# SECONDARY GOLD DEPOSITS IN THE LÍPEZ REGION (BOLIVIA)

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## INTRODUCTION

In the Lípez region small secondary gold-deposits are being exploited in minor scale (Fornari et al., 1989, Ramos, 1992, Ramos and Fornari, 1994). This paper summarizes general characteristic of gold grains, such as its distribution, morphoscopy and chemical composition. These results were used to relate it with the geological environment, the primary sources and to deduce exploration criteria in the district.

The zone is located in the Lípez region, southwest of Bolivia, near to Argentina border (Fig 1). The zone belongs to the geological provinces of the Cordillera Occidental, Altiplano and the Cordillera Oriental; the older outcrops consist of Ordovician rocks, which consist of sandstones, siltstones, quarzites and shales (Llandeillian-Caradocian, Kley et al, 1997). They are overlain by limestones, reddish and violaceous argillites of El Molino Formation (Cretaceous), whose outcrops are often limited by regional faults.

The Cenozoic consists of several km of detrital continental deposits associated with volcanic rocks which cover most part of the Altiplano. The magmatism is represented effusive volcanism of andesitic composition (Rondal lavas 22.1 ± 0.6 Ma Fornari et al., 1993), followed by the superposition of mainly dacitic volcanism from about 18 Ma. It includes explosive products (ignimbrites, pyroclastic deposits) and lavas, erupted from extended stratovolcanoes and caldera structures, besides of intrusive subvolcanics stocks (14.6 ± 0.5 Ma, Lema and Ramos, 1997).

The main tectonic features in the Lípez basin result from a compression of Oligocene age, which actuated two main boundary faults: the Uyuni-Khenayani fault to the west by and the San Vicente fault to the east (Baby et al., 1990).

## DISTRIBUTION, CHARACTERISTICS AND CHEMICAL COMPOSITION OF GOLD PARTICLES

The distribution of secondary gold-deposits in Lípez region (Fig. 4), show that Vilader, Guadalupe-Morokho and Esmoraca-Viluyo areas have greater concentrations; however they are small size, but some areas are being worked.

Systematic description of the gold particles (about 2100 particles) was based on the observation under binocular microscope of several morphological characters (e.g. length, wide, shape, ...) and chemical compositions were determined by electronic microprobe.

The studied gold particles show different morphologies and chemical analysis which are related with the ore sources (Fig. 3 and Table 1).

The gold particles form two contrasting groups; one consists of particles with angular, irregular morphology; in some cases they are still accompanied by quartz inclusions; the flatness index value is low (1 to 6), but increases in few cases up to 11. The chemical composition varies from 92 to 95 % Au and 8 up to 14 % Ag.

The other group consists of particles with sub-spherical shapes, sub-rounded to rounded morphologies, regular topographies and a low content of silver (<2 % Ag) and traces of Te and Hg. The flatness index is low (from 1 to 5).

The mean size of the particles is about 1 mm; however, they are some exceptions in Vilader and Esmoraca areas with particles up to 6 mm.

Gold particles with the different characteristics mentioned above are mixed in the secondary gold deposits in some areas. In such cases, these characteristics can be used to identify the relative contribution from several primary ore deposit; then the study gold particle is an important tool for mineral exploration.

Similar characteristics are described in the NW Argentine (Rinconada), where the chemical analysis of gold grains vary from 98.84 to 92.59% Au and from 1.16 to 6.71% Ag, but the gold from vein quartz (El Torno), contains 30.26 to 35.86 % Ag (Segal et al., 1997).

## PRIMARY MINERALIZATION

The primary mineralization consists of quartz gold veins in Ordovician rocks, polymetallic veins and zones of hydrothermal alteration in volcanics.

The greatest deposits formed by gold-quartz veins are located in the eastern area: e.g. Sucre, Candelaria, Khorykhoya, Chilcobija and Chilco; and can be related the "Au-Sb belt"(Lehrberger, 1988) in the austral part of the Cordillera Oriental; Vilader and Candelaria are in the western area (Fig.1).

For the vein mineralizations included in Ordovician outcrops, controls are structural and lithologic; exploration criteria are the same as those known regionally in the Central Andes, from southern Peru, Bolivia (Yani, Amayapampa, etc.) and northern Argentina (Sierra Rinconada, Segal et al., 1997, Zappettini et al., 1999).

The polymetallic veins and alterations zones of volcanites have gold traces. In some areas with propylitic, argillic and silicic alterations, the anomalies are up to 30 ppm Au, (e. g. 804 to 28400 ppb Au at the Galán Volcanic Complex, Ramos et al., 2001). In the Lípez zone, anomalous gold values are known at the Cerro Bonete (Lípeña, La moza, Barrayhuayco mines), Cerro Morokho and Cerro Lípez (Mesa de Plata and Machu

Socavon) between others. So, the volcanic complex in the southwest of Bolivia, appears as an important area for gold prospecting.

## CONCLUSIONS

The secondary gold deposits in the Lípez region are small, but in some cases they are interesting for exploitations in minor scale. The morphoscopic and chemical characteristics of the gold particles which are correlated with the geological environment, are used to characterize the primary sources of the mineralization and provide an efficient tool for mineral exploration.

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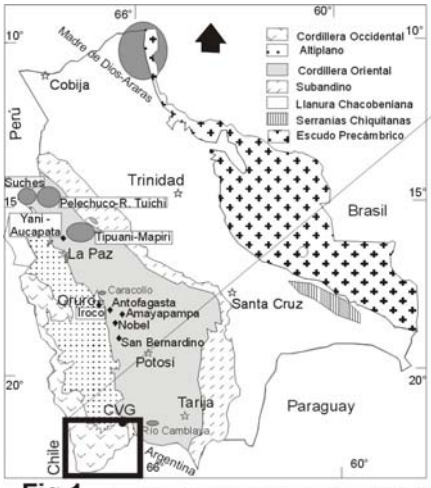



**Fig.1 .** Geologic provinces, major gold secondary and primary deposits of Bolivia Andes

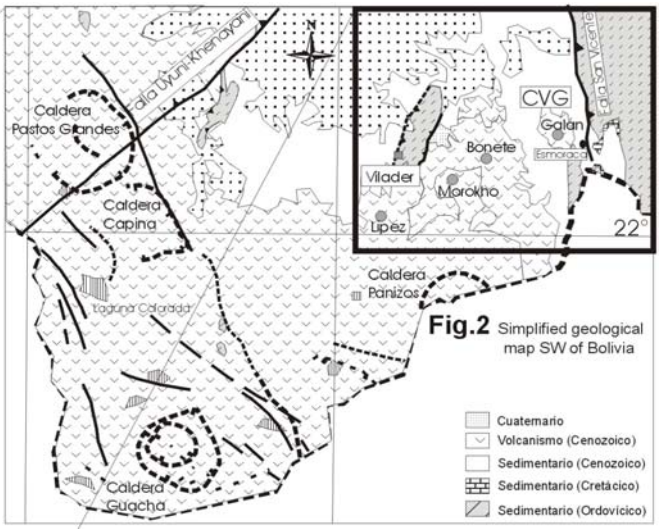
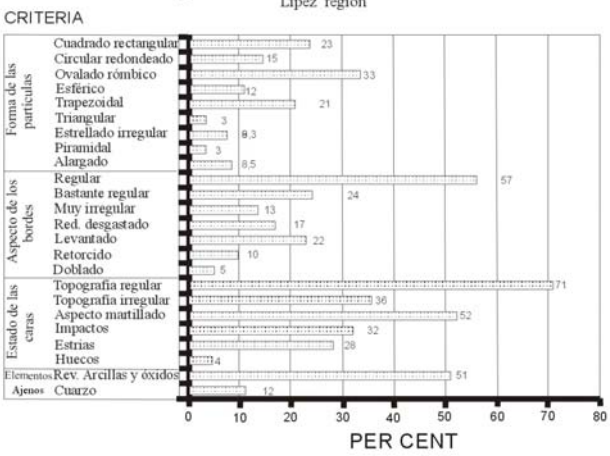



**Fig.2** Simplified geological map SW of Bolivia

**Fig.3** MORPHOLOGY OF GOLD GRAINS
Lipez region



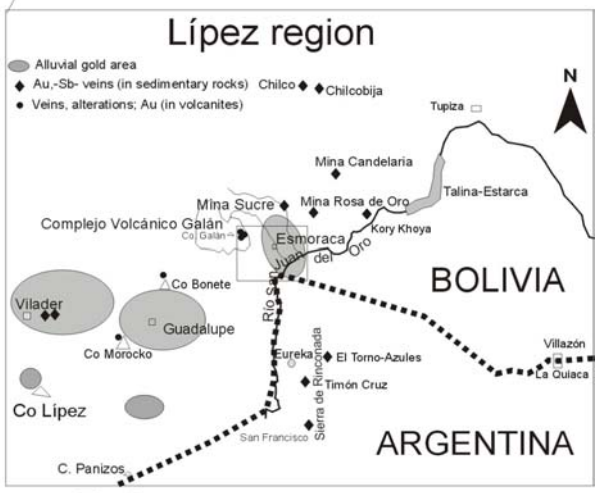




**Fig.4.** Secondary and primary gold deposits in the Lipez

| Secondary deposits | | | | Primary ore deposits | | |
|---|---|---|---|---|---|---|
| Size - shape | flatness index | Grade | Chemical composition | Related ore sources | Chemical composition | Grade |
| Mean 1 mm, some up to 5.6 mm, -angular, | Major until 4, rare up to 11 | Major <1 g/t, some up to 3 g/t | 92 % Au, 8 % Ag, rare 83% Au, 14 Ag (Vilader) | Quartz veins in ordovician rocks | 92 a 95 % Au, until 8 % Ag (Vilader) | Up to 2.5 g/t and 69 g/t (max) (Vilader) |
| Mean < 1 mm, some up to 3.3 mm, -rounded | Major until 5, rare up to 8 | <1 g/t | 98 % Au, hasta 2 % Ag. | Ignimbrites. Veins and alterations in volcanic rocks | | 6 to 24800 ppb de Au; <5 to 328 ppm de Ag (Galán) |

Table 1. Related secondary and primary gold deposits in the Lípez region (Bolivia).