PRECIOUS METAL TELLURIDES AND OTHER TE-BEARING MINERALS IN DIFFERENT PARAGENESIS OF ARGENTINA. A REVIEW

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ABSTRACT

Several polymetallic deposits containing tellurides and Te-bearing minerals occur in different geologic terrains of Argentina. Tellurides with Ag and /or Au are widespread in meso and epithermal environments; they are structurally controlled and genetically related to Jurassic or Miocene-Pliocene volcanism. These species are represented by calaverite, hessite, stützite, krennerite, sylvanite, petzite and cervellite. Other Te-bearing minerals are present not only in epithermal deposits but also in different assemblages such as intraplutonic W deposits, skarn and mafic-ultramafic bodies. They are Te, altaite, nagyágite, melonite-merenskyite, tetradymite, telurobismuthite, kawazulite, Te-canfieldite and goldfieldite. Paragenesis of the different deposits and chemical data of the minerals are given.

Keywords: *Tellurides, Te-bearing minerals, Precious metal minerals, Epithermal deposits.*

RESUMEN: *Los yacimientos con telururos y minerales portadores de telurio de Argentina.* En Argentina se han localizado diferentes yacimientos conteniendo telururos y minerales portadores de Te. Telururos con Ag y/u oro son comunes en ambientes epi- y mesotermales, los depósitos están controlados estructuralmente y genéticamente relacionados al volcanismo jurásico y mio-plioceno. Las especies halladas son: calaverita, hessita, stützita, krennerita, silvanita, petzita y cervellita. Otros minerales portadores de Te se presentan, además, en depósitos de W intraplutónicos, skarn, y cuerpos máfico-ultramáficos, como ser, Te, altaita, nagyágita, melonita-merenskyíta, tetradimita, telurobismutita, kawazulita, Te-canfieldita y goldfieldita. Se dan a conocer las diferentes paragénesis y la composición química de esos minerales.

Palabras clave: *Telururos, Minerales portadores de Te, Minerales de metales nobles, Depósitos epitermales.*

INTRODUCTION

In Argentina, several types of ores contain Te-bearing minerals and are located in different geological units. They are widely distributed but rarely abundant constituents of the deposits. From a genetic point of view they can be grouped into epithermal veins (high, intermediate and low sulphidation), meso-epithermal veins, deposits related to granites, to skarns and to mafic-ultramafic rocks. The epithermal Au-base metal deposits were considered with the classification of Heald *et al.* (1987), more recently modified by Sillitoe and Hedenquist (2003) and for the Bolivian type Ag-Sn deposits with the concepts of Cunnigham *et al.* (1991). The Au and Au-Ag tellurides found in several ores, calaverite, sylvanite, krennerite and petzite, and the Ag-tellurides: stützite, hessite and cervelleite, may contribute to the grade of precious metals in some ores. Other tellurides reported in the different deposits are altaite, nagyágite, the Bi-Te-bearing species tetradymite, tellurobismuthite, kawazulite, and minerals of the merenskiyite-melonite series. Te-canfieldite is present in Sn-Ag associations and goldfieldite in several ores. In some areas two or three types of mineralizations are cogenetic and occur nearby. The different localities are plotted in figure 1; the chemical composition, analyzed with different electron microprobes, will be shown in Table 1-9 and in Table 10 and 11 a summary of the deposits/minerals are given.
A condensed review of the occurrences is given below, beginning with epithermal deposits.

THE FARALLÓN NEGRO COMPLEX, PROVINCE OF CATAMARCA

The Farallón Negro volcanic complex, province of Catamarca is formed by a hypabisal volcanic system of Middle to Upper Miocene age emplaced in a Paleozoic basement (Sasso and Clark 1998). This cluster of polymetallic hydrothermal deposits comprises the world class La Alumbrera Cu-Au porphyry deposit, the porphyry-epithermal system of Agua Rica and the epithermal Capillitas and Farallón Negro vein type deposits (Fig.1-6).

The Capillitas district

The Capillitas district comprises numerous epithermal, high sulphidation veins, located in the Capillitas granite of Paleozoic age and in the volcanic rocks of the Miocene, to which the ores are related. They were mined for copper, silver and gold until the beginning of the 20th century, and at the present time there are well known sources of gem-quality rhodochrosite. The mineralogy is very complex with more than 120 different species present in massive, banded, brecciated and drussic textures (Marquez Zavalía

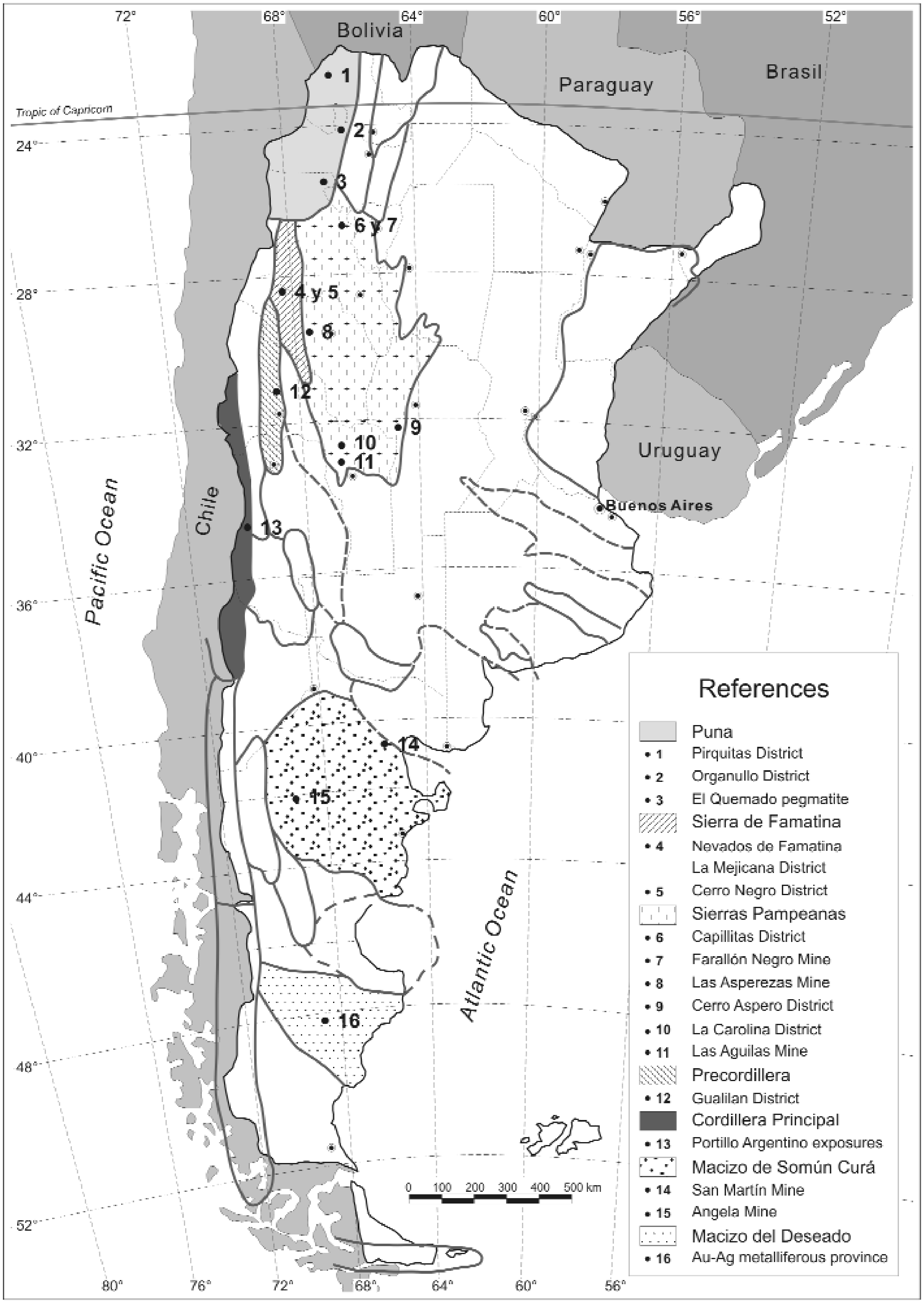

Figure 1: Location of deposits with tellurides and Te-bearing minerals.

1988, 1999). The most conspicuous minerals are chalcopyrite, sphalerite, pyrite, marcasite, tetrahedrite-tennantite, bornite, enargite. Minor species are pyrrhotite, arsenopyrite, bismuthinite, emplectite, wittichenite, boulangerite, bournonite, jamesonite, colusite, stannite, stannoidite, mawsonite, famatinite, luzonite, freibergite, germannite, renierite, thalcusite, hübnerite, wurtzite, Au, Ag, electrum and tetradymite. The gangue minerals are fluorite, calcite, rhodochrosite, siderite, barite, alunite, celestite and gypsum. Recently putzite and catamarcaite (Paar *et al.* 2004b, Putz *et al.* 2006) and other new facies under study were found. The tellurium mineralogy is characterized by the presence of Te, krennerite, calaverite, sylvannite, petzite, hessite, stützite, melonite, volynskite ? and goldfieldite (Marquez Zavalía and Craig 2004). The grains of these minerals are generally arranged in polycrystalline aggregates and occur in quartz, accompanied sometimes by hübnerite, pyrite, chalcopyrite, Biand Sn bearing minerals.

Six stages of mineralization were identified in this complex association, in which the native elements (Au and Te) and the Te- minerals are concentrated in the forth stage. Tellurium occurs locally in grains up to 10 μm and in association with the other Te-minerals. Sylvanite, krennerite and calaverite occur in subhedral to anhedral grains up to 15 μm. Stützite, melonite and volynskyite? are scarce; they occur as irregular 10-15 μm grains in contact with goldfieldite, hessite and petzite in grains up to 5-15 μm are distributed in goldfieldite and quartz. Tetradymite occurs as small inclusions in hübnerite and goldfieldite. Goldfieldite displays considerable variability and some grains correspond to stiboan goldfieldite and also to arsenoan goldfieldite which coexist. Some tetrahedrite and tennantite have also Te contents that vary between 0.10 and 4.18 weight percent.

The Farallón Negro vein

The low sulphidation Farallón Negro vein is situated 8 km from the La Alumbrera porphyry in an andesitic breccia and in the monzonitic stock Alto de la Blenda. The mineralization consists of manganocalcite, calcian rhodochrosite, kutnohorite, calcite, with very minor pyrite, sphalerite, chalcopyrite, galena, tennantite, polybasite, acanthite, Au and Ag. The secondary alteration of the manganesíferous carbonates result in a manganite, chalcophanite, cryptomelane and pyrolusite assemblage, who gave a black colour to the vein (Malvicini and Llambías 1963). Little nagyágite grains are located in quartz and was identified by X-ray analyses (Schalamuk and Nicolli 1975).

TABLE 1: Chemical composition of Au tellurides.

		Au	Ag	Fe	Te	Sb	Total
Calaverite	Capillitas	42.54	0.58	-	56.23	0.43	99.78
$AuTe_2$	La Mejicana	39.47	0.65	2.31	53.58	2.60	98.61

TABLE 2: Chemical composition of Au-Ag tellurides.

		Au	Ag	Cu	Te	S	Total
Krennerite	Capillitas	34.57	7.91	0.28	57.23	-	99.99
$AuAgTe_2$	La Mejicana	34.2	6.2	0.03	59.1	-	99.53
	Fátima	37.5	3.3	-	58.4	-	99.2
Sylvanite $(Au,Ag)_2Te_4$	Capillitas	25.8 - 32.99	7.38 -12.8	0.85	59.54 -62.35	0.17 - 0.47	
	Fátima	30.5	8.0	-	60.7		99.2
	Nev. de Famatina	23.34	10.94	1.94	58.95	-	95.17
	Upulungus var.1	24.3	12.6	0.7	62.4	-	100.0
	Upulungus var.2	28.6	9.4	0.3	61.0	-	99.3
Petzite	Upulungus	25.3	41.4	-	33.0	-	99.7
Ag_3AuTe_2	Fátima	25.0	41.4	-	32.6	-	99.0
	La Pilarica	24.16	42.40	-	32.65	-	99.21

TABLE 3: Chemical composition of Ag- tellurides.

		Ag	Cu	Sb	S	Te	Total
Hessite	La Mejicana	61.8	0.2	n.a.	n.a.	36.9	98.9
Ag_2Te	Capillitas *	61.20	0.80	0.39	0.28	37.10	99.67
Cervelleite	San Martín	64.5	5.2	n.a.	5.8	23.7	99.7
Ag_4TeS	Ángela	60.35	3.25	n.a.	5.68	22.70	99.98
Stützite	Capillitas**	55.7	0.48	-	-	41.18	97.36
Ag_{5}-xTe_3	Upulungus	57.6	0.2	-	-	42.6	100.4

* with traces of Bi, Zn. Pb. ** with traces of Pb, Fe.

SIERRA DE FAMATINA, PROVINCE OF LA RIOJA

The Cu and Ag districts of the eastern slope of the Famatina range are located about 35 km west of Chilecito city, province of La Rioja, in an altitude of 4,000-4,550 meters above sea level (4 in Fig. 1). The geology is made up of Ordovician pelites of the Negro Peinado Formation intruded by Devonic granitoids of the Ñuñorco Formation, and dacites of the Mogotes Formation of Lower Pliocene age to which the ores are related (Brodtkorb *et al.* 1996).

In this area a Mo-porphyry (Nevados de Famatina) associated to an epithermal high sulphidation system (La Mejicana) are present. Also some kilometers to the south, an intermediate sulphidation district (Cerro Negro) occurs. La Mejicana was exploited for Cu and Au in the late 19^{th} and in the 20^{th} century and Cerro Negro for silver in the 18^{th} and 19^{th} century.

The Mo-porphyry system ends with various epithermal veins of high sulphidation type (Losada Calderón and McPhail 1996).

La Mejicana district

In the vicinity of the Mo-porphyry is the important complex of La Mejicana with two main veins, Upulungus and San Pedro and a dozen of smaller ones, involved in a very strong hidrothermal alteration. The ore is composed of pyrite, famatinite, (this is the type locality for the species), luzonite, enargite, tetrahedrite, tennantite, with minor chalcopyrite, sphalerite, colusite, primary covelline, and scarce galena, bornite, molydenite, aikinite. The gangue minerals are quartz, alunite, fluorite and anhydrite (Losada Calderón 1992, 1996, Brodtkorb and Paar 1993a,b, Brodtkorb *et al.* 1996). In the Upulungus vein also goldfieldite, two varieties of sylvanite, stützite, petzite, krennerite, calaverite and hessite are found (Paar y Brodtkorb, 1998).

The Cerro Negro district

This district (5 in Fig. 1) lies about 10 km south of La Mejicana in the same regional geologic environment, and comprises different veins where La Peregrina is the most important. It is characterized by a complex Ag-Pb-Zn mineralization (Schalamuk and Logan 1994) accompanied by intense silicification and sericitic alteration. The mineralogy comprises pyrite, chalcopyrite, sphalerite and galena followed by argyrodite, gold, niccolite, niqueliferous skutterudite, rammelsbergite, safflorite and the Ag-assemblage pyrargyrite, proustite, miargyrite, freibergite, stephanite, pearceite/polybasite, acanthite and native ilver. In a third stage marcasite, wurtzite and scarce Te, altaíte and an unnamed Pb, As, Sb, Te compound was found. The gangue minerals are barite, siderite, ferroan rhodochrosite, calcite, adularia and quartz.

THE CERRO CACHO-SIERRA DE UMANGO DISTRICT, PROVINCE OF LA RIOJA.

This epithermal Se-district (Fig.1-8) is placed about 50 km south of Jagüé, in the Western Sierras Pampeanas, between the Cerro Cacho and the western slope of the Sierra de Umango. It is the type locality for umangite and klockmannite. In the area the Tumiñico, La Millonaria, Las Asperezas, are the most important deposits. Within Las Asperezas umangite, klockmannite, eucairite, naumannite, fischesserite, gold, berzelianite and merenskyite in a calcite gangue, are present. Merenskyite occur in minute crystals up to 30 μm within a umangite-klockmannite-eucairite assemblage (Paar *et al.* 2004a). The chemical data are shown in Table 6.

THE LA CAROLINA MESO-EPITHERMAL DISTRICT, PROVINCE OF SAN LUIS

The La Carolina Prospect (10 in Fig. 1) is lo-cated in the Sierra of San Luis, some 30 km north of the city of San Luis. The mineralization is related to the Miocene volcanic complex and is found in several sectors which present potassic, sericitic, silicic and argillic hidrothermal alteration. The ore includes pyrite, arsenopyrite, pyrrhotite, sphalerite, galena, marcasite, chalcopyrite, tetrahedrite s.l., pyrargyrite, wurtzite and the tellurides hessite and sylvanite. Hessite occurs as crystals and aggregates up to 40 μm related to sylvanite, tetrahedrite and sphalerite and shows the typical orange-deep blue anisotropy colours. Sylvanite, less common, is found as crystals up to 30 μm in length by 10 μm wide and show birreflectance and anysotropy in brown and blue shades (Urbina *et al.* 1998).

TABLE 4: Chemical composition of Pb-tellurides.

		Pb	Ag	Sb	Bi	Se	Te	Total
Altaite	Cerro Negro	58.50	0.04	0.30	-	0.06	39.72	98.62
PbTe	Cerro Áspero	63.2	0.02	-	0.08	0.04	37.0	100.34

TABLE 5: Chemical composition of Bi tellurides.

		Bi	Cu	Fe	Sb	As	S	Se	Te	Total
Tetradymite	Capillitas^	57.99	0.04	-	0.27	-	4.37	0,82	33.97	98.10
Bi_2Te_3S	Pirquitas	59.9	-	-	-	-	4.6	-	34.9	99,4
	Julio Verne*	57.7	1.9	0.1	0.35	-	4.2	-	34.7	99.5
	Portillo Argent	58.95	0.03	-	-	0.32	5.43		36.04	100,80
Teluro-bismuthite										
Bi_2Te_3	Las Águilas^^	48.42	-		0.71		0.38		49.91	99.42
Kawazulite										
Bi_2SeTe_2	Julio Verne**	55.1	2.1	0.37	0.35	-	2.25	7.7	30.2	98.77

^ with traces of Zn, In, Ga and Se. *with 0.6% Pb. ^^ with traces of Ni and Pd. ** with 0.7% Pb

TABLE 6: Chemical composition of the melonite-merenskyite series.

			Ni	Pd	Bi	Pt	Te	Total
Melonite	Capillitas *		14.08	-	-	-	78.04	92.58
$NiTe_2$	Las Águilas		10.52	9.78	18.62	0.05	60.76	99.73
Merenskyite	Las Águilas	a	6.97	17.38	7.37	0	67.64	99.36
$Pd(Te,Bi)_2$	b**		6.42	13.91	8.66	7.15	60.49	100.90
		c	1.13	24.12	11.24	1.20	60.49	99.66
		d	0.57	22.84	18.15	0	64.76	100.10
Merenskiyite	Las Asperezas		-	27.1	-	0.25	72.6	99.95

*with 0.46% Sb. ** with 1.72% Fe

TABLE 7: Chemical composition of Te-canfieldites.

		Ag	Sn	Cd	S	Te	Total
Te-canfieldite	Pirquitas	63.20	8.80	0.30	9.40	18.90	100.60
	Julio Verne	64.90	8.50	0	9.50	17.90	100.80

TABLE 8: Chemical composition of goldfieldites $Cu_{12}(Te,Sb,As)_4S_{13}$.*

	Cu	Ag	Fe	Bi	As	Sb	Te	S
Capillitas	47.33- 47.08	0.01- 1.86	0.16- 2.33	2.38- 7.67	0.5- 8.07-	2.82- 10.19	10.39- 14.85	24.17- 25.54
La Mejicana	40.47- 48.39	0.01- 1.97	0.02- 3.59	2.5	1.75- 7.05	1.40- 12.81	10.36- 26.00	22.49- 26.99
Nev. Famatina	45.00- 47.71	0- 0.51	0.11- 0.65	1.1- 7.3	7.87- 11.0	2.09- 5.91	7.18- 12.00	27.05- 28.79
Julio Verne	41.6- 45.2	0.11- 1.06	0.10- 1.45	-	3.4- 6.7	5.0- 8.5	11.7- 16.1	24.4- 26.1

* Minimum and maximum percentages.

TABLE 9: Chemical composition of tellurides..

	Te	S	Sb	Bi	Pb	Ag	Cu
La Peregrina	88.47- 97.24	0.47- 1.95	0.65- 0.70	-	4.12- 9.19	-	-
Ángela	100.2	0.05	-	0.10	0.06	0.01	0.07
Capillitas	96.30	-	0.74	-	-	0.89	-

THE LOS MANANTIALES MESO-EPITHERMAL DISTRICT, PROVINCE OF CHUBUT

The polymetallic ore of Los Manatiales district, province of Chubut, is situated 50 km south of the locality of Gastre (Fig.1-15). The mineralization is located in structurally controlled ore shoots of subvolcanic mesothermal- epithermal (intermediate sulphidation) type emplaced into andesitic to dacitic rocks corresponding to the Taquetrén Formation of Late Jurassic age. There are several veins, where Ángela and Susana Beatriz are the most important and were exploited in the middle of the 20th century. The paragenesis includes pyrite, chalcopyrite, sphalerite, galena, hematite and minor arsenopyrite, betekhtinite, bornite, matildite, electrum, Ag, Au. Galena presents inclusions of aikinite, wittichenite, Ag-wittichenite, miharaite, cervelleite, Te and the new mineral angelaite (Arizmendi *et al.* 1996, Topa *et al.* 2003). The gangue minerals are quartz and adularia.

THE DESEADO MASSIF EPITHERMAL, LOW SULFIDATION DISTRICT, PROVINCE OF SANTA CRUZ

The Au-Ag metalliferous province of Santa Cruz is situated in the Deseado Massif and comprises almost 20 deposits of epithermal, low sulphidation style (Fig.1-16). Cerro Vanguardia is the first working mine in this very interesting area. Over an Upper Precambrian-Lower Paleozoic basement some continental sediments were deposited. With the brakedown of Gondwana an important volcanic event took place in Jurassic times, to which the mineralization is related. The general scarce sulphide mineralization of these deposits comprises pyrite, chalcopyrite and some sphalerite, galena, acanthite, uytenbogaardtite, pyrargyrite and freibergite, together with gold, silver and electrum. In Cerro Vanguardia, La Manchuria and La Pilarica deposits, petzite was also found (Tessone 1999, Tessone *et al.* 1996, Zubia 1999).

TABLE 10: Distribution of tellurides.

	CALA	KREN	SYLV	PETZ	HESS	CERV	STÜT	Te
Epithermal high sulf.								
Capillitas, Catamarca	x	x	x	x	x		X	x
La Mejicana, La Rioja	x	x	x	x	x		X	
Epithermal low sulf.								
Cerro Negro, La Rioja								x
Macizo del Deseado,				x				
Epi-mesothermal								
La Carolina, San Luis			x		x			
Los Manantiales, Chubut						x		x
Type Ag-Sn Bolivia								
Fátima, Salta	x	x	x					
In skarn								
Gualilán, San Juan					x			
In granites								
San Martín, Río Negro					x	x		

CALA= calaverite; KREN= krennerite; SYLV= sylvannite; PETZ= petzite; HESS= hessite; CERV= cervellite; STUT= stützite, Te=tellurium

THE BOLIVIAN AG-SN-TYPE DEPOSITS, PROVINCES OF JUJUY AND SALTA

The Cenozoic metallogenetic province of the Puna is characterized by precious and base metal epi to mesothermal mineralizations belonging to the polymetallic province of Central Andes (Cunningham *et al.* 1991). The Sn-Ag deposits contrast with the Au-As association of porphyry copper lithocaps (Sillitoe *et al.* 1998), suggesting that different situations reflect the metal contents of the magmatic fluids. In northwestern Argentina the most southern deposits of the Bolivian Sn-Ag belt are the Pirquitas district, province of Jujuy, and the Organullo district, province of Salta, where different Te-bearing minerals are present.

Pirquitas District, province of Jujuy

This district (11 in Fig. 1) is situated about 135 km west of the locality of Abra Pampa, province of Jujuy. The most cons-picuous veins are Oploca, Potosí, San Pedro, San Miguel and Chocaya (Malvicini 1978). This mine provided three new mi-nerals in the last years: pirquitasite (Johan et Picot 1982), suredaíte (Paar *et al.* 2000 c) and coiraíte (IMA-2005-024). The mineralization is located in Ordovician shales and sandstones of the Acoyte Formation. Clastic continental sequences with interbedded pyroclastic rocks, ignimbrites and dacitic-rhyodacitic lavas (Cerro Galán) of Upper Tertiary age occur in the area, where the ores are related.

The lens-shapped veins present 0.2 to 2 m thick branches, accompanied by fine veinlets. The texture is massive in depth and colloform and brecciated at higher levels. The host rocks present a hydrothermal alteration composed of sericite, pyrite and quartz, whereas near the veins, kaolinitization and silicification prevails. At higher levels alunite was found.

The mineralization is polymetalic and complex and precipitated in several stages. Pyrite, pyrrhotite, arsenopyrite and casiterite crystallized in the first stage followed by minor temperature sequences of sphalerite, wurtzite, galena, marcasite, Sn and Ag sulphides and Sb-Pb sulfosalts such as pirquitasite, kësterite, hocartite, rhodostannite, toyohaite, petrukite pyrargyrite, miargyrite, freibergite, scarce cylindrite, diaphorite, stannite, matildite, pavonite, quatrandorite, ramdohrite, teallite, franckeite, tetradymite, Te-canfieldite and ferberite (Paar *et al.* 1996, 2001). Tetradymite is present as tablets not exceeding 60 μm in length, intergrown with pavonite and benjaminite, included in Te-canfieldite.

TABLE 11: Distribution of other Te-bearing minerals.

	ALT A	TED Y	TeBI	KAWA	MELO	MERE	TeCA	GOLF	NAGY
Epithermal high sulf.									
Capillitas, Catamarca		x			x			x	
La Mejicana, La Rioja								x	
Epithermal inter. sulf.									
Cerro Negro, La Rioja	x								
Epithermal low sulf.									
Farallón Negro, Catam.									x
Epi-telethermal									
Las Asperezas						x			
Type Ag-Sn Bolivia									
Pirquitas, Jujuy		x					x		
Julio Verne, Salta		x		x			x	x	
Fátima, Salta	x		x ?		x				
In skarn									
Portillo Argentino, Mza		x							
In granites									
Cerro Áspero, Córdoba	x								
Mafic-ultramafic seq.									
Las Águilas, San Luis			x		x	x			

ALTA= altaite: TEDY= tetradymite; TeBI= Te-bismuthite; KAWA= kawazulite; TeCA= Te-canfieldite, GOLF= goldfieldite, NAGY= nagyágite, MELO= melonite, MERE= merenskyite.

Organullo District, Province of Salta

The Organullo district (2 in Fig.. 1) lies 35 km south of San Antonio de los Cobres and comprises the Julio Verne mine and the Fátima prospect. In Julio Verne two major quartz veins with different sulphides, with a maximum thickness of 0.80 m, were exploited in the past. Pyrite, marcasite, melnickovite and the tetrahedrite group minerals are the most extensive mineral facies in the deposit. Three stages of mineralization can be discerned. Tetrahedrite, tennantite, "annivite" and goldfieldite are associated to chalcopyrite, arsenopyrite, enargite, famatinite, stannoidite, mawsonite, members of the stannite-kësterite series, Te-canfieldite, gold and electrum. The copper-tin-sulphids kuramite, mohite and viencien-nite lie as tiny inclusions in the tetrahedrite s.l. minerals. The bismuthiferous assemblage comprises emplectite-chalcostibite, aikinite and additional tetradymite, matildite, gustavite, schirmerite and wittichenite, and the minor facies benjaminite, gladite, hodrushite, kawazulite and krupkaite (Sureda *et al.* 1994, Paar *et al.* 2000b).

In the Fátima prospect also krennerite, petzite, sylvannite, melonite, altaite, Au and telurobismutite (Paar *et al.* 2000a) were found.

INTRAPLUTONIC W-DEPOSITS

Cerro Áspero District, Province of Córdoba

The district is located in the eastern flank of the Sierra de Comechingones, Eastern Sierras Pampeanas (9 in Fig. 1) some kilometers away from the city of Río Cuarto, province of Córdoba. This district comprises different veins and breccias with quartz-wolframite ores. After the deposition of these minerals a new pulse of sulphides occurred, comprising molybdenite, pyrite, chalcopyrite, bornite, sphalerite, galena with inclusions of altaíte, wittichenite, miharaite and stannoidite (Gon-zález Chiozza *et al.* 2002). Altaíte were detected as inclusions in galena; the grains are less than 30 μm in size.

The San Martín Mine, province of Río Negro

The San Martín mine is located in the Northpatagonian Massif (14 in Fig. 1), 25 km NNE of the village of Valcheta. The mineralization is located in a granitic intrusion of 230 Ma and the veins are structurally controlled. First a felspar alteration with quartz and hübnerite crystallization occured, followed by chalcopyrite with grains of tetrahedrite, kësterite and stannoidite, and galena with inclusions of aikinite, Ag-wittichenite associated to a new Bi-mineral under study (Brodtkorb and Brodtkorb 1969). In the upper part of the vein (Paar and Brodtkorb 1996) also some Cu-cervelleíte and hessite grains occur within galena. Cervelleíte occur as rounded grains up to 70 μm across, sometimes associated to hessite, wittichenite, chalcopyrite and sphalerite, whereas hessite are scarce and show rounded grains up to 30 μm.

SKARN DEPOSITS

Two different skarn deposits with Te-bearing minerals are known, one in the Precordillera and one in the Principal Cordillera.

Gualilán District, province of San Juan

The Gualilán district (12 in Fig. 1) is located 120 km NNW of the city of San Juan, in the Gualilán ranges of the Precordillera. The regional geology is made up of Ordovician limestones and Silurian pelites intruded by dacitic porphyries of Miocene age. This deposit was exploited for gold in the 19th and 20th centuries.

The limestone carried lens-shapped skarn deposits up to 30 m in thickness. There are exoskarns of distal type. The skarn is composed of pyroxenes (hedenbergite and johannite), garnet and calcite. In a first stage magnetite, pyrrhotite, chalcopirite, sphalerite are crystallized whereas in a final stage, galena, acanthite, hessite, gold and electrum. Hessite is present as small blebs in galena (Vallone 1991, Logan 1999).

Portillo Argentino, province of Mendoza

This prospect (13 Fig.. 1) is located about 150 km SW of the city of Mendoza, on the Chilean border. The country rocks are micashists and limestones of Proterozoic age intruded by granitoids of Neopaleozoic ages, forming hornfelses

and skarns in the contact zone. The last ones are formed by diopside, garnet and magnetite with chalcopyrite, sphalerite, and minor hematite, pyrrhotite, pyrite, galena, linneite, molybdenite and a Bi-assemblage composed of cosalite, galenobismuthite, bismuthite and tetradymite (Brodtkorb and de la Mota 1969, Brodtkorb and Wiechowski 1998).
Tetradymite is present as little lathes up to 150 μm in length and few microns in thickness; it shows high reflectivity, yellowish white colour, little birreflectance, and the anisotropy have brownish colours in diagonal position.

MAFIC-ULTRAMAFIC SEQUENCES

Las Águilas deposit, province of San Luis

The mafic-ultramafic rocks of the province of San Luis (11 in Fig. 1) are lens-shaped bodies in a NNE striking belt, some 100 km in length. There were attributed genetically to a differenciated mafic-ultramafic complex of stratified type and comprises dunites, harzburgites, piroxenites, norites, gabbros and anphibolites. The country rocks are different mica shists, quartzites, gneisses of the Precambrian-Cambrian basement. The most important studied deposit is Las Águilas. The mineralization occurs disseminated and massive and is composed of pyrrhotite, pentlandite and chalcopyrite with minor amounts of pyrite, chromites, cubanite and sulfoarsenides of Fe, Ni and Co. Platinum group minerals sperrylite, different phases of Ir-Rh-As-S and Pb-Bi-tellurides were also found (Bjerg *et al.* 1996, Gervilla *et al.* 1994, Mogessie *et al.* 2000).
Merenskyite is present in the pyroxenites, rich in Ni, without Pt and with Bi substituying Te. In the dunites, merenskyite contains 7% of Pt. In other places, in contact with cubanite there is a melonite fase rich in Pd, and also telurobismuthite with some Ni and Pd was found (Mogessie *et al.* 1998).

SUMMARY

In tables 10 and 11 a summary of the deposits/minerals are given.

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