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Polymetallic base metal veins, Río Oro area (Cerro San Lorenzo), Santa Cruz, Argentina

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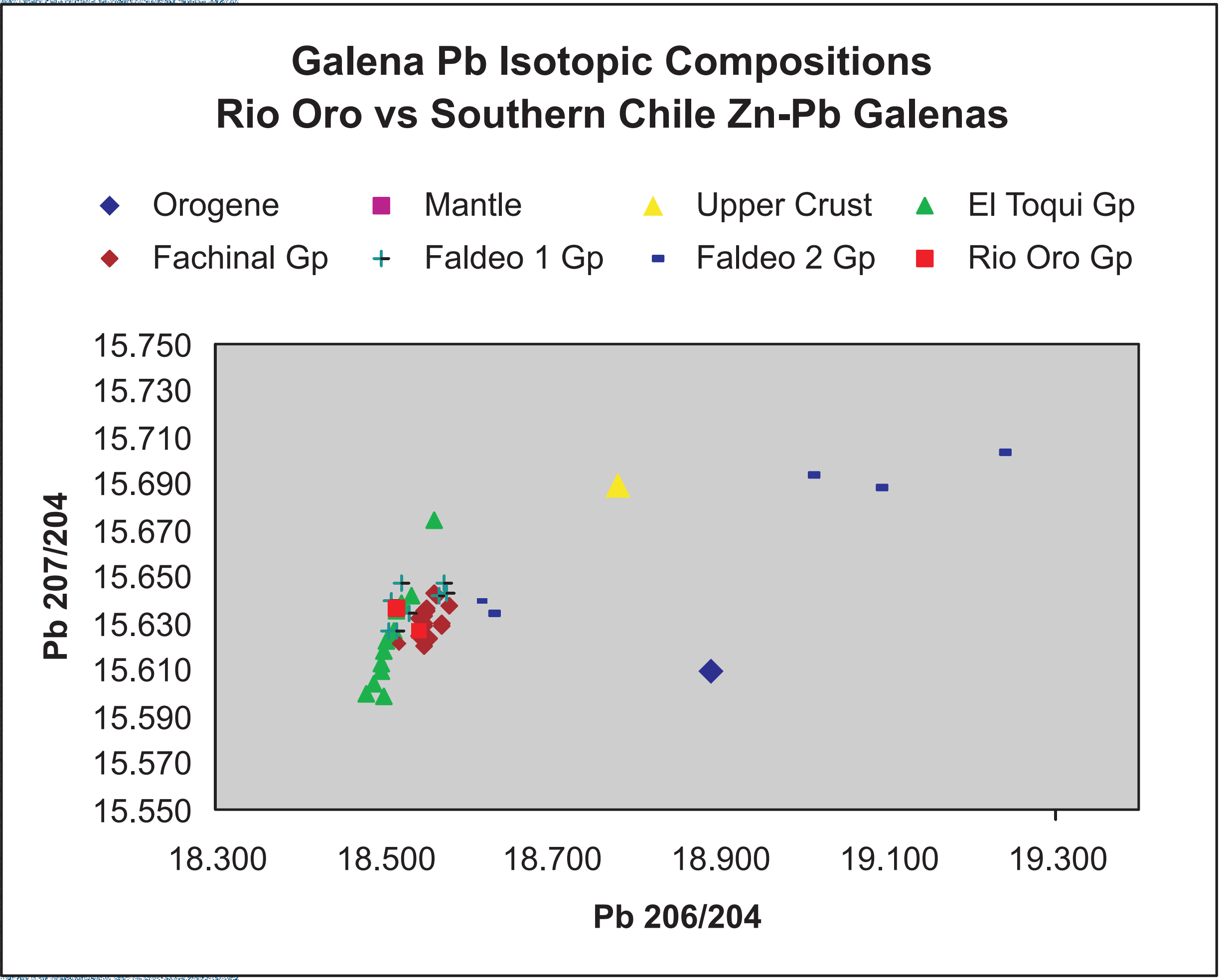

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POLYMETALLIC BASE METAL VEINS, RIO ORO AREA (Cerro San Lorenzo), SANTA CRUZ, ARGENTINA

Alan L. Sangster

INTRODUCTION

The Rio Oro occurrences are within SEGEMAR map sheet 4772-III – Lago Belgrano at a distance of about 30 kms from the village of lago Posadas. Access to the Rio Oro (Figure 1) area is easy by 2 wheel vehicle as far as the mouth of the Aroyo Aviles (Figure 2) on the north side of Rio Oro where a tent camp had been set up. All of the showings visited are located on the opposite (south side) of Rio Oro which was forded by 2 wheel drive vehicle. Water levels were abnormally low (perhaps 30 to 40 cm maximum) permitting crossing with a 2 wheel drive vehicle. All of the showings visited, with the exception of Rene and Pestizos, are located adjacent to active or former water courses where erosion has provided the exposures visited.

I was asked to pass an opinion on whether the mineralization has any potential for the exploration for SEDEX deposits.

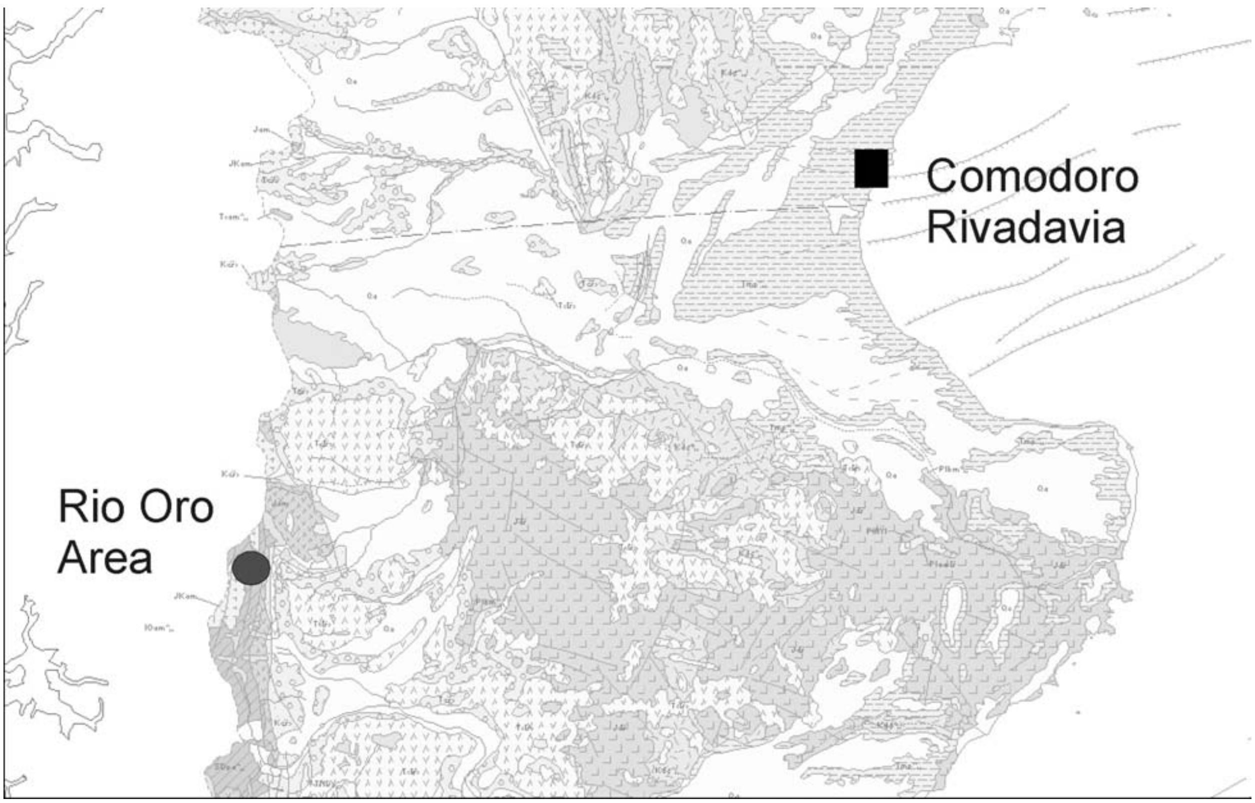

Figure 1: Location map of the Rio Oro area, Santa cruz, Argentina

PREVIOUS WORK

The last work on these occurrences was by a group of Japanese geologists accompanied by Adolfo Genini about 10 or 12 years ago. Over a period of about 1 month, they located and mapped most occurrences, including small underground workings, in the Rio Oro area and the area of Rio Furioso to the north. The area of the Rio Furioso veins was not visited due to difficult access. They are reported to be auriferous but much smaller than the veins at Rio Oro.

1) The Japanese report contains maps of individual occurrences which are satisfactory except that the Japanese appear to have set the declination of their compasses to the wrong side of zero as our measurements differed by about 25^{o} (declination about 12 degrees) from theirs.

2) Map locations of some occurrences (Argenta and San Jose) were wrong.

REGIONAL GEOLOGY

The Rio Oro veins occur within a Devono-Carboniferous sequence of psammo-pelitic rocks that resulted from the very low grade metamorphism of shales, greywackes and quartzites. The low grade metamorphism is characterized by chlorite and sericite but the rocks have undergone intense dynamic metamorphism that has resulted in widespread small scale folding and development of a pervasive cleavage. The unit contains a large number of metamorphic quartz sweats that parallel the foliation. They are essentially sulphide free. The pelitic and siliceous schists have been intruded by rhyolite dykes of possible Miocene age in the vicinity of most of the occurrences. They are overlain on the hilltops by Upper Jurassic ignimbrites.

OBSERVATIONS

Veta Cobre

The Cobre veins consist of two parallel quartz veins measuring 10 and 30 cm wide respectively in heavily foliated pelitic metasedimentary rocks. The veins strike 331^{o} dipping +/- 90^{o} in schists that strike 214^{o} and dip 61^{o} west. The vein quartz is granular and contains only minor milimetre-sized sulphide grains, including pyrite, chalcopyrite and traces of sphalerite. The location of the occurrence (GPS) is S47^{o} 27.558', W72^{o} 05.691'.

Veta San Lorenzo

The San Lorenzo vein is the most impressive of the veins seen. At the mouth of the adit, it consists of a composite vein consisting from west to east of

- 40 to 50 cm vein of sugary quartz with a 10 cm zone of massive sphalerite and galena.
- one metre of brecciated wallrock with disseminated pyrite, sphalerite and galena.
- 40 cm vein with disseminated sphalerite and galena.

Wallrock alteration is green probably chlorite and is associated with disseminated pyrite and minor sphalerite and galena for 10 to 20 cm from the vein. The vein attitude is 335^{o} +/-90^{o} and clearly cuts the foliation in the host rocks which is oriented at 204^{o-}70^{o} west.

A rhyolite dyke occurs about 50 metres west of the Cobre occurrence. The rhyolite is a massive rock that is porphyritic in both quartz and feldspar. It clearly cuts the foliation in the host rocks though may locally appear to be concordant. At this site, the rhyolite contains veinlets of sugary quartz, some containing pyrite, that are similar in orientation to the base metal veins. One vein measured 340°-56° southwest.

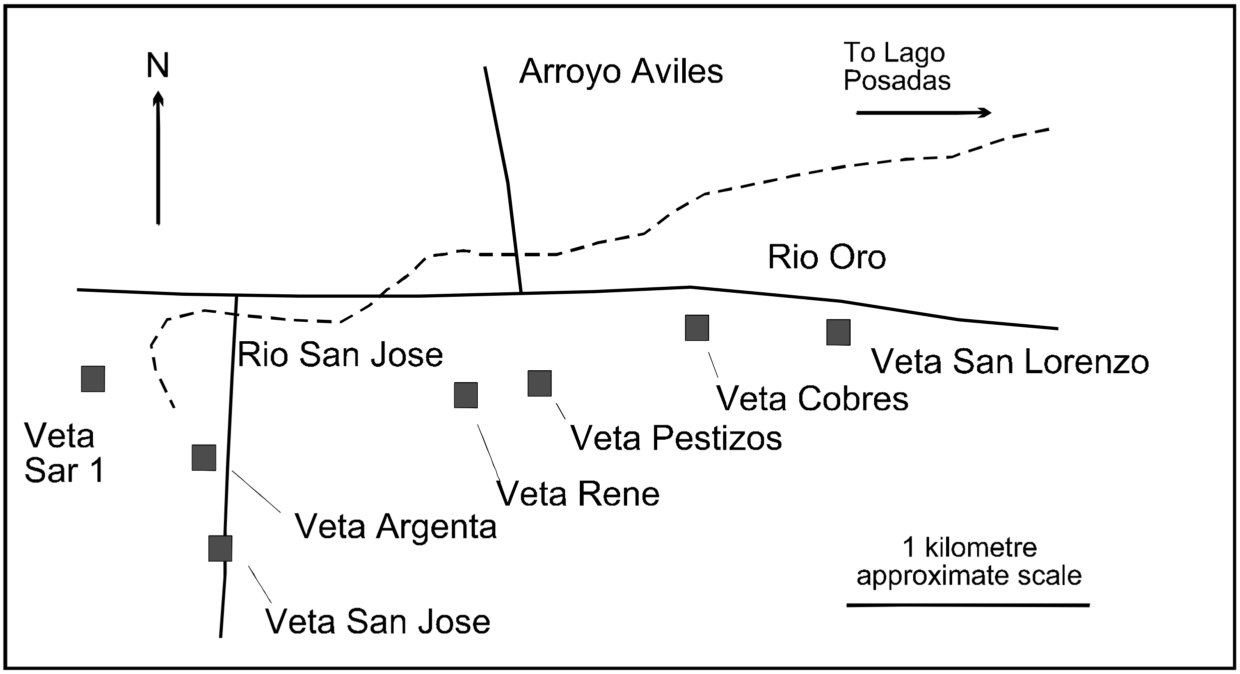

Figure 2: Sketch map of the location of mineral occurrences in the Rio oro area.

Veta Argenta

The Argenta vein is exposed in a single pit on the brow of the canyon on the west side of Rio San Jose about 1.5 km south of the location of the "hosteria" at the head of the terrace beside Rio Oro. The quartz vein is about 1 metre thick, contains fragments of wallrock pelite up to 2 cm, strikes 020° @ 55° southeast, and contains abundant sphalerite and galena. The vein is concordant with intense shearing in the wallrocks

Veta San Jose

The San Jose vein is in the bottom of the San Jose river canyon immediately south of a small tributary about 1 kilometer south of the Argenta vein. The mineralized zone is not strictly a quartz vein but rather a strongly silicified zone with locally abundant pyrite and minor galena. The wallrocks are pelite with thin sandstone layers and are strongly sheared and injected with boudinaged metamorphic quartz.

A six metre-thick rhyolite dyke is exposed in the river bank immediately south of the occurrence. It is massive, unfoliated and parallels both the foliation in the host rocks and the pyritic silicified zone. The dyke contains 1-2 percent limonite psuedomorphs of pyrite. The dyke is fractured and contains erratic thin veinlets of pyrite that appear strongest near the contact and diminish in size towards the centre of the dyke. The dyke contains excellent flow banding parallel to the contacts.

A small adit has been driven on the San Jose occurrence.

Veta SAR 1

The SAR 1 occurrence is located at the head of the alluvial terrace midway between the "Hosteria" and the ranch buildings west of Rio San Jose. The occurrence is developed by a small adit which was not entered. Above the adit, a 1 metre wide shear zone (attitude 355^o - 70^o east), that cuts the host rock pelites at (006^o - 70^o east) at a low angle, has been prospected over a length of 15 metres on small pods of massive pyrrhotite with pyrite that generally occur along the south margin of the zone adjacent to a thin quartz vein. The pods are up to 1 to 1.5 metres in length and up to 40 cm wide.

Veta Rene

The Rene and Pestizos (see below) veins occur on the south hillside of Rio Oro about 750 metres southwest of Veta San Lorenzo. The Rene vein is a 10 to 15 cm quartz vein, with textures indicating open space filling, that contains minor disseminated galena. The wallrocks to the vein are pelites with injections of barren, concordant, metamorphic quartz veins. The host rocks are intensely foliated and folded. And are cut by the vein striking 015^o - 76^o west.

Veta Pestizos

The Pestizos vein has been developed by an adit that is now caved. Examination of the dump showed no sulphides other than minor pyrite. However a 15 cm quartz vein with galena is poorly exposed in scrapings about 75 metres above the adit. The galena in the vein occurs both as coarse grained crystals with deformed cleavages, ribbon galena consisting of elongate grains developed through foliation and as mosaics of fine grains resulting from recrystallization. It is clear that at this site, there has been some deformation since the formation of the vein but not sufficient to destroy this small vein. The strike of the vein is 019^o - 85^o west while the attitude of the foliation is 045^o - 70^o east four metres east of the vein

LEAD ISOTOPIC STUDIES

Two galenas were selected for analysis by Geospec Laboratories as an aid in interpreting these deposits. The analytical results are documented in Table 1 and plotted with Chilean data in Figures 3 and 4.

Table 1: Results of lead isotopic analyses for the San Lorenzo and San Jose occurrences.

MIN OCCUR	206Pb/204Pb	207Pb/204Pb	208Pb/204Pb
Veta San Lorenzo	18.543	15.627	38.490
Veta San Jose	18.516	15.636	38.548

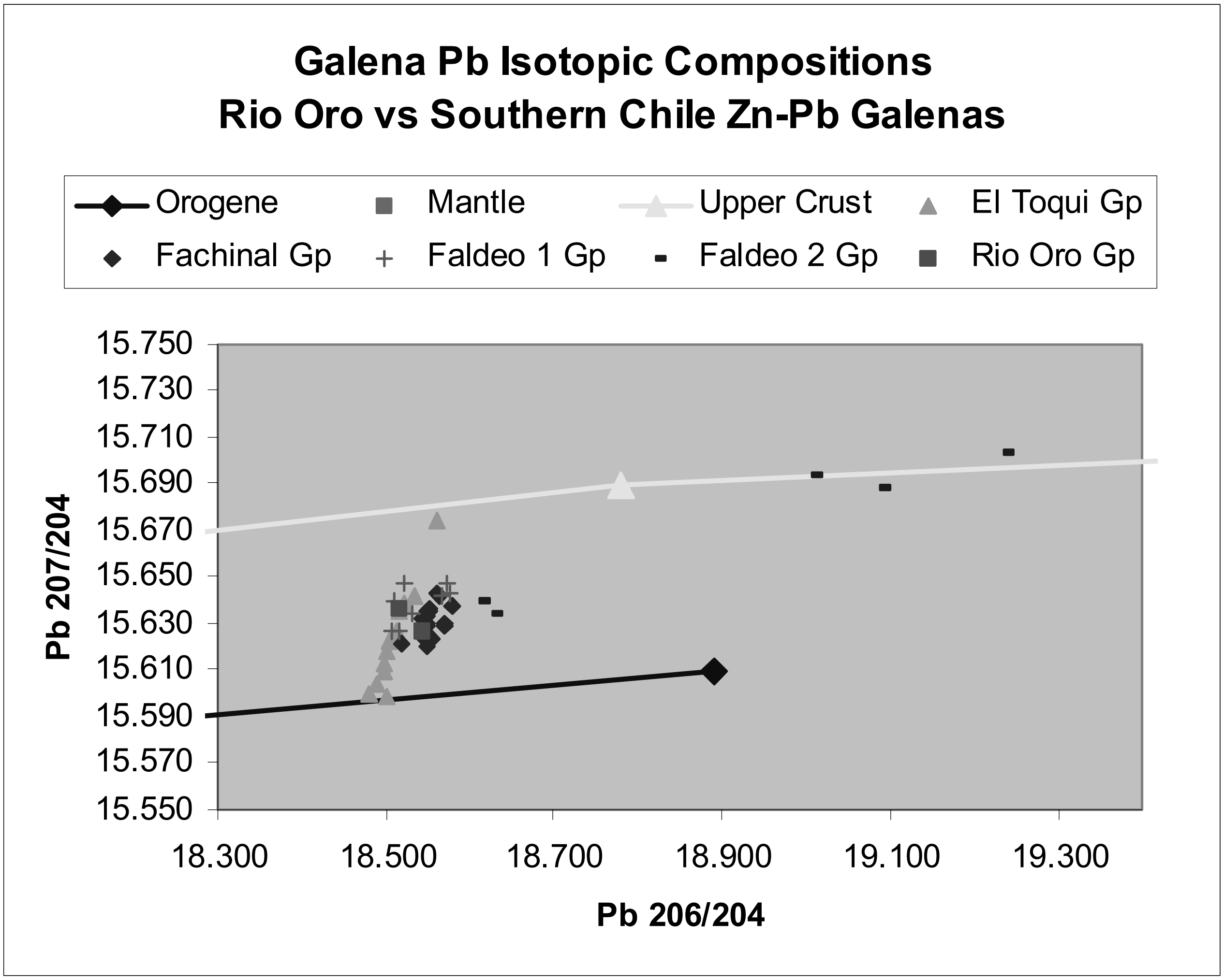

Figure 3: Comparison of Pb isotopic compositions of galenas from the San Lorenzo and San Jose base metal occurrences, Rio Oro, Santa Cruz, Argentina with the compositions of galenas from base metal occurrences in southern Chile after Townley and Palacios (1999). The Yellow and Blue curves are the Upper Crust and Orogene evolution curves of Zartman and Doe (1981). All data are in the upper crustal domain indicating a probable source of most of the Pb from crustal rocks. The Faldeo 1, El Toqui and Fachinal groups form a tight cluster of galena compositions with the Faldeo 1 Group having the least radiogenic galenas, the El Toqui Group having intermediate galena compositions, and the Fachinal group having the most radiogenic compositions. Within this cluster, both the Faldeo 1 and Fachinal analyses are clustered whereas the El Toqui analyses form a mixing line between the orogenic and upper crustal evolution curves, indicating a more varied and possibly more widespread source area for the Pb in the underlying rocks. The Faldeo 2 galenas exhibit a much wider range in compositions outside the grouping formed by the other Chilean occurrences, forming a mixing line between the group formed by the Chilean occurrences and a source of much more radiogenic lead. Within this framework, the Rio Oro galenas clearly fall within the main cluster of galena compositions.

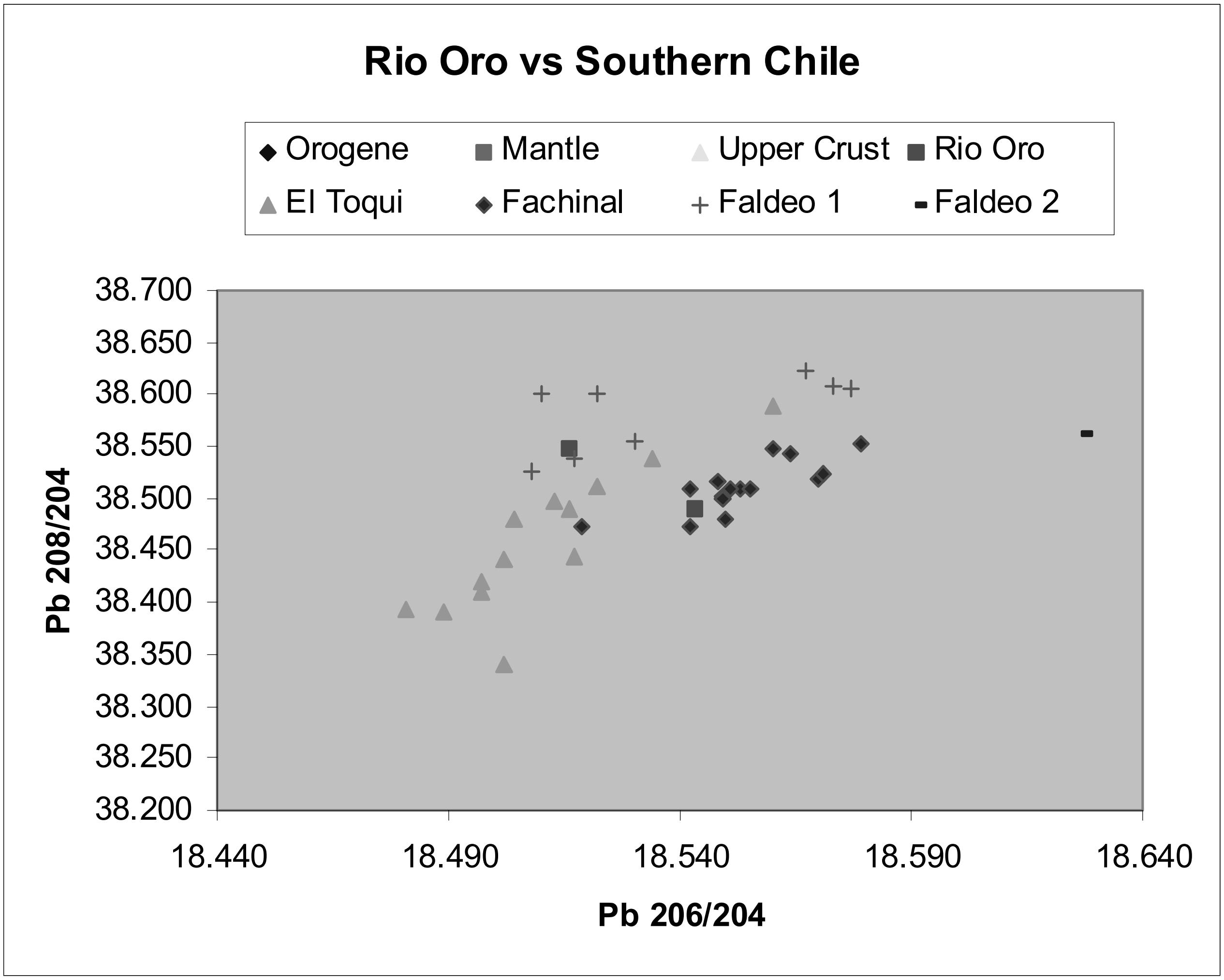

Figure 4: In 208/204 – 206/204 space, the El Toqui, Fachinal and Faldeo 1 subgroups all exhibit reasonable separation within the cluster of analyses. However, within this group the value for San Jose clearly falls within the Faldeo 1 group whereas the value for San Lorenzo clearly falls within the Fachinal group.

DISCUSSION

The reason for the visit to the Rio Oro area was to pass an opinion on whether the Rio Oro base metal veins might be in some way related to a SEDEX base metal system.

It is my opinion that the veins are not related to any form of SEDEX system. SEDEX deposits are formed by sulphide sedimentation on the seafloor or by diagenetic replacement of sediments immediately below the seafloor very soon after sedimentation by basin brines. As such the deposits exhibit features indicating metamorphism with the enclosing rocks.

The Rio Oro veins cut a very strong metamorphic foliation, metamorphic quartz veins that occur in the foliation, and folds that deform the foliation and so the veins must therefore be younger that the age of metamorphism. They show no evidence of folding and open space features were seen in several veins (vugs with quartz crystals) that would be destroyed by the degree of dynamic metamorphism seen in the host rocks.

The best framework for interpreting the Rio Oro veins is that provided by Brian Townley at the University of Chile in Santiago. His recently published papers provide a detailed outline of the metallogenic implications of similar mineralization in the Aysen region of Chile (Townley and Palacios, 1999; Townley and Godwin, 2001). The basis of Townleys' metallogenic characterization is based on mineral occurrence mineralogy and chemistry, and tectonics/geochronology and lead isotopes. A comparison of the two Rio Oro lead isotope analyses with Townleys Pb isotopic data (Townley and Palacios, 1999) is presented in Figures 3 and 4. Clearly the Rio oro galena compositions fit with the Jurassic-Cretaceous hydrothermal veins and skarns that compose the Faldeo 1, Fachinal and El Toqui groups of deposits defined by Townley and Palacios (1999). Based on the limited information that is available to me and the proximity of the Faldeo group of mineral occurrences to Rio Oro, I would suggest that the two groups of deposits are part of the same mineralizing system. The apparently errant San Lorenzo analysis (Figure 4) may reflect the derivation of the lead from an inhomogerious (re Pb composition) metamorphic basement. I have included copies of the Townley papers with this report.

RECOMMENDATIONS

Given the presence of the very significant El Toqui Zn-Ag-Au skarn deposit (http://www.breakwater.ca/oper/elto.htm) and the Fachinal epithermalgold deposit in Chile that are included in the larger population of deposits considered by Townley and Palacios, I would recommend that the Rio Oro and other similar mineralization in southern Chile be included in a larger scale study designed to locate foci of hydrothermal systems and centres for the possible presence of skarn (as El Toqui, Chile) and epithermal (as Fachinal, Chile) deposits.

I recommend that the analyses originally requested in in 1997 Table 2 below be completed and the Pb isotopic program be expanded to other occurrences to further correlate the Argentine deposits at Rio Oro and elsewhere in the region to those that have been thoroughly documented in Chile.

REFERENCES CITED

Townley, B.K. and Palacios, C., 1999

Ore deposits and metallogenesis of mainland Patagonia, Aysen, Chile; in, (A.Sangster and M. Zentilli editors) Latin American Mineral Deposits, Exploration and Mining Geology, v. 8, 1 & 2, p. 91-108.

Townley, B.K. and Godwin, C.I., 2001
Isotope characterization of lead in Galena from ore deposits of the Aysen Region, southern Chile, Mineralium Deposita, v. 36, p. 45-57.

Zartman, R.E. and Doe, B.R., 1981
Plumbotectonics – the model; Tectonophysics, v. 175, p. 135-162.

TRAINING

Field training

During the course of the field work, every effort was made to stimulate discussion on the rocks and possible interpretations with SEGEMAR geologists. This was done as an informal activity as part of the observations that were being made. In particular, at the San Lorenzo vein, the relationships between metamorphic textures and cleavage were discussed in the context of the origin of the veins relative to the previously proposed SEDEX model.

Office Training

Stable isotopes: A 1.5 hour informal lecture was given tin the Comodoro Rivadavia office of SEGEMAR on the use of stable isotopes in the study of mineral deposits. The lecture was attended by 5 geologists including Marcelo Marquez and Adolfo Genini. The Spanish delegation was in the office giving a presentation on changes to the regional mapping program on the same day which detracted from attendance.

The discussion included the following;

Sulphur isotopes: the isotopes of sulphur, Canyon Diablo standard, methods of reporting data, biogenic basis of fractionation of isotopes, direct reduction of seawater sulphate, concept of 3 stable isotope reservoirs (Mantle = 0, seawater sulphate=enriched in 34S, black shale (biogenic) pyrite/pyrrhotite=enriched in 32S), history of isotope ratios in seawater sulphate and biogenic reservoirs over geological time.

This was followed by review of several case histories including 1) my work at Nugget Pond Newfoundland, trying to use sulphur isotopes to identify pyrites associated with gold mineralization, 2) sulphur isotopes associated with black shale-hosted gold occurrences, 3) sulphur isotope compositions associated with massive sulphides, 4) use of sulphur isotopes in studies of the origin of nickel deposits.

I promised to send photocopies of appropriate articles on sulphur isotopes including; 1) Bruce Taylor's MDD short course notes on stable isotopes and ore forming processes, 2) Claypole's paper on sulphur isotopic composition of seawater through geological time, and others.

Carbon-Oxygen isotopes: not used a great deal as many hydrothermal sources produce similar C-O isotopic results. One of the major exceptions is the isotopic composition of Carbonate derived from the oxidation of organic carbon which is very distinctive. In this regard the curve generated by studies of C-O isotopic equilibrium exhibited by carbonates from oil wells where the composition and temperature of associated brines could be measured. Knowledge of this relationship can be useful in some cases of mineralizing fluids derived from metamorphism of carbonaceous rocks.

Lead isotopes.: Introduction to the Pb evolution model of Zartman and Doe, definitive statement that lead isotopes do not normally give reliable age determinations in post Precambrian rocks, concept of different mantle source areas of different composition, possible use of rock leads as a toll in defining galena associations, use of galena leads in establishing a correlation between deposits formed at same time from a common source.

Table 2: Samples collected at Rio Oro and analytical Recommendations. As of the time of preparation of this report, only tw Pb isotope analyses had been received.

Sample Number	Vein Name	Description	Whole Rock analysis	Trace Element analysis	Assay	Pb Isotope	S isotope
SFB97-001	Cobres						
SFB97-002	Cobres						
SFB97-003	San Lorenzo	massive sphalerite + galena		1 + Hg + Au	Pb, Zn		Py+Sph+Ga
SFB97-004	San Lorenzo	sugary quartz + pyrite					
SFB97-005	San Lorenzo	quartz with coarse galena				**1 Completed**	
SFB97-006	San Lorenzo	quartz sweat from schist for textural comparison with sample 004					
SFB97-007	San Lorenzo	massive sulphide and wallrock to cut for textural relations					
SFB97-008	San Lorenzo area rhyolite	pyritic rhyolite					Py
SFB97-009	San Lorenzo area rhyolite	pyritic quartz veins from rhyolite					Py
SFB97-010	Argenta	Sphalerite-galena quartz vein material		1 + Hg + Au	Pb, Zn		Sph+Ga
SFB97-011	Argenta	Sphalerite-galena quartz vein material					
SFB97-012	Argenta	Orientated sample footwall					
SFB97-013	San Jose	siliceous pyritic material with galena				**1 Completed**	Py+Ga
SFB97-014	San Jose	siliceous pelite with pyrite		1 +Hg + Au			
SFB97-015	San Jose	silicified pyritic zone					
SFB97-016	San Jose	pyrite vein from rhyolite					Py
SFB97-017	????						
SFB97-018	SAR I	massive pyrrhotite		1 + Hg + Au			Po
SFB97-019	Rene	massive rhyolite with 5 % pyrite					Py
SFB97-020	Los Pestizos	deformed galena		1 +Hg + Au	Pb		
TOTALS			0				

1. Trace element analysis indicates thae following minimum suite of elements Au as XRAL FA30/1, Ag, Cd, Co, Pb, Cu, Mo, Ni, Zn, Sb, As, Sn, W as in XRAL ICP80.
2. It would be useful to run a selection of these samples for HG as XRAL by method CHM-20 as this element may be a useful discriminator in exploration.