REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE BICOL NORTH AREA, THE REPUBLIC OF THE PHILIPPINES

PHASE Ⅱ

MARCH 2001

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 and entrusted to 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 Philippines a survey team headed by Mr. Kazuo Ito from December 8, 2000 to December 23, 2000.

The team exchanged views with the officials concerned of the Government of the Republic of Philippines and conducted field surveys in the Bicol North Area. After the team returned to Japan, further studies were made and the present report has been prepared.

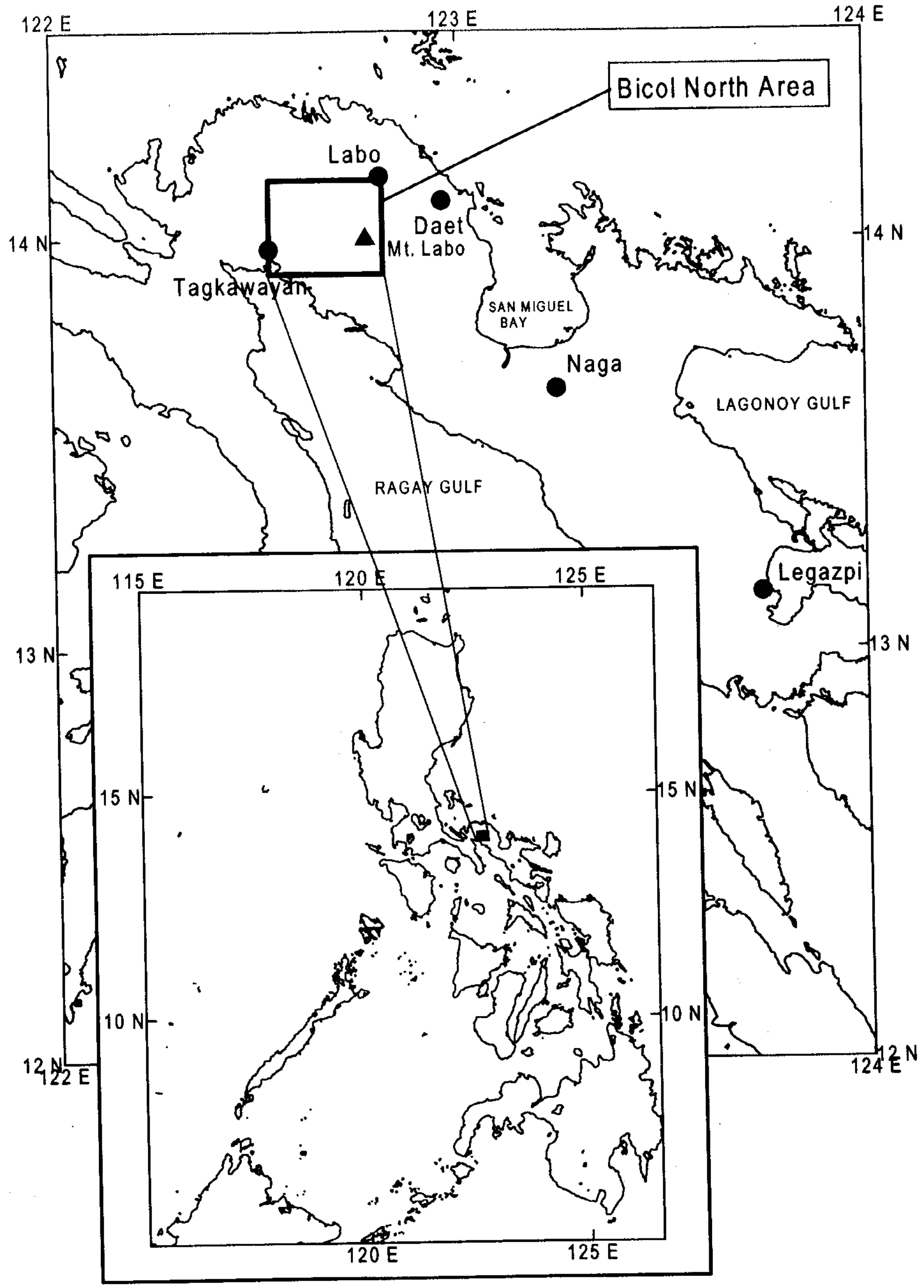
We hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

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

March, 2001

Kunihiko Saito
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan



Location Map of the 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 interpretation of geophysical data, geological traverse and mapping, and geochemical prospecting of stream sediments are conducted in this Second Phase Program. The airborne magnetic and radiometric data were only acquired in the First Phase survey.

The main part of the survey area belongs to the central zone, one of three geologic zones in Bicol area, that is covered mainly by the Pliocene to Pleistocene volcanics. The area near Labo town consists of Paleogene sedimentary rocks, and the west and southwest parts are underlain by the ophiolite sequence and Cretaceous sedimentary rocks. Those areas belong to the northeast zone and the southwest zone.

No active mines are present in the 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 near from Labo town.

In the survey area, there are many alteration zones including the alteration haloes of Nalesbitan deposit and Tuba deposit. The most pervasive alteration zone is situated along the Kilbay River's tributaries of the southern flank of the Susungdalaga Mountains. The west side accompanies high temperature hot springs, recent sinter terrace and sericite argillization with quartz-calcite veins. It means that this zone is formed by low-sulfidation system and is related to the active Labo geothermal field on the southwest flank of Mount Labo. The west side, Layaton Malaki–Maniknik -Baliwag area, provides a dominance of a silicified rock with partly vuggy texture containing alunite and enargite. This zone may have been produced by a high sulfidation system in relation to Pliocene volcanic activity. The Katakian alteration zone south of Tuba deposit has a potentiality for a skarn-type contact metasomatic mineralization related to plutonic bodies or mesothermal vein-type mineralization such as Tuba. Some small alteration zones contain kaolinite argillization and possible steam heated alteration, and it may indicate the upper parts of the epithermal system.

In the geophysical interpretation, it has been on identifying the units based on a combination of their distinctive geophysical characteristics, and the geophysical data outline the northwest trending fault system hosting the mineralisation - alteration system. The gamma-ray spectral data, in particular potassium, outline other areas of alteration in the study area. These possible alteration zones almost overlap with the geologically mapped alteration zones.

In the geochemical investigation, Au anomalies are recognized in Nalesbitan-Tuba, Katakian and Alawihaw. As anomaly in Nalesbitan extends eastward to Salobosogin-Yakalan, related to northwest trending faults delineated by airborne geophysical survey. Mo anomaly zones are delineated Nalesbitan and Maniknik-Layaton-Malaki. These alteration zones accompany a broad high potassium anomaly.

The six promising areas for further exploration assessed from these results are Maniknik-Layaton, Susungdalaga, Katakian, Salobosogin-Yakalan, Alawihaw, and Binangkawan-Taktak.

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Part I General Remarks

Part I General Remarks

Chapter 1 Introduction

1-1 Background of the Survey

The Republic of the Philippines is a country rich in mineral resources, producing gold, copper, nickel, chromite, etc. It has a high potentiality for porphyry copper deposits and hydrothermal deposits accompanying volcanic arc activity. The Philippines was one of major gold-copper producers in 1970s, but recently production has slumped because of depletion of ore body, delays for expansion, and few developments of new mines in spite of its high potentiality.

One of the causes was the insufficiency of foreign capitals for mining industry such as exploratory works due to legal restrictions. To get out of the situation and to promote the investment of foreign capital and activate domestic mining industry, the government of the Philippines was making effort of introducing foreign capital by the execution of Philippines Mining Act of 1995. However, the foreign investment has temporarily increased in accordance with the execution of the act, the investment for mining industry has not yet been activated due to proceeding depression.

Under the above circumstances, the cooperative exploration with Japanese government, "Regional survey for mineral resources in the Bicol Area (JICA and MMAJ, 1997-1998)", was carried out at the request of the government of the Philippines. Resulting from the exploration, one of promising areas, which is the Bicol North Area, was selected for this cooperative mineral resources exploration project.

In response to the request, on July 21, 1999, the "Implementing Arrangement (I/A)" was signed by Mr. Toshihiko HAYASHI of the Metal Mining Agency of Japan, and Mr. Horacio C. RAMOS, Director of the Mines and Geosciences Bureau of the Department of Environment and Natural Resources.

1-2 Outline of the First Phase Survey

The airborne magnetic and radiometric data were obtained in the First Phase survey. The objective of this phase survey is to clarify the geological structure and units and to select the possible alteration zones. The area for the airborne survey is shown on Fig.II-1-1. The airborne data were acquired by Fugro Airborne Surveys and its specification is as follows:

(Airborne survey specification)

Flight line spacing: 200m
Flight line direction: North-South
Tie line spacing: 1000m
Tie line direction: East-west
Sensor height: 80 m
Magnetometer sample interval: ~5 m
Magnetometer cycle rate: 0.1second
Magnetometer resolution: 0.001 nT
Radiometric sample interval: 40~50 m
Radiometric cycle rate: 1 second
GPS cycle rate: 1 second

The interpretation of the obtained data in combination with the Landsat imagery is made in this report.

1-3 Overview of the Phase II survey

1-3-1 The objective of the survey

The objective of the survey is to find out new mineral deposits by investigating into geological conditions, gold-copper mineralization and alteration, geochemical characteristics, and airborne geophysical study in the Bicol North Area of the Republic of the Philippines.

1-3-2 Survey Area

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 of southeastern Luzon. The famous Labo Volcano (inactive) is situated in the east part of this area.

1-3-3 Survey Method

The images and resultant geological, geochemical and geophysical maps are all based on the UTM (zone51N) and Luzon11 datum.

(1) Interpretation of the airborne geophysical survey data

Interpretation of airborne geophysical survey data (aero magnetic and aero radiometric data), which was acquired in the first phase program, has been conducted for determining geological units and structure, and selecting possible alteration zones.

(2) Geological and geochemical survey

The geological traverse and mapping was conducted along the main drainages for the purpose to determine the local geologic conditions, alteration zones, mineral occurrences, etc. The geochemical sampling was also carried out in the whole area for the purpose to delineate the mineralized zones.

1-3-4 Personnel of survey mission

Planning and Coordination

Japan		
	Toshihiko Hayashi	Metal Mining Agency of Japan
	Keita Kanda	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

Table I-1-1 Contents of the Survey

(1) Amount of the Survey

Item	Covering Area
Geological and geochemical survey	
Whole area	750 km^2
(Geochemical survey)	(460 km^2)
Traversed length	300 km

(2) Laboratory Test

Item	Quantity
Geology and geochemical survey	
Thin sections	48 pieces
Polished thin sections	30 pieces
X-ray diffraction examination	105 samples
Chemical analysis	
Ore samples (Au, Ag, Cu, Pb, Zn)	31 samples
Geochemical stream sediments samples (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, Tl, Ti, W, U, V, Zn, Au)	289 samples
Geochemical stream samples (BLEG) (Au, Cu)	35 samples
Fluid inclusion (Th and salinity)	5 samples
Whole rock analysis (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)	13 samples
K-Ar age determination	12 samples

1-3-5 Period of the survey

The field survey of the second phase survey was carried out according to the following schedules.

Geological and geochemical survey:

December 8, 2000 to December 23, 2000 (16 days)

Chapter 2 Geography of the Survey Area

2-1 Location and Accessibility

The Bicol North area locates 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 locates on 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 on 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.

Several local roads connect between villages and national highways, but most of those roads have not been paved and they become muddy and often collapsed during rainy season. There is no road connecting between the different drainage systems, therefore the survey teams accessed to the survey area from two base camps set in Labo and Tagkawayan.

2-2 Topography and drainage system

The Mount 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 central portion 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 consists of gentle hills. A nearly flat plain spreads in the south of the survey area.

The survey area is divided into three river basins: Labo River, Bosigon River, and Kilbay River. The Labo River and the Bosigon River basins cover the northern half of the survey area and both rivers run northward, while the Kilbay River basin covers the southern half. The 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.

2-3 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 occurrence of tropical cyclone.

The area is covered by thick vegetation because of the abundant rainfall. 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 Mount Labo. The agricultural fields (see mosaic portion of pink and yellow-green in color on Fig. II-1-1) are sporadically found even in the secondary forest in the Susungdalaga Mountains. The lowland and fluvial plain are mostly used for agriculture.

Chapter 3 Summary of the geology

The Bicol Area can be divided into three zones parallel in the direction, which are the northeast zone, the central zone and the southwest zone in accordance with the previous regional survey. The northeast zone and the southwest zone are underlain by Cretaceous basement rock with intrusion into it of Tertiary diorite bodies. Those basement rocks in the southwest zone are overlain by late

Tertiary sedimentary rocks. The central zone is covered widely by recent young volcanic rocks (JICA and MMAJ, 1999).

The mineral occurrences and deposits of porphyry copper-type, skarn-type, mesothermal vein-type, and volcanogenic massive sulfide-type mineralizations, occur in the northeast zone. The skarn-type deposits occur in the southwest zone. In the central zone, there are some deposits and mineral occurrences of epithermal mineralization.

The main part of the survey area belongs to the central zone that is covered mainly by the Pliocene to Pleistocene volcanics. The area near Labo town in the northeast of the survey area mainly consists of Paleogene sedimentary rocks, and the west and southwest part of the areas are underlain by the ophiolite sequence and Cretaceous sedimentary rocks. Those areas belong to the northeast zone and the southwest zone.

The survey area is chiefly underlain by the Late Cretaceous to Neogene sedimentary and volcanic rocks from below to upward: the Upper Cretaceous Tigbinan Formation in the west of the survey area, the Paleocene–Eocene Universal Formation in the northeasternmost of the area near Labo Town, the Lower Miocene Bosigon Formation in the lower part of Labo Valley and Bosigon Valley, and the Upper Miocene Macogon Formation and Susungdalaga Volcanics widely covering the central part of the survey area. The Pleistocene Labo Volcanics covers conformably the Pliocene rocks around Mount Labo in the east of the area.

Chapter 4 Summary of the Result of the Survey

4-1 Geologic structure, mineralization characteristics and control of the mineralization

Field mapping, interpretation of airborne magnetic data, and digital terrain model show the dominance of northwest~west-northwest trending structures in the main part of the survey area belonging to the central zone. This trend is almost parallel to the WNW trending Legazpi Lineament situated in the south of Bicol Peninsula, and these structures accompany most of mineralization and alteration zones in the survey area.

Though no active mine is present in the survey area, 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 in the northeasternmost of the area. The mineralization of Nalesbitan is centered on a hydrothermal breccia in a dilational jog related to a northwest striking, sinistral strike-slip fault zone, with pervasive chalcedonic silicification and lack of vuggy residual silica.

In the survey area, there are many alteration zones besides the alteration haloes of Nalesbitan deposit and Tuba deposit.

The most pervasive alteration zone exposes along the Kilbay River's tributaries of the southern flank of the Susungdalaga Mountains in a corridor extending about 13 km from Alawihaw to Baliwag. It trends west-northwest and ranges 2 to 3 km wide. The east side of this zone nearby Alawihaw accompanies hot springs at high temperature, recent sinter terrace and sericite argillization with quartz-calcite veins. It means that this zone is formed by low-sulfidation system and is related to the active Labo geothermal field on the southwest flank of Mount Labo. The west side, Layaton Malaki-Maniknik-Baliwag area, provides a dominance of a silicified rock with partly vuggy texture containing alunite and enargite. This zone may have been produced by a high sulfidation system in relation to Pliocene volcanic activity.

The Katakian alteration zone south of Tuba deposit is characterized by silicification and sericitic argillization associated with quartz veins in the sedimentary rocks in the Tigbinan Formation, and it is inferred a vein-type mesothermal mineralization, which is similar to Tuba. However, the occurrences of magnetite veinlets and calc-silicate rocks nearby the intrusion of Paracale Granite may indicate a skarn-type mineralization. This alteration zone seems to be associated with northeast-trending faults rather than northwest-trending faults.

The Salobosogin-Yakalan alteration zone about 2 to 3 km east of the Nalesbitan deposit yields floats of vuggy chalcedonic quartz and is associated with northwest-trending fault. It appears that this zone is situated on the same geologic setting with Nalesbitan.

Other small alteration zones are observed around upperstream of Labo River. Some of these are accompanied by kaolinite argillization and possible steam heated alteration rocks. It may indicate the upper parts of the epithermal system.

4-2 Interpretation of the airborne geophysical survey

Interpretation of airborne geophysical data and supporting Landsat imagery has enabled discrimination of the various volcanic packages within the survey area. The interpretation has focussed on the delineation of units based on their geophysical signature in both the magnetic and gamma-ray spectral data, and assignment of these units within the broad stratigraphic framework for the area.

The presently inactive volcano, Mount Labo, in the east of the area comprises a number of volcanic units with varying geomagnetic characteristics and which broadly equate with the mapped volcanic units. In the west, the Susungdalaga Volcanics are magnetically similar and probably represent the eroded roots of an older volcanic system, within which possible eruptive centres have been identified.

In the north, the probably older and weakly deformed volcanics of the Macogon Formation host the high-sulfidation Nalesbitan gold mineralisation, this represents the only significant mineral occurrence within the survey area. The geophysical data outlines the northwest-trending fault system hosting the mineralisation-alteration system, although not the mineralised faults themselves, as well as the broad potassic anomalism associated with the halo of argillic alteration. The resolution is not sufficient to delineate either the specific ore-hosting faults or ore-associated alteration.

The gamma-ray spectral data, in particular potassium, outline other areas of alteration in the study area. These possible alteration zones almost overlap with the geologically mapped alteration zones and include broad areas, presumably of pervasive alteration, situated in a corridor extending from the Alawihaw to Baliwag alteration zone, and more-focussed fault and hot spring-related alteration on the flanks of Mount Labo.

In the west of the pervasive alteration zone on the southern flank of the Susungdalaga Mountains, high potassium gamma-ray spectral values extend northward and northwestward. The area is coincident with an older eruptive center inferred by geomagnetic interpretation. This area has potentiality for high sulfidation mineralization.

The potentiality of porphyry Cu deposit is not clear because of no geologic evidence in the field. It is inferred by geophysical interpretation that Pliocene volcanic edifice still preserves in the Pliocene Susungdalaga Vocanics. Therefore, the erosional level of Pliocene rocks may be not deep enough to expose porphyry Cu system, even the upper alteration halo.

4-3 Geochemical characteristic

The Au anomalous values of the stream sediments samples are recognized in the following areas: Nalesbitan-Tuba mineral occurrences, the Katakian alteration zone and the Alawihaw alteration zone. It is seemed that, even though considering the contamination of mining activity and the location of samples, the original anomaly of Nalesbitan and Tuba may also extend widely around this area.

The sulfur anomaly zones, which may correspond to the volume of pyrite in the alteration zone, are around Nalesbitan, Tuba, Katakian, Alawihaw, Layaton-Maniknik, and Kampusta alteration zones.

The Mo anomaly zones are delineated at Nalesbitan area and the Maniknik alteration zone. The anomalous high Mo value in the Nalesbitan lodes were also reported by Sillitoe et al. (1990) and they suggested that acid-sulfate-type lode deposits containing Mo suite are characteristic of the upper part of porphyry Cu system. The Mo anomaly in Maniknik may support the possibility of the same type of mineralization as Nalesbitan in this alteration zone.

The anomaly of the mobile elements such as Sb, As and Hg are often characterized the upper part of the epithermal systems. The anomalous values concentrate in the following areas: Nalesbitan, Tuba and the area around Alawihaw. The As anomaly in Nalesbitan extends eastward to the Salobosogin-Yakalan alteration zone. It may indicate that there is possibility of existence of the similar mineralization to Nalesbitan-type considering the geological setting. The anomalous values of Sb, As and Hg are scattered in the upperstream of Kilbay River and the upperstream of Labo River.

The Z01 negative scores of PCA outline the anomalies of Au related pathfinder elements. The areas are Nalesbitan, Tuba, Katakian, Maniknik-Layaton, and the area around Alawihaw. The anomaly of the Katakian alteration zone extends broadly downstream in particular.

4-4 Selection of promising areas

The targets in the survey area are epithermal to mesothermal gold±copper mineralizations. As the promising areas for further exploration, extensive alteration zone, geochemical anomaly of gold related elements, and broad high potassium gamma-ray spectral zone are overlapped. In addition, the existence of the related plugs and domes are necessary for the high sulfidation or porphyry Cu mineralization. The following areas are consistent with above factors: the areas around Nalesbitan, Katakian, Maniknik-Layaton Malaki, and Alawihaw. In addition, the Salobosogin-Yakalan alteration zone, the Susungdalaga Area and the Binangkawan-Taktak alteration zone are included in these promising areas. Because the Salobosogin-Yakalan alteration zone has a broad high potassium anomaly and geochemical As anomaly. The Susungdalaga Area includes broad high potassium anomalies and inferred older volcanic eruptive center that may have been possible fluid source of the pervasive alteration of Kilbay River. No geochemical anomaly is detected in this area, but the density of geochemical samples is very low. Binangkawan-Taktak alteration zone which has a overlapping of kaolinite-smectite aleration zone and high potassium anomaly with an intersecition of NW trending structure and circular feature of the inferred Susungdalaga volcanic edifice determined by geophysical survey, but no remarkable geochemical anomaly, is also promising.

Nalesbitan has been already evaluated by many mining facilities, therefore any further exploration is no longer necessary in this project. The characteristic of these areas except Nalesbitan are described as follows:

(1) **Katakian Alteration Zone**

The alteration zone extends in the area of Cretaceous Tigbinan Formation and Pliocene Sta. Elena Formation. The Paracale Granite intrudes to the west of this zone on a large-scale, and the inferred another body intrude to the east of the area. The filed mapping is described silicification and sericitic argillization with quartz veins and abundant disseminated pyrite. Magnetite stringers and calc-silicate rocks is found on some outcrops. The geochemical anomaly of Au is detected and the anomaly of Au related elements extends broadly to downstream. The type of mineralization appears a skarn-type contact metasomatic mineralization related to plutonic bodies or mesothermal vein-type mineralization such as Tuba.

(2) **Maniknik-Layaton Malaki Alteration Zone**

The pervasive silicification in Pliocene Susungdalaga Volcanics is observed in this zone. The silicified rocks are accompanied by possible vuggy silica containing enargite in vugs and abundant alunite. These evidences show that this silicified zone was formed by typical high sulfidation type mineralization. The geochemistry of stream sediments reveals the anomaly of Au related elements and Mo in this area.

(3) **Susungdalaga Area**

The area is defined by broad high potassium gamma-ray anomalies extending from the Maniknik-Layaton alteration zone to north by 5 km. An inferred older volcanic eruptive center are expected resulting from airborne geophysical survey. No geochemical anomaly is detected in the stream sediments samples, but abundant silicified floats bearing Au were reported at Tonton River neighbor on the north of Baliwag Creek by JICA and MMAJ (1999). There is a possibility of high sulfidation mineralization in this area. Usually the potentiality of high sulfidation tends to become higher toward a volcanic center because of its necessity of the injection of magmatic fluid to the hydrothermal system. It has also a possibility that the pervasive alteration zone at the south flank of Susungdalaga Mountains was formed by a hydrothermal flow from this area.

(4) **Salobosogin-Yakalan Alteration Zone**

This alteration is related to northwest trending faults set cutting the Macogan Formation. The broad high potassium gamma-ray anomaly zone is also detected along northwest trending faults delineated by airborne geophysical survey. Abundant silicified floats similar to those of Nalesbitan are observed along its creek, but the distribution is not clearly known. Only As anomaly is detected from stream sediments. This area may be expected a Nalesbitan-type mineralization associating with a dilational jog of fault system.

(5) **Alawihaw Alteration Zone**

The sericitic argillization and partly silicification in Pliocene Susungdalaga Volcanics are observed in this area. These rocks contain quartz veins and dissemination of pyrite. Hot springs at high temperature and recent silica-carbonate sinter terrace are also found in the alteration zone. It indicates that this alteration zone is formed by low-sulfidation system, and at least a part of this alteration zone is related to the active Labo geothermal field on the southwest flank of Mount Labo. The geochemical anomalies of Au, Cu and As are detected around this alteration zone.

(6) **Binangkawan-Taktak Alteration zone**

The details have not yet been known. But this area has a overlapping of kaolinite-smectite alteration zone and high potassium anomaly but no remarkable geochemical anomaly. An intersection of NW-trending structure and circular feature were determined by geophysical survey.

This area is also interested.

The potentiality of other small alteration zones is briefly described as follows:

The area around Tuba deposit shows remarkable prominent geochemical anomaly by inferred contamination of small-scale mining activity, but no high potassium gamma-ray zone indicates the area is confined in a small area.

The Magasawang Bato alteration zone in the upper stream of Labo River shows no significant geochemical anomaly and lack of high potassium gamma-ray anomaly, but kaolinite argillization and possible steam heated alteration may indicate the upper parts of the epithermal system. In any case, this area becomes low priority: thereby this area shows as dotted boxes in Fig.II-4-1.

Chapter 5 Conclusion and Proposal for the Third Phase Exploration

5-1 Conclusion

The interpretation of geophysical data, geological traverse and mapping, and geochemical prospecting of stream sediments are conducted in this Second Phase Program. The airborne magnetic and radiometric data were only acquired in the First Phase survey.

The main part of the survey area belongs to the central zone of three zones in Bicol area that is mainly covered by the Pliocene to Pleistocene volcanics. The area near Labo town consists of Paleogene sedimentary rocks, and the west and southwest parts are underlain by the ophiolite sequence and Cretaceous sedimentary rocks. Those areas belong to the northeast zone and the southwest zone.

In the field survey, many alteration zones are revealed including the alteration haloes of Nalesbitan deposit and Tuba deposit. Some parts of these alteration zone contains low- and high-epithermal, mesothermal vein-type, skarn-type mineralizations. The geochemical exploration is also revealed the geochemical haloes and anomalies related to these alteration zone.

In the geophysical interpretation, it has been on identifying the units based on a combination of their distinctive geophysical characteristics and possible eruptive centers are estimated in the Pliocene volcanics. The gamma-ray spectral data, in particular on potassium, outlines other areas of alteration in the study area. These possible alteration zones almost overlap with the geologically mapped alteration zones.

The following six promising areas for further exploration and its possible type of mineralization are selected from the results of this phase survey:

Katakian Alteration Zone – skarn-type or mesothermal vein-type deposits
Maniknik-Layaton Alteration Zone – high sulfidation epithermal deposits
Susungdalaga Area – high sulfidation epithermal deposits
Salobosogin-Yakalan Alteration Zone – high sulfidation epithermal deposits
Alawihaw Alteration Zone – low sulfidation epithermal deposits
Binangkawan-Taktak Alteration Zone-high or low sulfidation? epithermal deposits

5-2 Proposal for the Third Phase exploration

This second phase survey in the Bicol North area is, practically, the reconnaissance survey at a grass-route field due to its density of geologic mapping and geochemical sampling. Significant mineralization zones, where the drilling survey would be immediately necessary, have not been presently discovered, therefore further detailed geologic and geochemical survey are still necessary in the selected promising areas for the purpose of the decision for the drilling targets. The proposed third phase survey is as follows:

(1) Maniknik-Layaton Alteration Zone and (2) Susungdalaga Area

These areas have potentialities 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, 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, detailed geologic 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 argillic zone surrounding silicified rock contains highly sulfide minerals, whereas silicified rock around vuggy silica, formed by the fluid descending temperature, shows high to medium resistivity and contains a little sulfide minerals. Therefore, it may be possible to detect the contrast by IP survey between both.

(3) Katakian Alteration Zone

This alteration zone appears 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 argillic zone and geochemical anomalies will be determined by detailed mapping and geochemical work including detailed stream sediments sampling. Once the mineralization zones will be specified, grid soil sampling will be effective to decide the drilling target.

(4) Salobosogin-Yakalan Alteration Zone

This area has potentiality of Nalesbitan-type high sulfidation mineralization accompanied by silicified breccia. Only smectite dominant argillization crops out, many silicified boulders including some vuggy texture accumulate along the stream. Thereby, firstly the detailed 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 few to 10 meters intervals at 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 this zone may only expose the shallow part of the system.

(5) Alawihaw Alteration Zone

It seems that this 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 to study a shallow system. The simultaneous detailed geologic mapping and rock-chip geochemical survey are recommended to specify the further promising area, then grid soil sampling will be carried out for the purpose of the decision of the drilling target.

However, the geothermal condition, the existence of hot springs at ~80℃, may interfere with the further survey including drillings.

(6) Binangkawan-Taktak Alteration zone

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

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 Area can be divided into three zones: the northeast zone, the central zone and southwest zone (JICA and MMAJ, 1999). The central zone represents the volcanics of the Philippines Arc and is underlain by young volcanic rocks, while the northeast zone and southwest zone respectively consist of older units, ophiolite complex, Mesozoic sedimentary rocks and Tertiary sedimentary and volcanic rocks, with intrusions of Tertiary diorite bodies.

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

The survey area is chiefly underlain by the Late Cretaceous to Neogene sedimentary and volcanic rocks: the Upper Cretaceous Tigbinan Formation in the west of the survey area, the Paleocene–Eocene Universal Formation in the northeasternmost of the area near Labo Town, the Lower Miocene Bosigon Formation in the lower part of Labo Valley and Bosigon Valley, and the Upper Miocene Macogon Formation and Susungdalaga Volcanics widely covering the central part of the survey area. The Pleistocene Labo Volcanics covers conformably the Pliocene rocks around Mount 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 geologic map, geologic profiles and a schematic geologic column of the Bicol North Area.

1-2 Field survey

The field work was carried out by two MGB's geologists' groups. They set base camps at Labo and Tagkawayan. Each group organized everal parties that are composed of 2 to 4 geologists and a driver with 4-wheel drive cars.

Japanese geologists did not enter the field activities because of security problem. Our base camp was set at Daet town, and the observation and interpretation of the route maps and the samples collected by MGB's geologists were carried out at Labo Base camp.

1-3 Description of geology

1-3-1 Volcanic rocks and sedimentary rocks

(1) Jurassic-Lower Cretaceous

Ophiolites

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

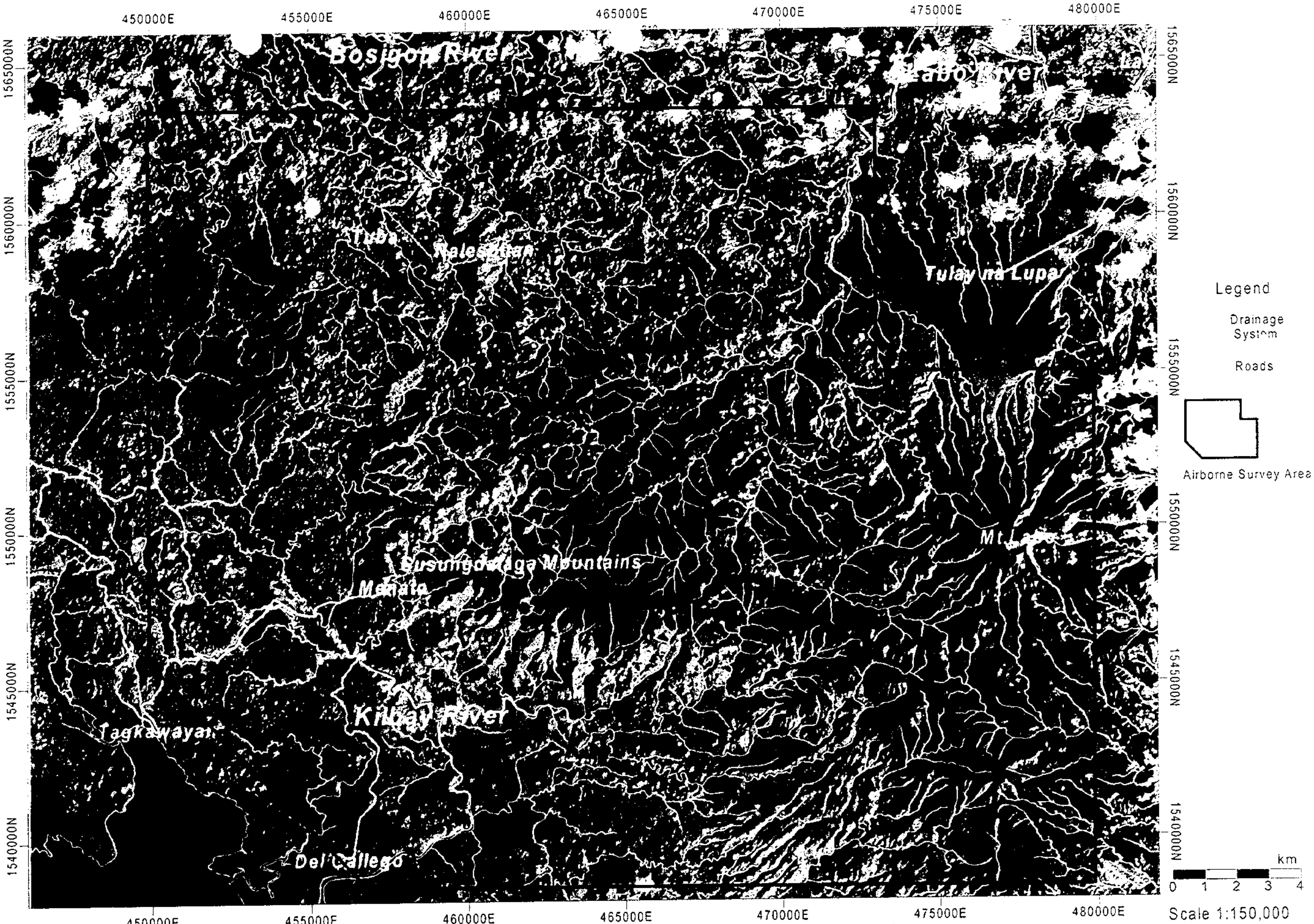


Fig. II-1-1 Landsat TM Bands 543 and L7 Pan Merged in RGB

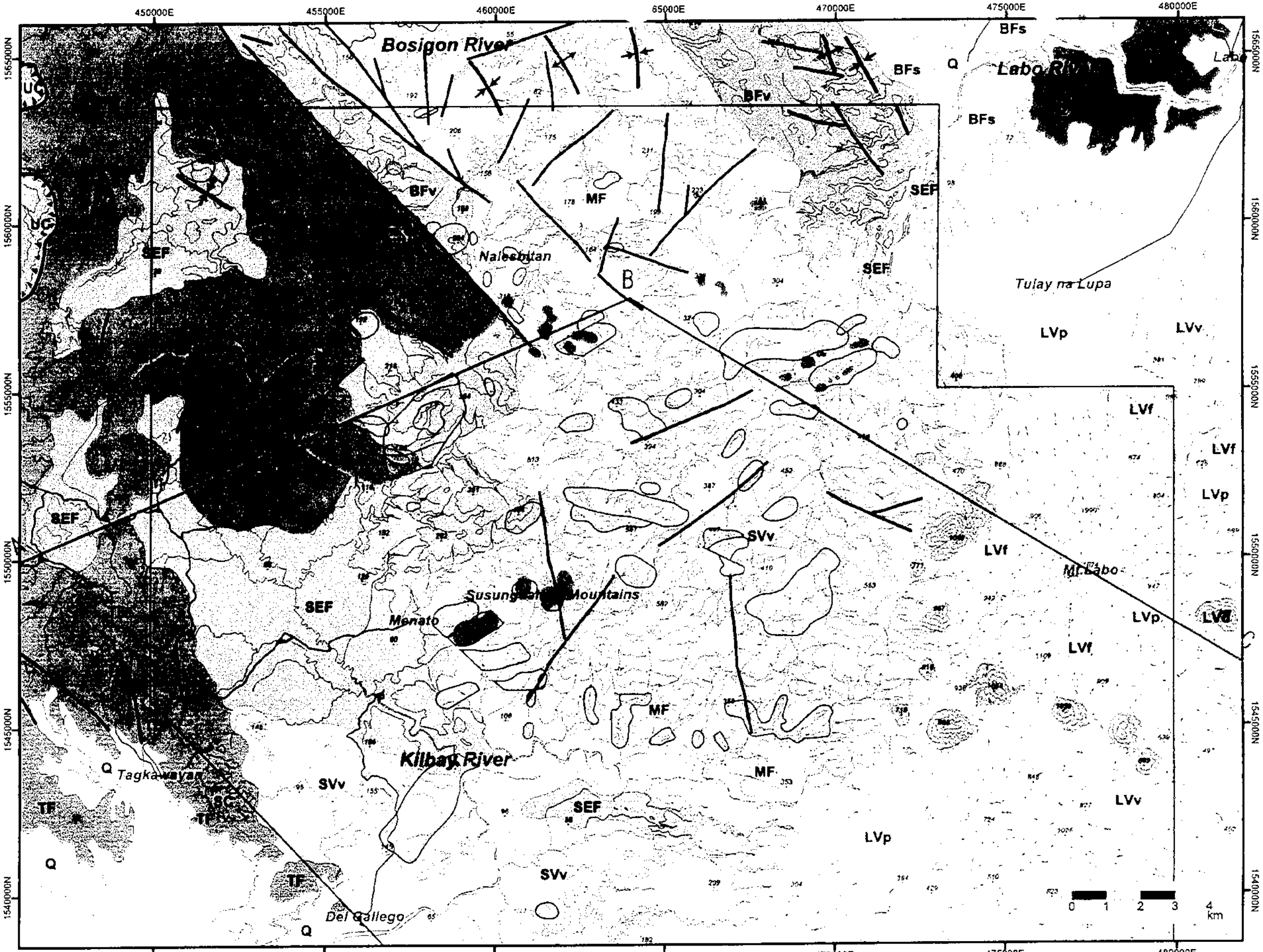
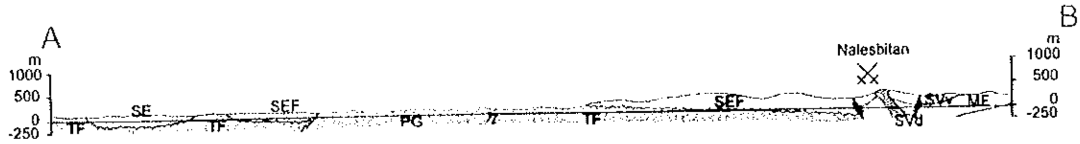
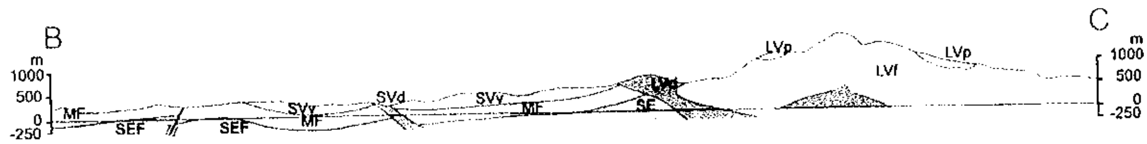


Fig.II-1-2 Geologic Map of the Bicol North Area





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
		Andesitic and dacitic plug dome
Susungdalaga Volcanics	SVf	Dacitic lava, tuff and pyroclastics
		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.		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, tuff and pyroclastic 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					
	Paleocene	UF	Universal F.	Limestone, marl and calcareous shale Conglomerate, arkose, tuffaceous and calcareous shale and graywacke		Benit Au deposits ? Tuba Au deposits
Cretaceous		TF	Tigbinan F.	Graywacke, spilite, chert, andesite, cherty limestone, black tuffaceous shale and arkosic sandstone	Ultramafic Complex	
Pre Cretaceous		SC	Schists	Green schist and quartzite		

Fig.II-1-4 Schematic geologic column of the Bicol North area

(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.

(3) Paleocene to Eocene

Universal Formation

This formation is divided into a lower member and an 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. This formation is distributed near Labo in the north-easternmost part of survey area. This formation is thought to be Paleocene to Eocene (Miranda and Caleon, 1979; BMG, 1982).

(4) Miocene

Bosigon Formation

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

This formation is recognized an upper member and a 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. This formation is considered as belonging to the early Miocene (BMG, 1982). However, United Nations (1987) distinguished this formation to be below the Universal Formation and Mitchell and Leach (1991) expressed the possibility.

Sta. Elena Formation (Upper Miocene)

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

(5) Pliocene

Macogon Formation

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

Susungdalaga Volcanics

The Susungdalaga Volcanics is defined as the volcanic unit of the 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 Mount Labo and the lower is named as the Susung Dalaga Formation. It is a mix volcanic-sedimentary unit up to 700 m in thickness, 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).

This volcanic unit is widely distributed in the center part of the survey area. The exposures in the survey area consist of mainly andesitic to dacitic lava flow and pyroclastics. The K-Ar age determination of outcropping volcanics in the Kilbay River gives Pliocene ages (JICA and MMAJ, 1999).

(6) Pleistocene

Labo Volcanics

This volcanic rock is named by Miranda and Caleon (1979). It widely covers the area in and around Mount 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 south-western flank of Mount Labo
- Central cone of pyroxene andesite, hornblende andesite and dacite lava, and laharic breccia, which overly the basal unit and possibly some of the 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

1-3-2 Intrusives

Paracale Granodiorite (Middle Miocene ?)

Paracale Granodiorite intruded into the Tigbinan Formation and the Sta.Elena Formation as stock and dike form. This 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. This bodied consists of quartz-diorite that is mainly composed of quartz, plagioclase and hornblende.

1-4 Structure

The fracture and fault system in two direction of NW～WNW and NE are predominant in the survey area. The northwest trending faults run through the northwestern part of the area, where the Nalesbitan and Tuba mineral deposits occur. The Nalesbitan deposit is believed to be centered on a minor dilational jog on the WNW-trending faults set (Sillitoe et al., 1990). The alteration zones extends as a EW～WNW trending corridor in the upper stream of the Kiblay River on the south of the Susungdalaga Mountains, and it may be related to the structure of this direction.

The western part of the area is cut by several NE-trending faults, and the Katakian alteration zone is situated at near these trending faults.

1-5 Mineral Occurrences and Alteration Zones

Many mineral occurrences and alteration zones occur in this area. The locations and names of these alteration zones are shown in Fig.II-1-5. The mineral assemblages checked by the X-ray diffraction analysis are shown in Fig.II-1-6 and Appendix 9.

The occurrences of each drainage system are detailed as below.

1-5-1 Mineral occurrences and alteration zone in the Kilbay Valley

(1) Alawihaw alteration zone

1) Location

Alawihaw Creek is politically a part of Barangay Bagong Silang, Del Gallego, Camarines 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 is 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-wheel drive vehicle trip from Del Gallego to Barangay Mansalaya and then a 4-hour walk on trail to the area, passing Barangay Bagong Silang.

3) Description

The silicification and argillization of a fine- to medium-grained grayish dacitic pyroclastic rock are observed from the mouth of the creek to about 500 meters upstream. 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. The dissemination of pyrite 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 upstream of the last silicified grayish outcrop, beyond this fault a jointed greenish propylitic rock crops out of the same composition. 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 exploration drilling site of the Banahaw Mining Corporation is located 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 in this outcrop, and contains abundant pyrite. It seems that this vein was a possible target of the drilling operation of Banahaw Mining. Hydrothermal brecciation is observed in the vein. This vein (KM15) contains 150ppb Au, 1.4ppm Ag, 230ppm As, 591ppm Cu, 1,355ppm Pb and 1,505ppm Zn. Pyrite, galena and sphalerite are identified by microscopy of the polished thin section. This vein is thinly enveloped by the smectite-kaolinite argillization halo (KM18 and KM19) accompanying two chalcedonic quartz-clay veins trending northeast and dipping northeast and southwest. These veins and clay are hosted by a silicified, pinkish to light grayish dacitic pyroclastics. Argillization was also noted in the wallrock as clay-altered plagioclases. Other two silicified veins, approximately 5 centimeters wide, occur in the

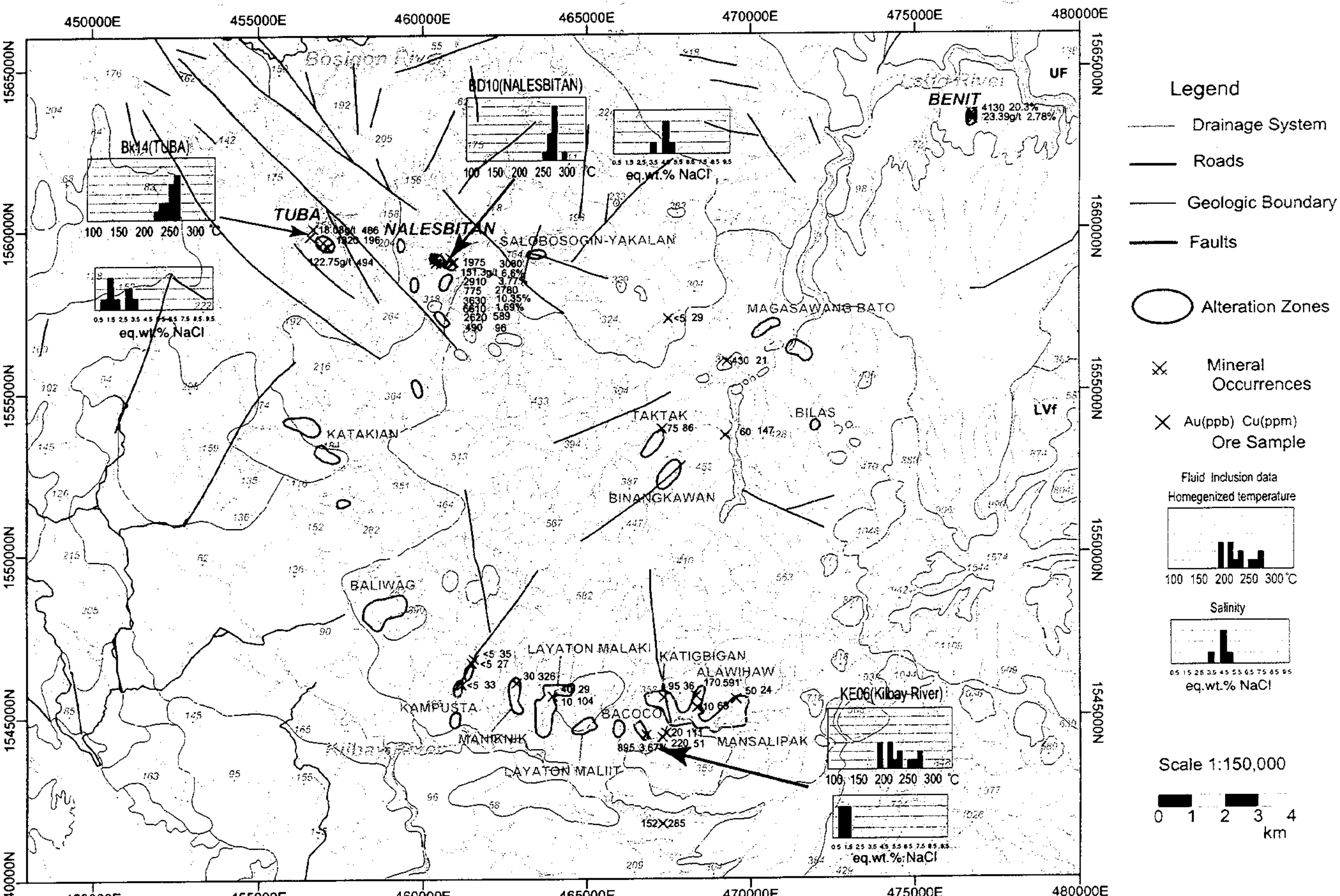


Fig.II-1-5 Mineral Occurrences and Alteration Zones

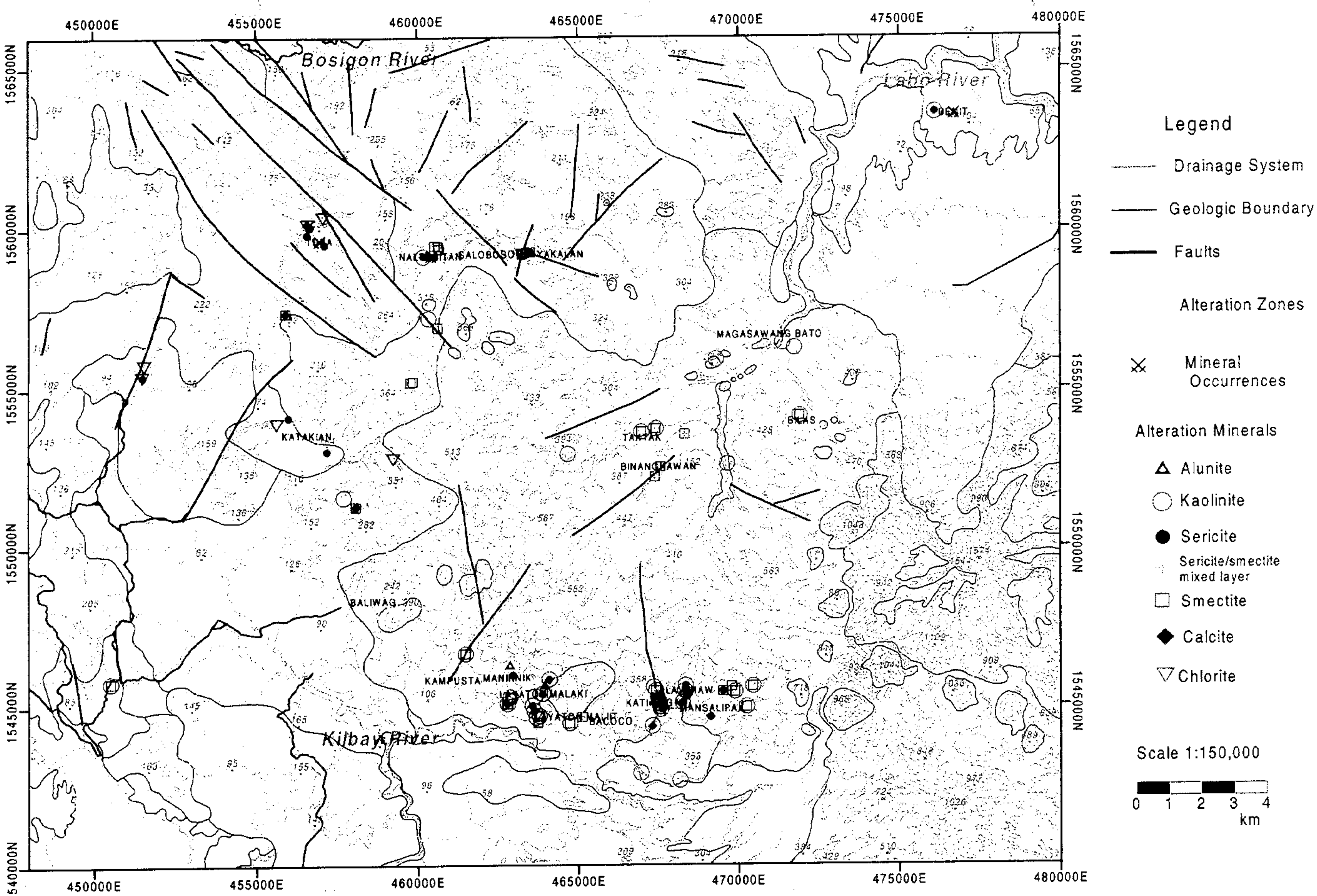


Fig.II-1-6 Distribution of Alteration Minerals by X-ray Diffraction Analysis outcrop of a few meters upstream.

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

(2) Mansalipak alteration zone

1) Location

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

2) Accessibility

Refer to the Alawihaw alteration zone

3) Description

The area is underlain by hydrothermally altered dacitic to andesitic pyroclastics of the Susungdalaga Volcanics. The alteration is confined along north-northeast trending fractures and the width of alteration varies ranging from 20 to 100 meters, depending on the permeability of the host rock. Only an argillic alteration was recognized on the outcrops. The gray to light gray clay is weathered to the white to yellowish clay in the surface. The mineral assemblages are quartz-sericite-smectite and quartz-kaolinite-smectite by the X-ray diffraction. Boulders of strongly silicified rocks are scattered in this creek, but no outcrop 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 3ppm Hg.

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

This alteration zone is observed along the Katigbigan Creek about 1.5 km west of the Alawihaw Creek. The area is centered at the UTM coordinates 467500E and 154700N.

2) Accessibility

Refer to the Alawihaw alteration zone

3) Description

The area is underlain by hydrothermally altered dacitic to andesitic pyroclastics of the Susungdalaga Volcanics. Argillization and silicification are observed along Katigbigan Creek. The mineral assemblage is quartz-kaolinite-smectite by the X-ray diffraction. Argillization occurs from the junction of main Kilbay River and Katigbigan Creek up to the hot spring situated about 350 meters from the junction. Hot spring ground lies below strongly silicified zone. The strongly silicified rock with disseminated pyrite (KC13) contains 95 ppb Au and 5.8 ppm Ag.

4) Mining Activity

The laborers reported gold panning by some people and gold exploration was active five years ago.

(4) Bacoco alteration zone

1) Location

The area is 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. Thence, from the barangay proper, one hour hike eastward towards the junction of Kilbay River and its tributary the Bacoco Creek. Access during rainy season especially when the spillway is impassable, motorized banca is used along Kilbay River to the approach in Barangay Sta. Rita I.

3) Description

The moderately argillized to slightly silicified dacitic flows of the Susungdalaga Volcanics exends in Bacoco Creek. The alteration rocks contains abundantly pyrite stringers. Floats of argillized flow breccia, cherty silica rocks and sinter are observed along the creek. MMAJ and JICA (1999) reported that the limonite stained silicified contains about 200 ppb Au and a quartz vein with 4 cm wide contains 340 ppm Au.

4) Mining Activity

There is no recorded mining activity of any form in the past and at present according to the local residents in Barangay Bagong Silang.

(5) Layaton Maliit alteration zone

1) Location

The site is a tributary of Kilbay River situated in Bagong Silang, Del Gallego, Camarines Sur. It is bounded by UTM coordinates 1,544, 447 North latitude and 464,732 East longitude.

2) Accessibility

The site is accessible by 4-wheel drive vehicle during dry season from Barangay Mansalaya through a 5.0 km barangay road going to Bagong Silang, Del Gallego. From Barangay Bagong Silang, the Layaton Maliit Creek can be reached by 30 minutes hike via logging road.

3) Description

Argillization are found in the Layaton Maliit Creek. The mineral assemblages are quartz-smectite-sericite/smectite mixed layer clay, and quartz-kaolinite-smectite by the X-ray diffraction. Length of altered exposure is approximately 400 m with occassional patches of unaltered dacite.

4) Mining Activity

No information is available, but at least there were no mining activities in the area during the time of the survey.

(6) Layaton Malaki alteration zone

1) Location

This zone is observed in Layaton Malaki Creek, a tributary of Kilbay River situated in Bagong Silang, Del Gallego, Camarines Sur. It is bounded by UTM coordinates 1,544,470 N and 463,739 E.

2) Accessibility

Refer to the Layaton Maliit alteration zone

3) Description

The dacite of the Susungdalaga Volcanics underwent argillization and partly silicification. The argillization mainly consists of an acid assemblage – pervasive kaolinization including alunite rich part. This acid zone is sandwiched between intermediate alteration containing smectite±calcite and haloes of propylitic zone in 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) and the silicified rock rich in alunite (KL13) contain 10 and 40 ppb Au, and 0.2 and 0.4 ppm Ag, respectively.

JICA and MMAJ (1999) reported that a lot of silicified and argillized rocks, including pyrophyllite-pyrite-kaolinite assemblage, were observed at the mouth of the creek. The alteration zone shifts upstream from a mixed layer clay zone to a kaolinite zone. The mixed layer clay zone is accompanied by quartz veinlets, while the kaolinite zone is accompanied by chalcedonic quartz veins. Both veins contains 200～300 ppb Au and 700～900 ppm Cu.

4) Mining Activity

There were no mining activities in the area at the time of this survey.

(7) Maniknik alteration zone

1) Location

Maniknik Creek is one of the tributaries in the northeastern portion of the Kilbay River Basin. The alteration zone falls under the jurisdiction of Barangay Mansalaya, Tagkawayan, Quezon.

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 Barangay Bagong Silang that can be reached by boat and trycicle from Tagkawayan. A foot trail is taken from Barangay Bagong Silang to Maniknik Creek. This trail leads to "Maniknik Falls" in the upper reaches of the creek.

3) Description

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

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

4) Mining Activity

No mining activity was known to have historically occurred within the vicinity of Maniknik Creek, including gold panning operations.

(8) Kampusta alteration zone

1) Location

Kampusta Creek is a tributary of Kilbay River and this area is within the jurisdiction of Mansalaya, Del Gallego, Camarines Sur. It is bounded by coordinates 1,544,762 N and 461,215 E. This creek is reported as "Susungdalaga Mountains South" in JICA-MMAJ (1999).

2) Accessibility

The site is accessible by 2-hours hike from Mansalaya, Del Gallego through a 3-km foot trail.

3) Description

The Kampusta Creek is underlain by the argillized and silicified dacite of the Susungdalaga Volcanics. The intense silicified rock with pyrite dissemination is observed on the upstream portion, while argillic alteration is confined on the downstream portion. The assemblages of altered minerals are quartz-alunite-pyrite in the silicified rock and quartz-kaolinite-smectite in the argillized rock. Length of altered exposure is approximately 300 m with occasional patches of unaltered dacite. No strong geochemical anomalous values are detected from rock samples: the propylitic andesite with pyrite dissemination (KL12), the silicified vein with abundant pyrite (KL23) and the silicified rock rich in alunite with pyrite dissemination (KL24).

4) Mining Activity

No mining activities were observed in the area.

(9) Baliwag alteration zone

1) Location

The zone is within the jurisdiction of Barangay Tonton, the westernmost barangay of Tagkawayan town in the province of Quezon. The Baliwag Creek is around the coordinates 1548200N and 459300E and loated at the south of Tonton River where Au-Cu mineralization is reported by JICA and MMAJ (1999).

2) Accessibility

Barangay Tonton could be reached by 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 Baliwag prospect is about 2 km west of Barangay Tonton and is accessible by a foot trail.

3) Description

This alteration zone is immediately north of a dacitic plug that manifests a large prominent dome. The host rock is intensely silicified (chalcedonic) that the original texture and mineralogy have been obliterated. The observed rocks are mainly scree or colluvial deposits along slope and nose of a small tributary draining the north face of the plug. The tributary drains towards the main river of Tonton. The silicified rocks are reddish brown staining on the surface but are mostly beige to creamy white in the fresher parts. Some rocks are vuggy in some parts with dissemination of pyrite (50-60%) replacing with most of the plagioclases. These scree materials are distributed within a stretch of about 1 km.

4) Mining Activity

Local residents are telling of some prospectors of gold and "carbon" some ten years ago. There were even foreign (caucasian) explorers according to them but no any known excavation or trenches were not observed.

(10) Katakian alteration zone

1) Location

This 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 could be reached on foot through trails from Barangay Mapulot, the northernmost interior barangay of Tagkawayan. Barangay Mapulot is accessible from the national highway fronting the town proper of Tagkawayan through feeder or network of barangay roads in a north-northeast 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 the Katakian Munti Creek. From the junction of the main Katikian River and the Katikian Munti Creek, greenish gray propylitic alteration could be discerned through the andesite outcrop. The porphyritic texture of andesite is still observable with moderate silicification. Chloritization is significant with about 5% pyrite dissemination. Stockwork of sulfides (mainly pyrite) and epidote are widespread, and the green rock sample rich in magnetite (KJ 01) is a calc-silicate rock consisting quartz and abundant epidote under microscopic observation. Upstream a sample of highly argillized rock (KJ02), probably andesite, yields pyrite in clusters in a quartz-clay matrix. This sample is composed of sericite-quartz-pyrite checked by X-ray diffraction. Some veinlets of magnetite are observed around the argillized rock. Boulder floats of silicified rocks and chloritized granite (KJ04) of 20-40 cm diameter are abundant around in the area. The probable extent of hydrothermal alteration could ranges from 1 to 1.5 kilometers.

The southern alteration is observed south of the northern zone and 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 (N47E) trending quartz veins (KJ 07) of about 2-5 cm thick are observed in the argillized rock. The quartz–clay matrix is generally deprived of sulfides (KJ 08) and its mineral assemblage is sericite-quartz.

4) Mining Activity

According to local residents of the area, exploration activities took place during the 1980's. Trenching and exploratory adits within the Katakian Munti alteration zone were driven on the northern bank of the tributary. One exploratory adit near the river trends generally towards northwest.

1-5-2 Mineral occurrences and alteration zone in the 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 centered at UTM coordinates 406377E, and 1559200N.

2) Accessibility

Nalesbitan area is accessible by 4-wheel drive truck taking three hours from Barangay Exciban, Labo, Camarines Norte.

3) Description

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

> The mineralization is thought to be centered on a dilational jog related to a northwest striking, sinistral strike-slip fault zone. The mineralization zone ranges in depth from 150 to 300 m above sea level to a ridge top. The principal lode comprised two descrete structures that flared and coalesced upwards to produce a 1300 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 formation. The principal lode underwent complete supergene oxidation to depth at least 130 m. The lodes are enveloped advanced argillic alteration composed of quartz, kaolinite and alunite, subordinate sericite and diaspore. Illite becomes progressively more abundant as the margins of the lode are approached, and the alteration minerals change transitionally outwards to a halo of intermediate argillic 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 2 to 7 ppm Au, but the supergene oxidized ore with abundant chrysocolla shows 151 ppm Au. 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) ranges 265 to 302℃ and salinities range from 3.5 to 5.2% NaCl equiv. It suggests that this vein was formed by high temperature and relatively dilute fluids.

4) Mining Activity

The deposit was explored in the 1930s by United Stated-financed companies, but construction of a 200 ton/day mill 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, as many as 20,000 high-graders were actively engaged in surface and underground mining and related activities (Sillitoe et al., 1990).

Gold Fields Asia Limited reexplored and mined from 1970s, but abandoned due to peace and order situations. Many active small-scale miners are still operating in the area now. El Dore Mining Company is holding the MPSA while GEMS Consultants are retained as geological consultants.

(2) Salobosogin-Yakalan alteration zone

1) Location

The site 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 bounded by UTM coordinates 1,559,192N and 463,238East.

2) Accessibility

The site can be reached by one-hour hike from Nalesbitan small-scale mining site via Nalesbitan Creek and foot trails.

3) Description

The area is underlain by volcaniclastics of the Macogon Formation. The argillization in outcrops and abundant vuggy chalcedonic quartz floats are observed along the creek. The silicified or chalcedonic quartz do not expose, thereby it is possible to be confined on higher elevation. Mineralization style appears to be similar with that of Nalesbitan Gold Prospect based on surface manifestations.

4) Mining Activity

No mining activities are 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 center 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 are situated at the center of the alteration zone.

3) Description

The Sta. Elena Formation overlies the area. The rocks in the vicinity of the area are a series of folded Cretaceous rocks consisting of greywacke, spilitic lava, flows, black shale and limestone. This formation is in unconformable contact with an Upper Miocene sedimentary sequence. A relatively strong 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. The color of the alteration is gray to light gray. It was noted that the observed minerals were quartz, biotite, and calcite with some chalcopyrite, bornite and some copper sulfide and iron/manganese oxide. Two quartz-vein samples obtained at old mine sites (BK13 and BK14) contain 18 ppm Au and 1,470 ppm Ag (BK13), and 123 ppm Au and 113 ppm Ag (BK14). Fine argentite included in pyrite crystal is observed by microscopy of BK13 polished thin sections. The float of quartz veinlets accompanied by silicified rock near the old mine site contains 1320ppb Au and 5 ppm Ag. The filling temperatures of quartz of BK14 ranges from 235 to 275℃, and the salinities ranges from 1.2 to 3.6% NaCl equiv.

4) Mining Activity

Tuba was reportedly worked during pre-War days for gold and silver. Remnants of concrete foundations of old mine buildings are still in the area. An abandoned mine road, about 13 km long connects the property to Tagkawayan, Quezon to the south and about 20 km logging road from Barangay Malibago, Labo, Camarines Norte to the north. Three shafts are found in the area, gold panniers were also seen recovering free gold from the detrital river deposits and soil.

1-5-3 Mineral occurrences and alteration zone in the Labo Valley

(1) Binangkawan Alteration Zone

1) Location

This alteration zone is found 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 five to six kilometers aerial distance from Barangay Baay following an old logging road and crossing the Labo River upstream.

3) Description

The alteration zone is mapped along the banks of Binangkawan tributary headstream. Moderately weathered dacite porphyry hosts the hydrothermal alteration. The altered rocks are generally gougy and argillic, and milky-white to orange/reddish brown with gray patches. It consists of quartz-smectite-sericite/smectite mixed layer clay minerals (LF03 and LF04). Mineralization is characterized by pyrite disseminations and aggregation as gray patches in the argillized rock and clay. 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 local people.

(2) Taktak Alteration Zone

1) Location

The alteration zone is in the watershed upstream of Taktak River in Barangay Baay, Labo, Camarines Norte. It is approximately centered at 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 forested areas of Barangay Baay through its boundary with Quezon province.

3) Description

A slight chloritization and moderate argillization hosted by andesite and tuff is observed in the area.

Argillized rock is accompanied by abundant pyrite stringers. Alteration mineral assemblage is quartz-kaolinite-smectie ± pyrite (LD04 and LD06). The strong silicified tuff with pyrite dissemination (LD05) contains 75ppb Au, 1.2 ppm Ag and 378ppm V.

4) Mining Activity

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

(3) Bilas Alteration Zone

1) Location

The area is situated within the jurisdiction of Barangay Baay, Labo, Camarines Norte. It is around 5 kilometers south of the barangay center.

2) Accessibility

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

3) Description

Bilas is underlain by dacitic pyroclastic. The altered zone is small and confined along a trail going to the streambed. North trending vertical veinlets of hematite or limonite can be found on argillized rock on what appears to be crystal lithic tuff. Remnants of biotite, quartz and hornblende are still evident. The mineral assemblage is kaolinite-smectite (LP01). 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 appears to be formed by a combination of steam heated alteration and later deep weathering.

4) Mining Activity

There are no mining activities in Bilas.

(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 could be accessible by hike from the Baay Barangay center after crossing the Tikbungan River. Baay can in turn be reached by road from Labo after passing through Tulay na Lupa. The most accessible outcrops are found at the left bank of Labo River.

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). Relicts of pyritization are evident as euhedral voids in the silicified rock.

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 found in the river. The alteration zone extends for more than 300 meters from banks of Labo River. The alteration appears to be the cause of steam heating.

4) Mining Activity

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

(5) Benit Au-Cu Occurrences

1) Location

The Benit alteration zone is in Barangay Benit, Labo, Camarines Norte. It lies about five aerial kilometers west-southwest of Labo town proper.

2) Accessibility

4WD vehicles can reach the small alteration zone all the way from Labo, passing through the Barangay centers of Tulay na Lupa, Napaod and Matanlang. A group of small houses along the road hides the gold panning sites and altered rocks of Benit.

3) Description

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

Except for the alteration, there is no visible mineralization from the surface, but muck material from small tunneling operations by prospectors yields vein materials of gray quartz coated with chrysocolla, malachite and chalcocite (LP09). Euheral wollastonite crystals are found in some of the altered clastic facies, indicating a possible contact metasomatic origin. Two samples accompanied by abundant Cu oxides minerals contain 4.3ppm Au, 146ppm Ag and 20.3%Cu (LP09), and 23.4ppm Au, 92.2ppm Ag, and 2.78% Cu (LP10) respectively. These samples are composed of Cu oxides minerals, chalcopyrite, chalcocite and electrum, and gang minerals of quartz and garnet examined by microscopy of polished thin sections.

4) Mining Activity

The area was actually mined before World War II by an American company and continued for some years thereafter. The local people reported that the company 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 investigating team, as the grade is reportedly highly variable. About a hundred miners worked on this area in the middle part of the 1980's. The main trend of the mineralization is roughly north-south as could be gleaned from the workings of the miners.

Chapter 2 Airborne Geophysical Survey

2-1 Objective

The objective of this survey is to clarify the geological structure and units and the possible alteration zones from a combination of airborne magnetic and radiometric data, and Landsat images, and to interpret the metallogenic potential of the study area.

2-2 Survey Area

The survey area is shown on Fig.II-1-1. The coordinates of the survey area are as follows:

14° 08' 35" N	122° 32' 10" E
14° 08' 35" N	122° 45' 00" E
14° 04' 00" N	122° 45' 00" E
14° 04' 00" N	122° 48' 50" E
14° 55' 00" N	122° 48' 50" E
14° 55' 00" N	122° 36' 00" E
14° 59' 00" N	122° 32' 10" E

2-3 Airborne survey specification

It is necessary for airborne measurement to keep the height above the ground constantly and as close to it as possible in order to obtain high precision data. It has been decided to make the measurement by a helicopter considering the pronounced unevenness of the terrain as a part of peninsula with volcanos. The survey acquired high-resolution magnetic data, and also potassium, uranium and thorium gamma-ray spectral data, along north-south oriented flight lines spaces 200 m apart. Survey specifications are as follows:

(Airborne survey specification)

Flight line spacing: 200m
Flight line direction: North-South
Tie line spacing: 1000m
Tie line direction: East-west
Sensor height: 80 m
Magnetometer sample interval: ～5 m
Magnetometer cycle rate: 0.1second
Magnetometer resolution: 0.001 nT
Radiometric sample interval: 40～50 m
Radiometiric cycle rate: 1 second
GPS cycle rate: 1 second

The equipment, acquired various datasets have been outlines in the First Phase report of this project.

2-4 Geophysical Imagery

Some main geophysical images superimposed in the alteration map are shown in this report. The original figures made by Fugro Airborne Surveys are attached as Appendix 11. The following imageries of the airborne geophysical data were used to assist the geophysical interpretation.

- Digital terrain model (DTM) as pseudocolour. This dataset was acquired along flight lines by radar altimeter, barometric altimeter and differential GPS satellite navigation system. This highlights prominent topographic lineaments, many of which correspond with faults (Fig. II-2-1).
- Total magnetic intensity (TMI) as pseudocolour. Due to the low magnetic latitude (magnetic inclination of 13.8°), magnetic bodies with induced magnetization appear as dipolar anomalies with a prominent low and a smaller high on the southern side.
- Reduction to the pole of total magnetic intensity (TMI-RTP). This recalculates the magnetic response as if the inducing magnetic field has an inclination of 90°, thus transforming dipolar anomalies into monopolar anomalies located directly over source body (assuming normal induced magnetization effects)(Fig.II-2-2).
- First vertical derivative (1VD) of TMI-RTP as both pseudocolour and gray scale images. This assists in defining boundaries of source bodies, trends, and rate of variability of magnetic response.
- Analytic Signal of total magnetic intensity as a grayscale image. This processing methodology produces data which provide a measure of the degree of magnetization irrespective of direction.
- Total count of gamma-ray spectral data, with a pseudocolour image (Fig.II-2-3)
- Potassium gamma-ray spectral image (Fig.II-2-4) assists in defining areas with high content of potassium minerals including alteration assemblages such as those with sericite and illite.
- Uranium gamma-ray spectral image (Fig. II-2-5), values are attributed to a combination of lithological, alteration and weathering controls.
- Thorium gamma-ray spectral image (Fig. II-2-6), this data may also reflect lithology, alteration and weathering.
- Combined potassium, uranium, thorium (Ternary) gamma-ray spectral image as a three color composite with K as red, U as blue and Th as green (Fig.II-2-7).
- Clipped potassium, uranium and thorium images retaining only the top 5% of data values.

Further background on the use of these various datasets and resultant images have been outlined in other geophysical interpretations undertaken by Fugro Airborne Surveys (formerly World Geoscience Corporation) for MMAJ in the Bicol Peninsula region (Batty and Harvey 1998a, 1998b, 1998c).

The following Landsat images were also used to assist the geophysical interpretation. These images were generated by Geoimage Pty Ltd of Brisbane for this study.

Landsat TM Bands 543 as red-green-blue, scene data from 14th February 1990

Landsat ETM bands 543 (resolution 30m/pixel) merged with pan (15m/pixel), as red-green-blue scene data from 12th August 2000

Landsat TM bands 543 plus Landsat ETM pan, as red-green-blue(Fig.II-1-1)

In some environments such as rock desert, the use of various band ratios plus further spectral processing can assist in highlighting lithological variations including those attributable to alteration. However, in this wet tropical settings, the dominance of vegetation minimizes the applicability of these techniques.

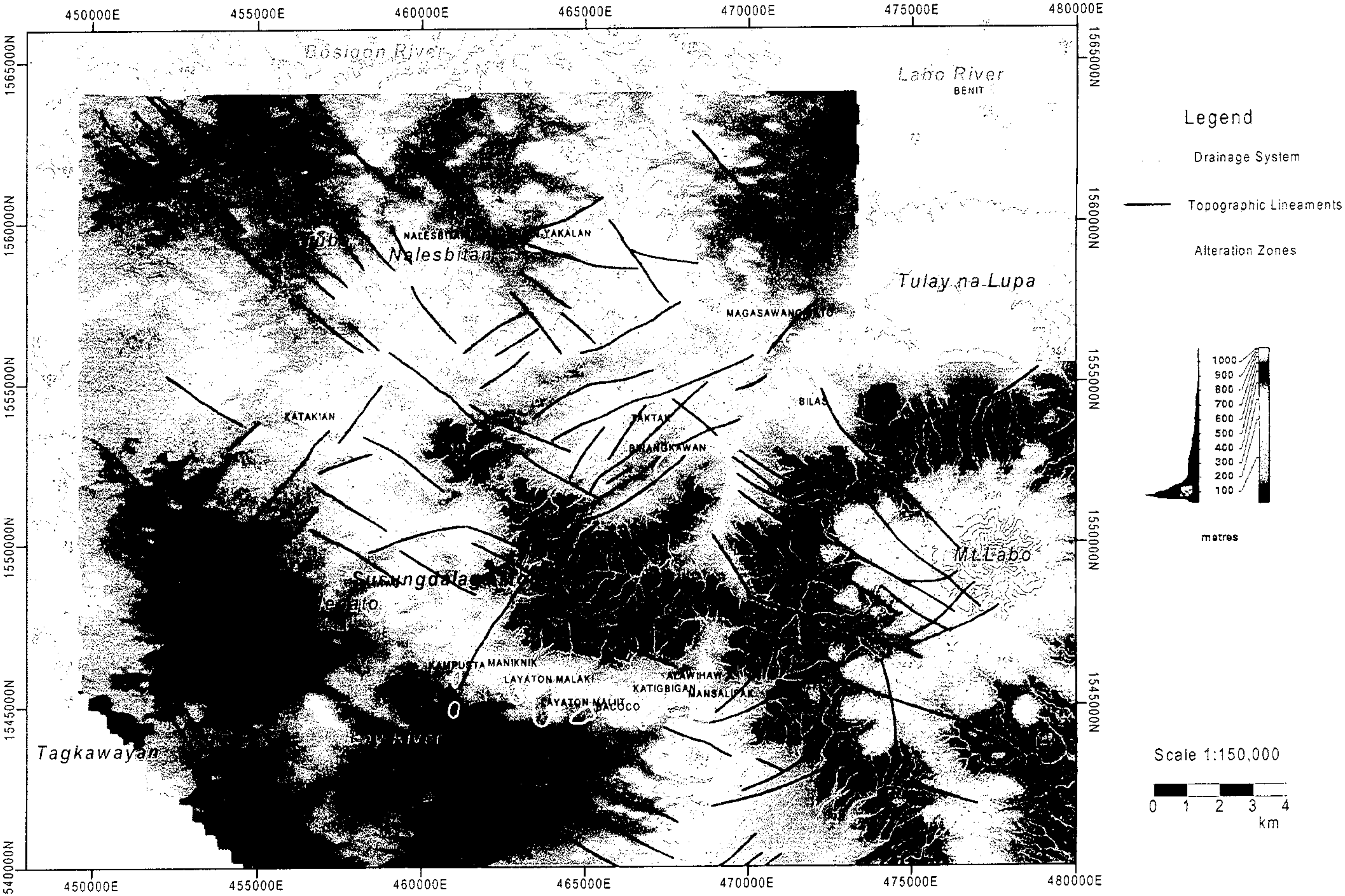


Fig. II-2-1 Digital Terrain Model Image

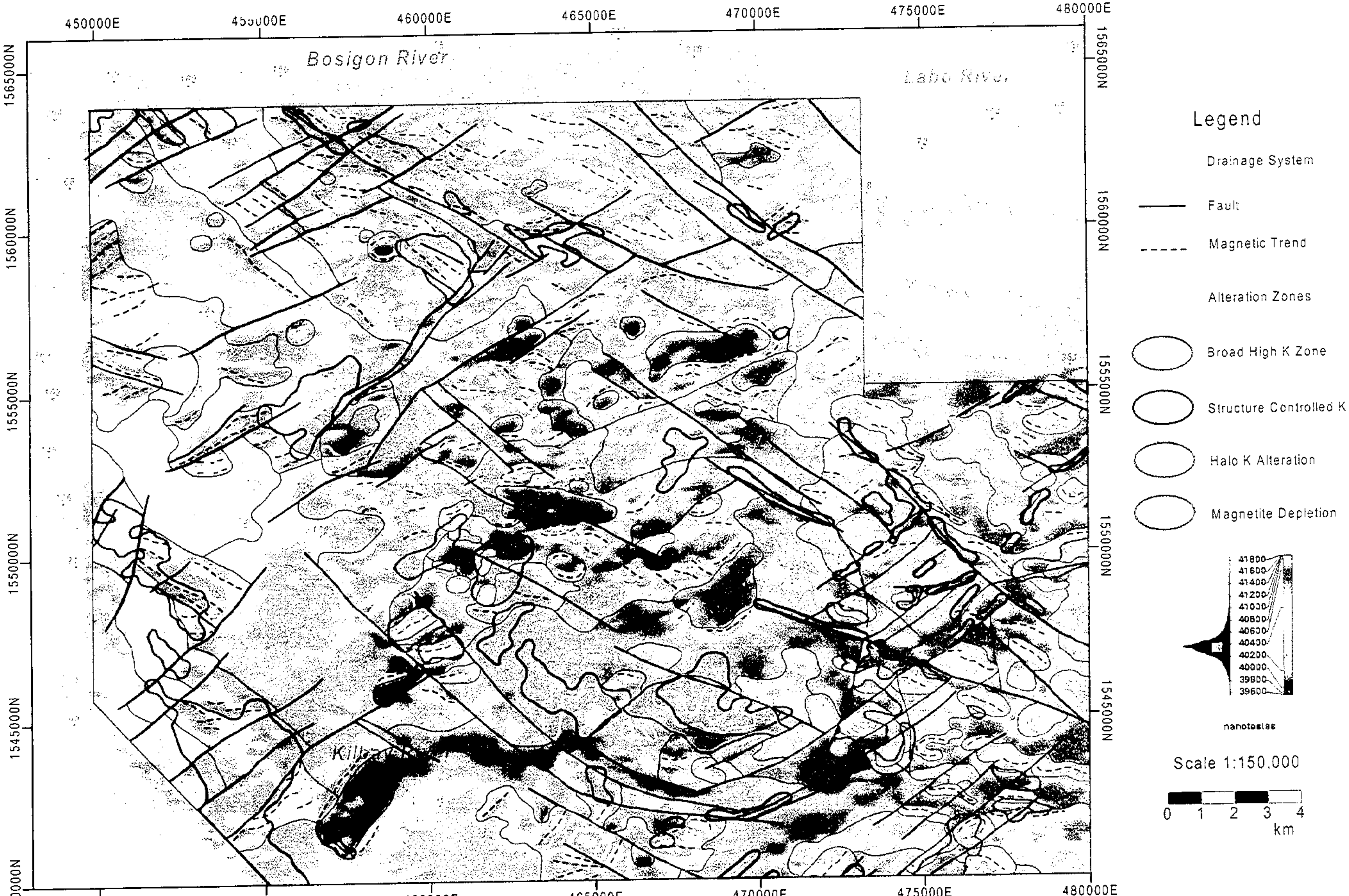


Fig. II-2-2 Total Magnetic Intensity Reduced to Pole Image (TMI-RTP)

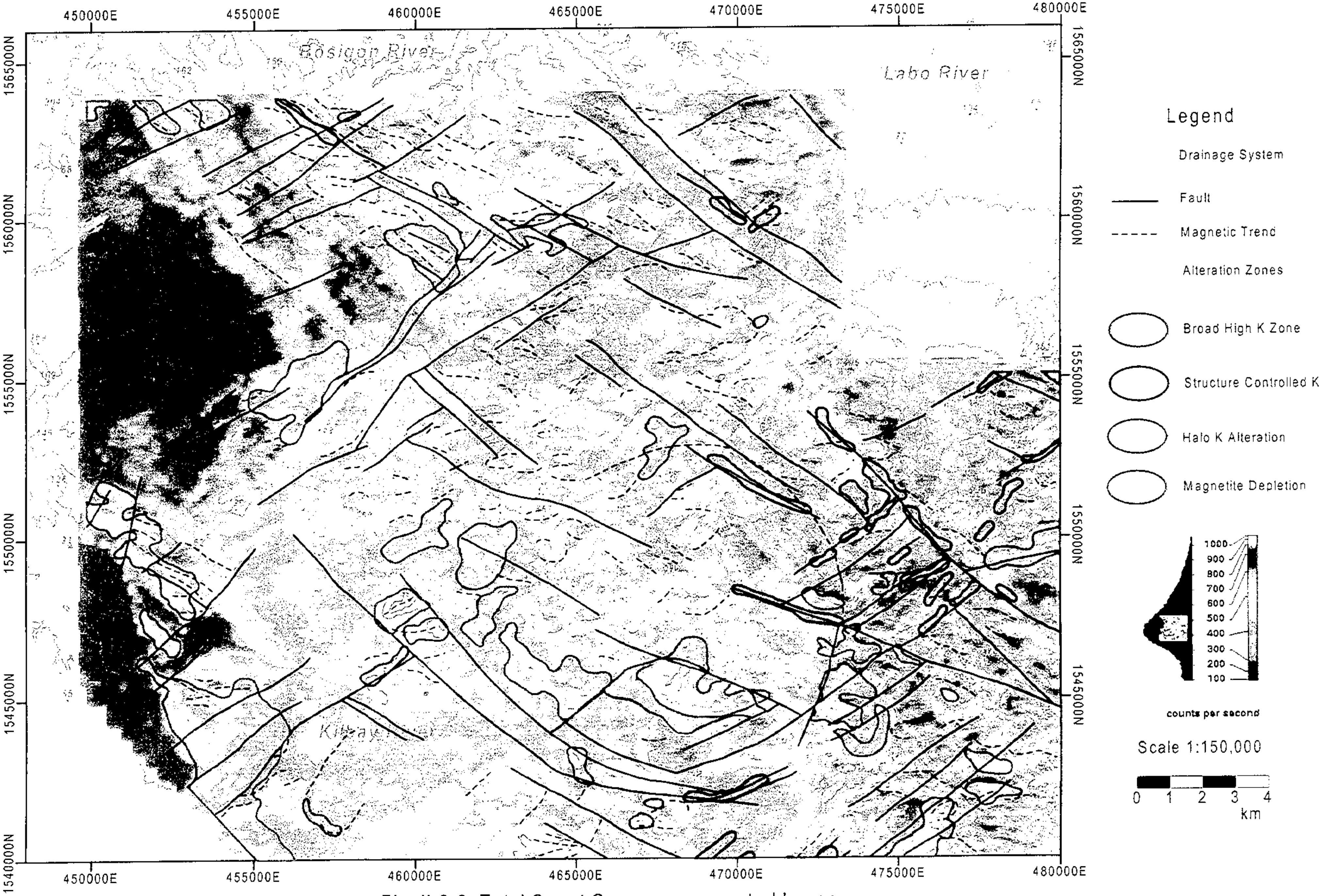


Fig. II-2-3 Total Count Gamma-ray spectral Image

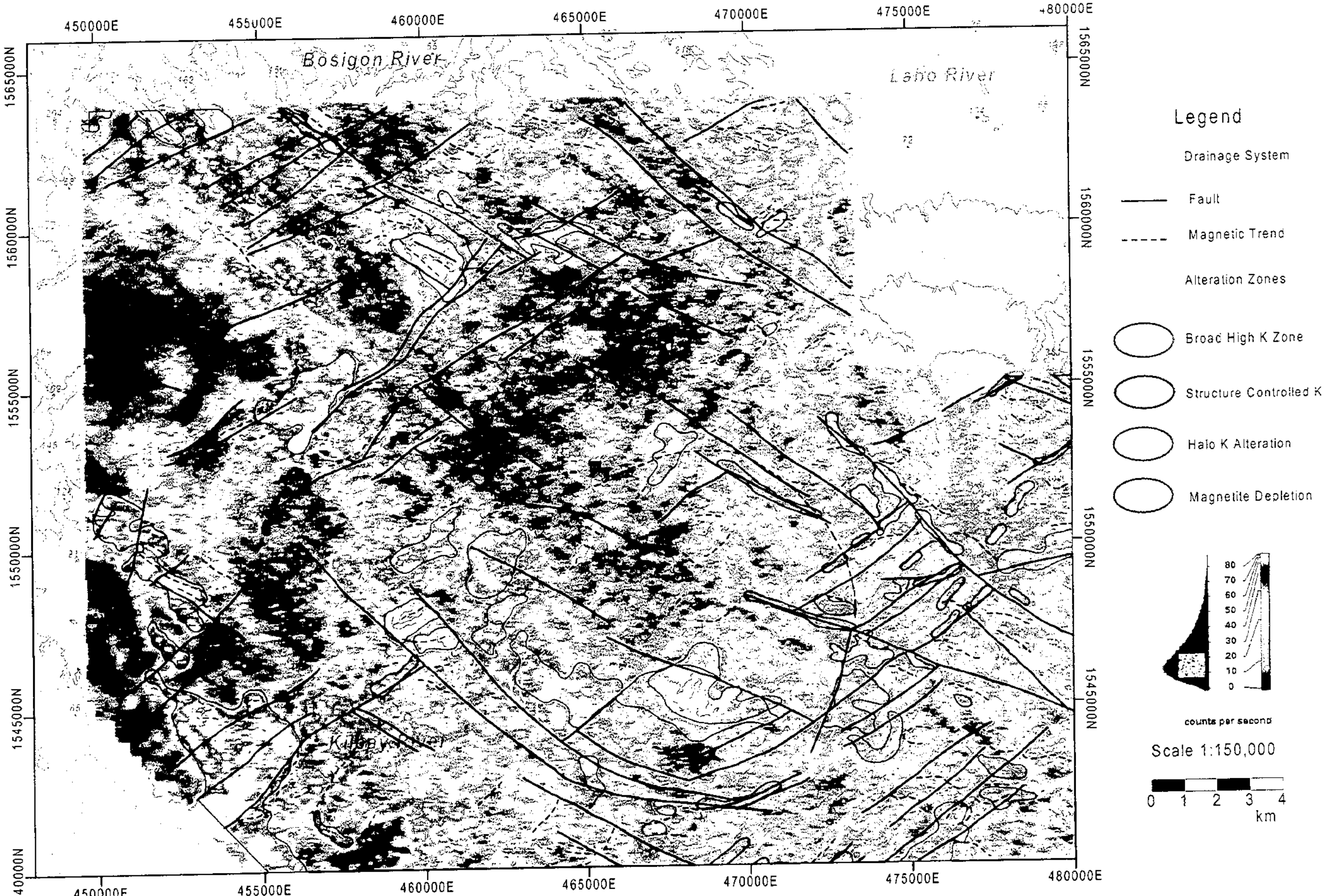


Fig. II-2-4 Potassium Gamma-ray Spectral Image

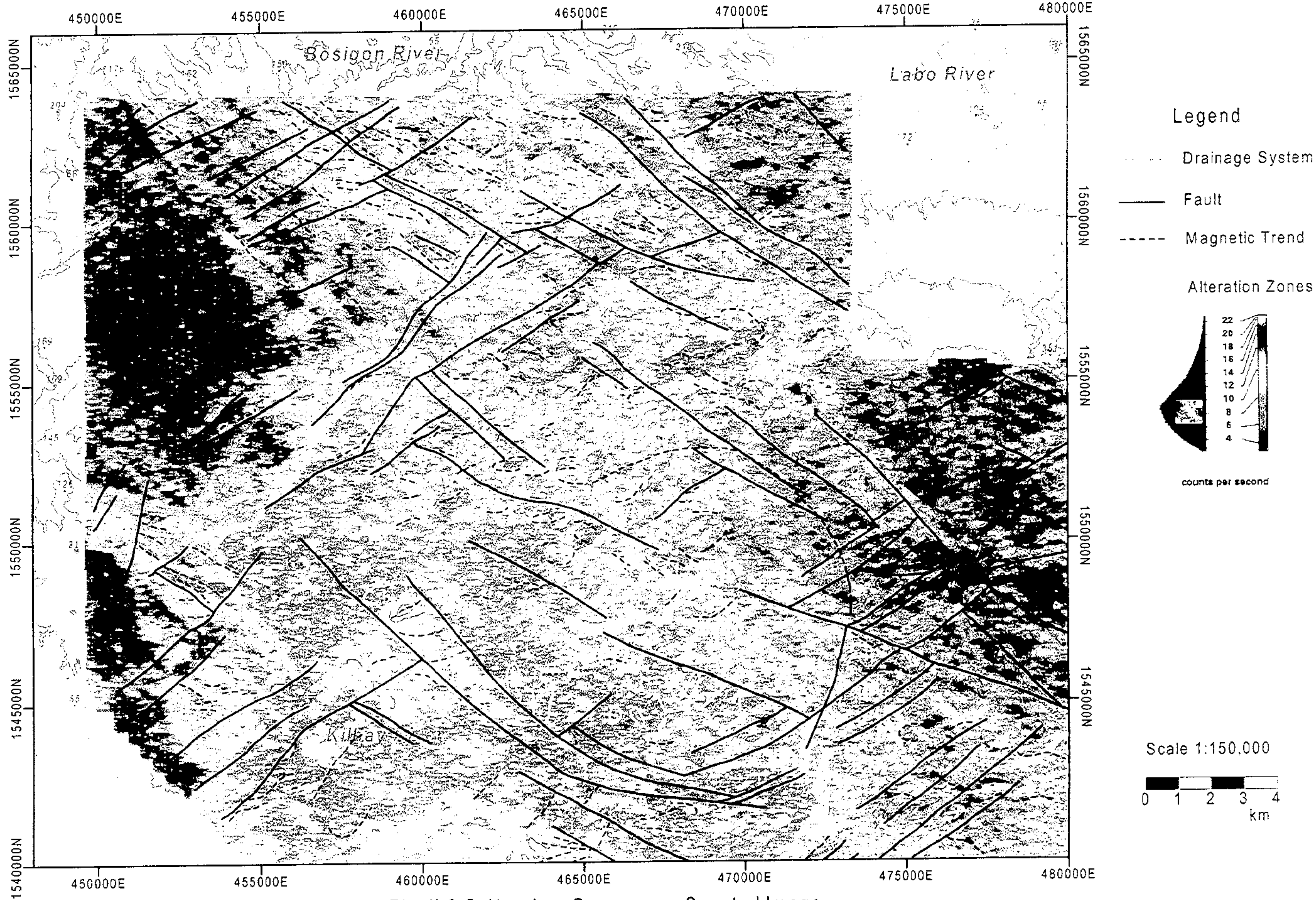


Fig. II-2-5 Uranium Gamma-ray Spectral Image

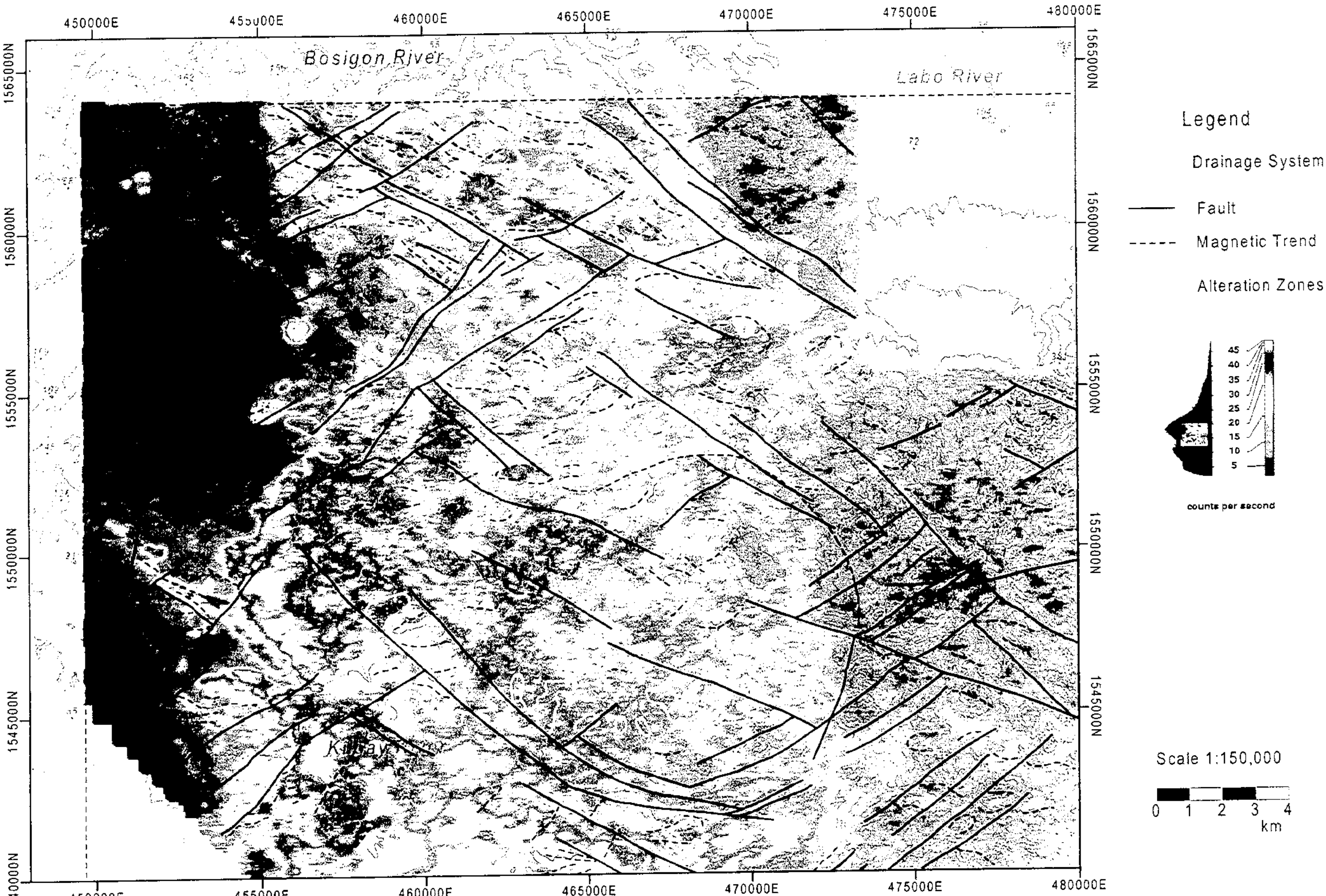


Fig. II-2-6 Thorium Gamma-ray Spectral Image

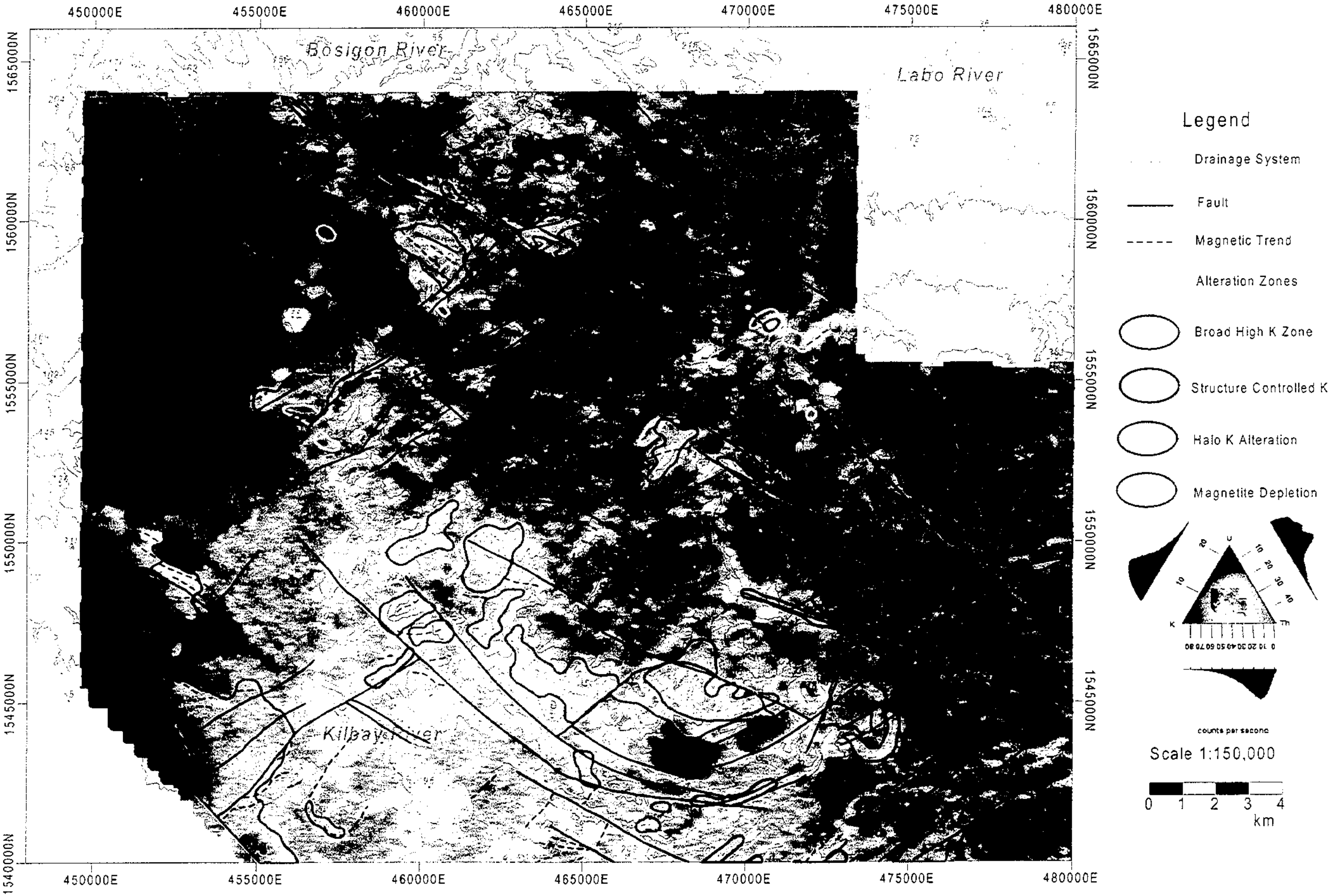


Fig. II-2-7 Ternary Gammma-ray Spectral Image