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CHARACTERISTICS OF THE GOLD OCCURRENCES IN THE SANTA VICTORIA DISTRICT, PROVINCIA DE SALTA, ARGENTINA

Pedro Argañaraz, Michel Fornari, Alfredo L. Castillo, Ricardo R. Battaglia

Abstract: The primary "in rock" gold occurrences crop out at higher elevations in the Sierra de Santa Victoria which forms part of the Eastern Cordillera itself located between the "Puna" geological province to the west and the Sub Andean foothills to the East (fig.1)

The geomorphic appearance corresponds to smooth sloped hilly countryside with a altitude of about 4000 m. Towards the East, elevations decrease rapidly towards the Andean foreland basin and in this area, auriferous gold placers occur in the watersheds of the Pilcomayo and the Bermejo rivers, both of which form part of the La Plata drainage basin.

The predominant lithologic formations are fine marine deposits of upper Proterozoic to lower Paleozoic. Gold mineralization occurs as narrow quartz veins with minor hematite and copper which are part of the Pb, Zn, Ag, Cu metallic province of La Quica. Gold forms free particles in the quartz and contains between 5% and 25% of silver.

Detrital gold of the alluvium averages between $0,08 g/m^3$ and $0,61 g/m^3$ but is highly variable depending on sample location. Gold particles are small and generally show irregular shapes. Flatness index values indicate short transport distances for about 25% of the gold particles and show transport distances of more than 30 km for the others particles. Gold particles exhibit thin external silver depleted rims indicative of "in situ" alteration.

P. Argañaraz, R. R. Battaglia: Dirección General de Mineria, Salta, Argentina.

M. Fornari, Orstom UR1H, CP 9214, La Paz, Bolivia

A. L. Castillo, Universidad Nacional de Salta y Dirección General de Mineria, Salta, Argentina.

INTRODUCTION

The Santa Victoria area contains several Pb, Zn, Ag, Cu occurrences mainly as quartz or barytine veins [1]. Some of these veins have been worked in the past, but by now mining activity decreased, except for then occasional exploitation of barites.

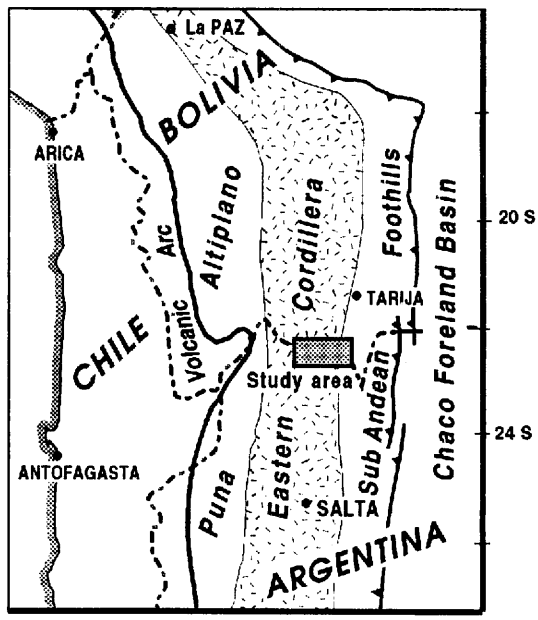
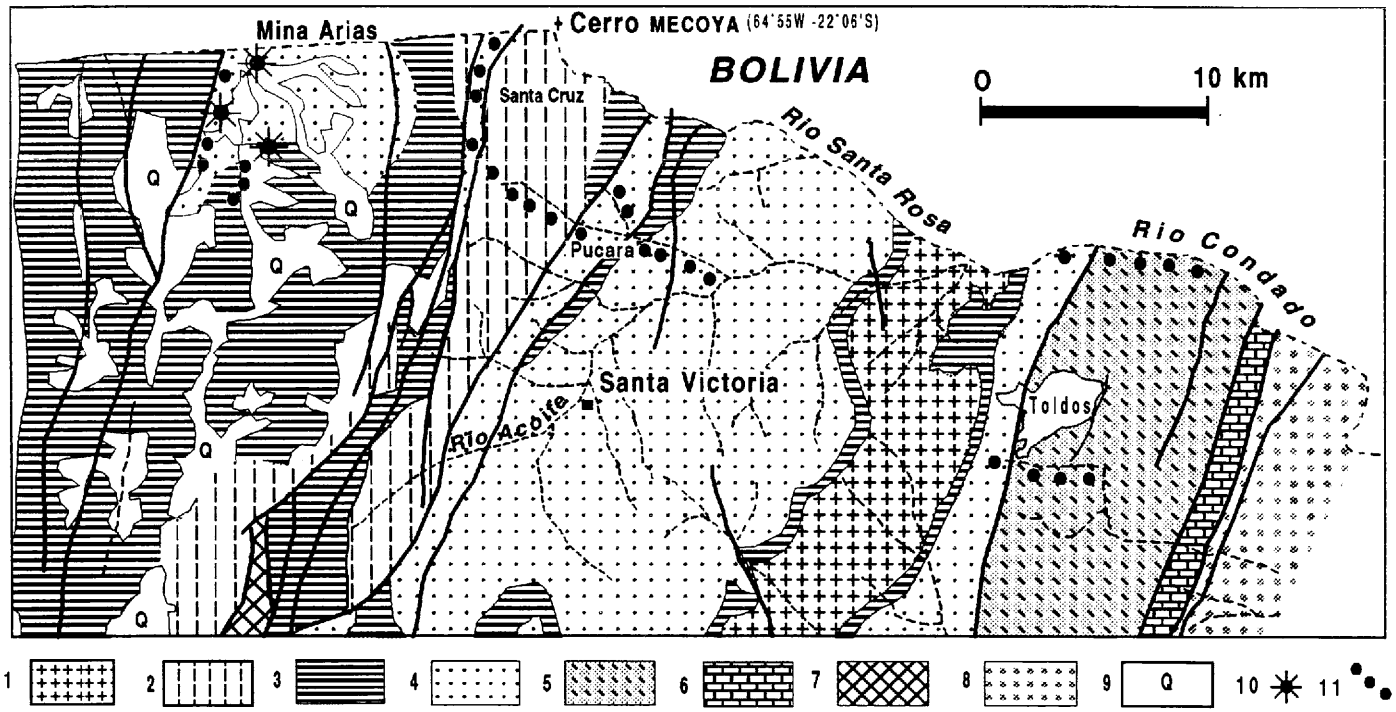


Fig. 1 : location of the study area.

The situation was modified ten years ago (1982) by the discovery of gold. The Dirección General de Minería of the Salta Province developed geological studies under the auspices of the Plan Inventario Minero Provincial and villagers started small scale mining of the detrital gold deposits.



1 = Granite and granodiorite Cañani. 2 = Puncoviscana Formation. 3 = Mezon Group (Cambrian). 4 = Santa Victoria Group (Ordovician)
5 = Silurian-Devonian. 6 = Carboniferous -Permian -Triassic -Jurassic. 7 = Salta group, Cretaceous. 8 = continental Cœnozoic.
9 = Quaternary sediments. 10 = Gold quartz vein mineralization. 11 = Gold-bearing alluvial deposits.

Fig. 2 : simplified geological map of the Santa Victoria area.

Preliminary explorations highlighted several interesting areas such as Viscachani, Minas, Santa Cruz, Pucara, Toldos, within a 60 km long, E-W trending area (fig. 2).

The Viscachani area is located near Bolivian border and the mineralized structures crop out in the "Quebrada Minas" and "Tres Lagunas" [2, 3] which form watershed tributaries to the Pilcomayo River. This paper presents some of the characteristics of the gold mineralization, mainly using data from the Mina Arias vein which appears representative of the area.

OUTLINE OF THE GEOLOGY

The area is part of the Eastern Cordillera [4] and consists of smooth hills with mean altitudes about 4000 m. The elevation decreases rapidly toward the Andean foreland basin.

The older lithological units correspond to the Puncoviscana Formation [5] and consist of thick marine turbiditic sediments with limited occurrences of limestones, spaning from upper Proterozoic to Mid Cambrian time interval.

The Puncaviscana rocks are mainly greenish shales, greywackes and quarzitic interbeds containing small intercalations of basic lavas.

The estimated thickness is about 2000 m. The sediments are folded and present low grade metamorphism. They are intruded by the Cañani granodiorite and granite dated between 520 and 535 Ma.

The Cambrian Mezon Group forms extended outcrops of silicic sandstones and lutites of about 3000 m thick and overlies the Puncaviscana Formation with an angular disconformity. This in turn, is covered by the Ordovician Santa Victoria Group with low angular disconformity.

The Santa Victoria group reaches a thickness of 5000 m comprising of grey and greenish pelites of the Tremadocian Santa Rosita Formation and of the Arening-Llanvirnian Acoite Formation. These lower Ordovician sediments host the gold quartz veins.

Eastward upper Paleozoic, Mesozoic and Tertiary continental sediments form North-South trending outcrops in the fold-thrust belt of the Sub Andean ranges.

The smooth topography of the Eastern Cordillera is in part related to the development of a 9 Ma old regional erosion surface which extents regionally northward in Bolivia and is known as the San Juan de Oro surface, [6]. Recent tectonic uplift is responsible for regional canyon incision and regressive erosion from the eastern foreland basin.

VEIN MINERALIZATIONS

The lower Paleozoic rocks host gold quartz veins such as the Minas Arias vein. They consist of 10-15 cm thick lutitic strata interbedded with quarzitic sandstones of 10 to 40 cm thickness. Occasionally the thickness of the quarzitic beds can reach 1 m. The strata strike NW-SE and dip moderately toward the NE. In the area of the mine the contact with the Cambrian sandstones lacks a corresponding basal conglomerate and does not present a strong unconformity.

The vein named Arias I strikes NE-SW with a steep (80°) dip to the NE. The mean thickness is about 20 cm but when the vein cuts the Cambrian sandstones it's thickness decreases and dies out.

The vein consists mainly of quartz with pyrite, arsenopyrite and hematite with traces of copper oxides also being present. The quartz is generally brecciated but microgeodic drusy intergrowth of quartz and pyrite are also present.

PLACER CHARACTERISTICS

Alluvial and eluvial materials cover extended parts of the area. At higher elevations, glacial and fluvio-glacial deposits dominate whereas torrential and fluvio-torrential material are present along the rivers.

Two main levels of terraces are present with another, more limited level, consisting of reworked material with abundant fine sands, clays and organic matter. The latter level may be related to the ultimate Holocene wet stage.

In the area of Las Minas, the river is currently caving the Ordovician bed rock and hence the deposits are about 1-2 m above the actual stream level.

Generally, the terrace deposits consist of heterometric clasts with individual boulders of 1.5 m of diameter. The mean clast diameter ranges between 25-40 cm with clasts showing sub-angular to sub-rounded shapes. The clasts are manly derived from Ordovician and Cambrian rocks. The matrix consists of silt and clay with yellow and ochre coloration.

Heavy minerals coexisting with the gold are mainly hematite and magnetite and in lower quantities zircon, garnet and rutile. Gold concentrations are highly variable depending on sample location with the average grade ranging between 0,08 g/m^3 and 0,61 g/m^3

GOLD CHARACTERISTICS

Dissolution of quartz vein fragments in concentrated fluoridric acid enable the recovery of gold particles. SEM examination of the gold particle from oxidized surface sample shown irregular topography with dissolution features. Camebax microprobe analysis of polished sections of gold particles indicate the presence of several types of gold in the vein. One type contains about 25%, one 14% and another 11.5% of silver. cf table 1.

Gold contains traces of As, Fe, Hg, Te and occasionally low concentration of Cu. Others elements such as Bi, Pb, Sb were also investigated but were not detected.

Gold particles from placers in the Minas area are recovered from a area of 800 x 200 m. The size of the particles is generally small, with the majority between 1 and 1.5 mm.

Gold particles present xenomorphic shapes and irregular outlines. They are relatively thick and generally show little evidences of flattening or blunted edges (fig. 3).

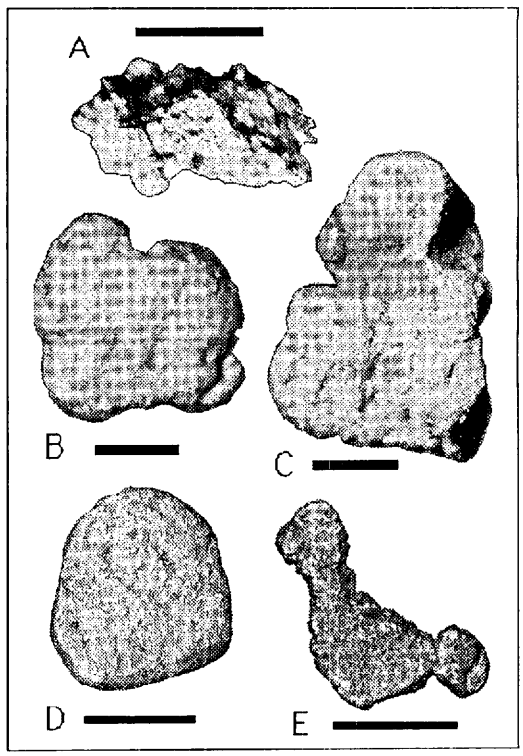


Fig. 3 : morphology of gold particles

A = angular particle with irregular outline, B and C = thick, blunted gold particles with folding. D = flattened and rounded particle, E = irregular outline and folded edge. A, B, C gold from the Mina Arias alluvium. D, E from the Pucara alluvium. Bar scales are 1 mm long.

The flatness index (F.I.) used here to describe the detrital grain is the Cailleux index [7] defined by the relation $\frac{L+b}{2t}$ where L is the length, b the breadth and t the thickness. For a spherical or cubic particle the F.I. is 1.

F.I. values between 2 and 3 are exhibited by 27% of the gold particles, thus indicating that the particles have undergone short transport distances and originate from primary mineralization of Mina Arias.

The remaining gold particles have F.I. values between 10 and 15, and are transported from undocumented primary mineralizations located about 30 km away [8].

Gold particles from the Pucara area show low silver content (8% to 3% cf table 1) and also contain traces of Cu, As and sometime Te, Fe, and Hg.

Thin silver depleted external rims exist in some of the gold particles and indicate a stage of in situ meteoric alteration.

CONCLUSION

The gold-quartz veins located in the early Paleozoic rocks of the Santa Victoria area appear to correspond to the Eastern Cordillera metallogenetic province as defined by Fornari and Hérail [9] in Southern Peru and Northern Bolivia.

These primary mineralization are the sources of the gold present in the fluvio-glacial and fluvatil deposits. The gold particles morphology and chemical composition allow to define the characteristics of the gold mineralization, and indicates that primary sources are not all identified.

Acknowledgements.

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Table 1: Chemical composition of gold particles using electron microprobe.
Camebax at Ecole des Mines de Paris, operating with 25 kV accelerating voltage, current of 15 nA and counting of 40 sec per element. (Bi, Sb, Pb, S were tested by not detected). Samples with V initial letter are from Mina Arias I vein. Samples with A initial letter are from detrital material.

Sample #	pt #	Au	Ag	Te	Hg	Cu	Fe	As	Sum	fineness
V Arias 2/93	87	88.41	12.02	0.02	0.00	0.00	0.01	0.05	100.49	880
V Arias 2/93	88	86.23	13.93	0.00	0.11	0.02	0.01	0.00	100.30	860
V Arias 2/93	89	88.01	12.35	0.00	0.00	0.00	0.02	0.05	100.44	877
V Arias 2/93	90	86.28	14.12	0.00	0.00	0.00	0.03	0.07	100.50	859
V Arias 2/93	91	88.36	11.98	0.07	0.00	0.00	0.00	0.06	100.48	881
V Arias S10G1	98	88.37	11.82	0.00	0.16	0.00	0.00	0.05	100.41	882
V Arias S10G1	99	88.44	11.86	0.00	0.00	0.00	0.00	0.05	100.09	884
V Arias S10G1	100	99.78	0.10	0.06	0.00	0.00	0.00	0.00	99.99	999
V Arias S10G1	101	88.48	11.58	0.00	0.13	0.01	0.00	0.04	100.25	884
V Arias S10G1	102	99.41	0.59	0.00	0.00	0.00	0.00	0.03	100.03	994
V Arias S10G1	103	89.04	11.00	0.00	0.00	0.00	0.02	0.00	100.06	890
V Arias S10G1	104	88.55	11.54	0.00	0.00	0.00	0.00	0.05	100.15	884
V Arias S11	49	75.37	25.15	0.00	0.10	0.00	0.00	0.00	100.62	750
V Arias S11	50	95.88	3.95	0.00	0.00	0.00	0.00	0.03	99.87	960
V Arias S11	51	73.21	26.67	0.00	0.00	0.00	0.00	0.00	99.88	733
V Arias S11	52	96.95	2.48	0.06	0.00	0.00	0.00	0.00	99.51	975
V Arias S11	53	75.99	23.89	0.06	0.00	0.00	0.00	0.00	99.89	761
V Arias S11	54	74.50	25.41	0.05	0.00	0.00	0.00	0.00	99.91	746
V Arias S11	61	72.55	27.19	0.03	0.00	0.00	0.00	0.00	96.88	727
A Minas S1	43	95.95	3.88	0.00	0.00	0.07	0.00	0.03	99.95	961
A Minas S1	44	100.46	0.11	0.00	0.00	0.00	0.03	0.00	100.61	999
A Minas S1	45	95.43	3.73	0.00	0.00	0.00	0.00	0.00	99.35	962
A Minas S1	46	93.74	4.05	0.04	0.10	0.07	0.02	0.00	98.03	959
A Minas S1	47	96.03	3.82	0.03	0.00	0.05	0.00	0.01	100.06	962
A Minas S1	48	94.71	3.76	0.00	0.00	0.06	0.00	0.10	98.66	962
A Minas S3	22	100.53	0.08	0.00	0.00	0.00	0.00	0.00	100.67	999
A Minas S3	23	97.15	2.32	0.00	0.00	0.06	0.00	0.00	99.69	977
A Minas S3	24	98.49	2.17	0.00	0.00	0.05	0.00	0.00	100.71	978
A Minas S3	25	97.74	2.21	0.03	0.22	0.05	0.00	0.05	100.12	978
A Minas S3	26	98.11	2.19	0.05	0.00	0.00	0.00	0.00	100.35	978
A Minas S3	27	98.73	2.25	0.04	0.00	0.08	0.02	0.03	101.16	978
A Minas S3	28	97.59	2.21	0.00	0.00	0.00	0.00	0.00	99.91	978
A Minas S4	29	96.50	3.20	0.02	0.00	0.06	0.00	0.05	99.89	968
A Minas S4	30	96.00	3.39	0.00	0.00	0.05	0.00	0.03	99.55	967
A Minas S4	31	100.57	0.13	0.00	0.00	0.00	0.00	0.00	100.80	999
A Minas S4	32	96.66	3.52	0.00	0.00	0.08	0.00	0.06	100.31	965
A Minas S4	33	96.78	3.57	0.02	0.00	0.04	0.00	0.02	100.46	964
A Minas S4	34	96.03	3.52	0.10	0.00	0.04	0.00	0.06	99.75	965
A Minas S5	35	92.55	6.17	0.00	0.00	0.00	0.00	0.05	98.84	938
A Minas S5	36	92.47	6.35	0.00	0.00	0.00	0.00	0.05	98.95	936
A Minas S5	37	100.13	0.06	0.00	0.10	0.00	0.00	0.00	100.33	999
A Minas S5	38	91.88	6.39	0.00	0.00	0.04	0.00	0.06	98.39	935
A Minas S5	39	92.87	6.21	0.00	0.00	0.00	0.02	0.03	99.23	937

Table 1. Continued

Sample #	pt #	Au	Ag	Te	Hg	Cu	Fe	As	Sum	fineness
A Minas S5	40	92.99	6.22	0.00	0.00	0.02	0.00	0.05	99.31	937
A Minas S5	41	99.99	0.00	0.00	0.00	0.00	0.00	0.00	100.00	1000
A Minas S5	42	92.37	6.15	0.05	0.00	0.00	0.00	0.08	98.72	938
A Minas S6	55	96.31	3.62	0.00	0.00	0.00	0.03	0.00	100.10	964
A Minas S6	56	99.53	0.31	0.00	0.00	0.00	0.00	0.06	99.96	997
A Minas S6	57	96.34	3.64	0.00	0.00	0.00	0.00	0.02	100.07	964
A Minas S6	58	96.34	3.63	0.00	0.00	0.06	0.01	0.06	99.72	964
A Minas S6	59	95.65	3.79	0.00	0.00	0.00	0.00	0.00	99.67	962
A Minas S6	60	95.90	3.58	0.00	0.00	0.04	0.00	0.04	99.67	964
A Minas S9	62	91.81	8.22	0.00	0.00	0.01	0.00	0.04	100.15	918
A Minas S9	63	99.94	0.10	0.00	0.00	0.00	0.00	0.00	100.05	999
A Minas S9	64	91.09	8.25	0.00	0.00	0.00	0.00	0.00	99.39	917
A Minas S9	65	91.16	8.06	0.00	0.00	0.00	0.00	0.00	99.28	919
A Minas S9	66	91.15	7.90	0.00	0.00	0.00	0.00	0.04	99.13	920
A Minas S9	67	90.22	7.82	0.00	0.00	0.00	0.00	0.05	98.17	920
A Minas S9	69	90.58	8.12	0.04	0.00	0.00	0.00	0.00	98.78	918
A Minas S9	70	99.12	0.01	0.00	0.00	0.00	0.00	0.00	99.18	1000
A Minas S8	71	99.16	0.08	0.04	0.22	0.00	0.00	0.00	99.54	999
A Minas S8	72	95.28	4.15	0.00	0.00	0.06	0.00	0.00	99.61	958
A Minas S8	73	100.00	0.39	0.00	0.00	0.01	0.00	0.00	100.53	996
A Minas S8	74	95.43	4.16	0.00	0.00	0.07	0.03	0.00	100.30	958
A Minas S8	75	99.96	0.54	0.00	0.08	0.00	0.03	0.00	100.75	995
A Minas S8	76	95.04	4.21	0.00	0.00	0.00	0.00	0.02	99.37	958
A Minas S8	77	99.18	0.35	0.00	0.00	0.00	0.00	0.00	99.60	996
A PUCARA -A	191	95.72	3.91	0.00	0.00	0.00	0.00	0.07	99.70	961
A PUCARA -A	192	95.84	3.96	0.02	0.00	0.00	0.00	0.02	99.85	960
A PUCARA -A	193	95.78	3.92	0.00	0.00	0.04	0.00	0.05	99.79	961
A PUCARA -A	194	95.87	3.87	0.00	0.00	0.00	0.00	0.05	99.84	963
A PUCARA -B	174	96.48	3.20	0.00	0.08	0.08	0.00	0.05	99.89	968
A PUCARA -B	175	99.83	0.03	0.00	0.00	0.00	0.00	0.07	99.93	1000
A PUCARA -B	176	96.50	3.19	0.00	0.00	0.07	0.00	0.06	99.83	968
A PUCARA -B	177	96.42	3.32	0.00	0.03	0.00	0.00	0.05	99.85	967
A PUCARA -B	178	96.65	3.13	0.00	0.00	0.03	0.00	0.05	99.87	969
A PUCARA -C	160	94.38	5.32	0.00	0.00	0.00	0.01	0.00	99.71	945
A PUCARA -C	161	94.39	5.17	0.00	0.00	0.02	0.00	0.05	99.63	948
A PUCARA -C	162	99.69	0.14	0.00	0.00	0.00	0.00	0.07	99.90	999
A PUCARA -C	163	94.36	5.21	0.00	0.00	0.00	0.00	0.00	98.79	948
A PUCARA -C	164	99.79	0.04	0.00	0.00	0.00	0.00	0.06	99.89	1000
A PUCARA -C	165	94.49	5.19	0.00	0.00	0.03	0.01	0.00	99.72	948
A PUCARA -C	166	94.16	5.50	0.00	0.00	0.06	0.00	0.05	99.77	945
A PUCARA -C	167	94.57	5.29	0.00	0.10	0.03	0.00	0.07	100.06	947
A PUCARA -C	168	99.79	0.11	0.00	0.00	0.00	0.00	0.05	99.95	999