REPORT ON THE COOPERATIVE MINERAL EXPLORATION IN THE BICOL NORTH AREA, THE REPUBLIC OF THE PHILIPPINES CONSOLIDATED REPORT MARCH, 2002 JICA MMA

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MARCH 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Philippines, the Japanese Government decided to conduct a Mineral Exploration Project in the Bicol North Area covering three provinces,Camarines Norte,Camarines Sur, and Quezon. It was for determining the potential of mineral resources by means of several surveys such as geophysical survey, geological survey, geochemical survey and so on. And the Japanese Government entrusted to survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The surveys have been conducted from July 1999 to March 2002 and have been completed as schedule with the cooperation of Mines and Geoscience Bureau of Department of Energy Natural Resources, The Republic of Philippines.

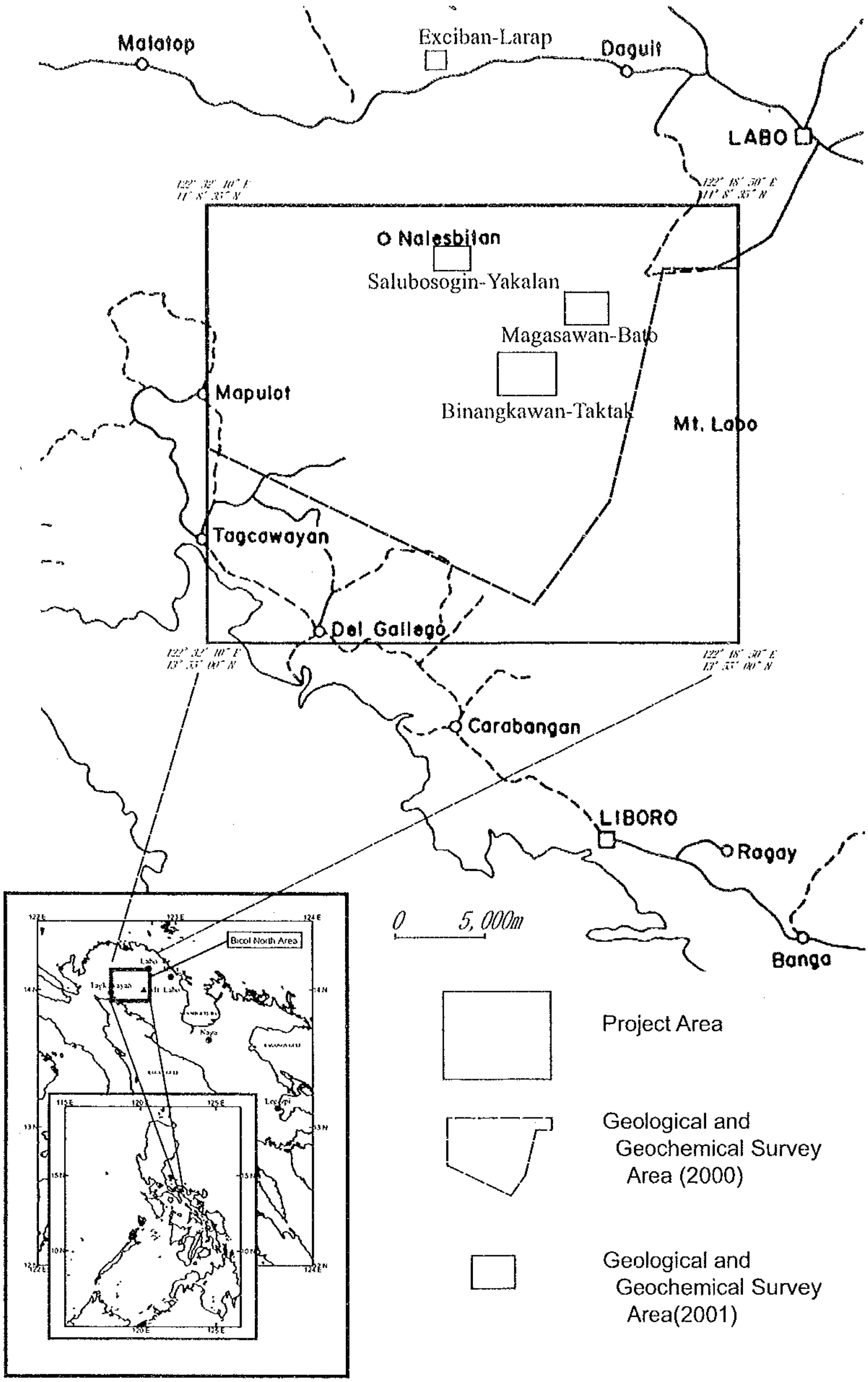
This is the final report resulting from the three years survey.

Finally, we wish to express our deep appreciation to the officials concerned of the Government of the Republic of Philippines, Ministry of Foreign Affaires, Ministry of Economy, Trade and Industry, and Japanese Emassy in the Philippines for their close cooperation extended to the survey.

March, 2002

Takao KAWAKAMI
President
Japan International Cooperation Agency

Norikazu MATSUDA
President
Metal Mining Agency of Japan



Location map of the geological and geochemical survey area.

SUMMARY

The survey area covers an area 750 km^2 in the province of Camarines Norte, Camarines Sur and Quezon on the northern part of the Bicol Peninsula.

The main part of the survey area belongs to the north west of central zone, one of three geologic zones in Bicol area, that is covered mainly by the Paleocene to Pleistocene volcanics. The north and western areas belong to the north- east and south- west zones underlain by the ophiolite sequence and sedimentary rocks.

No active mines are present in the area, but the Nalesbitan Au-Cu high sulfidation epithermal deposit and Tuba mesothermal vein-type deposit occur in the north-west of the area. In addition, Benit skarn-type small-scale deposit is present. For Phase-I, airborne geophysical survey has been conducted for obtaining data to evaluate the potential of possibly similar deposit. For Phase-II, the airborne geophysical saurvey data were analysed. Geological survey and geochemical survey of stream sediments were conducted and high potential and expected areas for the future exploration were selected. For Phase-III, geological survey and geochemical detail survey were conducted in Salubosogin-Yakalan, Binangkawan-Taktak and Magasawan-Bato areas out of above selected areas. In addition, Exciban-Larap areas was also targetted.

The alteration zones and a part of occurrences are associated with the epithermal high-sulfidation system and the low-sulfidation system gold mineralization , and the mesothermel and skarn-type gold(copper) mineralization. In Exciban-Larap occurrence in the north of the survey area, a porphyry copper-type deposit or a mesothermal vein-type deposit are associated. Various rock units were distingished by analysing the data of the air magnetic and gamma-ray spectrum. The center of volcanic activity of Pliocene was also delineated. A number of alteration zones were expected by analysing the high sodium anomaly of the gamma-ray spectrum. Those alterations are mostly coincided with its found by the field survey. The geochemical anomalies related to the alteration zones were also detected by the geochemical survey and the detail survey.

In the areas that were selected as the expected areas in Phase-II and were not surveyed in Phase-III, the detail geochemical survey and drilling will be necessary for the fyture evaluation. In the areas that the survey was conducted in Phase-III, the final evaluation targetting to the Au geochemical anomalies of epithermal deposit, will be necessary. In the Exciban-Larap Occerrences, the final evaluation targetting to the anomalies of Au-Cu deposit, will be necessary in the future.

From the results of the total analysis of those data in the wide area, the following eight areas are finally selected as the expected areas for the future exploration and potential areas of existence of deposits.

The areas and the type of deposits are followings.

Katakian alteration zone····· Skarn-type or Mesothermal-vein-type
Maniknik-Layaton alteration zone····· High-sulfidation epithermal type
Susungdalaga area····· High-sulfidation epithermal type
Alawihaw alteration zone····· Low-sulfidation epithermal type
Salubosogin-Yakalan alteration zone ····· High-sulfidation epithermal type
Magasawan-Bato alteration zone····· High-sulfidation epithermal type?
Binangkawan-Taktak alteration zone····· High-sulfidation epithermal type
Exciban-Larap occurences·····Porphyry copper-type deposit or Mesothermal vein-type deposit

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Part I General Remarks

Chapter 1 Outline of survey

1-1 Survey Area and Objective

The survey area is located in the northern area of the Bicol Peninsular, South-east of Luzon Island.The area covers about 750 sq.kmin the province of Camarines Norte, Camarines Sur, and Quezon. Mt.Labo is in the east of the area. The area is shown in the location map at the biginning of this report.

The Bicol north area of the Republic of The Philippines is targetted for the survey. The objective of the survey is to find out the potential of deposit by means of totally analysing and understanding the relation between the result of geophysical survey and geology, geological structure, the characteristics of Cu-Au mineralization, alteration, and geochemical characteristics.

1-2 Survey Method and Volume

At first, the airborne magnetic and radiometric survey were conducted to find out the geological structure and aiteration zone in whole targetted area. Then, geological survey and the stream sediment geochemocal survey were conducted in the selected areas. And the detail geological survey and the soil geochemical survey were conducted in the expected areas resulting from the previous survey.

Table-I-1-1, Fig.I-1-1 and Fig.I-1-2 are showing the contents of survey and the flow chart of the selected promising areas. All analitical figures in this report were drawn by UTM: Zone 51N and Datum:Luzon 11.

The survey has been carried out for three years. The content and the volume are as follows.

1-2-1 Phase-I

Airborne magnetic and radiometric survey were conducted as the geophysical survey in first year. The analysis was carried out at the biginning of second year. It helped the finding the geological structure and the alteration zones.

The area covered by the geophysical survey was about 750 sq.km. The area is shown in Fig.II-1-1.The survey was done by Fugro Airborne Survey (the former World Geoscience Corporation) of Austlaria. It was conducted by a helicopter because of the undulations of the area.

The specification was follows.

Flight line spacing : 200m
Tie line spacing : 1,000m
Sensor height : 80m
Magnetometer cycle rate : 0.1 second
Radiometric sample interval : 40-50m
GPS cycle rate : 1 second
Flight line direction : North-south
Tie line direction : East-west
Magnetometer sample interval : -5m
Magnetometer resolution : 0.001nT
Radiometric cycle rate : 1 second

1-2-2 Phase-II

The analysis of the data from the geophysical survey, geological survey, and stream sediments geochemical survey were conducted. The findings of the geological structure and alteration zone were done with analysing the data from the geophysical survey.

The geological survey was carried out for finding the geology, alteration zone, and mineralization zone in the area. At the same time, the samples were taken for analysing in laboratories. Stream sediments geochemical survey was conducted in whole area. Consequently, six areas were selected as the potential areas.

Table I-1-1 Contents of the Survey

Item			Phase I (1999)	Phase II (2000)	Phase III (2001)
Purpose of Survey			Deliniation of Alteration Area and Geological Interested Area utilizing Airborne Geophysics	Outlined the Promising Areas utilizing Airborne Geophysics, Geology and Geochemistry	Outlined the Promising Areas utilizing Geology and Geochemistry
Survey	Survey Items		Airborne Geophysical Survey(Magnetics,Radio metrics)Data Acquisition	Geological Survey Geochemical Survey Interpretation of Airborne Geophysics	Geological Survey Geochemical Survey
Survey	Area and Quantities		Area:750Km^2	Area:750Km^2 (460Km^2) Geological Traverse :300Km	Area:15Km^2 Geological Traverse :117Km
Indoor Test	Thin Section		-	48	12
Indoor Test	Polished Thin Section		-	30	12
Indoor Test	X-ray diffraction		-	105	23
Indoor Test	Age dating (K-Ar)		-	12	-
Indoor Test	Fluid Inclusion		-	5	5
Indoor Test	Chemical analysis	Stream Sed.	-	289	-
Indoor Test	Chemical analysis	Components	-	Al,Sb,As,Ba,Be,Bi,B,Cd,Ca,Cr,Co,Cu,Ga,Fe,La,Pb,Mg,Mn,Hg,Mo,Ni,P,K,Sc,Ag,Na,Sr,S,Th,Ti,W,U,V,Zn,Au	-
Indoor Test	Chemical analysis	BLEG	-	35	-
Indoor Test	Chemical analysis	Components	-	Au,Cu	-
Indoor Test	Chemical analysis	Whole Rock Analysis	-	13	-
Indoor Test	Chemical analysis	Components	-	Al_2O_3,CaO,Cr_2O_3,Fe_2O_3,K_2O,MgO,MnO,Na_2O,P_2O_5,SiO_2,TiO_2,LOI,TOTAL,FeO	-
Indoor Test	Chemical analysis	Soil Samples	-	-	685
Indoor Test	Chemical analysis	Components	-	-	Al,Sb,As,Ba,Be,Bi,B,Cd,Ca,Cr,Co,Cu,Ga,Fe,La,Pb,Mg,Mn,Hg,Mo,Ni,P,K,Sc,Ag,Na,Sr,S,Th,Ti,W,U,V,Zn,Au
Indoor Test	Chemical analysis	Rock Samples	-	-	43
Indoor Test	Chemical analysis	Components	-	-	Al,Sb,As,Ba,Be,Bi,B,Cd,Ca,Cr,Co,Cu,Ga,Fe,La,Pb,Mg,Mn,Hg,Mo,Ni,P,K,Sc,Ag,Na,Sr,S,Th,Ti,W,U,V,Zn,Au
Indoor Test	Chemical analysis	Ore Samples	-	31	40
Indoor Test	Chemical analysis	Components	-	Au,Ag,Cu,Pb,Zn	Au,Ag,Cu,Pb,Zn

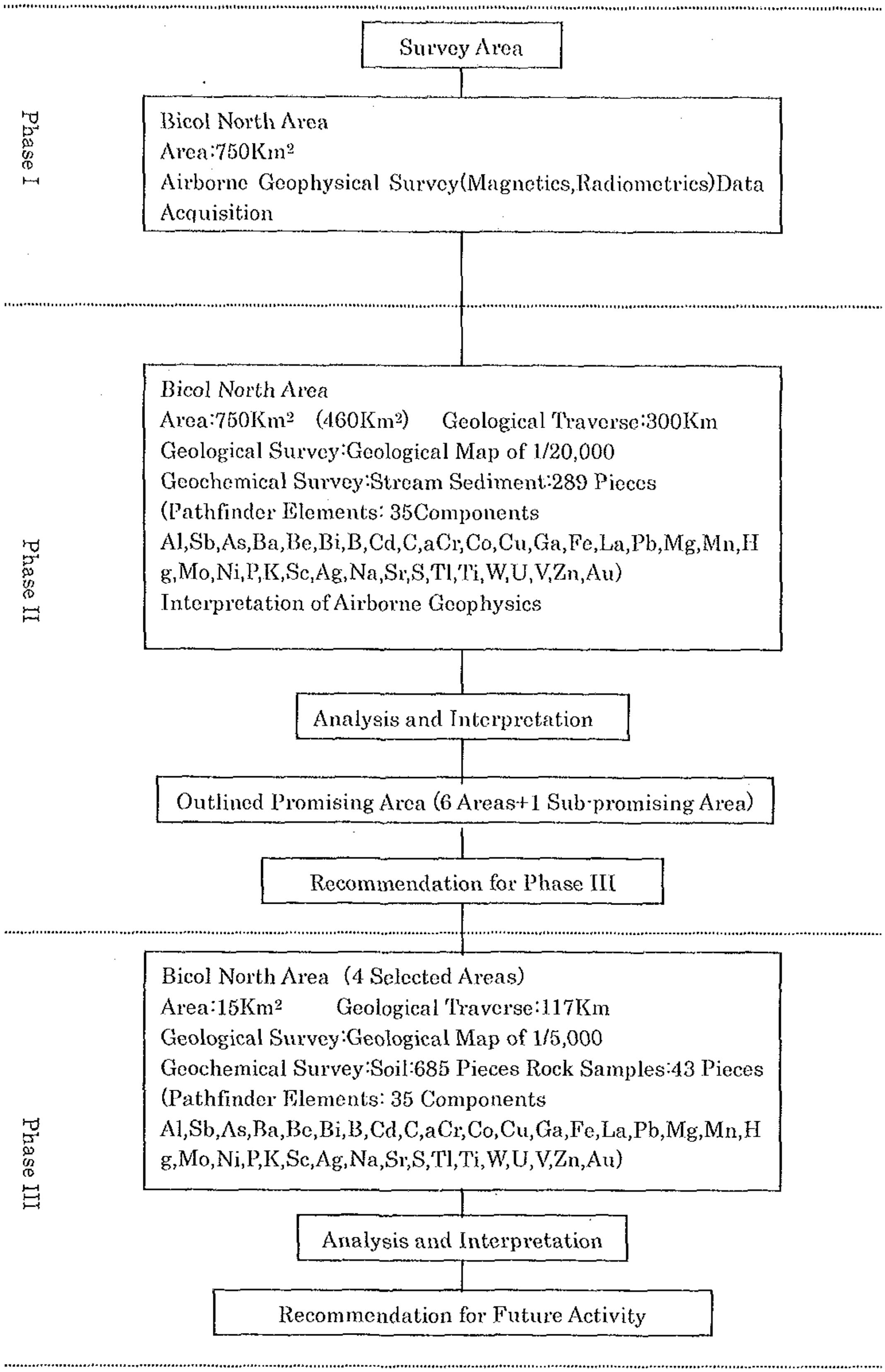


Fig.I-1-1 Flow Chart of Exploration Program

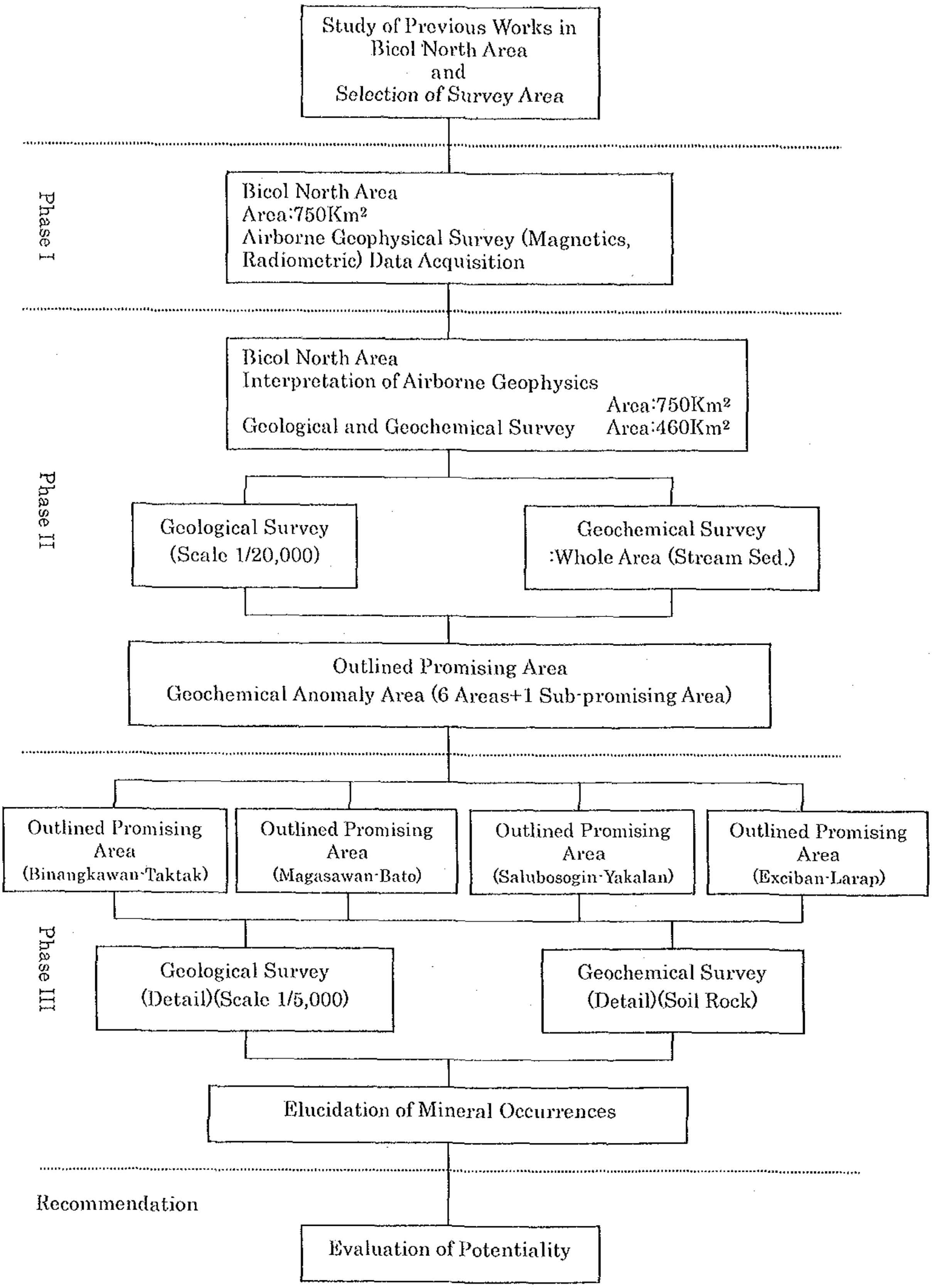


Fig.I-1-2 Flow Chart of Selecting Promising Area

1-2-3 Phase-III

Based on the results of the previous survey, three areas, Salubosogin-Yakalan, Binangkawan-Taktak, and Magasawan-Bato, were selected. Aside from the three areas, Exciban-Larap occurrences whose silicified argillized zone was reported by the Bicol regional survey by JICA and MMAJ (1998), was added as the fourth targetted area. Detail geological survey and soil geochemical survey were conducted with a object of finding the geology, alteration zone, mineralization zone ,and potential areas.

As the third year is the final phase, the potential and proposals in the Bicol North Area are summarized based on three years results in this report.

1-3 Organization and Personnel

The organizations and personnels are as follows.

Three base camps, Labo, Tagkawayan and Vinzons, were put up and the survey was carried out by two to four groups. Each group was composed of two to four geologists and one 4WD-vehicle with a driver. The geophysical survey was conducted by Fugro Airborne Surveys (the former WGC) of Australia.

Japanese survey team did not join the field survey except from the pre-survey in Phase-I. The team put up a base camp in Daet and visited the base camp of Philippines counterpart in Labo for determining the samples taken by the field survey teams and giving instractions in Phase-II and –III.

(1) Phase-I

Planning and Coordination

Japan

Toshihiko Hayashi	Metal Mining Agency of Japan
Masashi Kasai	Japan International Cooperation Agency
Hiroshi Shibasaki	Metal Mining Agency of Japan
Yoshiharu Kida	Metal Mining Agency of Japan

Philippines

Mario Rono	Department of Environment and Natural Resources
Pedro C. Calcon	Department of Environment and Natural Resources
Horacio C. Ramos	Director, Mines and Geosciences Bureau
Edwin G. Domingo	Mines and Geosciences Bureau
Romeo L. Almeda	Mines and Geosciences Bureau
Roland Pena	Mines and Geosciences Bureau
Claro Jose C. Manipon	Mines and Geosciences Bureau
Arnel F. Jusi	Mines and Geosciences Bureau

Geophisical Survey

Japan

Hiroshi Shibasaki	Metal Mining Agency of Japan
Takeshi Moriya	Metal Mining Agency of Japan
Yoshiharu Kida	Metal Mining Agency of Japan

Philippines

Romeo L. Almeda	Mines and Geosciences Bureau
Claro Jose C. Manipon	Mines and Geosciences Bureau
Dulcisimo S. Domingo III	Mines and Geosciences Bureau

Willam Churchward	Fugro Airborne Surveys
Pul Anthony Seghezzi	Fugro Airbone Surveys

(2) Phase-II

Planning and Coordination

Japan

Toshihiko Hayashi	Metal Mining Agency of Japan
Keita Kouda	Metal Mining Agency of Japan

Philippines

Horacio C. Ramos	Director,Mines and Geosciences Bureau
Edwin G. Domingo	Mines and Geosciences Bureau
Romeo L. Almeda	Mines and Geosciences Bureau

Field Survey Team

Japan

Kazuo Ito	Nittetsu Mining Consultants Co., Ltd.
Makoto Miyoshi	Nittetsu Mining Consultants Co., Ltd.

Philippines

Claro Jose C. Manipon	Mines and Geosciences Bureau
Rogel Santos	Mines and Geosciences Bureau
Salvio Laserna	Mines and Geosciences Bureau
Eleazar C. Mantaring	Mines and Geosciences Bureau
Ariel Bien	Mines and Geosciences Bureau
Dilson Montano	Mines and Geosciences Bureau
Raymond Abundo	Mines and Geosciences Bureau
Federico Jacoba, Jr.	Mines and Geosciences Bureau
Brian Zoilo Aurelio Esber	Mines and Geosciences Bureau
Resty Gomez	Mines and Geosciences Bureau
Gilbert Emerson Bascos	Mines and Geosciences Bureau
Aeschylus Obar	Mines and Geosciences Bureau

(3) Phase-III

Planning and Coordination

Japan

Keita Kouda	Metal Mining Agency of Japan

Philippines

Horacio C. Ramos	Director,Mines and Geosciences Bureau
Edwin G. Domingo	Mines and Geosciences Bureau
Romeo L. Almeda	Mines and Geosciences Bureau
Antonio N. Apostrol	Mines and Geosciences Bureau

Field Survey Team

Japan

Kazuo Ito	Nittetsu Mining Consultants Co., Ltd.
Yasunori Ito	Nittetsu Mining Consultants Co.,Ltd.

Philippines

Claro Jose C. Manipon	Mines and Geosciences Bureau
Fernando Sajona	Mines and Geosciences Bureau
Rogel Santos	Mines and Geosciences Bureau

Salvio Laserna	Mines and Geosciences Bureau
Marcel Laud	Mines and Geosciences Bureau
Gibert Bascos	Mines and Geosciences Bureau
Federico Jacoba	Mines and Geosciences Bureau
Dilson Montano	Mines and Geosciences bureau

1-4 Results of Phase-I and Phase-II

1-4-1 Phase-I

(1) Conclusion

Airborne magnetic and airborne radiometric survey were conducted as the geophysical survey. From the result of pre-analysis on the data, the followings were suggested. For understanding the geological structure and finding the alteration zones, the Th-gamma-ray response and K-U-Th gamma-ray response are effective for the geological classification. The high-K-signature and magnetic flat region show the existence of geothermal alteration zones. The occurrences presently known are overlapping on the high-K-signature and the magnetic flat region as well as the magnetic and topographic lineaments. The lineaments, dominat westnorthwest-eastsoutheast and lots of northeast-southwest lineaments can be found. From the results of the above preliminary interpretation, five areas, the known Nalesbitan Au-(Cu) deposit, Labo Valley, Kilbay Valley, Mt.Labo Zone, and Tagkawayan Zone, are selected as the expected areas for the future survey.

(2) Proposals

For Upper Pliocene, Susungdalaga Volcanics, the geology has been mostly understood. But the Tertiary plutonic rocks which may be in the west of the area, was not verified and the relation to the geothermal alteration and mineralization is not clear. The igneous rocks related to the mineralization should be found.

The Nalesbitan deposit is considered that it was formed by the ascending hydrothermal fluid along the dilational zone of west-north-west trending fault (Sillitoe et al., 1990). Before the geological survey, the pre-analysis for geological structure by means of aerial photograph and satellite image, will be necessary.

The geological mapping is also needed in the alteration zones estimated by airborne geophysical survey. And the geochemical survey for rocks, stream sediments, and heavy minerals, is also effective.

The instructions for the survey in each area are follows.

(Nalisbitan Au-(Cu) deposit)

Tuba area is included. The existence of alteration zones at the surrounding of high-K signature located at about four kilometers east of Nalesbitan and in the southeast of Nalesbitan, should be especially confirmed.

(Labo Valley)

The area from the upper stream of Labo River to Kilbay River is included. The target will be the surroundings of high-K- signature at midstream of Labo River.

(Kilbay Valley)

The west-north-west and east-south-east trending faults were found by the reagional survey. The existence of intrusions and the relation to the geothermal alterations, should be cleared.

(Mt. Labo Zone)

It is possible that the old igneous rocks may be exposed at the foot of Mt. Labo. The possibility of the existence of mineralization and alteration zones, should be verified.

(Tagkawayan Zone)

There are a few high-K signature and magnetic flat regions. It is possible that the old formation and mesothermal mineralization may be existing.

1-4-2 Phase-II

(1) Conclusion

A lot of alteration zones and occurrences were found by the geological mapping. The part of the alteration zones is associated with high-sulfidation-epithermal and low-sulfidation-gold mineralizations , and mesothermal-vein-type and skarn-type Au-(Cu) mineralizations. The geochemical anomalies related to the alteration zones were found by the geochemical survey.

The rock units were classified by means of analysis of the data of airborne magnetic and airborne radiometric. The center of volucanic activity in Pliocene was also estimated. A lot of alteration zones were estimated by means of analysis of high-K signature. The alteration zones mostly coincided with its by the field survey.

From the results of total analysis of the data, six areas were selected as the promising areas. The areas and the types of deposit are as follows.

Katakian alteration zone····· Skarn-type or Mesothermal-vein-type
Maniknik-Layaton alteration zone····· High-sulfidation epithermal type
Susungdalaga area····· High-sulfidation epithermal type
Alawihaw alteration zone····· Low-sulfidation epithermal type
Salubosogin-Yakalan alteration zone ····· High-sulfidation epithermal type
Binangkawan-Taktak alteration zone····· High-sulfidation epithermal type

Addition to the above six areas, Magasawan-Bato alteration zone was selected as a sub-promising area due to the lack of geochemical anomalies.

(2) Proposals

The field survey was just preliminary stage considering the accuracy of mapping and the density of geochemical sampling. Significant mineralization zones where the drilling survey would not be immediately necessary have not been presently found. Therefore further detail geological and geochemical survey are still needed in the selected areas for the purpose of the decision for the drilling targets. The proposed method of the next stage for survey in each area is mentioned below.

(Maniknik-Layaton Alteration Zone and Susungdalaga Area)

These areas have potential of high-sulfidation mineralization. In typical high-sulfidation mineralization accompanied by vuggy silica, the gold and its related elements usually concentrate at the vuggy silica portion, the center of acidic alteration zone where acidic fluid directly ascended. However, vuggy silica bodies do not always contain high anomaly gold values, it certainly needs the ascent of metal rich fluid on and after the leaching process. Therefore, to check the existence of the gold mineralization, detail geological mapping and geochemical work including continuous rock chip sampling and/or channel sampling at vuggy silica bodies and silicified rocks is necessary. Once the mineralization will be discovered, geophysical survey is effective to outline the extension of the mineralization. It is expected that ore body and argillized zone surrounding silicified rock contains highly sulfide minerals, whereas silicified rock around the vuggy silica, formed by the fluid descending temperature, shows high to medium resistivity and contains a little sulfide minerals. Thus, it may be possible to detect the contrast by IP survey between both.

(Katakian Alteration Zone)

The alteration zone occurs to be accompanied by a skarn-type contact metasomatic mineralization related to plutonic bodies or mesothermal vein-type mineralization such as Tuba-type. The extension of quartz vein outcrops and floats, silicified and argillization zone and geochemical anomalies will be determined by detail mapping and geochemical work including detail stream sediments sampling. Once the mineralization zones will be specified, grid soil sampling will be effective to decide the drilling target.

(Salubosogin-Yakalan Alteration Zone)

The area has potential as Nalesbitan-type high-sulfidation mineralization accompanied by silicified breccia, Only smectite dominant argillization crops out, a lot of silicified boulders including some vuggy texture accumulate along the stream. Thereby, firstly, the detail field mapping is necessary to identify the extension of exposed silicified rocks. After that, geochemical work including continuous rock chip sampling and/or channel sampling every a few to 10m intervals at the vuggy silica and brecciated silicified bodies is necessary with paying special attention for brecciation and decomposed sulfide minerals. Au-anomaly shows directly the mineralization. In addition, the mobile elements such as Hg, As and Sb are important, because the zone may only expose the shallow portion of the system.

(Alawihaw Alteration Zone)

It seems that the alteration zone was formed at a very shallow circumstance in a younger geothermal system due to the existence of sinter and active hot springs. The geochemical anomalies of mobile elements such as Hg, As and Sb are important for studying a shallow system. The simultaneous detail geological mapping and rock chip geochemocal survey are recommended to specify the further promising area, then grid sampling will be carried out for the purpose of the decision of the drilling target.

(Binangkawan-Taktak Alteration Zone)

The existence of the alteration zone was determined but the detail has not been known. At first, the detail geological mapping and rock chip geochemical survey are recommended to conducte in parallel. In case, any promising mineralization was found, grid soil sampling may be carried out in the area.

In Magasawan–Bato Alteration Zone along the midstream of Labo River, kaolinite clay and altered rocks of possibly steam heated-type were observed but neither K gamma-ray signature nor geochemical anomaly were found. In the alteration zone, any geochemical anomaly was not found, because the shallower alteration zone above old head is exposed. The detail of the area is not clear, therefore the potential seems to be lower than the above six areas.

Chapter 2 Previous Work

2-1 Background and Result

The natural resources, gold, copper, laterite nickel, chromium, and others, are abundant in the Philippines. The country is highly potential in porphyry copper-type deposit, epithermal vein-type deposit, and others. In 1970th , the Philippines was one of main producers of gold and copper but recently, the production is reducing in spite of the high potential. It is because the development of new mines and the expansion of existing mines are stagnant after the mined out of existing mines.

One of the reasons is that foreign investment for mining and exploration in the Philippines was obliged to be insufficient because of the issue of laws. For resolving the situation and promoting foreign investment to activate domestic mining industry, new mining act (Mining Act of the Republic of the Philippines No.7942 and the Implimentation Rules) was executed. Thus, the goverment is making effort of introducing foreign investment. The investment temporarily incresed with the excution of the new mining act and world exploration boom. But after the remarkable diminution, the investment has not yet activated.

Under the above situation, the government requested Japanese government cooperative exploration to discover new deposits. "Reagional survey for mineral resources in the Bicol Area(JICA and MMAJ,1997-1998)" was carried out. From the result the exploration, one of promising areas, the Bicol North Area, was selected. In response to the request by the Philippines goverment in May 1999, the "Implementing Arrangement(I/A)" was signed between JICA and MMAJ , and Department of Environment and Natural Resources,the Republic of the Philippines.

In the survey area, there were not any mines in operation. But Nalesbitan Gold-Copper deposit which may be high-sulfidation epithermal gold deposit, is located in the northeast of the area. And Tuba deposit which may be mesothermal vein-type deposit, is also located. And Benit deposit which is small skarn-type deposit, is in the northeast end of the area. In Exciban-Larap area located in the northeast of the survey area , there were a lot of former operated mines and mineralization zones. Larap Mine which was potential as porphyry copper-type deposit and gold basemetal deposit around the porphyry deposit, is known. Exciban Mine which may be mesothermal vein-type gold deposit, is known. Iron ore has been produced in Larap Mine and gold mineralization with quartz vein is known in Exciban Mine.

2-2 General Geology of Cercumference

From the result of JICA/ MMAJ(1998), the Bicol area can be divided into three zones in parallel with the elongate direction, which are the northeast zone, the central zone,and the southwest zone. The northeast zone and the southwest zone are underlain by Cretaceous basement rock intruded by Tertiary diorite. Those basement rocks in the southwest zone are overlain by late Tertiary sedimentary rocks. The central zone is widely covered by Pliocene-Recent volcanic rocks. The mineralization zone and deposits of porphyry-copper-type, skarn-type, messothermal-type, and volcanogenic massive sulfide-type occur in the northeast zone. The skarn-type deposits occurs in the southwest zone. There are some deposits and occurrences of epithermal mineralization in the central zone.

The Bicol North Area is located in the northwest end of the central zone. The main part of the survey area is mainly covered by Pliocene to Recent volcanics. Labo in the northeast of the survey area is situated in the northeast zone is mainly covered by sedimentary rocks. The west and southwest of the survey area is situated in the northeast zone or the southwest zone. The area is underlain by ophiolite sequence and sedimentary rocks.

The geology in the Bicol North Area is underlain by Late Cretaceous from below to upward: Upper Cretaceous; Tigbinan Formation in the west of the survey area , Paleocene-Eocene; Universal Formation in the northeast most of the area near Labo, Lower Miocene; Bosigon Formation in Labo Valley and Bosigon Valley, Upper Miocene; Macogon Formation in the west of the area, Pliocene; Macogon Formation and Susundalaga volcanics are widly covering the center of the area. Plistocene; Labo volcanics conformably covers Pliocene Formations around Mt.Labo in the east of the area.

Chapter 3 General Information of the Survey Area

3-1 Location and Accessibility

The Bicol North area is located within the range from 122° 32' 10" to 122° 48'50"E of Longitude and from 13° 55' 00" to 14° 8' 35" N of Latitude. Administratively, the area belongs to the province of Camarines Norte, Camarines Sur and Quezon, which is located in the northern part of the Bicol Peninsula.

Labo and Daet town (Camarines Norte) is situated to the northeast of the survey area, and Tagkawayan (Quezon province) and Del Gallego (Camarines Sur) are in the south of the survey area. Labo town is about 265 km from Metro Manila and it takes about 5 hours 30 minutes by car. Tagkawayan town is about 260km from Metro Manila and it takes about 5 hours by car.

In survey area, there are few accessible roads throughout year. It is obliged to access separately to the north area and the south area. Therefore, the survey teams accessed to the survey areas from base camps set in Labo and Vinzons in the north area and Tagkawayan in the south area.

3-2 Topography and Drainage system

The Mt. Labo, the Pleistocene stratovolcano, (1,572m) is in the east of the survey area. The dissected Susungdalaga Mountains ranging from 200 to 600 m above sea level dominates in the center of the area, and its range of mountains trends ENE～E-WSW～W. The range divides watersheds into the north and the south. The area in the north of the Susungdalaga Mountains is formed with gentle hills. A flat plain spreads in the south of the survey area.

The survey area is divided into three drainage systems: Labo River, Bosigon River, and Kilbay River. Labo River and Bosigon River basins cover the northern half of the survey area and both rivers run northward, while Kilbay River basin covers the southern half. Kilbay River runs westward in the south basin of the Susungdalaga Mountains and joins another main tributary at a flat low land, then runs southward.

3-3 Climate and Vegetation

The Bicol North Area is characterized by the absence of dry season and has a very heavy maximum rainy period generally in December and January. They also experience abnormal rainfall during July to January due to the passing of tropical cyclone.

The area is covered by thick vegetation because of the abundant rainfall throghout year. In viewing Landsat images (Fig. II-1-1), almost all areas are covered by vegetation. A like of primary forest is almost limited at the vicinity of Mt. Labo. The agricultural fields (see mosaic portion of pink and yellow-green in color) are sporadically found even in the secondary forest in the Susungdalaga Mountains. The lowland and fluvial plain are mostly used for agriculture.

Chapter 4 Conclusion and Proposals

4-1 Conclusion

No active mines are present in the survey area, but Nalesbitan Au-Cu high-sulfidation epithermal deposit and Tuba mesothermal vein-type deposit occur in the northwest of the area. In addition, Benit skarn-type small-scale deposit is present. For Phase-I, airborne geophysical survey has been conducted for obtaining data to evaluate the potential of possiblely similar deposit. For Phase-II, the data were analysed. Geological survey and geochemical survey of stream sediments were conducted. Six areas which were Maniknik-Layaton, Susungdalaga, Katakian, Salubosogin-Yakalan, Alawihaw, and Binagkawan-Takatak, were selected as high potential and expected for the future exploration. Magasawan-Bato was selected as a sub-promising area.

For Phase-III, the geological survey and geochemical detail survey were conducted in Salubosogin-Yakalan and Binangkawan-Taktak areas, Magasawan-Bato area out of above six areas. In addition, Exciban-Larap area was also targetted. Four areas, Maniknik-Layaton, Susungdalaga, Katakian, and Alawihaw, were not included for Phase-III due to peace and order in the areas.

The main part of the survey area belongs to the northwest of central zone, one of three geologic zones in the Bicol area, that is covered mainly by the Paleocene to Pleistocene volcanics. The north and western areas belong to the northeast and southwest zones underlain by the ophiolite sequence and sedimentary rocks.

The alteration zones and a part of occurences are associated with epithermal high-sulfidation system and low-sulfidation system gold mineralization and mesothermal and skarn-type gold (copper) mineralization. In the Exciban-Larap occurences in the north of the area, a porphyry copper-type deposit or a mesothermal vein-type deposit are associated.

Various rock units were distingished by analysing the data of aeromagnetic and gamma-ray spectrum. The center of volcanic activity of Pliocene was also delineated. A number of alteration zones were delineated by analysing the anomalies of the gamma-ray spectrum. Those alterations are mostly coincided with its found by the field survey. The geochemical anomalies related to the alteration zones were found by the geochemical survey and the detail geochemical survey.

The total comparison between the areas selected by Phase-II and the areas surveyed in Phase-III, on the same level, could not be made because of the difference of the accuracy.

In the areas that were selected as the promising areas in Phase-II and were not surveyed in Phase-III, the detail geochemical survey and drilling will be necessary for the future evaluation. In the areas that the survey was conducted in Phase-III, the final evaluation targetting to the Au geochemical anomalies of epithermal deposit, will be necessary. In the Exciban-Larap Occerrences, the final evaluation targetting to the anomalies of Au-Cu deposit, will be necessary in the future.

From the results of the total analysis of those data in the wide area, the following eight areas are finally selected as the promising areas for the future exploration and potential areas of existence of deposits. The areas and the types of deposit are followings.

Katakian alteration zone----- Skarn-type or Mesothermal-vein-type
Maniknik-Layaton alteration zone----- High-sulfidation epithermal type
Susungdalaga area----- High-sulfidation epithermal type
Alawihaw alteration zone----- Low-sulfidation epithermal type
Salubosogin-Yakalan alteration zone ----- High-sulfidation epithermal type
Magasawan-Bato alteration zone----- High-sulfidation epithermal type?
Binangkawan-Taktak alteration zone----- High-sulfidation epithermal type
Exciban-Larap occurences-----Porphyry copper-type deposit or Mesothermal vein-type deposit

4-2 Proposals for the Future Exploration

From the result of three years survey, eight areas, Katakian alteration zone, Maniknik-Layaton alteration zone, Susungdalaga Area, Alawihaw alteration zone, Salubosogin-Yakalan alteration zone, Magasawan Bato alteration zone, Binangkawan-Taktak alteration zone, and Exciban-Larap occurences, are selected as promising areas. In terms of the accuracy, substantially preliminary stage of grass-route surveyed areas based on the density of the field survey and the sampling of geochemical survey was conducted in some areas and the detail geochemical survey was conducted in other areas. In the future, it is recommended that detail geochemical survey for selecting the drilling targets should be conducted in some areas. In the areas where the detail geochemical survey was completed, geophysical survey on surface and the additional suprementary geochemical survey are recommended for deciding the drilling locations.

The recommended survey for the next stage in each promising areas are mentioned below.

(Maniknik-Layaton Alteration Zone, and Susungdalaga area)

These areas are potential of high sulfidation mineralization. In a typical high-sulfidation mineralization accompanied by vuggy silica, the gold and its related elements usually concentrate at the vuggy silica portion, the center of acidic alteration zone where acidic fluid directly ascended. However, the vuggy silica bodies do not always contain high anomalous gold values, it certainly needs the ascent of metal rich fluid on and after the leaching process. Therefore, to check the existence of the gold mineralization, detail geological mapping and geochemical work including continuous rock chip sampling and/or channel sampling at the vuggy silica bodies and silicified rocks is necessary.

Once the mineralization will be discovered, geophysical survey is effective to outline the extension of the mineralization. It is expected that ore body and argillization zone surrounding silicified rocks contains highly sulfide minerals, whereas silicified rocks around the vuggy silica, formed by the fluid descending temperature, show high to medium resistivity and contain a little sulfide minerals. Therefore, it may be possible to detect the contrast by IP survey between the both.

(Katakian Alteration Zone)

The alteration zone occured to be accompanied by a skarn-type contact metasomatic mineralization related to plutonic bodies or mesothermal vein-type mineralization such as Tuba-type. It is recommended that the distribution of calc-silicate, quartz-vein outcrops, floats, and alteration zones should be determined by the detail mapping and geochemical work including detail stream sediments sampling. After the mineralization zones will be specified, grid soil sampling is effective for the zones.

(Alawihaw Alteration Zone)

It seems that the alteration zone was formed at a very shallow circumstance in a younger geothermal system due to the existence of sinter and active hot springs. The simultaneous detail geological mapping and rock geochemical survey are recommended to specify the further promising area, then grid soil sampling should be carried out for the purpose of deciding the drilling target. The geochemical anomalies of Hg, As and Sb as well as Au are important to study a shallow system.

However, the geothermal condition, the existence of hot springs at ~80℃, may interfere with the further survey due to possibly high temperature in the underground.

(Salobosogin-Yakalan Alteration Zone)

The area is potential as Nalesbitan-type high-sulfidation mineralization accompanied by silicified breccia. The silicification zone and the surroundings argillization zone crop out along the faults traversing in the center of the area. Quartz vein with sulfied minerals filling the fracture zones was observed. The silicified zone along faults shows gold anomalies by soil geochemical survey. The brecciated zone is the target for drilling. It is expected that the center of mineralization might not be exposed, and the zone might be shallower than the Nalesbitan. Geochemical work including continuous rock chip sampling and/or channel sampling every a few to 10 meters intervals should be conducted.Sampling line must to cross faults and extend to Macogon Formation which is the host rocks of Nalesbitan epithermal gold deposit. A few drillings are recommended for evaluating the existence of mineralization for the targeted to Au-anomalies.

(Magasawan -Bato Alteration Zone)

In the area, Susungdalaga Volcanics are widely distributed. In the north of the area, the sedimentary rocks of Sta. Elena Formation (Upper Miocene) is limitedly distributed as the window shape. Northeast to east-north-east and northsouth trending faults were observed. In the southwest of the area, the intrusion of plug is expected by the airborne survey.

The mineralization was observed along mainly east-north-east structural line and pyrite dissemination was observed in the gouge. Under geochemical survey, the gold-anomaly is widely distributed along the fault trending northsouth and the east-north-east direction in silicification zones. The area might not be well eroded and the only shallow portion of geothermal alteration may be exposed. Sta. Elena Formation is located at the north of the area, therefore, Susungdalaga Volcanics may be thinner than southwest area. The gold-anomaly by soil geochemical survey situated in the southwest of the area where the intrusion of plug is inferred, may be higher potential. It is recommended that continuous rock chip sampling and/or channel sampling every a few to 10 meters intervals along northwest survey line in the gold anomalous zone, shoud be conducted. And a few drillings are recommended for evaluation.

(Binangkawan-Taktak Alteration zone)

In the area, northeast and northwest to west-south-west trends are dominant. Susungdalaga Formation is widely distributed in the area. In the northeast of the area, the intrusion of plug is expected under airborne survey.

The area along Taktak River is silicified, however silicification and argillization were observed in the limited zone along faults. Drussy quartz was also observed. The pocket and pyrite dissemination were observed in the silicification zone of dacitic pyroclastics. At the north side of northeast trending fault, gold-anomaly is detected under geochemical survey. Arsenopyrite was also observed. The geophysical survey such as IP or EM targetting sulfides of gold-anomaly and the below of dacitic flow within alteration zone is recommendable for determining drilling targets. One to two drillings are recommended for evaluating the existence of mineralization.

(Exciban-Larap Occurences)

In the area, north-south trend is domonant. Eocene, Universal Formation is distributed. The area is underlained by bedding of sandstone and shale, and basalt. The fauls and joints with various directios were minutely observed. The gouge with pyrite was observed. The zones are cut every a few meters. The zonation of geothermal alteration was observed and massive suifide with dominantly pyrite are distributed. The sulfide is associated with a small amount of chalcopyrite and chalcocite, which shows high value of Au; 19.55ppm. The phenocrysts and veinlets of quartz, chlorite and epidote were observed and veinlet of pyrite dissemination was observed. And diorite is distributed nearby. Therefore, porphyry copper-type deposit or mesothermal vein-type deposit are expected.

Au+Cu+Bi anomaly is detected between the window-shape silicification zone and the southern part of the silicification zone. The geophysical survey such as IP or EM targetting sulfides in the anomaly area is recommendable for determining the detail targets. A few drillings are recommended for evaluating the existence of mineralization.

For three years survey, security summits were organized with JICA, MMAJ, Counterpart, and a security consultant company for collecting information and making the security countermeasures. The information campaign for governor, city mayors, barangay captains, military, and police to be familialized with the purpose, period, areas, organization, methods, etc. of the survey. Consequently, any accidents and/or incidents have never happened during the survey periods and the field survey has been safely completed. In the future as well, the activities of Japanese survey team could be guaranteed by taking the same measures and it could be possible to realize the cooperation requested by counterparts. It is expected that the circumstance of investment in the area could be put in order by means of the preparation of social environment, promotion of employment, environmental control, etc

Part II Detailed Descriptions

Part II　Detailed Descriptions

Chapter 1　Geological Survey

1-1　Outline of the Geology

The survey area is located in the northern part of the Bicol Peninsula. The Bicol North Area consists of three zones: the northeast zone, the central zone and southwest zone. The central zone represents the volcanics of the Philippines Arc. And the northeast zone and southwest zone respectively consist of older units, ophiolite complex, Mesozoic sedimentary rocks and Tertiary sedimentary and volcanic rocks.

The main part of the survey area belongs to the nort-west of the central zone that is covered mainly by Pliocene to Pleistocene Volcanics. The area near Labo town in the northeast of the area mainly consists of carbonate rocks. And the west and southwest of the survey area are underlain by the ophiolite sequence, sedimentary rocks and intrusion of granitic rocks. Those areas belong to the northeast zone and the southwest zone.

The survey area is chiefly underlain, from below to upward, by Upper Cretaceous; Tigbinan Formation in the west of the area, Paleocene–Eocene; Universal Formation in the northeastern end of the area near Labo Town, Lower Miocene; Bosigon Formation in the lower part of Labo Valley and Bosigon Valley, Upper Miocene; Sta.Elena Formation in the west of the area, and Upper Miocene; Macogon Formation and Susungdalaga Volcanics widely cover the central part of the area. Pleistocene ,Labo Volcanics conformably covers Pliocene rocks around Mt.Labo in the east of the area. These formations can be largely distinguished by its dissected characteristics on the Landsat image (Fig. II-1-1).

Fig.II-1-2, II-1-3 and II-1-4 respectively show a geological map, geological profiles and a schematic geological column of the Bicol North Area.

The Landsat image was made by Geoimage Pty Ltd requested by Fugro Airborne Surveys for geophysical survey. The Landsat image was combined with the intensity information of Landsat TM Bands 543(RGB)(Resolution: 30m) and ETM Pan(Resolution:15m) of Landsat-7. In the area, only the topographic information can be obtained because of thick vegitation under the tropical climate.

1-2　Description of Geology

1-2-1 Igneous Rocks and Sedimentary Rocks

(1) Jurassic-Lower Cretaceous

Ophiolites

The serpentinized ultramafic complex exposes in the western end of the survey area. The volcanic and sedimentary units of the upper member of ophiolite are metamorphosed into greenschist and amphibolite. The greenschist crops out on a small scale nearby Tagkawayan.

(2) Upper Cretaceous

Tigbinan Formation

The Tigbinan Formation consists of marine sedimentary rocks and basic volcanic rocks: graywacke, spilite, andesite, chert, cherty limestone, black shale and arkosic sandstone. It is extensively distributed in the western part of the survey area.

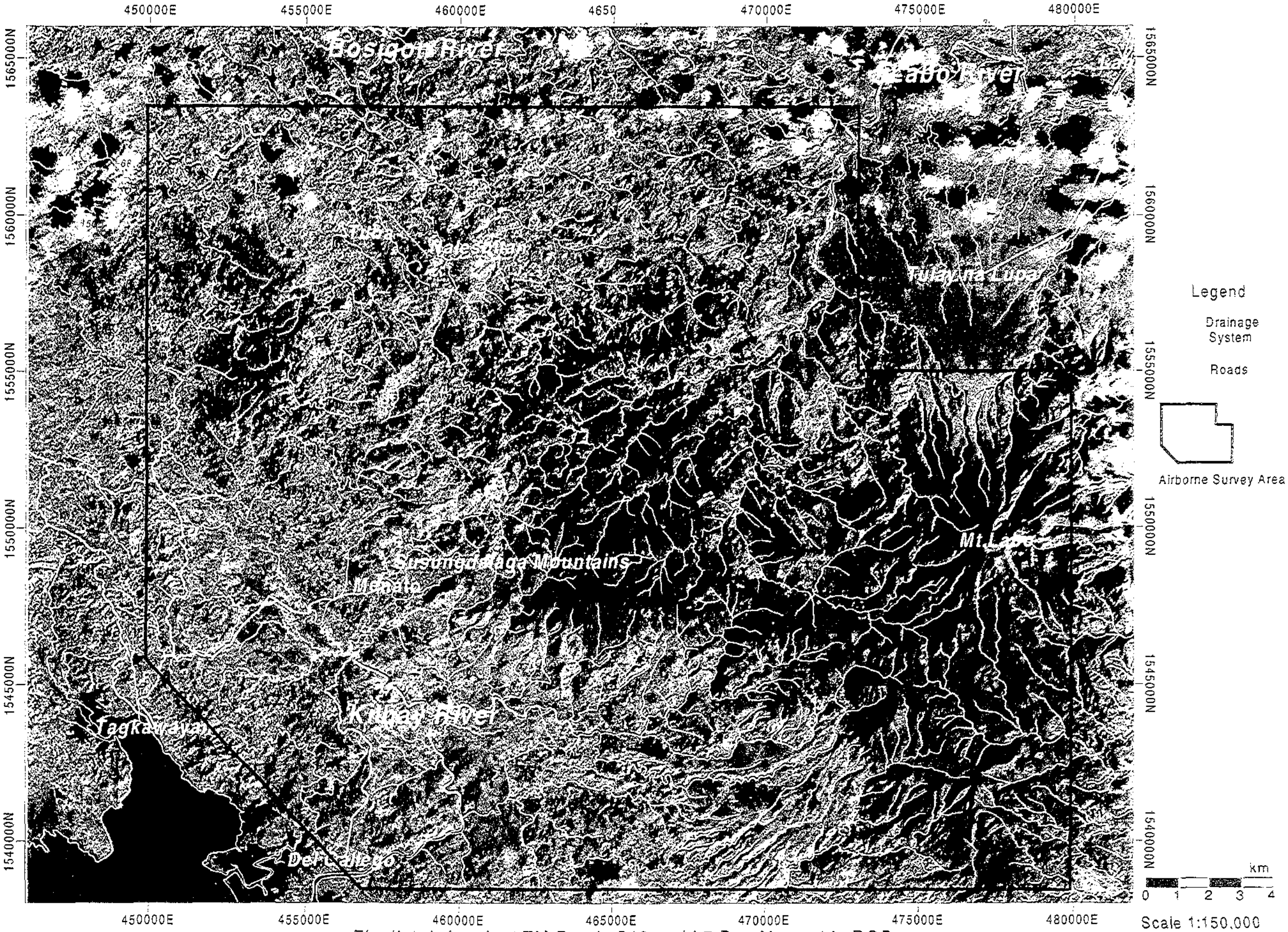


Fig. II-1-1 Landsat TM Bands 543 and L7 Pan Merged in RGB

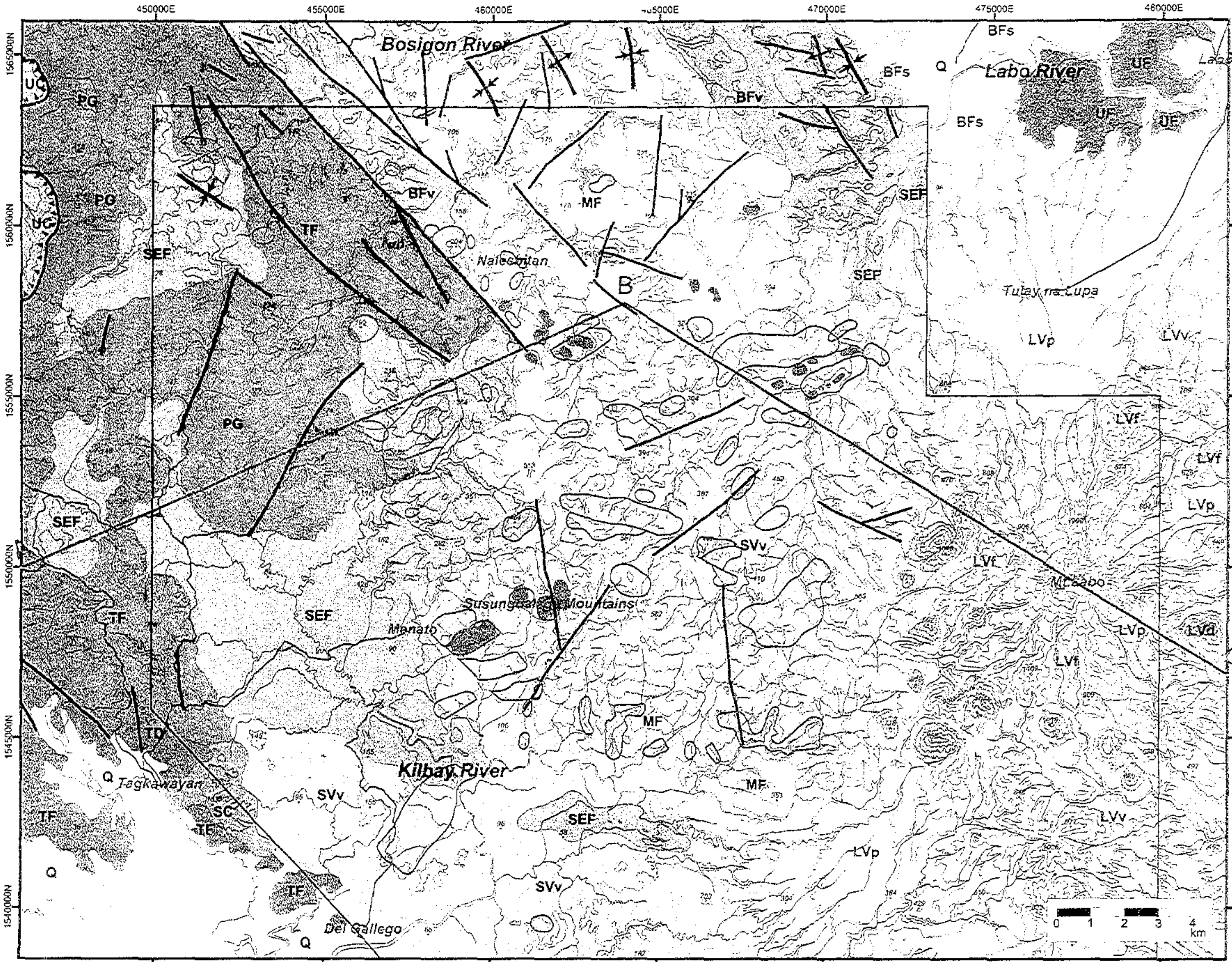
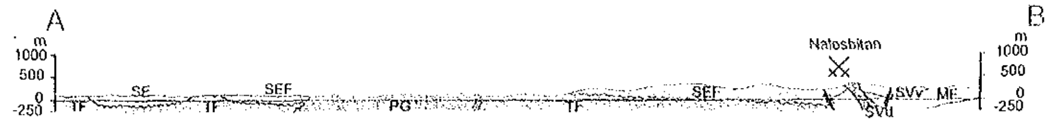
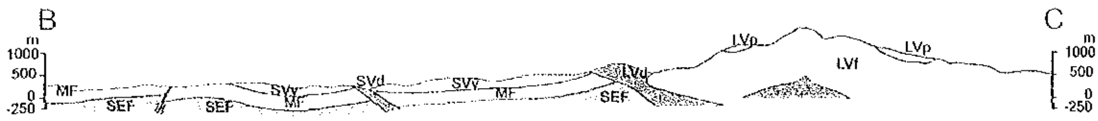


Fig.II-1-2 Geologic Map of the Bicol North Area





Scale 1:150,000

LEGEND

Alluvium	Q	Sand and gravel
Labo Volcanics	LVp	Pyroclastic flow
	LVf	Andesitic and dacitic lava
	LVv	Andesitic and dacitic pyroclastics
	LVd	Andesitic and dacitic plug dome
Susungdalaga Volcanics	SVv	Dacitic lava, tuff and pyroclastics
	SVd	Dacitic plug dome
Macogon F.	MF	Andesitic pyroclastics and tuffaceous black shale with minor basaltic flow
Sta. Elena F.	SEF	Conglomerate, sandstone, shale and minor limestone
Bosigon F.	BFv	Basaltic flows, volcanic wackes, tuff breccia, chert and limestone
	BFs	Conglomerate, sandstone, black calcareous shale and limestone
Universal F.	UF	Limestone, marl and calcareous shale
Tigbinan F.	TF	Graywacke, spilite, chert, andesite, cherty limestone, black tuffaceous shale and arkosic sandstone
Schists	SC	Green schist and quartzite

Inferred Cenozoic Intrusives (including magnetic lava ?) see Fig. II-2-8

Tamisan Diorite	TD	Diorite and dacite porphyry
Paracale Granodiorite	PG	Gneissic granodiorite
Ultramafic Complex	UC	Peridotite, gabbro and epidiorite

Fault — Thrust — Syncline — Anticline — Alteration zone — A———B Profile

Fig.II-1-3 Geologic Profile of the Bicol North Area

Period	Epoch	Symbols	Formation	Lithology	Igneous activity	Mineralization
Quaternary	Holocene	Q	Alluvium	Sand and gravel		
	Pleistocene	LVp LVd LVf	Labo Volcanics	Pyroclastic rocks Andesitic and dacitic lava Andesitic and dacitic plug dome		
Tertiary	Pliocene	SVv SVd	Susungdalaga Volcanics	Dacitic lava(SVv-f), tuff and pyro clastic(SVv-p),*Dacitic plug dome*		Nalesbitan Au-Cu deposits
		MF	Macogon F.	Andesitic pyroclastics and tuffaceous black shale with minor basaltic flow		
	Miocene	SEF	Sta. Elena F.	Conglomerate, sandstone, shale and minor limestone	Tamisan Diorite	
		BFv BFs	Bosigon F.	Basaltic flows, volcanicwackes, tuff breccia, chert and limestone Conglomerate, sandstone, black calcareous shale and limestone	Paracale Granodiorite	
	Oligocene					
	Eocene					Exiciban Cu-Au deposits
	Paleocene	UF	Universal F.	Limestone, marl and calcareous shale Conglomerate, arkose, tuffaceous and calcareous shale and graywacke		Benit ? Au deposits
Cretaceous		TF	Tigbinan F.	Graywacke, spilite, chert, andesite, cherty limestone, black tuffaceous shale and arkosic sandstone	Ultramafic Complex	Tuba ? Au deposits
Pre Cretaceous		SC	Schists	Green schist and quartzite		

Fig.II-1-4 Schematic Geologic Column of the Bicol North Area

(3) Paleocene to Eocene

Universal Formation

The formation is divided into the lower member and the upper member. The lower member is composed of arkosic sandstone, tuffaceous silt, calcareous shale and graywacke, and the upper member is composed of muddy limestone and calcareous shale. The Universal formation unconformably covers the pre-Tertiary rocks. The formation is distributed near Labo in the northeastern end of the survey area.

(4) Miocene

Bosigon Formation

The formation is named by Miranda and Caleon (1979). The formation consists of conglomerate, shale, arkosic sandstone, limestone, basaltic lava, wacke, tuffaceous shale and chert.

The formation is recognized the upper member and the lower member. The lower member consists of the alternation of conglomerate, sandstone, shale and limestone. The upper member consists of basaltic lava, volcanic wacke, tuff breccia, chert and limestone. The formation is considered as belonging to the early Miocene (BMG, 1982). However, United Nations (1987) distinguished the formation to be below Universal Formation and Mitchell and Leach (1991) expressed the possibility.

Sta. Elena Formation (Upper Miocene)

The formation was reported by Miranda and Caleon (1979). It consists of conglomerate, sandstone, siltstone, shale and small quantities of limestone. The formation unconformably covers Bosigon Formation. The formation is considered as the late Miocene (BMG, 1982).

(5) Pliocene

Macogon Formation

The formation crops out along Bosigon River and Palali River in the northern part of the survey area. It consists of andesitic to dacitic pyroclastic rocks, black tuffaceous shale and basaltic lava. The formation uncomformably covers Bosigon Formation. The formation hosts Nalesbitan epithermal gold deposit, the only significant mineral occurrences in the survey area (Sillitoe *et al*, 1990).

Susungdalaga Volcanics

The Susungdalaga Volcanics is defined as the volcanic unit of Susung Dalaga Formation described in Zaide-Delfin et al. (1995). Although Labo Volcanics are grouped collectively in the Mitchell and Balce (1990), the Labo Volcanics is subdivided into two main formations in the geothermal exploration on the southwestern side of Mt. Labo and the lower is named as Susung -dalaga Formation. The formation is widly distributed in the center of the area and consists of andesitic to dacitic lava flow, agglomerate and tuff, and subsurface intersections contains fossiliferous, carbonaceous, fine-grained clastic sediments, conglomerate and limestone. Palaeontology indicates late Miocene marine environment (Zaide-Delfin et al, 1995).

The K-Ar age determination of outcropping volcanics in the Kilbay River gives Pliocene age (JICA and MMAJ, 1999).

(6) Pleistocene

Labo Volcanics

The volcanic rock is named by Miranda and Caleon (1979). It widely covers the area in and around Mt. Labo, and uncomformably overlies the Pliocene rocks.

The Labo Volcanics consists of following units; basal unit of deeply weathered and variably altered hornblende andesite, basalt, and dacite lavas and lahars. Lava domes of biotite-pyroxene-hornblende dacite and biotite-hornblende andesite extruded over the basal unit, with several domes occurring on the southwestern flank of Mt. Labo. Central corn of pyroxene andesite, hornblende andesite and dacite lava, and laharic breccia, which overly the basal unit and the expected lava domes. Pyroclastic flow comprising andesitic to dacitic block and ash flows, erupted about 80,000 years ago, non-bedded and poorly consolidated to well compacted

1-2-2 Intrusive Rocks

Paracale Granodiorite (Middle Miocene ?)

Paracale Granodiorite intruded into Tigbinan Formation and Sta.Elena Formation as stock and dike shape. The granodiorite is medium to coarse, light gray in color. It is mainly composed of plagioclase, quartz, orthoclase and biotite.

Tamisan Diorite (Middle Miocene)

Tamisan diorite intruded near Tagkawayan in the southwest of the survey area. The body consists of quartz-diorite that is mainly composed of quartz, plagioclase and hornblende.

1-3 Geological Structure

The fracture and fault system in two direction of northwest to west-north-west and northeast are predominant in the survey area. A lot of northwest trending faults run through the northwest of the area, where Nalesbitan and Tuba mineral deposits occur. The Nalesbitan deposit is believed as the center in a minor dilational jog on the west-north-west trending faults set (Sillitoe et al., 1990). The alteration zones extend as a eastwest to west-north-west trending corridor in the upper stream of Kiblay River in the south of Susungdalaga Mountains, and the structural line may exist along the strike.

Katakian aiteration zone in the west of the area, several northeast trending faults were found and the alteration may be occured with the trending faults.

1-4 Deposit and Mineralization

Many mineral occurrences and alteration zones occur in the area. The locations of these alteration zones are shown in Fig.II-1-5. The mineral assemblages of altered rocks in each alteration zone are shown in Fig.II-1-6.

The occurrences of each drainage system are detailed as below. The detail of geology and deposit of the areas where geological survey was conducted in Phase-III, is mentioned in Chapter 4. Therefore, the outline based on the result of Phase-III is mentioned below.

1-4-1 *Mineral deposit and Alteration zone in Kilbay Valley*

(1) Alawihaw Alteration zone

1) Location

Alawihaw Creek is administratively a part of Barangay Bagong Silang, Del Gallego, Camarines

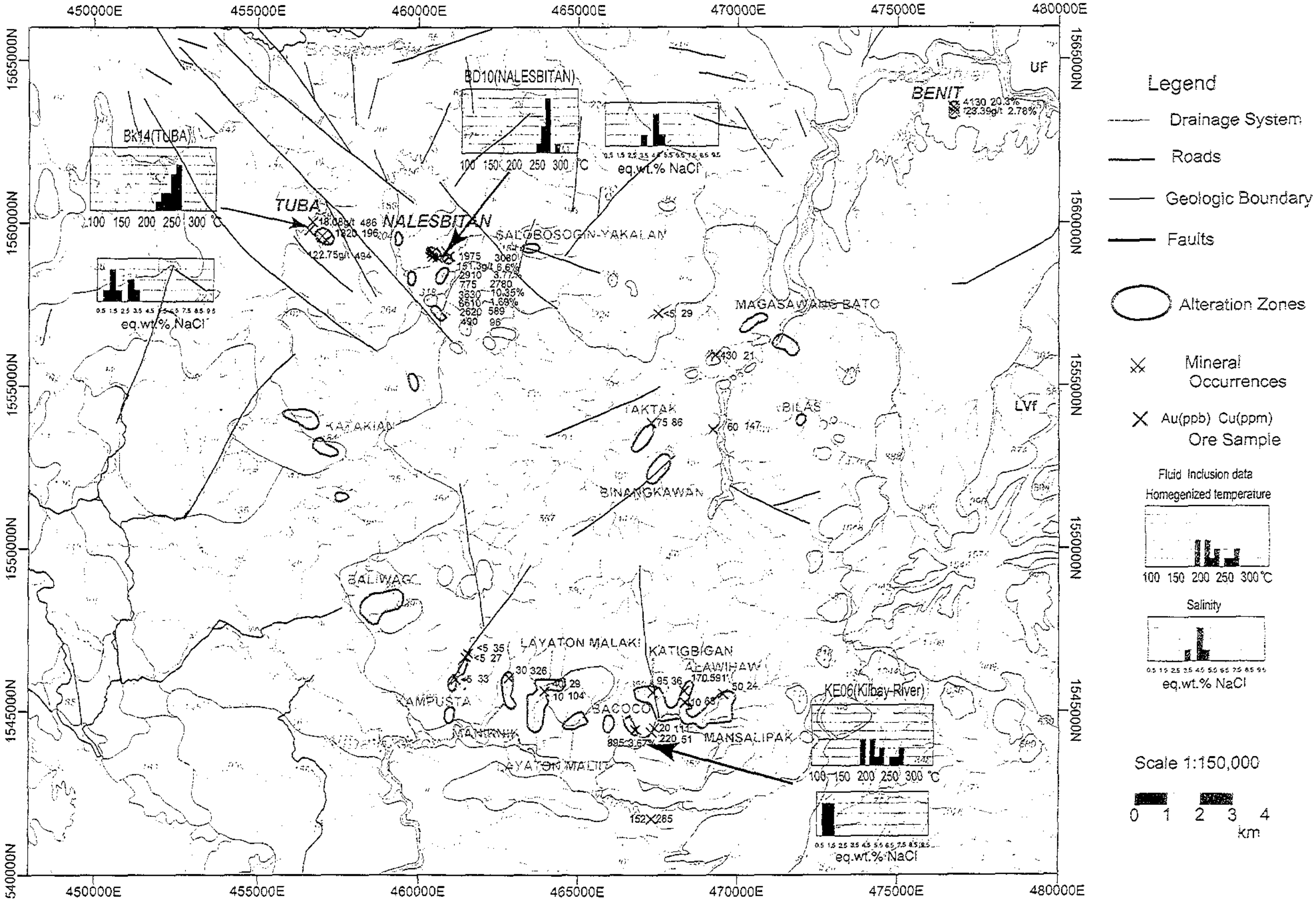


Fig.II-1-5 Mineral Occurrences and Alteration Zones

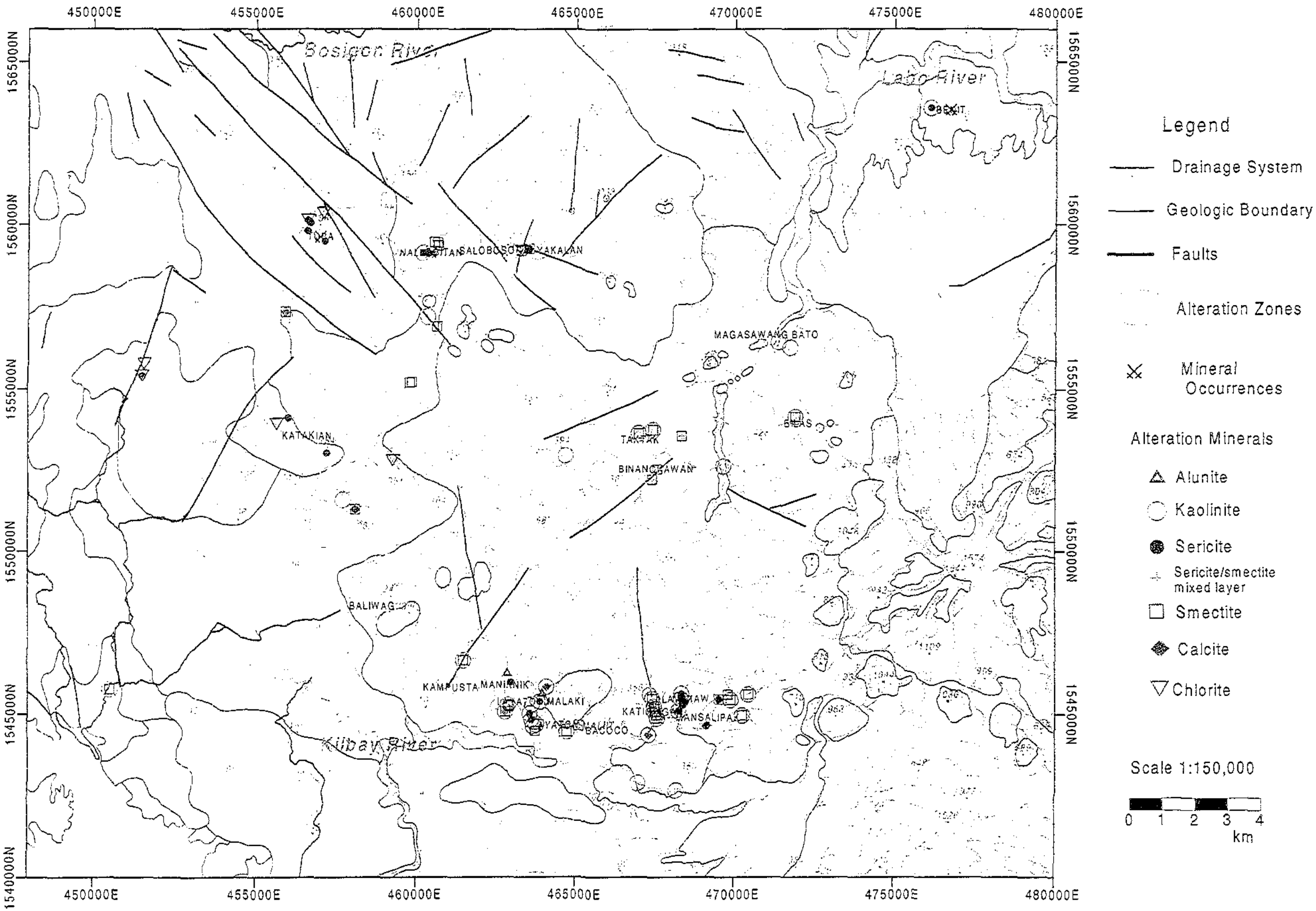


Fig.II-1-6 Distribution of Alteration Minerals by X-ray Diffraction Analysis

Sur. The alteration zone observed is centrally situated at UTM coordinates (Luzon Grid) 4568500 E longitude and 1545300 N.

2) Accessibility

To reach Barangay Bagong Silang, that has to pass through Barangay Sta. Rita -1and Sta. Rita-2. Barangay Sta Rita -1 can be reached by boat from Del Gallego town proper. A tricycle can be taken from Sta. Rita- 1 to Sta. Rita -2. Barangay Bagong Silang, it is good for one-hour hike from Barangay Sta. Rita- 2 and another one-and-a-half to two hours walk to reach the mouth of Alawihaw Creek.

Another option is a 25-minutes 4 WD-vehicle trip from Del Gallego to Barangay Mansalaya and then a walk on a trail to the area, passing Barangay Bagong Silang.

3) Description

The silicification and argillization of a fine- to medium-grained grayish dacitic pyroclastic rock were observed from the mouth of the creek to about 500 meters upstream. The alteration seems to be diminished as the texture of the pyroclastic rock coarsens. The clay minerals are mainly sericite, subordinate kaolinite according to X-ray diffraction. Pyrite dissemination is pervasively observed within the altered rock. In some cases, the pyrite is large enough to distinguish the crystal form. Some samples even reek with the smell of sulfur, as hot springs are known to occur in the area. A vertical fault trending N30° W cut at a few meters up of the last silicified grayish outcrop at downstream. Greenish dacitic pyroclastics with lots of joints were observed at upstream. The alteration may be primarily due to chloritization and/or epidotization but some relict plagioclases seem to be altered to clay. Joints trend N80° W and dip 55° NE.

The exploratoly drilling site of Banahaw Mining Corporation was remained on the major outcrop with northwest trending faults and joints, approximately 12 meters long and 5 meters high. The joints mainly dip northeast but some dip southwest. A dark grayish 4.2 m wide silica vein trending northwest and dipping vertically occurs at the outcrop. It seems that the vein was a possible target of the drilling operation of Banahaw Mining. Hydrothermal brecciation was observed in the vein. The vein (KM15) contains 150ppb Au, 1.4ppm Ag, 230 ppm As, 591ppm Cu, 1,355ppm Pb and 1,505ppm Zn. Pyrite, galena and sphalerite are identified under microscopy of the polished thin section. The vein is thinly enveloped by smectite-kaolinite argillization halo (KM18 and KM19) accompanying two chalcedonic quartz-clay veins striking northeast and dipping vertical and northeast. These veins and clay are hosted by a silicified, pinkish to light grayish dacitic pyroclastics. Argillization is also noted in the wallrock as clay-altered plagioclases. Other two silicified veins, approximately 5 centimeters wide, were observed at the outcrop at a few meters upstream.

A float of quartz-calcite vein with abundant pyrite and chalcopyrite (KE06) was taken in Kilbay River, and it is inferred that these samples derived from the alteration zone. It contains 895 ppb Au, 130 ppm Ag and 3.67% Cu. The filling temperatures of quartz varies ranging from 202 to 286℃, and the salinities are ranging from 1.0 to 1.8% NaCl equiv.

4) Mining Activity

As mentioned above, Banahaw Mining Inc. has already drilled in Alawihaw Creek. Recently, Phelps Dodge conducted a mineral exploration activity in the area. The extent of gold panning activities was not determined.

(2) Mansalipak Alteration zone

1) Location

The zone exists in the territorial jurisdiction of Barangay Bagong Silang, Del Gallego, Camarines Sur. The zone is centered at UTM coordinates 469500E and 1547000N.

2) Accessibility

Refer to Alawihaw alteration zone

3) Description

Hydrothermally altered dacitic to andesitic pyroclastics were observed. The alteration is confined along north-north-east trending fractures and the width of alteration varies ranging from 20 to 100 meters, depending on the permeability of the host rock. An argillic alteration was recognized at the outcrops. Gray to light gray clay is weathered to white to yellowish clay on the surface. The mineral assemblages are quartz-sericite-smectite and quartz-kaolinite-smectite. Boulders of strongly silicified rocks are scattered in the creek, but no outcrop of it was observed. The banded pyrite vein (KC02-2) contains high Fe and S reflecting high content of pyrite, but no anomalous value is obtained except Hg;3ppm.

4) Mining Activity

According to the laborers hired, there was gold panning activity some time ago but no small-scale mining operation.

(3) Katigbigan Alteration zone

1) Location

The alteration zone was observed along Katigbigan Creek at the west of Alawihaw Creek. The zone is centered at UTM coordinates 467500E and 154700N.

2) Accessibility

Refer to Alawihaw Alteration zone

3) Description

The area is underlain by hydrothermally altered dacitic to andesitic pyroclastics. Argillization and silicification were observed along Katigbigan Creek. The mineral assemblage is quartz-kaolinite-smectite. Argillization was observed from the junction of main Kilbay River and Katigbigan Creek up to the hot spring situates about 350 meters from the junction. The hot spring ground lies below strongly silicified zone. The strongly silicified rock wit pyrite dissemination(KC13,JICA and MMAJ,2001) contains Au;95 ppb and Ag; 5.8 ppm.

4) Mining Activity

The laborers reported gold panning by some people and gold exploration were done about five years ago.

(4) Bacoco Alteration zone

1) Location

The zone was observed along Bacoco Creek in the upstream tributary of Kilbay River. Bacoco Creek is next creek to the west of Katigbigan Creek.

2) Accessibility

During dry season, the area can be reached from Del Gallego town to its barangay in Bagong Silang through an approximately 13 kilometers of rough road before crossing the spillway of Kilbay river. By one hour hike eastward towards the junction of Kilbay River, its tributary Bacoco Creek is there. Access during rainy season especially when the spillway is impassable, motorized banca is used along Kilbay River to approach Barangay Sta. Rita- I.

3) Description

Moderately argillized to slightly silicified dacitic flows were observed. Kaolinite, illite, smectite, and limonite were observed as altered minerals. The altered rocks, abundantly contains pyrite stringers. Floats of argillized flow breccia, cherty silica rocks and sinter were observed. MMAJ and JICA (1999) reported that the limonite stained silicified contained about Au; 200 ppb and a quartz vein with 4 cm wide contains AU;340 ppb.

4) Mining Activity

There was no mining activity in the past time and at present, according to the local residents in Barangay Bagong Silang.

(5) Layaton Maliit Alteration zone

1) Location

The zone was observed along Layaton Maliit Creek, a tributary of Kilbay River. It is bounded by UTM coordinates 1,544, 447 North latitude and 464,732 East longitude.

2) Accessibility

The zone is accessible by 4-WD-vehicle during dry season from Barangay Mansalaya through a barangay road going to Bagong Silang. Layaton Maliit Creek can be reached by 30 minutes hike via logging roads.

3) Description

Argillization hosted by propylitic dacite was observed. The mineral assemblages are kaolinite-smectite/smectite mixed layer clay. Length of altered exposure is approximately 400 m with occassional patches of unaltered dacite.

4) Mining Activity

There are no mining activities in the area at present.

(6) Layaton Malaki Alteration zone

1) Location

The zone was observed along Layaton Malak Creek. UTM coordinates 1,544,470 N and 463,739 Eis in the center.

2) Accessibility

Refer to Layaton Maliit alteration zone

3) Description

The dacite of Susungdalaga Volcanics underwent argillization and partly silicification. The zone mainly consists of an acid assemblage – pervasive kaolinization including alunite rich part. At the surroundings of the alteration zone, intermediate alteration zone containing smectite±calcite at the end of the lower stream and upper stream of the creek. Length of altered exposure is approximately 800 m with occasional remnant patches of unaltered/fresh dacite. The strongly silicified rock (KL12, JICA and MMAJ,2001) and the silicified rock with rich alunite (KL13) contain AU; 10 and 40 ppb and Ag; 0.2 and 0.4 ppm respectively.

JICA and MMAJ (1999) reported that floats with pyrophyllite and pyrite-kaolinite assemblage, were observed at the mouth of the creek. The alteration zone shifts upstream from mixed layer clay zone to kaolinite zone. The mixed layer clay zone is accompanied with quartz veinlets, while the kaolinite zone is accompanied with chalcedonic quartz veins. Both veins contain AU; 200～300 ppb and Cu; 700～900 ppm.

4) Mining Activity

There are no mining activities in the area at present.

(7) Maniknik Alteration zone

1) Location

Maniknik Creek is one of the tributaries in northeastern of Kilbay River Basin. The area falls under the jurisdiction of Barangay Mansalaya, Del Gallego, Camarines Sur.

2) Accessibility

Maniknik Creek can be accessed from Barangay Mansalaya that can be reached from Tagkawayan town proper via a network of barangay roads. From there, the creek is accessible via foot trails leading to its junction with Kilbay River.

Another access route is via Del Gallego and Barangay Sta.Rita -1 as same as the accessibility to Alawihaw alteration zone. A foot trail is taken from Barangay Bagong Silang to Maniknik Creek. The trail leads to "Maniknik Falls" in the upper reaches of the creek.

3) Description

Alteration along Maniknik Creek is hosted by relatively fine-grained (sand-sized) dacitic pyroclastic rock. An outcrop near Manikinik Creek-Kilbay River junction exhibits a coarse -grained, non-altered dacitic pyroclastics. Green propylitic pyroclastic rock and dark gray to black bedded tuff were observed at the mouth of the creek. Argillization was observed at the midpoint in the northwest direction of the creek's major bend. The outcrop is dominantly composed of white smectite±kaolinite clay with dissemination of oxidized iron sulfide minerals, and lenses of gray clay occur at the base of the outcrop. Joint sets trending N80° E 75° SE and N50° W 57° SW was observed.

The hard and strongly leached rock was observed at or near Maniknik Falls. The residual silica (KM03, JICA and MMAJ,2001) is entirely composed of silica with lots of vugs but no original texture. The sample contains enargite crystals in its vugs, and enargite-chalcocite-covellite was also observed under microscopic observation. The sample (KM03,JICA and MMAJ,2001) contains AU; 30 ppb, Ag; 0.8 ppm, As; 116 ppm, and Cu; 326 ppm. Another sample (KM04) has an alunite-quartz mineral assemblage. Fracture density in the outcrops was increasing toward the falls.

4) Mining Activity

No mining activity is historically known within the vicinity of Maniknik Creek, including gold panning operations.

(8) Kampusta Alteration zone

1) Location

Kampusta Creek is located in the west of Maniknik Creek. The alteration zone is bounded by the coordinates 1,544,762 N and 461,215 E. The creek is reported as "Susungdalaga Mountains South" in JICA-MMAJ (1999).

2) Accessibility

The site is accessible by 2-hours hike from Mansalaya.

3) Description

Argillized and silicified Susungdalaga Volcanics were observed. The intensively silicified rock with pyrite dissemination was observed in the upstream portion, while argillized alteration was confined in the downstream portion. The assemblages are quartz-alunite-pyrite in the silicified rock and quartz-kaolinite-smectite in the argillized rocks. Length of altered exposure is approximately 300 m with occasional patches of unaltered dacite. Rock samples: propylitic andesite with pyrite dissemination (KL22, JICA and MMAJ,2001), silicified vein with abundant pyrite (KL23), and silicified rock with rich alunite with pyrite dissemination (KL24), were analysed. Any anomaly was found, except it of Ag; 0.2-0.6ppm.

4) Mining Activity

No mining activities were observed in the area but the residents reported JICA and MMAJ (1999) that gold panning was practiced.

(9) Baliwag Alteration zone

1) Location

The zone is within the jurisdiction of Barangay Tonton, the west end barangay of Tagkawayan town in the province of Quezon. The alteration zone is at the center of coordinates 1548200N and 459300E and located at the south of Tonton River where Au-Cu mineralization was reported by JICA and MMAJ (1999).

2) Accessibility

Barangay Tonton can be reached by a vehicle from the national highway fronting the town proper of Tagkawayan. The access is mainly through 10 km dirt road. From the barangay proper, the zone is about 2 km west of Barangay Tonton and is accessible by a foot trail.

3) Description

The alteration zone is immediately north of a dacitic plug that manifests a large prominent dome. The host rock is intensively silicified (chalcedonic) that the original texture is not seen. The rocks were mainly observed as floats or scree along slope and nose of a small tributary draining the north face of the plug. The silicified rocks are reddish brown staining on the surface but are mostly beige to creamy white at the fresher parts. Some rocks are vuggy in some parts with pyrite dissemination (50-60%) replacing with most of the plagioclases. These scree materials are distributed within a stretch of about 1 km.

4) Mining Activity

The local residents were telling of some prospectors of gold some tens of years ago. Even foreign (europian) explorers visited but any excavation or trenches were not observed.

(10) Katakian alteration zone

1) Location

The zone consists of two occurrences. The northern prospect is situated at the northern tributary of Katakian River named Katakian Munti and within the jurisdiction of Barangay Mapulot, Tagkawayan, Quezon. The southern prospect is immediately at the south of the main tributary.

2) Accessibility

The area can be reached on foot through trails from Barangay Mapulot. Barangay Mapulot is accessible from the national highway fronting the town proper of Tagkawayan through feeder or network of barangay roads in north-north-east general direction. The access is mainly dirt roads (some 13 kilometers from the highway junction) thus vulnerable to destruction (potholes, erosional canals) during rainy season.

3) Description

The northern alteration zone occurs in Katakian Munti Creek. From the junction of the main Katikian River and Katikian Munti Creek, propylitic alteration was observed through andesite outcrop. The porphyritic texture of andesite was still observable with moderate silicification. Chloritization is significant with about 5% pyrite dissemination. Stockwork of sulfides (mainly pyrite) and epidote are widespread, and green rock sample rich in magnetite (KJ 01,JICA and MMAJ, 2001) is calc-silicate rock consisting of quartz and abundant epidote under microscopic observation. At the upstream, a sample of highly argillized rock (KJ02, JICA and MMAJ, 2001), probably andesite, yields pyrite in clusters in quartz-clay matrix. The sample is composed of sericite-quartz-pyrite. Some veinlets of magnetite were observed. Boulder floats of silicified rocks of 20-40 cm diameter are abundant around the area. The probable extent of hydrothermal alteration seems to be ranging from 1 to 1.5 kilometers.

The southern alteration was observed at immediately south of the main tributary. Argillization of the host rock obliterates the original texture. Surface of the outcrop shows yellowish to brownish tints. Northeast trending quartz veins (KJ 07,JICA and MMAJ,2001) of about 2-5 cm thick were observed. The quartz--clay matrix is generally deprived of sulfides and its mineral assemblage is sericite-quartz.

4) Mining Activity

According to local residents of the area, some exploration activities have been carried out during the 1980's. Trenching and exploratory adits were driven on the northern bank of the tributary. One exploratory adit near the river trends generally towards northwest.

1-4-2 Mineral deposit and Alteration zone in Bosigon Valley

(1) Nalesbitan Au-(Cu) mineral deposit

1) Location

The area lies within the territorial jurisdiction of Barangay Dumagman, Labo, Camarines Norte. The area is at the center of UTM coordinates 406377E, and 1559200N.

2) Accessibility

Nalesbitan area is accessible by 4-WD-vehicle taking three hours from Barangay Exciban, Labo, Camarines Norte.

3) Description

The Nalesbitan deposit is hosted by Macogon Formation that comprises andesitic and dacitic pyroclastics and basaltic lavas. Detail mapping and study were carried out in Nalesbitan area by Sillitoe et al. (1990) and the outline of the deposit are described as below:

The mineralization is cotroled by a dilational jog related to northwest striking, sinistral strike-slip -fault zone. The mineralization zone ranges within 150 to 300 m above sea level at the ridge top. The principal lode comprised two descrete structures that flared and coalesced upwards to produce a 1,300 m long body of Au-bearing rock ranging from 12 to 145 m wide. Parts of the principal lode were detached and transported several hundred meters left-laterally by post-mineralization motion on the fault zone. The principal lode is marked by steep dipping, linear bodies of hydrothermal breccia, which are transitional outward to irregular patchy breccias and swarms of subparallel veins and veinlets that are characterized pervasive chalcedonic silicification. The multicyclic breccias and chalcedony show evidences for multiple stage of the formation. The principal lode underwent complete supergene oxidation to depth at least 130 m. The lodes are enveloped advanced argillized alteration composed of quartz, kaolinite and alunite, subordinate sericite and diaspore. Illite zone becomes progressively more abundant as the margins of the lode are approached, and the altered minerals change transitionally outwards to a halo of intermediate argillized assemblage by illite, semectite, mixed layer ilite-smectite, chlorite and calcite. The Au bearing hypogene mineralization consists of a suite of high-sulfidation Cu-bearing sulfides, the assemblages are pyrite-chalcocite, pyrite-bornite and pyrite-covellite in order of abundance. Enargite also accompanies chalcocite and bornite. Galena and sphalerite were not observed. Fluid inclusion measurements indicate that mineralization at Nalesbitan took place some 300-500 m beneath the paleo-water table from intermittently boiling fluid at temperature ranging from 223 to 255℃.

Eight ore samples contain the values mainly ranging from Au; 2 to 7 ppm, but the supergene oxidized ore with abundant chrysocolla shows Au; 151 ppm. Cu values vary ranging from several thousands ppm to 10 % above. They contain anomalous Mo values, maximum 384 ppm, and the anomalous values of As, Sb, Pb and Zn. The filling temperatures of fluid inclusions from bornite-brochantite oxide Cu ore with comb quartz veins (BD10, JICA and MMAJ, 2001) ranges 265 to 302℃ and salinities range from 3.5 to 5.2% NaCl equiv. It suggests that the vein was formed with high temperature and relatively dilute fluids.

4) Mining Activity

The development of the deposit was planned in the 1930s by an American company, but it was interrupted by the outbreak of World War II. Since the War, mining has been carried out more or less continuously at Nalesbitan, but only in a rudimentary fashion by illegal "high-graders". In the early 1980s, at the peak, as many as 20,000 high-graders have been actively engaged in surface and underground mining and related activities (Sillitoe et al., 1990).

Gold Fields Asia Limited reexplored and planned the operation from 1970s, but abandoned. Many active small-scale miners are still operating in the area at present. El Dore Mining Company is holding the MPSA at present.

(2) Salobosogin-Yakalan Alteration zone

1) Location

The zone is within the jurisdiction of Barangay Dumagmang, Nalesbitan, Camarines Norte. It is 2.5 km to the east of Nalesbitan Gold Prospect. The creek is a tributary of Palali River. It is at the center of UTM coordinates 1,559,192N and 463,238East.

2) Accessibility

The zone can be reached by one-hour hike from Nalesbitan Prospect via Nalesbitan Creek and foot trails.

3) Description

The smectite argillization at outcrops and abundant vuggy chalcedonic quartz floats were observed along the creek. The silicified or chalcedonic quartz were not exposed, thereby it is possible to be confined at higher elevation. Mineralization style seems to be similar with Nalesbitan Gold Prospect based on surface manifestations.

4) Mining Activity

No mining activities were found in the area.

(3) Tuba mineral occurrence

1) Location

The area is situated at southwest of the municipality of Labo, Camarines Norte. It is within the jurisdiction of Barangay Malaya.

2) Accessibility

The area is accessible from Labo town along the Maharlika Highway to Barangay Malibago. From here, it is accessible by a 4-hours walk along logging road crossing Bosigon River and its tributaries going to Barangay Malaya. An old mine sites were situated at the center of the alteration zone.

3) Description

Sta. Elena Formation overlies the area with greywacke, spilitic lava, flows, black shale and limestone. The formation is in unconformable contact with Upper Miocene sedimentary sequence. A northwest trending fault passing through the area, might have some bearing on the emplacement of gold and silver values in the area.

The alteration consists of argillization and sericitization with minor calcite and pyrite. Quartz, biotite, and calcite were observed as gangue minerals and chalcopyrite, bornite and some copper sulfide and iron/manganese oxide were observed as ore minerals. Two quartz-vein samples taken at old mine sites (BK13 and BK14, JICA and MMAJ, 2001) respectively contain Au; 18 ppm and Ag; 1,470 ppm (BK13), and Au; 123 ppm and Ag; 113 ppm (BK14). Fine argentite included in pyrite crystal is observed under microscopy of BK13 polished thin sections. The float of silicified rocks accompanied by quartz veinlet near the old mine site contains Au; 1320ppb and Ag; 5 ppm. The filling temperature of quartz of BK14 ranges from 235 to 275℃, and the salinity ranges from 1.2 to 3.6% NaCl equiv.

4) Mining Activity

Tuba Prospect has been mined during pre-War days for gold and silver. Remnants of concrete foundations of old mine facilities are still in the area. An abandoned mine road, about 13 km long connects the property to Tagkawayan to the south and about 20 km logging road from Barangay Malibago, Labo to the north. Three shafts are found in the area, gold panners were recovering free gold from the detrital river deposits and soil.

1-4-3 Mineral deposit and Alteration zone in the Labo Valley

(1) Binangkawan Alteration zone

1) Location

The alteration zone is located at a tributary of Binangkawan Creek within the jurisdiction of Barangay Baay, Labo, Camarines Norte. It is within UTM Coordinates of 467250 E, 1553300N

2) Accessibility

The area is at five to six kilometers aerial distance from Barangay Baay following an old logging road along Labo River toward upstream.

3) Description

The zone is distributed along the banks of Binangkawan tributary headstream. Moderately weathered dacite porphyry hosts the hydrothermal alteration. The altered rocks are generally moderately weathered dacite and milky-white to orange/reddish brown argillized rocks with gray patches of pyrite dissemination. The alteration extends to a length of ±500 m and ±15 m wide with pinch and swell characteristics.

4) Mining Activity

There were no mining activities in the area, although some prospectors worked within the vicinity seven years ago according to the report by the residents in the area.

(2) Taktak Alteration zone

1) Location

The alteration zone is in the upper basin of Taktak River in Barangay Baay. It is at the center of UTM coordinates 1554111-1553799 N and 467742 - 467117E.

2) Accessibility

The area can be reached by foot trails from Barangay Baay crossing the main Labo River, thence, southwestwardly through a rugged and rolling terrain approximately 8 kilometers of gruelling hike before reaching the junction of Gibabayong and Taktak Rivers. To the right of Taktak River going upstream, a former logging road was used to traverse the reforested areas of Barangay Baay through its boundary with Quezon province.

3) Description

An argillization hosted by porphyritic plagioclase andesite was observed in the area. The argillized rock is accompanied by abundant pyrite stringers. Altered mineral assemblage is quartz-kaolinite-smectie±pyrite (LD04 and LD06,JICA and MMAJ,2001). The strong silicified tuff with pyrite dissemination (LD05, JICA and MMAJ, 2001) contains Au; 75ppb, Ag; 1.2 ppm and V; 378ppm.

4) Mining Activity

There is no record of any form of mining activity in the past time and at present according to the local residents in the area.

(3) Bilas Alteration zone

1) Location

The alteration zone is situated in the jurisdiction of Barangay Baay, Labo, Camarines Norte. It is at around 5 kilometers south from the barangay center.

2) Accessibility

The area is accessible only by a few hours hike from Barangay Baay. Baay is accessible by a road from the town proper of Labo after passing Barangay Tulay na Lupa.

3) Description

Bilas is underlain by dacitic pyroclastic. The alteration zone is small and confined along a trail going down to the streambed. Northsouth trending vertical veinlets of hematite or limonite were observed in argillized rocks. Remnants of biotite, quartz and hornblende were still evident. The mineral assemblage is kaolinite-smectite (LP01, JICA and MMAJ, 2001). On the streambed itself are outcrops of matrix-supported tuff breccia grading to lithic tuff and fine tuff. The color varies from light gray to reddish brown. The alteration seems to be formed by combination of steam heated alteration and later deep weathering.

4) Mining Activity

There are no mining activities in the area.

(4) Magasawang Bato Alteration zone

1) Location

The area is situated between the boundaries of Barangay Baay and Barangay Pagasa, Labo, Camarines Norte.

2) Accessibility

The outcrops can be accessible by hike from the Baay Barangay. Baay can be reached by a road from Labo after passing through Tulay na Lupa.

3) Description

The Susungdalaga Volcanics underlies the area. The volcanic rocks are strongly argillized and silicified, giving it a mottled white and gray color. The dominant clay mineral is kaolinite (LP02 and LP04, JICA and MMAJ, 2001). Relicts of pyritization are evident in the silicified rocks.

The prominent rock edifices in the area are rounded hilly knobs of altered volcanic rock. These are red to brown in color and devoid of vegetation. Large volcanic boulders with the same alteration are distributed in the riverbed. The alteration zone extends for more than 300 meters from banks of Labo River. The alteration seems to be the cause of steam heating.

4) Mining Activity

Local residents reported that the area has been mined briefly for clay and sold to local ceramic manufacturers.

(5) Benit Occurrences

1) Location

The alteration zone is in Barangay Benit, Labo, Camarines Norte. It lies about 5km west-south-west from Labo town proper.

2) Accessibility

4-WD-vehicle can reach the small alteration zone all the way from Labo. A group of small houses along the road hides the gold panning sites and altered rocks of Benit.

3) Description

The clastic members of Universal Formation underlie the area. These consist of steeply dipping eastwest trending calcareous sandstone and shale. These rocks are mostly argillized and moderately pyritized. Deeply weathered portions dominate the rock face near the surface.

There is no visible mineralization on the surface, but muck material from small tunneling operations by prospectors yields vein materials of gray quartz coated with chrysocolla, malachite and chalcocite (LP09, JICA and MMAJ, 2001). Euheral wollastonite crystals are found in some of the altered clastic facies. It may indicate a expected contact metasomatic origin. Two samples accompanied by abundant Cu oxides minerals contain Au; 4.3ppm, Ag; 146ppm and Cu; 20.3% (LP09,JICA and MMAJ,2001), and Au; 23.4ppm, Ag; 92.2ppm, and Cu; 2.78% (LP10,JICA and MMAJ,2001) respectively. Aside from Cu-oxides minerals, chalcopyrite, chalcocite, and electrum were observed as ore minerals, and as gang minerals, quartz and garnet were observed under microscopy of polished thin sections.

4) Mining Activity

The area has been actually mined before the World War II by an American company for a few years and continued for some years thereafter. The local people reported that the company has applied underground mining before it finally stopped operations in the 1960's. Today, a small group of high graders uses hydraulicking and sluicing to gather small grains of gold. Their production was never divulged to the survey team. It was reported that the grade was reportedly highly variable. About a hundred miners worked in the area in the middle part of the 1980's. The main trend of the mineralization is roughly northsouth as refered from the workings of the miners.

1-4-4 Mineral deposit and Alteration zone in Exciban-Larap Area

(1) Exciban-Larap Occurrences

1) Location

The alteration zone is located in Barangay Exciban, Labo, Camarines Norte. It lies about 45km northwest from Diet city and 26km northwest from Labo town proper.

2) Accessibility

The area is situated at about 2km north of the national highway via Labo on the way from Diet to Manila .

It can be reached by 4-WD -vehicle. In the area, survey was carried out on foot.

3) Description

Universal Formation, Eocene, underlie the area. The geology consists of conglomerate, medium to coarse grain arkose sandstone, tuffacious siltstone, calcareous shale, and greywacke. JICA and MMAJ (1999) reported that the gold mineralization was observed along a shear zone or a quartz vein of shear zones, hosted by conglomerate, sandstone, and shale. Alteration zone is silcified and argillized, and altered epidote and chlorite were observed. In the area, there are lots of mineral occurrences and mines such as Larap Mine which has produced iron ore. Intrusion of granite, and mineralization of Mo and Cu were observed in Larap Mine. Gold mineralization with quartz vein hosted by Pliocene Larap volcanics of Universal Formation is known in Exciban Mine. James,L.P. and Fuchs,W.A.(1999) reported maximum of 19g/t Au at around 100-150m deep for gold-copper-tellurium mineralization from the result of exploration in Exciban. As ore minerals, mainly pyrite, and a little spharelite and galena assembling with Bi-Ti minerals were reported. A small amount of As was reported. In consideration of occurrences and minaral assemblage of the deposit in whole area, a vein-type gold-base metal deposit and/or a mesothermal vein-type gold deposit which can be observed in and around porphyry copper deposit are expected.

4) Mining Activity

Some small scale mining activities and drilling targetting gold are seen around Larap Mine and Exciban Mine at present.