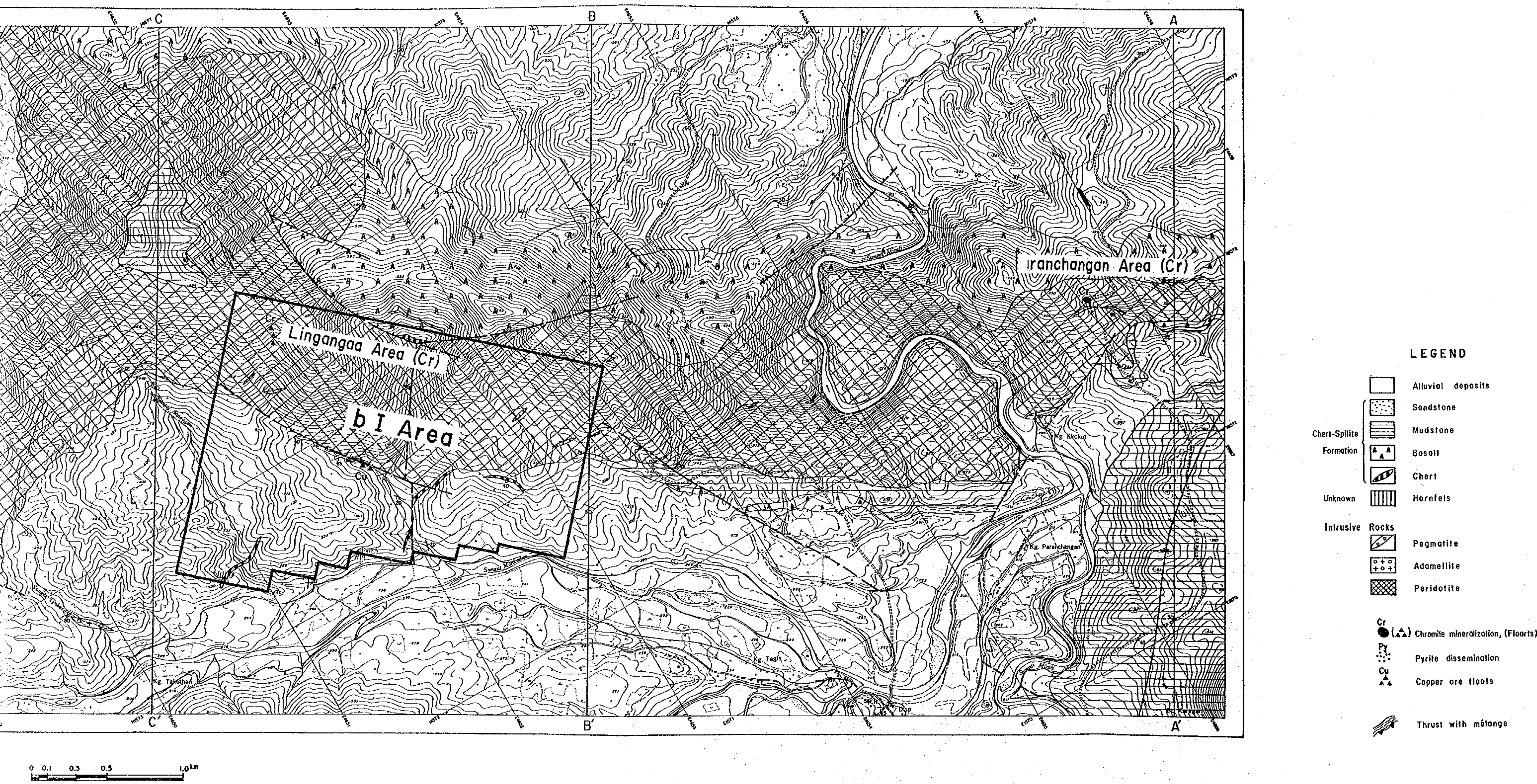


Fig. III-1 Geological Map of Mankadau (B, b) Arc



Geological Map of Mankadau (B, b) Area

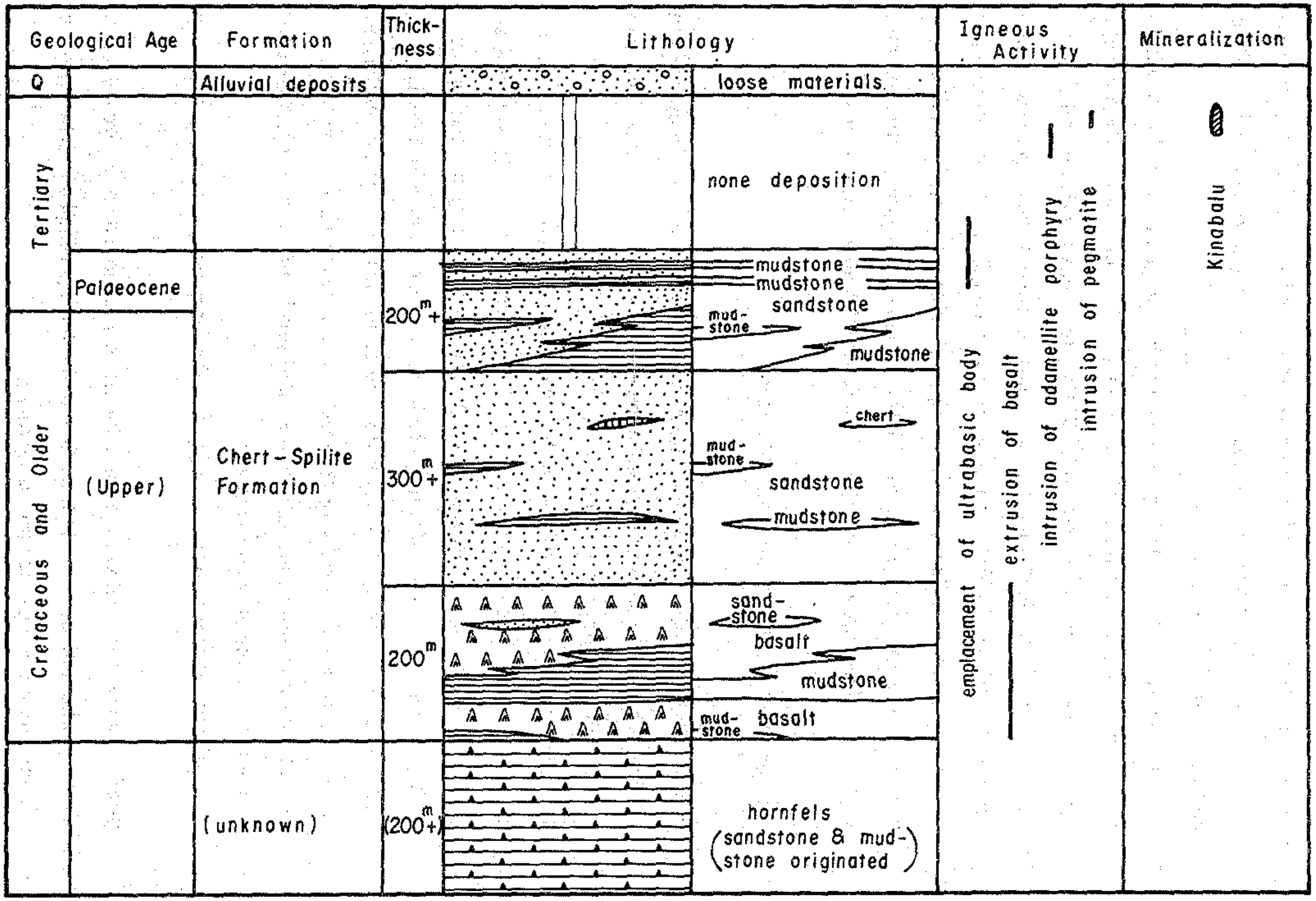


Fig. III-2 Generalized Stratigraphic Section of Mankadau (B, b) Area

Massive Sandstone

The rock is widely distributed near spilitic basalt, and also in the lower reaches of Sasapan creek. The thickness reaches up to more than several hundred metres, and varies greatly in places.
The sandstone is gray to dark gray, medium to fine-grained, hard and compact rock, is poor in facies change. It often contains the concretion disseminated by pyrite of one centimetre, almost spherical sandy to silty concretion rarely reaching up to two metres in diametre. A sole mark is also observed on the weathered surface of the rock. Breccias of basalt are rarely contained at the bottom of the sandstone, suggesting that it would occupy the upper sequence of spilitic basalt lava. The sandstone is intercalated with thin layers of dark gray, a little soft mudstone and reddish brown, well bedded chert. It yields no fossile in general.

Alternating Beda of Sandstone and Mudstone

It is distributed at the eastern end in the lower reaches of Sasapan creek in the survey area and spreads widely toward the outside of the survey area. The thickness seems to be more than 200 metres.
The member is rich in mudstone in the lower part and predominant in sandstone in the upper part. The former is distributed at the eastern end of the survey area. It is dark gray to black, hard and compact rock, often forming alternating beds of dark gray sandstone and shale. It is well bedded as compared with massive sandstone in the lower part. The latter is distributed in the lower reaches of the Sasapan creek. It is gray, hard and compact rock, showing rhythmical alternation beds of dark gray mudstone with laminae and small amount of shale, with repetition of the banding of 10 to 30 cm wide.
No fossile was discovered from any layer of the formation.

Stratigraphic relationship of the three members mentioned above are conformable each other and these are in the relation of interfinger in places. The formation unconformably covers the underlying rocks.

(3) Quaternary Sediments

The sediments are distributed in the valley of the Mankadau river and the Mirali river, consisting of unconsolidated sand and gravel. These sediments form the river terrace and the flood plain. The gravels are made up of various rocks including adamellite and adamellite porphyry which form the Kinabalu mountain.

1-2-2 Igneous Rocks

The intrusive rocks distributed in the area consist of peridotite, adamellite porphyry and pegmatite.

(1) Peridotite

The rock is widely distributed in the survey area extending northwest, and thins out at the eastern end of the area. In the western part of the area, the distribution is limited to the shallow part of subsurface because it rests on the underlying rocks by the thrust.

The rock is generally melancratic and lustrous, and contains olivine with a small quantity of rhombic pyroxene, corresponding to harzburgite in composition. The occurrence of small lenticular dunite was confirmed in the vicinity of the Paranchangan chromite deposit. However, the original texture has not remained because of strong serpentinization. Brecciation can be observed everywhere, and platy or fibrous talc is found. The intensity of brecciation varies from place to place, with an irregular distribution.

In the western part of the survey area, the mélange which has formed by the thrust movement of the peridotite is distributed, and the schistosity is observed in the peridotite immediately above the mélange. It contains subangular to subround pebbles of peridotite and hornfels in a muddy to sandy matrix. The size of the pebbles is various, ranging from one metre to several metres. The thickness reaches up to 10 m. The mélange is considered to be the tectonic mélange formed by the tectonic movement.

The peridotite with distinct schistosity is distributed in harmonious with the mélange, containing the blocks of the same source. The peridotite with schistosity grades into the massive one.

(2) Adamellite Porphyry

It is distributed in northwest of Takuthan.

The rock shows a form of dike intruded along the fault, extending west-northwesterly.

The rock is characterized by large crystals of potash feldspar of two centimetres across, and shows a porphyritic texture. The phenocrysts consist of potash feldspar, hornblende, plagioclase and biotite. A matrix is holocrystalline, consisting of fine-grained quartz and potash feldspar. The joint is often prevalent at the exposures, obliquely intersecting the direction of extension of rock body.

(3) Pegmatite

The pegmatite is mainly distributed in the peridotite mass in the central part of the survey area. It generally strikes east to west and dips vertically. The length of extension on the surface is not clear but it is assumed to reach up to 200 m. The width of the dikes varies, with a maximum width of 30 m.

It is generally leucocratic, equigranular and holocrystalline, mainly consisting of quartz and plagioclase, accompanied with small quantities of hornblende and biotite. Resistance for weathering is very high. Qartz and plagioclase are a few centimetres in size, but large crystals more than 10 centimetres long are also observed. Hornblende and biotite show a euhedral to subhedral form and tend to be unevenly distributed unlike quartz and plagioclase.

1-3 Geological Structure

The most important structure in the survey area is the thrust which controls the bottom plane of the peridotite intrusive. It is clear that the peridotite distributed in the western part of the area does not continue to the deeper level due to the thrust movement.

The Chert-Spilite Formation distributed in the upper sequence is unconformable with the peridotite, but it is distributed harmoniously. Therefore, it is highly possible that the sequence in the area corresponds to the ophiolite sequence consisting of peridotite, spilitic basalt and sedimentary rocks in an ascending order.

The fault found in the area consists of a NW-SE system and oblique systems such as N-S, NE-SW and ENE-WSW systems. Among them, the NW-SE system is most prominent, which controls the distribution of the peridotite and provides the field of intrusion of adamellite porphyry in the neighborhood of Village Takuthan. Furthermore, the Mankadau river which flows in the southern part of the area is also controlled by the fault. Other systems are not considered to control the major structure, only affecting the local structure.

As the folding structure of the area is very complicated, the details have not been made clear yet. However, from the regional point of view, an anticlinal structure is recognized, in which peridotite extending northwesterly forms the core.

Local synclinal structures oblique to the anticlinal structure are observed at the southeastern end of the area and the Sasapan creek area.

It is likely that the thrust movement was completed before late Cretaceous, and faulting and folding took place associated with the thrust. It is understood that the following structural movement would continued to the Kinabalu plutonism which is represented by the faults of NW-SE system controlling the fault structure of the area.

Chapter 2 Mineralization

The alteration found in the area consists of spilitization in basalt lava, serpentinization in peridotite and silicification in hornfels observed in the western part of the area.

Spilitization is commonly observed in basalt lava distributed in the area. The basalt lava is presumed to belong primarily to tholeiitic series of non-alkali basalt and is characterized by albitization of calcareous plagioclase. Under the microscope, serpentinization of olivine, epidotization of pyroxene and other secondary minerals such as zeolite, calcite and chlorite are observed.

Serpentinization is common in peridotite distributed in the central part of the survey area extending northwesterly. Serpentine consists mainly of antigorite and chrysotile, being pale green to dark green. Locally, abundant talc is present.

Silicification is found in hornfels in the western part of the area and is recognized partially in peridotite positioned in the upper sequence of hornfels.

Regarding the mineralization, there are pyrite dissemination in hornfels in the western part of the area and chromite deposit in Paranchangan of the eastern area both of which were confirmed in Phase II, and the floats of the massive sulphide copper ore scattered along the Lingangaa creek, which have been known and the chromite floats distributed in the uppermost reaches of the creek, which were newly found and surveyed in Phase I.

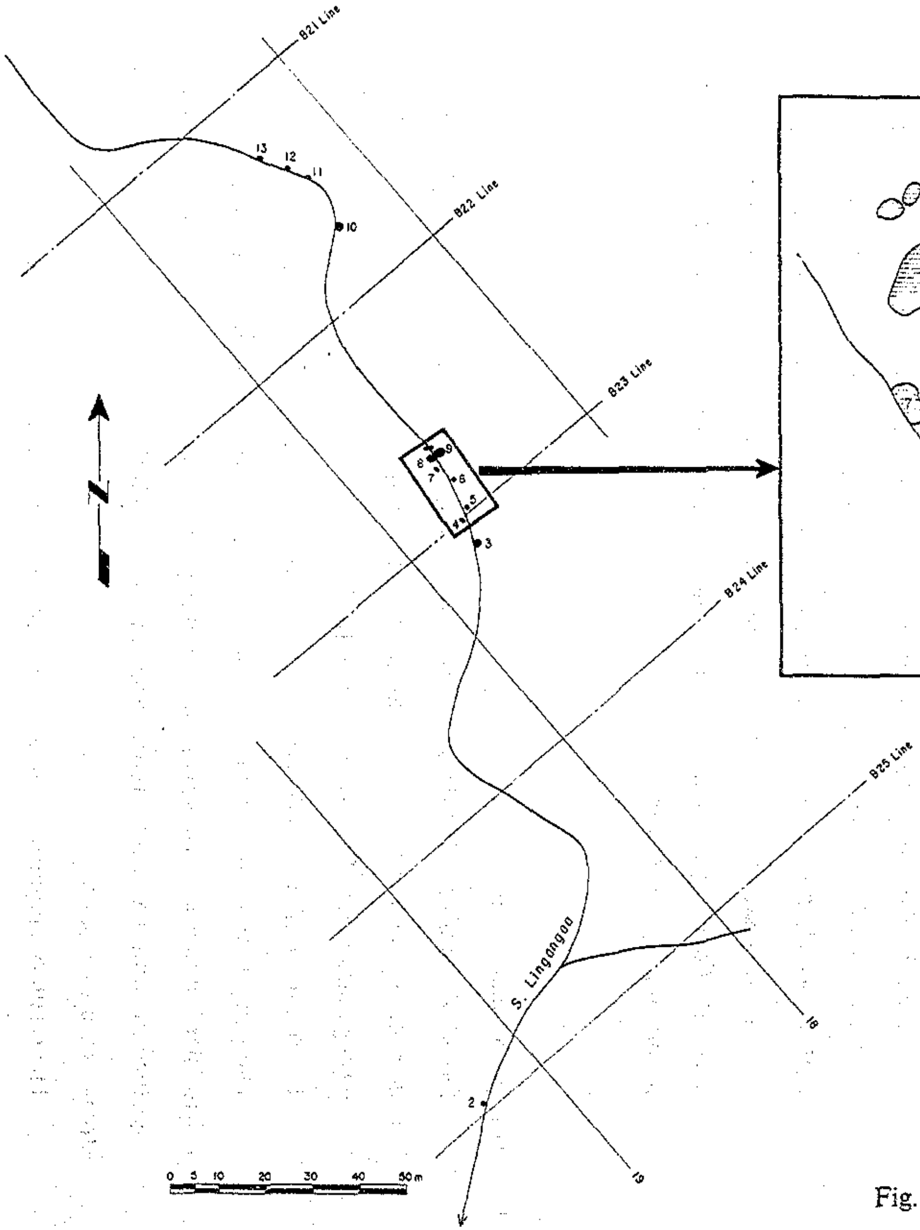
(1) Massive Sulphide Ore

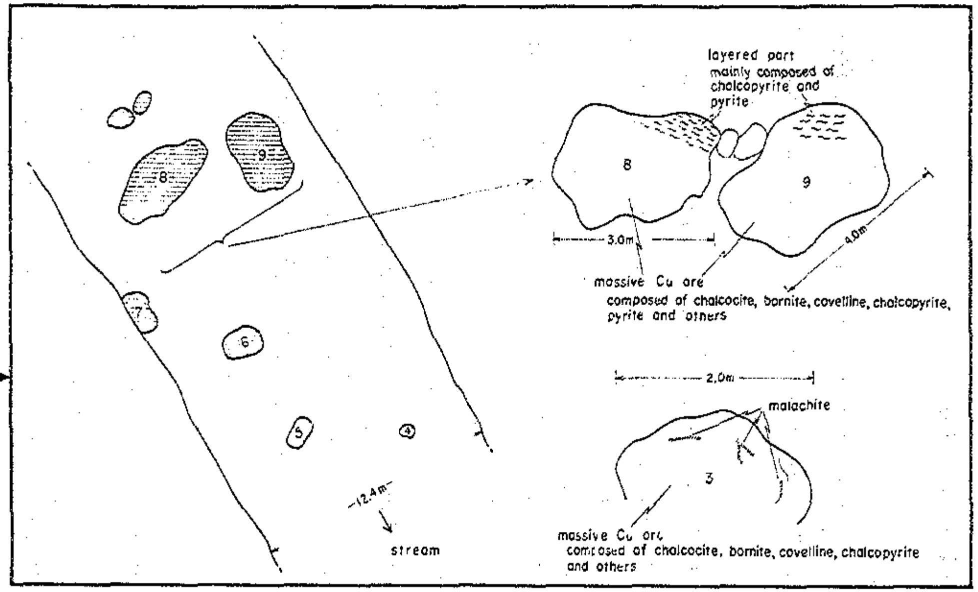
Floats of massive sulphide ore are found in Lingangaa creek along the fault contact between sedimentary rocks and peridotite. The distribution of such floats is only confined to the Lingangaa creek. (Fig. III-1 and Fig. III-3)

The ore minerals are chalcocite, bornite, covellite, chalcopyrite and pyrite.

The gangue mineral is ferruginous quartz. The occurrence of these minerals in floats is irregular but massive. However the assemblage of chalcopyrite-bornite shows a banded structure in some parts. The ferruginous quartz is reddish brown in color and malachite streaks are also observed.

The result of chemical analysis of the ore is shown in Table III-1, showing high copper





SIZES

No. 1	0.2 x 0.2 x 0.2m (out of this area)
2	0.4 x 0.4 x 0.4
3	2.0 x 1.5 x 1.3
4	0.3 x 0.3
5	0.5 x 1.0
6	1.0 x 0.5
7	1.0 x 0.5
8	3.0 x 1.5 x 2.0
9	4.0 x 2.0 x 2.0
10	1.3 x 1.7 x 0.6
11	0.6 x [illegible] x 0.3
12	0.6 x 0.3 x 0.3
13	[illegible] x 0.4 x [illegible]

Fig. III-3 Sketch showing Copper Boulder values.

Table III-1 Chemical Composition of Copper Boulder of Mankadau (bI) Area

Sample No.	Location	Specimen	Au (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	Hg (%)
Y-50 (1)	B23-19	massive sulphide ore	1.16	48.28	0.03	0.02	0.034	<0.001
Y-50 (2)	B23-19	massive sulphide ore	31.00	41.12	0.25	0.19	0.060	<0.001
Y-31	B23-19	massive sulphide ore	1.85	24.61	0.08	0.14	0.012	<0.001
Y-51	B23-19	massive sulphide ore	1.37	64.88	0.10	0.02	0.096	<0.001

The distribution of floats described above has been reported from earlier investigation which included some chemical analyses. For example, Soriano y Cia. figure (1962) was 45.2% of copper and Lim Peng Siong's figures (1982) were 38.0% and 34.0%. The gold contents are also very high, 1 to 2 g/t. In our samples 31 g/t of gold was detected for Y-50 (2). However no gold grains were observed under the microscope. Therefore the occurrence of gold could be local.

The occurrences and characteristics of floats of massive sulphide ore are summarized as follows:

1 The distribution is limited only to Lingangaa creek.

2 High copper content in the ore is due to secondary enrichment. The assemblage of primary ore minerals is recognized as pyrite-chalcopyrite and/or pyrite-bornite.

3 Banded structures are present in parts of the sulphide ore and the ferruginous quartz occur as a gangue mineral.

4 Ferruginous quartz is distributed not only in Lingangaa creek but also in Pompudum creek: however it is limited only to near the boundary between sedimentary rocks and peridotite.

5 Ferruginous quartz contains minor sulphide minerals.

6 No sulphide mineral is found in peridotite.

(2) Floats of Chromite Ore

loats of chrome ore were newly found in Phase I. It is distributed in the uppermost stream of the main Lingangaa creek (Fig. III-1). The floats of chromite are distributed in areas occupied by peridotite. It extends for more than 200 metres in N-S direction along the creek, with the maximum boulder of 5 x 2 x 5 m in size. The distribution is shown in Fig. III-4.

The chromite ore is black colored, massive, hard and compact, with streaks (1 mm ± in width) filled by pure green colored chlorite. Ore mineral is only chromite. Common gangue minerals are serpentine and chlorite. Although these floats of chromite ore occur in harzburgite area, it is considered that they are associated with dunite in harzburgite as well as other deposits in Sabah.

The results of chemical composition for these chromite specimens are shown in Table III-2. The result shows that the specimens contain Cr_2O_3 of about 30 wt% and belong to Picotite. The contents of Ni and Co are also very high.

Table III-2 Chemical Composition of Chromite Boulder of Mankadau (bl) Area

Sample No.	Location	Specimen	Cr_2O_3 (%)	Total (%)	SiO_2 (%)	Al_2O_3 (%)	MgO (%)	Ni (ppm)	Co (ppm)
Y-52 (1)	B06-05	chromite ore	32.66	13.11	6.13	22.87	17.19	1,809	174
Y-52 (2)	B06-05	chromite ore	31.28	12.00	7.84	23.07	16.90	1,709	160
T-34	B05-05	chromite ore	29.73	11.29	10.79	19.85	15.63	1,629	156

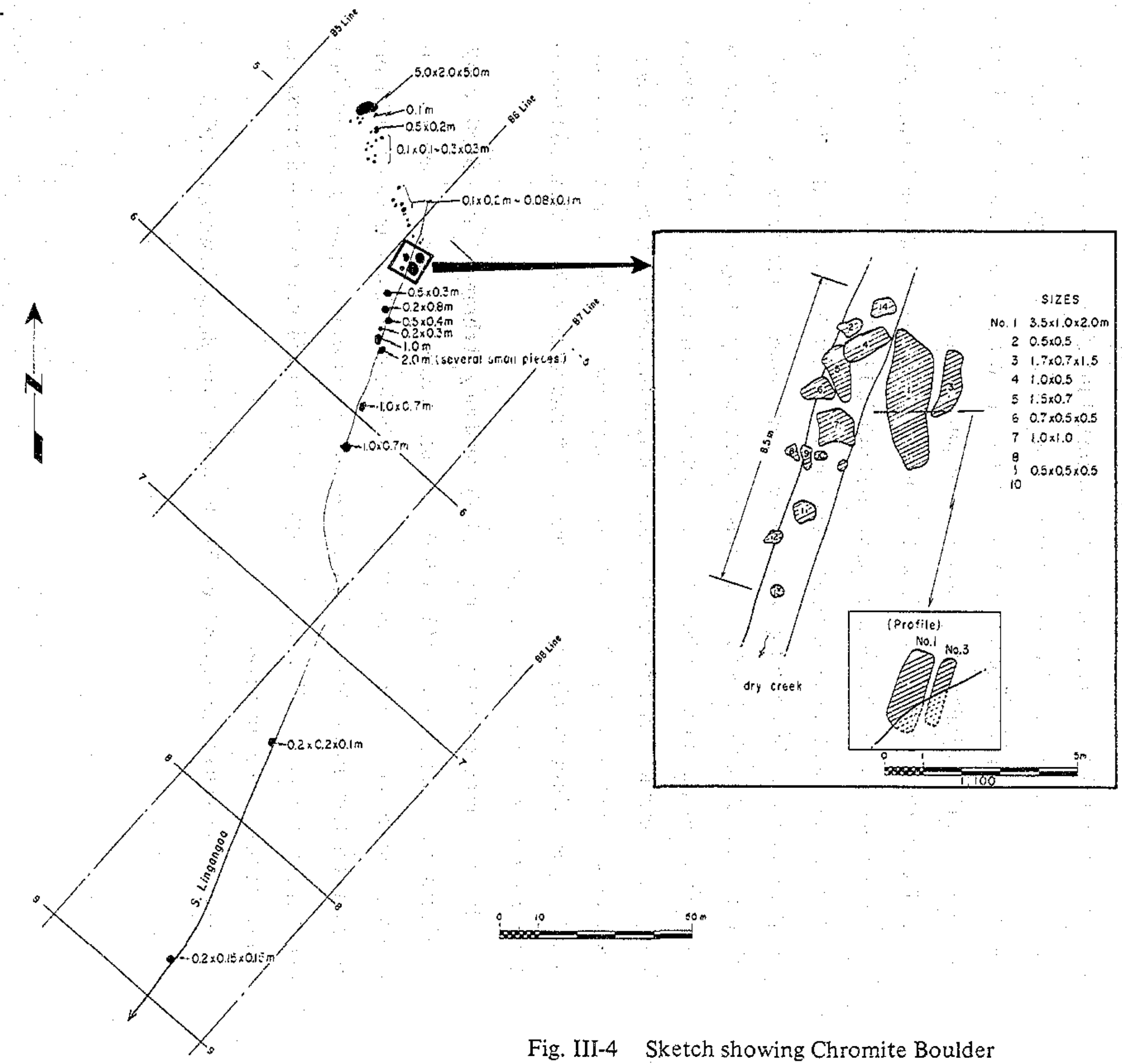


Fig. III-4 Sketch showing Chromite Boulder

(3) Paranchangan Chromite Deposit

The ore deposit is located about 1.5 kilometres north-northeast of Paranchangan (Fig. III-1).

The deposit was discovered by R.R. Pilz in 1910. In 1957, Collenette P. conducted pitting, trenching and geochemical survey, and reported the details. The report states that the deposit shows a small lenticular shape, though somewhat irregular, and that the volume up to the depth of 7 feet (2.1 metres) below the surface is calculated to be 150 yd^3 (114.5 m^3), which vertically extends toward the depth (see Fig. III-5).

A detailed geological survey was carried out in Phase II over the area of 100 m x 60 m surrounding the deposit. The result of survey is shown in Fig. III-6.

According to the Collenette report, the deposit seems to be distributed in the southern part of the area shown in Fig. III-6. However, no outcrop could be found out so far other than the chromite ore floats and wastes excavated by pitting and trenching in the past, being scattered on the surface. The ore floats are several to several tens centimetres in size, and found in abundance in the southern part of the area and in the southern adjacent area as shown in the Fig. III-6. In the surrounding area, weathered, leached and massive low-grade chromite disseminated zone is distributed over the area of 100 metres north to south by 40 metres east to west.

The ore is black, compact and hard, mainly consisting of chromite with a small quantity of serpentine and chlorite. Although the texture is cataclastic, it is coarse-grained in general, reaching up to 5 millimetres in grain size. On the other hand, the lowe-grade ore distributed in the surrounding area is the dissemination bearing a small quantity of chromite in peridotite, and the fine chromite streaks seem to be of primary chromite removed from elsewhere, can be observed.

The assay result of ore is as follows. The location of samples is shown in Fig. III-6.

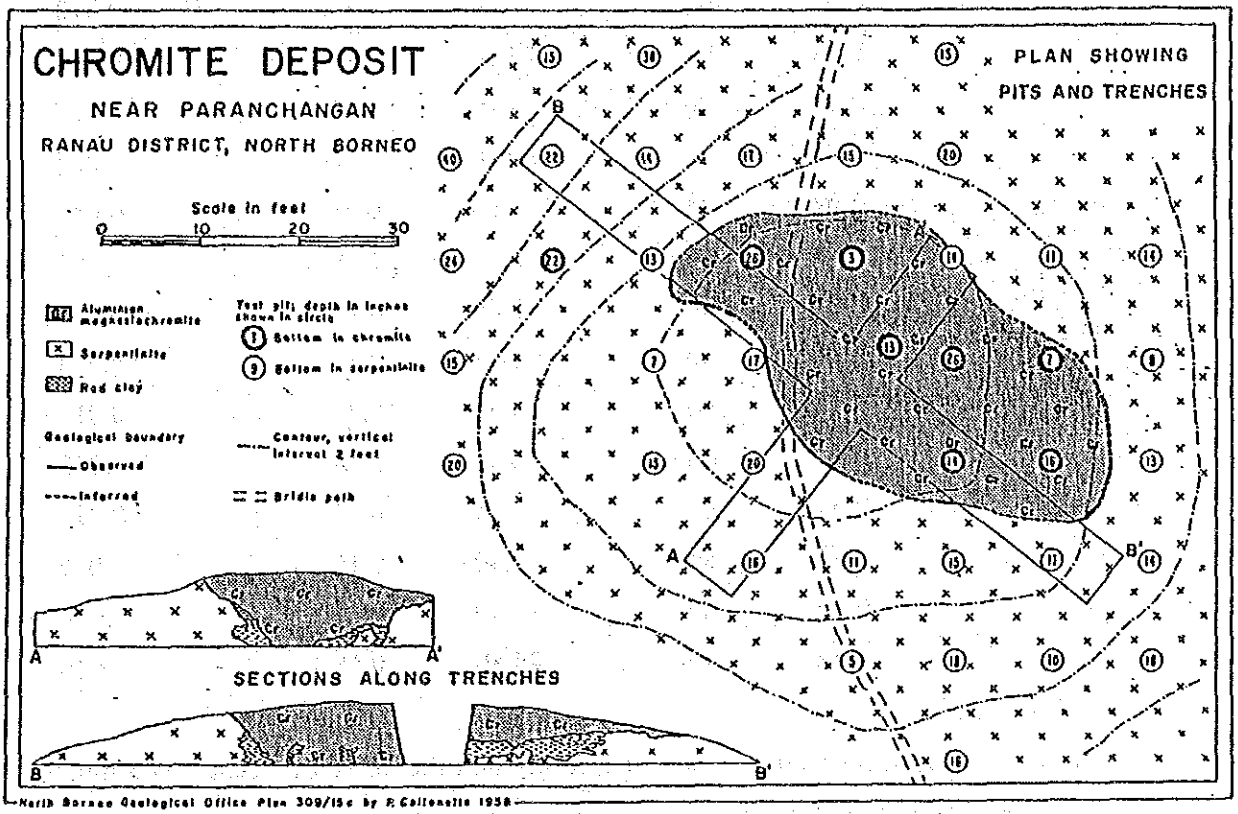


Fig. III-5 Map showing Chromite Ore Distribution in Paranchangan (B) Area

Sample No.	Location	Cr_2O_3 (%)	Ni (%)	Co (%)
P-01	Paranchangan	28.80	0.12	0.016
P-02	do	0.86	0.22	0.012
P-04	do	28.20	0.12	0.014
P-05	do	29.40	0.14	0.020
P-06	do	30.20	0.12	0.017
P-07	do	2.63	0.91	0.083
P-08	do	2.87	0.89	0.071
P-09	do	1.66	0.22	0.013
P-11	do	1.63	0.25	0.013
P-13	do	0.64	0.23	0.013
P-14	do	0.51	0.28	0.013
P-15	do	0.45	0.22	0.012
P-16	do	31.40	0.16	0.019
P-17	do	31.90	0.15	0.020
P-18	do	29.80	0.15	0.025

From the above-mentioned result, it is to say that the deposit is related with dunite found in peridotite, however the shape can not be delineated at present stage. The low-grade ore is irregularly distributed on the footwall side of dunite, which is considered to reach up to several tens metres in thickness.

The nature of the ore resembles to the floats discovered at the uppermost reaches of the Lingangaa creek.

(4) Pyrite Disseminated Zone

The dissemination is found in hornfels under peridotite mass bordered by the thrust. Fig. III-1 shows their location. The mineralized zone is accompanied with strong silicification (quartz veins of various sizes). The bleaching associated with the mineralization is locally observed.

The intensity of the pyrite dissemination is weak and no ore minerals are detected in the quartz vein.

The ore minerals found in the disseminated zone in hornfels consist mainly of pyrite, accompanied with small quantities of pyrrhotite and sphalerite.

The assay result is as follows:

Sample No.	Location	Au (g/t)	Cu (%)	Pb (%)	Zn (%)	Mo (%)	Hg (%)
N-16	Mankadau	<0.07	<0.01	<0.01	<0.01	<0.01	<0.01
N-18	do	<0.07	<0.01	<0.01	<0.01	<0.01	<0.01

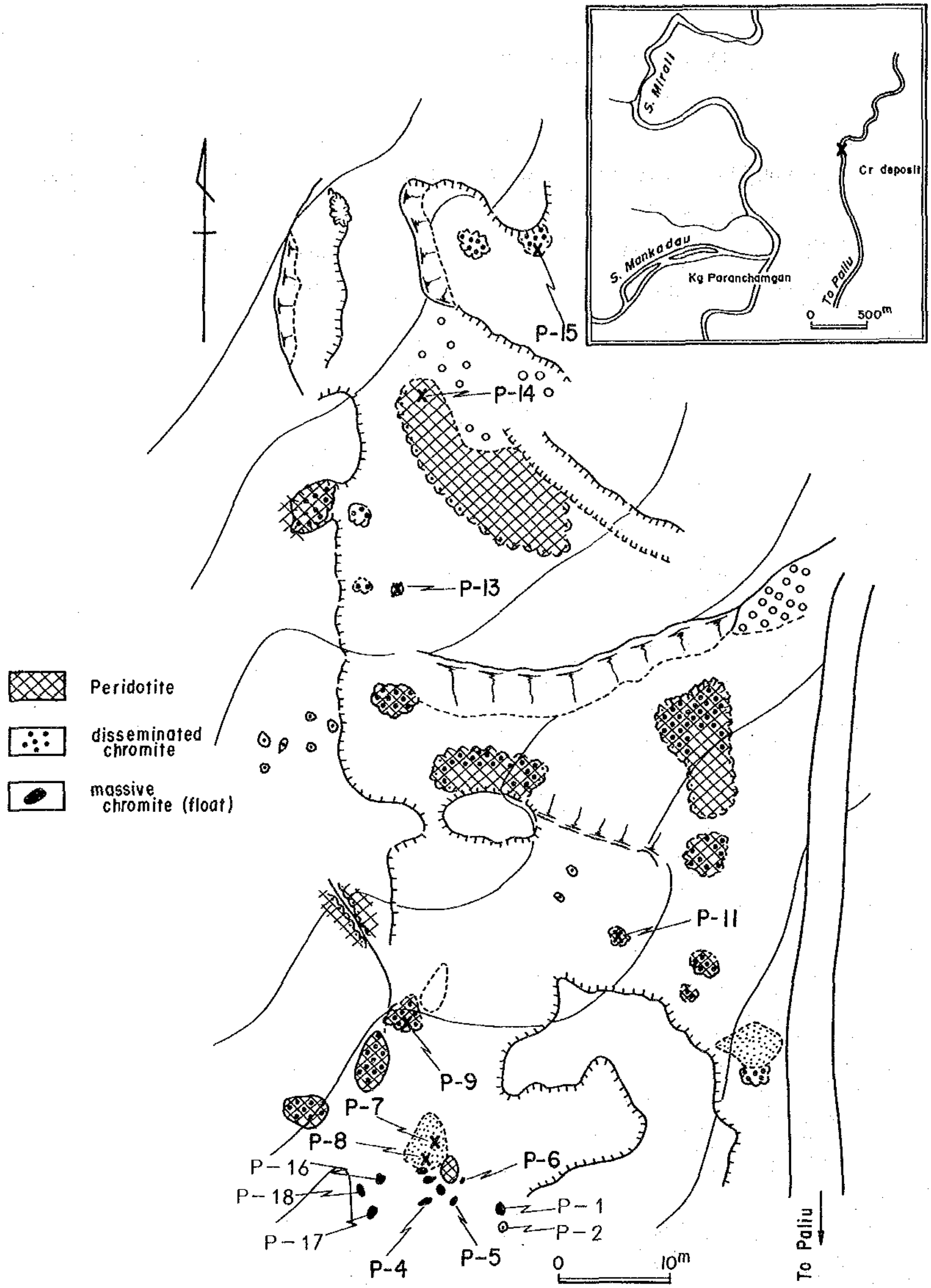


Fig. III-6 Sketch Shwoing Chromite Mineralization in Paranchangan (B) Area

Chapter 3 Geochemical Survey (Soil)

3-1 Outline of Survey

Geochemical surveys by soil were carried out in bI area (4 km^2) in the first year (Phase I) and in bII area (50 km^2) in the seond year. (Phase II)

The locations of samples were determined by handy survey, reffering to the existing 1/50,000 scale topograhical map in Phase I, while samples were taken at the possible ore deposit area by spot sampling. Number of samples are 1,981 in Phase I and 235 in Phase II.

The samples prepared at the site were promptly sent to the Geological Survey of Malaysia, Sabah and chemically analyzed by atomic absorption method. The samples were analyzed for five components such as Au, Cu, Pb, Zn and Mo. Among these, Au analysis was made for selected samples.

The detection limit was 0.03 ppm for Au, and 1 ppm for Cu, Pb, Zn and Mo.

3-2 Result of Survey

The result of Phase I is as follow.

(1) Single Variate Analysis

It was estimated that the background of each element analyzed would be different each other because of different chemical composition for each rock distributed in the target area. Therefore, a histogram was produced to examine the mode of distribution of the assay values for each element (Fig. III-7). As a result, it became clear that the distribution of assay values shows a normal distribution on the histogram. Cumulative frequency curves by element are shown in Fig. III-8. As each curve shows in a straight line, the extraction of anomalies using values of $\overline{\chi}$ + 2t as threshold which occupy about 2.5 per cent of the entire population. $\overline{\chi}$ + t and $\overline{\chi}$ + 3t were also used in the distribution diagrams as the supplementary values. These values are shown in Table III-3.

The distribution of each element is as follows,

Cu: The values are generally low, ranging from 5 to 75 ppm. An anomalous zone with larger than $\overline{\chi}$ + 2t values corresponds to the basalt area. Some anomalies are also scattered in the peridotite in the northeastern area.

Pb: The values range from 7 to 63 ppm. Anomalous zones with larger than $\overline{\chi}$ + t values cross the peridotite body at a right angle. The anomalies with larger than $\overline{\chi}$ + 2t distributed in the western end of the survey area, trend to extend northwards over the area.

Zn: Range: 11-186 ppm. The values larger than $\bar{\chi} + 2t$ values are distributed in the basalt area and the western area.

Some Zn anomalies are obtained in the Cu anomaly zones.

(2) Multi-Variate Analysis

Since the assay results of the samples provided for the analysis were relatively low in grade (the maximum values of each element were 79 ppm Cu, 63 ppm Pb and 186 ppm Zn), it is difficult to extract the intrinsic geochemical anomalous zones. It seems, however, that the procedure by score sum (SCORESUM) is powerful for examining the potential of mineralization. Therefore this method was introduced. The characteristics of the procedure are as follows.

- The kinds of geochemical data are not constrained.
- The number of the elements analyzed or the samples are not limited.
- Classification of rock facies can be easily reflected.
- Even the low anomalies can be accentuated.
- It is possible to delineate the outline of anomalous zones and they are easily to be ranked.
- Many data can be plotted on one or several sheets of diagrams.

It is thought that score sum is effective for the analysis of this area in the aspect that the anomalous zones can be extracted by a set of values even if a single element is low in grade, as mentioned in the above, and that the classification of rock facies can be considered.

(i) The method of analysis

- The values of $\bar{\chi} + t$, $\bar{\chi} + 2t$ and $\bar{\chi} + 3t$ are calculated for each rock facies used in simple statistical analysis.
- Scores are given to each class established on the basis of the values calculated in the above.

Class	Score
less than $\bar{\chi} + t$	0
$\bar{\chi} + t$ to $\bar{\chi} + 2t$	1
$\bar{\chi} + 2t$ to $\bar{\chi} + 3t$	2
larger than $\bar{\chi} + 3t$	3

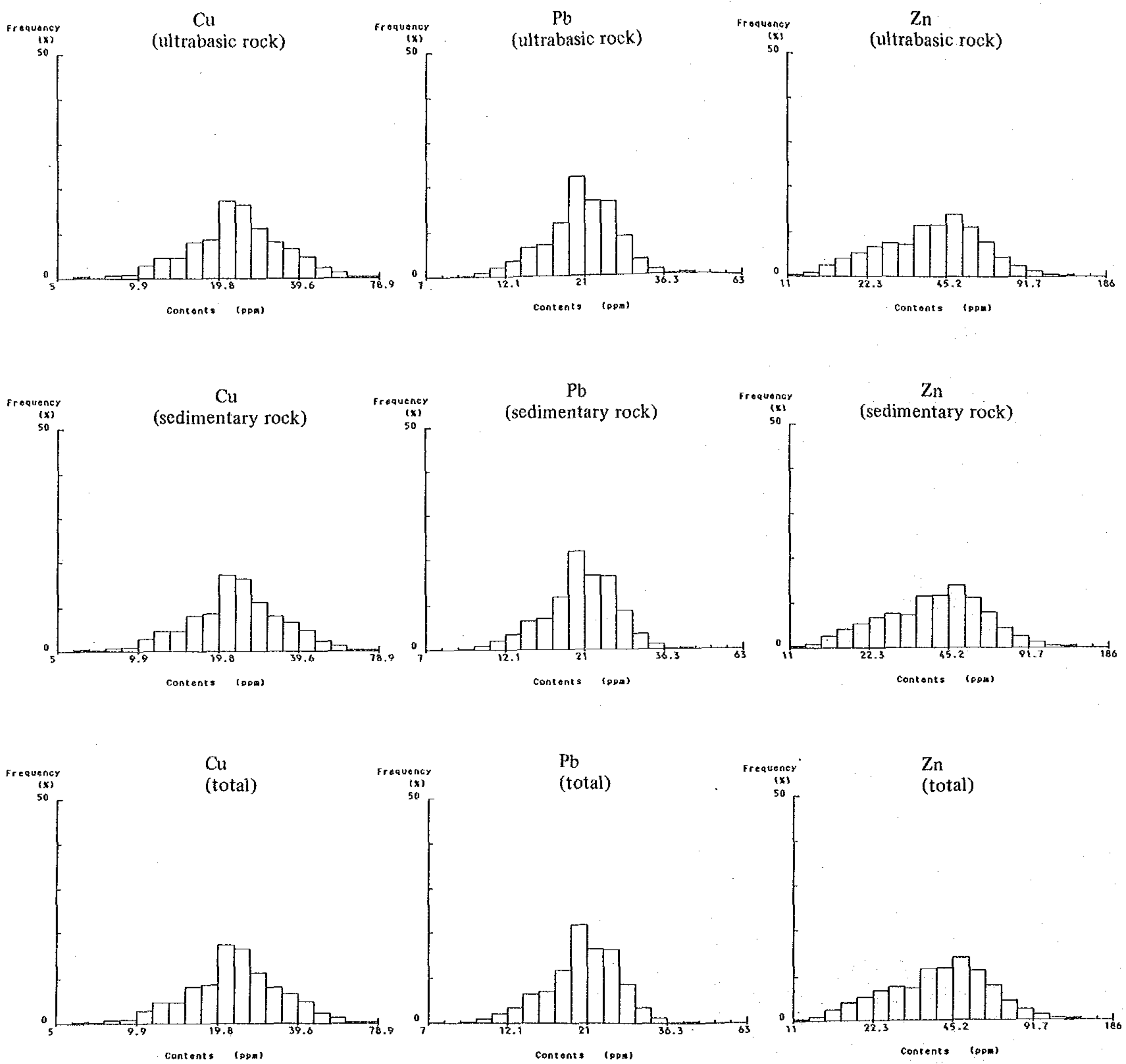


Fig. III-7 Histgram for Soil Samples in Mankadau (bI) Area

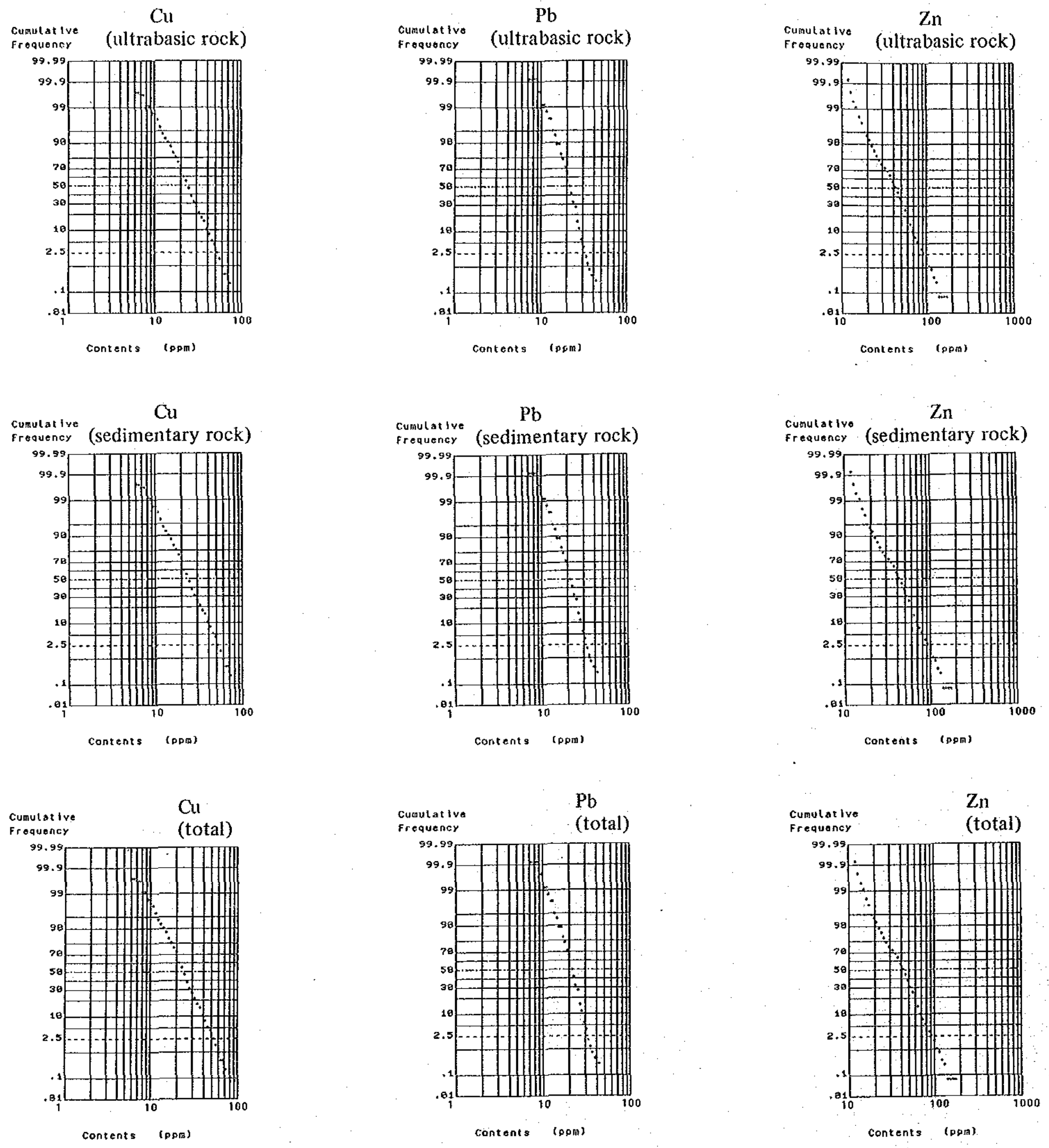


Fig. III-8 Cumulative Frequency Curve for Solid Samples in Mankadau (bI) Area

Table III-3 Statistic Values for Soil Samples in Mankadau (bI) Area

			Intrusive rock	Sedimentary rock	Total
Cu (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	462	383	462
	Minimum value	(Vmin)	1	1	1
	Geometric mean	($\bar{X}$)	41.3	14.3	19.4
	Standard deviation	(t)	0.409	0.379	0.440
	$10^{\log\bar{x}+t}$		105.9	34.2	53.4
	$10^{\log\bar{x}+2t}$		271.6	81.9	147.2
	$10^{\log\bar{x}+3t}$		(695.5)	196.0	405.3
Pb (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	235	601	601
	Minimum value	(Vmin)	14	8	8
	Geometric mean	($\bar{X}$)	46.1	31.0	34.7
	Standard deviation	(t)	0.244	0.266	0.271
	$10^{\log\bar{x}+t}$		80.9	57.2	64.8
	$10^{\log\bar{x}+2t}$		141.8	105.5	120.9
	$10^{\log\bar{x}+3t}$		(248.7)	194.7	225.6
Zn (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	250	282	282
	Minimum value	(Vmin)	8	6	6
	Geometric mean	($\bar{X}$)	48.1	24.4	29.7
	Standard deviation	(t)	0.262	0.323	0.335
	$10^{\log\bar{x}+t}$		87.9	51.3	64.2
	$10^{\log\bar{x}+2t}$		160.7	108.0	138.9
	$10^{\log\bar{x}+3t}$		(293.9)	(227.2)	(300.4)
Mo (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	11	5	11
	Minimum value	(Vmin)	ND	ND	ND
	Geometric mean	($\bar{X}$)	–	–	–
	Standard deviation	(t)	–	–	–
	$10^{\log\bar{x}+t}$		–	–	–
	$10^{\log\bar{x}+2t}$		–	–	–
	$10^{\log\bar{x}+3t}$		–	–	–
Au (ppm)	Number of samples	(n)	470	680	1150
	Maximum value	(Vmax)	0.72	0.23	0.72
	Minimum value	(Vmin)	ND	ND	ND
	Geometric mean	($\bar{X}$)	0.049	0.048	0.048
	Standard deviation	(t)	0.337	0.314	0.352
	$10^{\log\bar{x}+t}$		0.106	0.099	0.108
	$10^{\log\bar{x}+2t}$		0.231	0.204	0.243
	$10^{\log\bar{x}+3t}$		0.503	(0.420)	0.546

note) ( ) ; value not present

Correlation Matrix

	Intrusive rock			Sedimentary rock			Total		
	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn
Pb	–0.030	–	–	0.494	–	–	0.298	–	–
Zn	0.363	0.603	–	0.589	0.755	–	0.546	0.698	–
Au	0.199	0.004	–0.023	0.174	0.052	0.009	0.174	0.032	–0.002

- The score of the sample is determined by totaling the score of each element for each sample.
- As a result, the anomalous zones are ranked by these scores, in which score 9 is the maximum in the case of analysis of these components (all three components show the values larger than $\bar{\chi} + 3t$).
- The results are shown on geological map, and geochemical anomalies were extracted after examining the relationship with the result of geological mapping.

(ii) Distribution of Elements

Each distribution of three elements such as copper, lead and zinc out of five elements chemically analyzed is summarized as follow:

Molybdenum could not be the objective of analysis because all the assay values were below the detection limit (1 ppm). Gold was also excluded from the objective of this time because the chemical analysis was made only for selected samples.

Copper (Cu)

The maximum assay value is 79 ppm and the minimum 5 ppm, being low in general.

Since the distribution of assay values is different for each rock facies, they were roughly divided into peridotite and the sedimentary rock facies.

The widest zone with values larger than $\bar{\chi} + 2t$ is shown in the vicinity of B23-02, corresponding to the distribution of basalt, having a tendency to extend beyond the boundary of the survey area.

Lead (Pb)

The maximum assay value is 63 ppm and the minimum 7 ppm. The average value is higher in the sedimentary rock facies than in peridotite.

The distribution tends to extend northeasterly in the northwestern part and the central part of the survey area.

The values larger than $\bar{\chi} + 2t$ are distributed in the peridotite having a lateral extent of 2,250 m^2, showing a tendency to extend northward beyond the boundary of the survey area.

Zinc (Zn)

The maximum assay value is 186 ppm and the minimum 11 ppm. The average value is 49.7 ppm in the peridotite, whilst 29.7 ppm in the sedimentary rock facies, showing lower value in the latter.

In connection with the values of $\bar{\chi} + t$, they are homogeneously distributed throughout the survey area.

The values larger than $\bar{\chi}+2t$ found in the vicinity of B23-01 corresponds to the distribution of basalt, tending to extend northeasterly beyond the boundary of the survey area. Those in the vicinity of B01 -35, B02 -04, B05-32, B23-01 and B40-23 are well consistent with the area of $\bar{\chi}+2t$ of Cu.

(iii) Result of Analysis by Score Sum

The highest score was five. It means that in each rock facies classified, at least one elements among the three of Cu, Pb and Zn contains the value larger than $\bar{\chi}+2t$.

This is the same as for score four. Therefore, the distribution was considered up to four of the score.

The number of points where the scores are more than four is 24. Among these, 10 are found in the terrain of peridotite and 14 in that of sedimentary rock facies. The ratio of number of high score samples to the whole number of samples is 1.08 per cent in the peridotite and 1.86 per cent in the sedimentary rock facies. When the sedimentary rock facies is divided into sandstone and basalt, the ratios are 30.0 per cent and 1.09 per cent respectively.

Thus it was made clear that basalt held the first priority from the standpoint of rock facies. It must be noted, however, that the number of samples collected in the basalt terrain is scarce and that basalt was treated as the sedimentary rock facies collectively because it belongs to the same formation of the sedimentary rocks.

The high score (four and five in score) zone is classified into the zones form I to V. These zones are shown in Fig. III-9 (shown as areas I - V).

It can be assumed that the distribution of the high score zones is influenced by the rock facies represented by the Zone IV, and that it is controlled by the structures including the faults represented by the Zone II and Zone III. The Zone I and Zone V are not necessarily consistent with such geological environments.

(iv) Discussion

Regarding the five zones extracted by the score sum method, discussion is made on the possibility of extracting geochemical anomalous zones taking into account the alteration zones and mineralized zones obtained by geological mapping.

The characteristics of the zones are as follows (Fig. III-9).

Zone I:

The distribution is consistent very well with that of lateritic soil in the peridotite. Cu and Pb anomalies were obtained by statistical treatment of the geochemical survey data.

Zone II:

The distribution is consistent with the spread of lateritic soil found in the area where peridotite is in a fault contact with sandstone. The geochemical survey detected the anomalies of three elements such as Cu, Pb and Zn.

Zone III:

The distribution is consistent with the weakly argillized zone in sandstone developed along the fault. Although the geochemical survey detected the anomalies of Cu, Pb and Zn, their assay values are relatively low.

Zone IV:

The zone is found in the basalt terrain and overlaping lateritic soil and argillized zone. The geochemical survey detected the anomalies of Cu and Zn, but no Pb anomaly was found.

Zone V:

The zone is distributed in sandstone. The relationship with alteration and mineralization is indistinct. Correlation with structural factors including fault are also unclear. Geochemical survey detected the anomalies of Cu, Pb and Zn.

From the above, Zone I, Zone II and Zone IV may be extracted as the geochemical anomalous zones. All of these are considered to be closely associated with lateritic soil. However, it should be noted that these zones are different in their characters because these anomalous zones have different characteristics in rock facies and structures and have different combination of elements showing the anomalous values. On the other hand, Zone III appears to be a local anomaly along the fault, showing relatively low anomalous values.

As to Zone V, relationship with alteration and mineralization obtained from geological mapping is indistinct, leading to difficult judgement at the present stage.

The geochemical survey resulted in detection of no anomalies as to the floats of massive sulphide ore distributed along the Lingangaa creek.

(2) The result of Phase II is as follow.

Single-Variate Analysis

Since there is significant differences in the metal content of each rock distributed in the survey area from the result of analysis in Phase I, it is desirable to investigate by divid-

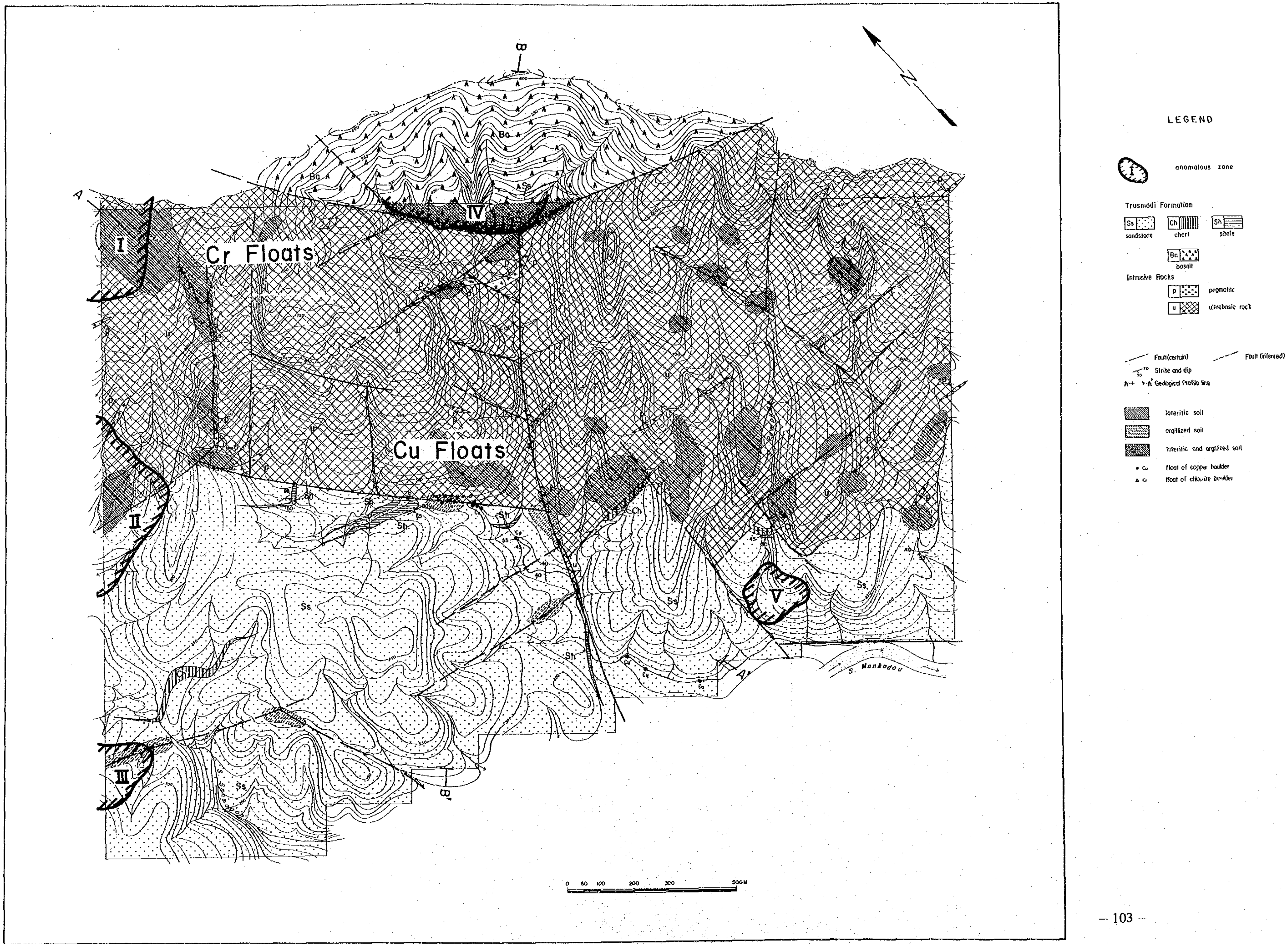


Fig. III-9 Geochemical Interpretation Map of Mankadau (bI) Area

ing into each rock facies. But the analysis was performed in one group in this year without dividing into each rock facies, because of small number of samples collected, such as 289, including 53 collected during Phase I.

Fig. III-10 shows the histogram of each element. According to the figure, in spite of Cu and Zn showing the normal distribution, Au and Pb show the bimodal distribution, and Mo does not show any regularity.

The cumulative frequency curve (Fig. III-11) shows that Cu, Pb and Zn are approximately on a straight line, and Au is on a curve close to the straight line although it is dispersed to some extent. Only Mo is exception. Therefore, the threshold value $\bar{\chi} + 2t$ was adopted, which correspond to about 2.5 per cent of the whole population and is generally used for the analytical procedure in the geochemical survey.

For the analysis, it was necessary to utilize the assay data of Phase I, those values were interpolated using the values estimated from the trend of distribution of metal content, because 29 samples among 53 samples have not been chemically analyzed for Au and Mo.

For the extraction of anomalies, the values of not only the threshold but also $\bar{\chi}$ + 0.5t, $\bar{\chi}$ + 1.0t and $\bar{\chi}$ + 1.5t as were supplementarily used. Table III-4 shows these statistic values and correlation factors between the elements.

Factor Analysis

The factor analysis is a method to set up a small number of theoretical variates (factor) from many variates and to indicate, by factor score, how much each sample maintains these factors.

In the case of the geochemical data, it is expected that some of these factors generally indicate some kinds of the mineralization and the rock facies and it is thought that the factor score would tell the intensity of mineralization of each sample.

The above mentioned procedure is treated by the varimax method using computer.

(i) Distribution of Elements

Each distribution of five elements such as gold, copper, lead, zinc and molybdenum are as follows:

Gold (Au): A high content of gold, not corresponding to the geology, is distributed (on the high slope) in the eastern area, eventhough no distinct characteristic point can be detected.

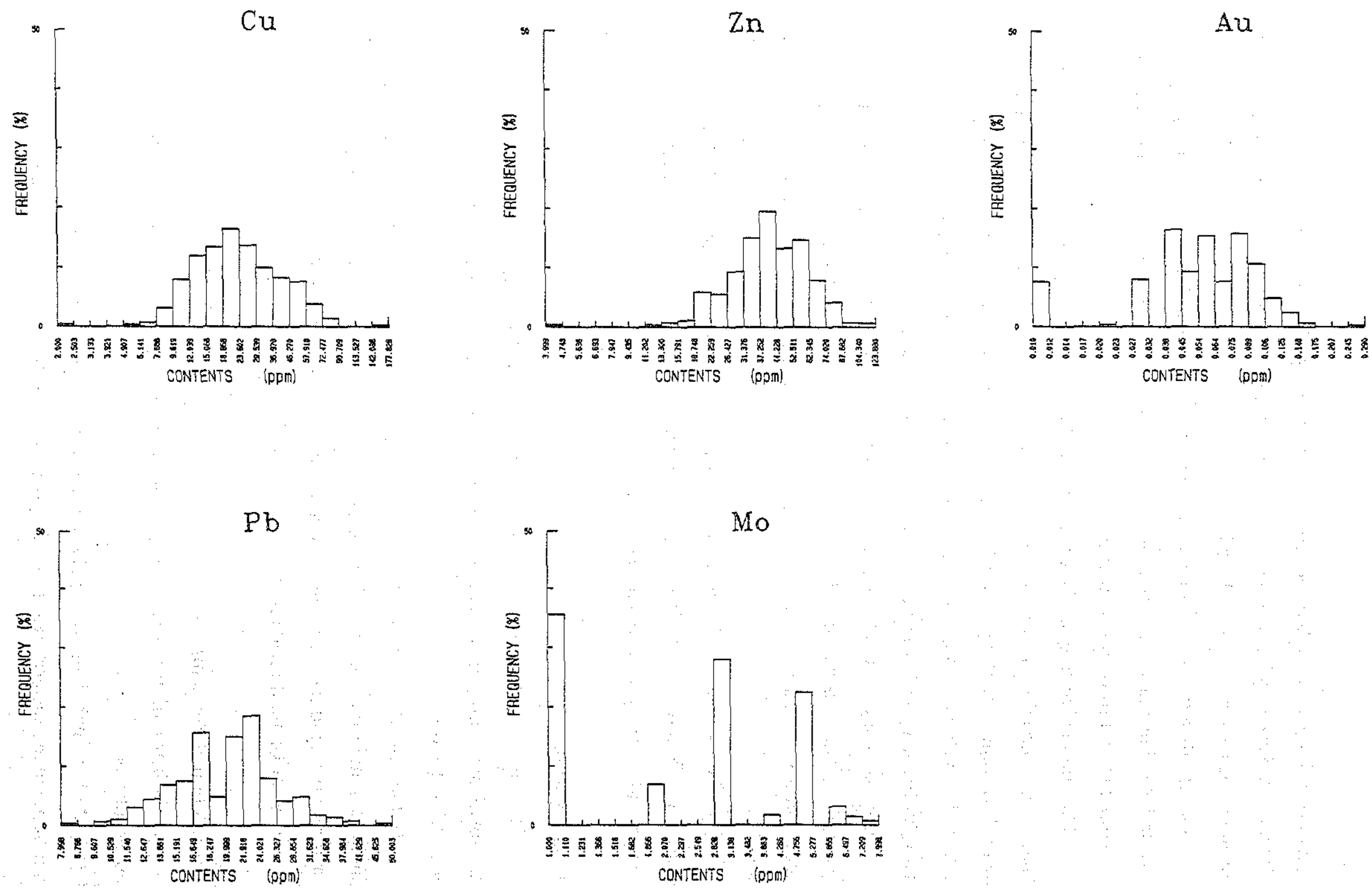


Fig. III-10 Histgram for Soil Samples in Mankadau (bII) Area

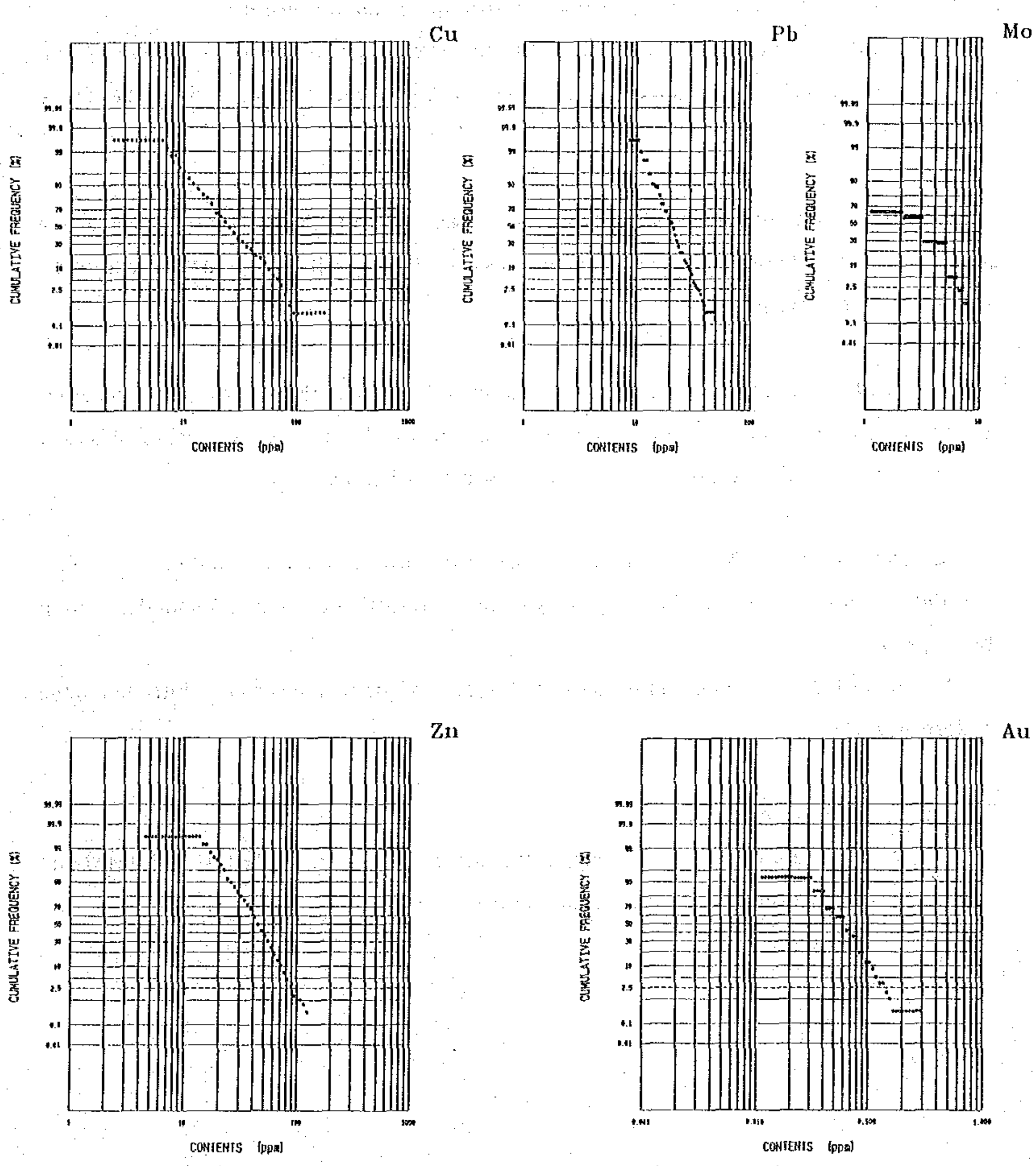


Fig. III-11 Cumulative Frequency Curve for Soil Samples in Mankadau (bII) Area

Copper (Cu): It has a tendency that the copper content is high in spilitic basalt lava and relatively high value is obtained in peridotite which is distributed in the eastern area. A limited anomaly has been detected in hornfels which is distributed in the western area.

No dominant anomalies were confirmed in the area, where many floats of massive sulphide copper ore scatter along the upper reaches of the Lingangaa creek so far, as well as Phase I survey.

Lead (Pb): The lead distribution tends to increase in sedimentary rock and decrease in basalt lava and peridotite, and it shows high values exceeding $\bar{\chi} + 2t$ (= 64 ppm) in the hornfels occurring in the western area.

Zinc (Zn): It shows high values in peridotite and in basalt, and the pattern of distribution is similar to the pattern of copper. In the area of sedimentary rock, the value is very low. It is clear that the copper variation coinsides with the difference of rock facies.

Molybdenum (Mo): No prominent tendency of the distribution is found due to relatively low content. However, a local difference may be distinguished as a value of 6 ppm detected in the western area.

No high value is distributed in the surrounding area of adamellite porphyry intruded in the western area.

(ii) Results of Factor Analysis

As the result of the factor analysis, the factor-1 (Cu-Zn), the factor-2 (Pb-Mo) and the factor-3 (Au-Pb) have been detected (Table III-5).

Table III-4 Statistic Values for Soil Samples in Mankadau (bII) Area

Cu (ppm)	Number of samples		289
	Maximum value	(Vmax)	178
	Minimum value	(Vmin)	2
	Geometric mean	($\bar{x}$)	23.0
	Standard deviation	(t)	0.249
	$10^{\log\bar{x}+t}$		41
	$10^{\log\bar{x}+2t}$		72
Pb (ppm)	Number of samples		289
	Maximum value	(Vmax)	50
	Minimum value	(Vmin)	8
	Geometric mean	($\bar{x}$)	19.9
	Standard deviation	(t)	0.119
	$10^{\log\bar{x}+t}$		26
	$10^{\log\bar{x}+2t}$		34
Zn (ppm)	Number of samples		289
	Maximum value	(Vmax)	124
	Minimum value	(Vmin)	4
	Geometric mean	($\bar{x}$)	40.8
	Standard deviation	(t)	0.179
	$10^{\log\bar{x}+t}$		62
	$10^{\log\bar{x}+2t}$		93
Mo (ppm)	Number of samples		289
	Maximum value	(Vmax)	8
	Minimum value	(Vmin)	1
	Geometric mean	($\bar{x}$)	2.3
	Standard deviation	(t)	0.297
	$10^{\log\bar{x}+t}$		5
	$10^{\log\bar{x}+2t}$		9
Au (ppm)	Number of samples		289
	Maximum value	(Vmax)	0.29
	Minimum value	(Vmin)	0.01
	Geometric mean	($\bar{x}$)	0.54
	Standard deviation	(t)	0.272
	$10^{\log\bar{x}+t}$		0.10
	$10^{\log\bar{x}+2t}$		0.19

Correlation Matrix

	Cu	Pb	Zn	Mo	Au
Cu	1.000				
Pb	.075	1.000			
Zn	.734	.021	1.000		
Mo	.037	.200	.047	1.000	
Au	.062	.178	.066	.074	1.000

Table III-5 Result of Factor Analysis

Factor Loading

Cu	factor-1 .845	factor-2 .059	factor-3 .128
Pb	.004	.345	.321
Zn	.852	.038	.091
Mo	.011	.446	.100
Au	.016	.089	.420

Factor Contribution

factor	contribution
1	1.4398
2	.3308
3	.3143

Communarity

Cu	.7340
Pb	.2225
Zn	.7349
Mo	.2089
Au	.1847

(a) Factor-1

The factor loading shows a high value of Cu:0.845, Zn:0.852. Because of the high correlation coefficient between copper and zinc, it may be the factor explaining the close relationship between these elements.

The samples showing the high factor score in plus (Fig. III-12) are abundantly distributed in the basalt lava of the eastern area and the high score in minus are abundant in the hornfels of the western area. There are some possibilities that it is the factor characterizing the occurrence of basalt lava and hornfels, as confirmed by the single variate analysis for copper or zinc element. Since the geochemical anomalies of the stream sediments by the United Nations program and the weakly pyrite disseminated zone by Phase II survey are detected in the area of hornfels and peridotite zone which is distributed in the western area, some effects of the mineralization can be considered (Fig. III-13).

Regarding the group of high factor score in minus concentrating around Paranchangan area, it has been delivered from the high contamination caused by the present artificial development.

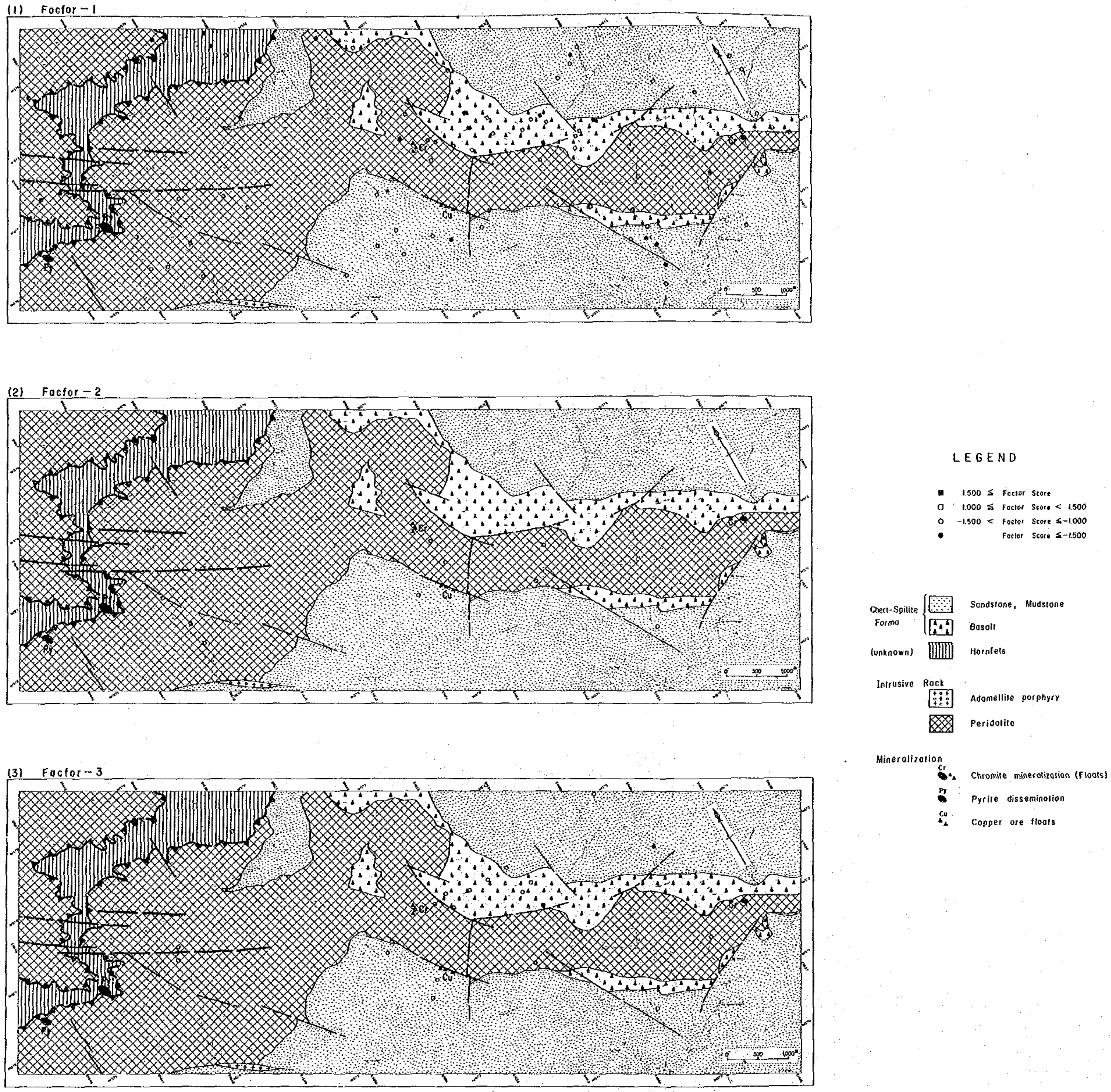


Fig. III-12 Map showing Distribution of Factor Score in Mankadau (bII) Area

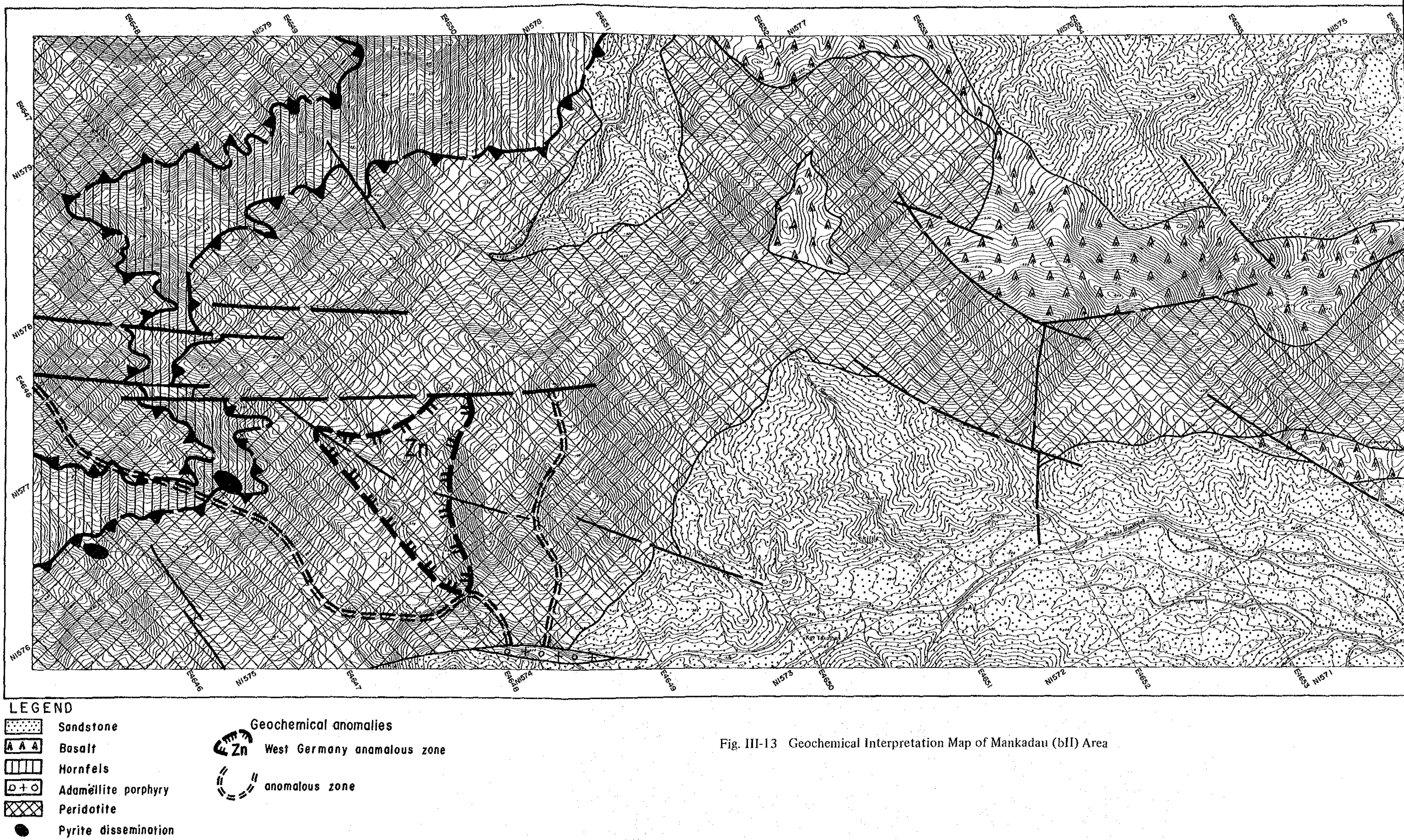


Fig. III-13 Geochemical Interpretation Map of Mankadau (bII) Area

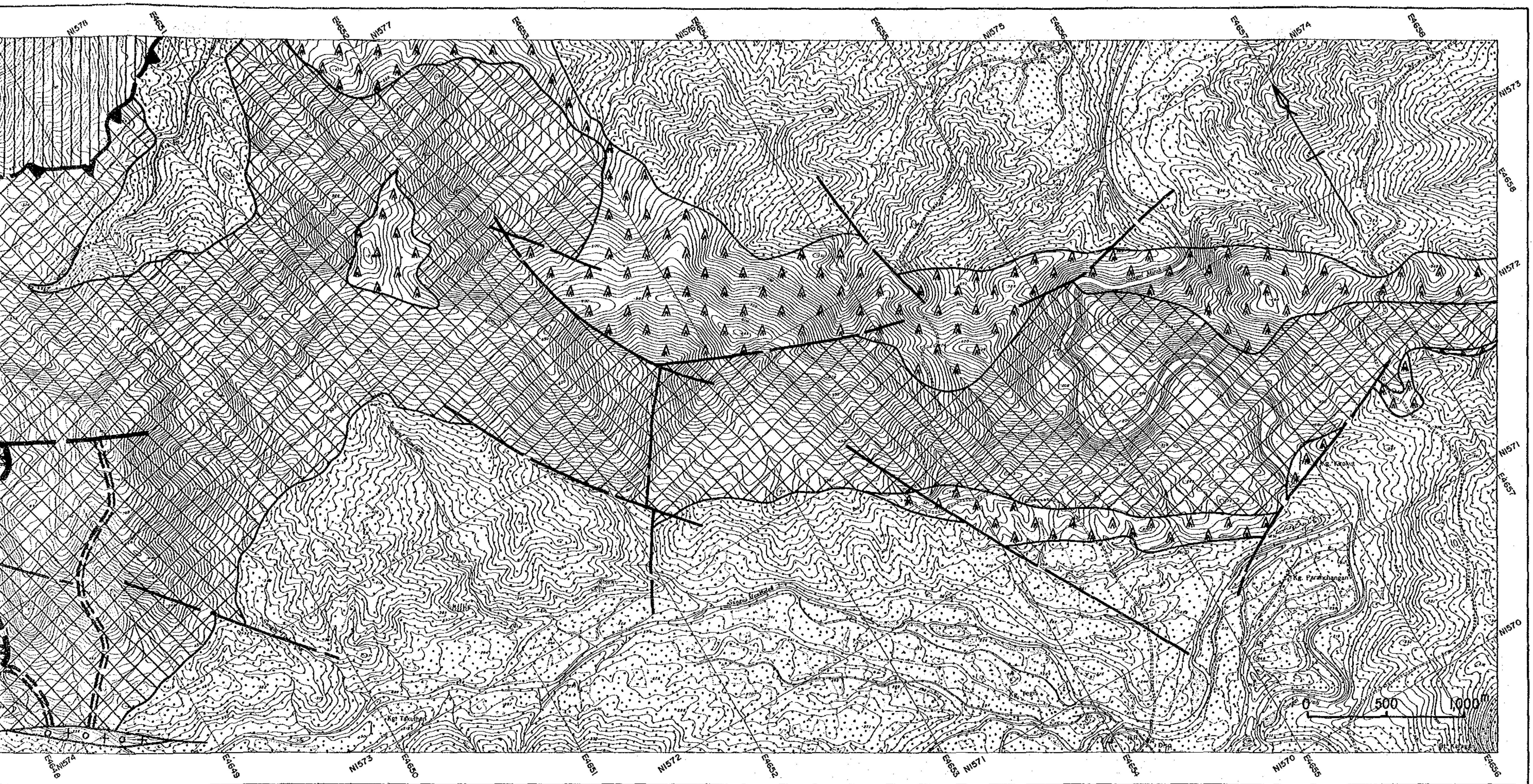


Fig. III-13 Geochemical Interpretation Map of Mankadau (bII) Area

(b) Factor-2

It shows rather high factor loading of lead and molybdenum. There are some correlation between lead and molybdenum from the single variate analysis. The ratio of the factor contribution is 0.33, a lower value than that of factor-1. The factor scores are generally low and the samples which have high factor scores only scatter in the peridotite of the central and the western areas.

(c) Factor-3

The factor characterizing the relation of gold and lead, shows the similar factor contribution to factor-2. The factor scores are generally low and the samples which have high factor score scatter in the basalt lava of the central area.

(iii) Discussion

No independent factor representing the mineralization has been drawn out so far. Factor-1 is the one reflected the rock facies, moreover it is distributed in the peridotite and the hornfels zones which have originally less contents.

Therefore, it is assumed that the partial samples of high factor scores contain some factor indicating the mineralization eventhough it is very weak.

In and around the Lingangaa creek, no high factor scores were obtained in any combination of the factor. It is to say that the zone of weak pyritization in western part of the area which has a high Cu-Zn factor score, has no direct relationship with the secondary massive sulphide ore floats, since they have few zinc content (Fig. III-12, III-13).