

Figure II-3-2 Comprehensive map including geologic structure, hydrothermal alteration, and groundtruth-site, Eastern Andean area.



Table II-3-1 Summary of survey results of selected hydrothermal alterations, Macho Muerto area and Valle del Cura area

a. Macho Muerto Area

	potassic alteration	advanced argillic alteration	neutral pH alteration	quartz vein	major hypogene secondary mineral (except quartz)
La Ollita	yes *1 (qz-diorite)	no	yes (phyllitic)	sparse	sericite
Tamberias	no	no	yes (phyllitic)	rare	sericite
La Vicunita	no	no	yes (phyllitic)	rare	sericite
El Potro	yes (fine-grained granite)	no	yes (phyllitic)	stock-work, ubiquitous	magnetite, biotite, K-feldspar, sericite
Los Mogotes	uncertain	no	yes (phyllitic)	ubiquitous partly stockwork	sericite, pyrite, qz vein with molybdenite impregnation
Rio Blanco	yes *2 (dc porphyry)	a part	yes (probably phyllic)	sparse	sericite, partly including phyrophyllite + diaspore
Filo Amarillo	no	yes	yes (HS-peripheral)	no	native sulfur, alunite abundant, (vuggy quartz), sericite outward
Bordo Atravezado	no	a part	yes (probably phyllic)	sparse	sericite, subtle alunite
La Flecha	no	yes	a part (HS-peripheral)	very rare	native sulfur, alunite abundant, s/s int. clay
Cordon de la Inca	no	yes	a part (HS-peripheral)	sparse	alunite abundant, (vuggy quartz), sericite, s/s int. outward

\*1: Potassic alteration was recognized in a drill core by El Dorado.

\*2: El Dolado recognized potassic alteration, but our survey didn't.

\*3: Usage of HS and LS means epithermal alteration of high sulfidation and low sulfidation, respectively.

b. Valle del Cura Area

	potassic alteration	advanced argillic alteration	neutral pH alteration	quartz vein	major hypogene secondary mineral, etc.
Carmen Norte	no	yes	a part (HS-peripheral)	sparse	alunite abundant, chalcadonic to opalin silica, vuggy qz, s/s int. clay
Veladero Norte	no	a part	probably yes (HS-peripheral and LS ?)	no (breccia pipe)	alunite, vuggy qz, dense silicification, (qz+adularia vein, silica sinter)*
Guanaco Zonzo	no	probably yes	yes (HS-peripheral)	no	alunite, native sulfur, dense silicification
Veladero Sur (Northwest)	no	yes	yes (HS-peripheral)	no	alunite, kaolinite
Veladero Sur (Mula Twelta)	no	no	yes (HS-peripheral ?)	common	s/s int. clay
Zancarron	no	yes	not observed	no	enargite, alunite, vuggy qz
Rio Frio	no	yes	yes (HS-peripheral)	rare	alunite, pyrophyllite, diaspore, sericite, s/s int. clay
Despoblados	no	no	yes (phyllitic ?)	common	sericite, s/s int. clay

\*: based on the survey of Argentina Gold

que el sistema hidrotermal La Ollita-Tamberías-Vicuñita es el único conjunto de criaderos donde no aflora la alteración potásica. La correlación inversa de las leyes de oro y de molibdeno probablemente se debe a la influencia de la zona con inclinación vertical. Los criaderos del río Blanco también presenta alteración potásica, y podría ser comparable con las zonas de alteración del sistema porfídico. Por otro lado, en el reconocimiento de campo se ha verificado la combinación de pirofilita+diáspora, lo que sugiere la conservación de la parte inferior de la argilización avanzada.

Las zonas de alteración y mineralización tipo alta sulfidación y epitermal se ubican en el sur de Macho Muerto, en la cuenca del Río Macho Muerto y de su tributario Río del Inca. Corresponde a esta categoría las zonas de alteración del sistema hidrotermal del Filo Amarillo-Bordo Atravesado, La Flecha y del Cordón de la Inca. Se caracterizan por la presencia de las rocas silicificadas que contienen elevado porcentaje de alunita hipogénica y sílice vuggy. Frecuentemente se asocian con azufre nativo (Table II-3-1a). Normalmente se observa gran cantidad de yeso supergénico en la superficie. Estas zonas de alteración ácidas se hallan circundadas por zonas de alteración blanca constituida por sericita o sericita-esmectita. El grado del desarrollo de las zonas de alteración blanca depende de la permeabilidad de las rocas de caja; es muy intenso cuando son de rocas piroclásticas. Casi en el borde de estas zonas de alteración blanca, se observan frecuentemente la alteración con las rocas volcánicas propilitizadas. La alteración constituida por la alteración ácida > argilización con esmectita > propilitización es una característica común en el grupo de yacimientos epitermales del tipo alta sulfidación o de bisulfato (Heald, et al., 1987; Harvey y Vitariano, 1964). El grado de mineralización de las zonas de alteración tipo alta sulfidación y epitermal de Macho Muerto es del nivel de anomalías geoquímicas en la zona de alteración ácida del centro, y alto en la zona de alteración blanca. Normalmente, las zonas de alteración blanca se asocian con pequeña cantidad de venillas de cuarzo, las cuales arrojan una ley del orden de Au:0,n g/t ó más. (Cordón de la Inca y otros).

Todas las zonas de alteración y mineralización estudiadas del Valle del Cura parecen ser hidrotermales (Table II-3-1b, salvo Despoblados cuyos detalles se desconocen). Particularmente predomina la alteración de alta sulfidación, y se distribuyen también los típicos yacimientos de alta sulfidación y epitermal caracterizados por la presencia de sílice vuggy + enargita como Zancarrón. Salvo Despoblados, todas las zonas de alteración presentan alunita hipogénica. Asimismo se observan cuarzo vuggy en Zancarrón, Carmen Norte y Veladero Norte. Las venillas de cuarzo son sumamente raras en estas zonas de alteración ácida, mientras que son comunes en la alteración neutra colindante. A diferencia de las zonas de alteración de Macho Muerto, la composición de las zonas de mineralización que conforman las zonas de alteración es muy variada: en Zancarrón, el cuarzo vuggy de las zonas de alteración ácida está asociado con mineralización de oro-cobre; en Carmen Norte y Río Frío, la alteración neutra circundante de las zonas de alteración ácida presenta una ley de oro elevada, y; en Veladero Norte se distribuyen las zonas de mineralización con elevadas leyes asociadas con la mineralización de oro del tipo baja sulfidación.

En la Fig. II-3-2 se indican los yacimientos del Terciario según Jones et al. (1996), quien señala las siguientes posibilidades: (1) que el Valle del Cura pertenece al sector argentino de la Faja El Indio; (2) que estos yacimientos se dividen en dos grupos en la parte sur, y la prolongación este forma el sub-sector que incluye La Poposa, y; (3) que el extremo sur de la Faja Maricunga coincide con el área de Macho Muerto. En el presente estudio se procuró obtener mayor datos metalogénicos posible para realizar un análisis detallado. Algunos de estos resultados se muestran en la Fig. II-3-2. El análisis de la edad metalogénica K-Ar de las zonas de mineralización de Macho Muerto indica que la edad de Los Mogotes es de 17,1 +/- 0,4Ma y la del Filo Amarillo es de 23,1 +/- 0,6Ma. Este resultado coincide con los datos de los yacimientos conocidos de la Faja de Maricunga (Fig. I-3-4) y

sustenta la interpretación de Jones et al. (1996).

También se estableció nuevas informaciones a partir del análisis de la edad metalogénica. La sericita y propilita de El Potro corresponde a la edad K-Ar  $73,7 \pm 0,2$  Ma y  $88,9 \pm 0,4$  Ma, respectivamente (Cretáceo Superior) que es comparable con la edad de alteración del yacimiento El Bronce (79-88 Ma) de Chile (Fig. II-3-1, I-3-5). Por lo tanto, se ha esclarecido que la formación del grupo de los criaderos tipo porfídico de Macho Muerto ha tenido dos fases: Cretáceo superior y Neógeno. Cabe recordar que en la Cordillera Oriental Andina, se conoce que las rocas ígneas cretácicas están presentes en la Formación El Pachón (andesitas y riolitas) en la Cordillera Principal, más no se ha identificado su presencia en Macho Muerto.

### **3-2-2 Zona de mineralización del margen este de la zona de distribución del Pérmico a Triásico (Castaño, Tocota-Colangull y Cordón de la Brea)**

En el margen este de la zona de distribución del Pérmico a Triásico existen los yacimientos y criaderos tipo pórfido grandes y medianos como Paramillos, San Jorge, Alcaparossa, Chita, etc. Además también están los criaderos de oro epitermal explotados antiguamente como Castaño Nuevo, La Poposa, etc. El reconocimiento de terreno de la Cordillera Oriental Andina fue orientado no sólo en estos criaderos conocidos, sino también en las zonas de alteración y los criaderos de los que no se tienen informaciones geológicas completas. Particularmente, el área de Castaño donde se concentran numerosas zonas de alteración fue considerada como una de las áreas prioritarias en esta etapa del estudio, por la ausencia de los datos geológicos y porque ha sido identificado como el área promisoría en el análisis de las imágenes de satélite.

En el Cuadro II-3-2 se resumen los resultados de estudio de las zonas de alteración de Castaño. Se esclareció que Venezuela, Portezuelo Amarillo, Avestruces y Manrique identificadas en el análisis de las imágenes corresponden a las zonas de alteración neutra asociada parcialmente con sericitización.

La alteración ácida que da lugar a alunita hipogénica se observa únicamente en la cima de la zona de alteración Venezuela. También se esclareció que en estas zonas de alteración se distribuyen pequeños filones débilmente silicificadas compuestos por cuarzo y turmalina fina. Por lo general, este tipo de alteración blanca constituida por la zona polimineral se halla controlada por la permeabilidad de la roca de caja. Los bordes de la alteración de Venezuela y Portezuelo Amarillo presentan alternación de las rocas piroclásticas y volcánicas que presentan alteración blanca y propilitización (verde) respectivamente. Las muestras arrojaron leyes de oro-cobre del nivel de anomalías geoquímicas en todas las zonas de alteración. De estas, llama la atención la ley de oro de las muestras de Manrique (Au 200ppb) y de Venezuela (65ppb). Las zonas de alteración del área de Castaño se asemejan entre sí, y por la formación de Venezuela se deduce que corresponden al grupo de zonas de alteración tipo alta sulfidación y epitermal de avanzado grado de denudación, o la parte superior del sistema porfídico.

James et al. (1996) recalca la posibilidad de que parte del área de Castaño corresponda a la prolongación SE de la zona de yacimientos del Valle del Cura, y que los criaderos sean del Terciario (Fig. II-3-2). Entre los criaderos reconocidos en el primer y segundo año de estudio, los pórfidos de El Retamal y Animas, los yacimientos polimetálicos de Castaño Viejo y Castaño Nuevo han sido restituidos dentro de las zonas posiblemente terciarias. Sin embargo, el análisis de K-Ar de las muestras de los diques de alteración tomadas en El Retamal en el primer año arrojó una edad de  $374,5 \pm 6,2$  Ma (Devónico superior), lo cual indica que no todos los criaderos corresponden al Terciario.

Otro área de interés constituye las zonas de alteración Las Burras en el oeste de Manrique, aunque esta vez no se ha podido realizar el reconocimiento. Estas zonas están dentro de la zona de distribución de las rocas volcánicas terciarias y contienen alunita,

Table II-3-2 Summary of survey results of selected hydrothermal alterations, Castano area, Tocota - Colanguil area, and Cordon de la Brea area.

	host rock	alteration	qz. vein	tourmaline occurrence	mineralization expected	maximum Au (ppb)	maximum Cu (ppm)	maximum Mo (ppm)
Castano								
Venezuela	Choiyoi andesitic lava+pyroclastics	zoning: vuggy silica, alunite+ kaolinite > sericite, s/s int. clay, propylite (in alteration fringe)	rare	yes	HS epithermal	65	20	10
dacite stock in Animas	dacite porphyry (Tertiary?)	zoning: qz+sericite+py > qz+s/s int. clay	common	yes	pul-ton-related (mesothermal)	40	80	7
Portezuelo de Amarillo	Choiyoi andesitic lava+pyroclastics	qz+s/s int. clay	common	yes	(survey insufficient)	tr	29	10
Potreriillos	Choiyoi dacite	qz+s/s int. clay			(survey insufficient)	tr	19	6
Vizcachas	Choiyoi rhyolite	potassic (magnetite+K-fel) with phyllic overprint (qz+sericite)	common	yes	porphyry ?	10	3	4
Avestruces	Choiyoi andesitic lava+ pyroclastics, dacite	qz+sericite, qz+s/s int. clay	common	yes	epithermal	5	61	25
Manrique	Choiyoi andesitic lava+ pyroclastics, dacite, limestone	qz+sericite, qz+s/s int. clay	ubiquitous	yes	epithermal	200	44	214
Tocota-Colanguil								
Tocota	Tocota granodiorite, Carboniferous sedimentary rock	qz+tourmaline+arsenopyrite vein, with K-fel selvage	common	abundant	pul-ton-related (mesothermal)	6210 (ore)	2910 (ore)	10 (ore)
Vicunita (El Salado)	dacite porphyry (Tertiary?)	zoning: potassic (magnetite+biotite+K-fel) > phyllic (qz+sericite)	stockwork	no	porphyry	1530	7820	201
Las Aguaditas	Granodiorite (Tertiary?)	qz+tourmaline	common	abundant	pul-ton-related (mesothermal)	3670	230	30
Cordon de la Brea								
Ranchillos	Carboniferous sedimentary rock	qz+sericite	rare	yes	epithermal ? pul-ton-related ? (mesothermal)	95	141	3
Pastos Largos	Granite	qz+tourmaline+epidote+K-fel	ubiquitous, calcite common	yes	pul-ton-related (mesothermal)	20	4130	25

según la literatura existente (González y Sato, 1998). El análisis de los datos de JERS-1 OPS también indica la presencia de la alteración ácida constituida por caolinita o alunita, sugiriendo que sean zonas de alteración asociadas con los intrusivos terciarios de la prolongación sur del Valle del Cura. Estas zonas también han sido identificadas por James et al (1996) como geología discontinua que se extiende desde el Valle del Cura (Fig. II-3-2).

Los criaderos de las áreas de Tocota-Colanguil y del Cordón de la Brea son variados, y llaman especial atención los del tipo porfídico. Dentro del batolito de Colanguil se distribuyen los criaderos con mineralización de oro tipo alta sulfidación y epitermal del Mioceno superior como La Poposa, o los criaderos tipo porfídico como Chita y Vicuña (El Salado) cuya edad se está analizando actualmente. Es probable que existan también los yacimientos tipo porfídico asociados con los intrusivos terciarios.

Además también existen los criaderos asociados con segmentos de las rocas plutónicas ácidas con alteración de turmalina+cuarzo, o los criaderos asociados con chimenea de brechas de turmalina + cuarzo formada en areniscas y fangolitas del Carbonífero. La mineralización observada durante el reconocimiento de campo puede ser clasificada en dos tipos: la mineralización de cobre (San Francisco, parte de El Retamal, Tocota - Dos Amigos y Margarita) y la mineralización de oro (Las Aguatidas, Tocota - Colo-Colo y Krimer). Se observa claramente que la mineralización de algunos de estos yacimientos no se debe al proceso de alteración de turmalina+cuarzo, sino más bien por efecto de las venillas de cuarzo que los cortan (Margarita). En otras palabras, no existe una relación petrogenética entre la alteración de turmalina+cuarzo y la mineralización. Más bien, el segmento de alteración turmalina+cuarzo puede haber servido de corredor de las aguas termales. Se deduce que estos yacimientos son del Pérmico a Triásico, por la edad de las rocas graníticas que son rocas ígneas relativas. Sin embargo, las dioritas que constituyen la roca de caja del criadero Las Aguatidas son terciarias, y es probable que su mineralización sea más reciente. En todo caso, no se ha llegado a esclarecer la edad de los yacimientos durante el estudio.

Como otros criaderos de las áreas de Tocota-Colanguil y del Cordón de la Brea se mencionan la alteración blanca constituida por sericita como son Ranchillos, Pastos Largos y El Fierro. Estas zonas de alteración tienen por caja a las rocas ácidas asociadas con turmalina y se caracterizan por la formación de pequeña cantidad de venillas de cuarzo. Además también se distribuyen los yacimientos vetiformes de oro asociados con las rocas plutónicas como Las Opeñas y los yacimientos polimetálicos como El Salado y El Fierro.

### **3-2-3 Zonas de mineralización del conjunto ordovícico (Pre-Cordillera en La Rioja y San Juan)**

El conjunto ordovícico constituye una geología calificada como "promisoria" en el primer año del estudio. Los intrusivos ácidos del Terciario se extienden frecuentemente hasta la Pre-Cordillera o la Sierra de Pampeanas, y las rocas intrusivas pueden aparecer dentro del conjunto ordovícico. Las calizas de diversos tamaños o los bloques de ofiolita emplazados en este conjunto son susceptibles a las aguas termales, pudiendo dar lugar a la formación de criaderos con altas leyes, como se indicó en el informe del primer año. En esta fase del estudio se realizó el reconocimiento de tres criaderos de San Juan (Corral, Abundancia-Salamanca y Guachi) y el criadero La Criollita de La Rioja, tomando en cuenta que estos se localizan dentro del conjunto ordovícico. En la Fig. II-3-3 se muestra la sección esquemática de estos criaderos.

De las estructuras, zonas de mineralización y de alteración observadas durante el reconocimiento de campo, se deduce que los criaderos asociados con el conjunto





ordovícico se clasifican, a grosso modo, en dos grandes grupos. El primero corresponde a los criaderos fuertemente controlados por las estructuras existentes (fallas, etc.) como Corral y Guachi (Fig. II-3-3a). Los intrusivos terciarios de estos criaderos (Lic. Cardó de SM) son todos pórfidos dacíticos y presentan diques o stock que intruyen a lo largo de las fallas en la superficie. Las zonas de mineralización y de alteración asociadas están controladas por las fallas, y pueden llegar a constituir grandes zonas de alteración identificables en las imágenes de satélite (por ejemplo, Guachi). Estas zonas favorecen la formación de las venillas abundantes en minerales sulfurados, tanto es así que es posible encontrar frecuentemente las venillas de altas leyes de mena en poco tiempo. El segundo grupo corresponde a los criaderos tipo skarn como los que se localizan en Abundancia-Salamanca y La Criollita (Fig. II-3-3b). Sus rocas intrusivas se asocian con granitos que tienen máficos de anfíbol y biotita (en Abundancia-Salamanca se observan parcialmente los pórfidos de la misma combinación de minerales). Las rocas graníticas aparecen formando una masa grande como batolito, y la intrusión se halla poco controlado por las fallas. En las zonas de mineralización tipo skarn se distribuye el skarn de magnetita + granate + epidota +/- hematita con fuerte mineralización de oro y cobre. Estas zonas de mineralización se localizan únicamente en el contacto entre las rocas graníticas y calizas. Las zonas de silicificación cercanas (Criollita) o las zonas de disseminación de pirita silicificada y fina (Abundancia) presentan leyes de oro apenas de varias decenas de ppb. La forma y el tamaño de estas zonas de alteración cercanas se desconocen. En todo caso éstas pueden estar controladas por estratificación u otras estructuras relativamente menores en comparación con las fallas.

Esta diferencia del tipo de mineralización entre los dos grupos puede haberse derivado de la diferencia de la presión de confinación incidida en el sistema hidrotermal. En el caso del primer grupo, ya existían los corredores que permitieron fluir libremente las aguas termales, y las aguas que fueron libradas por el enfriamiento de magma se mezclaron inmediatamente con las aguas meteóricas en un entorno casi hidrostático, permitiendo la penetración de las aguas meteóricas desde la fase temprana de las actividades hidrotermales. En el interior del sistema se produjeron varios lugares donde el entorno ha sido alterado drásticamente (ebullición, dilución, etc.) lo que provocó la acumulación eficaz de los elementos metálicos durante un tiempo relativamente largo. Mientras tanto, en el caso del grupo de los criaderos tipo skarn, no se ha llegado a formar un sistema hidrotermal muy abierto desde el asentamiento hasta el enfriamiento del magma, y se deduce que se ha mantenido durante largo tiempo el entorno casi hidrostático con elevada presión de confinación. Sin embargo, dado que en Criollita se observan también pequeñas masas de rocas hidrotermales no asociadas con sulfuros, lo cual sugiere que a finales del periodo se llegó a formar se un sistema abierto.

De todo lo anterior, se concluye que en el caso de existir la denominada "preparación estructural (structural preparation) en las rocas de cajas susceptibles del conjunto ordovícico, es probable encontrar las zonas de mineralización con elevadas leyes.

### 3-3 Potencial de los yacimientos

En esta sección se hace una evaluación integral de los resultados del reconocimiento de terreno efectuado en dos años, y se entregan algunos comentarios concretos sobre las áreas propensas a exploración. Para los efectos, se seleccionaron los yacimientos relativamente grandes y los criaderos con reservas latentes, aplicando los criterios de clasificación descritos anteriormente. Las áreas sujetas a proyectos de exploración en desarrollo han sido fundamentalmente excluidas.

Los yacimientos de oro tipo bisulfato localizados en Macho Muerto y Valle del Cura tienden a arrojar leyes de oro relativamente alta en la alteración neutra en el borde de la alteración ácida, lo cual constituye objeto de exploración. Las zonas de alteración en la frontera entre Argentina y Chile son más grandes que las zonas del interior, y por ende, el potencial de exploración es mayor. Los yacimientos conocidos de estas áreas como Veladero Norte y El Indio conservan la bonanza en la profundidad de las zonas de alteración, libre de denudación. También por este aspecto se considera que el potencial de desarrollo de los criaderos es alto. Por estos motivos, la zona de alteración Río Frío del Valle del Cura ha sido calificada como una zona de particular importancia desde el punto de vista de exploración. Pese a que el reconocimiento de terreno fue efectuado en una limitada superficie se ha podido verificar la existencia de filones silicificados de Au:0,37g/t y Ag:5g/t, lo que sugiere que los criaderos son ricos en oro y plata. Asimismo la zona de alteración es lo suficientemente grande (7,5 Km X 5Km) que permite ser identificada en las imágenes de satélite. Por lo tanto, se considera como otra zona candidata a exploración. El Cordón de la Inca y el Filo Amarillo-Bordo Atravesado del sistema hidrotermal también constituyen zonas de alteración de interés.

Entre los criaderos del sistema porfídico de Macho Muerto, las zonas de alteración El Potro y La Ollita-Vicuñita también merecen atención. Estos criaderos, pese a su gran tamaño, no han sido estudiados hasta ahora y por lo tanto merecería realizar una exploración.

De los diversos tipos de criaderos y las zonas de alteración existentes en el borde este de la zona de distribución del Pérmico a Triásico, especial importancia revisten los criaderos tipo porfídico asociados con los intrusivos terciarios. En el área de Paramillos (Mendoza) se concentra este tipo de sistema porfídico. Desde el punto de vista del potencial de exploración, son importantes las zonas de alteración de Paramillos Norte - Crestón Amarillo y Cortaderous - San Benicio. Particularmente la primera corresponde a una zona de alteración circular de 5 Km de diámetro identificada en las imágenes de "ratio" de LANDSAT TM a color (Fig. II-3-4); no obstante el área explorada hasta la fecha es muy limitada, y merecería realizar una nueva exploración más completa especialmente en el sector este de la zona. Un estudio detallado fue realizado en una parte del extremo oeste de la zona de alteración denominada Paramillos Norte, en donde fue identificado el sistema porfídico asociado con enriquecimiento secundario. Por lo tanto, se espera encontrar mineralización también en el resto de la zona. También se identifica un sistema porfídico en San Benicio - Cortaderous, aunque sus leyes y el tamaño son menores en comparación con la zona de alteración circular de Paramillos Norte. También ésta constituye una zona de interés puesto que pocos proyectos de exploración han sido efectuados hasta la fecha.

Además de los anteriores, merece mencionar el batolito de Colanguil, donde se distribuyen esporádicamente las rocas intrusivas jóvenes como en el caso de Vicuña, sugiriendo la presencia de criaderos tipo porfídico.

Ateniéndose a este punto, en el estudio de la Cordillera Oriental Andina se efectuó el reconocimiento de El Fierro, Quebrada de Conconta y Quebrada de Potrereros de Pancha con la expectativa de descubrir nuevos criaderos. Sin embargo, en ninguna de las tres áreas se encontró un criadero.

Además del sistema porfídico, merece atención al zona de alteración de Manrique





2600

2800

3000

TM CRC 3/1 4/5 5/7 BGR

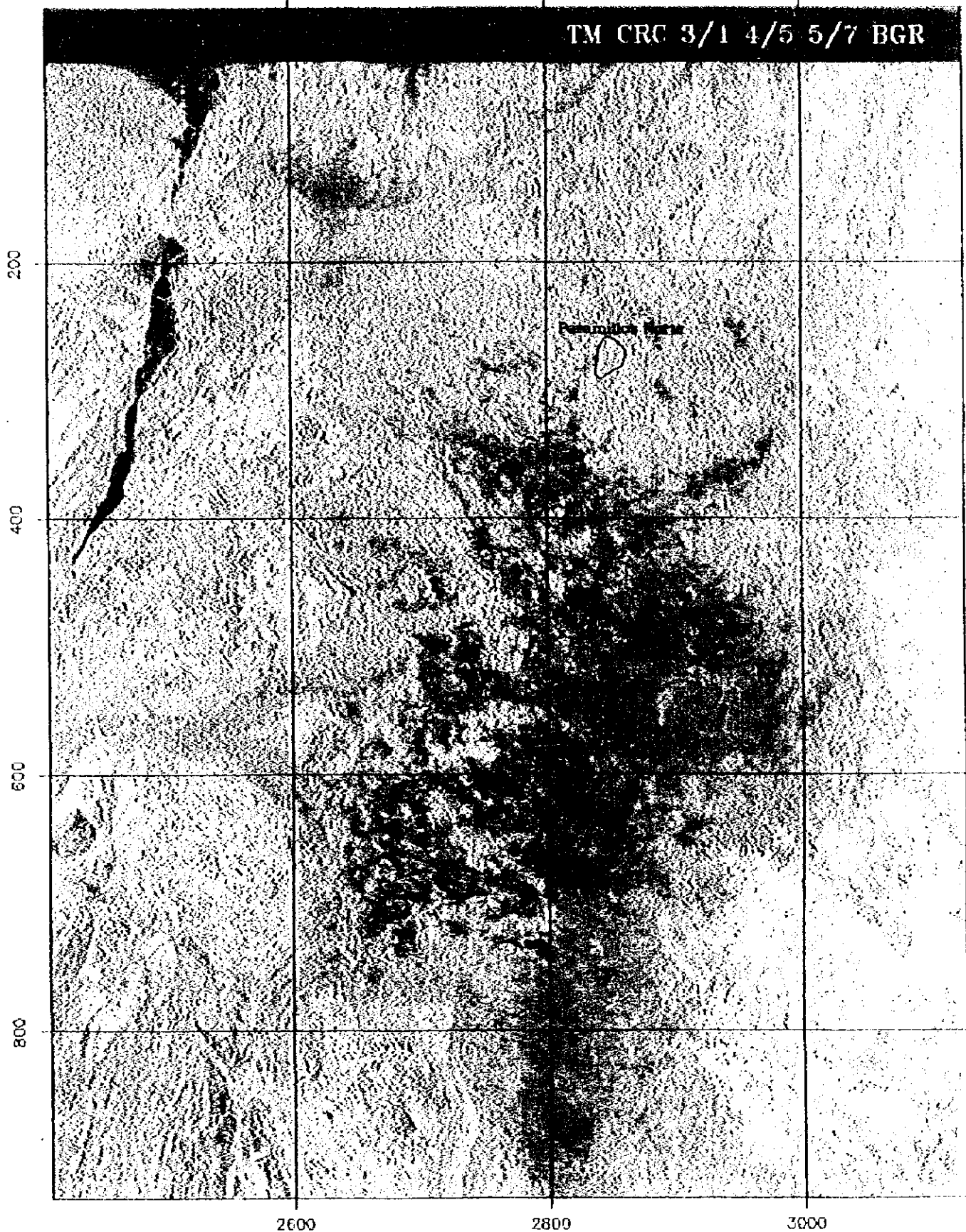


Figure II-3-4 Idealized ore-deposit model of Pre-Cordillera in La Rioja and San Juan



por la reserva potencial de los yacimientos de oro epitermal. Esta es una gran zona de alteración que llega a medir hasta 5,5 Km de largo, y que alberga un criadero con una ley de Au:0,2g/t (ley máxima de 1 g/t según Cardó y Pérez, 1995), por lo que merece ser explorada. El desarrollo de las venillas de cuarzo es más dinámico en comparación con otras zonas de alteración similares del área de Castaño. El análisis de las inclusiones líquidas del cuarzo de venillas indica una Th:200°C ó menos (formación a baja temperatura) y su salinidad es comparable con el sistema de baja sulfidación (<0,3wt-%NaCl), lo cual es un indicio del potencial de la mineralización en la profundidad.

La zona de alteración Las Burras en el oeste de Castaño también merece atención por su reserva potencial de yacimiento de oro tipo alta sulfidación y epitermal del Terciario.

En cuanto al área de distribución del conjunto ordovícico en general, se considera que el potencial de exploración es bajo, con excepción de Guachi donde se efectuó el reconocimiento de el primer año, puesto que no existen zonas de alteración identificables en las imágenes de satélite de escala 1:250.000.

En conclusión, los criaderos y las zonas de alteración que albergan un potencial pero que ahora no están sujetos a ningún proyecto de exploración son las siguientes nueve zonas (Table II-3-3):

La Rioja El Potro, La Ollita-Vicuñita

San Juan Río Frio, Cordón de la Inca, Filo Amarillo-Bordo Atravesado, Manrique y Guachi

Mendoza Zona de alteración circular Paramillos Norte, Crestón Amarillo, San Benicio-Cortadorous

Finalmente se menciona el batolito de Colanguil como una zona prioritaria para descubrir nuevos criaderos. Merece atención la distribución de las rocas igneas intrusivas terciarias. Asimismo, la zona de alteración Las Burras en el oeste de Castaño también constituye una zona que merece ser explorada.







Table II-3-3 Promising groundtruth sites in the Eastern Andean project

Zone*	Area of Groundtruth	Style of Mineralization	Cu contents	Au contents	Dimension	Tertiary Intrusive	Altitude	Access	Reason why selected	Mining Lease	Evaluation
<b>La Rioja</b>											
Zone 1	El Potro	porphyry	0.31%	0.33ppm	9X2.5km	Late Cretaceous	4500-5000m	4x4 vehicle available in summer	Here is well-known Porphyry Au-Cu-Mo mineralized site recognized in Plan-La Rioja, 30years ago. However, it seems that this area has never experienced intensive exploration in spite of its geological potential. The survey team recognized a typical porphyry style alteration and some mineralization.	YAMIRI**	A-
Zone 1	Rio las Tamberias: La Ollita	porphyry (upper part)	370ppm	2.98ppm	20X5.5km (a part)	?	4000-4100m	4x4 vehicle available in summer	These three areas are closely located in the eastern margin of huge alteration of AA6068, and probably cogenetic each other. The most favorable character of these areas is high-gold content. The auriferous porphyry-style mineralization might be encountered at a little more deeper level.	YAMIRI	B+~A-
	Rio las Tamberias: Tamberias		66ppm	(2.92ppm)							
	La Vicunita		(3.29%)	(6.68ppm)							
<b>San Juan</b>											
Zone 1	Rio Frio	epithermal, high-sulfidation	88ppm	(9.9ppm)	7.5X5km	X	4500m	4x4 vehicle available in summer	Both the huge dimension of alteration and high gold value are attractive factors for applying further intensive exploration. Easy access to the Pacific coast. Good target in the Eastern Andean area.	Private	A-
Zone 1	Cordon de la Inca	epithermal, high-sulfidation	22ppm	0.10ppm	8.5x1.5km	?	4200-4500m	4x4 vehicle available	Target of exploration is a neutral pH alteration surrounding acid sulfate alteration core. Limited exploration has been applied.	Private	B+
Zone 1	Filo Amarillo (Cerro Amarillo)	epithermal, high-sulfidation	30ppm	0.065ppm	1.5X0.5km	?	4300-4500m	4x4 vehicle available	Target of exploration is a neutral pH alteration surrounding acid sulfate alteration core. Bordo Atravesado, with fairly large alteration, possibly corresponds to a wide neutral pH fringe of Filo Amarillo. Limited exploration has been applied in both areas.	Private	B~B+
	Bordo Atravesado	high-sulfidation peripheral	960ppm	(0.405ppm)	1.5X0.5km						
Zone 2	Manrique	epithermal gold	44ppm	0.2ppm	5.5X1km	?	3200-3500m	by horse, 20km accessible except winter	Low-sulfidation epithermal gold mineralization can be expected. The vein system and geochemical anomaly are best developed among the white alteration in the Castano area. Fluid inclusion data explains that deeper portion is more promising.	Private	B+
Zone 3	Guachi/Huachi	epithermal style, and possibly porphyry	3.58%	22.8ppm	(5.0x1.7km)	X	3400m	by horse, 7km; accessible except winter	Gold mineralization can be expected. Because of existence of potassic alteration, porphyry system is also possible mineralization to meet. Good exploration target.	Private (mosaic of small mining lease)	A-
<b>Mendoza</b>											
Zone 2	Paramillos Norte	porphyry	(950ppm)	18.14ppm	1.3x1.5km (0.75x0.5km)	X	3100m	4x4 vehicle available, accessible all year around	It is expected that the other porphyry Au-Cu mineralization is found in a circular hydrothermal alteration. There might be an active exploration site in part.	Private	A-
Zone 2	Cortaderas-San Benicio	porphyry? epithermal?	(578ppm)	0.31ppm	(2x1km)	X	3000m+	4x4 vehicle available, accessible all year around	This area clearly shows a porphyry alteration zoning with copper showing. However, limited exploration has been applied.	Private	A-

\*Zone 1: Tertiary volcanic region, along the Chile-Argentina nation boundary      Zone 2: Eastern margin of Permo-Triassic igneous rocks  
 Zone 3: Ordovician horizon in Pre-Cordillera  
 \*\*Mining sector of provincial government of La Rioja. Private company interested in such sites needs to make a joint venture with YAMIRI.



## Tercera Parte



## TERCERA PARTE

### Capítulo 1 Conclusiones

El segundo año del estudio de la Cordillera Oriental Andina incluyó la identificación de los minerales de alteración utilizando los datos de JERS-1 OPS y el reconocimiento en campo.

Al comparar las informaciones recogidas en el reconocimiento en campo con los resultados del análisis, se detectaron los siguientes hechos: (1) en el mapa de análisis de JERS-1 OPS frecuentemente se confunden alunita con caolinita, aunque cuando éstas son englobadas como minerales de alteración ácida, los resultados del análisis son lo suficientemente precisos; (2) las zonas de alteración hidrotermal identificadas relacionadas con sericitización según las imágenes de LANDSAT TM (primer año del estudio) coinciden en la mayoría de los casos con la geología superficial real, y; (3) los resultados del análisis pueden ser falsos en otras áreas que no sean zonas de alteración hidrotermal, especialmente en los cuerpos de agua, lo que plantea la necesidad de verificar su validez comparando con las imágenes de "ratio" o de falso color. Es posible elaborar los mapas detallados de las zonas de alteración si se toman en cuenta los factores mencionados.

Para el reconocimiento en terreno del segundo año se escogió un total de 40 sitios de las siguientes seis áreas: (1) Área de Castaño, (2) Tocota - Colanguil, (3) Criadero La Criollita, (Pre-Cordillera, La Rioja), (4) Cordón de la Brea, (5) Macho Muerto, y (6) Valle del Cura. La mayoría de los yacimientos ubicados en la zona fronteriza con Chile donde predominan las rocas ígneas terciarias (Macho Muerto y Valle del Cura) corresponden a las zonas de alteración de alta sulfidación y epitermales, asociados con los criaderos de oro, según el reconocimiento en campo. En estas zonas de alteración, las venillas de cuarzo de las zonas de alteración neutra formada en el borde de la alteración ácida merecen ser exploradas por presentar una ley de oro relativamente alta. Estas áreas corresponden al Mioceno inferior a medio (Los Mogotes y Filo Amarillo) al igual que la Faja de Maricunga, o al Cretácico Superior (El Potro).

En el borde este del área de afloramiento de las rocas ígneas del Pérmico a Triásico se forman múltiples yacimientos y criaderos como Castaño, Tocota-Colanguil y Cordón de la Brea. Estos incluyen los yacimientos tipo pórfido, yacimientos vetiformes polimetálicos, yacimientos vetiformes de oro, yacimientos de oro o cobre asociados con la roca de caja turmalinizada y cuarcificada. De estos, los yacimientos tipo pórfido con intrusivos relativamente jóvenes, llaman especial atención desde el punto de vista de la exploración. Particularmente, los intrusivos que están dentro del batolito de Colanguil merecen ser explorados, con expectativa de encontrar nuevos criaderos. Con estas bases, se realizó el estudio de dos zonas de sericitización identificada como áreas promisorias según el análisis de JERS-1 OPS, aunque no se llegó a descubrir criaderos. Asimismo, del grupo de las zonas de alteración del distrito de Castaño, calificado como el área promisorio según el análisis de las imágenes de satélite del primer año, llama la atención la zona de alteración Manrique, como posible yacimiento epitermal de oro.

El reconocimiento fue realizado también en el Ordovícico de la Pre-Cordillera (La Criollita) aunque no se llegó a descubrir nuevos criaderos promisorios. Del análisis de las imágenes de satélite no se identifican las zonas de alteración salvo Guachi, y por consiguiente el potencial de este distrito debe ser menor que otras zonas geológicas.

Al integrar los resultados del primer y segundo año, se identificaron las siguientes nueve áreas como promisorias de la Cordillera Oriental Andina donde existen elevado potencial de exploración y se identifican los posibles criaderos de cobre u oro:

- La Rioja Zonas de alteración El Potro y La Ollita-Vicuñita
- San Juan Río Frío, Cordón de la Inca, Filo Amarillo-Bordo Atravesado, Manrique y Guachi
- Mendoza Zona de alteración circular Paramillos Norte, Crestón Amarillo, San

#### **Benicio-Cortadorous**

**Además de los anteriores, las zonas de distribución de las rocas ígneas terciarias que incluyen el batolito de Colanguil (San Juan) y la zona de alteración Las Burras en el oeste del distrito de Castaño también encubren el potencial de descubrimiento de nuevos criaderos.**

## Capítulo 2 Recomendaciones para los futuros estudios

En primer lugar se entregan algunos comentarios sobre la metodología de la exploración en las siguientes nueve áreas calificadas como promisorias.

La Rioja El Potro

San Juan Río Frío, Cordón de la Inca, Filo Amarillo-Bordo Atravesado, La Ollita-Vicuñita, Manrique, Guachi

Mendoza Paramillos Norte, Crestón Amarillo, San Benicio-Cortadorous

Para todas las áreas promisorias es importante realizar la exploración superficial. El trabajo consistiría en realizar muestreo completo de fragmentos de rocas e identificar todos los criaderos sobre la base de un mapa de escala 1:5.000. De ser necesario, se debe efectuar el muestreo en cuadrícula, trincheras y perforación de prueba. Además de este estudio básico, para las zonas de alteración relativamente grandes como Río Frío, Cordón de la Inca, Filo Amarillo-Bordo Atravesado, etc. convendría racionalizar los trabajos utilizando los datos de satélite. La alteración neutra en los bordes de la alteración ácida en estas zonas está frecuentemente asociada con criadero de oro, por lo que la localización de esta parte constituiría la clave de la exploración. La interpretación de los minerales sobre la base de los datos de JERS-1 OPS presenta todavía varios problemas que se debe resolver, pero en lo que concierne a la interpretación de la alteración ácida y neutra específicamente, sus resultados ofrecen cierto grado de precisión. Por lo tanto, antes de realizar el estudio de la superficie, se propone preparar un mapa de escala 1:10.000 (o similar) que permita interpretar cada pixel y determinar previamente las áreas que deberían ser estudiadas con mayor prioridad.

Además de las áreas promisorias mencionadas, se propone realizar más reconocimiento en terreno con miras a descubrir nuevos criaderos, particularmente en las áreas de Tocota-Colanguil y en el batolito de Colanguil. Este último es una gran zona de distribución de granitos, de más de 200 km. de largo (con rumbo S-N), por lo que es mucho más eficiente realizar el estudio utilizando las imágenes de satélite. Sin embargo, es importante tomar nota de que el batolito está asociada ampliamente con sericita (muscovita), y podría confundir las anomalías de la Banda 7 de LANDSAT TM correspondiente al batolito y las anomalías de alteración hidrotermal correspondiente a las rocas intrusivas jóvenes. Como una solución, se recomienda utilizar las imágenes de ratioing para resaltar las zonas de alteración y tener como supervisor al área de Vicuñita (El Salado), para buscar el espectro y características similares a este criadero conocido. En efecto, el único criadero tipo pórfido conocido dentro del batolito de Colanguil es un criadero descubierto recién en la década de los 90, y es probable que sean descubiertas las zonas de similares características geológicas.

Por otro lado, la zona de alteración del oeste de Castaño, incluyendo Las Burras puede estar sobre la prolongación sur del Valle del Cura, aunque estos sitios son difíciles de acceder. Es importante conocer de antemano la posibilidad de descubrir y las características generales de la alteración a través de un estudio preliminar.



























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Table II-1-1 Legend of a comprehensive interpretation map.

Legend	
<u>Geology and Geologic Structure</u>	<u>Geography</u>
 geologic boundary	 major river
 hydrothermal alteration	 lake
 lineament, joint (broken line: not sure)	 national major road
 lineament of thrust fault	 provincial major road
 circular structure (broken line: not sure)	 minor road
 bedding (low/ moderate/ high inclination)	 rail way
 anticline	 city, town, village
 syncline	 nation boundary
 overturned anticline	 crowd coverage
 overturned syncline	
 cauldron, volcanic pit	
 <u>Hydrothermal Alteration</u>	
 area of JERS-1 OPS data analysis	
<b>AA1001</b> number of hydrothermal alteration	
 atunite dominant alteration detected by JERS-1 OPS data	
 Kaolinite dominant alteration detected by JERS-1 OPS data	
 Sericite dominant alteration detected by JERS-1 OPS data	

## Lithology

Unit	Photo-characteristics		Drainage		Rock Resistance	Bedding	Inferred Lithology (Correlation to published geologic maps)
	Tone	Texture	Pattern	Density			
Qa	gray, grayish white	fine	meandering	very low	very low	-	Unconsolidated sediments composed of gravel, sand, and silt (Quaternary: recent alluvial deposits)
Qd	yellow	medium	-	-	very low	-	Unconsolidated sediments mainly composed of sand (Quaternary: eolian deposits)
Qe	white, bluish white	fine	-	-	very low	-	Unconsolidated evaporated sediments (Quaternary: Marshy sediments)
Qf	light purple, gray	fine	distributary	medium to high	very low	-	Unconsolidated sediments composed of gravel, sand, etc. (Quaternary: composite fan deposits)
Qg	blue	fine	-	-	very low	-	Glacial deposits (Quaternary: glacial deposits)
Qv	dark gray, brown	medium	radial	low	medium to high	almost massive	Recent volcanic products (Quaternary: stratovolcanos composed of andesite and basalt)
Pt	reddish brown	fine	parallel	very low	very low	-	Unconsolidated sediments composed of laterized gravel, sand, silt (Pleistocene: talus deposits)
Psf	purplish gray	coarse	parallel	high	medium	-	Unconsolidated composite fan deposits composed of gravel, sand, etc. (Pleistocene)
Plv	dark purple, brown	medium	radial	low	medium to high	almost massive	Relatively young lavas (Pliocene: stratovolcanos composed of andesite and basalt)
Pls	light purple, gray	fine	pinnate, parallel	high	low to medium	partly bedded	Fine to medium-grained brittle sedimentary rocks (Upper Pliocene: conglomerate, sandstone, mudstone, etc.)
Pisf	purplish gray	coarse	parallel	high	medium	-	Composite fan deposits composed of gravel, sand, etc. (Pliocene)
Pli	light gray, light purple	coarse	pinnate	high	low	densely bedded	Fine to medium-grained brittle sedimentary rocks (Lower Pliocene: sandstone, mudstone, etc.)
MiPI	bluish green gray	medium	dendritic	high	medium	partly bedded	Andesitic, rhyolitic, and basaltic volcanic rocks (Miocene to Pliocene: volcanic rocks)
Mis	light purplish gray, grayish white	fine	pinnate, parallel	high	medium	well bedded	Fine to medium-grained sedimentary rocks (Upper Miocene: conglomerate, tuffaceous sandstone, mudstone, etc.)
Mim	dark greenish blue	fine	pinnate	high	medium	partly bedded	Fine to medium-grained sedimentary rocks (Middle Miocene: sandstone, conglomerate, mudstone)
Miv	dark gray, gray	fine	pinnate	medium	medium	-	Volcanic rocks (felsic?) (Middle Miocene: dike rocks, effusive rocks, etc.)
Mii	greenish gray, yellowish gray	fine	pinnate	medium	medium	-	Intermediate volcanic rocks (Lower Miocene: effusive rocks etc.)
Mimv	greenish brown	coarse	pinnate, dendritic	low to medium	high	-	Volcanic rocks (Middle Miocene: acidic volcanic rocks)
Mi	gray	fine	pinnate	medium	medium	almost massive	Fine to medium-grained sedimentary rocks (Miocene: gravel, sand, silt, ignimbrite, etc.)
OI	dark green	fine	pinnate, trellis	high	medium	partly bedded	Fine to medium-grained sedimentary rocks (Oligocene: sandstone, conglomerate, mudstone, andesitic volcanic breccia, etc.)
OIMiv	dark green	fine	pinnate, trellis	high	medium	partly bedded	Volcanic and pyroclastic rocks (Paleocene to Miocene: acidic volcanic rocks, etc.)
Ev	brownish blue, dark grayish blue	coarse	dendritic	high	low to medium	partly bedded	Volcanic and pyroclastic rocks (Paleocene to Eocene: continental lava, ignimbrite, sandstone, agglomerate, etc.)
PaEo	bluish purple	fine	dendritic	high	medium	-	Acidic volcanic rocks (Paleocene to Eocene: rhyolitic, basaltic lavas)
KTv	brownish blue, dark grayish blue	coarse	dendritic	high	low to high	partly bedded	Volcanic and pyroclastic rocks (Upper Cretaceous to Lower Tertiary: andesitic/rhyolitic lava, volcanic breccia, ignimbrite, etc.)
Ks	greenish gray	medium	pinnate, dendritic	high	medium	partly bedded	Medium to coarse grained sedimentary rocks (Upper Cretaceous: andesite, dacite, etc.)
K	dark greenish gray, yellowish brown	medium	sub-dendritic	high	low to medium	bedded	Medium to coarse-grained sedimentary rocks (Cretaceous: sandstone, conglomerate, mudstone, etc.)
Km	bluish green	coarse	dendritic	medium	high	-	Medium to coarse-grained sedimentary rocks (Middle Cretaceous: sandstone, conglomerate, etc.)
Ki	light brown	fine	pinnate	medium	low to medium	bedded	Fine to medium-grained sedimentary rocks (Lower Cretaceous: sandstone, mudstone, siltstone, conglomerate, limestone, etc.)
Kia	bluish brown	fine	dendritic	very high	low	-	Volcanic rocks (Lower Cretaceous: andesitic, dacitic, volcanic breccia, etc.)
Kib	whitish yellow	coarse	parallel	medium	medium	-	Fine to medium-grained sedimentary rocks (Lower Cretaceous: sandstone, calcareous sandstone, etc.)
Js	dark brown, brown	coarse	dendritic, sub-parallel	medium	medium to high	partly bedded	Medium to coarse-grained sedimentary rocks (Upper Jurassic: conglomerate, sandstone, andesitic volcanic breccia, etc.)
J	brown	medium	dendritic, pinnate	medium to high	medium to high	sparse	Fine to medium-grained sedimentary rocks (Jurassic: conglomerate, sandstone, tuff, etc.)
Ja	brown	coarse	dendritic	medium	medium	-	Medium to coarse-grained sedimentary rocks (Jurassic: sandstone, calcareous sandstone, etc.)
Jb	greenish brown, yellowish gray, brownish gray	fine to medium	pinnate	medium	medium to high	partly bedded	Volcanic sedimentary rocks, fine to medium-grained sedimentary rocks (Jurassic: andesitic tuff, conglomerate, sandstone, siltstone, etc.)
Jv	brownish blue, dark grayish blue	coarse	pinnate, dendritic	high	medium	partly bedded	Volcanic and pyroclastic rocks (Jurassic: andesitic tuff, lava, etc.)
Ji	light brownish gray	fine	pinnate	high	medium	bedded	Fine to medium-grained sedimentary rocks (Jurassic: sandstone, calcareous sandstone, limestone, mudstone, etc.)

Trs	gray, whitish gray	fine	dendritic	medium	low	partly bedded	Fine to medium-grained sedimentary rocks (Upper Triassic: continental sandstone, mudstone, intermediate tuff, etc.)
Trv	purplish brown	fine	dendritic	high	medium	partly bedded	Volcanic rocks (Upper Triassic: effusive rocks)
Trms	dark blue, purplish brown	fine to coarse	pinnate, dendritic	high	medium to high	partly bedded	Fine to medium-grained sedimentary rocks and volcanic rocks (Middle to Upper Triassic: sandstone, conglomerate, mudstone, and volcanic rocks)
Tr	brown, brownish gray	medium	pinnate	high	medium	partly bedded	Fine to medium-grained sedimentary rocks (Triassic: sandstone, conglomerate, siltstone, volcanic rocks, etc.)
Tre	grayish green	fine	sub-dendritic	low	medium	partly bedded	Fine to medium-grained sedimentary rocks (Triassic: continental sandstone, mudstone, etc.)
Trd	light yellowish brown	coarse	pinnate, sub-trellis	high	high	well bedded	Fine to medium-grained sedimentary rocks (Triassic: continental sandstone, mudstone, etc.)
Trc	purplish gray, green	fine	trellis	medium	low	partly bedded	Medium to coarse-grained sedimentary rocks (Triassic: continental sandstone, mudstone, etc.)
Trb	light purplish gray	medium	dendritic	medium	medium	-	Medium to coarse-grained sedimentary rocks (Triassic: continental sandstone, mudstone, etc.)
Tra	purplish gray, dark green	medium	dendritic	low	medium	partly bedded	Medium to coarse-grained sedimentary rocks (Triassic: continental tuffaceous sandstone, black mudstone, conglomerate, etc.)
Trm	blue, dark blue, yellowish white	coarse	parallel, dendritic	high	low to medium	partly bedded	Medium to coarse-grained sedimentary rocks (Middle Triassic: continental sandstone, conglomerate, intermediate tuff, etc.)
Tri	yellowish gray, white, greenish gray	medium	dendritic	high	medium	bedded	Fine to medium-grained sedimentary rocks (Lower Triassic: continental sandstone, conglomerate, acidic tuff, etc.)
PTrv	light brownish gray	medium	dendritic	medium	medium	massive	Volcanic rocks (Upper Permian to Triassic: volcanic rocks)
Ps	brownish gray, purplish brown	coarse	pinnate, dendritic	high	medium to high	partly bedded	Fine to medium-grained sedimentary rocks (Upper Permian: continental quartzose sandstone, conglomerate, etc.)
Psv	green, yellowish green	coarse	pinnate, trellis	high	medium	-	Volcanic rocks (Upper Permian: acidic to intermediate volcanic rocks)
Psvb	green, greenish gray	coarse	dendritic	very low	high	-	Volcanic rocks (Upper Permian: acidic porphyry)
Psva	greenish brown	medium	pinnate	medium	medium to high	partly bedded	Volcanic rocks (Upper Permian: dacite, rhyolite)
Pmv	reddish brown, dark green	coarse	dendritic	high	medium	partly bedded	Intermediate volcanic rocks (Middle Permian, andesite, dacite)
P	yellowish brown, light yellowish gray	coarse	pinnate, sub-trellis	medium	medium to high	partly bedded	Fine to medium-grained sedimentary rocks (Permian: continental quartzose sandstone, conglomerate, etc.)
Piv	dark blue	medium	dendritic	medium	medium	massive	Volcanic rocks (Lower Permian: volcanic rocks)
CTr	purplish brown	medium	parallel	medium	medium	-	Volcanic rocks (Carboniferous to Triassic: tuff, volcanic breccia, etc.)
CTrv	brownish purple	medium	dendritic	high	medium	massive	Volcanic rocks (Carboniferous to Triassic: tuff, volcanic breccia, lava, ignimbrite, etc.)
CP	brown	coarse	pinnate	high	medium	almost massive	Fine-grained sedimentary rocks (Carboniferous to Permian: mudstone, slate, sandstone, conglomerate, limestone, etc.)
CPb	reddish brown	coarse	dendritic	medium	high	partly bedded	Fine to medium-grained sedimentary rocks (Carboniferous to Permian: continental sandstone, etc.)
CPa	bluish brown	medium	dendritic	medium to high	medium	partly bedded	Fine to medium-grained sedimentary rocks (Carboniferous to Permian: continental sandstone, etc.)
Csv	dark brown	medium	sub-trellis	medium	medium to high	partly bedded	Volcanic rocks (Upper Carboniferous: porphyry, agglomerate, volcanic breccia, andesite lava, etc.)
Cs	light pinkish gray	coarse	trellis	medium	medium to high	bedded	Medium-grained sedimentary rocks (Upper Carboniferous: sandstone, mudstone, volcanic breccia, etc.)
Ci	light brown	coarse	trellis	medium	medium	bedded	Medium to coarse-grained sedimentary rocks (Lower Carboniferous: conglomerate, sandstone, etc.)
Dc	purplish brown	fine	dendritic	low	medium to high	partly bedded	Coarse-grained sedimentary rocks (Devonian to Carboniferous: sandstone, mudstone, conglomerate, etc.)
Ds	purplish brown, dark bluish brown	medium	trellis, parallel	medium	medium to high	partly bedded	Fine to medium-grained sedimentary rocks (Upper Devonian: sandstone, mudstone, etc.)
D	purplish brown	coarse	dendritic	medium	medium	-	Medium to coarse-grained sedimentary rocks (Devonian: marine sediments)
Di	dark purple	fine	trellis	medium	high	partly bedded	Medium-grained sedimentary rocks (Lower Devonian: mudstone, sandstone, etc.)
SD	purplish brown	medium	trellis	high	medium to high	partly bedded	Fine to medium-grained sedimentary rocks (Silurian to Devonian: sandstone, conglomerate, etc.)
S	light purplish brown	coarse	pinnate	high	low	partly bedded	Fine-grained sedimentary rocks (Silurian: mudstone, etc.)
Os	purplish brown	coarse	trellis	high	high	almost massive	Fine-grained sedimentary rocks (Upper Ordovician: sandstone, mudstone, etc.)
Osc	light brownish gray	medium	pinnate	medium	medium	partly bedded	Fine-grained sedimentary rocks (Upper Ordovician: limestone?)
O	gray to white	medium	-	high	medium	-	Fine-grained sedimentary rocks (Ordovician: marine sediments)
Oim	purplish brown, light pinkish gray	coarse	dendritic	high	medium to high	almost massive	Fine-grained massive sedimentary to metamorphic rocks (Lower to Middle Ordovician: meta-sedimentary rocks, volcanic rocks)
Oi	light pinkish gray	fine	trellis	medium	very high	almost massive	Medium-grained sedimentary rocks (Lower Ordovician: phyllite, schist, limestone, etc.)
Oiv	purplish brown	coarse	dendritic	medium	medium to high	almost massive	Fine to medium-grained sedimentary rocks (Lower Ordovician: meta-sedimentary rocks, volcanic rocks)
Es	grayish white, light brownish gray	medium	pinnate, trellis	high	high	-	Medium to coarse-grained sedimentary rocks (Upper Cambrian: limestone, dolomite, chert, etc.)

Pzm	dark blue	medium	dendritic	high	very high	massive	Medium-grained meta-sedimentary rocks (Paleozoic: schist, meta-sandstone, gneiss, etc.)
PRs	bluish gray, grayish white	coarse	dendritic	high	high	-	Sheared metamorphic rocks (Proterozoic: quartzite, calcareous, etc.)
PRm	purplish brown	coarse	dendritic, rectangular	high	very high	massive	Medium-grained sedimentary rocks (Proterozoic: gneiss, schist, etc.)
PR	brown, greenish brown, purple	coarse	dendritic	high	high	-	Sheared metamorphic rocks (Proterozoic: gneiss, schist, etc.)
$\gamma t$	light grayish white	coarse	dendritic	high	high	-	Felsic igneous rocks (Tertiary: undivided granitic rocks)
$\alpha m$	yellow, brown	medium	dendritic	medium	medium	-	Intermediate volcanic rocks (Late Triassic: intrusive rocks at the bottom of volcano)
$\beta m$	dark purple	coarse	parallel	medium	medium	massive	Mafic igneous rocks (Triassic: basalt)
$\gamma m$	light brownish gray	medium	dendritic	medium	high	-	Felsic igneous rocks (Permian/Triassic: undivided granitic rocks)
$\delta p$	yellow, brown	medium	pinnate	medium	medium	-	Volcanic rocks (Middle Permian: rhyolite)
$\gamma pd$	gray	medium	-	-	very high	-	Dyke rocks in $\gamma p$
$\rho p$	brown	fine	dendritic	medium	very high	-	Felsic igneous rocks (Permian: porphyritic rocks)
$\gamma p$	light grayish white	coarse	dendritic, rectangular	high	very high	-	Felsic igneous rocks (Silurian/Devonian; undivided granitic rocks)
$\sigma Pb$	light green, purplish brown	coarse	pinnate	high	medium	-	Mafic igneous rock (Paleozoic: gabbro, diorite)
$\sigma Pa$	bluish gray	fine	pinnate	medium	high	-	Mafic igneous rocks forming annular structure (Paleozoic: peridotite, serpentinite)
$\gamma pr$	purplish brown, light greenish brown	coarse	dendritic, trellis	high	very high	-	Felsic igneous rocks (Proterozoic: undivided granitic rocks)

## Alteration

Number of Alteration	Lithology observed	Dimension (km)	Elongation	Intensity of alteration*	Structure Texture	Alteration Mineralogy mapped by JERS-1 OPS Data	Prospect included
AA6025	Miv	8X2.5		2	lineament (NNE-SSW, NNW-SSE)		Veradero Sur
AA6026	Miv	3X3		2			Los Desdoblados
AA6027	Miv	2X1		2	Intrusive		
AA6028	Miv	1.5X1		2			
AA6030	Ps/Triv	7.5X4		2	lineament (NNW-SSE)		Cerro Colorada, Veladero Centro
AA6031	Ps/Triv	6X3		2			
AA6032	γp, Ps/Triv	18X5		2	lineament (N-S)	In northern central, Kao zone is located with small Alu zone in the NW, Alu zones are distributed in four zones at the northern area and four Ser zones are scattered in north east end and west edge of northern central area	La Ortiga
AA6033	γp	6X3		2			Nevada (Chile), Lama
AA6035	γp	2.5X0.5	N-S	2			Los Amarillos
AA6036	γp	12X3	NNW-SSE	2	lineament (N-S)		Manifestation NN
AA6037	γp	2.5X1.5		2		Kao predominates in the west and Alu predominates in the east	
AA6038	Mim, γt	4.5X1.5		2	lineament (NNW-SSE)	Small Kao zone is located at the north end with very small Alu zone while Alu zone with small Ser and Kao zone is located in the south	
AA6043	Mim	2X1		1		Long narrow Alu zone is located in N-S direction, surrounded by three Kao zones and Ser zone in the peripheral	
AA6045	Mim	0.5X0.5		1	argillitic intrusive or playa		
AA6047	Ps/Triv	1.5X1.5		2	lineament (N-S)	Kao area predominates in central and surrounded by Ser zone. Small Alu zone is located in the south end	
AA6048	Mim	1.5X0.5		1	playa (?)		
AA6051	γp, OIMiv	6X5		1		Alu zones are distributed in 6 zones, one in northern edge is along with small Kao and Ser zone, small Kao area is located besides second one from north	
AA6052	OIMiv	1.5X0.5		1		Alu predominates	
AA6053	OI/OIMiv	2X1		2	lineament (NW-SE)	Alu predominates in northern part while Ser predominates in southern area	Rio de la Flecha
AA6054	γt	1.5X0.5		2	lineament (NNE-SSW)	Kao predominates and Ser zone is located in eastern edge	
AA6055	OI/OIMiv	8.5X1.5	NE-SW	2		Three zones are distributed. Kao area is surrounded by Ser in the east and surrounded by Alu in the west, while the other is pure Kao zone	Cordon de la Inca
AA6056	γt	1.5X0.5	NE-SW	2	Intrusive	Alu zone is surrounded by Kao, Ser zone is located in the western edge	Cerro Amarillo
AA6057	OI/OIMiv	0.5X0.5		2	circular structure, lineament (NE-SW)	Ser is distributed in the NE edge in NW-SE direction	
AA6058	γp	4X1.5		2		Alu predominates in northern area and Kao predominates in southern area	Los Mogotes
AA6059	γp	1.5X1		2	lineament (ENE-WSW)	Ser predominates in center	Ranchillos
AA6060	Cs	3X1.5		2		Ser zones are distributed besides Goe zones	Las Sapitos
AB6001	DC	0.5	N-S	1	N-S		Umango
AA6063	γp, OIMiv	9X2.5		2		Zonal distributions of Alu in northern central and Kao in southern central, small zone of Kao in northern edge and those of Kao and Alu in western area	El Potoro
AA6064	γp, OIMiv	3X1.5		2	lineament (NE-SW)	Zonal distribution of Kao in northern area	
AA6065	OI/OIMiv	3.5X1		1	lineament (NE-SW)		
AA6066	Qv	2X1.5		2		Kao predominates in southern area and small Alu areas are distributed in northern edge	Rio Blanco
AA6067	Qv	1X0.5		2	Intrusive	Kao predominates while small Ser zone in center and Alu zone in western edge	
AA6068	γp, Tv	20X5.5	NE-SW	2	lineament (N-S)	Kao predominates in several scattered areas in center, Alu and Ser zone is distributed in north-eastern and western area	Cerro Colorada, La Olita
AA6073	Cs	5X1	NNE-SSW	2	lineament (NE-SW)	Clear Alu zone in northern edge. Ser and Alu areas are distributed in southern area	Carnerito
AA6074	Cs	1X0.5		2			
AB7001	Ds	1.5X0.5	NE-SW	2	lineament (NNW-SSE)		
JE101	ρt	7.5X5	N-S	2	lineament (N-S)	Kao predominates in most of the area	Rio Frio
AA7043	γp, Oimiv	4X3.5	E-W	2		Kao predominates in most of the area and Ser zones are located in north- and west-end	Del Carmen (Carmen Norte)
JE102	γp	4X1	N-S	2		Kao predomates the area with Ser fringe. Alu appears at NE corner	



JE103	yp	6X2.5	N-S	2		Kao predominates the area with Ser fringe	
JE104	yp	1.5X0.5	NW-SE	1		Kao predominates	
JE105	yp	1.5X1	N-S	1		Kao predominates	
AA7048	yp,Qf	2X1.5	E-W	0.5			
AA7047	yp	3.5X2	N-S	0.5			
AA7049	yp	9X3	NNW-SSE	1			Las Openas
AA7050	CPb	2X1.5	E-W	1		Kao predominates in central with very small Alu zones at the north	(weathered granite w/ muscovite)
AA7051	yp	2X1	NNW-SSE	1		Ser predominates	
JE106	Cpa	0.5		1		central Kao with Ser fringe	(weathered granite w/ muscovite)
AA7052	CPb	2X1	NW-SE	2		Kao predominates	
AA7053	CPb	3X1.5	NNW-SSE	2			
AA7054	CPb	3.5X1.5	N-S	0.5			Quebrada de Pismanta
AA7055	CPb	2.5X1.5	WNW-ESE	1	circular structure	Kao zones are located in north and south	La Poposa
AA7056	ym	5.5X5	N-S	2	lineament (NW-SE, N-S)	Ser zones are distributed in three parts in which small Kao zones are located	
AA7057	Cpa,CPb	1.5X0.5	N-S	1		Kao predominates in central small area with small Ser zones	
AA7058	yp,CPb	3X1.5	NNW-SSE	1		Goe zones are distributed with small Kao zone	
AA7059	am	5.5X2	N-S	1		Kao predominates in central area surrounded by Ser zones	Guanaqueros
AA7060	yp	1.5X1	NNW-SSE	1	circular structure		San Francisco de los Andes
AA7061	Psva	1.5X1	N-S	1		Kao predominates surrounded by Ser areas	
AA7062	Psva	5X1.5	ENE-WSW	1		Kao predominates in northern area and Ser predominates in southern area	
AB8001 (AA7054)	Ps,am	6X1.5	N-S	2	circular structure	Ser and Kao distributes. Ser predominates in western half	El Retamal
AA7065	yp	2X1	N-S	2		Alu predominates with small two Kao zones surrounded by Ser zones in the north	
AA7066	am	5X2	N-S	2	circular structure, lineament (NW-SE)	Kao predominates in western area while Ser zones are located in the east	Avestruces
AA7067	am	3.5X1.5	N-S	2	margin of circular structure	Ser zones are located in two areas	Portezuero de Amarillo
AA7068	Trv	2.5X1.5	WNW-ESE	2	circular structure	Kao predominates in south and Ser predominates in north	Venezuera
JE107	Trv			2		Aggregate of smallish Ser alteration crotts	Potrerosillos
AA7069	yp	5.5X1	ENE-WSW	2	lineament (N-S, NW-SE), circular structure	Ser zone is located from west to NE with small three Kao zones in the west	Manrique
AA7070	Psva	5X1	N-S	1	lineament (N-S, E-W)	Kao predominates northern area and Ser predominates in the south	Portezuero Las Burras
AA7071	am	1X0.5	NNE-SSW	2		Ser predominates	
AA8054	Ps	2.5X0.5	NW-SE	1	lineament (N-S, NW-SE)	Kao predominates with small Goe zone in center and small Ser zone in NE edge	
AA8070	Ps,yp,Trv	4X3	E-W	2			
AA8057	OIMiv	1X0.5	NNE			Ser predominates in the south and Kao predominates in the north with very small Alu zone	
AA8010	yp	2X1.5	N-S	2	intrusive	Kao predominates with small two Ser zones in the SE	
AA8011	yt	2X1.5	NE-SW	2	intrusive	Kao predominates with small two Ser zones in the north and south, and Goe zones are located in the edges of east and west	
AA8012	yt	2X1.5	NE-SW	2		Kao predominates with Ser zones in northern to western edge	Rincones de Araya
AA8013	yt	1X0.5	NW-SE	2		Kao predominates with small Ser zone in the southern edge	
AA8014	yt	2.5X1.5	NNW-SSE	2		Kao zone is located from NW to SE along with Ser zone	
AA8015	yt	3X2	NE-SW	1	circular structure		
AA8016	Ps	1.5X0.5	N-S	2	lineament (NNW-SSE)	Two areas divided to Ser zone and Kao zone	
AA8020	yt	3.5X2	WNW-ESE	2	lineament (NNW-SSE), Intrusive	Kao predominates with Ser zone in east and south edge	El Alter, Rincon del Cenicero
AA8022	Jb	2X1.5	WNW-ESE	2		Kao predominates with Ser zone in the western edge	
AA8023	yt	2.5X1.5	NE-SW	2		Ser zone runs from NEE to WSW in which small Kao zone is located	
AA8025	Ks	6X2	ENE-WSW	2	circular structure lineament (NNW-SSE)	Kao predominates with Ser zone in SE	El Pachon
AA8028	Mii	3X1.5	NE-SW	2		Ser zones are located in the peripherals	Yunque
AA8030	Mii	2X1.5	WNW-ESE	2	circular structure	Small Kao zone in the west	
AA8049	Ks,Mipl	4X2.5	N-S	2	circular structure		El Indio
AA8058	yt	2X1	NNW-SSE	2	intrusive	Ser predominates with Kao zone in the north to west peripherals	

AA8059	$\gamma t$	2X1	E-W	1	circular structure (a little vague)		
AA8060	Ps	1.5X1	NNE-SSW	1		Kao predominates with Ser zone in the peripherals	
AA8061	$\gamma t$	4X1	NE-SW	2		Kao predominates with Ser and alu zones in the peripherals	
JE108	$\gamma t$	1.2X0.5	E-W	1		Ser predominates	
AA8062	Olmiv	3X1	N-S	1	lineament (N-S)	Kao and Ser zones runs from S to N	
AA8066	$\gamma p$ Ps	5.5X2	ENE-WSW	2			
AA8067	Trs	5X2	N-S	1			
AB7003	Cs	1.5X0.5	N-S	2	lineament (NE-SW, N-S)		Guachi, Las Tolas
AA8056	Trv	2X1.5	NNE-SSW	2	circular structure	Ser predominates	
AA8063	Ps	1.5X1	ENE-WSW	0.5			
AA8064	Ps	1X0.5	E-W	0.5			
AA8065	Ps	4X1.5	NNW-SSE	0.5			
AA8070	Ps, $\gamma p$ , Trv	4X3	E-W	2	circular structure	Ser zones are scattered in three areas	
AB8003	$\gamma p$	4.5X1	NNW-SSE	2			Alcaparossa
AB8004	Ps	2.5X2	E-W	1			
AB8005	Ps	2X0.5	NE-SW	0.5		Small Kao zone with Ser zone to the south	
AB8006	Ps	2X1	E-W	2			Leoncito
AB8007	SD	1X1		1			Cerro Blanco Alteration
AB8008	PR	2.5X1	NE-SW	2			La Negrita, Cortaderas, San Benicio
AB8009	S	1X0.5	NE-SW	2	circular structure		Paramillos Norte
AB8010	S	1X0.5	E-W	2	circular structure		Creston Amarillo
AB9004	C	<0.5		2	center of circular structure		Paramillos Sur

\*: Point 2, hydrothermal alteration with high confidence level; pts.1, possibly hydrothermal alteration; pts.0.5, possibly mis-understanding for weathering or other clayey feature.

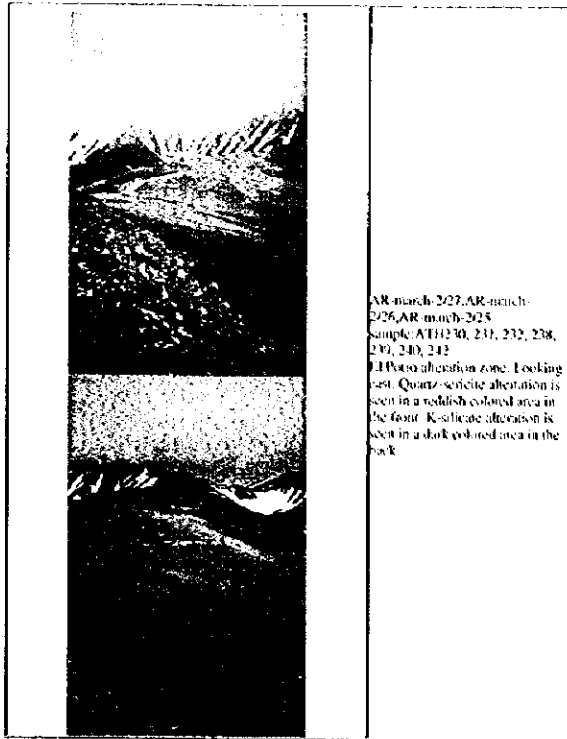


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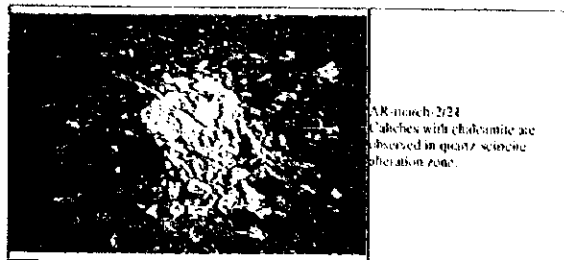


# Eastern Andes Area Image Library

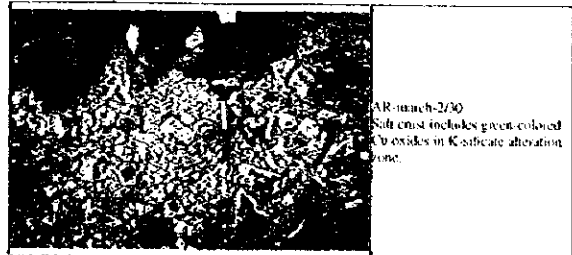
## El Potro area



AR-march-227, AR-march-226, AR-march-225  
 Sample: AH130, 231, 232, 238, 239, 240, 242  
 El Potro alteration zone. Looking east. Quartz-sericite alteration is seen in a reddish colored area in the foreground. K-sulfate alteration is seen in a dark colored area in the rock.

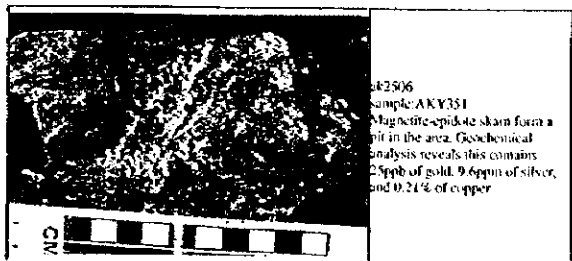


AR-march-224  
 Calcites with chloromitic are observed in quartz-sericite alteration zone.

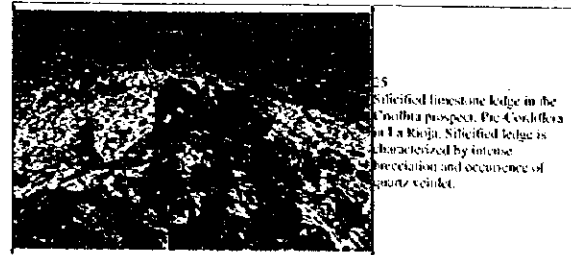


AR-march-230  
 Sulf crust includes green-colored Cu oxides in K-sulfate alteration zone.

## Criollita area

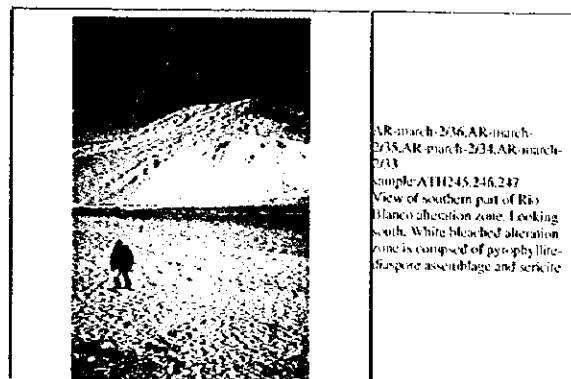


AR2506  
 sample: AKY351  
 Magnetite-epidote skarn form a pit in the area. Geochemical analysis reveals this contains 25ppb of gold, 9.6ppm of silver, and 0.21% of copper.

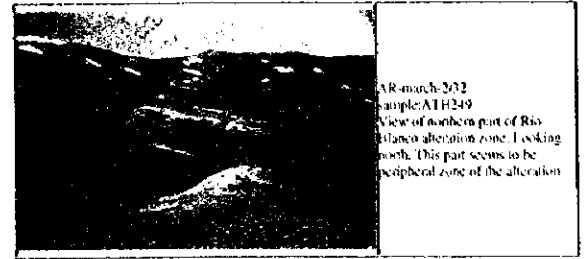
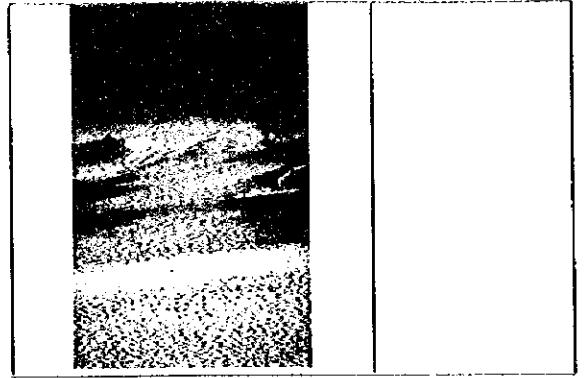
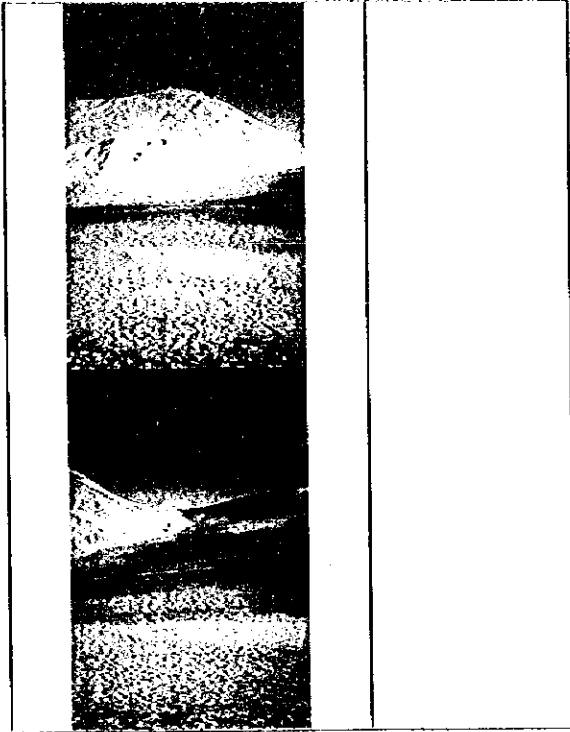


AR-march-225  
 Silicified limestone ledge in the Cuchilla prospect, Rio Criollita in La Rioja. Silicified ledge is characterized by intense brecciation and occurrence of quartz veins.

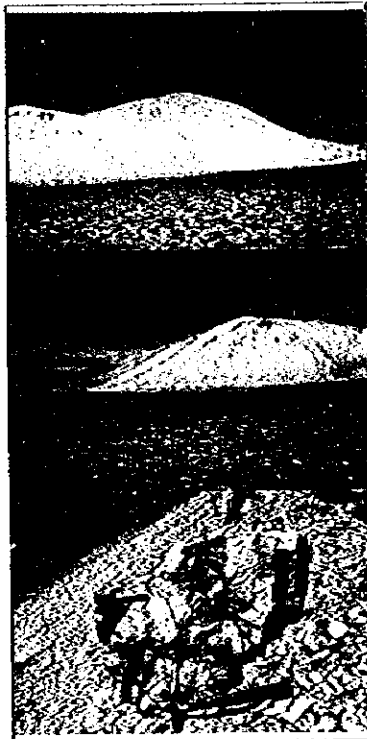
## Rio Blanco area



AR-march-206, AR-march-205, AR-march-204, AR-march-203  
 sample: AH1245, 246, 247  
 View of southern part of Rio Blanco alteration zone. Looking south. White bleached alteration zone is composed of pyro-phylite-fluopore assemblage and sericite.



AR-march-2022  
sample:ATH249  
View of northern part of Rio  
Blanco alteration zone. Looking  
north. This part seems to be  
peripheral zone of the alteration

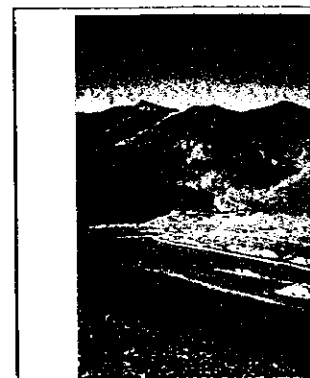


40, 41, 42  
sample ASM220  
Overview of the Rio Blanco  
prospects, Macho Muerto area  
(Plate 40 and 41). A dacitic lava  
dome (right higher hill) intrudes  
into andesitic lava and  
pyroclastics (left, lower hill). Plate  
42 shows occurrence of quartz  
vein (ASM220). Au: 20ppm, Ag: 11,  
Cu: 50ppm). Dark gray silica  
vein network without sulfides are  
hosted in highly silicified  
andesitic rock. Fluid inclusion test  
of vein quartz shows a range of  
homogenized temperature 230 to  
262 °C with salinity of 2.9 to 3.8  
wt-%NaCl.

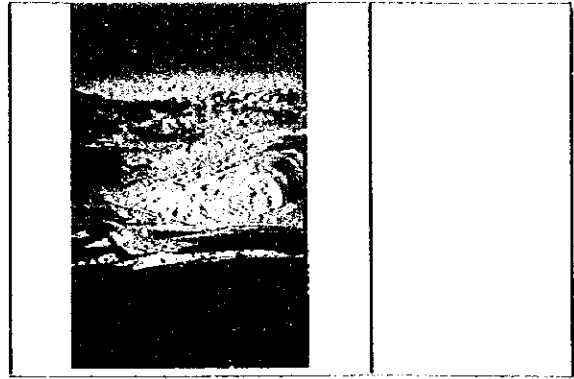
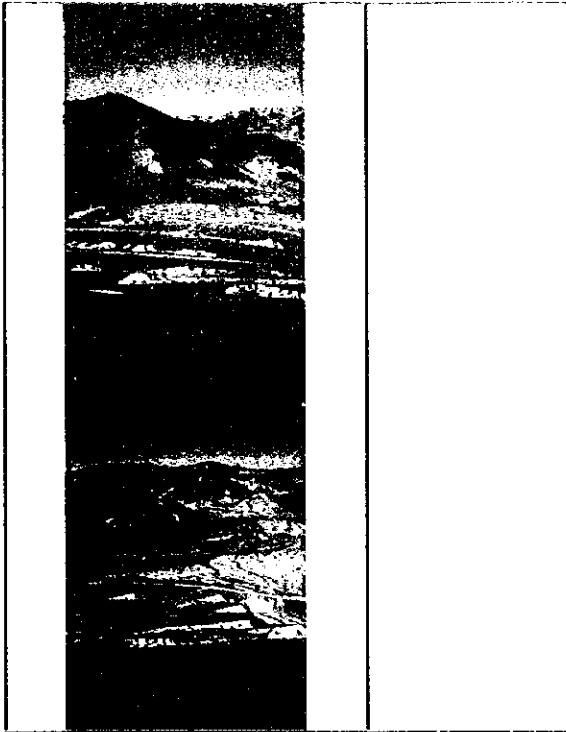
**La Vicuña area**



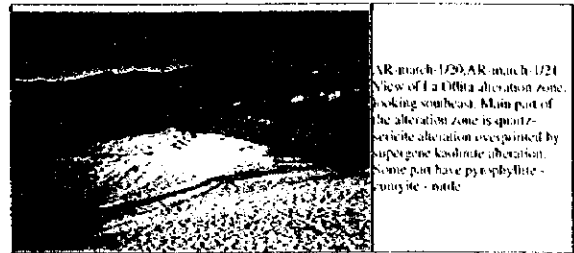
AR-march-1/29  
ATH219, 220  
View of La Vicuña alteration  
zone. Looking north. Dark  
colored hill in the back of the  
alteration zone is composed of  
propylitic andesite.



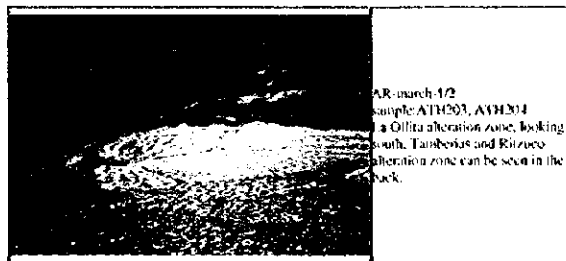
AR-march-20/AR-march-  
26/AR-march-25,AR-march-26  
ATH221, 223, 224, 225, 227  
La Vicuña alteration zone.  
Looking southwest. Quartz-  
sericite alteration zone (the red  
area) is surrounded by propylitic  
alteration. Dacitic intrusion  
exposed on the right hand side.



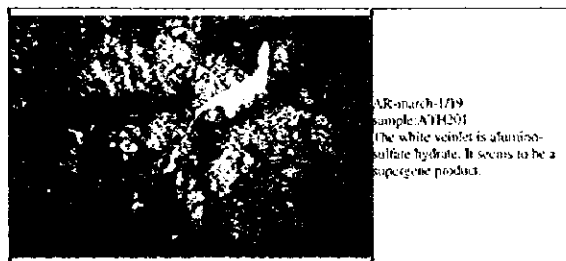
La Ollita area



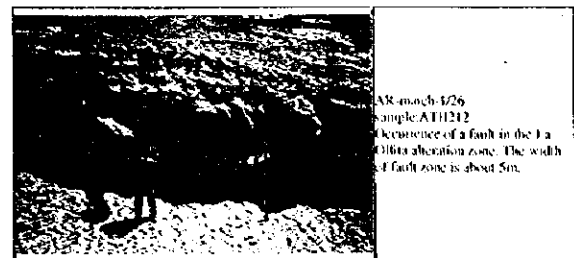
AR-march-1/20, AR-march-1/21  
View of La Ollita alteration zone, looking southeast. Main part of the alteration zone is quartzite alteration overprinted by supergene kaolinite alteration. Some part have pyrophyllite - muscovite - talc.



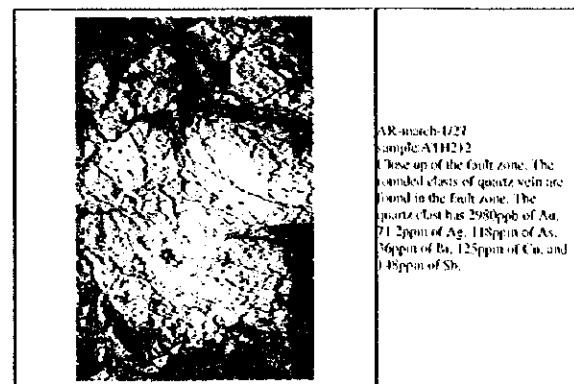
AR-march-1/2  
sample: ATH203, ATH204  
a Ollita alteration zone, looking south. Tamboritas and Ritzuco alteration zone can be seen in the back.



AR-march-1/19  
sample: ATH201  
The white veinlet is aluminosulfate hydrate. It seems to be a supergene product.

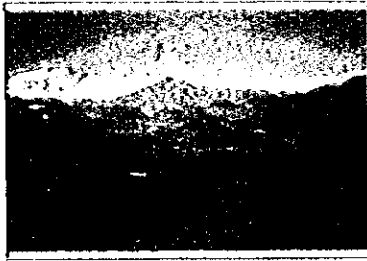


AR-march-1/26  
sample: ATH212  
Occurrence of a fault in the La Ollita alteration zone. The width of fault zone is about 5m.

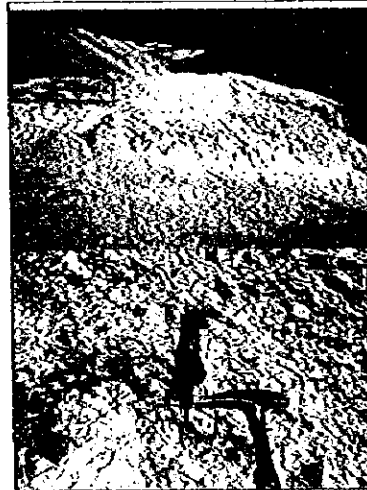


AR-march-1/27  
sample: ATH212  
Close up of the fault zone. The rounded clasts of quartz vein are found in the fault zone. The quartz clast has 2980ppb of Au, 71.2ppm of Ag, 118ppm of As, 56ppm of Bi, 125ppm of Cu, and 0.49ppm of Sb.





AR-march 422  
 Overview of the upstream of Rio de la Pena Negra. Looking north La Vicuña, La Ollita, and Tamberias alteration zones are seen. The highest mountain is Cerro Caseros, 5197m.



37, 38, 39  
 ASSM201  
 Argillized and weakly silicified small ledge includes highly mineralized quartz vein fragment ASSM201 Au: 0.12g/t, Ag: 1g, Cu: 150ppm). Location of banner of Plate 37 and 38 is the same. Such small ledge trends N79E. Plate 39 shows appearance of quartz vein float in the both eastern area. Numerous vein floats can be recognized in limited scale with a diameter of 10cm. Quartz vein usually accompanies dense limonite coating.



Las Tamberias area



AR-march 436  
 sample: ATH21X, 214, 218  
 View of Tamberias alteration zone. Looking southwest. White bleached alteration zone is surrounded by propylitic alteration zone.

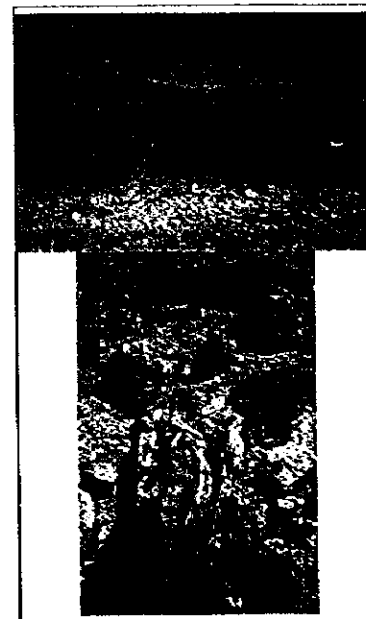
Pastos Largos area



AR99\_602  
 Occurrence of epidote vein in granitic rocks at Pastos Largos. The epidote vein has slightly white bleached halo and pinkish feldspar halo.



AR99\_603  
 sample: ATH21  
 The quartz vein with chalcocopyrite has pinkish feldspar halo.



26, 27  
 Overview of the surveyed area in the Pastos Largos prospect, Cordón de la Brea area, La Rioja. The survey is operated in the light grayish part of the ridge (Plate 26). Occurrence of quartz veins (Plate 27).

Ranchillos area

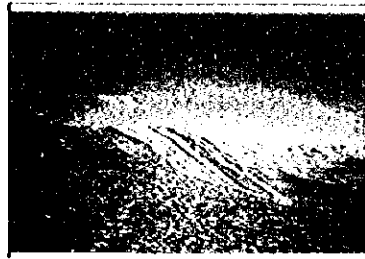


AK2545  
sample AKV352b  
Variation of mode of occurrence of quartz-feldspar veinlets. Geochemical analysis shows the upper right sample (AKV352b) and upper left sample (AKV352c) contain 19ppb Au, 2.0ppm Ag, 1,800ppm As, and 50ppb Au, 792ppm As respectively. Quartz-feldspar altered rock hosts these veinlets.



AK2547  
sample AKV353b  
Geochemical analysis reveals this quartz-inclusion vein contains 45ppb Au, 1,000ppm As. Fluid inclusion test shows that homogenization temperature is 211.4 degree Celsius.

Laguna de las Huaycas area



AK99\_627  
View of Laguna de las Huaycas alteration zone. Looking east. Rugged nature ledge is welded tuff with silica-alumina alteration.



AK99\_629  
sample A1H431, A1H432  
Albite veinlets in welded tuff. The albite veinlets occur along the linear structure which runs along the welding structure.

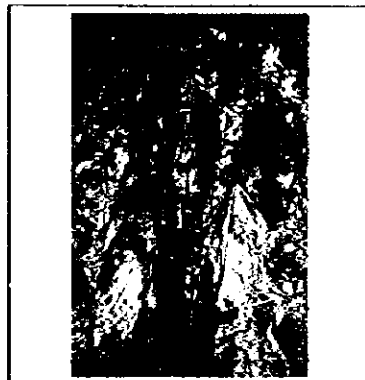


28, 29, 30  
Overview of the Laguna de las Huaycas. Continuous rugged ledge of silicified rock elongates to N75-35E (Plate 28, 29). Heavily limonitized silica-rock (raggy quartz) has numerous ragged top bearing hypogene albite (Plate 30).

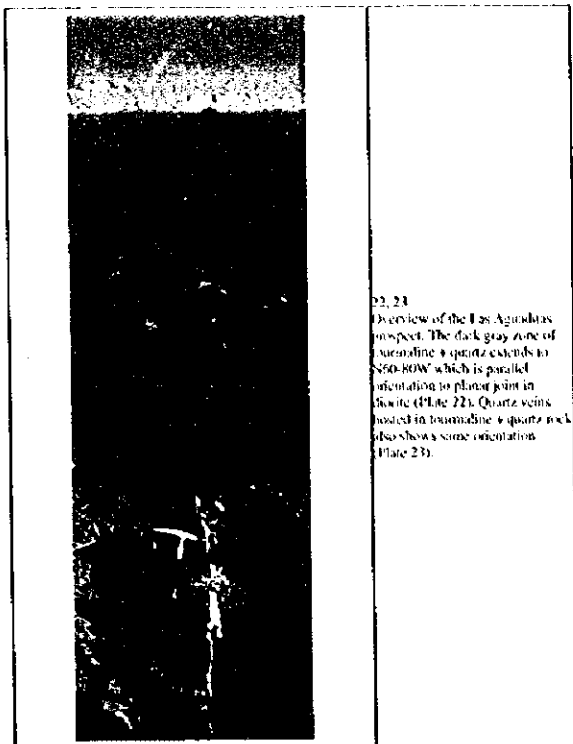
Las Aguaditas area



AK99\_521  
Occurrence of iron sulfide dikes at Aguaditas. The iron sulfide dikes colored black, intrude into chlorite, Fe-stained Mt. Cerro Negro. The width varies from 10m to a few ten centimeter.

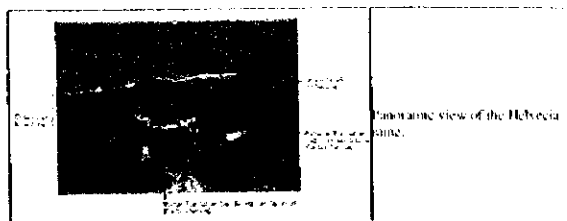


AK99\_520  
Occurrence of iron sulfide spars in vein. Some part are bleached. The chlorite adjacent to the iron sulfide vein is bleached.

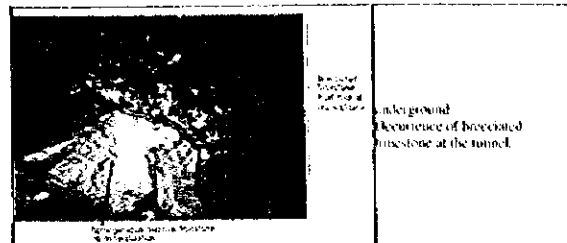


22, 23  
 Overview of the Las Aguaditas prospect. The dark gray zone of tourmaline + quartz extends to N50-80W which is parallel orientation to planar joint in flowite (Plate 22). Quartz veins hosted in tourmaline + quartz rock also shows some orientation (Plate 23).

### Helvecia area

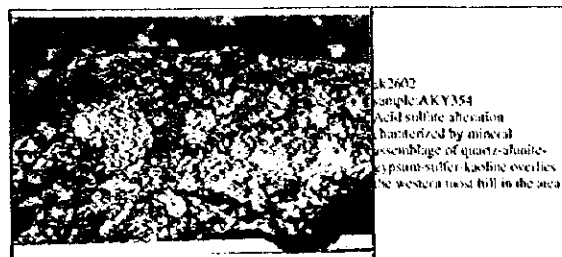


panoramic view of the Helvecia mine.

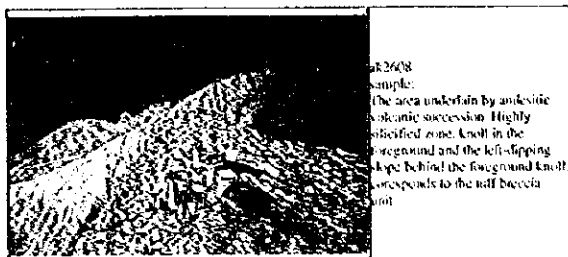


underground occurrence of brecciated limestone at the tunnel.

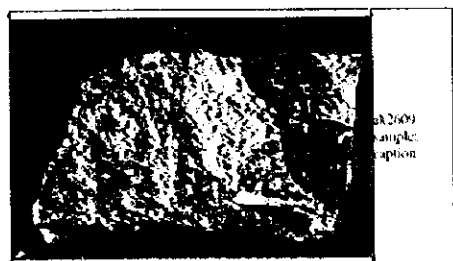
### La Flecha area



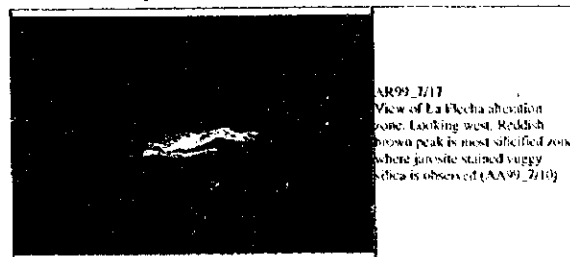
AK2602 sample AKY354 acid sulfate alteration characterized by mineral assemblage of quartz-alunite-cypsum-sulfur-kashite overthrust westernmost hill in the area



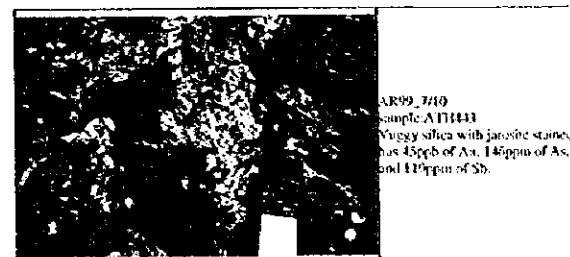
AK2608 sample. The area underlain by andesite volcanic succession. Highly silicified zone. Knoll in the foreground and the left-dipping slope behind the foreground knoll corresponds to the hill breccia unit.



AK2609 sample caption



AR99\_2/17 View of La Flecha alteration zone. Looking west. Reddish-brown peak is most silicified zone where jarosite stained vuggy silica is observed (AA99\_2/10)



AR99\_2/10 sample AT1443 Vuggy silica with jarosite stained has 45ppb of Au, 146ppm of As, and 110ppm of Sb.

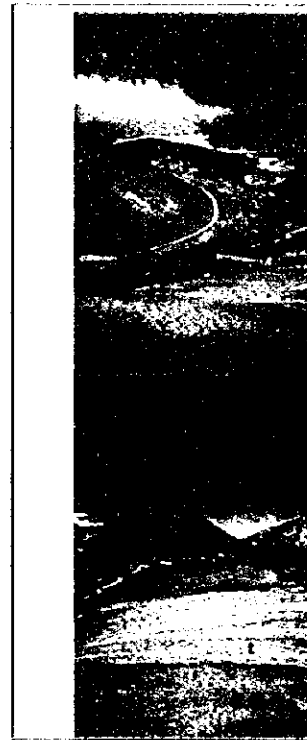
**Bordo Atravezado area**



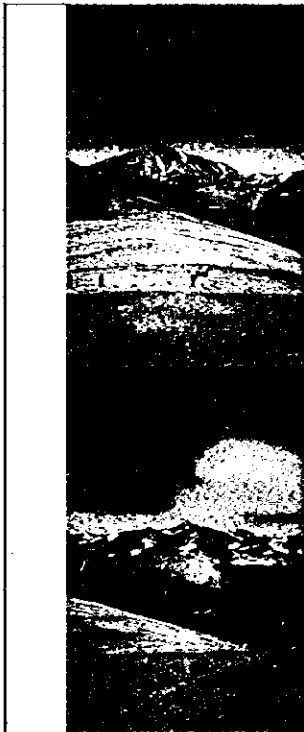
AKY170  
sample AKY170  
Euhedral hematite, center,  
plumite, and diasporite, white  
sulfone are observed in highly  
silicified breccia in the area.  
Chemical analysis shows this  
contains 15ppm Au. The long  
side is 70um long.



AR-march-326  
sample AH1253, 254, 255, 256  
View of Bordo Atravezado  
alteration zone. Looking south.  
Dark brown craggy rocks shows  
silicified ledges. The ledges  
occur along the direction of  
260°-70E, which runs along the  
Macho Muerto Valley.



AR-march-315, AR-march-  
316, AR-march-317, AR-march-  
318  
sample AH1253, 254, 255, 256  
Bordo Atravezado alteration zone.  
Looking southwest. Quartz-  
sericite alteration overprinted by  
supergene kaolinite alteration.

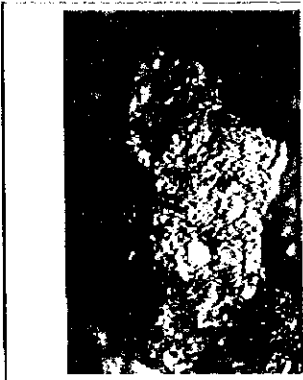


AR-march-322, AR-march-  
323, AR-march-324  
sample AH1258, 259, 261, 265,  
AH1285, 286  
View of Cerro Amantillo from  
Bordo Atravezado. Looking north.  
High sulfidation alteration is  
distributed at the upper part of  
Cerro Amantillo, where consists of  
pyroclastics and dacite. The dacite  
occurs the right hand side of  
Cerro Amantillo in dark color part.  
In northern foot of Cerro  
Amantillo, sericite alteration is  
distributed.



AR-march-322, AR-march-  
323, AR-march-324  
sample AH1258, 259, 261, 265,  
AH1285, 286  
View of Cerro Amantillo from  
Bordo Atravezado. Looking north.  
High sulfidation alteration is  
distributed at the upper part of  
Cerro Amantillo, where consists of  
pyroclastics and dacite. The dacite  
occurs the right hand side of  
Cerro Amantillo in dark color part.  
In northern foot of Cerro  
Amantillo, sericite alteration is  
distributed.

Margarita area



32827  
sample AKV357  
Strongly filamentized hydrothermal brecciated zone observed in the area at the surface is floating boulder. Mode of occurrence of hematite, center, with that maroon color and fine grained matrix reveals this is indigenous hematite. In a chunk of rock suggests this was formed after primary copper sulfide. Chemical analysis shows this contains 70ppb Au and 0.35 Cu, and 1.565ppm As. The long side is 70mm long



32828  
sample AKV358  
Quartz veins that cut quartz-hematite breccia occur with copper oxide with no exception, while the breccia shows no mineralization. This vein contains significant amount of copper. 4.51%



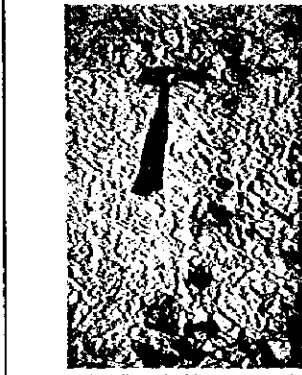
36  
Hematite-quartz breccia pipe at the Margarita prospect, Cochabamba in Bolivia. Breccia often includes silicified Carboniferous sedimentary rocks.

Los Mogotes area



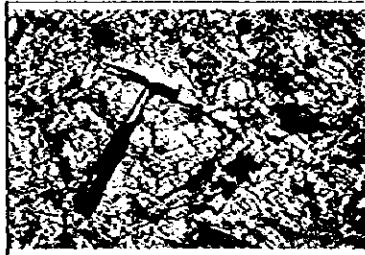
AR-march-45, AR-march-47, AR-march-42, AR-march-44, AR-march-43  
sample ACH273, 274, 275, 276, 277, 278  
A view of Los Mogotes alteration zone, looking northeast. Major part is quartz-sericite alteration with quartz vein stockworks which have molybdenum mineralization. The outcrop at the right hand side is a granodioritic sphyry. The K/Ar age of the rock shows 15.3 ± 10.2 Ma of Middle Miocene age.



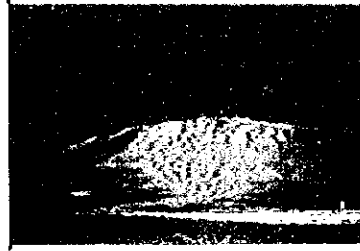


AR-march-335  
sample:ATH269, 270  
Occurrence of quartz vein and sericite alteration. The width of vein varies from 6cm to 40cm. The K/Ar age of the sericite adjacent to the vein indicates 0.1-0.4 Ma of Middle Miocene age.

**Cordon de la Inca area**



AK2618  
sample:AKY373  
White colored silicified rock after andesite (D) with quartz stock work in the area. A chunk of rock contains 100ppb Au from this outcrop.



AK99-726  
View of Cordon de la Inca alteration zone looking south. See small craggy rock as on the top of the hill. The rock is highly silicified.

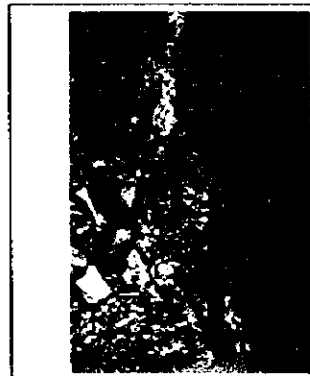


AK99-722  
sample:ATH454  
Occurrence of silicified rocks looking south from the top of the hill. The dark brown craggy rocks form some ledges.



AK99-725  
sample:ATH155  
Clay veins are cropped out on the rock of the highly silicified rocks. The clay veins consist of pyrophyllite, sericite/muscovite mixed layer clay, chlorite/muscovite mixed layer clay, barite, garnet, and diaspore.

**Guachi area**



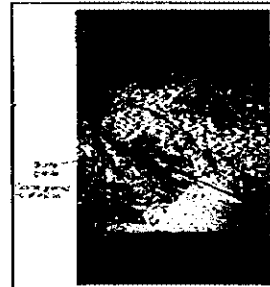
Occurrence of a base metal vein, Guachi area. Refer sketch corresponds to the rectangle in the picture.



granite porphyry  
barite  
chlorite/muscovite mixed layer clay

Granite porphyry near the El Fierro Raja mine.

**El Fierro Bajo area**



biotite granite near the El Fierro Bajo mine

**Cerro Amarillo area**



AR-march-328, AR-march-329, AR-march-330  
sample:ATH262, 263, 264  
Alteration of pyroxenes and lavas is seen in southern foot of Cerro Amarillo. The diatitic pyroxenes with white bleached coloration are composed of quartz, sericite/muscovite mixed layer clay. The andesite lavas with greenish coloration are composed of pyrophyllite alteration. This may indicate a permeability control. Bond Atrevesado is also seen the other side of the valley.



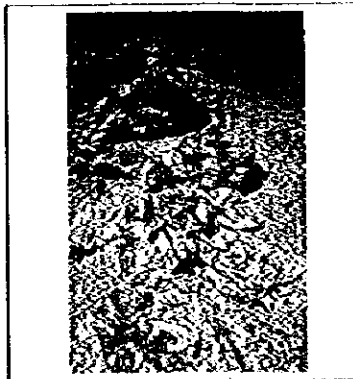
43, 44, 45  
 Overview of the outcrops of acid-etched ledge (back) and porphyritic andesite (front) (Plate 43). Plate 44 and 45 show the texture of residue silica. Because while the tuff breccia is totally leached except silica, such rocks shows white to grayish appearance and light weight. Residual silica is partly accompanied to subtle greenish copper staining and intense jarosite-hematite staining.



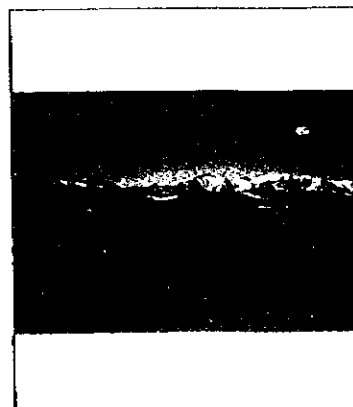
Despoblados area



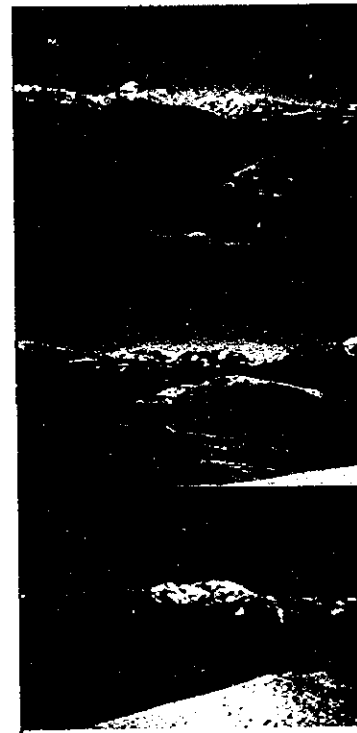
42818  
 Samples: AKY 402a,b  
 Quartz-fibrous vein in sericite-argillite altered andesite and tuff breccia. Supergene alteration (scipinita) is observed.



42819  
 Sample: AKY 414  
 Sericite-argillite altered tuff breccia with jarosite-quartz stockwork. The stockwork contains 140ppb Au.



AR99\_10/17, AR99\_10/18, AR99\_10/15, AR99\_10/19  
 Samples: A111500, 501, 502  
 Panoramic view of northern part of Valle del Cura region. Looking west from the top of the hill of Despoblados alteration zone. From left (north) to right (south), we can see the alteration zone of Veladero Sur, Veladero Centro, Guanaco Zorro, Veladero Norte, Pasco, Lama, and Fabiana. Tolhuas Formation covers Dena Ana Formation which is major host rocks of hydrothermal alteration in Valle del Cura region. Reddish colored mountain may comprises of Cretaceous granitic rock which may crop out as a geological window. White leached alteration zone at the front is Despoblados alteration zone.



**Veladero Norte area**



ak2717  
panoramic view looking from the  
Guimaco Zonzo area.



ak2714  
sample AKY384  
Fonatic drops are often observed  
in vug of highly sulfidated matrix  
from the Amable area. The long  
side is 70mm long.

**Veladero Sur area**



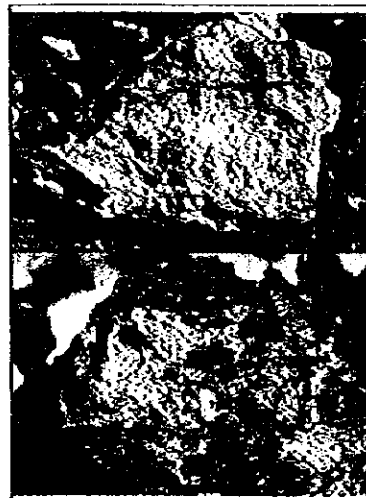
ak2719, ak2721  
samples AKY387a, AKY387b  
Argillic alteration in the area is  
characterized by quartz-amine-  
kaolinite matrix assemblage. This  
sample contains no significant  
amount of the pathfinder  
elements. The long side of the  
upper picture is 7cm long and  
1cm long in lower one.



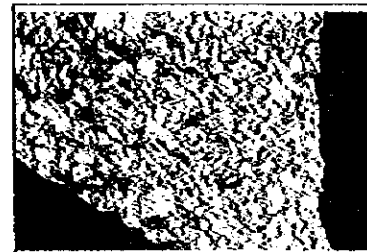
34, 35  
Overview of the Veladero Sur  
area. Individual lithology is  
following: left dark colored  
- andesite, purple andesite, high  
montanous yellowish  
- andesite, brownish, fine grained sulfidated  
- andesite, white surface,  
supergene gypsum dominated  
area.



**Rio Frio area**



ak2802, ak2804  
sample AKY395  
White quartz-kaolinite veinlet  
occur in quartz-sericite argillic  
altered rock, upper, many of them  
are oxidized, lower. The chunk in  
the lower one contains 480ppb Au  
because of secondary enrichment  
of gold in supergene process.

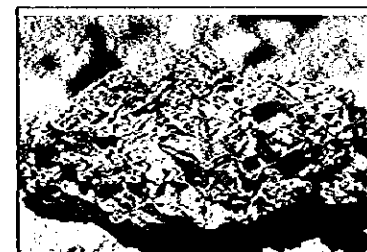


ak2805  
sample AKY397  
Quartz-sericite argillic altered  
dacite porphyry



ak2807  
sample AKY398  
Sulfidated rock. Crystalline quartz  
and sulfur are in vug. This sample  
was taken near porphyritic dacite,  
and from sericite argillic  
alteration zone.

**Zancarron area**



ak2733, ak2734, ak2736  
sample AKY394  
Argillic and hypogene alunite are  
observed commonly in the. These  
minerals and alteration  
characteristics suggest that the  
mineralization system of the area  
is high sulfidation state  
epithermal system. The long side  
is 70mm long.





AR99\_923  
View of Chilean side of Sarcocornu deposits. High sulfidation style alteration zone develops across the border between Argentina and Chile

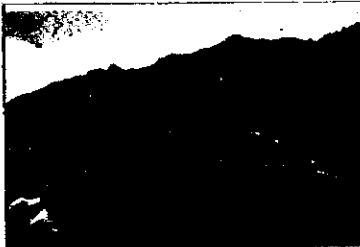


AR99\_925  
sample ATH68  
Occurrence of alunite vein. The strike is N18E and it runs along the bend of silicified ridge and fracture system.

El Salado area

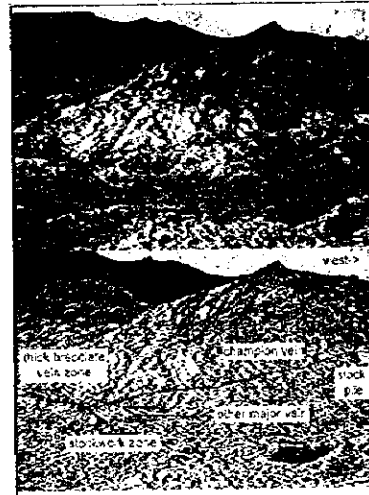


AR99\_430  
The mineralized vein locates in granitic rock which lie between andesitic dike and granitic rock. The vein width is about 1.5m. Its strike is N30E. The vein consists of subequal lath of barite and minor goethite and sphalerite.

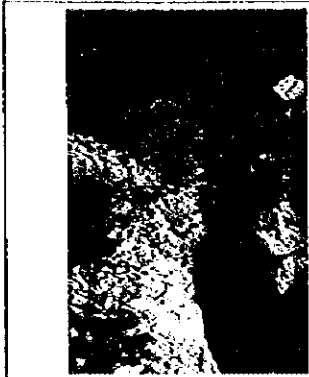


20, 21  
Overview of the northern outcrop Mina El Salado, Tucumán-Colombia area (Plate 20), and a occurrence of vein-ore and altered andesite with diastatic dike in the same outcrop

Las Openas area



A2429  
Overview of the vein system in the area



AR99\_5/16  
An old workings at Miranda vein showing EW in Las Opeñas. The vein has azcopyrite and its secondary scorodite.

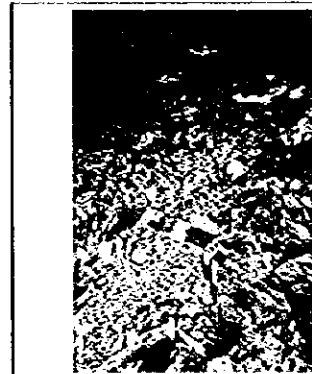
Carmen Norte area



AK2623  
sample AKY374  
Pyritic altered andesite, dark rag colored outcrop in the foreground, hosts acid sulfate alteration zone.



AK2626  
sample AKY375  
A floating boulder from residual siliceous zone contains 495ppb Au, 7.80ppm Ag



AK2630  
Residual siliceous rock forms small spires because of its resistant nature against erosion. These usually accompany breccia zone.



AK2631, AK2634  
samples AKY380a, AKY380b  
White-colored coarse-grained pyrite-sulfur vein, 60cm thick, upper chunk, and associated thin veins, lower one, are situated in a siliceous spire. Chemical analysis reveals these contain 165ppb Au and 1.445ppb Au respectively.



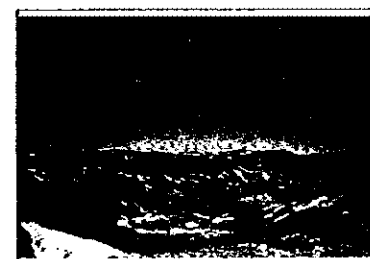
AK2635  
sample AKY381  
Typical alteration mineral assemblage in the area, quartz-alunite-gypsum-rutile-sulfur, suggests that strongly acidic, might be less than pH2, sulfate rich solution attack the geologic system. This chunk contains significant amount of gold, 1100ppb Au, while this is typical argillic altered rock.



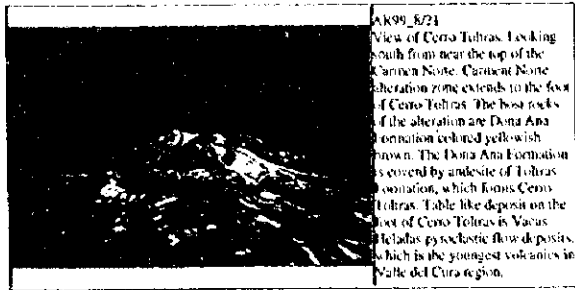
AK2701  
Panoramic view of the area looking from west of the area.



AK2705  
sample AKY383  
Some chaledonic quartz veins in the area contain significant amount of gold. Chemical analysis shows this gray portion contains 2.280ppb Au.



AR99\_6/22  
View of Carmen Norte alteration zone, looking east from near the top of the Carmen Norte. The alteration zone are quite large. It extends over the Chilean border.



AR99\_8/21  
View of Cerro Tolhuas. Looking south from near the top of the Carmen Norte. Carmen Norte alteration zone extends to the foot of Cerro Tolhuas. The host rocks of the alteration are Dona Ana formation colored yellowish brown. The Dona Ana formation is covered by andesite of Tolhuas formation, which forms Cerro Tolhuas. Table like deposit on the foot of Cerro Tolhuas is Vacas Heladas pyroclastic flow deposits, which is the youngest volcanics in Valle del Cura region.



AR99\_8/4  
sample ATH160  
Occurrence of aluminite in Carmen Norte. This buff colored aluminite occurs as vein in highly silicified rock. Aluminite also replaces diaspore phenocrysts and breccias in pyroclastics.



AR99\_8/19  
sample ATH169  
View of the top of Carmen Norte. Craggy dark colored rocks are pipe-shaped hydrothermal breccia with quartz-alunite alteration.



AR99\_8/14  
sample ATH168  
Occurrences of hydrothermal breccia pipes.



AR99\_8/20  
samples ATH169, 470  
Occurrences of hydrothermal breccia pipes.



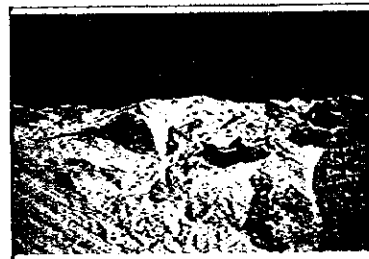
AR99\_8/23  
Close up of AR99\_8/20. Highly silicified breccia cemented with limonite-impregnated chalcadonic silica.



AR99\_8/24  
Chalcadonic silica vein in the hydrothermal breccia pipe



AR99\_8/25  
sample ATH169  
Chalcadonic silica vein in the hydrothermal breccia pipe



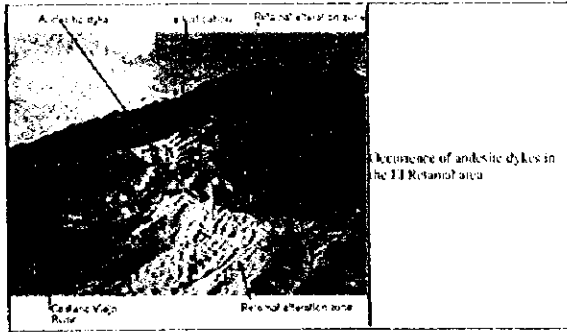
AR99\_8/7  
samples ATH168, ATH165, ATH163  
Occurrence of silicified ledges and hydrothermal breccia in Carmen Norte



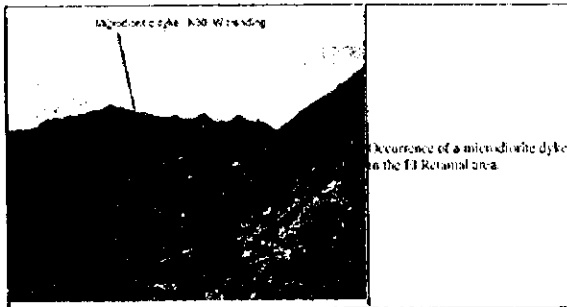
01, 32, 33  
Wuggy quartz ledge extending N- to NNE-SS, northwest flank of the Carmen Norte prospect (see text).



El Retamal area

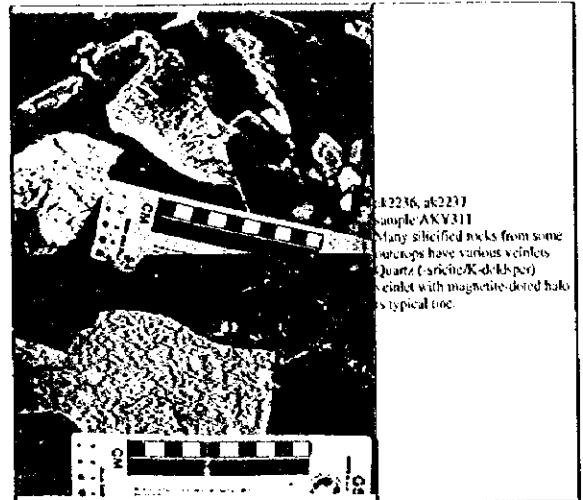


Occurrence of andesite dykes in the El Retamal area



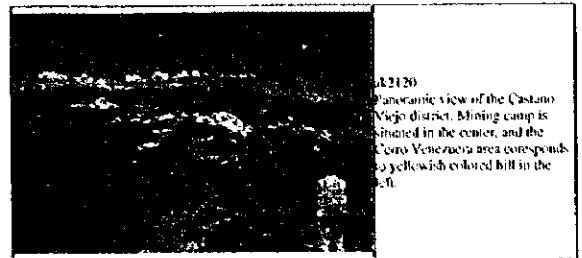
Occurrence of a microdiorite dike in the El Retamal area

Vizcachas area

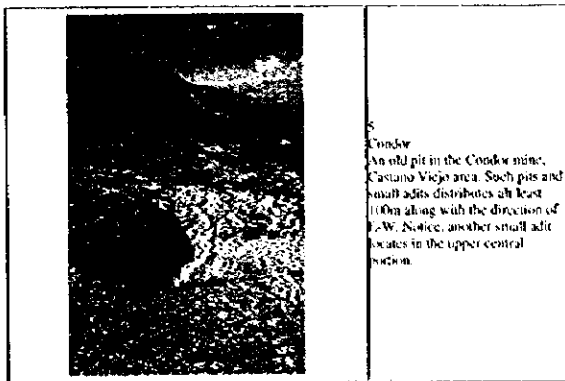


Many silicified rocks from some outcrops have various veinlets. Quartz (arctite/K-dolomite) veinlet with magnetite-dotted halo is typical one.

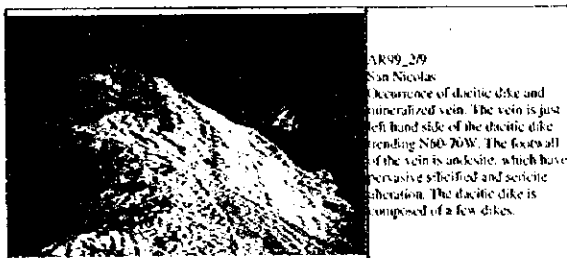
Castano Viejo District area



Panoramic view of the Castano Viejo district. Mining camp is situated in the center, and the Coro Venezuela area corresponds to yellowish colored hill in the left.

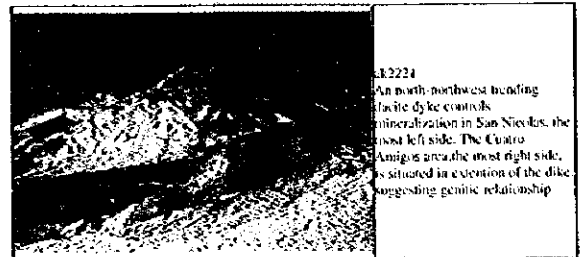


Condor  
An old pit in the Condor mine, Castano Viejo area. Such pits and small adits distributed all over 100m along with the direction of E-W. Notice, another small adit locates in the upper central position.

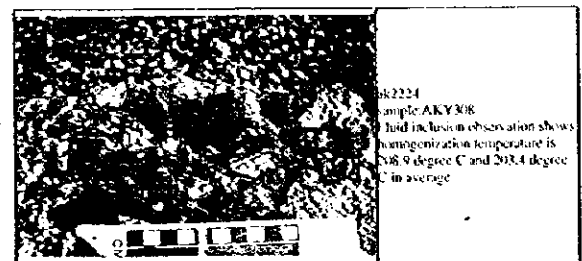


AR99\_209  
San Nicolas  
Occurrence of dacitic dike and mineralized vein. The vein is just left hand side of the dacitic dike trending N60-70W. The footwall of the vein is andesite, which have pervasive silicified and sericite alteration. The dacitic dike is composed of a few dikes.

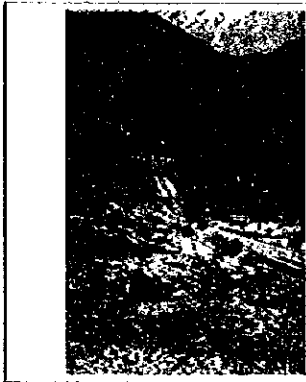
Cuatro Amigos area



E2224  
An north-northeast trending dacite dike controls mineralization in San Nicolas, the most left side. The Cuatro Amigos area, the most right side, is situated in extension of the dike, suggesting genetic relationship.

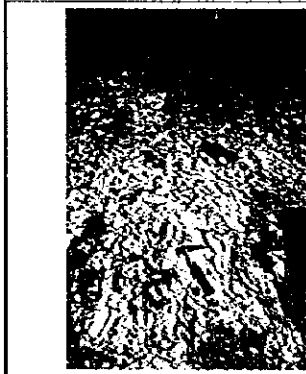


Fluid inclusion observation shows mineralization temperature is 138.9 degree C and 203.4 degree C in average.



An old pit of the Chuño Amigos, the second largest silver-lead-zinc-lead mine in the Castano Viejo area.

**Avestruces area**



AK2307 samples AKY322a,b. Small outcrop in that quartz veinlets are developed is situated in argillite alteration zone characterized by sericite, smectite and layer clay mineral. The veinlets have no significant amount of pathfinder elements while fluid inclusion analysis reveals the homogenization temperature is 160.6 degrees C in average.



AK99\_365 samples AH329, 330, 331, 332, 333. View of northern block of Avestruces alteration zone lacking southwest colored red and dark brown silicified ledge.



10, 11. Silicified ledge and surrounding silicified argillized part. Avestruces alteration, Castano area (10). This location is a top of the mountain in northern altered portion. In Plate 11, both white peak and surrounding yellowish-white parts consist of quartz and sericite/smectite mixed-layer clay. Less eroded part, such as peak, is more siliceous than the surrounding depressed area.

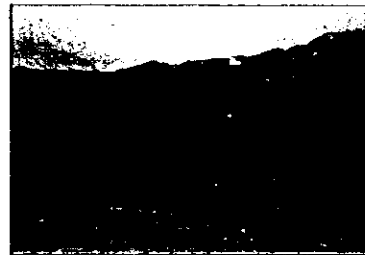
**Manrique area**



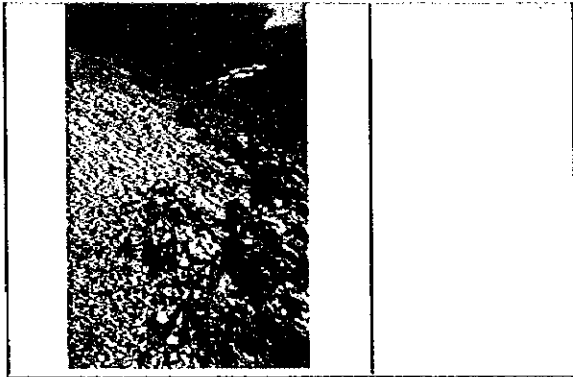
AK2327, 2324, 2336 samples AKY324b, AKY324a. Mode of occurrence of quartz vein system in the area varies gradually in lateral direction from dacite intrusive body to peripheral basalt rock, andesite volcanic rocks stockwork veining, the upper one is observed within the dacite, while massive vein the middle one is observed in the argillite volcanic rocks. Silicified zone has sparse network of quartz, the lower one.



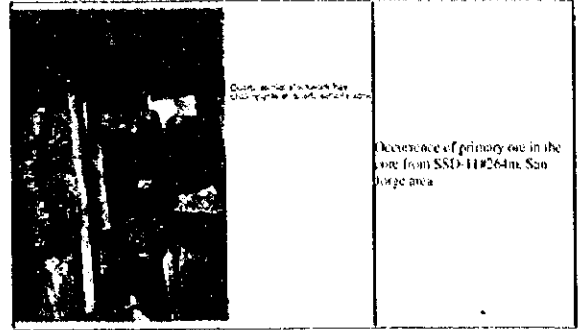
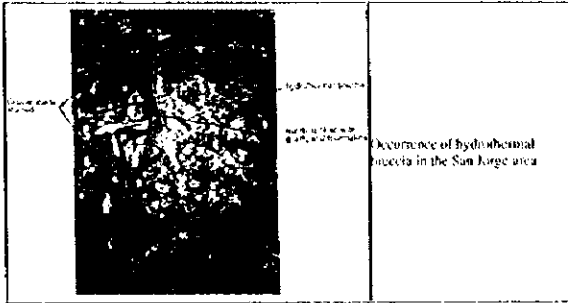
AK99\_320 samples AH349, 350. Occurrence of quartz veinlet stockwork with sericite alteration.



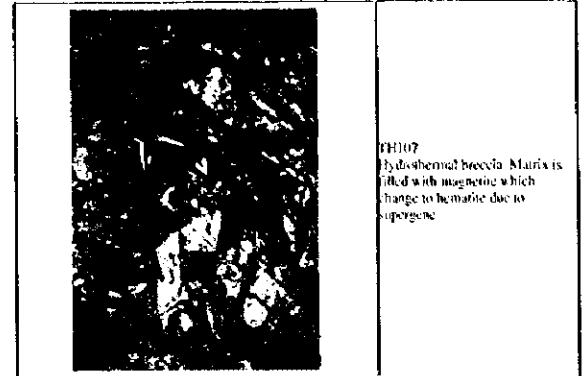
12, 13. Overview of the altered ridge surveyed, southwestern part of Arroyo Choca, alteration Manrique (Plate 13). Plate 14 shows a N70E-15N boundary of the lower silicified andesite and upper intensely silicified limestone, southwestern part of Arroyo Cuevas, Manrique.



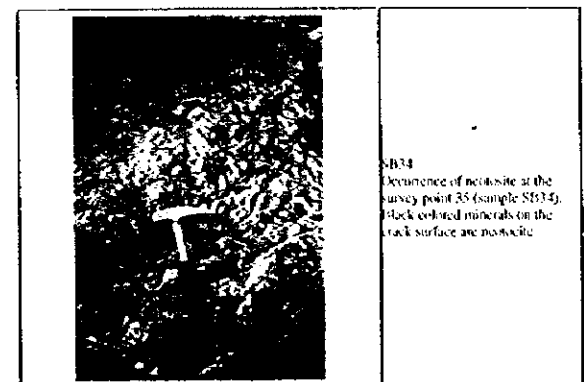
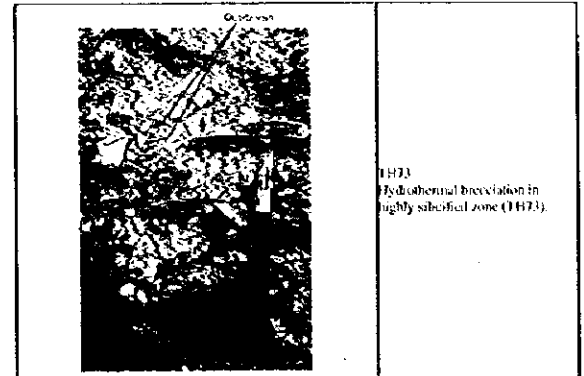
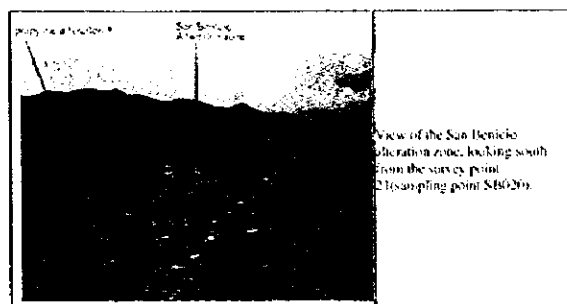
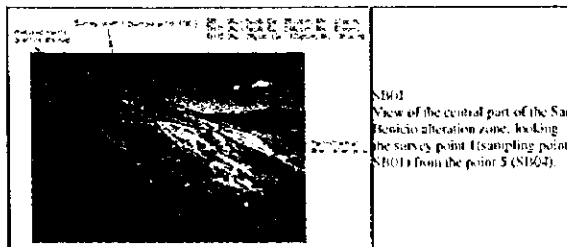
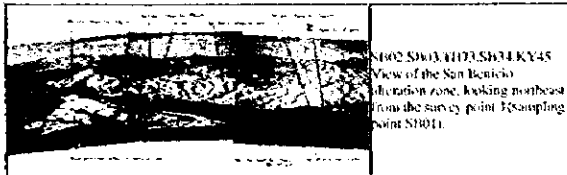
San Jorge area

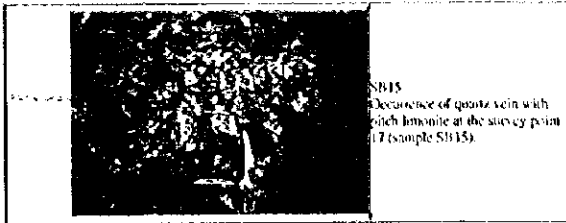


Paramillos Norte area

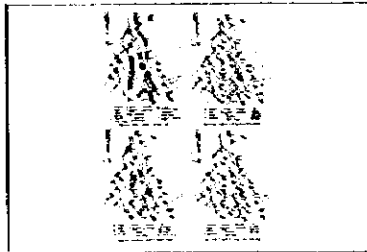


San Benicio area



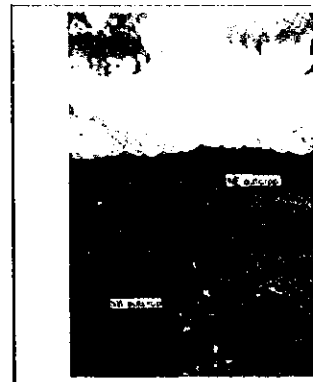


SB15  
Occurrence of quartz vein with  
limonite at the survey point  
7 (sample SB15)



Geology and alteration map (see  
overview)  
Geochemical anomaly of Au (see  
overview)  
Geochemical anomaly of Cu (see  
overview)  
Geochemical anomaly of Mo (see  
overview)

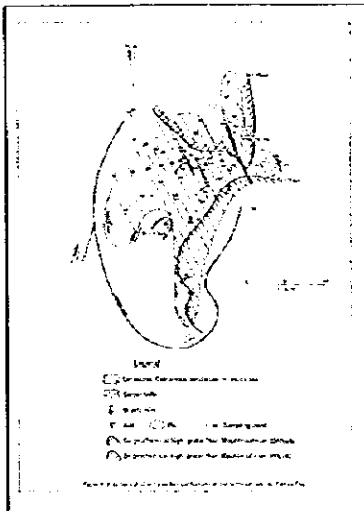
**Pampa Fria area**



Overview of the northeast  
outcrop, Pampa Fria area. Pale  
reddish yellow color characterizes  
the outcrop extending 300x200m  
which recognizable in 1:250,000  
satellite image.

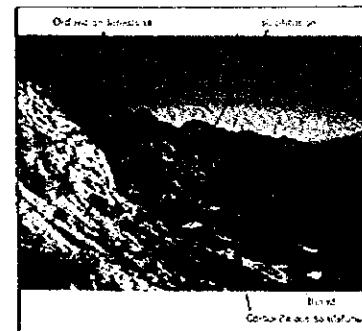


Occurrence of the quartz vein in  
the northeast outcrop, Pampa Fria  
Formation of the vein can be  
classified at least two stages:  
major vein stage, and stockwork  
vein stage. It is observed the  
major vein is cut by later  
stockwork at several points. An  
fluid inclusion study on SM54  
shows that secondary quartz in  
major vein (at stockwork stage?)  
crystallized at very low  
temperature of around 120  
degrees Celsius. The salinity was  
low (0.6% NaCl eq).

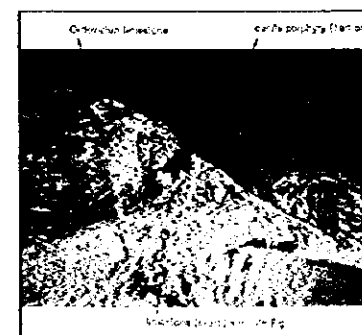


Geological and geochemical  
features in the northeast outcrop,  
Pampa Fria  
(see overview)

**Corral area**



Thrust contact between  
Carboniferous sandstone and  
Ordovician limestone, Corral  
area

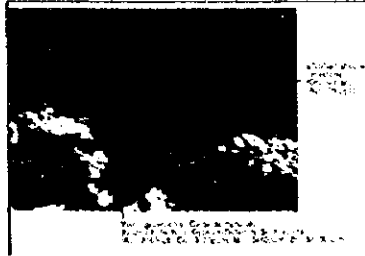


Occurrence of dacite porphyry,  
Corral area.



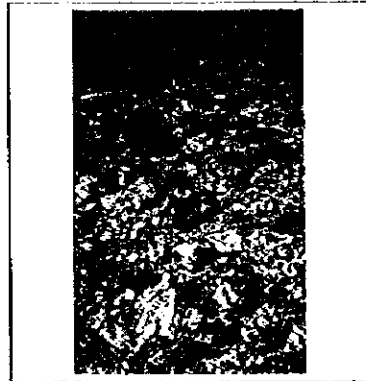


limestone xenolith within the feldspar porphyry, Corral area

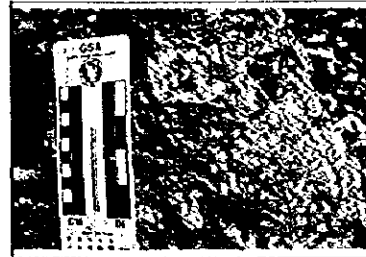


Silicified limestone with Cu-oxide stain in the Corral area

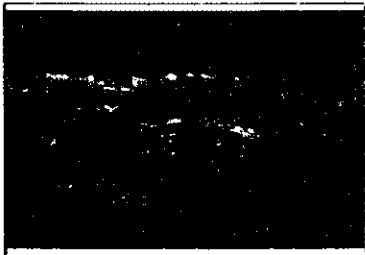
Cerro Venezuela area



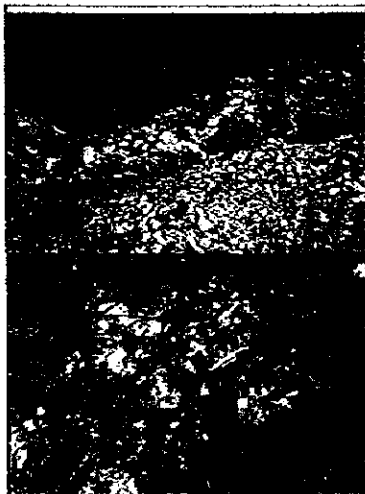
AK2307 sample AKY361  
Precipitated and silicified andesite is stained by chlorite mainly while its fragments are cemented by kaolinite (dickite). However the mode of occurrence shows this is hydrothermal breccia; geochemical analysis reveals this has no significant amount of pathfinder elements for ore deposit.



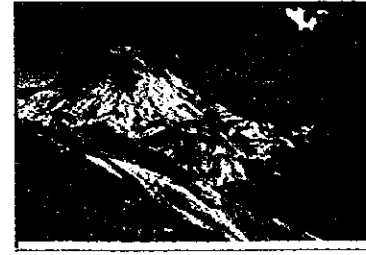
AK2208 sample AKY364  
Close up of highly silicified rock, intercalated tourmaline are detected by XRD. No significant amount of pathfinder elements is observed.



Regional view of the Cerro Venezuela area, San Juan. A striking brownish-argillized small mountain at upper left corresponds to the "Venezuela" alteration, flatly elongated brownish-argillized hill at the central portion to dacite intrusion hosting the "Mina Antina", respectively.



2, 3, 4  
A silicified-tourmalinized ledge at the eastern flank of Venezuela alteration (Plate 2), and an enlargement of tourmaline rich part in the same ledge (Plate 3). Dark gray color, plate 3, comes from very fine-grained aggregate of tourmaline and subtle amount of quartz. Overview of the Venezuela alteration (Plate 4). This mountainous alteration can be divided to three zones from upper to lower: grayish rhizolite pyroclastics, medium reddish silicified zone, and whitish interstratified clay zone (see text). Lithology at the skirt of the mountain corresponds to an alteration consists of andesitic pyroclastics (white) and andesite (dark gray).

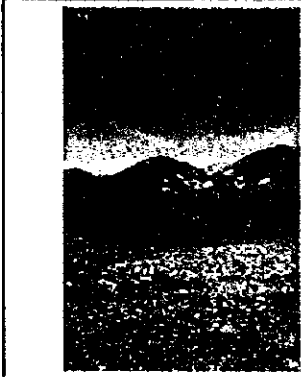


Portezuelo de Amarillo area



Overview of the Portezuelo de Amarillo alteration. A less eroded rugged layer in upper left corresponds to a silicified layer. The other whitish part mainly consists of argillized pyroclastics with sericite/muscovite mixed-layer clay and subtle amount of silica. Lithology in a dark gray central smallish hill is massive porphylic andesite.

Potrerillos area



Alteration Potrerillos consists of numerous small alteration spots. The groundtruth fulfilled the left-most argillized clay which composed of sericite/smectite mixed-layer clay and silica.

Sarnoso area

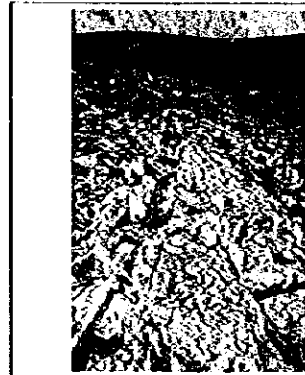


Sphylite lava dome and the Sarnoso old adit. It is rare to encounter both mineralized and altered rock even beneath the sphylite shows dense and fine flow band.

Vicunita (El Salado) area



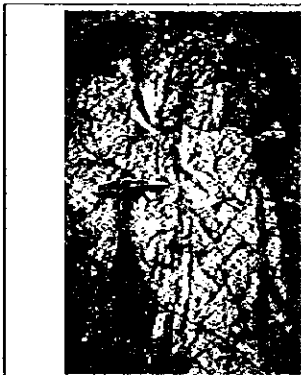
32411  
Overview of the center to western side of the area looking from the south. The roads are for exploration conducted by Poma. Biotite-magnetite alteration zone surrounded by quartz-biotite-sericite alteration zone is situated in dark grey small knoll in the right and small exploration pits(?) for copper oxides are located in next to the knoll and the left of the picture.



32415  
Preferred orientation is observed in most of the outcrop in that quartz stockwork develops. The direction of the stockwork in the picture strikes N20-40E, while the direction in respective outcrop varies N45E to N50E.



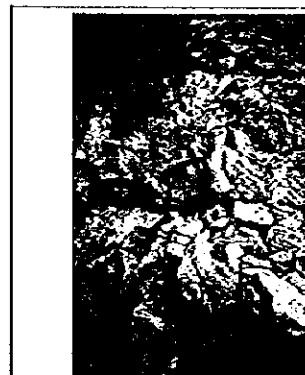
32417  
Close up of quartz-magnetite stockwork within biotite-magnetite alteration zone.



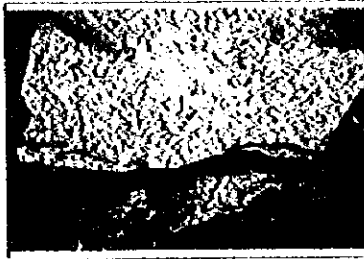
AR99\_508  
Occurrence of quartz vein stockwork in transition zone, where quartz-sericite alteration overprints potassic alteration. The quartz vein are stained with oxide copper minerals.



AR99\_509  
sample ATH393  
Occurrence of quartz vein stockwork in potassic alteration. The quartz vein are stained with oxide copper minerals. Not only green colored copper oxides but black colored copper oxides such as neostibite and pitch blende are observed in potassic alteration zone.



AR99\_510  
sample ATH395  
Occurrence of magnetite vein in potassic alteration zone. The width of the magnetite vein is about 5cm and the strike is N80E. Magnetites also occur in dissemination in the porphyry. The magnetite vein has 515ppm of Au, 460ppm of Cu.



AR99\_5011  
 sample A1H194  
 Quartz veinlets stockwork in sericite alteration zone. Note the veinlet density is quite high some veinlets have K-feldspar inclusions. While the coarse grained biotites might be primary magmatic, fine grained greenish colored biotites might be hydrothermal products. The rock has 254ppb of Au and 499ppm of Cu.

**Granite area**



Weathered coarse grained granite and limonite-rich mudstone in the Granite area.  
 Metacherty dipping Devonian-Carboniferous sedimentary rocks overlies granite and amphibolite with unconformity (a). Detailed observation and XRD analysis revealed sandstone contains weathering kaolinite which characterized gray white color (b).

**Quebrada de Conconta area**



1819  
 Lithology of alteration spot in Quebrada de Conconta. Groundtruth revealed that all the alteration clots delineated as "sericite" alteration based on URS-1 OPS data are weathered granite including sericite (muscovite) (Plate 48). The area of interest looks more bright due to weathering, and seems to more reflective, than the surrounding terrain.

**Leonardo area**



24  
 Occurrence of major magnetite (m) in the Leonardo, Toconota-Pelunguid area.

**Southwest of Margarita area**



AR99\_6223  
 samples A1H425, 426, 427, 428, 429, 430  
 View of Southwest of Margarita alteration zone. Dark colored pyrobitic (b) is observed in the center of the bleached alteration zone.

85  
 22



