No. 24

REPORT
ON
THE MINERAL EXPLORATION:
SUPRA-REGIONAL SURVEY
IN
CENTRAL SABAH, MALAYSIA

(PHASE IV)

(Investigation of Locality of Mineral Occurrence)

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION:
SUPRA-REGIONAL SURVEY
IN
CENTRAL SABAH, MALAYSIA

(PHASE IV)

(Investigation of Locality of Mineral Occurrence)

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of Malaysia, has decided to conduct a mineral exploration programme in the State of Sabah, Malaysia and has entrusted the survey work to the Japan International Cooperation Agency. The Agency, considering the importance of technical nature of the survey work, in turn, has sought the cooperation of the Metal Mining Agency of Japan to accomplish the work.

The survey work in the survey area will be carried out within a period of four years commencing from 1990.

Metal Mining Agency of Japan dispatched the survey mission consisting of five members to the Sabah from July, 1993 to September, 1993 as a part of the survey work in the fourth year.

The survey work in Sabah was carried out successfully with cooperation of the Malaysian Government authorities, the Geological Survey Department (Geological Survey of Malaysia), Ministry of Primary Industries.

This report summarizes the result of the investigation of the localities of mineral occurrence among the survey work carried out in the third year and also forms a part of the final consolidated report which will be submitted to the Government of Malaysia aafter completion of the survey work.

We wish to take this opotunity to express our heartfelt gratitude to the officials of the Government of Malaysia, Ministries of Foreign Affairs and International Trade and Industry of Japan, the Embassy of Japan in Malaysia, the Consulate of Japan in Kota Kinabalu, Sabah, and the authorities concerned.

March, 1994

Kensuke Yanagiya
President
Japan International Cooperation Agency

Takashi Ishikawa
President
Metal Mining Agency of Japan

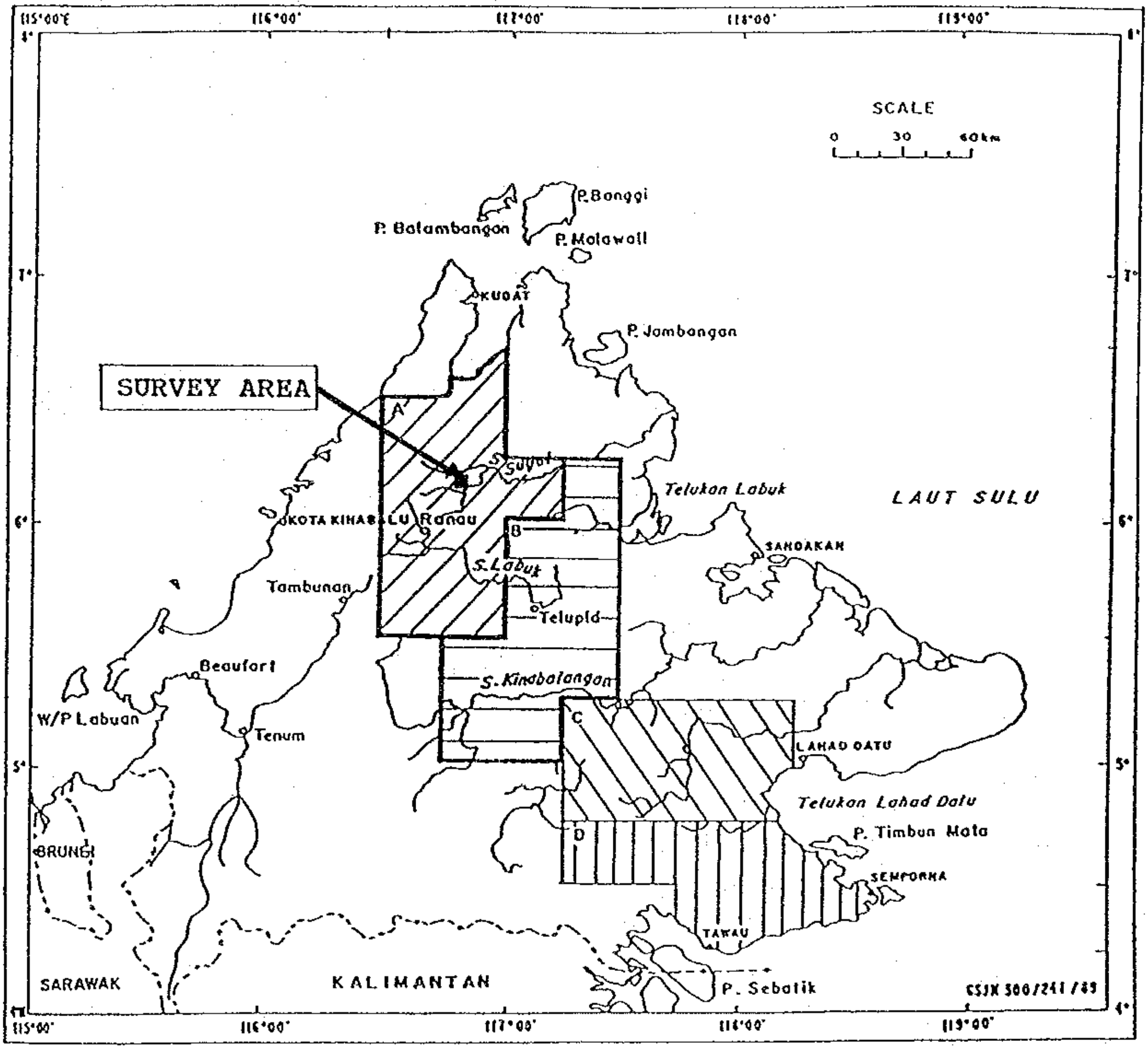


Fig.1 LOCATION MAP OF SURVEY AREA

SUMMARY

The mineral exploration programme has been carried out in the state of Sabah, Malaysia since 1990 in response to the request of the Government of Malaysia.

The investigation of the localities of mineral occurrence accompanied by geological survey and the laboratory work of the samples taken in the survey area at the time of the investigation have been conducted as a part of the survey works in the fourth year from July, 1993 to February, 1994.

The investigation of the localities of mineral occurrence in the Bt. Tampang-Kpg. Poring area during July 8 to August 23, 1993 and the additional work at the Sabah office of Geological Survey of Malaysia in Kota Kinabalu during August 24 to August 30, 1993 were carried out by one Japanese geologist.

The contents of the investigation of the localities of mineral occurrence accompanied by geological survey and the laboratory work, carried out in order to discover new locality of gold occurrence and clear up the possibility of the emplacement of gold deposit in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrence of epithermal gold deposit was discoverd by the investigation of locality of mineral occurrence in 1992, are as follows:

1. The investigation of the localities of mineral occurrence in the field
   Forty-two localities of mineral occurrence in total including three localities discovered in 1992 were investigated.
2. Laboratory work
   (1) K-Ar age determination of rock
   Ten samples of representative rock out of rock samples taken for chemical analysis and microscopic observation were dated by means of whole rock K-Ar method.
   (2) Chemical analysis of rock
   Forty samples in total of representative host rocks taken at the main localities of mineral occurrence and typical rocks distributed in the survey area, including 10 samples same as those for K-Ar dating, were assayed.

(3) Microscopic observation of thin section of rock

Sixty thin sections made from representative rocks at the localities of mineral occurrence and typical rocks in the survey area, including the same samples of rock as those for chemical analysis, were observed under a microscope.

(4) Assay of ore

Sixty-five samples of ore taken at 42 localities of mineral occurrence investigated were assayed.

(5) Microscopic observation of polished section of ore

The polished sections made from 30 samples of representative ore out of 65 ore samples for assay were observed microscopically.

(6) X-ray diffraction examination of hydrothermally altered rock

The X-ray diffraction examination of 50 samples of hydrothermally altered host rock taken at and around the localities of mineral occurrence was conducted in order to identify hydrothermal alteration mineral in the hydrothermal alteration zone.

(7) Measurement of the homogenization temperature of fluid inclusions in quartz

Homogenization temperature of fluid inclusions in quartz taken from quartz veinlets and quartz networks at 20 localities of mineral occurrence in order to study the formation temperature of quartz which seems to contain gold was measured.

The result of the investigation of the localities of mineral occurrence and laboratory work mentioned above reveals the followings.

(1) Pyrite・gold (0.10 to 2.48 g/t)・copper (0.22 to 0.64%)・arsenic (1,175 to 5,063 ppm)・mercury (1,399 to 38,785 ppb)-bearing quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones, which seem to form a low grade gold-bearing big quartz networks zone as a whole, are distributed concentratedly on the southern and eastern hillsides, especially on the southern hillside, of Bt. Tampang.

(2) These mineralized zones are hosted in sandstone belonging probably to the Crocker Formation, felsic tuff overlying unconformably sandstone, and strongly altered rock of unknown origin, all of which have been strongly subjected to hydrothermal alteration consisting mainly of silicification, sericitization, and kaolinization.

The alteration mineral assemblage (mainly quartz-sericite-kaolinite) of the hydrothermal alteration zone seems to represent that of the hydrothermal alteration zone accompanying epithermal gold deposit of the intermediate type between the adularia-sericite and acid sulfate types (Hayba et al., 1986; Heald et al., 1987) or between the low sulfidation and high sulfidation types (Hedenquist, 1987).

(3) Considering that felsic tuff seems to have undergone hydrothermal alteration probably 7.34±0.48 to 7.44±0.46 Ma ago (late Miocene) which was indicated by the age determination of hydrothermally altered felsic tuff by means of the K-Ar method and that acidic to intermediate pyroclastic and volcanic rocks found in the area to the east of Kpg. Poring belong to the calc-alkaline rock series, low grade gold-bearing quartz networks zone found on the southern and eastern hillsides of Bt. Tampang seems to be epithermal gold deposit formed by intermediate hydrothermal fluid related to the volcanic activity of the calc-alkaline rock series in late Miocene.

Therefore, there is a possibility that higher grade gold-bearing quartz networks or gold-bearing quartz veins of the bonanza-type (vein-type) are present below this low grade gold-bearing quartz networks zone.

As mentioned above, there is a possibility that higher grade gold-bearing quartz networks or gold-bearing quartz veins of the bonanza-type (vein-type) are present under the low grade gold-bearing quartz networks zone found on the southern and eastern hillsides of Bt. Tampang.

Therefore, the following exploration works are recommended in order to confirm the above possibility.

(1) The trenching on the southern and eastern hillsides of Bt. Tampang and on the ridge and the systematic sampling at the trench and assaying of the sample for the purpose of clarifying the detailed distribution of gold grade on the surface are proposed.

(2) In case the emplacement of higher grade portion of gold below the low grade gold-bearing quartz networks zone is expected as the result of trenching, sampling, and assaying of the samples, the diamond drilling aiming at the higher grade portion expected are proposed.

CONTENTS

Preface

Location map of the survey area

Summary

Page

PART 1 THE GENERAL

CHAPTER 1 INTRODUCTION 1

1-1 Progress of the Survey 1

1-2 Conclusion and Recommendation based on the Survey in the Third Year 2

1-2-1 Conclusion 2

1-2-2 Recommendation 5

1-3 Outline of the Survey in the Fourth Year 7

1-3-1 Survey Area 7

1-3-2 Objective of the Survey 7

1-3-3 Members of the Survey Mission 7

1-3-4 Contents and Result of the Survey 11

1-3-5 Period of the Survey 16

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA 25

2-1 Topography and Drainage System 25

2-2 Climate and Vegetation 25

CHAPTER 3 GENERAL GEOLOGY 29

CHAPTER 4 SYNTHETIC STUDY ON THE RESULT OF THE SURVEY 31

4-1 Characteristic of Geological Structure and Mineralization and Structural Control of Mineralization 31

4-2 Possibility of Emplacement of "Expected Ore Deposit" 33

CHAPTER 5 CONCLUSION AND RECOMMENDATION ········ 34

5-1 Conclusion ········ 34

5-2 Recommendation for Phase IV Survey ········ 35

PART II THE PARTICULAR

CHAPTER 1 KINABALU REGION ········ 73

1-1 Contents of the Survey ········ 73

1-2 Geology ········ 81

1-3 Result of the Survey ········ 93

1-4 Assay Result of Ore ········ 128

1-5 Consideration ········ 131

CHAPTER 2 LABUK REGION ········ 135

2-1 Contents of the Survey ········ 135

2-2 Geology ········ 141

2-3 Result of the Survey ········ 143

2-4 Assay Result of Ore ········ 175

2-5 Consideration ········ 180

PART III CONCLUSION AND RECOMMENDATION

CHAPTER 1 CONCLUSION ········ 183

CHAPTER 2 RECOMMENDATION FOR PHASE IV SURVEY ········ 186

REFERENCES ········ 189

ILLUSTRATIONS

Figures: Page

Figure I-1 Detailed Map of Survey Area 9

Figure I-2 Physiographic Sub-regions of Sabah .... 27~28

Figure II-1 Geological Map of Bt. Tampang-Kpg. Poring Area .... Appendix

Figure II-2 Diagrammatic Geological Sections in Bt. Tampang-Kpg. Poring Area .... Appendix

Figure II-3 Locality Map of Mineral Occurrence in Bt. Tampang-Kpg. Poring Area .... Appendix

Figure II-4 Location Map of Samples in Bt. Tampang-Kpg. Poring Area .... Appendix

Figure II-5 SiO_2-Na_2O+K_2O Diagram of Intermediate to Acidic and Pyroclastic Rocks 67

Figure II-6 FeO*-Na_2O+K_2O-MgO Trigonal Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks 69

Figure II-7 SiO_2-FeO*/MgO Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks 71

Figure II-8 FeO*-FeO*/MgO Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks 73

Figure II-9 Histograms of Homogenization Temperature of Fluid Inclusions in Quartz (BT-1-Q, BT-7-Q, BT-10-Q, BT-11-Q) 105

Figure II-10 Histograms of Homogenization Temperature of Fluid Inclusions in Quartz (BT-13-Q, BT-14-Q, BT-15-Q, BT-16-Q) 107

Figure II-11 Histograms of Homogenization Temperature of Fluid Inclusions in Quartz (BT-26-Q, BT-31-Q, BT-32-Q, BT-37-Q) 109

Figure II-12 Histograms of Homogenization Temperature of Fluid Inclusions in Quartz (BT-44-Q, BT-45-Q, BK-12-Q) 111

Figure II-13 Histograms of Homogenization Temperature of Fluid Inclusions in Quartz (KP-4-Q, KP-7-Q, KP-9-Q, KP-18-Q) 113

Tables:

Table I-1	Quantity of the Survey	17
Table I-2	List of Localities of Mineral Occurrence	19～24
Table II-1	Stratigraphy of the Bt. Tampang-Kpg. Poring Area	41
Table II-2	List of Localities of Mineral Occurrence	45～50
Table II-3	List of Samples taken for Laboratory Work	51～56
Table II-4	Result of K-Ar Dating of Rock	59～60
Table II-5	Assay Result of Rock	63～66
Table II-6	Result of Microscopic Observation of Thin Sections of Rock	77～80
Table II-7	Assay Result of Ore	83～88
Table II-8	Result of Microscopic Observation of Polished Sections of Ore	91～94
Table II-9	Result of X-ray Diffraction of Hydrothermally Altered Rock	97~100
Table II-10	List of Homogenization Temperature of Fluid Inclusion in Quartz	103~104

Part I The General

PART I THE GENERAL

CHAPTER 1 INTRODUCTION

1-1 Progress of the Survey

In response to the request of the Government of Malaysia, the Government of Japan decided to conduct a mineral exploration programme, which will be carried out within a period of four years commencing from 1990, in the State of Sabah, Malaysia, in order to explore and assess the mineral potential of the survey area.

The digitizing of the topographical and geological maps, 1:500,000 in scale respectively, of the survey area and topographical data, 1:50,000 in scale, of the detailed survey area and drawing of the superimposed birds's eye views synthesized by the digitized topographical and geological data of the survey area and by the digitized topographical and Landsat image data of the detailed survey area as well as collection, compilation and analysis of the existing data on geological survey, investigation of the mineral deposit and occurrence, and prospecting which were carried out in the survey area were done from October, 1990 to February, 1991 as a part of the survey work in the first year (1990).

The work for collection, compilation and analysis of the existing data was carried out at the Sabah office of Geological Survey of Malaysia in Kota Kinabalu, Sabah, for sixty days from October 7, 1990 to December 5, 1990.

In the second year (1991) and the third year (1992), the investigation of the localities of mineral occurrence and laboratory work of the samples taken in the survey area at the time of the investigation were conducted from August, 1991 to February, 1992 for the Segama and Semporna regions and from August, 1992 to February, 1993 for the Kinabalu and Labuk regions respectively.

The investigation of the localities of mineral occurrence in the second year (1991) and in the third year (1992) were carried out in the Segama and Semporma regions from August 19 to October 5, 1991 and in the Kinabalu and Labuk regions from August 7 to September 23, 1992 respectively, and the additional works for the analysis of the survey result at the Sabah office of Geological Survey of Malaysia in Kota Kinabalu were carried out from October 6 to October 12, 1991 and from September 24 to September 30, 1992 respectively.

The contents of the investigation of the localities of mineral occurrence and the laboratory work carried out in order to explore and assess the mineral potential of the survey area, through understanding geology and mineralization at the localities of mineral occurrence which are found in the survey area and then clarifying the characteristic of the mineralization in the survey area are as follows.

1. The investigation of the localities of mineral occurrence in the field

   (1) Second year (1991)
   Fifty-five localities of mineral occurrence in total, nine in the Segama and forty-six in the Semporna region, were investigated.

   (2) Third year (1992)
   Forty localities of mineral occurrence in total, twelve in the Kinabalu and twenty-eight in the Labuk region, were investigated.

2. Laboratory work

   (1) K-Ar age determination (20 samples in 1991, 20 samples in 1992)
   (2) Chemical analysis of rock (40 samples in 1991, 50 samples in 1992)
   (3) Microscopic observation of thin section of rock (40 samples in 1991, 50 samples in 1992)
   (4) Assay of ore (50 samples in 1991, 60 samples in 1992)
   (5) Microscopic observation of polished section of ore (30 samples in 1991, 30 samples in 1992)
   (6) X-ray diffraction examination of hydrothermally altered rock (40 samples in 1991, 15 samples in 1992)
   (7) Measurement of homogenization temperature of fluid inclusion in quartz (20 samples in 1991, 10 samples in 1992)

1-2 Conclusion and Recommendation Based on the Survey in the Third Year

1-2-1 Conclusion

It seems that base metal deposit with possibility of discovery in the future in the Kinabalu and Labuk regions surveyed in 1992 may be gold deposit in Bt. Tampang area of Kinabalu region and Cyprus-type cupriferous iron sulfide deposits in and around

Sungai Telupid, Kg. Porog, and S. Tungud mineralized zones in the Labuk region.
The mineralized zone of veinlets, network, and dissemination, consisting of quartz with minor amounts of pyrite and limonite, embedded in acidic to intermediate volcanic and pyroclastic rocks subjected to hydrothermal alteration, is found at the western and southern foots of Bt. Tampang.
This gold-bearing mineralized zone seems to correspond to the upper part of epithermal gold deposit accompanying intermediate to weak alkaline hydrothermal fluid related to the volcanic activity which took place probably during Miocene to Pliocene time, considering that some veinlets in the mineralized zone contain gold (2.68 g/t), antimony (0.13%), and mercury (22.05 ppm, 22.45 ppm) and the alteration mineral assemblage of hydrothermally altered rock consists mainly of quartz, sericite, kaolinite, and chlorite accompanied, in places, by some potash felspar and smectite and that homogenization temperature of fluid inclusions in quartz taken from quartz veinlets ranges from 218° to 259°C except for 278° to 284°C of one sample.
Therefore, there is a possibility that gold-bearing quartz vein of the bonanza-type or vein-type may be present under this mineralized zone.
It is possible that such a gold-bearing mineralized zone may be found at the eastern and northern foots and the hillside of Bt. Tampang besides the western and southern foots.
It seems that a hill ranging to the west-northwest of Bt. Tampang, Bt. Kotud, Bt. Tambiau, Bt. Kalarakan, and Bt. Tu'us to the north of Bt. Tampang may be formed of acidic to intermediate volcanic and pyroclastic rocks. If so, there is also a possibility that gold-pyrite-quartz bearing mineralized zone, accompanied by hydrothermal alteration zone, as found at the foot of Bt. Tampang may be present at the foots and hillsides of these hills.

The mineralized zone of Cyprus-type cupriferous iron sulfide found in the Bidu Bidu Hills and Telupid areas seems to be present in the area where basalt, dolerite, gabbro, and ultrabasic rock constituting the ophiolite complex are distributed complicatedly due to many faults and seems to be embedded in basalt and some dolerite associated with gabbro, especially, in the area between relatively big ultrabasic rock bodies within the above area.
It appears that the Bidu Bidu Hills area, Bt. Luminintong area, and the area between Telupid and S. Karang have the above geologic conditions.
It is said that network ore body of Cyprus-type cupriferous iron sulfide accompanies overlying massive ore body in general. However, there is a possibility that each ore body may exist individually or both the ore bodies may occur together at the

same depth in the area, where faults dominate and geology is complicated, in the Labuk region.

The promising mineralized zones of Cyprus-type cupriferous iron sulfide except known ore deposits and mineral occurrences in the Bidu Bidu Hills area are the Sungai Telupid mineralized zone, Kg. Porog mineralized zone, and S. Tungud mineralized zone, judging from the above geological condition and the result of the survey in 1992.

The Sungai Telupid mineralized zone which is embedded in basalt and some dolerite found along the Sungai Telupid consists mainly of pyrite, limonite, quartz and chalcopyrite accompanied, in places, by bornite, chalcocite, covellite, malachite, sphalerite, and magnetite. This mineralized zone is semi-massive, lenicular, veined, networked, and disseminated in occurrence at each locality of mineral occurrence, and the whole mineralized zone can be regarded as a network ore body with a length of about 155 meters in the direction of the northeast and a width of about 15 meters.

In case this mineralized zone is regarded as a network ore body, network body will be poor in ore and of low copper grade. However, there is a possibility that network ore body or massive ore body of high copper grade may be emplaced near this mineralized zone.

Kg. Porog mineralized zone is composed of two outcrops and floats, which can be nearly regarded as a outcrop, of massive gossan consisting of limonite and hematite. These massive gossans are considerably similar to those which are found at the surface of Cyprus-type massive cupriferous iron sulfide deposits of West Sualog and Kiabau in the Bidu Bidu Hills area in point of megascopic observation, microscopic observation, and assay result.

Therefore, it seems that massive gossans at three localities of mineral occurrence have been probably formed by oxidation of Cyprus-type massive cupriferous sulfide body near the surface and there is a possibility that massive cupriferous iron sulfide body not oxidized may be emplaced under outcrop and its extension.

The S. Tungud mineralized zone consisting of pyrite, quartz, and a minor amount of chalcopyrite, over 20 meters long and over 8 meters high, is found along the S. Unsadan, a tributary of the S. Tungud, in the Bt. Luminintong area. This mineralized zone is semi-massive, networked, and disseminated in occurrence, but the whole mineralized zone is nearly semi-massive and poor in copper.

Considering that high copper and zinc anomalies of geochemical surveys by the use of stream sediment, carried out by the Malaysia-Germany exploration project for 1980 to 1984 and by the base metal exploration project of Geological Survey of Malaysia for 1986 to 1990, were detected in the upper basin of the S. Unsadan including this Tg-1 locality of mineral occurrence, there is a possibility that ore body of bigger size and of higher grade of copper than the Tg-1 mineralized zone may be emplaced near the Tg-1 locality and that the mineralized zone of Cyprus-type cupriferous iron sulfide other than the Tg-1 may be present in the upper basin of the S. Unsadan.

In addition to the above, the veined hydrothermal alteration zones accompanied, in places, by some limonite and quartz are found along many parallel joints in quartz monzonite porphyry around Bt. Luminantai. Hydrothermal alteration veins are narrow in width (1 to 30 centimeters) and form network as a whole.
There is a possibility that these hydrothermal alteration veins may correspond to the SCC alteration zone (sericite-clay-chlorite) accompanying the upper part of porphyry copper deposit, judging from the results of assay of limonite·quartz veinlet accompanying hydrothermal alteration vein, X-ray diffraction examination of hydrothermal alteration vein, and measurement of homogenization temperature of fluid inclusion in quartz taken from limonite·quartz veinlet. However, considering that ore samples for assay, clay samples for X-ray diffraction, and quartz sample for measurement of homogenization temperature are short of the number and that quartz monzonite porphyry between hydrothermal alteration veins has not been subjected to hydrothermal alteration, a definite conclusion about the above must be reserved.
Therefore, it is necessary to conduct further detailed geological mapping, assay of ore sample, X-ray diffraction examination, and measurement of homogenization temperature and salinity of fluid inclusion in quartz in order to clarify whether these hydrothermal alteration veins accompany the upper part of porphyry copper deposit or not.

1-2-2 Recommendation

As mentioned in the above "1-2-1 Conclusion", it seems that base metal deposit with possibility of discovery in the future in the Kinabalu and Labuk regions surveyed in 1992 may be gold deposit in Bt. Tampang area of Kinabalu region and Cyprus-type cupriferous iron sulfide deposits in and around Sungai Telupid, Kg. Porog, and S. Tungud mineralized zones in the Labuk region.
Therefore, the following follow-up works for the above promising mineralized zones are recommended.

1. Bt. Tampang mineralized zone

(1) Detailed geological mapping; K-Ar dating, chemical analysis, and microscopic observation of host rock; systematic sampling, assay, and microscopic observation of ore; X-ray diffraction examination of hydrothermally altered rock; measurement of homogenization temperature and salinity of fluid inclusion in quartz taken from quartz veinlets; and geolchemical survey by the use of soil at the foot and hillside of Bt. Tampang.

(2) The same of follow-up works as the above, except for geochemical survey, at the foots and hillsides of a hill ranging to the west-northwest of Bt. Tampang, Bt. Kotud, Bt. Tambiau, Bt. Tu'us, and Bt. Kalarakan to the north of Bt. Tampang.

2. Sungai Telupid mineralized zone

Detailed geological mapping; K-Ar dating, chemical analysis, and microscopic observation of host rock; systematic sampling, assay, and microscopic observation of ore; and geochemical survey by the use of soil in and around the mineralized zone.

3. S. Porog mineralized zone

Detailed geological mapping; K-Ar dating, chemical analysis, and microscopic observation of host rock; systematic sampling, assay, and microscopic observation of ore; and geochemical survey by the use of at and around outcrops.

4. S. Tungud mineralized zone

Detailed geological mapping; K-Ar dating, chemical analysis, and microscopic observation of host rock; systematic sampling, assay, and microscopic observation of ore; and geochemical survey by the use of soil in and around mineralized zone.

Next, the detailed geological mapping; chemical analysis, microscopic observation, and X-ray diffraction examination of hydrothermal alteration vein; assay and microscopic observation of limonite•quartz veinlets in hydrothermal alteration veins; and measurement of homogenization and salinity of fluid inclusion in quartz taken from limonite•quartz veinlets are recommended in order to clarify whether hydrothermal alteration veins in quartz monzonite porphyry around Bt. Luminantai accompany the upper part of porphyry copper deposit or not.

1-3 Outline of the Survey in the Fourth Year (1993)

1-3-1 Survey Area

The survey area in 1993, occupying an area of about fifty square kilometers, is located in the Langanan, Bangkud, and Luhan basins including Bt. Tampang area to the northeast of Ranau.

1-3-2 Objective of the Survey

The objective of the survey in 1993 is to clear up the possibility of the emplacement of gold deposit and discover new mineral occurrence of gold in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrences of epithermal gold deposit were discovered by the investgation of locality of mineral occurrence in 1992, through conducting the follow-up survey as mentioned in the section 1-3-4.

1-3-3 Members of the Survey Mission

Participants in Planning and negotiation and survey members for the fourth year (1993) are as follows.

(1) Participants in Planning and Negotiation

a) Malaysian members

Fateh Chand	Deputy Directer-General, Geological Survey of Malaysia, Kuala Lumpur
D. Lee Tian Choi	Director, Geological Survey of Malaysia, Sabah
Lim Peng Siong	Principal Geologist, Geological Survey of Malaysia, Sabah
Joanes Muda	Project Manager, Geological Survey of Malaysia, Sabah

b) Japanese member

Takafumi Tsuzimoto	Metal Mining Agency of Japan
Haruhisa Morozumi	Metal Mining Agency of Japan
Yoshiaki Igarashi	Metal Mining Agency of Japan

(2) Survey Members

a) Malaysian members

Lim Peng Siong	Principal Geologist, Geological Survey of Malaysia
Joanes Muda	Project Manager, Geological Survey of Malaysia
Cleafos Totu	Geologist, Geological Survey of Malaysia
Amin A.Y. Basimin	Geologic Assistant, Geological Survey of Malaysia

b) Japanese member

Shuro Matsuhashi	Chief Geologist, Overseas Mineral Resources Development Co., Ltd.

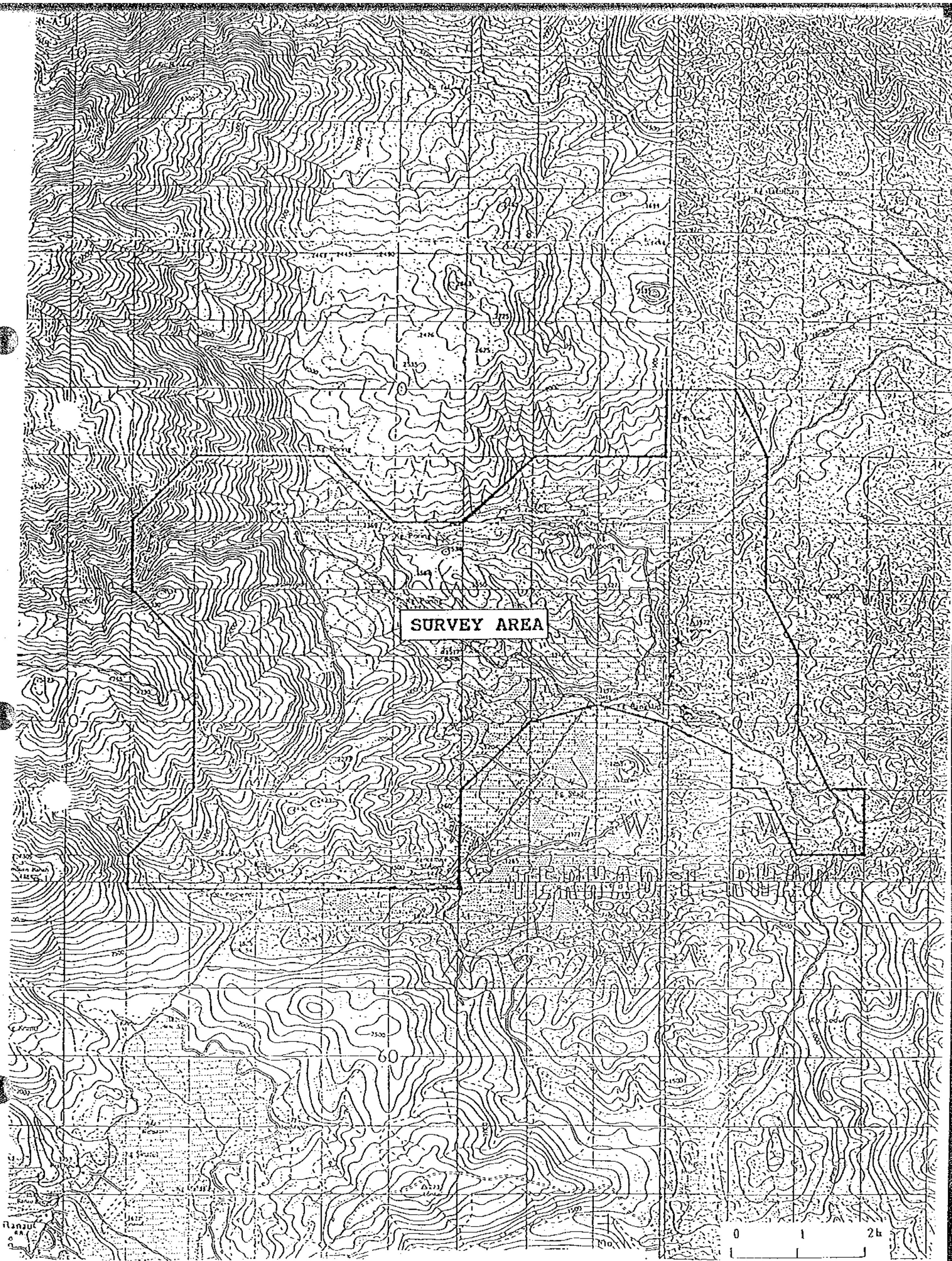


Figure I－1 Detailed Map of Survey Area

1-3-4 Contents and Result of the Survey

The contents and result of the survey in the fourth year (1993) are as follows and quantity of the survey work is shown in the Table I-1.

1. Investigation of Locality of Mineral Occurrence

The investigation of the locality of mineral occurrence accompanied by geological survey was conducted in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrence of epithermal gold deposit was discovered by the investigation of locality of mineral occurrence in 1992, in order to discover new locality of gold occurrence and clear up the possibility of the emplacement of gold deposit in the survey area.

The result of the investigation of the locality of mineral occurrence is summarized in the Table I-2 and geology and geologic section of the survey area and the locations of the locality of mineral occurrence are shown respectively in the Fig. II-1, II-2, II-3 attached at the end of this report.

The localities of mineral occurrence investigated in 1993 are 42 localities including 3 localities (BT-1, BT-17, BT-38) which were discovered in 1992. Thirty-eight localities, except 2 quartz veins in sandstone (BK-12, KP-4), quartz vein in granodiorite (KP-7), and quartz pebble in gravel bed of Quaternary (KP-9), out of 42 localities, are outcrops of quartz veinlets (4 localities), quartz networks (13 localities), veins of silicified zone (11 localities), and silicified and argillized zones (10 localities), which appeared to contain gold at the time of the investigaton, in sandstone, mudstone, and acidic to intermediate volcanic and pyroclastic rocks, altered hydrothermally.

Quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones found at above-mentioned 38 localities consist mainly of quartz with subordinate amounts of limonite, pyrite, and in places hematite, and chalcopyrite is present at localities of BT-10 and BT-11 only.

Host rocks of 38 localities are altered sandstone (22 localities), altered mudstone (1 locality), altered acidic to intermediate volcanic rock (2 localities), altered acidic to intermediate pyroclastic rock (9 localities), and strongly altered rock (3 localities). These host rocks have been subjected to silicification at all the localities, sericitization and kaolinization at majority of 38 localities, and adularization or tourmalinization in places.

Ten localities, where gold over 0.1 g/t is contained (0.10 to 2.48 g/t), 4 localities, where copper over 0.1% is contained (0.22 to 0.64%), and 6 localities, where arsenic, which accompanies generally gold mineralization together with mercury, over 1,000 ppm is contained (1,175 to 5,063 ppm), are distributed concentratedly on the southern and eastern hillsides of Bt. Tampang, (especially 11 localities on the southern hillside), out of 42 localities of mineral occurrence investigated.

2. Laboratory Work

The list of the samples taken for the following laboratory works is given in the Table II-3 and the locations of the samples are shown in the Figure II-4 attached at the end of this report.

(1) K-Ar Age Determination of Rock

Ten representative rock samples, namely four samples of hydrothermally altered sandstone, two samples of hydrothermally altered tuff, and four samples of acidic intrusive rock, out of rock samples taken for the chemical analysis and microscopic observation, have been dated by means of the K-Ar method using whole rock.

The result is given in the Table II-4. Table II-4 shows that acidic intrusive rocks and hydrothermally altered tuffs have been dated as 6.73 ± 0.42 to 8.03 ± 0.59 Ma (Late Miocene) and 7.34 ± 0.48 to 7.44 ± 0.46 Ma (Late Miocene) respectively and are about the same in age, whereas hydrothermally altered sandstones have been dated as 7.70 ± 0.56 to 8.01 ± 0.64 Ma (Late Miocene), 13.8 ± 1.0 to 14.2 ± 1.0 Ma (Middle Miocene), 35.3 ± 4.2 to 38.4 ± 4.2 Ma (Early Oligocene), and 112 ± 7.0 Ma (Early Cretaceous) with wide range in age and are older than acidic intrusive rocks and hydrothermally altered tuffs in age.

(2) Chemical Analysis of Rock

The assay result of 40 samples of representative host rock obtained from the localities of mineral occurrence investigated and typical rock taken in the survey area, namely 24 samples of hydrothermally altered sandstone, 1 sample of hydrothermally altered mudstone, 3 samples of hydrothermally altered acidic to intermediate tuff, 3 samples of acidic to intermediate volcanic rock, 1 sample of intermediate dyke rock, 5 samples of acidic intrusive rock, and 3 samples of ultrabasic rock, including 10 rock samples taken at the same localities as the samples for K-Ar age determination, is given in the Table II-5.

The analyses of 7 rock samples, namely 3 samples of hydrothermally altered acidic to intermediate tuff, 3 samples of acidic to intermediate volcanic rock, and 1 sample of intermediate dyke rock, out of 40 rock samples assayed, have been plotted on the $FeO+Fe_2O_3-Na_2O+K_2O-MgO$, $SiO_2-FeO+Fe_2O_3/MgO$, $FeO+Fe_2O_3-FeO+Fe_2O_3/MgO$ diagrams as shown in the Fig. II-6, II-7, II-8. The result reveals that seven rock samples belong to the calc-alkaline rock series.

The assay result also reveals that the samples BT-56-R (weakly altered fine sandstone) and BT-58-R (strongly altered tuff) contain 1.18 g/t and 0.215 g/t of gold respectively and that the rock samples at 9 localities are rich in arsenic and mercury which accompany, in general, gold mineralization, namely arsenic over 100 ppm (110 to 559 ppm) is contained in 5 samples and mercury over 10 ppm (11.1 to 73.6 ppm) is contained in 4 samples.

The Table II-5 also reveals that hydrothermally altered rocks, namely hydrothermally altered sandstone, mudstone, tuff, and volcanic rock, are very low in CaO and Na_2O and very high in SiO_2. It seems that this is ascribed to the decomposition of plagioclase and the formation of secondary quartz caused by hydrothermal alteration.

(3) Microscopic Observation of Thin Section of Rock

The thin sections made from 50 samples of representative host rock obtained at the localities of mineral occurrence investigated and typical rock taken in the survey area, including 40 rock samples taken at the same localities as the samples for chemical analysis, have been observed under a microscope. The result of the observation is given in the Table II-6.

The Table II-6 reveals that 39 samples of hydrothermally altered rock, namely altered sandstone (27 samples), altered mudstone (2 samples), altered acidic to intermediate tuff (5 samples), altered acidic to intermediate volcanic rock (2 samples), and strongly altered rock (3 samples), out of 50 rock samples observed under a microscope, have been mostly subjected to strong silicification and sericitization, and 22 samples, namely 16 samples of altered sedimentary rock, 5 samples of altered volcanic and pyroclastic rocks, and 1 sample of strongly altered rock, out of 39 samples, have undergone kaolinization in addition to silicification and sericitization.

(4) Chemical Analysis of Ore

The assay result of 65 ore samples taken at 42 localiteis of mineral occurrence investigated is given in the Table II-7. Table II-7 indicates that the samples which contain gold over 0.1 g/t are BT-1-0-1 (1.27 g/t), BT-2-0-1 (0.57 g/t), BT-2-0-2 (0.40 g/t), BT-5-0 (0.16 g/t), BT-6-0 (2.48 g/t), BT-11-0 (0.24 g/t), BT-13-0-2 (0.22 g/t), BT-14-0-1 (0.10 g/t), BT-43-0 (0.24 g/t), and BT-45-0 (0.11 g/t) and that the samples which contain copper over 0.1% are BT-6-0 (0.46%), BT-7-0 (0.64%), BT-10-0-1 (0.51%), BT-10-0-2 (0.22%), BT-11-0 (0.31%), and also shows that many samples are rich in arsenic and mercury which accompany, in general, gold mineralization, namely 8 samples contain arsenic over 1,000 ppm (1,175 to 5,063 ppm) and 41 samples contain mercury over 1.0 ppm (1.2 to 38.8 ppm).

Therefore, assay result reveals that the samples which contain gold are rich in mercury and in arsenic generally, whereas copper has no interrelation with gold, arsenic, and mercury.

(5) Microscopic Observation of Polished Section of Ore

The polished sections made from 30 representative samples out of 65 ore samples taken for assay have been observed under a ore microscope. The result of the observation is given in the Table II-8 and shows that most samples consist mainly of a large amount of quartz, a large to a very small amount of limonite and pyrite, and a middle to a very small amount of secondary hematite and that one to four ore mineral(s) out of a small to a very small amount of chalcopyrite, a very small amount of bornite, chalcocite, covellite, and sphalerite, in addition to the above four major minerals, is (are) contained in 11 samples.

(6) X-ray Diffraction Examination of Hydrothermally Altered Rock

The result of the X-ray diffraction examination of 50 samples of hydrothermally altered rock taken at and around 42 localities of mineral occurrence, namely 33 samples of altered sandstone, 3 samples of altered mudstone, 9 samples of altered acidic to intermediate tuff, 2 samples of altered acidic to intermediate volcanic rock, and 3 samples of strongly altered rock, is given in the Table II-9.

The Table II-9 indicates that all of 50 hydrothermally altered rock samples contain a large amount of quartz; 42 samples, namely 32 samples of altered sedimentary rock, 9 samples of altered pyroclastic and volcanic rocks, and 1 sample of strongly altered rock, contain a middle to very small amount of sericite; and 29 samples, namely 21 samples of altered sedimentary rock, 6 samples of altered pyroclastic and volcanic rocks, and 2 samples of strongly altered rock, contain a middle to very small amount of kaolinite, and that 12 samples, that is, 6 samples of altered sedimentary rock, 4 samples of altered pyroclastic and volcanic rocks, and 2 samples of strongly altered rock, contain a large to very small amount of potassic felspar and 7 samples, that is, 5 samples of altered sedimentary rock and 2 samples of altered tuff, contain a small to very small amount of tourmaline. Therefore, the result of the X-ray diffraction reveals that alteration minerals in hydrothermally altered rock consist mainly of quartz, sericite, and kaolinite. Thus, it seems that this alteration mineral assemblage represents that of the hydrothermal alteration zone acompanying epithermal gold deposit of the intermediate type between the adularia-sericite and acid sulfate types (Hayba et al., 1986; Heald et al., 1987) or between the low sulfidation and high sulfidation types (Hedenquist, 1987).

(7) Measurement of Homogenization Temperature for Fluid Inclusions in Quartz

Homogenization temperature of fluid inclusions in 20 samples of quartz taken from quartz veinlets and networks, namely 7 samples in hydrothermally altered sandstone, 6 samples in hydrothermally altered tuff, 2 samples in strongly altered rock, 2 samples in sandstone, 1 sample in granodiorite, and 1 sample of quartz pebbles in gravel bed of Quaternary, at 20 localities out of 42 localities of mineral occurrence, has been measured to study formation temperature of quartz.

The result of measurement of 19 samples except for 1 sample (BT-20-Q) which contains no fluid inclusion is given in the Table II-10 and the histograms of the Figs.II-9 to II-13.

The histograms of the Figs.II-9 to II-13 show that the homogenization temperature of only 3 samples, out of 18 samples except the BT-20-Q sample which contains no fluid inclusion and the BT-13-Q sample which contains only one fluid inclusion makes nearly the normal distribution and that of remaining 15 samples makes roughly the uniform distribution.

The result of analysis on homogenization temperature reveals that 14 quartz samples from quartz veinlets and networks embedded in hydrothermally altered rock, namely altered sandstone, altered tuff, and strongly altered rock, are divided into 6 samples which have relatively low homogenization temperature (184° to 353°C) and 8 samples which have wide range of temperature (186° to 467°C) and have the low temperature zone (186° to 340°C) and the high temperature zone (307° to 467°C).

The analysis on homogenization temperature also reveals that homogenization temperature (184° to 353°C) of above six samples falls within the range of 135° to 350°C of adularia-sericite type epithermal gold deposit related to the volcanic activety in the Western-Pacific Island Arcs after Sillitou, 1988.

1-3-5 Period of the Survey

The period of the survey in Malaysia is as follows:

Travelling:	July 4 ~ July 7, 1993
Survey work in the field:	July 8 ~ August 23, 1993
Supplemental work in Kota Kinabalu:	August 24 ~ August 30, 1993
Travelling:	August 31 ~ September 2, 1993

Table I-1 Quantity of the Survey Work

Contents of the Survey	Quantity
[Field Work]	
1. Investigation of locality of mineral occurrence	42 localities
2. Geological survey	
(1) Area	54 km^2
(2) Total length of the route	77 km
[Laboratory Work]	
1. K-Ar Age determination	10 samples
2. Chemical analysis of rock 22 constituents: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, LOI, Ag, As, Au, Cu, Hg, Mo, Pb, S, Sb, Zn	40 samples (880 constituents)
3. Microscopic observation of thin section of rock	50 samples
4. Chemical analysis of ore 10 constituents: Ag, As, Au, Cu, Hg, Mo, Pb, S, Sb, Zn	65 samples (650 constituents)
5. Microscopic observation of polished section of ore	30 samples
6. X-ray diffraction examination	50 samples
7. Measurement of homogenization temperature of fluid inclusion in quartz	20 samples

Table I-2 List of Localities of Mineral Occurrence

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-1 (T-10)	lim+qz	lim·qz veinlets-bearing argillized & silicified zone	?	W=2.2m+	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-1-0-1 BT-1-0-2
	BT-2	lim+qz	lim·qz lens-bearing argillized & silicified zone	?	W=3.1m+	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-2-0-1 BT-2-0-2
	BT-3	lim·hem+qz	lim·hem·qz veinlets-bearing argillized & silicified zone	?	W=4.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-3-0
	BT-4	lim·hem·qz	lim·hem·qz network-bearing silicified & argillized zone	?	W=2.0m+	altered sandstone	silicification	BT-4-0
	BT-5	lim·hem+qz	vein of silicified zone	N40°E·75°SE	T=0.3~0.5m	altered sandstone	silicification	BT-5-0
	BT-6	lim·py·qz	network	?	W=2.5m+	altered felsic tuff	silicification, kaolinization, adularization	BT-6-0
	BT-7	qz+lim·py	veinlets	N80°E·16°N	T=0.5~2.0cm, L=1.3m	altered felsic tuff	silicification, kaolinization, sericitization, adularization	BT-7-0
	BT-9	lim	lim-bearing argillized zone	?	W=2.0m+	fine tuffaceous sandstone	sericitization, silicification, kaolinization	BT-9-0
	BT-10	qz+py·lim·cp	network	N50°W·30°N N80°W·90°	W=3.5m, L=4.5m (T of qz vein=2~10cm)	strongly altered rock	silicification, adularization, sericitization, kaolinization	BT-10-0-1 BT-10-0-2
	BT-11	qz+py·lim·cp	network	N44°E·90°	W=0.5m, L=2.0m+ (T of qz vein=1~2cm)	strongly altered rock	silicification, adularization, sericitization, kaolinization	BT-11-0
	BT-12	qz+lim	veinlet	N82°W·35°S	T=0.5cm	strongly altered rock	silicification, sericitization, kaolinization	BT-12-0
	BT-13	qz+lim	vein	N48°E·90°	T=1~25cm	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-1
		qz·lim	vein of silicified zone	N-S·60°N	T=0.65m	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-2
		qz·lim	vein of silicified zone	?	T=1.3m	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-3
	BT-14	qz+lim·hem	network	N70°E·43°N	W=8.0m+, H=6.0m+ (T of qz vein=0.5~5cm)	strongly altered felsic tuff	silicification, sericitization	BT-14-0-1 BT-14-0-2
	BT-15	qz	network	N60°E·53°N	W=8.0m+, H=6.0m+ (T of qz vein=0.5~6.0cm)	strongly altered felsic tuff	silicification, sericitization	BT-15-0
	BT-16	qz+lim	vein and network	N70°W·90°	T=1.2m, W=3.0m, L=6.0m+	strongly altered felsic tuff	silicification, sericitization	BT-16-0
	BT-17 (T-1)	qz+py·lim	network	N45°W·86°N	W=38.0m, H=3.0m+ (T of qz vein=0.5~5.0cm)	strongly altered dacitic agglomerate	silicification, kaolinization, sericitization, chaloritization	BT-17-0-2~ BT-17-0-14

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-20	qz+lim·hem	vein	?	T=0.6m, L=1.1m+	?	?	
	BT-26	qz	network	?	T=0.5~3.0cm	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-26-0
	BT-28	lim·py+(qz)	lim·py ·minor qz veinlets-bearing argillized and silicified zone	?	W=6.0m	altered andesite	silicification, sericitization kaolinization, adularization	BT-28-0-1 BT-28-0-2 BT-28-0-3 BT-28-0-4
	BT-31	qz+lim	vein and network	N50°E·80°S	T=2~5cm, W=0.6m, H=2.4m	strongly altered tuff	silicification sericitization	BT-31-0
	BT-32	qz	network	?	W=6.0m+, H=3.0m+ (T of qz vein=0.3~3.0cm)	coarse sandstone	silicification, sericitization	BT-32-0
	BT-37	qz+lim	vein	N25°W·90°	T=2~5cm, H=1.0m+	altered sandstone	silicification, sericitization	BT-37-0
	BT-38 (T-3)	qz+lim·py	lenticular silicified zone	?	L=0.25m, T=0.1m	altered rhyolite	silicification, kaolinization, sericitization, chloritization	BT-38-0
	BT-41	qz+lim	network	?	w=4.0m+, H=1.5m+	altered sandstone	silicification, sericitization, kaolinization	BT-41-0
	BT-42	qz·lim·hem	qz veinlets·lim·hem-bearing silicified & argillized zone	?	W=2.0m+, H=1.5m+	altered sandstone	silicification, sericitization, kaolinization	BT-42-0
	BT-43	qz·lim	network	horizontal	T=1.3m, L=5.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-43-0
	BT-44	qz+lim	qz lens·lim-bearing silicified and argillized zone	N20°W·80°E	W=3.0m, L=5.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-44-0
	BT-45	qz+lim·py	lim·qz network·py-bearing breccia vein	N68°E·87°S	T=0.4m, H=4.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-45-0
	BT-46	qz·lim	qz network-bearing vein of silicified zone	N70°E·74°S	T=0.7m, L=6.6m+	altered sandstone	silicification, sericitization, kaolinization	BT-46-0
	BT-47	qz+lim	lim-bearing vein of silicified zone	N74°E·90°	T=0.75m, H=1.2m+	altered sandstone	silicification, sericitization, kaolinization	BT-47-0
	BT-48	qz+lim·py	py·lim-bearing vein of silicified zone	E-W·70°S N70°E·70°S	T=0.3m, L=3.0m+, H=1.2m+ T=0.75m	altered sandstone	silicification, sericitization, kaolinization	BT-48-0-1 BT-48-0-2
	BT-49	qz+lim	vein of silicified zone	N35°E·80°W	T=0.55m, L=3.0m	altered sandstone	silicification, sericitization, kaolinization	BT-49-0
	BT-50	qz·lim	lim-bearing silicified breccia vein	N12°E·70°W	T=1.0m	altered fine sandstone	silicification, sericitization	BT-50-0
	BT-51	qz·lim	lim-bearing silicified breccia zone	N17~35°W·90°	W=9.0m	altered fine sandstone	silicification, sericitization	BT-51-0

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-58	qz+lim	network	N20°E·70°W	W=3.5m+, H=5.0m+	strongly altered tuff	silicification, sericitization	BT-58-0
Bt. Kotud	BK-12	qz+py	network	?	W=1.0m, L=2.0m+	sandstone	none	BK-12-0
Kg. Poring	KP-4	qz	vein	?	T=2~5cm	sandstone	none	
	KP-7	qz	vein	N44°W·60°S	T=5cm, H=1.3m+	granodiorite	none	
	KP-9	qz	pebble in Quaternary gravel bed	?	?	Quaternary gravel bed	silicification, sericitization kaolinization	KP-9-0-1 KP-9-0-2
	KP-13	qz·lim·py	py·lim-bearing silicified and argillized zone	?	W=8.0m+	altered sandstone	silicification, sericitization chloritization	KP-13-0-1 KP-13-0-2
	KP-14	qz·lim·py	lim·py-bearing silicified and argillized zone	N70°W·90°	W=3.0m	altered mudstone	silicification, sericitization, kaolinization	KP-14-0
	KP-18	qz	vein of silicified zone	N30°E·64°E	T=0.35m, H=0.4m+	altered sandstone	silicification, sericitization, kaolinization	KP-18-0

[Abbreviations]
qz: quartz, py: pyrite, lim: limonite, hem: hematite, cp: chalcopyrite, W: width, T: thickness, L: length, H: height, 2.2m+: 2.2 meters and over
(T-1), (T-3), (T-10): number of locality of mineral occurrence found in 1992.

CHAPTER 2 GEOGRAPHY OF THE SURVEY AREA

2-1 Topography and Drainage System

Sabah can be divided into four main physiographic sub-regions, namely the Western Lowlands, the Western Cordillera, the Central Uplands, and the Eastern Lowlands, as shown on the Fig. I-2 (after Collenette, P., 1963).

The survey area in 1993 comprises the eastern slope of the Kinabalu Massif situated in the northeastern part of the Crocker Range belonging to the Western Cordillera and hilly terrain belonging to the Central Uplands in the east. The hilly terrain in the eastern part, 270 to 680 meters above sea level, is consist of relatively gentle hills and alluvial flats associated with flood plains along rivers, while the eastern slope of the Kinabalu Massif in the west, 500 to 1,260 meters in altitude, is steeply sloping mountainous terrain with deeply incised valleys.

The survey area is mainly drained by the Langanan River flowing east in the northern part of the survey area, its major tributaries, namely, the Kipungit, Mamut, Mantukungan, and Bruntukungan Rivers, which flow east in the northwestern part, the Bangkut River flowing east in the central part, and the Luhan River flowing east in the southern part. The Langanan, Bangkud, and Luhan Rivers are the upper reaches of the Sugut River which drains into the Sulu Sea.

2-2 Climate and Vegetation

The climate of the survey area is hot and humid. Temperature varies scarcely throughout the year, but varies with altitude falling at a rate of about 1.5°C for every 300 meters increase in altitude so that above about 1,200 meters there is a change from the tropical rainy climate to the warm temperature rainy climate.

No temperature readings are available for the survey area, but it is thought that temperature in the eastern part with lesser altitude is 21°C to 32°C. At Kundasang outside the survey area, 1,371 meters above sea level, which is situated on the southern slope of the Kinabalu Massif and is slightly higher in altitude than the western part of the survey area, the highest monthly temperature recorded from 27° to 30°C and the lowest from 10° to 16°C.

No rainfall records are available for the survey area, but at Kundasang mentioned above, the average annual rainfall is about 2,030 millimeters, most of which falls in the second half of the year. At the Nation Park Headquarters near Tenompok outside the survey area, 1,615 meters above sea level, situated on the same southern slope of the Kinabalu Massif as Kundasang, the average annual rainfall is about 3,050 millimeters.

Generally, the driest months are February, March, and April, and the wettest months are May, June, September, October, and November.

The majority of the survey area is covered with tropical rain forest, but a part of the slopes and foots of the hills and most of the alluvial flats in the eastern part have been cleared for cultivation and grazing of cattle. Tropical rain forest is divided into two types, namely primeval jungle which has been kept in a state of nature and secondary jungle, in which big trees had been cut down already. The majority of the eastern slope of the Kinabalu Massif, namely upper drainage areas of the Langanan, Kipungit, Mamut, Mantukungan, and Bruntukungan Rivers, in the western part of the survey area is covered with primeval jungle, whereas most of hills in the eastern part is covered by secondary jungle.

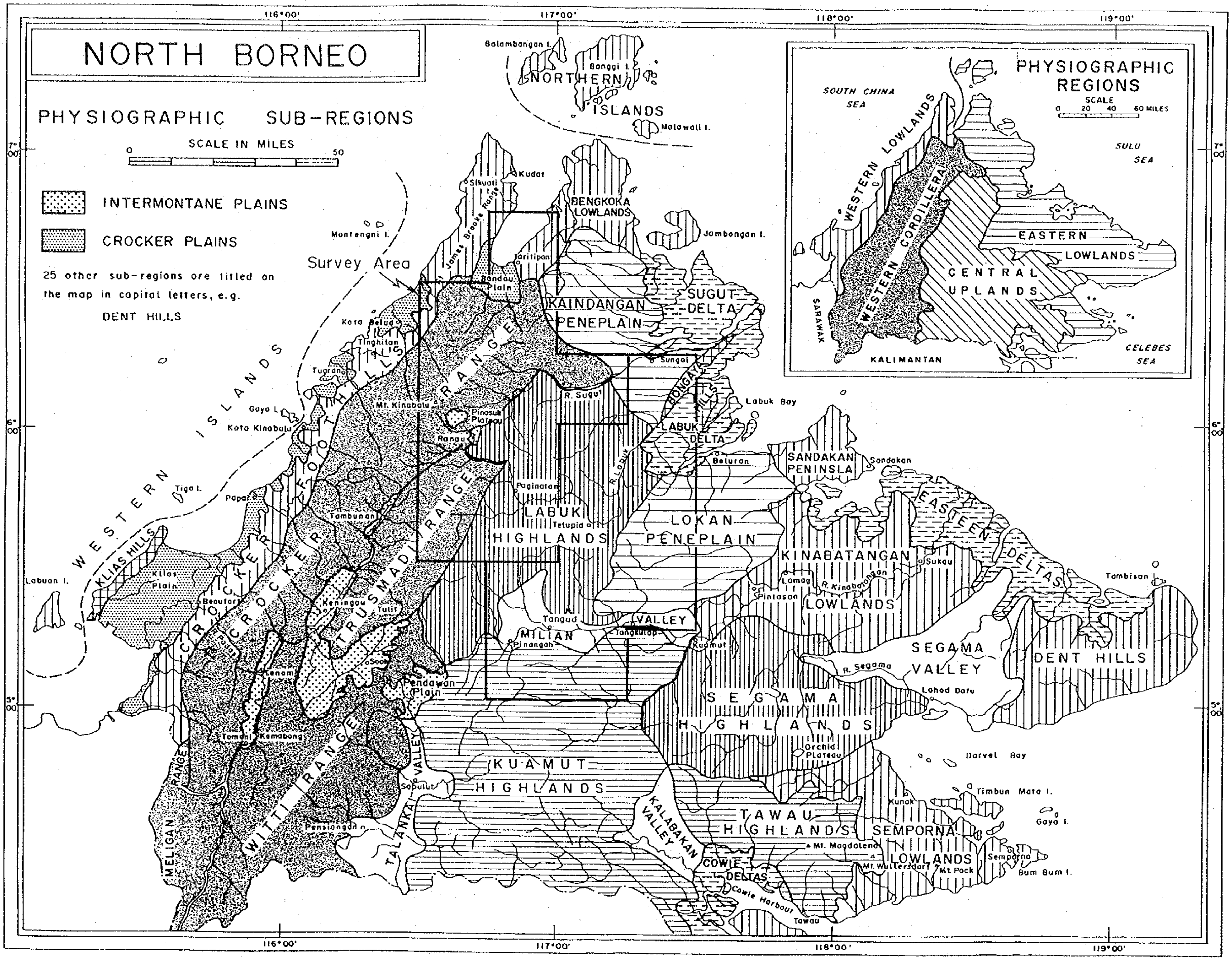


Figure I-2 Physiographic Sub-regions of Sabah (After Collenette P., 1962)

CHAPTER 3 GENERAL GEOLOGY (GEOLOGY OF KINABALU AREA)

The area is largely underlain by sediments of the Crocker and Trusmadi Formations but with extensive ultramafic and granitic rocks and some tilloid deposits. There are also local occurrences of metamorphic rocks such as hornfels, schist, quartzite, metaultramafics and metasediments. Rare volcanic flows include spilite, dacite and andesite.

The oldest unit in the Kinabalu area is the Crystalline Basement which consists of biotite-hornblende schist, actinolite schist and plagioclase-hornblende gneiss. It is believed to have been originated as upfaulted slices of presumably Mesozoic or earlier age.

Unconformable deposition of sediments on the Basement rocks from Upper Cretaceous to Miocene resulted in a thick sequence of sediments which forms the Trusmadi and Crocker Formations. The two formations are believed to be faulted against each other, the Trusmadi Formation being the older one. They are lithologically and structurally similar except that the Trusmadi Formation is more argillaceous and the Crocker Formation more arenaceous.

The Trusmadi Formation consists mainly of dark-coloured shale which is thickly bedded or interbedded with thin siltstone and sandstone beds. It is believed to have been deposited in a marine environment at moderate depth. Sedimentary structures such as those found in the Crocker Formation are common. The rocks are strongly folded and thrusted, commonly sheared and brecciated, and in places metamorphosed. No diagnostic fossils have been found but Paleocene to Eocene age has been inferred.

The Crocker Formation consits predominantly of sandstone which is thickly-bedded or interbedded with siltstone, red and grey shale, mudstone and argillite. It is believed to have been deposited in a deep water marine environment. Sedimentary structures such as graded bedding, small-scale cross-bedding, sole markings and ripple marks are common. The rocks are strongly folded resulting in isoclinal and recumbent folds, and often brecciated. No diagnostic fossils have been found but the age is inferred to range from Paleocene to Early Miocene.

Minor outcrops of slump breccia belonging to the Wariu Formation have been recorded and are believed to be deposited unconformably on the older sediments during the Miocene.

The ultramafic rocks consist of predominantly peridotite but with rare occurrences of dunite. Lherzolite is reported common around Gunung Kinabalu but harzburgite is common elsewhere; they are both invariably serpentinized so that serpentinite is widespread. They are commonly sheared and brecciated and faulted against the country rocks, indicating a tectonic emplacement.

The major granitic intrusives consist of granite and its porphyritic varieties; the minor intrusives include granodioride, monzonite and microdiorite, with rare occurrences of aplite and dolerite. They were emplaced during Pliocene to Miocene. Extrusive rocks are very rare, mainly dacite; others include andesite, spilite and basalt.

The youngest unit is formed by tilloid deposits of the Pinosuk Gravels. These deposits are poorly sorted and were probably derived from the mountains by solifluction during glacial epochs. Two unconformable members were recognised. The lower member contains angular to subangular blocks mainly of ultramafic or sedimentary rocks ranging in size from pebbles to boulders; the materials are mostly well-consolidated. The upper member is clayed to sandy and contains angular to rounded clasts of various rock types, including granitic boulders; the materials are mostly poorly consolidated.

(after "Summary of Geology" of Geological Map of the Kinabalu Area, Sabah, Malaysia, Sheet 6/116/15)

CHAPTER 4 SYNTHETIC STUDY ON THE RESULT OF THE SURVEY

4-1 Characteristic of Geological Structure and Mineralization and Structural Control of Mineralization

Outcrops of quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones accompanied by minor amounts of limonite, pyrite, and in places hematite or chalcopyrite are found in hydrothermally altered sandstone, mudstone, and acidic to intermediate volcanic and pyroclastic rocks, which are distributed in the area to the east of Kpg. Poring.

Outcrops which contain gold over 0.10 g/t (0.10 to 2.48 t/t), copper over 0.1% (0.22 to 0.64%), and arsenic, which accompanies generally gold mineralization together with mercury, over 1,000 ppm (1,175 to 5,063 ppm) are distributed concentratedly on the southern (11 outcrops) and eastern (2 outcrops) hillsides of Bt. Tampang.

Pyrite・gold・copper・arsenic・mercury-bearing quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones found on the southern hillside of Bt. Tampang are hosted in felsic tuff, strongly altered rock of unknown origin, and sandstone, all of which have been strongly subjected to hydrothermal alteration consisting mainly of silicification, sericitization, and kaolinization.

The alteration mineral assemblage (mainly quartz-sericite-kaolinite) of the hydrothermal alteration zone found in the area to the east of Kpg. Poring including the southern and eastern hillsides of Bt. Tampang seems to represent that of the hydrothermal alteration zone accompanying epithermal gold deposit of the intermediate type between the adularia-sericite and acid sulfate types (Hayba et al., 1986; Heald et al., 1987) or between the low sulfidation and high sulfidation types (Hedenquist, 1987).

The gold mineralization found on the southern and eastern hillsides of Bt. Tampang is hosted in hydrothermally altered sandstone and felsic tuff which are distributed in the area to the east of Kpg. Poring. Hydrothermally altered sandstone belonging probably to the Crocker Formation has considerably wide range of the K-Ar age, whereas hydrothermally altered felsic tuff overlying unconformably sandstone has been dated as 7.34 ± 0.48 to 7.44 ± 0.46 Ma (late Miocene) by means of the K-Ar method.

Judging from that felsic tuff has strongly undergone sericitization, it seems that the K-Ar age of hydrothermally altered felsic tuff indicates probably the age of hydrothermal alteration, to which tuff was subjected.

Pyrite・gold・copper・arsenic・mercury-bearing quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones found at the localities of mineral occurrence on the southern and eastern hillsides of Bt. Tampang seem to form a big quartz networks zone as a whole.

Judging from that the mineralized zone of gold found on the southern and eastern hillsides, especially southern hillside, of Bt. Tampang has been embedded in hydrothermally altered sandstone belonging probably to the Crocker Formation and felsic tuff overlying unconformably sandstone, it seems that the gold mineralization has been probably controlled by the surface of unconformity.

Quartz taken from quartz veinlets and networks found at the localities of mineral occurrence on the southern and eastern hillsides of Bt. Tampang is divided into two groups in terms of the homogenization temperature of fluid inclusion in quartz, namely 5 samples which have relatively low homogenization temperature and 4 samples which have considerably wide range of homogenization temperature (131° to 536°C). Three samples out of five samples of relatively low temperature contain 0.22 to 1.27 g/t of gold.
The rativeIy low homogenization temperature of 5 samples falls within the range of 135° to 350°C of adularia-sericite type epithermal gold deposit related to the volcanic activity in the Western Pacific island Arcs after Sillitou (1988).

Considering that acidic to intermediate pyroclastic and volcanic rocks found in the area to the east of Kpg. Poring belong to the calc-alkaline rock series as shown in the $FeO+Fe_2O_3-Na_2O+K_2O-MgO$, $SiO_2-FeO+Fe_2O_3/MgO$, and $FeO+Fe_2O_3-FeO+Fe_2O_3/MgO$ diagrams, on which the analyses of pyroclastic and volcanic rocks have been plotted for the petrological study, in addition to the above conclusions, it seems that mineralized zone of gold found on the southern and eastern hillsides of Bt. Tampang is epithermal gold-bearing quartz networks formed by intermediate hydrothermal fluid related to the volcanic activity of the calc-alkaline rock series in late Miocene.

4-2 Possibility of Emplacement of "Expected Ore Deposit"

Pyrite・gold・copper・arsenic・mercury-bearing quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones found at the localities of mineral occurrence on the southern and eastern hillsides of Bt. Tampang seem to form a low grade gold-bearing big quartz networks zone as a whole.

Judging from the assemblage of metal constituent contained in the mineralized zone, the alteration mineral assemblage of the hydrothermal alteration zone associated with gold mineralization, and the K-Ar age of host rock, this mineralized zone seems to be epithermal gold deposit formed by intermediate hydrothermal fluid related to the volcanic activity of the calc-alkaline rock series in late Miocene.

Therefore, there is a possibility that higher grade gold-bearing quartz networks or gold-bearing quartz veins of the bonanza-type (vein-type) are present below this low grade gold-bearing quartz networks zone.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

The follow-up survey in 1993, namely the investigation of locality of mineral occurrence accompanied by geological survey, which was conducted in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrence of epithermal gold deposit was discovered by the investigation of locality of mineral occurrence in 1992, in order to discover new locality of gold occuurrence and clear up the possibility of the emplacement of gold deposit in the survey area, reveals that pyrite・gold (0.10 to 2.48 g/t)・copper (0.22 to 0.64%)・arsenic (1,175 to 5,063 ppm)・mercury (1,399 to 38,785 ppb)-bearing quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones, which seem to form a low grade gold-bearing big quartz networks zone as a whole, are distributed concentratedly on the southern and eastern hillsides, especially on the southern hillside, of Bt. Tampang.

These mineralized zones are hosted in sandstone belonging probably to the Crocker Formation, felsic tuff overlying unconformably sandstone, and strongly altered rock of unknown origin, all of which have been strongly subjected to hydrothermal alteration consisting mainly of silicification, sericitization, and kaolinization. The alteration mineral assemblage (mainly quartz-sericite-kaolinite) of the hydrothermal alteration zone seems to represent that of the hydrothermal alteration zone accompanying epithermal gold deposit of the intermediate type between the adularia-sericite and acid sulfate types (Hayba et al., 1986; Heald et al., 1987) or between the low sulfidation and high sulfidation types (Hedenquist, 1987).

Considering that felsic tuff seems to have undergone hydrothermal alteration probably 7.34 ± 0.48 to 7.44 ± 0.46 Ma ago (late Miocene) which was indicated by the age determination of hydrothermally altered felsic tuff by means of the K-Ar method and that acidic to intermediate pyroclastic and volcanic rocks found in the area to the east of Kpg. Poring belong to the calc-alkaline rock series, low grade gold-bearing quartz networks zone found on the southern and eastern hillsides of Bt. Tampang seems to be epithermal gold deposit formed by intermediate hydrothermal fluid related to the volcanic activity of the calc-alkaline rock series in late Miocene.

Therefore, there is a possibility that higher grade gold-bearing quartz networks or gold-bearing quartz veins of the bonanza-type (vein-type) are present below this low grade gold-bearing quartz networks zone.

5-2 Recommendation for the Future

As mentioned in the above "5-1 Conclusion", there is a possibility that higher grade gold-bearing quartz networks or gold-bearing quartz veins of the bonanza-type (vein-type) are present under the low grade gold-bearing quartz networks zone found on the southern and eastern hillsides of Bt. Tampang.

Therefore, the following exploration works are recommended in order to confirm the above possibility.

(1) The trenching on the southern and eastern hillsides of Bt. Tampang and on the ridge and the systematic sampling at the trench and assaying of the sample for the purpose of clarifying the detailed distribution of gold grade on the surface are proposed.

(2) In case the emplacement of higher grade portion of gold below the low grade gold-bearing quartz networks zone is expected as the result of trenching, sampling, and assaying of the samples, the diamond drilling aiming at the higher grade portion expected are proposed.

Part II The Particular

PART II THE PARTICULAR

CHAPTER 1 CONTENTS OF THE SURVEY

1-1 Investigation of Locality of Mineral Occurrence and Geological Survey

The investigation of the locality of mineral occurrence and geological survey were conducted in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrence of epithermal gold deposit was discovered by the investigation of locality of mineral occurrence in 1992, in order to discover new mineral occurrence of gold and then clear up the possibility of the emplacement of gold deposit in the survey area, through clarifying the characteristics of geology and mineralization at the localities of mineral occurrence of gold found in the survey area.

1-2 Laboratory Work

The following laboratory works on the samples of ore, host rock, hydrothermally altered rock, and quartz taken at the localities of mineral occurrence and on the representative rock samples obtained in the survey area were conducted for the purpose of clarifying the characteristics of mineralization and geology at and around the localities of mineral occurrence of gold in the survey area. The contents of the laboratory works are shown in the Table I-1.

(1) K-Ar age determination of rock
(2) Chemical analysis of rock
(3) Microscopic observation of thin section of rock
(4) Chemical analysis of ore
(5) Microscopic observation of polished section of ore
(6) X-ray diffraction examination of hydrothermally altered rock
(7) Measurement of homogenization temperature of fluid inclusions in quartz.

CHAPTER 2 GEOLOGY

The survey area is largely underlain by sediments of the Trusmadi and Crocker Formations but with relatively extensive ultrabasic rock, acidic to intermediate pyroclastic and volcanic rocks, acidic intrusive rocks, acidic to intermediate dyke rocks, and Pinosuk Gravels of Pleistocene.

(1) Trusmadi Formation

The Trusmadi Formation, which is reportedly of Paleocene to Eocene and is believed to be older than the Crocker Formation, consists mainly of thickly-bedded dark colour mudstone interbedded with thin siltstone and sandstone and is mainly exposed along the upper reaches of the S. Bangkud and the Mamut road (Mamut mine-Luhan disposal dam).

It is in fault contact with the Crocker Formation and ultrabasic rock and has been in places thermally metamorphosed into biotite hornfels.

(2) Crocker Formation

The Crocker Formation which is reportedly of Paleocene to Oligocene consists predominantly of thickly-bedded sandstone interbedded with thin siltstone and mudstone and is exposed in the northwestern part, especially along Kipungit, Mamut, Mantukungan, and Bruntukungan rivers, and in the central to eastern part of the survey area.

Sandstones which probably belong to the Crocker Formation have been dated as 7.85 ± 0.60, 14.0 ± 1.0, 36.8 ± 4.2, and 112 ± 7.0 Ma by means of the K-Ar method using whole rock. Some sandstone which is distributed on the southern and eastern hillsides of Bt. Tampang hosts gold mineralization.

It is in fault contact with the Trusmadi Formation and ultrabasic rock and has been subjected to hydrothermal alteration, mainly silicification, sericitization, and kaolinization, in the central to eastern part.

(3) Ultrabasic rock

Ultrabasic rock which is thought to be a member of the ophiolite complex probably resulted from the obduction of the occeanic crust accompanying the subduction of the occeanic plate is exposed in the southwestern and northwestern parts of the survey area and consists of serpentinized lherzolite and serpentinite.

It is in fault contact with the Trusmadi and Crocker Formations.

(4) Acidic to intermediate pyroclastic and volcanic rocks

This rock unit, consisting mainly of felsic tuff and dacitic agglomerate with subordinate amounts of interlayered rhyolite, dacite, and andesite, unconformably overlies the Crocker Formation and is exposed around Bt. Tampang. These rocks have strongly undergone hydrothermal alteration, mainly silicification, sericitization, and kaolinization. Altered and strongly altered felsic tuffs and strongly altered rock of unknown origin which are distributed on the southern hillside of Bt. Tampang host gold mineralization. Hydrothermally altered felsic tuff has been dated 7.34±0.48 to 7.44±0.46 Ma by means of the K-Ar method using whole rock.

(5) Acidic intrusive rocks

Acidic intrusive rocks distributed in the survey area consist of granodiorite stock exposed around S. Kipungit and the upper reaches of S. Langanan in the northwestern part of the survey area and three stocks of quartz diorite porphyry found around Bt. Kotud and Bt. Tambian and in a northern tributary of S. Bangkud, all of which have intruded into the Crocker Formation.

Granodiorite and quartz diorite porphyry have been dated as 7.40±0.52 Ma and 6.78±0.45 to 8.03±0.59 Ma respectively by means of K-Ar method using whole rock.

(6) Acidic to intermediate dyke rocks

Small dykes of dacite and andesite have intruded into the Crocker Formation distributed to the north of the S. Langanan.

(7) Pinosuk Gravels

The Pinosuk Gravels of Pleistocene is the youngest unit in the survey area and is distributed on the gently sloped hillside between Kpg. Poring and Kpg. Bangkud.

This unit is poorly sorted and consolidated and contains angular to rounded clasts of various rock types ranging from pebble to boulder in size, including granitic boulders, in sandy to clayey matrix. The Pinosuk Gravels was probably derived from the Kinabalu mountains by solifluction during glacial epochs.

It seems that there are four kinds of directions of faults in the survey area, all of which are inferred from geology and topographic feature, namely predominant northwest diretion with subordinate northeast, north-south, and east-west directions.

Table II-1 Stratigraphy of the Bt. Tampang-Kpg. Poring Area

AGE	SEDIMENTARY ROCKS	IGNEOUS ROCKS	ABSOLUTE AGE m.y.
HOLOCENE	RECENT ALLUVIUM: boulder gravel		
PLEISTOCENE	PINOSUK GRAVELS: cloyey to sandy boulder gravel		5
PLIOCENE	Non-deposition	Extrusion of volcanic rocks and pyroclastic flow; intrusion of acidic intrusive rocks and dyke rocks	7
MIOCENE		Emplacement of ultrabasic rocks by fauling	9
OLIGOCENE	CROCKER FORMATION: sandstone, interbedded with siltstone, shale, and mudstone		26
EOCENE	TRUSMADI FORMATION: grey and dark grey mudstone, interbedded with siltstone and sandstone		38
PALAEOCENE			54
UPPER CRETACEOUS	(CHERT-SPILITE FORMATION: chert, greywacke, limestone)	(Basic intrusive and extrusive rocks: mainly spilite and sodic dolerite)	65
			100

(Adopted from Jacobson, G., 1970)

CHAPTER 3 THE RESULT OF THE SURVEY

3-1 Investigation of Locality of Mineral Occurrence

The investigation of the locality of mineral occurrence accompanied by geological survey was conducted in the Langanan, Bangkud, and Luhan basins, where anomalies of gold were detected in 1992 by geochemical survey employing stream sediment, including Bt. Tampang area, where mineral occurrence of epithermal gold deposit was discovered by the investigation of locality of mineral occurrence in 1992, in order to discover new locality of gold occurrence and clear up the possibility of the emplacement of gold deposit in the survey area.

The result of the investigation of the locality of mineral occurrence is summarized in the Table II-2 and geology and geologic section of the survey area and the locations of the locality of mineral occurrence are shown respectively in the Fig. II-1, II-2, II-3 attached at the end of this report.

The localities of mineral occurrence investigated in 1993 are 42 localities including 3 localities (BT-1, BT-17, BT-38) which were discovered in 1992. Thirty-eight localities, except 2 quartz veins in sandstone (BK-12, KP-4), quartz vein in granodiorite (KP-7), and quartz pebble in gravel bed of Quaternary (KP-9), out of 42 localities, are outcrops of quartz veinlets (4 localities), quartz networks (13 localities), veins of silicified zone (11 localities), and silicified and argillized zones (10 localities), which appeared to contain gold at the time of the investigaton, in sandstone, mudstone, and acidic to intermediate volcanic and pyroclastic rocks, altered hydrothermally.

Quartz veinlets, quartz networks, veins of silicified zone, and silicified and argillized zones found at above-mentioned 38 localities consist mainly of quartz with subordinate amounts of limonite, pyrite, and in places hematite, and chalcopyrite is present at localities of BT-10 and BT-11 only.

Host rocks of 38 localities are altered sandstone (22 localities), altered mudstone (1 locality), altered acidic to intermediate volcanic rock (2 localities), altered acidic to intermediate pyroclastic rock (9 localities), and strongly altered rock (3 localities). These host rocks have been subjected to silicification at all the localities, sericitization and kaolinization at majority of 38 localities, and adularization or tourmalinization in places.

The assay result of ore and rock samples from 42 localities of mineral occurrence reveals that 10 localities of mineral occurrence, where gold over 0.1 g/t is contained, are BT-1 (1.27 g/t), BT-2 (0.57 g/t, 0.40 g/t), BT-5 (0.16 g/t), BT-6 (2.48 g/t), BT-11 (0.24 g/t), BT-13 (0.22 g/t), BT-14 (0.10 g/t), BT-43 (0.24 g/t), BT-45 (0.11 g/t), and BT-58 (0.22 g/t), and 4 localities, where copper over 0.1% is contained, are BT-6 (0.46%), BT-7 (0.64%), BT-10 (0.51%, 0.22%), and BT-11 (0.31%), and that many localities of mineral occurrence are rich in arsenic and mercury which accompany generally gold mineralization, that is, 6 localities, where arsenic over 1,000 ppm is contained, are BT-1 (1,729 ppm, 2,703 ppm), BT-2 (1,508 ppm, 4,567 ppm), BT-6 (5,063 ppm), BT-10 (1,431 ppm), BT-12 (1,283 ppm), and BT-43 (1,175 ppm), and 41 samples from 31 localities contain mercury over 1.0 ppm (1.2 to 38.8 ppm). On the other hand, quartz samples from four localities (BK-12, KP-4, KP-7, KP-9), where host rocks have not been subjected to hydrothermal alteration, scarcely contain above-mentioned metal.

The investigation of locality of mineral occurrence and assay of ore sample reveal that localities of mineral occurrence, where gold, copper, and arsenic are relatively rich, are distributed on the southern hillside (BT-1, BT-2, BT-5, BT-6, BT-7, BT-10, BT-11, BT-12, BT-13, BT-14, BT-58) and the eastern hillside (BT-43, BT-45) of Bt. Tampang.

The directions of fissures, in which quartz veins and quartz networks at 42 localities of mineral occurrence are embedded, are divided into four groups, that is, firstly the east-west system (N68°E to N70°W, 11 localities), secondarily the northeast system (N30° to 60°E, 7 localities), thirdly the north-south system (N20°E to N20°W, 5 localities), and fourthly the northwest system (N25° to 50° W, 4 localities). These four direction systems of fissure are consistent with those of faults which are, in general, found in Sabah.

Table II-2 List of Localities of Mineral Occurrence

1/3

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-1 (T-10)	lim+qz	lim·qz veinlets-bearing argillized & silicified zone	?	W=2.2m+	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-1-0-1 BT-1-0-2
	BT-2	lim+qz	lim·qz lens-bearing argillized & silicified zone	?	W=3.1m+	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-2-0-1 BT-2-0-2
	BT-3	lim·hem+qz	lim·hem·qz veinlets-bearing argillized & silicified zone	?	W=4.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-3-0
	BT-4	lim·hem·qz	lim·hem·qz network-bearing silicified & argillized zone	?	W=2.0m+	altered sandstone	silicification	BT-4-0
	BT-5	lim·hem+qz	vein of silicified zone	N40°E·75°SE	T=0.3~0.5m	altered sandstone	silicification	BT-5-0
	BT-6	lim·py·qz	network	?	W=2.5m+	altered felsic tuff	silicification, kaolinization, adularization	BT-6-0
	BT-7	qz+lim·py	veinlets	N80°E·16°N	T=0.5~2.0cm, L=1.3m	altered felsic tuff	silicification, kaolinization, sericitization, adularization	BT-7-0
	BT-9	lim	lim-bearing argillized zone	?	W=2.0m+	fine tuffaceous sandstone	sericitization, silicification, kaolinization	BT-9-0
	BT-10	qz+py·lim·cp	network	N50°W·30°N N80°W·90°	W=3.5m, L=4.5m (T of qz vein=2~10cm)	strongly altered rock	silicification, adularization, sericitization, kaolinization	BT-10-0-1 BT-10-0-2
	BT-11	qz+py·lim·cp	network	N44°E·90°	W=0.5m, L=2.0m+ (T of qz vein=1~2cm)	strongly altered rock	silicification, adularization, sericitization, kaolinization	BT-11-0
	BT-12	qz+lim	veinlet	N82°W·35°S	T=0.5cm	strongly altered rock	silicification, sericitization, kaolinization	BT-12-0
	BT-13	qz+lim	vein	N48°E·90°	T=1~25cm	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-1
		qz·lim	vein of silicified zone	N-S·60°N	T=0.65m	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-2
		qz·lim	vein of silicified zone	?	T=1.3m	altered felsic tuff	silicification, sericitization, kaolinization	BT-13-0-3
	BT-14	qz+lim·hem	network	N70°E·43°N	W=8.0m+, H=6.0m+ (T of qz vein=0.5~5cm)	strongly altered felsic tuff	silicification, sericitization	BT-14-0-1 BT-14-0-2
	BT-15	qz	network	N60°E·53°N	W=8.0m+, H=6.0m+ (T of qz vein=0.5~6.0cm)	strongly altered felsic tuff	silicification, sericitization	BT-15-0
	BT-16	qz+lim	vein and network	N70°W·90°	T=1.2m, W=3.0m, L=6.0m+	strongly altered felsic tuff	silicification, sericitization	BT-16-0
	BT-17 (T-1)	qz+py·lim	network	N45°W·86°N	W=38.0m, H=3.0m+ (T of qz vein=0.5~5.0cm)	strongly altered dacitic agglomerate	silicification, kaolinization, sericitization, chaloritization	BT-17-0-2~ BT-17-0-14

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-20	qz+lim•hem	vein	?	T=0.6m, L=1.1m+	?	?	
	BT-26	qz	network	?	T=0.5~3.0cm	altered tuffaceous sandstone	silicification, sericitization, kaolinization	BT-26-0
	BT-28	lim•py+(qz)	lim•py •minor qz veinlets-bearing argillized and silicified zone	?	W=6.0m	altered andesite	silicification, sericitization kaolinization, adularization	BT-28-0-1 BT-28-0-2 BT-28-0-3 BT-28-0-4
	BT-31	qz+lim	vein and network	N50°E•80°S	T=2~5cm, W=0.6m, H=2.4m	strongly altered tuff	silicification sericitization	BT-31-0
	BT-32	qz	network	?	W=6.0m+, H=3.0m+ (T of qz vein=0.3~3.0cm)	coarse sandstone	silicification, sericitization	BT-32-0
	BT-37	qz+lim	vein	N25°W•90°	T=2~5cm, H=1.0m+	altered sandstone	silicification, sericitization	BT-37-0
	BT-38 (T-3)	qz+lim•py	lenticular silicified zone	?	L=0.25m, T=0.1m	altered rhyolite	silicification, kaolinization, sericitization, chloritization	BT-38-0
	BT-41	qz+lim	network	?	w=4.0m+, H=1.5m+	altered sandstone	silicification, sericitization, kaolinization	BT-41-0
	BT-42	qz•lim•hem	qz veinlets•lim•hem-bearing silicified & argillized zone	?	W=2.0m+, H=1.5m+	altered sandstone	silicification, sericitization, kaolinization	BT-42-0
	BT-43	qz•lim	network	horizontal	T=1.3m, L=5.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-43-0
	BT-44	qz+lim	qz lens•lim-bearing silicified and argillized zone	N20°W•80°E	W=3.0m, L=5.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-44-0
	BT-45	qz+lim•py	lim•qz network•py-bearing breccia vein	N68°E•87°S	T=0.4m, H=4.0m+	altered sandstone	silicification, sericitization, kaolinization	BT-45-0
	BT-46	qz•lim	qz network-bearing vein of silicified zone	N70°E•74°S	T=0.7m, L=6.6m+	altered sandstone	silicification, sericitization, kaolinization	BT-46-0
	BT-47	qz+lim	lim-bearing vein of silicified zone	N74°E•90°	T=0.75m, H=1.2m+	altered sandstone	silicification, sericitization, kaolinization	BT-47-0
	BT-48	qz+lim•py	py•lim-bearing vein of silicified zone	E-W•70°S N70°E•70°S	T=0.3m, L=3.0m+, H=1.2m+ T=0.75m	altered sandstone	silicification, sericitization, kaolinization	BT-48-0-1 BT-48-0-2
	BT-49	qz+lim	vein of silicified zone	N35°E•80°W	T=0.55m, L=3.0m	altered sandstone	silicification, sericitization, kaolinization	BT-49-0
	BT-50	qz•lim	lim-bearing silicified breccia vein	N12°E•70°W	T=1.0m	altered fine sandstone	silicification, sericitization	BT-50-0
	BT-51	qz•lim	lim-bearing silicified breccia zone	N17~35°W•90°	W=9.0m	altered fine sandstone	silicification, sericitization	BT-51-0

Area	Locality Number	Mineral Assemblage	Occurrence	Strike & Dip	Size of Mineralized Zone	Host Rock	Alteration of Host Rock	Ore Sample Number
Bt. Tampang	BT-58	qz+lim	network	N20°E·70°W	W=3.5m+, H=5.0m+	strongly altered tuff	silicification, sericitization	BT-58-0
Bt. Kotud	BK-12	qz+py	network	?	W=1.0m, L=2.0m+	sandstone	none	BK-12-0
Kg. Poring	KP-4	qz	vein	?	T=2~5cm	sandstone	none	
	KP-7	qz	vein	N44°W·60°S	T=5cm, H=1.3m+	granodiorite	none	
	KP-9	qz	pebble in Quaternary gravel bed	?	?	Quaternary gravel bed	silicification, sericitization kaolinization	KP-9-0-1 KP-9-0-2
	KP-13	qz·lim·py	py·lim-bearing silicified and argillized zone	?	W=8.0m+	altered sandstone	silicification, sericitization chloritization	KP-13-0-1 KP-13-0-2
	KP-14	qz·lim·py	lim·py-bearing silicified and argillized zone	N70°W·90°	W=3.0m	altered mudstone	silicification, sericitization, kaolinization	KP-14-0
	KP-18	qz	vein of silicified zone	N30°E·64°E	T=0.35m, H=0.4m+	altered sandstone	silicification, sericitization, kaolinization	KP-18-0

[Abbreviations]
qz: quartz, py: pyrite, lim: limonite, hem: hematite, cp: chalcopyrite, W: width, T: thickness, L: length, H: height, 2.2m+: 2.2 meters and over
(T-1), (T-3), (T-10): number of locality of mineral occurrence found in 1992.

Table II-3 List of Samples taken for Laboratory Work

Area	Locality Number	Dating	Assay of Rock	Thin Section	Assay of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
Bt. Tampang	BT-1				BT-1-0-1			BT-1-Q	
	"				BT-1-0-2				
	BT-2			BT-2-T	BT-2-0-1		BT-2-X		
	"				BT-2-0-2				
	BT-3				BT-3-0	BT-3-P	BT-3-X		
	BT-4	BT-4-D	BT-4-R	BT-4-T	BT-4-0		BT-4-X		
	BT-5				BT-5-0	BT-5-P			BT-5-0-S
	BT-6				BT-6-0	BT-6-P	BT-6-X		
	BT-7			BT-7-T	BT-7-0	BT-7-P	BT-7-X	BT-7-Q	
	BT-9		BT-9-R	BT-9-T	BT-9-0		BT-9-X		
	BT-10				BT-10-0-1		BT-10-X	BT-10-Q	BT-10-0-1-S
	"				BT-10-0-2	BT-10-P			
	BT-11			BT-11-T	BT-11-0	BT-11-P	BT-11-X	BT-11-Q	BT-11-0-S
	BT-12				BT-12-0				
	BT-13	BT-13-D	BT-13-R	BT-13-T	BT-13-0-1		BT-13-X	BT-13-Q	BT-13-0-1-S
	"				BT-13-0-2				
	"				BT-13-0-3	BT-13-P			
	BTD-14			BT-14-T	BT-14-0-1	BT-14-P	BT-14-X	BT-14-Q	
	"				BT-14-0-2				
	BT-15				BT-15-0	BT-15-P		BT-15-Q	
	BT-16				BT-16-0	BT-16-P	BT-16-X	BT-16-Q	BT-16-0-S
	BT-17				BT-17-0-2	BT-17-P	BT-17-X		
	"				BT-17-0-3				
	"				BT-17-0-4				
	"				BT-17-0-6				
	"				BT-17-0-7				
	"				BT-17-0-8				
	"				BT-17-0-9				
	"				BT-17-0-10				
	"				BT-17-0-11				
	"				BT-17-0-12				
	"				BT-17-0-13				
	"				BT-17-0-14				
	BT-18	BT-18-D	BT-18-R	BT-18-T			BT-18-X		BT-18-D-S
	BT-19			BT-19-T			BT-19-X		

Area	Locality Number	Dating	Assay of Rock	Thin Section	Assay of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
Bt. Tampang	BT-20				BT-20-O	BT-20-P		BT-20-Q	
	BT-21						BT-21-X		
	BT-22						BT-22-X		
	BT-23		BT-23-R	BT-23-T			BT-23-X		
	BT-24		BT-24-R	BT-24-T			BT-24-X		
	BT-25						BT-25-X		
	BT-26		BT-26-R	BT-26-T	BT-26-O		BT-26-X	BT-26-Q	
	BT-28				BT-28-O-1				
	"				BT-28-O-2				
	"				BT-28-O-3				
	"			BT-28-T	BT-28-O-4	BT-28-P	BT-28-X		BT-28-O-4-S
	BT-29		BT-29-R	BT-29-T			BT-29-X		
	BT-30		BT-30-R	BT-30-T			BT-30-X		
	BT-31	BT-31-D	BT-31-R	BT-31-T	BT-31-O		BT-31-X	BT-31-Q	BT-31-O-S
	BT-32	BT-32-D	BT-32-R	BT-32-T	BT-32-O	BT-32-P	BT-32-X	BT-32-Q	
	BT-33		BT-33-R	BT-33-T					BT-33-R-S
	BT-34		BT-34-R	BT-34-T			BT-34-X		
	BT-35	BT-35-D	BT-35-R	BT-35-T					BT-35-D-S
	BT-36		BT-36-R	BT-36-T			BT-36-X		
	BT-37		BT-37-R	BT-37-T	BT-37-O	BT-37-P	BT-37-X	BT-37-Q	
	BT-38				BT-38-O	BT-38-P			
	BT-40	BT-40-D	BT-40-R	BT-40-T			BT-40-X		BT-40-D-S
	BT-41		BT-41-R	BT-41-T	BT-41-O	BT-41-P	BT-41-X		
	BT-42				BT-42-O	BT-42-P			
	BT-43				BT-43-O	BT-43-P			
	BT-44				BT-44-O	BT-44-P		BT-44-Q	
	BT-45		BT-45-R	BT-45-T	BT-45-O	BT-45-P	BT-45-X	BT-45-Q	BT-45-O-S
	BT-46				BT-46-O	BT-46-P			
	BT-47				BT-47-O	BT-47-P			
	BT-48				BT-48-O-1	BT-48-P			
	"				BT-48-O-2				
	BT-49				BT-49-O	BT-49-P			
	BT-50		BT-50-R	BT-50-T	BT-50-O	BT-50-P	BT-50-X		
	BT-51				BT-51-O	BT-51-P			
	BT-52			BT-52-T			BT-52-X		

Area	Locality Number	Dating	Assay of Rock	Thin Section	Assay of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
Bt. Tampang	BT-54		BT-54-R	BT-54-T			BT-54-X		
	BT-55						BT-55-X		
	BT-56		BT-56-R	BT-56-T			BT-56-X		
	BT-57		BT-57-R	BT-57-T			BT-57-X		
	BT-58		BT-58-R	BT-58-T	BT-58-O	BT-58-P	BT-58-X		
Bt. Kotud	BK-1		BK-1-R	BK-1-T					BK-1-R-S
	BK-2		BK-2-R	BK-2-T			BK-2-X		
	BK-4	BK-4-D	BK-4-R	BK-4-T					BK-4-D-S
	BK-5		BK-5-R	BK-5-T					BK-5-R-S
	BK-6		BK-6-R	BK-6-T			BK-6-X		
	BK-7						BK-7-X		
	BK-9		BK-9-R	BK-9-T			BK-9-X		BK-9-T-S
	BK-10		BK-10-R	BK-10-T			BK-10-X		
	BK-11			BK-11-T			BK-11-X		
	BK-12				BK-12-O	BK-12-P		BK-12-Q	
Kg. Poring	KP-1	KP-1-D	KP-1-R	KP-1-T					KP-1-D-S
	KP-2		KP-2-R	KP-2-T			KP-2-X-1		
	"						KP-2-X-2		
	KP-4				KP-4-O			KP-4-Q	
	KP-5	KP-5-D	KP-5-R	KP-5-T					KP-5-D-S
	KP-7				KP-7-O			KP-7-Q	
	KP-8		KP-8-R	KP-8-T					KP-8-R-S
	KP-9				KP-9-O-1			KP-9-Q	
	"				KP-9-O-2				
	KP-10		KP-10-R	KP-10-T					
	KP-11		KP-11-R	KP-11-T			KP-11-X		
	KP-12		KP-12-R	KP-12-T					
	KP-13		KP-13-R	KP-13-T	KP-13-O-1	KP-13-P	KP-13-X		
	"				KP-13-O-2				
	KP-14			KP-14-T	KP-14-O		KP-14-X		
	KP-18			KP-18-T	KP-18-O		KP-18-X	KP-18-Q	
Kg. Lohan	KL-1		KL-1-R	KL-1-T					KL-1-R-S
Total		10	40	50	65	30	50	20	20

3-2 Laboratory Work

The list of the samples taken for the following laboratory works is given in the Table II-3 and the locations of the samples are shown in the Figure II-4 atacched at the end of this report.

3-2-1 K-Ar Age Determination of Rock (10 samples)

Ten representative rock samples, namely four samples of hydrothermally altered sandstone, two samples of hydrothermally altered tuff, and four samples of acidic intrusive rock, out of rock samples taken for the chemical analysis and microscopic observation, have been dated by means of the K-Ar method using whole rock.

The result is given in the Table II-4. Table II-4 shows that acidic intrusive rocks and hydrothermally altered tuffs have been dated as 6.73±0.42 to 8.03±0.59 Ma (Late Miocene) and 7.34±0.48 to 7.44±0.46 Ma (Late Miocene) respectively and are about the same in age, whereas hydrothermally altered sandstones have been dated as 7.70±0.56 to 8.01±0.64 Ma (Late Miocene), 13.8±1.0 to 14.2±1.0 Ma (Middle Miocene), 35.3±4.2 to 38.4±4.2 Ma (Early Oligocene), and 112±7.0 Ma (Early Cretaceous) with wide range in age and are older than acidic intrusive rocks and hydrothermally altered tuffs in age.

Table II-4 Result of K-Ar Dating of Rock

Area	Sample Number	Numbers in Laboratory	Sample Type	Potassium (K wt%)	Rad. ^{40}Ar (10^{-8}cc/g)	K-Ar Age (Ma)	Air Cont. (%)
Bt. Tampang	BT-4-D	S29-110	Whole Rock	0.03	4.53±0.14	38.4±4.2	59.1
		-125	(Altered sandstone)	±0.03	4.16±0.16	35.3±4.2	62.6
"	BT-13-D	S29-109	Whole Rock	2.16	62.2±0.7	7.40±0.46	12.4
		-111	(Altered felsic tuff)	±0.04	62.5±0.7	7.44±0.46	13.3
"	BT-18-D	S29-101	Whole Rock	0.95	52.5±0.8	14.2±1.0	31.9
		-133	(Altered sandstone)	±0.03	51.2±0.8	13.8±1.0	32.6
"	BT-31-D	S29-105	Whole Rock	2.38	67.9±0.8	7.34±0.48	18.5
		-126	(Altered tuff)	±0.05	68.1±0.8	7.36±0.48	19.1
"	BT-32-D	S29-103	Whole Rock	1.48	44.2±0.7	7.70±0.56	31.3
		-142	(Weakly altered sandstone)	±0.03	46.3±0.8	8.01±0.64	39.0
"	BT-35-D	S29-100	Whole Rock	4.08	108±1.4	6.78±0.45	21.9
		-128	(Quartz diorite porphyry)	±0.08	108±1.4	6.82±0.46	23.1
"	BT-40-D	S29-129	Whole Rock	0.50	223±2.5	112±7.0	12.9
		-132	(Weakly altered sandstone)	±0.03	222±2.5	112±7.0	12.8
Bt. Kotud	BK-4-D	S29-104	Whole Rock	2.32	70.9±1.0	7.87±0.54	24.8
		-143	(Quartz diorite porphyry)	±0.05	72.4±1.1	8.03±0.59	32.6
Kg. Poring	KP-1-D	S29-106	Whole Rock	4.04	107±1.0	6.83±0.43	13.2
		-131	(Granite)	±0.08	106±1.0	6.73±0.42	12.7
"	KP-5-D	S29-107	Whole Rock	3.32	95.1±1.3	7.37±0.52	27.8
		-108	(Granodiorite)	±0.07	95.9±1.4	7.43±0.52	28.3

3-2-2 Chemical Analysis of Rock (40 samples)

The assay result of 40 samples of representative host rock obtained from the localities of mineral occurrence investigated and typical rock taken in the survey area, namely 24 samples of hydrothermally altered sandstone, 1 sample of hydrothermally altered mudstone, 3 samples of hydrothermally altered acidic to intermediate tuff, 3 samples of acidic to intermediate volcanic rock, 1 sample of intermediate dyke rock, 5 samples of acidic intrusive rock, and 3 samples of ultrabasic rock, including 10 rock samples taken at the same localities as the samples for K-Ar age determination, is given in the Table II-5.

The analyses of 7 samples, namely 3 samples of hydrothermally altered acidic to intermediate tuff, 3 samples of acidic to intermediate volcanic rock, and 1 sample of intermediate dyke rock, out of 40 rock samples assayed, have been plotted on the following several diagrams for the petrological study, and its result is as follows.

(1) SiO_2-Na_2O+K_2O diagram

The analyses of SiO_2 and Na_2O+K_2O have been plotted on the SiO_2-Na_2O+K_2O diagram and the result is given in the Fig. II-5. The Fig. II-5 shows that seven samples have been plotted near the boundary between alkaline and subalkaline rock series and within the field of subalkaline rock series.

(2) FeO*-Na_2O+K_2O-MgO trigonal diagram (MFA diagram)

The MFA trigonal diagram of the Figure II-6, on which the analyses of FeO* calculated as total FeO* from the analyses of FeO and Fe_2O_3 (FeO+Fe_2O_3× 0.9=Total FeO*), Na_2O+K_2O, and MgO have been plotted, indicates that all seven rocks belong to the calc-alkaline rock series.

(3) SiO_2-FeO*/MgO diagram

The SiO_2-FeO*/MgO diagram of the Fig. II-7, on which the analyses of SiO_2 and FeO*/MgO values calculated from the analyses of Total FeO* and MgO have been plotted, shows that all seven rocks belong to the calc-alkaline rock series.

(4) FeO*-FeO*/MgO diagram

The FeO*-FeO*/MgO diagram of the Fig. II-8 reveals that all seven rocks have been plotted within the field of the calc-alkaline rock series.

The assay result also reveals that the samples BT-56-R (weakly altered fine sandstone) and BT-58-R (strongly altered tuff) contain 1.18 g/t and 0.215 g/t of gold respectively and that the rock samples at nine localities are rich in arsenic and mercury which accompany, in general, gold mineralization, namely 123 ppm of As and 7.6 ppm of Hg in the BT-13-R (strongly altered felsic tuff), 11.8 ppm of Hg in the BT-18-R (altered fine sandstone), 200 ppm of As in the BT-24-R (altered tuffaceous sandstone), 110 ppm of As and 11.1 ppm of Hg in the BT-32-R (weakly altered sandstone), 73.6 ppm of Hg in the BT-37-R (altered sandstone), 145 ppm of As and 25.2 ppm of Hg in the BT-50-R (altered fine sandstone), 559 ppm of As in the BT-56-R (weakly altered fine sandstone), 12.0 ppm of Hg in the BT-58-R (strongly altered tuff), and 132 ppm of As in the KP-11-R (altered sandstone) respectively.

The Table II-5 also reveals that hydrothermally altered rocks, namely hydrothermally altered sandstone, mudstone, tuff, and volcanic rock, are very low in CaO and Na_2O and very high in SiO_2. It seems that this is ascribed to the decomposition of plagioclase and the formation of secondary quartz caused by hydrothermal alteration.

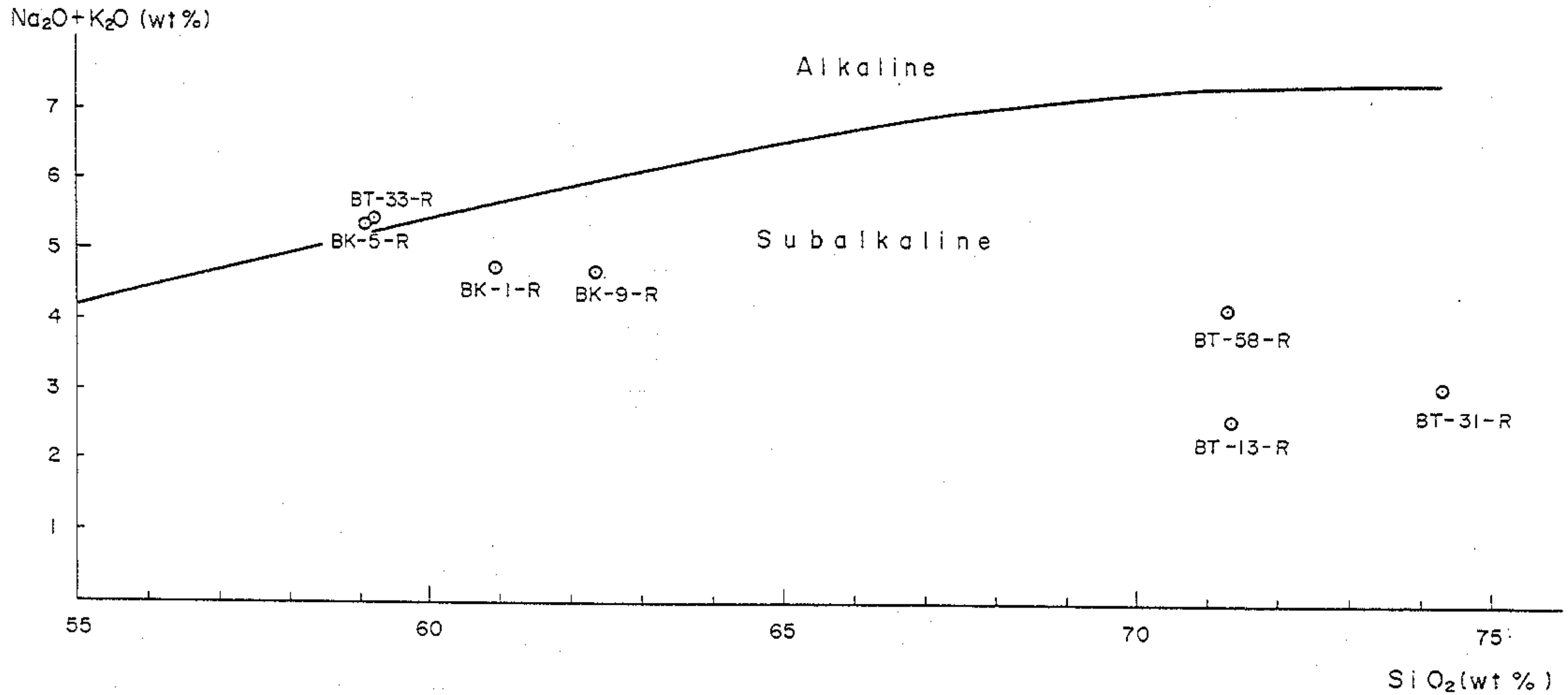
Table II-5 Assay Result of Rock

1/2

Area	Sample Number	Rock Name	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	Ig-loss %	Total	Au ppb	Ag ppm	As ppm	Cu ppm	Hg ppm	Mo ppm	Pb ppm	S %	Sb ppm	Zn ppm
Bt. Tampang	BT-4-R	Altered Sandstone	95.70	0.26	0.45	1.77	0.62	<0.01	0.01	0.05	<0.01	0.03	0.12	0.54	99.560	<1	0.3	80	85	445	<1	43	0.010	4	46
	BT-9-R	Weakly Altered Fine Tuffaceous Sandstone	86.27	0.33	7.87	0.27	0.35	<0.01	0.30	0.01	0.01	1.75	0.07	2.21	99.445	2	<0.1	19	6	717	<1	25	0.006	2	8
	BT-13-R	Strongly Altered Felsic Tuff	71.32	0.66	16.83	1.60	0.40	0.01	0.73	0.03	0.02	2.55	0.10	5.41	99.66	<1	0.4	123	35	7,597	10	50	0.015	23	50
	BT-18-R	Altered Fine Sandstone	88.36	0.35	6.42	0.53	0.31	0.01	0.31	0.03	0.01	1.34	0.07	1.70	99.44	2	0.1	23	8	11,773	<1	39	0.007	6	11
	BT-23-R	Altered Fine Sandstone	85.98	0.37	8.43	0.14	0.31	<0.01	0.27	0.02	0.02	1.38	0.06	2.38	99.365	17	<0.1	79	6	796	<1	38	0.008	<1	5
	BT-24-R	Altered Tuffaceous Sandstone	87.00	0.28	7.36	0.34	0.37	<0.01	0.37	<0.01	0.01	1.49	0.07	2.17	99.470	78	<0.1	200	9	796	<1	70	0.005	6	7
	BT-26-R	Altered Tuffaceous Sandstone	88.85	0.35	6.17	0.30	0.31	<0.01	0.33	<0.01	0.01	1.32	0.05	1.81	99.510	<1	<0.1	26	6	1,608	<1	41	0.006	2	4
	BT-29-R	Altered Mudstone	68.65	0.83	18.55	1.16	0.62	<0.01	0.72	0.12	0.05	4.64	0.14	3.98	99.465	<1	<0.1	14	72	172	<1	41	0.264	3	15
	BT-30-R	Altered Sandstone	85.83	0.23	5.44	2.89	0.87	0.01	0.63	0.05	0.06	0.90	0.06	2.50	99.47	<1	<0.1	43	155	338	23	44	2.126	3	27
	BT-31-R	Strongly Altered Tuff	74.29	0.63	14.00	2.70	0.24	0.01	0.65	0.11	0.25	2.81	0.11	3.60	99.40	<1	<0.1	28	10	1,348	<1	24	0.028	13	9
	BT-32-R	Weakly Altered Sandstone	89.58	0.28	5.50	0.67	0.37	<0.01	0.27	0.05	0.08	1.46	0.05	1.22	99.535	6	<0.1	110	5	11,062	<1	9	0.012	4	6
	BT-33-R	Andesite (Diorite Porphyry?)	59.21	0.67	15.41	2.42	4.59	0.15	3.66	5.37	2.79	2.64	0.22	2.48	99.61	<1	0.2	4	56	128	<1	33	0.034	<1	91
	BT-34-R	Weakly Altered Sandstone	88.71	0.29	6.49	0.11	0.31	<0.01	0.30	0.03	0.07	1.27	0.05	1.94	99.575	<1	<0.1	15	4	1,559	<1	14	0.005	1	6
	BT-35-R	Quartz Diorite Porphyry	61.37	0.50	15.17	3.05	2.61	0.09	2.25	4.89	2.48	4.93	0.29	1.88	99.51	<1	0.3	<1	9	264	<1	20	0.026	<1	41
	BT-36-R	Altered Fine Sandstone	83.62	0.39	9.24	1.12	0.31	<0.01	0.43	0.04	0.07	2.67	0.05	1.64	99.585	2	<0.1	36	5	522	<1	22	0.009	9	14
	BT-37-R	Altered Sandstone	87.75	0.29	6.53	0.97	0.31	0.01	0.41	0.02	0.03	1.89	0.09	1.39	99.69	50	0.1	34	7	73,638	<1	85	0.011	18	13
	BT-40-R	Weakly Altered Sandstone	85.96	0.23	4.95	0.39	1.93	0.06	0.77	1.29	1.13	0.55	0.08	2.15	99.49	<1	0.1	<1	10	440	<1	10	0.032	<1	46
	BT-41-R	Altered Sandstone	87.43	0.27	7.25	0.17	0.40	<0.01	0.31	0.04	0.08	1.58	0.06	2.05	99.645	<1	<0.1	50	6	1,715	<1	61	0.010	2	8
	BT-45-R	Altered Sandstone	88.55	0.27	5.75	0.67	0.41	<0.01	0.21	0.04	0.06	1.05	0.06	2.40	99.475	<1	<0.1	94	43	1,857	<1	37	0.499	8	38
	BT-50-R	Altered Fine Sandstone	85.52	0.35	7.61	1.66	0.44	<0.01	0.90	0.12	0.17	1.31	0.06	1.55	99.695	21	0.4	145	12	25,235	11	48	0.011	63	26

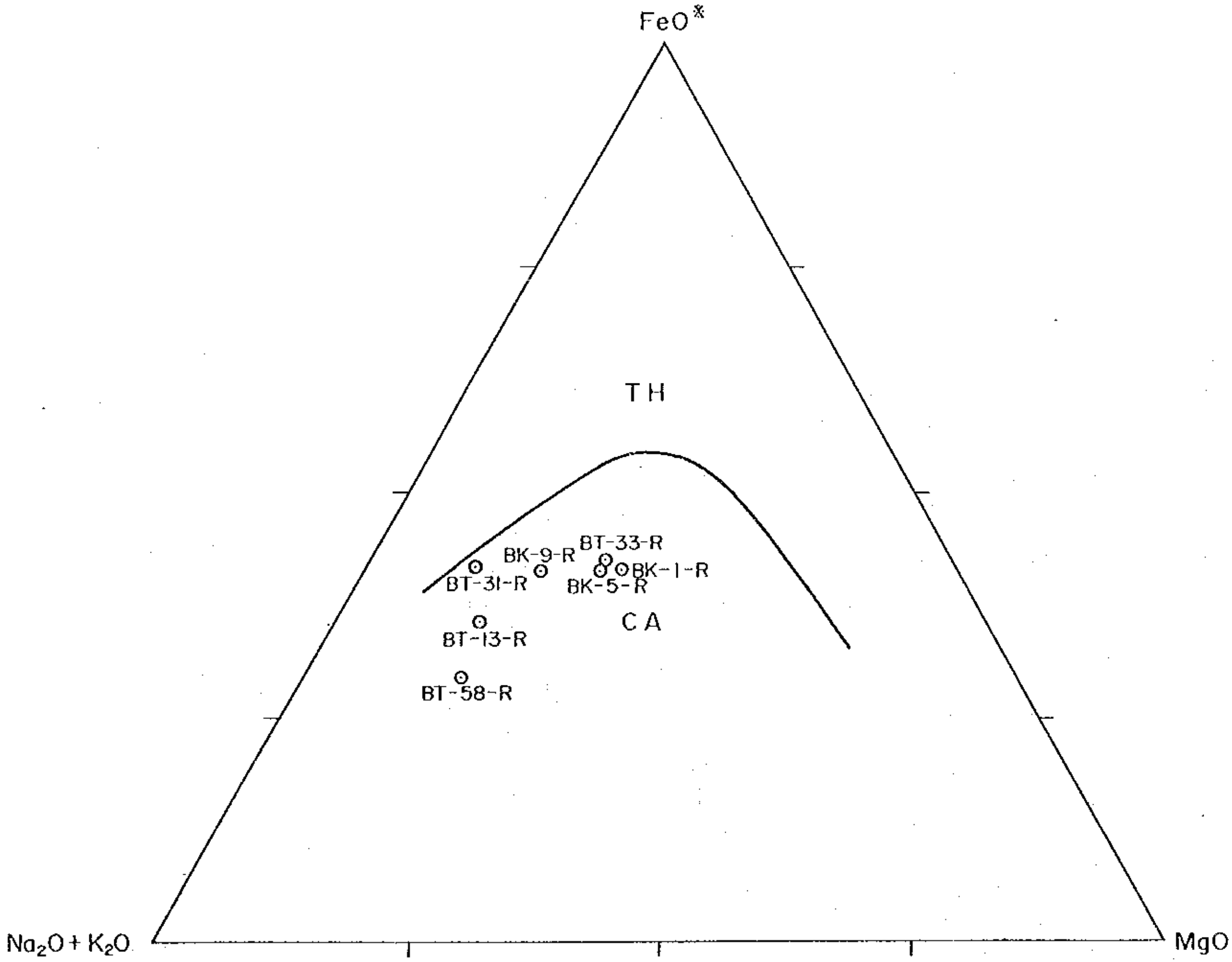
Area	Sample Number	Rock Name	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ig-loss	Total	Au	Ag	As	Cu	Hg	Mo	Pb	S	Sb	Zn
			%	%	%	%	%	%	%	%	%	%	%	%		ppb	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
Bt. Tampang	BT-54-R	Altered Sandstone	93.03	0.21	3.95	0.29	0.55	<0.01	0.58	0.17	0.05	0.06	0.05	0.53	99.475	2	<0.1	2	5	566	<1	13	0.005	2	6
	BT-56-R	Weakly Altered Fine Sandstone	88.89	0.31	6.18	0.44	0.13	<0.01	0.38	<0.01	0.02	1.42	0.05	1.79	99.620	1180	<0.1	559	5	2,777	<1	10	0.004	3	6
	BT-57-R	Altered Sandstone	87.87	0.27	6.07	1.59	0.13	0.01	0.54	0.05	0.04	1.42	0.05	1.50	99.54	43	<0.1	31	40	2,355	<1	32	0.009	10	24
	BT-58-R	Strongly Altered Tuff	71.27	0.68	15.51	2.37	0.13	0.01	1.19	0.07	0.04	4.18	0.11	3.89	99.45	215	0.2	34	13	12,040	<1	263	0.015	61	20
Bt.Kotud	BK-1-R	Andesite	60.93	0.68	15.25	1.69	4.48	0.10	3.64	4.80	2.35	2.39	0.22	2.97	99.50	<1	0.2	3	37	118	<1	24	0.064	<1	100
	BK-2-R	Weakly Altered Sandstone	80.48	0.37	7.98	1.22	1.12	0.03	1.00	1.64	1.54	1.23	0.11	2.90	99.62	<1	0.1	4	12	151	<1	15	0.078	1	35
	BK-4-R	Quartz Diorite Porphyry	59.18	0.70	15.87	2.76	3.73	0.13	3.47	4.34	2.71	2.67	0.22	3.66	99.44	<1	<0.1	2	38	131	<1	19	0.051	<1	70
	BK-5-R	Diorite Porphyry (Andesite?)	59.05	0.66	16.38	4.70	2.05	0.12	3.53	5.20	2.82	2.53	0.23	2.51	99.78	<1	0.2	2	50	104	<1	21	0.039	<1	63
	BK-6-R	Altered Sandstone	87.25	0.33	7.07	0.41	0.13	<0.01	0.53	0.04	0.03	2.17	0.06	1.44	99.465	3	0.1	7	6	109	<1	25	0.005	2	13
	BK-9-R	Weakly Altered Dacite	62.34	0.59	16.31	3.79	1.25	0.08	1.97	5.06	2.25	2.45	0.24	3.25	99.58	<1	0.3	3	12	230	<1	25	0.063	<1	59
	BK-10-R	Altered Sandstone	81.60	0.25	5.87	1.94	0.13	0.06	1.11	3.18	0.62	0.71	0.10	4.07	99.64	<1	0.2	16	15	76	<1	8	0.024	<1	25
Kg. Poring	KP-1-R	Granite	62.22	0.54	14.86	2.19	3.98	0.10	2.74	5.03	2.48	4.39	0.28	0.79	99.60	3	<0.1	1	49	12	<1	18	0.284	<1	48
	KP-2-R	Altered Fine Sandstone	88.60	0.38	6.46	0.51	0.13	<0.01	0.25	0.02	0.03	1.49	0.05	1.62	99.545	<1	<0.1	<1	5	52	<1	16	0.006	<1	12
	KP-5-R	Granodiorite	62.43	0.65	14.39	3.73	2.42	0.11	3.81	5.30	2.22	3.29	0.29	1.06	99.61	<1	<0.1	<1	14	122	<1	24	0.032	1	69
	KP-8-R	Serpentinized Harzburgite	32.30	0.01	0.58	9.55	0.18	0.15	39.75	0.49	<0.01	0.01	0.04	16.68	99.745	<1	<0.1	<1	3	607	<1	<1	0.019	3	48
	KP-10-R	Granodiorite Porphyry	63.82	0.49	14.69	2.07	3.23	0.12	2.68	4.53	2.60	4.53	0.25	0.77	99.78	3	<0.1	<1	49	72	<1	26	0.029	<1	66
	KP-11-R	Altered Sandstone	91.38	0.22	4.54	0.84	0.13	<0.01	0.18	0.03	0.03	0.85	0.05	1.22	99.475	5	0.2	132	64	46	<1	37	0.014	1	11
	KP-12-R	Partly Serpentinized Lherzolite	41.58	0.10	2.98	3.45	4.54	0.13	36.78	2.74	0.06	0.02	0.04	7.23	99.65	<1	<0.1	<1	20	143	<1	2	0.025	1	48
	KP-13-R	Altered Sandstone	91.84	0.15	2.95	0.49	1.43	0.02	0.90	0.03	0.03	0.36	0.04	1.27	99.51	<1	0.3	5	46	15	<1	141	0.215	<1	104
Kg.Luhan	KL-1-R	Partly Serpentinized Lherzolite	41.80	0.02	1.76	3.29	3.91	0.11	39.15	2.07	0.24	0.01	0.04	7.11	99.51	<1	<0.1	<1	7	59	<1	2	0.016	1	41

Figure II－5　SiO_2-Na_2O+K_2O Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks



Alkaline / subalkaline discriminant line is from Kuno (1966)

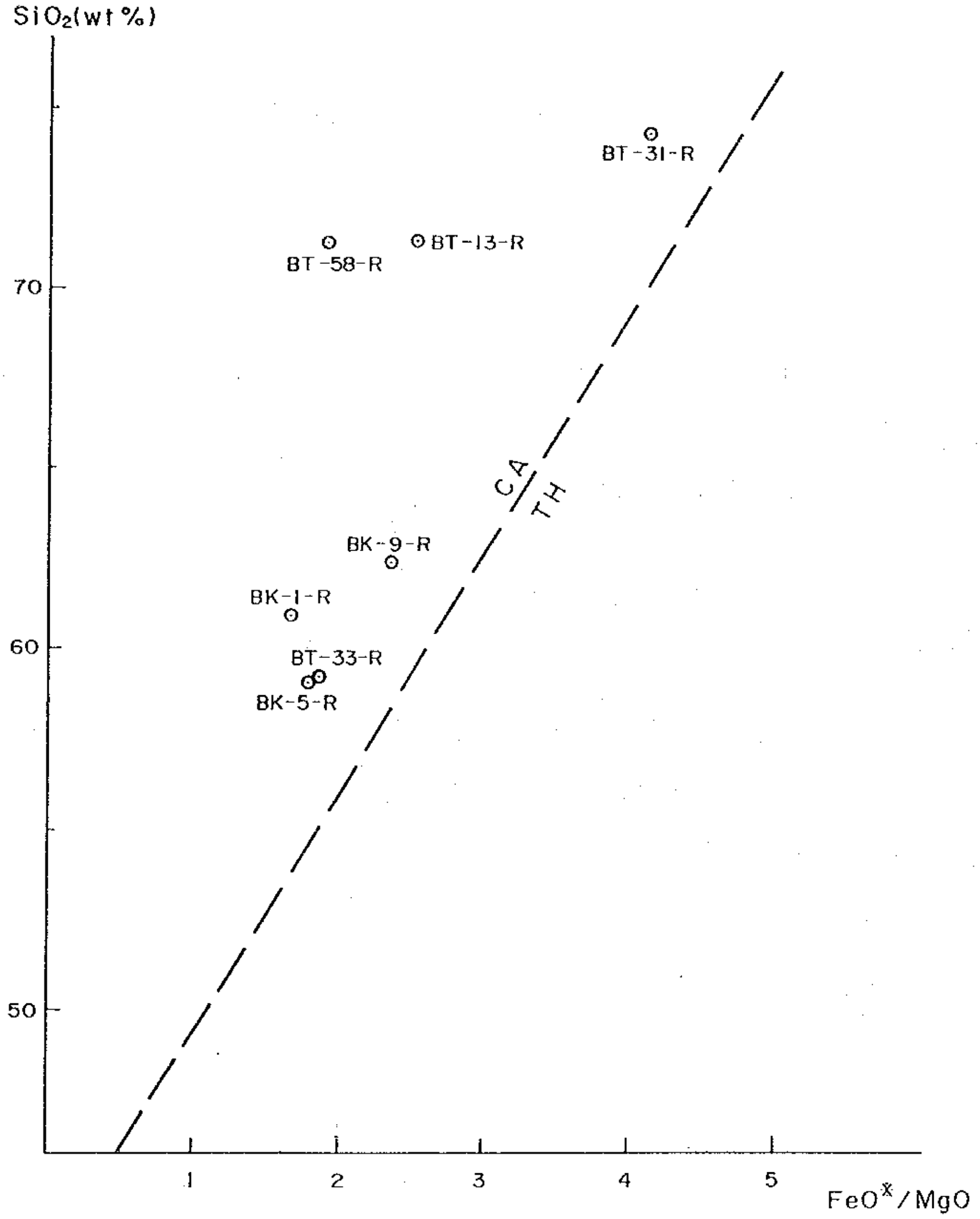
Figure II-6 FeO^{*}-Na_2O+K_2O-MgO Diagram (MFA Diagram) of Intermediate to Acidic Volcanic and Pyroclastic Rocks



FeO^{*}: Total Fe as FeO ($FeO + Fe_2O_3 \times 0.9$)

Solid line is boundary between tholeiite series (TH) and calc-alkaline series (CA) after Irvine and Barager (1971)

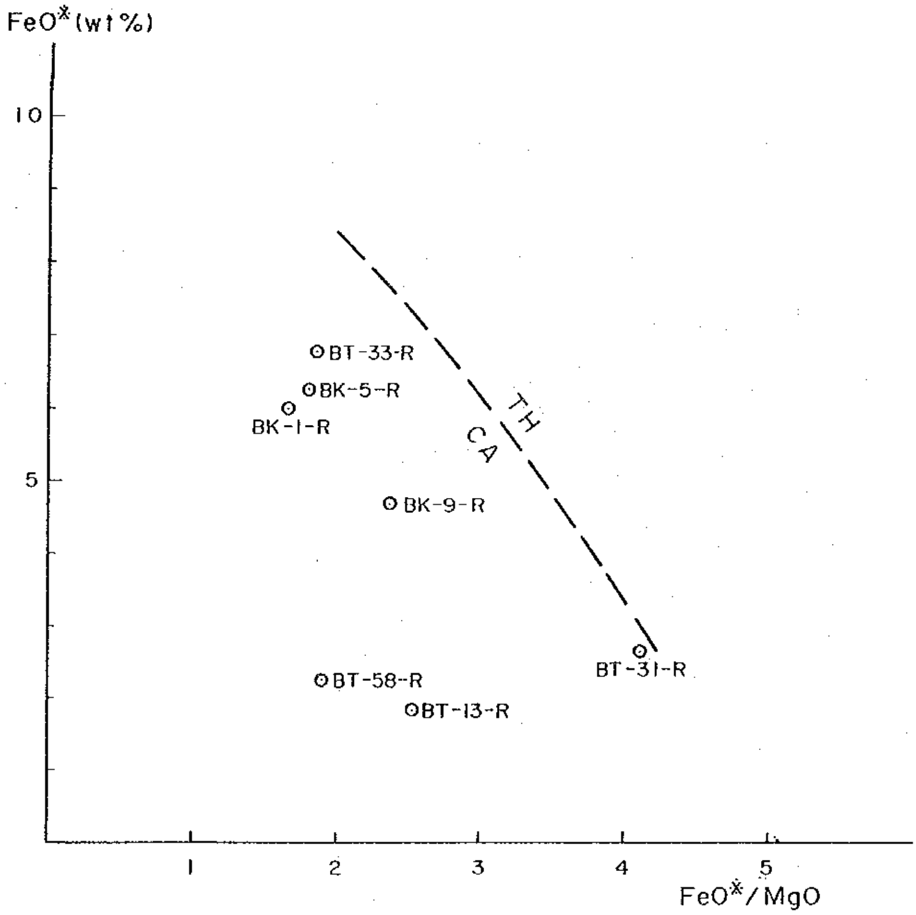
Figure II－7　SiO₂-FeO*/Mgo Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks



FeO*: Total Fe as FeO (FeO + Fe_2O_3 x 0.9)

TH(tholeiitic) / CA(calc-alkaline) boundary: after Miyashiro (1974)

Figure II－8　FeO※–FeO※/Mgo Diagram of Intermediate to Acidic Volcanic and Pyroclastic Rocks



TH(tholeiitic)/CA(calc-alkaline) boundary: after Miyashiro (1974)

FeO*: Total Fe as FeO (FeO + Fe_2O_3 x 0.9)

3-2-3 Microscopic Observation of Thin Section of Rock (50 samples)

The thin sections made from 50 samples of representative host rock obtained at the localities of mineral occurrence investigated and typical rock taken in the survey area, namely 27 samples of hydrothermally altered sandstone, 2 samples of hydrothermally altered mudstone, 6 samples of hydrothermally altered acidic to intermediate tuff, 2 samples of strongly altered rock, 5 samples of acidic to intermediate volcanic rock, 5 samples of acidic intrusive rock, and 3 samples of ultrabasic rock, including 40 rock samples taken at the same localities as the samples for chemical analysis, have been observed under a microscope. The result of the observation is given in the Table II-6.

The Table II-6 reveals that 39 samples of hydrothermally altered rock, namely altered sandstone (27 samples), altered mudstone (2 samples), altered acidic to intermediate tuff (5 samples), altered acidic to intermediate volcanic rock (2 samples), and strongly altered rock (3 samples), out of 50 rock samples observed under a microscope, have been mostly subjected to strong silicification and sericitization, and 22 samples, namely 16 samples of altered sedimentary rock, 5 samples of altered volcanic and pyroclastic rocks, and 1 sample of strongly altered rock, out of 39 samples, have undergone kaolinization in addition to silicification and sericitization.

Table II-6 Result of Microscopic Observation of Thin Section of Rock

1/2

Area	Sample Number	Rock Name	Texture	Phenocrysts, Crystal & Rock Fragments							Groundmass, Matrix, Accessary Minerals							Secondary Minerals								Remarks
				Quartz	Plagioclase	K-feldspar	Biotite	Mudstone	Tuff	Others	Quartz	Plagioclase	Glass	Zircon	Tourmaline	Opaque Minerals	Hematite	Quartz	K-feldspar	Sericite	Chlorite	Kaolinite	Montmorillonite	Tourmaline	Others	
Bt. Tampang	BT-2-T	Sandstone	clastic	◎					○		◎			+	+	+		◎		○		○				altered tuffaceous sandstone.
	BT-4-T	Sandstone	blastopsammitic	◎				#			◎			+		+		◎							+*	* illite, matamorphosed sandstone with well recrystallized quartz.
	BT-7-T	Tuff	pyroclastic		#		#				◎		◎	+		○	#	◎	○	○		◎				strongly altered felsic tuff, plagioclase and biotite are pseudomorphs.
	BT-9-T	Sandstone	clastic	◎					+		◎			+	+	#	+	#		◎		#				weakly altered fine tuffaceous sandstone.
	BT-11-T	Altered rock	granoblastic											+		#	○	◎	◎	+	+					strongly altered and recrystallized rock of unknown origin.
	BT-13-T	Tuff	pyroclastic													○	#	◎		◎		◎				strongly altered felsic tuff with feldspar and biotite pseudomorphs.
	BT-14-T	Altered rock	granoblastic											+		○	#	◎		◎		#				strongly altered rock, probably felsic tuff origin.
	BT-18-T	Sandstone	clastic	◎				#		+*				+	+	+		○		○		#				* sandstone, altered fine sandstone.
	BT-19-T	Sandstone	clastic	◎		#		#	#					#	+	#	#	#		○		○				weakly altered fine sandstone.
	BT-23-T	Sandstone	clastic	◎		#		#	#					+	+		#	◎		◎			#			altered fine sandstone.
	BT-24-T	Sandstone	clastic	◎				+	+					+	+	+		○		◎						altered sandstone.
	BT-26-T	Sandstone	clastic	◎	+	+			+					+	+		#	○		◎		#				altered sandstone.
	BT-28-T	Andesite	porphyritic intersertal		◎		#					◎	◎			○		◎	○	◎		○				altered andedesite.
	BT-29-T	Mudstone	clastic	◎											+	○		○		◎		○				argillized mudstone with sericite network.
	BT-30-T	Sandstone	clastic	◎										+		#		◎		◎	○			+		altered sandstone.

◎: abundant ○: common #: a little +: rare

Area	Sample Number	Rock Name	Texture	Phenocrysts, Crystal & Rock Fragments									Groundmass, Matrix, Accessary Minerals										Secondary Minerals									Remarks
				Quartz	Plagioclase	K-feldspar	Hornblende	Clinopyroxene	Biotite	Mudstone	Tuff	Others	Quartz	Plagioclase	Clinopyroxene	Glass	Apatite	Sphene	Zircon	Tourmaline	Opaque Minerals	Hematite	Quartz	Sericite	Epidote	Chlorite	Kaolinite	Montmorillonite	Calcite	Tourmaline	Others	
Bt. Tampang	BT-31-T	Tuff	pyroclastic		○														+		○	○	◎	◎								strongly altered tuff.
	BT-32-T	Sandstone	clastic	◎						○			◎						+	+			○	◎								coarse sandstone with weak alteration.
	BT-33-T	Andesite	porphyritic intergranular		○		◎	+	○					◎			+				+		#	#		#						relatively fresh andesite.
	BT-34-T	Sandstone	clastic	◎						#			○						+	+			○	◎			#					weakly altered sandstone.
	BT-35-T	Quartz diorite porphyry	porphyritic, hypidiomorphic granular		◎	#		◎	○				#	◎	#		+	+	+		+				○	○					#*	* hornblende.
	BT-36-T	Sandstone	clastic	○						#								+	+	+	+	+	○	◎			+					altered fine sandstone.
	BT-37-T	Sandstone	clastic	◎						#									+	+		#	○	◎								altered sandstone.
	BT-40-T	Sandstone	clastic	◎	○	#				#	#		◎						+	+	+			#		#			○			weakly altered sublithic arenite.
	BT-41-T	Sandstone	clastic	◎						○	#		◎						+	+		#	◎	◎			○					altered sandstone.
	BT-45-T	Sandstone	clastic	◎	+					#	#								+	+	#		◎	◎			#			+		altered sandstone.
	BT-50-T	Sandstone	clastic	◎						#			◎						#			#	◎	◎						○		altered fine sandstone.
	BT-52-T	Tuff	pyroclastic		#				◎		○	○*	◎			◎					+			○			○	○				* pumice, altered vitric crystal tuff.
	BT-54-T	Sandstone	clastic	◎						#			◎						#				◎							○		altered sandstone.
	BT-56-T	Sandstone	clastic	◎						#			◎						+	+	+		○	○			#			+		weakly altered fine sandstone.
	BT-57-T	Sandstone	clastic	◎															+			#	◎	○			#			○		altered sandstone.

◎: abundant ○: common #: a little +: rare

Area	Sample Number	Rock Name	Texture	Phenocrysts, Crystal & Rock Fragments									Groundmass, Matrix, Accessary Minerals									Secondary Minerals								Remarks
				Quartz	Plagioclase	K-feldspar	Hornblende	Clinopyroxene	Biotite	Mudstone	Tuff	Others	Quartz	Plagioclase	Hornblende	Apatite	Sphene	Zircon	Tourmaline	Opaque Minerals	Hematite	Quartz	Sericite	Biotite	Epidote	Chlorite	Kaolinite	Calcite	Tourmaline	
Bt. Tampang	BT-58-T	Tuff	pyroclastic		○													+				◎	◎				#		+	strongly altered, sericite-rich rock of tuff origin.
Bt. Kotud	BK-1-T	Andesite	porphyritic intergranular		○		◎		○					◎	#	+				+			+	#		#		#		relatively fresh andesite
	BK-2-T	Sandstone	clastic	◎	#	#				#		+*	◎					+		+		#	○		#	#		○		* andesite, weakly altered, relatively fresh sandstone.
	BK-4-T	Quartz diorite porphyry	porphyritic, hypidiomorphic granular	○	◎			#	○				○	◎		+		+		#		+		○		○				quartz diorite porphyry with weak biotite-chlorite alteration.
	BK-5-T	Diorite porphyry	porphyritic intergranular		◎		◎		○					◎		+				#		+	#			#		+		diorite porphyry with slightly fine groundmass.
	BK-6-T	Sandstone	clastic	◎						#			◎					+	+	○	#	○	○				#			altered sandstone.
	BK-9-T	Dacite	porphyritic intergranular	#	◎		○					#*	◎	○		+		+		+		+				○		○		* garnet, weakly chloritized and carbonated dacite.
	BK-10-T	Sandstone	clastic	◎	#					+	+		◎					+	+			+	○			+	#	○		altered sandstone.
	BK-11-T	Altered Rock	granoblastic		○																○	◎	◎							strongly altered rock of unknown origin, plagioclase pseudomorph suggests either tuff or lava.
Kg. Poring	KP-2-T	Sandstone	clastic	◎						#		+*	◎					+	+	#		○	◎							* chert, altered fine sandstone.
	KP-10-T	granodiorite porphyry	porphyritic, hypidiomorphic granular	◎	◎	○	◎		○								+			#					+	#				
	KP-11-T	Sandstone	blastopsammitic	◎						#								+	+	#		◎	◎							altered sandstone.
	KP-13-T	Sandstone	blastopsammitic	○						#			○					+		#		◎	○			#				altered sandstone.
	KP-14-T	Mudstone	clastic	◎									◎					+	+	○	○	◎	◎				#			altered brecciated mudstone.
	KP-18-T	Sandstone	clastic	◎	+					#	#		◎					+	+	#		◎	◎				○		+	altered sandstone.

◎: abundant ○: common #: a little +: rare

Area	Sample Number	Rock Name	Texture	Primary Minerals								Secondary Minerals						Accessory Minerals					Remarks
				Quartz	Plagioclase	K-feldspar	Hornblende	Clinopyroxene	Orthopyroxene	Olivine	Biotite	Quartz	Plagioclase	Chlorite	Sphene	Calcite	Tremolite	Apatite	Zircon	Sphene	Opaque Minerals	Picotite	
Kg. Poring	KP-1-T	Granite	hypidiomorphic granular	○	◎	○	○				○			+				+	+	+	+		
	KP-5-T	Granodiorite	hypidiomorphic granular	○	◎	○	○	#			○			#				+	+		+		
	KP-8-T	Serpentinite	mesh												◎	○					○	+	completely replaced by serpentine and calcite, probably harzburgite origin.
	KP-12-T	Lherzolite	hypidiomorphic granular					○	○	◎					○						○	#	partly serpentinized lherzolite.
Kg. Luhan	KL-1-T	Lherzolite	hypidiomorphic granular	·				○	○	○				#	○		#				#		

◎: abundant ○: common #: a little +: rare

3-2-4 Chemical Analysis of Ore (65 samples)

The assay result of 65 ore samples taken at 42 localiteis of mineral occurrence investigated is given in the Table II-7. Table II-7 indicates that the samples which contain gold over 0.1 g/t are BT-1-0-1 (1.27 g/t), BT-2-0-1 (0.57 g/t), BT-2-0-2 (0.40 g/t), BT-5-0 (0.16 g/t), BT-6-0 (2.48 g/t), BT-11-0 (0.24 g/t), BT-13-0-2 (0.22 g/t), BT-14-0-1 (0.10 g/t), BT-43-0 (0.24 g/t), and BT-45-0 (0.11 g/t) and that the samples which contain copper over 0.1% are BT-6-0 (0.46%), BT-7-0 (0.64%), BT-10-0-1 (0.51%), BT-10-0-2 (0.22%), BT-11-0 (0.31%), and also shows that many samples are rich in arsenic and mercury which accompany, in general, gold mineralization, namely 8 samples contain arsenic over 1,000 ppm (1,175 to 5,063 ppm) and 41 samples contain mercury over 1.0 ppm (1.2 to 38.8 ppm).

Therefore, assay result reveals that the samples which contain gold are rich in mercury and in arsenic generally, whereas copper has no interrelation with gold, arsenic, and mercury.

Table II-7 List of Assay Result of Ore

1/3

Area	Locality Number	Sample Number	Au g/t	Ag g/t	As ppm	Cu ppm	Hg ppb	Mo ppm	Pb ppm	S %	Sb ppm	Zn ppm	Occurrence of Ore
Bt. Tampang	BT-1	BT-1-0-1	1.27	0.3	2,703	47	3,687	<1	163	0.02	81	16	limonite・quartz veinlets-bearing argillized and silicified zone
		BT-1-0-2	0.01	<0.1	1,729	20	4,198	<1	176	0.02	27	16	
	BT-2	BT-2-0-1	0.57	<0.1	1,508	24	7,597	<1	145	0.01	81	13	limonite・quartz lens-bearing argillized and silicified zone
		BT-2-0-2	0.40	<0.1	4,567	40	11,329	<1	230	0.01	119	20	
	BT-3	BT-3-0	0.03	0.9	319	157	2,426	6	43	0.31	24	58	limonite・hematite・quartz veinlets-bearing argillized and silicified zone
	BT-4	BT-4-0	0.06	<0.1	340	682	188	<1	47	0.04	29	113	limonite・hematite・quartz network-bearing silicified and argillized zone
	BT-5	BT-5-0	0.16	0.1	644	230	18,304	4	175	0.05	186	27	limonite・hematite-bearing vein of silicified zone
	BT-6	BT-6-0	2.48	2.7	5,063	4,610	23,680	10	191	3.85	74	83	limonite・pyrite・quartz network
	BT-7	BT-7-0	0.01	4.1	245	6,368	5,576	124	50	1.74	6	503	limonite・pyrite-bearing quartz network
	BT-9	BT-9-0	<0.01	<0.1	507	21	1,875	<1	45	0.02	7	12	limonite-bearing argillized and silicified zone
	BT-10	BT-10-0-1	0.03	2.0	1,431	5,111	296	6	46	2.58	15	75	pyrite・chalcopyrite-bearing quartz veinlets
		BT-10-0-2	<0.01	1.2	206	2,237	124	3	31	0.70	5	44	pyrite・chalcopyrite-bearing quartz veinlets
	BT-11	BT-11-0	0.24	1.2	475	3,094	6,175	6	31	1.99	11	118	pyrite・chalcopyrite-bearing quartz network
	BT-12	BT-12-0	<0.01	0.4	1,283	130	3,243	174	34	0.03	7	60	limonite-bearing quartz veinlet
	BT-13	BT-13-0-1	0.02	0.1	116	55	22,391	6	156	0.03	87	30	limonite-bearing quartz vein
		BT-13-0-2	0.22	2.5	142	181	38,785	53	160	0.04	190	62	limonite-bearing vein of silicified zone
		BT-13-0-3	0.02	1.2	9	30	9,774	<1	26	<0.01	66	32	limonite-bearing vein of silicified zone
	BT-14	BT-14-0-1	0.10	<0.1	52	105	3,532	22	93	0.07	33	36	limonite・hematite-bearing quartz network
		BT-14-0-2	0.06	<0.1	22	59	784	20	146	0.02	26	27	
	BT-15	BT-15-0	0.02	<0.1	50	28	370	<1	70	0.02	12	32	quartz network
	BT-16	BT-16-0	0.02	0.4	27	92	2,888	4	52	0.02	38	25	limonite-bearing quartz vein and network

Area	Locality Number	Sample Number	Au g/t	Ag g/t	As ppm	Cu ppm	Hg ppb	Mo ppm	Pb ppm	S %	Sb ppm	Zn ppm	Occurrence of Ore
Bt. Tampang	BT-17	BT-17-0-2	0.09	0.1	31	880	8,885	7	261	2.38	22	40	pyrite•limonite•quartz netowrk-bearing silicified and argillized zone
		BT-17-0-3	0.03	<0.1	23	40	378	4	331	1.75	5	97	
		BT-17-0-4	<0.01	0.1	22	31	113	3	379	1.56	4	73	
		BT-17-0-6	0.03	<0.1	29	31	8,041	1	340	1.80	11	54	
		BT-17-0-7	0.01	0.2	15	59	750	2	327	0.80	9	43	
		BT-17-0-8	<0.01	0.1	8	68	285	<1	219	0.71	2	39	
		BT-17-0-9	<0.01	<0.1	8	36	441	<1	147	0.68	2	47	
		BT-17-0-10	<0.01	<0.1	8	45	39	<1	209	1.04	3	50	
		BT-17-0-11	<0.01	0.2	12	22	425	<1	168	1.42	17	76	
		BT-17-0-12	<0.01	<0.1	9	40	663	<1	125	1.56	4	54	
		BT-17-0-13	0.02	0.4	8	32	2,666	<1	201	0.87	17	43	
		BT-17-0-14	0.02	0.6	23	33	4,909	3	275	1.09	20	48	
	BT-20	BT-20-0	<0.01	0.2	198	23	8,663	<1	119	8.39	10	9	limonite•hematite-bearing quartz vein
	BT-26	BT-26-0	<0.01	0.1	36	5	7,131	<1	9	0.03	1	8	quartz network
	BT-28	BT-28-0-1	<0.01	1.7	105	574	10,129	1	145	0.11	26	181	limonite•hematite•minor quartz veinlets-bearing argillized and silicified zone
		BT-28-0-2	0.05	1.9	208	688	18,482	2	174	0.82	68	231	
		BT-28-0-3	0.01	1.2	254	470	13,284	<1	139	1.96	22	173	
		BT-28-0-4	0.02	1.5	59	230	1,222	<1	123	2.86	8	119	pyrite disseminated hydrothermally altered andesite
	BT-31	BT-31-0	<0.01	<0.1	61	7	2,355	<1	10	0.02	27	7	limonite-bearing quartz vein
	BT-32	BT-32-0	<0.01	0.4	162	5	14,439	<1	4	<0.01	13	6	quartz network
	BT-37	BT-37-0	0.03	1.9	58	17	38,696	<1	140	0.01	169	18	limonite-bearing quartz vein
	BT-38	BT-38-0	0.10	1.2	39	215	13,506	1	153	1.39	20	45	pyrite•limonite-bearing lenticular silicified zone
	BT-41	BT-41-0	0.03	<0.1	297	9	1,977	<1	40	0.06	8	15	limonite-bearing quartz network
	BT-42	BT-42-0	0.06	0.6	909	32	11,951	<1	192	0.04	27	17	limonite•hematite-bearing quartz veinlet in silicified and argillized zone

Area	Locality Number	Sample Number	Au g/t	Ag g/t	As ppm	Cu ppm	Hg ppb	Mo ppm	Pb ppm	S %	Sb ppm	Zn ppm	Occurrence of Ore
Bt. Tampang	BT-43	BT-43-0	0.24	1.1	1,175	28	9,063	<1	88	0.01	28	19	limonite-bearing quartz network
	BT-44	BT-44-0	0.04	1.5	513	34	2,155	<1	49	0.05	38	8	limonite-bearing quartz lens in silicified and arigillized zone
	BT-45	BT-45-0	0.11	0.2	424	20	1,399	<1	21	0.37	8	30	limonite·pyrite-bearing quartz vein in silicified and argillized breccia vein
	BT-46	BT-46-0	<0.01	<0.1	203	12	7,553	<1	23	0.12	6	26	limonite-bearing quartz network in vein of silicified zone
	BT-47	BT-47-0	<0.01	0.3	158	34	4,687	<1	57	0.12	4	24	limonite-bearing vein of silicified zone
	BT-48	BT-48-0-1	0.01	0.5	43	41	408	<1	67	0.24	3	22	pyrite·limonite-bearing vein of silicified zone
		BT-48-0-2	<0.01	0.8	95	20	7,242	<1	51	0.02	6	19	
	BT-49	BT-49-0	0.06	0.2	227	12	1,182	<1	93	<0.01	4	13	limonite-bearing vein of silicified zone
	BT-50	BT-50-0	0.03	0.4	210	41	12,928	<1	68	0.02	50	22	limonite-bearing silicified breccia vein
	BT-51	BT-51-0	0.07	0.3	139	51	727	<1	143	0.24	7	32	limonite-bearing silicified breccia zone
	BT-58	BT-58-0	<0.01	<0.1	348	36	14,261	<1	85	0.03	232	30	limonite·hematite-bearing quartz network
Bt. Kotud	BK-12	BK-12-0	<0.01	<0.1	6	67	127	<1	12	0.20	1	20	pyrite-bearing quartz network
Kg. Poring	KP-4	KP-4-0	0.01	<0.1	2	5	91	<1	20	<0.01	<1	7	quartz vein
	KP-7	KP-7-0	<0.01	0.2	4	11	110	<1	47	0.01	<1	12	quartz vein
	KP-9	KP-9-0-1	<0.01	0.1	<1	3	83	<1	1	<0.01	<1	6	quartz pebble in hydrothermally altered Quaternary gravel bed
		KP-9-0-2	<0.01	0.3	<1	3	68	<1	1	<0.01	<1	9	
	KP-13	KP-13-0-1	<0.01	0.3	5	36	126	<1	60	0.17	<1	122	pyrite disseminated lenticular silicified zone
		KP-13-0-2	<0.01	0.3	23	25	120	<1	55	0.01	1	27	limonite-bearing silicified and argillized zone
	KP-14	KP-14-0	0.01	18.0	349	229	522	<1	352	0.21	3	82	limonite·pyrite-bearing silicified and argillized zone
	KP-18	KP-18-0	<0.01	0.2	2	11	70	<1	8	0.01	<1	23	vein of silicified zone

3-2-5 Microscopic Observation of Polished Section of Ore (30 samples)

The polished sections made from 30 representative samples out of 65 ore samples taken for assay have been observed under a ore microscope. The result of the observation is given in the Table II-8 and shows that most samples consist mainly of a large amount of quartz, a large to a very small amount of limonite and pyrite, and a middle to a very small amount of secondary hematite and that one to four ore mineral(s) out of a small to a very small amount of chalcopyrite, a very small amount of bornite, chalcocite, covellite, and sphalerite, in addition to the above four major minerals, is (are) contained in 11 samples, namely BT-6-P, BT-7-P, BT-10-P, BT-11-P, BT-15-P, BT-16-P, BT-17-P, BT-28-P, BT-32-P, BT-41-P, BT-48-P.

Table II-8 Result of Microscopic Observation of Polished Section of Ore

1/2

Area	Sample Number	Occurrence	Chalcopyrite (cp)	Bornite (bn)	Chalcocite (cc)	Covellite (cv)	Sphalerite (sp)	Pyrite (py)	Hematite (hm)	Limonite* (mostly geothite)	Gangue minerals Q:quartz	Remarks
Bt. Tampang	BT-3-P	Quartz veinlet, hematite veinlet and hematite dissemination						·	○	●	◎q	weathered
	BT-5-P	Quartz veinlet and hematite veinlet						·	○	●	◎q	weathered
	BT-6-P	Quartz veinlet and pyrite dissemination	·		·	·	·	○	·	●	◎q	partly weathered
	BT-7-P	Pyrite-quartz vein	·		·	·	·	●		·	◎q	partly weathered
	BT-10-P	Chalcopyrite-pyrite-quartz vein	●		·	·		●		·	◎q	partly weathered
	BT-11-P	Chalcopyrite-pyrite-quartz vein	●		·	·		●			◎q	
	BT-13-P	"Limonite" boxwork, mainly consisting of goethite						·	·	◎	○q	strongly weathered
	BT-14-P	Botryoidal "limonite", mainly consisting of goethite							·	◎	○	strongly weathered
	BT-15-P	Qauartz vein	·		·	·	·	·			◎q	
	BT-16-P	Qauartz vein	·		·	·		·	·	●	◎q	partly weathered
	BT-17-P	Pyrite-quartz vein					·	◎			○q	
	BT-20-P	Breccia vein?						·	●	●	◎	weathered
	BT-28-P	Pyrite veinlet and pyrite dissemination	·	·	·		·	○		·	○	partly weathered
	BT-32-P	Quartz vein	·				·	·	·	·	◎q	partly weathered
	BT-37-P	Quartz vein						·	·	·	◎q	partly weathered
	BT-38-P	Pyrite dissemination						○			◎	
	BT-41-P	Quartz veinlet and goethite veinlet	·					·	·	●	◎q	partly weathered
	BT-42-P	Goethite veinlet						·		●	◎	partly weathered
	BT-43-P	Goethite veinlet						·		●	◎	partly weathered

Note 1 ◎: Abundant, ○: Common, ●: Rare, · : Trace
Note 2 Limonite*: The term "limonite" is used as a general field term.

Area	Sample Number	Occurrence	Chalcopyrite (cp)	Bornite (bn)	Chalcocite (cc)	Covellite (cv)	Sphalerite (sp)	Pyrite (py)	Hematite (hm)	Limonite* (mostly geothite)	Gangue minerals Q:quartz	Remarks
Bt. Tampang	BT-44-P	Quartz veinlet and goethite dissemination						·	·	○	◎Q	· partly weathered · goethite occurs as pseudomorph after pyrite
	BT-45-P	Pyrite veinlet, goethite veinlet and pyrite dissemination						●	·	●	◎	partly weathered
	BT-46-P	Goethite veinlet						·		●	◎	partly weathered
	BT-47-P	Goethite veinlet						·	·	●	◎	· partly weathered · goethite occurs as pseudomorph after pyrite
	BT-48-P	Pyrite-quartz veinlet and pyrite dissemination			·	·		●			◎Q	
	BT-49-P	Quartz veinlet and goethite dissemination						·	·	●	◎Q	· partly weathered · goethite occurs as pseudomorph after pyrite
	BT-50-P	Goethite veinlet						·	·	●	◎	partly weathered
	BT-51-P	Goethite veinlet						·	·	○	◎	weathered
	BT-58-P	Quartz veinlet and goethite-hematite veinlet						·	●	○	◎Q	weathered
Bt. Kotud	BK-12-P	Pyrite-quartz veinlet						○		·	◎Q	· partly weathered · anhedral pyrite and colloform pyrite in quartz veinlet
Kg. Poring	KP-13-P	Pyrite veinlet and pyrite dissemination						●			◎	

Note 1 ◎: Abundant, ○: Common, ●: Rare, · : Trace
Note 2 Limonite*: The term "limonite" is used as a general field term.

3-2-6 X-ray Diffraction Examination of Hydrothermally Altered Rock (50 samples)

The result of the X-ray diffraction examination of 50 samples of hydrothermally altered rock taken at and around 42 localities of mineral occurrence, namely 33 samples of altered sandstone, 3 samples of altered mudstone, 9 samples of altered acidic to intermediate tuff, 2 samples of altered acidic to intermediate volcanic rock, and 3 samples of strongly altered rock, is given in the Table II-9.

The Table II-9 indicates that all of 50 hydrothermally altered rock samples contain a large amount of quartz; 42 samples, namely 32 samples of altered sedimentary rock, 9 samples of altered pyroclastic and volcanic rocks, and 1 sample of strongly altered rock, contain a middle to very small amount of sericite; and 29 samples, namely 21 samples of altered sedimentary rock, 6 samples of altered pyroclastic and volcanic rocks, and 2 samples of strongly altered rock, contain a middle to very small amount of kaolinite, and that 12 samples, that is, 6 samples of altered sedimentary rock, 4 samples of altered pyroclastic and volcanic rocks, and 2 samples of strongly altered rock, contain a large to very small amount of potassic felspar and 7 samples, that is, 5 samples of altered sedimentary rock and 2 samples of altered tuff, contain a small to very small amount of tourmaline.

Therefore, the result of the X-ray diffraction reveals that alteration minerals in hydrothermally altered rock consist mainly of quartz, sericite, and kaolinite. Thus, it seems that this alteration mineral assemblage represents that of the hydrothermal alteration zone acompanying epithermal gold deposit of the intermediate type between the adularia-sericite and acid sulfate types (Hayba et al., 1986; Heald et al., 1987) or between the low sulfidation and high sulfidation types (Hedenquist, 1987).

Table II-9 Result of X-ray Diffraction of Hydrothermally Altered Rock

Area	Sample Number	Rock Name	Quartz	Plagioclase	K-feldspar	Sericite	Chlorite	Kaolinite	Montmorillonite	Chlorite-Montmori. Mixed Layer	Calcite	Tourmaline	Pyrite	Hematite	Goethite
Bt. Tampang	BT-2-X	Altered tuffaceous sandstone	◎			⧺		⧺							
	BT-3-X	Altered sandstone	◎			○		⧺				⧺		⧺	
	BT-4-X	Altered sandstone	◎												
	BT-6-X	Altered felsic tuff	◎		○			○							
	BT-7-X	Altered felsic tuff	◎		○	+		○					⧺		
	BT-9-X	Weakly altered fine tuffaceous sandstone	◎			⧺		+					+		
	BT-10-X	Strongly altered rock	◎		◎	+		+							
	BT-11-X	Strongly altered rock	◎		◎			⧺							⧺
	BT-13-X	Altered felsic tuff	◎			○		○							⧺
	BT-14-X	Strongly altered felsic tuff	◎			○						+			
	BT-16-X	Strongly altered felsic tuff	◎			○								⧺	
	BT-17-X	Strongly altered dacitic agglomerate	◎			+		○				+			
	BT-18-X	Altered sandstone	◎			⧺		+							
	BT-19-X	Weakly altered fine sandstone	◎		+	⧺		⧺							
	BT-21-X	Weakly altered tuffaceous siltstone	◎			+		⧺							
	BT-22-X	Weakly altered tuffaceous sandstone	◎					⧺							
	BT-23-X	Altered fine sandstone	◎		+	⧺		⧺				+			
	BT-24-X	Altered tuffaceous sandstone	◎			⧺						+			
	BT-25-X	Altered tuffaceous sandstone	◎	⧺		○									
	BT-26-X	Altered tuffaceous sandstone	◎			⧺		+							
	BT-28-X	Altered andesite	◎	⧺	⧺	+		⧺					+		
	BT-29-X	Altered mudstone	◎			⧺		⧺							
	BT-30-X	Altered sandstone	◎			+							+		
	BT-31-X	Strongly altered tuff	◎			⧺									
	BT-32-X	Weakly altered sandstone	◎			+									

[Notes] ◎: Abundant, ○: Common, ⧺: a little, +: rare

Area	Sample Number	Rock Name	Quartz	Plagioclase	K-feldspar	Sericite	Chlorite	Kaolinite	Montmorillonite	Chlorite-Montmori. Mixed Layer	Calcite	Tourmaline	Pyrite	Hematite	Goethite
Bt. Tampang	BT-34-X	Weakly altered sandstone	◎			+		+							
	BT-36-X	Altered fine sandstone	◎			⧺									
	BT-37-X	Altered sandstone	◎			+									
	BT-40-X	Weakly altered sandstone	◎	⧺		+					+				
	BT-41-X	Altered sandstone	◎			+		+							
	BT-45-X	Altered sandstone	◎			+		+							
	BT-50-X	Altered fine sandstone	◎			+						+			
	BT-52-X	Altered vitric crystal tuff	◎			+		⧺	⧺						
	BT-54-X	Altered sandstone	◎									⧺			
	BT-55-X	Weakly altered fine sandstone	◎			+		⧺							
	BT-56-X	Weakly altered fine sandstone	◎			+		+							
	BT-57-X	Altered sandstone	◎			+		+							
	BT-58-X	Strongly altered tuff	◎			⧺									
Bt. Kotud	BK-2-X	Weakly altered sandstone	◎	○	+	+					+				
	BK-6-X	Altered sandstone	◎			+									
	BK-7-X	Altered tuffaceous fine sandstone	◎			+		⧺		⧺					
	BK-9-X	Weakly altered dacite	◎	○			⧺				⧺		+		
	BK-10-X	Altered sandstone	◎	⧺		+		⧺			⧺				
	BK-11-X	Strongly altered rock	◎			⧺							+		
Kg. Poring	KP-2-X-1	Altered fine sandstone	◎			+									
	KP-2-X-2	Altered tuffaceous fine sandstone	◎		+	+		+							
	KP-11-X	Altered sandstone	◎		+	+									
	KP-13-X	Altered sandstone	◎			+	+								
	KP-14-X	Altered brecciated mudstone	◎			+		+							
	KP-18-X	Altered sandstone	◎	+	+			+							

[Notes] ◎: Abundant, ○: Common, ⧺: a little, +: rare

3-2-7 Measurement of Homogenization Temperature for Fluid Inclusions in Quartz (20 samples)

Homogenization temperature of fluid inclusions in 20 samples of quartz taken from quartz veinlets and networks, namely 7 samples in hydrothermally altered sandstone, 6 samples in hydrothermally altered tuff, 2 samples in strongly altered rock, 2 samples in sandstone, 1 sample in granodiorite, and 1 sample of quartz pebbles in gravel bed of Quaternary, at 20 localities out of 42 localities of mineral occurrence, has been measured to study formation temperature of quartz.

The result of measurement of 19 samples except for 1 sample (BT-20-Q) which contains no fluid inclusion is given in the Table II-10 and the histograms of the Figs.II-9 to II-13.

The histograms of the Figs.II-9 to II-13 show that the homogenization temperature of only 3 samples (BT-1-Q, KP-4-Q, KP-9-Q), out of 18 samples except the BT-20-Q sample which contains no fluid inclusion and the BT-13-Q sample which contains only one fluid inclusion makes nearly the normal distribution and that of remaining 15 samples makes roughly the uniform distribution.

The Table II-10 and the Figs.II-9 to II-13 also show that 18 samples mentioned above are divided into two groups, that is, 10 samples (BT-1-Q, BT-7-Q, BT-11-Q, BT-15-Q, BT-31-Q, BT-45-Q, BK-12-Q, KP-4-Q, KP-7-Q, KP-9-Q) which have relatively low homogenization temperature (172° to 353°C, average 203° to 292°C) and 8 samples (BT-10-Q, BT-14-Q, BT-16-Q, BT-26-Q, BT-32-Q, BT-37-Q, BT-44-Q, KP-18-Q) which have wide range of homogenization temperature (131° to 536°C, average 276° to 360°C) and have the low temperature zone (186° to 340°C, average 234° to 289°C) and the high temperature zone (307° to 467°C, average 344° to 413°C).

The above result of analysis on homogenization temperature reveals that 14 quartz samples from quartz veinlets and networks embedded in hydrothermally altered rock, namely altered sandstone, altered tuff, and strongly altered rock, are divided into six samples (BT-1-Q, BT-7-Q, BT-11-Q, BT-15-Q, BT-31-Q, BT-45-Q) which have relatively low homogenization temperature (184° to 353°C, average 203° to 292° C) and eight samples (BT-10-Q, BT-14-Q, BT-16-Q, BT-26-Q, BT-32-Q, BT-37-Q, BT-44-Q, KP-18-Q) which have wide range of temperature (186° to 467°C, average 276° to 413°C) and have the low temperature zone (186° to 340°C, average 234° to 289°C) and the high temperature zone (307° to 467°C, average 344° to 413°C) and that temperature of four samples, namely three samples from quartz veinlets in sandstone (BK-12-Q, KP-4-Q) and granodiorite (KP-7-Q) and one sample of quartz pebbles in gravel bed of Quarternary, is 172° to 303°C (average 204° to 283°C) and is a little lower than that of six samples and the low temperature zone of eight samples mentioned above.

The analysis on homogenization temperature also reveals that homogenization temperature (184° to 353°C) of above six samples falls within the range of 135° to 350°C of adularia-sericite type epithermal gold deposit related to the volcanic activity in the Western-Pacific Island Arcs after Sillitou, 1988.

Table II-10 List of Homogenization Temperature of Fluid Inclusion in Quartz

Area	Sample Number	Occurrence	Number of Inclusion (N)	Whole Range of Homogenization Temperature (℃) (M:Mean, SD:Standard Deviation)	Range of Concentrating Zone of Temperature (℃)
Bt. Tampang	BT-1-Q	Quartz veinlets in altered sandstone	30	225~303 (M=250, SD=12)	225~261 (N=29, M=248, SD=8)
	BT-7-Q	Quartz veinlets in altered tuff	25	184~353 (M=254, SD=54)	———
	BT-10-Q	Quartz network in altered rock	27	228~536 (M=360, SD=79)	251~340 (N=11, M=289, SD=35) 370~467 (N=14, M=413, SD=29)
	BT-11-Q	Quartz network in altered rock	24	167~421 (M=308, SD=57)	240~337 (N=18, M=292, SD=25)
	BT-13-Q	Quartz network in altered tuff	1	319	———
	BT-14-Q	Quartz network in altered tuff	25	220~400 (M=309, SD=58)	243~295 (N=13, M=264, SD=17) 344~400 (N=11, M=371, SD=16)
	BT-15-Q	Quartz network in altered tuff	24	153~413 (M=279, SD=60)	235~327 (N=18, M=273, SD=28)
	BT-16-Q	Quartz vein in altered tuff	19	199~531 (M=345, SD=97)	231~320 (N=9, M=271, SD=26) 369~452 (N=7, M=411, SD=29)
	BT-20-Q	Quartz vein	0	———	———
	BT-26-Q	Quartz network in altered sandstone	23	221~409 (M=341, SD=60)	244~276 (N=6, M=263, SD=12) 368~389 (N=13, M=378, SD=6)
	BT-31-Q	Quartz vein in altered tuff	16	195~315 (M=261, SD=35)	214~315 (N=15, M=265, SD=31)
	BT-32-Q	Quartz network in altered sandstone	20	212~407 (M=308, SD=57)	212~263 (N=6, M=234, SD=19) 307~407 (N=13, M=344, SD=33)
	BT-37-Q	Quartz vein in altered sandstone	27	182~388 (M=276, SD=55)	213~295 (N=16, M=253, SD=32) 320~388 (N=9, M=348, SD=25)
	BT-44-Q	Quartz lens in altered sandstone	16	131~403 (M=289, SD=89)	193~288 (N=7, M=241, SD=34) 371~403 (N=6, M=387, SD=10)
	BT-45-Q	Quartz vein in altered sandstone	8	186~378 (M=233, SD=60)	186~224 (N=6, M=203, SD=14)
Bt. Kotud	BK-12-Q	Quartz network in sandstone	28	156~437 (M=259, SD=57)	205~289 (N=22, M=241, SD=23)
Kg. Poring	KP-4-Q	Quartz vein in sandstone	26	184~367 (M=254, SD=44)	184~270 (N=23, M=240, SD=23)
	KP-7-Q	Quartz vein in granodiorite	8	172~249 (M=204, SD=26)	172~249 (N=8, M=204, SD=26)
	KP-9-Q	Quartz pebble in gravel bed	30	254~303 (M=283, SD=13)	254~303 (N=30, M=283, SD=13)
	KP-18-Q	Quartz vein in altered sandstone	5	246~435 (M=340, SD=69)	246~281 (N=2, M=263, SD=17) 351~435 (N=3, M=391, SD=34)