

LEGEND

- Longt wavelength High
- Long wavelength Low
- ◐ Large amplitude LW High
- ◐ Large amplitude LW Low
- - - Landsat TM lineament

- Existing Porphyry-Cu Deposits & Prospects
- 1: Rasario
- 2: Jamiralla
- 3: Dos Hermanas
- 4: Campanane
- 5: Tignamar
- 6: Camarones
- 7: Mocha
- 8: Cucho
- 9: Queen Elizabeth
- 10: Santa Rosa
- 11: Flor del Desierto
- 12: Cerro Colorado
- 13: Tigre-San Carlos
- 14: Sagasca
- 15: La Planada
- 16: Hundida
- 17: Arauco
- 18: Copaquire
- 19: Rasario(Collahuasi)
- 20: Venus
- 21: Ponderosa
- 22: Tarapaca
- 23: Ujina(Collauasi)
- 24: Esperanza
- 25: Quebrada Blanca
- 26: Olga,Lorena,Caniqueta

Fig. 2-3-49
Existing Porphyry-Cu Deposits & Prospects, Lineaments and LW Magnetic Anomalies



- 409 ~ 410 -

Table 2-3-5 Characteristic Relations between Porphyry-Cu Deposits and Magnetic Anomalies

No.	Name	Coordinate(km)		Medium wavelength anomaly					Short wavelength Anomaly							24,475 - 24,525 nT RTP zone	
		Northing	Easting	Neighboring anomaly (No.)	Position/Distance(km) from Prospect/Deposit	Paleo-magnetism	Geology of anomaly area	Suscep. of Anomaly area	Neighboring anomaly (No.)	Position/Distance(km) from Prospect/Deposit	Relation with MW anomaly	Paleo-magnetism	Geology of anomaly area	Suscep. of Anomaly area	Correlation with topography		Correlation with volcano
1	Rosario	7981.434	428.160	-	Far (8.0km)	-	Tig,Qv	Low	L(23)	Mo (1.0km)	Far (2.5km)	-	Tig,Qv	Low	No	No	C
2	Jamiralla	7981.042	427.199	-	Far (8.0km)	-	Tig,Qv	-		Mo		-	Tig,Qv	Low			C
3	Dos Hermanas	7977.300	423.900	L(9)	Far (5.0km)	-	Tig,Kv(i)	-	H(37)	Mo (1.0km)	Far (3.5km)	-	Kgd,Tig	High	No	No	M
4	Campanane	7975.231	426.572		Far (3.0km)	-	Tig,Kv(i),Kdg	-	L(32)	M	Far (1.5km)	-	Tig,Qv	Low	No		M
									H(42)	Far (3.0km)	M	-	Kv(i),Tig	-	No	No	
5	Tignamar	7947.289	451.872	H(11)	Mi (1.0km)	-	,Kv(s),Qv,Qvr	Low	L(55)	Mo	M	-	Kv(s),Qvr	Low	No	No	M
6	Camarones	7905.880	435.120	L(25)	M	-	Qvc,Tig,Kv(i)	Low	H(96)	Mo (1.5km)	Mo (1.0km)	-	Tig	Low	No	No	M
7	Mocha	7809.106	470.379	L(49)	Mo (1.0km)	-	Tig,Kv(i),Jm(s),Kdg	Low	L(142)	Mo (0.5km)	M	-	Tig,Qvc,Kv(i)	High	No	No	M
8,9,10	Cucho, Queen Elizabeth, Santa rosa	7803.670	504.211	L(48)	Mo (1.5km)	-	Qv,Jm(s),Qvr	Low	H(204)	M	M	-	Jm(s),Tig,Qvc,Qv	High	No	No	M
				H(44)	M	-	Kgd,Qv	High									
11	Flor del Desierto	7783.848	486.599	L(54)	M	N(3.0)	Kv(i),Tig,	Low	L(171)	M	M	-	Kv(i),Kgd	-			M
									H(224)	M (0.5km)	M	-	Kv(i),Kgd	-	No	No	
12	Cerro Colorado	7783.799	473.117	H(49)	M	N	Kv(i),Qvc,Kgd,Tig	High	L(168)	Far (2.0 km)	M	-	Kv(i),Tig,Qvc	-	No	No	M
13	Tigre-San Carlos	7773.463	490.112	L(59)	M	-	Kv(i),Tig,Kgd,Qvc	Low	H(245)	Far (4.0km)	I	-	Kv(i),Kgd	-	No	No	M
15	La Planada	7770.086	492.991		Mi (1.5km)	-	Kv(i),Tig,Kgd,Qvc	Low		Mo (1.0km)		-	Kv(i),Kgd	Low			
16	Hundida	7769.089	492.444		Mi (2.0km)	-	Kv(i),Tig,Kgd,Qvc	Low		Mi (0.5km)		-	Kv(i),Kgd	Low			
17	Arauco	7768.622	492.700		Mi (1.5km)	-	Kv(i),Tig,Kgd,Qvc	Low		Mi (1.0km)		-	Kv(i),Kgd	Low			
18	Copaquire	7687.116	511.023	L(73)	M	-	Jm(s),Kv(m),Kv(i)	Low	H(294)	M	M	-	Kv(i),Qcp	Low	No	No	M
19	Rosario(Collahuasi)	7681.321	531.544	L(75)	Mo (0.5km)	R	Jm(s),Kv(i),Kv(m)	Low	H(306)	Far (2.5km)	M	-	Kv(i),Kv(m),Kgd	Low	No	No	M
20	Venus	7680.891	532.121		M	R	Jm(s),Kv(i),Kv(m)	Low		Far (3.0km)		-	Kv(i),Kv(m),Kgd	Low			
21	Ponderosa	7680.448	532.225		Mo (0.5km)	R	Jm(s),Kv(i),Kv(m)	Low		F(2.0)		-	Kv(i),Kv(m),Kgd	Low			
22	Tarapaca	7680.008	530.768		Mi (0.5km)	R	Jm(s),Kv(i),Kv(m)	Low		Far (1.5km)		-	Kv(i),Kv(m),Kgd	Low			
23	Ujina(Collahuasi)	7679.299	537.701	L(76)	C	-	Kgd,Kv(i),Tig,Qcp	Low	H(303)	Mo(0.5)	I	-	Tig,Qvc	Low	No	No	Far (2.5km)
24	Esperanza	7679.012	530.455	L(75)	M	R	Jm(s),Kv(i),Kv(m)	Low	H(306)	Mo(0.5)	M	-	Kv(i),Kv(m),Kgd	Low			Mo (0.5km)
					Mo (2.5km)	R	Jm(s),Kv(i),Kv(m)	Low	H(305)	Mo(1.5)	M	R	Kv(m)Kv(i)	Low	No	No	M
25	Quebrada Blanca	7678.106	520.079	H(71)	Mi (0.5km)	R	Pzg,Kv(m),Kv(i),Kgd	High			Mo (0.5km)						
26	Olga,Lorena, Caniqueta	7668.305	502.181	L(78)	M	-	Jm(s),Pzg,Pc,Kgd	-	-			-		-	No	No	M

N:Normal
R:Reverse

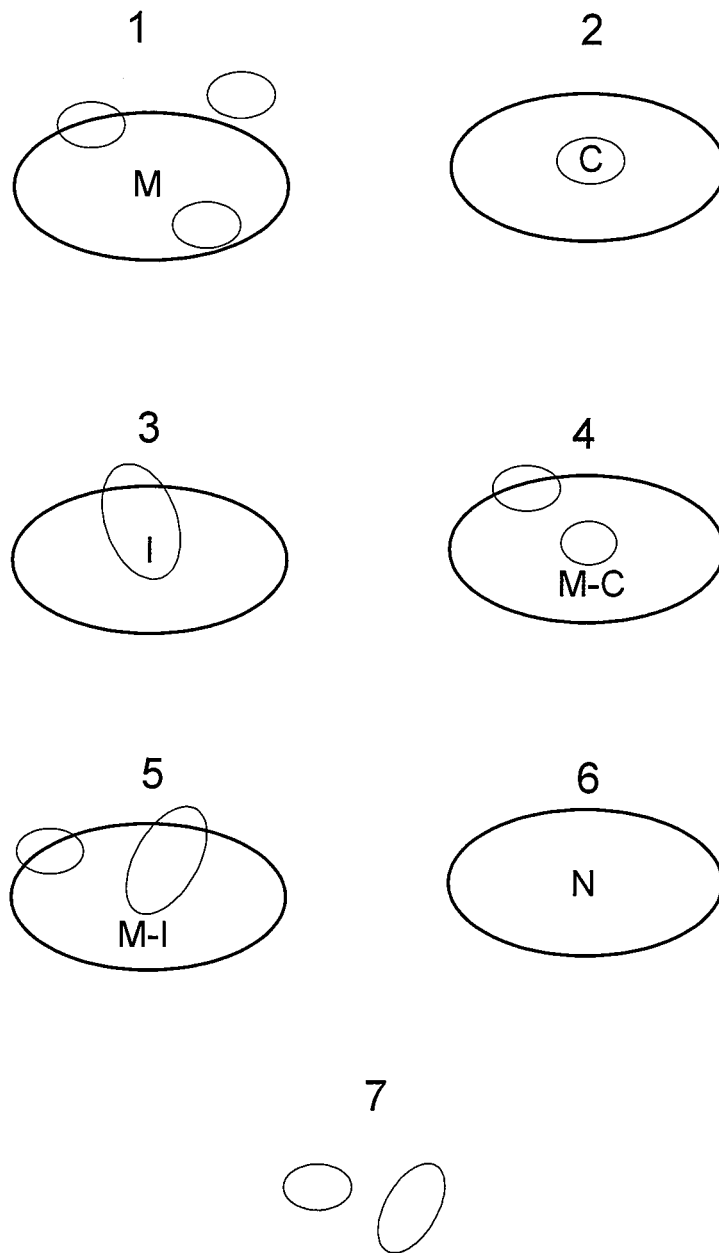


Fig. 2-3-50 Schematic relations between SW and MW Magnetic Anomalies

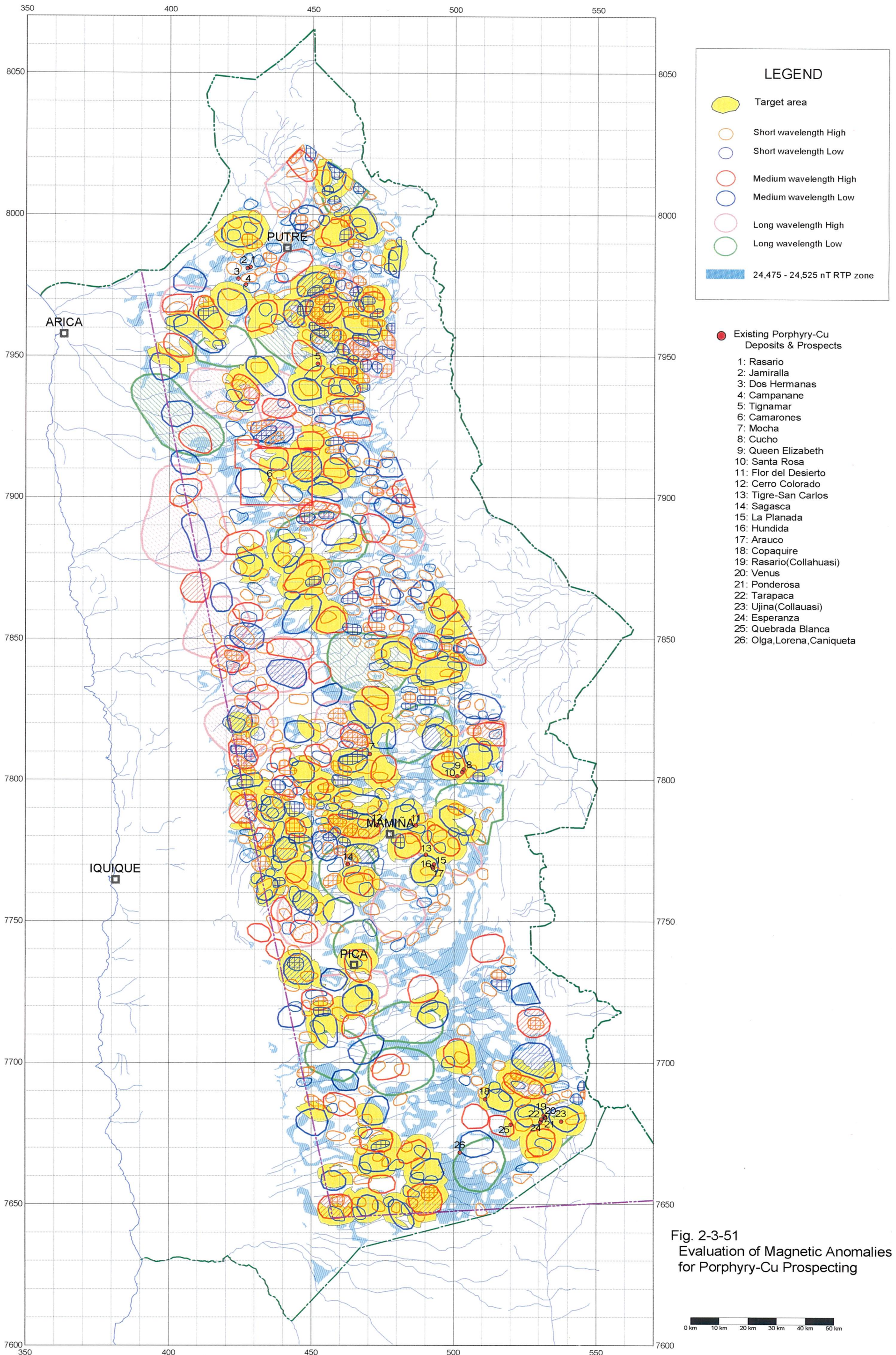


Fig. 2-3-51
Evaluation of Magnetic Anomalies
for Porphyry-Cu Prospecting

**PART III CONCLUSIONS AND
RECOMMENDATIONS**

PART III CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1 CONCLUSIONS

The following results were obtained from the third year mineral exploration survey of the Region I area consisting of geological survey, drilling survey, and re-analysis of the airborne magnetic survey data which were acquired during the earlier part of this project.

Geological Survey

Magnetic susceptibility was measured for the whole area, and the results were provided for the re-analysis of the airborne magnetic survey which was carried out during the year 2000. The relation between the magnetic susceptibility and the rock species and alteration was clarified. The intrusive rocks have the highest magnetic susceptibility. The susceptibility decreases by phyllic and acidic alteration, but is not affected by propylitic alteration.

The remanent magnetism and magnetic susceptibility of samples mainly collected from outcrops of the vicinity of medium wavelength airborne magnetic low anomalies were measured. The polarity of the remanent magnetism of 6 localities out of 14 is estimated to be reverse. Also as low airborne magnetic anomalies occur in areas of high surface magnetic susceptibility, it is inferred that many airborne low magnetic anomaly zones with reverse magnetic polarity exist in the survey area. Reverse magnetic polarity and high magnetic susceptibility zones with low airborne magnetic anomaly possibly indicate blind igneous intrusion or solidified magma. This naturally is the case with high airborne magnetic anomaly areas.

A total of 14 areas extracted by airborne magnetic survey analysis as having high mineral potential were surveyed geologically for verification, and also for geological reconnaissance. As a result, Chusmisa and Camiña were extracted as areas with high mineral potential because of their relatively abundant features related to porphyry copper type mineralization. In both of the above areas, the occurrence of horizontally extensive phyllic alteration, the occurrence of porphyry or granitic rocks associated with mineralization, and the occurrence of intrusive bodies of 65 to 48Ma were confirmed. This occurrence Paleocene to Early Eocene intrusive bodies is similar to those associated with the porphyry copper deposits in northern Chile ~ Peru. Although the above geologic features were confirmed, neither network quartz veins nor Cu, Mo rock geochemical anomalies were found. The pyrite dissemination in

quartz porphyry of the western alteration zone in Camiña area is similar to the Pyrite shell of the San Manuel - Kalamazoo model of Lowell and Guilbert (1970).

In the area south of Chusmisa, Paleocene-Eocene (65-48Ma) porphyry copper belt and Eocene-Oligocene (43-31Ma) porphyry copper belt occur parallel with a boundary in the N-S direction. North of Chusmisa, Paleocene-Eocene porphyry copper belt is mainly developed, and the Eocene-Oligocene belt is dissected by NW-SE trending Tertiary-Quaternary volcanic rocks. In the area north of Tignamar, Miocene intrusive bodies occur and thus the possibility of the existence of Late Eocene-Early Oligocene intrusive is believed to be small. Therefore, Late Eocene-Early Oligocene porphyry copper belt could be buried beneath the Neogene-Quaternary volcanics, and possibly may not exist as in the case of north of Tignamar.

Phyllic or acidic alteration zones were confirmed in 9 areas out of the 14 surveyed. These alteration or mineralized zones occur in: the periphery or vicinity of medium wavelength airborne magnetic anomaly zones, within or vicinity of intermediate magnetic intensity zones, and the periphery or vicinity of short wavelength anomaly zones. In these cases, about half of the medium wavelength anomalies are high anomalies and the other half low anomalies, but about 70% of the short wavelength anomalies are high anomalies. It can be said that magnetic anomalies occur near alteration zones, mineralized zones, and intrusive bodies, but the reverse is not necessarily true. And magnetic anomalies (overlap of the periphery of medium wavelength magnetic anomaly and intermediate magnetic intensity zones) do not necessarily indicate the existence of alteration zones, mineralized zones, or shallow intrusive bodies.

Drilling

A total of 12 holes were drilled in the overlapping zones or their vicinity of intermediate airborne magnetic intensity zones and medium wavelength magnetic anomalies. Of these, only 3 holes (MJC-1, 11, 12) in the Camarones area reached the pre-Early Oligocene formations which is the porphyry copper bearing horizon. MJC-1 and MJC-11 both confirmed quartz porphyritic brecciated intrusive rocks and quartz porphyry intrusive bodies, and strong pyrite mineralization. Quartz porphyry is the host rock of the Camarones Porphyry Copper Prospect. It is highly possible that these two drill holes located porphyry copper type mineralization and alteration. MJC-12 confirmed the occurrence of quartz diorite which is believed to be the product of Early Eocene activity, and also confirmed weak pyritization.

On the other hand, the 9 holes drilled in other areas penetrated Oligocene-Miocene conglomerate or through younger units. MJC-10 in area northeast of Camiña confirmed the occurrence of pyritization and epithermal type mineralization and acidic alteration zone in Tertiary-Quaternary volcanic rocks.

The relation between the basement depth and medium wavelength airborne magnetic anomalies or short wavelength magnetic anomalies cannot be determined from the geology of the drill holes and the changes of magnetic susceptibility of cuttings. The distance from the surface distribution of the pre-Oligocene area to the drilling site is less than 1km and this short distance is believed to be the reason for engaging the pre-Oligocene Series in Camarones area.

The general trend of the magnetic susceptibility changes of the cuttings corresponds to the changes of the geology of the drill holes. Namely the susceptibility of the mafic igneous rocks are high, and that of the Tertiary System, and Neogene-Quaternary conglomerate is higher than that of pyroclastic rocks and shallow gravel layers. Also the magnetic susceptibility of phyllic alteration zones, acidic alteration zones, and oxidized zones are relatively low and that of the propylitic alteration zones is high.

Re-analysis of Airborne Magnetic Survey

Frequency analysis of the airborne magnetic survey data revealed magnetic anomaly patterns characteristic to porphyry copper mineralized zones. This pattern consists of a relatively large medium wavelength magnetic anomaly, small short wavelength magnetic anomalies, and intermediate magnetic intensity zones.

The genesis of this magnetic anomaly pattern is considered as follows. Medium wavelength magnetic anomaly was formed by batholithic complex body, which is a product of activity precursory to porphyry copper type mineralization. While short wavelength magnetic anomalies were formed by hypabyssal rocks including the ore deposits, and the intermediate magnetic intensity zones expresses the hydrothermal alteration zones associated with igneous intrusive activity.

During the process of delineating promising areas using these magnetic anomaly patterns, it is necessary to consider the following. Namely, similar magnetic anomaly patterns may appear in volcanic areas; intrusive igneous bodies may lose magnetism in large-scale

alteration zones and may not be extracted as short wavelength magnetic anomalies; medium wavelength magnetic anomalies may not occur because of the interaction and mutual elimination by induction magnetism and remanent magnetism, and medium wavelength magnetic anomalies may be formed by topography and conglomerate formations.

CHAPTER 2 RECOMMENDATIONS FOR FUTURE SURVEY

Cooperative mineral exploration carried out in the Region I Area during the past three years resulted in the acquisition airborne magnetic data, geological and geochemical data, and other information which are very relevant for mineral exploration of the area. As this area is considered to be highly prospective regarding porphyry copper deposits, it is recommended that future prospecting be carried out fully utilizing these data.

It would be desirable to take note of the following points in the future work.

1. Survey Methods

In this area, thick young volcanic rocks cover the surface and it is difficult to detect the mineral deposits lying under these rocks. Airborne magnetic survey and gravity survey were implemented in order to clarify many of the problems concerning the geology of the area. The potential and problems of these methods are as follows.

(1) Airborne magnetic survey

CODELCO has shown that high macroscopic correlation exists between the major porphyry copper deposits of northern Chile and transverse magnetic anomalies. This fully applies to the major porphyry copper deposits in the central to southern parts of Region I. But transverse magnetic anomalies are not clear in the northern part, and thus in the present survey investigation was not limited to transverse magnetic anomalies, but all magnetic anomalies were analyzed and examined. Frequency analysis was adopted in order to consider the relation between porphyry copper deposits and magnetic anomalies in the level of individual anomalies. The existence of magnetic anomaly patterns each consisting of a set of medium wavelength magnetic anomaly, short wavelength magnetic anomalies, and intermediate magnetic intensity zones was discovered characteristic to known porphyry copper mineralized zones. Pattern analysis was carried out for these magnetic anomaly sets, and the results were applied to the survey area and promising zones for mineral prospecting were extracted on this basis.

Regarding the extracted promising zones, confirmation of alteration zones, mineralized zones, and of related igneous bodies will be the next step. Two-dimensional or 3-dimensional detailed modeling using airborne magnetic data is believed to be effective for determining the existence and scale of such igneous bodies. Modeling will not necessarily provide accurate information regarding the depth of these bodies and thus application of other methods (drilling, gravity, electromagnetic methods and others) is recommended.

(2) Gravity survey

The results of gravity survey carried out during the second year are believed to be effective for understanding the geologic structure such as the thickness of ignimbrite, but since the method is expensive in terms of areal coverage, it would be necessary to limit the area of survey. Also the usefulness of magnetic data will increase significantly by carrying out joint analysis with gravity data. In the future, if gravity survey - airborne or land - can be used to cover wide area economically, this would indeed be a very effective method to apply in this area.

2. Porphyry Copper Belts

Regarding the porphyry copper belt in Region I, its continuity north of Queen Elizabeth Prospect was not clear because of insufficient radiometric age data. The age determination carried out during the present survey clarified the metallogenic province of this area, and it is anticipated that the newly acquired data would contribute to the delineation of promising areas.

3. Promising Areas

It is recommended that the following survey be carried out in the future in order to clarify the geology and mineral deposits of the promising areas extracted by the present survey.

(1) Magnetic anomaly zones extracted by re-analysis of airborne magnetic survey.

Extract surface manifestations by satellite image analysis in the magnetic anomaly zones delineated by pattern analysis.

(2) Mineralized and altered zones extracted by geological survey

Carry out further detailed geological and other relevant surveys in the seven areas extracted by geological survey, namely Mocha-Soleda, La Planada, Queen Elizabeth, Tignamar, Diana, Chusmisa, and Camiña areas.

(3) Promising areas extracted by drilling survey

Carry out further drilling for blind buried porphyry copper mineralized zones inferred to occur in the Camarones area.

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PHOTOGRAPHS

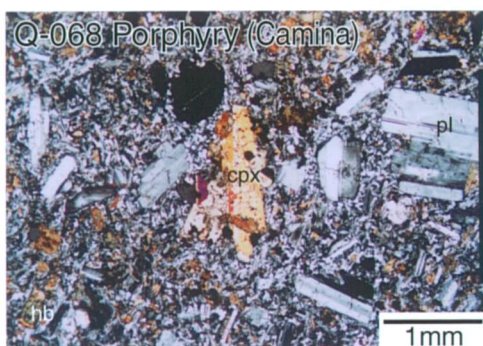
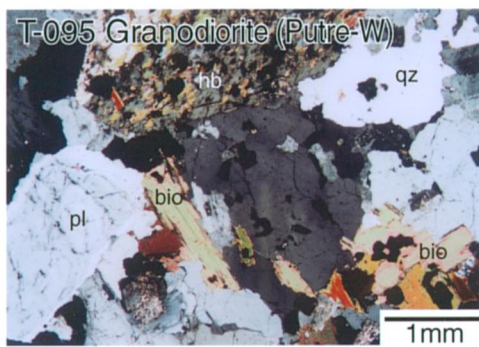
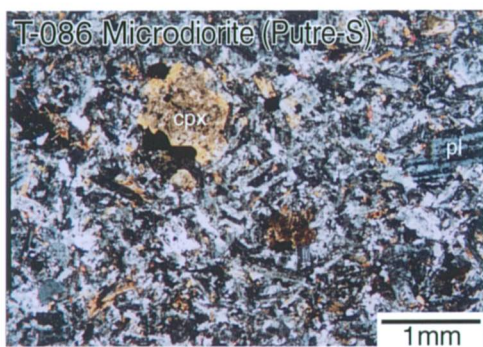
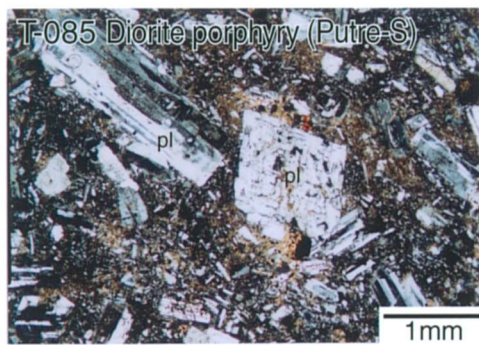
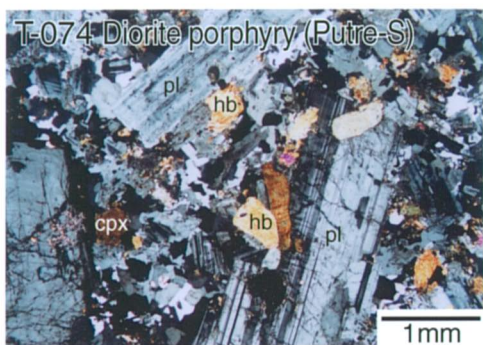
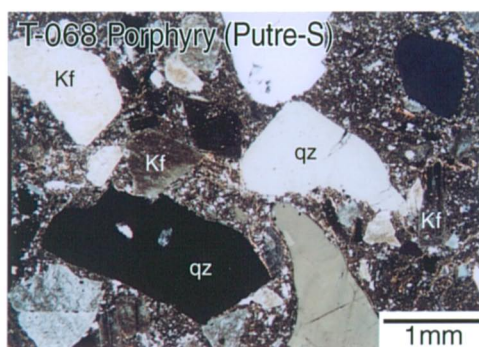
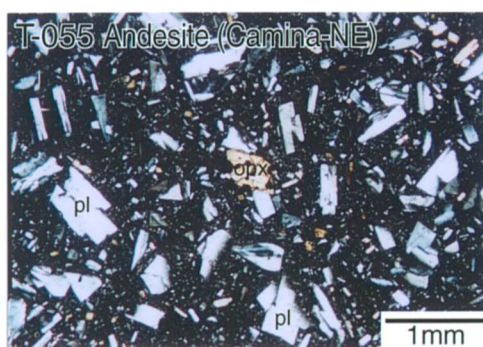
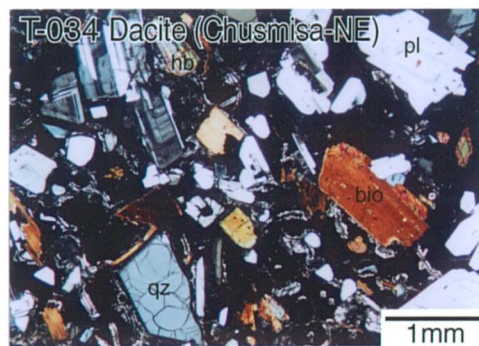
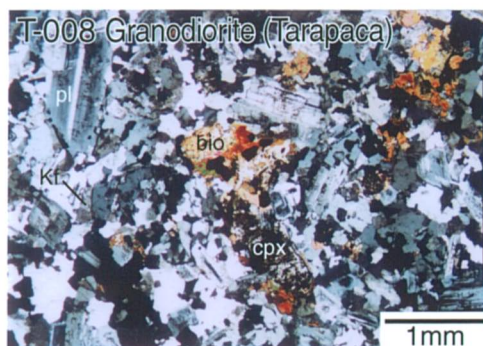


Photo 1 Photomicrographs of Thin Sections (Phase 3) (1)
refer AP-2

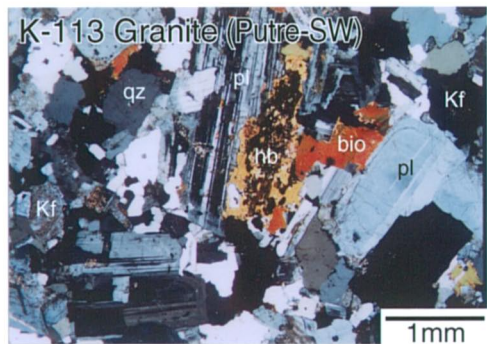
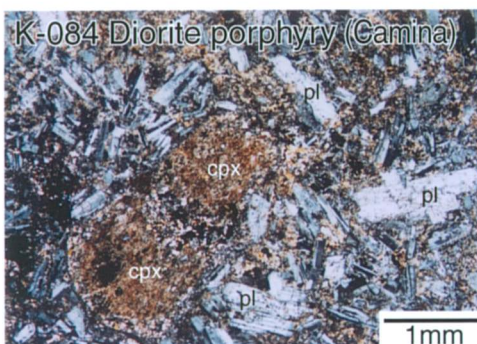
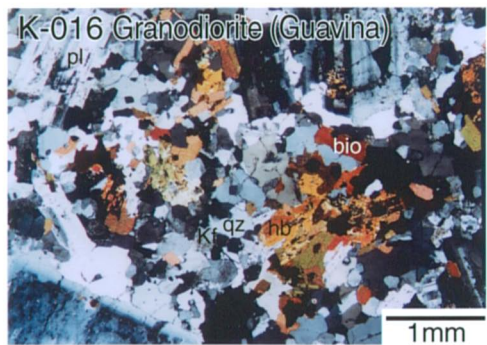
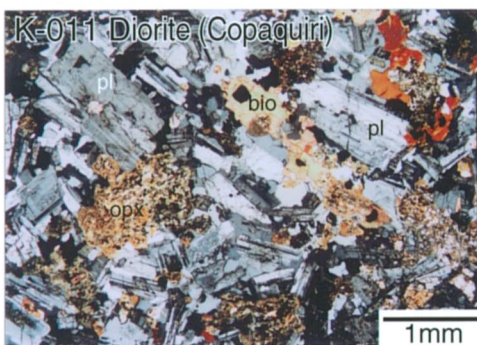
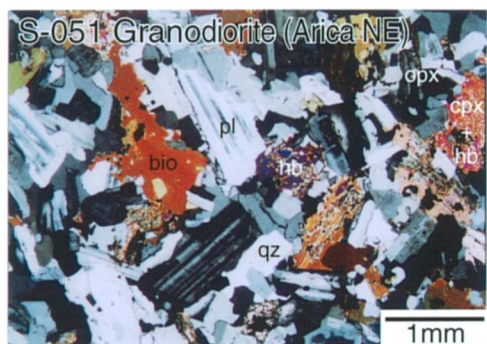
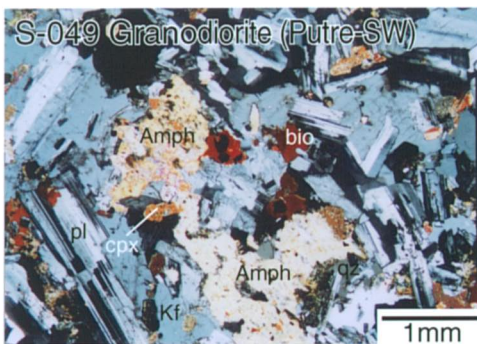
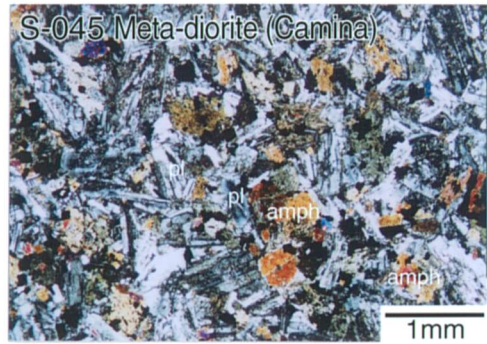
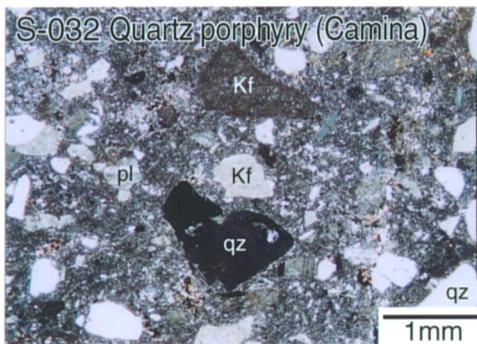
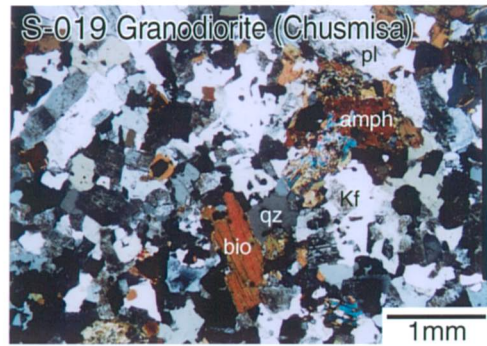
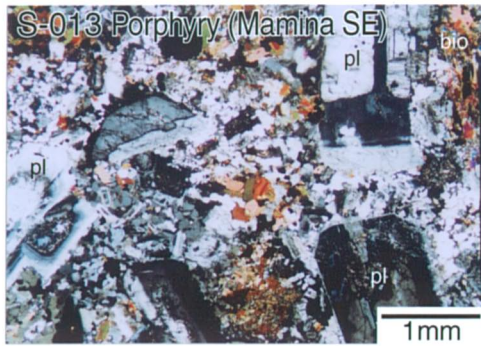


Photo 1 Photomicrographs of Thin Sections (Phase 3) (2)
refer AP-2

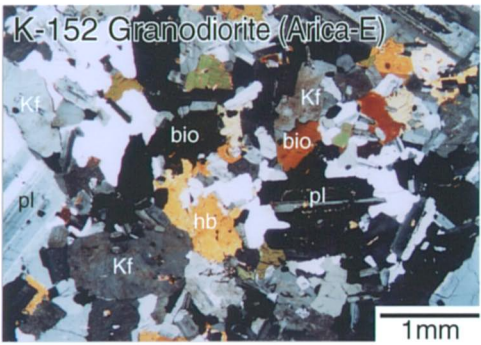
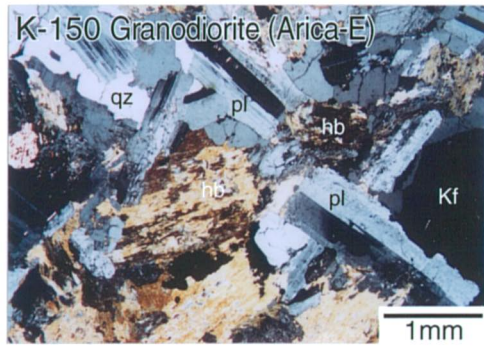
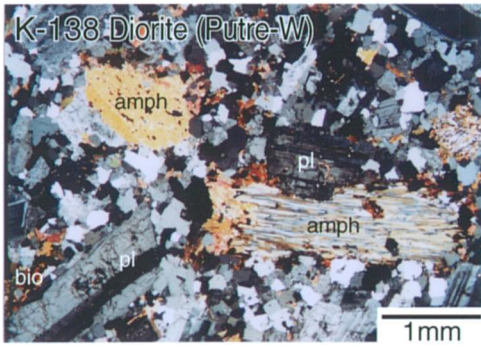
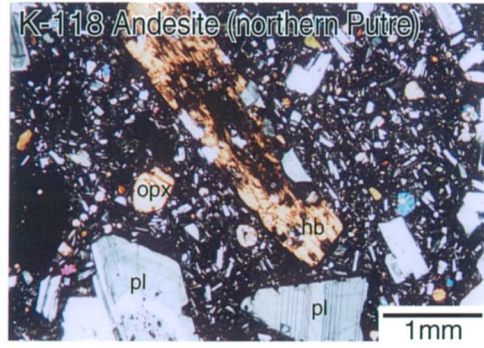
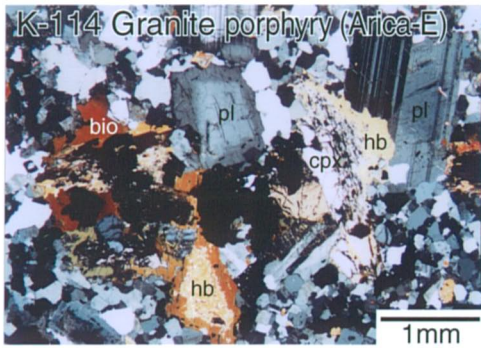


Photo 1 Photomicrographs of Thin Sections (Phase 3) (3)
refer AP-2

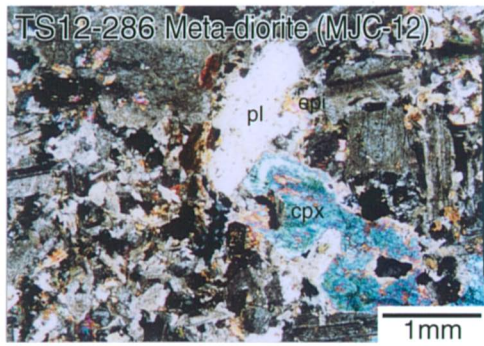
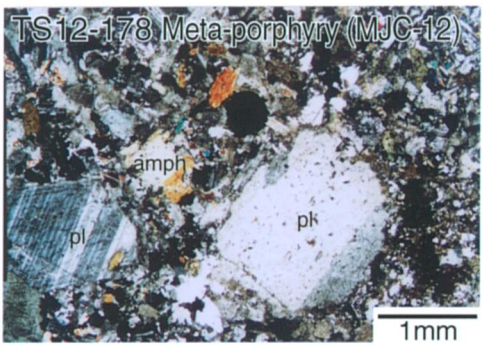
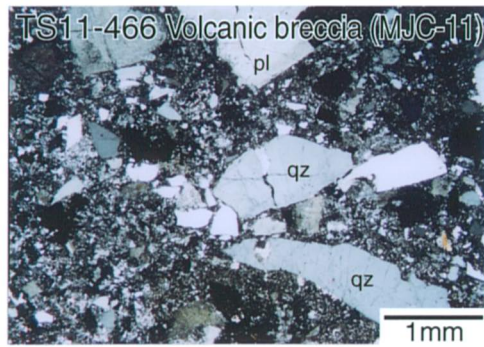
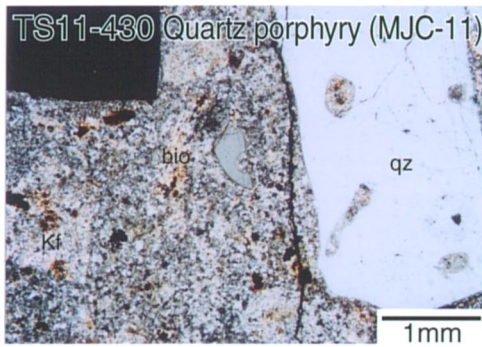
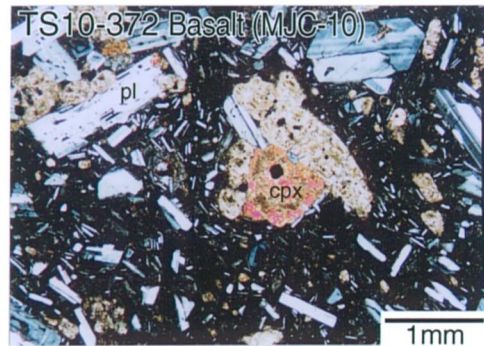
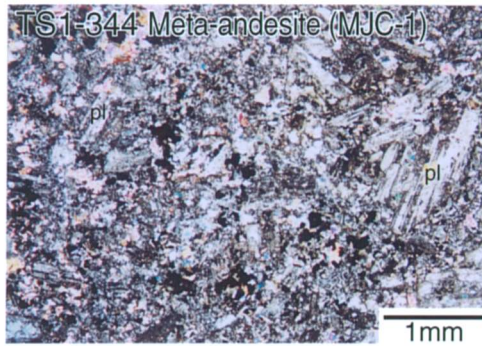


Photo 1 Photomicrographs of Thin Sections (Phase 3) (4)
refer AP-49

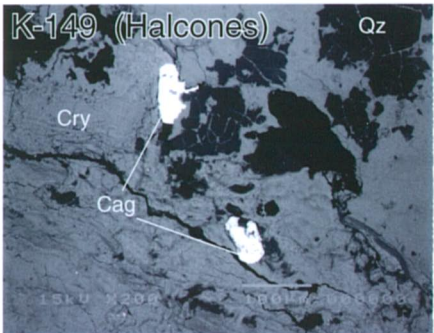
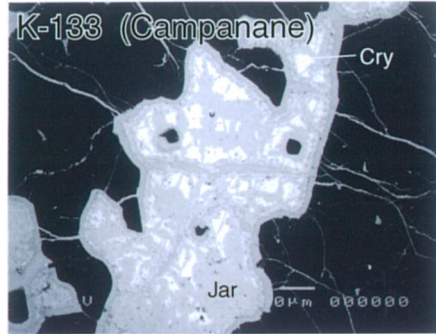
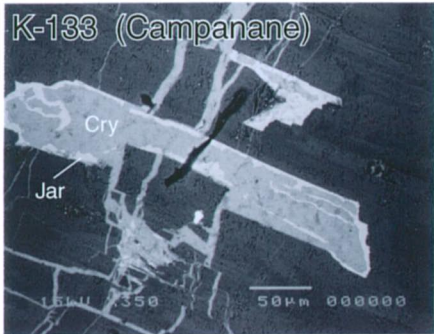
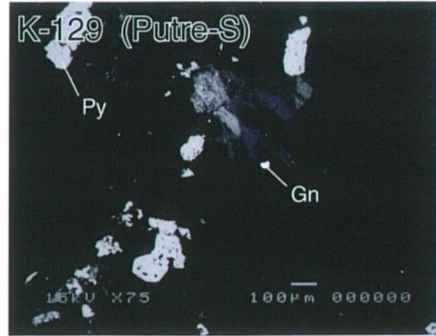
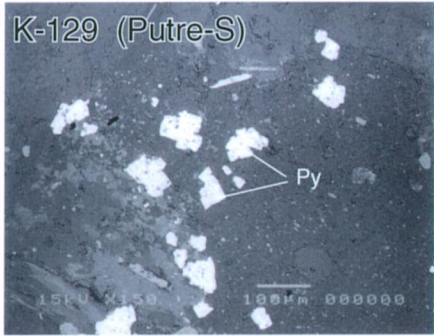
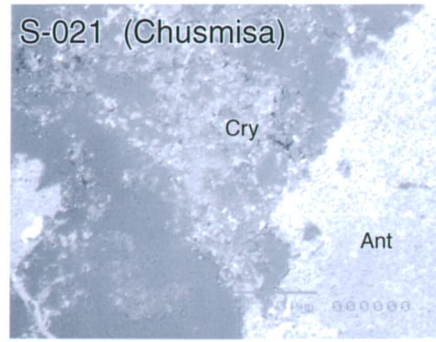
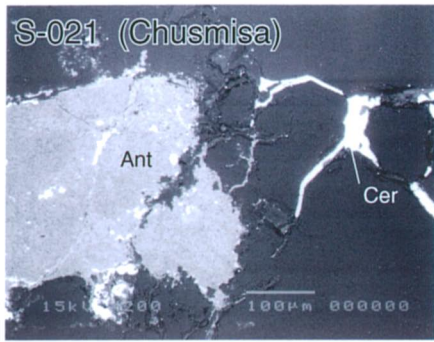
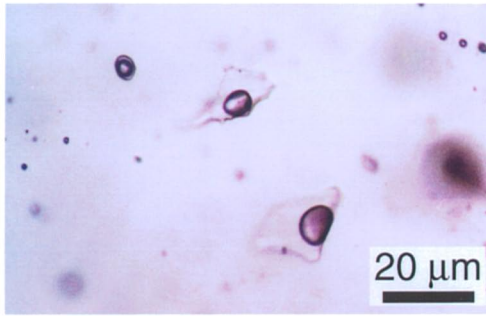
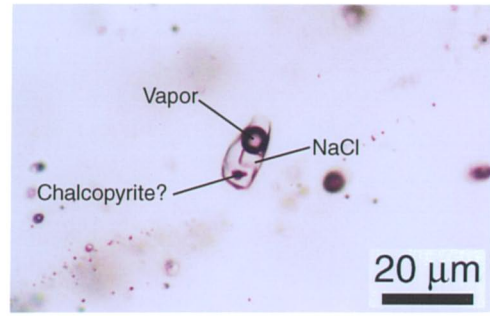


Photo 2 Photomicrographs of Polished Sections (Phase 3)
refer AP-3

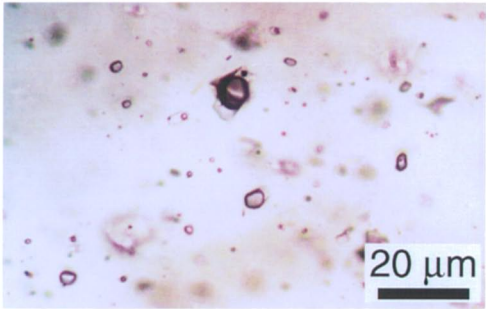
T-093 (Palmanilla)



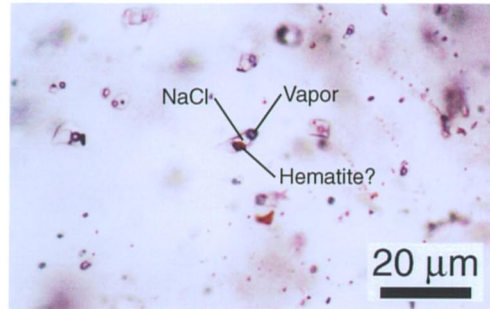
T-093 (Palmanilla)



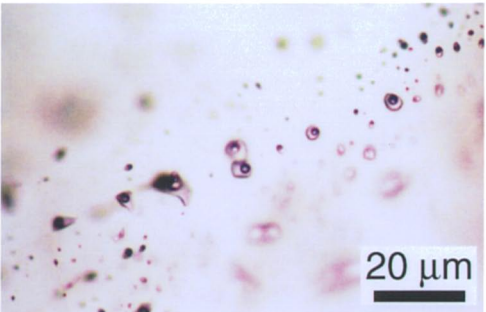
K-005 (Ujina, Collahuasi)



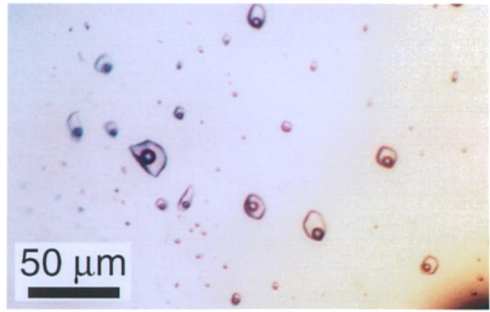
K-005 (Ujina, Collahuasi)



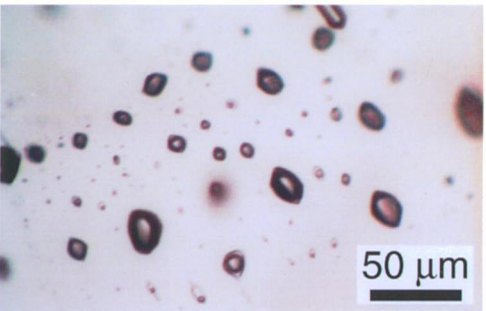
K-007 (Trinidad)



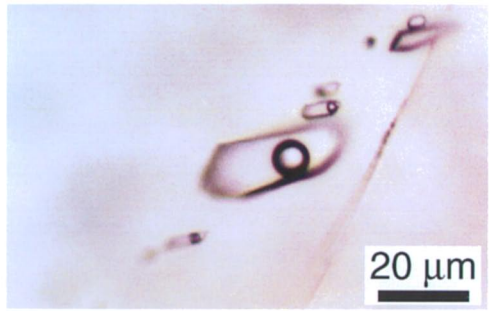
K-052 (Casiri)



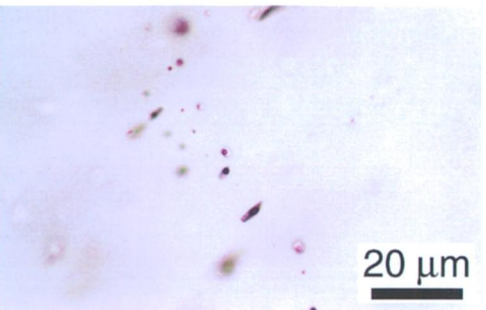
K-052 (Casiri)



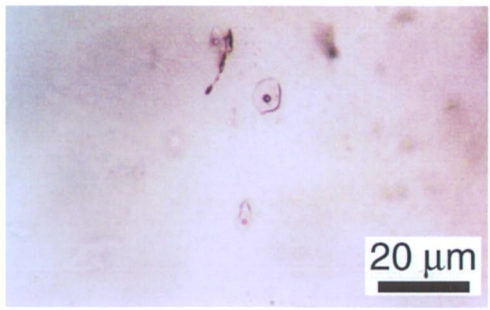
K-139 (Campanane)



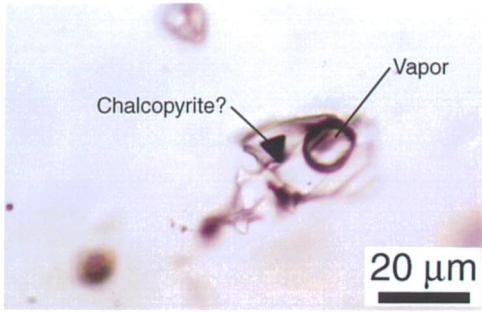
K-140 (Campanane)



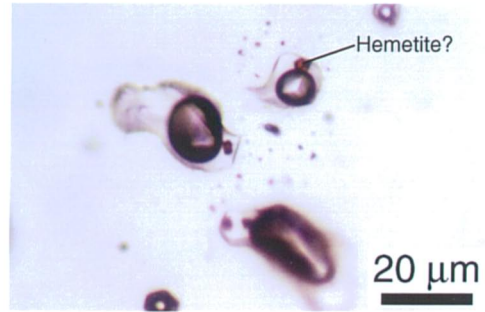
K-151 (Halcones)



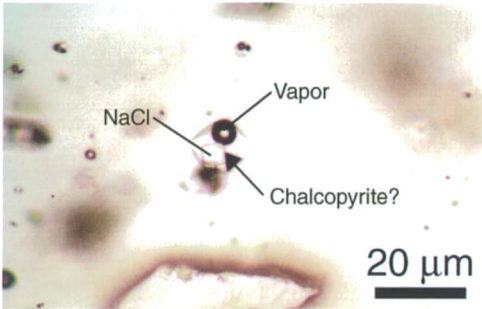
K-158 (Jamiralla)



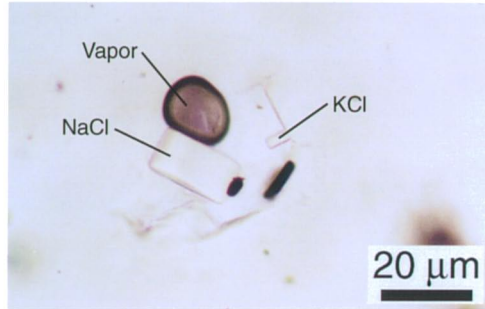
K-158 (Jamiralla)



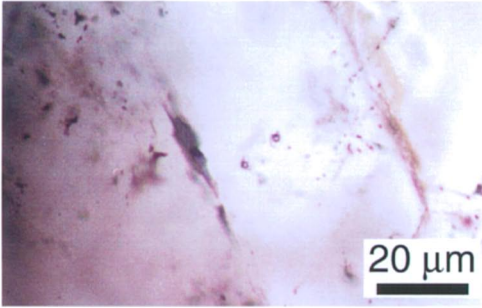
K-201 (Cerro Colorado)



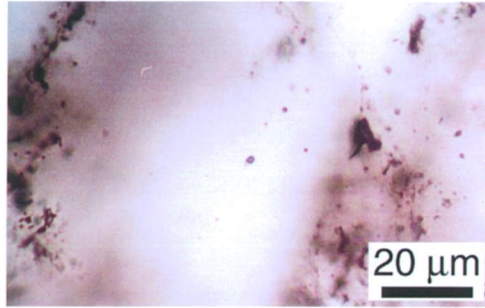
K-201 (Cerro Colorado)



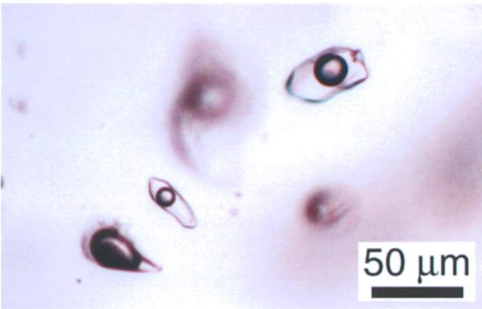
Q-006 (Copaquiri)



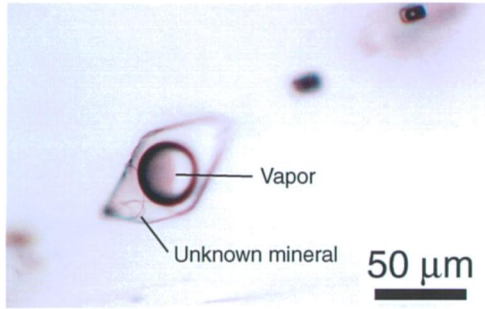
Q-006 (Copaquiri)



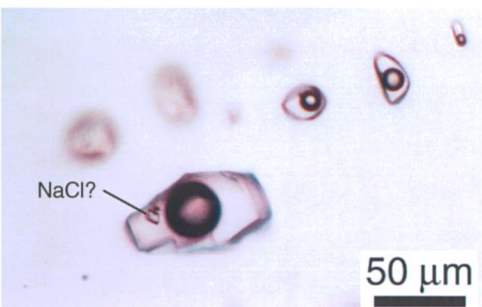
Q-164 (Rosario)



Q-164 (Rosario)



Q-166 (Rosario)



Q-166 (Rosario)

