SOURCES OF THE DETRITAL GOLD MINERALIZATIONS IN THE BOLIVIAN ALTIPLANO.

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ABSTRACT: The study of the gold placers located in the southern part of the Bolivian Altiplano allows to define two main types of primary mineralizations. One is the free gold mineralizations in quartz vein ocurring in Lower Paleozoic rocks whereas the other derive from the erosion of explosive products of the calc-alcaline volcanism related to the Andean magmatic arc. This last source appears to be a new one by the fact that gold is not derived from classical epithermal occurrences but is dispersed within ignimbritic layers.

The Southern Altiplano of Bolivia presents a general flat topography with a main altitude of about 3900 m; above this surface stand up volcanic apparatus of lower Miocene (e.g. C° Bonete, C° Morokho, C° Lipez), Middle to upper Miocene (e.g. C° Panizo on the Argentina border), and Plio-Quaternary ages.

The area presents a semi-arid climate and many temporary streams have running water only during the rainfall season (from December to March). These conditions make that in the area only placers of reduced size are present which are worked occasionally. Only along the main rivers (rio San Juan de Oro) and in part along the rio Guadalupe, rio Viluyo, rio Pedrenal, fluvial sediments crop out in voluminous terraces.

The studied area is about 80 x 60 km and is located between the border with Argentina at the eastern side and the C° Lipez at the Western side (21°30'-22°15'S/66°15'-67°W).

The local geology consists mainly of outcrops of strongly folded (Ocloyic Orogeny, ca.435 Ma) lower Paleozoic shales and quartzites (probably Ordovician).

The lower Paleozoic beds were later implicated in complex thrust structures during the Andean Orogeny. The erosion of these structures furnished material of the detrital deposits of the San Vicente Formation (Oligocene) and was followed by the main volcanic activity. This activity began with the emission of lavas flows, sills, dykes of mainly basic composition and of alcaline affinity (Formation Rondal, ± 23 Ma, Fornari et al., 1989, Kussmaul et al., 1975), followed by the main calc-alcaline activity which spans to actual time.

The calc-alcaline activity produced great volumes of pyroclastic rocks (ignimbrites and tuffs), domes and sub-volcanic intrusives and lava flows; these rocks are generally of dacitic composition. Several paleovolcanoes and calderas have been identified (e.g. C° Bonete, C° Morokho); the pyroclastic tuffs and the ignimbritics deposits form extended outcrops which in many places are preserved as flat plateaus (mesetas).

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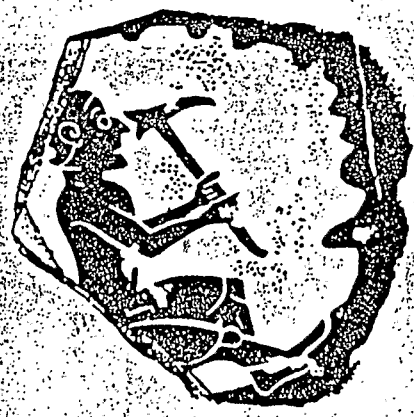

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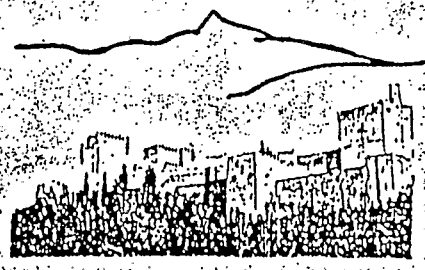

Sampling with gold pan of the numerous headwaters in the drainage red cutting these plateaus and also of the soils and proximal colluvial deposits formed on the ignimbrites allowed to recover numerous gold grains. Gold grains were also recovered from the main rivers (Rio Guadalupe, Pedrenal), and from the Vilader placer.

The placer of Vilader which is located near C° Lipez, at an altitude of 4190 m, consists of an alluvial fan made of slope material eroded from Lower Paleozoic outcrops (Ramos, 1993, Fornari et al., 1991).

The gold grains recovered in the placer are small; the mean length is about 0.94 mm with a range of 0.1 to 6 mm and their distribution has a skewness to the small dimensions. The mean flatness index (Length + breadth / 2*thickness) is about 2.6, corresponding to grains that are not flattened. The grains have morphoscopic features (irregular shapes, inclusion of quartz) that indicate a very short distance of transportation. In fact, the gold is derived from the erosion of gold-quartz veins located in the Ordovician rocks.

The analyses of the chemical composition of the gold grains made by electron microprobe indicate silver contents of about 4%, 7-9% and 14%.

Furthermore some grains show change in composition, with silver-depleted external rims; the presence of a low Ag rim is interpreted as a preferential leaching of silver developed in weathering profile.

So the gold recovered from the Vilader placer provides the identity of the Lower Paleozoic source, as confirmed by the composition of some gold particles recovered from small quartz vein, although they show a narrow range in their silver contents.

The gold grains recovered from the main rivers show morphoscopic features such as folded border, smoothed outlines, striation marks, which are characteristic of transport in permanent streams of water. These characteristics are acquired in a relatively short distance of transport (less than 10 km).

The gold grains recovered from samples of the soils on ignimbrites and from the small headwaters that cut the ignimbritic plateaus, show a particular morphology with globular forms and consequently small values of the flatness index (between 1 and 4); crystalline shapes are preserved, not only in the hollows of the grain but also in the border of the grain (figure). These facts indicate that the gold grains are of local origin and come from the erosion of the ignimbrites.(Pozzo, 1990, Fornari et al., 1991).

These "volcanic" gold grains show also a characteristic composition: the gold is very pure (0 to 3% Ag, generally less than 1%, with the same content in the centers and in the rims of the grains).

This volcanic gold appear to be dispersed with very low grade within the ignimbrites: preliminary analysis of whole rocks gave Au-content around the clarke of felsic rocks (2-3ppb) and in any case lower than 10 ppb.

The distribution of these volcanic gold grains, although widely present in many places in tuffs and ignimbrites of the Southern Altiplano is not homogeneous and some ignimbritic levels of the area of the Cerro Pabellon near Guadalupe which were emitted from the Cerro Bonete center appear to be richer in gold than those of the same type emitted from the Cerro Morokho center.

This "volcanic" gold is not related to the Bi, Ag, (Zn, Pb) vein mineralizations present in the area. The study of the mineral paragenesis of the Mina Bolivar located in dacitic resurgent domes of the C° Bonete, no revealed the presence of gold, (Ahlfeld & Scheider-scherbina, 1964, Baily et al., 1992).

The reconstitution of the successive volcanic events for the C° Morokho and the C° Bonete centers shows that there is an early stage of explosive type during which are deposited pyroclastic tuffs and ignimbrites followed by a stage of emplacement of resurgent domes, with breccias and lava flows; a late stage of alteration and sometimes of vein mineralization concludes this evolution.

The gold appear to be exhaled with the pyroclastic deposits, at the early stage, probably in a manner analogous to the case of the Mount Erebus volcano where the presence of gold grains in the eruptive products has been recently documented (Meeker et al., 1991)

The fact that gold can be emitted with the volatile phase implies particular magmatic conditions and can be an unfavorable factor for the further presence of epithermal Au-mineralizations.

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Figure:
A Gold grain from the Co Pabellon area: characteristic globular form, SEM photography, scale bar 100µm
B: globular gold grain (SEM photography, scale bar 50µm)
C: Detail of B: primary crystalline outlines conserved on the surface of the gold grain (scale bar 10µm).