REPUBLIC OF THE PHILIPPINES

REPORT ON GEOLOGICAL SURVEY OF MINDORO ISLAND

PHASE III

AUGUST 1984

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request of the Government of the Republic of the Philippines, decided to conduct collaborative mineral exploration in Mindoro Island of the Philippines and entrusted its execution to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

Between 21 November 1983 and 27 March 1984, Metal Mining Agency of Japan dispatched a survey team headed by Mr. Hiroshi Fuchimoto to conduct the Phase III of the project.

The survey had been accomplished under close cooperation with the Government of the Republic of the Philippines and its various authorities.

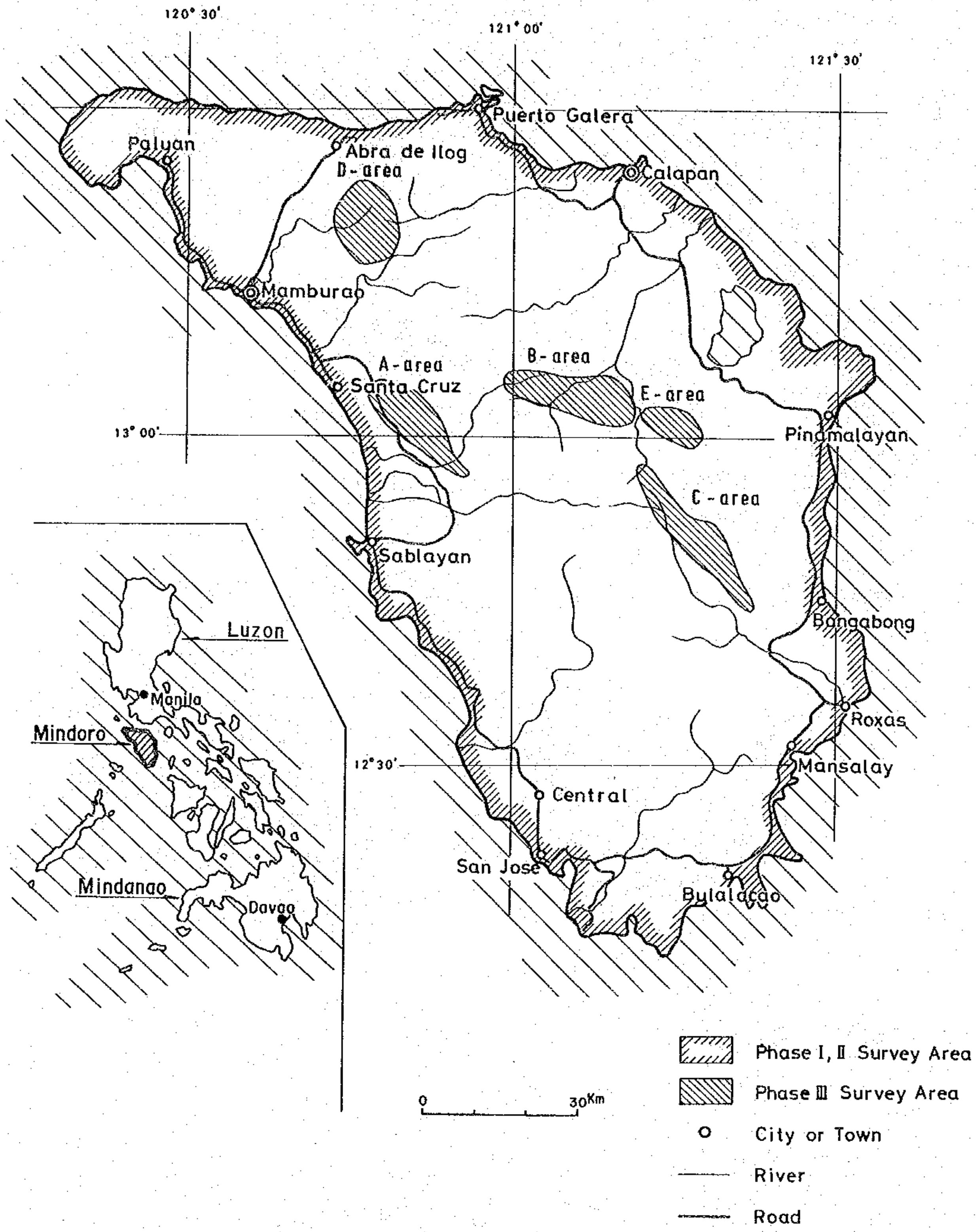
This report is a compilation of the survey of the Phase III, and after completion of the project, the consolidated report will be submitted to the Government of the Republic of the Philippines.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the Project, the Government of the Republic of the Philippines, Bureau of Mines and Geo-Sciences (BMG), and other authorities and the Embassy of Japan in the Philippines.

June 1984

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan



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ABSTRACT

The Geological Survey of Mindoro Island, Philippines, aims on the evaluation of potential for all kinds of mineral resources. The Phase I and Phase II surveys clarified the occurrence of various ore deposits and the genetic relationship between mineralization and igneous activities as well as the stratigraphy and the geological structure. As a result, A-, B-and C-areas for chrome, D-area for iron and E-area for copper were chosen from the geological and economic-geological points of view as having potential for mineral resources. This year, Phase III of this survey, geological survey was carried out for A-, B- and C-areas with trenching, for D-area with ground magnetic survey and for E-area with geochemical survey for soil and stream sediment.

The each survey result is as follows.

1. A-area is composed of the Ultramafic complex (Pintin body), mainly consisting of harzburgite and accompanying gabbro on its west side. Many chromite showings found in this phase are arranged in the direction parallel to the elongation of complex, suggesting the horizon of chromite deposition. Trenching at two places varified that these showings are small in scale.

2. B-area is composed of the large-scale Ultramafic complex (Ogos body) which has intruded in the E–W direction in the central portion of the east side. This complex is made of dunite, harzburgite and lherzolite, some of which show a layered structure. Chromite showings are such related to dunite that the Ogos orebody found in Phase II and new outcrops in this phase occur in dunite. The Ogos orebody has been identified with a layered body with a 6.5 m wide and a 33% of Cr_2O_3 grade.

3. C-area is composed of the Ultramafic complex (Bongabong body) which is made of dunite and harzburgite, showing a layered structure. Chromite showings occur in dunite and can be classified into two types, viz, layered type and massive type, both of which are determined to be small by trenching.

4. D-area is the iron deposit area located in the northern part of the central range. There are many magnetite deposits of the metasomatic type and are related to the Palaeogene dioritic rocks. The three ore deposits which seemed to be promising have proven to have considerable ore reserves.

5. E-area is the copper mineralization area which is located in the upper reaches of the Pula River. The mineralization consists of chalcopyrite – pyrrhotite – quartz vein of high grade of Cu. Geochemical surveys for soil and stream sediment have verified that contents of Cu, Pb and Zn are generally low and that few geochemical anomalies occur in the area.

I. GENERAL REMARKS

CHAPTER 1. OUTLINE OF THE SURVEY

1–1 Purpose and Scope of the Survey

The purpose of this project is to evaluate the mineral resources of Mindoro Island by determining their potential for exploitation by clarification of the geological structure, the favorable geological environment for mineralization and the mineral showings. To achieve this, geological and geochemical surveys, photo-interpretation and airborne magnetic survey were carried out for all of Mindoro Island (10,000 km^2) in Phase I and were followed by geological and geochemical surveys in Phase II for areas remaining untouched in Phase I and for the mineralization areas.

In Phase III, a detailed survey was executed for the purpose of studying the mineralized zone which was determined potential for mineral resources from Phases I and II.

1–2 Outline of the Survey

Geological survey including trenching, geochemical survey and ground magnetic survey were conducted for three areas of A, B and C where chromite showings are distributed, D-area where iron showings of a metasomatic type are concentrated and E-area where copper mineralization of a vein type are found. All of the areas were chosen for these by the Phase I and Phase II surveys.

The contents of the field work of Phase III are shown in Table 1.

Table 1 Outline of Field Survey in Phase III

	Area					Total
	A	B	C	D	E	
Survey Area (km^2)	170	180	210	180	60	800
Length of Geological Survey Route (km)	76.5	82.5	80.5	74.3	64.8	378.6
Length of Trench (m)	20.0	48.0	26.0	–	–	94.0
Length of Magnetic Survey Route (km)	–	–	–	29.62	–	29.62
No. of Geochemical Samples (pcs)	–	–	–	–	618	618

1–3 Organization of the Survey Team

The personnel who participated in the planning, negotiation and the field survey are as follows.

(A) Planning and Negotiation

(Japan)

Toru Miura	Metal Mining Agency of Japan
Yoshitaka Hosoi	do
Yukihiro Minami	do
Takahisa Yamamoto	do
Jiro Osako	do (Manila Representative)

(Philippines)

Juanito C. Fernandez	Bureau of Mines & Geo-Sciences
Guillermo R. Balce	do
Mariano G. Pacis	do

(B) Survey Team

(Japan)

Hiroshi Fuchimoto (Leader)	Metal Mining Agency of Japan
Mikio Kajima	do
Yoshiaki Shibata	do
Nobuhiro Goto	do

(Philippines)

Mariano G. Pacis (Leader)	Bureau of Mines & Geo-Sciences
Lope M. Cariño	do
Ronaldo Miranda	do
Eleazar Mantaring	do
William Bondame	do
Ariel Malicse	do

CHAPTER 2. OUTLINE OF THE SURVEY AREA

Among five areas of A, B, C, D and E for this phase survey, four areas except for E-area are located in the mountains and each access is so difficult that it takes two days on foot to get there from the end of the road.

Location, access, topography and vegitation of each area are as follows.

A-area – This area (25 km x 7 km) is located in Occidental Mindoro, lying on the east side of the main road from Sablayan to Sta. Cruz. It is hilly and the elevation is less than 300 m. Except for the rainy season when the main road is held up, it is easy to get this area within 30 minutes by car from Sablayan or Sta. Cruz. As the area is covered with grass and some bushes, it is utilized as a pastureland.

B-area – This area (EW 25 km x NS 7 km) is located in the upper reaches of both the Magasawangtubig and Amnay Rivers, stretching to over Oriental and Occidental provinces. It is mountainous and very steep-slope, ranging from 100 to 1,000 m in elevation. Valleys are deeply dissected and high waterfalls cascade at places. It takes about one hour to get Villacerveza (nearest barrio to this area) from Calapan. Trails are hardly found after Villacerveza, and so, it is very difficult to enter the mountain when it rains. The area has rainfall which is evenly distributed throughout a year and is covered with big trees called Tangili, Lawaan and Tanapa etc.

C-area – This area (NW 35 km x NE 6 km) is located in Oriental Mindoro, covering a large part of the mountain ranges, rising in the east side of the Bongabong River. The elevation ranges 400 – 1,400 m. The topography is very steep and high cliffs often run on both sides of the range. It is not so far (10 – 15 km) from the main road in the east but 1 – 2 days are needed to get this area on foot along rivers. Especially, the level of rivers go up suddenly when it rains, and it makes very hard to climb the mountain. Vegetation is very thick and logging is operated locally.

D-area – This area (circular area with a 15 km diameter) is mountainous, ranging 40 – 1,300 m in elevation, and covers the upper reaches of the Mamburao River and the middle courses of the Pagbahan River. Limestone is widely distributed, showing a peculiar topography of limestone with high cliffs and dolines. As surface water easily infiltrates underneath, creaks in the area are usually dried up. While the downstreams are flooded by riverbed water in rainy days. In order to get this area no other course can be found but either taking a steep mountain trail from Abra de Ilog or going up to the Mamburao River with great boulders (3 – 10 m in diameter). But both way are so difficult that it takes at least two days to get there on foot. Many of the mountains are almost bare due to deforestation by burning except for some strips along creek where a little vegetation is found.

E-area – This area (elliptic area 12 km x 6 km) is located in the middle courses of the Pula River. It can be reached either from Putol na Bato (30 minutes drive from Socorro) on foot along the Pula River or from Villacerveza via a mountain trail crossing many ridges. It takes two days to get there in either case. The elevation is 200 – 900 m, which is not so high but many cliffs of basalt lava rise in places, forming a steep topography. Vegetation was so thick that brushing was needed along the all survey lines set in the geochemical survey (soil) area.

Ⅱ. GEOLOGY AND ORE DEPOSIT

CHAPTER 1. GENERAL REMARKS

The geology of the Mindoro Island consists of, in a general view as shown in Fig. 2, the Mesozoic (to Palaeozoic) rocks trending northwestward at the center and the Cenozoic rocks on both sides of the above rocks showing a tendency to dip northeast in the eastern side and southwest in the western side, and a large anticlinal structure having a northwestward trending axis is shown on the whole.

The stratigraphy of the Island is classified in the ascending order into the Halcon metamorphics, the Baco Group (this is further subdivided into the Mansalay Formation and the Lumintao Formation), the Mamburao Group, the Bongabong Group, the Soccoro Group and the Alluvium. The intrusive rocks consist of the Ultramafic complex forming large-scale bodies, the acidic to intermediate rocks (granodiorite, quartz diorite, diorite and diorite porphyry and the basic rocks (dolerite and gabbro) showing the exposures in a small scale.

Various kinds of mineral showings are observed in the Mindoro Island. The metallic ore deposits include chromite deposits associated with ultramafic rocks, contact metasomatic-type iron deposits, vein-type copper deposits and placer gold deposits. The nonmetallic ore deposits include those of barite, jade, marble and coal.

In order to clarify the details of the mineralized zones of chrome, copper and iron, which are considered to be promising based on the results of Phase I and II, geological survey was conducted in the five areas of A, B, C, D and E this year. In addition, the trenching work was conducted in the areas of A, B and C, the ground magnetic survey in D-area and the geochemical survey in E-area.

Although the result of survey is to be mentioned in detail in the following, many showings were newly confirmed as a result of this survey and the sufficient data to evaluate the deposits in the above were obtained. However, it was also made clear that the scale of the showings is very small except the iron deposits in D-area and the Ogos chromite deposit in B-area.

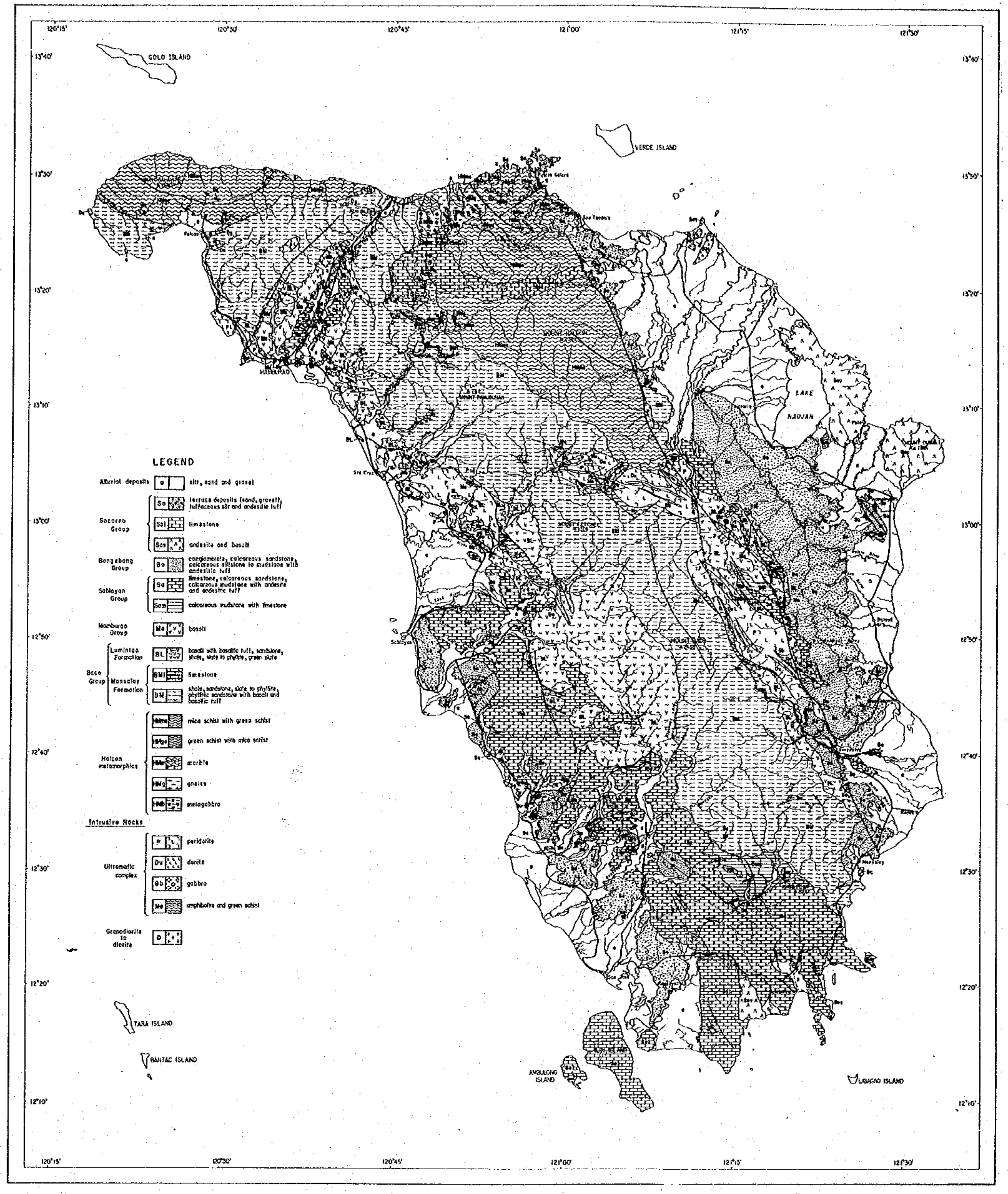
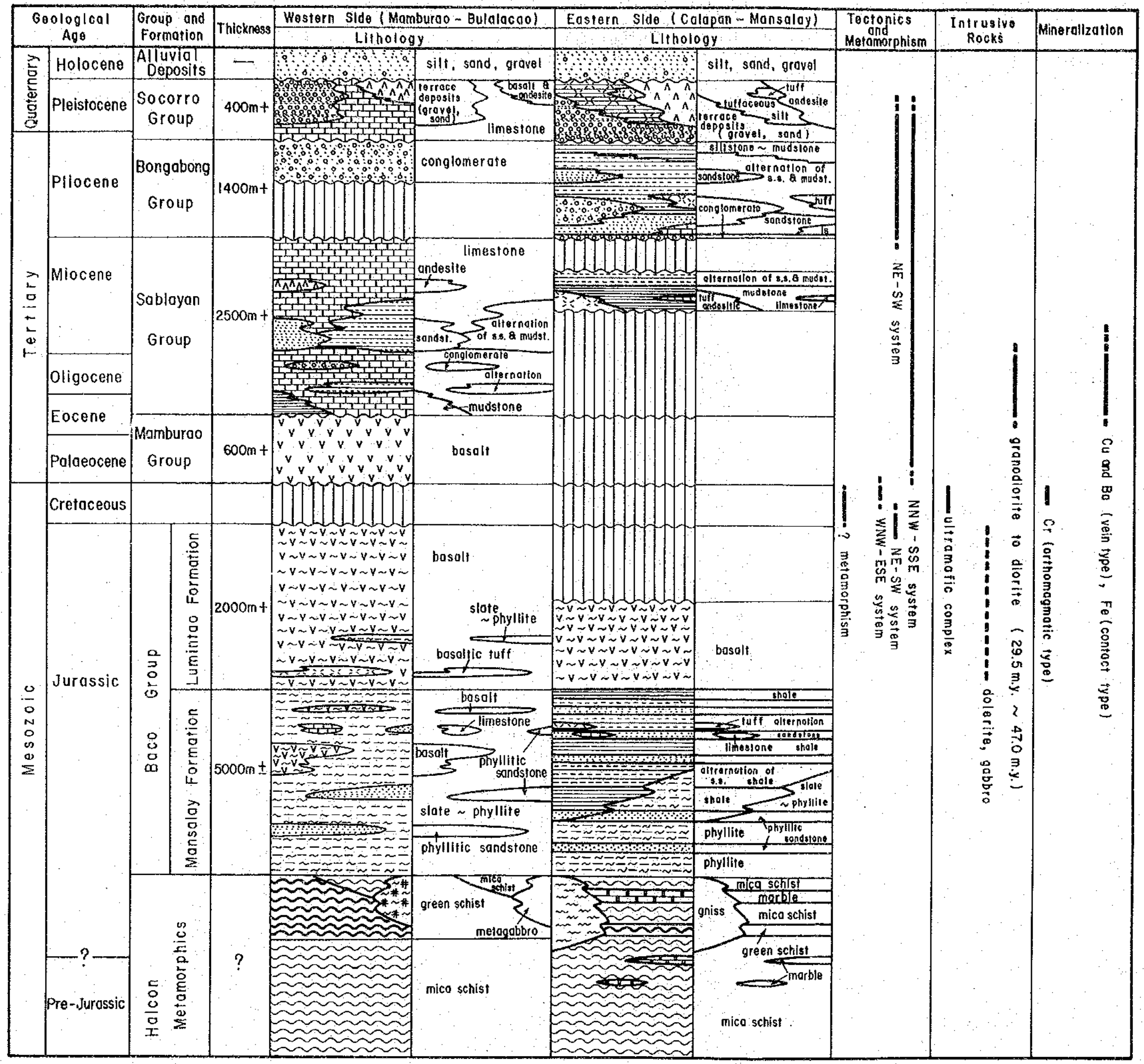


Fig. 2 Geological Map of the Mindoro Island

Table 2 Generalized Stratigraphic Section of the Mindoro Island



CHAPTER 2. A, B AND C-AREAS (CHROME MINERALIZED ZONE)

2–1 Geology

In the three areas of A, B and C, beside the Ultramafic complex, the Halcon metamorphics and the Baco Group which have been intruded by the Ultramafic complex, and the Sablayan and Bongabong Groups conformably overlying the Halcon metamorphics and Baco Group are distributed. Although the metamorphic rocks, which are closely associated with the Ultramafic complex, had been included in the Halcon metamorphics in Phase I and II, they were in this phase treated as a part of the Ultramafic complex, from the viewpoint of the difference in metamorphic grade and of that it is strongly related to the Ultramafic complex.

2–1–1 Ultramafic Complex

The Pintin body is distributed in the A-area, the Ogos body in the B-area and the Bongabong in the C-area, and these have the extent such as 40 km long and 9 km wide, 22 km long and 10 km wide and 34 km long and 8 km wide, respectively. These bodies are considered to have intruded into the Halcon metamorphics and the Baco Group in a solid state.

(1) Rock Facies

The complex which is accompanied with the block-like metamorphic rocks at the peripheral part and inside of the body, mainly consists of dunite, harzburgite, lherzolite and gabbro.

Dunite has a different extension of exposure in the different body. It occupies almost a half of the whole Ogos body, but any mappable one cannot be observed in the Pintin body. Dunite is black to dark grey in color at the fresh part, and it shows dark green to dark greyish green tint by serpentinization at the altered or weathered part. Because it has a smooth surface which often shows brown in color and contains few pyroxene, it is easily discriminated from other types in fields unless it has been highly serpentinized.

Harzburgite is extensively exposed in any body. The rock is dark green, pale greenish brown and black in color, and has been mostly affected by serpentinization, although there are some differences in degree. It is easy to distinguish the rock from dunite in fields because many pyroxene crystals can be observed on the surface at the outcrop. It is difficult, however, to discriminate it from lherzolite.

Under the microscope, a cataclastic texture is shown in most of harzburgite, however it is not shown in some which contain orthopyroxene showing an exsolution texture. It is, therefore, thought that the harzburgite which belongs to a cumulate type, beside a tectonite type may exist.

Lherzolite is found in all the three bodies, but the distribution is more limited than the two types of rocks mentioned above. It is dark grey at the fresh part and dark green at the serpentinized part. Deducing from the facts that orthopyroxene showing exsolution texture is observed under the microscope and the cataclastic texture can not be observed as far as the samples taken in this survey, it is considered that these are all lherzolite of a cumulate type.

Gabbro is exposed in both bodies of Pintin and Bongabong, but not found in the Ogos body. The gabbro of the largest scale is distributed at the western end of the Pintin body, showing an exposure 7 km long and 500 m wide. Although this gabbro is in reverse fault contact with harzburgite, all the others have intruded into peridotite such as harzburgite etc. Several kinds of gabbro can be distinguished under the microscope as follows: augite gabbro, augite-hypersthene gabbro, hornblende-hypersthene gabbro, hornblende-augite-hypersthene gabbro and hornblende gabbro.

Beside the four rock types in the above, the complex includes weherlite, orthopyroxenite, hornblendite, diorite porphyry and trondhjemite. These are in a small scale and a few m to several hundred m in width.

As previously mentioned, metamorphic rocks in a form of block are contained at the peripheral part and inside of the complex. These are composed of amphibolite, amphibole schist and green schist, and are higher in metamorphic grade than the Halcon metamorphics. And these are in contact with the low grade metamorphic rocks of the Baco Group in most case. Therefore, it seems that these rocks were brought over from the deeper part at the time of intrusion of the ultramafic rocks. Although the metamorphic rocks are found at the periphery of each body, the rocks existing inside the body as xenoblock are only observed in the Pintin body and in the western part of the Ogos body.

The xenoblocks consist not only of the metamorphic rocks, but of basalt lava of the Lumintao Formation in some cases. The one in the Pintin body has a scale of 4.5 km long and 500 m wide.

(2) Geological Structure

The structure of each body can be cleared by the layering formed by alternating beds of dunite and peridotite rich in pyroxene such as harzburgite, the distribution of dunite and the arrangement of chromite showings.

In the Pintin body, it is recognizable that the structure of a NW–SE system at the center – the southern part gradually changes to that of an E–W system in the northern part based on the arrangement of chromite showings and the trend of elongation of xenoblocks and gabbro as shown in Fig. 3.

In the Ogos body, the structure of a WNW–ESE system is known in its eastern half from the arrangement of dunite and the layering as shown in Fig. 4. In the eastern half, however, that of an E–W system is shown in the western part, which shifts to NE–SW system in the eastern part. Because the distribution of dunite becomes discontinuous and an extensive fracture zone was confirmed at the boundary between the eastern half and the western half, the fault of a NE–SW system can be inferred.

In the Bongabong body, it is considered that it has the structure of a NW–SE system, from the arrangement of dunite and chromite showings, and also the confirmed layering shown in Fig. 5.

2–1–2 Halcon Metamorphics

The Halcon metamorphics are exposed in the northern part of the B-area.

The metamorphics mainly consist of mica schist, accompanied with green schist. Mica schist is grey to pale grey in color and shows a distinct schistosity. It is fine-grained and belongs to the one called sericite schist in general, Microfolding is often observed. Green schist is pale green in color, and the schistosity is not so distinct as in mica schist. The rock is intercalated in mica schist and is 10 to 40 m thick.

Considering from the general trend of schistosity, the Halcon metamorphics in the B-area strike N40–50°W in the adjacent part of the Mindoro Fault in the eastern part, which change to strike N70°W on the west. The rocks dip 45° to 65°SW in general although the dip is not uniform because of prevailing microfolds. The relation between these rocks and the Ultramafic complex seems to be of intrusion from the distribution of the both rocks and the structure.

2–1–3 Baco Group

(1) Mansalay Formation

The formation is distributed in the northern part of the A-area, in the western part and the southern part of the B-area and in the western part and the northeastern part of the C-area. The time of deposition of the formation is considered to be Jurassic based on the ammonite fossils contained inside at a locality to the west of Mansalay.

The Mansalay Formation mainly consists of slate and phyllite, intercalated with indurated sandstone and phyllitic sandstone. Slate and phyllite is calcareous in general and black to dark grey in color. Schistosity or cleavage is well developed and is very fissile. It is often accompanied with segregation veins of quartz. Indurated sandstone and phyllitic sandstone are greyish white in color and arkosic. The rock forms alternating beds with slate or phyllite with a thickness under 10 cm in some parts, or the thicker beds of about 10 m thick being intercalated in those rocks in other parts.

The strike of schistosity shown by the formation is parallel to the outline of the Ultramafic complex in most parts. Although the relation between the formation and the Ultramafic complex is considered to be of intrusion in general, there are the portions inferred to be in fault contact of high angle in the Ogos body and the Bongabong body.

(2) Lumintao Formation

The formation crops out in the northern part, the eastern part and the southern part of the A-area, in the eastern part of the B-area and in the southern part and the northern part of the C-area. The time of its deposition is considered to be Late Jurassic because the formation conformably overlies the Mansalay Formation.

The Lumintao Formation mainly consists of basalt lava which partially intercalates green slate, slate and phyllite. The basalt lava is mostly composed of pillow lava which is dark green or reddish brown in color, locally accompanied by massive lava, autobrecciated lava and hyaloclastic breccia. The rocks have been highly altered, and the veinlets of albite, calcite, chlorite-epidote and zeolite in a form of vein or network are observed. Green slate, slate and phyllite are intercalated in the formation as the beds less than 50 m thick at the boundary with the Mansalay Formation.

Although the structure of the formation is not distinct because of poor bedding, it tends to strike parallel or intersecting in a low angle with the outline of the Ultramafic complex. The relation between the Lumintao formation and the Ultramafic complex is considered to be of intrusive relation or in fault contact of high angle.

2–1–4 Sablayan Group

The Sablayan Group is distributed in the western part of the A-area, the eastern part of the B-area and the eastern part of the C-area. The group consists of the beds predominant in Upper Eocene to Upper Miocene limestone.

The Sablayan Group in the areas is composed primarily of calcareous mudstone and sandstone. The mudstone is well exposed in the upper reaches of the Banus River, and it is calcareous, showing grey to black in color. It forms thick beds, being massive without any bedding. It is intercalated with limestone containing larger foraminiferas indicating Miocene age. The sandstone

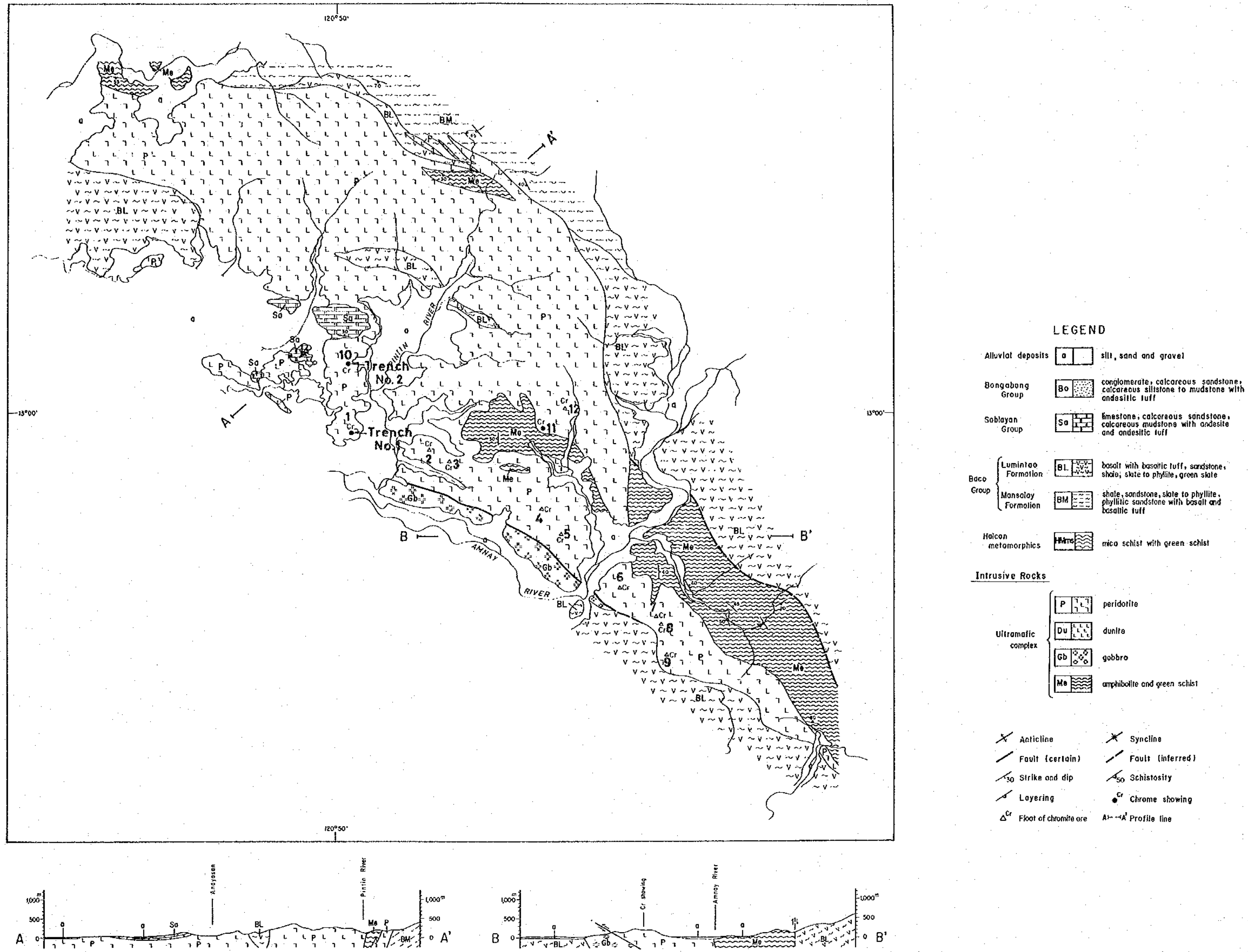


Fig. 3 Geological Map of the A-area

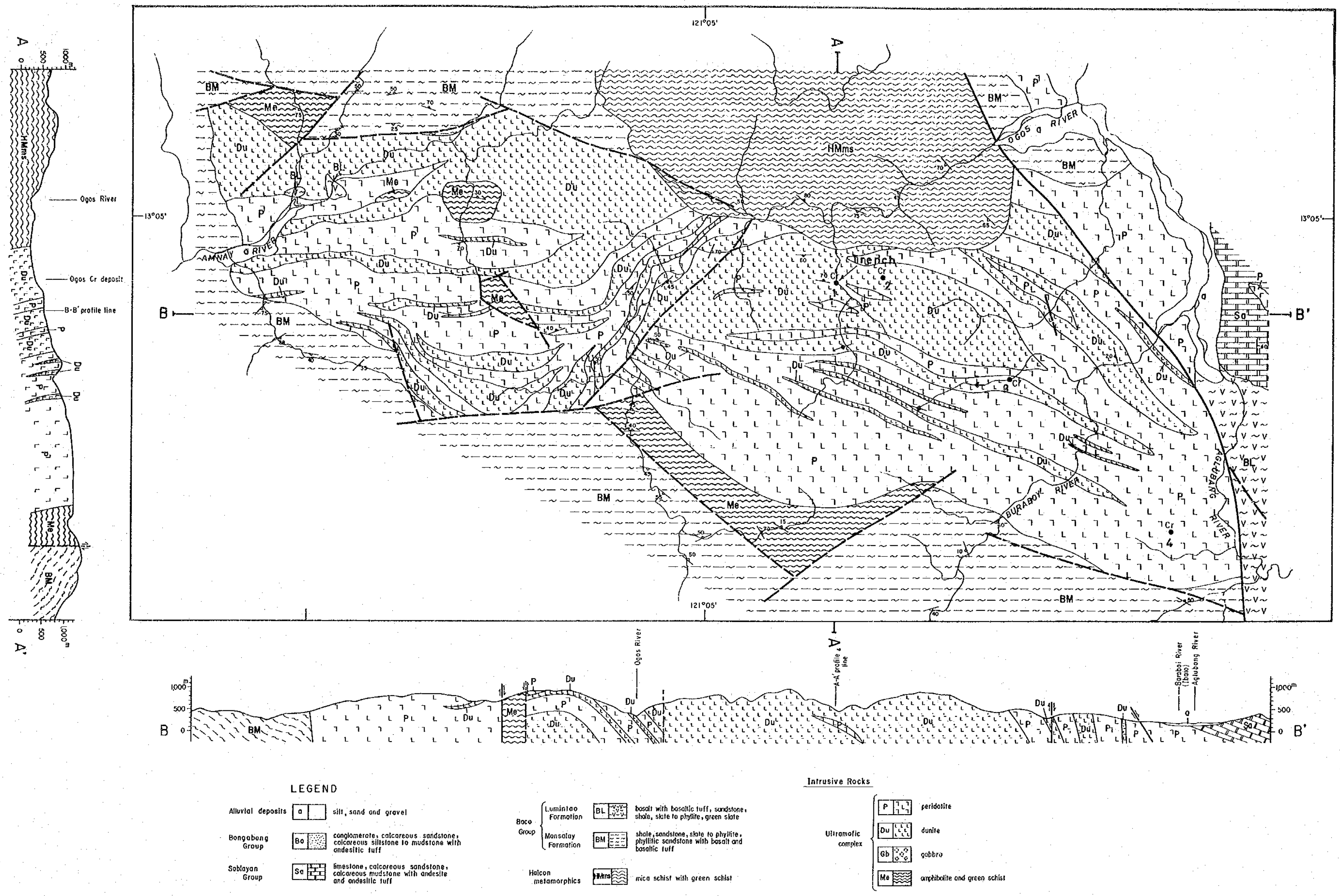


Fig. 4 Geological Map of the B-area

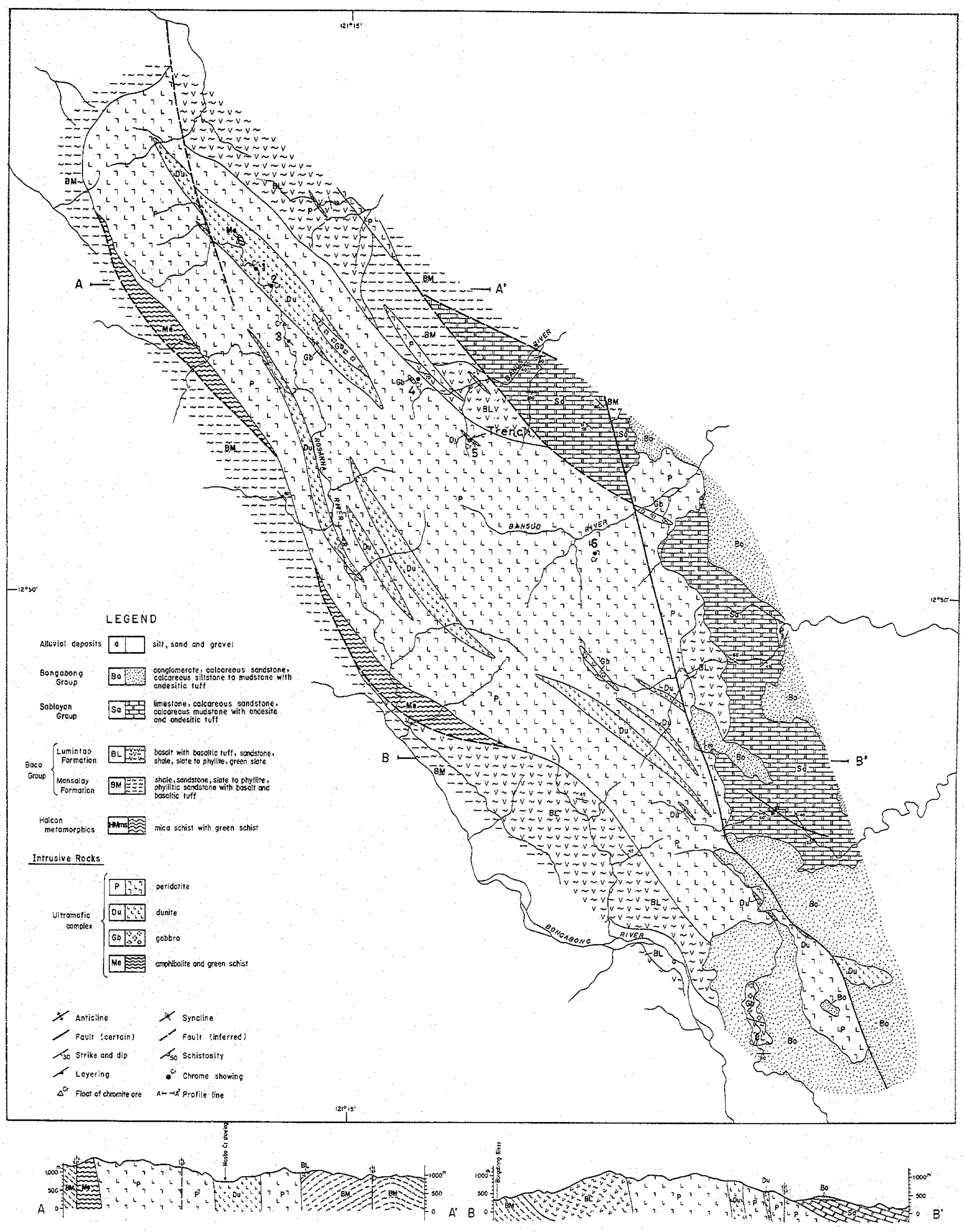


Fig. 5 Geological Map of the C-area

beds are of less than 100 m thick, being interbedded between the thick mudstone. It is greyish white and pale greyish green in color, and fine to medium-grained in most cases. The matrix is generally calcareous. The alternating beds of mudstone and sandstone are distributed in the A-area and B-area.

The group unconformably overlies the Ultramafic complex and the Baco Group. A syncline of a NE–SW system on a small scale occurs in the A-area, and an anticline and a fault are observed in the C-area, showing a little complicated structure.

2–1–5 Bongabong Group

The Bongabong Group is exposed in the eastern part and the southern part of the C-area. The time of deposition of the group is indicated to be Pliocene age deduced from the planktonic foraminiferas contained in the group.

The rock facies of the group consists of sandstone and mudstone in the eastern part of the C-area, and limestone, conglomerate and sandstone in the southern part. Sandstone and mudstone are tuffaceous and calcareous, showing distinct bedding. Limestone is grey in color and massive. The conglomerate is composed of round to subround pebbles consisting of ultramafic rocks and the matrix of coarse-grained sandstone.

The group unconformably overlies the Sablayan Group in the eastern part of the C-area, gently dipping east, while it unconformably overlies the Ultramafic complex in the southern part, gently dipping south or southeast.

2–2 Ore Deposit

In the survey of this phase, the continuity of the mineralized zone was clarified by ground survey, and the trenching was conducted at three places to confirm the scale of ore deposit. The result of survey of the areas is as follows.

2–2–1 A-area

In the area, the two occurrences of floats of chromite ore had been confirmed by the survey of Phases I and II, and the survey of this phase resulted in further to confirm the outcrops at three places and the floats at seven places. These floats are all distributed on the ridge and considered to be in situs. The twelve showings in total were checked in the survey. As obviously shown in Fig. 3, the showings from No.1 to No.9 are arranged on a straight line for about 10 km northwestward. This trend of arrangement is considered to show a horizon in which chromite was formed because it is in consistent with the direction of extension of gabbro and the

Pintin body. The remaining No. 10 to 12 seem to be the showings along another line. It is a characteristic of this mineralized zone that all these showings are not distributed in dunite, but in peridotite mainly of harzburgite.

The details of the mineralized zone are described separately on the western part, the central part and the eastern part in the following.

(1) Pintin west mineralized zone (No. 1 and 10 in Fig. 3)

Two showings are found in this mineralized zone, which are situated on a small hill on the west bank of the Pintin River. The trenching was conducted at these outcrops to make clear the downward extension and the relation with the country rock.

As a result, it clarified, as shown in Fig. 6, that the No.1 showing consists of several lenticular orebodies, 1 m long and about 20 cm wide in maximum, emplaced in harzburgite. The general strike and dip shown by these orebodies are N85°E and 35°S respectively. The ore is massive and no dissemination is observed. The occurrence of chromite in the ore is shown by an aggregate of xenomorphic crystals 0.01 to 0.4 mm across, showing a cataclastic texture.

The analytical results of the ores are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–013	(massive ore)	39.81	26.63	10.91	6.28	6.97	0.32	336
KR3–019a	(do.)	38.93	19.13	12.96	9.35	13.30	0.19	272
KR3–019b	(do.)	38.14	15.05	13.00	10.62	15.84	0.14	240
KR3–020	(do.)	41.30	26.89	5.46	6.68	6.77	0.31	323

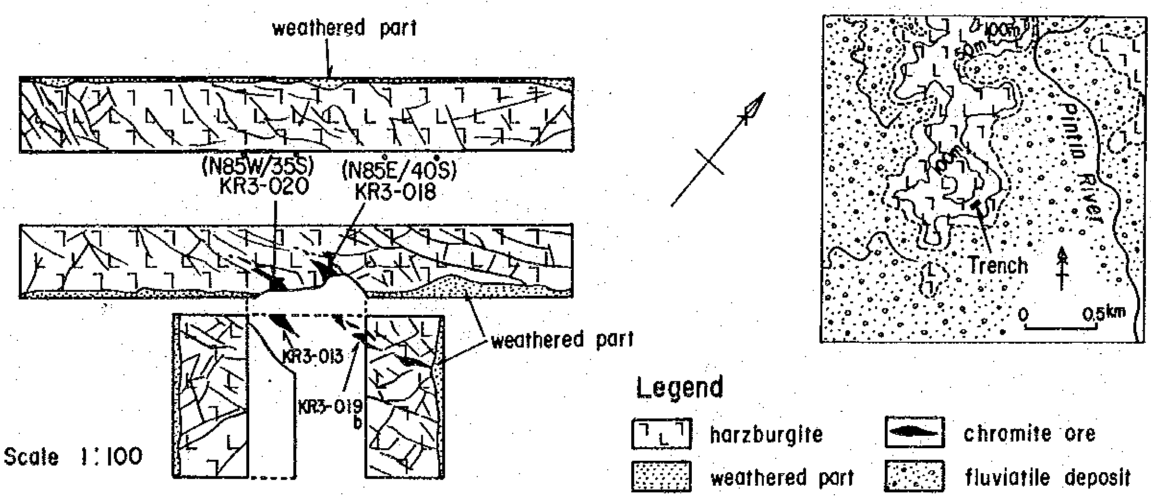


Fig. 6 Geological Sketch of No.1 Trench in A-area

As for the No. 10 showing, it has become clear that it is a lenticular orebody, 1 m long and 15 cm wide in maximum, emplaced in harzburgite as in the No. 1 showing (Plate 4). The strike and dip of the ore body are N23°W and 24°S respectively. The ore is massive to spotted, and chromite in the ore forms the aggregate of idiomorphic to hypidiomorphic crystals 0.1 to 1 mm across, and many irregular cracks are found inside the crystals.

Assay results of the ore are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–014	(massive ore)	40.19	14.89	11.26	11.63	14.49	0.23	232
KR3–023	(do.)	39.92	14.80	10.11	12.63	15.41	0.16	254

(2) Pintin central mineralized zone (No. 2 to 5, 11, 12 in Fig. 3)

The six showings have been confirmed in this mineralized zone. The showings of No. 4 and 5 were checked in Phase II, where the trace of trenching is observed and about two tons of massive to spotted ore have been piled as the stock. These six showings are indicated by the floats of ore likely to be in situs except for No. 11, where 2 to 10 pieces of massive to spotted ore with 5 to 40 cm in size are scattered. Although No. 11 is an outcrop, the shape of orebody is not confirmed because most of the ore has been digged out by trenching.

Regarding to the country rock, dunite is scarcely observed in the vicinity of the No. 4 showing, but all the orebodies seems to have been emplaced in harzburgite. Chromite in the ore forms an aggregate of xenomorphic crystals with 0.05 to 1.0 mm across, showing a cataclastic texture.

Assay results of the ore are as follows.

Sample No. (No. of showing)		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–011a	(No. 2)	48.94	13.81	6.76	12.38	12.44	0.17	274
KR3–011b	(No. 3)	47.62	19.33	8.65	7.76	9.08	0.25	314
FR3–013	(No. 11)	51.40	17.69	2.96	8.74	11.64	0.22	264

(3) Pintin east mineralized zone (No. 6 to 9 in Fig. 3)

The mineralized zone is situated to the southeast of the Amnay River, and the showings were confirmed at four places within a distance of 2.5 km. Similar to the west and the central, the showings are distributed in peridotite mainly of harzburgite. The ore is almost massive, and disseminated ore is very small in amount. Several pieces of floats less than 40 cm in size are scattered in each showing. Chromite in the ore forms an aggregate of xenomorphic to hypidiomorphic crystals 0.1 to 2.0 mm across, and many irregular cracks are observed inside the crystals.

The ore has partly undergone shearing, resulted in to be broken to breccias less than 0.1 mm across, showing a cataclastic texture.

Assay results of the ore are as follows.

Sample No. (No. of showing)		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–005	(No. 7)	33.18	9.86	6.78	26.06	18.74	0.16	207
KR3–006	(No. 7)	30.30	9.14	9.02	24.79	18.98	0.12	144
KR3–007	(No. 6)	56.10	11.88	6.34	8.76	13.64	0.25	300

2–2–2 **B-area**

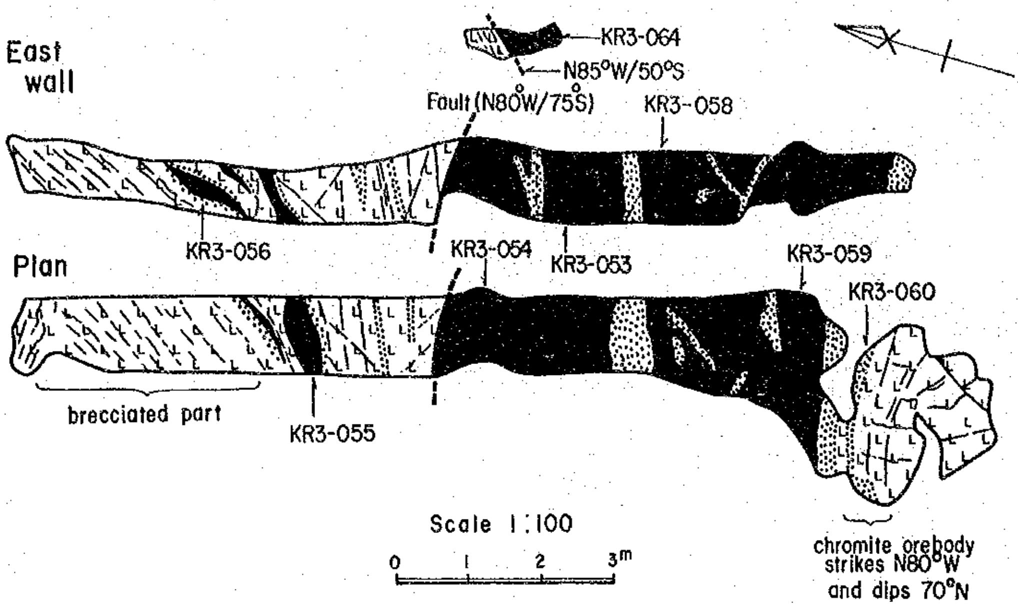
No chromite showings had been known in the area before the start of this survey, where the first showing (Ogos orebody) was confirmed in Phase II along the tributary (Alagag River) in the middle reaches of the Ogos River, and further the showings were discovered at three places in this phase.

The Ogos orebody (No. 1 in Fig. 4) has a width of more than 5 m as reported in Phase II, but the extension had not been confirmed because of the fluviatile deposit covering all the surroundings of the outcrop. In this phase, therefore, the trenching was conducted on five sites. As a result, the bed rock was reached only in the Trench No. 1 because the gravel bed was so thick in other trenches, as shown in Fig. 7 and Plate 2. In the Trench No. 1, it was clarified that the layered orebody with a total width of 6.5 m (6.0 m for the main orebody) was emplaced in dunite. The orebody consists mostly of massive ore, grading into disseminated ore close to the wall. On the northern side of main orebody, however, the massive part is directly in fault contact with dunite, striking N80°W and dipping 75°S. The main orebody strikes N80°W and dips 70°S.

Microscopic observation and chemical analysis were carried out for the ore of the Ogos orebody. Microscopic observation has revealed that the ore consists of an aggregate of idiomorphic to hypidiomorphic crystals 0.1 to 3.0 mm across and many cracks are formed inside the crystals. It also has become clear that a cataclastic texture is partly shown and a very small amount of pyrite (less than 0.03 mm across) is contained.

Among the eight samples chemically analyzed, the representative are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–053	(massive)	33.71	12.35	17.54	9.47	21.63	0.13	191
KR3–054	(do.)	30.16	11.30	14.65	15.23	22.64	0.11	143
KR3–059	(do.)	37.36	13.51	8.13	18.15	15.09	0.11	196
KR3–060	(disseminated)	27.05	12.69	13.25	14.80	23.05	0.13	173



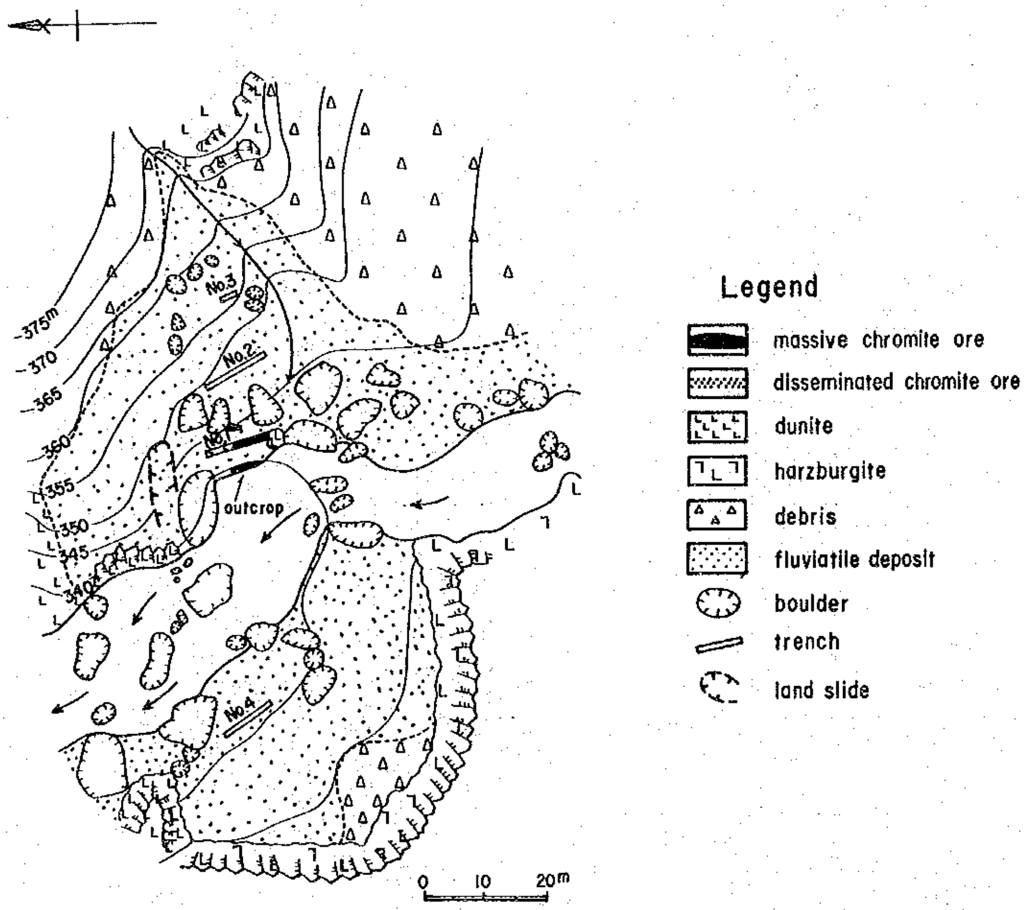


Fig. 7 Geological Sketch of No.1 Trench in B-area

Beside the Ogos orebody mentioned above, the outcrop (No. 2) 1 m wide was found at almost the same horizon about 1 km to the east of the above, and another outcrop (No. 2) 0.1 m wide was encountered further 4 km to the southeast. These are emplaced in dunite. The chromite network zone (No. 4) more than 5 m wide was observed in harzburgite on the west bank of the Aglubang River in the eastern part. Chromite in these ores shows a dense porphyritic texture of the idiomorphic to hypidiomorphic crystals 0.01 to 2.0 mm across, and many irregular cracks are found inside the crystals. The ore is partly subjected to shearing, showing a cataclastic texture.

The assay results of the typical samples are as follows.

Sample No. (No. of showings)		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
KR3–051a	(No. 2)	39.92	11.02	9.97	14.41	21.12	0.12	194
KR3–051b	(do.)	44.11	9.79	10.89	10.06	18.06	0.14	243
YR3–150	(do.)	37.20	10.80	11.81	11.97	20.89	0.07	182
FR3–015	(do.)	45.82	14.00	6.61	9.49	15.17	0.20	265

2–2–3 C-area

Although no chromite showings had been known in the C-area likewise in the B-area, a showing (Banus orebody) was confirmed in the upper reaches of the Banus River in Phase II, and furthermore, the outcrops and the float were newly discovered in this phase at four places and at one locality respectively. Among these, those of No. 4 to No. 6 in the Banus-Bansud mineralized zone distributed on the northeastern part in Fig. 5 are emplaced in dunite in a layered form, while the No. 1 and 2 showings in the Masbo River mineralized zone on the northern occur in a shear zone in a lenticular form.

(1) Banus River-Bansud River mineralized zone

Since only a part of the Banus orebody (No. 5 in Fig. 5) had been confirmed in Phase II, a detailed survey was conducted in this phase for the surroundings. As a result, the outcrops were newly discovered about 20 m downstream of the River.Trenching was conducted this time because the surrounding area of the outcrop is covered by talus deposit, having resulted in Fig. 8, the distribution of many lenticular orebodies of a small scale have been cleared. The orebodies are emplaced in 3 – 7 m thick dunite which has been highly serpentinized. The ore is massive and no disseminated ore can be observed, and it exhibits a very irregular lenticular form as shown in Fig. 8. The size of the largest orebody is 4 m in length along the strike and has a maximum

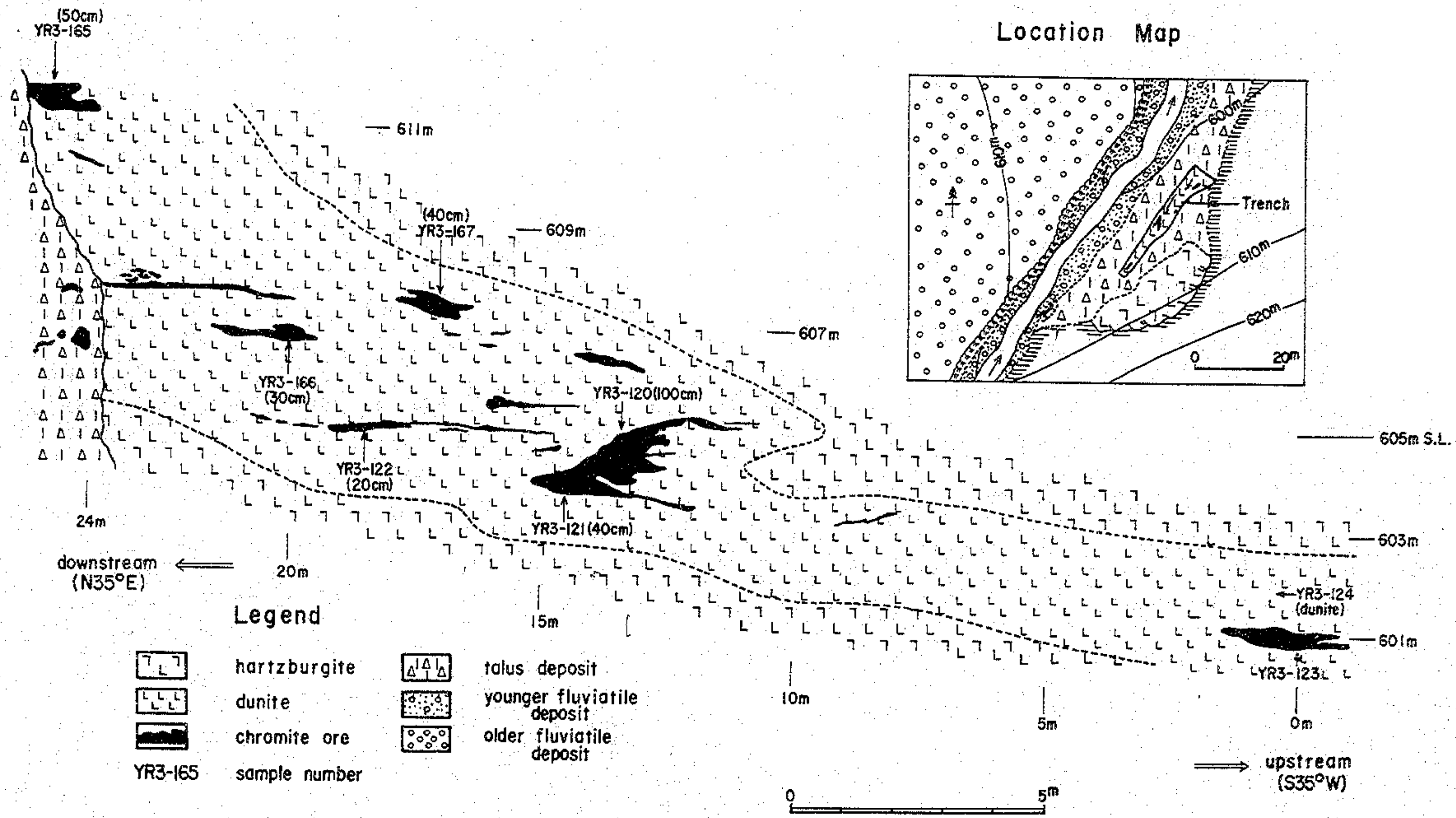


Fig. 8 Geological Sketch of No.1 Trench in C-area

width of 1 m. Chromite in the ore forms an aggregate of idomorphic to xenomorphic crystals, 0.05 to 2 mm across, having many irregular cracks inside the crystals. A very small amount of pyrite grains are observed in them.

Of the seven ore samples chemically analyzed, the typical assay results are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
YR3–120	(massive ore)	37.97	10.98	10.73	10.90	21.02	0.12	186
YR3–121	(do.)	46.11	11.88	4.86	12.69	17.15	0.10	187
YR3–166	(do.)	43.43	11.73	7.06	13.40	16.80	0.10	193

The No. 6 showing in the upper reaches of the Bansud River shows an occurrence similar to the Banus orebody mentioned above, in which a number of lenticular orebodies on a small scale are continually distributed at almost the same horizon in dunite about 10 m thick, showing a layered form on the whole. The orebodies mainly consist of massive ore, partly accompanied with disseminated ore. The zone in which these orebodies are contained has an extent of 30 m in length along strike and 0.8 m in maximum width. A unit orebody has a maximum length of 3 m and a maximum width of about 0.2 m. The strike and dip of ore body are N47°W and 25°S, respectively.

Assay results of the ores are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
YR3–114	(massive ore)	42.02	11.65	8.02	10.00	19.79	0.10	184
YR3–116	(do.)	46.12	11.65	6.77	10.76	18.43	0.08	203

Beside them, the No. 4 showing was found in dunite at a place 2 km to the northwest of the Banus orebody, on the trend of extension of the No. 5 and No. 6 showings, which was small on a scale having a maximum width of 0.05 m and a length of 2 m.

The assay result of the ore is as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
YR3–161	(massive ore)	41.23	10.08	9.11	12.85	19.73	0.09	171

(2) Masbo River mineralized zone

The two outcrops (No. 1 and 2 showings) and one locality of float (No. 3 showing) of chromite ore are found along the Masbo River, a tributary of the Rosanna River. At the showings of No. 1 and No. 2, several lenticular orebodies, which are 1.5 m long and about 0.3 m in maximum width, occur in a shear zone of NW–SE system developed in dunite (Fig. 9).

Ore is slightly brown in color and massive. The float at the No. 3 showing is about 1 m in size and seems to have been derived from a similar type of showing to the No. 1 and No. 2, considering from the location.

Chromite in the ore forms an aggregate of idiomorphic to hypidiomorphic crystals 0.03 to

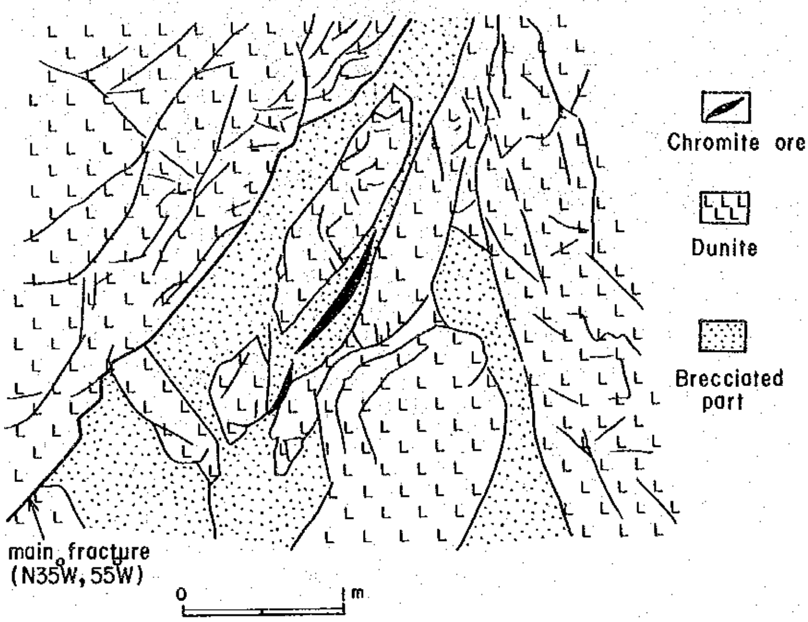


Fig. 9 Chromite Occurrence in the Masbo River

1.0 mm across, having many irregular cracks inside the crystals. A very small amount of pyrite crystals are also observed.

The assay results are as follows.

Sample No.		Cr_2O_3 %	Fe %	SiO_2 %	Al_2O_3 %	MgO %	Ni %	Co ppm
YR3–135	(No. 2)	44.98	11.59	8.58	9.79	19.24	0.09	186
YR3–140	(No. 1)	41.85	12.17	6.18	15.65	16.85	0.10	171
YR3–142	(No. 3)	41.47	9.86	8.11	13.64	19.47	0.12	188

2–2–4 Discussion on Assay Results of Chromite Ore

The characteristics of chromite ore were investigated on sixty samples, which were the data of 21 samples taken in Phase I and Phase II and 39 samples chemically analyzed in this phase. On each diagram, the marks were put to discriminate the Ultramafic complex where ore samples were obtained.

When the data of analysis are plotted on the $FeO–Cr_2O_3–Al_2O_3$ diagram of Fig. 10–(1), the ores distributed in the Bongabong body take relatively homogeneous values, which occupy only some parts of the ranges taken by the ores from the Ogos body and the Pintin body. On the contrary, it is evident that those of the Pintin body occupy a wide range as compared with the others, showing that the content of FeO and Al_2O_3 spreads over a wide field. The samples richest in Al_2O_3 are KR3–005 and 006 in the Pintin body, and those richest in FeO is also taken in the Pintin body excepting the particular ones. Those in the Ogos body also occupy a wide range, and it is clear that the content of Al_2O_3 is spreading.

The ores of Igososo and Paluan show the similar range, though they are not contained in the surveyed areas of this year, and are contained within the range of the ores from the Pintin body, but they occupy the rich part in Cr_2O_3. Also it has become clear that the ores from Liwliw are plotted into the rich part in Cr_2O_3 within the range occupied by those of the Bongabong and the Ogos body and that the ores from San Vicente has higher content of Al_2O_3 than the ore rich in Al_2O_3 from the Pintin body.

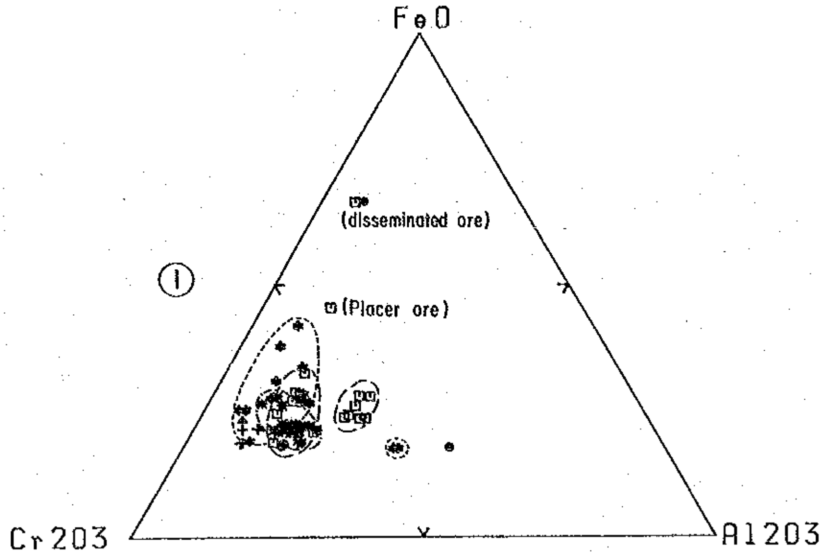
When the result above mentioned is compared with the data of the ores of other areas, it is known that the ore in the Bongabong body belongs to metallurgical chromite ore such as produced in the Acoje mine etc., and that a part of those from the Pintin body belong to refractory chromite ore. It is also obvious that many of those from the Ogos body show an intermediate component between the metallurgical and refractory grades although those of metallurgical grade are partly contained.

The variation of FeO, Al_2O_3, MgO and SiO_2 against Cr_2O_3 is shown in Fig. 11.

No particular relation can be observed between Cr_2O_3 and FeO, and the content of FeO is almost constant. However, when the ores are compared for each body, there is a tendency that those in the Pintin body are rich in FeO.

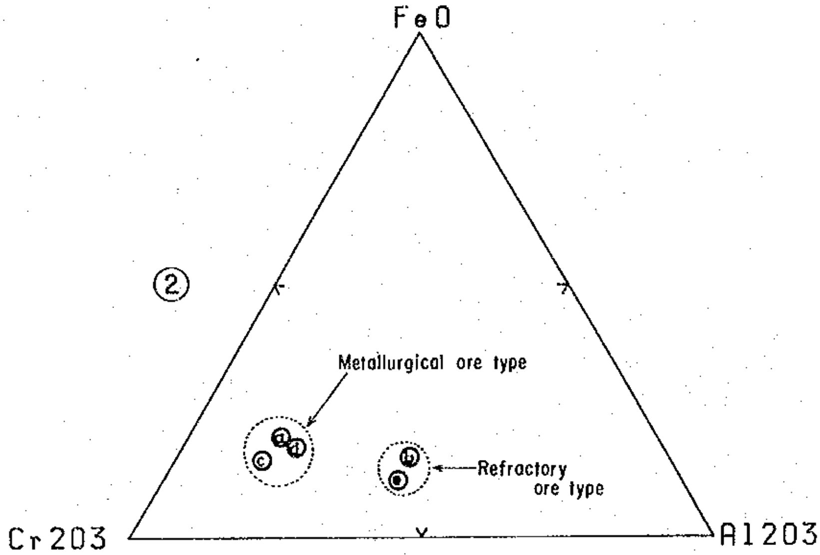
In connection with the relation between Cr_2O_3 and Al_2O_3, a similar characteristic in Fig. 10–(1) is observed, and there is a tendency as shown in the following succession from the body containing less Al_2O_3 ores toward those rich in Al_2O_3: Igsoso, Paluan < Pintin < Bongabong, Liwliw < Ogos < San Vicente < a part of Pintin.

On the other hand, in the relation between Cr_2O_3 and MgO as well as SiO_2, both MgO and SiO_2 have a tendency of decreasing in the ore rich in Cr_2O_3, showing a reverse correlation. It is considered that this is caused by the ratio between the chromite and serpentine filling the interstices of the chromite grains.



Remarks (sample location);

- Pintin body
- Ogos body
- Bongabong body
- Paluan bodies
- San Vicente body
- Igsoso body
- Liwliw body



Remarks ;

a Acoje metallurgical ore
b Masinloc Refractory ore
c Turkey ore
d United States ore
e Japan (Tottori pref.) ore

Fig. 10 FeO-Cr_2O_3-Al_2O_3 Diagram of Chromite Ore

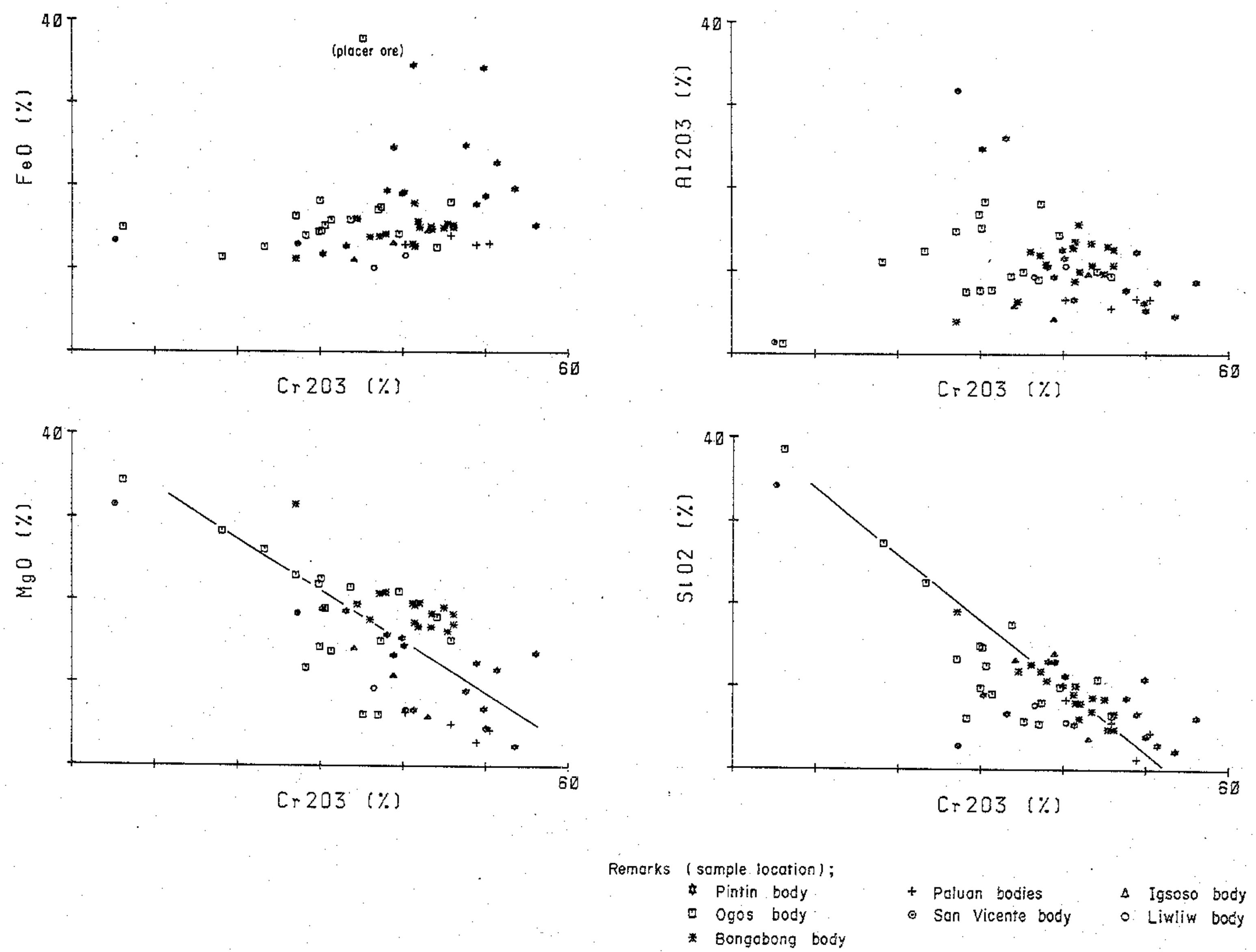


Fig. 11 Cr_2O_3-FeO, Al_2O_3, MgO, SiO_2 Diagram of Chromite

CHAPTER 3. D-AREA (IRON MINERALIZED ZONE)

3–1 Geology

The rocks distributed in this area are composed of pre-Jurassic to Jurassic Halcon metamorphic rocks, Jurassic Mansalay Formation, Tertiary Sablayan Group, which has overlain the former two, and Tertiary dioritic rocks which have intruded into the Mansalay Formation and the Sablayan Group.

The Halcon metamorphics is composed of mica schist, green schist, amphibolite, metagabbro and marble. It is widely distributed chiefly in the Pagbahan River basin in the southeast. Its general strike has a NW–SE system with a dip of 30 – 45° SW, showing a monoclinic structure. The Mansalay Formation is composed of slate and phyllite with a few greywacke sandstone. It occupies the southwest side of the Halcon metamorphics. The stratigraphic relationship between these two seems to be conformable in the Pagbahan River. The Sablayan group consists of mudstone bed, upper limestone bed, clastic bed of mudstone, sandstone and conglomerate, and lower limestone bed in the decending order. The thickness of each bed is 400 – 600 m. The group is distributed in the center to the northern part of this area.

Many dioritic rocks consisting of diorite, diorite porphyry and quartz diorite, crop out at the Mamburao riberbed as small-scale stocks. They have metamorphosed the limestone of the Mansalay Formation and the Sablayan Group, and have formed iron deposits.

3–2 Ore Deposit

The iron deposits in the area are of a contact metasomatic type, consisting mainly of compact and massive magnetite with a small amount of skarn minerals. As the Phase II survey confirmed three ore deposits of Nagsabongan, Lasala and Lapa-ao located in the upper reaches of the Mamburao River, the geological survey and the ground magnetic survey were conducted for these to verify their extension. Check survey were also carried out for the unidentified ore deposits.

(A) Nagsabongan deposit

The deposit is located on the northern slope of the Nagsabongan creek, the eastern branch of the Mamburao River. The hard magnetite outcrop extends along the creek forming a steep cliff. It is, as a whole, a massive body with 130 m (E–W), 50 m (N–S) and 40 m (height).

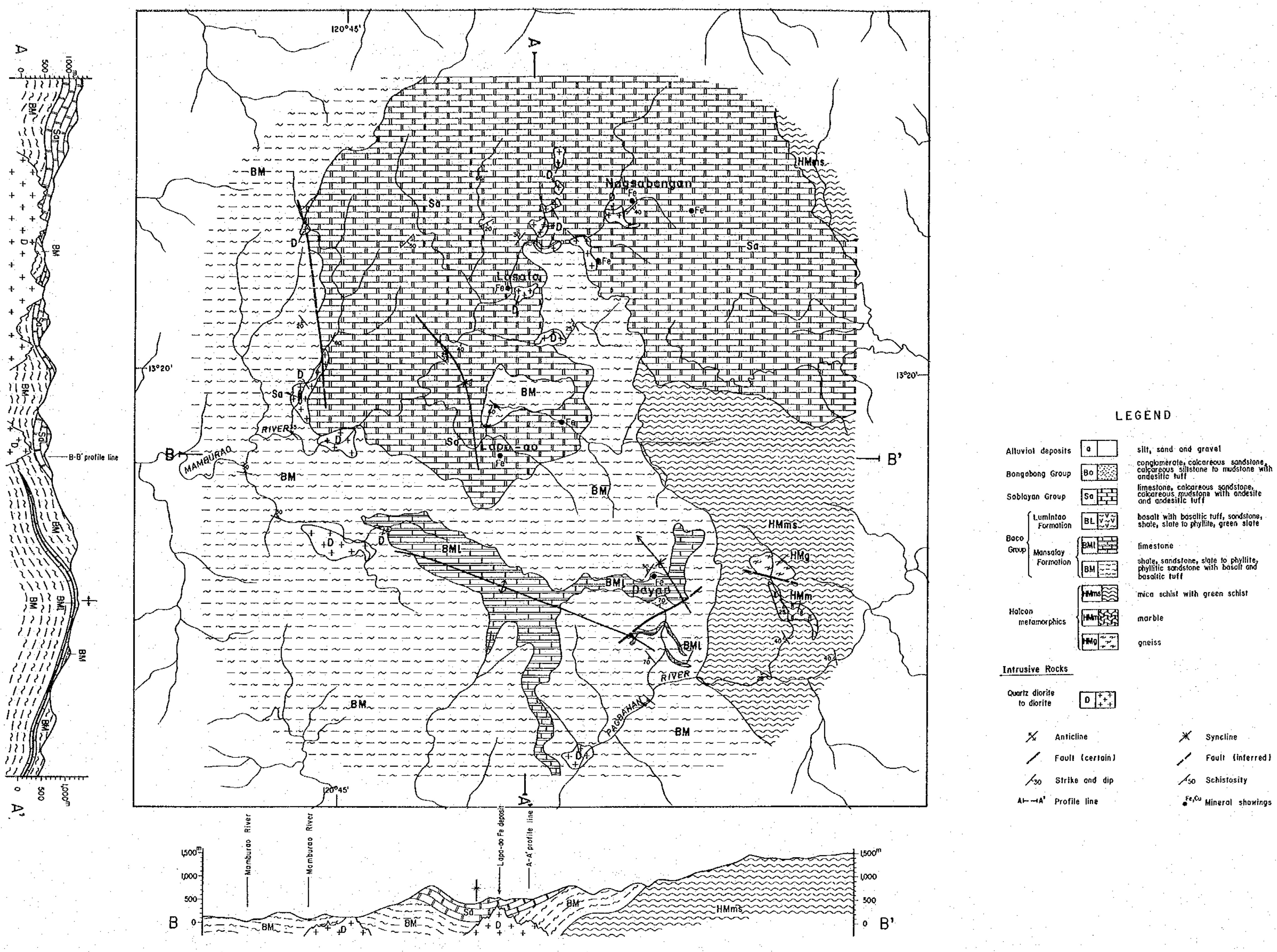


Fig. 12 Geological Map of D-area

The ore minerals mostly consist of magnetite. Microscopically a small amount of maghemite and hematite which replace magnetite along the cracks in an irregular form. Some amount of fine-grained (0.1 – 0.8 mm in size) and euhedral – subhedral pyrite are observed. The analytical grades of the typical ore are as follows.

Sample No.	Fe %	Cu ppm	V ppm	Ti ppm	P ppm
KR3–028a	67.32	61	12	44	111

A epidote skarn zone with a 20 – 50 m width is developed around the outcrop. A stock of quartz diorite is exposed in the western branch. The magnetite float zone with big boulders (probably in loci) on the eastern slope of the Nagsabongan creek, 150 m east of the outcrop, seems to indicate another deposit. The ore minerals and their texture are quite similar to those of Nagsabongan deposit. The grade of iron is high as the following.

Sample No.	Fe %	Cu ppm	V ppm	Ti ppm	P ppm
YR3–054	64.56	356	23	46	256
YR3–064	69.92	105	28	122	168

According to the BMG report (1974), the Elizalde Co. carried out the exploration for the Nagsabongan deposit from 1962 to 1965 and its thickness is said to be 35 m at the center. However, the detailed data are not available.

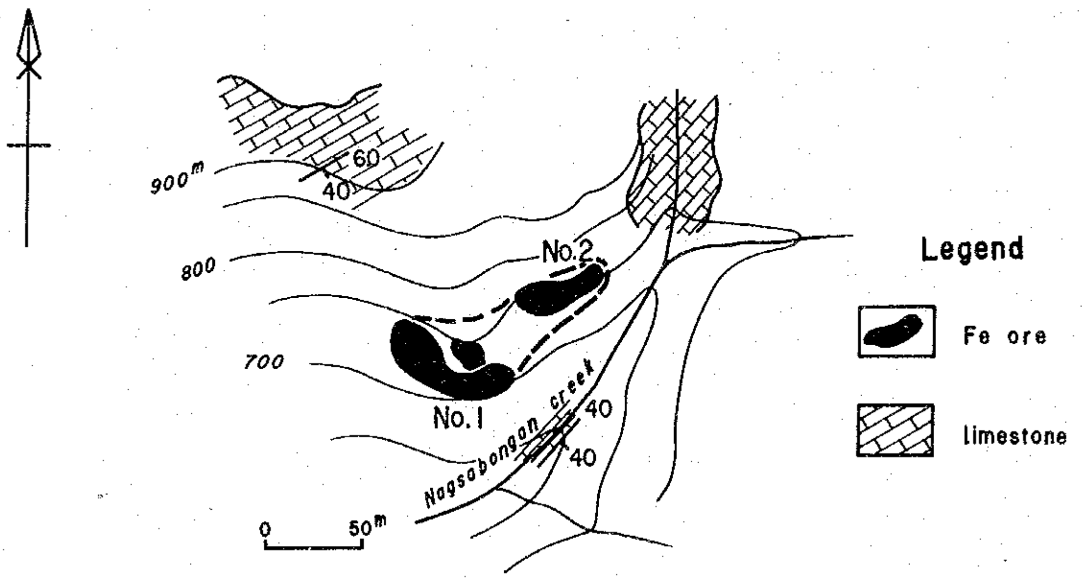


Fig. 13 Geological Map of Nagsabongan Iron Deposit

(B) Lasala deposit

The deposit is located at the place of about 400 m above sea level in the upper reaches of the Mamburao River, 3 km southwest of the Nagsabongan deposit. On the west side of the Mamburao River, limestone of the Sablayan Group forms a steep cliff at a high place of more than 550 m above sea level and a gentle slope composed mainly of skarn continues to the river-bed. Many magnetite floats scatter in the skarn zone. The deposit was once explored by the Mayorga Mining Company in the period from 1961 to 1964. In Phase II, 2 tunnels, 2 pits and 24 trenches were confirmed on the western slope of the Mamburao River but the details were not uncovered because most of the tunnels, pits and trenches were buried or did not reach to the bed rock.

In the Phase III survey, a magnetite zone of 10 – 20 m wide which is composed of outcrops and floats, extending from the point 207–27 to point 209–26 of the magnetic survey line were found. Since quartz diorite – diorite occur as stocks in the branch running near by the south of these outcrops and in the branch passing near by the north of the magnetic survey area, the skarn zone is considered not to be too thick.

Under the microscope, the ore of the outcrop consists of fine-grained (0.1 – 1 mm in size) and euhedral – subhedral magnetite. The magnetite has many shear cleavages, along which hematitization or limonitization has advanced.

Assay results:

Sample No.	Fe %	Cu ppm	V ppm	Ti ppm	P ppm
GR–030	54.87%	1,984	47	313	1,254

(C) Lapa-ao deposit (No. 49)

The deposit has been found in the upper reaches of the Lapa-ao River, the eastern branch of the Mamburao River. It is located about 3.5 km south of the Lasala deposit.

The area is composed of slate and phyllite of the Mansalay Formation, limestone of the Sablayan Group which overlies unconformably the Mansalay Formation and quartz diorite – diorite which intrudes into the above formations.

The Phase II report mentioned that the Lapa-ao deposit was formed by metasomatic replacement of the Mansalay limestone – dolomite and the Sablayan limestone did not undergo skarnization. The Phase III survey, however, has revealed the following.

1. A clear surface of unconformity can be recognized between the Mansalay Formation and the Sablayan Group, and this surface is curved.
2. The magnetite outcrop described in the Phase II report extends more than 300 m as shown

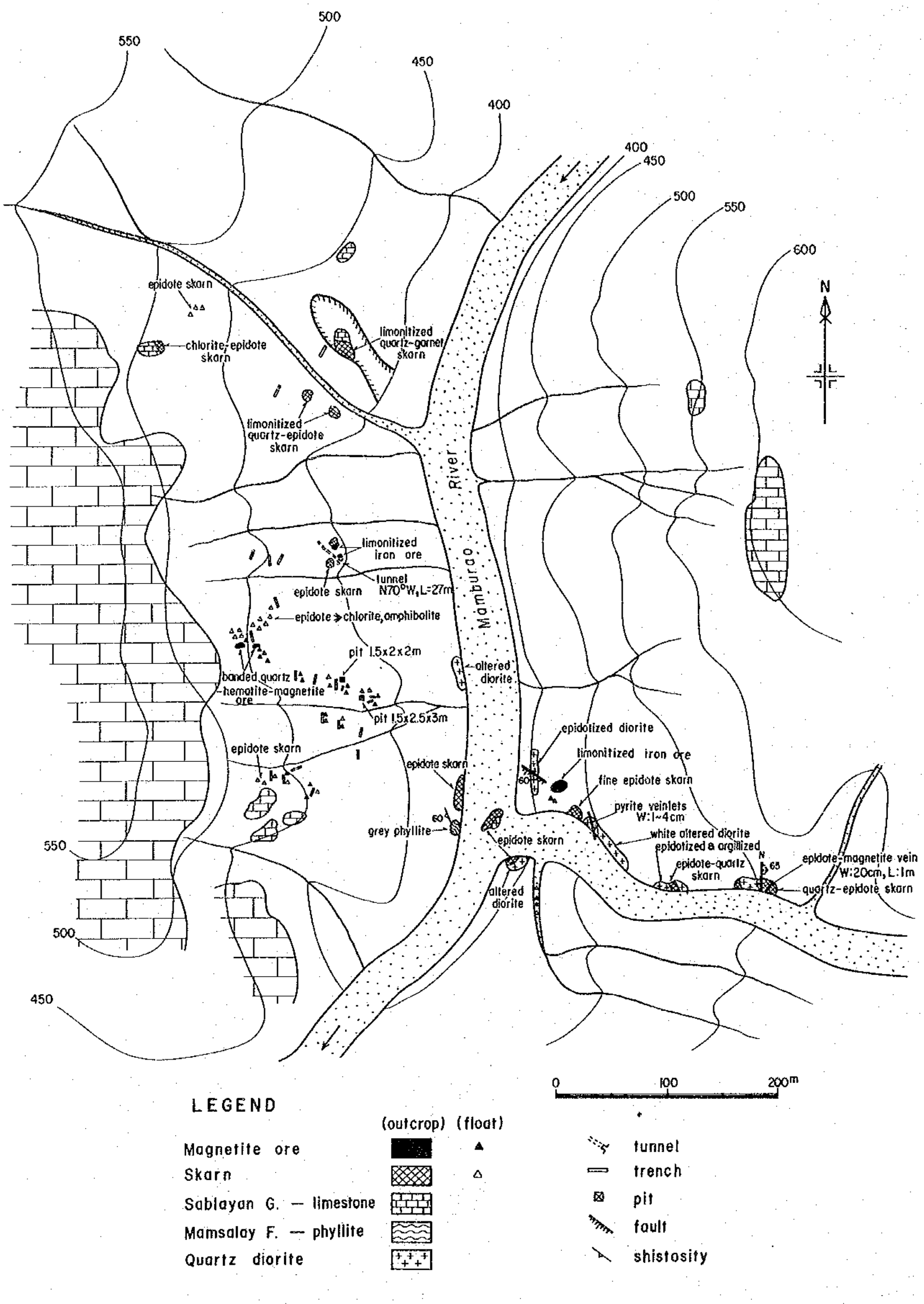


Fig. 14 Geological Route Map of Lasala Area

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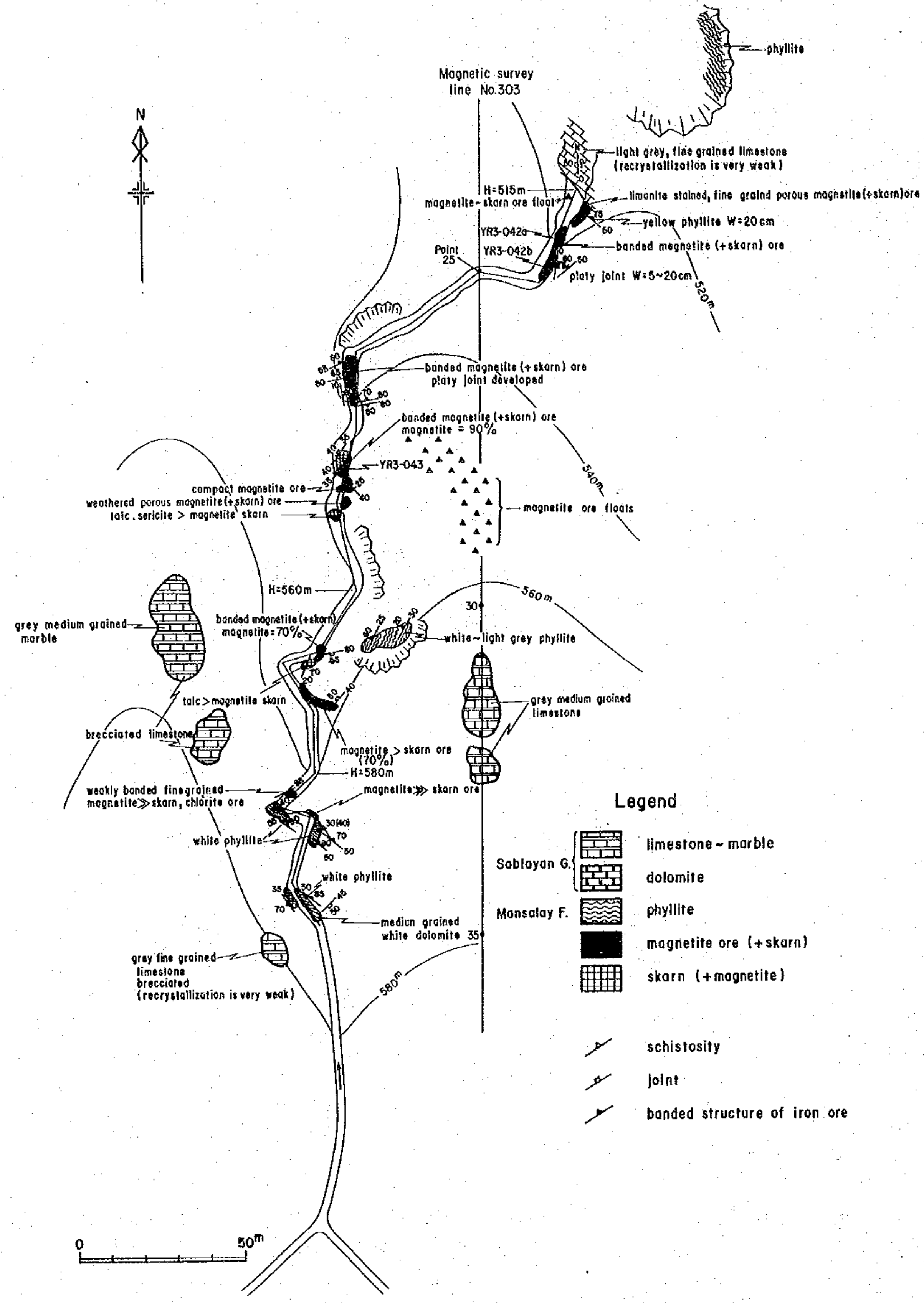

Fig. 15 Geological Route Map of Lapa-ao Area

(3)

by ore float zone, which is surely formed by replacement of the Sablayan limestone.

3. The very contact between the magnetite outcrop and the Mansalay phyllite can not be observed. But it is inferred from the surrounding circumstances that there is a unconformity plane between the magnetite deposit and the phyllite, in other words, the replaced limestone is not a member of the Mansalay Formation but a member of the Sablayan Group.

4. A small-scale diorite is distributed in the creek, 500 m southeast of the outcrop. A new magnetite float zone (L=100 m, W=50 m) has been found near the diorite.

Assay results of the typical ore from the float zone

Sample No.	Fe %	Cu ppm	V ppm	Ti ppm	P ppm
KR3–032a	55.41	244	22	28	69
KR3–032b	63.85	26	71	60	41
KR3–032c	60.24	32	71	59	74

Under the Microscope, the ore consists of an aggregate of euhedral and subhedral magnetite (0.1 – 1 mm in size). The magnetite has many fine cleavages which have progresses in maghemitization and limonitization. A very small amount of pyrite (0.05 mm in size) are associated with magnetite.

The ore minerals and texture of the Lapa-ao deposit are quite same as those of the Nagsabongan and the Lasala deposits but skarn is richer in the Lapa-ao.

(D) Dayap deposit

The deposit is located in the headwater of the Dayap creek, western branch of the Pagbahan

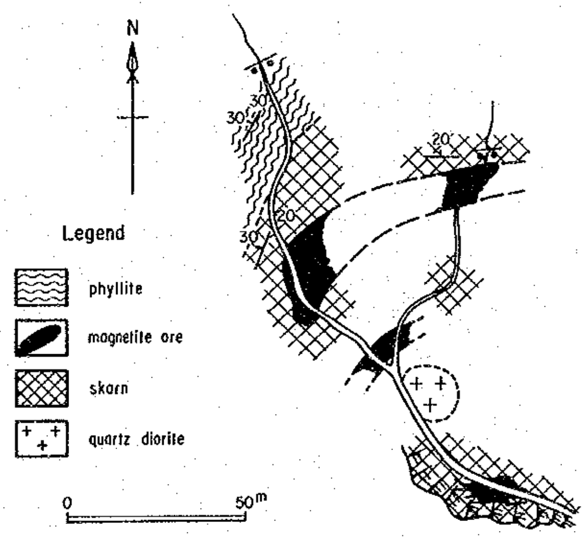

Fig. 16 Geological Map of Dayap Iron Deposit

River, about 4 km southeast of the Lapa-ao deposit. The elevation is 1,050 m above sea level.

This deposit was reported in the BMG report (1974). The Phase I and Phase II surveys could not confirm this because any information was not afforded.

The deposit is of a contact metasomatic type and has replaced the Mansalay limestone. As shown in Fig. –16, three magnetite bodies occur in the garnet – epidote – chlorite skarn zone which is developed along the Dayap creek. The upper ore body is the largest (thickness – 10 m) and can be traced more than 60 m. The middle massive ore body and the lower network body have a 3.0 m thickness, but their sizes are not clear due to poor exposures.

The ore minerals mostly consists of magnetite. Microscopically a small amount of maghemite and hematite has replaced magnetite along its irregular cleavages. A very small amount of pyrite (0.3 mm in size) are associated with magnetite and are partly replaced by hematite.

Analytical values of each ore body are as follows.

Sample No.	Width m	Fe %	Cu ppm	V ppm	Ti ppm	P ppm
FR3–005 (Lower)	3.00	56.73	213	83	278	22
FR3–006 (Middle)	3.00	70.43	220	33	98	128
FR3–007 (Upper)	10.00	65.37	89	32	71	30

It takes five hours to get this site along the steep and narrow ridge from the Pagbahan River (elevation difference; 1,000 m). This poor access may be a bottleneck in the exploitation.

3–3 Results of Magnetic Survey

3–3–1 Survey Method

Magnetic survey was carried out for precisely chosen areas of Nagsabongan, Lasala and Lapa-ao. Total values of magnetic intensity were measured at the points which were planned in a rectilinear grid pattern where the point interval was 20 m and the line (crossing ore deposits at a right angle) interval was 100 m. To varify the shapes of the ore deposits more in detail the line interval was narrowed to 50 m from necessity. The measurement was conducted as planned except for some parts of limestone cliff areas in the Nagsabongan and the Lasala.

3–3–2 Data Processing

The total values of magnetic intensity and the coordinates survey point were processed by using a computer system of the Hewlett-Packard Inc.

As the measured values include many noises caused by the surrounding geology, the isomagnetic intensity map (total-intensity map) shows too much complication to interpret magnetic anomalies. Accordingly, the noises were removed by smoothing the total intensity values by using the moving average method. The moving average method is usually applied for some serial points

Table 3 Magnetic Susceptibility of Rock Samples

Sample Name	Sample No.	Locality	Magnetic Susceptibility (x10⁻⁶ cgsemu)	Average Magnetic Susceptibility (x10⁻⁶ cgsemu)	
Iron ore	KR3–028a	Nagsabongan	521*	> 10,000 (*except KR3–028a)	> 10,000
	KR3–028b	Nagsabongan	>145,000		
	KR3–028c	Nagsabongan	115,963		
	YR3–054	Nagsabongan	9,591		
	YR3–064	Nagsabongan	>112,000		
	GR3–028	Lasala	>147,980	>10,000	
	GR3–030	Lasala	12,134		
	GR3–031	Lasala	105,860		
	KR3–032a	Lapa-ao	>133,900	>133,900	
	KR3–032b	Lapa-ao	>133,900		
	KR3–033c	Lapa-ao	>133,900		
Skarn	KR3–029a	Nagsabongan	301	209	123
	KR3–029b	Nagsabongan	140		
	YR3–051	Nagsabongan	316		
	YR3–057	Nagsabongan	77		
	YR3–065	Lasala	107	75	
	GR3–003	Lasala	54		
	GR3–035	Lasala	78		
	GR3–053	Lasala	61		
	KR3–033a	Lapa-ao	80	86	
	KR3–033b	Lapa-ao	87		
	KR3–036	Lapa-ao	88		
	KR3–037	Lapa-ao	87		
Limestone	YR3–052	Nagsabongan	15	17	30
	YR3–053	Nagsabongan	15		
	YR3–059	Nagsabongan	22		
	KR3–027	Nagsabongan	14		
	GR3–012	Lasala	165	67	
	GR3–014	Lasala	31		
	GR3–021	Lasala	6		
	KR3–030	Lapa-ao	13	19	
	KR3–031	Lapa-ao	9		
	YR3–056	Lapa-ao	35		
	YR3–070	Lapa-ao	23		
	GR3–043	Lapa-ao	15		
Dioritic Rocks	YR3–055	Nagsabongan	44	89	77
	GR3–023	Nagsabongan	56		
	GR3–029	Nagsabongan	166		
	YR3–068	Lasala	32	38	
	YR3–069	Lasala	44		
	YR3–071	Lapa-ao	92	85	
	YR3–072	Lapa-ao	80		
	KR3–034a	Lapa-ao	84		
	KR3–034b	Lapa-ao	74		
	GR3–060	Lapa-ao	93		
Slate	KR3–035a	Lapa-ao	50	48	48
	KR3–035b	Lapa-ao	49		
	KR3–035c	Lapa-ao	45		
	KR3–038	Lapa-ao	47		

on the line. This time, however, all values existing within a 50 m radius (which corresponds to the moving average of 5 points on the line) were averaged because the lines sometimes have some bendings.

The total-intensity maps of Nagsabongan, Lasala and Lapa-ao are shown in Fig. 17, 18 and 19.

3–3–3 Magnetic Susceptibility

A total of 49 samples (12 samples from Nagsabongan, 16 from Lasala and 21 from Lapa-ao were collected and crushed into pieces for study. The magnetic susceptibilities were measured in each sample by using Bison 3101 Susceptibility Meter. The tested samples consists of 11 pcs of iron ore, 12 pcs of skarn, 12 pcs of limestone and 10 pcs of dioritic rock and 4 pcs of slate. The results are shown in Table 3.

As is evident from this table, the rocks can be classified into the followings by magnetic susceptibitity.

Iron ore ..... strong magnetic rock
Skarn ..... weak magnetic rock
Dioritic rock ..... weak magnetic rock
Slate ..... weak magnetic rock
Limestone ..... weak magnetic rock

From the results of magnetic susceptibility, it can be expected that the iron ores cause magnetic anomalies of a large amplitude, while the dioritic rocks and skarn cause anomalies of a small amplitude.

3–3–4 Results of Analysis

To analyze the distribution of magnetic bodies in the magnetic intensity map, quantitative speculation for isomagnetic intensity map and its filter map or qualitative speculation by using a curve – matching method are usually applied. As the magnetic survey was a ground survey and was carried out on or near the deposits, anomaly patterns obtained were deformed by the edge effect of the deposits and differed from the theoretical patterns, so it was very difficult to suppose complicated models. Considering that the deposits are of the metasomatic type, a globular or cylindrical model was applied for the magnetic anomalous bodies. The depth of the center, radius and magnetic susceptibility of the speculated models (iron deposits) were semi-qualitatively calculated.

(1) Nagsabongan area (Fig. 17)

Near the points of Line-108, No. 25 and Line 109, No. 34 high total magnetic intensities (over 51,000 γ and 47,000 γ respectively) form remarkable anomalous zones with large amplitudes. Another weak magnetic anomalous zone with a amplitude of 400 γ exists near the point of Line 104, No. 23. These anomalous zones are tentatively named as Ia, Ib and Ic and the dimensions of the speculated models are shown below.

Table 4 Speculated Magnetic Model for Nagsabangan Deposit

Anomaly	Model	Location of the Center	Depth of the Center	Radius	Length	Magnetic Susceptivity
Ia	Globe	Line 108, No.25	100 m	100 m	–	0.74 cgsemu
Ib	Globe	Line 109, No.34	80 m	80 m	–	0.73 cgsemu
Ic	Globe	Line 104, No.23	100 m	60 m	–	0.74 cgsemu

Compared with the geological results, the Ia indicates the ore outcrop itself and the Ib matches the magnetite float zone with large blocks located on the eastern slope of the Nagsabongan creek, suggesting that the float zone is an another deposit on the basis of the anomalous pattern. The Ic is located at the place where old mine office existed and there are no exposures. Therefore, this anomaly may or may not be caused by ore deposit.

(2) Lasala area (Fig. 18)

Low magnetic anomalies under 36,000 γ were detected in the area from Line 205, No. 13 to Line 207, No. 13. Another anomalous zone consisting of a pair of negative and positive anomalies, with an amplitude of 2,900 γ was also extracted in the area of Line 208, No. 25. Any other remarkable anomalies were not obtained except these two zones. Two anomalous zones are tentatively named as IIa and IIb. Dimensions of the speculated models are shown below.

Table 5 Speculated Magnetic Model for Lasala Deposit

Anomaly	Model	Location of the Center	Depth of the Center	Radius	Length	Magnetic Susceptivility
IIa	Globe	Line 205, No.12.5	100 m	100 m	–	0.32 cgsemu
	Globe	Line 207, No.12.5	75 m	75 m	–	0.34 cgsemu
IIb	Globe	Line 208, No.25	100 m	100 m	–	0.17 cgsemu

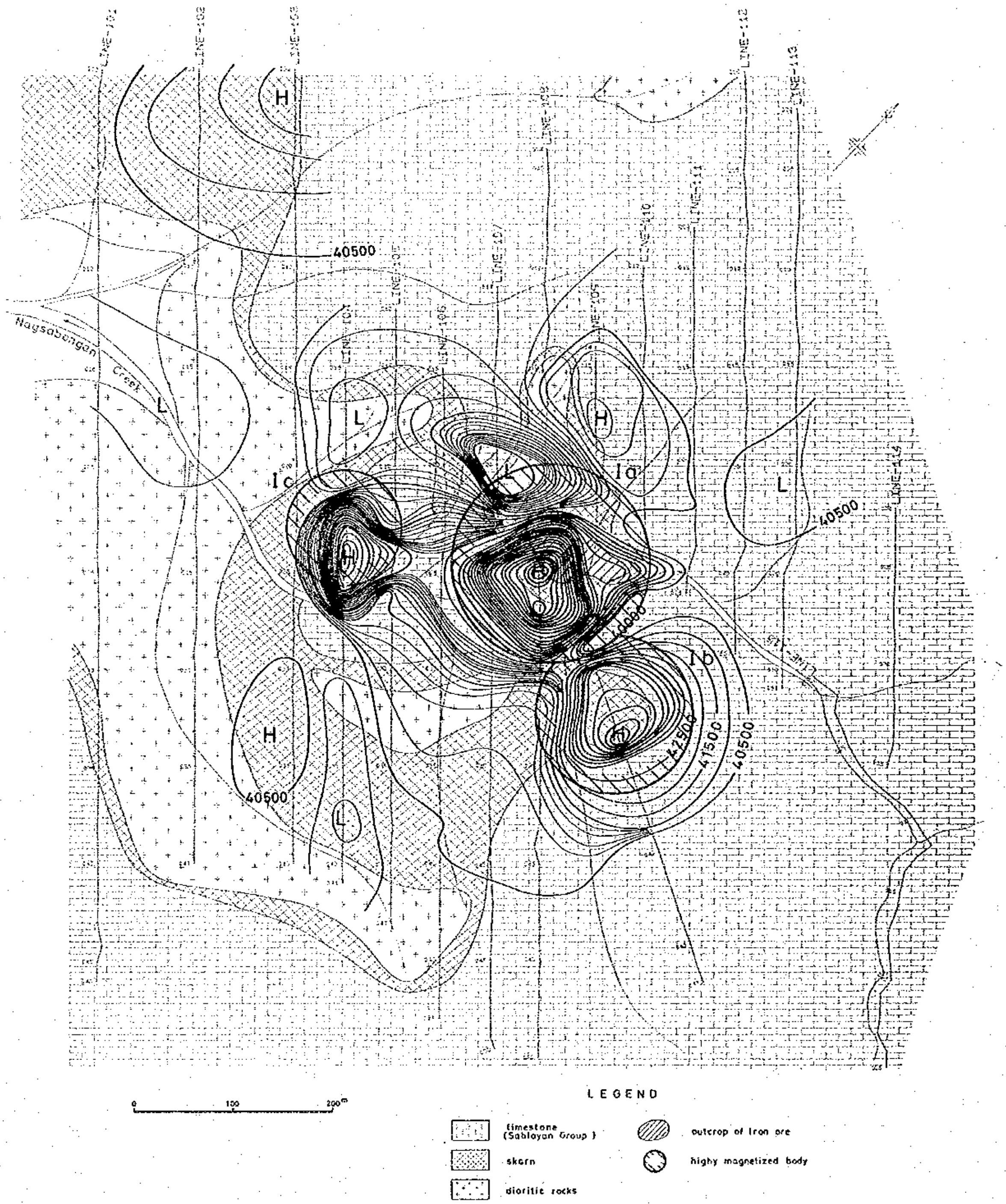

Fig. 17 Interpretation Map of Total Magnetic Intensity in Nagsabongan Area

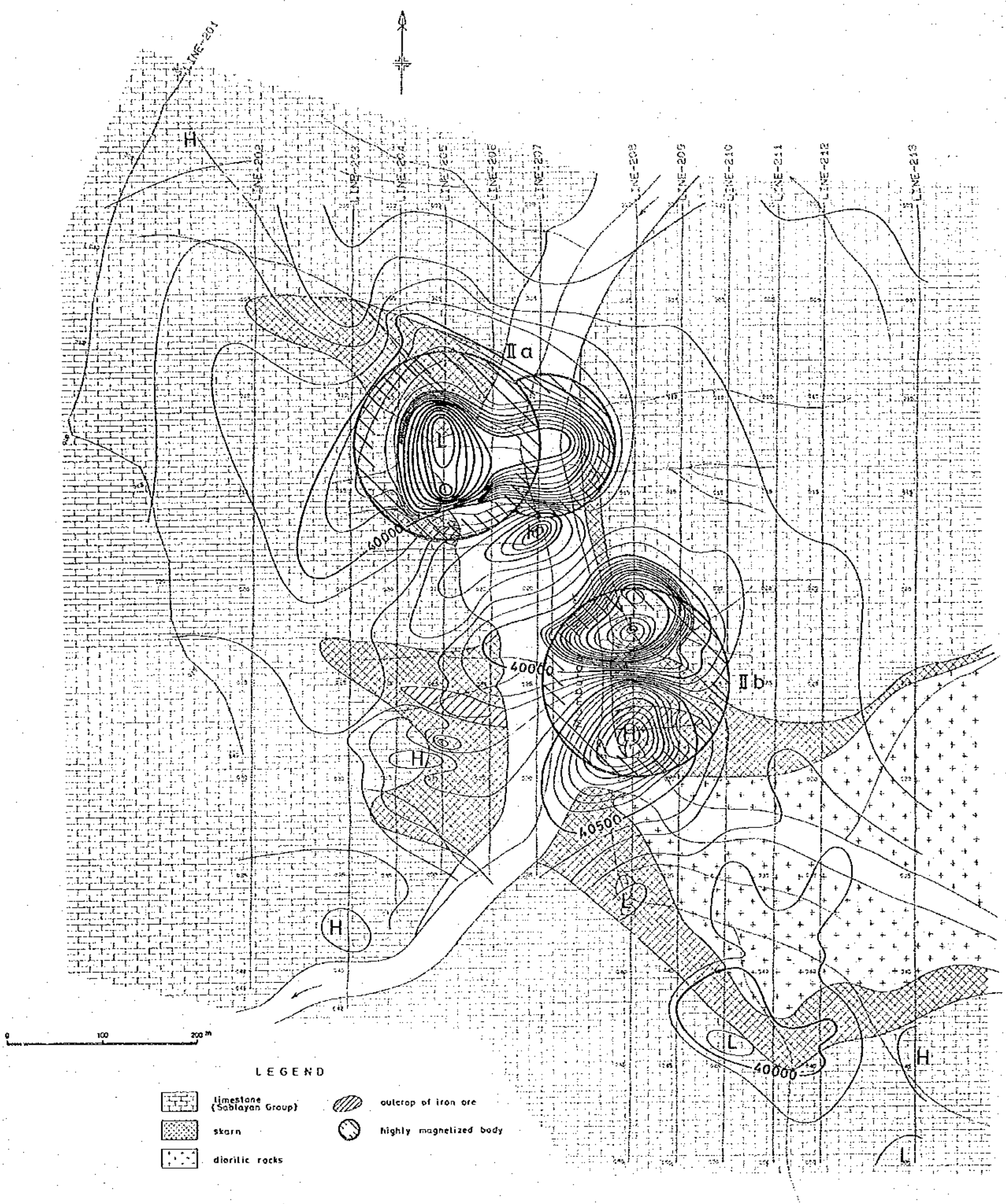

Fig. 18 Interpretatien Map of Total Magnetic Intensity in Lasala Area

As these anomalous zones are located in a grassland and so, rocks are poorly exposed. At Line 205, No. 17 the southern end of the IIa anomaly, there is a trench where a small limonitized magnetite outcrop can be found. The IIb anomaly is seen in a skarn zone and the outcrop and float zone of magnetite extending from Line 208, No. 27 to Line 209, No. 27 may be a part of the magnetic body centering at Line 28, No. 25.

(3) Lapa-ao area

A pair of positive and negative anomalies with an amplitude of 5,000 γ is located on the Line 303. The negative anomalies are centering around Line 303, No. 24 and extend in an E–W direction. On the southeast of these anomalies, there is other anomalies stretching in the E–W direction, with an amplitude of 1,700 γ. The lower magnetic anomalies centering at Line 306, No. 45 in the central south of the area are also detected. These anomalous zones are tentatively named as IIIa, IIIb and IIIc. Dimensions of the speculated models are shown below.

Table 6 Speculated Magnetic Model for Lapa-ao Deposit

Anomaly	Model	Location of the Center	Depth of the Center	Radius	Length	Magnetic Susceptivility
IIIa	Globe	Line 303, No.23	150 m	150 m	–	0.1 cgsemu
IIIb	Cylinder	Line 306, No.23	90 m	90 m	150 m	0.12 cgsemu
IIIc	Globe	Line 306, No.44	90 m	90 m	–	0.54 cgsemu

The IIIa anomalies occur in the area centering at the No. 1 and No. 2 outcrops exposed in the southern creek of the Lapa-ao River. It was estimated that one orebody extended towards east from the distribution of ore floats on the mountain slope at first. But judging from the shape of magnetic anomalies, two magnetic bodies of the IIIa and IIIb possibly lie closely. The IIIc anomaly corresponds to the magnetite float zone distributed around Line 305, No. 45 – Line 306, No. 45 and is accompanied with a skarn zone, indicating an independent orebody. The magnetite float zone near the southern end of Line 307 also suggests another ore deposit.

Fig. 19 Interpretation Map of Total Magnetic Intensity in Lapa-ao Area

CHAPTER 4. E-AREA (COPPER MINERALIZED ZONE)

4–1 Geology

The rocks distributed in the area consists of the Mansalay Formation of Jurassic, the Sablayan Group and the Bongabong Group of Tertiary in an ascending order, and they have been intruded by the Ultramafic complex.

The Mansalay Formation is composed of black-dark grey slate and is intercalated with thinly bedded medium-grained sandstone. It is locally distributed along the main stream and branches of the Pula River, striking NE–SW and dipping 40–50°N on the west and striking NW–SE and dipping 40–60°N on the east of the Pula River, which forms a anticlinal structure with an axis of N–S to NNW–SSE in direction.

The Lumintao Formation is mainly composed of dark grey to dark green basalt lavas which are characterized by auto-brecciated and pillow structures and are partly accompanied with basic tuff. It occupies a large part in this area, overlying the Mansalay Formation unconformably.

The Sablayan Formation is composed of calcareous mudstone, while the Bongabong Group is mainly composed of conglomerate, tuffaceous sandstone and mudstone; both of formation and group overlies the Lumintao Formation and are distributed in the northwest and east parts, showing generally NW–SE in strike, with a 40°N dip.

The Ultramafic complex consisting of dunite, harzburgite and gabbro, have intruded in the Mansalay and the Lumintao Formations. An individual rock body with a scale of 10 km x 2 km tends to stretch in a NNW–SSE direction, being controlled by the Wasig Fault.

4–2 Ore Deposit

The area has four mineral showings, viz, Manamburao, Masnon, Shawood and Bambanon. All of them are veins filling fissures which develop in the basalt lavas or the Ultramafic complex. The ore minerals are chalcopyrite, sphalerite, pyrrhotite, pyrite and quartz.

As mentioned in the Phase II report, Manamburao is located in the western tributary of the Pula River. The elevation is 500 m above sea level. Two places, about 50 m apart from each other, have two outcrops, all of which have some stringers (width 0.01 – 0.15 m) of chalcopyrite and pyrite in quartz or silicified veins (width 1.10 – 2.20 m). An average grade of Cu is about 2% with few Au and Ag. The extension of the outcrops cannot be traced because of poor exposure. A small serpentinite dike (width 20 m) is exposed at the place 500 m southwest of these outcrops.

The Masnon is located on the western bank of the main stream of the Pula River and fills fissures of a NE–SW system formed near the boundary between harzburgite and dunite. The

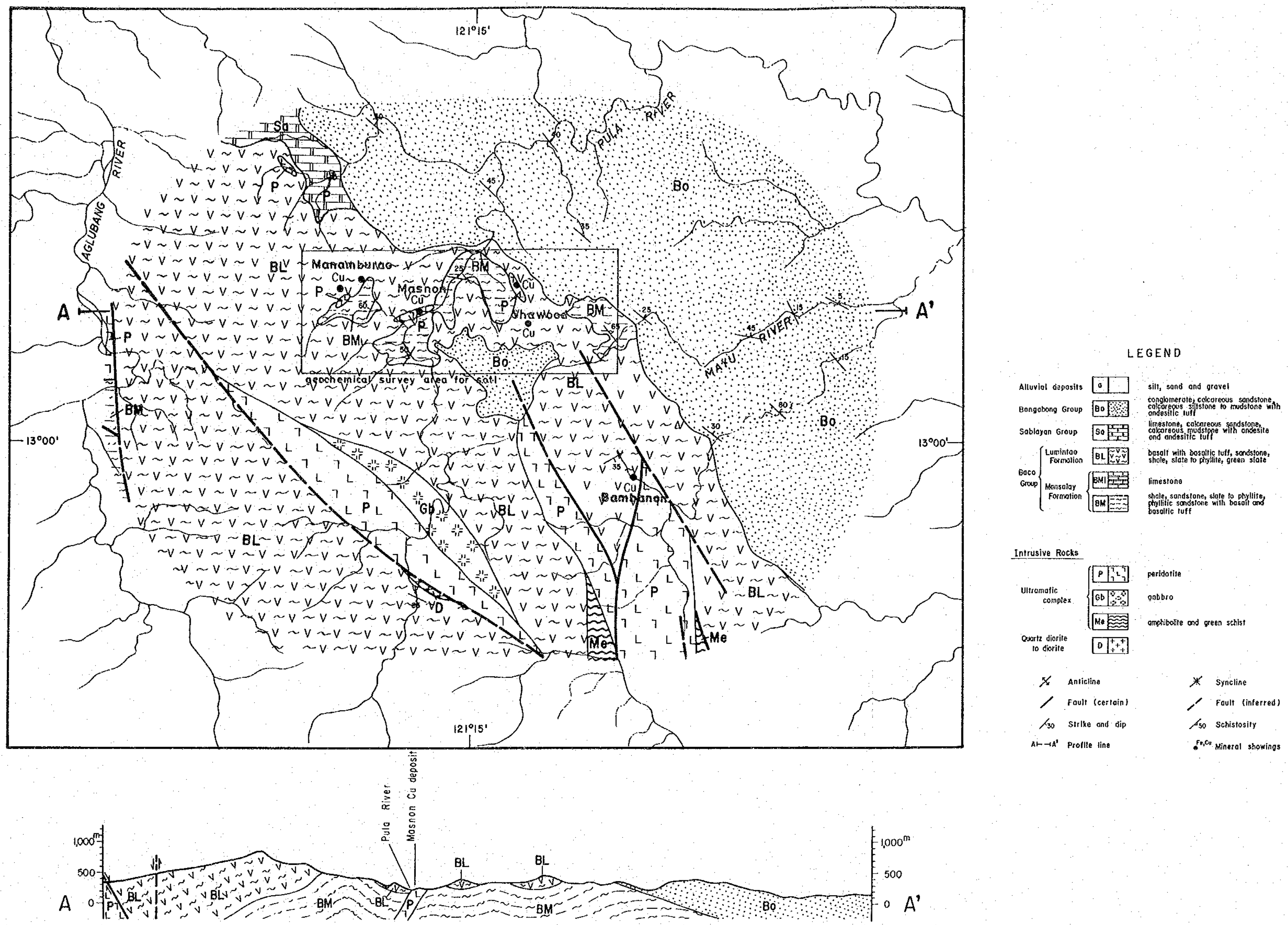

Fig. 20 Geological Map of E-area

ore is massive and mainly consists of chalcopyrite, pyrrhotite and pyrite. As shown in Fig. 21, there are recognized three veins, one of which is traceable for about 50 m on the strike side. The vein width vary from 0.10 to 0.30 m. The grades are Au: 2.4 – 14.8 g/T and Cu: 2.05 – 2.77%. Little wall rock alteration is recognized as well as Manamburao's.

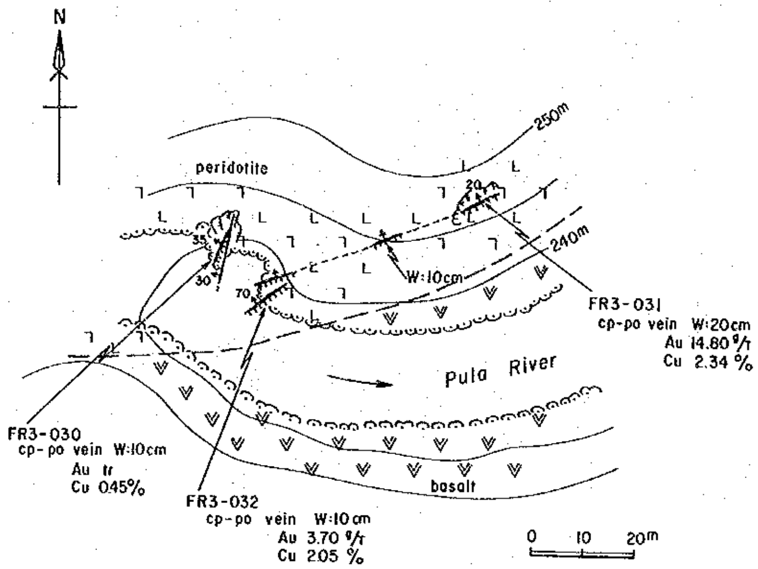

Fig. 21 Geological Map of Masnon Copper Showing

Shawood is located in the Shawood creek, eastern tributary of the Pula River. There are two outcrops at 300 m and 400 m in elevation.

The outcrop at 300 m is a vein of chalcopyrite which fills fine fissures (width: some mm) developed in harzburgite. This outcrop has once been likely trenched.

Assay results:

Sample No.	Width m	Au g/T	Ag g/T	Cu %	Pb %	Zn %	Fe %	S %
FR3–002	0.10	8.33	4.5	11.93	0.16	0.20	21.99	15.24

The outcrop at 400 m is composed of three pyrrhotite ≫ pyrite > chalcopyrite-sphalerite veins (width: 0.10 – 0.20 m) in a silicified zone (width: 2.00 m). The extension is not traceable because of poor exposure.

Assay results of the outcrop are as follows.

Sample No.	Width m	Au g/T	Ag g/T	Cu %	Pb %	Zn %	Fe %	S %
FR3–026	0.20	1.90	1.2	0.28	0.17	0.20	37.65	18.91
FR3–010	0.20	tr	tr	11.95	0.23	0.61	22.76	15.47

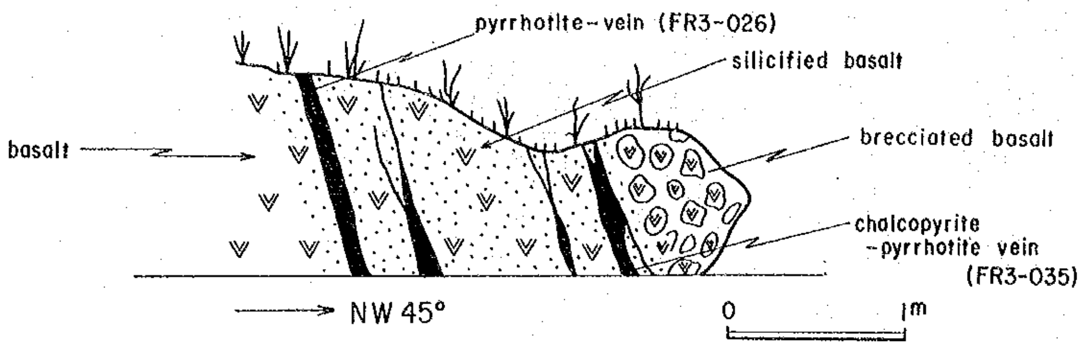

Fig. 22 Geological Sketch of Shawood Copper Showing (+400mASL)

Bambanon is located in the Bambanon River, the western tributary of the Mayu River (southern tributary of the Pula River). The last phase survey confirmed a pyrite-disseminated quartz vein (width 0.40 m) in basalt. According to BMG report, another massive sulphide with a 0.10 – 0.30 m width occurs lenticularly in peridotite.

The Tertiary quartz diorite intruded as a stock form at 10 km north and at 5 km south from this area, is considered to be closely related to the copper mineralization.

4–3 Results of Geochemical Survey

Since trees grow too thick to observe exposures, geochemical survey for soil was carried out for the area (2 km x 5 km) covering three showings of Manamburao, Manson and Shawood with a relatively high grade of copper. At the same time geochemical survey for stream sediment was so conducted for the surroundings (50 km^2) as to cover areas remaining untouched.

4–3–1 Soil

As shown in Fig. 25, soil samples from the B horizon were taken at the points of rectilinear grid (200 m x 100 m). To verify the mineralization area more in detail, the spacing was narrowed to 100 m in necessity. A total of 591 soil samples were thus collected. The samples are composed of the following.

Bongabong sandstone	100 pcs
Lumintao basalt	402 pcs
Mansalay slate	83 pcs
Ultramafic rock	6 pcs
Total	591 pcs

The samples were screened into – 80 mesh fractions after natural drying and were digested in the mix acid for two hours. The filtrates were analyzed for Cu, Pb, Zn by means of ICAP.

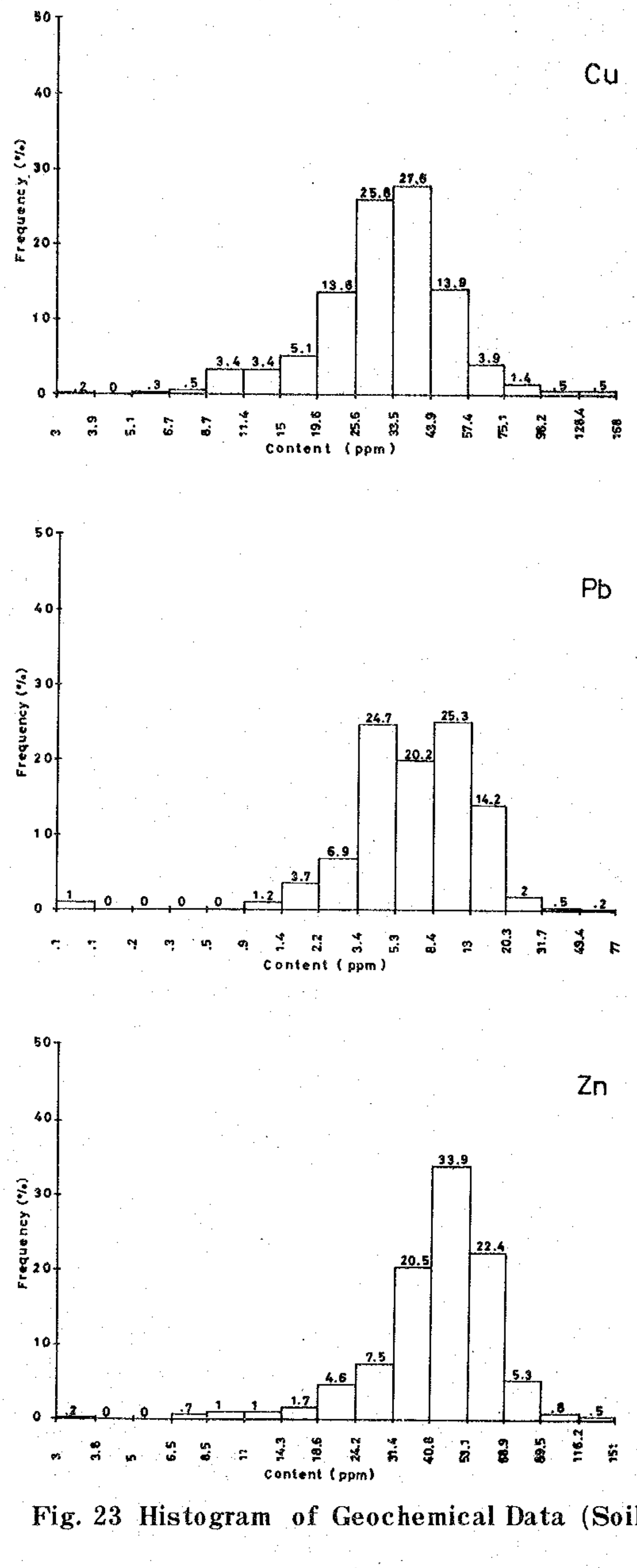

Fig. 23 Histogram of Geochemical Data (Soil)

Table 7 Statistic Values of Geochemical Data (Soil)

Cu

	Bongabong Sandstone	Lumintao Basalt	Mansalay Slate	Ultramafic Rocks	Total
Number of Samples	100	402	83	6	591
Minimum ppm	6	3	11	26	3
Maximum ppm	58	168	76	46	168
Mean (M) ppm	25.1	32.4	34.5	34.0	31.2
S.D. (log)	0.223	0.206	0.147	–	0.207
M + S.D. ppm	42.0	52.0	48.3	–	50.2
M + 2S.D. ppm	70.1	83.6	67.8	–	80.9

Pb

	Bongabong Sandstone	Lumintao Basalt	Mansalay Slate	Ultramafic Rocks	Total
Number of Samples	100	402	83	6	591
Minimum ppm	0	0	1	3	0
Maximum ppm	20	38	28	15	38
Mean (M) ppm	9.6	6.1	8.4	5.3	7.0
S.D. (log)	0.258	0.363	0.272	–	0.342
M + S.D. ppm	17.3	14.1	15.8	–	15.3
M + 2S.D. ppm	31.4	32.5	29.6	–	33.6

Zn

	Bongabong Sandstone	Lumintao Basalt	Mansalay Slate	Ultramafic Rocks	Total
Number of Samples	100	402	83	6	591
Minimum ppm	3	26	7	42	3
Maximum ppm	78	87	151	77	151
Mean (M) ppm	35.7	42.6	49.9	56.3	42.3
S.D. (log)	0.248	0.174	0.110	–	0.187
M + S.D. ppm	63.2	63.6	64.2	–	65.1
M + 2S.D. ppm	111.9	95.0	82.7	–	100.1

Table 8 Correlation Matrix of Geochemical Data (Soil)

	Bongabong Sandstone		Lumintao Basalt		Mansalay Slate		Total	
	Cu	Pb	Cu	Pb	Cu	Pb	Cu	Pb
Pb	0.254	–	–0.072	–	–0.251	–	–0.069	–
Zn	0.837	0.135	0.433	0.208	0.403	0.136	0.558	0.150

③

Histograms for all data and cumulative frequency distribution curves are shown in Figs. 23 and 24 and statistic values, in Table 7.

As is evident from these figures and table, analytical data of each formation approximates to lognormal distribution except Pb element, and the means and standard deviations are almost the same values. So, all data were processed in the lump because a number of data is too small to be processed statistically, when the data are grouped by formation.

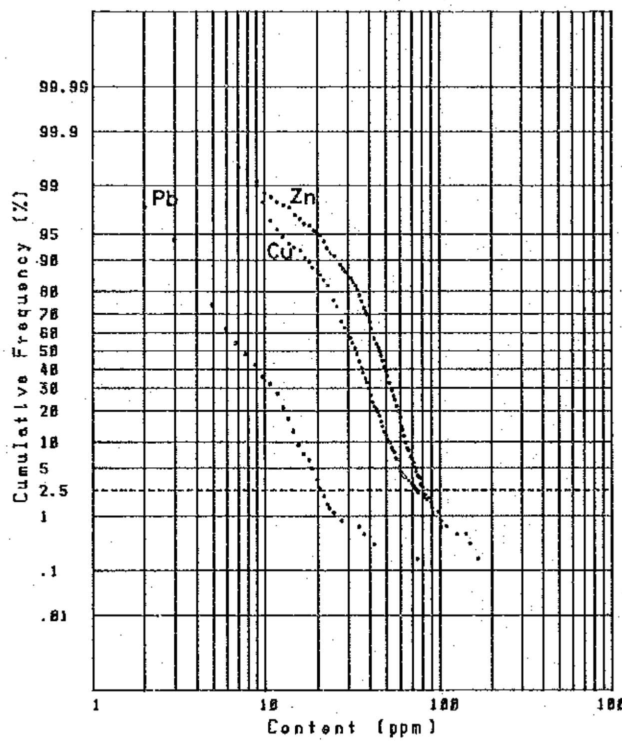

Fig. 24 Cumulative Frequency Distribution of Each Element

The distribution of each metal content is shown in Fig. 25, where isoplethes of 10% and 2.5% values from the highest are drawn. As a whole, metal contents of each elements are low and the chemical anomalies tend to be isolated.

The anomalies of each element are outlined as follows.

Cu

Copper has not concentrated in the surroundings of the known showings. That is, in Manamburao Cu anomalies have not occurred in the two creek basins where the outcrops are exposed, but only a relatively high value (103 ppm) has occurred on the ridge (Line 27, No. 15) between the two creeks.

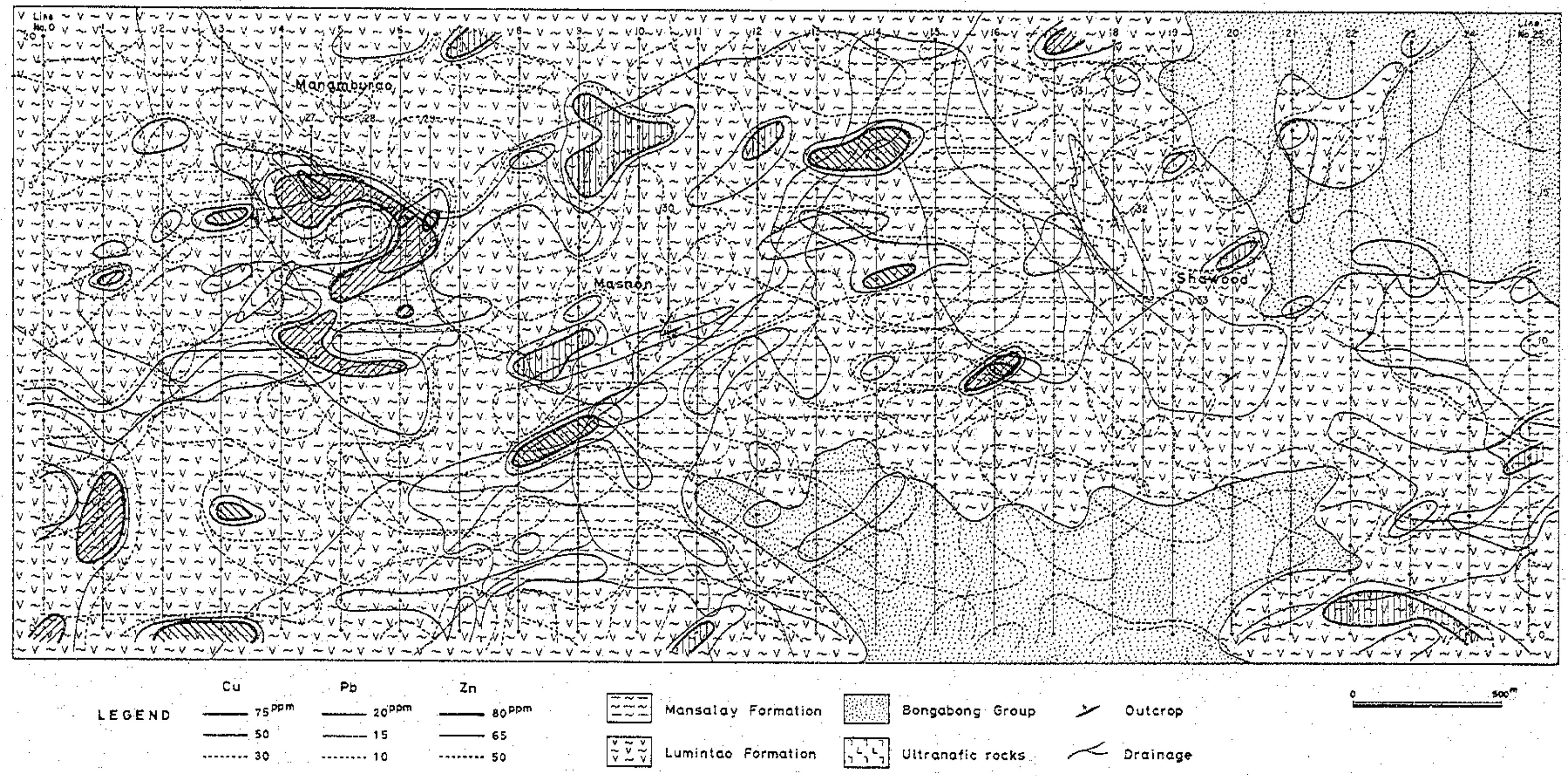

Fig. 25 Geochemical Anomalies in the Copper Mineralized Zone

Masnon has the most continuous outcrop. Any anomalies, however, were not detected near the outcrop but at two sites (Line 8, No. 9 and Line 9, No. 10) in the basalt. The anomalous zone (covering Line 9, No. 15, Line 9, No. 16, Line 9, No. 18 and Line 10, No. 17), with the highest value of 168 ppm in the survey area, is also in the basalt. Any gossan or float could not be found in the anomalous zone (though there are poor exposures), but this zone suggests an existence of veins like ones seen in Manamburao.

In the Shawood area, there are no Cu anomalies near the two outcrops but an anomaly of 143 ppm was obtained at the middle point (Line 20, No. 13) between the two outcrops.

This anomaly tends to extend toward a NE–SW direction, just parallel to the strike of the 400 m outcrop, suggesting the existence of new parallel veins.

The anomalous zone (Line 22, No. 1, Line 23, No. 1) in the upper reaches of the Mayu River is also in the basalt. Any mineral showing was not encountered but some chalcopyrite – pyrite disseminated ore floats (FR3-024, Cu: 1.01%) in the lower reaches of the river suggest their source in the neighborhood.

Pb

Geochemical anomalies of Pb are distributed as to reflect the vein arrangement exactly. That is, the anomaly connecting two points of 5–12 and 6–13 rests on the chalcopyrite – quartz vein outcrops of a NE–SW system, and the anomalous zone composed of points 4–15, 27–14, 27–15 and 5–15 (where a geochemical contrast max/t = 2.2) is fairly caused to the vein of an E–W system. The latter anomalous zone is seemed to extend to the points 4–10, 5–9 and 6–9, which suggests the existence of a parallel vein.

A weak anomaly extending from 0–0 to 1–5 (geochemical contrast = 1.1) is located on the southwest-extended line of a NE–SW system vein in Manamburao, which suggests there is a close relationship between the anomaly and the vein. Besides these, Pb anomalies were detected at three points of 1–10, 16–9 and 17–21. They are assumed to extend in a NE–SW direction, though they are isolated and the details are not clear.

Near Masnon and Shawood showings, Pb values are almost the same as the background value, indicating that the Cu-mineralization is very limited.

Zn

Geochemical anomalies of Zn have been obtained at points of 26–15 and 29–14 but no anomalies have been detected in Manson and in Shawood.

There can be mentioned anomalies at the southern end points of Lines 2 and 3, anomalies from 8–6 to 9–7 and anomalies consisting of 13–16, 14–16 and 14–17 as the anomalies extending over adjacent two points. The first anomalies, with the highest value of 151 ppm in the area, are located in basalt and are not accompanied by Cu or Pb anomalies, which seems to be less significant. The second anomalies are also in basalt near the bountary between slate and basalt. They correspond to the Pb anomalies, and their contents are not so high. The last anomalies are in slate and basalt. They are partly accompanied with copper anomalies. As the sampling localities are on the bank of the Pula River, they might be "seepage anomalies"

4–3–2 Stream Sediment

In Phase I and Phase II, 69 stream sediment samples were collected in this area and this time 27 additional samples were taken from the unsurveyed creeks.

Data processing was performed for these samples as a whole. The results are given below.

Histograms and probability graphs of cumulative frequency distribution of Cu, Pb and Zn are shown in Figs. 26 and 27. The samples are not many and so their contents do not show a lognormal distribution. In this paragraph the drainages with higher metal contents over threshold values (t) will be discussed on the assumption that t is geometric mean (m) + 2 x standard deviation (s.d.).

Table 9 Statistic Values of Geochemical Data (Stream Sediment)

	Cu			Pb			Zn		
	m	s.d.	t	m	s.d.	t	m	s.d.	t
Steam sediment (96 pcs)	35.2	0.250	111	3.9	0.409	25.8	60	0.216	165

(in ppm)

m; geometric mean
s.d.; standard deviation
t; threshold value

Cu anomalous values were obtained from the creek of Manamburao outcrops and one branch of the Agluban River, 4 km west of Manamburao. The former is caused by the already – mentioned upstream outcrops. The latter has 154 ppm in content, suggesting that it is affected by mineralization. However, it seems to be small in scale, judging from the following facts, (1) Ore floats could not be found (2) no anomalies were obtained from the adjacent creeks and (3) metal contents are lower than Manamburao whose geological setting is quite alike.

Pb anomalous value of 25 ppm (sample No. W1–140) was observed in Phase I at a point in the main stream of the Agluban River. This is probably accidental because the Phase II survey collected stream sediment samples with no significant values from each tributary of the upper reaches of the same river over more than 10 km.

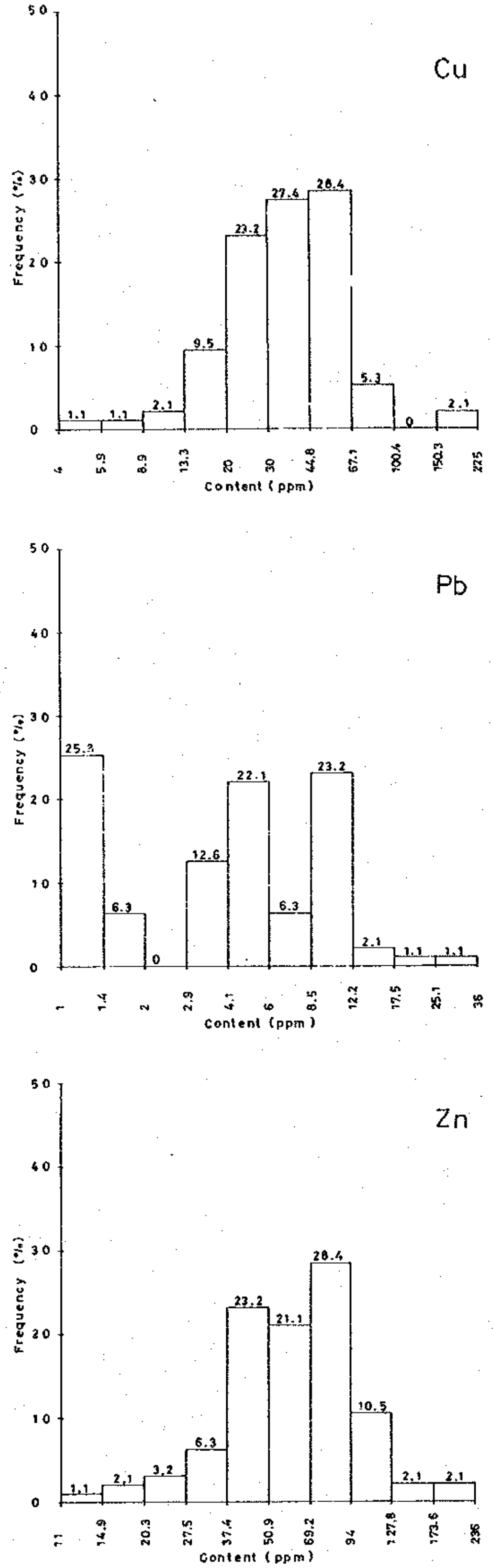

Fig. 26 Histogram of Goechemical Data (Stream Sediment)

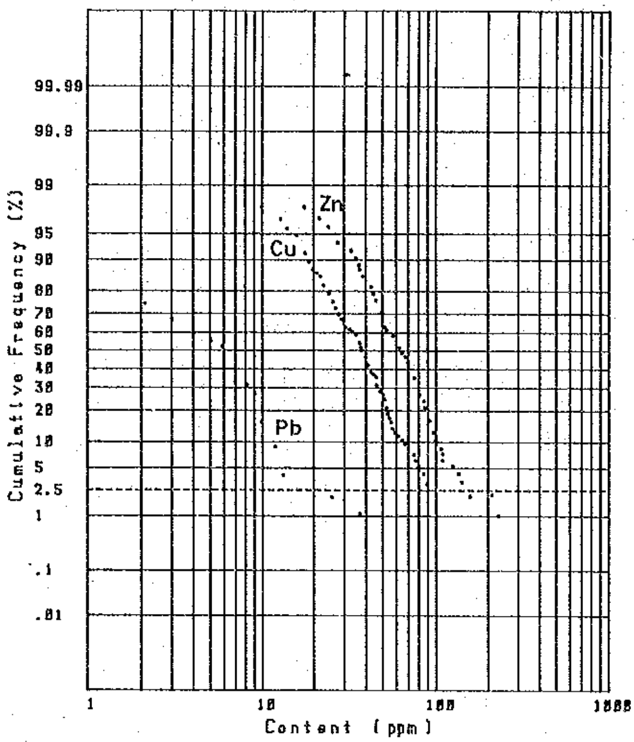

Fig. 27 Cumulative Frequency Distribution of Each Element

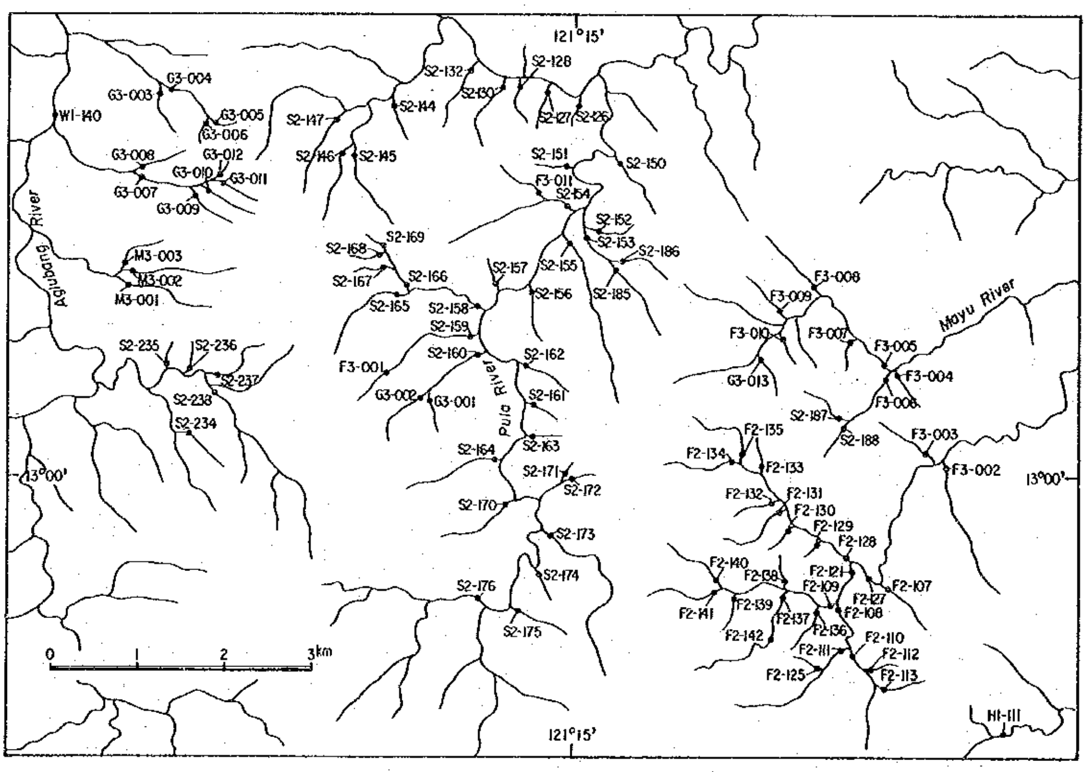

Fig. 28 Location Map of Stream Sediment Samples

An anomalous value of Zn of 212 ppm (H1−111) was disclosed in the tributary located at the southeast corner of the survey area where the younger conglomerate and sandstone beds of the Bongabong Group are mainly distributed. Therefore, the anomaly is not caused by the primary mineralization.

4−3−3 Results of Analysis

Based on the results of detailed geological survey and geochemical soil survey for the limited area including three showings of Manamburao, Masnon and Shawood and stream sediment survey for the surrounding area, the following consideration can be made.

(1) The overlapped anomalies of Cu, Pb and Zn in soil were only observed Manamburao, where a relatively high anomalous zone (Cu 75 − 168 ppm, Pb 20 − 43 ppm, Zn 80 − 126 ppm) tends to extend in a NE−SW direction. As veins of the outcrops have filled fault fissures of N−S, E−W and NE−SW systems, mineralization is considered to have progressed along the weak zone of a NE−SW direction.

(2) Although two showings of Masnon and Shawood have very high contents of Au and Cu (but their widths are small), the values of three elements in soil are as low as the background values. Little rock alteration is recognized and so the mineralization is possibly limited.

(3) Cu, Pb and Zn contents in soil are generally very low and there are no remarkable anomalies. Geochemical stream sediment survey also found no remarkable anomalies in the surrounding area. From these evidences, copper mineralization in this area is concluded to be very weak.

Ⅲ. CONCLUSION AND RECOMMENDATION

CHAPTER 1. CONCLUSION

Based on the results of Phase I and Phase II surveys, five areas such as A, B and C for chrome, D for iron and E for copper were selected from geological and economic-geological points of view, as having potential for mineral resources.

In this phase, Phase III, geological survey was carried out for A, B and C areas with trenching, for D area with ground magnetic survey and for E area with geochemical survey for soil and stream sediment, in order to confirm the extension of mineralized zone.

The conclusions are as follows;

1. A-area is composed of the Ultramafic complex (Pintin body), mainly consisting of harzburgite. In the body 12 outcrops and ore floats zones of chromite, (Ore grades: Cr_2O_3 40 – 50%, maximum width at exposures: 0.20 m, Length 1.0 m) are arranged on the two lines. Trenching which was carried out at two places, has proven that the ore bodies do not extend in both horizontal and vertical directions. All of them are considered to be small scale lenticular orebodies.
2. B-area is composed of the Ultramafic complex (Ogos body) consisting of dunite, harzburgite and lherzolite, some of which show a layered structure extending in an E–W direction. The chromite showing (Ogos body) found in Phase II occurs in dunite and the trench survey confirmed a layered body (6.5 m thick, 30% Cr_2O_3 and length may be some tens m). The new outcrop (1.0 m wide, Cr_2O_3 42%) occurs at the almost same horizon in dunite as the Ogos', the Ogos body can be expected to extend eastwards.
3. C-area is composed of the Ultramafic complex (Bongabong body) mainly consisting of dunite and harzburgite. The dunite distribution and the layered structure indicate that the body has a structure of a NW–SE system. Six chromite showings arrange on the two lines in dunite, three of them are of the layered type (maximum width: 1.0 m, length: 4.0 m, Cr_2O_3 38 – 46%) and the rest are of a lenticular type (maximum width: 0.2 m, Length: 3.0 m, Cr_2O_3 42 – 46%), occurring in the sheared zone. All showings are considered small.
4. D-area is composed of the Halcon metamorphics and the Mansalay Formation of pre Jurassic to Jurassic, the Sablayan Group of Tertiary and the dioritic rocks of Tertiary. The iron deposits are magnetite deposits formed by replacement of the Sablayan limestone.

The ground magnetic survey indicated the volume of the magnetic bodies, corresponding to the three deposits of Nagsabongan, Lasala and Lapa-ao.

On the assumption that the specific gravity of ore is 4.0 and a safety rate including change of wast-ore ratio is 50%, each ore reserve is estimated as below.

Ore Deposit (Magnetic bodies)	Reserve	Average Grade (Fe) of Outcrops
Nagsabongan (Ia + Ib)	12×10^6 ton	63%
Lasala (IIa + IIb)	18×10^6	61
Lapa-ao (IIIa + IIIb)	36×10^6	48

5. E-area is composed of Jurassic Mansalay and Lumintao Formations, Sablayan and Bongabong Groups and late Mesozoic intrusive of the Ultramafic complex. Copper mineralization is of the vein type, filling fissures developed in the complex or the Lumintao Formation. Geochemical soil and stream sediment surveys carried out in the area covering Manamburao, Masnon and Shawood showings, indicated that strong anomalies of Cu, Pb, Zn could not be detected, suggesting that the copper mineralization is very limited, considering in connection with the very weak rock alteration.

CHAPTER 2. RECOMMENDATION

Based on the survey results of Phase III, the followings can be recommended.

1. Chromite showings in the B-area

The Ogos body occurs in dunite in the layered or banded form and is the largest in scale (width 6.5 m, Cr_2O_3 33% and length may be some tens m). As the body is expected to extend toward east from the geological point of view, the exploration to confirm its extension is recommended. To achieve this, a trench survey using heavy equipments etc., is considered to be carried out.

2. Iron Deposits in the D-area

The ground magnetic survey estimated the ore reserve of each deposit, viz, Nagsabongan, Lasala and Lapa-ao, as a 10^7 ton level. As the Fe-grade may range largely towards depth, a drilling exploration is recommended to get more detailed data on ore reserves and grade.

REFERENCE

Andal, D.R. & Caagusan, N.L. (1967) — Geology of the iron deposits of northern Mindoro. Second Geological and First Symposium on the geology of the Philippines and neighboring countries, Jan. 1967, Proc., Vol. 1, P. 121–136.

Bacuta, G.C., Jr. (1979) — Geology of some alpine-type chromite deposits in the Philippines. Jour. Geol. Soc. Phil., Vol. 33, no. 2, p. 44–81.

Banba, T. (1963) — Genetic study on the chromite deposits of Japan. Rept. Geol. Surv. Japan, no. 200.

Caculitan, P.R.; Custodio D.; Rollan R.R. & Ferrer N.V. (1977) — Report on the regional geological mapping and mineral canvassing of Abra de Ilog quadrangle, Occidental Mindoro. Bureau of Mines, Manila, unpublished.

Caculitan, P.R.; Gonzales R.V; Balisi, V.V. & Ang, V., Jr. (1976) — Progress report on the regional geological mapping and mineral canvassing of northern Mindoro. Bureau of Mines, Manila, unpublished.

Coleman, R.G. (1977) — Ophiolites. Springer-Verlag.

Fisher, D.J.; Frueh, A.J., Jr.; Hurlbut, C.S., Jr. & Tilley, C.E. (1963) — International Mineralogical Association – Papers and proceedings of the third general meeting. Min. Soc. America, Special paper No.1.

Irvine, T.N. (1974) — Petrology of the Duke Island ultramafic complex, southeastern Alaska. Goel. Soc. America, Mem. 138.

Narita, E. (1976) — Chromite deposits of the Philippines (in Japanese). Metal Mining Agency of Japan, Oversea data no. 76.

Reyes, F.T. (1970) — Geological and geochemical investigation of copper prospects in Socorro, Oriental Mindoro. Bureau of Mines, Manila, unpublished.

Santiago, J.U. (1970) — Geologic investigation of outcrops for copper mineralization in Socorro, Oriental Mindoro. Bureau of Mines, Manila, unpublished.

Stoll, W.C (1958) — Geology and petrology of the Masinloc chromite deposit, Zambales, Luzon, Philippine Islands. Bull. Geol. Soc. America, Vol. 69, p. 419–448.

Wyllie, P.J. (1967) — Ultramafic and related rocks. John Wiley & Sons, Inc.

(3)