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# *Faja del Potro and Cordón de la Brea Ore Deposits, La Rioja and San Juan.*

## Radiometric dating, analytical results and sample documentation

André Panteleyev y Osvaldo Cravero

Vistas del Cordón de la Brea (arriba)
y del área del Potro (abajo)


Buenos Aires, 2001

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SECRETARÍA DE ENERGÍA Y MINERÍA

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# FAJA DEL POTRO AND CORDÓN DE LA BREA ORE DEPOSIT, LA RIOJA AND SAN JUAN

## *RADIOMETRIC DATING, ANALYTICAL RESULTS AND SAMPLE DOCUMENTATION*

*André Panteleyev y Osvaldo Cravero*


## SUMMARY

Two elongate belts of rocks containing large hydrothermal alteration zones with indications of porphyry gold and copper-gold mineralization, as well as potential for epithermal gold-silver deposits, were examined near the border of Argentina with Chile in southern La Rioja and northern San Juan Provinces. On the west along the height of land a zone consists predominantly of Tertiary volcanic rocks and is referred to as the 'Faja de Potro'. This region is roughly midway between the well-mineralized porphyry gold – epithermal gold-silver Maricunga district in Chile to the north and the large, newly discovered high-sulphidation epithermal gold-silver Pascua-Veladero district that straddles the Argentinean-Chilean border to the south. To the east this belt of economic interest, the Cordón de la Brea, is made up of mainly Paleozoic felsic volcanic and sedimentary units and Permo-Triassic granitic and volcanic rocks. There the exploration interest has been both the base metal and gold potential.

The Tertiary volcanic rocks in the study area consist of a basal unit of back-arc rocks of predominately andesitic composition that form eroded fields of coalescing lava flow and pyroclastic units; a number of small, dark-coloured domes in this unit are made of basalt. Overlying volcanic units that comprise the bulk of the Cordillera consist of dacitic to andesitic arc rocks, and less commonly quartz-phyric rocks ('rhyolite'), that give rise to pyroclastic accumulations with locally abundant flow domes. All Tertiary volcanic accumulations include locally derived volcanigenic sediments. Previously all the older volcanic units in this region were regarded to be equivalent to, and correlated with, the late Oligocene to early Miocene (26 – 21 Ma) Doña Ana Group. The term 'Group' is used in Chile whereas the equivalent rocks in Argentina are commonly referred to 'Formations'. The overlying successions of dacitic to andesititc rocks, with minor basalt units, are equivalent to the middle to late Miocene Cerro de Las Tortolas Group (17 to 10 Ma). In this study we have recognized that the oldest volcanics are late Eocene to Oligocene in age. They crop out as andesite and lesser basaltic units in the Rio Peña Negra area and to the east of Rio Blanco at the Sapitos prospect. In this report we present results of new Ar-Ar dating results from these, and the other map units. These new data better constrain regional correlation of the Tertiary volcanic units. We also present new petrochemical data that characterize the volcanics and allow a refined interpretation of their tectonic setting. This work can lead to the construction of a regional stratigraphic framework that is constrained by radiometric dating in which the regional metallogeny can be considered.

The older rocks of the Cajón de la Brea belt, in addition to copper mineralization, locally have significant gold enrichment. This appears to be associated in both granitic and rhyolitic hostrocks with quartz-feldspar porphyry dykes containing distinctive bipyrimidal, 'smoky' grey quartz phenocrysts. A single Ar-Ar date from K-feldspar from one of these dykes gives an Eocene age (52 Ma). This suggests that a Tertiary precious metal mineralizing episode occurred in this older Cordilleran terrane.

Visits to a number of the alteration zones identified in the 1993 Norwest study, and a few other areas, have provided a large, well-documented sample collection for those interested in details about the various alteration zones. This information is presented in Appendix C. In addition to whole rock petrochemistry some alteration minerals have been analyzed by infra-red spectrometry (PIMA), and there are a number of exploration geochemical sample analyses (assays).

## INTRODUCTION

Fieldwork as part of PASMA *[Proyecto Apoyo al Sector Minero Argentino]* was conducted during March 1998 in southern La Rioja and the adjoining part of northern San Juan Province. The project area encompasses a region between Latitudes 28° 17' and 28° 41' South, and from the Chilean frontier on the west to approximately Longitude 69°10'W. The western belt of hydrothermally altered rocks and mineral prospects in this part of the high Cordillera of the Andes along the Argentinean-Chilean border has been referred to as the 'Faja de Potro'. To the east the mountain ranges and hills of predominantly Paleozoic and Early Mesozoic rocks are called the Cordón de la Brea. The two belts offer contrasting metallogenic environments. The western is a zone with alteration related to Tertiary high-level intrusions and subvolcanic hydrothermal activity with potential for porphyry copper and gold, as well as precious metal epithermal deposits. The eastern belt, the Cordón de la Brea, is hosted principally by Paleozoic and Early Mesozoic rocks with potential for base metal deposits, notably vein and tourmaline breccia-related copper deposits. An overall elevated geochemical signature of lithophile suite elements, with some gold, from apparently Tertiary hydrothermal activity is indicated.

A number of areas with zones of hydrothermal alteration were selected for field examination. All the sites, with two additional ones, were identified from satellite image analysis by Norwest Mine Services Inc. and described in their 1993 report entitled *'Feasibility Study to Encourage Mining Investment in Argentina'* commissioned by the Secretaria de Minería. It is likely that all of the areas of interest identified in the report have been visited by SEGEMAR geologists, and most have been recently examined for their mineral potential by various exploration companies. A number of the sites have been extensively explored since the mid-1990s, including some testing by drilling. Others have received only superficial geologic examination by private interests. Currently Tenke Mining Corporation holds a large property (over 26,000 ha) in the Peña Negra – Los Mogotes region, referred to as the Vicuña property.

The main purpose of the field visits and examinations during the PASMA program was two-fold. In addition to offering opinion about the types of deposits, their origins and the style of alteration - a classification and genetic modeling exercise, the main objective was to generate new petrochemical, mineralogical and radiometric age data from samples collected from the mineral prospects and their host lithologies. This type of information can serve as a base for fundamental metallogenic research and provide guides for future mineral exploration. Altogether, the reassessed and newly gained information will assist the evaluation of regional mineral potential for the various types of mineral deposits likely to occur in the region.

Much consideration during this project was given to outlining lithostratigraphic units, recognizing the mineralized ones, and sampling them in order to characterize their petrochemistry. Equally important, samples were sought from hydrothermal alteration assemblages and their hostrocks to provide material suitable for radiometric age determination. These new petrochemical and age data will contribute to the scientific understanding about the age of volcanic units, mineralized and other, and hopefully will enable regional correlation of potentially mineralized lithologies and stratigraphic units that will make them attractive to the exploration community.

The field party convened in La Rioja on March 5, 1998 and consisted of: Osvaldo V. Cravero, party chief, Delegación La Rioja, Andre Panteleyev, PASMA contract geologist, Domingo Vargas, driver and cook, Delegación La Rioja, and Antonio Roberto Villacorta, camp assistant, Delegación La Rioja. Discussions and reviews of reports and information about previous work in the area took place at the La Rioja offices prior to fieldwork; departure for the field took place on March 7. The project terminated in La Rioja on March 29, 1998.

## GEOLOGICAL SETTING

The Argentinean Andes are in large part constructed on, and their tectonic history is dominated by, metamorphosed Paleozoic basement rocks. There are large blocks of these rocks exposed over relatively large north-south ranges; the Cordón de la Brea is one such mountain range. Small fault-bounded blocks of Paleozoic rocks can be found near even the highest regions of the Faja de Potro belt (see Figure 1).

The younger Andean superstructure in the project area is in large part terrigenous Tertiary basin-fill and Quaternary cover, with in places (surprisingly) thin volcanic accumulations of relatively young age, mainly Pliocene-Pleistocene to Recent. This volcanic cover results in only local development (or exposure?) of the large Middle Miocene and older volcanic complexes and eroded stratovolcanoes such as those to the west in Chile. A notable exception seems to be the project area of southern La Rioja (Rio Peña Negra region) and northern San Juan Province in the

Rio del Macho Muerto headwater area, and to the west and south. There, extensive volcanic units and related intrusions of supposedly early and middle Miocene age are present. This makes the region particularly attractive for mineral exploration, similar to the Maricunga, El Indio-Pascua belts in Chile, and to the Veladero-Valle del Cura epithermal districts in Argentina to the south.

Permo-Triassic intrusive bodies such as Carnerito granites and their cogenetic felsic volcanic complexes, as well as similar volcanic rocks of the Choiyoi Group, are mineralized, for example at and near Mina Margarita in the Cajón de la Brea area. The question of whether there are Tertiary intrusions cutting the older rocks seems to be answered by an Eocene Ar-Ar date obtained from a quartz-Kfeldspar porphyry dyke to the south of Mina Margarita in the Cajón de la Brea area. Additional mapping and radiometric dating of 'Paleozoic' plutons and felsic volcanic units is highly desirable.

The Paleozoic to Triassic rocks that form the uplifted tectonic block that constitutes the Cordón de la Brea are cut by north- to northeasterly-trending, steep and shallow-dipping (thrust) faults, some of which contain hydrothermally altered zones such as at Barreales de Ranchillos, Laguna de las Huaycas and Las Carachas. The age of the fault-related alteration is unknown but suspected to be entirely Tertiary. The evidence from the new Ar-Ar dating is that Sapitos prospect is hosted in an Eocene/ Oligocene Tertiary volcanic edifice. The feldspar hornblende porphyry dykes, flows and subvolcanic plugs at Sapitos apparently represent basal Tertiary volcanic units that occur well to the east of the other Miocene, and younger, volcanic deposits.

The structural style of the region is that of a highly block-faulted zone, with relatively little folding, that is dominated by arc-parallel, north to northeasterly-trending faults. The main architecture is a result of movements with episodic compressional to extensional events during an early Tertiary (Eocene?) to Pliocene transpressive regime related that is related to oblique subduction. Early faulting resulted in large block uplifts with little apparent lateral movement. Later faulting commonly displays sinistral offsets. Nothwesterly-striking structures of undetermined age appear to have an important control on mineralized districts, mainly because these structures appear to control the emplacement of high-level intrusions (Mpodozis *et al.*, 1995). At a local scales of exploration interest, such as at Vicuña property (Tenke, 2000) and the Veladero district to the south, breccia complexes appear to be important for the epithermal gold-silver mineralizations.

*Regional Map Units*

Map units in which the altered zones occur were examined during field visits are described briefly below. The map unit names used on Figure 1, and their ages, are those shown on the Pastillos map (Fauqué, 2000).

*Ranchillos Formation* (Map unit 3), Carboniferous: Dark to pale coloured fine-grained sandstones, commonly highly micaceous, with extensive shale sequences. The rocks occur in massive, indistinct to thin-bedded successions.

*Choiyoi Group* (Map unit 4) and *Carnerito Formation* (Map-units 5,5a,5b), Permian to Triassic: The granitic rocks (unit 5) are typically coarse-grained and porphyritic granite and granodiorite. The (rhyolitic) volcanic rocks (unit 5a) form ingnimbritic units that are virtually indistinguishable in the field from Choiyoi rocks. All these rocks are weakly iron-stained, pale orange to buff and cream coloured. In places they are pink to purple in colour due to the presence of pervasive earthy hematite. Many of these rocks previously mapped as Choiyoi are now shown on the Pastillos map to be part of Carnerito Formation (unit 5a). Volcanic successions of mainly andesitic composition are shown as unit 5b.

*Peña Negra 'Formation', Doña Ana* and *Cerro de Las Tortolas Formations* (Map unit 8), Oligocene to middle Miocene: These Tertiary rock are a heterogeneous, multi-hued assemblage of lava flows, pyroclastic rocks and flow-dome complexes.Basalts are generally dark in colour and form splintery, vitreous to hornblende-phyric domes. Andesitic rocks are characterized by the presence of plagioclase and hornblende phenocrysts; more siliceous rocks approaching dacite compositions have biotite and rare, fine-grained quartz grains. The younger successions (Doña Ana and Cerro de Las Tortolas equivalents) comprise both andesite and rhyodacite to rhyolite units; the latter two contain both biotite and hornblende. There are also basalt units recognized in the Cerro de Las Tortolas Formation.

*Rio de la Sal, Ollita and Barrancas Viejas Formations* (Map unit 9), middle to late Miocene, and younger in part: these are mainly ignimbrites and continental sediments.

*Veladero Formation* (Map unit 10), Pliocene to Pleistocene: basalt to andesitic lavas erupted from large volcanic edifices, commonly overlying alluvial deposits and terraces.

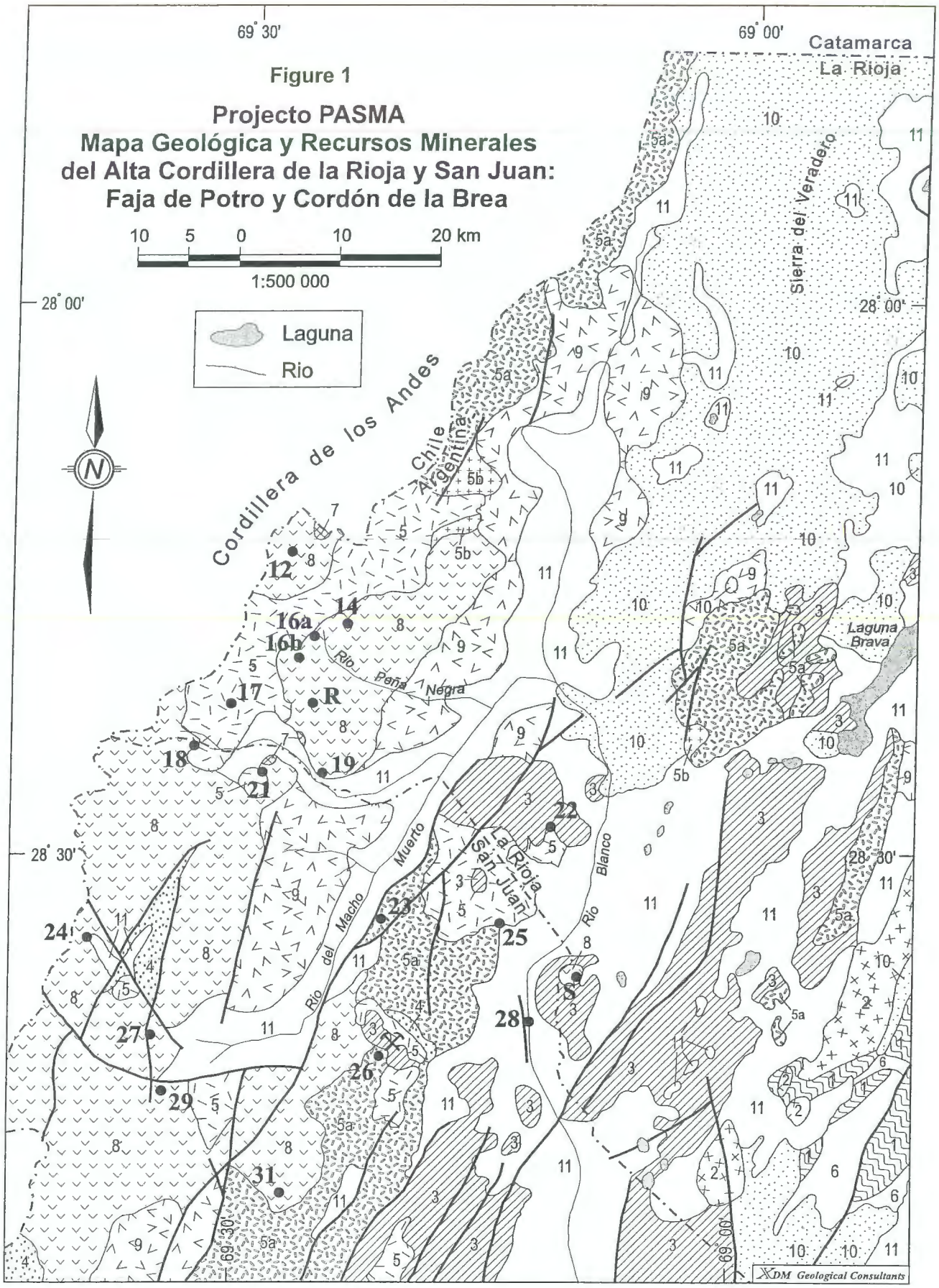
Figure 1
Projecto PASMA
Mapa Geológica y Recursos Minerales
del Alta Cordillera de la Rioja y San Juan:
Faja de Potro y Cordón de la Brea
10 5 0 10 20 km
1:500 000
69° 30'
69° 00'
28° 00'
28° 30'
Catamarca
La Rioja
Laguna
Rio
Cordillera de los Andes
Chile
Argentina
Sierra del Veradero
Laguna Brava
Río Peña Negra
Río del Macho
Río Muerto
Río La Rioja
Río San Juan
Río Blanco
XDM Geological Consultants

Figure 1: Geologic Map Legend


**Mineral Prospects**

| | | | |
|---|---|---|---|
| o 12 | Cero Caserones | • 24 | Cero Los Mogotes |
| • 14 | La Vicuñita | • 25 | Quebrada Ranchillos |
| • 16a | La Ollita | • 6 | Cajon de la Brea |
| • 16b | (Rio) Tamberias | o 29 | Bordo Atraveso |
| o 17 | Rio Bermejo | • 27 | Filo Amarillo (Rio del Inca) |
| o 18 | El Potro | • 28 | Barreales de Ranchillos |
| o 19 | Rio Blanco | ⚒ | Mina Margarita |
| o 21 | Arroyo Batedero | • 31 | Las Carachas |
| • 22 | Pastos Largos | • R | Rizuko caldera |
| • 23 | Laguna de las Huaycas | • S | Sapitos |

Generalized geologic map of PASMA 1998 project area, modified from *Secretaria de Minería* 1:500 000 geological maps of San Juan (1995), La Rioja (1993) and updated from 1:250 000 map Pastillos 2969-I (2000) by L. Fauqué. Prospect numbers refer to *Norwest* report on 'Mining in Argentina' (1993); R and S sites are not discussed in the *Norwest* report. Closed symbols denote visited sites.

Figure 1 (presented in both colour and blackline) shows the simplified regional geology in the project area and the locations of alteration zones identified in the Norwest (1993) report. Alteration zones in the 'Faja de Potro' include: Cerro Caserones, La Vicuñita, La Ollita, Rio Tamberias, Rio Bermejo, El Potro, Rio Blanco, Arroyo Batedero, Cerro Los Mogotes, Filo (Cerro) Amarillo, and Bordo Atraveso. The Cordón de la Brea area, and alteration zones along its margins, include: Pastos Largos, Laguna de Las Huaycas, Quebrada de Las Ranchillos, Cajón de la Brea and Mina Margarita, Barreales de Ranchillos, and Las Carachas. In addition to these areas identified in the Norwest report, it was opportune during this program to examine new areas of interest - the Ritzuko caldera and Sapitos prospect. The thirteen deposits visited during this program are indicated on the Figure 1 legend pages. Figures 2 and 3 (photographs) show the physiography of the study area and feature some of the brightly coloured hydrothermally-altered zones of interest.

*Quaternary* rocks (Map unit 11). Thick accumulations of alluvium, inclduing fluvial and glacial deposits. Included are large zones with transported mass wasting deposits.

Map units not encountered in this survey but shown on the Pastillos regional map and Figure 1 include: *Punilla Formation* (Map unit 1), Devonian and younger; Granitic rocks (Map unit 2), Carboniferous; *El Aspero and Santo Domingo Formations* (Map unit 6), Triassic; and *Las Chapitas Formation* (Map unit 7), Cretaceous (?).

## NEW AR-AR DATING RESULTS

Until the late 1990s there were no published radiometric dates from the study area but recent work has produced a number of K/Ar dates. On the Pastillos 1: 250 000 map (Fauqué, 2000) shows a number of sites in volcanic units mapped as Doña Ana rocks (unit 8 on Figure 1) with ages of 20, 20.7, 21, and two with 25 Ma (analytical errors not noted). The Japanese Mining Engineering Centre study (JMEC, 1999) reports the following K/Ar dates: 17.1 from hydrothermal muscovite ('sericite') and 15.3 Ma from dacite at the Cerro Los Mogotes prospect (number 24, Figure 1) and 23.1 Ma on alunite from Filo (Cerro) Amarillo (prospect number 27, Figure 1). Possibly the most interesting among the JMEC (1999) results are the 74 and 89 Ma ages from granites at the El Potro porphyry prospect (number 18, Figure 1). The presence of these late Cretaceous intrusive rocks has not been previously recognized and illustrates the greater than expected complexity of the region. To the north of the study area at the La Ortiga property, near 29°19' S and 69°50' W, Triassic rhyolitic pyroclastic rocks and volcaniclastic sediments of the Choiyoi Group have been dated by U-Pb on zircon to have 243±4 and 211±6 Ma ages (Steven *et al.*, 1998). In contrast, to the south at Mina Margarita (near site 26 on Figure 1) felsic volcanic rocks previously mapped as part of the Choiyoi Group returned a single Permian radiometric date of 280 Ma (Fauqué, 2000). These rocks are now included as part of the Permian Carnerito Formation. Three additonal K/Ar dates report by JMEC (1999) are Triassic ages of 246±12, 235±12 and 217±11 Ma from granitic rocks, part of the Carneritos granites, from near the Quebrada de Ranchillos prospect (number 25 on Figure 1). Clearly in this region much revision of map unit ages can be expected if additional age determinations are done.

In our study we selected a number of samples for dating from chloritized hornblende ± plagioclase-phyric rocks in the Peña Negra area, and a few from elsewhere (see Table 1 and Appendix A for analytical data and Ar-Ar step-heating spectra plots). The Ar-Ar analytical work was done by Paul Layer, Geochronology Laboratory, University of Alaska, Fairbanks, U.S.A. and was funded by Watts, Griffis, McOuat Limited. Five

**Table 1:** Summary of Ar-Ar Age Determinations

| Sample | Min. | Integrated Age (Ma) | Plateau Age (Ma) | Comment | Isochron Age (Ma) |
|---|---|---|---|---|---|
| 98AP02-6/1-32 | Bi | 22.6 ± 0.5 | 22.9 ± 0.5 | Good plateau, 10 fract, 94% rel. | No isochron |
| 89AP02-3/1-10 | Hbd #1 | 20.2 ± 1.0 | (34.1 ± 2.1) highest age reached | Ar loss, 0 age reset, Minimum age | 24.0 ± 8.9 4 fract, init = 660 ± 465 |
| | Hbd #2 | 27.3 ± 1.6 | 36.3 ± 1.7 | Good plateau 4 fract, 70% rel. 0 age reset | 35.9 ± 2.1 5 fract init = 314 ± 82 |
| 98AP02-8/3-44 | Hbd | 30.9 ± 1.2 | 35.6 ± 1.9 | Ar loss, plateau is minimum age 4 fract, 39% rel. | 29.2 ± 4.5 5 fract init = 428 ± 211 |
| 98AP02-15/5-73 | Hbd | 37.7 ± 0.5 | 37.3 ± 0.5 | 6 fract 72% rel. Evidence of excess argon | 36.0 ± 0.5 11 fract, init = 344 ± 8 |
| 98AP02-10/1-51 | Kspar | 57.9 ± 0.8 | 52.3 ± 0.9 | Saddle age 6 fract, 44% rel. | 52.3 ± 2.5 6 fract init = 367 ± 11 |

Preferred interpretive ages are denoted in bold. rel. = $^{39}Ar$ released, fract = fractions in the step heating experiment, init = initial $^{40}Ar/^{36}Ar$ ratio. All errors reported at 1 sigma.

samples were dated as part of this study. The samples were crushed, sieved and mineral crystals between 250 and 500 microns in size were selected. These minerals were irradiated at the McMaster Reactor, Hamilton, Ontario, Canada along with the biotite standard Bern 4B with an age of 17.25 Ma.

*Discussion of Samples*

The following discussion is in large part based on the report by the analyst, Paul Layer. See Appendix A for analytical data and plots of step-heating ages and Ca/K spectra, and Appendix C for sample documentation.

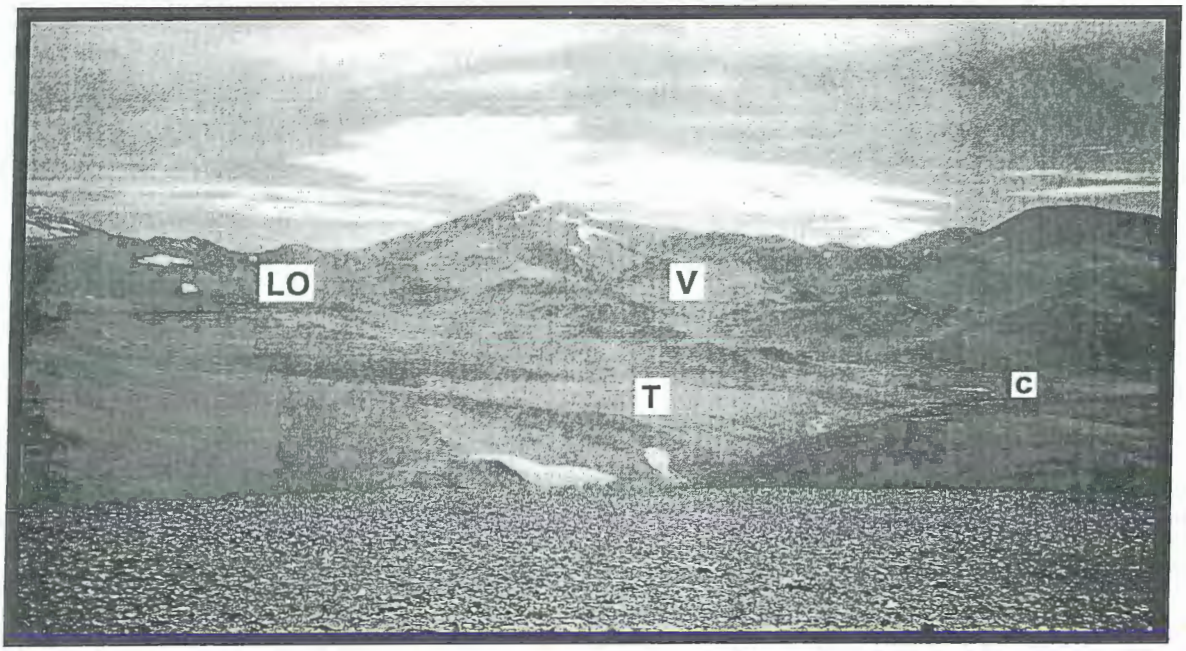


**Figure 2.** Rio Peña Negra headwater area, view to north-northwest towards Chilean border. Pale coloured alteration zones marked: V - Vicunita, LO - La Ollita, T - Rio Tamberias; C is site of Eldorado exploration camp, elevation ~3850 m.

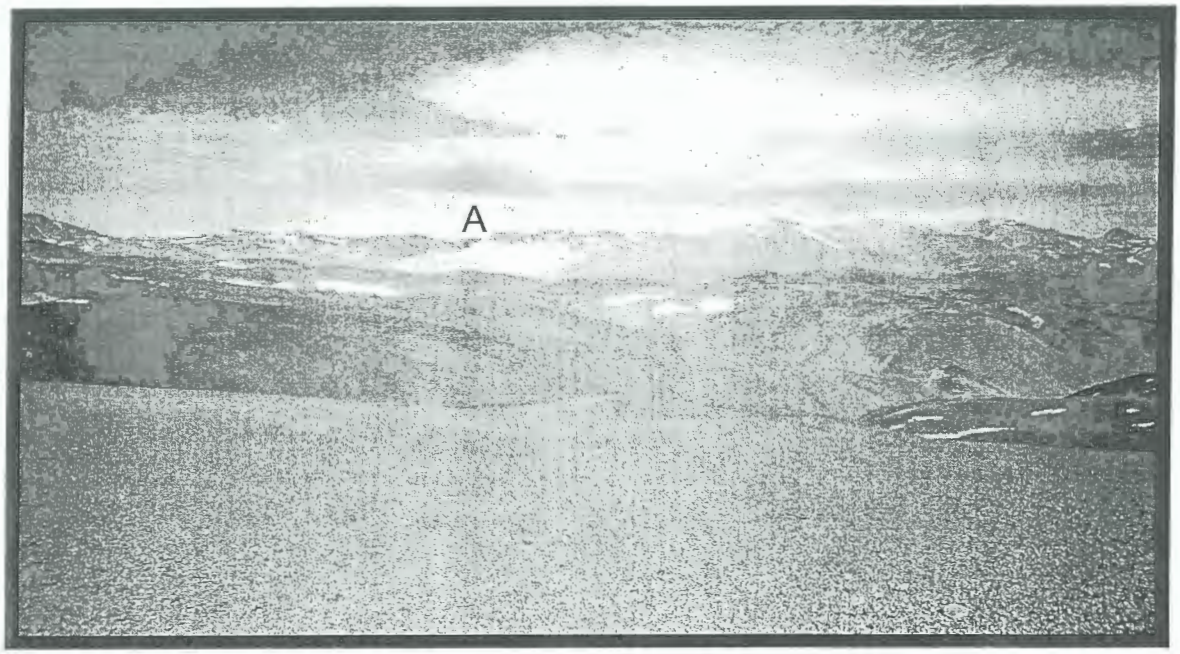


**Figure 3.** Cordon de la Brea area, view westerly across extensive areas of limonitic Paleozoic felsic volcanics in foreground and Tertiary volcanics in distance; elevation at photo is about 4500 metres. Quartz-alunite and clay alteration give rise to the pale-coloured resistant ridge at Filo Amarillo (location A). Los Mogotes prospect at far left on far ridges just beyond view of photo.

*98AP02-6/1-32 Las Carachas:* Biotite from this 'pristine' reddish-mauve colored siliceous biotite-hornblende and plagioclase-bearing rhyodacite flow rock shows a well defined plateau age of 22.9 ± 0.5 Ma based on 10 fractions and 94% of gas release. There is little or no evidence of post-eruptive resetting or alteration of the biotite. This age is consistent with Doña Ana stage volcanism.

*89AP02-3/1-10 Rio Tamberias:* Hornblende from this hornblende plagioclase porphyry with andesite composition was dated. Because the results from the first analysis were somewhat surprising, a second split of the sample was dated to confirm the results. This hornblende seems to be composed of two discrete phases, a chloritic biotite phase (Ca/K < 10) and an amphibole phase (Ca/K > 20). The chloritized hornblende phase is seen in the first 20-30% of gas release and has a 0 age. For sample #2, the hornblende has a 4-fraction 70% plateau age of 36.3 ± 1.7 Ma. This mineral is also characterized by a flat Ca/K spectrum as well. In the first specimen, the hornblende shows a stairstep-up pattern in both age and Ca/K, which we interpret to reflect alteration and resetting in this sample (these are single grain samples, so some variability is possible from grain to grain). The oldest age step in this sample is 34.1 ± 2.1, which approaches the plateau age of the less altered amphibole

*98AP02-8/3-44 Eldorado camp flow-dome:* Hornblende from hornblende porphyry with basalt composition (50.4% $SiO_2$) that forms a small dome about 250 metres across was dated. The sample shows a stairstep-up pattern as was seen in the more altered sample from 89AP02-3/1-10. Thus ages from this sample should be considered to be 'minimum' as well. The highest temperature steps (4 fractions, 39% release) have a 'plateau age' of 35.6 ± 1.9 Ma consistent with the age from the Rio Tamberias sample. As with 89AP02-3/1-10, there is evidence of recent (0 age) argon loss, which is associated with chloritic alteration of the amphibole. This is seen in lower Ca/K ratios for the young age steps.

*98AP02-14/5-73 Sapitos:* Hornblende from this hornblende-plagioclase porphyry andesite sample was dated. There is some evidence of alteration of the amphibole as seen in low Ca/K ratios, and some evidence of excess argon as well. The sample has an apparent plateau age of 37.3 ± 0.5 (6 fractions, 72% release), however due to the presence of excess argon, the whole-sample (all fractions) isochron age is slightly younger at 36.0 ± 0.5 Ma (initial $^{40}Ar/^{36}Ar$ ratio = 344). We prefer the isochron age as the best interpretation for the age of this amphibole. This age is identical to the plateau age from sample 89AP02-3/1-10 (Rio Tamberias).

*98AP02-10/1-51 Ranchillos:* K-feldspar was dated from this 8-metre-wide quartz-K-feldspar-sericitized biotite porphyry „rhyolite" dyke that intrudes Permo-Triassic granite. The spectrum shows some evidence of excess argon but has identical isochron and plateau/saddle ages (6 fractions, 45% release) of 52.3 ± 0.9 Ma. There may be older phases present in the feldspar, but there is no direct evidence of pre-Tertiary ages. If this porphyry is old, this age could represent a complete resetting of the argon isotopic system, perhaps associated with sericitization. More likely, this date reflects the age of this younger dyke that crosscuts the older units. This 'smoky' grey quartz-Kfeldspar porphyry is identical to dykes seen at Pastos Largos as well as the Cajon de la Brea alteration zone to the south of Mina Margarita (number 26 on Figure 1).

### *Summary of Age Determinations*

Amphiboles from volcanic rocks in the Rio Peña Negra area near the Eldorado Camp and the Rio Tamberias and Sapitos prospects (samples 98AP02-8/3-44, 89AP02-3/1-10, and 98AP02-15/5-73) are all about 36 Ma in age (Eocene/Oligocene). Because of chloritic alteration on some of the amphiboles, K-Ar ages might be in error (too young) for these volcanic rocks. All samples show evidence of young, (recent) argon loss associated with the chloritic alteration. Based solely on our hornblende and biotite data, we conclude that the amphibole-bearing samples are all the same age and are late Eocene to early Oligocene. The Eocene/Olgiocene age is significantly older than the unaltered biotite from Las Carachas rhyodacite (sample 98AP02-6/1-32), which is about 23 Ma (latest Oligocene to early Miocene). The K-feldspar from Quebrada de Ranchillos (sample 98AP02-10/1-51) is enigmatic. It is clearly older than the other samples dated. It is probably early Tertiary (Eocene) in age, and younger that the Permo-Triassic granitic rocks which it intrudes. Additional dating, could further refine the age and timing of alteration of the Eocene amphiboles.

### *Discussion*

The Tertiary volcanic successions in the Peña Negra - Rio Tamberias region, referred to as the

Peña Negra 'Formation' by Marcos *et al.*, (1971) and 'the Peña Negra (volcanic) complex' by Rios Gomez *et al.* (1997), consist of a basal late Eocene to Oligocene assemblage. The overlying units are equivalent to the Doña Ana and Cerro de La Tortolas Formations. The Peña Negra volcanics and the small body of similar rocks in the Sapitos area can be correlated in age, and are likely equivalent, to the 'Tobas Valle del Cura Formation' of the Cordilleras de La Brea and Zancarrón further to the south in San Juan Province. These are described by Limarino *et al.*, (1999) from a region centered on

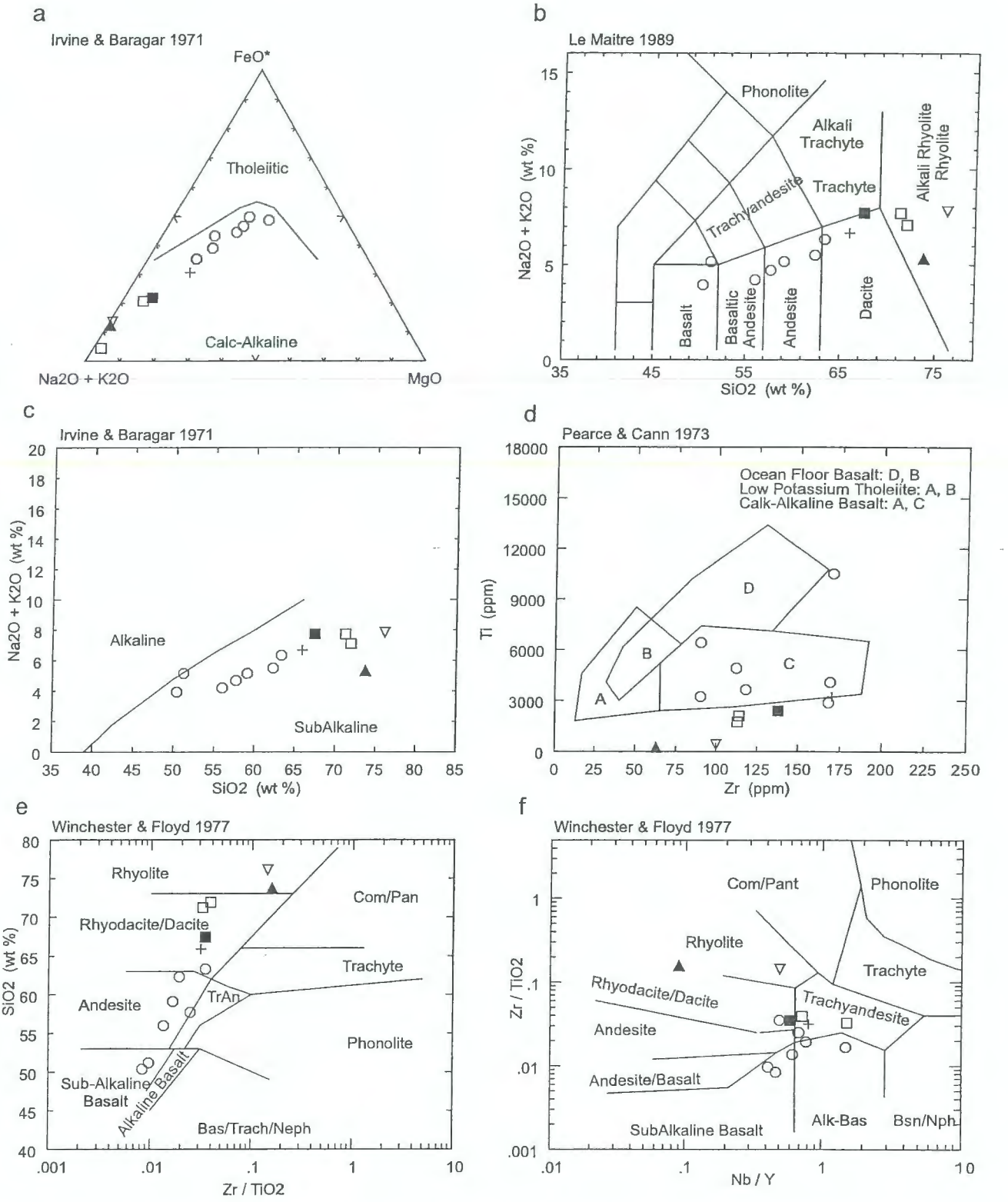


**Figure 4:** Chemical discrimination plots – see Appendix B for petrochemical analysis data for whole rock major oxides, minor and trace elements.

roughly 29°19' S and 69°50' W. They have determined K/Ar ages of 45±2, 44±2 and 36±1 Ma from andesites and 34±1Ma from dacite-rhyodacites. Additional ages of about 36 Ma are reported from northern Argentina (Zappettini, 2000) in the Fiambala quadrangle near the Chilean border and from the Santa Ines Volcanic Complex in the Socompa quadrangle. The Santa Ines unit hosts the Taca Taca Bajo porphyry copper deposit. These latest Eocene to Oligocene dates are particularly interesting because this age coincides with magmatism and hydrothermal activity that gave rise to a number of major porphyry copper deposits in northern Chile.

## PETROCHEMISTRY

Whole rock petrochemical analytical results are listed in Appendix B. Calculated CIPW norms and rock classifications according to various major oxide and minor element discrimination plots are provided on Table 2. The various classification schemes show the Tertiary rocks to be arc rocks with a consistent subalkaline, low potassium calcalkaline affinity. They are predominantly andesite in composition, with rare basalt and some dacite to rhyodacite. The quartz-feldspar porphyry that forms the flow-domes at Cerro Amarillo is rhyolite. The sole analyzed sample from Doña Ana ignimbritic units at Las Carachas is rhyodacite to rhyolite in composition. It contains biotite in excess of hornblende. The basalts analyzed are both from domes or small plug-like intrusions. The sample from Sapitos is a dark vitreous rock but the other is a hornblende porphyry. The andesites contain abundant hornblende and plagioclase grains ranging in size from microlites to medium-sized phenocrysts. Where plagioclase is abundant, rare small grains of quartz can be seen and the rocks approach dacite compositions, for example near Rio Tamberias.

The Peña Negra volcanics contain less potassium than do the volcanics of the Doña Ana and Cerro de Las Tortolas Formations. The higher potassium content in Doña Ana and Cerro de Las Tortolas volcanics is documented by Godeas *et al.* (1993), and from the same samples by *Otamendi et al.,* (1994). When the potassium content of these volcanics is expressed as normative orthoclase (*Or*), the average values for the Peña Negra rocks is 9 % *Or* [see Table 2] compared to the 16.4% normative *Or* for Doña Ana and 21% *Or* for Cerro de Las Tortolas rocks. Godeas and her co-authors state that potassium content in Argentinean Doña Ana and Cerro de Las Tortolas volcanics is greater than in the equivalent rocks in Chile. They interpret this to be because the volcanism in Argentina took place at greater distances (inboard) from the subduction zone.

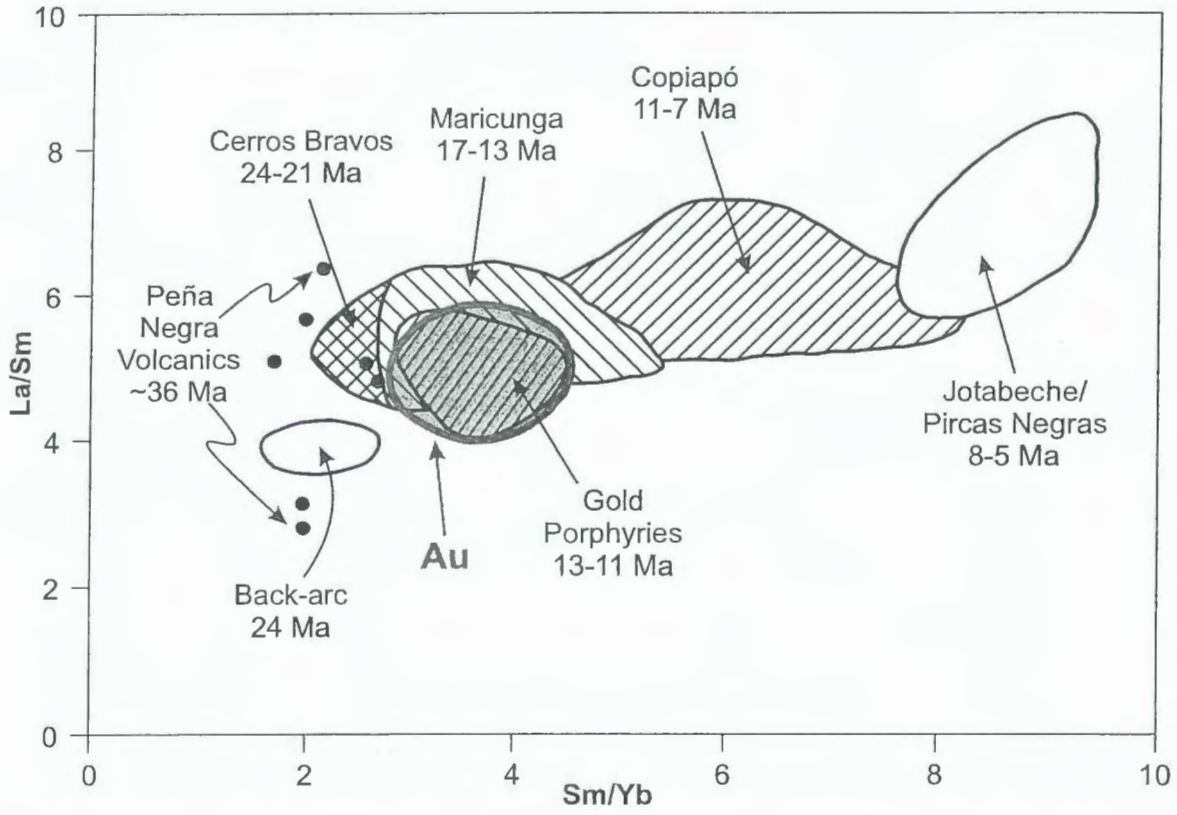


**Figure 5:** La-Sm-Yb ratios from various volcanic rock units in the Maricunga belt, after Kay *et al.*, (1999). Increasing element concentrations reflect increased crustal thickness in progressively younger units, in contrast to the composition of the older, thinner-crust back-arc volcanics.

Minor element discrimination plots have been used by Mpdozis *et al.*, (1995) and *Kay et al.*, (1999) to interpret tectonic regimes during volcanism. Plots of element ratios, mainly La, Sm and Yb, have proven to be most useful. Our data from the Peña Negra volcanics for La/Sm versus Sm/Yb, is compared to data from the volcanic units with different ages from the Maricunga belt, as shown shown on Figure 5. The relatively low element content of Peña Negra rocks are consistent with other older Andean volcanics that formed in back-arc environments. Because the Peña Negra volcanics contain abundant hornblende they can be interpreted to be derived from moderate crustal depths (pressures), signifying relatively thin-crust conditions. The Peña Negra volcanics were deposited prior to the onset of the important episodes of Au-Cu mineralization that began around 20 Ma (Mpodozis *et al.*, 1995). This coincided with shallowing of the subduction zone and the rapid build-up (thickening) of the Andean crust.

## ALTERATION ZONES AND MINERAL PROSPECTS

Descriptions of samples taken from the various alteration zones are given in Appendix C. This extended documentation of the samples provides additional information about the altered zones. Assays of samples from a number of altered zones are summarized in Table 3. They provide a geochemical characterization of the typical altered rocks found there.

The western belt of altered rocks, the 'Faja de Potro' is a zone of Tertiary hydrothermal activity related to high-level granitic intrusions with alteration zones controlled by (fault) structures and permeable volcanic strata peripheral to the intrusions. Some of the alteration is related to subvolcanic hydrothermal systems associated with flow-domes. In the Peña Negra there are a number of small intrusions composed of hornblende-rich basaltic andesite or hornblende feldspar porphyry

| Sample | 2/3-5 | 2/8-8 | 3/1-10 | 4/5-16 | 5/1-5 | 6/1-32 | 8/3-44 | 10/7-57 | 13/2-AX7 | 13/3-64 | 14/4-72 | 14/5-73 | 14/5-74 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Vicunita | Tambarias | Tambarias | Mogotes | Co. Amarillo | Carachas | PenaNegra | Ranchillos | CajonBrea | CajonBrea | Sapitos | Sapitos | Sapitos |
| Rocktype | andesite | dacite | andesite | dacite | rhyolite/ rhyodacite | rhyolite/ rhyodacite | basalt | dacite | QFP/ rhyolite | rhyolite | baslat | andesite | basalt/ andesite |
| Q | 12.41 | 18.52 | 12.87 | 21.43 | 33.82 | 32.33 | 0.06 | 23.93 | 49.32 | 39.21 | 0.00 | 11.42 | 8.19 |
| Or | 7.48 | 15.99 | 7.47 | 18.21 | 24.93 | 20.81 | 6.13 | 24.31 | 22.80 | 28.72 | 8.29 | 12.20 | 8.83 |
| Ab | 33.78 | 32.02 | 30.11 | 40.80 | 32.45 | 31.28 | 25.34 | 23.42 | 15.30 | 26.38 | 30.33 | 26.03 | 22.10 |
| An | 30.58 | 19.95 | 29.57 | 11.59 | 3.58 | 8.81 | 35.38 | 16.64 | 5.56 | 1.86 | 24.58 | 22.83 | 29.86 |
| Lc | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ne | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C | 0.00 | 0.72 | 0.91 | 1.03 | 3.65 | 1.40 | 0.00 | 0.00 | 0.00 | 1.46 | 0.00 | 0.00 | 0.00 |
| Wo | 0.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.15 | 0.16 | 1.43 | 0.00 | 1.57 | 0.43 | 0.61 |
| En | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.76 | 0.08 | 0.16 | 0.00 | 0.54 | 0.10 | 0.19 |
| Fs | 0.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.22 | 0.08 | 1.41 | 0.00 | 1.07 | 0.35 | 0.45 |
| Hy | 4.60 | 4.61 | 7.57 | 2.35 | 0.50 | 1.55 | 10.02 | 4.61 | 0.00 | 0.20 | 5.23 | 4.94 | 7.18 |
| Hy | 6.43 | 5.64 | 7.79 | 2.79 | 0.43 | 2.38 | 8.06 | 4.41 | 0.00 | 1.69 | 10.36 | 16.92 | 16.99 |
| Ol | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.62 | 0.00 | 0.00 |
| Mt | 1.45 | 1.20 | 1.67 | 0.68 | 0.17 | 0.56 | 2.31 | 1.05 | 0.20 | 0.32 | 4.29 | 3.23 | 3.37 |
| Hm | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Il | 1.05 | 0.93 | 1.33 | 0.78 | 0.00 | 0.56 | 2.09 | 1.06 | 0.08 | 0.14 | 3.22 | 1.08 | 1.52 |
| Ap | 0.45 | 0.42 | 0.72 | 0.33 | 0.11 | 0.31 | 0.47 | 0.25 | 0.02 | 0.02 | 0.91 | 0.47 | 0.72 |
| Colour Index | 2.49 | 2.13 | 2.99 | 1.46 | 0.17 | 1.12 | 4.40 | 2.11 | 0.28 | 0.46 | 7.51 | 4.31 | 4.89 |
| Different'n Index | 53.67 | 66.53 | 50.45 | 80.44 | 91.19 | 84.43 | 31.54 | 71.67 | 87.42 | 94.31 | 38.62 | 49.65 | 39.11 |

Norms calculated using MINPET software; anhydrous with Fe conversion according to Baragar and Irvine (1971)
All sample prefixes: AP98-02 ; ‚QPF' - quartz feldspar porphyry

**Table 2:** CIPW Normative Minerals and Classification According to Le Maitre (1989) and Winchester and Floyd (1977)

andesite. The domes themselves do not appear to be altered but the surrounding rocks and faults cutting them commonly are. Elsewhere in Doña Ana map-units, the rhyodacite (quartz-feldspar porphyry) intrusions can form flow-domes complexes. One highly-visible, pale bleached-looking highly visible dome is seen at at Filo Amarillo (see Figure 3) where there is advanced argillic alteration with quartz-alunite 'ledges' and zones containing pyrophyllite and dickite. This central high-temperature advanced argillic alteration is surrounded by zones with clays (mainly illite) that grade outward into peripheral zones with mixed-layer illite/smectite, smectite and finally epidote-rich propylitic assemblages. Other highly clay-altered rocks are the caldera-fill deposits at the Ritzuko caldera. In many of these altered zones, silicification is weak to absent in outcrop and much of the alteration is (kaolinitic) clay and lesser clay-alunite that appear to be formed by acid sulphate high-level (geothermal) steam-heated groundwaters and supergene processes. Where there is deeper erosion and exposure of intrusions, some quartz stockworks are present and in places carry rare molybdenite, for example at Los Mogotes and in the northeast part of Vicuñita (J.A. Riós Gómez, personal communication, 1998), or rarely enargite. Copper-bearing stockworks have been intersected below the extensive zone of clay-altered rocks at La Ollita in what appears to be a porphyry copper deposit environment.

In the Cordón de la Brea Paleozoic felsic volcanic rocks formerly considered to be part of the Choiyoi Group, are now thought to be volcanic components of the mainly granitic Carneritos Formation. These rocks are intruded by Triassic stocks of porphyritic granite from which 243 to 217 Ma K/Ar ages have been reported by JMEC (1999). Locally there are dykes of quartz – Kfeldspar porphyry carrying distinctive smoky bipyrimidal quartz phenocrysts. The dykes contain rare quartz-bearing fractures and show elevated gold values at Cordón de la Brea prospect near Mina Margarita, and probably also in the similar geological setting at Quebrada de Ranchillos. (Hydro)thermally altered zones at intrusive contacts of a number of the stocks are attractive for exploration. At Ranchillos country rocks along a gently-dipping intrusive contact have a large rusty zone with widespread sericite alteration. In many places throughout the Cordón de la Brea district sericite is a common alteration product. It is derived from original micas in mica-rich quartzite hostrocks that are the predominant rock type in the region. In rare cases rocks at the granite contacts display some silicification, with elevated gold values in brecciated zones, for example at Pastos Largos. Within intrusive bodies, rare small quartz veins occur, with or without

| Sample | Ag | As | Au | Ba | Bi | Cd | Cu | Hg | Mo | Pb | Sn | W | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all ppm | * | | | * | * | | * | | * | * | * | | * |
| 98AP02-9/4AX1 | < | 45 | 5 | 904 | < | < | 10 | < | 6 | 13 | < | 14 | 14 |
| 98AP02-9/4AX2 | < | 44 | 1 | 913 | < | < | 17 | < | 5 | 21 | < | 32 | 6 |
| 98AP02-9/5AX3 | 0.4 | 13 | 4 | 858 | < | < | 15 | < | 6 | 13 | < | 39 | 3 |
| 98AP02-11/2AX4 | 0.5 | 294 | 3 | 2950 | 10 | 4 | 35 | < | 14 | 5 | < | 163 | 184 |
| 98AP02-12/2AX5 | < | 3 | 1 | 30309 | < | < | 3 | < | 3 | 4 | < | 91 | 32 |
| 98AP02-12/2AX6 | 0.4 | 84 | 1 | 967 | < | 1 | < | < | 2 | 5 | < | 350 | 28 |
| 98AP02-13/2AX7 | 0.4 | 16 | 1 | 317 | < | 2 | 7 | < | 4 | 11 | < | 240 | 1160 |
| 98AP02-14/1AX8 | < | 55 | 39 | 635 | 19 | < | 27 | < | 5 | 9 | 12 | 136 | 33 |

AX1 Ritzuko Caldera: clay-altered pyroclastic, limonite on fractures
AX2 Ritzuko Caldera: brecciated clay-altered pyroclastic, gypsum on fractures
AX3 Ritzuko Caldera:quartzose pyroclastic -clay-altered, intensely jarositic, supergene alunite in veinlets
AX4 Pastos Largos: mosaic breccia with limonite on fractures, in quartzite at granite contact
AX5 Barreales de Ranchillos: sparse carbonate-veined quartzite, weakly brecciated rocks in fault zone
AX6 Barreales de Ranchillos: Orange-weathering carbonate in fractures in fracured quartzite in (regional?) fault zone
AX7 Cajon de la Brea: chip samples from weakly chalcedonic quartz-veined quartz-feldspar porphyry dyke
AX8 clay-altered, limonitic highly fractured sediments, from trenches in area of RC drilling"

* denotes ICP analysis, all others NAA. Laboratory: XRAL, Argentina"
< denotes less than detection limit

**Table 3:** Assay Samples From Altered Zones, representative grab samples"

tourmaline; more commonly there are lenses and zones of feldspar-muscovite-tourmaline pegmatite. Elsewhere, such as at Mina Margarita, tourmaline replacements in thin-bedded sedimentary rocks and massive tourmaline replacement zones with breccias carry some chalcopyrite, chalcocite, pyrite and pyrrhotite, but this mineralization reveals little evident gold potential. The cupriferous zones near surface are oxidized and test leaching of the secondary copper minerals has been done.

In summary, the following are the mineralized environments represented by the alteration zones visited:

**Porphyry systems:** *La Ollita and Rio Tamberias*. At *La Vicuñita* there is also an advanced argillic alteration zone in the northwest related to a structurally-controlled dyke intrusion. At *Los Mogotes* sericite (muscovite) fracture filling with pyritic and enargite-bearing quartz veinlet demonstrate a high-sulphidation overprint attended by extensive clay alteration and fracture fillings with native sulphur, alunite and gypsum.

**High sulphidation epithermal:** *Filo (Cerro) Amarillo displays quartz-alunite 'ledges' in a kaolinite-altered zone in which there locally developed zones* with dickite and pyrophyllite. The geological setting is a rhyodacite (quartz-feldspar porphyry dome) with alteration in the cupola and flow-dome carapace rock.

**Clay altered zones with epithermal (?) settings:** Lagunas de las Huaycas, Las Carachas and Sapitos.

**Intrusion-related gold mineralization:** Quartz vein and/or vein and fracture stockworks or disseminations with some elevated gold values in Paleozoic hornfelsed rocks occur at Pastos Largos and Quebrada de Ranchillos. At these occurrence and certainly the Cajón de la Brea, the gold is possibly related to Eocene quartz-Kfeldspar porphyry ('rhyolite') dykes.

**Fault-related alteration in Paleozoic sedimentary rocks:** Assays with elevated *barium* were collected from the Barreales de Ranchillos prospect. No other significant geochemical enrichment was detected.

## DISCUSSION

Tertiary volcanic successions in our study area include older (Peña Negra) volcanics as well as units equivalent to the Doña Ana and lesser ammounts of Cerro de Las Tortolalas Formations. To the east and north (see Figure 1) are large accumulations of economically less interesting Pliocene, and younger, volcanic and terrigenous sedimentary units and, in places, thick alluvial cover. Peña Negra back-arc volcanics sit unconformable on mainly Paleozoic sedimentary rocks and locally underlie the extensive volcanic successions that make up the bulk of the high Andes and are equivalent to the Doña Ana and Cerro de Las Tortolas Formations. These older volcanic rocks have been deeply dissected in many place and expose cogenetic domes or other high-level intrusions and their near-surface altered cupolas (for example La Ollita). In this setting the style of mineralization can be expected to be predominately porphyry-type, with possibly locally-developed or flanking (high sulphidation) overprints. This is the case in Los Mogotes and possibly the Faja de Potro prospects.

The geological setting in this study area of the high Cordillera with its younger, and most abundant, volcanic units of the Doña Ana and Cerro de Las Tortolas Formations is similar to the Maricunga belt. Collectively this zone referred to as the Faja de Potro can be considered to be a southern extension of the Maricunga. In that region there has been extensive mapping and radiometric dating of volcanic units. The successions of variably eroded, coalescing stratovolcaoes and dome fields have been subdivided into 6 magmatic pulses ranging in age form 26 to 5 Ma (Mpdozis *et al.*, 1995) but only two stages are known to host significant mineralization - the 26-21 Doña Ana and the 17-11 Ma Cerro de Las Tortolas Formations. Ages of mineralized hostrocks in the El Indio belt to the south are similar although in that district Jannas *et al.*, (1999) emphasize the importance of 8 to 6 Ma ages of high sulphidation epithermal mineralization. A similar age of mineralization, but perhaps as old as 14 Ma, has been proposed for the Veladero district in Argentina, (D. Heberlein, personal communication, October 2000).

In our Project area there are indications of two main types of ore deposits: gold or cupriferous gold porphyry and epithermal precious metal deposits. The gold porphyry despots are associated with high-level, diorite to quartz diorite stocks, perhaps better regards to be subvolcanic andesitic to dacitic bodies, in which the cupolas contain sets of sheeted, narrow quartz veins and silicified fractures. These are the main deposit type in the Maricunga belt, Chile. This mineralization is associated with magnetite-rich potassic alteration in the cores of the intrusive bodies that has been extensively overprinted by a phyllic (illite) to propylitic alteration. Sulphide content in these deposit is generally low, with only small amount of pyrite and minor chalcopyrite, bornite and molybdenite

(Vila and Sillitoe, 1991). Muntean (1998) has concluded from detailed studies of these porphyry gold deposits in the Maricunga belt that the sulphide minerals, as well as the gold, were introduced together with silica in a system of sheeted narrow quartz veins and quartz-bearing fractures. There can also be overprinting or laterally-developed zones of enargite-bearing high sulphidation epithermal gold-silver mineralization. The uppermost part of these systems can be overprinted by barren, steam-heated, advanced argillic alteration or they can progress outward into zones of argillic to propylitic alteration.

The gold-silver deposit most likely to occur in the region will be those similar to the high sulphidation epithermal deposits found in Chile in the El Indio district to the south and the La Coipa deposit in the northern Maricunga belt. These deposits consist of the following: vein systems, both gold-quartz veins and enargite–rich veins (El Indio), hydrothermal breccias and diatremes (Tambo, Veladero, Pascua), stratabound or tabular blankets controlled by primary lithologic permeability (Esperanza of Pascua district and Pascua), and combinations of disseminated mineralizations with with structural controls (parts of Pascua).

## ACKNOWLEDGEMENTS

I thank Greg Fernette, PASMA project manager, Watts, Griffis, McOuat Limited, Denver, Colorado for facilitating my work in this project. Most importantly Watts, Griffis, McOuat Limited funded the Ar-Ar work reported here and three of the chemical analyses. The project leader and my colleague in the field was Osvaldo Cravero, SEGEMAR, Delegación La Rioja. I thank him, and his family, for extending me their hospitality in La Rioja. Discussions in the field with Julio Rios Gomez enlightened me about the exploration history of the area, and its geology. Valuable discussions and access to company reports was provided by Gary Nordin, Eldorado.Gold Corporation, Vancouver, Canada. Gerry Ray and Don MacIntyre, past colleagues at the British Columbia Geological Survey Branch, assisted with computer petrologic programs. Mike Fournier of MAF Graphix prepared the figures.

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# Appendix A

## Ar-Ar Dating

## Appendix A: Ar-Ar dating - analytical data

**98AP02-3/1-10** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0.0025 | 1908.371 | 4711.134 | 1.510 | 4.319 | 9.531 | 23.556 | 147.6 | 2.77 | 7.94 | 0.1050 | 0.3801 | -908.7 | 2271.7 | -114.3 | 294.9 |
| 300 | 0.0777 | 105.932 | 16.386 | 0.515 | 0.116 | 0.520 | 0.098 | 145.0 | 0.95 | 0.21 | 0.0288 | 0.0152 | -47.7 | 18.4 | -5.8 | 2.3 |
| 600 | 0.2058 | 101.772 | 16.203 | 0.987 | 0.163 | 0.390 | 0.064 | 113.2 | 1.81 | 0.30 | 0.0251 | 0.0090 | -13.5 | 6.3 | -1.6 | 0.8 |
| 900 | 0.2889 | 133.797 | 18.139 | 1.698 | 0.241 | 0.502 | 0.074 | 110.8 | 3.12 | 0.44 | 0.0599 | 0.0275 | -14.5 | 9.6 | -1.8 | 1.2 |
| 1200 | 0.3303 | 457.705 | 327.482 | 14.278 | 10.214 | 0.260 | 0.214 | 16.5 | 26.44 | 19.09 | 0.0871 | 0.0714 | 385.6 | 280.4 | 46.4 | 33.3 |
| 1500 | 0.4537 | 241.256 | 8.124 | 7.932 | 0.271 | 0.140 | 0.035 | 17.0 | 14.63 | 0.50 | 0.0408 | 0.0114 | 201.4 | 12.9 | 24.4 | 1.6 |
| 1800 | 0.6132 | 257.820 | 9.311 | 9.059 | 0.295 | 0.079 | 0.035 | 8.8 | 16.72 | 0.55 | 0.0466 | 0.0080 | 236.6 | 13.9 | 28.6 | 1.7 |
| 2100 | 0.7704 | 287.139 | 13.548 | 9.913 | 0.429 | 0.160 | 0.021 | 16.2 | 18.31 | 0.80 | 0.0531 | 0.0080 | 242.2 | 13.8 | 29.3 | 1.7 |
| 2500 | 0.9052 | 327.954 | 16.408 | 11.080 | 0.536 | 0.163 | 0.033 | 14.5 | 20.48 | 1.00 | 0.0520 | 0.0100 | 282.5 | 17.3 | 34.1 | 2.1 |
| 3000 | 0.9941 | 321.746 | 19.271 | 11.592 | 0.687 | 0.222 | 0.043 | 20.2 | 21.43 | 1.28 | 0.0413 | 0.0082 | 258.8 | 20.1 | 31.3 | 2.4 |
| 8500 | 1.0000 | 294.119 | 240.115 | 9.149 | 7.547 | 2.263 | 1.976 | 227.2 | 16.89 | 14.01 | -0.0351 | 0.1589 | -376.3 | 372.8 | -46.4 | 46.6 |
| Integrated | | 246.725 | 10.489 | 7.473 | 0.317 | 0.276 | 0.017 | 32.8 | 13.78 | 0.59 | 0.0455 | 0.0046 | 166.6 | 8.3 | 20.2 | 1.0 |

**98AP02-3/1-10** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0.0172 | 1611.603 | 889.274 | 3.412 | 2.102 | 5.252 | 2.946 | 96.3 | 6.28 | 3.87 | 0.1059 | 0.1613 | 60.0 | 161.1 | 7.3 | 19.6 |
| 300 | 0.1934 | 137.169 | 18.614 | 0.791 | 0.144 | 0.504 | 0.082 | 108.5 | 1.45 | 0.26 | 0.0346 | 0.0153 | -11.6 | 13.8 | -1.4 | 1.7 |
| 600 | 0.2370 | 582.622 | 144.582 | 17.316 | 4.312 | 1.708 | 0.465 | 86.4 | 32.13 | 8.09 | 0.0633 | 0.0582 | 80.0 | 62.7 | 9.7 | 7.6 |
| 900 | 0.2579 | 1038.006 | 496.712 | 64.649 | 30.965 | 3.368 | 1.634 | 95.4 | 123.83 | 61.92 | 0.0505 | 0.1124 | 49.6 | 88.1 | 6.0 | 10.7 |
| 1200 | 0.2841 | 1044.261 | 570.142 | 42.549 | 23.238 | 2.471 | 1.403 | 69.6 | 80.30 | 45.10 | 0.0442 | 0.0697 | 326.3 | 217.5 | 39.3 | 25.9 |
| 1500 | 0.5159 | 333.376 | 21.391 | 11.467 | 0.744 | 0.124 | 0.035 | 10.7 | 21.20 | 1.39 | 0.0438 | 0.0069 | 299.9 | 21.9 | 36.2 | 2.6 |
| 1800 | 0.7763 | 332.364 | 17.566 | 11.245 | 0.600 | 0.124 | 0.024 | 10.8 | 20.79 | 1.12 | 0.0537 | 0.0070 | 298.6 | 17.3 | 36.0 | 2.1 |
| 2100 | 0.8623 | 428.108 | 67.568 | 11.118 | 1.770 | 0.387 | 0.113 | 26.5 | 20.55 | 3.30 | 0.0467 | 0.0213 | 316.7 | 57.8 | 38.2 | 6.9 |
| 2500 | 0.9839 | 343.906 | 41.922 | 12.208 | 1.491 | 0.163 | 0.063 | 13.7 | 22.58 | 2.78 | 0.1842 | 0.0269 | 299.1 | 40.9 | 36.1 | 4.9 |
| 3000 | 0.9850 | 602.712 | 5362.523 | -2.810 | 26.215 | -7.257 | 64.928 | -355.8 | -5.15 | 47.93 | -1.1424 | 10.4143 | 2742.0 | 24434.2 | 306.5 | 2511.9 |
| 8500 | 1.0000 | 180.392 | 115.268 | 4.115 | 2.684 | 0.667 | 0.698 | 109.2 | 7.57 | 4.95 | 0.1078 | 0.1961 | -16.6 | 164.3 | -2.0 | 20.0 |
| Integrated | | 373.228 | 17.037 | 11.579 | 0.532 | 0.508 | 0.035 | 40.0 | 21.41 | 0.99 | 0.0638 | 0.0078 | 225.7 | 13.1 | 27.3 | 1.6 |

**98AP02-6/1-32** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0.0076 | 1503.054 | 681.757 | 0.192 | 0.829 | 4.785 | 2.186 | 94.1 | 0.35 | 1.52 | 0.0211 | 0.1025 | 89.1 | 86.5 | 10.8 | 10.5 |
| 200 | 0.0172 | 645.665 | 230.984 | -0.112 | 0.442 | 1.672 | 0.617 | 76.5 | -0.21 | 0.81 | 0.0636 | 0.1054 | 151.4 | 70.1 | 18.4 | 8.5 |
| 300 | 0.0425 | 489.066 | 49.151 | 0.026 | 0.145 | 0.980 | 0.132 | 59.2 | 0.05 | 0.27 | -0.0172 | 0.0234 | 199.4 | 33.0 | 24.1 | 4.0 |
| 450 | 0.1190 | 326.033 | 11.497 | 0.054 | 0.061 | 0.492 | 0.037 | 44.6 | 0.10 | 0.11 | 0.0342 | 0.0103 | 180.5 | 11.7 | 21.9 | 1.4 |
| 600 | 0.2100 | 304.989 | 14.887 | 0.043 | 0.057 | 0.378 | 0.032 | 36.7 | 0.08 | 0.10 | 0.0225 | 0.0067 | 193.2 | 12.1 | 23.4 | 1.5 |
| 750 | 0.3133 | 270.668 | 9.475 | 0.022 | 0.053 | 0.284 | 0.024 | 31.0 | 0.04 | 0.10 | 0.0304 | 0.0037 | 186.7 | 9.2 | 22.6 | 1.1 |
| 900 | 0.4211 | 253.822 | 9.830 | -0.020 | 0.053 | 0.201 | 0.024 | 23.4 | -0.04 | 0.10 | 0.0295 | 0.0037 | 194.3 | 10.0 | 23.5 | 1.2 |
| 1050 | 0.4927 | 244.778 | 8.037 | 0.098 | 0.075 | 0.203 | 0.045 | 24.5 | 0.18 | 0.14 | 0.0312 | 0.0065 | 184.7 | 14.7 | 22.4 | 1.8 |
| 1200 | 0.5583 | 235.980 | 8.546 | 0.148 | 0.101 | 0.095 | 0.043 | 11.9 | 0.27 | 0.18 | 0.0401 | 0.0073 | 208.0 | 14.7 | 25.2 | 1.8 |
| 1350 | 0.6656 | 214.154 | 8.200 | 0.020 | 0.042 | 0.113 | 0.013 | 15.6 | 0.04 | 0.08 | 0.0362 | 0.0060 | 180.7 | 7.8 | 21.9 | 0.9 |
| 1500 | 0.7465 | 252.537 | 10.519 | 0.011 | 0.068 | 0.194 | 0.021 | 22.7 | 0.02 | 0.13 | 0.0287 | 0.0071 | 195.1 | 9.9 | 23.6 | 1.2 |
| 2000 | 0.9232 | 209.393 | 5.126 | -0.001 | 0.034 | 0.077 | 0.021 | 10.9 | 0.00 | 0.06 | 0.0259 | 0.0040 | 186.5 | 7.6 | 22.6 | 0.9 |
| 3000 | 0.9860 | 307.210 | 19.949 | -0.008 | 0.061 | 0.401 | 0.037 | 38.6 | -0.01 | 0.11 | 0.0326 | 0.0087 | 188.7 | 14.5 | 22.8 | 1.7 |
| 8500 | 1.0000 | 229.914 | 72.534 | 0.384 | 0.449 | 0.543 | 0.235 | 69.8 | 0.70 | 0.82 | 0.0449 | 0.0519 | 69.5 | 52.5 | 8.5 | 6.4 |
| Integrated | | 273.916 | 3.693 | 0.034 | 0.020 | 0.295 | 0.010 | 31.9 | 0.06 | 0.04 | 0.0297 | 0.0024 | 186.6 | 3.6 | 22.6 | 0.5 |

**98AP02-8/3-44** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | -0.0036 | -2636.705 | 4617.424 | -2.054 | 4.290 | -9.975 | 17.600 | 111.8 | -3.76 | 7.85 | -0.0938 | 0.3352 | 310.4 | 833.8 | 37.4 | 99.5 |
| 300 | 0.0306 | 352.595 | 77.094 | 1.289 | 0.450 | 1.073 | 0.314 | 89.9 | 2.37 | 0.83 | -0.0238 | 0.0431 | 35.7 | 63.3 | 4.4 | 7.7 |
| 600 | 0.0612 | 516.333 | 140.055 | 2.845 | 0.809 | 1.221 | 0.411 | 69.8 | 5.23 | 1.49 | -0.0520 | 0.0321 | 156.1 | 84.3 | 18.9 | 10.2 |
| 900 | 0.1146 | 436.082 | 54.652 | 4.059 | 0.549 | 0.771 | 0.159 | 52.1 | 7.47 | 1.01 | 0.0121 | 0.0184 | 209.2 | 46.2 | 25.3 | 5.6 |
| 1200 | 0.2085 | 324.119 | 16.008 | 9.302 | 0.476 | 0.264 | 0.061 | 23.8 | 17.17 | 0.88 | 0.0618 | 0.0262 | 248.4 | 21.8 | 30.0 | 2.6 |
| 1500 | 0.3862 | 272.604 | 13.698 | 10.857 | 0.559 | 0.084 | 0.034 | 8.8 | 20.06 | 1.04 | 0.0340 | 0.0066 | 250.3 | 16.2 | 30.2 | 2.0 |
| 1800 | 0.6101 | 308.112 | 13.270 | 11.362 | 0.502 | 0.187 | 0.031 | 17.7 | 21.00 | 0.93 | 0.0334 | 0.0054 | 255.4 | 14.2 | 30.9 | 1.7 |
| 2100 | 0.7667 | 349.162 | 15.878 | 11.001 | 0.517 | 0.242 | 0.043 | 20.2 | 20.33 | 0.96 | 0.0369 | 0.0074 | 280.5 | 17.8 | 33.9 | 2.1 |
| 2500 | 0.9357 | 315.422 | 10.890 | 10.519 | 0.378 | 0.123 | 0.041 | 11.2 | 19.43 | 0.70 | 0.0261 | 0.0075 | 281.9 | 15.5 | 34.0 | 1.9 |
| 3000 | 0.9732 | 436.546 | 86.276 | 10.617 | 2.122 | 0.177 | 0.188 | 11.8 | 19.62 | 3.95 | 0.0197 | 0.0566 | 387.8 | 94.8 | 46.6 | 11.3 |
| 8500 | 1.0000 | 607.971 | 155.434 | 11.722 | 3.013 | 0.933 | 0.401 | 45.2 | 21.67 | 5.61 | 0.0656 | 0.0789 | 335.8 | 129.2 | 40.5 | 15.4 |
| Integrated | | 349.132 | 8.468 | 9.919 | 0.246 | 0.323 | 0.024 | 27.1 | 18.32 | 0.46 | 0.0306 | 0.0051 | 256.1 | 9.3 | 30.9 | 1.2 |

**98AP02-10/1-51** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

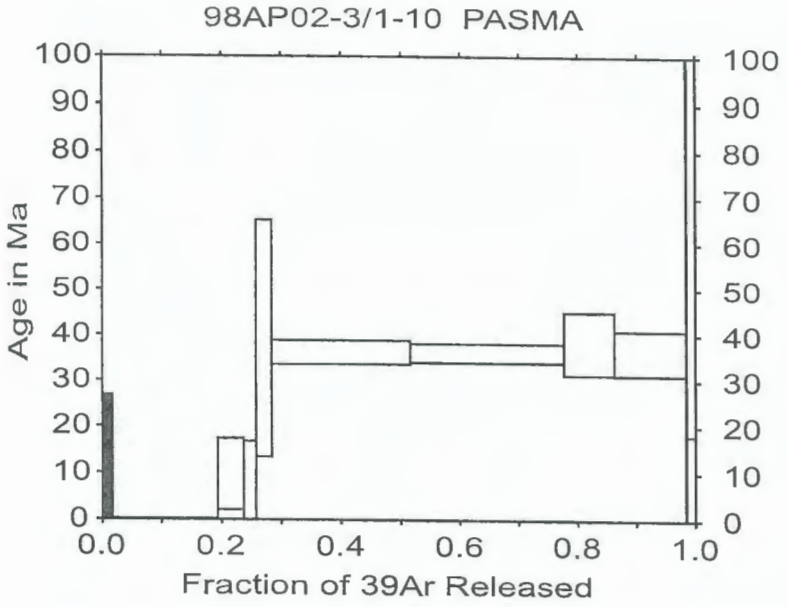
| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0.0000 | 591251.386 | 42989165.707 | -401.884 | 29220.678 | 1665.469 | 121094.223 | 83.2 | -584.49 | 33684.68 | 1.4547 | 106.8201 | 78529.7 | 4525769.1 | 3321.5 | 87477.3 |
| 300 | 0.0172 | 4141.393 | 242.919 | -0.217 | 0.068 | 10.057 | 0.590 | 71.8 | -0.40 | 0.13 | 0.0015 | 0.0101 | 1169.3 | 74.3 | 137.1 | 8.4 |
| 600 | 0.1259 | 927.864 | 13.034 | -0.017 | 0.009 | 1.356 | 0.014 | 43.2 | -0.03 | 0.02 | 0.0014 | 0.0011 | 527.2 | 11.7 | 63.1 | 1.4 |
| 900 | 0.1701 | 960.735 | 22.268 | -0.035 | 0.022 | 1.333 | 0.034 | 41.0 | -0.06 | 0.04 | -0.0013 | 0.0028 | 566.8 | 13.9 | 67.8 | 1.6 |
| 1200 | 0.1971 | 711.739 | 18.231 | -0.065 | 0.028 | 0.718 | 0.029 | 29.8 | -0.12 | 0.05 | -0.0022 | 0.0046 | 499.5 | 14.4 | 59.9 | 1.7 |
| 1500 | 0.2245 | 882.815 | 15.378 | -0.042 | 0.031 | 1.318 | 0.029 | 44.1 | -0.08 | 0.06 | 0.0005 | 0.0041 | 493.4 | 10.3 | 59.1 | 1.2 |
| 1800 | 0.2608 | 965.834 | 27.548 | -0.020 | 0.017 | 1.769 | 0.055 | 54.1 | -0.04 | 0.03 | 0.0002 | 0.0036 | 443.1 | 14.4 | 53.2 | 1.7 |
| 2100 | 0.3056 | 950.336 | 6.445 | -0.032 | 0.026 | 1.777 | 0.023 | 55.3 | -0.06 | 0.05 | -0.0273 | 0.0143 | 425.1 | 6.7 | 51.1 | 0.8 |
| 2500 | 0.3541 | 939.080 | 11.862 | -0.041 | 0.018 | 1.718 | 0.024 | 54.0 | -0.07 | 0.03 | 0.0031 | 0.0037 | 431.5 | 6.7 | 51.8 | 0.8 |
| 3000 | 0.4056 | 863.845 | 23.537 | -0.009 | 0.014 | 1.475 | 0.042 | 50.5 | -0.02 | 0.03 | -0.0022 | 0.0031 | 428.0 | 12.2 | 51.4 | 1.5 |
| 3500 | 0.4750 | 807.310 | 13.271 | -0.008 | 0.014 | 1.215 | 0.021 | 44.5 | -0.01 | 0.03 | -0.0005 | 0.0026 | 448.1 | 8.1 | 53.8 | 1.0 |
| 4000 | 0.5488 | 778.198 | 41.033 | -0.015 | 0.013 | 1.179 | 0.063 | 44.8 | -0.03 | 0.02 | -0.0049 | 0.0019 | 429.8 | 23.1 | 51.6 | 2.7 |
| 4500 | 0.7053 | 752.489 | 10.368 | 0.013 | 0.006 | 1.058 | 0.012 | 41.5 | 0.02 | 0.01 | 0.0037 | 0.0010 | 439.9 | 9.8 | 52.8 | 1.2 |
| 8000 | 1.0000 | 745.863 | 9.311 | 0.011 | 0.003 | 0.880 | 0.005 | 34.9 | 0.02 | 0.00 | 0.0022 | 0.0007 | 485.9 | 8.7 | 58.3 | 1.0 |
| Integrated | | 882.013 | 5.584 | -0.015 | 0.003 | 1.349 | 0.008 | 45.2 | -0.03 | 0.01 | -0.0003 | 0.0009 | 483.3 | 4.1 | 58.0 | 0.8 |

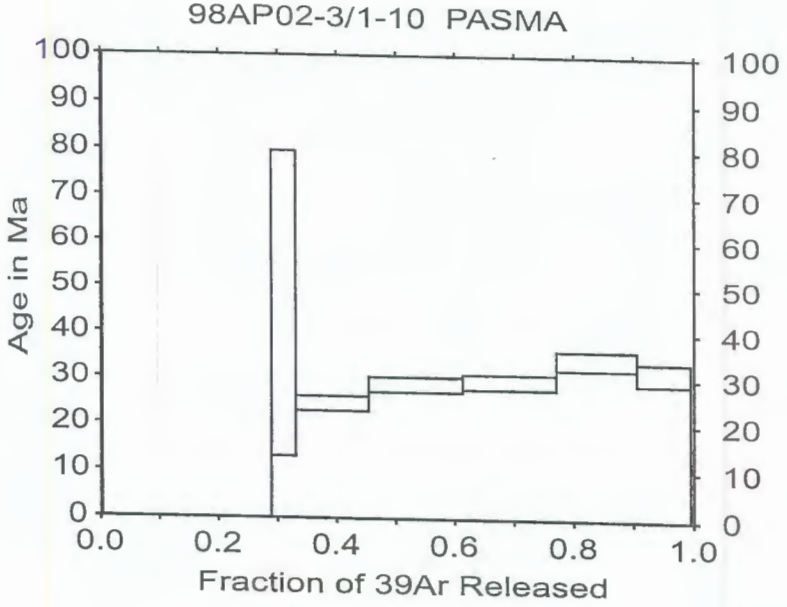
**98AP02-15/5-73** PASMA

Weighted average of J from standards = 0.000068 +/- 0.000001

| Laser Power (mW) | Cumulative 39Ar | 40Ar/39Ar measured | +/- | 37Ar/39Ar measured | +/- | 36Ar/39Ar measured | +/- | % Atmospheric 40Ar | Ca/K | +/- | Cl/K | +/- | 40*/39K | +/- | Age (Ma) | +/- (Ma) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 0.0050 | 2978.699 | 778.143 | 0.495 | 0.341 | 7.607 | 1.993 | 75.5 | 0.91 | 0.63 | 0.1728 | 0.0516 | 731.0 | 196.9 | 86.9 | 22.9 |
| 300 | 0.0159 | 2028.679 | 238.821 | 1.022 | 0.182 | 4.993 | 0.608 | 72.7 | 1.88 | 0.33 | 0.0549 | 0.0283 | 553.8 | 81.2 | 66.2 | 9.5 |
| 600 | 0.0520 | 637.278 | 21.631 | 0.682 | 0.057 | 1.054 | 0.044 | 48.9 | 1.25 | 0.11 | 0.0077 | 0.0054 | 326.0 | 14.0 | 39.3 | 1.7 |
| 900 | 0.1297 | 366.916 | 11.463 | 0.369 | 0.024 | 0.190 | 0.021 | 15.3 | 0.68 | 0.04 | 0.0105 | 0.0028 | 310.7 | 11.4 | 37.5 | 1.4 |
| 1200 | 0.2759 | 327.645 | 5.135 | 0.797 | 0.015 | 0.118 | 0.009 | 10.6 | 1.46 | 0.03 | 0.0239 | 0.0016 | 292.9 | 5.4 | 35.3 | 0.6 |
| 1500 | 0.3819 | 336.837 | 3.419 | 2.416 | 0.035 | 0.112 | 0.013 | 9.8 | 4.44 | 0.06 | 0.0574 | 0.0016 | 304.4 | 4.9 | 36.7 | 0.6 |
| 1800 | 0.4861 | 345.927 | 7.052 | 4.276 | 0.089 | 0.145 | 0.008 | 12.3 | 7.87 | 0.17 | 0.0795 | 0.0027 | 304.2 | 6.7 | 36.7 | 0.8 |
| 2100 | 0.5684 | 371.080 | 6.529 | 3.388 | 0.067 | 0.217 | 0.013 | 17.2 | 6.23 | 0.12 | 0.0673 | 0.0040 | 307.9 | 6.6 | 37.1 | 0.8 |
| 2500 | 0.6712 | 379.169 | 6.305 | 4.415 | 0.078 | 0.214 | 0.011 | 16.6 | 8.12 | 0.14 | 0.0937 | 0.0027 | 317.2 | 6.2 | 38.2 | 0.7 |
| 3000 | 0.8027 | 396.742 | 3.586 | 3.532 | 0.039 | 0.287 | 0.012 | 21.3 | 6.50 | 0.07 | 0.0437 | 0.0027 | 312.8 | 4.6 | 37.7 | 0.6 |
| 8500 | 1.0000 | 363.371 | 2.735 | 2.564 | 0.032 | 0.184 | 0.006 | 14.9 | 4.71 | 0.06 | 0.0442 | 0.0009 | 309.6 | 2.9 | 37.3 | 0.3 |
| Integrated | | 401.519 | 2.207 | 2.589 | 0.017 | 0.303 | 0.004 | 22.3 | 4.76 | 0.03 | 0.0501 | 0.0008 | 312.6 | 2.1 | 37.7 | 0.5 |

Analysis by Paul Layer, Geochronology Laboratory, University of Alaska, Fairbanks, Alaska, U.S.A.


98AP02-3/1-10 PASMA
Age in Ma
Fraction of 39Ar Released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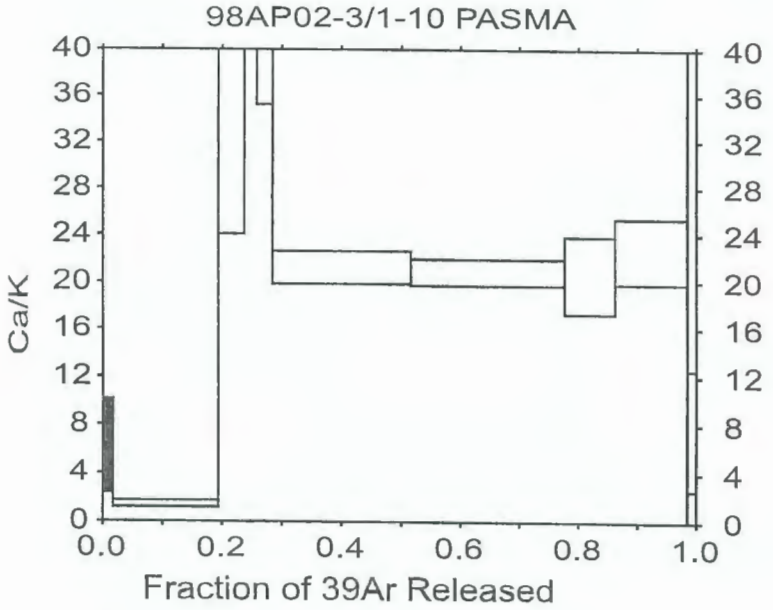
Age in Ma
Fraction of 39Ar Released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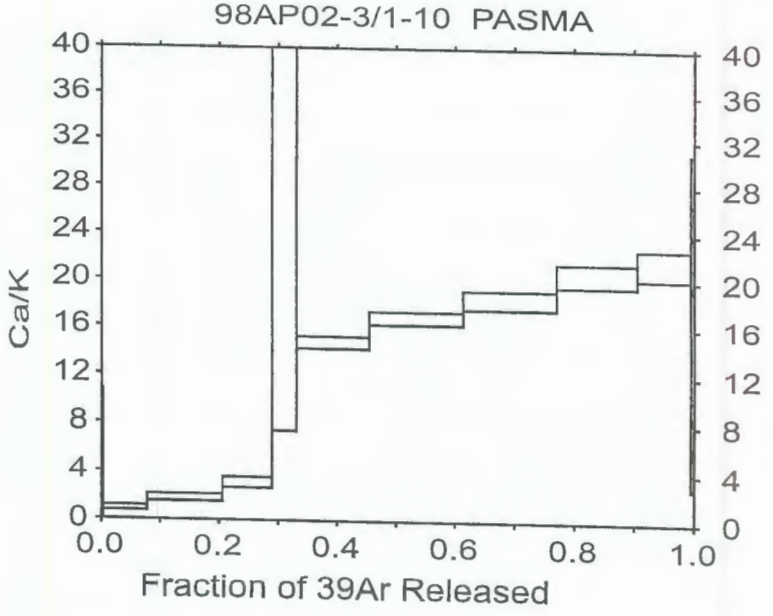
Ca/K
Fraction of 39Ar Released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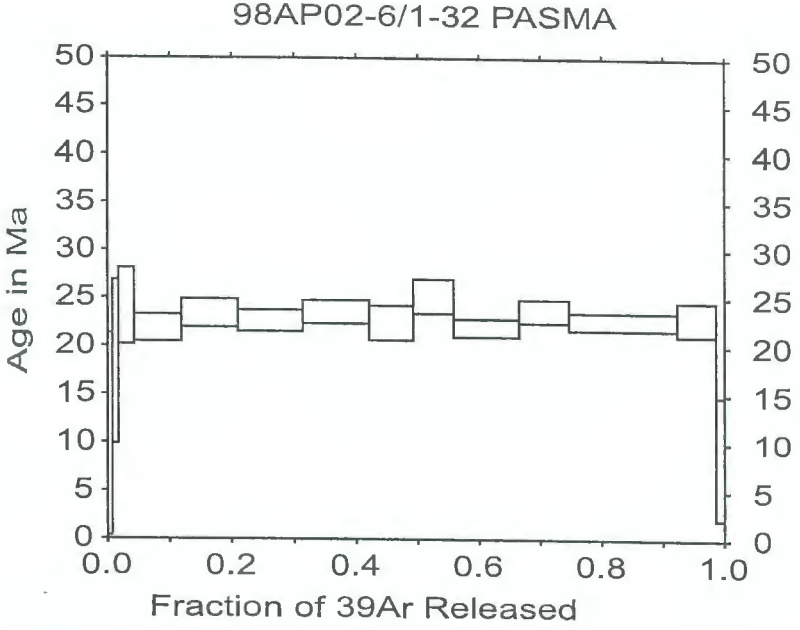
Ca/K
Fraction of 39Ar Released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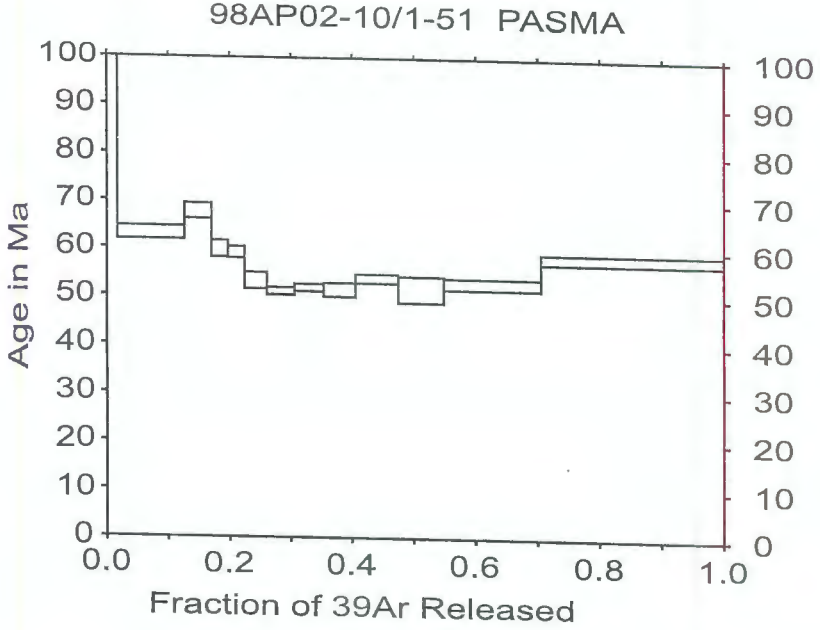
Age in Ma
Fraction of 39Ar Released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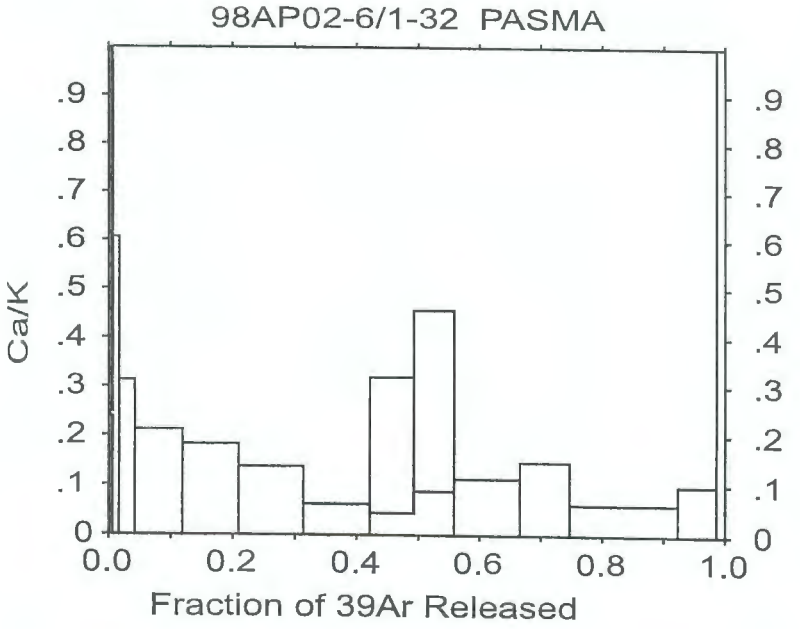
Age in Ma
Fraction of 39Ar Released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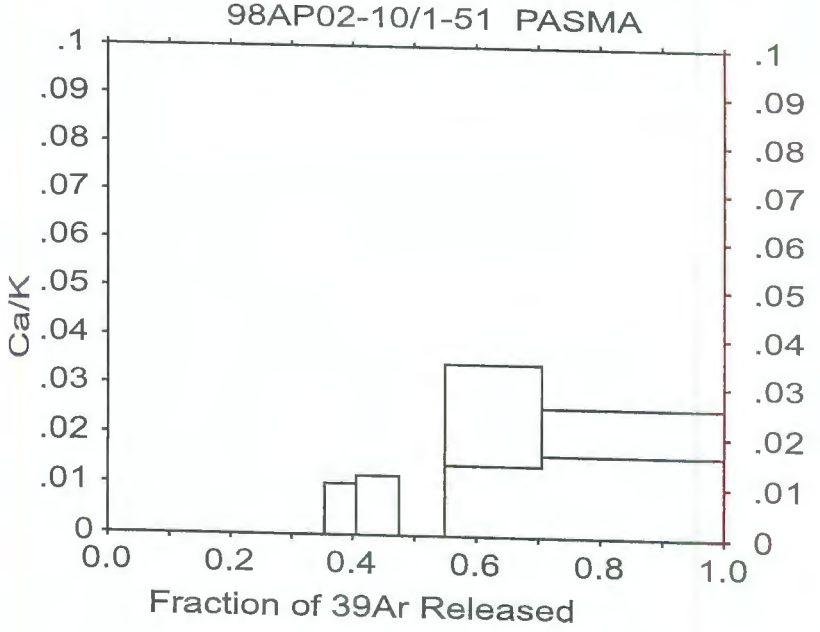
Ca/K
Fraction of 39Ar Released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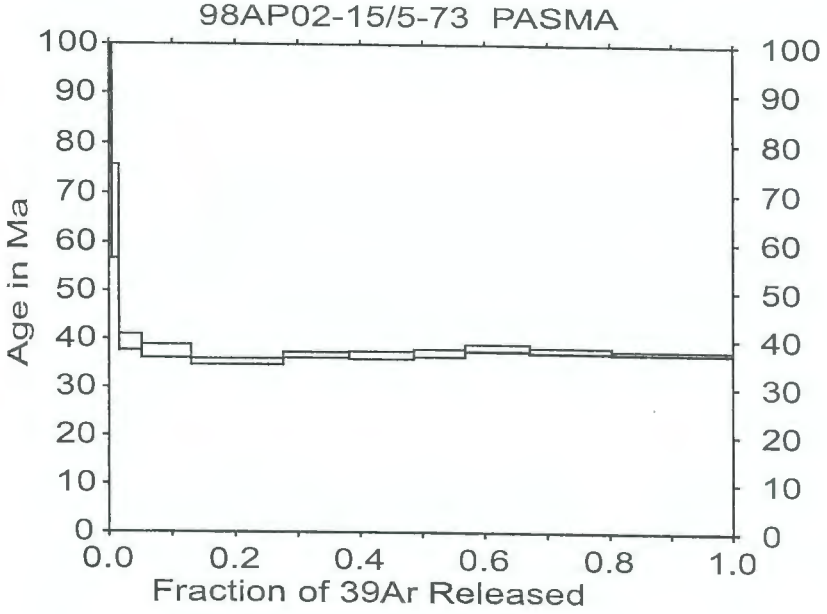
Ca/K
Fraction of 39Ar Released


98AP02-15/5-73 PASMA
Age in Ma
Fraction of 39Ar Released
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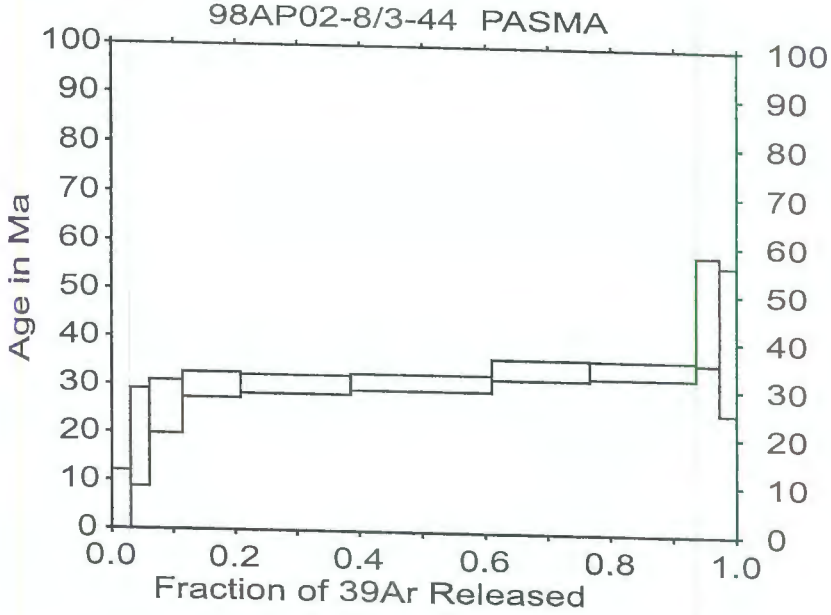
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50
60
70
80
90
100


98AP02-8/3-44 PASMA
Age in Ma
Fraction of 39Ar Released
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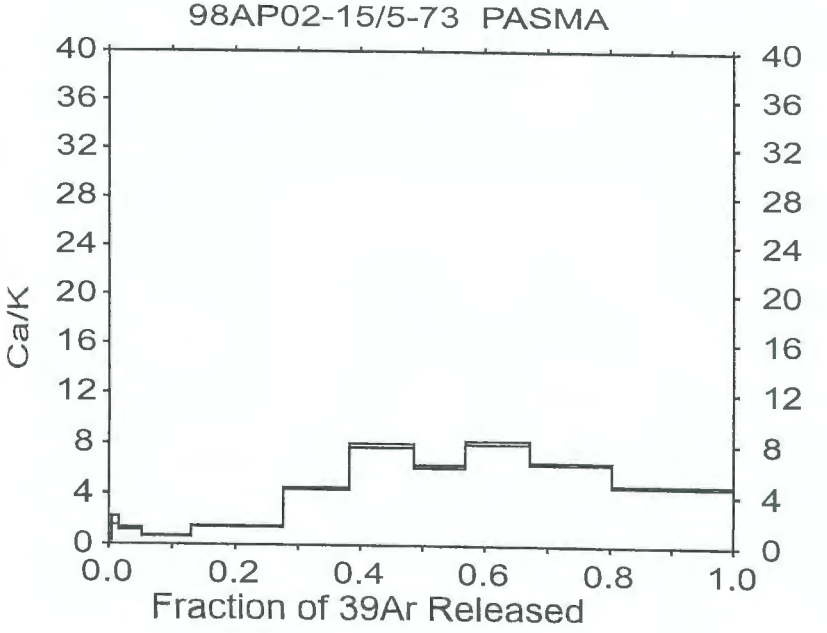
0.6
0.8
1.0
0
10
20
30
40
50
60
70
80
90
100


98AP02-15/5-73 PASMA
Ca/K
Fraction of 39Ar Released
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0.6
0.8
1.0
0
4
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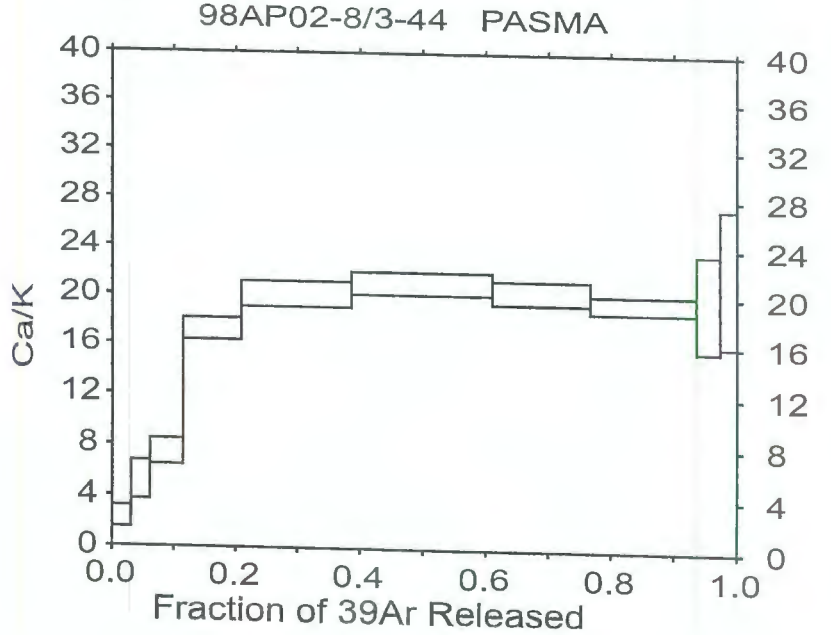
12
16
20
24
28
32
36
40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Ca/K
Fraction of 39Ar Released
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0.4
0.6
0.8
1.0
0
4
8
12
16
20
24
28
32
36
40

# Appendix B

## Petrochemical Analyses

Appendix B: Petrochemical Analysis of Whole Rock Samples - Minor and Trace Elements

| Sample | Location | As | Ba | Bi | Ce | Co | Cr | Cs | Cu | Dy | Er | Eu | Ga | Gd | Ge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/3-5 | Vicunita | 39 | 449 | 0.07 | 31.6 | 10.1 | 45 | 1.2 | 17 | 2.49 | 1.5 | 0.985 | 20 | 3 | 1.3 |
| 2/8-8 | R. Tamberias | 6 | 658 | 0.58 | 49 | 8.7 | 58 | 2.8 | 17 | 2.92 | 1.77 | 1.03 | 18 | 3.58 | 2 |
| 3/1-10 | R. Tamberias | 1 | 554 | 0.01 | 54.3 | 12.2 | 41 | 1.9 | 5 | 3.5 | 2.06 | 1.431 | 21 | 4.6 | 1.3 |
| 4/5-16 | Los Mogotes | 1 | 1000 | 0.82 | 49.8 | 3.7 | 54 | 2.1 | 33 | 1.26 | 0.62 | 0.933 | 25 | 2.5 | 0.9 |
| 5/1-5 | Filo Amarillo | 859 | 38.5 | 15 | 3.1 | 10 | 1.3 | 0.7 | 0.4 | 20 | 1.6 | | | | |
| 6/1-32 | Las Carachas | 15 | 930 | 0.09 | 50.6 | 2.9 | 36 | 6.3 | 5 | 2.14 | 1.29 | 0.667 | 16 | 2.79 | 2.3 |
| 8/3-44 | R. Pena Negra | 1 | 276 | 0.12 | 25.4 | 26.4 | 41 | 0.9 | 62 | 3.51 | 2.02 | 1.286 | 20 | 4.21 | 1.5 |
| 10/7-57 | Ranchillos | 428 | 80 | 17.5 | 13.3 | 20 | 4.3 | 2.4 | 0.9 | 19 | 5.5 | | | | |
| 13/2-AX7 | Cajon de la Brea | 16 | 317 | 33 | 48 | 4 | 2 | 7 | 0.5 | | | | | | |
| 13/3-64 | Cajon de la Brea | 7 | 129 | 0.11 | 49.6 | 0.2 | 115 | 5 | 5 | 6.78 | 4 | 0.335 | 17 | 6.53 | 1.1 |
| 14/4-72 | Sapitos | 1 | 553 | 0.06 | 47.8 | 28.6 | 42 | 3.5 | 57 | 6.49 | 3.64 | 1.921 | 21 | 6.95 | 1.5 |
| 14/5-73 | Sapitos | 1 | 753 | 0.08 | 49.9 | 5.6 | 66 | 2.2 | 5 | 3.58 | 2.23 | 1.39 | 19 | 4.43 | 1.5 |
| 14/4-74 | Sapitos | 1 | 487 | 0.01 | 48.8 | 12.8 | 19 | 0.8 | 14 | 3.52 | 1.95 | 1.522 | 21 | 4.39 | 1.2 |

| Sample | Location | Hf | Ho | In | La | Lu | Mo | Nb | Nd | Ni | Pb | Pr | Rb | Sb | Sm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/3-5 | Vicunita | 2.9 | 0.46 | 0.05 | 16.6 | 0.203 | 2.2 | 12 | 15.2 | 5 | 8 | 3.63 | 27.8 | 1.1 | 2.95 |
| 2/8-8 | R. Tamberias | 4.2 | 0.54 | 0.05 | 24.6 | 0.351 | 2.5 | 9.6 | 21.3 | 68 | 12 | 5.25 | 93.8 | 0.45 | 3.84 |
| 3/1-10 | R. Tamberias | 4.5 | 0.65 | 0.05 | 25.3 | 0.284 | 1.1 | 9.3 | 26.8 | 5 | 7 | 6.13 | 27.8 | 0.02 | 5.03 |
| 4/5-16 | Los Mogotes | 4.1 | 0.2 | 0.05 | 24 | 0.112 | 4.2 | 5.9 | 22.7 | 5 | 30 | 5.56 | 99.1 | 0.16 | 3.59 |
| 5/1-5 | Filo Amarillo | 3 | 0.1 | 21.5 | 51 | 13 | 14 | 4 | 30 | 4.1 | 131 | 2.3 | | | |
| 6/1-32 | Las Carachas | 4.1 | 0.41 | 0.05 | 25 | 0.204 | 2 | 11.6 | 20.2 | 5 | 17 | 5.35 | 125 | 0.4 | 3.2 |
| 8/3-44 | R. Pena Negra | 3 | 0.67 | 0.05 | 10.9 | 0.261 | 1.7 | 5.7 | 16.4 | 24 | 5 | 3.42 | 26.3 | 0.11 | 3.91 |
| 10/7-57 | Ranchillos | 7 | 0.8 | 40.5 | 0.3 | 19 | 31 | 10 | 20 | 8.7 | 201 | 5.7 | | | |
| 13/2-AX7 | Cajon de la Brea | 3 | 20.7 | 0.72 | 4 | 40 | 1 | 11 | 166 | 1.1 | 6.3 | | | | |
| 13/3-64 | Cajon de la Brea | 5 | 1.22 | 0.05 | 19.2 | 0.524 | 1.9 | 22.7 | 24.1 | 5 | 17 | 5.67 | 255 | 1.21 | 6.22 |
| 14/4-72 | Sapitos | 5.1 | 1.19 | 0.05 | 20.6 | 0.459 | 1.4 | 11.6 | 28.4 | 38 | 17 | 5.99 | 55.2 | 0.14 | 6.64 |
| 14/5-73 | Sapitos | 3.3 | 0.67 | 0.05 | 24.3 | 0.298 | 1.6 | 11.7 | 24.7 | 5 | 11 | 5.79 | 74.3 | 0.19 | 4.86 |
| 14/4-74 | Sapitos | 3.4 | 0.64 | 0.05 | 22.7 | 0.253 | 1.3 | 9.6 | 25.6 | 5 | 12 | 5.87 | 39.7 | 0.26 | 4.92 |

Analytical laboratory: samples 5, 44 & 57 - *ALS Chemex*, Canada; all others - *XRAL*. Argentina. AI sample prefixes: 98AP-02

Analytical method: (Chemex) tungsten carbide ring crush, trace elements - ICP-MS. XRAL: trace elements - ICP-MS or NAA. File: NP056955WRtrace

Appendix B: Petrochemical Analysis of Whole Rock Samples - Minor and Trace elements

| Sample | Location | Sn | Sr | Ta | Tb | Th | Tl | Tm | U | V | W | Y | Yb | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/3-5 | Vicunita | 0.2 | 653 | 0.9 | 0.36 | 3.54 | 0.1 | 0.212 | 1.04 | 91 | 1.1 | 14.2 | 1.44 | 69 | 107 |
| 2/8-8 | R. Tamberias | 0.7 | 506 | 0.83 | 0.43 | 10.4 | 0.56 | 0.244 | 2.43 | 65 | 1.9 | 16.9 | 1.72 | 73 | 152 |
| 3/1-10 | R. Tamberias | 1 | 559 | 0.46 | 0.54 | 2.68 | 0.19 | 0.28 | 0.47 | 87 | 0.8 | 19.7 | 1.93 | 85 | 191 |
| 4/5-16 | Los Mogotes | 0.6 | 780 | 0.44 | 0.23 | 5.2 | 0.78 | 0.074 | 1.66 | 41 | 1.4 | 6.6 | 0.53 | 190 | 143 |
| 5/1-5 | Filo Amarillo | 1 | 295 | 3.5 | 0.1 | 8 | 0.5 | 0.1 | 4.5 | 25 | 66 | 8.5 | 0.7 | 4 | 114 |
| 6/1-32 | Las Carachas | 0.7 | 220 | 1.14 | 0.33 | 11.5 | 0.46 | 0.188 | 2.49 | 28 | 2.1 | 13.1 | 1.44 | 36 | 142 |
| 8/3-44 | R. Pena Negra | 0.5 | 500 | 0.34 | 0.56 | 3.32 | 0.17 | 0.289 | 0.5 | 206 | 2.4 | 19.3 | 1.84 | 75 | 89 |
| 10/7-57 | Ranchillos | 13 | 198 | 10 | 0.7 | 29 | 0.2 | 0.3 | 9.5 | 95 | 59 | 23.5 | 2.5 | 35 | 170 |
| 13/2-AX7 | Cajon de la Brea | 38 | 1.9 | 1 | 18 | 4.3 | 3 | 240 | 58 | 5.5 | 1160 | 63 | | | |
| 13/3-64 | Cajon de la Brea | 0.2 | 55.8 | 2.33 | 0.96 | 31.1 | 1.68 | 0.547 | 8.02 | 9 | 2.7 | 39.4 | 3.76 | 27 | 112 |
| 14/4-72 | Sapitos | 0.6 | 514 | 0.76 | 0.95 | 4.86 | 0.31 | 0.486 | 1.19 | 198 | 1.4 | 34.6 | 3.27 | 96 | 187 |
| 14/5-73 | Sapitos | 0.6 | 480 | 1.04 | 0.56 | 6.66 | 0.5 | 0.295 | 2.48 | 83 | 2.2 | 21 | 2.09 | 114 | 115 |
| 14/4-74 | Sapitos | 0.6 | 588 | 0.67 | 0.56 | 4.54 | 0.24 | 0.258 | 1.49 | 87 | 1.3 | 19 | 1.82 | 70 | 122 |

Analytical Laboratory: Samples 5, 44 & 57 - *ALS Chemex*, Canada; all others - *XRAL*, Argentina. All sample prefixes: 98AP02
Analytical method: (Chemex) tungsten carbide ring crush, ICP-MS. XRAL: trace elements - ICP or NAA. File: NP056955WRtrace

Appendix B: Petrochemical Analyses of Whole Rock Samples - Major Oxides and Selected Minor Elements

| Sample | Location | SiO2 | Al2O3 | CaO | Na2O | K2O | Fe2O3 | MgO | MnO | TiO2 | P2O5 | LOI | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 98AP02-2/3-5 | Vicunita | 59.10 | 18.80 | 6.70 | 3.92 | 1.24 | 6.03 | 1.95 | 0.14 | 0.54 | 0.20 | 2.80 | 101.42 |
| 98AP02-2/8-8 | R. Tamberias | 63.30 | 16.80 | 4.15 | 3.70 | 2.64 | 4.94 | 1.80 | 0.11 | 0.48 | 0.19 | 2.70 | 100.81 |
| 98AP02-3/1-10 | R. Tamberias | 57.70 | 18.50 | 6.18 | 3.47 | 1.23 | 6.84 | 2.95 | 0.16 | 0.68 | 0.32 | 2.70 | 100.73 |
| 98AP02-4/5-16 | Los Mogotes | 67.40 | 16.20 | 2.46 | 4.72 | 3.01 | 2.69 | 0.92 | 0.06 | 0.40 | 0.15 | 2.20 | 100.21 |
| 98AP02-5/1-5 | Filo Amarillo | 71.21 | 15.20 | 0.75 | 3.68 | 4.04 | 0.41 | 0.19 | 0.01 | 0.35 | 0.05 | 2.69 | 98.58 |
| 98AP02-6/1-32 | Las Carachas | 71.90 | 14.30 | 1.91 | 3.64 | 3.46 | 2.24 | 0.61 | 0.04 | 0.29 | 0.14 | 1.20 | 99.73 |
| 98AP02-8/3-44 | R. Pena Negra | 50.37 | 18.54 | 9.61 | 2.92 | 1.01 | 9.40 | 4.98 | 0.16 | 1.07 | 0.21 | 1.42 | 99.17 |
| 98AP02-10/7-57 | Ranchillos | 65.89 | 14.68 | 3.46 | 2.69 | 3.99 | 4.17 | 1.82 | 0.08 | 0.54 | 0.11 | 1.28 | 98.71 |
| 98AP02-13/2-AX7 | Cajon de la Brea | 73.70 | 8.64 | 5.21 | 1.70 | 3.62 | 0.84 | 0.06 | 0.18 | 0.04 | 0.01 | 4.80 | 98.80 |
| 98AP02-13/2-64 | Cajon de la Brea | 76.10 | 12.30 | 0.38 | 3.06 | 4.76 | 1.38 | 0.08 | 0.02 | 0.07 | 0.01 | 1.20 | 99.36 |
| 98AP-0214/4-72 | Sapitos | 51.20 | 17.00 | 6.41 | 3.71 | 1.45 | 10.30 | 4.17 | 0.19 | 1.75 | 0.43 | 3.00 | 99.61 |
| 98AP-0214/5-73 | Sapitos | 62.30 | 16.80 | 5.42 | 3.30 | 2.21 | 5.46 | 2.16 | 0.09 | 0.61 | 0.23 | 1.60 | 100.18 |
| 98AP02-14/5-74 | Sapitos | 56.00 | 17.30 | 6.87 | 2.68 | 1.53 | 7.01 | 3.02 | 0.15 | 0.82 | 0.34 | 4.60 | 100.32 |

| Sample | Location | Ba | Rb | Sr | Y | Zr | Nb | +H2O | -H2O | FeO |
|---|---|---|---|---|---|---|---|---|---|---|
| 98AP02-2/3-5 | Vicunita | 409 | 33 | 554 | 12 | 90 | 18 | | | |
| 98AP02-2/8-8 | R. Tamberias | 584 | 102 | 437 | 14 | 168 | 7 | | | |
| 98AP02-3/1-10 | R. Tamberias | 483 | 33 | 480 | 16 | 169 | 11 | | | |
| 98AP02-4/5-16 | Los Mogotes | 876 | 113 | 624 | 5 | 138 | 3 | | | |
| 98AP02-5/1-5 | Filo Amarillo | 859 | 131 | 295 | 8.5 | 114 | 13 | 1.36 | 0.63 | 0.01 |
| 98AP02-6/1-32 | Las Carachas | 650 | 138 | 200 | 11 | 113 | 8 | | | |
| 98AP02-8/3-44 | R. Pena Negra | 258 | 29 | 435 | 17 | 90 | 8 | 0.73 | 0.43 | 3.54 |
| 98AP02-10/7-57 | Ranchillos | 428 | 201 | 198 | 23.5 | 170 | 19 | 1.26 | 0.04 | 2.62 |
| 98AP02-13/2-AX7 | Cajon de la Brea | 61 | 185 | 35 | 56 | 63 | 5 | | | |
| 98AP02-13/2-64 | Cajon de la Brea | 109 | 274 | 50 | 32 | 100 | 16 | | | |
| 98AP-0214/4-72 | Sapitos | 480 | 66 | 443 | 29 | 170 | 12 | | | |
| 8AP-0214/5-73 | Sapitos | 659 | 83 | 422 | 18 | 118 | 14 | | | |
| 98AP02-14/5-74 | Sapitos | 425 | 49 | 508 | 16 | 112 | 10 | | | |

Analytical laboratory: samples 5, 44 & 57 - *ALS Chemex*, Vancouver, Canada; all others - *XRAL*, Argentina. Analytical Method: (Chemex) - tungsten carbide ring crush, whole rock: XRF, trace elements: ICP-MS. (*XRAL*) - whole rock: ICP; trace elements: ICP-MS or NAA. File: NP059797WRmajor.xls

# Appendix C

## Sample Documentation

# Appendix C: Sample documentation

## PASMA Project, Argentina - "Yacimientos del Alta Cordillera de La Rioja y San Juan: Faja de Potro y Cordón de la Brea"

**Sample Documentation from Geological Fieldwork, March 1-31, 1998 including sample data on: hand specimens, radiometric dating, whole rock silicate and minor element petrochemistry, and assay samples. Samples are in the custody of SEGEMAR in Buenos Aires.**

### SAMPLES COLLECTED

### I. *FAJA de POTR0 Suite ( 98AP02-traverses 1 to 9, samples 1 to 50)*

Eldorado Camp: March 09-12, 18,19 ; Traverses 1 to 3,8,9
Location: Lat - 28° 19.122'S Long - 69° 25.411'W ; el. "3850"m ± (12,630')
Macho Muerto Camp: March 13-17; Traverses 4 to 7
Location: Lat - 28° 39'58"S Long - 69° 31' 35"W ; el. '4050m'

1. Sample No: **98AP02-1/5-1 La Ollita**
Sample Location: 28° 18.07'S Long - 69° 26.303'W ; elevation: ~4000m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 09, 1998
Location Description: Peña Negra area, La Ollita prospect. N-S trench area along main altered ridge
Sample Description: seriate (biotite) hornblende plagioclase porphyry dike/plug. Typical of a number of short, bulbous dikes in area, to 20 m wide; mostly ~3 to 5m. Rusty but weakly propylitic-altered, minor pyrite on fractures.
Geological Setting: Stubby dikes or small plugs in clay altered hostrocks, post main (clay) alteration but weakly pyritic fractures. Equivalent (?) to numerous plugs (domes) in area - eg. 98AP02-7/3-44 and ? 98AP02-3/1-10. Hornblende too chloritized for radiometric dating; minor biotite.
Host Formation: Peña Negra volcanics, this is informal name. Volcanic are NOT correlative with Doña Ana Formation but appear to be Eocene/Oligocene in age, possibly equivalent to Fm. Tobas Valle del Cura
Estimated Age: Latest Eocene to Oligocene (~ 36Ma)
Work completed: Norwest 1993 Report anomaly **16a.** Extensive recent (1995-'97) Eldorado Gold Corporation exploration . Much trenching/drilling with large grid-drilling area in W and S of alteration zone through tuffaceous? sedimentary unit capping intrusive body.

2. Sample No: **98AP02-1/9-2 La Ollita**
Sample Location: Lat - 28° 18.174'S Long - 69° 26.164'W, elevation: 3940m
Location Description: Peña Negra area, **La Ollita** prospect. At collar RC hole PNR 53; hole drilled -53° to N.
Sample Description: 'dacite' quartz-rich ash-lithic tuff, totally clay altered (kaolinite). Fractures have thin fillings of waxy secondary alunite veinlets
Geological Setting: quartzose lithic ash tuff unit "dacite", with dust and coarse ash beds/lenses, average <1m thick. Some lapilli tuff members with rounded clasts. Everything is extensively clay-altered. All looks "steam-heated" acid sulphate-leached; little silicification evident. Generally on average 50:50 Jarosite:Goethtite limonite fracture-filling; Hematite is surficial supergene thermal-type (sun-baked jarosite).
*(For other information, see above)*
Work completed: Norwest 1993 Report anomaly **16a.** Extensive recent (1996/97) Eldorado exploration.

3. Sample No: **98AP02-1/9-3 La Ollita**
Sample Location: Lat - 28° 18.174S Long - 69° 26.164'W elevation: 3940m
Location Description: Peña Negra area, La Ollita, same as 1/9-2 at RC hole PNR 53 site
Sample Description: waxy, massive tan/buff veinlets to 2 mm in totally clay altered (kaolinite) 'dacite' (quartz-rich ash-lithic tuff). Secondary alunite veinlets - compact, dense 2ndary alunite as thin crusts, with kaolinite. Crumpled, wavy layered appearance to crusts. Gypsum abundant.
Geological Setting: quartzose lithic ash tuff unit, with dust and ash beds; some lapilli tuff members with rounded clasts. Intensely clay-altered; veinlets 2ndary alunite
*(For other information, see above)*

4. Sample No: **98AP02-1/10-4 , 4a La Ollita**
Sample Location: Lat - 28° 18.161' Long - 69° 26.150'W +50m north, el. 3910m
Location Description: Peña Negra, La Ollita prospect; trenched area, on lower NE-facing slope
Sample Description: 4 – 10 cm clast of quartz-phyric feldspar porphyry from intensely clay-altered porphyritic dacitic breccia matrix. #4a - clay altered 'hotspring' [phreatic] breccia with 'bubbly' texture, finely laminated gypsum? and crusty layers of white fibrous zeolite?
Geological Setting: andesite flows and dactitic tuffs, with hornblende feldspar porphyry sills? All very highly clay-altered. Strongly faulted/altered zone with ~20m width. Main cross-cutting feature is phreatic breccia with milled, rounded fragments; many quartz clasts to 10 cm, also quartz feldspar porphyry clasts (phreatomagmatic? breccia). ~10 m-wide breccia zone has medial quartz 'sliver/lens' i.e. vein with laminated, fluidized flow-structure in wallrocks. Possibly quartz lens is transported into this location. Overall breccia structure trends E-W and dips 35° N, but might be rotated from original subvertical body. Hostrocks are massive andesitic flows with dacitic pyroclastic interbeds/units of dust, ash and lesser lapilli tuffs. Breccia zones has trace pyrite; very little silicification evident.
*(For other information, see above)*

5. Sample No: **98AP02-2/3-5 Vicuñita**
Sample Location: Lat - 28° 17.003'S Long - 69° 24.435'W elevation: 4095m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 10 a.m., 1998
Location Description: Peña Negra area, Vicuñita prospect. Dark dome-like body. topographically prominent dark dome variably called 'basalt' 'andesite' or 'dacite'. Locally referred to informally as 'La Teta Negra'.
Sample Description: propylitic fine- to medium grained, phaneritic hornblende "andesite" ('basalt'); possibly (in part?) quartz-bearing dacite?? intrusion/dome. Possibly contains pyroxene.
Geological Setting: Intrusion (dome); very distinctive prominent equant-circular, dark-coloured knoll "La Teta Negra". In subhorizontally to gently dipping, well-layered sequence of quartzose (dacitic) dust and ash tuffs. Extensive peripheral sericite/kaolinite alteration zone; on NW side is quartz-feldspar porphyry dyke with silica-alunite alteration (high-sulphidation gold-bearing?) or acid sulphate (steam-heated barren?) alteration zone.
Host Formation: Peña Negra volcanics, older volcanic unit than Doña Ana Fm
Estimated Age: Latest Eocene to Oligocene volcanism.
Work completed: Norwest 1993 Report anomaly **14.** Extensive recent (1996/97) Eldorado exploration, mainly trenching and rock chip assays.
Work Completed: whole rock **petrochemistry** (see Appendix B)

6. Sample No: **98AP02-2/3-6 Vicuñita**
Sample Location: Stn 3 @ Lat - 28° 17.003'S Long - 69° 24.435'W +70m East; el: 4095m
Location Description: Peña Negra area, Vicuñita prospect. In highest E-W trenches
Sample Description: fine grained feldspar and quartz crystal (lithic) dust/ash tuff, dacitic ? Clay-

altered: sericite-clay-chlorite alteration, probably sericite-dominant with (pinkish) rutile? Pin-prick vuginess, tan/buff rutile? in small patches.

Geological Setting: Extensive peripheral sericite/kaolinite alteration zone to S of dome. Main area of trenching in alteration zone in subhorizontally to gently dipping, well-layered sequence of quartzose (dacitic) dust and ash tuffs. Overall Goethite:Jarosite 90:10; extensive surficial blood-red supergene hematite. Minor pyrite locally preserved; very rare thin quartz veinlets or crystals on fractures; overall silicification minor.

*(For other information, see above)*

7. Sample No: **98AP02-2/4-7 Vicuñita**

Sample Location: Station 4 @ Lat -28° 17.081'S Long - 69° 24.320'W + 135m to East; el: 4048m

Location Description: In E-W trenches, midway downhill and approaching east side of Vicunita alteration zone.

Sample Description: ash/lapilli dacitic lithic tuff; interspersed fine-grained phaneritic feldspathic ± quartz flows and/or dikes/sills

Geological Setting: At E side of extensive peripheral sericite/kaolinite alteration zone to S of dome at limit of trenching. Hostrocks are subhorizontally to gently dipping, well-layered sequence of quartzose (dacitic) dust and ash tuffs. Alteration is pervasive clay-sericite. Interclast silicification, weak quartz veinlets, dominant clay = kaolinite? smectite?? some rutile? Zone marks change from sericite to 'clay'. Overall goethite:jaroiste 90:10, but limonite weak; silicification strongest seen but overall still (very) weak.
Dis/unconformably overlain to E by unaltered, dark grey to purple-maroon (much ? younger) volcanic units

*(For other information, see above)*

8. Sample No: **98AP02-2/8-8 Rio Tamberias**

Sample Location: Lat - 28° 19.080'S Long - 69° 26.385'W; elevation: 3980m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 10 p.m., 1998

Location Description: least altered rocks at southernmost switchback on roadcuts

Sample Description: (quartz biotite) hornblende feldspar porphyry flow rock; units includes flow breccias of same

Geological Setting: Dacite or quartzose andesite, typical of main type flows in area. Sample from least-altered part of bright clay-limonitic alteration zone in hillside. Not sure of what was encouraging for exploration; possibly rock gold geochemistry was interesting. Alteration is weak clay intensity with ~ nil silicification. It is said that the company located a cryptic intrusion to north of altered (trenched zone) slope.

Host Formation: Peña Negra volcanics, mapped as equivalents to Doña Ana Fm, but rock are older

Estimated Age: Latest Eocene to Oligocene (~36 Ma) volcanism.

Work completed: Norwest 1993 Report anomaly **16b.** Crown Resources (1996?) bulldozer roadcuts and 3-4 drill holes.

Work Completed: whole rock **petrochemistry** (see Appendix B)

9. Sample No: **98AP02-2/9-9, 9a Rio Tamberias**

Sample Location: Stn 9 @ Lat - 28° 19.255'S Long -69° 25.955'W; el; ~3887m

Location Description: on roadcuts; sample 9 @ Station 8+50 to 150m toward Station 9. Sample 9a near Station 9

Sample Description: 9 is (only? type) of dyke of biotite hornblende plagioclase porphyry intruding typical hornblende feldspar porphyry hostrock altered zone. Extensive zones Mn-limonite stain; locally narrow pure jarosite fracture zones.

Geological Setting: In pale clay-limonitic alteration zone in hillside; hostrocks are altered 'dacite' flows/flow breccias. For exploration possibly rock gold geochemistry was Interesting but alteration is weak clay intensity with ~ nil silicification. It is said that

there is a cryptic intrusive body to north of altered (trenched) rock face at valley wall.
Host Formation: Peña Negra volcanics, mapped as equivalent to Doña Ana Fm but rocks are older
Estimated Age: Latest Eocene to Oligocene (~36 Ma) volcanism
Work completed: Norwest 1993 Report anomaly **16b.** Crown Resources prospect (1996?); zig-zag road cut up the sidehill and 3-4? holes drilled into alteration zone.

10. Sample No: **98AP02-3/1-10 Rio Tamberias (regional)**
Sample Location: Lat - 28° 18.732'S Long - 69° 26.655'W; elevation: 3940m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collectors: Andre Panteleyev/Osvaldo Cravero Date collected: March 11, 1998
Location Description: On W side of Rio Tamberias a few km to S of Eldorado camp and R. Tamberias alteration zones
Sample Description: Fresh grey-green, weathered with reddish brown patina. 5-10% squat to rarely elongate hornblende phenocrysts, randomly oriented, also fine-grained biotite 2-3%. Plagioclase phenocrysts and chlorite-plagioclase-rich matrix. Typical of biotite hornblende plagioclase-phyric (?quartzose) "andesite".
Geological Setting: Outcrop knoll of well-jointed equant to slabby and locally platy to 5cm thick, resistant, fresh hornblende plagioclase porphyry, typical of main regional hostrocks to alteration zones. Probably an andesitic dome or thick, homogeneous composition/texture flow unit. Notion is that this rock type intrudes, or overlies, the widespread quartzose dacitic rocks in the region in which there is clay alteration like that at La Ollita.
Host Formation: Mapped as equivalent to Doña Ana Fm but these are older volcanics
Estimated Age: Latest Eocene to Oligocene (~36Ma) volcanism
Work completed: none - pristine outcrops, in natural state
New Work Completed: Whole rock **petrochemistry** (see Appendix B). Chloritized hornblende dated by Ar-Ar: age is ~ **34 to 36 Ma** (see Appendix A). This rock type characterizes the extensive andesitic volcanic rocks of region.

11. Sample No: **98AP02-4/1-11, 11a, 11b, 11c Los Mogotes**
Sample Location: Lat - 28° 34' 17"S Long - 69° 39' 42.9"W; ~4500m ±
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 13, 1998
Location Description: Station 1 outcrops in cirque floor with debris from surrounding amphitheater, all rocks altered and brightly limonite coloured.
Sample (suite) Descriptions: 11 - quartz veinlets/stockworks with grey translucent high-temperature, fine-grained crystallline quartz typical of intrusive-related environments. In pervasively clay-altered (sericite with kaolinite/dickite?) pale 'rhyodacite'; typical altered rock type. 11a - dark grey quartz veins with fine-grained 'enargite' on vein margin, also pyrite; might have trace bornite? or sulphosalt mineral?? 11b - typical vein/stockworks in quartz-phyric (15% grey quartz grains to 3mm) flow/tuff? Fine-grained patchy clay (kaolinite/dickite??) replacement of feldspars in 'rhyodacite' 11c - Station 1+50 to 200m East along ridge of cirque wall debris - supposedly altered 'granite' - none seen; all rhyolite. Quartz abundant in dark veinlets/stockworks, clay altered, trace pyrite.
Geological Setting: Most deeply eroded part of alteration zone centered on intrusion, surrounded By (snow-covered) peripheral limonitic rocks on cirque walls. Highly siliceous zone with extensive quartz stockworks and quartz veinlets with enargite, sericite and gypsum on fractures; presumably native S in clay-altered higher/peripheral "caprocks' (to west). Environment is a high-temperature advanced argillic lithocap setting - high sulphidation epithermal and/or porphyry (Mo) potential.

Supposedly a 'granite' body occurs to west at ~5000m in snowfield; debris supports this. Rare quartz veins from supposed granite contain rare molybdenite. Bulk tonnage gold potential.

Host Formation: Basal units are unamed volcanics probably equivalent to Doña Ana Fm. Overlying (mineralized?) unit is younger Co. de Las Tortolas suite. Tertiary granitic

intrusions, possible correlation with Infiernillos intrusive suite. Locally exposed are Paleozoic metasedimentary basement rocks.

Estimated Age: Late Oligocene to Early Miocene (27 - 18 Ma is age of Doña Ana stage volcanism). Here include some Middle Miocene, equivalents to Co. de Las Tortolas and Farallones stages or 'Formations' (~17-9 Ma)? Infiernillos intrusion are 20-17 Ma

Work completed: Norwest 1993 Report anomaly **24.** Some recent preliminary exploration by Cia. Minera Macho Muerto; one RC drill hole to 134m. Largely untested zone.

New Work Completed: **K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **17.1 Ma** on (sericite) from the altered zone and **15.3 Ma** on (chloritized) hornblende from 'Hayashi dacite', sample 98AP02-4/5-16).

12. Sample No: **98AP02-4/2-12, 12a Los Mogotes**

Sample Location: Lat - 28° 34' 21.7"S Long - 69° 39' 41.6"W, el. ~4505m

Location Description: Along silicified (quartz veins/stockworks) ridge from stations 2 to 3 in centre of alteration zone in cirque floor; ridge trends NW-SE.

Sample Description: 12 - Pure (monomineralic) cream to buff-silvery fine-grained micaceous mineral (sericite) plus crystalline quartz, gypsum and native S as fracture fillings to vuggy 30cm-wide quartz-breccia veins; average 8cm trending 140°, 5 to 20 m long. Kaolinite/sericite vein envelopes (perhaps dickite). Hostrock is rhyodacite. Sericite vein is identical to sample 4/3-13. 12a - very dark silicified rock patches to 20cm across of 'hornfels xenolith?' Dark colour possibly due to fine-grained sulphide minerals or chlorite/biotite??

Geological Setting: Quartz breccia veins/altered fractures with sericite vein filling cut BOTH granodiorite and rhyolite country rocks. All part of quartz stockworking-enargite high-sulphidation mineralization. Silicified ridge trends NW-SE ~120 degrees

Host Formation: Basal units are volcanics equivalent to Doña Ana Fm. Overlying (mineralized?) unit is younger Co. de Las Tortolas suite. Tertiary granitic intrusions, possible correlation with Infiernillos intrusive suite. Locally exposed are Paleozoic metasedimentary basement rocks.

Estimated Age: Early Miocene (27 - 18 Ma) Doña Ana late stage volcanism. In part Middle Miocene, equivalents to Co. de Las Tortolas and Farallones stages or 'Formations' (~17-9 Ma) with Infiernillos intrusions 20-17 Ma.

*(For other information, see above)*

Work Completed: **K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **17.1 Ma** on (sericite) from the altered zone and **15.3 Ma** on (chloritized) hornblende from 'Hayashi dacite', sample 98AP02-4/5-16).
PIMA analysis of dated mica: muscovite.

13. Sample No: **98AP02-4/3-13 Los Mogotes**

Sample Location: Lat - 28° 34' 20.6"S Long - 69° 39' 37.8"W; el. 4525m

Location Description: Main resistant ridge formed by 1 to 5m wide NE-trending granodiorite dykes with flanking parallel clay altered and silicified fracture zones in rhyodacite (quartz porphyry).

Sample Description: Pure (monomineralic) cream to buff-silvery fine-granular sericite with crystalline quartz, gypsum and native S as fracture fillings to vuggy 30cm-wide quartz-breccia veins. Mineralized zones and dykes trend NE/80 W. Clay (kaolinite/illite? ) (dickite??) vein envelopes to 15cm in medium-grained porphyritic granodiorite (dyke) rocks.

Geological Setting: Quartz breccia veins/altered fractures with sericite vein filling cut BOTH granodiorite and rhyolite country rocks. All part of quartz stockworking-enargite high-sulphidation mineralization.

*(For other information, see above)*

Work Completed: Sericite for Ar-Ar dating is identical to #12. **K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **17.1 Ma** on (sericite) from the altered zone and **15.3 Ma** on (chloritized) hornblende from 'Hayashi dacite', sample 98AP02-4/5-16).

14. Sample No: **98AP02-4/3-14 Los Mogotes**
Sample Location: Lat - 28° 34' 20.6"S Long - 69° 39' 37.8"W; el. 4525m
Location Description: Main resistant ridge formed by 1 to 5m wide NE-trending granodiorite dykes with flanking parallel clay altd and silicified fracture zones in rhyodacite (quartz porphyry). Same location as #13.
Sample Description: Hostrock to #13 sample. Medium grained wkly porphyritic granodiorite (dyke). Propylitic alteration with chloritic? mafics and trace pyrite on fractures. Relatively fresh rock for being in middle of alteration zone.
Geological Setting: Dykes, part of underlying stock? Age uncertain but dykes are parallel alteration/quartz veins suggesting same age as quarttz stockworking-enargite high-sulphidation mineralization - around 17 Ma.
*(For other information, see above)*

15. Sample No: **98AP02-4/4-15, 15a Los Mogotes**
Sample Location: Station 4 is 515m @226° from Stn2 @ Lat - 28° 34' 21.7"S Long - 69° 39' 41.6"W, el. ~4568m
Location Description: On SW cirque wall, high up in pale clay alteration zone, little limonite.
Sample Description: Hostrocks from cirque, relatively weakly clay-altered, little silicification. 15 - flow banded fine-grained rhyolite, chalky appearance with little limonite (rare jarosite). 15a - Coarse ash to lapilli tuff.
Geological Setting: Typically weak/moderately clay-altered periphery of alteration zone. Locally are weakly limonitic fracture/clay-sericite-quartz zones to 3m wide with fracture-filling veinlets of vuggy quartz-gypsum-sericite trending 020°.
*(For other information, see above)*

16. Sample No: **98AP02-4/5-16 (Hayashi Dacite) Los Mogotes**
Sample Location: Lat - 28° 34' 38.1"S Long - 69°39' 52"W; el. ~4700m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Toshishiko Hayashi Date collected: March 13, 1998
Location Description: Highest examined part of southernmost cirque wall. Periphery of alteration zone.
Sample Description: 'Hayashi Dacite'. Small rib of pale grey biotite hornblende porphyry with fresh to weakly chloritized mafics. Large sample taken for mafic mineral separation for dating.
Geological Setting: Small plug? ~100m across in Paleozoic basement metasediments. Virtually unaltered, so post-dates alteration.
Geological Setting: Typically weak/moderately clay-altered periphery of alteration zone. Locally are weakly limonitic fracture/clay-sericite quartz zones to 3m wide with fracture-filling veinlets of vuggy quartz-gypsum-alunite trending 020°.
Host Formation: Basal volcanic hostrocks are Doña Ana Fm. But this plug is part of younger magmatic suite, probably equivalent to Co. de Las Tortolas volcanics.
Estimated Age: The post-alteration 'dacite' is middle Miocene, equivalents to Co. de Las Tortolas and Farallones stages or 'Formations' (~15 Ma).
*(For other information, see above)*
Work Completed: Whole rock **petrochemistry** (see Appendix B). **K/Ar dating** on hornblende and/or biotite.by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **17.1 Ma** on (sericite) from the main altered zone and **15.3 Ma** on (chloritized) hornblende from 'Hayashi dacite', (this) sample 98AP02-4/5-16.

17. Sample No: **98AP02-4/6-17, 17a Los Mogotes**
Sample Location: Lat - 28° 34.403' S Long - 69°39.333'W; el. 4390m
Location Description: At lowest part of cirque basin near outlet SE into main river valley, well to east and ~100m below base elevation of alteration zone.
Sample Descriptions: Two dyke types in regional hostrock units of andesite flow/flow

breccias. Dykes are in propylitic andesite and have strong Mn oxides on fractures. #17 - typical propylitic andesite (hornblende porphyry) dyke, probably similar composition to regional flow units. 17a - Quartz-Kfeldspar phyric in aphanitic buff matrix 'rhyolite porphyry', epidote alteration. Cogenetic ? with altered granodiorite in Mogotes zone?

Geological Setting: Main dyke types in regional units in the andesite flow/flow breccias; the clay-altered, limonitic Mogotes zone is to the west and probably in fault contact with these rocks.

Estimated Age: Doña Ana stage volcanism of Late Oligocene to Early Miocene (27 - 18 Ma). Here the post-alteration 'dacite' is determined to be Middle Miocene (15.3 Ma; see sample 4/5-6 K/Ar date). The rocks are equivalents to Co. de Las Tortolas and Farallones stages or 'Formations' (~17-9 Ma) .

Work completed: Norwest 1993 Report anomaly **24**. Pristine outcrops; no work in vicinity. **K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **17.1** Ma on (sericite) from the altered zone and **15.3 Ma** on (chloritized) hornblende from 'Hayashi dacite', sample 98AP02-4/5-16

*Filo Amarillo Sample Suite - starting from South side of Quartz-Feldspar Porphyry dome, sampled up towards peak (samples 18 to 24); then passing by east side (sample 25), and sampling along E to W line, low in valley on N side (samples 26 to 31).*

18. Sample No: **98AP02-5/1-1 (18) Filo Amarillo**

Sample Location: Station 1 @ Lat - 28° 40.532'S Long - 69° 35.231'W; el. 4470m +150m @ 152°
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 14, 1998

Location Description: Low bench to south of altered zone (quartz-feldspar porphyry dome and its breccia carapace))

Sample Description: Strongly epidotized pyroclastic flow (coarse ash-sized clasts). Propylitic epidote-green clays give buff-olive green colour to volcanics

Geological Setting: Subhorizontal units of propylitized andesitic flows and tuffs intruded to N by Quartz-feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia setting. Dome (rhyolite to rhyodacite) in part has autobrecciated carapace, a flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

Host Formation: Volcanic hostrocks are informally correlated with Doña Ana Fomation.

Estimated Age: Doña Ana stage volcanism (younger than the Peña Negra volcanics to north) is Late Oligocene to Early Miocene (27 - 18 Ma).

Work completed: Norwest 1993 Report anomaly **27.** Extensive bulldozer cuts and roads in eroded gullies and on lower SW slopes on flank of QFP dome; one RC drill hole to 80m.
1996 work by Cia. Macho Muerto S.A.
**K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **23.1 Ma** on alunite from the altered zone in 'dacitic pyroclastic'
PIMA analysis of clay minerals: illite with lesser chlorite.

19. Sample No: **98AP02-5/1-2, 2a (19) Filo Amarillo**

Sample Location: 2 - Station 1 @ Lat - 28° 40.532'S Long - 69° 35.231'W; el. 4470m +90m @330°. 2a - Station 1 @ Lat - 28° 40.532'S Long - 69° 35.231'W; el. 4470m +70m @090°

Location Description: Low bench to south of altered zone (quartz-feldspar porphyry dome and its breccia carapace))

Sample Description: 2 - Kaolinite-altered lapilli tuff/breccia; supergene jarosite crystals on fractures. Overlain by ~20m thick quartz-feldspar porphyry flow/sill? With more resistant, well-jointed character. Contacts are brecciated and silicified, trending ~220°. 2a - vuggy lens/vein to 25cm of chalcedonic quartz-barite breccia; abundant gypsum,

limonite-stained. Hostrocks are highly leached with residual vuggy quartz and abundant alunite; derived from ?lapilli tuffs, now leach/vuggy "scoraceous' looking with ~50% voids to 5 cm.

Geological Setting: Quartz-feldspar porphyry ('rhyolite') intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a typical flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

Work Completed: PIMA analysis of clay minerals: pyrophyllite

20. Sample No: **98AP02-5/1-3 (20) Filo Amarillo**

Sample Location: Station2 @Lat - 28° 40.450'S Long - 69° 35.274'W; el. 4532m

Location Description: Climbing up SE slope of QPF dome from Station 1, pacing ~330° for ~90m to Station 2.

Sample Description: Clay alteration (smectite + kaolinite) here just below ledges of vuggy silica-clay-alunite. All formed in pyroclastic hostrocks just below/flanking quartz-feldspar porphry dome. Probably sills of porphyry are interspersed in volcanic units. Further to NW is quartz-feldspar porphyry intrusion which is acid-leached acid-sulphate (advanced argillic) alteration zone.

Geological Setting: Quartz feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a typical flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

21. Sample No: **98AP02-5/1-4 (21) Filo Amarillo**

Sample Location: From Station 2 @ Lat - 28° 40.450'S Long - 69° 35.274'W+50m NW

Location Description: Climbing up SE slope of porphyry dome from Stations 1&2. From Station 2, pacing ~330° for 50m

Sample Description: Quartz-feldspar porphyry sill?, silica-kaolinite altered vuggy silica ledge. Alteration looks to be stratabound zone @ ~025°/20°W. Dominant alteration in zone is kaolinite.

Geological Setting: Quartz-feldspar porphyry ('rhyolite') intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a typical flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

Work Completed: PIMA analysis of clay mineralogy: dickite

22. Sample No: **98AP02-5/1-5 (22) Filo Amarillo**

Sample Location: From Station 2 @ Lat - 28° 40.450'S Long - 69° 35.274'W+152m NW; el. 4570m

Location Description: Climbing up SE slope of quartz-feldspar porphyry dome from Stations 1&2. From Station 2, pacing ~330° for 152m. @ el. 4570m

Sample Description: Rock type and alteration change @ el. 4560m. Blocky-jointed pale buff/tan fine-grained quartz-feldspar porphyry sill? Alteration is coarse sericite. Top of this sill and alteration is @ el.4585m where silica-kaolinite + alunite occurs (see sample #23).

Geological Setting: Quartz-feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a true flow-dome complex. Dome and

surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

Work Completed: whole rock **petrochemistry** (see Appendix B). PIMA analysis of clay minerals: clay psudomorphs after feldspar and matrix are illite.

23. Sample No: **98AP02-5/1-6 (23) Filo Amarillo**

Sample Location: From Station 2 @ Lat - 28° 40.450'S Long - 69° 35.274'W+183m NW; el. 4595m

Location Description: Climbing up SE slope of dome from Stations 1&2. From Station 2, pacing ~330° for 183m. @ el. 4595m

Sample Description: Quartz-feldspar porphyry with clay alteration kaolinite. ~30m beyond this alteration zone starting ~ el. 4640m is SILICA-ALUNITE caprocks.

Geological Setting: Quartz-feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a true flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

Work Completed: Alteration replacement of original mafic minerals checked by PIMA: micaceous clay minerals are smectite and lesser illite.

24. Sample No: **98AP02-5/1-7 (24) Filo Amarillo**

Sample Location: At Station 3 @ Lat - 28° 40.450'S Long - 69° 35.274'W+260m NW; el. 4650m

Location Description: Climbing up SE slope of dome from Stations 1&2. From Station 2, pacing ~330° for 260m. @ el. 4650m. Silica-alunite cap starts @ el. 4640m

Sample Description: Quartz-feldspar porphyry altered to silica-alunite caprock. Feldspars are replaced by pink alunite pseudomorphs. Some x-cutting clay altered fracture, rare fracture-filling is BARITE with limonite

Geological Setting: Quartz-feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a true flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

Work Completed: **K/Ar dating** by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **23.1 Ma** on alunite from the altered zone in 'dacitic pyroclastic' PIMA analysis of alteration minerals: K-rich alunite and kaolinite.

25. Sample No: **98AP02-5/1-8 (25) Filo Amarillo**

Sample Location: Station 4 @ Lat - 28° 40.261'S Long - 69° 35.011'W; el 4430m

Location Description: East side of dome on bench at base of carapace breccia talus slope

Sample Description: Talus block samples representative of slope outcrops above (to W) of 'carapace breccia'. This is (brecciated) flow component - the uppermost part of the quartz-feldspar porphyry flow-dome complex. Sample 8 (25): siliceous breccia; 8a (25a : silicified breccia with veinlets secondary alunite and small clusters of primary? white crystalline alunite as fracture filling.

Geological Setting: Quartz-feldspar porphyry intrusion/dome ~1.5 km across, similar to Co. Rico de Potosi, Bolivia. Dome intrudes subhorizontal units of propylitized andesitic flows and tuffs. Dome, in part, has autobrecciated carapace, a typical flow-dome complex. Dome and surrounding hostrocks are extensively acid-leached, typical of lithocap with acid sulphate alteration.

*(For other information, see above)*

*(Samples 26-31 taken from north side of quartz-feldspar porphyry dome, along lower slope along (main) valley)*

26. Sample No: **98AP02-5/1-9 (26) Filo Amarillo**
Sample Location: From Station 5 @Lat - 28° 40.036'S Long - 69° 34.564'W; el. 4188m +122m due South @ el. 4260m
Location Description: North side of dome, along lower slope along (main) valley. Clay alteration zone along N side of QFP dome.
Sample Description: Platy outcrops with well-developed primary layering at 080°/12°S. Crystal-lithic ash tuff with ~10% quartz and ~5% plagioclase clasts, a few shale? chips to 3cm. A felsic ashfall tuff. Alteration is selective carbonate/clay (smectite), and probably fine-grained epidote/chlorite, across 1-3m thick selective layers (beds)
Geological Setting: Peripheral country rocks to quartz-feldspar porphyry intrusion/dome. Dome intrudes these subhorizontal propylitized andesitic flows and dacitic tuffs. This is well away from areas with acid-leached rocks and lithocap with acid sulphate alteration.
Host Formation: Volcanic hostrocks are informally correlated with Doña Ana Formation.
Estimated Age: Doña Ana stage volcanism is Late Oligocene to Early Miocene (27 - 18 Ma).
Work completed: Norwest 1993 Report anomaly **27.** Extensive bulldozer cuts and roads, probably a few drill holes, in eroded gullies and on eroded slopes of SW and northern flanks of QFP dome; recent work by Cia. Macho Muerto.
New Work Copmpleted: K/Ar dating by Toshihiko Hayashi, JICA/MMAJ 1999), gives dates of **23.1 Ma** on alunite from the altered zone in 'dacitic pyroclastic'
PIMA analysis of clay minerals: mixed layer illite-smectite.

27. Sample No: **98AP02-5/1-10 (27) Filo Amarillo**
Sample Location: From sample #26 location @ Statioin 5 Lat - 28° 40.036'S Long - 69° 34.564'W +122m due South @ el. 4260m, pacing at 320° for 198m to this sample site (#27) at el. 4242m
Location Description: North side of dome, along lower slope along (main) valley. Clay alteration zone along N side of QFP dome.
Sample Description: Same crystal-lithic ash tuff as #26, with increased alteration. Epidote common; probably pervasive smectite. Some fractures have limonitic selvages suggesting original sulphide minerals.
Geological Setting: Peripheral country rocks to quartz-feldspar porphyry intrusion/dome. Dome intrudes these subhorizontal propylitized andesitic flows and dacitic tuffs. This is on margin of acid-leached rocks and lithocap with acid sulphate alteration to southwest.
Work completed: Norwest 1993 Report anomaly **27.** Extensive bulldozer cuts and roads, probably a few drill holes, in eroded gullies and on lower eroded slopes on SW flank of dome; recent work by Cia. Macho Muerto
PIMA analysis of clay minerals: smectite.

28. Sample No: **98AP02-5/1-11,11a (28, 28a) Filo Amarillo**
Sample Location: Pacing from sample site #27 @320° for 75m.
Location Description: North side of dome, along lower slope along (main) valley. Clay alteration zone along N side of quartz-feldspar porphyry dome.
Sample Description: Same lithologies as #26 and 27 - lithic-crystal ash tuffs in well-bedded succession. Here ~250°-trending fracture zones with (smectitic/SCC-type) clay alteration give rise to 'ribs' of more/less altered rock. #11 (28): clay altered tuff; 11a (28a): same as 11 but less altered
Geological Setting: Peripheral country rocks to quartz-feldspar porphyry intrusion/dome. Dome intrudes these subhorizontal propylitized andesitic flows and dacitic tuffs. This is peripheral, fracture controlled (low intensity) clay alteration zones marginal to the acid-leached rocks and lithocap with acid sulphate alteration to southwest.
*(For other information, see above)*

Work completed: PIMA analysis of clay minerals: smectite.

29. Sample No: **98AP02-5/1-12 (29) Filo Amarillo**
Sample Location: GPS Station 6 Lat - 28° 39.881'S Long - 69° 34.655'W; el. 4182m
Location Description: North side of dome, along lower slope along (main) valley. In clay alteration zone cut by bulldozer road along N side of QFP dome; in drill site area. Drill site is 30-60 m from start of craggy outcrops to south forming the silicified and pale clay and limonite-coloured bluffs that form the steep slope/valley wall.
Sample Description: Same lithic-crystal ash tuff with strong advanced argillic alteration: abundant pink *alunite* and kaolinite; silicification overall weak as residual silica
Geological Setting: Acid-leached periphery of intrusion/dome. Dome intrudes the subhorizontal, well-layered units of dacitic tuffs. In part alteration is fracture controlled, intense acid sulphate type clay superimposed on pervasive kaolinitic alteration with acid sulphate alteration to southwest.
*(For other information, see above)*
Work Completed: PIMA analysis of clay mineral that accompanies alunite: illite and kaolinite.

30. Sample No: **98AP02-5/1-13 (30) Filo Amarillo**
Sample Location: GPS Station 7 Lat - 28° 39.676'S Long - 69° 34.893'W; el. 4190
Location Description: North side of dome, along lower slope along (main) valley. In clay alteration zone cut by bulldozer road to drill site at N side of dome. Sample site is near West edge of clay alteration zone.
Sample Description: Unusual rock - probably crystal-lithic ash tuffs as elsewhere in area. Kaolinite ? is dominant alteration mineral; silicification weak.
Geological Setting: Acid-leached periphery of intrusion/dome. Dome intrudes the subhorizontal, well-layered units of dacitic tuffs. In part alteration is fracture controlled, intense acid sulphate type clay superimposed on pervasive kaolinitic alteration with acid sulphate alteration to southwest.
*(For other information, see above)*
Work Completed: PIMA analysis of clay mineralogy: illite.

31. Sample No: **98AP02-5/1-14 (31) Filo Amarillo**
Sample Location: GPS Station 1 @ Lat - 28° 40.532'S Long - 69° 35.231'W; el. 4470m
Location Description: North side of dome, along lower slope along (main) valley. Clay alteration zone along N side of dome.
Sample Description: Large lapilli tuff/breccia with clasts replaced by primary pinkish alunite and kaolinite; rock contains much residual vuggy silica to impart "scoraceous' appearance. Intensely acid-leached advanced argillic type acid sulphate alteration example.
Geological Setting: Acid-leached periphery of intrusion/dome. Dome intrudes the subhorizontal, well-layered units of dacitic tuffs. In part alteration is fracture controlled, intense acid sulphate type clay superimposed on pervasive kaolinitic alteration with acid sulphate alteration to southwest.
*(For other information, see above)*
Work Completed: PIMA analysis of alunite: K-rich alunite.

32. Sample No: **98AP02-6/1-32 Las Carachas**
Sample Location: Lat - 28° 45.550'S Long - 69° 27.897'W; el. 4300m +244m @ 215°
UTM location measured from map: ~ 2455000 ; 6815000
Country: Argentina Province: San Juan Map Sheet: San Juan 1:500K
Collector: Andre Panteleyev Date collected: March 15, 1998
Location Description: Broad gravel-filled valley has altn zones at both sides. NNW side has small limonitic (jarositic) clay alteration zone with minor chalcedony veinlets. Main rocks forming low ridges are purplish maroon/brown, fresh biotite hornblende plagioclase porphyry flows/flow breccias.
Sample Description: Pristine Tertiary volcanics - slabby flow rocks with fresh biotite and

hornblende for dating. This rock hosts alteration.

Geological Setting: Extensive Paleozoic basement exposures with thin carapace of (basal) units of Tertiary volcanics, presumably equivalent of Doña Ana Fm volcanics. Alteration zones outline a NNW-SSE -trending fracture/alteration zone, with a ganodioritic intrusion at southern end.

Host Formations: Basement is Paleozoic cherts and felsic units (Choiyoi Fm) with basal Tertiary Doña Ana Fm equivalents overlying. Intrusive stock of quartz diorite/granodiorite; age is uncertain.

Estimated Age: Doña Ana stage volcanism is Latest Oligocene to Early Miocene (27 - 18 Ma). N

Work completed: Norwest 1993 Report anomaly **31**. Explored first by Crown Resources and in 1996 by Oro Belle (Viceroy). Roadcuts and some drilling, mainly in SSE zone on plateau to south.

New Work Completed: **Ar-Ar date** on biotite of **22.9 Ma** (see Appendix A). Whole rock **petrochemistry** (see Appendix B).

33. Sample No: **98AP02-6/2-33, 34, 35** (marked 32a,b and 33 respectively) **Las Carachas**

Sample Locations: From Station 2 @ Lat - 28° 44.546'S Long - 69° 27.586'W; el. 4263m, pacing along bulldozer road to SE towards Station 3

Location Description: Broad gravel-filled valley has alteration zones at both NNW and SSE sides. SSE side has broad, Mn-rich limonitic zone with (smectitic ?) lowgrade clay altn (SCC-type and/or propylitic) in granodioritic rocks

Sample Description: 33, 34 - Stn 2+~70m SE: fine-granular biotitic (quartz) diorite/granodiorite (or porphyritic dacite/andesite), maybe a series of dykes. Rocks are cut by E-W steep fracture zones with rare quartz veinlets; carbonate common on fractures, minor Mn-rich goethitic limonite, minor pyrite. 35 – Station 2+100m SE: Small hornblende and plagioclase phenocrysts in purplish aphanitic matrix in ? (quartz) diorite to diabasic-textured rock.

Geological Setting: Extensive Paleozoic basement exposures with thin cover of (basal) units of ignimbrites equivalent to Doña volcanics. Alteration zones outline a NNW-SSE -trending fracture/alteration zone, with a ganodioritic intrusion at southern end. SE side of zone is low-grade SCC/propyltiic altn mainly in granodiorite; broad plateau to S and SE is evidently interesting for exploration; site of some drilling. Altertion as (SCC-type) clay occurs in steep fracture zones a few metres in width in weakly propylitic rocks. Some ~N-S clay-altered shears, gouge zones locally.

*(For other information, see above)*

34. Sample No: **98AP02-6/3-36** [marked #5] **Las Carachas**

Sample Location: GPS Station 3 @Lat - 28° '44.633S Long - 69° 27.377'W; el. 4315m. At SE end roadcut where road breaks onto plateau surface.

Location Description: Broad gravel-filled valley has alteration zones at both NNW and SSE sides. SSE side has broad, Mn-rich limonitic zone with (smectitic ?) low-grade clay alteration (SCC-type and/or propylitic) in granodioritic rocks. This site is major (reactivated?) faults zone @ 160° that marks contact of altered intrusion and Paleozoic Choiyoi rocks; a basalt neck intrudes the fault ~1 km to the south.

Sample Description: Paleozoic Choiyoi Fm chert pebble conglomerate in micaceous schist unit.

Geological Setting: Extensive Paleozoic basement exposures with thin carapace of (basal) units of Tertiary volcanics equivalent to Doña Ana Fm. volcanics. Alteration zones outline a NNW-SSE -trending fracture/alteration zone, with a ganodioritic intrusion in the southern Part.

*(For other information, see above)*

35. Sample No: **98AP02-6/4-37** [marked #6] and **38 Las Carachas**

Sample Location: From Station 2 @ Lat - 28° 44.546'S Long - 69° 27.586'W; el. 4263m, heading down roadcut at ~185°

Location Description: Broad gravel-filled valley has alteration zones at both sides. NNW side

has small limonitic (jarositic) clay zone in maroon Tertiary volcanics. Here in SSE part of alteration system weakly limonitic rocks with (smectitic ?) lowgrade clay altn (SCC-type and/or propylitic) occur in granodioritic rocks.

Sample Description: Fine-granular biotitic (quarttz) diorite/granodiorite (or porphyritic dacite/andesite), maybe a series of dykes. Rocks are cut by sets of steep fracture zones with clay and, rare quartz veinlets; carbonate common on fracturess, minor Mn-rich goethitic limonite, tr pyrite. 37 - typical 'andesite' ~260m from Station 2, also 38 - at GPS stn 4 @ Lat - 28°44.518'S Long - 69° 27.702'W. Samples 37 & 38 are either intrusive or granular andesitic/dacitic volcanics.

Geological Setting: Extensive Paleozoic basement exposures with thin carapace of (basal) units of Tertiary volcanics equivalent to Doña Ana Formation. Alteration zones outline a NNW-SSE -trending fracture/altn zone, with a ganodioritic intrusion at southern end (and/or 'andesitic' volcanics). In area N-S and NE-SW clay-altered fracture zones occur in weakly altered fine-grained grandioritic rock.

Host Formations: Basement is Paleozoic cherts and felsic units of Fm. Carneritos units (originally mapped as Grupo Choiyoi) with basal Doña Ana rocks.

*(For other information, see above)*

*(All 4 samples spaced closely together around clay-altered zone)*

36. Sample Nos: **98AP02-7/1-39, 40, 41, 42 Laguna de las Huaycas**

Sample Locations: Station 1 @ Lat - 28° 34.041'S Long - 69° 22.104'W; el. 4052m; Station 2 @ Lat - 28° 33.904'S Long - 69° 22.225'W; el. 4060m; Station 3 @ Station 2 +365m due South; Station 4 @ Station3 +175m due East
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 16, 1998

Location Description: #39 @ Station 3 - in granodiorite stock; # 40,41 @ Station 4 over to Station 1, all same alteration type in Tertiary volcanics; #42 @Station4 - dyke in clay-altered volcanics

Sample Description: #39 - xenolithic medium-grained phyric granodiorite; 40,41 - Tertiary flow/tuff unit, clay altered small chips; kaolinite/smectite? With no silicification; #42 – 1m thick 'latite' dyke in clay-altered Tertiary rocks.

Geological Setting: Extensive Paleozoic basement exposures on West intruded by small granodiorite stock, with wedge of Tertiary volcanics, presumably equivalent of Doña Ana Fm, to east. Small clay ('silica-alunite') alteration zone along portion of contact; possibly alteration controlled by unconformity, or thrust fault? Possibly coincident hydrothermal feeder along steep NW-SE structure in valley @ Station 1.

Host Formations: Paleozoic chloritic green/grey and salmon pink (quartz phyric) rhyolite (Choiyoi Fm), now silvery micaceous schists with pink to pale green/grey colours. Much hematite staining. Tertiary Doña Ana Fm equivalent volcanics overly, or are in thrust contact with the Fm. Carneritos felsic volcanics (originally mapped as Grupo Choiyoi) and intrusive stock.

Estimated Age: Tertiary alteration system. Hostrocks are Doña Ana stage equivalent volcanics of older Peña Negra volcanics. Age of stock is Paleozoic. No published radiometric dates.

Work completed: Norwest 1993 Report anomaly 23. Examined by Crown Resources; no physical work on ground evident. SEGEMAR has 0.16g/t Au in rock chip anomaly from outcrop.

37. Sample No: **98AP02-8/1-43, 43a Eldorado Camp zone**

Sample Location: Lat - 28° 18.977'S Long - 69° 25.521'W; el. 3877m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 17, 1998

Location Description: "T" trenches at "Camp" clay alteration zone located ~ 310m at 335° from Eldorado camp @ Lat - 28° 19.122'S Long - 69° 25.411'W ; el. "3850"m

Sample Description: 43 - Clay alteration in (hornblende) andesite flows; weak limonite with locally Mn. 43a - silicification in clay-altd zone; this is about as strong as it gets here and is, overall, weakly developed.

Geological Setting: Isolated clay alteration zone, part of La Ollita clay-alteration system, Small zone near camp; trenched.
Host Formation: Peña Negra volcanics; here mainly andesitic flow units
Estimated Age: Older than 27 - 18 Ma Doña Ana Fm volcanism. New Ar-Ar dating: ~36 Ma (see sample 8/3-44 data).
Work completed: Norwest 1993 Report anomaly **16a**; small isolated zone, might be part of main La Ollita zone that is ~ 2km further to NW. Trenching by Eldorado.

38. Sample No: **98AP02-8/3-44 Eldorado Camp zone flow-dome**
Sample Location: Lat - 28° 18.859'S Long - 69° 25.521'W; el. 3885m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 17, 1998
Location Description: Andesite (hornblende porphyry) dome ~580m NNW of Eldorado camp.
Sample Description: Typical of hornblende porphyry "andesite" from domes; probably intrusive equivalent to main flow units in area.
Geological Setting: Domes form distinctive knolls a few hundred metres across of generally dark coloured, well-jointed to slabby, relatively unaltered-looking rocks; probably intrusive equivalent to major flow units in region.
Host Formation: Peña Negra volcanics; domal intrusive equivalents.
Estimated Age: Older than 27 - 18 Ma Doña Ana stage volcanism. See new Ar-Ar data with ~36 Ma age.
Work completed: Norwest 1993 Report anomaly **16a** area; these unaltered country rocks have received little attention.
New Work Completed: **Ar-Ar date: 35.6 Ma** on hornblende (see Appendix A). Whole rock **petrochemistry** (see Appendix B).

*(Series of samples along bulldozer roadcut transecting altered area, the 'Ritzuko Caldera', at roughly same elevation. Traverse started initially at western margin of alteration zone, passed eastward through centre, and then exited through the N side)*

39. Sample Nos: **98AP02-9/2-45, 45a Ritzuko Caldera**
Sample Location: Station 2 @ Lat - 28° 21.586'S Long - 69° 27.356'W; el. 4240m
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 18, 1998
Location Description: 'Ritzuko caldera' alteration zone. West side in propylitic andesite (hornblende-phyric) flow rocks. #45 at Station 2+152m to East; #45a at Station 2+925m to East.
Sample Description: #45 - propylitic regional quartzose andesite flows; mafics weakly chloritized, carbonate, chlorite, epidote alteration in fractures; magnetite dusting and fracture selvages. #45a - fresh hornblende plagioclase-phyric 'andesite'
Geological Setting: Spectacular limonitic clay alteration zone centered on quartz-feldspar porphyry dyke intrusions surrounded/cut by various type of quartz-phyric 'dacitic' breccias of probably both flow-dome and hydrothermal origin. Regional hostrocks are typical hornblende-phyric units typical of region. Company interpretation suggests caldera.
Host Formation: Volcanics, represented by flow-dome intrusive equivalents.
Estimated Age: Latest Eocene to Oligocene or Early Miocene (27 - 18 Ma) Doña Ana stage volcanism.
Work completed: Eldorado road cuts/trenches bisecting alteration zone; geological studies leading to 'caldera' interpretation. Prospecting has located S°, realgar and orpiment in rimming breccias; supposedly K-silicate alteration occurs in 'dacite'. No drilling. No Norwest 1993 Report anomaly; location shown as **'R'** on Figure 1 in this report.

40. Sample No: **98AP02-9/4-46 Ritzuko Caldera**

Sample Location: Station 4 at Lat - 28° 21.152'S Long - 69° 26.428'W; el. 4250m
Location Description: 'Ritzuko caldera' alteration zone. At western margin of clay alteration zone. Clay starts by station 3 @ Lat - 28° 21.865'S Long - 69° 26.485'W; el. 4215m.; rocks here are fragmental and probably altered due to high permeability. Station 4 at split in road .
Sample Description: Pale limonitic Goethite:Jarosite 50:50 strongly clay-altered. Might be some very fine-grained alunite here. Some fractures with supergene lacquer-like, resinous to 'bubbly' oolite-like crusts of supergene hematite but NOT "lively: type after chalcocite.
*(for other information see above)*

41. Sample Nos: **98AP02-9/4 to 5-47, AX1, AX2 Ritzuko Caldera**
Sample Locations: From Stn 4 #47 at Lat - 28° 21.152'S Long - 69° 26.428'W + 213m at ~050°; AX1 grab sample from 213 to 305m; AX2 from 365 to 427m on NE-trending traverse along roadcut towards Stn 5 (at 519m).
Location Description: 'Ritzuko caldera' alteration zone; in kaolinite alteration sector.
Sample Description: #47 - Stn 3++ 213m at ~050° : typical clay (kaolinite?) alteration in quartzose pyroclastic? rock; strong limonite on fractures. Hypogene alunite might be present. AX1 taken as grab sample; barite on fractures and much gypsum. 30 cm-wide steep breccia zones (hydrothermal streaming?) but not silicified. AX2 - 365 to 427m all brecciated rock, some (matrix) silicification evident.
*(for other information see above)*
Work Completed: **Assay** samples AX1and AX2 (see Table 3)

42. Sample Nos: **98AP02-9/5-48, AX3 Ritzuko Caldera**
Sample Location: Station 5 at Lat - 28° 21.135'S Long - 69° 26.206'W; el. 4208m
Location Description: 'Ritzuko caldera' clay alteration zone; central part of zone. Very intense yellow jarositic colour to rocks. Sample AX3 at Station 4+488 to 519m NE, or from Station 5 grab over 30m to SW . #48 at Station 5+53m NE - road cut showing different stages of limonite-filled fracture and supergene alunite veinlets.
Sample Description: AX3 from silicified brecciated zone with strong jarosite (active leaching site), vuggy veinlets with quartz crystals and some realgar and orpiment, secondary supergene veinlets. Various stages of limonite-filled fractures with jarosite/goethite/hematite. #48 sample of supergene alunite in veinlets.
*(for other information see above)*
Work Completed: **Assay** sample AX3 (see Table 3). PIMA analysis of alunite: supergene K-rich alunite with minor kaolinite.

43. Sample No: **98AP02-9/6-49 Ritzuko Caldera**
Sample Location: From Station 5 at Lat - 28° 21.135'S Long - 69° 26.206'W +70m at ~350° For 50 m to Station 6 at Lat - 28° 21.528'S Long - 69° 26.370'W el. 4086m.
Location Description: 'Ritzuko caldera' northern part of alteration zone. At S end of trenches in northern part of clay alteration zone in valley bottom, probably caldera in-fill.
Sample Description: Pervasive kaolinite alteration of ?flows; no silicification. Rocks are very homogeneous with little relict primary texture. Looks like extensively acid-leached. Probably steam-heated (acid condensate) zone with subhorizontal attitude controlled by topography (reflecting paleosurface, specifically paleo-watertable influence). Sample similar to #50.
*(for other information see above)*

44. Sample No: **98AP02-9/7-50 Ritzuko Caldera**
Sample Location: From Station 6 at Lat - 28° 21.528'S Long - 69° 26.370'W pacing 065° for 455m, then 025° for305m and then 005° for 425m to Station 7
Location Description: 'Ritzuko caldera' northernmost part of clay alteration zone in valley bottom. At northern and eastern end of trenched area in clay alteration zone.
Sample Description: Similar to #49. Pervasive kaolinite alteration of ?flows; no silicification.

Rocks are very homogeneous with little relict primary texture. Looks like extensively acid-leached. Probably steam-heated (acid condensate) zone with subhorizontal attitude controlled by topography (reflecting paleosurface, specifically paleo-watertable influence).

*(for other information see above)*

## II. *CORDÓN de La BREA Suite ( 98AP02-traverses 10 to 14, samples 51 to 74)*

Cajón de la Brea Camp (Compania Minera Macho Muerto): March 23-27,
Location: Lat - 28° 41.061'S Long - 69° 19.160'W; Camp elevation: 3825m ±
1:500K map location UTM/latitude-longitude correlations: 6828000 = ~28° 40' ;
6792000 = ~29° 00' ; 6865500 = ~28° 20' ; and 2451000 = ~69° 30'

45. Sample No: **98AP02-10/1-51 Ranchillos** ('Quebrada de los Ranchillos')
Sample Location: Station 1 at Lat - 28° 658'S Long - 69° 14.657'W; el. 3910m
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 23, 1998
Location Description: Station 1 + 70m @020°. Dyke 8m wide trending ~EW/60°N at east side granitic intrusion in countryrock of dark hornfels.
Sample Description: 51 - Euhdedral, bipyrimidal smoky quartz phenos to 3mm in quartz-Kfeldspar biotite sericite porphyry 'rhyolite' intruding host granites. K-feldspar are 2-4mm euhedral laths of cream/buff-pinkish colour; suitable for single crystal Ar-Ar-work. This rock is identical to the 'mineralized' dyke at Cordon de la Brea property (see March 26, traverse 13 notes, sample # 63); also seen in dykes at Pastos Largos.
Geological Setting: Large 'Permian' intrusion in 'Carboniferous-Permian' units to east of metasedimentary and lesser volcanic rocks. Here intruded rocks have large clay alteration zone with moderate limonitic expression. The broad pervasive altered zone has an uniform outcrop appearance and weathering characteristics.
Host Formation: Carboniferous - Permian metasediments (and volcanics); part of F. Ranchillos, probably equivalent to F. Aguas Negras, and others. Permian granitic suite. Devonian units to east, or closely underlying.
Estimated Age: Carboniferous - Permian stratified units; Permian intrusions. Quartz-Kfeldspar porphyry dykes with 'smokey' bipyramidal quartz are TERTIARY based on new Ar-Ar dating (see Appendix A).
Work completed: Limited road cuts/trenches in mid-late 1990s by Crown Resources; some RC drilling completed. A prominent zig-zag roadcut starts in valley bottom and transects the main slope with altered rocks along east flank of intrusion. Norwest 1993 Report anomaly **25.** Little interest evidently lower in valley bottom.
New Work Completed: Ar-Ar **radiometric dating** gives **52.3 Ma** date on K-feldspar (see Appendix A). Rock is identical to (equivalent of) mineralized dykes at Cajon de la Brea Prospect (Norwest prospect 26) and at Pastos Largos (Norwest prospect 22). "Paleozoic" age of dykes elsewhere in the Paleozoic granitic intrusive suites ((280-217 Ma) of this map-area should be refined.
PIMA analysis of clay minerals: illite.

46. Sample No: **98AP02-10/1-52a,52b Ranchillos**
Sample Location: Station 1 at Lat - 28° 658'S Long - 69° 14.657'W; el. 3910m
Location Description: 52 at Station 1+ 70m @020° @#51 site; 52a +152m NW from 51/52; 52b +213m NW from 51/52.
Sample Description: 52 - typical very fine-grained dark massive hornfels; hostrock to #51 dyke. 52a – spotted hornfels [andalusite?]; 52b – kyanite? cordierite?? hornfels, compact, dense dark rocks contains bluish fibrous mineral.
Geological Setting: Large 'Permian' intrusion in 'Carboniferous-Permian' units with metasedimentary

and lesser volcanic rocks to east. Here intruded rocks deep in valley bottom at base of hill are little hydrothermally altered but are strongly thermally affected along intrusive contact; considerable (high temperature) rexllization. Intrusion is medium- to coarse-grained matrix with large feldspar phenocryst-porphyritic texture and mesozonal pluton appearance.

*(For other information see above)*

47. Sample No: **98AP02-10/2-53, 53a,53b Ranchillos**

Sample Location: Lat - 28° 33.352'S Long - 69° 14.220'W; el. 4080m

Location Description: East side of alteration zone, on steep E-facing slope at switchback to west in road near RC site

Sample Description: Quartzite with pervasive sericite and minor carbonate alteration. Well fractured rock with orange coloured, powdery limonite derived from iron carbonate minerals also some goethite but overall weak limonite as thin patina on fractures and on weathered surface. Overall alteration is low intensity, neutral pH. Probably a small pyrite component originally here. No significant silicification other than rare quartz veinlets to 1 cm.

Geological Setting: Neutral pH sericite-carbonate hydrothermal alteration zone on flank of intrusion; no skarn potential in quartzites. Low mineralization potential because no significant brecciation, fracture stockworks nor quartz veining is developed. Possibly weak supergene kaolin overprint.

*(For other information see above)*

Work completed: PIMA analysis of clay minerals: well-crystallized illite.

48. Sample No: **98AP02-10/3to4-54, 54a Ranchillos**

Sample Location: Station 3 at Lat - 28° 33.218'S Long - 69° 14.450'W; el. 4120m. Station 4 at ~375m westerly of Station 3 @ Lat - 28° 33.249'S Long - 69° 14.634'W; el. 4140m

Location Description: 54 - Intrusive rock, from Station 3 ~ 240m westerly near contact in granite body. 54a - dyke in granite @ Station 4.

Sample Description: 2 types altered intrusive rocks: 54 - granite ; 54a – quartz-feldspar porphyry dyke. Alteration is same in dyke as other hostrocks: Sericite-carbonate-(kaolinite)

Geological Setting: Neutral pH sericite-carbonate hydrothermal alteration zone on flank of intrusion; no skarn potential. Low mineralization potential because no significant breccias, fracture stockworks nor quartz veins are developed. Possibly weak supergene kaolin overprint.

*(For other information see above)*

Work Completed: PIMA analysis of clay alteration mineralogy: illlite with minor kaolinite.

49. Sample No: **98AP02-10/5-55 Ranchillos**

Sample Location: From Station 1 at Lat - 28° 658'S Long - 69° 14.657'W; el. 3910m + 800-1200m upstream north-northwesterly, all in granite. @1200m sample site called "station 5".

Location Description: Near eastern margin of intrusion; pegmatitic zones common. Appears that there are dykes of same granitic unit forming less altered, resistant ribs of highly jointed rock. Some country rock xenoliths sporadic throughout.

Sample Description: pegmatitic granite with quartz+tourmaline+white clay (kaolinite+sericite)

Host Formation: 'Permian' granitic rocks, part of or equivalent to Granito Carnerito intrusive suite

Estimated Age: 'Permian' intrusions have been determined by K/Ar dating (JMEC/MMAJ 1999) to be Triassic (**246 to 217 Ma**) in Ranchillos area, with a 280 Ma date reported by Fauqué (1999) in the Pastillos map-area south of Mina Margarita, Cordón de la Brea

area..
Work completed: Road cuts/trenches (above) to north in alteration zone. Norwest 1993 Report anomaly **25.**
*(For other information see above)*
Work completed: PIMA analysis of clay minerals: illite with kaolinite

50. Sample No: **98AP02-10/6-56 Ranchillos**
Sample Location: Station 1+1400m NNW upstream along creek bed called "station 6".
Location Description: Near eastern margin of intrusion; pegmatitic zones common.
Sample Description: Pegmatite quartz + K-feldspar vein. Hostrock is like #55. Sampled for Possible dating of pegmatitic K-feldspar.
Geological Setting: Near eastern margin of intrusion; pegmatitic zones common. Appears that there are dykes of same granitic unit forming less altered, resistant ribs of highly jointed rock. Some country rock xenoliths sporadic throughout.
Sample Description: pegmatitic granite with quartz+tourmaline+white clay (kaolinite/dickite? + sericite
*(For other information see above)*
Work Completed: **K/Ar radiometric dating** by JMEC/MMAJ (1999) provides 3 Triassic dates for Ranchillos granitic rocks (246-217 Ma).

51. Sample No: **98AP02-10/7-57 Ranchillos**
Sample Location: Location from station 1+175m NNW at 330° fro 500 m.
Location Description: Well away from intrusive contact within fresh part of intrusive stock of porphyritic granite/granodiorite.
Sample Description: Bulk sample pink feldspar hornblende-biotite porphyritic granite/granodiorite.
Geological Setting: Main part of granitic intrusion at east side of stock. Fresh rock.
Estimated Age: 'Permian' intrusion; probably similar to rocks at Ranchillos dated by K/Ar by JMEC/MMAJ (1999) as Triassic (246-217 Ma).
*(For other information see above)*
Work Completed: Whole rock **petrochemistry** (see Appendix B).

52. Sample No: **98AP02-11/1-58 Pastos Largos**
Sample Location: Stn 1 at Lat - 28° 31.021'S Long - 69° 12.658'W; el. 4060m. Sample from Station 1+300m @~100°.
Country: Argentina Province: La Rioja Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 24, 1998
Location Description: Veinlets from well within intrusive body, near contact. Weakly altered; minor tourmaline on fractures, rare quartz veinlets ±carbonate, chloritization of mafics, locally pink ?albitization prevalent in medium-grained porphyritic granite. Virtually nil limonite; weak fracturing.
Sample Description: Rare example of mineralization in fine-grained pink granite; typical quartz vein with chalcopyrite and pyrite grains. Note dykes of #51 type seen at Cordón de la Brea and Ranchillos (smoky bipyramidal quartz phenocrysts), dated as Eocene (52 Ma) at Cajón de la Brea.
Geological Setting: There is small, weakly expressed silicified alteration zone in quartzites along contact of (Triassic) Carnerito granite body. Probably Tertiary mineraliztion. Previously sampling from silicified brecciated zone found 0.2 ppm Au in quarttz veilets and 0.6 ppm Au from rock chips. #58 is example of chalcopyrite-bearing quartz vein in wkly tourmalinize-altered part of intrusion.
Host Formation: Quartzite is Devonian-Permian Ranchillos Fm; granite is Permian Carnerito Suite; possibly Triassic similar to Ranchillos intrusions.
Estimated Age: Mineralization suggested to be Tertiary and relate to the Eocene smokey quartz-K-felspar porphyry dykes but just as likely Triassic/Permian.
Work completed: Undeveloped prospect' examined by Crown Resources. Norwest 1993 Report

anomaly **22**.

53. Sample No: **98AP02-11/2-59 Pastos Largos**
Sample Location: Station 2 Lat - 28° 31.045'S Long - 69° 12.365'W; el. 3872m
Location Description: Quartzite in thin-bedded succession near intrusive contact
Sample Description: very brittle mosaic breccia with goethite matrix and fracture-fill. Weakly rusty. Sericite alteration; weak silicification.
Geological Setting: fine-grained quartzite at granite contact. Thermally metamorphosed brittle rock, highly fractured and brecciated; strongly oxidized.
*(For other information see above)*
Work completed: Road cuts/trenches, Norwest 1993 Report anomaly **22**

54. Sample No: **98AP02-11/2-[59] AX4 Pastos Largos**
Sample Location: Stn 2 Lat - 28° 31.045'S Long - 69° 12.365'W; el. 3872m
Location Description: Station 2, same as above, grab sample over 4m of silicified zone; much ferricrete here.
Sample Description: quartzite at granite contact. Contact has zones of very brittle mosaic breccia with goethite matrix and fracture-fill. Weakly rusty, sericite alteration and silicification – probable site of earlier gold assay samples with 1 to 2 ppm Au. Silicified + sericitic goethitic (oxidized) quartzite breccia.
*(For other information see above)*
Work Completed: Grab sample taken (**AX4**) across 4m along brecciated quartzite at granite contact. Assay results are shown in Table 3.

55. Sample No: **98AP02-12/1-60 Barreales de Ranchillos**
Sample Location: Lat - 28° 41.743 'S Long - 69° 12.867'W, el. 3555m
UTM location measured from map: ~ 2480000 ; 6828000 = 28° 40'
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 25, 1998
Location Description: West bank of Rio Blanco at E-W arroyo cutting through thrust fault near river
Sample Description: white thick-bedded quartzite
Geological Setting: Thickly bedded, well-layered Paleozoic sedimentary units trending ~ 015°/35° E, in hangingwall zone of northerly-trending shallow west-dipping thrust fault that defines (in part) Rio Blanco valley.
Host Formation: Carboniferous - Permian sedimentary units (Fm. Ranchillos ?) ( maybe as old as Cambrian)
Estimated Age: Tertiary ? thrust faulting in Paleozoic terrane
Work completed: Favorable geologic (structural) setting; Norwest 1993 Report anomaly **28**

56. Sample No: **98AP02-12/1-61 Barreales de Ranchillos**
Sample Location: From station 1 @ Lat - 28° 41.743 'S Long -69° 12.867'W + 175m@075°
Location Description: outcrops in arroyo south wall
Sample Description: olive/tan 'areniscas' micaceous sandstone (Carbonaceous ?); unit overlying #60 quartzite
Geological Setting: well-bedded succession trending 018°/28°E
Host Formation: possibly Ranchillos Fm (uncertain)
*(For other information see above)*

57. Sample No: **98AP02-12/2to3-AX5 Barreales de Ranchillos**
Sample Location: (Station 2) Lat - 28° 41.632'S Long - 69° 12.476'W + (downstream) for 350m @ 160°; elevation 3365m
Location Description: 350 m to south of arroyo/Rio Blanco confluence. Following along trend of N-Southerly trending fractured zone along thrust fault to zone of rusty (orange-red

carbonate) alteration in stockworks/brecciated rocks.
Sample Description: Dark, micaceous shaly sedimentary rocks. Orange-weathering carbonate matrix crackle breccia/stockworks with low-temperature (carbonate) epithermal/geothermal-style alteration
Geological Setting: In zone of thrust faulting trending ~135/305° with westerly dip, at intersection with subsidiary 170°/60°W fault.
*(For other information see above)*
Work Completed: **Assay (AX5)** for geochemical metal characterization shows high value for Barium (~ 3%). (See Table 3)

58. Sample No: **98AP02-12/2to3-AX6 Barreales de Ranchillos**
Sample Location: (Station 2) Lat - 28° 41.632'S Long - 69° 12.476'W + (downstream) 350-400m quartz-carbonate veins and fractures with sparse fine-grained crystalline quartz infill
Location Description: 350 to 400m south of arroyo/Rio Blanco confluence. Following along trend of N-Southerly trending fractured zone along thrust fault to zone of rusty (orange-red carbonate) alteration in stockworks/brecciated rocks.
Sample Description: same area as AX5; grab of carbonate-veined and brecciated quartzite. Slightly more quartz veinlets than AX5
*(For other information see above)*
Work Completed: **Assay (AX6)** for geochemical metal characterization (See Table 3)

59. Sample No: **98AP02-12/4-62 Cordón de la Brea – Mina Margarita**
Sample Location: Lat - 28° 40.131'S Long - 69° 20.821'W, el. 4520m (trenches).
UTM location (measured from map): ~ 2465500 ; 6827000
*Sample collected from dump at test leach plant by camp; sample source from station 12/4 -* Mina Margarita bulk sample trenches high up on ridge to west of camp.
Country: Argentina Province: San Juan Map Sheet: San Juan 1:500K
Collector: Andre Panteleyev Date collected: March 25, 1998
Location Description: Trenches at top of hill - sampled from dump at leach pad site
Sample Description: Mainly massive black tourmaline cut by quartz-tourmaline veinlets with fine-grained acicular tourmaline crystals and quartz veins. 'Malachite' (probably brochantite) and rare azurite on fractures; rare pyrite and chalcopyrite. Several small grains 'ruby silver' ?? or cuprite (reddish streak). Hostrock is quartzite. Cross-cutting (late fracture-related) alteration: (Fe) carbonate+sericite/kaolinite.
Geological Setting: (Trenches) Well-bedded 1 to 5 cm beds quartzite in ~E-W/40°S succession are extensively replaced along bedding and also cut by tourmaline replacement zones, patches and veins. Replacement zone form as massive black tourmalinized outcrop/trenched area about 100x200m in area. Tourmaline is cut by thins quartz veins; 015°/70°W is common vein orientation. Paleozoic intrusion-related or rhyolite dome-associated "lithophile suite" copper mineralization; tourmaline breccia base metal association in Paleozoic terrane.
Host Formation: Carboniferous - Permian sedimentary units (Fm. Ranchillos ?, and equivalents)
Estimated Age: Paleozoic (Carboniferous - Permian)
Work completed: Trenched and bulk-sampled prospect; dump and test leaching facility at Cajon de la Brea campsite. Norwest 1993 Report (part of ) anomaly **26**. Tourmaline alteration is on N side of clay alteration zone.

60. Sample No: **98AP02-13/2-63 Cajón de la Brea**
Sample Location: Station 2 @ Lat - 28° 41.128'S Long - 69° 22.152'W; el. 4585m
UTM location at centre of alteration system, measured from map: ~ 2464500 ; 6825000
Country: Argentina Province: San Juan Map Sheet: Pastillos 1:250 00K
Collector: Andre Panteleyev Date collected: March 26, 1998
Location Description: Cajon de La Brea 'epithermal' alteration zone 2.5 km to SW of tourmaline breccia at Mina Margarita. Staton 2 is in middle of NW-SE trending 1 km-wide

(limonitic clay) alteration zone.

Sample Description: Quartz-feldspar porphyry dykes bisect clay-altered quartz-eye rhyolite country rocks, and presumably are the source of alteration and (weak) gold mineralization. Dyke is same porphyry with creamy-tan aphanitic matrix and 2% fine-grained smoky, bipyrimidal quartz to 2mm and 5%, tan/pink K-felsspar phenocrysts to 4mm. Rare veinlets of vitreous quartz; weak limonite on fractures. Identical to dyke rocks at Ranchillos (sample #51) and Pastos Largos.

Geological Setting: bleached and weakly silicified limonitic felsic, considered by Fauqué (1999) to be part of Fm. Carnerito volcanics, are intruded by distinctive smoky quartz-K-feldspar porphyry dykes. Dyke is ~16m wide, trends 025°/V in overall NW-SE alteration zone; other dykes trend ~E-W. Overall country rock rhyolite accumulationa are probably rhyolite flow-dome complex or ignimbrites, part of Fm. Carnerito porphryitic rhyolite suite.

Host Formation: Carnerito Fm. felsic volcanics and ?Eocene flow-dome rhyolite/quartz-feldspar porphyry complex.

Estimated Age: Perno-Triassic intrusion-related "lithophile suite" copper mineralization of tourmaline breccia base metal association in Paleozoic terrane. Gold anomalies possibly of same age but more likely relate to Tertiary overprint by Eocene quartz-Kfeldspar porphyry dyes.

Work completed: Raw prospect with ~1ppm Au in rock chips. Norwest 1993 Report (part of anomaly **26**).

61. Sample No: **98AP02-13/2-AX7 Cajón de la Brea**

Sample Location: : Station 2 @ Lat - 28° 41.128'S Long - 69° 22.152'W; el. 4585m

Location Description: Station 2, as above; same site as sample 13/2-63

Sample Description: *Chip sample from #63 quartz-feldspar porphyry dyke* to determine gold content related to (weak) quartz veining. Quartz veinlets are sparse, a few mm wide and random orientation to possibly ~ NNW-SSE/70°W trending. Overall quartz veins are thin gashes and narrow dilation fillings; hostrocks are very brittle so some vein margins are brecciated. Quartz is white to more commonly vitreous with some vugginess; rare calcite and trace pyrite cubes in veins

Geological Setting: Permo-Triassic intrusion-related or rhyolite dome-associated "lithophile suite"copper mineralization of tourmaline breccia base metal association in Paleozoic terrane. Gold anomalies possibly of same age but more likely relate to Tertiary overprint by Eocene quartz-Kfeldspar porphyry dykes.

Estimated Age: Latest Paleozoic. Probably Permian (~280 Ma) Carnerito unit. Suggested Tertiary age epithermal overprint.

Work completed: Raw prospect with ~1ppm Au in rock chip samples reported. Norwest 1993 Report (part of ) anomaly **26**

*(For other information see above)*

New Work Requested: **Assay sample (AX7)** [see Table 1]. Whole rock **petrochemistry** (see Appendix B).

62. Sample No: **98AP02-13/3-64 Cajón de la Brea**

Sample Location: Station 3 @ Lat - 28° 41.244'S Long - 69° 22.479'W; el. 4585m

Location Description: SW border of limonitic alteration zone, in distinctly salmon pink-coloured rhyolite country rocks. Thin quartz-felspar porphyry/flow banded rhyolite dykes are emplaced in these rocks.

Sample Description: Salmon pink to reddish outcrops of slabby-jointed (flow banded), dense felsic volcanic flows. 5% pale, chalky feldspar phenocryss to 4 mm; probably overall chloritic, smectitic and hematitic pervasive alteration

Geological Setting: Country rocks in felsic volcanic stratigraphic unit, with local accumulation as ? flow-dome complex of quartz-felspar porphyry/rhyolite defining zone of alteration. Intrusion-related or rhyolite dome-associated "lithophile suite" copper mineralization of tourmaline breccia base metal association in Paleozoic terrane. Gold anomalies possibly

66. Sample No: **98AP02-14/1-68 Sapitos**
Sample Location: From Station 1 @ Lat - 28° 36.737'S Long - 69° 69 09.587'W, +234 ±10m northerly along bulldozer trench
Location Description: In trench to N of station 1; south-central part of alteration zone
Sample Description: chloritized hornblende plagioclase porphyritic andesite flow or dyke. Very crumbly clay/chlorite altered with orange-weathering carbonate on fractures. Alteration is smectite-SCC type of low-grade argillic; no silicification.
*(For other information see above)*

67. Sample No: **98AP02-14/1-69 and AX8 Sapitos**
Sample Location: From Station 1 @ Lat - 28° 36.737'S Long - 69° 69 09.587'W, +284m Northerly along bulldozer trench; ~ 8m to south of RC drill hole. 174m to S of Stn 2 (see #70 site)
Location Description: Central part of alteration zone; area has a number of intersecting trenches contouring around the small outcrop knolls; in vicinity of a number of RC drill holes. Jarositic limonite, strong clay and overall bleaching (but rare quartz) suggest this is a (geochemically) interesting part of alteration zone.
Sample Description: 69: Limonitic micaceous (tuffaceous ?) sediments; here strongly altered, oxidized and leached. Goethite:jarosite 50:50 on fractures; rare quartz on fractures. Possibly secondary sericite alteration here.
AX8 : selected chips of most fractured rocks with heavy limonite/jarosite/hematite; minor quartz on rare fractures (chalcedonic) or sporadic quartz grains on fractures.
*(For other information see above)*
Work Completed: **Assay sample AX8** with 39 ppb Au (see Table 3).

68. Sample No: **98AP02-14/2-70 Sapitos**
Sample Location: Station 2 @ Lat - 28° 36.527'S Long - 69° 9.60'W; el. 3690m +100m to South in trench; 67 m to N of RC drill hole
Location Description: Trench intersections in central part of alteration zone; RC drilling in vicinity
Sample Description: Most intensely clay-altered, bleached and limonitic part of altered zone. Some quartz veinlets, limonite with major jarosite component on many fractures, gypsum/selenite is abundant. Clays here are supergene kaolinite, but primary alteration is probably kaolinite/smectite type, less probably SCC.
*(For other information see above)*

69. Sample No: **98AP02-14/3-71 Sapitos**
Sample Location: From Station 3 @ Lat - 28° 36.073'S Long - 69° 09.826'W; el. 3680m. +183m to South.
Location Description: N-S trench along northern margin of clay alteration/limonitic zone.
Sample Description: Pervasively bleached, clay altered sediments (acid-leached supergene or steam-heated ?), probably superimposed on chloritic/smectitic low intensity alteration. Interesting Liesegang diffusion ring pattern of limonites on fractures but no silicification. Locally earthy hematite is very abundant.
Geological Setting: Thin dykes (chloritic hornblende ) feldspar porphyry in otherwise same micaceous low-intensity clay-altered (tuffaceous?) sediments. Dykes are chloritic/smectitic; bedded rocks are bleached (supergene?) kaolinite or steam-heated acid-leached.
*(For other information see above)*

70. Sample No: **98AP02-14/4-72 Sapitos**
Sample Location: Lat - 28° 35.898'S Long - 69° 9.926'W; el. 3715m +152m @ 310° Location Location Description: N of clay alteration zone; prominent black knolls encircling altered zone as corona of relatively unaltered resistant volcanic rock.

Sample Description: Dark green/black, glassy with rare very fine-grained feldspar microlites, massive splintery flow of basaltic andesite based on colour.
Geological Setting: Resistant, dark-coloured ridge to N of clay-altered sediments to S. Stubby flow unit, first considered to be dome; very hard, splintery, dense volcanic rock. Unit appears to unconformably overlie (altered) micaceous strata in valley bottom and area to south where exploration has been done.
Host Formation: Part of 'andesite' intrusive unit on regional geology map; included in possibly Devonian, more likely Carboniferous assemblage. Unit it Tertiary volcanic edifice with intrusive/extrusive components.
Estimated Age: Shown as Paleozoic on maps; Tertiary age is confirmed by Ar-Ar dating with Eocene ~36 Ma date.
Work Completed: Outcrop knolls with no evident exploration interest or work done in this area.
New Work Completed: whole rock **petrochemistry** (see Appendix B).

71. Sample No: **98AP02-14/5-73 Sapitos**
Sample Location: Lat - 28° 36.985'S Long - 69° 10.758'W; el. 3835m.
Location Description: (North) westernmost exposures forming height of land surrounding clay-altered zone to east.
Sample Description: Quartz feldspar hornblende porphyry; chloritic alteration with epidote.
Geological Setting: Resistant, dark-coloured ridge to W and NW of clay-altered zone to S. Appears to be subvolanic intrusion; well jointed resistant knoll that intrudes both the altered micaceous sediments and their overlying andesite/basaltic andesite flow units (like #72 and 74) .
Host Formation: Part of 'andesite' intrusive unit on regional geology map; included in possibly Devonian, more likely Carboniferous assemblage. Tertiary age is confirmed by Ar-Ar *dating with Eocene ~36 Ma date.*
Estimated Age: Shown as Paleozoic on maps; this overlying volcanic unit is Tertiary edifice with intrusive/extrusive components.
Work Completed: Outcrop knolls with no evident exploration interest or work done in area.
New Work Completed: **Radiometric dating** of unit by Ar-Ar gives **~36 Ma** date (see Appendix A). Whole rock **petrochemistry** (see Appendix B).

72. Sample No: **98AP02-14/4to5-74 Sapitos**
Sample Location: Roughly midway between Station 4 @ Lat - 28° 35.898'S Long - 69° 9.926'W and Station 5 @ Lat - 28° 36.985'S Long - 69° 10.758'W.
Location Description: Main outcrops to north of clay altered zone forming low-rising ridge.
Sample Description: Sparse quartz feldspar phenocystic porphyry; very hard, tough splintery medium grey/green rock. Probably flow unit or part of flow-dome complex; unit is cut by similar dykes. Considered to be 'andesite' but chemical composition shows basaltic composition.
*(For other information see above)*
Work Completed: whole rock **petrochemistry** (See Appendix B).