Chapter 4. Results of Drilling Survey

4–1 General Description

The drilling exploration was conducted to confirm the subsurface extension of the manganese outcrop No.110 that is the largest one in the area A. In this exploration a total drilled length of 300.00 m was achieved by 17 drill holes at 8 sites.

The manganese outcrop No.110 is located along ridges of low hills, 75 to 90 m above sea level, in the area A. The general strike and dip are N45°W and 30 ~ 80°S in the eastern part while E–W and N-dipped in the central to western part. The manganese beds show a tendency that in the eastern part ore beds are thicker than those in the western part.

According to these surface ore occurrence, 12 drill holes out of all 17 holes were drilled in the eastern part and the remaining 5 holes in the western part.

By this exploration ore beds were confirmed in 11 drill holes, although the proven range of the extensions are generally less than 20 m below surface. The maximum depth of the ore bed confirmed is 24.70 m by the No.9 drill hole.

The geology, ore beds, and ore grade in each drill hole are described hereafter. The details are shown as geological logs on a scall of 1:200 in Fig. A–5. In this drilling exploration, the drill-hole lithology was compiled by the observations of cuttings. Cuttings were distinguished according to their tone as red chert, white chert, brown to light brown chert, and black chert. The black chert includes manganese minerals, therefore, black chert can be treated as ore bed. Shale was not distinguished clearly because it generally tended to be minutely pulverized.

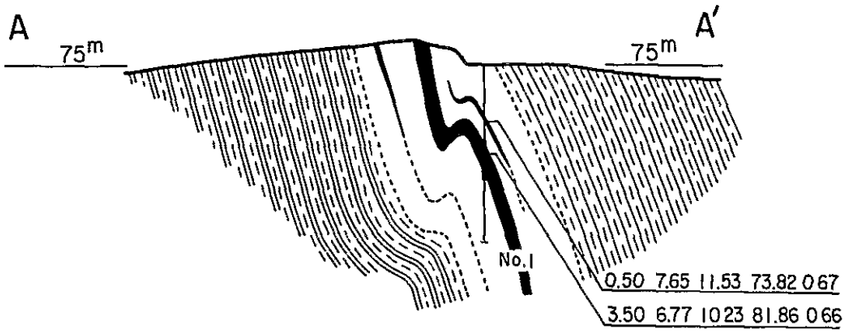
Based on the geology of each hole geological profiles were made as shown in Fig. II–2–1~2.

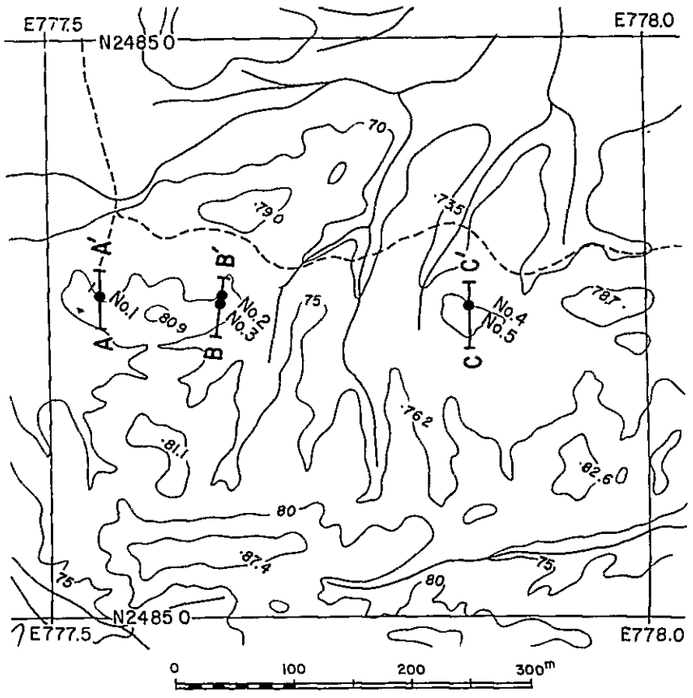
4–2 Geology of Drill Hole

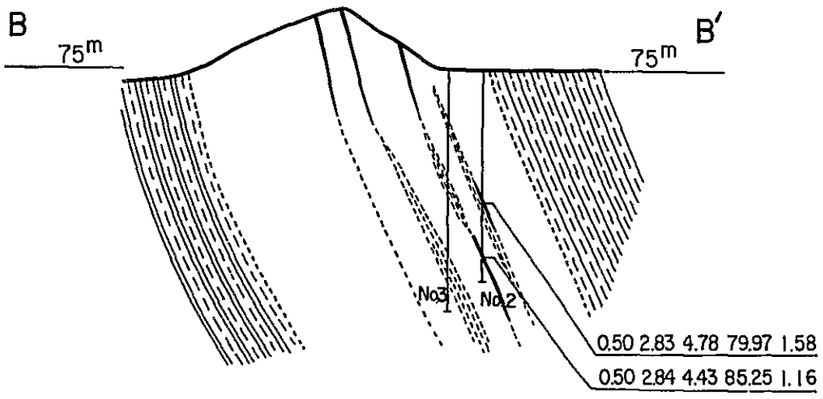
4–2–1 No.1 drill hole

The No.1 drill hole was, as shown in Fig. II–1, conducted at the western end of the manganese outcrop No.110 to check the subsurface extensions of the outcropping ore beds. The drilling area is underlain by the alternation of light gray to light pink chert and reddish brown shale. General strike and dip of the alternation are N70°E and 80°N. A 1-m-thick manganese bed, EW-trended and 85°N-dipped, is exposed to the south of the drilling site.

The drill-hole geology is as follows: 0–3.00 m; red chert and white chert, 3.00–4.50 m; red chert and rare black chert, 4.50–5.00 m; manganese ore, 5.00–6.50 m; brown chert, 6.50–10.00 m; manganese ore, 10.00–11.50 m; brown chert, 11.50–13.50 m; red chert and white chert, 13.50–15.50 m; red chert and light brown chert.







LEGEND

- alternating bed of white chert and light gray shale
- alternating bed of white chert and reddish brown shale
- alternating bed of reddish brown muddy chert and reddish brown shale
- manganese layered ore
- manganese nodular ore

Sampling width (m)	Mn (%)	Content of Elements MnO_2(%)	SiO_2(%)	Fe (%)
0.50	7.65	11.53	73.82	0.67

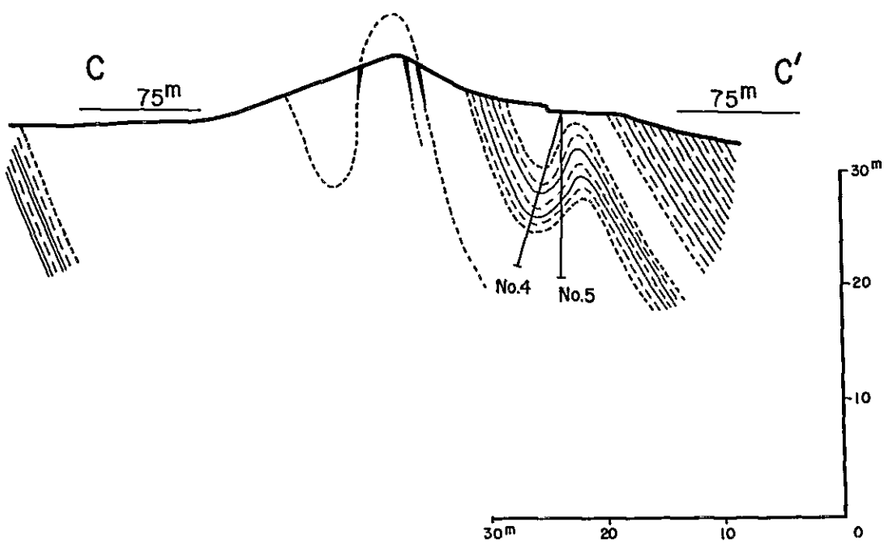
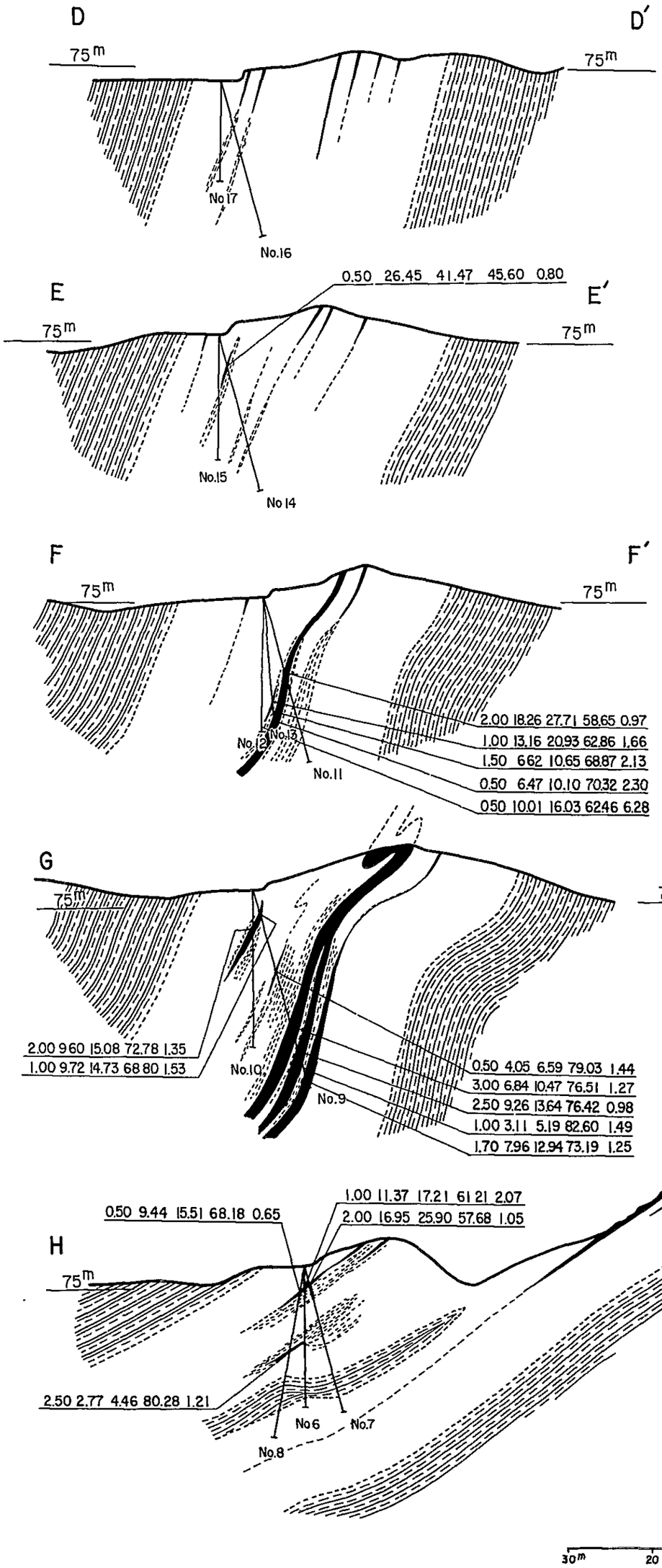
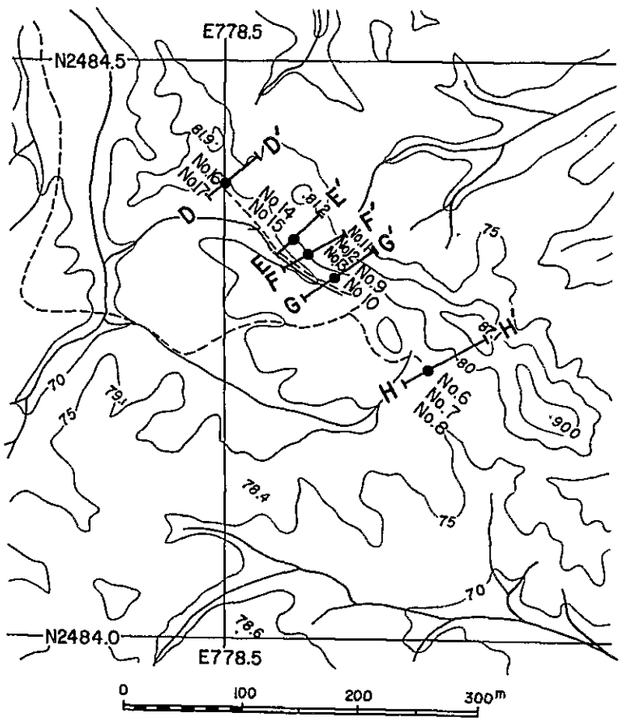


Fig. II—2—1 Geological Profile of the Drilling Area (No. 1~5)





LEGEND

- alternating bed of white chert and light gray shale
- alternating bed of white chert and reddish brown shale
- alternating bed of reddish brown muddy chert and reddish brown shale
- manganese layered ore
- manganese nodular ore

Sampling width (m)	Mn (%)	Content of Elements MnO_2(%)	SiO_2(%)	Fe (%)
1.00	18.55	27.60	58.65	0.95

Fig. II—2—2 Geological Profile of the Drilling Area (No. 6~17)

By this drilling two ore beds were encountered. The lower ore bed is, as shown in Fig. II–2–1, considered to be the lower extension of the outcrops. The ore beds are estimated to continue showing small-scale anticline and syncline. The assay of the ore beds is shown below. The ore grades are generally low as about 10% MnO_2.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L1	4.50– 5.00	0.50	7.65	11.53	73.82	0.67
L2	6.50– 7.00	0.50	5.23	8.04	84.71	0.86
L3	7.00– 7.50	0.50	7.55	11.46	80.31	0.67
L4	7.50– 8.00	0.50	9.05	14.08	77.01	0.61
L5	8.00– 8.50	0.50	4.94	7.49	83.17	0.88
L6	8.50– 9.00	0.50	5.27	7.70	85.26	0.63
L7	9.00– 9.50	0.50	9.71	14.77	76.61	0.49
L8	9.50–10.00	0.50	5.65	8.04	85.94	0.47

4–2–2 No.2 drill hole

The No.2 drill hole was conducted to make clear the lower extension of the manganese beds in the western part of the outcrop No.110. The drilling area is underlain by the alternation, of light gray chert and reddish brown shale trending N70°E and dipping 70°N. 20 to 30 cm thick of manganese beds trending N60°E, dipping 60° to 70°N are exposed to the south of the drilling site.

The drill-hole geology is as follows; 0–10.00 m; mainly red chert (4.00–6.00 m and 8.00–10.00 m; white chert), 10.00–11.00 m; brown chert, 11.00–11.50 m; manganese ore, 11.50–13.50 m; brown chert, 13.50–15.50 m; red chert and white chert, 15.50–16.00 m; manganese ore, 16.00–18.30 m; red chert and brown chert (rare white chert).

The two ore beds encountered are considered to be the lower extension of the 10 cm-think of ore beds to the north of the main outcrop. The assay of the ore beds is shown below. The ore grades are low as about 5% MnO_2.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L9	11.00–11.50	0.50	2.83	4.78	79.97	1.58
L10	15.50–16.00	0.50	2.84	4.43	85.25	1.16

4–2–3 No.3 drill hole

The No.3 drill hole was, as shown in Fig. II–1, conducted at the point to the south of the No.2 drill hole in the western part of the outcrop No.110. The drilling site is under lain by the alternation of reddish brown chert and reddish brown shale.

The drill-hole geology is as follows: 0–8.00 m; mainly red chert (3.00–5.00 m; rare black chert, 4.00–7.00 m; white chert), 8.00–11.00 m; brown chert and rare black chert, 11.00–15.00 m; red or purple chert and minor white chert, 15.00–20.00 m; brown chert and rare black chert.

By this drilling no main ore bed was recognized but 3 minor black chert beds. These beds are, as shown in Fig. II–2–1, probably lower extensions of the ore beds of the surface and upper extensions of the ore beds in the No.2 drill hole. From these mode of occurrences the ore beds are estimated to be intermittent in both directions of strike and dip.

4–2–4 No.4 drill hole

The No.4 drill hole was, as shown in Fig. II–1, conducted to make clear the subsurface extention of the ore beds in the western part of the outcrop No.110.

The drilling site is underlain by the thick alternation of brown muddy chert, brown chert, and reddish brown shale and by the thin alternation of light gray chert and light gray shale. These alternations trend N70°E to EW and show small-scale paired anticlinal-synclinal structures.

The drill-hole geology is as follows: 0–5.00 m; red chert, 5.00–6.00 m; red chert and white chert, 6.00–11.00 m; white chert, 11.00–14.00 m; red chert.

No ore bed was encountered in this drill hole, however, the fold structure was clearly deliniated as shown in Fig. II–2–1.

4–2–5 No.5 drill hole

The No.5 drill hole was conducted to confirm the deeper extension of the exposed ore beds at the same site of No.4.

The drill-hole geology is as follows: 0–1.00 m; red chert and white chert, 1.00–9.00 m; white chert, 9.00–14.50 m; white chert and red chert.

No ore bed was recognized by this drilling, however, as shown in Fig. II–2–1, the white chert part of this hole continues to the white chert part of the No.4 drill hole and, farther, to the alternation of light gray chert and shale on surface deliniating an anticlinal structure.

4–2–6 No.6 drill hole

The No.6 drill hole was conducted at the eastern end of the outcrop No.110 as shown in Fig. II–1. The drilling was aimed to confirm the subsurface continuation of the exposed ore beds.

The drilling site is occupied by the alternation of brown muddy chert and shale. The alternation trends N45°W and dips 15° to 40°S. A 2-m-thick ore bed lies on the slope and another 50-cm-thick one comes under the main bed.

The drill-hole geology is as follows: 0–1.00 m; red chert and white chert, 1.00–2.00 m; brown chert and minor black chert, 2.00–3.00; manganese ore, 3.00–9.50 m; mainly brown chert (7.00–9.50 m; brown chert and rare black chert), 9.50–16.00 m; red chert and white chert (14.00–15.00 m; white chert only), 16.00–17.00 m; light brown chert.

In this drill hole, one ore bed was recognized. The ore bed is, as shown in Fig. II–2–1, the extension of the ore bed exposed 7 m north of the drill hole. This drill hole did not reach the extension of the target outcrop. The assay of the ore bed encountered is shown below.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L11	2.00–2.50	0.50	11.18	16.98	61.74	2.07
L12	2.50–3.00	0.50	11.55	17.44	60.68	2.07

4–2–7 No.7 drill hole

The No.7 drill hole was conducted at the same drilling site of the No.6 drill hole to confirm the lower part of the outcrops.

The drill-hole geology is as follows: 0–2.00 m; red chert and brown chert, 2.00–4.00 m; manganese ore, 4.00–8.00 m; brown chert and rare black chert, 8.00–11.00 m; brown chert, 11.00–13.00 m; red chert and white chert, 13.00–16.00 m; white chert, 16.00–18.00 m; red chert.

By this drilling one ore bed was recognized. The bed is the same one found in the No.6 drill hole. The assay of the ore bed is shown below.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L13	2.00–3.00	1.00	21.04	32.00	49.41	0.88
L14	3.00–4.00	1.00	12.86	19.80	65.94	1.21

4–2–8 No.8 drill hole

The No.8 drill hole was conducted at the same site of the No.6 drill hole to confirm the lower part of the outcrop of ore beds and white chert beds.

The drill-hole geology is as follows: 0–1.00 m; red chert and white chert, 1.00–3.00 m; red chert and rare black chert, 3.00–3.50 m; manganese ore, 3.50–8.00 m; brown chert and rare black chert, 8.00–10.50 m; manganese ore, 10.50–21.00 m; mainly red chert (15.00–18.00 m; white chert).

In this drill hole two ore beds were recognized. The upper bed is likely the extension of the ore bed in the No.6 drill hole, and the lower bed probably continue to the black chert bed found in the depth interval of 7.00 to 9.00 m of the No.6 drill hole. Consequently, the main ore bed was not reached even by this hole. As shown in Fig. II–1 the extention of the main outcrop probably lies in deeper part. The assay of the ore beds in this hole is shown below.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L15	3.00– 3.50	0.50	9.44	15.51	68.18	0.65
L16	8.00– 8.50	0.50	3.04	5.03	83.23	1.45
L17	8.50– 9.00	0.50	2.58	4.10	80.19	1.67
L18	9.00–10.00	1.00	1.74	2.89	81.48	0.65
L19	10.00–10.50	0.50	4.75	7.40	75.04	1.62

4–2–9 No.9 drill hole

The No.9 drill hole was, as shown in Fig. II–1, conducted to confirm the lower part of the relatively continuous outcrops in the eastern part of the outcrop No.110. The drilling site is occupied by the alternation of brown muddy chert and shale that trends N45°W and dips 60° to 70°S. To the north of the site 2 m thick of ore bed is exposed with another samll-scaled 3 ore bes.

The drill-hole geology is as follows: 0–2.50 m; brown chert and red chert, 2.50–3.50 m; manganese ore, 3.50–10.00 m; brown chert and minor red chert, 10.00–11.50 m; manganese bed, 11.50–16.00 m; brown chert and rare black chert, 16.00–24.70 m; manganese ore.

Among the 3 ore beds found in this drill hole, the upper 2 beds are small-scalled. The 2-m-thick ore bed on the surface is considered to continue to the lowest ore bed of the drill hole. This bed extends more than 30 m from the surface showing a gentle fold structure as shown in Fig. II–2–2.

The assay of the ore beds is shown below. The relatively high-grade part (32.22% MnO_2)

is recognized in the depth interval of 21.00 to 21.50 m. The remaining parts are generally of low grade (5.19 to 17.88% MnO_2).

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L20	2.50– 3.00	0.50	11.65	17.25	65.60	1.48
L21	3.00– 3.50	0.50	7.79	12.20	71.99	1.58
L22	10.00–10.50	0.50	4.05	6.59	79.03	1.44
L23	16.00–16.50	0.50	9.94	14.98	71.79	0.92
L24	16.50–17.00	0.50	5.67	9.20	76.31	1.55
L25	17.00–17.50	0.50	4.08	7.10	75.48	2.01
L26	17.50–18.00	0.50	8.50	13.22	75.32	1.26
L27	18.00–18.50	0.50	7.19	10.97	77.33	1.14
L28	18.50–19.00	0.50	5.66	7.32	82.81	0.74
L29	19.50–20.00	0.50	4.79	7.54	78.64	1.80
L30	20.00–20.50	0.50	6.01	8.46	85.25	0.57
L31	20.50–21.00	0.50	8.79	12.54	77.26	0.83
L32	21.00–21.50	0.50	21.76	32.22	54.03	0.99
L33	21.50–22.00	0.50	4.94	7.45	86.93	0.69
L34	22.00–23.00	1.00	3.11	5.19	82.60	1.49
L35	23.00–24.00	1.00	5.99	9.49	77.94	1.26
L36	24.00–24.70	0.70	10.79	17.88	66.41	1.23

Manganese minerals and gangue minerals were identified by X-ray diffraction on 3 samples (L26, L32, L35) and by microscopic observation on 1 sample (L32). The results are shown in Table A–2 and A–4. The noteworthy points are that relatively much amount of cryptomelane was detected from L32 and that a weak peak of rhodochrosite was obtained from L35.

4–2–10 No.10 drill hole

The No.10 drill hole was conducted at the same site of No.9 drill hole to investigate the deeper extention of the outcrops.

The drill-hole geology is as follows: 0–3.00 m; red chert and white chert, 3.00–4.00, brown chert, 4.00–6.00; manganese ore, 6.00–19.00; mainly brown chert (minor black chert at 10, 15, and 16 m).

The ore bed found in this drill hole is, as shown in Fig. II–2–2, the extension of the small-

scale bed on surface and the black chert beds from 10 to 16 m depth might continue to the ore bed at 10 m depth of the No.9 drill hole. The assay of the ore beds found in this drill hole is below. The ore beds are of low grade.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L37	4.00–5.00	1.00	10.95	17.88	65.30	1.98
L38	5.00–6.00	1.00	8.25	12.28	80.25	0.71

4–2–11 No.11 drill hole

The No.11 drill hole, as shown in Fig. II–1, was conducted to catch the subsurface extension of the exposed ore beds in the eastern part of the outcrop No.110. The drilling site is underlain by the alternation of brown muddy chert and shale that strikes N45°W and dips 75° to 85°S. Two ore beds, 1.9 m and 0.5 m in thickness, are exposed to the north of the drilling site.

The hole-geology is as follows: 0–8.50 m; mainly red chert, 8.50–12.50 m: manganese ore, 12.50–13.50 m; brown chert and minor black chert, 13.50–18.00 m; manganese ore and minor brown chert, 18.00–21.00 m; brown chert.

By this drilling 2 ore beds were recognized. These ore beds are considered to continue up to the two outcrops as shown in Fig. II–2–2. The assay of the upper bed is as follows:

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L39	9.50–10.50	1.00	13.52	21.36	63.82	1.43
L40	10.50–11.50	1.00	22.99	34.05	53.48	0.51

4–2–12 No.12 drill hole

The No.12 drill hole was conducted at the same site of the No.11 drill hole to check the deeper continuation of the outcrops.

The drill-hole geology is as follows: 0–15.00 m; red chert and rare white chert, 15.00–16.00 m; brown chert and minor black chert, 16.00–16.50 m; manganese ore.

The ore bed recognized is inffered to continue to the ore bed found in the No.11 drill hole.

The assay of the ore bed is below. The ore bed shows extremely high Fe-content comparing to those of other ore beds. The high Fe content is probably due to the Fe-rich chert. However, the detail is not yet clear.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L41	16.00–16.50	0.50	10.01	16.03	62.46	6.28

4–2–13 No.13 drill hole

The No.13 drill hole was conducted at the same site of the No.11 and 12.

The drill-hole geology is as follows: 0–12.50 m; mainly red chert, 12.00–12.50 m; black chert, 12.50–15.50 m; manganese ore.

The ore bed found is the extension of that of the No.11 drill hole. The assay of the ore bed is below. The relatively high-grade part occurs in the depth interval of 12.50 to 13.00 m. (26.32% MnO_2). The deeper parts show slightly high Fe contents.

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L42	12.50–13.00	0.50	16.23	26.32	59.27	1.37
L43	13.00–13.50	0.50	10.08	15.53	66.44	1.95
L44	13.50–14.00	0.50	5.96	9.92	72.46	1.99
L45	14.00–15.00	1.00	6.95	11.02	67.08	2.20
L46	15.00–15.50	0.50	6.47	10.10	70.32	2.30

4–2–14 No.14 drill hole

The No.14 drill hole, as shown in Fig. II–1, was conducted to check the lower extensions of the ore outcrops in the eastern part of the outcrop No.110.

The drilling site is occupied by the alternation of brown muddy chert and shale that strikes N50°W and dips 60°S. Many ore beds are exposed to the north of the drilling site.

The drill-hole geology is as follows: 0–3.50 m; mainly brown chert, 3.50–4.00 m; manganese ore, 4.00–19.00 m; mainly brown chert (rare black chert).

The ore bed found in this drill hole is likely a small lens as shown in Fig. II–2–2. The black chert beds might be the extension of the ore beds on surface. The assay of ore sample is as follows:

Sample No.	Depth(m)	Interval length(m)	Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
L47	3.50–4.00	0.50	26.45	41.47	45.60	0.80

4–2–15 No.15 drill hole

The No.15 drill hole was conducted at the same site of the No.14 to check the lower continuation of the outcrops.

The drill-hole geology is as follows: 0–5.50 m; mainly red chert, 5.50–15.00 m; mainly brown chert. The black chert is found from 6.50 to 9.00 m in small scale.

No major ore bed was recognized in this drill hole, however, the minor black chert beds are, as shown in Fig. II–2–2, considered to be the extensions of the ore bed found in the No.14 drill hole.

4–2–16 No.16 drill hole

The No.16 drill hole, as shown in Fig. II–1, was conducted to check the subsurface extension of the ore beds in the eastern part of the outcrop No.110.

The drilling site is occupied by the alternation of reddish brown muddy chert and shale and by the alternation of brown muddy chert and shale. These beds strike N30°W and dip 70° to 80°S. Many ore beds are exposed to the north of the drilling site.

The drill-hole geology is mainly composed of brown chert. Minor black chert beds occur in the depth intervals of 5.00 to 6.00 m and 8.00 to 9.00 m.

No ore bed was found by this drilling. The two black chert beds are probably the extensions of the outcrops.

4–2–17 No.17 drill hole

The No.17 drill hole was conducted at the same site of the No.16.

The drill-hole geology is mainly composed of brown chert. Minor black chert beds were recognized in the interval of 1.00 to 10.00 m. Those black chert beds are the extensions of those found in the No.16 drill hole.

4–3 Summary of Results

By the drilling exploration it was confirmed that one ore bed near the No.9 drill hole extends to the depth of 30 m from the surface. However, the ore beds on surface show a tendency to grade into thin black chert beds within the range of 10 to 15 m below surface.

Therefore, it could be said that the dip-side continuity of the most ore beds is poor as same as the strike-side one.

According to the X-ray diffractions and microscopic studies, the manganese-mineral assemblage of the deeper part is almost similar to that of the outcrops.

By the results of the ore assaying, it was proven that the ore grades are generally low as an average grade of 13.49% MnO_2 although some small-scale high-grade parts occur. In contrast, Fe contents show higher values than those of outcrops. Particularly, the ore bed found in the No.12 drill hole shows the exceptionally high Fe content (6.28% Fe).

APPENDICES

APPENDICES

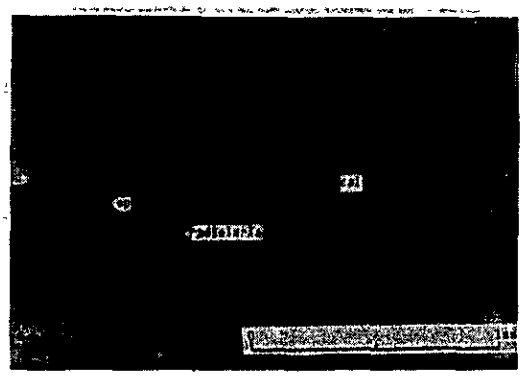
Fig. A—1 Microphotograph of Thin Section

Abbreviations

qz : quartz
pl : plagioclase
hy : hypersthene
au : augite
cal : calcite
chl : chlorite
serp : serpentine
Mn min. : manganese mineral
op : opaque mineral

only lower polar

Sample No. : G124
Location : N2457.5, E761.0
Formation : Halfa formation (Hmr)
Rock Name : yellow chert



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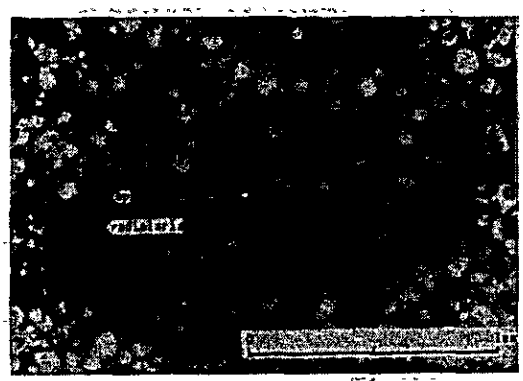
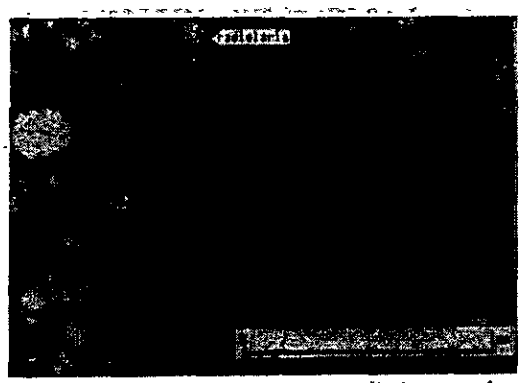
Sample No. : K104
Location : N2485.0, E777.5
Formation : Halfa formation (Hmw)
Rock Name : light grey chert



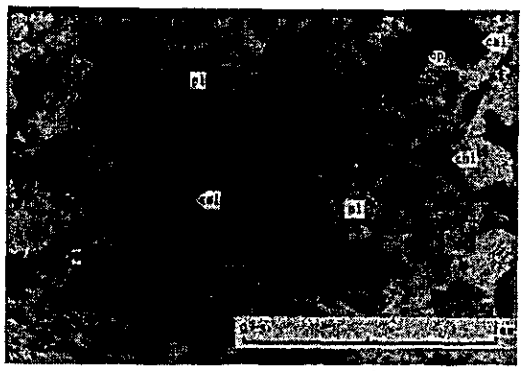
only lower polar

Sample No. : K106
Location : N2484.5, E778.5
Formation : Halfa formation (Hmr)
Rock Name : reddish brown chert

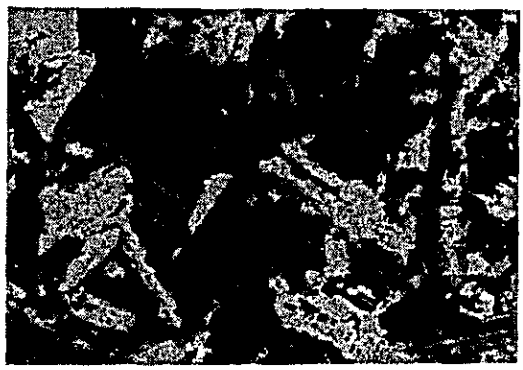


only lower polar

Sample No. : K112
Location : N2484.5, E778.5
Formation : Halfa formation (Hmr)
Rock Name : light brown muddy chert

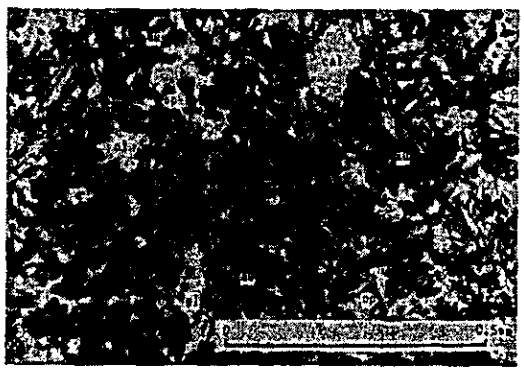


only lower polar

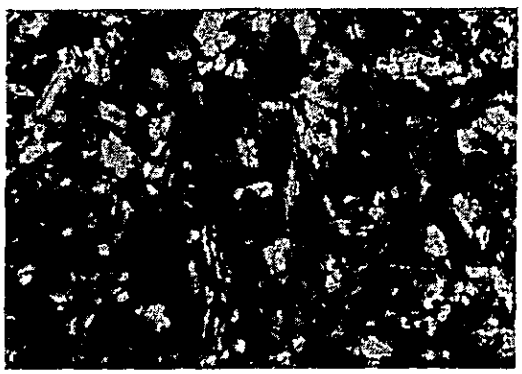


crossed ploars

Sample No. : H014
Location : N2453.5, E761.0
Rock Name : trachyandesite

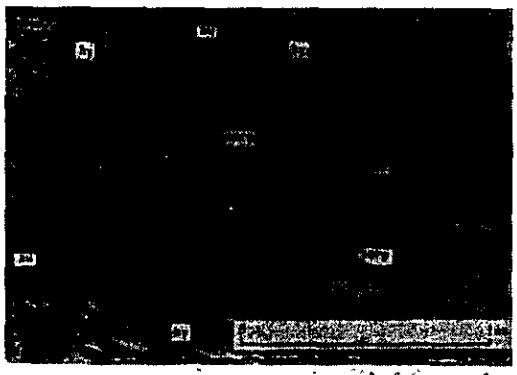


only lower polar



crossed ploars

Sample No. : K006
Location : N2453.5, E772.0
Rock Name : dolerite



only lower polar

crossed ploars

Sample No. : K150
Location : N2455.5, E763.5
Rock Name : Pyroxenite

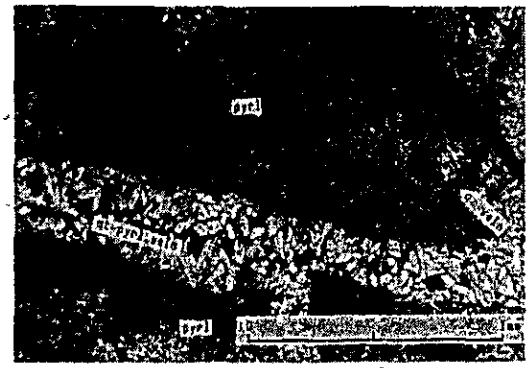
Fig. A—2 Microphotograph of Polished Section

Abbreviations

pyrl : pyrolusite

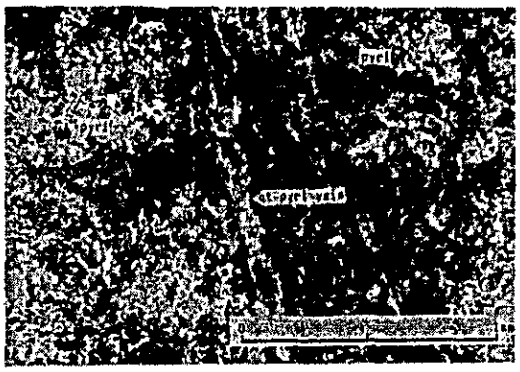
only lower polar

Sample No. : G015
Location : N2458.0, E760.5
Formation : Halfa formation (Hmr)
Ore Name : manganese ore
Type of Ore : banded



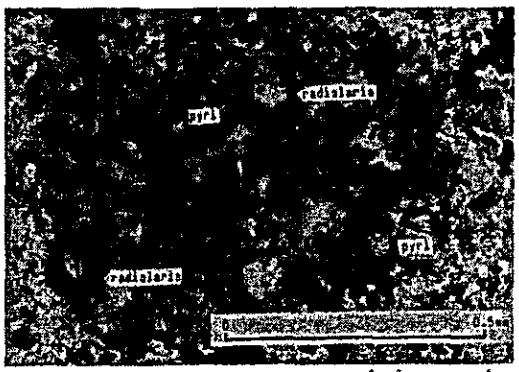
only lower polar

Sample No. : G020
Location : N2456.5, E761.0
Formation : Halfa formation (Hmr)
Ore Name : manganese ore
Type of Ore : network



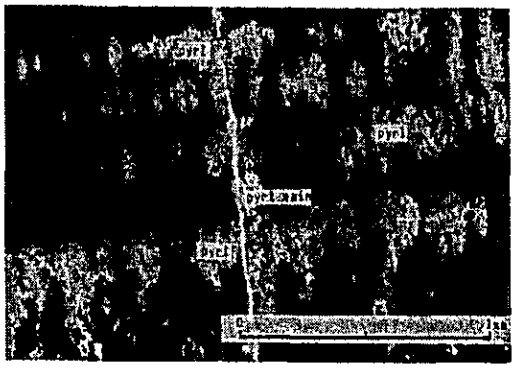
only lower polar

Sample No. : G058
Location : N2457.5, E760.5
Formation : Halfa formation (Hmr)
Ore Name : manganese ore
Type of Ore : nodular



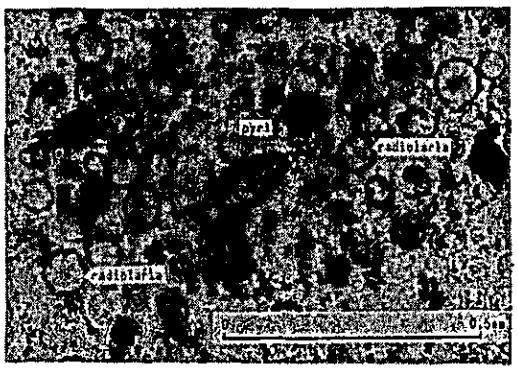
only lower polar

Sample No. : H048
Location : N2462.5, E759.5
Formation : Halfa formation (Hmr)
Ore Name : manganese ore
Type of Ore : massive



only lower polar

Sample No. : K018
Location : N2458.0, E758.5
Formation : Halfa formation
Ore Name : manganese ore
Type of Ore : fine-banded, breccieted



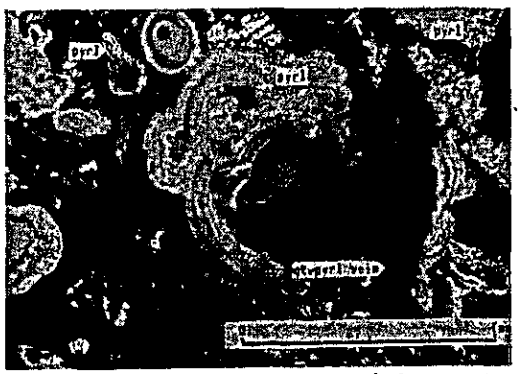
only lower polar

(outside of nodule)

Sample No. : K069
Location : N2455.0, E771.0
Formation : Halfa formation
Ore Name : manganese ore
Type of Ore : nodular

only lower polar

(inside of nodule)



only lower polar

Sample No. : K100
Location : N2484.5, E778.5
Formation : Halfa formation
Ore Name : manganese ore
Type of Ore : massive

Fig. A—3 Microphotograph of Fossil

Plate I

1. Eucyrtidium(?) ptyctum Riedel and Sanfilippo
2. Saitoum sp.
3. Thanarla conica (Aliev)
4. Parvicingula boesii Parona
5. P. sp.
6. P. cf. citae Pessagno
7. Pseudodictyomitra sp.
8. Dictyomitra sp.
9. Xitus(?) sp.
10. Xitus(?) sp.
12. Sethocapsa sp.
13. S. sp.
14. S. sp.
15. Tricolocapsa sp.

All specimens taken from Sample K-106

Magnification: x 250 for No. 2

x 175 for the other specimens.

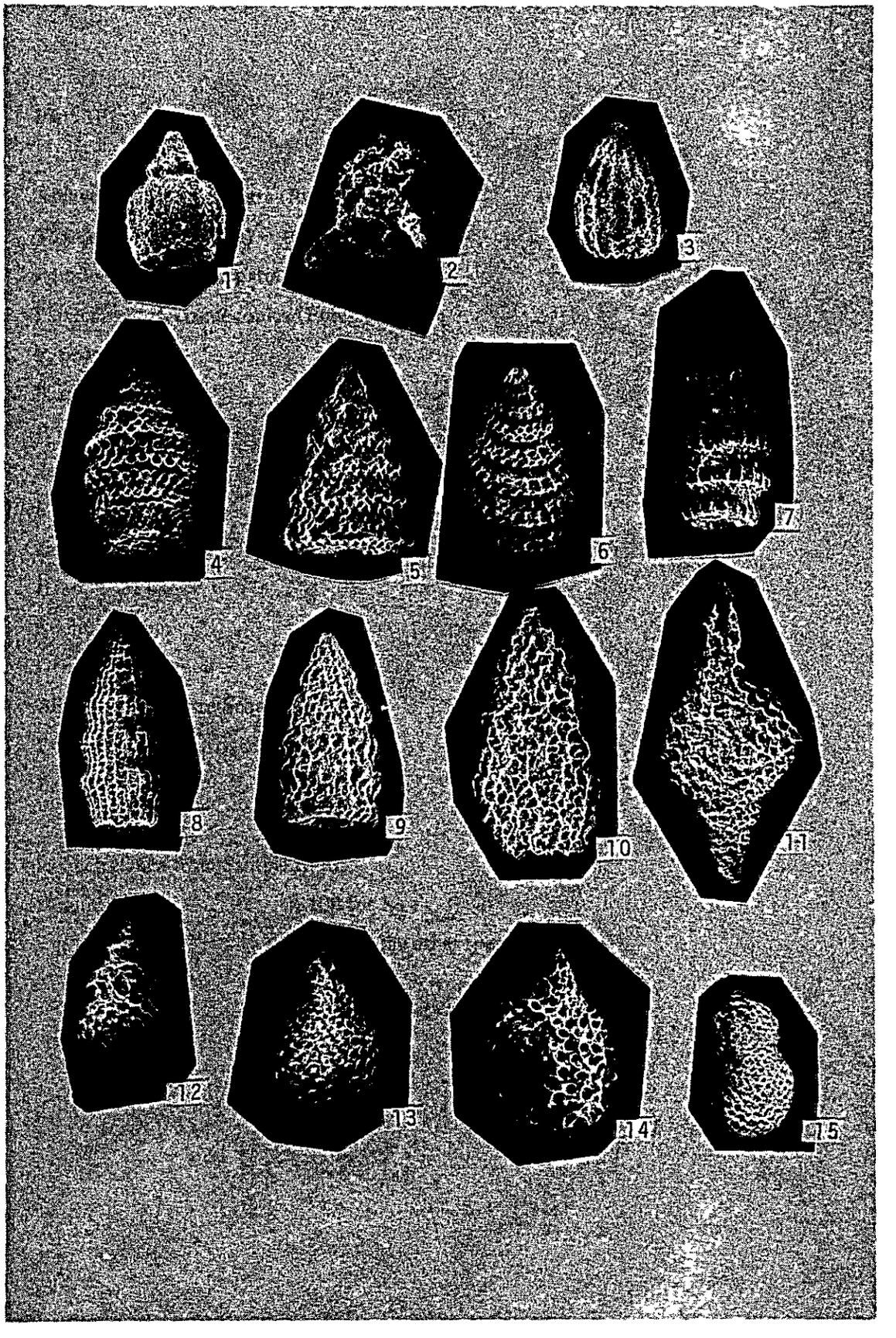

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Plate II

1. Archaeodictyomitra apiara (Rust)
2. Thanarla conica (Alieve)
3. Pseudodictyomitra carpatica (Lozyniak)
4. Parvicingula cf. cosmoconica (Foreman)
5. P. boesii Parona
6. P. sp.
7. P. sp.
8. Sethocapsa sp.
9. S. sp.
10. Hemicryptocapsa sp.
11. H. sp.
12. Stichocapsa sp.
13. Gen. sp. indet.
14. Alievium cf. helenae Schaaf
15. Pantanellium cf. corriganensis Pessagno
16. Emiluvia sp.

All specimens taken from Sample K-103

Magnification: x 100 for No.4

x 175 for the other specimens

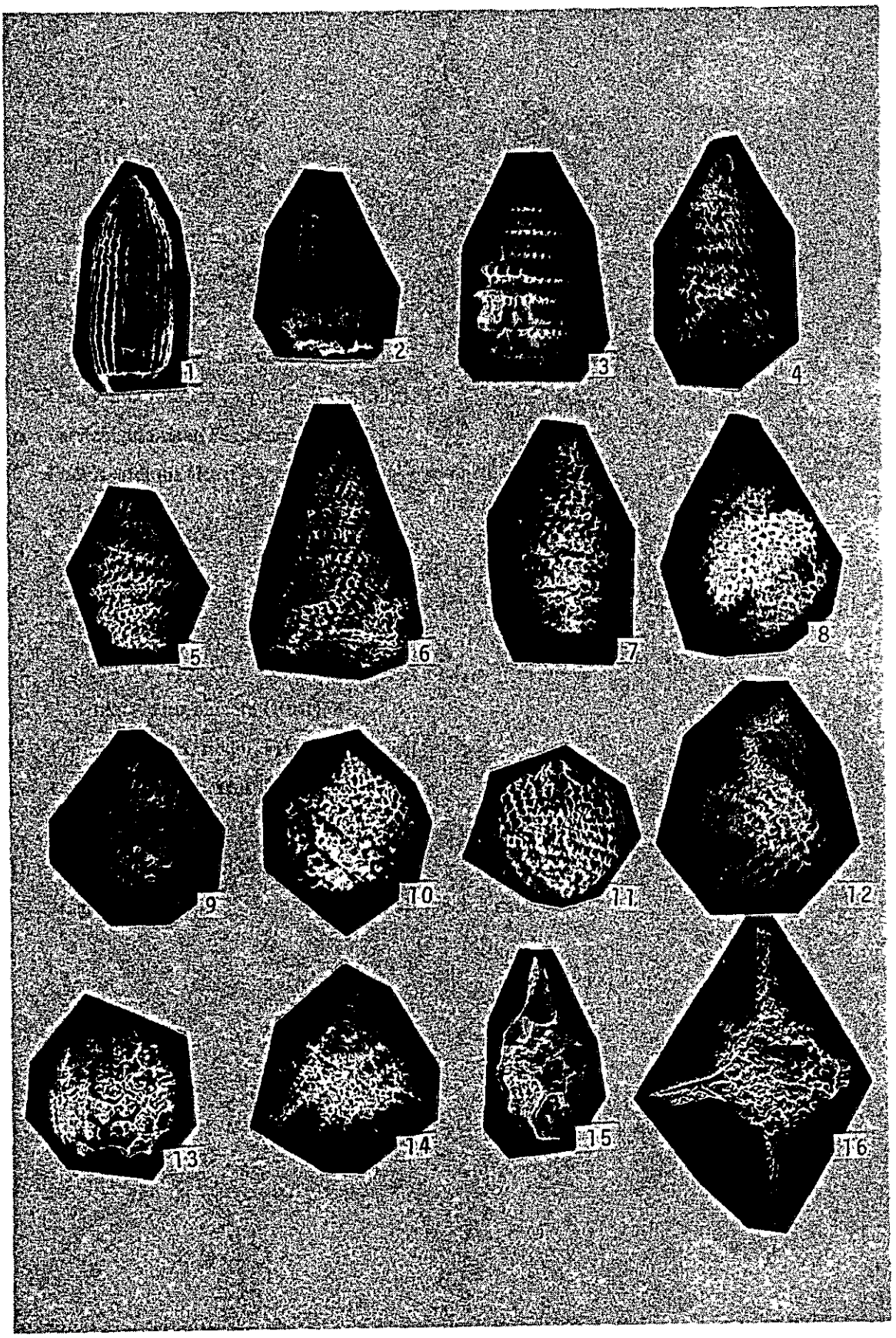

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Plate III

1. Archaeodictyomitra vulgaris Pessagno
2. A. lacrimula (Foreman)
3. Dictyomitra sp.
4. Thanarla purchra (Squinabol)
5. Pseudodictyomitra carpatica (Lozyniak)
6. Parvicingula citae Pessagno
7. Eucyrtis tenuis (Rust)
8. Podobursa sp.
9. Siphocampium sp.
10. Gen. sp. indet.
11. Sethocapsa sp.
12. Hemicryptocapsa sp.
13. Acaeniotyle umbilicata (Rust)
14. Pantanellium cf. riedeli Pessagno
15. Cecrops septenporatus (Parona)

All specimens taken from Sample K-93

Magnification: x 175 for all specimens.

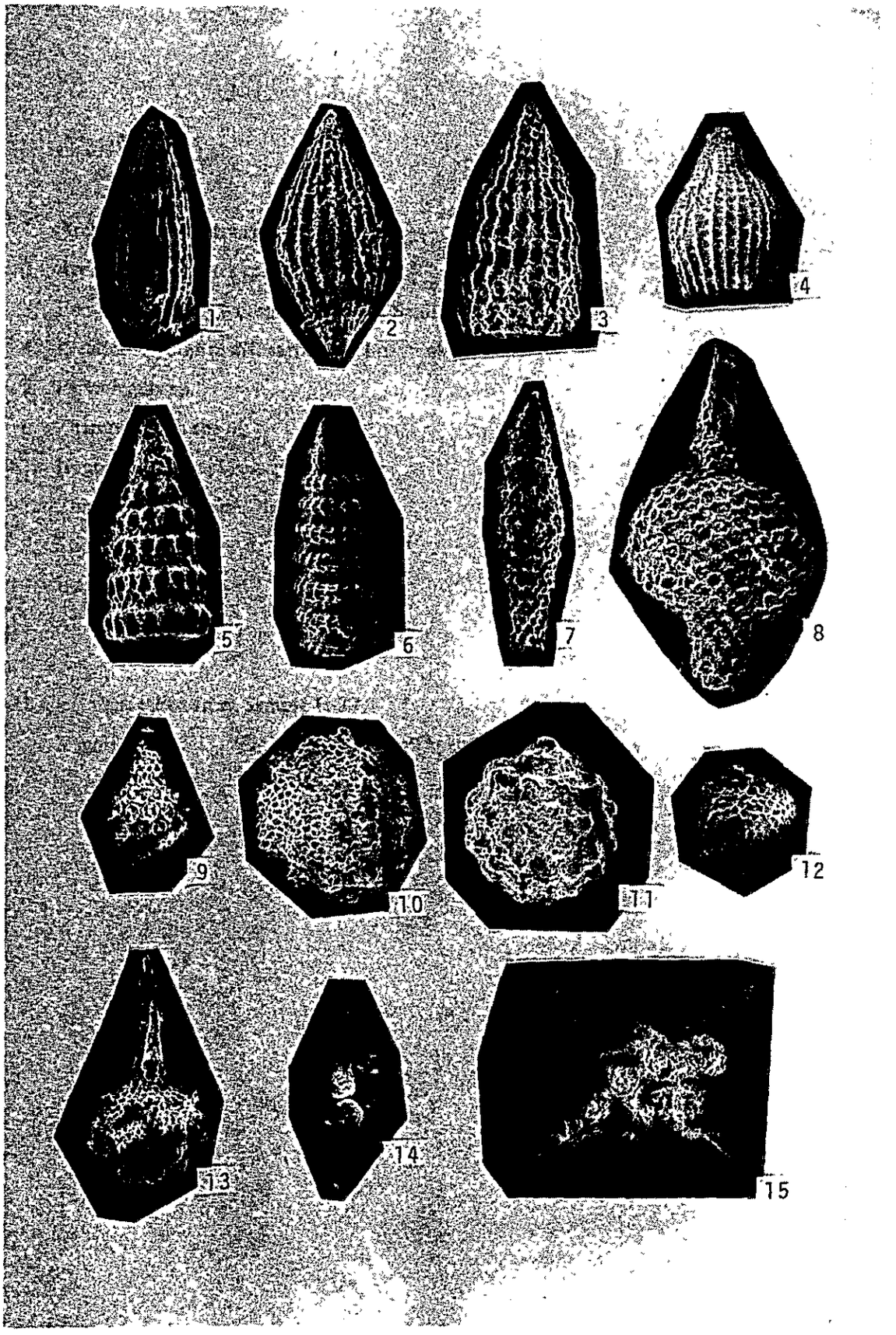

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Plate IV

1. Archaeodictyomitra apiara (Rust)
2. Archaeodictyomitra sp.
3. Eucyrtidium (?) ptyctum Riedel and Sanfilippo
4. Pseudodictyomitra aff. carpatica (Lozyniak)
5. Parvicingula sp.
6. Zhamoidellum sp.
7. Napora aff. bukryi Pessagno
8. Zhamoidellum ovum Dumitrica
9. Stichocapsa sp.
10. Eucyringium (?) sp.
11. Alievium (?) sp.

All specimens taken from Sample H-37.

Magnification: x 260 for all specimens.

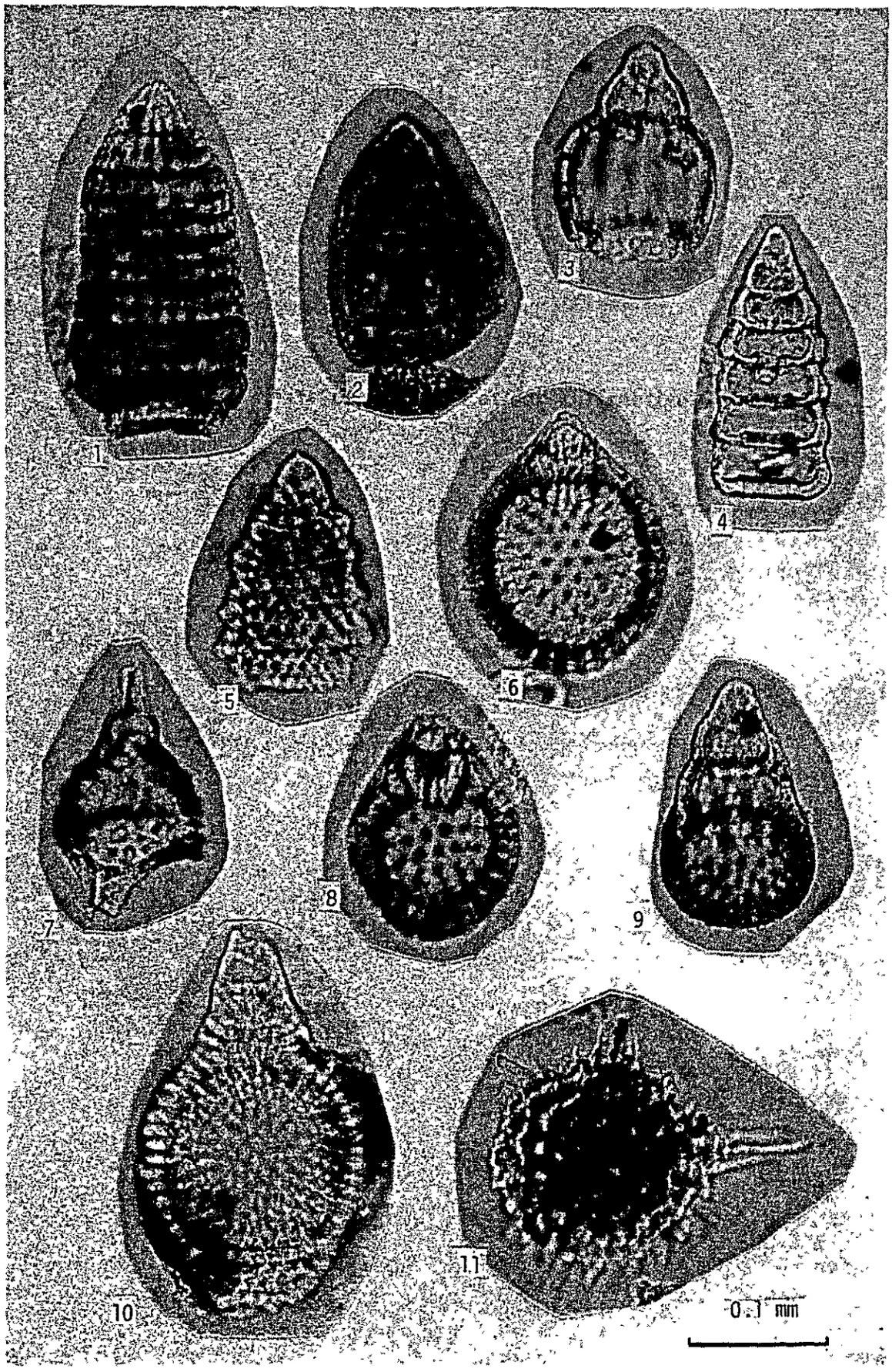
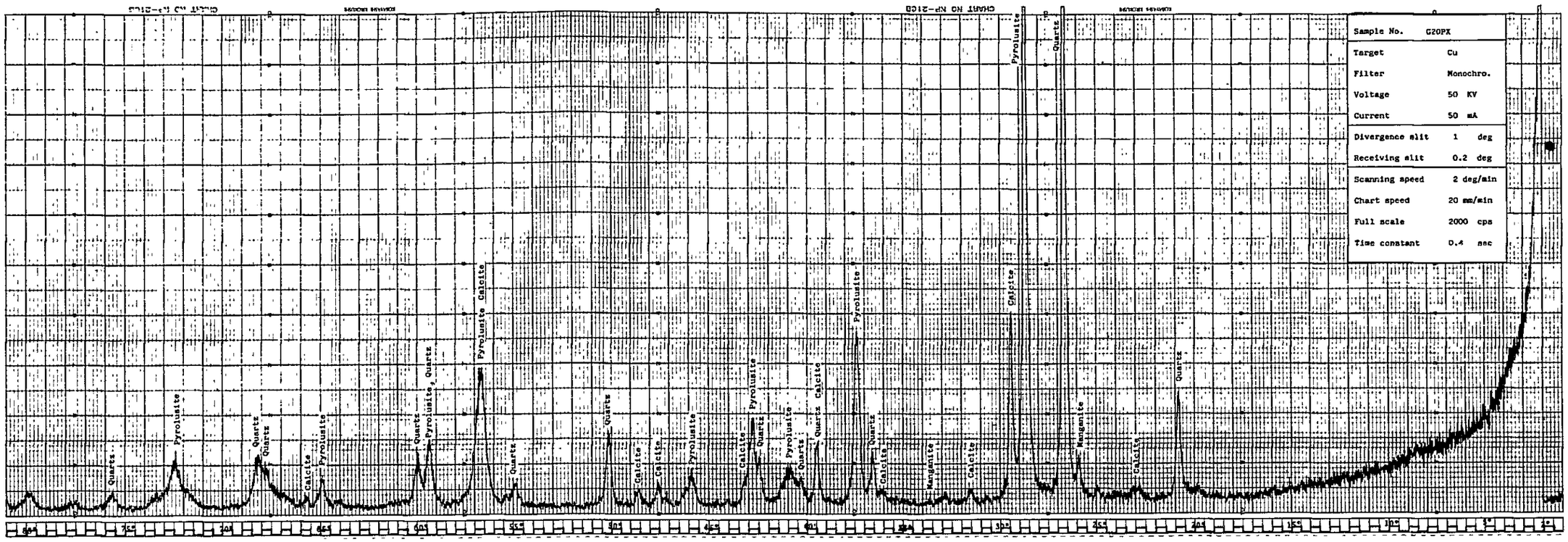
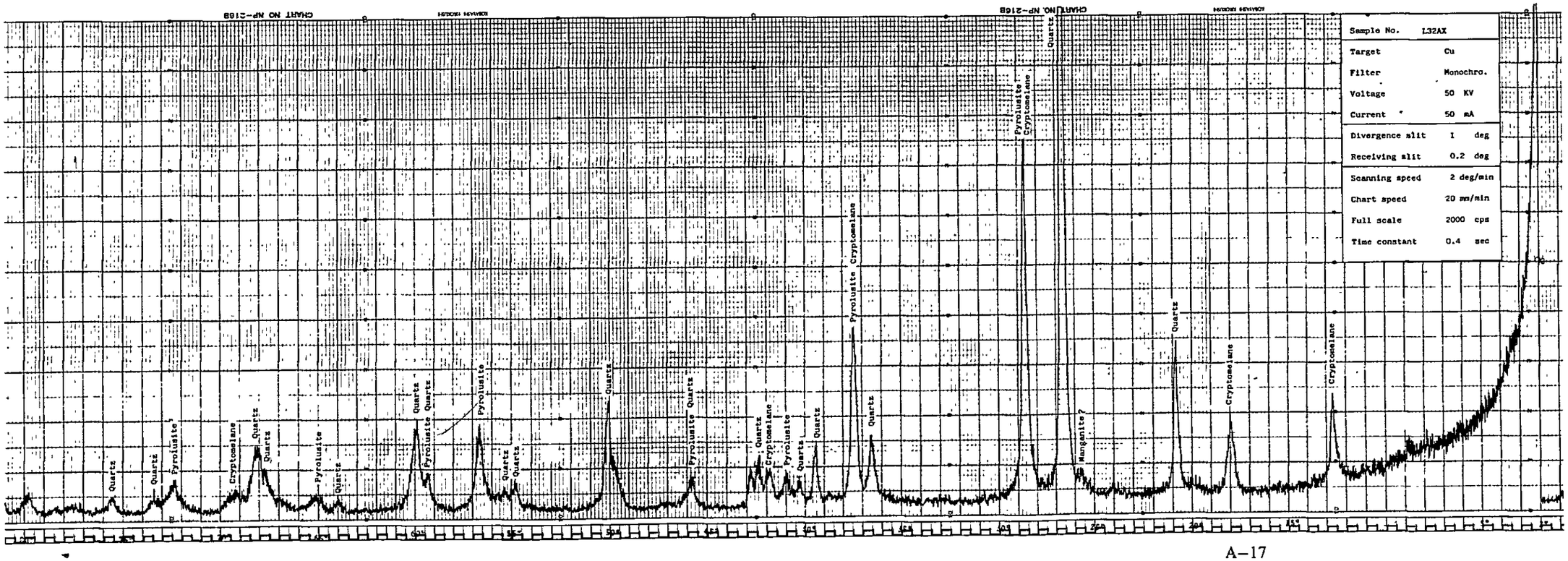
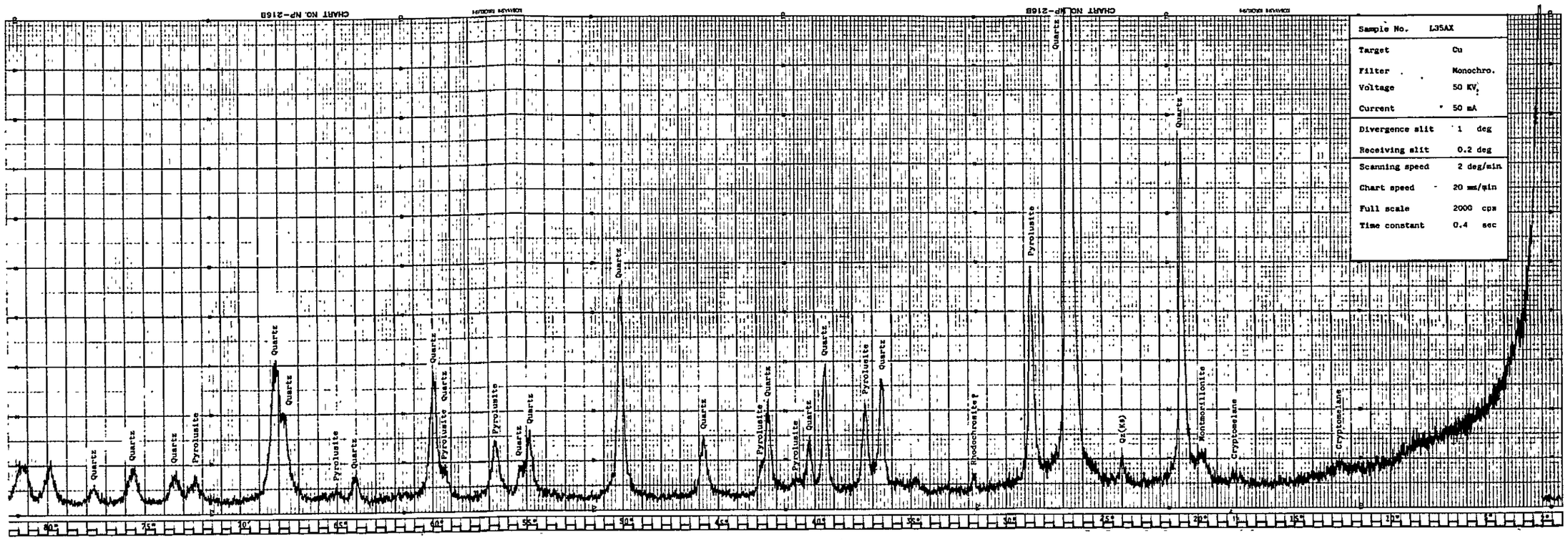

1
2
3
4
5
6
7
8
9
10
11
0.1 mm

Fig. A—4 Chart of X—ray Powder Diffractive Analysis


Sample No. G20PX
Target Cu
Filter Monochro.
Voltage 50 KV
Current 50 mA
Divergence slit 1 deg
Receiving slit 0.2 deg
Scanning speed 2 deg/min
Chart speed 20 mm/min
Full scale 2000 cps
Time constant 0.4 sec
Quartz
Pyrolusite
Calcite
Manganite


Sample No. L32AX
Target Cu
Filter Monochro.
Voltage 50 KV
Current 50 mA
Divergence slit 1 deg
Receiving slit 0.2 deg
Scanning speed 2 deg/min
Chart speed 20 mm/min
Full scale 2000 cps
Time constant 0.4 sec
Quartz
Pyrolusite
Cryptomelane
Manganite ?


Sample No. L35AX
Target Cu
Filter Monochro.
Voltage 50 KV
Current 50 mA
Divergence slit 1 deg
Receiving slit 0.2 deg
Scanning speed 2 deg/min
Chart speed 20 mm/min
Full scale 2000 cps
Time constant 0.4 sec
Quartz
Pyrolusite
Rhodochrosite?
Qz(Kβ)
Montmorillonite
Cryptomelane
CHART NO. NP-2168

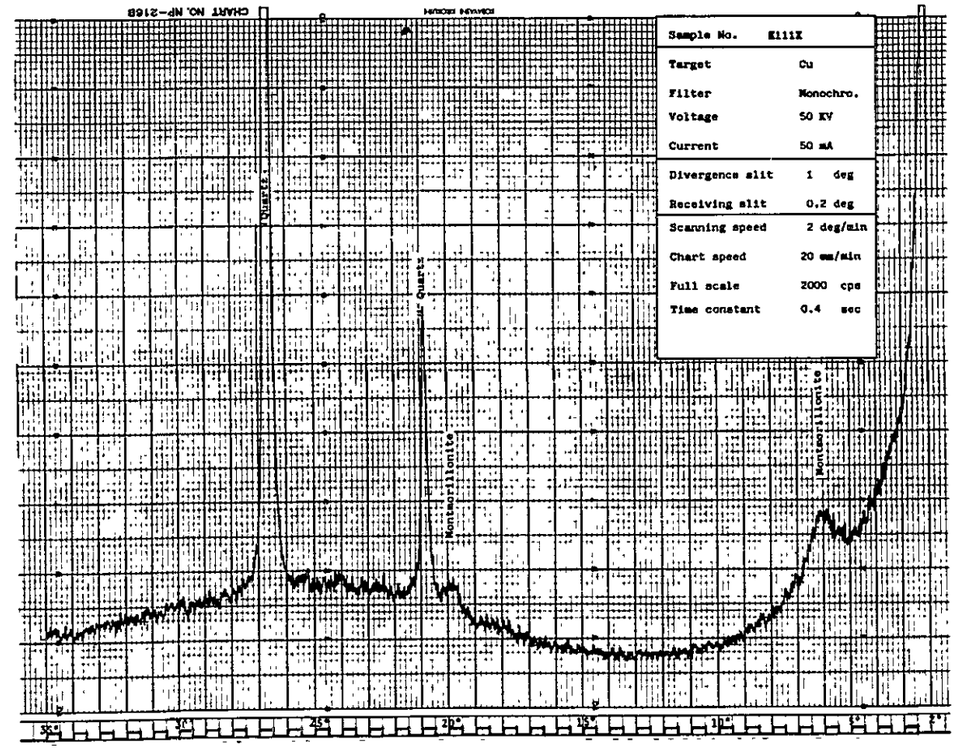

Sample No. E111X
Target Cu
Filter Monochro.
Voltage 50 KV
Current 50 mA
Divergence slit 1 deg
Receiving slit 0.2 deg
Scanning speed 2 deg/min
Chart speed 20 mm/min
Full scale 2000 cps
Time constant 0.4 sec
Quartz
Montmorillonite
CHART NO. NP-2168

Fig. A—5 Geological Log and Assay (1 : 200)

No. 1	(15.50 m)	No. 11	(21.00 m)
No. 2	(18.30 m)	No. 12	(16.50 m)
No. 3	(20.00 m)	No. 13	(15.50 m)
No. 4	(14.00 m)	No. 14	(19.00 m)
No. 5	(14.50 m)	No. 15	(15.00 m)
No. 6	(17.00 m)	No. 16	(19.00 m)
No. 7	(18.00 m)	No. 17	(12.00 m)
No. 8	(21.00 m)		
No. 9	(24.70 m)		
No. 10	(19.00 m)		

- red to reddish brown muddy chert and brown shale
- white to light gray chert and light gray shale
- brown muddy chert and brown shale
- black chert and manganese lens
- manganese ore with brown muddy chert
- manganese ore

ch = chert

No. 1

Depth (m)	Core Log	Assay: Sample No.	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	Description
0								0.00-3.00 red ch and white ch
								3.00-4.50 red ch ≫ black ch
		L-1	0.50	7.65	11.53	73.82	0.67	4.50-5.00 manganese ore
5								5.00-6.50 brown ch
		L-2	0.50	5.23	8.04	84.71	0.86	6.50-10.00
		L-3	0.50	7.55	11.46	80.31	0.67	
		L-4	0.50	9.05	14.08	77.01	0.61	manganese ore
		L-5	0.50	4.94	7.49	83.17	0.88	black colored
		L-6	0.50	5.27	7.70	85.26	0.63	
		L-7	0.50	9.71	14.77	76.61	0.49	
		L-8	0.50	5.65	8.04	85.94	0.47	
10								10.00-11.50 brown ch
								11.50-13.50 red ch and white ch
								13.50-15.50 red ch and pale brown ch
15 15.50								

No. 2

Depth (m)	Core Log	Assay: Sample No.	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	Description
0								0.00-4.00 reddish purple ch ≫ white ch
5								4.00-6.00 red ch and white ch
								6.00-8.00 reddish purple ch
								8.00-10.00 red ch and white ch
10								10.00-11.00 brown ch
		L-9	0.50	2.83	4.78	79.97	1.58	11.00-11.50 manganese ore
								11.50-13.00 brown ch ≫ black ch
								13.00-15.50 red ch and white ch
15								15.50-16.00
		L-10	0.50	2.84	4.43	85.25	1.16	manganese ore
								16.00-18.30 brown ch > red ch and white ch
18.30								

No. 3

Depth (m)	Core Log	Assay						Description
		Sample No.	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	
0								0.00-2.00 red to purple ch
								2.00-3.00 red ch ≫ white ch
								3.00-4.00 red ch ≫ black ch
								4.00-5.00 purple ch ≫ white ch > black ch
5								5.00-7.00 red to purple ch and white ch
								7.00-8.00 dark purple ch and red ch
								8.00-10.00 brown ch ≫ black ch
10								10.00-11.00 dark brown ch with manganese
								11.00-15.00 purple ch > red ch > white ch
15								15.00-19.00 brown ch > black ch
								19.00-20.00 dark brown ch
20.00								

No. 4

Depth (m)	Core Log	Assay						Description
		Sample No.	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	
0								0.00-5.00 red ch
5								5.00-6.00 red ch and white ch
								6.00-11.00 white to gray ch
10								11.00-14.00 red ch
14.00								

No. 5

Depth (m)	Core Log	Assay						Description
		Sample No.	Width (m)	Mn (%)	MnO_2 (%)	SiO_2 (%)	Fe (%)	
0								0.00 – 1.00 red ch and white ch 1.00 – 9.00 white ch
5								
10								9.00 – 12.00 white ch and red ch 12.00 – 14.50 purple to red ch and white ch
14.50								

No. 6

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO_2 (%)	SiO_2 (%)	Fe (%)	
0								0.00 – 1.00 dark purple ch, red ch and white ch 1.00 – 2.00 dark brown ≫ black ch
		L-11	0.50	11.18	16.98	61.74	2.07	2.00 – 3.00 manganese ore
		L-12	0.50	11.55	17.44	60.68	2.07	3.00 – 4.00 red ch and white ch ≫ black ch
5								4.00 – 7.00 brown ch > red ch and white ch 7.00 – 9.50 brown ch ≫ black ch
10								9.50 – 10.00 red ch 10.00 – 11.00 red ch and white ch 11.00 – 14.00 purple ch, red ch and white ch 14.00 – 15.00 white ch
15								15.00 – 16.00 white ch > red ch 16.00 – 17.00 grayish brown ch
17.00								

No. 7

Depth (m)	Core Log	Assay: Sample No.	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	Description
0								0.00 — 1.00 dark purple ch, red ch, white ch 1.00 — 2.00 dark brown ch and red ch
		L 13	1.00	21.04	32.00	49.41	0.88	2.00 — 4.00 manganese ore ≫ red ch
		L 14	1.00	12.86	19.80	65.94	1.21	
5								4.00 — 5.00 red ch ≫ black ch 5.00 — 6.00 brown ch and red ch 6.00 — 8.00 brown ch ≫ black ch
10								8.00 — 11.00 brown ch 11.00 — 12.00 red ch and white ch 12.00 — 13.00 white ch ≫ red ch 13.00 — 16.00 white to gray ch
15								16.00 — 18.00 red ch
18.00								

No. 8

Depth (m)	Core Log	Assay: Sample No.	Width (m)	Mn (%)	MnO (%)	SiO (%)	Fe (%)	Description
0								0.00 — 1.00 dark purple ch, red ch, white ch 1.00 — 3.00 dark purple ch ≫ black ch
		L 15	0.50	9.44	15.51	68.18	0.65	3.00 — 3.50 manganese ore 3.50 — 5.00 purple ch and black ch 5.00 — 7.50 brown ch ≫ black ch
5								
		L 16	0.50	3.04	5.03	83.23	1.45	7.50 — 8.00 pale brown ch 8.00 — 10.00 manganese ore ≫ brown ch
		L 17	0.50	2.58	4.10	80.19	1.67	
		L 18	1.00	1.74	2.89	81.48	0.65	
10		L 19	0.50	4.75	7.40	75.04	1.62	10.00 — 10.50 manganese ore 10.50 — 13.00 red ch
								13.00 — 13.50 red ch > white ch 13.50 — 15.00 white ch > red ch 15.00 — 18.00 white to gray ch
15								
								18.00 — 19.00 red ch > white ch 19.00 — 20.00 brown to red ch
20								20.00 — 21.00 white ch > red ch
21.00								

No. 9

Depth (m)	Core Log	Assay: Sample No	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	Description
0								0.00 – 2.00 red ch, white ch > brown ch
								2.00 – 2.50 brown ch ≫ red ch
		L 20	0.50	11 65	17 25	65.60	1.48	2.50 – 3.50 manganese ore
		L 21	0 50	7.79	12 20	71 99	1.58	
								3.50 – 4.00 brown ch
5								4.00 – 6 50 red ch
								6.50 – 8.00 brown ch ≫ red ch
								8.00 – 10.00 brown ch
10		L 22	0 50	4 05	6.59	79.03	1.44	10.00 – 10.50 manganese ore
								10.50 – 11.50 manganese ore ≫ brown ch
								11.50 – 16 00 brown ch ≫ black ch
15								
		L 23	0 50	9.94	14 98	71 79	0.92	16.00 – 19.00 manganese ore
		L 24	0.50	5.67	9.20	76.31	1.55	
		L 25	0.50	4.08	7.10	75.48	2.01	
		L 26	0.50	8.50	13.22	75.32	1.26	
		L 27	0.50	7 19	10.97	77 33	1.14	
		L 28	0 50	5.66	7.32	82.01	0.74	19.00 – 19 50 manganese ore ≫ brown ch
20		L 29	0 50	4.79	7.54	78 64	1.80	19.50 – 22 00 manganese ore
		L 30	0 50	6.01	8 46	85.25	0 57	
		L 31	0 50	8.79	12 54	77 26	0.83	
		L 32	0.50	21.76	32 22	54.03	0.99	
		L 33	0.50	4.94	7.45	86.93	0 69	
		L34	1 00	3.11	5.19	82.60	1.49	22.00 – 23.00 manganese ore ≫ brown ch
		L35	1 00	5.99	9.49	77.94	1 26	23.00 – 24.70 manganese ore
24.70 25		L36	0 70	10.88	17.88	66.41	1.23	

No. 10

Depth (m)	Core Log	Assay: Sample No.	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	Description
0								0.00 – 2.00 red ch and white ch
								2.00 – 3.00 red ch
								3.00 – 3.50 brown ch
		L 37	1 00	10.95	17.88	65.30	1.98	3.50 – 4.00 brown ch ≫ black ch
5		L 38	1 00	8.25	12.28	80.25	0 71	4.00 – 6.00 manganese ore
								6.00 – 8.00 brown ch ≫ black ch
								8.00 – 9.00 brown ch ≫ red ch
								9.00 – 10.00 red ch
10								10.00 – 11.00 brown ch ≫ black ch
								11.00 – 14.00 brown ch
								14.00 – 15.00 brown ch ≫ black ch
15								15.00 – 16.00 brown ch
								16.00 – 17.00 brown ch and black ch
								17.00 – 19.00 brown ch
19.00								

No. 11

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	
0								0.00 – 2.00 red ch and white ch
								2.00 – 6.00 red ch
5								
								6.00 – 8.50 red ch and brown to orange ch
								8.50 – 9.50 manganese ore ≫ brown ch
10		L39	1.00	13.52	21.36	63.82	1.43	9.50 – 11.50 manganese ore
		L40	1.00	22.99	34.05	53.48	0.51	
								11.50 – 12.50 manganese ore ≫ brown ch 12.50 – 13.50 pale brown ch ≫ black ch 13.50 – 18.00 manganese ore ≫ brown ch
15								
								18.00 – 21.00 pale brown ch
20								
21.00								

No. 12

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	
0								0.00 – 1.00 red ch 1.00 – 3.00 red ch ≫ white ch
								3.00 – 4.00 brown to red ch 4.00 – 5.00 orange ch 5.00 – 7.00 red ch
5								
								7.00 – 9.00 orange to red ch
								9.00 – 11.00 red ch
10								
								11.00 – 13.00 white ch and red ch
								13.00 – 14.50 red ch 14.50 – 15.00 red ch ≫ black ch 15.00 – 16.00 brown ch ≫ black ch
15								
16.50		L41	0.50	10.01	16.03	62.46	6.28	16.00 – 16.50 manganese ore ≫ brown ch

No. 13

Depth (m)	Core Log	Sample No.	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	Description
0								0.00 – 1.00 purple to red ch and white ch 1.00 – 2.00 red ch 2.00 – 4.00 orange to red ch
								4.00 – 5.00 red ch > white ch 5.00 – 8.00 red to orange ch
5								
								8.00 – 11.00 brown ch and red ch
10								
								11.00 – 12.00 red ch 12.00 – 12.50 red ch and black ch
		L 42	0.50	16.23	26.32	59.27	1.37	
		L 43	0.50	10.08	15.53	66.44	1.95	12.50 – 13.00 manganese ore ≫ brown ch
		L 44	0.50	5.96	9.92	72.46	1.99	13.00 – 13.50 manganese ore
15		L 45	1.00	6.95	11.02	67.08	2.20	
15.50		L 46	0.50	6.47	10.10	70.32	2.30	13.50 – 15.00 manganese ore ≫ brown ch 15.00 – 15.50 manganese ore

No. 14

Depth (m)	Core Log	Sample No	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	Description
0								0.00 – 2.50 yellow to orange ch and red ch
								2.50 – 3.00 brown ch ≫ black ch
		L 47	0.50	26.45	41.47	45.60	0.60	3.00 – 3.50 purplish red ch ≫ black ch
5								3.50 – 4.00 manganese ore 4.00 – 5.00 dark brown ch ≫ black ch 5.00 – 6.00 brown ch, red ch ≫ black ch 6.00 – 7.00 grayish brown ch
10								7.00 – 9.00 brown ch > red ch and white ch 9.00 – 11.00 brown to dark brown ch 11.00 – 12.00 brown ch ≫ black ch 12.00 – 13.00 dark brown ch
15								13.00 – 14.00 brown ch, red ch and black ch 14.00 – 15.00 brown ch, red ch and white ch 15.00 – 19.00 brown ch
19.00								

No. 15

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	
0								0.00 – 2.00 orange to red ch
								2.00 – 6.00 red to brownish red ch > white ch
5								
								6.00 – 6.50 red ch 6.50 – 7.00 brown ch ≫ black ch 7.00 – 9.00 brown ch, red ch, white ch and black ch 9.00 – 13.00 brown ch
10								
								13.00 – 15.00 reddish brown ch
15.00								

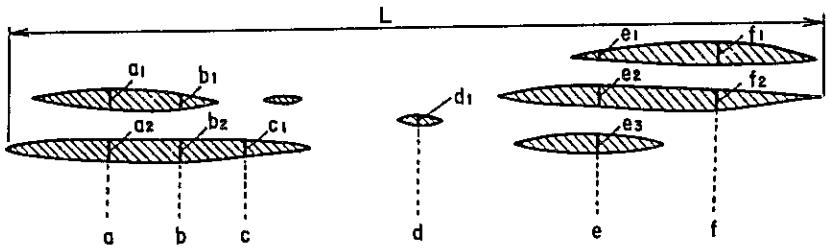
No. 16

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO2 (%)	SiO2 (%)	Fe (%)	
0								0.00 – 1.00 dark brown ch ≫ red ch, white ch 1.00 – 3.00 dark brown to brown ch
								3.00 – 5.00 brown ch > red ch and white ch
5								5.00 – 6.00 brown ch ≫ red ch and white ch > black ch 6.00 – 7.00 brown ch, red ch and white ch 7.00 – 8.00 brown ch > red ch and white ch > black ch 8.00 – 9.00 brown ch ≫ black ch 9.00 – 19.00 brown ch
10								
15								
19.00								

No. 17

Depth (m)	Core Log	Assay						Description
		Sample No	Width (m)	Mn (%)	MnO2(%)	SiO2(%)	Fe (%)	
0								0.00 – 1.00 dark brown ch, red ch, white ch 1.00 – 4.00 dark brown ch and black ch 4.00 – 5.00 dark brown ch, red ch, white ch, black ch 5.00 – 10.00 brown ch > black ch > red ch and white ch 10.00 – 12.00 dark brown ch ≫ red ch
5								
10								
12.00								

Schematized Distribution of Manganese Ore Beds



$$\left.\begin{aligned} Ta &= a_1 + a_2 \\ Tb &= b_1 + b_2 \\ Tc &= c_1 \\ Td &= d_1 \\ Te &= e_1 + e_2 + e_3 \\ Tf &= f_1 + f_2 \end{aligned}\right\} \text{thickness of manganese layers in each sampling sites}$$

Ore Reserve = L x F_1 x T x F_2 x D x S

L : length of strik side

F_1 : length factor (0.8)

T : average thickness

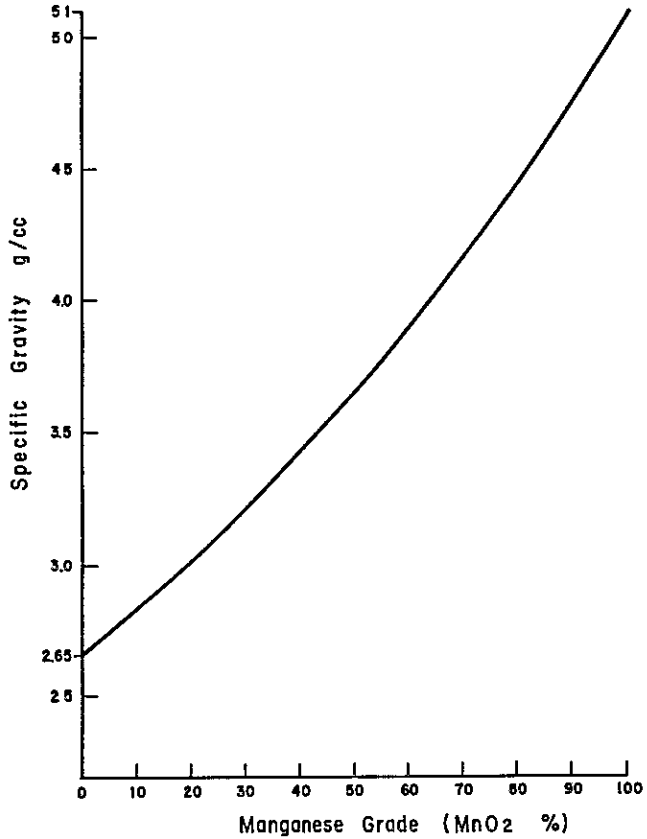
$T = Ta + Tb + Tc + Td + Te + Tf / n$

n : number of sampling site

F_2 : shape factor (0.8)

D : length of dip side (30m)

S : specific gravity



Correlation Curve between Manganese Grade (MnO_2) and Specific Gravity

Fig. A—6 Calculation Method of Manganese Ore Reserve

Table A—1 Microscopic Observation of Thin Section

(Sedimentary Rock)

No.	Sample No.	Location			Rock name	Fragments								Matrix										Characteristics
		Area	Co-ordination			Rocks		Minerals															radiolaria fossil	
			Latitude	Longitude		basalt	chert	quartz	potash feldspar	plagioclase	biotite	sericite	opaque minerals	quartz	calcite	sericite	kaoline	carbonate	clay minerals	hematite	limonite	opaque minerals		
15	J083	A	N 24 85.0	E 7 77.5	reddish brown chert									◎	•		•			•		•	◎	laminated
16	J084	A	24 85.0	E 7 77.5	redish brown chert									◎	•				•	•		•	◎	laminated
17	K010	D	24 49.5	7 71.0	limestone	○	?								○							○		
18	K073	D	24 54.5	7 71.0	reddish brown muddy chert									◎			•		•	•			◎	
19	K074	D	24 54.5	7 71.0	reddish brown chert									◎	•	•	•			•		•	◎	laminated
20	K075	D	24 54.5	7 71.0	light grey chert									◎		•	•		•				○	laminated
21	K076	D	24 54.5	7 71.0	light red chert									◎	•	•	•		•				◎	laminated
22	K079	D	24 54.5	7 71.5	light grey chert									◎		○			•					
23	K104	A	24 84.5	7 78.5	light grey chert									◎	○	•						•	○	laminated
24	K106	A	24 84.5	7 78.5	reddish brown chert									◎					•	•		•	◎	laminated
25	K112	A	24 84.5	7 78.5	light brown muddy chert									◎	•				•	•		•	◎	laminated
26	K113	A	24 84.5	7 78.5	reddish brown muddy chert									◎		•	•		•	•			◎	laminated
27	K114	A	24 84.0	7 78.5	white muddy chert									◎	•	•			○				•	lamainted

◎ : abundant ○ : common • : rare

(Sedimentary Rock)

No.	Sample No.	Location			Rock name	Fragments								Matrix										Characteristics
		Area	Co-ordination			Rocks		Minerals																
			Latitude	Longitude		basalt	chert	quartz	potash feldspar	plagioclase	biotite	sericite	opaque minerals	quartz	calcite	sericite	kaoline	carbonate	clay minerals	hematite	limonite	opaque minerals	radiolaria fossil	
1	G027	B	N 24 55.5	E 7 61.5	white chert									◎	•			•					○	laminated
2	G064	B	24 57.5	7 61.0	light grey chert									◎		•		•				•	○	laminated
3	G077	B	24 57.5	7 61.0	red muddy chert									◎	•	•	•	•	•			•	◎	laminated
4	G124	B	24 57.5	7 61.0	yellow chert									◎	•							○	◎	brecciated
5	G125	B	24 57.5	7 61.0	reddish brown muddy chert									◎		•			•			•	◎	laminated
6	G126	B	24 57.5	7 61.0	black chert									◎								○	◎	with Mn mineral
7	H012	D	24 53.5	7 69.5	limestone										◎							•		
8	H032	B	24 58.5	7 61.5	brecciated red chert									◎		•	•					•	◎	
9	H035	B	24 59.5	7 61.0	black chert									◎	•							◎		with Mn mineral
10	J033	C	24 51.0	7 67.0	grey chert									◎					•				○	
11	J040b	B	24 61.0	7 60.0	black chert									◎	◎							◎		with Mn layer
12	J047a	B	24 61.5	7 58.0	limestone									○	◎							•	○	
13	J053	B	24 62.0	7 59.5	yellow chert									◎	◎							◎	◎	brecciated
14	J058	B	24 61.0	7 59.0	light grey chert									◎	•				•				○	

◎ : abundant ○ : common • : rare

(Igneous Rock)

Sample No.	Location		Rock Name	Texture	Minerals																																	Remarks
					Phenocryst										Groundmass												Secondary minerals											
	Area	Co-ordination			quartz	potash feldspar	plagioclase	biotite	hornblende	alkali amphibole	augite	hypersthene	olivine	opaque minerals	quartz	potash feldspar	plagioclase	biotite	hornblende	clinopyroxene	orthopyroxene	sphene	apatite	zircon	cassiterite	opaque minerals	chlorite	epidote	sericite	zeolite	quartz	siderite	calcite	kaolinite	titanite	prehnite	serpentine	
H014	D	N 2453.5 E 761.0	trachyandesite	trachytic			(●)							●													●						●					An40 Ab60
K006	D	2453 5 772.0	dolerite	porphyritic			●	●			◎						◎			○						●		●					●					
K150	B	2455.5 763.5	pyroxenite	equigranular							◎	◎	●																				●				●	

(●) : abundant ○ : common ● : rare

Table A—2 Microscopic Observation of Polished Section

No.	Sample No.	Area	Co-ordinates		Type of Ore	Texture	Ore Mineral				Fossil	Remarks
			Latitude	Longitude			Pyrl	man	crpt	hem		
1	G015	B	N 2458.0	E 760.5	banded		•					
2	G020	B	2456.5	761.0	network		◎	?			◎	secondary segregation vein
3	G058	B	2457.5	760.5	nodular	banded,	◎					
4	G063	B	2457.5	761.0	massive		◎					
5	G109	B	2457.5	761.0	massive		◎					
6	G110	B	2457.5	761.0	banded		◎					
7	H048	B	2462.5	759.5	massive		◎	?				
8	J037	D	2452.5	771.5	veinlet		◎					secondary segregation vein
9	K018	B	2458.0	758.5	fine-banded, brecciated	colloform-banded	◎		?			
10	K060	D	2455.0	771.0	nodular		◎					
11	K069	D	2455.0	771.0	nodular		◎	?	?		◎	secondary segregation vein
12	K092	B	2457.5	761.0	massive		◎					
13	K100	A	2484.5	778.5	massive	colloform	◎	?				
14	K102	A	2484.5	778.5	brecciated		◎					secondary segregation vein
15	K108	A	2484.5	778.5	massive		◎					
16	L032	A	Drilling No.9		massive ?		◎		•			drilling cutting

◎ : abundant, ○ : common, • ; rare, ? ; uncertain

Abbreviations

pyrl : pyrolusite man : manganite crpt : cryptomelane hem : hematite

Table A—3 List of Fossil (Radiolaria)

Sample No.	H003F	H017F	H037F	K012F	K013F	K070F	K071F	K075F	K076F	K077F	K078F	K079F	K081F	K082F	K093F	K103F	K104F	K105F	K106F	K107F
Area	D	D	B	C	C	D	D	D	D	D	D	D	D	D	B	A	A	A	A	A
Member	Hmw	Hls	Hls	Hms	Hmr	Hmr	Hmr	Hls	Hls	Hmr	Hmw	Hls	Hmw	Hmr	Hmr	Hmw	Hmw	Hmr	Hmr	Hmr
Estimated age	Early Creta. (Valanginian ~ Barremian)	Not estimated (Radiolaria not detected)	Late Jura ~ Early Creta. (Tithonian) (Berriacian)	Late Jura. ~ Early Creta. (Tithonian) (Berriacian)*	Early Creta. (Valanginian ~ Barremian)	Not estimated (Radiolaria not detected)	Early Creta. (Valanginian ~ Barremian)	Early Creta. (Stage not specified)	Late Jura. ~ Early Creta. (Tithonian) (Hauterivian)	Early Creta. (Valanginian ~ Berriacian)	Early Creta. (Barremian ~ Aptian)	Not estimated (Radiolaria not detected)	Early Creta. (Valanginian ~ Barremian)	Early Creta. (Valanginian ~ Barremian)	Early Creta. (Barremian ~ Aptian)	Early Creta. (Valanginian ~ Barremian)	Early Creta. (Barremian ~ Aptian)	Not estimated (Radiolaria not detected)	Early Creta. (Valanginian ~ Berriacian)	Early Creta. (? ~Barremian?)
Acaeniotile diaphorogona Foreman														○						
A. sp.															○					
Acanthocircus dicranocanthos (Squinabol)																○			○	
Alievium helenae Schaaf	○												○		○		○			
A. sp.							○				○			○		○			○	
Archaeodictyomitra apiara (Rüst)	○		○	○				○			○					○			○	○
A. aff. *apiara* (Rüst)									○											
A. lacrimula (Foreman)													○	○	○		○			
A. pseudoscalaris (Tan Sin Hok)															○		○			
Archaeospongoprunum cf. *imlayi* Pessango								○												
A. cf. *tehamaensis* Pessango					○															
A. spp.							○													
Ceclops septemporatus (Parona)																	○			
C. sp.													○		○					
Crucella sp.				○																
Dictyomitra(?) sp.							○		○											
Emilvia sp. cf. *purissimaensis* Pessango					○															
E. sp.	○							○												
Eucyrtidium (?) *ptyctum* Riedel and Sanfilippo			○	○					○										○	
E. sp.			○											○						
Eucyrtis micropora (Squinabol)															○		○			
E. tenuis (Rüst)													○		○		○			
E. sp											○									
Hemicryptocapsa cf. *capita* Tan									○											
H. sp.	○												○							
H. spp.																○				
Hiuum (?) sp.											○									
Mirifusus baileyi Pessango					○															○
M. sp.									○						○	○				
M. (?) sp.																				○
Napora sp.			○		○															
Obesacapsula sp. cf. *Morroensis* Pessango					○															
Pantanellium sp.	○				○											○				
P. spp.							○							○	○		○		○	
Parvicingula boessi (Parona)	○			○	○				○					○	○	○			○	
P. sp. cf. *boessi* (Parona)							○													
P. sp.			○	○	○				○						○		○		○	○
Paronaella sp.			○	○				○												
Patulibracchium sp.							○		○											
Podobursa sp.	○						○	○	○				○		○					○
P. spp.				○	○															
Podocapsa (?) sp.					○															
Protunuma sp.			○						○											
Pseudodictyomitra carpatica (Lazyniak)	○			○							○			○		○			○	
P. aff. *minoensis* Mizutani			○	○	○															
P. cf. *pseudomacrocephara*															○					
P. sp.	○				○								○	○	○					○
Saitoum sp.			○	○	○															
Sethocapsa lelostraca Foreman													○	○						
S. trachyostraca Foreman					○								○	○			○			
S. cf. *trachyostraca* (Foreman)															○					
S. uterculus (Parona)	○						○													
S. sp.				○					○		○		○							○
S. (?) sp.			○								○									
Spongosatunatis (?) sp.							○													
Staurosphaera septempotata Foreman							○													
S. septemporatus (Parona)	○																			
Stichomitra sp.									○											
S. (?) sp.													○							
Thanaria conica (Aliev)	○			○					○					○	○				○	
T. aff. *conica* (Alive)																○				
T. pulchra (Squinabol)	○										○		○	○	○	○				
Triactoma cellulosa Foreman							○		○											
T. hybum Foreman														○						
Tricolocapsa sp.			○																○	
Ultranapora sp.							○										○			
Xitus sp.	○																○		○	

Table A—4 Result of X—ray Powder Diffractive Analysis

No.	Sample No.	Area	Rock name	Minerals							Indetermined small peak
				pyrl	man	crpt	rhc	qz	cal	mn	
1	G15PX	B	manganese ore	•				◎	○		
2	G20PX	"	" (network)	◎	•			◎	○		3.56Å, 2.72Å
3	G58PX	"	" (nodular)	◎	?			○			7.6Å
4	G109PX	"	"	◎	?			•			
5	G110PX	"	"	◎				◎			
6	H48PX	"	"	◎	•			○			
7	J37PX	D	" (veinlet)	◎				◎			2.03Å
8	K18PTX	B	"	◎		•		○			
9	K69PTX	D	" (nodular)	◎	•	•		•	○		
10	K92APX	B	"	◎	?			•	○		
11	K100PX	A	"	◎	•	?		?			
12	K102PX	"	" (veinlet)	○				◎			
13	L26	"	"	◎	?	•		○		•	
14	L32	"	"	○	?	○		◎			
15	L35	"	"	○		•	?	◎		•	2.58Å
16	G34TX	"	light pink muddy chert					◎	•	•	
17	K111X	"	light brown muddy chert					◎	•	•	

Abbreviations : pyrl ; pyrolusite, man ; manganite, crpt ; cryptomelane, rdc ; rhodochrosite, qz; quartz, cal; calcite, mn; montmorillonite.

◎ ; abundant, ○ ; common, • ; rare, ? ; uncertain.

Table A—5 Result of Chemical Analysis of Manganese Ore in Geological Survey

No.	Sample No.	Location			Type of Ore	Sampling Width (cm)	Content of Elements			
		Area	Outcrop No.	Co-ordination			Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
1	G009	B	178	N–2458.0 E– 760.5	nodular	70	10.44	17.48	75.94	0.61
2	G014	B	177	N–2458.0 E– 760.5	layered	15	20.06	31.72	60.95	0.56
3	G026	B	186	N–2456.5 E– 762.0	do	30	13.29	23.49	70.96	0.31
4	G028	B	187	N–2455.5 E– 761.5	do	10	39.61	62.71	28.86	0.11
5	G029	B	187	N–2455.5 E– 761.5	do	30	24.63	39.82	52.32	0.16
6	G043	B	179	N–2458.0 E– 760.5	do	5	18.34	28.95	63.05	0.27
7	G045	B	159	N–2458.0 E– 760.5	layered nodular	80	8.97	14.66	74.11	0.60
8	G046	B	159	N–2458.0 E– 760.5	do	40	6.76	10.75	70.85	1.16
9	G047	B	159	N–2458.0 E– 760.5	nodular	50	10.24	16.59	66.68	1.00
10	G048	B	159	N–2458.0 E– 760.5	do	30	13.32	21.38	62.78	1.04
11	G053	B	159	N–2458.0 E– 760.5	do	50	18.39	29.48	62.39	0.53
12	G054	B	159	N–2458.0 E– 760.5	layered	50	11.90	20.18	73.21	0.63
13	G055	B	159	N–2458.0 E– 760.5	do	25	7.07	12.98	80.54	0.79
14	G056	B	159	N–2458.0 E– 760.5	do	75	15.25	26.41	66.39	0.63
15	G057	B	159	N–2458.0 G– 760.5	do	40	8.67	14.38	78.69	0.68
16	G058	B	159	N–2457.5 E– 760.5	layered nodular	120	11.50	20.79	68.72	0.66
17	G059	B	159	N–2457.5 E– 760.5	do	30	20.57	32.24	46.45	1.46
18	G060	B	159	N–2457.5 E– 760.5	nodular~ layered	25	15.94	25.20	67.36	0.25
19	G061	B	159	N–2457.5 E– 760.5	layered~ nodular	110	29.35	46.20	46.25	0.20
20	G062	B	159	N–2457.5 E– 760.5	do	190	17.57	28.45	60.46	0.27
21	G063	B	180	N–2457.5 E– 761.0	layered	20	52.97	85.14	4.73	0.07
22	G065	B	159	N–2457.5 E– 761.0	layered ~nodular	300	20.43	32.88	56.88	0.25
23	G066	B	159	N–2457.5 E– 761.0	layered	40	37.43	59.52	31.12	0.11
24	G067	B	159	N–2457.5 E– 761.0	do	60	20.97	33.64	53.75	0.24
25	G075	B	159	N–2457.5 E– 761.0	layered ~nodular	200	13.59	22.00	47.15	0.74
26	G076	B	159	N–2457.5 E– 761.0	do	100	24.18	37.53	35.15	0.45
27	G078	B	159	N–2457.5 E– 761.0	layered	25	17.17	26.85	65.74	0.22
28	G080	B	159	N–2457.5 E– 761.0	do	130	21.81	34.47	56.05	0.22
29	G081	B	159	N–2457.5 E– 761.0	nodular	50	17.45	29.01	63.09	0.41
30	G083	B	159	N–2457.5 E– 761.0	do	30	21.21	35.46	59.67	0.52

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
31	G085	B	159	N–2457.5 E– 761.0	layered	90	28.32	44.11	45.35	0.20
32	G086	B	159	N–2457.5 E– 761.0	do	20	26.77	44.70	40.45	0.34
33	G087	B	159	N–2457.5 E– 761.0	do	50	18.02	31.43	61.44	0.31
34	G088	B	159	N–2457.5 E– 761.0	do	25	39.40	62.85	30.19	0.10
35	G089	B	159	N–2457.5 E– 761.0	do	50	27.00	44.22	43.34	0.20
36	G090	B	159	N–2457.5 E– 761.0	do	20	16.58	26.39	67.15	0.19
37	G091	B	159	N–2457.5 E– 761.0	do	25	5.10	8.68	84.82	0.81
38	G092	B	159	N–2457.5 E– 761.0	do	100	32.28	52.55	37.56	0.11
39	G093	B	159	N–2457.5 E– 761.0	do	40	17.34	28.14	67.89	0.25
40	G094	B	159	N–2457.5 E– 761.0	do	25	26.48	42.15	47.54	0.20
41	G095	B	159	N–2457.5 E– 761.0	do	100	22.28	36.02	49.03	0.22
42	G096	B	159	N–2457.5 E– 761.0	layered ~nodular	70	21.33	35.38	54.90	0.56
43	G097	B	159	N–2457.5 E– 761.0	do	110	18.53	31.47	61.92	0.58
44	G098	B	159	N–2457.5 E– 761.0	do	50	28.46	46.92	42.41	0.37
45	G099	B	159	N–2457.5 E– 761.0	layered	30	32.59	50.87	39.57	0.19
46	G100	B	159	N–2457.5 E– 761.0	do	100	20.91	34.90	61.19	0.17
47	G101	B	159	N–2457.5 E– 761.0	do	30	27.13	44.52	48.01	0.10
48	G102	B	159	N–2457.5 E– 761.0	do	80	41.69	68.10	23.74	0.06
49	G103	B	159	N–2457.5 E– 761.0	nodular	100	20.26	36.47	55.12	0.30
50	G104	B	159	N–2457.5 E– 761.0	layered	50	23.06	37.44	54.43	0.19
51	G105	B	159	N–2457.5 E– 761.0	do	30	24.36	40.06	56.40	0.17
52	G106	B	159	N–2457.5 E– 761.0	do	30	28.37	46.80	47.22	0.33
53	G108	B	159	N–2457.5 E– 761.0	do	240	14.63	23.71	72.20	0.17
54	G109	B	159	N–2457.5 E– 761.0	do	200	25.61	40.46	52.36	0.15
55	G110	B	159	N–2457.5 E– 761.0	do	250	33.05	52.34	36.66	0.13
56	G111	B	159	N–2457.5 E– 761.0	do	120	32.21	53.41	31.54	0.17
57	G112	B	159	N–2457.5 E– 761.0	nodular~ layered	100	15.64	30.44	27.55	0.65
58	G113	B	159	N–2457.5 E– 761.0	layered	20	21.65	34.46	52.28	0.27
59	G114	B	159	N–2457.5 E– 761.0	do	35	20.76	33.36	54.23	0.20
60	G115	B	159	N–2457.5 E– 761.0	do	30	24.25	41.89	42.78	0.48

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
61	G116	B	184	N–2457.0 E– 761.0	layered ~nodular	250	13.63	25.09	70.23	0.47
62	G117	B	184	N–2457.0 E– 761.0	layered	70	14.30	23.23	66.89	0.41
63	G119	B	184	N–2456.5 E– 761.0	layered ~nodular	80	18.62	33.75	52.94	0.52
64	G121	B	184	N–2456.5 E– 761.5	do	100	14.54	26.94	67.72	0.51
65	G122	B	184	N–2456.0 E– 761.5	do	100	19.43	37.18	62.85	0.38
66	G123	B	184	N–2456.0 E– 761.5	do	60	14.02	23.23	66.25	0.40
67	H011	D	194	N–2453.5 E– 769.0	layered	30	12.60	20.35	69.65	0.30
68	H023	C	188	N–2452.5 E– 766.5	do	25	22.26	34.75	52.87	0.38
69	H028	C	188	N–2452.5 E– 766.5	do	50	33.40	52.43	38.14	0.25
70	H029	C	190	N–2452.0 E– 766.5	do	40	29.68	47.07	44.13	0.20
71	H033	B	173	N–2459.5 E– 761.5	do	80	21.20	34.07	56.37	0.19
72	H038	B	172	N–2459.5 E– 760.5	do	60	38.01	61.36	30.26	0.11
73	H039	B	172	N–2459.5 E– 760.5	do	30	11.01	18.75	73.28	0.23
74	H040	B	171	N–2460.0 E– 760.5	do	25	29.24	46.99	45.75	0.16
75	H041	B	158	N–2460.0 E– 760.5	do	300	20.50	29.88	54.92	0.20
76	H043	B	158	N–2460.5 E– 760.5	do	350	29.81	47.49	45.24	0.23
77	H044	B	158	N–2460.5 E– 760.5	do	60	28.11	44.31	47.47	0.37
78	H045	B	155	N–2463.0 E– 759.5	do	65	25.92	41.11	49.85	1.08
79	H046	B	168	N–2463.0 E– 759.5	do	60	21.85	34.56	56.78	0.27
80	H047	B	170	N–2462.5 E– 759.5	do	70	40.08	65.94	27.21	0.16
81	H049	B	169	N–2462.5 E– 759.5	do	130	25.61	41.47	51.52	0.28
82	H062	A	93	N–2484.0 E– 779.0	do	20	33.20	51.94	40.95	0.16
83	H064	A	94	N–2483.5 E– 779.0	do	35	16.69	27.58	67.87	0.26
84	H070	A	69	N–2481.5 E– 780.5	do	10	20.82	34.00	61.25	0.19
85	H071	A	69	N–2481.5 E– 780.5	do	10	10.27	17.24	79.44	0.36
86	H072	A	69	N–2481.5 E– 780.0	do	17	20.28	32.99	61.10	0.25
87	H073	A	69	N–2481.5 E– 780.0	do	15	12.56	21.15	75.62	0.29
88	H074	A	69	N–2481.5 E– 780.0	do	55	13.48	22.34	71.00	0.27
89	H075	A	69	N–2481.5 E– 780.0	do	25	32.77	52.74	40.84	0.19
90	H076	A	69	N–2481.5 E– 780.0	do	12	8.15	13.57	82.94	0.33

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
91	H077	A	69	N–2481.5 E– 780.0	layered	50	9.96	17.42	77.69	0.30
92	H078	A	69	N–2481.5 E– 780.0	do	50	8.11	12.15	83.13	0.30
93	H079	A	69	N–2481.5 E– 780.0	do	40	18.39	27.75	64.48	0.18
94	H081	A	71	N–2481.5 E– 780.0	do	60	18.51	30.22	65.93	0.25
95	H082	A	71	N–2481.0 E– 780.0	do	40	21.56	34.73	59.32	0.22
96	H083	A	71	N–2481.0 E– 780.0	do	315	14.80	23.24	67.03	0.53
97	H084	A	71	N–2481.0 E– 779.5	do	190	14.72	23.57	68.26	0.57
98	H085	A	110	N–2484.0 E– 778.5	do	70	34.98	55.38	37.16	0.11
99	H086	A	110	N–2484.5 E– 778.5	do	30	28.31	44.36	48.47	0.17
100	H087	A	110	N–2484.5 E– 778.5	do	30	16.57	26.27	70.19	0.23
101	H088	A	110	N–2484.5 E– 778.5	do	50	24.84	39.51	53.55	0.26
102	H089	A	110	N–2484.5 E– 778.5	do	50	30.07	46.82	26.40	0.16
103	H090	A	110	N–2484.5 E– 778.5	do	100	21.19	33.79	61.38	0.19
104	H091	A	110	N–2484.5 E– 778.5	do	35	19.06	29.90	63.19	0.32
105	H092	A	110	N–2484.5 E– 778.5	do	30	41.29	65.85	27.07	0.01
106	H093	A	110	N–2484.5 E– 778.5	do	120	13.42	21.17	73.28	0.27
107	H094	A	110	N–2484.5 E– 778.5	do	30	34.88	56.20	36.65	0.13
108	H095	A	110	N–2484.5 E– 778.5	do	70	17.86	28.38	64.66	0.29
109	H096	A	110	N–2484.5 E– 778.5	do	50	17.56	27.51	67.61	0.32
110	H097	A	110	N–2484.5 E– 778.5	do	190	15.79	25.77	67.65	0.38
111	H098	A	110	N–2484.5 E– 778.5	do	20	20.04	32.30	61.14	0.30
112	H099	A	110	N–2484.5 E– 778.5	do	55	18.94	30.93	64.54	0.22
113	H100	A	110	N–2484.5 E– 778.5	do	20	15.17	23.73	69.75	0.26
114	H101	A	110	N–2484.5 E– 778.5	do	23	8.38	13.34	81.78	0.28
115	H102	A	110	N–2484.5 E– 778.5	do	27	12.77	19.33	72.96	0.30
116	H103	A	110	N–2484.5 E– 778.5	do	20	15.90	24.13	68.74	0.25
117	H104	A	110	N–2484.5 E– 778.5	do	30	24.88	39.40	51.04	0.22
118	H105	A	110	N–2484.5 E– 778.5	do	70	13.24	21.05	70.64	0.34
119	H106	A	110	N–2484.5 E– 778.5	do	60	9.67	15.09	79.25	0.32
120	H107	A	110	N–2484.5 E– 778.5	do	55	21.55	33.64	58.12	0.25

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
121	H108	A	110	N-2484.5 E- 778.5	Layered	18	15.47	25.86	60.01	0.30
122	H109	A	110	N-2484.5 E- 778.5	do	60	13.69	21.87	70.48	0.32
123	H110	A	110	N-2484.5 E- 778.5	do	15	8.14	12.93	83.37	0.27
124	H111	A	110	N-2484.5 E- 778.5	do	75	14.66	23.35	70.61	0.27
125	H112	A	110	N-2484.5 E- 778.5	do	27	12.87	19.82	75.53	0.33
126	H113	A	110	N-2484.5 E- 778.5	do	26	12.62	19.57	75.65	0.27
127	H114	A	110	N-2484.5 E- 778.5	do	13	15.75	24.46	70.54	0.29
128	H116	A	110	N-2484.5 E- 778.0	do	17	13.90	21.88	72.00	0.45
129	H118	A	110	N-2484.5 E- 778.0	do	13	11.85	18.45	74.01	0.79
130	H119	A	110	N-2484.5 E- 778.0	do	20	15.36	25.03	71.29	0.34
131	H121	A	110	N-2484.5 E- 778.0	do	8	12.87	22.07	72.14	0.44
132	H122	A	110	N-2484.5 E- 778.0	do	22	14.05	23.51	71.16	0.55
133	H123	A	110	N-2484.5 E- 778.0	do	59	8.39	14.42	80.49	0.67
134	H126	A	110	N-2484.5 E- 778.0	do	13	6.16	10.83	86.44	0.48
135	H127	A	110	N-2484.5 E- 778.0	do	19	12.39	20.46	76.34	0.32
136	H128	A	110	N-2485.0 E- 778.0	do	54	26.77	42.77	49.64	0.24
137	H129	A	110	N-2485.0 E- 778.0	do	11	8.16	12.39	83.58	0.31
138	H131	A	110	N-2485.0 E- 778.0	do	9	21.57	34.42	49.73	0.25
139	H132	A	110	N-2485.0 E- 778.0	do	12	17.32	27.43	67.04	0.45
140	H133	A	110	N-2485.0 E- 777.5	do	28	18.34	30.18	65.83	0.27
141	H135	A	110	N-2485.0 E- 777.5	do	28	12.32	19.22	70.39	3.00
142	H136	A	110	N-2485.0 E- 777.5	do	17	19.70	30.61	63.64	0.27
143	H137	A	110	N-2485.0 E- 777.5	do	17	11.77	18.51	78.79	0.31
144	H138	A	110	N-2485.0 E- 777.5	do	14	21.77	32.72	60.20	0.32
145	H139	A	110	N-2485.0 E- 777.5	do	24	16.09	24.90	69.69	0.29
146	H140	A	110	N-2485.0 E- 777.5	do	52	20.06	31.98	61.70	0.23
147	H141	A	110	N-2484.5 E- 778.5	do	30	18.13	28.69	64.35	0.22
148	H142	A	110	N-2484.5 E- 778.5	do	135	28.81	44.98	47.85	0.19
149	H143	A	110	N-2484.0 E- 778.5	do	95	23.89	38.18	54.24	0.26
150	J024	C	161	N-2452.0 E- 767.0	do	160	9.27	14.98	78.91	1.61

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
151	J025	C	161	N–2452.0 E– 767.0	Layered	110	7.90	12.34	81.88	0.43
152	J073	A	140	N–2483.5 E– 776.0	do	51	8.30	13.88	82.96	0.29
153	J074	A	140	N–2483.5 E– 776.5	do	60	20.61	32.86	62.03	0.19
154	J075	A	140	N–2483.5 E– 776.5	do	49	19.75	31.96	62.61	0.25
155	J087	A	136	N–2484.5 E– 776.5	do	38	17.94	28.10	66.97	0.27
156	J088	A	136	N–2484.5 E– 776.5	do	38	15.17	24.35	70.92	0.38
157	J089	A	136	N–2484.5 E– 776.5	do	37	18.16	28.98	65.36	0.29
158	J090	A	136	N–2484.5 E– 776.5	do	45	16.76	25.97	68.96	0.33
159	J091	A	136	N–2484.5 E– 776.5	do	36	12.55	20.13	73.46	0.52
160	J092	A	136	N–2484.5 E– 776.5	do	45	25.22	39.60	53.77	0.15
161	J093	A	136	N–2484.5 E– 776.5	do	56	21.43	34.35	59.13	0.55
162	J094	A	136	N–2484.5 E– 776.5	do	23	12.97	20.25	74.16	0.33
163	J095	A	136	N–2484.5 E– 776.5	do	41	15.21	23.42	69.86	0.30
164	J096	A	136	N–2484.5 E– 776.5	do	20	24.60	38.74	54.58	0.30
165	J097	A	136	N–2484.5 E– 776.5	do	38	13.40	21.42	72.90	0.30
166	J098	A	136	N–2484.5 E– 776.5	do	31	7.64	12.40	84.13	0.32
167	J099	A	136	N–2484.5 E– 776.5	do	25	29.50	46.23	48.74	0.21
168	J100	A	136	N–2484.5 E– 776.5	do	42	20.31	31.97	60.17	0.32
169	J101	A	136	N–2484.5 E– 776.5	do	62	12.98	20.35	72.97	0.29
170	J102	A	136	N–2484.5 E– 776.5	do	73	17.40	28.11	67.44	0.22
171	J103	A	136	N–2484.5 E– 776.5	do	35	18.08	29.08	65.50	0.39
172	J104	A	136	N–2484.5 E– 776.5	do	82	16.26	25.95	69.82	0.32
173	J105	A	136	N–2484.5 E– 776.5	do	70	14.37	22.85	72.98	0.22
174	J106	A	136	N–2484.5 E– 776.5	do	35	11.22	18.19	78.96	0.30
175	J107	A	136	N–2484.5 E– 776.5	do	41	18.64	29.27	65.75	0.33
176	K004	D	160	N–2454.5 E– 771.0	do	60	18.19	29.28	66.76	0.30
177	K016	B	185	N–2456.5 E– 763.0	do	60	22.77	36.86	56.66	0.31
178	K017	B	185	N–2456.5 E– 763.0	do	30	21.13	35.53	59.34	0.31
179	K019	B	174	N–2458.0 E– 758.5	do	70	44.37	71.29	19.56	0.04
180	K020	B	175	N–2458.0 E– 758.5	do	20	14.71	24.74	71.51	0.33

No.	Sample No.	Area	Location Outcrop No.	Co-ordination	Type of Ore	Sampling Width (cm)	Content of Elements			
							Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
181	K022	B	176	N–2458.0 E– 758.5	layered	30	28.55	45.14	45.00	0.24
182	K024	B	181	N–2457.5 E– 759.0	do	40	22.48	35.44	55.76	0.20
183	K026a	B	183	N–2457.0 E– 759.0	do	31	36.10	56.89	33.76	0.44
184	K026b	B	183	N–2457.0 E– 759.0	do	39	10.87	17.49	73.94	0.41
185	K027	B	182	N–2457.5 E– 758.5	do	28	44.61	71.49	19.02	0.07
186	K050	D	160	N–2454.5 E– 771.0	do	25	30.22	48.82	41.96	0.16
187	K051	D	160	N–2454.5 E– 771.0	do	25	12.77	20.15	72.80	0.37
188	K052	D	160	N–2454.5 E– 771.0	do	50	15.55	24.73	69.46	0.27
189	K053a	D	160	N–2455.0 E– 771.0	do	33	30.11	48.30	45.02	0.18
190	K053b	D	160	N–2455.0 E– 771.0	do	35	14.02	22.90	70.46	0.28
191	K054	D	160	N–2455.0 E– 771.0	do	140	18.92	30.89	64.51	0.25
192	K055a	D	160	N–2455.0 E– 771.0	do	70	16.68	26.38	69.17	0.25
193	K055b	D	160	N–2455.0 E– 771.0	do	60	31.56	49.96	43.27	0.16
194	K055c	D	160	N–2455.0 E– 771.0	do	270	28.17	45.59	43.55	0.18
195	K056	D	192	N–2454.5 E– 771.0	do	17	29.00	46.22	46.55	0.16
196	K057a	D	192	N–2455.0 E– 771.0	do	25	36.75	59.63	34.11	0.13
197	K057b	D	192	N–2455.0 E– 771.0	do	30	19.48	30.86	57.87	0.27
198	K058a	D	192	N–2455.0 E– 771.0	do	80	25.73	42.63	45.88	0.14
199	K058b	D	192	N–2455.0 E– 771.0	do	20	23.36	37.89	47.99	0.21
200	K059	D	192	N–2455.0 E– 771.0	do	29	39.39	64.05	26.22	0.90
201	K060	D	160	N–2455.0 E– 771.0	do	150	32.24	51.75	36.27	0.15
202	K061	D	160	N–2455.0 E– 771.0	do	110	40.62	61.12	31.90	0.15
203	K062	D	160	N–2455.0 E– 771.0	do	20	15.45	25.45	67.01	0.34
204	K063	D	160	N–2455.0 E– 771.0	do	40	19.03	30.55	58.31	0.34
205	K064	D	160	N–2455.0 E– 771.0	do	15	6.83	11.02	82.26	0.51
206	K090	B	159	N–2457.5 E– 761.0	do	300	23.99	37.93	46.20	1.14
207	K091	B	159	N–2457.5 E– 761.0	do	170	16.06	26.06	59.40	0.41

Table A—6 Result of Chemical Analysis of Manganese Ore in Drilling Survey

No.	Sample No.	Hole No.	Depth	Sampling Width (cm)	Content of Elements			
					Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
1	L01	No.1	4.50m ~ 5.00m	0.50	7.65	11.53	73.82	0.67
2	L02		6.50 ~ 7.00	0.50	5.23	8.04	84.71	0.86
3	L03		7.00 ~ 7.50	0.50	7.55	11.46	80.31	0.67
4	L04		7.50 ~ 8.00	0.50	9.05	14.08	77.01	0.61
5	L05		8.00 ~ 8.50	0.50	4.94	7.49	83.17	0.88
6	L06		8.50 ~ 9.00	0.50	5.27	7.70	85.26	0.63
7	L07		9.00 ~ 9.50	0.50	9.71	14.77	76.61	0.49
8	L08		9.50 ~10.00	0.50	5.65	8.04	85.94	0.47
9	L09	No.2	11.00 ~11.50	0.50	2.83	4.78	79.97	1.58
10	L10		15.50 ~16.00	0.50	2.84	4.43	85.25	1.16
11	L11	No.6	2.00 ~ 2.50	0.50	11.18	16.98	61.74	2.07
12	L12		2.50 ~ 3.00	0.50	11.55	17.44	60.68	2.07
13	L13	No.7	2.00 ~ 3.00	1.00	21.04	32.00	49.41	0.88
14	L14		3.00 ~ 4.00	1.00	12.86	19.80	65.94	1.21
15	L15	No.8	3.00 ~ 3.50	0.50	9.44	15.51	68.18	0.65
16	L16		8.00 ~ 8.50	0.50	3.04	5.03	83.23	1.45
17	L17		8.50 ~ 9.00	0.50	2.58	4.10	80.19	1.67
18	L18		9.00 ~10.00	1.00	1.74	2.89	81.48	0.65
19	L19		10.00 ~10.50	0.50	4.75	7.40	75.04	1.62
20	L20	No.9	2.50 ~ 3.00	0.50	11.65	17.25	65.60	1.48
21	L21		3.00 ~ 3.50	0.50	7.79	12.20	71.99	1.58
22	L22		10.00 ~10.50	0.50	4.05	6.59	79.03	1.44
23	L23		16.00 ~16.50	0.50	9.94	14.98	71.79	0.92
24	L24		16.50 ~17.00	0.50	5.67	9.20	76.31	1.55
25	L25		17.00 ~17.50	0.50	4.08	7.10	75.48	2.01
26	L26		17.50 ~18.00	0.50	8.50	13.22	75.32	1.26
27	L27		18.00 ~18.50	0.50	7.19	10.97	77.33	1.14
28	L28		18.50 ~19.00	0.50	5.66	7.32	82.81	0.74
29	L29		19.50 ~20.00	0.50	4.79	7.54	78.64	1.80
30	L30		20.00 ~20.50	0.50	6.01	8.46	85.25	0.57

No.	Sample No.	Hole No.	Depth	Sampling Width (m)	Content of Elements			
					Mn(%)	MnO_2(%)	SiO_2(%)	Fe(%)
31	L31	No.9	20.50 ~21.00	0.50	8.79	12.54	77.26	0.83
32	L32		21.00 ~21.50	0.50	21.76	32.22	54.03	0.99
33	L33		21.50 ~22.00	0.50	4.94	7.45	86.93	0.69
34	L34		22.00 ~23.00	1.00	3.11	5.19	82.60	1.49
35	L35		23.00 ~24.00	1.00	5.99	9.49	77.94	1.26
36	L36		24.00 ~24.70	0.70	10.79	17.88	66.41	1.23
37	L37	No.10	4.00 ~ 5.00	1.00	10.95	17.88	65.30	1.98
38	L38		5.00 ~ 6.00	1.00	8.25	12.28	80.25	0.71
39	L39	No.11	9.50 ~10.50	1.00	13.52	21.36	63.82	1.43
40	L40		10.50 ~11.50	1.00	22.99	34.05	53.48	0.51
41	L41	No.12	16.00 ~16.50	0.50	10.01	16.03	62.46	6.28
42	L42	No.13	12.50 ~13.00	0.50	16.23	26.32	59.27	1.37
43	L43		13.00 ~13.50	0.50	10.08	15.53	66.44	1.95
44	L44		13.50 ~14.00	0.50	5.96	9.92	72.46	1.99
45	L45		14.00 ~15.00	1.00	6.95	11.02	67.08	2.20
46	L46		15.00 ~15.50	0.50	6.47	10.10	70.32	2.30
47	L47	No.14	3.50 ~ 4.00	0.50	26.45	41.47	45.60	0.80

Table A—7 Result of X—ray Fluorescence Analysis of Chert aud Shale

Sample No.		K-104	K-107	K-115	K-116
Rock Name		white muddy chert	red chert	red chert	white chert
Chemical Composition	SiO_2(%)	100.24	97.31	81.05	83.52
	TiO_2	0.05	0.06	0.52	0.42
	Al_2O_3	1.22	1.34	7.68	6.62
	Fe_2O_3	0.25	0.66	4.68	2.71
	MnO	0.00	0.02	0.03	0.48
	MgO	0.12	0.32	1.77	1.78
	CaO	0.25	0.37	0.76	0.72
	Na_2O	0.15	0.20	0.19	0.20
	K_2O	0.18	0.19	1.40	1.18
	P_2O_5	0.01	0.01	0.03	0.03
	$H_2O^{(+)}$	1.46	1.81	3.77	3.56
	$H_2O^{(-)}$	(0.08)	(0.11)	(3.13)	(2.23)
	S(ppm)	130	260	370	450
	Cl	130	450	70	100
	Co	–	–	10	5
	Ni	10	–	30	50
	Cu	–	–	30	20
	Zn	–	20	50	50
	Ga	–	–	–	20
	Rb	–	16	70	35
	Sr	29	63	139	225
	Y	–	–	10	10
	Zr	10	10	100	90
	Nb	–	–	30	10
	Ba	–	–	–	–
	Pb	–	–	–	–
	Mo	–	–	–	–
	As	–	–	–	–
	V	n.d.	n.d.	n.d.	n.d.
	Cr	n.d.	n.d.	n.d.	n.d.
Total(%)		103.93	102.29	101.88	101.22