REPORT
ON
THE COOPERATIVE MINERAL EXPLORATION
IN
THE JUNIN AREA
REPUBLIC OF ECUADOR

(PHASE Ⅰ)

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to request of the Government of the Republic of Ecuador, the Japanese Government decided to conduct a mineral exploration project in the Junin area and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Republic of Ecuador a survey team headed by Hiroshi Kusaka from Septmber 23, 1991 to January 8, 1992.

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

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

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

March, 1992

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

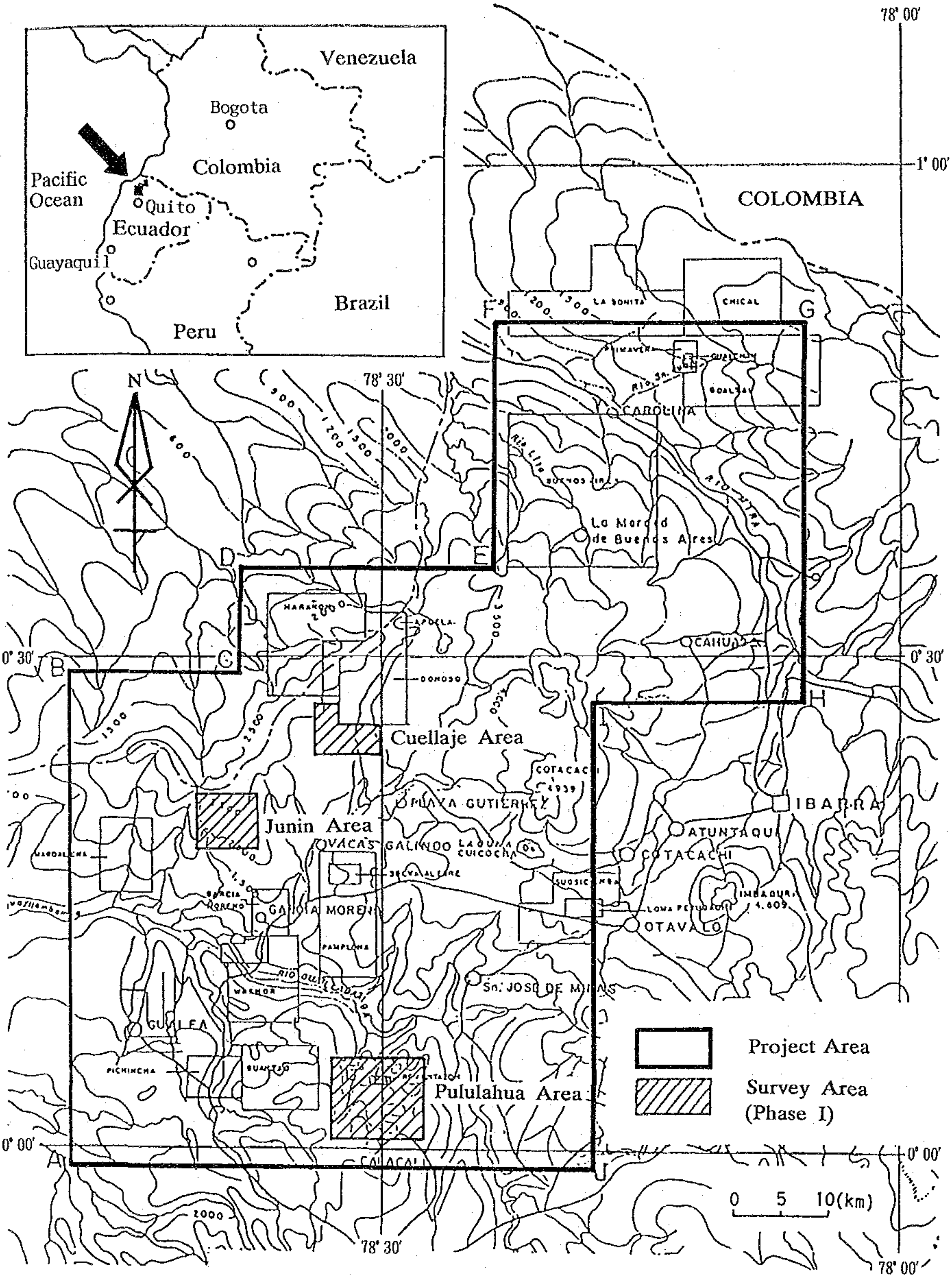


Fig.1 Location of the project area

ABSTRACT

(1) Geology of Junin area

Geology of Junin area consists of Apuela–Nanegal batholith of granodiorite and stock or dike of quartz porphyry and diorite porphyry, which intrude into batholith of granodiorite (Figs.II–1–1 and II–2–1). Lineaments were also analyzed to radiate outlying section of the drainage system from the Junction of Q. Limonita and Q. Crysocola.

(2) Mineralization and alteration in the Central Zone of Junin area

Mineralized and alteration zones in this Zone were clasified in three types based on their occurrences: Type I, Type II and type III (Tables II–4–1 and II–1–12, and Fig.II–1–3).

Type I occured mainly in the granodiorite around stocks or dikes of quartz por–phyry. Mineralized zones, which are characterized by Cu–Mo mineral dissemination (› network of quartz stringers with sulfides), disributed in the down stream of Q.Li monita and in the middle to down stream of Q.Verde, accompanied with phyllic alterat ion zone. The assay result of ore samples were 1.35 % Cu and 1.44 % Cu respectively.

Type II were recognized in various zones such as the up stream of Rio Jinin, the up stream of Q.Limonita, the Q.Crisocora, the down stream of Q.Controvercia and the up atream of Q. La Rica. Type II, which occured as veins composed of as same ore mineral assembly as Type I, was divided into two sub–type Type IIA and Type IIB on their occurrences.

1) Type IIA : abundant in ore minerals which was scattered in clay, principal gangue mineral.
2) Type IIB : quartz veins with ore minerals.

Both phyllic and potassic alteration zones were identified along the vein contacts. The assay results of ore samples were as follows: 0.3 g/t Au, 137.2 g/t Ag and 42.42 % Cu for Type IIA of Q.Limonita; 0.1 g/t Au, 4.6 g/t Ag, 2.17 % Cu and 0.97 % Mo for Type IIB of Rio Junin mineralized zone.

Type III was observed to be as acidic alteration zone being accompanied with networky quartz veins.

The distribution of these three types of mineralized zones are summaried as follows: The Type I dominates in the Central Zone and extends southeastward and northeastward; Type II dominates in the Central Zone mainly and extends northwest–ward and southeastward, further to the Surrounding Zone of Junin area; and Type III

is limited in the eastern half of the Central Zone.

(3) Drilling survey

Drilling Hole No. MJJ–1, which was carried out in the western edge of the Q.Limonita mineralized zone and drilled down to 151.50 m in depth. The MJJ–1 revealed that the lower part of the hole intersected and corresponded to the marginal section of the Q.Limonita mineralized zone.

(4) Mineralization in the Surrounding Zone of Junin area (Fig.II–2–3)

The Q.Espelanza mineralized zone, which was proved to be similar to type IIA and Type IIB of the Central Zone, were accompanied with phyllic alteration zone. Ore grade assayed was as follows: 0.6 g/t Au, 784 g/t Ag, 20.97 % Cu and 0.28 % Zn.

The Q. Fortuna mineralized zone was recognized to be similar to the Type I and the Type IIA of the Central Zone. A section corresponding to the Type I was accompanied with phyllic alteration zone and graded to be 8.3 to 1.1 g/t Ag, 2.68 to 0.33 % Cu and 0.09 % Mo or under, while the other section corresponding to Type IIA was assayed to be 0.2 g/t Au or under, 3.5 to 1.8 g/t Ag and 1.26 to 0.37 % Cu.

In the Q.Cristal branch alteration zone, several mineralized sections were recognized to be corresponded to Type I and Type IIB defined in the Central Zone.

(5) Result of geochemical exploration

As the results of rock geochemical exploration in the Central Zone of Junin area, the zoning of alteration mineral assemblage was proved precisely to be reflected on the distribution of geochemical anomalous zones which were corresponded also to each mineralized zones respectively (Figs.II–1–7 and II–1–8). For instance, Cu–Mo geochemical anomalous zone was centered on a intense mineralized zone, on the other hand Pb–Zn anomalous zones were distributed generally in surrounding part of each mineralized center.

The Au–Ag anomalous zone was suspected only to show a vague relationship with mineralized zone. Every Au–Ag anomalous zone over 10 ppm of Au was, anyhow, delineated within the Type III acidic alteration zones.

Cu–Pb–Zn geochemical anomalies were detected by stream sediments in areas corresponding to the mineralized outcrops along the Q.Limonita, the Q.Fortuna, and a branch of the Q.Cristal of the Surrounding Zone of Junin area (Fig.II–2–6).

(6) Cuellaje area

Geology of Cuellaje area consists mainly of the Apuela–Nanegal batholith of granodiorite, and stocks or dikes of andesitic porphyry, dioritic porphyry and/or quartz porphyry, which intrude the batholith (Fig.II–3–1).

The Rio Magdarena mineralized zone was accompanied with a zonal structure of three alteration mineral assemblages: the potassic alteration zone; the phyllic alteration aone; and propylitic alteration zone in outward order.

The assay result of ore samples there was 5.2 g/t Ag, 1.66 % Cu and 0.11 % Mo. These mineralized zones could be comparable in extension and intensity with those of the Central Zone of Junin area.

The Q.San Miguel mineralized zone was observed to be surrounded by the propylitic alteration zone.

Both the Rio Cristopamba mineralized zone and the mineralized zone between Rio Magdarena and Q.San Miguel contain Type II zones which are accompnied with contact zonal alteration in the vicinity of veins: the phyllic alteration zone at the central part, the propylitic alteration zone outwards.

The assay results of the Rio Cristopamba and the Q.San Miguel mineralized zones were as follows: 45.6 to 6.3 g/t Ag, 6.97 to 1.43 % Cu and 0.13 % Mo; 0.4 g/t Au, 36.5 g/t Ag, 7.98 % Cu and 0.03 % Mo respectively.

(7) Pululahua area

Geology of Pululahua area consists of the Cretaceous Macuchi formation (andesitic coarse tuff mainly), the Cretaceous Yunguilla formation (mudstone mainly), the Quaternary Talus breccias, Pululahua volcanic explosions, its mud–flow, and its detritus falls (Fig.II–4–1).

There are two areas of interest for prospect in this area, which are known as the Tanachi deposit and the Reventazon alteration zone.

The Tanachi deposit, which situates in the northwestern part of the area, occurs as secondary deposit of ore breccias. These ore breccias were supposed to be derived from polymetallic epithermal deposits formed in Quaternary age associating with the acidic hydrothermal activities, and to be transported possibly by landslide movement.

The assay result of ore samples obtained from waste stock pile in the Tanachi mine was 1.7 to 0.3 g/t Au, 182.5 to 52.3 g/t Ag, 3.99 to 0.57 % Cu, 9.34 to 0.06 % Pb and 24.8 to 0.08 % Zn. The Rebentazon acidic alteration zone situates in the central part of the Pululahua ara. The assay result of ore was under detectable level.

Junin and Cuellaje areas were proved to have high potential of Cu–Mo dissemination and vein deposits. Followings are, therefore, recommended for Phase II survey.

(1) Central Zone of Junin area (Fig.2–1)

According to the steep topography, it is difficult to adopt the geophysical exploration. Drilling survey is, consequently, commended although a transportaion ploblem needs to be solved.

Taking the movilization of diamond drilling machine into consideration,the recommended order of drilling survey is as follows:

1) Q.Limonita mineralized zone (Type I)

2) An area between Q.Limonita and Q.verde mineralized zones (Type I)

3) Rio Junin mineralized zone (Type II)

A detailed geological survey is, furtheremore, recommended to be carried out in the area of Q.Verde mineralized zone (Type I) and mineralized zones of Q.Limonita up stream, Q.Crisocora, Q.Controvercia and Q.La Rica (Type II) in order to delineate promissive mineralized zone for future drilling survey.

(2) Surrounding Zone of Junin area (Fig.2–2)

To correlate mineralization between Central Zone and Surrounding Zone of Junin area, detailed geological survey and geochemical exploration are recommended to be carried out in the three mineralized zones, Q.Espelanza mineralized zone, Q.Fortuna mineralized zone, and Q.Cristal branch mineralized zone.

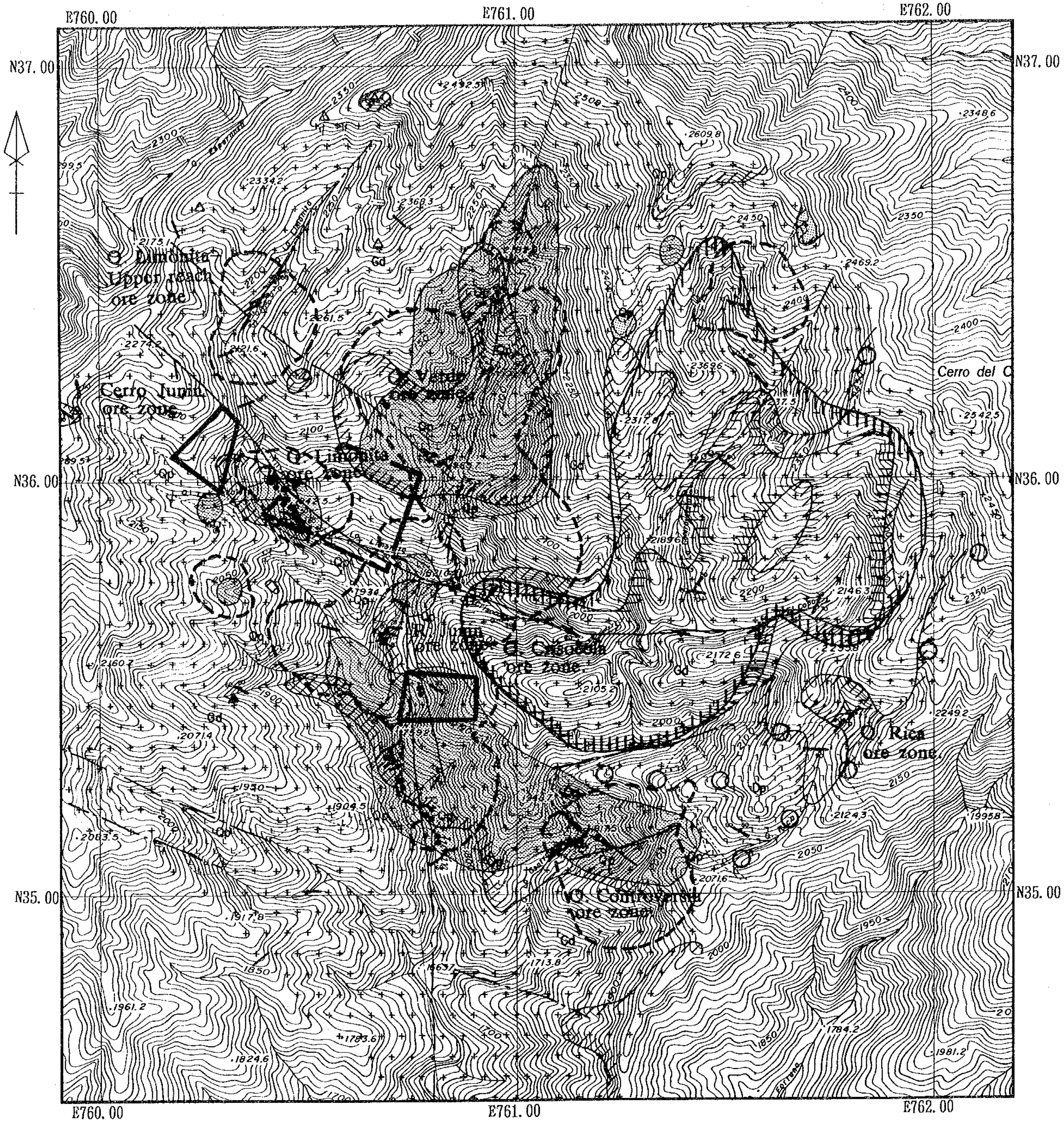
(3) Cuellaje area (Fig.2–3)

Detailed geological survey, rock geochemical exploration, and geophysical exploration are recommended to be carried out in Rio Magdarena mineralized zone and a limited area between Rio Cristopamba and Q.San Miguel mineralized zones.

The reason of recommendation is as follows:

–Topography in Cuellaje area is comparatively gentler than that of Junin area, geophysical exploration method should be adoptable consequently.

–Occurrence of mineralization here is quite similar to that of Junin area, geological and geochemical survey could be efficient exploration methods.



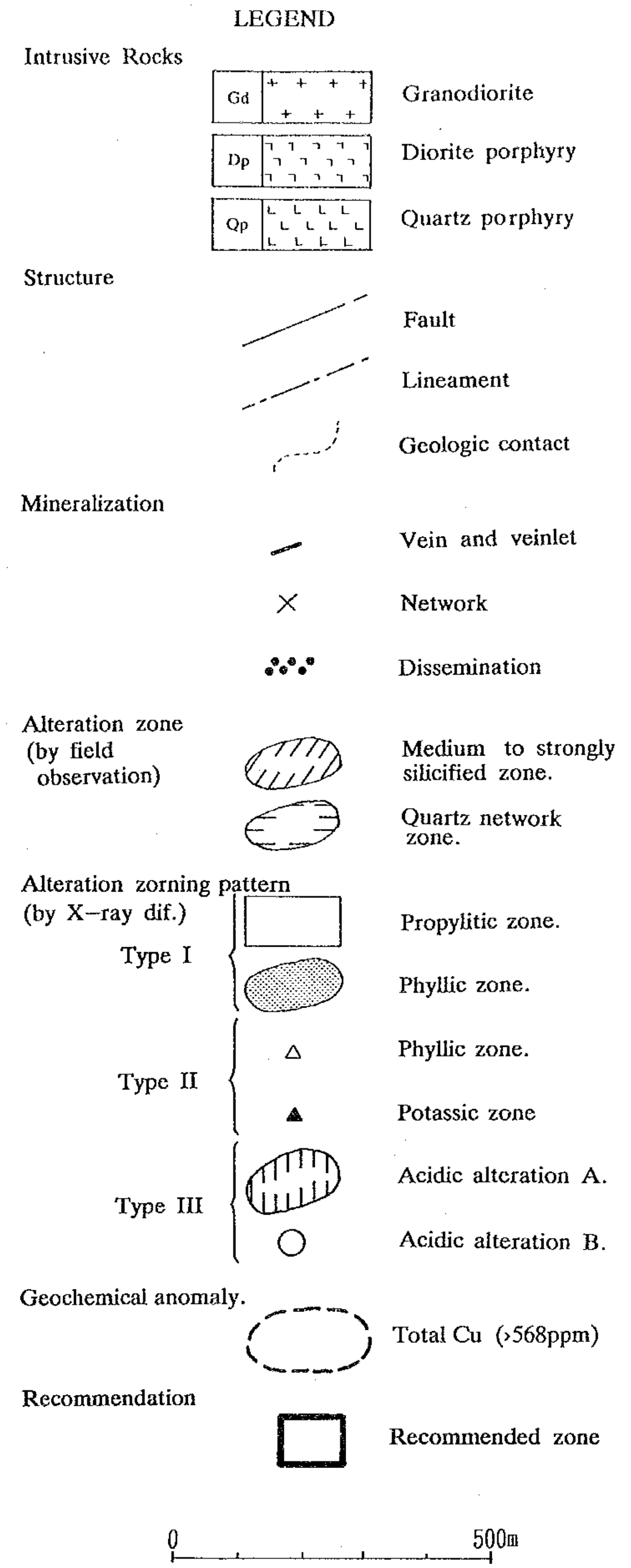


Fig.2–1 Survey results and recommendation for further survey (Central zone, Junin area)

Fig.2–2 Survey results and recommendation for further survey (Surrounding zone,Junin area)

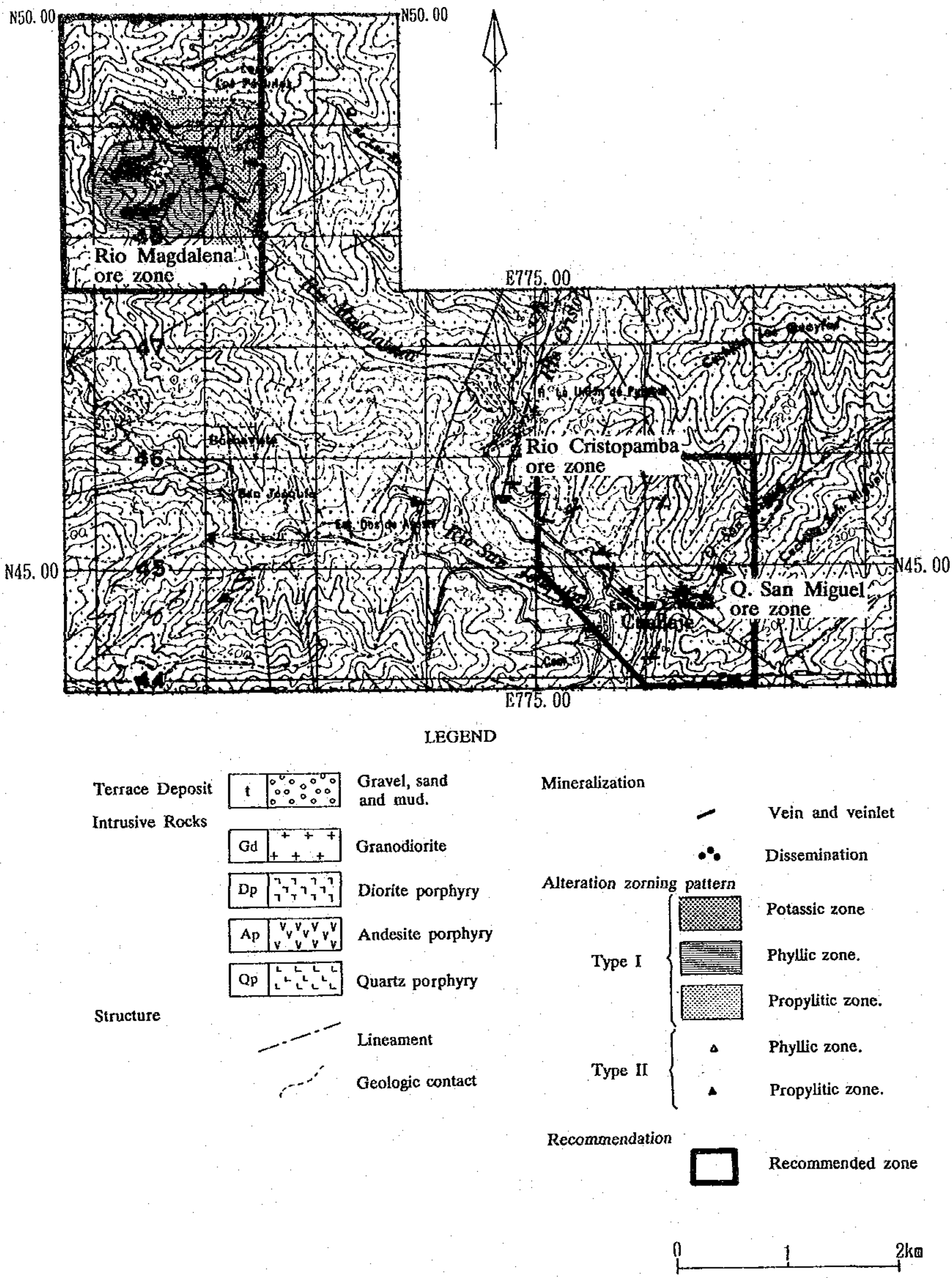


Fig.2–3 Survey results and recommendation for further survey (Cuellaje area)

CONTENTS

PART I GENERAL

PART II DETAILS

PART III CONCLUSIONS AND RECOMMENDATIONS

PART I GENERAL

Chapter 1 Introduction

1–1 Background and purpose of survey

The Junin Project area lies in the western flank of Occidental Cordillera of Ecuador, where predominates a porphyry copper belt which is known to run consistent–ly from North to South of America.(Fig.1)

The area and its vicinity were surveyed as " Northwestern Project" during 1981 and 1982 by DGGM*. The survey resulted in sellecting several promissive areas of porphyry copper type mineralization. These areas, however, have not been followed up with advanced survey method owing to the difficulties of national economical circum–stances, although a limited and conventional geological survey was carried out in Junin area.

Meantime, a cooperative mineral exploration was proceeded in the " Provincia de Bolivar" , the middle part of the Ecuador during 1988 through 1991 under the agree–ment signed by Governments of Ecuador and Japan. The counter–organization of ecuador was *INEMIN*** *, which is now named CODIGEM****.

In 1990,Ecuadrian Government decided to pick mineral resources development project as a principal project of the Governmental policy in order to rebuilt nation's economy. Consequently, Ecuadorian government requested Japanese Government cooperative technological asistance which was reuired for mineral exploration. In re spond to such request, Japanese government sent a Mission, which consisted of repres entatives of JICA and MMAJ, from 14th to 29th of July, 1991, and agreed the Scope of Work on cooprative mineral exploration with Ministry of Energy and Mine of Ecuador.

The Purpose of the project is to confirm the potential of ore deposits by clarifying geology and mineralization in the Junin area, Republic of Ecuador.

1–2 Area, Objectives and Outline of the Phase I survey

The survey area of the Phase I consists of four areas: the Central Zone of Junin area; the Srrounding Zone of Junin area; the Cuellaje area; and the Pululahua area, which were selected in accordance with the geological data and information

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{Remarks} * DGGM: Direccion General de Geologia y Minas; ** INEMIN; Instututo Ecuatoriano de Mineria; *** CODIGEM; Corporacion de Desarrollo e Investigacion Geologico–mineria y metalurgica.

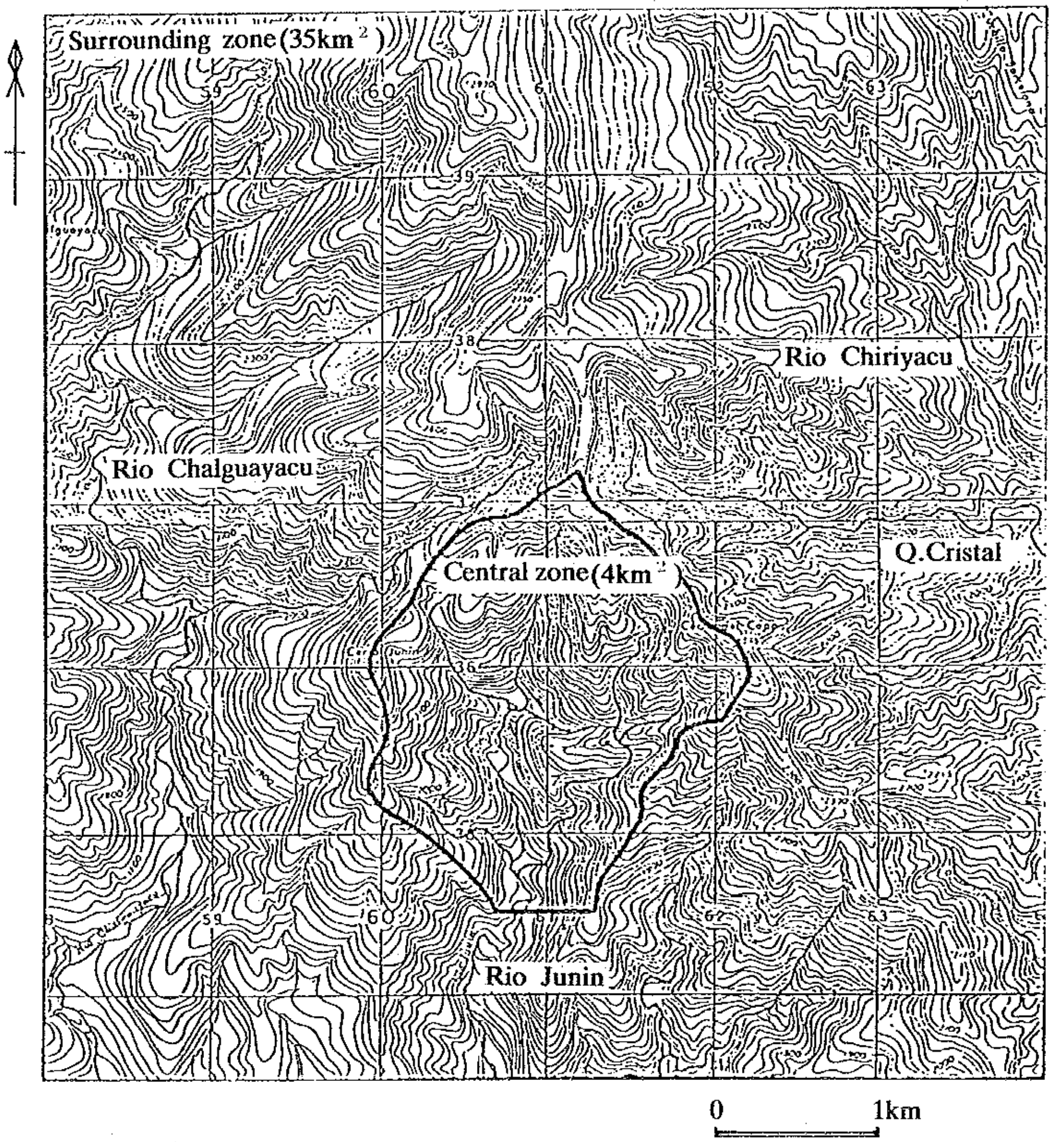


Fig.I–1–1(1) Location of the survey area(Junin area)

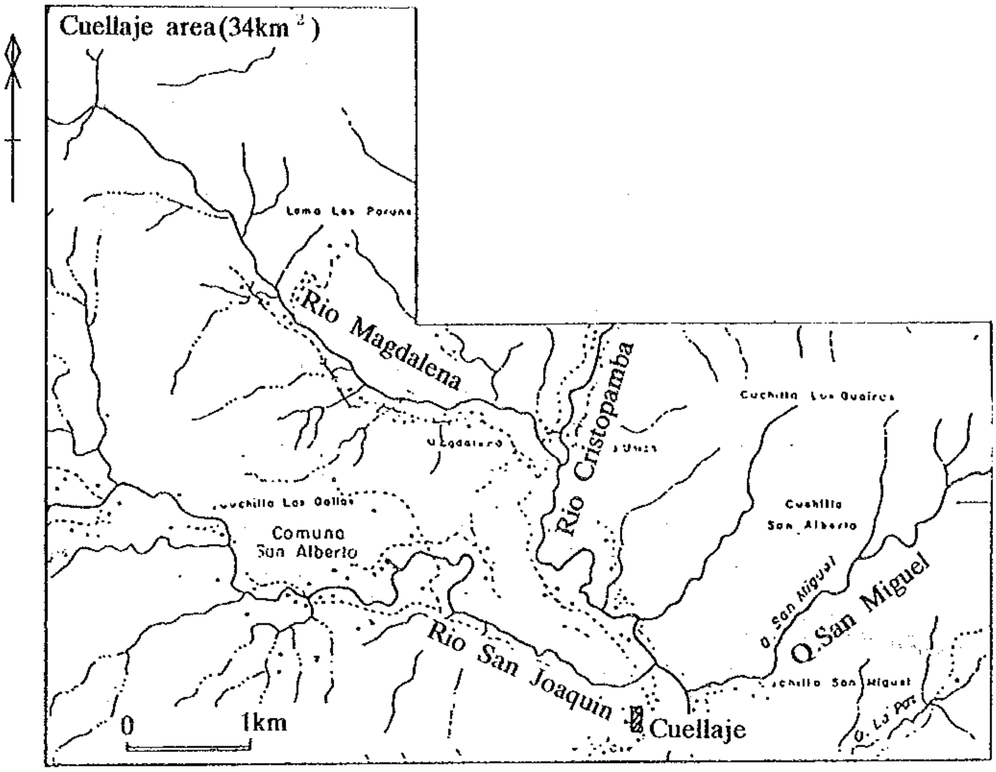


Fig.I–1–1(2) Location of the survey area(Cuellaje area)

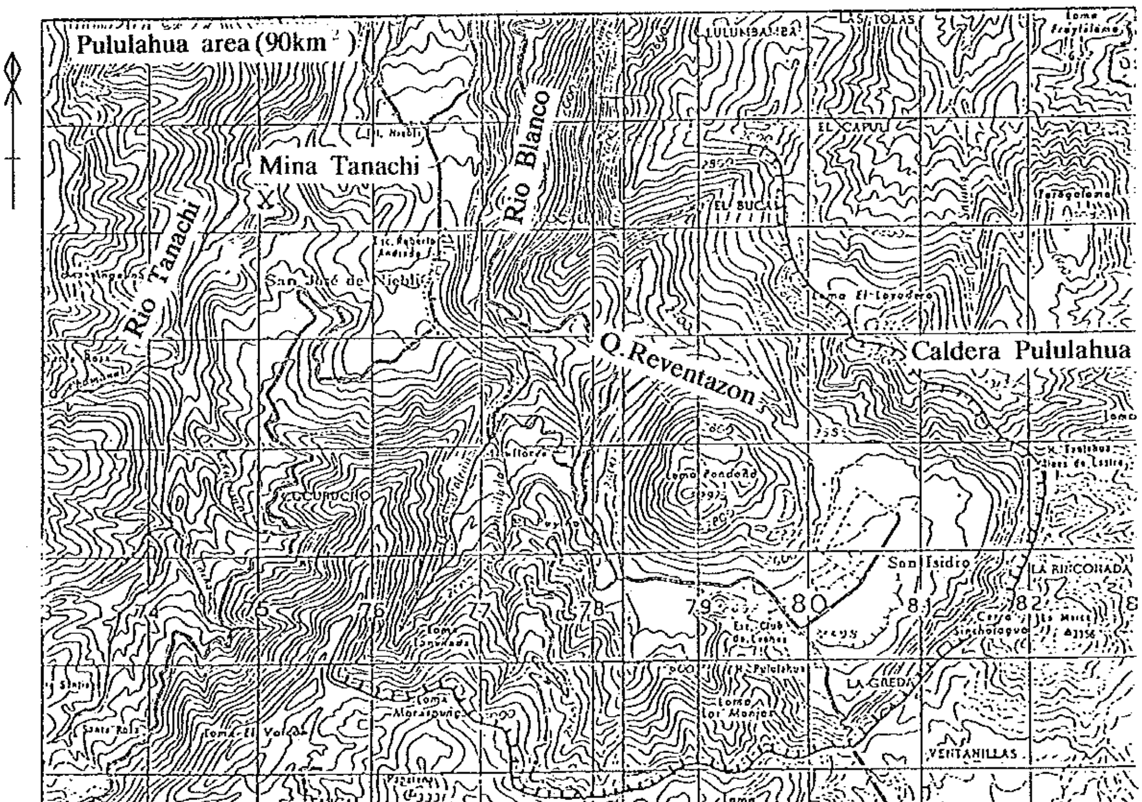


Fig.I–1–1(3) Location of the survey area(Pululahua area)

Tab.I-1-1 Amounts of field works and laboratory tests

Area	Survey contents	Survey amount			
		Area covered	Route length	Geochem. sample	Drilling Survey
Central zone, Junin	Geol.detail survey Rock geochemistry (current survey)	$4km^2$	19.2km	304 pcs	150m x 1h
Surrounding zone, Junin	Geol.semi-detail surv. Stream sediment geochemistry (current survey)	$35km^2$	48.0km	160 pcs	---
Cuellaje	Geol.reconnaissance survey (current survey)	$34km^2$	42.0km	---	---
Pululahua	Geol.reconnaissance survey (current survey)	$90km^2$	70.0km	---	---

Area	Items and contents of laboratory work	Amouns (current survey)	
		Geological and Geochemical Survey	Drilling Survey
Central zone, Junin	Thin section	6	3
	Polished section	11	5
	Whole rock analysis	3	
	Ore analysis	52	62
	Rock geochem.analysis	252	
	@Rock geochem.analysis	52	
	X-ray diffraction	150	60
	K-Ar dating	1	
	EPMA	3	2
Surrounding zone, Junin	Thin section	6	
	Polished section	5	
	Whole rock analysis	7	
	Ore analysis	21	
	Strm.geochem.analysis	160	
	X-ray diffraction	20	
	K-Ar dating	3	
Cuellaje, pululahua (reconnaissance)	Thin section	6+6=12	
	Polished section	5+5=10	
	Whole rock analysis	6+4=10	
	Ore analysis	33+9=42	
	X-ray diffraction	24+8=32	
	K-Ar dating	4+2= 6	

Remarks:@;T-Cu,So-Cu
Current survey amounts in reconnissaance survey areas show those of Cuellaje area with left side and Pululahua right.

Tab.I-1-2 Member list of project administration

Japanese counterparts		Ecuadorian counterparts	
Katsumi Yokokawa	MMAJ	Nunez del Arco	MEM
Shigeki Sakurai	MITI	Edgar Lopez	CODIGEM
Hideya Metsugi	MMAJ	Wilson Santamaria	CODIGEM
Masamichi Maejima	JICA	Jorge Guzman	CODIGEM
Kousuke Takamoto	MMAJ	Luis Quevedo	CODIGEM

MMAJ:Metal Mining Agency of Japan
MITI:Ministry of International Trade and Industry
JICA:Japan International Cooperation Agency
MEM :Ministerio de Energia y Minas
CODIGEM:Corporacion de Desarrollo e Investigacion
Geologico-Minera y Metalurgica

Tab.I-1-3 Member list of survey team

Japanese counterparts		Ecuadorian counterparts	
Hiroshi Kusaka	Leader BEC Geol.geochem.surv.	Wilson Santamaria	Geol.geochem.surv.CODIGEM
Tadahiko Momma	Geol.geochem.surv.BEC	Luis Quevedo	Geol.geochem.surv.CODIGEM
Norio Ikeda	Geol.geochem.surv.BEC	Jorge Barragan	Geol.geochem.surv.CODIGEM
Motomu Goto	Geol.geochem.surv.BEC	Carlos Ortiz	Geol.geochem.surv.CODIGEM
Toshio Murakami	Geol.geochem.surv.BEC	Luis Gaona	Geol.geochem.surv.CODIGEM
Tsukasa Ambo	Drilling BEC	Ricardo Rosales	Geol.geochem.surv.CODIGEM
Zenzo Kodate	Drilling BEC	Laureano Saltos	Geol.geochem.surv.CODIGEM
Hiroshi Mito	Drilling BEC	Rolando Toro	Geol.geochem.surv.CODIGEM
		Luis de La Torre	Drilling CODIGEM
		Alfonso Vaca	Drilling CODIGEM
		Patricio Colon	Drilling CODIGEM

BEC:Bishimetal Exploration Co.,Ltd.

prepared by Ecuadorian Institution, INEMIN. (Fig.I–1–1)

In the Central Zone of Junin area, detailed geological and geochemical survey and drilling survey were carried out. In the Surrounding Zone of Junin area, semi–detailed geological and geochemical survey have been done, furthermore, in the Cuell aje and Pululahua areas, regeonal geological survey were proceeded. (Tables I–1–1)

The objectives of geological and geochemical survey were to clarify the correl– ation between mineralization and geological structure and/or igneous activities, and to characterize mineralizational zonation for selecting promissive mineralized zone.

The purpose of Drilling survey was to confirm the extension of mineralized zone observed along the Q. Limonita in the Central Zone of Junin area laterally and vertically.

1–3 Organization of survey

Personnel who were involved in the Project, as administraters and surveyers are shown on the Tabs.I–1–2 and I–1–3.

1–4 Period of survey

Planning and negociation

From 14th of July, 1991 to 29th of July, 1991

Field survey

Geological and geochemical survey:

From 23rd of September, 1991 to 19th of December, 1991

Drilling survey

From 5th of November, 1991 to 8th of January, 1992

Analysis and Documentation

From 20th of December, 1991 to 28th February, 1992

Chapter 2 Geography of survey area

2–1 Location and Transportation

The Project area of Junin locates about 20 to 80 km north of Quito, the capital city of Ecuador. The area extends through two Provinces, the Provincia de Imbabura and the Provincia de Pichincha.

The Phase I survey includes three survey areas, which were Junin, Cuellaje, and Pululahua selected by Ecuadorian Institution (Fig.I–1–1 and Tab.I–1–1).

Junin area divided into two zones: Central Zone and Surrounding Zone, size of them are 4 km^2 and 35 km^2 respectively. Cuellaje and Pululahua areas have 34 km^2 and 90 km^2 respectively (TableI–1–1).

Base–camp was located at Nangulbi, which is about 180 km of road distace and four hours drive from Quito via Otavalo (110 km of paved road between Quito and Otavalo, and 70 km of unpaved road between Otavalo and Nangulbi). From Nangulbi to Chalguayacu Alto, the entrance of Junin, two hours drive approximately for 40 km of unpaved road via Garcia Moreno. From Chalguayacu Alto to " Junin Camp" in the Central Zone of Junin area, 7 km (estimated on the map) requires three hours and a half on horseback in dry season. To advance further from Junin Camp to the northwestern part of Srrounding Zone of Junin, three hours or more on foot.

From Nangulbi to the eastern part of Surrounding Zone of junin, a village Balcelona, one hour and a half of drive by Jeep through 20 km of unpaved road.

From Nangulbi to the Cuellaje area, fourty minutes of drive through 17 km of unpaved road.

It takes 40 minutes only from Quito to Calacali in the Pululahua area, road distance between them is 30 km.

2–2 Topography and drainage system

The project area lies in the western flank of West–Andian mountain range. The topography of the project area is very steep, altitutional fractuation is between 1,500 m and 3,000 m above sea level in Junin area, between 1,800 m and 2,600 m above see level in Cuellaje area, and between 1,500 m and 3,400 m above sea level in Pululahua area.

The prominent summit distributed inside of the Project area is Mt Cotacachi (4,937 m ASL) which occupies about 20 km east of the Cuellaje area, and the other prominent summit outside is Mt Cayambe (5,790 m ASL) which rises high at about 50 km east of the Pululahua area.

Junin and Cuellaje areas situate on the southern flank and southeastern flank of Cordillera de Toisan.

In the Project area, the principal drainage system originates from the Andian mountain rage and consists macroscopically of the E–W direction represented by Rio Guayllabamba running to the west in southern area and the NW–SE direction represent–ed by Rio Mira streaming toward the northwest direction.

Adding to these directions, second digree drainage systems are developed, which are characterized with NE–SW system and N–S system. Three survey areas, Junin, Cuel–laje, and Pululahua, are distributed in an area along a Branch of upper stream of Rio Guayabamba.

2–3 Climate and vegetation

Climate in the survey area is tropical, high humudity in lower altitution area and temperate, dry in higher altitution area. The records show that annual humidity be from 50% to 75%. Presipitation sums up 2,000 mm to 3,000 mm annually.

The rain season runs from Dicember to April. In Junin area,it is very common to start rainning in the afternoon and decresing temperature from October. It rains through day and night from Dicember.

Pululahua area, which situates in the eastern part of the Project area, shows dry climate. Its alutitution is the highest among three survey areas and its climate is much more temperate. In the higher place than Pululahua area, perpetual snow gets covering sumits and peaks (for instance,Mt Cotacachi etc).

Vegetation mainly consists of jungles. Plantaions of suger caine and banana exist along valleys, and fields of corn and beans or ranchos are developed partly in highland.

Chapter 3 General geology

3–1 Outline of geology

DGGM found out high copper anomaly 2,500 ppm of Cu in the lower stream zone of Rio Junin river by means of stream sediment geochemical survey carried out during 1981 and 1982 under the name of " Northwestern project" which covered 8,100 km^2 including the Junin Project area.

Thereafter, Belgian Mision assisted DGGM to conduct exploration in the upper stream zone of Rio Junin river by means of semi–detailed to detailed geological and geochemical survey and geophysical exploration from 1984 to 1985 (MRNE/DGGM, 1985).

Outline of this survey is as follows: Semi–detailed geochemical survey was carried out with samples of stream sediments, heavy minerals, rocks and soils indiv–idually.

Stream sediment survey revealed several geochemical anomalous zones (1,000–36,000 ppm of Cu, 7,000 ppm of Mo, 300–1,700 ppm of As and 200–655 ppm of W). Geoch–emical indicators adopted were such elements as Cu, As, Ag, Sb, Bi, Pb, Ni, Co, Mo, Sn, and W for 113 pieces of samples collected.

As a rusult of rock and soil geochemical survey, several anomarous zones were disclosed (3,000–603,300 ppm of Cu in rock; 180 ppm of Cu in soil). Indicators adop–ted were Cu, Pb, Zn, Mo, Ag, As, W, and Sn. Number of samples analyzed was 38 pieces for rock and 458 pieces for soil.

These geochemical data and information resulted in delineating a potential area of 17.5 km2. Then a prommisive zone of 4 km^2 was selected within the potential area for further exploration with IP method electric survey.

Those detailed investigations in Junin area indicated a posivility of a porphy–ry copper type ore deposits in the prommisive zone and proposed to carry out a dril–ling survey in Q.Limonita and a drilling–and–drift survey beween Q.verde and Q.Cont–rovercia.

According to the recommendation mentioned above INEMIN followed up the investi–gation in Junin, and made a plan of a drilling survey amounting 3,800 m for 18 holes (INEMIN, 1987).No comprehensive investigation were atempted in Junin area since then 1987.

In Cuellaje area geochemical anommary more than 600 ppm ofCu, partly over 2,000 ppm of Cu, have been pointed out in the northwestern part of Cuellaje village and in the western part of Rio San Joaquin (ENADIMSA, 1977); geochemical anomaly of 20–40 ppm of Pb in up stream zone of Rio San Joaquin and in the northern most part of the Cuellaje area; geochemical anomaly of Zn 300–500 ppm in northern Cuellaje village and 200–300 ppm in up stream zone of Rio San Joaquin. Owing to counterparts' information, geophysical exploration and drilling survey may have been carried out in Cuellaje area. Geophysical survey was carried out in the down stream side of " Q. Magdarena mineralized zone" which was reconfirmed during the Phase I field survey of this project. Adding this three holes may have been practiced: one on the other side of Rio Cristopamba; the other two holes on the geochemical anomarous zones along Rio Magdarena. Depth of each hole may have been as shallow as 17 m, and 33 m in deepest. Any result of drilling survey, however, has not been recorded.

In the Pululahua area Tanachi mine, which has been explored for 60 years by means of drifts, is situated in the principal mineralized zone. Followings are the outline of significant surveys:

–Inspection survey for gold mine consession (DGGM et al, 1984)

–Geochemical survey with stream sediments, stream water and rocks (Sosa and Leon, 1986)

–Check survey for geochemical survey in Tanachi mine area (INEMIN et al, 1988)

Tanachi mine was concluded to be of polymetallic mineralization. Exploration permit was accepted for Tanachi mine area, which was requested by a private company group. Exploration activities has not yet been started, however, and the drifts of the mine have been abandoned.

3–2 Geological setting

Ecuador situates in the northwestern part of South American Continent and occupies an area between Columbia and Pelu geographically. Geotechtonically, Ecuador belongs to so–called mobile belt of the Andian geosyncline, which is formed in a narrow stripe along the western margin of the Guiana–Brazil shield, and which is characterized such geotechtonic structure with faults, folds and violent volcanic activities as eugeosyncline is.

The geology of Ecuador consists of rocks from Pre–Cambrians up to Quaternaries. Principal geologic structure shows NNW–SSE trend which reflects upon the distribution of the three geo–techtonic ranges: Coast; Mountains; and Orient.

Geology of coastal range is composed of Mesozoic marine formation (the Pinon formation), Tertiary formation and Quaternary formations.

Geology of Mountain ranges is composed of three geologic zones: the West–Cordillera; the Andian inner valley; and the East–Cordillera.

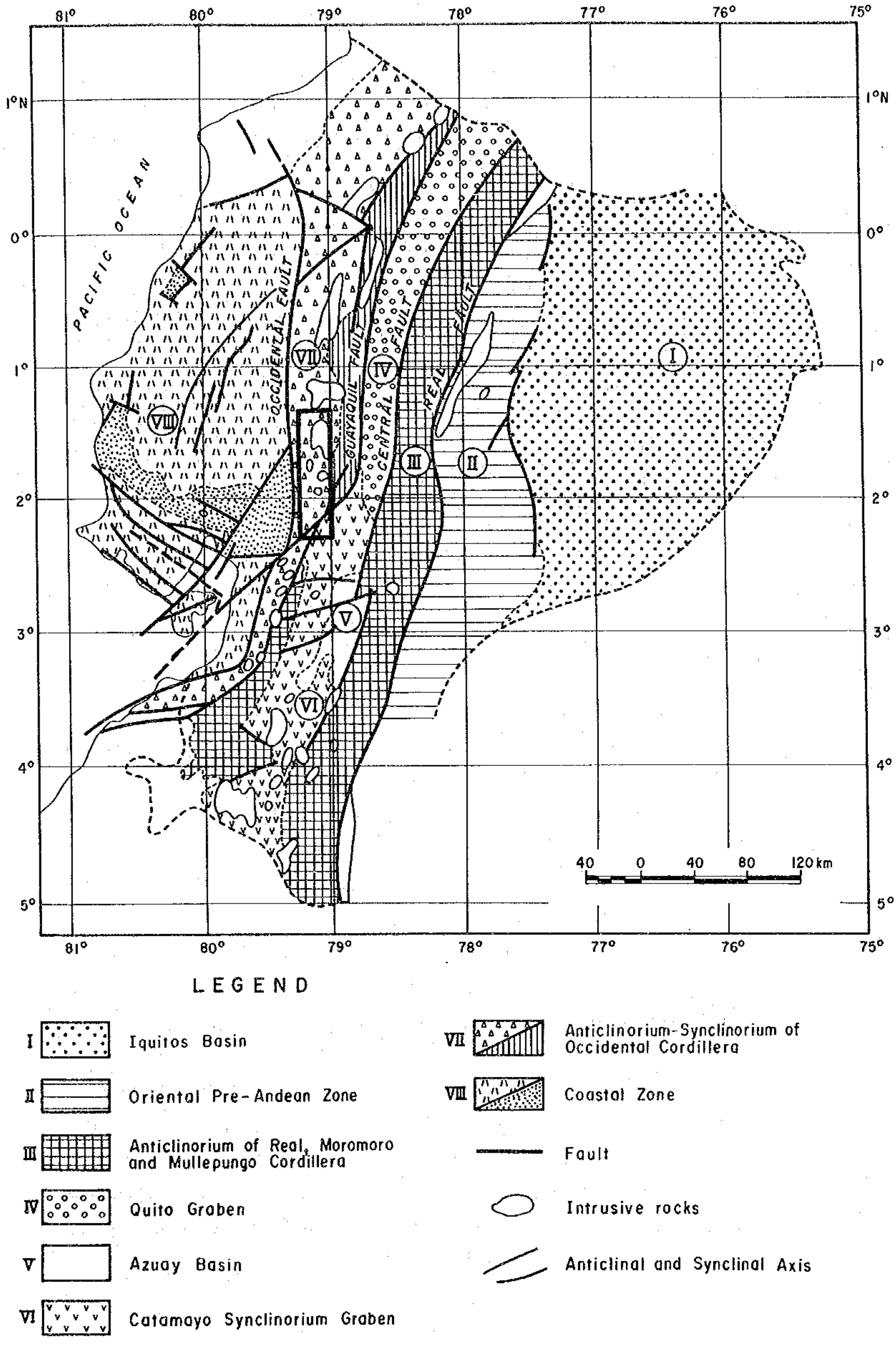


Fig.I–3–1 Geotectonic and metallogenic zones of Ecuador

Tab.I–3–1 Classification of metallogenic zones

Topography		Geology	Metallogenic Province	Metallogenic Zone	Metallogenic Sub-Province
Galapagos Islands		Pliocene ~ Quaternary			Cu-Ni-Co Sub-Province of Ocean Floor (Quaternary)
Coast		Pre-Cretaceous ~ Pleistocene (Pinion Formation)	Occidental (Ocean Crust, Eugeosyncline)	VIII. Coastal Zone	Fe-Ti-Pt Sub-Province of Coast (Jura ~ Early Cretaceous)
Mountain Range	Occidental Cordillera	Cretaceous ~ Paleocene (flysh) (Macuchi Formation)		VII. Anticlinorium-Synclinorium of Occidental Cordillera	Cu Sub-Province of Occidental Cordillera (Cretaceous ~ Miocene)
	Interandean Depression	Neogene ~ Holocene		VI. Catamayo Synclinorium Graben	Polymetalic Sub-Province of High Plateau (Paleocene ~ Quaternary)
				V. Azuay Basin	
				IV. Quito Graben	
	Real Cordillera	Metamorphic Rocks of Paleozoic and Mesozoic	Oriental (Continental Crust, Miogeosyncline)	III. Anticlinorium of Real, Moromoro and Mullepungo Cordillera	Sn-W-U Sub-Province of Real Cordillela (Later Paleozoic)
Orient		Carboniferous ~ Cretaceous		II. Oriental Pre-Andean Zone	Au Sub-Province of Orient Basin (Mesozoic ~ Cenozoic)
		Tertiary ~ Quaternary		I. Iquitos Basin	

In the West–cordillera volcanic rocks, which are dated to be from Cretaceous to Pareogine (the Macuchi formation), are piled up enormously. In the southern part of this geologic range, Paleozoic and Pre–Cambrian basements are recognized to distribute. In the Andian inner valley, scattered are many depositional basins which are filled with sediments and volcanic detritus.

Geology of Orient is composed of sedimental layers from Carboniferous to Quaternary.

Ecuador has two major Metallogenic Provinces: Oriental and Occidental, each of which is subdivided into three and five Metallogenic Zones respectively (INEMIN, 1988). Classification of these zones is interpreted on Tab.I–3–1, and their distri–bution are shown in Fig.I–3–1.

The Junin area is situated in the Metallogenic Zone VII, a anticlinorium–syncl–inorium of Occidental Metallogenic Province. The Zone VII extends north–south: nor–thern most limit may be around the Piedrancha deposits in Columbia (50Ma, JICA–MMAJ, 1983); to the south, El Torneado mineralized zones (30/24Ma, JICA–MMAJ, 1989) and Chaucha deposits (Eocene, OMRD, 1972); and southern most limit may be around the Michiquillay deposts (46/21 Ma, Stewart et al, 1974)

In the vicinity of Piedrancha, Later stage auriferous mineralization is also recognized. Massive sulfide deposits have been mined at the La Plata mine and the Macuchi mine which are just south of Quito, and polymetallic deposits are being mined at the Portovelo mine in the southern part of Ecuador. Therefore the Zone VII may have a high potential of ore deposits, especially of porphyry copper type deposits.

Geology of Junin area consists of Cretaceous Macuchi formation, Silante formation and Yunguilla formation, which are intruded by acidic to intermediate granitic rocks (MRNE/DGGM, 1982). In the eastern part of the area, Quaternary volcanic detritus and lavas distribute extensively. The Macuchi formation is composed of basic to intermediate volcanic rocks, thickness of which is over 5,000 m. The Silante formation is composed of reddish volcanic debris, thickness of which is over 4,000 m. The Yunquilla formation is composed of shale, thickness of which is estimated to be over 2,000 m.

Limiting to the Phase I survey area, The Macuchi and Yunquilla formations are recognized in Pululahua area only, the other two areas consist of granitic rocks. Henderson (1979) described that within the Macuchi formation just outside of the Project area identified were marine fossil fauna (Inoceramus peruanas) and fossil foraminifera (Globotruncana sp.) corresponding to upper Cretaceous, and fossil foraminifera (Nummulites nummulitiformis Rutten, Amphistegina spp.) corresponding to Eocene; and that the Macuchi was dated to be 51.5+2.5 Ma with K–Ar method, which corresponded to Lower Eocene. Furthermore batholith of granodiorite in the Project area was determined to be 13 to 15 Ma; Stocks of porphyritic rocks were to be 6 to 11 Ma with K–Ar method.

Principal geologic structure show N–S and NNE–SSW directions which are represented by distributional characteristics of Apuela–Nanegal batholith.

Four types of mineralization and alteration were recognized in the Project area.

–Type 1 : Cu–Mo mineralization observed as dissemination of copper and molibdenum minerals in granitic rocks
(Porphyry copper type).....(In Junin and Cuellaje areas)

–Type 2 : Cu–Mo mineralization observed as vein in granitic rocks
(Porphyry copper type).....(In Junin and Cuellaje areas)

–Type 3 : Acidic hydrothermal alteration observed in granitic rocks
(In Junin area).

–Type 4 : Cu–Pb–Zn mineralization observed in Quaternary volcanic detritus (In Pululahua area).

–Macuchi deposits : (closed) Cu, (Zn) massive sulfide type

–Chaucha deposits : (under exploration) Cu, Mo porphyry copper type

In Junin Project area, prospectiing activities, which have been reported, are as follows:

–Southern bank of Rio Intaq in southern Junin...:.for gold

–Tanachi mine in the Pululahua area.....for gold and polymetal

–Lebentason mineralized zone, east of Tanachi.....for gypsum

Technical cooperation in the mineral industry have been granted by following countries: United Nations, Great Britain, Spain,Belgue, West Germany, Italy and Japan.

The survey area Junin was investigated in 1984 and 1985 under the cooperative mineral investigation program of Belgue. Cuellaje area was also investigated in 1976 and 1977 under the Spanish cooperative mineral investigation program.

3–3 Outline of mineral industry

In pre–historic age Ecuador was considered to be significant gold producing country. Actually many types of deposits have been prospected and investigated, whatever they were metallic or non–metallic deposits. And the potential of mineral resorces in the country should be high geologically.Reserch and development of them, however, have been delayed because development of petroleum was first important activities under the national development policy and strategy.

Ore deposits, which were developed as modernized operation, are as follows:

–Portovelo deposits: (in operation) Au, Cu, Pb, Zn vein type

–La Plata deposits : (closed) Cu, Zn massive sulfide type

Chapter 4 Compilation and consideration of the Phase I survey

4–1 General consideration on geology, geological structure and volcanic activities

(1) Central Zone of Junin area and Surrounding Zone of Junin area

Geology of the Central Zone of this survey area consists of grandiorite, quartz–porphyry and diorite–porphyry. The granodiorite belongs to Apuela–Nanegal batholith. The quartz–porphyry nad diorite–porphyry, which formed dikes or stocks, intruded into the granodiorite batholith (Figs.II–1–1, and II–2–1).
The stocks of quartz–porphyry and/or diorite–porphyry distribute on a scale of 1 km in diameter as maximum, several tens of meter to several handreds of meters as aver–age and distributional density of stock tends to be dominate in the Central Zone of Junin area.

As the results of chemical analysis of these three kinds of rocks, most of rocks here were classified into the categoly of granodiorite , of I–type series, and of magnetite series (Tab.II–1–1, and Fig.II–1–2).

Isotopic age determination with K–Ar method was carried out for the batholith of granodiorite, dike or stock of quartz–porphyry and diorite–porphyry. The results were 14.5+1.0 Ma, 5.6+0.2 to 6.1+0.2 Ma, and 7.3+0.3 Ma respectively (Tab.II–1–2). The age determined shows that batholith be defined precisely in the middle of Mio–cene, Tertiary Period, and that porphyries be defined in the later stage of Miocene, Tertiary.

As the conspicuous structure, the lineaments are mainly developed the NE–SW and the NW–SE directions, and lineaments with the N–S and the E–W directions overlap on the former structures, especially in the Central Zone. Moreover, The radius lineam–ents develop from the area of the juncture of the Rio Junin and the Q.Limonita and the Q.Crisocolla.

(2) Cuellaje area

The geology of this area consists of granodiorite mainly which forms batholith, and of andesitic– and dioritic–porphyries which intrude into granodiorite batholith as stocks or dikes, and then of quartz–porphyry which forms dikes (Fig.II–3–1).

As the results of chemical analysis of these four kinds of rock, most of which were classified also into the category of granodiorite, of I–rype series, and of ma–gnetite series (Tab.II–1–1, and fig.II–1–2).

Isotopic age determination with K–Ar method was carried out for granodiorite, andesite–porphyry and quartz–porphyry. As the results, the age of each rock are as follows: 13.0+0.6 Ma for granodiorite; 11.1+0.6 to 10.4+0.5Ma for andesite–porphyry; and 8.8+0.4 Ma for quartz–porphyry (Tab.II–1–2).

The age showed the same tendency as Junin, granodiorite is corresponded to the middle Miocene of Tertiary, while porphyries are corresponded to the later Miocene of Tertiary. the rocks in Junin area seemed to be younger slightly than those in balusapamba area.

The lineament with the directions of the NNE–SSW and the NW–SE are conspicuous, and lineaments the N–S and the E–W are also developed (Tab.I–4–1, Fig.II–1–3, Tabs, II–1–3 and Tab.II–1–12).

(3) Pululahua area

Geologyof Cuellaje area consists of Cretaceous Macuchi and Yunguilla formations and of Quaternary talus deposits, Plulahua volcanics, volcanic mudflow deposits, and volcanic detritus falls in ascending order (Fig.II–4–1). The macuchi formation is composed of andesitic coarse tuffs mainly, and of andesitic lapili tuffs which are accompanied with fine tuffs to sliceous shale frequently and with sandstone and mud–stone as intercalates partly. Yunguilla formation is composed of mudstone mainly and accompanied with sandstone and/or conglomerates also. Quaternary formations are com–posed of lava flow and various types of detritus deribed from andesitic volcanic activities, which cover Cretaceous formations unconformably.

4–2 Charactristics of mineralization and its controlling factor

4–2–1 Central Zone of Junin area

The mineralized and alteration zone in the Central Zone of this area is divided into three types on their occurences.

1) Type I: Mineralized zone consisted of impregnation deposit(>stockwork deposit) which are observed typically in the lower reaches of Q.La Limonita and the lower to middle reaches of Q.Verde.
2) Type II: Mineralized zone consisted of vein deposit, which are obseved typically in the upper reaches of Rio Junin and Q.Limonita, in the lower reaches of Q.Crisocolla, Q.Controversia and in the upper reach of Q.La Rica, which are accompanied with the phyllic to potassic alteration zones in the vicinity of vein contact.

Tab.I—4—1 Summary of survey results

Type of survey	Name of area investigated	Area (Km²)	Geology	Mineralization: Name of zone	Type (Occurrence)	Lateral Extension	Ore Minerals	Host Rock	Alteration	Cu (%)	Pb (%)	Zn (%)	Au (g/t)	Ag (g/t)	Mo (%)	Sample No.	Evaluation
Detail	Central zone, Junin	4	Intrusives of: ho-bi gd., di. por. and qz. por..	Q. Limonita to Q. Escalera	diss.	200m	Mo-Cp-Py	Gd	sil., arg.	1.35	<0.01	<0.01	<0.1	3.4	<0.01	A1001	A
										0.63	<0.01	<0.01	<0.1	1.4	<0.01	B1011	
					vein	0.15m (N80W45S)	Cp-Bo-Py	Qp	sil.	1.33	<0.01	0.02	<0.1	9.9	<0.01	B1009	
										1.28	<0.01	0.02	<0.1	3.5	0.74	B1010	
										3.68	0.01	0.18	0.1	10.6	0.13	A1004	
										4.32	<0.01	<0.01	<0.1	14.5	0.08	B1007	
										1.45	<0.01	0.02	0.1	25.2	<0.01	B1008	
					network to vein	0.1m (N10E80W)	Mo-Cp-Py	Gd	sil., arg.	15.51	<0.01	<0.01	0.1	43.8	<0.01	C1010	
										32.02	<0.01	0.01	1.7	97.0	0.01	A1008	
					vein	0.1mx3.0m (N30E70E)	Cc-Chr-Bo-Py	Gd	sil.								
				Up. reach of Q. Limonita	Veins (5 in 150m)	0.2 to 0.4m	Cc-Chr-Bo -Cup	Gd	sil.	18.07	<0.01	<0.01	0.2	81.8	<0.01	A1011	A
										42.42	<0.01	0.01	0.3	137.2	<0.01	A1012	
										4.80	<0.01	<0.01	<0.1	12.5	<0.01	A1013	
										20.65	<0.01	0.01	0.2	74.8	<0.01	A1014	
										0.07	<0.01	0.01	<0.1	0.4	<0.01	A1015	
				Q. Verde	network/diss.	75m	Cp-Bo-Cc-Cup	Gd	sil.	1.44	<0.01	<0.01	<0.1	<0.1	<0.01	C1001	A
										0.37	<0.01	<0.01	<0.1	0.7	0.01	C1007	
					diss.	10m	Cup-Cc	Gd	sil.	0.07	<0.01	<0.01	<0.1	0.3	<0.01	C1003	
					network	10m	Py-Cp	Gd	sil.	0.09	<0.01	<0.01	<0.1	7.9	<0.01	C1009	
					diss.	10m	Bo-Cp	Gd	sil.	1.09	<0.01	<0.01	<0.1	2.0	<0.01	C1008	
										0.07	<0.01	<0.01	<0.1	0.5	<0.01	C1005	
										0.01	<0.01	<0.01	<0.1	<0.1	<0.01	C1006	
				Q. Crisocara	diss.	10m	Chr-Bo-Py	Gd	sil.								A
					vein	0.3 to 0.5m (N60W75N)	Cup-Cc-Chr	Gd	sil.	41.26	0.03	0.07	<0.1	<0.1	0.39	E1002	
					vein	0.8 to 1.0m (N80W80S)	Cc-Chr-Cup	Gd	sil.	42.28	<0.01	0.01	0.1	8.1	0.02	E1003	
				Q. Contra-vercia	vein	0.2mx10m (N80W45N)	Cp-Bo-Py	Qp	sil.	26.32	<0.01	0.01	0.1	77.1	<0.01	D1004	A
										0.19	<0.01	<0.01	<0.1	3.8	0.01	D1002	
					diss.	100m	Py-Cp-Mo	Gd	sil.	0.97	<0.01	<0.01	<0.1	1.0	0.01	D1006	
										0.13	<0.01	<0.01	<0.1	0.4	0.51	D1007	
					vein	0.2mx8m (N50W70N)	Mo-Py-Cp	Gd	sil.								
				Q. Rica	vein	0.4m (N50E90)	Mo-Cc-Bo -Cp-Py	Gd	sil.	0.66	<0.01	<0.01	<0.1	0.5	0.01	E1011	A
										6.23	<0.01	<0.01	0.2	32.0	1.14	E1012	
										2.48	<0.01	0.01	0.1	14.2	0.01	E1014	
					vein	0.4m (N50E75S)	Cc-Bo-Py	Gd	sil.	3.76	<0.01	0.03	0.1	23.6	0.06	E1015	
				Rio Junin	diss. & veins (5 in 100m)	0.05 to 1.5m (EW)	(Mo)-Cp-(Bo) -Chr	Gd	sil.	0.14	<0.01	<0.01	<0.1	0.5	0.01	C1011	A
										0.16	<0.01	<0.01	<0.1	2.4	0.02	C1012	
										0.26	<0.01	<0.01	<0.1	6.4	0.01	C1013	
										1.63	<0.01	<0.01	<0.1	2.7	<0.01	C1014	

Type of survey	Name of area investigated	Area (Km)	Geology	Mineralization: Name of zone	Type (Occurrence)	Lateral Extension	Ore Minerals	Host Rock	Alteration	Cu (%)	Pb (%)	Zn (%)	Au (g/t)	Ag (g/t)	Mo (%)	Sample No.	Evaluation
Detail	Central zone, Junin	4	Intrusives of: ho-bi gd., di. por. and qz. por..	Rio Junin	vein	1.5mx40m (N50W90)	Mo-Cp	Gd	sil.	2.17	<0.01	0.01	0.1	4.6	0.97	C1015	A
					veins (4 in 50m)	0.5m (N65E75S)	Mo-Bo-Cc-Cp	Gd	sil.	0.28	<0.01	<0.01	<0.1	4.4	0.14	C1016	
					diss.	50m	Cp	Gd	sil.	0.25	<0.01	<0.01	<0.1	1.3	<0.01	C1017	
										0.72	<0.01	<0.01	<0.1	1.7	<0.01	C1021	
					diss.	20m	Py-Cp	Gd	sil.	0.37	<0.01	<0.01	<0.1	3.5	<0.01	C1018	
					diss.	40m	Bo-Cc-Cp -(Py)	Qp, Gd	sil.	0.10	<0.01	<0.01	<0.1	0.8	<0.01	C1019	
										1.22	<0.01	<0.01	<0.1	1.3	0.01	C1020	
				Cerro Junin	veins (5 in 600m)		Lim	Gd		0.17	<0.01	<0.01	0.1	1.7	<0.01	B1002	B
										0.10	<0.01	<0.01	<0.1	0.4	<0.01	B1003	
										0.10	<0.01	<0.01	0.1	0.6	0.01	B1004	
										0.46	<0.01	<0.01	0.1	9.3	<0.01	B1005	
					vein		Lim	Gd		0.03	<0.01	<0.01	<0.1	19.4	<0.01	B1006	
				Others	vein			Gd		0.24	0.01	2.23	<0.1	23.4	<0.01	A1018	C
					vein		Lim	Gd		0.06	<0.01	<0.01	<0.1	23.0	<0.01	D1001	
					vein		Lim	Gd		0.01	0.01	<0.01	<0.1	<0.1	<0.01	B1001	
Semi-Detail	Surrounding zone. Junin	35	Intrusives of : ho-bi gd., di. por. and qz. por.	Q Esperanza	veins	0.4mx4mx3m (N70W90)	Lim	Gd	sil.								A
						0.6mx3m (N70W85S)	Cp-Bo-Py-Cc	Gd	sil., arg.	20.97	<0.01	0.28	0.6	748.0	<0.01	D1021	
						0.6mx4mx2m (N70E80S)	Mo-Cp-Bo-Cc	Gd	sil.	2.38	<0.01	0.02	<0.1	156.7	0.01	D1022	
						0.3mx2m (N70E90)	Cp-Py	Gd	sil.	10.47	0.01	0.02	<0.1	13.9	<0.01	D1023	
						1mx8mx4m (N50E80S)	Cc-Mo-Bo-Cp -Py	Gd	sil., arg.	11.07	0.01	<0.01	0.1	27.3	<0.01	D1024	
						1.6mx10m (N60E80S)	Mo-Py-Cp	Gd	sil., arg.	5.77	<0.01	<0.01	<0.1	31.0	0.01	D1025	
						1.6mx5mx3m (N60E80S)	Mo-Cp-Py	Gd	sil., arg.	0.66	0.03	0.07	<0.1	27.9	<0.01	D1026	
						1mx6mx3m (N40E90)	Mo-Py	Gd	sil.	0.34	<0.01	0.01	<0.1	12.1	0.01	D1027	
				Q Fortuna	diss.	100m	Ttr-Py-Cp	Gd	sil.	0.25	<0.01	<0.01	0.1	1.1	<0.01	E1021	B
										0.63	<0.01	<0.01	<0.1	1.4	<0.01	E1022	
										2.68	<0.01	<0.01	<0.1	4.5	<0.01	E1025	
					veins	0.1m (N15W60E)	Py	Gd	sil.	0.37	<0.01	<0.01	0.2	3.5	<0.01	E1020	
						0.1m (N35E50SE)	Py	Gd		1.26	<0.01	<0.01	<0.1	1.8	<0.01	E1023	
						0.4m (N50E45SE)	Py-Cp-Cc	Gd		0.33	<0.01	<0.01	<0.1	8.3	0.09	E1024	
				Q Cristal	? (float)	?	Cp-Py	?	?	0.22	0.02	0.02	0.7	11.7	<0.01	D1044	C
				Branch of Q Cristal		?	Mo-Py-Cp	?	?	1.10	<0.01	<0.01	<0.1	24.8	<0.01	G1001	C

Type of survey	Name of area investigated	Area (Km²)	Geology	Mineralization Name of zone	Type (Occurrence)	Lateral Extension	Ore Minerals	Host Rock	Alteration	Cu (%)	Pb (%)	Zn (%)	Au (g/t)	Ag (g/t)	Mo (%)	Sample No.	Evaluation
Recon-nais-sance	Cuellaje	34	Inrusives of : ho-bi gd., di. por. and. por. and qz. por..	Branch of Rio Magdalena	diss.	100m	Cup-Cp-Py	Gd	sil.	0.74 1.66 0.28 0.53	<0.01 <0.01 <0.01 <0.01	<0.01 <0.01 <0.01 <0.01	<0.1 <0.1 <0.1 <0.1	4.8 5.2 <0.1 1.9	0.01 0.11 <0.01 <0.01	F1010 F1011 F1012 F1016	A
				Rio Magdalena	diss.	100m	Cp-Py	Gd	sil.	0.15 0.36	<0.01 <0.01	<0.01 <0.01	<0.1 0.1	<0.1 5.5	<0.01 <0.01	C1039 C1042	A
				Loma Los Purunes	diss./films	150m	Py-Cp	Gd	sil.	0.07 0.07	<0.01 <0.01	<0.01 <0.01	<0.1 <0.1	<0.1 <0.1	<0.01 <0.01	E1035 E1036	A
				Q. San Miguel	diss. veins (2 in 200m)	30m 0.03 to 0.04m	Cp-Py-Chr Lin-Cp	Gd Gd	sil., chl.	0.53 0.17 7.98 7.31	<0.01 <0.01 <0.01 <0.01	<0.01 0.01 0.01 0.01	<0.1 <0.1 0.4 0.1	<0.1 <0.1 36.5 30.7	<0.01 <0.01 0.03 <0.01	E1030 G1007 E1031 E1032	B
				Rio Crystopamba	veins (12 in 1km)		Cp-Cc-Bo-Chr	Gd	sil., arg.	6.94 1.43 6.97	<0.01 <0.01 <0.01	0.02 0.02 <0.01	<0.1 0.1 <0.1	<0.1 45.6 6.3	<0.01 <0.01 <0.01	C1029 C1031 C1032	D
				San Joaquin	films films	2 to 3mm (N70E80E) 3 to 4mm	Cp-Bo Cp-Cc	Gd Gd	sil., chl.	0.42 0.05 0.05	<0.01 <0.01 <0.01	<0.01 <0.01 <0.01	<0.1 <0.1 0.3	0.9 <0.1 6.1	<0.01 <0.01 0.05	D1054 F1006 F1007	D
				Others	films		Cp-Py	Gd									D
Recon-nais-sance	Pululahua	90	Colluvial: Lake deposits: Cangagua consisted of ash fall deposit with pumices. Mud flow: Talus: Pululahua volcanic rocks consisted of ho andesite and pyroclastic rocks. Yunguilla Formation consisted of shale, sandstone and pebble gravel conglomerate. Macuchi Formation consisted of andesitic pyroclastic rocks.	Mina del Tanachi	hydrothermal		Ga-Sph-Cp	lh	arg.	3.99 1.52 0.57 1.10	0.06 0.08 11.91 9.34	0.05 0.62 24.80 22.31	1.7 1.3 1.1 0.3	182.5 93.5 52.3 58.3	<0.01 <0.01 <0.01 <0.01	C1043 C1044 C1045 E1037	C
				Q. Reventazon	hydrothermal	150mx50m	Gyp-Py-Mar	Mac. lh	arg.	<0.01 <0.01 0.01	<0.1 <0.1 <0.1	<0.01 <0.01 <0.01	<0.1 <0.1 <0.1	<0.1 <0.1 <0.1	<0.01 <0.01 <0.01	C1060 C1061 C1063	D
				Others	hydrothermal hydrothermal	200mx300m 10mx10m	Py Py	Mac. Mac.	arg., sil. arg., sil.	<0.01	<0.1	<0.01	<0.1	<0.1	<0.01	C1055	D

Ranking of evaluation : A > B > C > D

3) Type III: Acidic alteration zone with stockworky quartz vein.

The natures and the scales of these three types of mineralized and alteration zones were clarified: The distributions of the mineralized zones Type I and Type III were limited within the Central Zone; The Type II was dominate mainly in the Central Zone and to extend outwards to the northwestern part and to the southeastern part of the Southern Zone of Junin area.

(1) Type I Mineralization and alteration

The mineralized zone of Type I was recognized within granodiorite around quartz –porphyry. The markable distributions were in the lower reach of Q.Limonita (Q.Limo–nita mineralized zone, Fig.II–1–4) and in the middle to lower reaches of Q.Verde (Q.Verde mineralized zone). They distributed on a scale of 200m to 10m at six places along the river. The major deposit was dissemination deposit with stockwork veins of molibdenite–chalcopyrite developed paartly in Q.Limonita mineralized zone. Disse–mination and film deposits were recognized in Q.Verde mineralized zone. Addition to them, Dissemination and film deposits were also observed in the upper reaches of Rio Junin(Junin mineralized zone) and in the lower reaches of Q.Controversia(Q.Controve–rsia mineralized zone).

Sulfide minerals observed were chalcopyrite, bornite and chalcocite (as secondary mineral), pyrite and molybdenite (occurs rarely). Oxide minerals were chrysocolla, cuprite and tenorite.

The central part of each mineralized zone was included in medium to strong sil–icification zone. The mineralassemblages identified by powderly X–ray diffractive analysis method were quartz– serisite–epidote (phyllic alteration zone) in Q.Verde mineralized zone, Q.Limonita mineralized zone and Rio Junin to Q.Controversia miner–alized zone, and quartz–chlorite–epidote (propylitic alteration zone) in the surrou–nding part of the mineralized zone (Tab.II–1–3, and Appendix 3). The chemical analys is of ore samples obtained from Q.Verde (C1001) and Q.Limonita(A1001)proved to be so high grade of copper as 1.44% Cu and 1.35% Cu for the highest one, respectively (Appendix 4), and the average grade of all the samples assayed was 0.7 to 0.8% Cu. While the average grades of copper were 0.3% Cu and 0.6% Cu, in Rio Junin mineraliz–ed zone and in Q.Controversia mineralized zone, respectively.

(2) Type II Mineralization and alteration

The mineralized zone of Type II consisted of vein deposits characterized as the same mineral assemblage as Type I. According to the nature of veins, the veins were divided into the following two sub–types:

1) Type IIA : Abundant in clay as the major constituent minerals of vein and rich in ore minerals;

2) Type IIB : Quartz vein with ore minerals.

The Type II A was obseved in the upper reaches of the Q.Limonita mineralized zone and the Q.Crisocolla mineralized zone. The Type II B in the Rio Junin mineralized zone, the Q.La Rica mineralized zone and the Junin mountain(Cerro Junin) mineralized zone. The mineralized zones, which showed both natures of Type II A and Type II B, were recognized to distribute in the Q.Limonita and the Q.Controversia, the width of which varied from about 5 cm to about 3 m.

The Q.Limonita mineralized zone was observed to show echelon structure and to extend for 200 m approximately along NE–SW linesment. The Q.Crisocolla mineralized zone was characterized with its abundance of cuprite, tenorite, chalcocite native copper and so on. The Rio Junin mineralized zone was concluded to contain five quartz–veins or more, width of which were over 1m, and extention of which, however, were not estimable because quartz–veins were recognized along the Rio Junin river only to be perpendicular or oblique against the N–S lineament. The Q.Controvercia mineralized zone was cropped out at its down reach and obseved to dominate around quartz porphyry dike elongated in NW–SE direction. Type II was also recognized to be overlapped upon the Type I in the mineralized zones of the Q.Limonita, the Rio Junin and the Q.Controvercia.

Phyllic and potassic alteration zones were observed around vein and its contact with country rock.

According to chemical analysis of ore samples, the grade of Type II A was proved to be as follows: 0.3g/t Au, 132/t Ag and 42.42% Cu,for the sample (A1012) obtained from vein rich in ore minarals with abundant clay in the Q.La Limonita; 41.62% Cu, 0.03% Pb, 0.07% Zn and 0.39% Mo, for the sample (E1002) obtained from vein in the Q.Crisocolla (Appendix 4).

The grades of theType II B, quartz vein with ore minarals were as follows: 0.1g/t Au, 4.6g/t Ag, 2.17% Cu and 0.97% Mo,for sample (C1015) obtained from the Rio Junin; and 0.2g/t Au, 32.0g/t Ag, 6.32% Cu and 1.14% Mo,for the sample (E1012) obtained from the Q.La Rica mineralized zone.

The EPMA analysis for high Ag content samples was carried out to examine the contents of Cu, Fe, Ag and S. As the results, Ag element was proved to be contained in bornite distinctively, though in small contents.

As regards the sampling method, A1012 was collected by means of channel sampl–

ing method. Other vein samples were collected by means of modified channel sampling method similar to the channel sampling. When the samples of ore vein were collected in a form of chip, the number of chips were increased in order to get assay of the mineralized outcrops as averaged correctly as possible.

(3) Type III Alteration

The alteration zone of Type III was divided into two sub–types, Type III A and Type III B.

A silicificated zone of Type III A was observed in an area of 1km east–west and 400 m north–south toward the upper reaches between the Q.Crisocolla and the Q.Controversia. The silicificated zone was composed mainly of stockworky quartz veinlets, only in a part of which quartz vein of 50cm to 1 m in width were recognized in naked eye. Sericite, kaolinite and (halloysite) were identified in addition to quartz by powderly X–ray diffractive analysis method. Ore mineral identified here was chrysocolla generally, though the other ore mineral, cuprite for instanse, was observed in veins which distributed within the Q.Crisocolla minaralized zone.

(4) Drilling survey

As the results of drilling survey which was carried out at the western margin of the Q.Limonita mineralized zone, geology, mineralization and alteration are as follows:

0.00 to 7.00 m	Soil
7.00 to 12.00	Quartz porphyry (weathered)
12.00 to 127.60	Granodiorite; pyrite› Chalcopyrite film› dissemination, propylitic alteration zone
127.60 to 137.50	Quartz porphyry (dike);dissemination of Pyrite–Chalcopyrite propylitic alteration zone
137.50 to 151.50	Granodiorite; pyrite› chalcopyrite film› dissemination, propylitic alteration zone

As the assay result of drilling cores, the grade was under 0.1% Cu. Dissemination of pyrite and chalcopyrite was, however, recognized to increase in the vicinity of granodiorite–quartz porphyry contact, where intense alteration was also observed and classified into phyllic alteration zone partly. Therefore, lower parts of the drill hole were considered to have intersected the western margin of the Q.Limonita mineralized zone.

(5) Consideration

The metallogenetic process of above three mineralized and alteration zones are considered as follows: The trend of granodiorite batholith(Aquela–Nanegal batholith) is the N–S or NNE–SSW directions which is the same of the direction of Andes as a large structure. The distinguished direction of NE–SW and NW–SE of the lineaments is medium scaled structure. They are considered to be conjugate set. And, these three structures are presumed to have existed as a basement structure for quratz–diabase magma which rose through the structures and formed stocks.

The Central Zone of Junin area is considered to be a place where these structural and igneous activity concentrated. The radius lineament develops from the area of the juncture of Q.Limonita and Q.Crisocolla. These fractures can be considered to have been the weak structure, and which have been intruded by porphyry accompnied with ore solution. By the mineralization and alteration of Type I together with Type II which occured in this unique place, each type of ore deposit was formed (Type I and II are considered to be porphyry–copper type).

The mineralization was finished by the acidic hydrothermal alteration of Type III in the final stage. After that, the secondary copper minerals are crystallized by the local circulation of ground water, however, oxidation zone or the zone of secondary enrichment are presumed not to be formed, because of extreme shortage of pyrite. (however, the zone of secondary enrichment was formed in Q.Crisocolla mineralized zone, because the leaching progressed along the fault).

By the structural analysis of the fractures Type II and III, the thrust from the deeper part of Q.Verde toward the surface is presumed.

4–2–2 Surrounding Zone of Junin area (Fig.II–2–3)

(1) Type I Mineralization and alteration

The Q.Fortuna mineralized zone is composed of dissemination and network of pyrite–(chalcopyrite)–(tetrahedrite)–(cuprite)–(chalcocite) found in the granodiorite and/or quartz–porphyry, which occurrences are classified into the Type I defined in the Central Zone. The alteration zone is also considered to be phyllic alteration zone based on the mineral assemblage of alteration minerals. As the results of chemical analysis of ore,the grades were as follows: 8.3 to 1.1g/t Ag, 2.68% Cu and 0.09% Mo. The Q.Cristal branchmineralized zoneis composed of dissemination and film of pyrite and limonite in granodiorite and quartz–porphyry, alteration zone of which is thought also to belong to phyllic alteration zone.

(2) Type II Mineralization and alteration

The Q.Esperanza mineralized zone is composed of two types of veins: one is abundant in sulfide minerals (Type II A) and the other quartz vein with sulfide minerals (type II B)(Tab.I–4–1). This mineralized zone is also thought to be a extension to northwest ward extension of the ore and quartz vein of NE–SW direction, which are distributed and observed in tne upper most reach of Q.Limonita.

The major ore mineral are pyrite and chalcopyrite, with small amount of tetrahe drite. The gangue mineral is quartz. Silicification and argillization are mainly obs erved in the vicinity of contact beween vein and wall rock, and width of them is app roximately 2 of 3 meters. Quartz and sericite are recognized as alteration minerals in the contact zone. As the assay result, same sample with high contents are as foll ows: 0.6 g/t Au, 784.0 g/t Ag, 20.97% Cu, 0.01% Pb snd 0.28% Zn.

Q.Fortuna mineralized zone is composed of abundant sulfide minerals which are classified into Type I and Type IIA. Three ore veins are confirmed: one is vein with the NNW–SSE direction and 10 cm in width; the other two are veins with the NE–SW direction and 10 to 40 cm in width. Quartz and sericite are recognized as altered minerals developed in or vicinity of vein contact. As the result of assay, ore grade is as follows: 0.2g/t Au, 3.5 to 1.8 g/t Ag, and 1.26 to 0.37% Cu.

The Q.Cristal mineralized zone is composed of chalcopyrite–pyrite–quartz (Type II B), which grade is as follows: 0.7 g/t Au, 11.7g/t Ag, 0.22% Cu, 0.02% Pb, 0.02% Zn and 0.01% Mo. Ore sample assayed was found in Q.Cristal as block of Type II B.

(3) Consideration

In the Surrounding Zone, three mineralized and alteration zones were found, which were considered to extend outwards from the Central Zone of Junin area to the Surrounding Zone: mineralized zones such as the Q.Esperanza, the Q.Fortuna,and the Q.Cristal mineralized zones.

The Q.Esperanza mineralized zone is composed of ore vein classified into Type II, which was defined in the Central Zone.

The Q.Fortuna mineralized zone is composed of dissemination deposit of Type I and of ore vein of Type II.

The Q.Cristal branch nineralized zone is composed of the phyllic alteration zone which is considered to correspond to the Type I defined in the Central Zone and a boulder which is also considered to be of Type II.

4–2–3 Cuellaje area

In Cuellaje area, in addition to the vein deposit(Type II in Junin area) along Q.Cristopamba near Cuellaje village known as a potential area of ore deposit, two mineralized zones, which were composed of dissemination deposit (Type I in Junin area) were confirmed by this survey: one in the upper reaches of Rio Magdalena in the northwestern area and the other along Q.San Miguel in the southeastern area as shown in Fig.II–3–3.

(1) Type I Mineralization and alteration

The mineralized and alteration zone is observed in the upper reaches of Rio Magdalena in the northwestern area (the Magdalena minaralized zone) and around Q.San Miguel in the southeastern area (the Q.San Miguel mineralized zone).

Dissemination to film deposit of chalcopyrite and pyrite with small amount of bornite and chalcocite are observed in four places along the river within the section of 100 to 200 m around the center of andesitic–porphyry stock in the Rio Magdalena mineralized zone. Molybdenite stockwork is observed in the central part of the stock.

By X–ray diffraction method, the zonal structure which consists of the mineral composition of K–feldspar in the center, sericite–chlorite around the center and chlorite–calcite in the outer rim, is identified.

By the chemical analysis of ore samples, the grade of the Rio Magdalena minera–lized zone is as follows : Cu 1.66%, Mo 0.11% and Ag 5.2g/t. The scale of the zone and Ag content is comparable to those of the Central Zone of Junin. Chalcopyrite and pyrite dissemination and film with a small amount of chrysocolla are observed with–in the 30 m section in the lower reaches of Q.San Miguel in the Q.San Miguel minera–lized zone. The alteration of country rock is weak chloritization and silicificat–ion. Furthermore weak mineralization of pyrite, chalcopyrite and cuprite is recogn–ized 2km north of this area. Where the alteration of country rock is silicification. No sericite was identified by X–ray diffraction method.

(2) Type II Mineralization and alteration

Mineralized zone of Type II is recognized at nine places(Rio Cristopamba miner–alized zone) within the section of 9km along Rio Cristopamba near Cuellaje village, mineralized zones of Type I are also observed around the Rio Magdalena mineralized zone and Q.San Miguel mineralized zone. The occurrences of these mineralized zones are generally composed of veinlet to film of chrysocolla–limonite, partly of chalco–pyrite–bornite–chalcocite–quartz vein. Their direction is approxi– mately E–W.

Addition to these, there are veinlet to film of chrysocolla–limonite along Q.San Joaquin.

The mineral assemblages identified by X–ray diffraction method are sericite–chlorite inner part and chlorite–calcite outer part as the alteration of the country rocks in the vicinity of veins.

The grades of ore samples of the RioCristopamba and the Q. San Miguel minerali–zed zones were as follows : 0.1g/t Au, Ag 36.5g/t Ag 1.43% Cu and 0.02% Zn for the Rio Cristopamba mineralized zone (C1029), 6.3g/t Ag, 6.97% Cu and 0.13% Mo for rio Cristopamba mineralized zone (C1032) and 0.4g/t Au, 36.5g/t Ag, 7.98% Cu, 0.01% Zn and 0.03% Mo for the Q.San Miguel mineralized zone (E1031).

The difference between this area and Junin area is as follows; In this area, andesitic–porphyry distributes in the center of Typr I and quartz–porphyry distri–butes around Type II, on the other hand, quartz–porphyry distributes in association with Type I and diabase–porphyry distributes around Type II.

(3) Consideration

Stockwork deposits distribute in the center, dissemination deposits around them and vein deposits in the outer rim in the Rio Magdalena mineralized zone. The miner al assemblage of altered minerals is differentiated as the change of the mineralizat ion types: K–feldspar zone, sericite–chlorite zone and chlorite–calcite zone in outw ard order. These zonal assemblages coinside with potassic alteration zone, phyllic a lteration zone and propylitic alteration zone of general porphyry–copper deposit. The zoning of mineralization is also coinside markedly with that of general prophyry–copper deposit.

The scale of the mineralization and Cu content in this area are resemble to those of the Central Zone of Junin area.

From the viewpoint of zonal structure of porphyry–copper deposit,the Q.San Miguel mineralized zone is presumed to exist in inner part, and the Rio Cristopamba mineralized zone in outer part laterally. The center of the mineralization is, furthermore, expected to be in deeper part vertically.

4–2–4. Pululahua area

Tanachi ore deposit and Reventazon acidic alteration zone (including gypsum deposits) can be pointed out as known two ore deposits and alteration zones in this area (Fig.II–4–5).

(1) Tanachi ore deposit

The Tanachi ore deposit locates along the branch of Rio Tanachi in the north–western part of this survey area.

There are four old drifts in this ore deposit within the section of 150m arran–ged the direction of NW. Three of the drifts collapsed, the inside of the mine can be observed in one drift. The roof and floor are bordered with clay which is more than 70cm thick include various sizes of sub–rounded gravels to sub–angular breccias of 1cm to 5cm in average diameter(the maximum diameter is 15cm). Gravels more than 1 m in diameter are included in the clay layer according to the documents. The mineral compositions of the gravels are galena–zincblende–chalcopyrite–quartz, pyrite–chalco pyrite–quartz, chloritizated–silicificated–pyritizated rock(Macuchi Formation), arg–illizated–chloritizated rock(Yunguilla Formation) and coarse grained silicificated–pyritizated rock(Quarternary andesite).

The isotope age determination was carried out for andesitic rock of small central dome. The result is under 0.8 Ma(Tab.II–1–2). The age of mineralization of the Tanachi deposit is considered to be that of Quaternary.

The matrix of this ore deposit consists of white clay. The altered minerals such as sericite/montmorillonite mixed layer, kaolinite and quartz were identified with powderly X–ray diffractive analysis. The alteraed mineral assemblage identified the one which is recognized in the alteration zone relating with the acidic hydro–thermal alteration activities.

By chemical analysis of the slime from the old drift, the following grades are obtained; 0.3g/t to 1.7g/t Au, 182.5g/t to 52.3g/t Ag 3.99% to 0.57% Cu, 9.34% to 0.06% Pb, and 24.8% to 0.08% Zn.

(2) Reventazon acidic alteration zone

Reventazon acidic alteration zone locates in the central part of this area. Six alteration zones of 100m to 500m are recognized including secondary moved alteration zone within the area of 1km square. These alteration zones are initially accompanied with pyrite of dissemination and network of pyrite–limonite–malachite–gypsum–white clay (kaolinite) in brecciated andesitic tuff of Macuchi Formation whic h is accompanied with strong silicification–chloritization. It is so–called acidic hydrothermal alteration zone. Hydrothermal breccias are observed at three places and sulfur sinters are also observed at two places.

Altered minerals such as kaolinite, pyrophyllite, quartz and gypsum were identified in this altered zone by X–ray diffraction method. In addition to these minerals, montmorillonite and anhydrite were also recognized.

The mineral assemblage of these minerals identified are recognized in the alteration zone which is considered to be associated with acidic hydrothermal activities.

Chemical analysis of pyrite–gypsum ore was carried out. As the result, the contents of Cu, Pb, Zn, Mo, Au and Ag were all less than the detectable limit.

Two more alteration zones, which show as same alteration character as Reventa–zone alteration zone, distribute about 2 km southwest and about 1 km west of the rev entazone acidic alteration zone. The former extends over 500 m squares and accompany s with sulfer sinter.

(3) Consideration

Tanachi ore deposit is aggregates of breccias with ore minarals and argillizat–ed layer of more than 70cm put between mudflow deposit.

The estimated metallogenesis of Tanachi ore deposit by the geological features of Reventazon acidic alteration zone is as follows:

The metallogenic epoch is presumed to be Quarternary by the following reasons;

1) the floor of ore deposit includes mudflow deposit with the breccias of Quarternary andesite, and

2) includes breccias of coarse–grained silicificated–pyritizated rocks (Quarternary andesite ?).

The mechanizm of mineralization and metallogenetic process is considered on the following reson mentioned below that the hydrothermal solution with metals such as Pb–Zn–Cu rose along the fracture of the direction of NW–SE, and rised the metal components precipitated as sulfide minerals(so–called supergene deposit) initially, then the deposit moved by subsidence with volcanic activity, collapse and landslide secondarily. It is presumed, consequently, that the form of primary deposit was not able to be preserved.

1) The mineral assemblage identified in this mineralized and alteration zone is the same as that of the acidic alteration zone

2) The texture of ore and gangue minerals is obseved to be fructured and brecciated

4–3 Correlation between mineralization and geochemical anormaly

(1) Central Zone of Junin area

The results of geochemical survey was well interpreted because distribution pattern of geochemical anormalous zones were corresponded with those of mineralizat– ion and/or alteration (Figs.II–1–7 and II–1–8). For instance, Cu–Mo gechemical anor– malous zones were delineated over ovious minerzlized zones, while Pb–Zn geochemical anormlous zone were scattered around the mineralized zone.

The low ratio of soluble Cu vs total Cu imply to contain abundant sulfide miner al in the sumples. Distribution pattern of low ratio samples reflects the character– istics of each mineralized zones. Mineralized zones characterized with low ratio samples are as follows: The Q.Limonita mineralized zone; the upper most reaches of Q.Limonita mineralized zone; the Q.Verde mineralized zone; and the Q.Controvercia mineralized zone. Contrary, high ratio sample (few sulfides) were observed to distr– ibute around the mineralized zone and in the Rio Junin mineralized zone. Distribut– ion pattern of Au–Ag geochemical anormalous zone did not show any correspondence with that of Cu mineralized zone. The samples over 10 ppb Au were all detected in the area of Type III acidic alteration zone.

(2) Surrounding Zone of Junin area

Cu–Pb–Zn geochemical anormalous zone were detected in the Q.Esperanza mineraliz ed zone, the Q.Fortuna mineralized znoe and the Q.Fortuna mineralized zone and the Q.Cristal branch alteration zone.

4–4 Potential of ore deposits

Taking all the results of the survey into consideration, the area with high potential of dissemination type and vein type ore deposits are as follows:

(1) Central Zone of Junin area (Fig.2–1)

1) The Q.Limonita mineralized zone, and intermediate area between the Q.Limonita and the Q.Verde mineralized zones.

2) The Q.verde mineralized zone.

3) The Rio Junin mineralized aone

4) The upper reaches of Q.Limonita,Q.Crisocolla, Q.Controvercia mineralized zones 5) The Q.Cristopamba mineralized zone and Q.San Miguel mineralized zone

(2) Surrounding Zone of Junin area (Fig.2–2)

1) The Q.Esperanza mineralized zone

2) The Q.Fortuna mineralized zone

3) The Q.Cristal branch mineralized zone.

(3) Cuellaje area

1) The Rio Magdarena minerlized zone

2) The Rio Cristopamba mineralized zone and Q.San Miguel mineralized zone

The potential around tanachi mine in Pululahua area has not been studied completely, however, Tanachi deposits were considered to be formed by secondary deposition of ore. Therefore to take the density and extension of ore gravels into account, which were erroded and transported. The exploration is extramly hard for th is type of deposits.

Chapter 5 Conclusions and Recommendations

5–1 Conclutions

(1) Geology of Junin area

Geology of Junin area consists of Apuela–Nanegal batholith of granodiorite and stock or dike of quartz porphyry and diorite porphyry, which intrude into batholith of granodiorite (Figs.II–1–1 and II–2–1). Lineaments were also analyzed to radiate outlying section of the drainage system from the Junction of Q. Limonita and Q. Crysocola.

(2) Mineralization and alteration in the Central Zone of Junin area

Mineralized and alteration zones in this Zone were clasified in three types based on their occurrences: Type I, Type II and type III (Tables II–4–1 and II–1–12, and Fig.II–1–3).

Type I occured mainly in the granodiorite around stocks or dikes of quartz porphyry. Mineralized zones, which are characterized by Cu–Mo mineral dissemination (› network of quartz stringers with sulfides), disributed in the down stream of Q.Limonita and in the middle to down stream of Q.Verde, accompanied with phyllic alteration zone. The assay result of ore samples were 1.35 % Cu and 1.44 % Cu respectively.

Type II were recognized in various zones such as the up stream of Rio Jinin, the up stream of Q.Limonita, the Q.Crisocora, the down stream of Q.Controvercia and the up atream of Q. La Rica. Type II, which occured as veins composed of as same ore mineral assembly as Type I, was divided into two sub–type Type IIA and Type IIB on their occurrences.

1) Type IIA : abundant in ore minerals which was scattered in clay, principal gangue mineral.

2) Type IIB : quartz veins with ore minerals.

Both phyllic and potassic alteration zones were identified along the vein contacts. The assay results of ore samples were as follows: 0.3 g/t Au, 137.2 g/t Ag and 42.42 % Cu for Type IIA of Q.Limonita; 0.1 g/t Au, 4.6 g/t Ag, 2.17 % Cu and 0.97 % Mo for Type IIB of Rio Junin mineralized zone.

Type III was observed to be as acidic alteration zone being accompanied with networky quartz veins.

The distribution of these three types of mineralized zones are summaried as follows: The Type I dominates in the Central Zone and extends southeastward and northeastward; Type II dominates in the Central Zone mainly and extends northwestward and southeastward, further to the Surrounding Zone of Junin area; and Type III is limited in the eastern half of the Central Zone.

(3) Drilling survey

Drilling Hole No. MJJ–1, which was carried out in the western edge of the Q.Limonita mineralized zone and drilled down to 151.50 m in depth. The MJJ–1 revealed th at the lower part of the hole intersected and corresponded to the marginal section of the Q.Limonita mineralized zone.

(4) Mineralization in the Surrounding Zone of Junin area (Fig.II–2–3)

The Q.Espelanza mineralized zone, which was proved to be similar to type IIA and Type IIB of the Central Zone, were accompanied with phyllic alteration zone. Ore grade assayed was as follows: 0.6 g/t Au, 784 g/t Ag, 20.97 % Cu and 0.28 % Zn.

The Q. Fortuna mineralized zone was recognized to be similar to the Type I and the Type IIA of the Central Zone. A section corresponding to the Type I was accompanied with phyllic alteration zone and graded to be 8.3 to 1.1 g/t Ag, 2.68 to 0.33 % Cu and 0.09 % Mo or under, while the other section corresponding to Type IIA was assayed to be 0.2 g/t Au or under, 3.5 to 1.8 g/t Ag and 1.26 to 0.37 % Cu.

In the Q.Cristal branch alteration zone, several mineralized sections were recognized to be corresponded to Type I and Type IIB defined in the Central Zone.

(5) Result of geochemical exploration

As the results of rock geochemical exploration in the Central Zone of Junin area, the zoning of alteration mineral assemblage was proved precisely to be reflected on the distribution of geochemical anomalous zones which were corresponded also to each mineralized zones respectively (Figs.II–1–7 and II–1–8). For instance, Cu–Mo geochemical anomalous zone was centered on a intense mineralized zone, on the other hand Pb–Zn anomalous zones were distributed generally in surrounding part of each m ineralized center.

The Au–Ag anomalous zone was suspected only to show a vague relationship with mineralized zone. Every Au–Ag anomalous zone over 10 ppm of Au was, anyhow, delineated within the Type III acidic alteration zones.

Cu–Pb–Zn geochemical anomalies were detected by stream sediments in areas corresponding to the mineralized outcrops along the Q.Limonita, the Q.Fortuna, and a branch of the Q.Cristal of the Surrounding Zone of Junin area (Fig.II–2–6).

(6) Cuellaje area

Geology of Cuellaje area consists mainly of the Apuela–Nanegal batholith of granodiorite, and stocks or dikes of andesitic porphyry, dioritic porphyry and/or quartz porphyry, which intrude the batholith (Fig.II–3–1).

The Rio Magdarena mineralized zone was accompanied with a zonal structure of three alteration mineral assemblages: the potassic alteration zone; the phyllic alteration aone; and propylitic alteration zone in outward order.

The assay result of ore samples there was 5.2 g/t Ag, 1.66 % Cu and 0.11 % Mo. These mineralized zones could be comparable in extension and intensity with those of the Central Zone of Junin area.

The Q.San Miguel mineralized zone was observed to be surrounded by the propylitic alteration zone.

Both the Rio Cristopamba mineralized zone and the mineralized zone between Rio Magdarena and Q.San Miguel contain Type II zones which are accompnied with contact zonal alteration in the vicinity of veins: the phyllic alteration zone at the central part, the propylitic alteration zone outwards.

The assay results of the Rio Cristopamba and the Q.San Miguel mineralized zones were as follows: 45.6 to 6.3 g/t Ag, 6.97 to 1.43 % Cu and 0.13 % Mo; 0.4 g/t Au, 36.5 g/t Ag, 7.98 % Cu and 0.03 % Mo respectively.

(7) Pululahua area

Geology of Pululahua area consists of the Cretaceous Macuchi formation (andesitic coarse tuff mainly), the Cretaceous Yunguilla formation (mudstone mainly), the Quaternary Talus breccias, Pululahua volcanic explosions, its mud–flow, and its detritus falls (Fig.II–4–1).

There are two areas of interest for prospect in this area, which are known as the Tanachi deposit and the Reventazon alteration zone.

The Tanachi deposit, which situates in the northwestern part of the area, occurs as secondary deposit of ore breccias. These ore breccias were supposed to be derived from polymetallic epithermal deposits formed in Quaternary age associating with the acidic hydrothermal activities, and to be transported possibly by landslide movement.

The assay result of ore samples obtained from waste stock pile in the Tanachi mine was 1.7 to 0.3 g/t Au, 182.5 to 52.3 g/t Ag, 3.99 to 0.57 % Cu, 9.34 to 0.06 % Pb and 24.8 to 0.08 % Zn. The Rebentazon acidic alteration zone situates in the central part of the Pululahua ara. The assay result of ore was under detectable level.

5–2 Recommendations for Phase II survey

Junin and Cuellaje areas were proved to have high potential of Cu–Mo dissemination and vein deposits. Followings are, therefore, recommended for Phase II survey.

(1) Central Zone of Junin area (Fig.2–1)

According to the steep topography, it is difficult to adopt the geophysical exploration. Drilling survey is, consequently, commended although a transportaion ploblem needs to be solved.

Taking the movilization of diamond drilling machine into consideration,the recommended order of drilling survey is as follows:

1) Q.Limonita mineralized zone (Type I)
2) An area between Q.Limonita and Q.verde mineralized zones (Type I)
3) Rio Junin mineralized zone (Type II)

A detailed geological survey is, furtheremore, recommended to be carried out in the area of Q.Verde mineralized zone (Type I) and mineralized zones of Q.Limonita up stream, Q.Crisocora, Q.Controvercia and Q.La Rica (Type II) in order to delineate promissive mineralized zone for future drilling survey.

(2) Surrounding Zone of Junin area (Fig.2–2)

To correlate mineralization between Central Zone and Surrounding Zone of Junin area, detailed geological survey and geochemical exploration are recommended to be carried out in the three mineralized zones, Q.Espelanza mineralized zone, Q.Fortuna mineralized zone, and Q.Cristal branch mineralized zone.

(3) Cuellaje area (Fig.2–3)

Detailed geological survey, rock geochemical exploration, and geophysical exploration are recommended to be carried out in Rio Magdarena mineralized zone and a limited area between Rio Cristopamba and Q.San Miguel mineralized zones.

The reason of recommendation is as follows:

–Topography in Cuellaje area is comparatively gentler than that of Junin area, geophysical exploration method should be adoptable consequently.

–Occurrence of mineralization here is quite similar to that of Junin area, geological and geochemical survey could be efficient exploration methods.

PART II DETAILS

Chapter 1 Central Zone of Junin area

Detailed geological survey, rock geochemical survey and drilling survey were carried out this year for 4 km^2 which was the planned for the follow-up survey by Equadorian side.

1-1 Geological Survey

1-1-1 Purpose and method of survey

The purpose of the survey is to clarify the geological structure and detailed circumstances of mineralization and alteration in the Central Zone of Junin area.

Before the survey, the new map drawn on a scale of one to ten thousand was made based on the existing aerial photographs, and route map on a scale of one to five thousand was also made by enlargment of the new map. The survey routes were decided with careful examination of the existing data.

The results of the survey was summarized in the geological plan map (Pl.II-1-1) and the geological profile (Pl.II-1-2) on a scale of one to five thousand. The geological map on a reduced scale and the sampling positions are shown in Fig.II-1-1 and Pl.II-1-3, respectively.

1-1-2 Geology and geological structure

Geology of the Central Zone of this area consists of granodiorite(Gd), quartz-porphyry (Qp) and diabase-porphyry(Dp). The granodiorite belongs to Apuela- Nanegal batholith. The quartz-porphyry and diabase-porphyry which forms dykes or stocks, which intruded into the granodiorite batholith.

(1) Granodiorite(Gd)

The Granodiorite shows greyish color and is medium grained, and includes biotite and hornblende as a colored minerals.

The microscopic observation of typical rock is as follows(Appendix 1):

Granodiorite(A1016)
Location: the upper most reaches of Quebrada La Limonita
Texture :subhedral granular
Main and accessory minerals: plagioclase› quartz› K-feldspar› biotite› hornblende,
apatite, Zircon, opaque minerals

Altered minerals: chlorite

Biotites are slightly altered to chlorite.

(2) Quartz–porphyry(Qp)

The scale of the distribution of quartz–porphyry is 400 m of maximum extention, and 150m in width as dyke, and 250m in the maximum diameter as stock. The distribution is concentrated in Q.Limonita to Q.Escalera, Q.Verde, Q.Controversia and Rio Junin. The rock includes quartz phenocrysts of 2 to 5 mm in fine groundmass. Joint system develops more distinctively in the body of quartz–porphyry in comparison with that of granodiorite.

The microscopic observation of typical rock is as follows(Appendix 1):

Quatz–porphyry(A1003)
Location: Q.Limonita
Texture : porphyritic
Phenocryst : plagioclase› quartz› hornblende› biotite›
Ground mass: plagioclase› quartz› K–feldspar
Altered minerals: sericite› chlorite› epidote› calcite› limonite

Almost all the biotites are slightly altered to chlorite. Plagioclases phenocryst and groundmass are replaced by calcite, sericite and chlorite.

(3) Diorite–porphyry(Dp)

Stocks of diorite–porphyry distribute on the scale of 500m in diameter in the south–eastern area, and the rock body of 1km in diameter exposes in the southeastern part of this area. The rock includes abundant hornblende phenocrysts and less quartz phenocrysts in comparison with those of quartz–porphyry.

The microscopic observation of typical rock is as follows(Appendix 1):

Diorite–porphyry(E1013)
Location: Q. La Rica
Texture : porphyritic
Phenocryst : plagioclase› quartz› biotite› opaque minerals,
Ground mass: plagioclase› quartz› K–feldspar
Altered minerals: quartz› sericite› chlorite› K–feldspar› beryl› limonite

Almost all the biotites are slightly altered to chlorite. Plagioclases of phenocryst and groundmass are replaced by sericite and chlorite.

As the results of chemical analysis of bulk rock, the chemical variation diagrams of these three kinds of rocks, Normative quartz–orthoclase–plagioclase Diagram, ACF Diagram and SiO_2–(Fe^{3+}/Fe^{2+}) Diagram are shown on Tab.II–1–1 and in Fig.II–1–2, respectively. The results indicated that sample number A1016 was classified in granite and the other two rocks were in granodiorite. A1003 and A1015 were classified in S–type, while C1002 was in I–type.

All of them are classified in magnetite series.

Isotope age determination with K–Ar method was carried out in quartz–porphyry which forms stock. The result was 5.58 +0.20 Ma (Tab.II–1–2). The age showed later Miocene of Tertiary Period. It is latter than that in Bolivar area.

(4) Geological structure

As the conspicuous structure, the lineaments are mainly developed the NE–SW and the NW–SE directions, and lineaments with the N–S and the E–W directions overlap on the former structures. Almost all the lineaments converge around the juncture of Q.La Limonita, Q.La Verde and Q.La Crisocolla.

1–1–3 Mineralization and alteration

The mineralized and alteration zone in the Central Zone of this area is divided into three types on their occurences.

1) Type I: Mineralized zone consisted of impregnation deposit(›stockwork deposit) which are observed typically in the lower reaches of Q.La Limonita and the lower to middle reaches of Q.Verde.
2) Type II: Mineralized zone consisted of vein deposit, which are obseved typically in the upper reaches of Rio Junin and Q.Limonita, in the lower reaches of Q.Crisocolla, Q.Controversia and in the upper reach of Q.La Rica, which are accompanied with the phyllic to potassic alteration zones in the vicinity of vein contact.
3) Type III: Acidic alteration zone with stockworky quartz vein.

The natures and the scales of these three types of mineralized and alteration zones were clarified: The distributions of the mineralized zones Type I and Type III were limited within the Central Zone; The Type II was dominate mainly in the

Central Zone and to extend outwards to the northwestern part and to the southeastern part of the Southern Zone of Junin area. The mineral assemblage of these three types and the distribution map of the mineralized and alteration zones are shown on Tab.II–1–3 and in Fig.II–1–3, respectively.

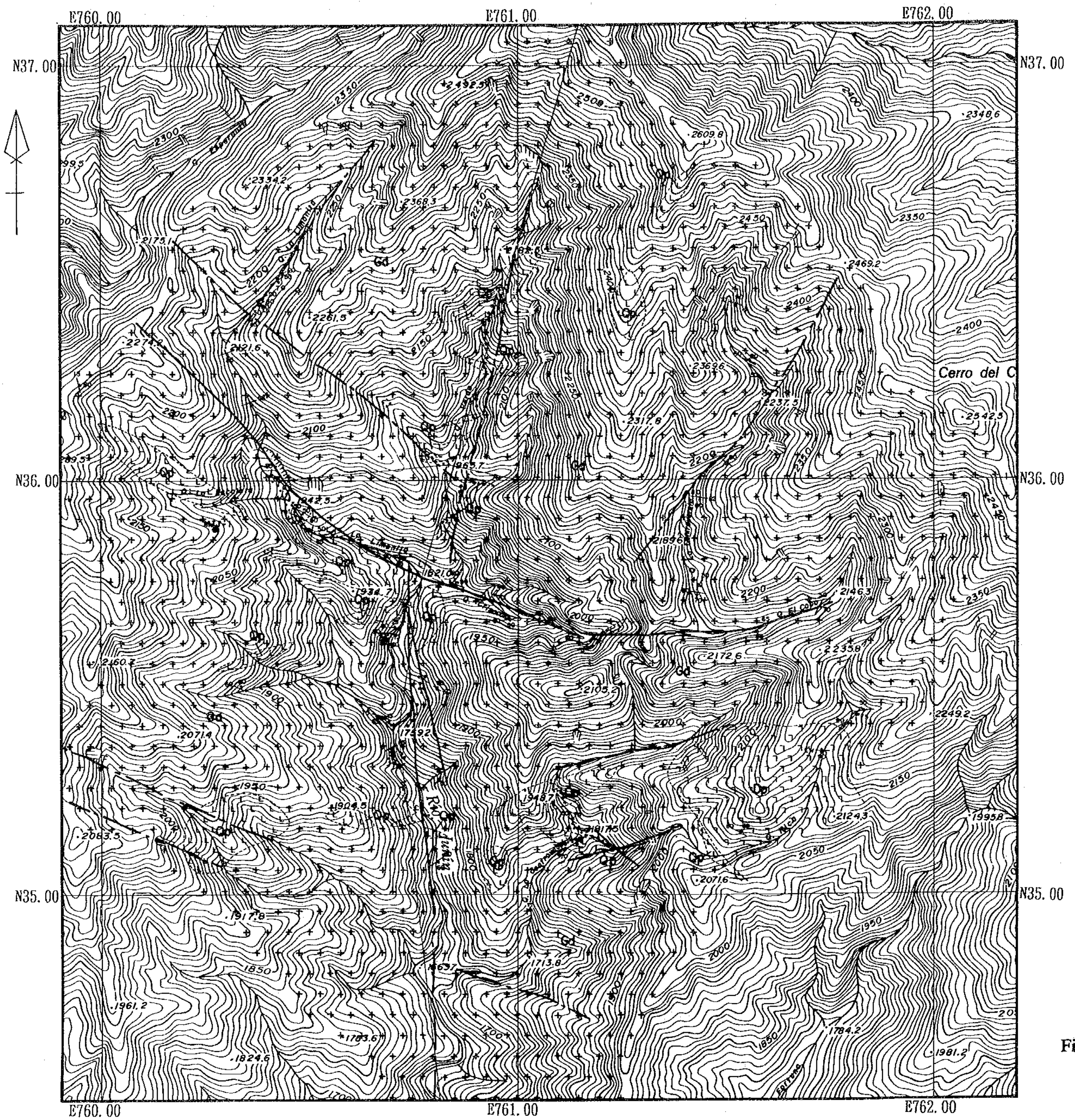
(1) Type I Mineralization and alteration

The mineralized zone of Type I was recognized within granodiorite around quartz –porphyry. The markable distributions were in the lower reach of Q.Limonita (Q.Limonita mineralized zone, Fig.II–1–4) and in the middle to lower reaches of Q.Verde (Q.Verde mineralized zone). They distributed on a scale of 200m to 10m at six places along the river. The major deposit was dissemination deposit with stockwork veins of molibdenite–chalcopyrite developed paartly in Q.Limonita mineralized zone. Dissemination and film deposits were recognized in Q.Verde mineralized zone. Addition to them, Dissemination and film deposits were also observed in the upper reaches of Rio Junin(Junin mineralized zone) and in the lower reaches of Q.Controversia(Q.Controversia mineralized zone).

Sulfide minerals observed were chalcopyrite, bornite and chalcocite (as secondary mineral), pyrite and molybdenite (occurs rarely). Oxide minerals were chrysocolla, cuprite and tenorite.

The microscopic observation of polished sections are listed up on Appendix 2.

The central part of each mineralized zone was included in medium to strong silicification zone. The mineralassemblages identified by powderly X–ray diffractive analysis method were quartz– serisite–epidote (phyllic alteration zone) in Q.Verde mineralized zone, Q.Limonita mineralized zone and Rio Junin to Q.Controversia mineralized zone, and quartz–chlorite–epidote (propylitic alteration zone) in the surrounding part of the mineralized zone (Tab.II–1–3 and Appendix 3). The chemical analysis of ore samples obtained from Q.Verde (C1001) and Q.Limonita(A1001)proved to be so high grade of copper as 1.44% Cu and 1.35% Cu for the highest one, respectively (Appendix 4), and the average grade of all the samples assayed was 0.7 to 0.8% Cu. While the average grades of copper were 0.3% Cu and 0.6% Cu, in Rio Junin mineralized zone and in Q.Controversia mineralized zone, respectively.



LEGEND

Intrusive Rocks

Gd	Granodiorite
Dp	Diorite porphyry
Qp	Quartz porphyry

Structure

Fault

Lineament

Geologic contact

0 500m

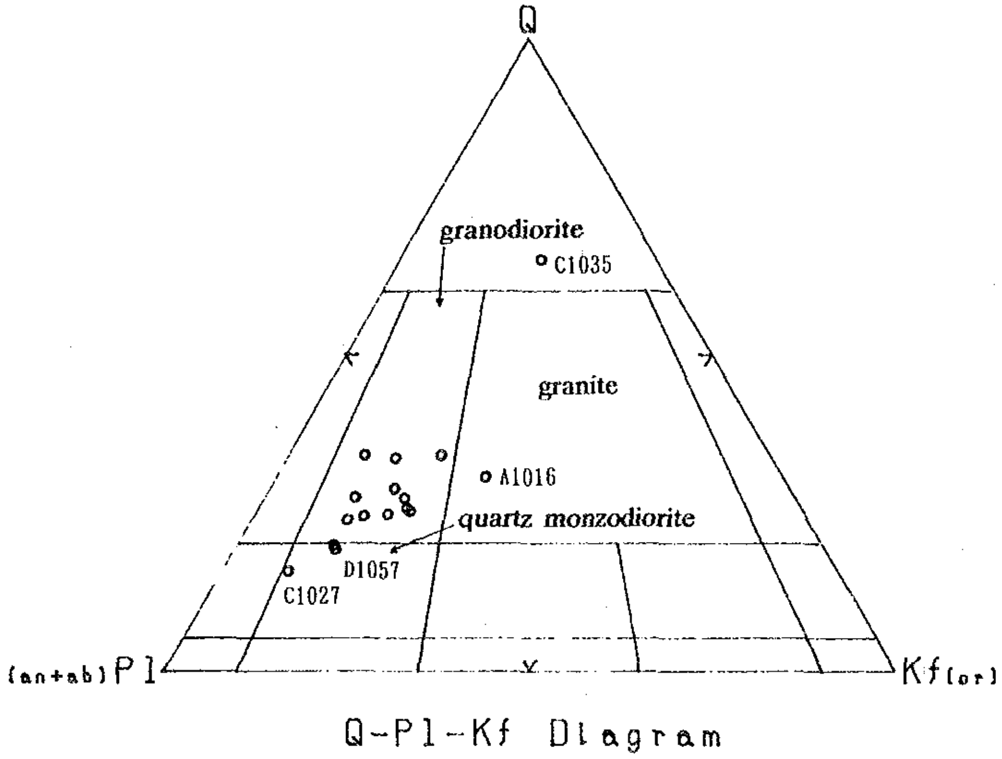
Fig.II–1–1 Geologic map of the Central zone, Junin area

Tab.II–1–1 Analytical data of rock samples

No.	Sample No.	Location	Geological Unit	Rock Name	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	BaO	LOI
1	A1003	Central zone, Junin area	Qp	quartz porphyry	71.03	0.20	14.78	1.10	1.02	0.05	0.83	0.56	5.49	3.01	0.10	0.07	1.28
2	A1016	ditto	Gd	granodiorite	65.97	0.44	15.25	2.23	2.17	0.07	1.82	2.59	2.64	4.12	0.11	0.15	2.07
3	C1002	ditto	Qp	quartz porphyry	70.90	0.18	14.88	1.24	0.76	0.03	0.70	1.57	5.05	2.73	0.09	0.09	1.28
4	C1022	Surrounding zone, Junin area	Gd	granodiorite	66.07	0.47	15.88	2.10	1.92	0.08	1.87	4.15	3.79	2.75	0.13	0.06	0.45
5	C1027	ditto	Dp	diorite porphyry	58.93	0.58	18.43	2.77	3.06	0.08	2.96	6.17	3.91	1.30	0.19	0.05	1.33
6	D1015	ditto	Gd	granodiorite	62.13	0.56	16.67	2.09	3.25	0.10	2.86	5.54	3.78	1.88	0.15	0.04	0.78
7	D1028	ditto	Gd	granodiorite	65.59	0.47	16.22	1.83	2.61	0.08	1.95	2.45	3.03	2.93	0.19	0.06	2.27
8	D1045	ditto	Gd	granodiorite	66.43	0.45	15.45	2.02	2.17	0.07	1.92	3.80	3.56	3.06	0.12	0.06	0.71
9	E1026	ditto	Dp	diorite porphyry	69.82	0.21	16.37	1.22	0.64	0.06	0.63	1.23	4.76	2.28	0.10	0.06	2.30
10	E1027	ditto	Qp	quartz porphyry	70.04	0.12	15.65	0.40	0.64	0.22	0.37	1.34	5.15	3.35	0.10	0.08	1.97
11	C1030	Cuellaje area	Dp	diorite porphyry	63.80	0.46	15.11	3.99	0.19	0.05	1.86	4.03	3.87	1.81	0.15	0.05	4.42
12	C1033	ditto	Gd	granodiorite	63.47	0.42	16.16	3.80	0.95	0.06	1.60	5.16	3.69	2.22	0.15	0.06	2.08
13	C1035	ditto	Qp	quartz porphyry	77.35	0.08	13.08	0.67	0.13	0.05	0.20	0.13	1.59	2.86	0.07	0.03	3.24
14	D1046	ditto	Gd	granodiorite	63.90	0.44	16.52	3.93	1.14	0.08	2.16	5.04	3.85	1.95	0.16	0.06	0.47
15	D1057	ditto	Ap	andesite porphyry	61.03	0.49	15.83	3.85	1.66	0.12	4.48	3.35	4.34	1.88	0.14	0.03	2.56
16	F1008	ditto	Ap	andesite porphyry	70.05	0.25	15.36	1.69	0.89	0.03	1.02	2.14	4.71	1.60	0.13	0.07	1.92
17	B1025	Pululahua area	An	andesite	62.34	0.53	16.92	2.96	2.74	0.09	2.55	5.82	4.48	1.12	0.16	0.05	0.01
18	C1059	ditto	An	andesite	61.96	0.57	16.41	3.52	2.42	0.09	2.99	5.68	4.32	1.16	0.16	0.06	0.35
19	C1069	ditto	Do	dolerite	50.04	0.62	17.32	5.70	5.67	0.17	3.32	9.89	3.20	0.30	0.07	0.01	3.35
20	D1092	ditto	An	andesite	63.01	0.55	16.40	2.86	2.93	0.08	2.58	5.48	4.52	1.12	0.18	0.05	0.05

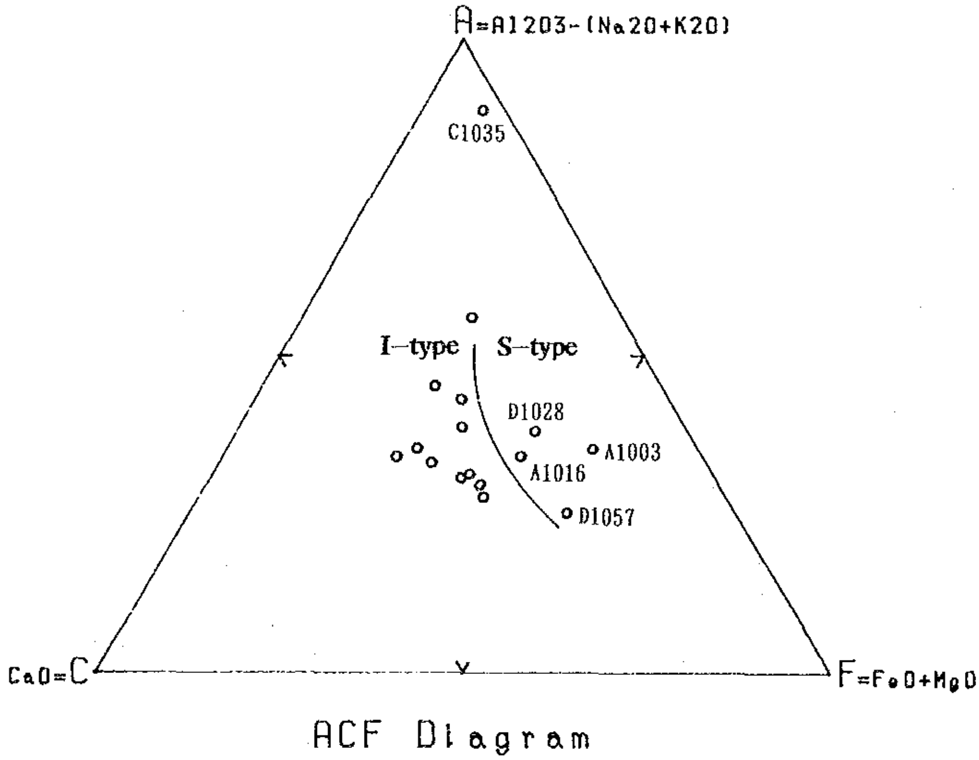
Sample No	A1003	A1016	C1002	C1022	C1027	D1015	D1028	D1045	E1026	E1027
q	25.54	26.87	27.36	22.18	13.31	16.55	28.71	23.00	30.95	24.24
c	1.74	2.05	0.99	0.00	0.00	0.00	4.18	0.00	4.19	1.37
or	18.14	25.00	16.43	16.37	7.80	11.23	17.79	18.26	13.83	20.33
ab	47.30	22.93	43.58	32.32	33.59	32.32	26.32	30.38	41.38	44.76
an	2.17	12.48	7.35	18.36	29.39	23.19	11.20	17.33	5.60	6.19
ne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ns	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
wo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diwo	0.00	0.00	0.00	0.64	0.20	1.51	0.00	0.39	0.00	0.00
dien	0.00	0.00	0.00	0.46	0.14	0.95	0.00	0.27	0.00	0.00
difs	0.00	0.00	0.00	0.12	0.05	0.46	0.00	0.10	0.00	0.00
hyen	2.12	4.66	1.77	4.22	7.36	6.25	4.93	4.57	1.62	0.95
hyfs	0.76	1.61	0.13	1.08	2.55	3.11	2.76	1.65	0.00	1.11
olfo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
olfa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mt	1.62	3.32	1.83	3.07	4.09	3.06	2.73	2.96	1.68	0.59
hm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
il	0.38	0.85	0.34	0.89	1.12	1.08	0.91	0.85	0.42	0.23
tn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ap	0.23	0.25	0.21	0.30	0.44	0.35	0.46	0.28	0.23	0.23
cc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.01	100.02	99.98	100.02	100.03	100.06	100.04	100.03	99.99	100.02

Sample No	C1030	C1033	C1035	D1046	D1057	F1008	B1025	C1059	C1069	D1092
q	24.64	21.78	59.02	21.06	15.55	31.48	16.48	17.11	5.86	17.43
c	0.00	0.00	7.50	0.00	0.91	2.34	0.00	0.00	0.00	0.00
or	11.23	13.41	17.55	11.64	11.40	9.63	6.62	6.91	1.83	6.62
ab	34.35	31.99	13.96	32.83	37.82	40.70	37.99	36.81	28.09	38.33
an	19.41	21.46	0.24	22.22	16.20	10.02	22.84	22.12	33.27	21.24
ne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ns	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
wo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diwo	0.22	1.57	0.00	0.81	0.00	0.00	2.12	2.18	7.19	2.03
dien	0.19	1.35	0.00	0.70	0.00	0.00	1.50	1.74	4.26	1.39
difs	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.18	2.57	0.49
hyen	4.67	2.73	0.52	4.73	11.48	2.59	4.88	5.75	4.34	5.07
hyfs	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.60	2.70	1.81
olfo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
olfa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mt	0.00	2.07	0.38	2.69	4.45	2.28	4.31	5.15	8.58	4.16
hm	4.19	2.46	0.44	2.11	0.89	0.16	0.00	0.00	0.00	0.00
il	0.91	0.82	0.15	0.84	0.95	0.49	1.01	1.08	1.22	1.04
tn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ap	0.37	0.35	0.16	0.37	0.32	0.30	0.37	0.37	0.16	0.42
cc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.18	99.99	100.01	99.99	99.99	99.99	100.03	100.01	100.08	100.03



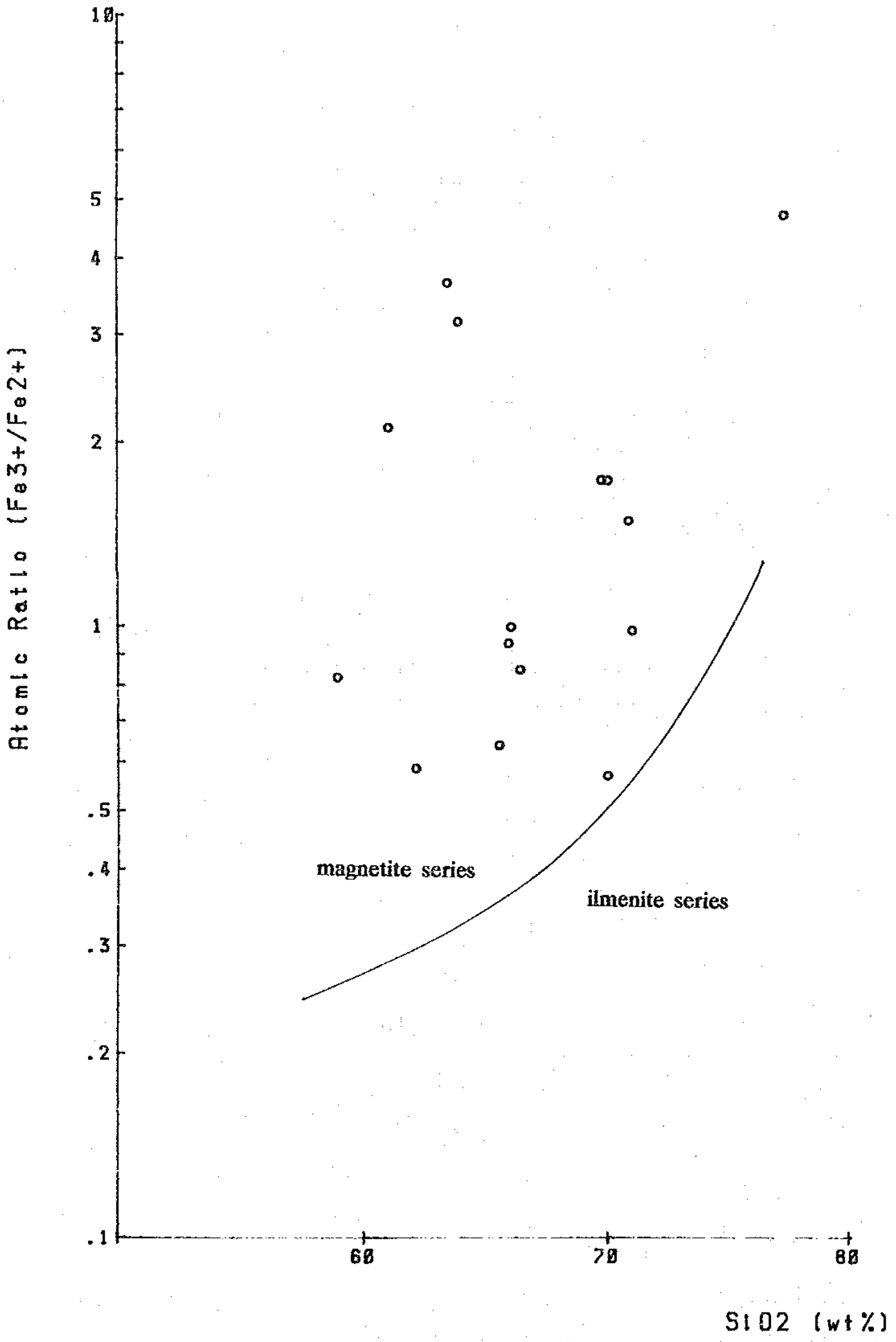
Geotimes(1973)

Fig.II-1-2(1) Chemical variation diagram:normative quartz(Q) -orthoclase(Or)-plagioclase(Ab+An)



Takahashi,M. et al (1980)

Fig.II-1-2(2) Chemical variation diagram:ACF diagam



Sako,K. and Ishihara,S. (1983)

Fig.II–1–2(3) Chemical variation diagram:SiO2–(Fe3+/Fe2+)

Tab.II-1-2 Results of isotopic age determination(K-Ar method)

Ser. No.	Area	Sample No.	Rock Name	Sample Type	Potassium (wt%)	Radiogenic ^{40}Ar (10^{-8}cc/g)	K-Ar Age (Ma)
1	Junin (C)	A1003	quartz porphyry	whole rock	2.30	49.9	5.6 ± 0.2
2	Junin (S)	C1022	granodiorite	hornblende	0.60	33.9	14.5 ± 0.2
3		E1026	diorite porphry	whole rock	1.95	55.0	7.3 ± 0.3
4		E1027	quartz porphry	whole rock	2.60	61.0	6.1 ± 0.2
5	Cuellaje	C1033	granodiorite	biotite	4.10	20.8	13.0 ± 0.6
6		C1035	quartz porphry	whole rock	1.99	6.8	8.8 ± 0.4
7		D1057	andesite porphyry	whole rock	1.50	6.5	11.1 ± 0.6
8		F1008	andesite porphyry	whole rock	1.22	4.9	10.4 ± 0.5
9	Pululahua	C1059	andesite	hornblende	0.32	<1	<0.8
10		D1092	andesite	hornblende	0.31	<1	<0.8

C : Central zone, S : Surrounding zone.

(2) Type II Mineralization and alteration

The mineralized zone of Type II consisted of vein deposits characterized as the same mineral assemblage as Type I. According to the nature of veins, the veins were divided into the following two sub–types:

1) Type IIA : Abundant in clay as the major constituent minerals of vein and rich in ore minerals;

2) Type IIB : Quartz vein with ore minerals.

The Type II A was obseved in the upper reaches of the Q.Limonita mineralized zone and the Q.Crisocolla mineralized zone. The Type II B in the Rio Junin mineralized zone, the Q.La Rica mineralized zone and the Junin mountain(Cerro Junin) mineralized zone. The mineralized zones, which showed both natures of Type II A and Type II B, were recognized to distribute in the Q.Limonita and the Q.Controversia, the width of which varied from about 5 cm to about 3 m.

The Q.Limonita mineralized zone was observed to show echelon structure and to extend for 200 m approximately along NE–SW linesment. The Q.Crisocolla mineralized zone was characterized with its abundance of cuprite, tenorite, chalcocite native copper and so on. The Rio Junin mineralized zone was concluded to contain five quartz–veins or more, width of which were over 1m, and extention of which, however, were not estimable because quartz–veins were recognized along the Rio Junin river only to be perpendicular or oblique against the N–S lineament. The Q.Controvercia mineralized zone was cropped out at its down reach and obseved to dominate around quartz porphyry dike elongated in NW–SE direction. Type II was also recognized to be overlapped upon the Type I in the mineralized zones of the Q.Limonita, the Rio Junin and the Q.Controvercia.

As alteration of wall rocks, silicification was recognized principally in the vicinity of vein deposites, which was distinguishable in naked eyes. The affected part, however, were limited in 2 m or 3 m in width. Quartz, K–feldspar and serisite were identified as altered minerals there (Tab.II–1–3 and Appendix 3).

According to chemical analysis of ore samples, the grade of Type II A was proved to be as follows: 0.3g/t Au, 132/t Ag and 42.42% Cu,for the sample (A1012) obtained from vein rich in ore minarals with abundant clay in the Q.La Limonita; 41.62% Cu, 0.03% Pb, 0.07% Zn and 0.39% Mo, for the sample (E1002) obtained from vein in the Q.Crisocolla (Appendix 4).

The grades of theType II B, quartz vein with ore minarals were as follows: 0.1g/t Au, 4.6g/t Ag, 2.17% Cu and 0.97% Mo,for sample (C1015) obtained from the Rio Junin; and 0.2g/t Au, 32.0g/t Ag, 6.32% Cu and 1.14% Mo,for the sample (E1012)

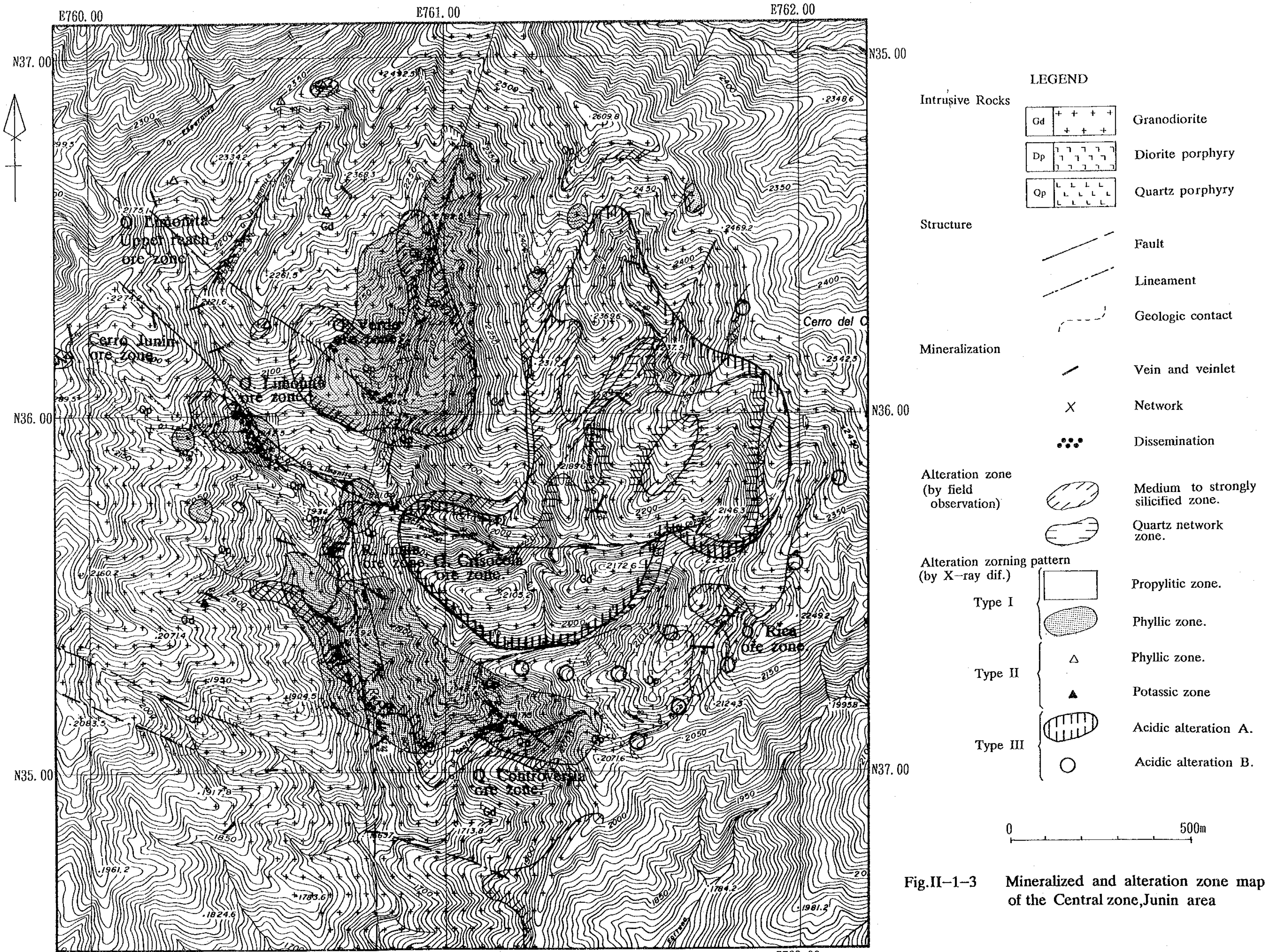


Fig.II-1-3 Mineralized and alteration zone map of the Central zone, Junin area