REPORT

ON

THE COOPERATIVE MINERAL EXPLORATION

GEOLOGICAL ASSESSMENT OF CHROMITE, BASE METALS, PLATINUM AND RELATED PRECIOUS METAL OCCURRENCES IN SOUTH CENTRAL PALAWAN, THE REPUBLIC OF PHILIPPINES

PHASE II

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Republic of the Philippines, the Japanese Government decided to conduct a Mineral Exploration Project in Souh Central Palawan and Northeastern Panay, and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of the Philippines a survey team headed by Mr. Akio Shida from September 9 to November 8, 1991.

The team exchanged views with the officials concerned of the Government of the Republic of the Philippines and conducted a field survey in the South Central Palawan area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

March, 1992

Kensuke Yanagiya

President

Japan International Cooperation Agency

Gen-ichi Fukuhara

President

Metal Mining Agency of Japan

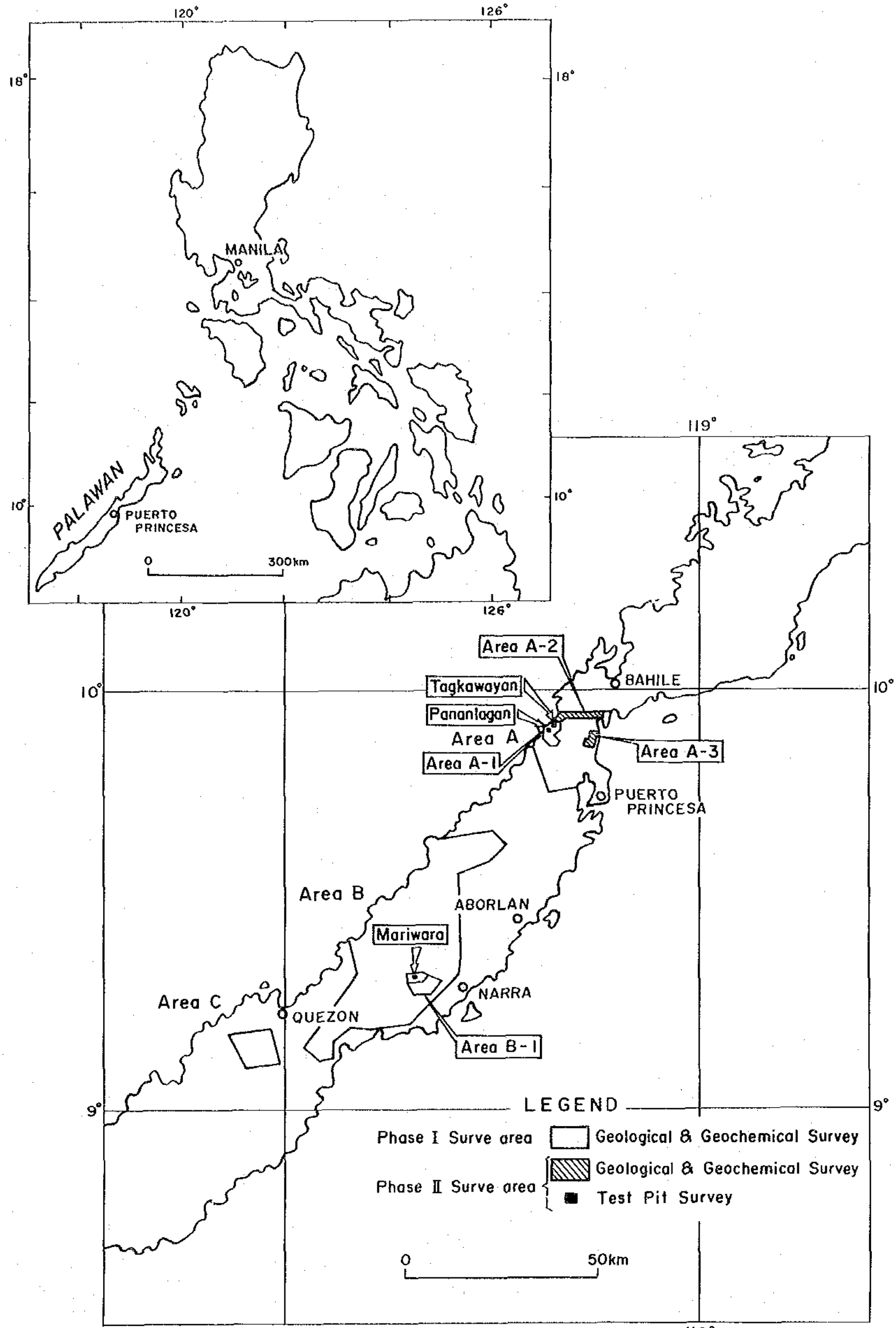

Fig. 1 Location map of the survey area

SUMMARY

The geological survey and geochemical prospecting were conducted as the Phase 2 cooperative mineral exploration project in the Palawan area, Philippines. The detailed geological mapping and close spaced soil sampling were carried out in area A-2 and A-3 defined by the result of the regional survey of the Phase 1 exploration program. At the same time, test pitting surveys were operated in Pananlagan area and Tagkawayan area extracted from area A-1 and Mariwara area from area B-1.

1) Area A-2 is about 20 kilometers north of Puerto Princesa. The area is mainly underlain by nappe of ultramafic complex. Chromite deposits occur mostly in a dunite tectonite near Nagtabon Pass. Nagtabon No. 1 deposit is slightly large among the deposits, and the volume of 2,000 tons as chromite was estimated. Soil geochemical prospecting detects chromium anomalies sporadically in some places, but they have no association with the distribution of dunite tectonites and ore deposits. Therefore promising area for chromite deposit could not be defined by this result. Iron and nickel anomalies occur to the north of Bacungan, south of Mt. Airey and north of Maranat, where have potential for nickeliferous laterite. As for platinum related elements, the northwestern portion of the area shows high content.

2) Area A-3 is about 15 kilometers north of Puerto Princesa. The area consists mainly of ultramafic complex. Dunite tectonite is distributed at high elevation part in the middle of the area, and main 3 deposits occur in it. Among them Pagasa 1 deposit has the mineralized area of 150 x 150 meters with the estimated volume of 40 to 60 thousand tons as chromite. Soil geochemical prospecting shows chromium anomalies around Pagasa 1 deposit, south of Pagasa 2 deposit and west of national highway. The platinum related elements' anomalies are detected in the area southward from Pagasa 1 deposit, from Pagasa 2 deposit to Pagasa 4 deposit and to the west of national highway. Among these, the promising areas for chromite deposits are around Pagasa 1 deposit and south of Pagasa 2 deposit, where overlaps chromite anomalies and the distribution of dunite tectonite.

3) Area A-1 is situated at the west coast. Pananlagan area is in the middle of the area A-1 and some chromite pods and bands occur in dunite tectonite. Forty-six test pits were sunk around two old workings in the upper Pananlagan River. Pitting survey confirmed the extension of dissemination type ore cropped out in the lower old working and another chromite band elongated parallel to the outcrop. An outcrop of massive chromite ore, 2 meters in width and more than 7 meters in length, was also found near the upper old working.

Other four pits were sunk in the chromium geochemical anomaly area at lower Pananlagan River. They revealed that this anomaly was the false anomaly.

Tagkawayan area is in the north of the area A-1, and small old workings of chromite and mineral showings were found in dunite tectonite. Fifty test pits were sunk in this area, but no mineralized part was found.

4) Area B-1 is about 10 kilometers west of Narra. One hundred test pits were sunk in Mariwara area in area B-1. The area is underlain by dunite. Chromite mineralization was recognized in 13 pits. In particular, a massive chromite ore was found in the middle of the area. The platinum related elements' contents of the bottom soil are also high around this mineralized zone. Other mineral showings consist of chromite dissemination and thin chromite bands, and the content of chromite is low.

As the result of above mentioned survey, it is preferable that the further detailed exploration including drilling survey will be conducted at Pagasa 1 deposit in area A-3 and maybe Nagtabon No. 1 deposit in area A-2 to clarify the occurrence of subsurface ore body.

Several mineral showings were newly discovered through test pitting survey in area A-1 and B-1, but they are all small in scale. Therefore further survey may not be necessary in these two areas.

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PART I GENERAL REMARKS

Chapter 1 Introduction

1-1 Background and objective

The South Central Palawan has high potentiality about the mineral resources such as chromite, nickel, platinum, massive sulfide ores that are associated with ophiolite.

In response to the request of the Government of the Republic of the Philippines, the Japanese Government decided to conduct a Mineral Exploration Project in the Palawan Island, and the Phase 1 survey started from 1990. This year's survey is the Phase 2 of the mineral exploration project program.

In the Phase 1, the regional geological survey and geochemical prospecting were conducted in the A, B and C area covering 1400 km^2. As a result of the Phase 1 survey, the area A-1, A-2, A-3 and B-1 were selected as target areas, and following further geological survey and geochemical prospecting were conducted in the area A-1 and B-1.

The objectives of the Phase 2 survey are to estimate the potentiality of mineral deposits in the area A-2 and A-3 by clarifying the geological setting through detailed geological survey and geochemical prospecting, and to get targets directly by pitting survey in the selected area from the area A-1 and B-1.

1-2 Contents of the survey

The detailed geological survey and geochemical prospecting were conducted in the area A-2 and A-3, and the test pitting surveys in the area A-1 and B-1. Contents of the survey are shown in Table 1 and 2.

1) Geological survey and geochemical prospecting

Geological survey was conducted in combination with soil sampling. Geologic mapping was conducted using topographic maps on the scale of 1:10,000, that were enlarged from topographic maps on the scale of 1:50,000. The mineral showings were observed precisely and their shapes and scales were delineated by means of simple surveying.

Each soil sampling site along streams and ridges was predetermined on the map. The density of sampling site was set to be even in whole area. Soil from B horizon had been taken at each site, and the results of the observation were recorded on the route map.

2) Test pitting survey

Test pitting survey was mainly operated with the rectangular grid system. The direction of survey lines was decided to cross the general geologic trend, the spacing between survey lines was 100 meters, and the interval between pits was ranging from 20 to 25 meters. Each test pit was sunk downward until basement by hand.

Table 1 Contents of the field survey

Name of area	Contents (Geological and Geochemical survey)		
	Area	Route length	Geochemical samples
A-1 area (Test pit survey)	----	----	Test pits 102 Soil samples: 204
A-2 area	50 km^2	106 km	Soil samples: 443
A-3 area			Soil samples: 104
B-1 area (Test pit survey)	----	----	Test pits: 100 Soil samples: 200

Table 2 Laboratory examinations

Examination Items	Quantity
Preparation of thin section	14 pcs
Preperation of polished thin section	16 pcs
Chemical analysis	
1 Geochemical analysis (Pt, Pd, Au, Ni, Cr, Fe, Co)	951 pcs
2 Ore sample (Cr_2O_3, Al_2O_3, Fe_2O_3, SiO_2, Ni)	33 pcs
EPMA quantitative analysis	10 pcs

1-3 Personnel and schedule

1) Survey planning and negotiation

A team was sent for survey planning and negotiation of the Cooperative Mineral Exploration in South Central Palawan and Northeastern Panay. The arrangement was signed on July 5, 1991, titled the Implementing Arrangement for Geological Assessment of Chromite, Base Metal, Platinum and related Precious Metal Occurrence in South Central Palawan and Northeastern Panay.

Personnel of planning and negotiation

JAPAN	PHILIPPINES
Yoichi Yamaguchi (MMAJ)	Joel D. Muyco (MGB:Director)
Norio Nakano (Ministry of Foreign Affairs)	Salvador Martin (MGB)
Hajime Ikeda (JICA)	Edwin G. Domingo (MGB)
Kyoichi Koyama (MMAJ)	Romeo L. Almeda (MGB)
Yoshitaka Hosoi (MMAJ)	Noel V. Ferrer (MGB)
Yuji Kajitani (MMAJ:Manila Office)	
Kenzo Masuta (MMAJ)	

2) Phase 2 survey

Period August 23, 1991 to February 20, 1992

(Field Survey from September 9 to November 8, 1991)

Personnel of field work

JAPAN	PHILIPPINES
Akio Shida	Noel V. Ferrer
Yasunori Ito	Antonio N. Apostol Jr.
Makoto Miyoshi	Ronaldo Miranda
	Joselito Velasquez
	Emmanuel Santos
	Jimmy Crisoloso
	Eleazar Mantaring

Chapter 2 Geography

2-1 Location and access

Palawan Island is situated in the southwestern end of the Philippine archipelago. It faces the Sulu Sea to east and the South China Sea to west. The area A-1, A-2 and A-3 are located between the latitude of 9°46'N and 9°57'N. The area B-1 is located between the latitude of 9°16'30" and 9°18'30".

Simpucan is the south edge of area A-1 by the west coast and about 80 kilometers from Puerto Princesa City. A paved national highway runs through the east coast. An unpaved road branches at Iwahig and leads to Simpucan by way of Napsan at the west coast. As this rough road crosses some large rivers as Iwahig River, it is sometimes impossible to cross the deep rivers in rainy season. The daily passenger jeepny service is available between Puerto Princesa City and Napsan, and it takes about 3 hours and a half even in good road condition from Puerto Princesa City to Simpucan.

Area A-2 is about 20 kilometers north of Puerto Princesa City. A national highway leads from Puerto Princesa City to the eastern part of area A-2 by way of Bacungan. An unpaved road branches from Bacungan crossing the backbone range and leads to Nagtabon Beach by the west coast. Since this road is rough and partly very steep, four-wheel drive car is needed to get to the west coast. It takes about 30 minutes from Puerto Princesa City to Bacungan, and about another 30 minutes from Bacungan to Nagtabon Beach by car.

Area A-3 is along the national highway and about 15 kilometers north of Puerto Princesa City. It takes about 20 minutes from Puerto Princesa City to area A-3 by car.

Area B-1 is about 10 kilometers west of Narra. A fully paved national highway runs southward from Puerto Princesa City to Narra. It takes about 2 hours to Narra by car. An unpaved road leads from Narra to Mariwara, the south edge of area B-1. It takes about 10 minutes from Narra to Mariwara. The test pitting site is about one hour's walk from Mariwara.

2-2 Topography

Generally the lithofacies decide the topography in South Central Palawan. The ultramafic rock's area forms very steep, whereas gabbro, basalt and sedimentary rocks' area forms gentle hill.

In the A area, backbone range runs parallel to the shore line, which divides the survey area into two, the east side and the west side. The west side is very steep, while the deeply dissected east side forms gentle hill.

Steep and rugged mountains, centering Victoria Peak, are dominant in B area, because Ultramafic rock is widely distributed in backbone range. Mountains are approached very near to west coast, whereas flat alluvial land occupies along east coast. The southern half of area B-1 where deeply weathered gabbro and basalt are distributed shows gentle topography. The northern half is very rigid because of ultramafic rock's area.

2-3 Climate and vegetation

The survey area belongs to the tropics, and season is divided into the wet season and dry season. Generally the dry season starts in December and ends in May. The wet season starts in June and ends in November. Annual rainfall in South Central Palawan is about 2,700 millimeters. In the end of dry season, April and May, small rivers dry out and serious lack of water occurs in Puerto Princesa City.

Virgin forests are found at deep mountains. It mainly consists of latifoliate trees. Secondary forests, consisting of small tree and bush, are found around the village. They have mainly made by slash and burn. Rice fields occupy the lowland along small streams and rivers near the east coast. There are many orchards and pastures in the hills from Puerto Princesa City to Bacungan. Colonies of mangrove are observed along the east coast.

2-4 General information

Puerto Princesa City, where the base camp was settled, is the capital city of Province of Palawan, and almost equipment is available within the city. Electricity and water are supplied in Puerto Princesa City and other main towns.

Flatlands along the big rivers are studded with villages. Only a few persons live in the deep mountains, but many trails exist in the mountain for charcoal and lumber making and resin sampling.

Main industry of the area is agriculture and fishery. Rice, coconut, cashew, and fruit are produced in Palawan.

Chapter 3 Existing geological information

3-1 Previous works

The Palawan Island is a long and narrow island, located in the southwest of Philippine archipelago. Palawan has the potentiality of the deposits associated with ophiolite, hydrothermal deposit and vein type deposits. As for chromite deposits, it appears that many private companies explored during 1970's to early 1980's, but very little has been reported about their results. The geology and mineral deposits of the Philippines Archipelago are summarized by Bureau of Mines and Geo-Sciences (1982, 1986). The regional geology and mineral deposits of Palawan Island are stated in these reports.

The stratigraphy, geological structures, and mineral deposits in Central Palawan are described and *interpreted the tectonic evolution of Palawan Island by UNDP (1985). The Geologic Map of the* Bacungan Quadrangle (BMG-UNDP, 1986) was published based on UNDP's survey results.

JICA-MMAJ conducted the RP-JAPAN Mineral Exploration Project at several areas in Philippines during five years from 1984 to 1988, and the regional geological survey and geochemical exploration were conducted in the whole areas of Palawan Island. The stratigraphy, geological structure, and mineral showings in Palawan Island were described by JICA-MMAJ (1987, 1988) and at the same time the geochemical anomalies were delineated in their reports. The geological survey and geochemical prospecting were conducted as the Phase 5 of the RP-JAPAN Project in the South Central Palawan that was extracted by the regional survey (JICA-MMAJ, 1989).

UNRFNRE (1990) conducted the precise geological survey and geochemical exploration in the west coast area of Palawan to identify economically minable deposits of metallurgical-grade chromite. They described the geochemical anomalies and mineral showings.

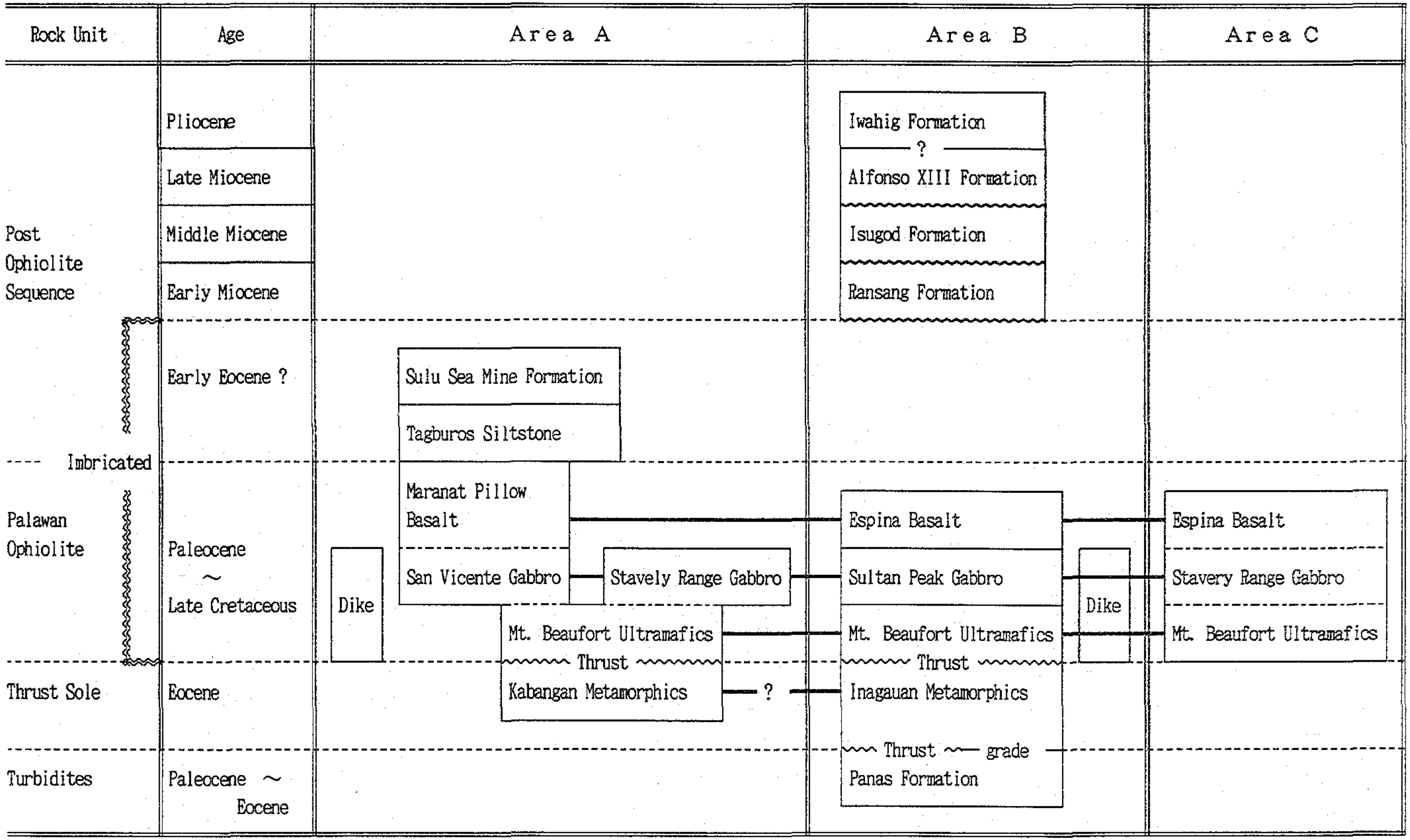


Fig. 3 Columnar section of the survey area

3-2 General geology and ore deposit

1) General geology

South Palawan is thought to be constructed by the northwestward thrust movements of overlying ophiolite to the north Palawan block during the formation of the South China Sea and the Sulu Sea. North Palawan block is a microcontinent drifted away from East Asia during the formation of the South China Sea Basin. North Palawan and South Palawan were bordered by Sabang Fault. North Palawan mainly consists of continental metamorphic rocks, whereas South Palawan basic rocks of ophiolite.

Palawan Ophiolite, from the base upward, is composed of Mt. Beaufort Ultramafics, the Stavely Range Gabbro and the Sultan Peak Gabbro, and the Espina Basalt. The Inagauan Metamorphics are distributed at the thrust sole. The upper part of Inagauan Metamorphics consists mainly of amphibolite, whereas the lower part consists of pelitic and psammitic schist, metamorphosed turbidites.

2) Ore deposit

A chromite mine and a nickel mine are actively operated in South Central Palawan.

Ore deposits in Palawan Island are orthomagmatic and placer chromite deposit, nickeliferous laterite deposit, massive sulfide deposit, hydrothermal mercury deposit and vein type antimony deposit. In particular, Palawan Island is known to produce metallurgical-grade chromite ore of high chromium content.

Chromite deposits mainly occur in dunite tectonite and cumulate dunite in this area as podiform type, which consist of compact massive and disseminated type ore. Chromite bodies have irregular shape and vary markedly in thickness ranging from several ten centimeters to several meters as the result of the deformation of peridotite body by the large scale thrust movement.

Nickeliferous laterite is recognized in peridotite area of gentle topography.

Chapter 4 Comprehensive discussion

4-1 Geological survey and geochemical prospecting

4-1-1 Area A-2

Area A-2 is mainly underlain by nappe of ultramafic complex (Mt. Beaufort Ultramafics). The ultramafic complex has been thrust over gabbro (San Vicente Gabbro) at east part of the area and sedimentary rocks (Sulu Sea Mine Formation) at west part of the area. Metamorphic rocks (Inagauan Metamorphics), which consists of quartz schist, is distributed near thrust fault at Maranat. The ultramafic complex consists mainly of harzburgite and dunite. The dikes of pyroxenite, fine gabbro, porphyrite pegmatite intrude into the ultramafic rocks at places.

The chromite mineralization occurs in dunite bodies of Mt. Beaufort Ultramafics. The rather large scales of dunite bodies are distributed in the southwest slope of Mt. Airey and around Nagtabon Pass. Small diapir-like dunite bodies ranging in width several ten centimeters to several meters are also found in all over the harzburgite. The dunite body around Nagtabon Pass has the highest potential for chromite deposits, because many chromite deposits and mineral showings of both the massive and disseminated type ores occur in it. Ore bodies vary markedly in width, but they are generally under 2 meters in width. These deposits are mostly small in scale and each volume is presumed to be less than 1,000 tons as chromite. Nagtabon No. 1 deposit is rather large among these, though it consists mainly of disseminated ore. Though the subsurface occurrence is not clear, as far as disseminated ore is concerned, this deposit can be estimated the volume about 2,000 tons as chromite by presuming the extension of ore body 10 meters downward and 24 % of chromite content.

As for the geochemical prospecting, 7 elements, platinum, palladium, gold, nickel, chromium, iron and cobalt, were selected as pathfinder elements.

The correlation between platinum and palladium is very high; thereby they have very similar geochemical pattern each other. An anomalous zone of both elements is distributed along a small river north of Maranat, where some samples exceed 100 ppb.

The nickel, chromium, iron and cobalt contents in soil are relatively high in the ultramafic rocks area, whereas very low in the metamorphic and gabbroic rocks areas. The contents vary even in the ultramafic rocks. This contents variations of these elements are influence of secondary enrichment and leaching by

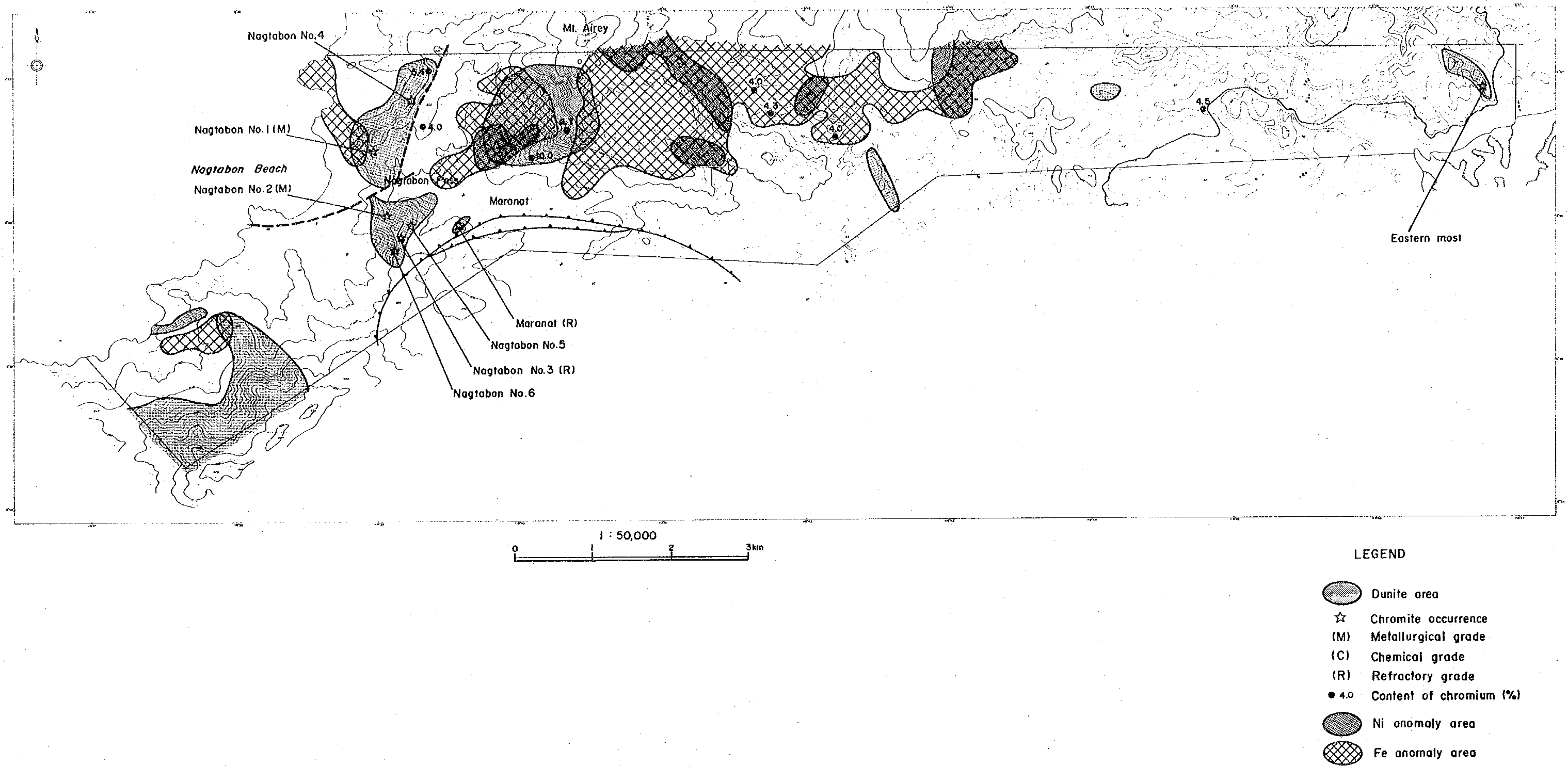


Fig. 4 Interpretation map of area A-2

relating the weathering process, in particular, the nickeliferous laterite forming process. The anomalies of nickel occur to the north of Bacungan, south of Mt. Airey and north of Maranat within iron anomaly area. It is inferred that the thick residual laterite formed in these areas, thereby these areas have high potential for nickeliferous laterite.

The anomalous values of chromium are detected to the south of Mt. Airey, north of Maranat and north of Nagtabon Pass, but they have no association with the distribution of dunite tectonites and ore deposits. Generally chromium contents must be high in the area around the chromite deposits, because Area A-2 was extracted as one of the chromium anomaly areas by the regional geochemical prospecting last year, and many chromite indications are discovered by this survey. It is inferred Chromite deposit does not always have clear geochemical halo like this area. Chromite grains are observed not only in dunite around deposits but also in dunite and harzburgite apart from deposits. Therefore promising area for chromite deposit couldn't be defined by this soil geochemical prospecting.

On the basis of the electron microprobe analysis of chromite, the mineral occurrences in this area yield the varied composition of chromite. The composition of chromite suggests the grade of chromite ore. From this point of view, the deposits are divided into metallurgical-grade; Nagtabon No. 1 and No. 2 deposit, chemical-grade; easternmost, and refractory-grade; Nagtabon No. 3 deposit.

4-1-2 Area A-3

Same as area A-2, area A-3 mainly consists of ultramafic complex (Mt. Beaufort Ultramafics). Gabbro body (San Vicente Gabbro) is distributed in west and north of the area being thrust by the ultramafic complex. The ultramafic complex comprises of harzburgite, dunite and pyroxenite. Dunite tectonite is distributed around the 291m peak at the high elevation part in the central portion of the area. The main chromite deposits occur in this dunite. These deposits were explored by private company, Country Mineral Resources Corporation, during later half of 1970's. Since the name of claim was "Pagasa", they named the possible areas Pagasa 1 to Pagasa 5. Mining and exploration might have been operated in Pagasa 1, 2 and 4. Among these, Pagasa 1 deposit is rather large in scale. Many outcrops of massive and disseminated chromite ores occur in Pagasa 1, and mineralized area covers more than 150 x

150 meters. On the basis of assumptions of the 150 x 150 meters promising area, the extension of deposit 10 meter downward, 20 to 30 % ore existence and 30% of chromite content, it may be inferred that the volume of chromite is 40 to 60 thousand tons. Pagasa 2 and 4 deposits is smaller than Pagasa 1 deposit.

As for the geochemical prospecting, 7 elements, platinum, palladium, gold, nickel, chromium, iron and cobalt, were selected as pathfinder elements.

The anomalies of chromium occur in Pagasa 1 vicinity, to the south of Pagasa 2 and the opposite side of the Pagasa 1 separated by a national highway. Anomaly zones of platinum and palladium are distributed in the area from Pagasa 1 to southward, on the south of Pagasa 2, the area Pagasa 2 to Pagasa 4 and west of the national highway. No nickel and cobalt anomalies are found in the area.

Almost chromite deposits occur in the dunite tectonite around the 291 m peak, it can be stated that the areas of high chromium content in soil within this dunite tectonite are delineated as high potential area about chromite deposits; therefore the area around Pagasa 1 and south of Pagasa 2 are promising.

The composition of chromite suggests that chromite ores of Pagasa 1 and 4 are metallurgical-grade.

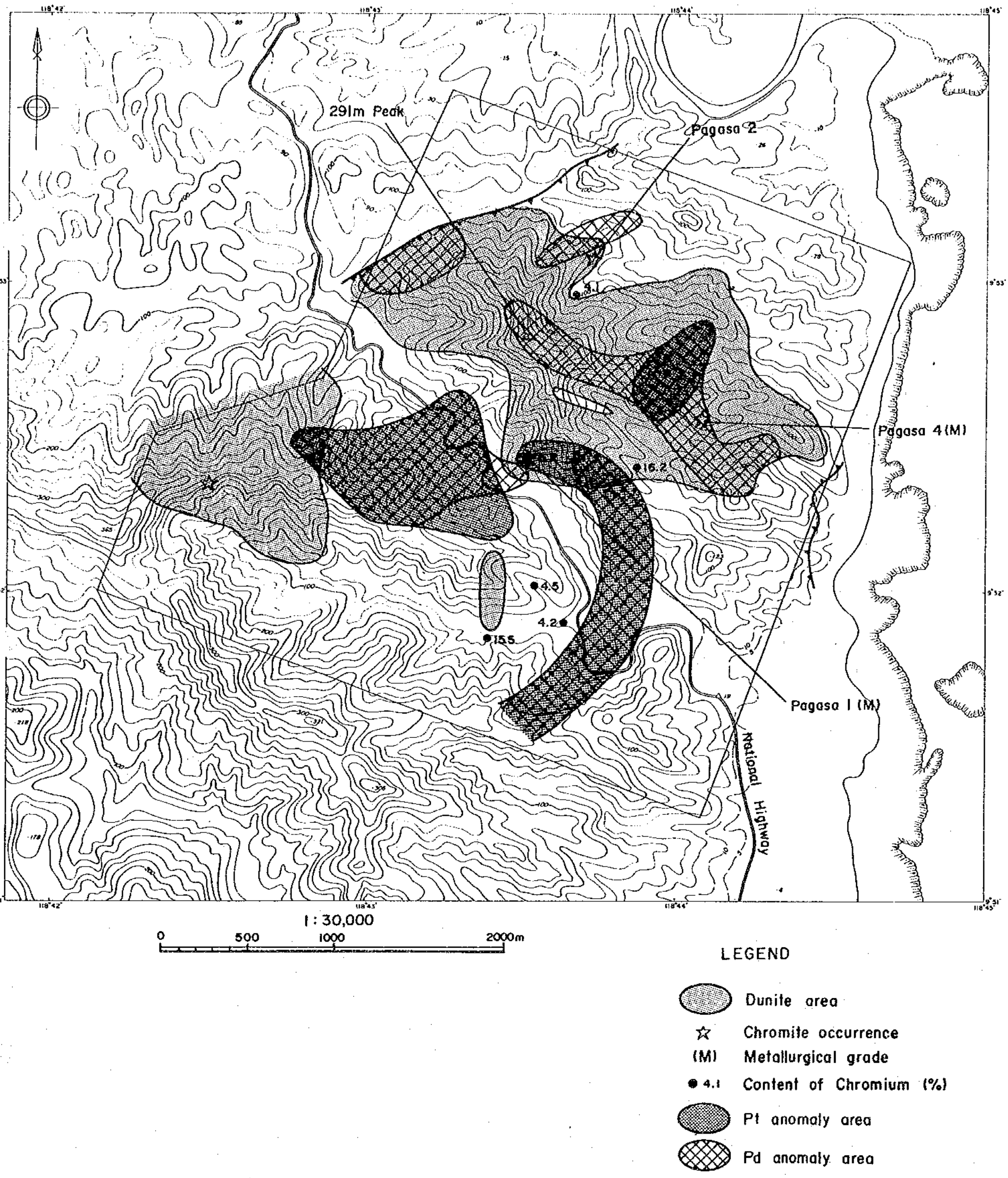


Fig. 5 Interpretation map of area A-3

4-2 Test pitting survey

The follow-up work with test pitting survey was carried out at the areas selected last year by the detailed geological survey and geochemical prospecting in area A-1 and B-1.

4-2-1 Area A-1

1) Pananlagan area

Three areas were selected for test pitting survey in the Pananlagan area.

1. The lower Pananlagan

Two test pits were sunk to make clear the extension of the lower Pananlagan ore body, but no extension was recognized.

2. Chromium anomaly along the branch of the Pananlagan River

A remarkable geochemical anomaly was detected last year by soil geochemical prospecting. Though four test pits were sunk to clarify this anomaly, no chromite mineralization was recognized in basement rock. Topographically this anomaly might be a false anomaly by secondary concentration of chromite.

3. The upper Pananlagan

Two old workings are recognized in the north slope of the Pananlagan River. Forty-six test pits were sunk along 5 survey lines in the direction crossing general geologic trend around the showings.

A disseminated type ore extending in the E-W direction crops out 10 meters long in the lower working. The extension of ore body was confirmed at the pit PA051, 10 meters apart from outcrop. Another chromite band, which is inferred parallel to the direction of outcrop, was discovered in the pit PA015, 25 meters apart from PA051. The analysis of this band shows 18.10% Cr_2O_3.

Another old working occupies the area of 50 x 200 meters, but no outcrop was recognized in the working where only several tons of massive chromite ores are stocked. An outcrop of massive chromite ore, more than 7 meters long and 2 meters wide, was newly discovered 100 meters apart from the old working, and it strikes N45°W and dips 40°NE. The analysis shows 49.00% Cr_2O_3. No new deposit was found around this area.

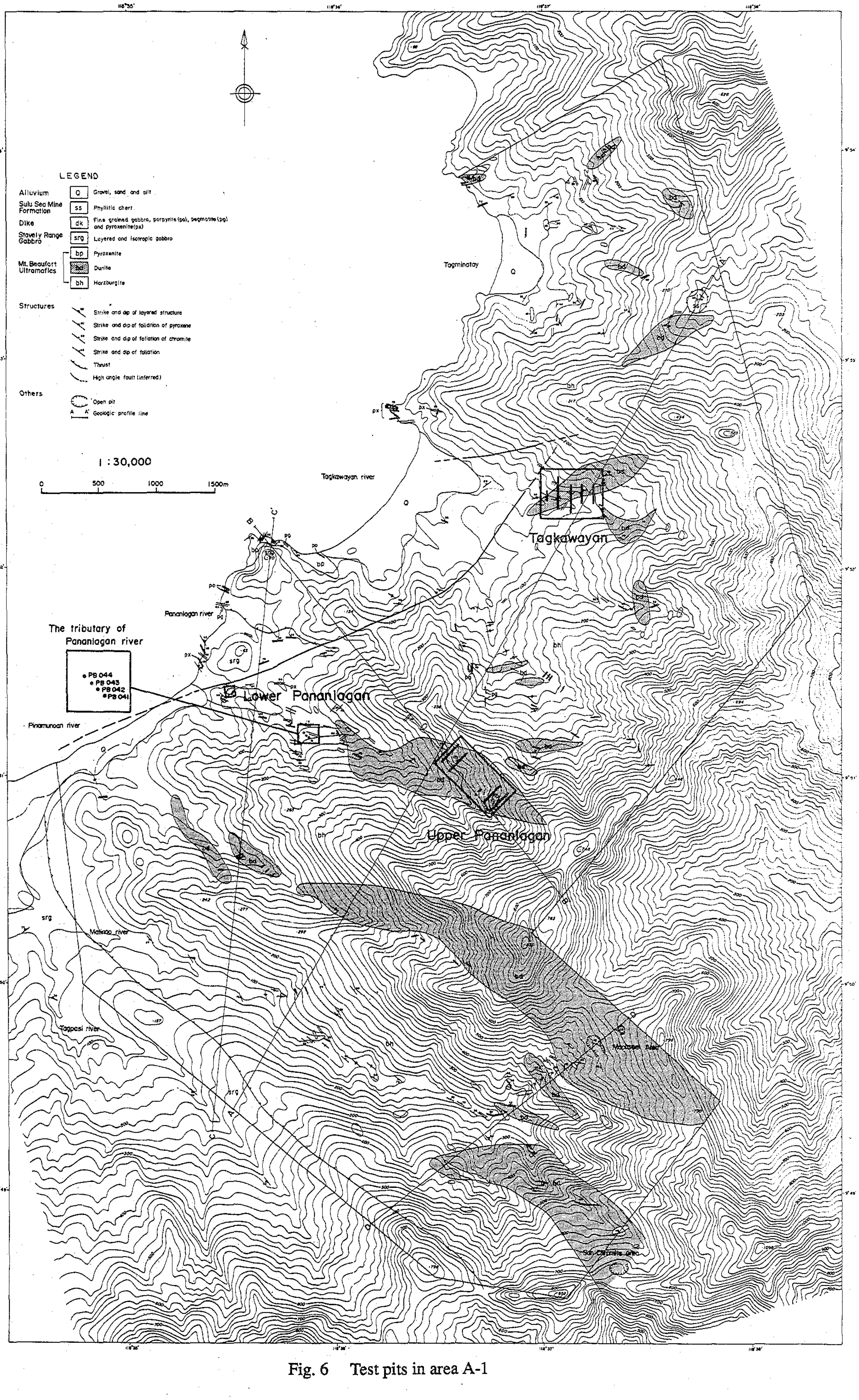


Fig. 6 Test pits in area A-1

2) Tagkawayan area

A remarkable chromium anomaly was detected and two chromite occurrences were reported last year by Phase 1 Follow-up survey in the Tagkawayan area. Fifty test pits were sunk along 5 survey lines set in the N-S direction to cross the general trend of dunite.

A small old working stocked several tons of massive chromite ores was discovered, and the analysis shows is 35.30% Cr_2O_3. A Little amount of massive chromite ores is stocked in another old working near pit TG030. It is inferred that small scale prospecting was conducted before. The dunite is almost barren in this area, and no other mineral showing was found by test pitting survey.

4-2-2 Area B-1

One hundred test pits were sunk along 5 survey lines in the Mariwara area where is extraceted as chromite anomalous area last year by Phase 1 follow-up survey. Dunite body is distributed in the area. Chromite dissemination occurs in transition zone and cumulate dunite.

Floats of massive chromite ore and leopard type nodular ore were found at the branch of Marinao River, and the analysis of massive ore shows 30.50% Cr_2O_3.

On the basis of the distribution of heavy minerals' weight in soil from pit bottom, it may be inferred that some chromite disseminated zones exist ranging in width from 20 to 50 meters considering the trend of chromite bands and dunite.

Mineral showings were found at 13 pits. Massive chromite ore body was found at NG034 pit in the central portion of the area, though almost mineral showing consists of very low grade chromite dissemination and thin chromite bands, The scale of massive chromite ore is 1.4 meters wide and more than 2 meters long, and the analysis of 1.4 meter channel sample shows 26.70% Cr_2O_3.

Contents of platinum related elements are also high around pit NG034. Soil samples collected from the pit bottom show Pt; 1,600 ppb and Pd; 3,400 ppb for NG034 pit, and Pt; 1,200 ppb and Pd; 740 ppb for NG100 pit.

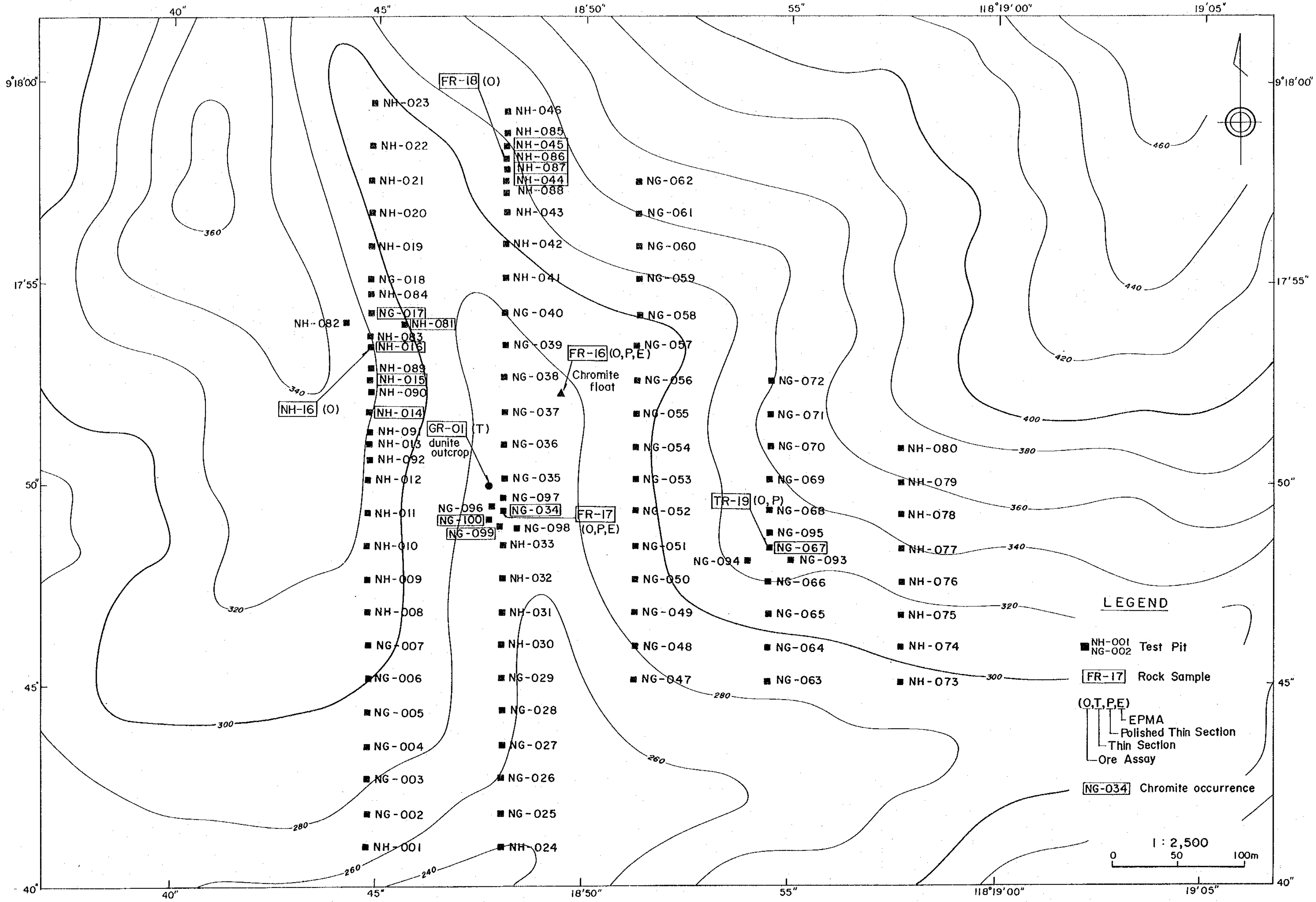


Fig. 7 Mineral occurrences and test pits in the Mariwara area

Chapter 5 Conclusion and recommendation

5-1 Conclusion

[Geological survey and geochemical prospecting in area A-2]

1) Area A-2 is mainly underlain by the nappe of ultramafic complex, consisting of harzburgite, dunite and pyroxenite.

2) Large dunite tectonites are distributed in southwest of Mt. Airey and the vicinity of Nagtabon Pass.

3) Almost chromite deposits occur in the dunite tectonite around Nagtabon Pass. Ore bodies consist of massive and disseminated types' chromite ores, which vary markedly in width. The scale of occurrences is small except the Nagtabon No. 1 deposit.

4) The disseminated type's ore is well-exposed in the Nagtabon No. 1 deposit, and massive ore was once mined. Though subsurface occurrence is not clear, the volume of 2,000 tons as chromite is estimated only from the disseminated type's ores near surface.

5) From soil geochemical prospecting, the chromium anomalies were detected scatteringly at places in the area. They don't seem to be coincide with the distribution of dunite tectonite and ore deposits. Therefore promising areas for chromite deposits could not define only by this result. An anomaly zone of platinum related elements is distributed along a small river to the north of Maranat, where some sample shows more than 100 ppb of both platinum and palladium. Nickel and iron anomalies overlap the area in the north of Bacungan, south of Mt. Airey and north of Maranat. These areas have potential for nickeliferous laterite.

[Geological survey and geochemical prospecting in area A-3]

1) Area A-3 is mainly underlain by ultramafic complex, consisting of harzburgite, dunite and pyroxenite.

2) Dunite tectonite is distributed around 291m peak in the central portion of the area. Pagasa 1, 2 and 4 deposit are located in this dunite tectonite.

3) Many massive and disseminated ores crop out in Pagasa 1 deposit. The mineralized zone covers at least 150 x 150 meters. Though it is difficult to estimate the volume of ore only by surface survey, 40 to 60 thousand tons of chromite is thought to be estimated.

4) The disseminated and massive chromite ore bodies occur in Pagasa 2 and 4 deposits. Massive chromite

ore body usually does not extend so much and vary markedly in width.

5) As the results of soil geochemical prospecting, chromium anomalies are recognized in the area south of Pagasa 1 and south of Pagasa 2, and these areas are thought to be promising for chromite deposit. The anomalies of platinum related elements are distributed in the area south of Pagasa 1, from Pagasa 2 to Pagasa 4, and west of national highway.

[Test pitting survey in area A-1]

1) Extension of massive chromite ore body in lower Pananlagan was not confirmed by this survey.

2) Test pits revealed that geochemical anomaly along the branch of the Pananlagan River was a false anomaly by secondary concentration of chromite.

3) Extension of disseminated chromite ore body at lower old working in upper Pananlagan is confirmed to extend to the pit 10 meters apart. Another chromite band parallel to this ore body was also recognized in another pit.

4) Outcrop of massive chromite ore was newly discovered near the upper old working in upper Pananlagan. The ore body strikes N45°W, dips 40°NE, and extends more than 7 meters in length and 2 meters in width. The analysis shows 49.00% Cr_2O_3. No other ore body was found around this area.

5) Two small old workings were found in Tagkawayan area, and the analysis of a stock shows 35.30% Cr_2O_3. The dunite is almost barren in this area. No other mineral showing was found.

[Test pitting survey in area B-1]

1) Chromite mineralization was recognized at 13 pits in the Mariwara area.

2) Massive chromite was discovered at NG034 pit in the central portion of the area. The analysis of this ore shows 26.70% Cr_2O_3. Contents of platinum related elements are also high around this pit. The bottom samples of pit show Pt; 1,600 ppb, Pd; 3,400 ppb at NG034 and Pt 1,200 ppb, Pd 740 ppb at NG100.

3) Other mineralized zones consist of disseminated chromite and thin chromite band, but the grade is low.

4) Floats of massive chromite ore and leopard type nodular ore were found in the branch of Marinao River. The analysis shows 30.50% Cr_2O_3.

5-2 Recommendation for Phase 3 survey

Many chromite occurrences are distributed in area A-2 and A-3. The evaluation has led that the Nagtabon No. 1 deposit in area A-2 and the Pagasa 1 deposit in area A-3 have potential for the chromite deposit. Therefore it is preferable that the further detailed exploration including drilling survey will be conducted at Pagasa 1 deposit and maybe Nagtabon No. 1 deposit to clarify the occurrence of subsurface ore body.

Several mineral showings were newly discovered through test pitting survey in area A-1 and B-1, but all of them are small in scale. Therefore further survey may not be necessary in these two areas.

PART II SURVEY RESULT

Chapter 1 Geological survey and geochemical prospecting

1-1 Area A-2

1-1-1 Geology

The area A-2 is mainly composed of nappe of ultramafic complex (Mt. Beaufort Ultramafics). The ultramafic rocks have been thrust over gabbro (San Vicente Gabbro) at east side of the area, and sedimentary rocks (Sulu Sea Mine Formation) at west side of the area. Metamorphic rocks (Inagauan Metamorphics), which consists of quartz schist, are distributed at near Maranat (Fig. 8).

The ultramafic complex is composed of harzburgite, dunite and pyroxenite. Dunite bodies are distributed within this harzburgite as diapir-like bodies. Dunite sometimes occurs alternated with harzburgite and pyroxenite.

The dikes of pyroxenite, fine grained gabbro, porphyrite and plagioclase-hornblende pegmatite intrude into the ultramafic rocks at places.

1) Mt. Beaufort Ultramafics

These ultramafic rocks are largely distributed in the whole area of the survey area. It is mainly composed of moderately serpentinized harzburgite, and contains some dunite and pyroxenite.

The harzburgite, which consists of several millimeters to 2 centimeters of olivine and orthopyroxene, differs in color between the weathered parts and the fresh parts. It is brown to pale brown in the weathered parts, and dark grayish green to black in the fresh parts. The orientation of orthopyroxene and compositional foliation due to the difference of volume ratio of orthopyroxene and chromian spinel are observed on the clearly polished weathered surfaces along the stream. The rocks were serpentinized microscopically even in the fresh parts, and show mesh texture with antigorite. Orthopyroxene often altered to bustite. Dark green to black chromite (chromian spinel) is accompanied as an accessory mineral.

Dunite is distributed within the harzburgite as diapir-like form ranging from some ten centimeters to several hundred meters in width, and often alternated with harzburgite and pyroxenite. It shows olive to dark grayish green color on the fresh surfaces. They are also slightly altered to serpentine, and shows a mesh texture with antigorite under the microscope even megascopically fresh rock.

The large scale diapir-like dunite body is distributed around Nagtabon Pass in west of the area. This body is associated with numerous bands, seams and lenses of chromite.

Dunite alternated pyroxenite layer ranging from 0.5 to 1 meter in thickness is distributed to the north of Nagtabon Beach. Pyroxenite is websterite containing a very small amount of olivine.

2) Inagauan Metamorphics

This formation was termed the Kabangan Metamorphics by UNDP (1985). In this report, this formation was regrouped to Inagauan Metamorphics, because lithofacies and occurrences are the same as those of Inagauan Metamorphics distributed in south Palawan.

The metamorphic rocks are distributed in small areas along the margin of the Bacungan Window located in west of the area. They consist of mica schist and quartz schist. Quartz schist is mainly composed of quartz and muscovite, and shows lepidoblastic texture.

3) San Vicente Gabbro

This gabbro is thrust by ultramafic rocks in southeast of the survey area. The rocks are strongly weathered to become sandy at many outcrops, and the area of this rocks forms gentle topography by deep weathering. This gabbro is a massive rock with a weak compositional layering, augite gabbro by microscopic observation.

4) Sulu Sea Mine Formation

This formation underlies the Inagauan Metamorphics in southwest of the survey area. It is composed of reddish chert and reddish ferruginous rock intercalated with basaltic lava and tuff breccia.

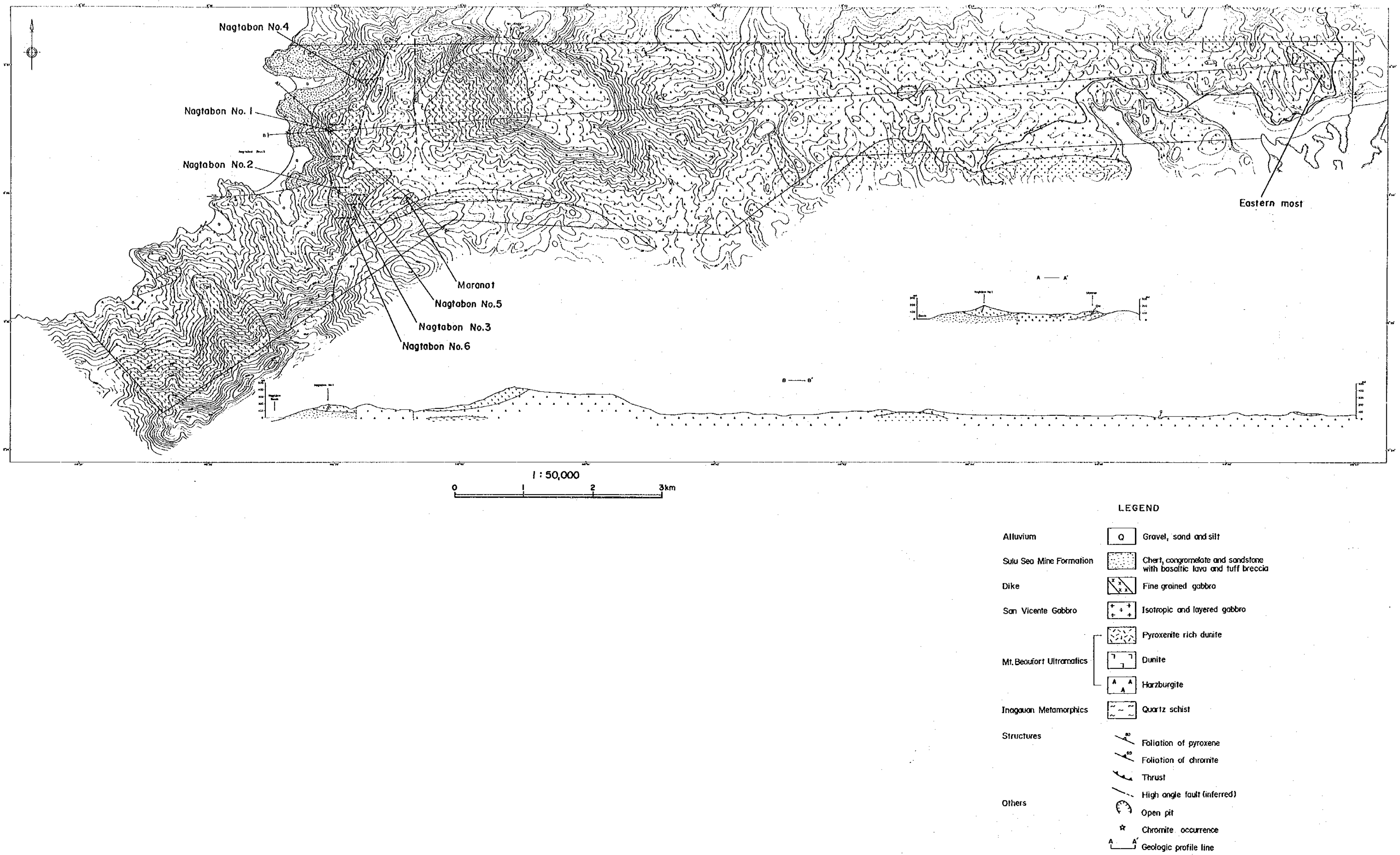


Fig. 8 Geologic map and profile in area A-2

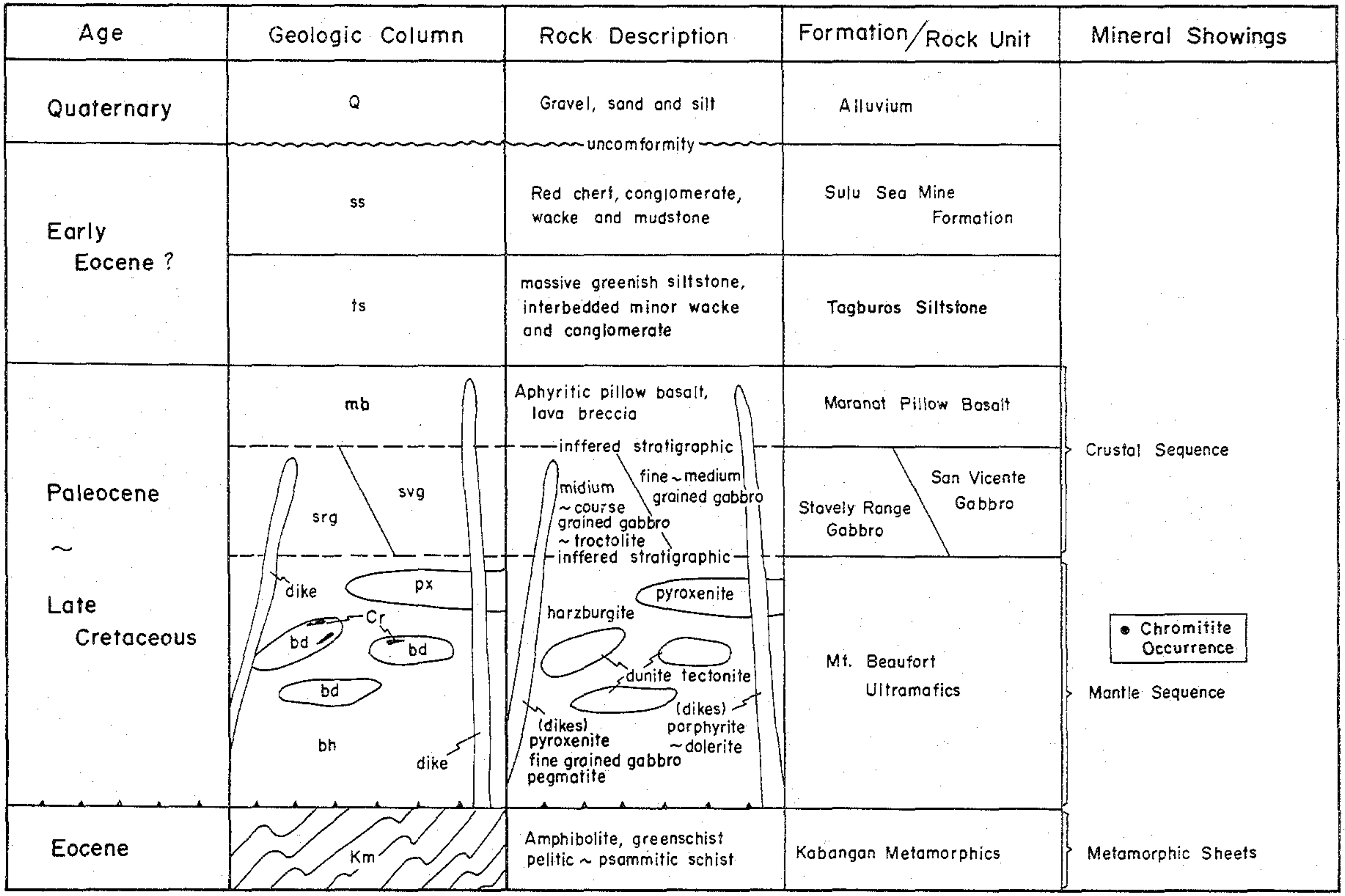


Fig. 9 Schematic geologic column in area A-2 and A-3

1-1-2 Ore deposits and mineral showings

The most important ore deposits of the area A-2 are of chromite deposits. The chromite deposits are mainly distributed around the Nagtabon Pass (Fig. 8). No operating mines are found in area A-2, but it seems that the exploration was conducted vigorously by private companies in later half of 1970's. These chromite deposits are grouped in Maranat deposit and Nagtabon deposits. Most of these deposits are small in scale except Nagtabon No. 1 deposit. Nagtabon No. 1 deposit is rather large in scale, though it consists mainly of disseminated chromite ore on the surface. It may be able to be mined depend on the subsurface occurrence. Precise descriptions of each deposit are as follows.

1) Maranat deposit

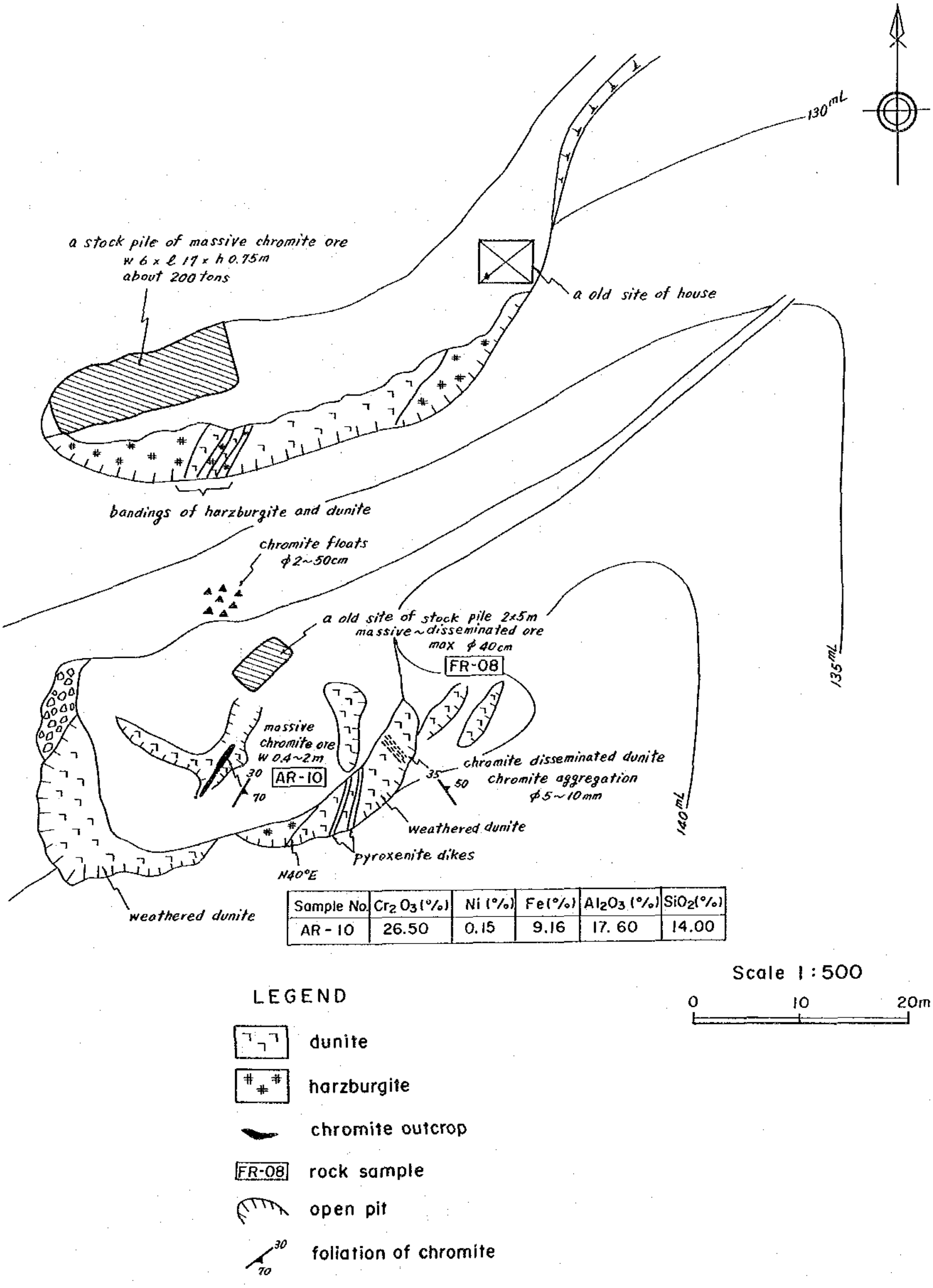
There is an old working on the gentle ridge south of Maranat Village (Fig. 10). Vegetation is grass and small trees around the working.

Chromite ore occurs in small weathered dunite body. Thrust fault is found 200 meters east of the deposits. Quartz schist crops out as window in the ultramafics on the upper part of the ridge. It is supposed that the bottom of the ultramafics is shallow, some ten meters, in this area.

There are two open cuts. Chromite ore was mined from upper open cut. Massive chromite ore body of 3 meters wide still remains in weathered dunite. It trends N10°E and dips 60°E. About 15 meters of trench-like old working extends to this direction, and no chromite ore crops out in the lower open cut 40 meters apart. From these it may be inferred that the length of ore body was about 15 meters and pinched out. About 200 tons of massive chromite ore are stocked in the lower old cut. Residents referred that Golden Island Co. Ltd. mined surface float ore and subsurface ore body. They stopped mining at January 1977 because they ran short of budget, and meanwhile they shipped twice the same amount of stocked ore. This means that about 600 tons of massive ore was mined from this deposit.

Though the extension below the surface is not clear, the Maranat deposit might have been podiform in shape with about 1,000 tons of massive ore at the thought of the thin thickness of the ultramafic rocks, a small dunite body and only one ore body.

The ore sample from this ore body seemed to be very high grade, but the ore (AR-10) shows 26.50 % of Cr_2O_3 and rich in aluminum. It is classified into refractory grade ore.



Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
AR - 10	26.50	0.15	9.16	17.60	14.00

Fig. 10 Map of the Maranat old working

2) Nagtabon No. 1 deposit

An old working is situated to the 450 meters north of Nagtabon Pass (Fig. 11). A good road, passable by car, leads from the Pass to the working. The east side of the working to Bacungan consists of gentle hills, whereas the west side of the working forms steep cliffs.

This deposit occurs in serpentinized dunite and consists mainly of disseminated chromite ore. This area was stripped along the ridge extending about 70 meters. The disseminated chromite ore body is being able to pursue for 40 meters. The outcrop is 7.5 meters in width at the lowest part, but it is separated into 3 or 4 ore strings at the upper part on the ridge. Each string consists of disseminated type ore with 1.5 meter in width. The lowest part of the outcrop consists of close spaced chromite bands ranging from 1 to 40 cm in width. The average chromite content is megascopically about 30 %. Six channel samples of the lowest part of the outcrop shows 12.59% Cr_2O_3 average. The microprobe analysis of chromite is obtained about 53.4 % Cr_2O_3, hence the chromite content of ore is estimated about 24 %.

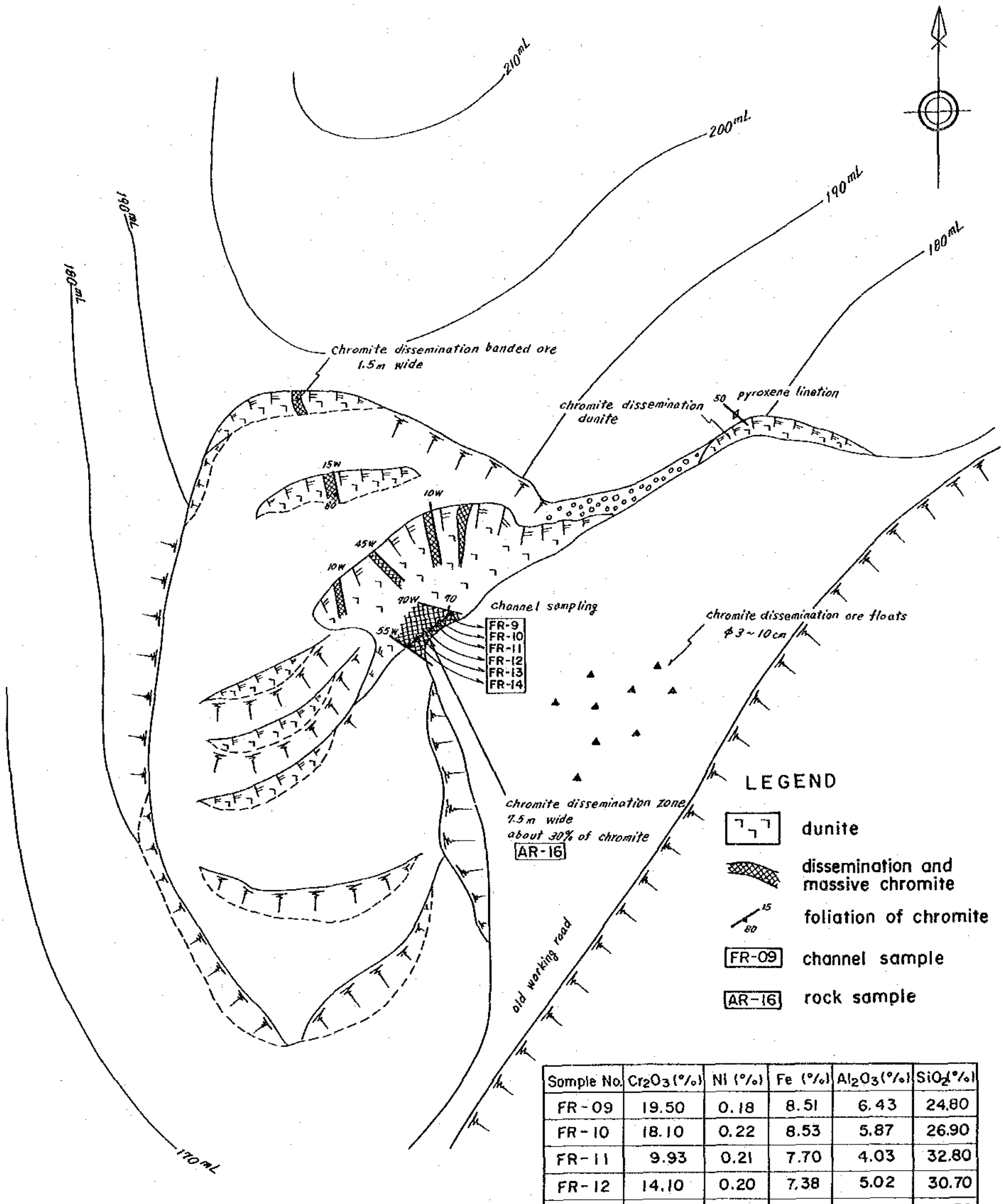
Residents referred that massive ore was mined at first, but mined out already. Only floats of massive ore are recognized now. Underground mining was not operated. There is no data about the occurrence of subsurface massive chromite ore body.

The tonnage of massive chromite ore is not clear, but as far as disseminated ore is concerned, this deposit can be estimated the tonnage about 2,000 tons as chromite by presuming the extension of ore body 10 meters downward and 24% of chromite content.

3) Nagtabon No. 2 deposit

Two old mine roads run southward from Nagtabon Pass. One road is the east side of ridge, and the other is the west of ridge. Former one leads to Nagtabon No. 2 deposit (Fig. 12), which is 500 meters south of Nagtabon Pass and situated in the bed of a small stream flowing eastward. Vegetation is thicket around the working.

The ore body consists of massive chromite extending 6 meters, trending N35°E and dipping 65°W. The maximum width is 70 centimeters. The analytical result of chromite ore (AR-12) is 38.40 % Cr_2O_3. The ore body occurs in serpentinized dunite that is strongly fractured. The ore body is stretched to the direction of shear N10°E, and divided into echelon veins.

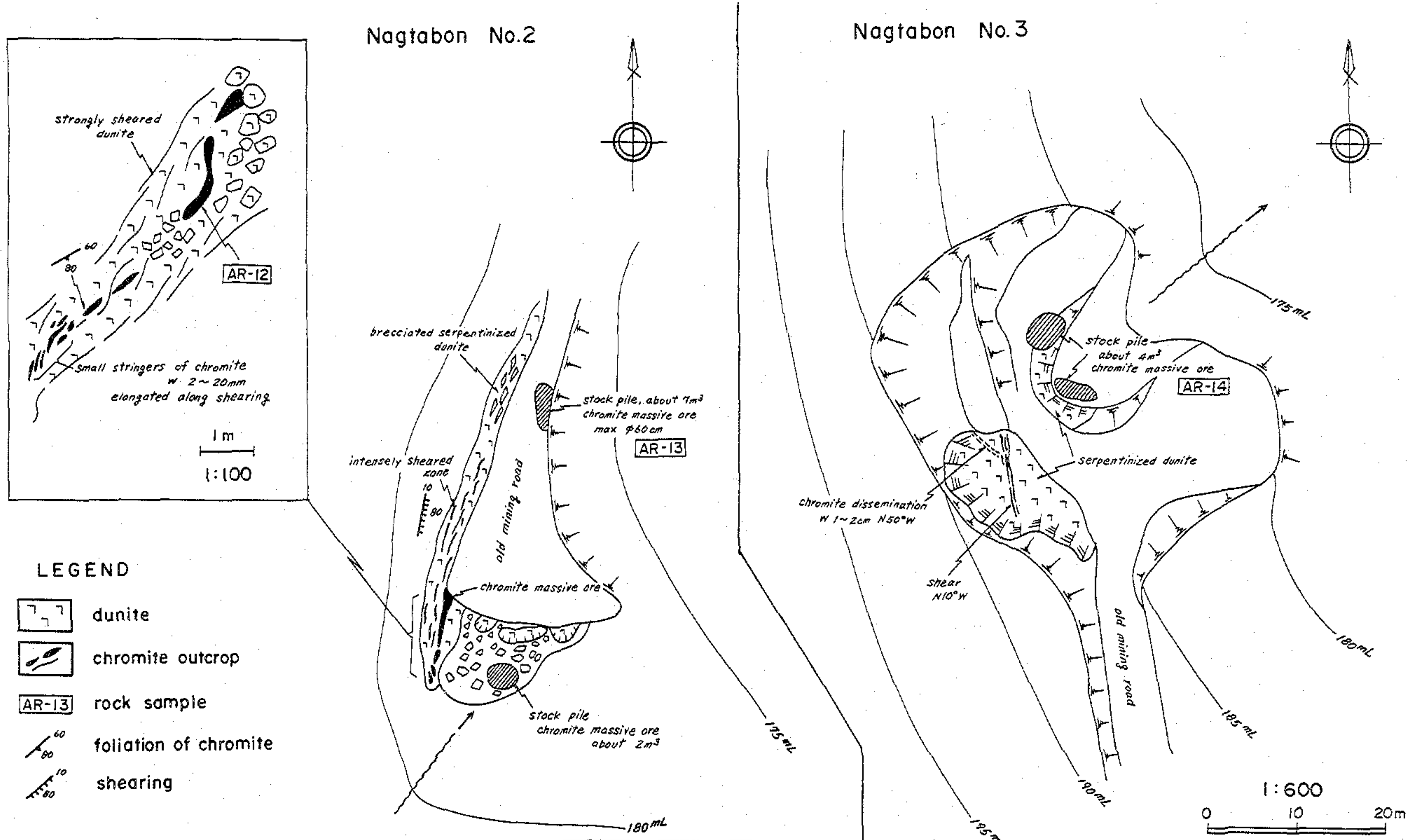


Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
FR-09	19.50	0.18	8.51	6.43	24.80
FR-10	18.10	0.22	8.53	5.87	26.90
FR-11	9.93	0.21	7.70	4.03	32.80
FR-12	14.10	0.20	7.38	5.02	30.70
FR-13	2.31	0.27	6.11	1.27	38.50
FR-14	11.60	0.29	7.96	4.34	37.00

Scale 1 : 600

0 10 20 30m

Fig. 11 Map of the Nagtabon No. 1 old working



Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
AR - 12	38. 40	0.08	10.27	21.10	5.60
AR - 13	37. 80	0.06	9.97	22.60	3.86

Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
AR - 14	39.60	0.08	10.71	20.50	5.09

Fig. 12 Map of the Nagtabon No. 2 and No. 3 old workings

About 20 tons of massive chromite ore are stocked in the working. The analytical result of ore sample (AR-13) shows 37.80% Cr_2O_3. This deposit can be calculated about 200 tons of tonnage as chromite, presuming 10 meters extension of ore body from the top downward, hence this ore body is very small in scale.

4) Nagtabon No. 3 deposit

The old mine road of the west side of ridge leads southward from Nagtabon Pass to an old working, which is 500 meters south of Nagtabon Pass and 50 x 50 meters in scale (Fig. 12). Serpentinized dunite crops out in the working, but no outcrops of chromite ore are found. About 30 tons of massive chromite ores are stocked in the working. The analysis of ore sample (AR-14) from this stock pile shows 39.60% Cr_2O_3. A small amount of disseminated ore is also found in the stocked ores; therefore the ore body is presumed a lens-like massive ore body same as Nagtabon No. 2 deposit. The width of lens must be at least 60 centimeters, because maximum size of stocked ore exceeds 60 cm in diameter.

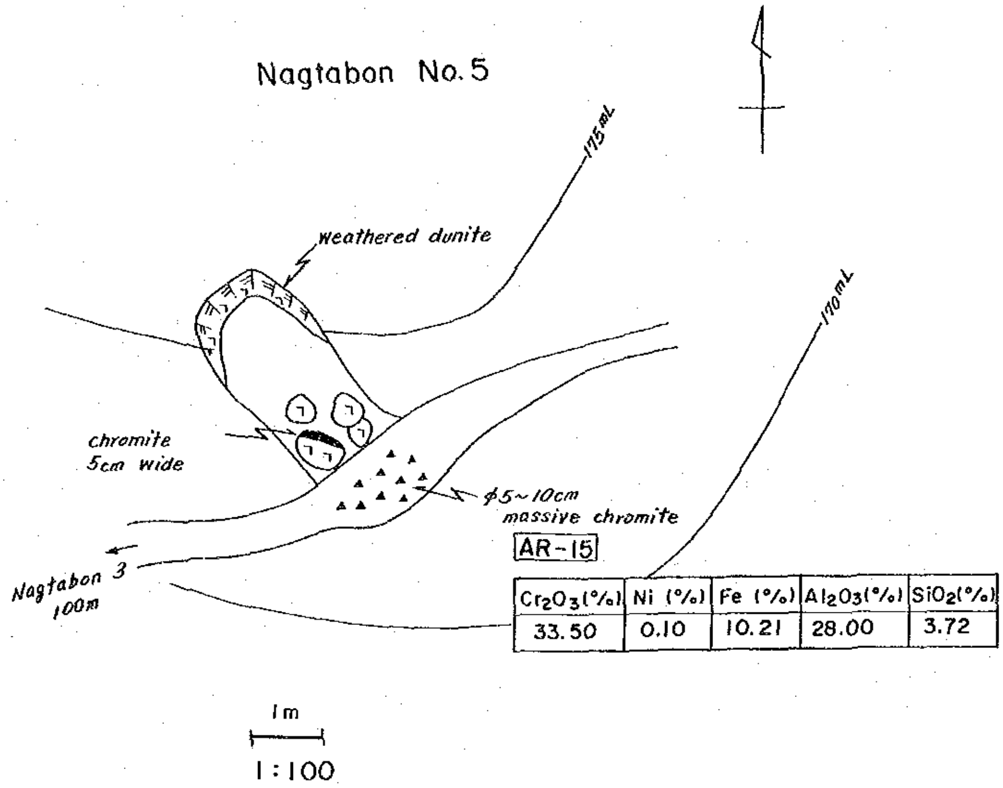
The scale of ore deposit is difficult to presume, because there is no outcrop and working site was put into disorder. The tonnage of deposit is presumed to be 1,000 tons as chromite, thinking the size of working here is bigger than that of Nagtabon No. 2 deposit, but smaller than that of Nagtabon No. 1 deposit.

5) Nagtabon No. 4 mineral showing

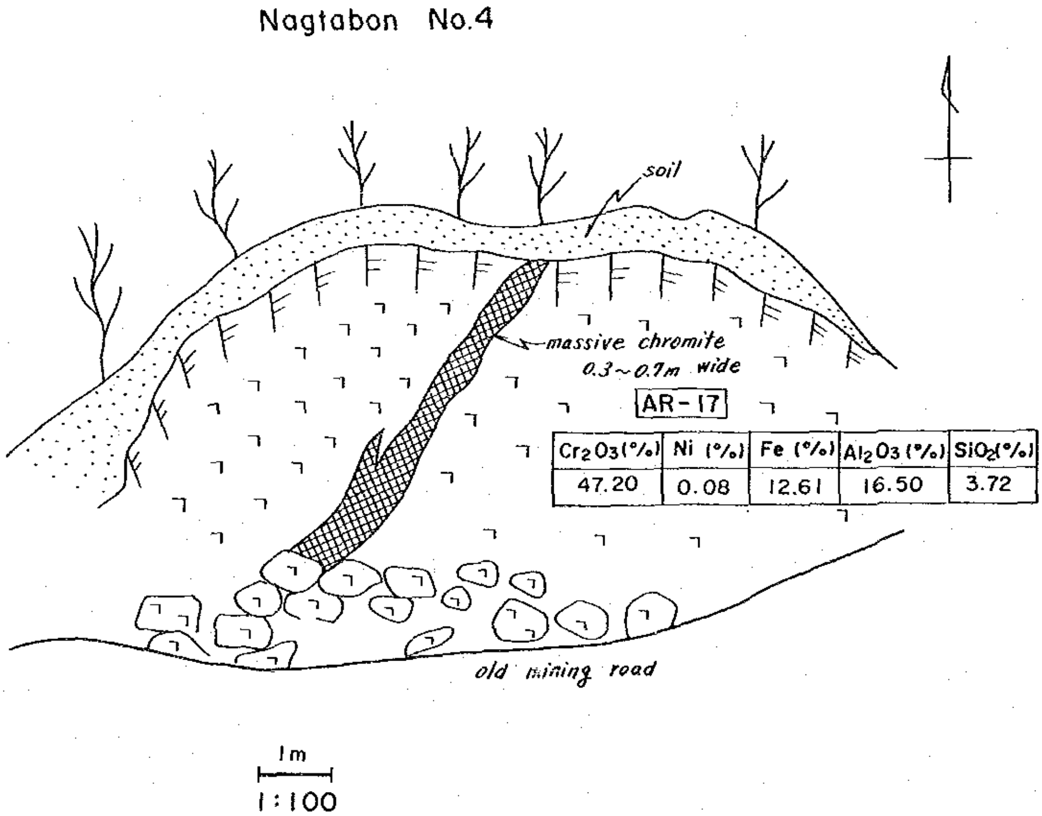
A small massive chromite ore body occurs in weathered dunite on the road cutting to the north of Nagtabon No. 1 deposit (Fig. 13). This ore body is 70 cm wide and 6 meters long. Chromium oxide content of this ore (AR-17) is 47.2 %. There is no other ore body around here. The ore body consists of massive chromite ores, and this deposit can be calculated the tonnage ranging from 200 to 300 metric tons presuming the extension of ore body 10 meters downward.

6) Nagtabon No. 5 mineral showing

A small trench, 1 meter wide and 2 meters long, is found at northeast of Nagtabon No. 3 deposit (Fig. 13). Small massive chromite ore ranging in diameter from some centimeters to 10 centimeters is scattered around the trench. The analysis of sample (AR-15) shows 33.50 % Cr_2O_3. The weathered dunite is cropped out in the trench, but no outcrop of chromite ore was discovered.



Cr_2O_3(%)	Ni (%)	Fe (%)	Al_2O_3(%)	SiO_2(%)
33.50	0.10	10.21	28.00	3.72



Cr_2O_3(%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2(%)
47.20	0.08	12.61	16.50	3.72

Fig. 13 Sketch of the Nagtabon No. 4 and No. 5 mineral occurrences

7) Nagtabon No. 6 mineral showing

This mineral showing is 200 meters south of Nagtabon No. 3 deposit. Floats of disseminated chromite ore are scattered in the trench which is 1.5 meters wide and 4 meters long. Chromium oxide content of these floats (AR-18) is 31.80 %. The maximum size of ore is 40 centimeters in diameter.

8) Other mineral showings

A very small chromite pod occurs in a small dunite body at the easternmost part of the survey area. It consists of massive chromite ore. About 1 metric ton of chromite ore is stocked around this pod. Chromium oxide content of this ore (CR-04) is 41.20%.

Some chromite bands are scattered in the dunite bodies distributed around Nagtabon Pass and south of Mt. Airey. These chromite bands consist of one to several bands ranging in width from several to 10 centimeters.

1-1-3 Soil geochemistry

Area A-2 was followed up with detailed mapping and close spaced soil sampling designed along spur and ridges.

1) Sampling

Soil geochemical survey was conducted in combination with geological mapping at the scale of 1:10,000. Each sampling site along ridges and streams was mainly predetermined in the area distributed ultramafic rocks on the map. About 1 kilogram of B-horizon soil was taken at each site. If the site is along a stream, soil was collected from the site above the highest water level of the stream. The density of sampling site is about ten points per 1 km^2. Four hundred and forty-three samples were air-dried and screened with an 80 mesh sieve. About 100 grams of minus 80 mesh fraction of each dried sample was sent to laboratories for chemical analyses. The locations of the soil samples are shown in PL. 2.

2) Pathfinder elements and chemical analyses

Seven elements were selected as pathfinder elements, because ore deposits associated with ultramafic rocks are expected in this area. Analyzed elements were platinum (Pt), palladium (Pd), gold (Au), nickel (Ni), chromium (Cr), iron (Fe) and cobalt (Co). The elements of Ni, Cr, Fe and Co were analyzed by atomic absorption in PETROLAB, while the analyses of Pt, Pd and Au were done by inductive coupled

plasma method in Chemex Labs. Ltd. The detection limits are 2ppb for Pd and Au; 5ppb for Pt; 1 ppm for Ni, Cr and Co; 0.1 % for Fe. The results of analyses and sampling conditions are shown in Appendix 4.

3) Data analyses

The combined data of area A-2 and A-3 were used for data processing, because both of the areas are mainly underlain by the same Mt. Beaufort Ultramafics and the distance from area A-2 to area A-3 is very short.

The logarithmic transformation of raw data was done before the data processing. Some raw values for Pt, Pd and Au are below-detection-limit. If the value of raw data is below-detection-limit, half of the detection limit value is used for processing.

The range, median, mean value and standard deviation are shown in Table 3. Histogram and cumulative probability curve of each element are shown in Appendix 5. The class interval of the histogram is a half of the standard deviation. Each element shows almost a log-normal distribution curve.

Correlation coefficients between these elements are shown in Table 4. The strong positive correlation is recognized with the relations of Pt-Pd, Pt-Fe, Ni-Cr-Fe-Co. The scatter diagrams are shown in Fig. 14. Each data set is standardized [standardized data = (data - mean) / standard deviation] on the scatter diagram for the definition of correlation coefficient.

The content of each element is classed by mean value and standard deviation, and plotted on the element content map (Fig. 15 to Fig. 18). Anomalous values are also shown on the element content map. Because of comparing the soil geochemistry of area A-2 and A-3 with the result of the area A-1 soil geochemical survey in Phase 1, the same thresholds with the values of area A-1 soil geochemical survey are used in this survey. Thresholds are as follows;

Pt; 55 ppb	Pd; 32 ppb	Au; 10 ppb	
Ni; 7,700 ppm	Cr; 4.0 %	Fe; 25.8 %	Co; 800 ppm

4) Geochemical pattern

The correlation between Pt and Pd is very high; thereby they have very similar geochemical pattern each other. A high anomaly zone of both elements is distributed along a small river north of Maranat. The values of more than 100 ppb are found in this zone

Table 3 Basic statistic quantities of soil samples in area A-2 and A-3

Basic statistic quantity (A-2 & A-3)				linear		logarithmic		
element	range	(*)	median	mean	std. dev	mean	10^mean	std. dev
Pt(ppb)	<5 - 290	31	25	39.1	35.5	1.429	26.9	0.406
Pd(ppb)	<2 - 260	64	14	24.8	32.2	1.102	12.7	0.556
Au(ppb)	<2 - 66	205	4	7.2	9.3	0.563	3.7	0.512
Ni(ppm)	13 - 15000	0	4600	4428.3	2590.9	3.476	2990.4	0.563
Cr(ppm)	200 - 162000	0	14000	15612.4	13671.8	4.041	10979.1	0.444
Fe(%)	2.5 - 57.0	0	18.6	21.3	11.5	1.266	18.4	0.242
Co(ppm)	10 - 1640	0	430	427.5	219.0	2.545	350.9	0.326

(*) The number of the below-detection-limit samples. n=547

Table 4 Correlation coefficients of soil samples in area A-2 and A-3

Correlation coefficients (A-2 & A-3)

	Pt	Pd	Au	Ni	Cr	Fe
Pd	0.708					
Au	0.249	0.331				
Ni	0.339	0.179	-0.113			
Cr	0.357	0.222	-0.127	0.782		
Fe	0.513	0.410	0.047	0.598	0.543	
Co	0.443	0.279	-0.043	0.862	0.770	0.680

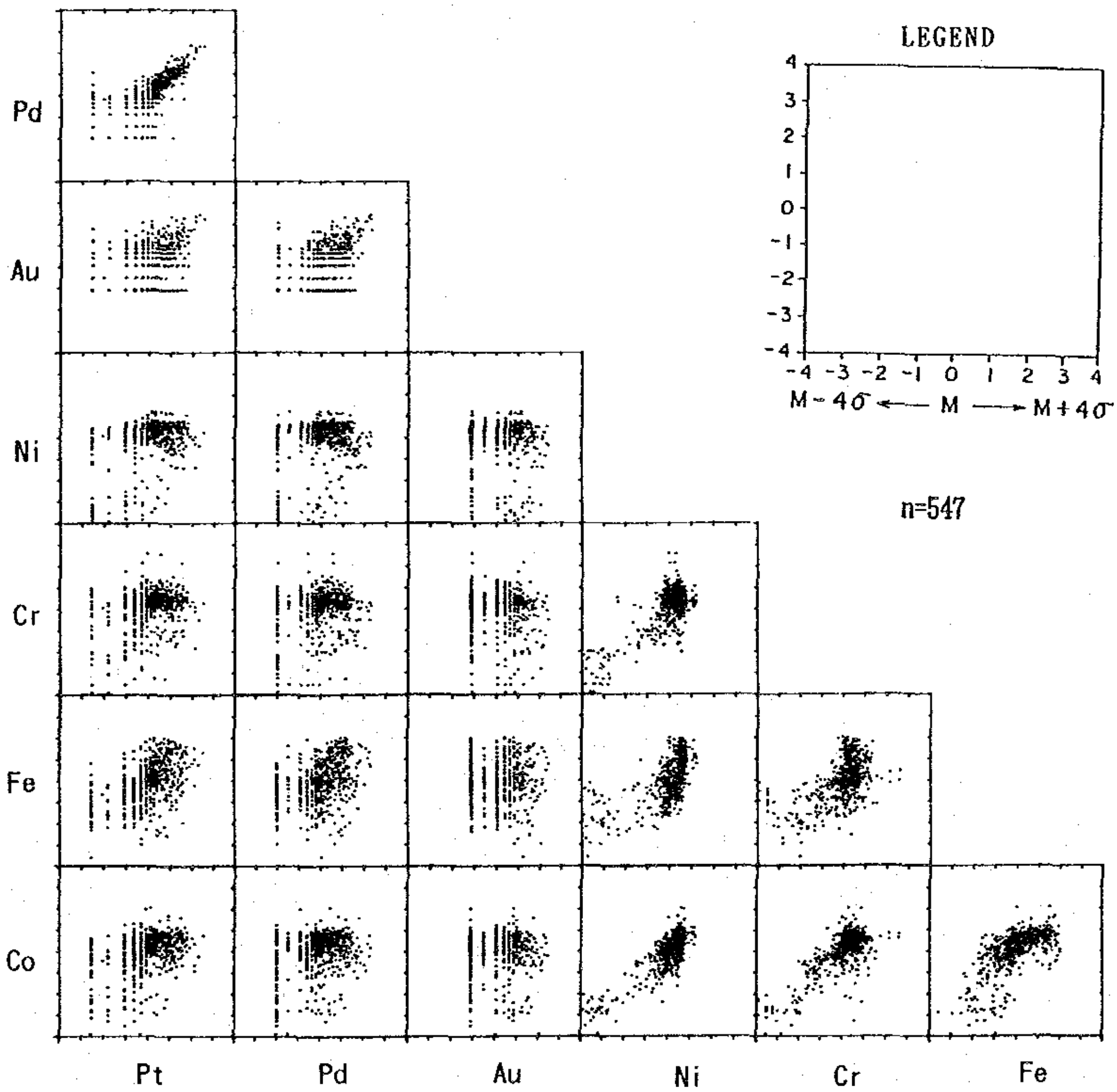
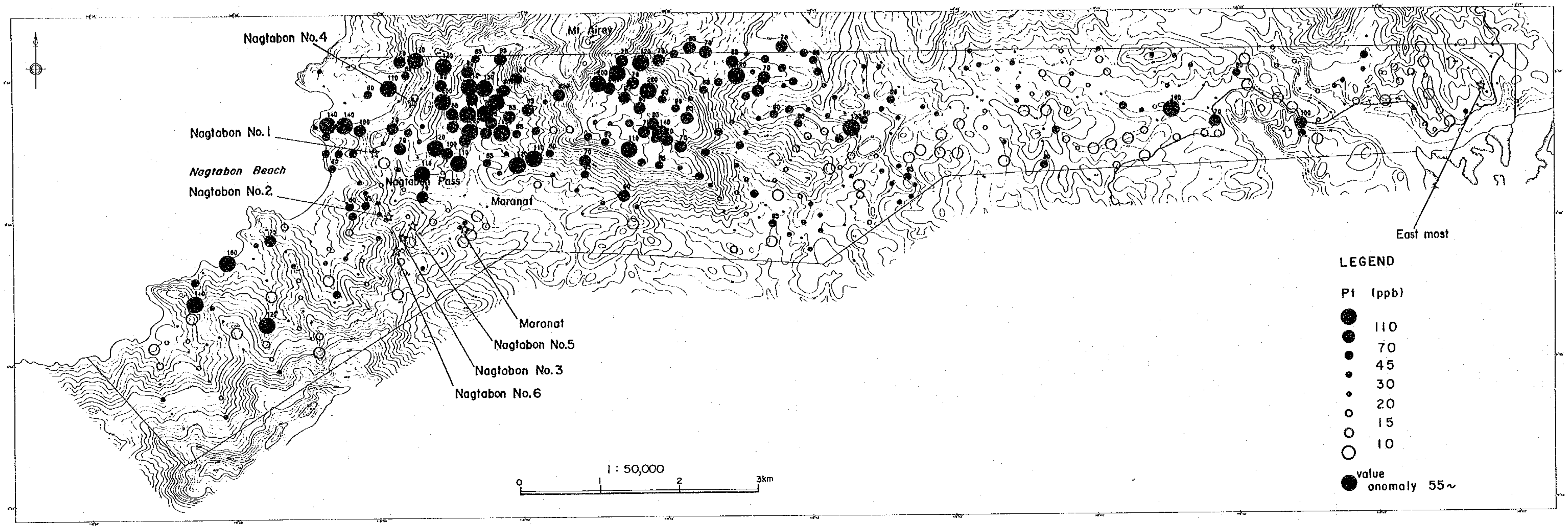


Fig. 14 Scatter diagram of soil samples in area A-2 and A-3



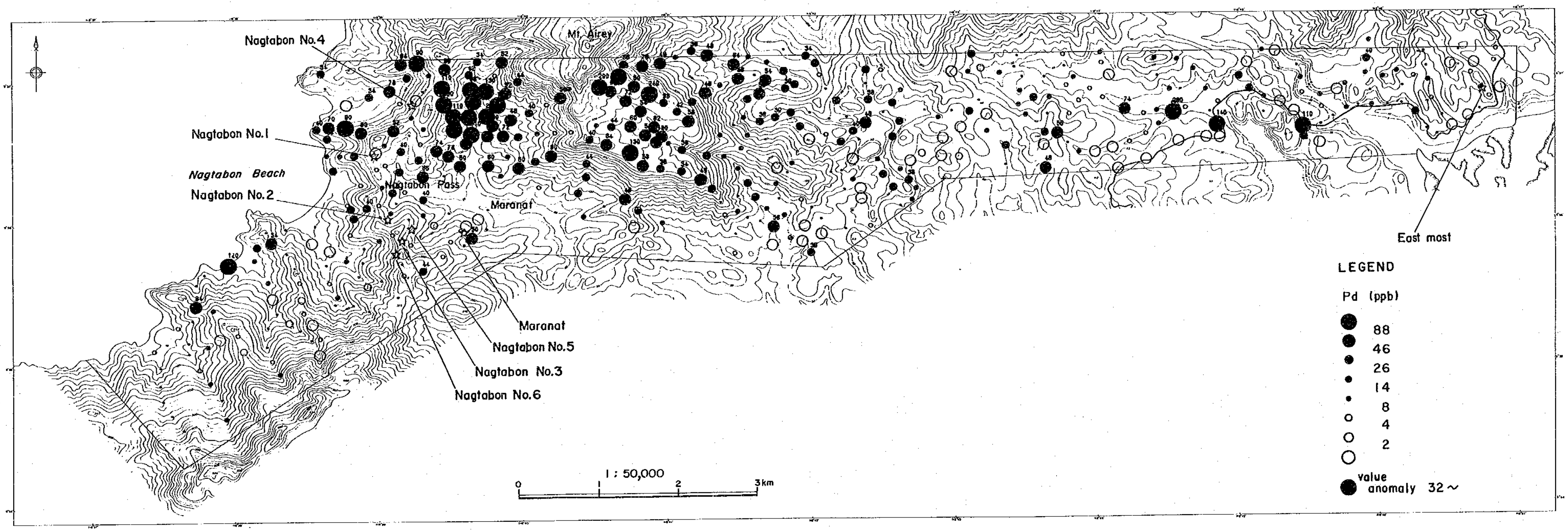


Fig. 15 Pt and Pd content of soil samples in area A-2

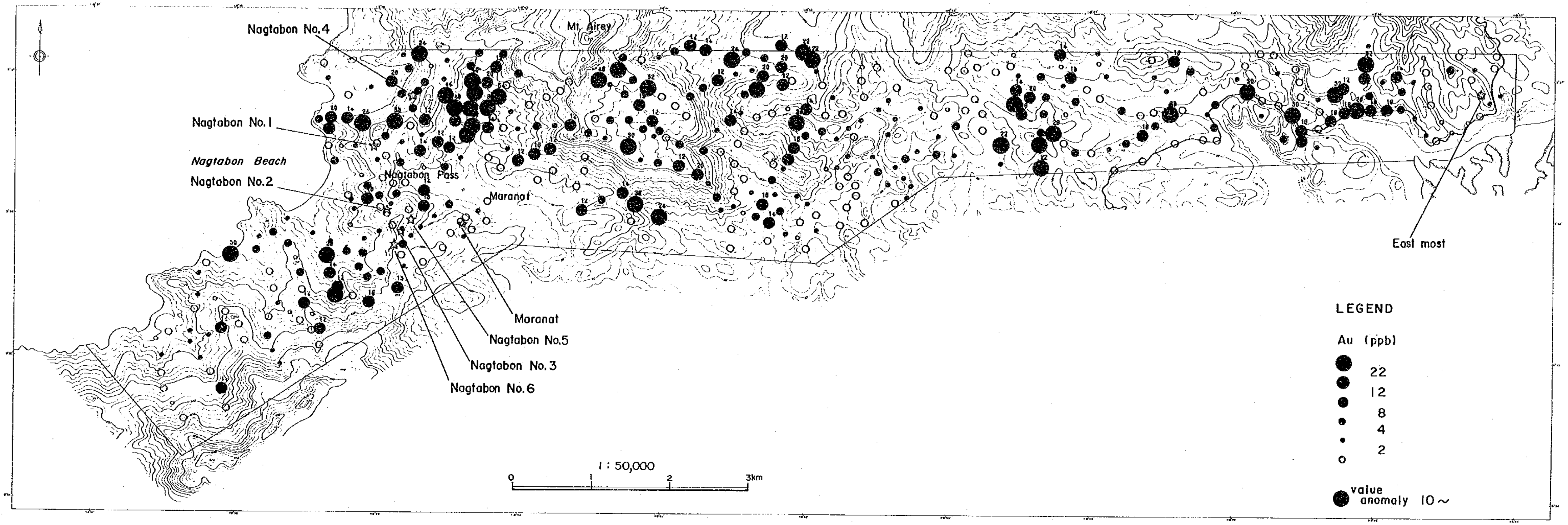
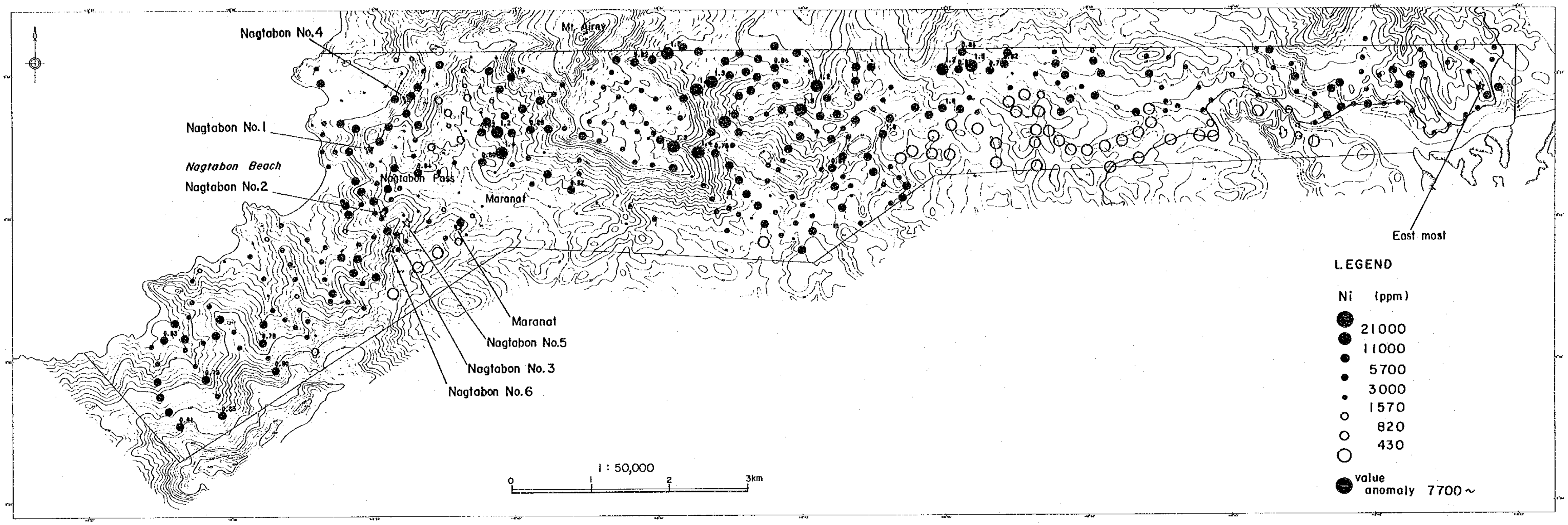


Fig. 16 Au content of soil samples in area A-2



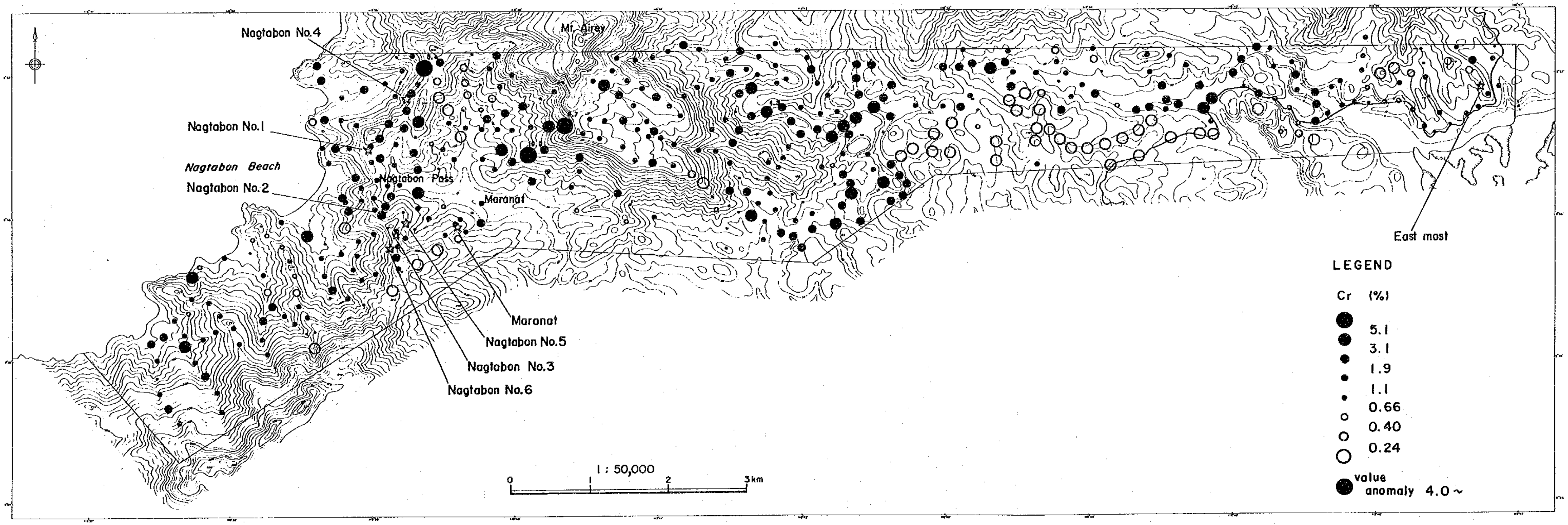
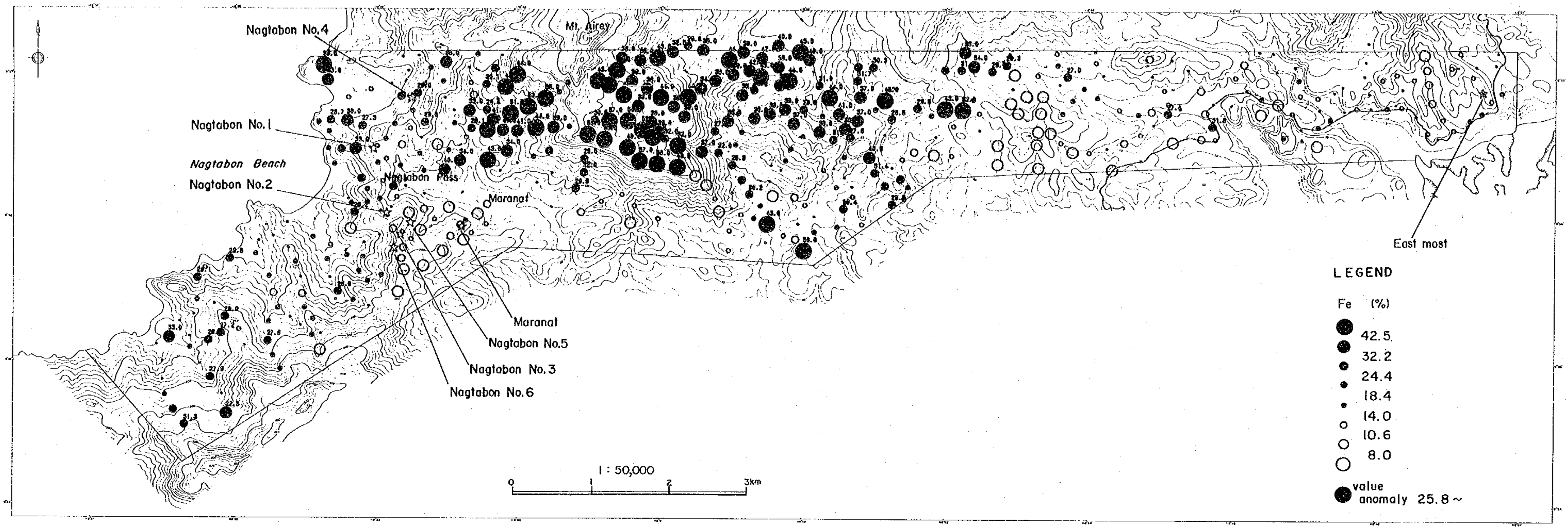


Fig. 17 Ni and Cr content of soil samples in area A-2



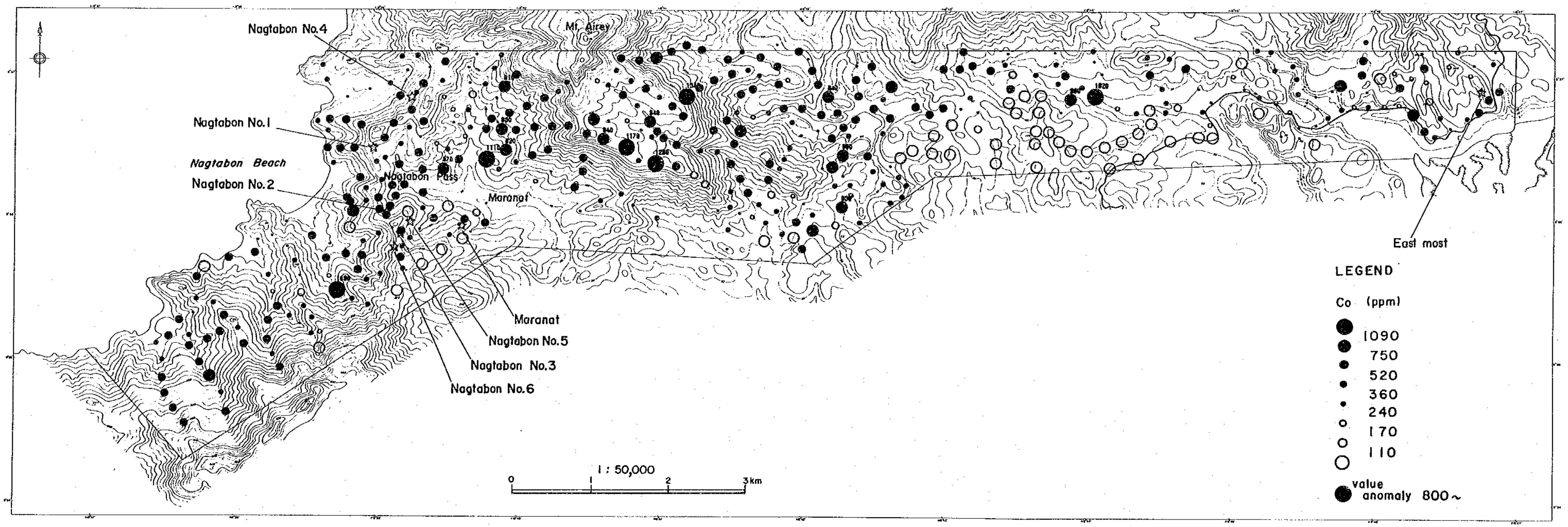


Fig. 18 Fe and Co content of soil samples in area A-2

The Au content is very low in this area.

The Ni, Cr, Co and Fe contents in soil are relatively high in the area distributed ultramafic rocks whereas very low in the metamorphic rocks and gabbro area. But contents exhibit variations not only due to the different kind host rocks but also between the different parts of the same area distributed ultramafic rocks. The content variations of these elements are due to influence of secondary enrichment and leaching by relating the weathering process, in particular, the nickeriferous laterite forming processes.

The high Fe areas exist around Bacungan and the North of Maranat. From the rock geochemical survey of Phase 1 survey, the Fe contents in peridotites of Mt. Beaufort Ultramafics fall within the range of 4 to 5 %, whereas the Fe contents in some of soil samples are more than 50 %. The residual laterite zone of nickeriferous laterite is formed by leaching of silica and enrichment of iron, cobalt and chromium during weathering process. The residual laterite, from the top downward, consists of iron crust zone, pisolites zone, and plastic laterite. The residual laterite shows characteristically high content of iron. The anomalous zone of iron may suggest the presence of nickeliferous laterite deposits.

The geochemical anomalies of nickel, more than 7,700 ppm, occur to the north of Bacungan, south of Mt. Airey and north of Maranat. They overlap with the anomalies of Fe. The anomalous values of Cr are detected to the south of Mt. Airey, north of Maranat and north of Nagtabon Pass. The anomalies of Co are distributed in the Southwest of Mt. Airey and the north portion of Maranat.

1-1-4 Discussion

The chromite deposits occur in dunite bodies of Mt. Beaufort Ultramafics. The rather large scale of dunite bodies are distributed in the southwest slope of Mt. Airey and the vicinity of Nagtabon Pass. Small diapir-like dunite bodies ranging in width from several ten centimeters to several meters are also found at all over the area. Among them, the one around Nagtabon Pass has the highest potential for chromite deposits, because many chromite deposits and mineral showings of both the massive and disseminated types occur in this dunite body. These deposits are named Nagtabon No. 1 to No. 6. The Nagtabon No. 1 deposit is rather large among these deposits.

Main purpose of geochemical prospecting is to delineated the high potential area for chromite deposits. Soil geochemistry generally reflects the character of lithological basement, because soil is

derived from these rocks by weathering. The test pitting survey was clarified that chromite tends to concentrate in residual laterite, thereby soil geochemical survey of chromium could be delineated the potential area more sensitively than rock geochemical survey. Nevertheless the geochemical anomaly area for chromite deposit could not be extracted from this soil geochemical survey.

Chromium content must be generally high in the area around the chromite deposits. Area A-2 was extracted as one of the chromium anomaly areas by the regional geochemical prospecting last year, and many chromite indications are discovered by this survey. In this area chromite grains are not observed only in dunite around ore deposits but also in dunite and harzburgite apart from deposits. This means that the chromite deposit does not always have clear geochemical halo in this area. In this case it is needed to detect the anomaly concerning directly with ore deposits itself. The geochemical anomaly area was not extracted by this prospect because the chromite deposits in this area are generally very small.

Soil geochemical exploration of chromite is effective in the following two cases.

1. Regional exploration to delineate the potential areas
2. Grid prospecting (grid interval; from several meters to several ten meters) to identify the anomaly areas derived directly from ore deposits

The geochemical prospecting last year in A, B and C area belongs to first case, and many mineral showings were recognized by detailed survey in the extracted anomaly areas.

As to nickel deposits, the areas of high nickel content are north of Bacungan, south of Mt. Airey and north of Maranat. It is inferred that the thick residual laterite formed in these areas, thereby these areas have high potential for nickeliferous laterite.

1-2 Area A-3

1-2-1 Geology

Geology of area A-3 is almost the same as that of area A-2. Area A-3 mainly consists of ultramafic complex (Mt. Beaufort Ultramafics). Gabbro (San Vicente Gabbro) is distributed in west and north of the area thrust by the ultramafic complex. The ultramafic complex consists mainly of harzburgite, and contains some dunite and pyroxenite. The ultramafic complex forms the steep slopes and cliffs, whereas the gabbro forms gentle hills. The Inagauan Metamorphics occur in thrust fault contact with the ultramafics near the east coast.

1) Mt. Beaufort Ultramafics

Mt. Beaufort Ultramafics is dominant in the area A-3. It consists mostly of serpentinized harzburgite, with subordinate amount of dunite and pyroxenite. The large dunite body is distributed around the 291 m peak at the high elevation part of the central portion of the area, hence dunite body overlies harzburgite. All the deposits in the area occur in this dunite body. Many pyroxenite dikes intruded into harzburgite and dunite.

2) Inagauan Metamorphics

This rocks is found in a small scale near the east coast. It is composed of amphibolite here.

3) San Vicente Gabbro

The gabbro is distributed in the west and north part of the area. No fresh rock crops out in the area. By the observation of floats, this rock is medium grained augite gabbro.

1-2-2 Ore deposits and mineral showings

The main mineral deposits are chromite deposits in this area. Most of them occur in a dunite body distributed in the central portion of the area (Fig. 19). These deposits were explored by private company, Country Mineral Resources Corporation, during later half of 1970's. Since the name of claim was "Pagasa", they named the possible areas Pagasa 1 to Pagasa 5. It seems that Pagasa 3 and Pagasa 5 was only possible areas of chromite deposit by the result of geochemical prospecting, and no ore bodies were

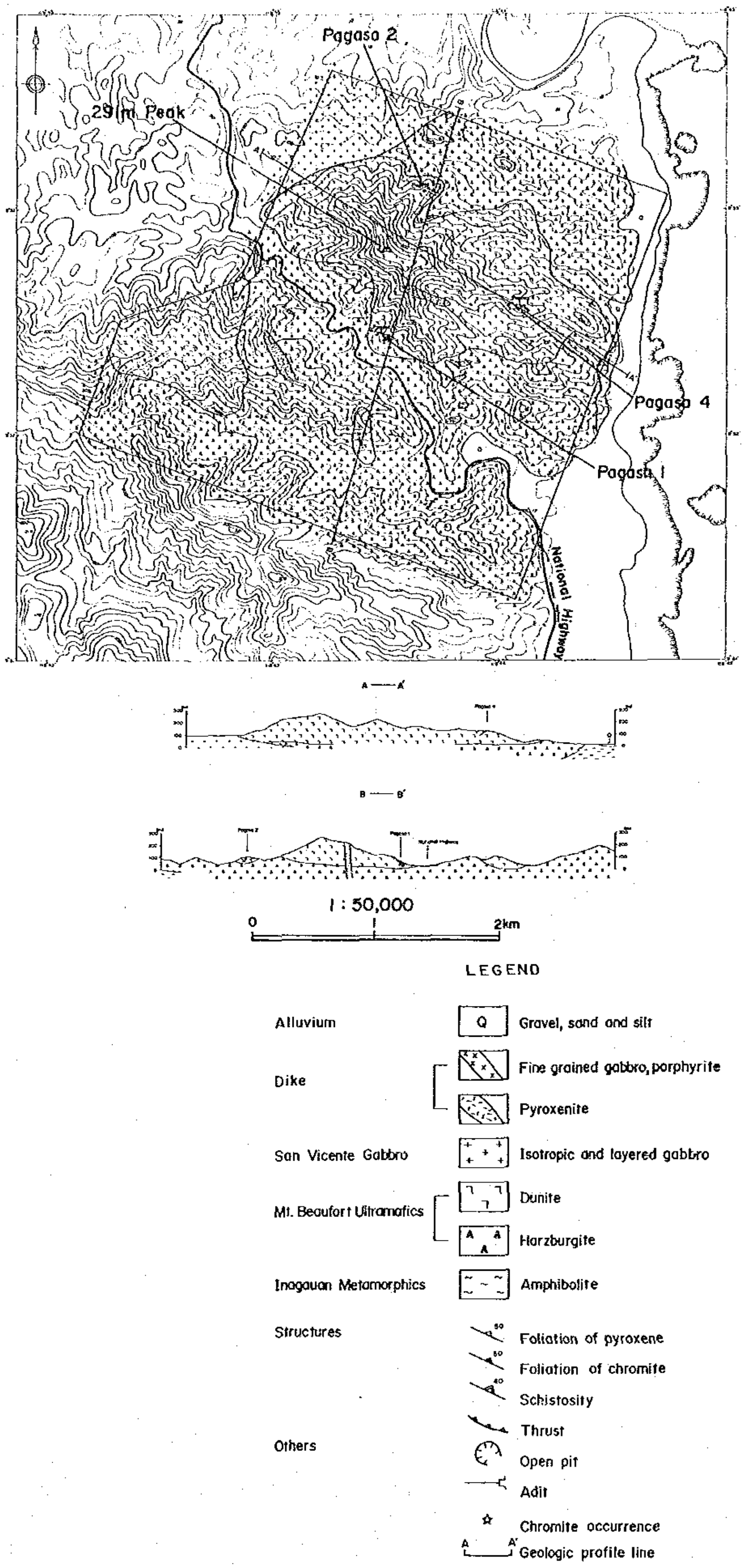


Fig. 19 Geologic map and profile in area A-3

recognized in this survey.

Mining and exploration might have been operated in Pagasa 1, 2 and 4. Several old mine roads lead to these areas. The dunite is well-exposed due to the lack of soil because of rigid topography, in addition, construction of mine road and stripping made cropped out chromite ores. In particular, many outcrops of massive chromite ore occur in Pagasa 1 area and promising area is rather large. For this reason Pagasa 1 deposit may be possible to estimate several ten thousand tons as chromite.

1) Pagasa 1 deposit

An old mine road branches northeastward off the national highway along the ridge and leads to Pagasa 1 area, where the mineralized area covers more than 150 x 150 meters and more than 10 outcrops of massive and disseminated chromite ore occur in dunite, along this mine road (Fig. 20). Vegetation is small trees around here, but soil is very thin and many boulders piled up upper part of the ridge.

The dunite has been sheared in the direction of E-W. This dunite is distributed from 50 meters' level to the upper part of the ridge, hence chromite deposit might be also limited above 50 meters' level.

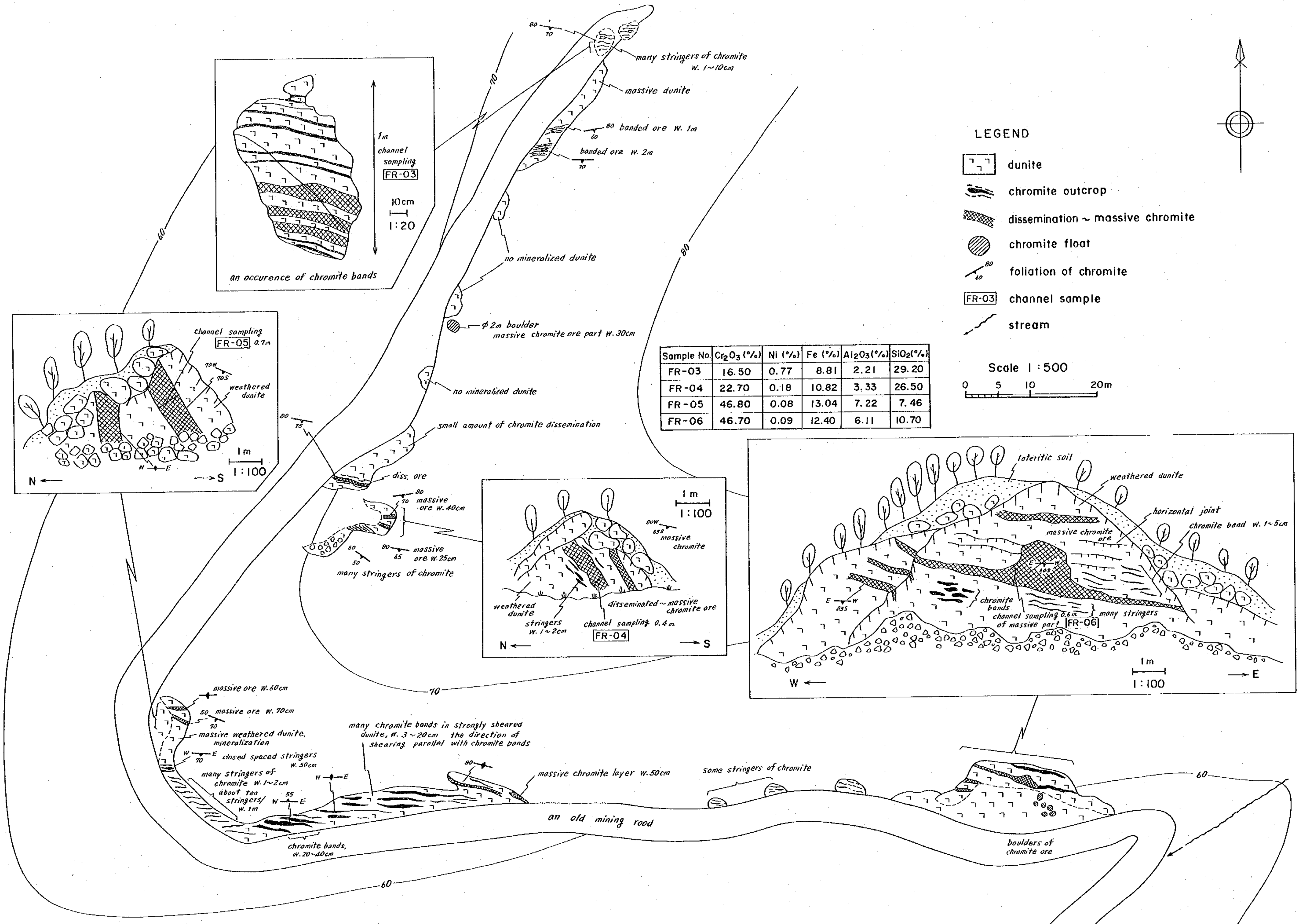
Chromite lenses and bands trend generally E-W, dip steeply southward, and they are ranging in width from several ten centimeters to 2 meters. They consist of close spaced chromite stringers ranging in width from several millimeters to 2 centimeters. Chromium oxide content of channel samples shows FR-03: 16.50%, FR-04: 12.70%, FR-05: 46.80%, and FR-06: 46.70%. The electron microprobe studies show that chromite in this deposit contains about 60 % Cr_2O_3. On the basis of this result, chromite content of the channel samples is calculated 30 to 80 %.

It is rather difficult to calculate the volume of the deposits based on only surface survey. On the basis of the assumptions of the 150 x 150 meters promising area, the extension of deposit 10 meters downward, 20 to 30 % ore existence and 30 % of chromite content, it may be inferred that the weight of chromite is 40 to 60 thousand tons.

2) Pagasa 2 deposit

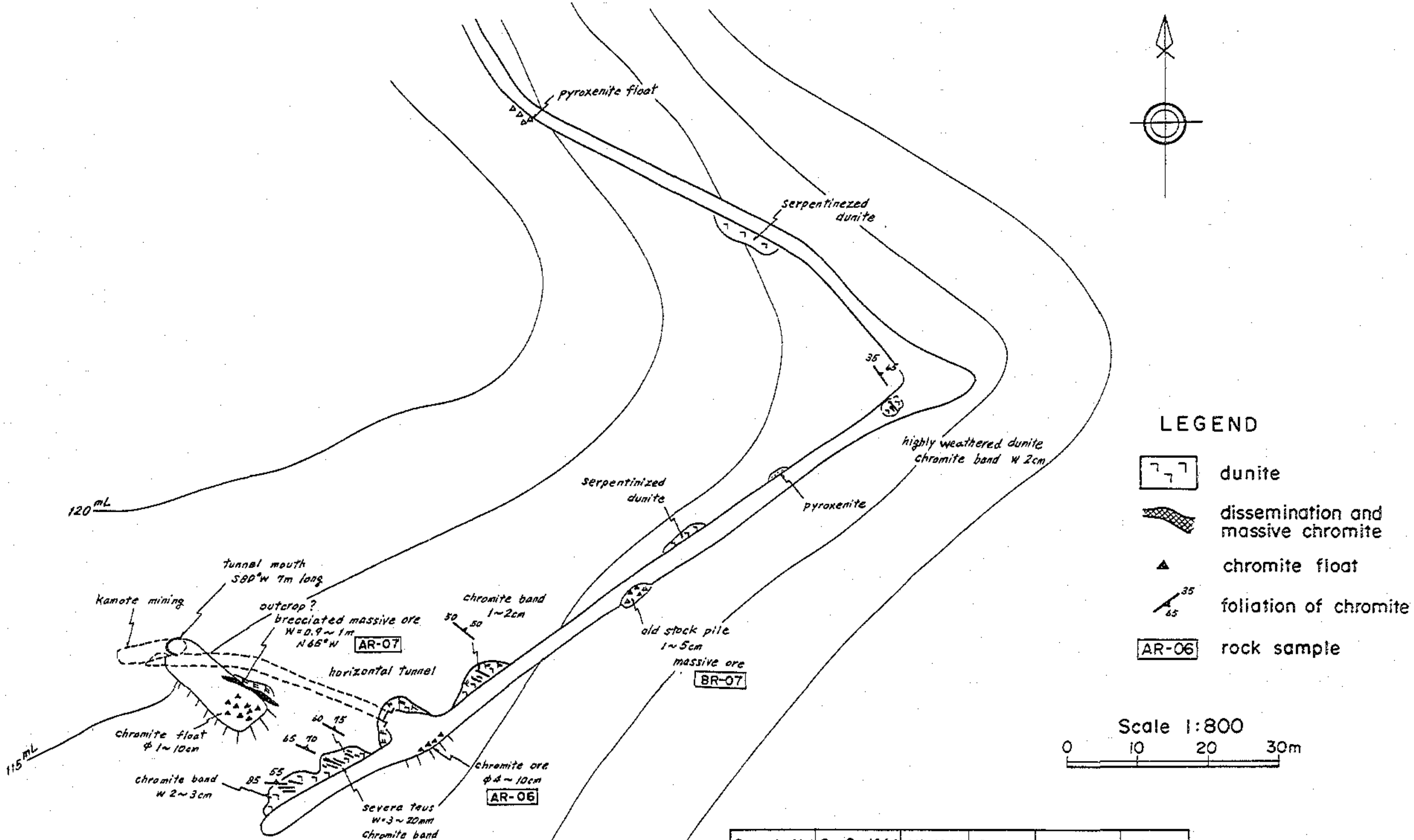
The old mine road runs eastward in the north of the area. The old subsurface mining site is situated at the end of this road (Fig. 21). Vegetation is tall grasses and shrubs around here.

Chromite band and disseminated ore occur in chromite disseminated dunite around the adit,



Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
FR-03	16.50	0.77	8.81	2.21	29.20
FR-04	22.70	0.18	10.82	3.33	26.50
FR-05	46.80	0.08	13.04	7.22	7.46
FR-06	46.70	0.09	12.40	6.11	10.70

Fig. 20 Map of the Pagasa 1 old workings



Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
AR – 06	49.00	0.09	12.07	7.62	7.32
AR – 07	51.30	0.06	14.06	9.30	3.51
BR – 07	46.60	0.05	12.95	17.10	2.73

Fig. 21 Map of the Pagasa 2 old working

especially at southern part. They strike N80°W, dip steeply northwest. The level adit is about 35 meter long, and connected with another inclined adit at the heading. The trend of level adit coincides with that of chromite bands. Small floats of massive chromite ores scatter around the entrance of the adit, and the analysis of this (AR-06) shows 49.00 % Cr_2O_3. Another ore (BR-07) collected from a stock near the entrance shows 46.60 %. Though residents said that massive chromite ore body exposed 1.5 meters wide in the adit, the chromite ore is not found in the adit now because the surface of the adit is wholly covered by rock powder. Width of the level adit is almost regular, whereas that of inclined adit is irregular, thereby it seems that mining was operated at the inclined adit. Small breccias of oxidized massive chromite ore are found extending to N80°W at the entrance of the inclined adit. The grade of this ore (AR-07) is 51.30 % Cr_2O_3.

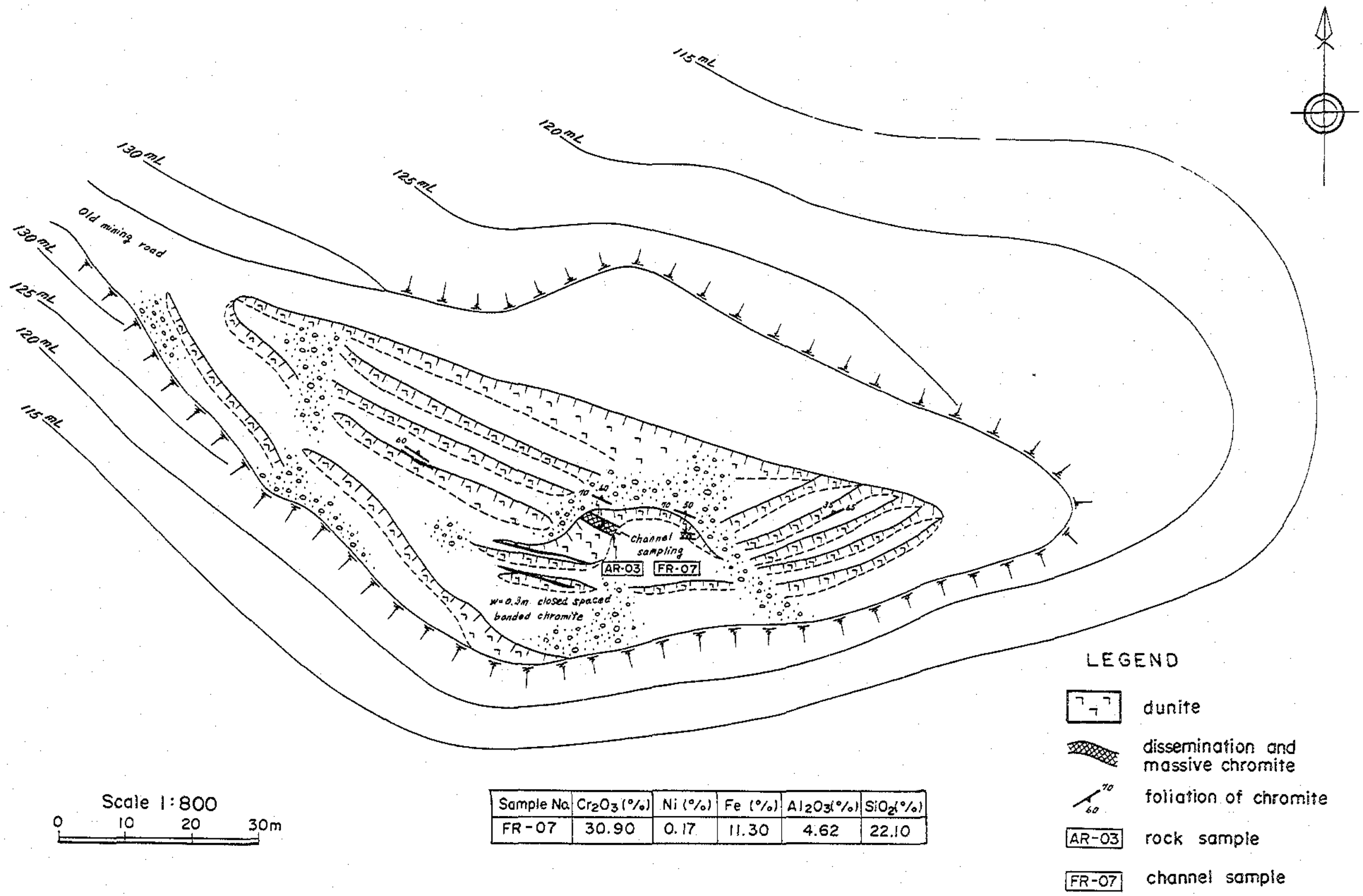
It is very difficult to estimate the volume of deposit, because outcrops of chromite ore are scarce and occurrence of chromite body is not clear under the adit level. The deposit might be small in scale, because only one massive ore body has been mined in small scale and a small amount of chromite bands is observed on the surface.

3) Pagasa 4 deposit

An old working of open pit mining is situated at the ridge extending to east from 291m peak that is east of national highway. Residents said that massive chromite ores were mined around area A-3 and transported to east coast. From the location of this deposit, it may be inferred that the ore was mined at this deposit and was shipped.

Lenses and dissemination type chromite ore occur in weathered dunite. Stripping was conducted in a wide scale around the deposit area about 140 meters east to west and 70 meters north to south (Fig. 22). Outcrop of massive chromite ore is found at central portion of the working and it consists of chromite lens ranging in width from 0.6 to 1.2 meter. The lens strikes N70°E, and dips 60°E. The analysis of 1.2 meter's channel sample (FR-07) from this lens shows 30.90 % Cr_2O_3. This lens pinches out both sides of cutting, and this chromite lens seems to be completely mined.

There are other 3 or 4 small outcrops in the working. Each outcrop strikes N70 to 80°E, and dips 50°E. They are ranging in width from 0.3 to 2 meters, and consist of 1 to 5 centimeters close spaced chromite bands.



Sample No.	Cr_2O_3 (%)	Ni (%)	Fe (%)	Al_2O_3 (%)	SiO_2 (%)
FR-07	30.90	0.17	11.30	4.62	22.10

Fig. 22 Map of the Pagasa 4 old working

4) Other mineral showings

Several chromite bands ranging in width from 1 to 5 centimeters occur on the ridge between Pagasa 1 and Pagasa 2. Each band is a small scale disseminated one and spaces apart. There is scarce potentiality for chromite deposit.

Outcrop of massive chromite ore in width several ten centimeters occur in the westernmost part of the area. Considering the small scale of this dunite tectonite, it hardly seems possible to find other deposits. The analysis of this ore (ER-03) shows 11.70% Cr_2O_3.

1-2-3 Soil geochemistry

Area A-3 was followed up with detailed mapping and close spaced soil sampling designed along spur and ridges.

1) Sampling

Soil geochemical survey was conducted in combination with geological mapping at the scale of 1:10,000. Each sampling site along ridges and streams was mainly predetermined in the area distributed ultramafic rocks on the map. One hundred and four samples were collected in area A-3. The locations of the soil samples are shown in PL. 7.

2) Pathfinder elements and chemical analyses

The same 7 elements as area A-2 survey were selected as pathfinder elements, because ore deposits associated with ultramafic rocks are also expected in this area. Elements were platinum (Pt), palladium (Pd), gold (Au), nickel (Ni), chromium (Cr), iron (Fe) and cobalt (Co). The elements of Ni, Cr, Fe and Co were analyzed by atomic absorption in PETROLAB, while the analyses of Pt, Pd and Au were done by inductive coupled plasma method in Chemex Labs. Ltd. The detection limits of Pd and Au are 2 ppb; Au is 5 ppb; Ni, Cr and Co are 1 ppm; Fe is 0.1 %. The results of analyses and sampling conditions are shown in Appendix 6.

3) Data analyses

The combined data of area A-2 and A-3 were used for data processing, because both of areas are mainly underlain by the same Mt. Beaufort Ultramafics and the distance from area A-3 to area A-2 is

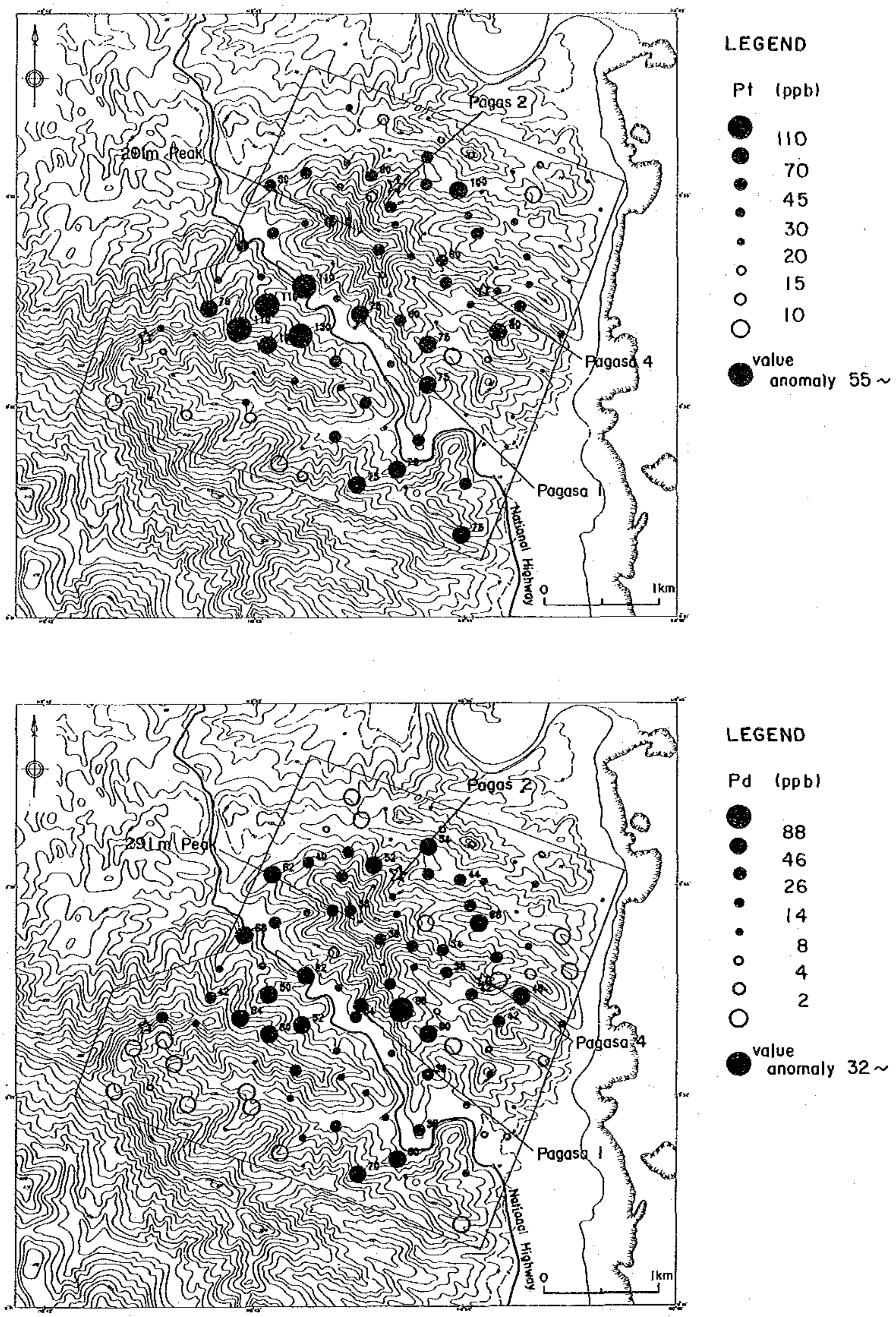


Fig. 23 Pt and Pd content of soil samples in area A-3

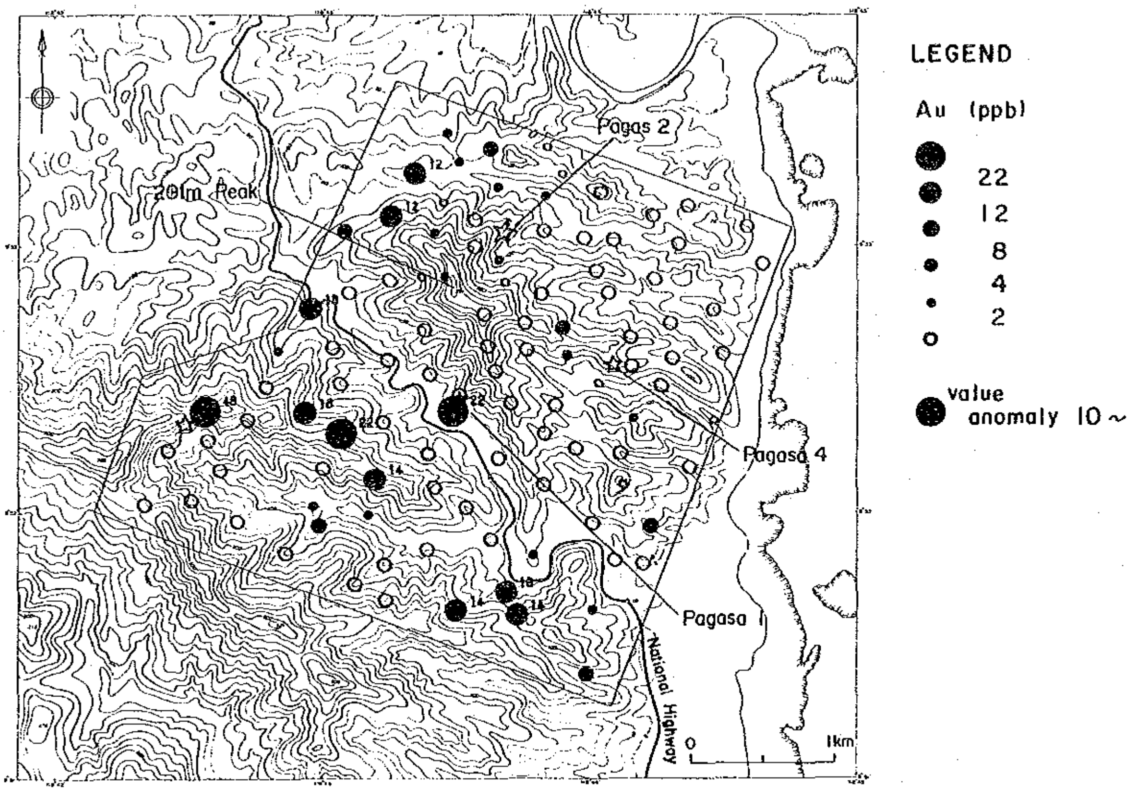


Fig. 24 Au content of soil samples in area A-3

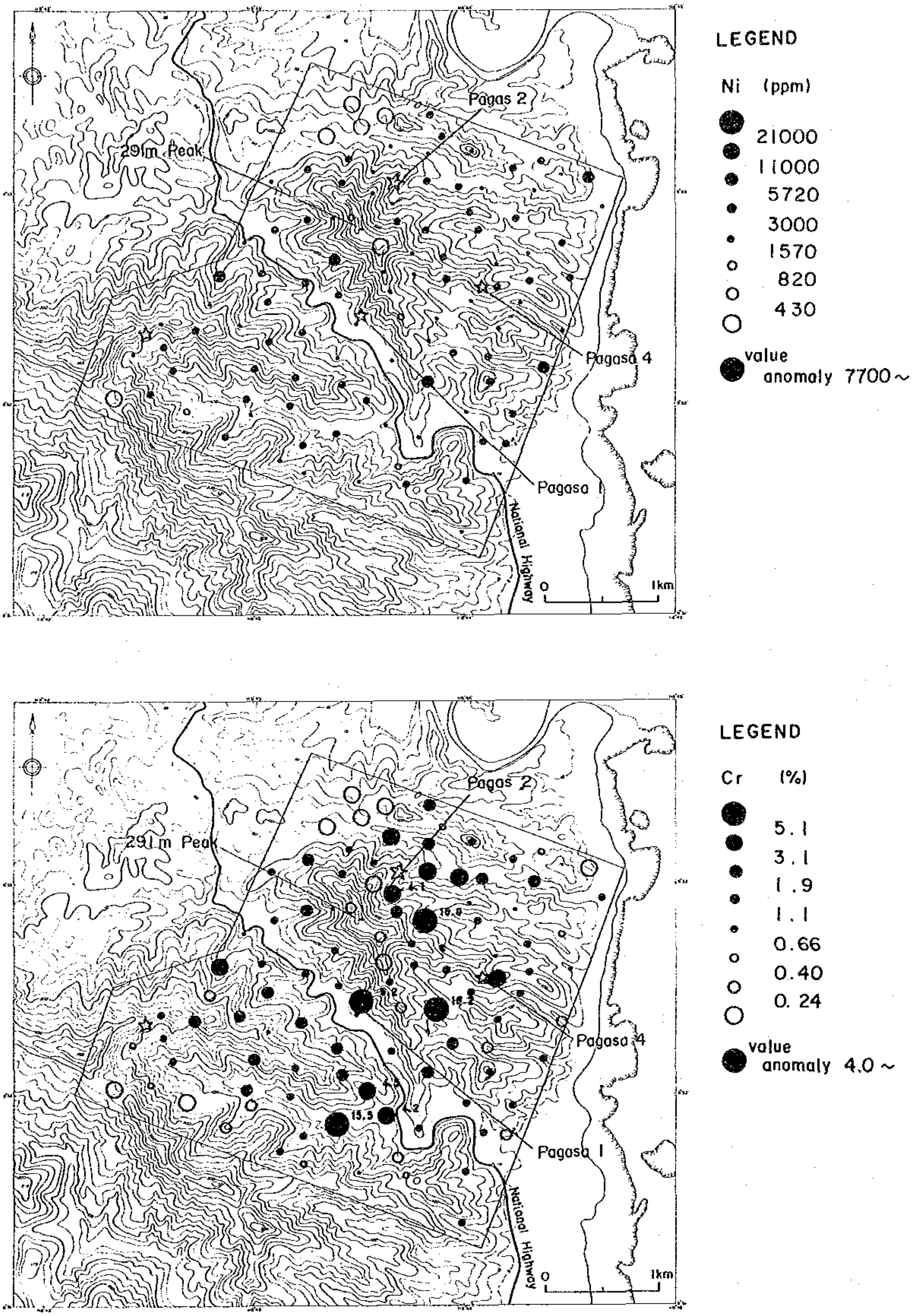


Fig. 25 Ni and Cr content of soil samples in area A-3