MINERALISATION RELATED TO CRUSTAL SHORTENING: THE MANTO-VEIN, GOLD-POLYMETALLIC UBINA DEPOSIT, BOLIVIA

Stewart D. REDWOOD(1), Stephen C. NANO(2), and Mario FLORES A.(3)

(1) Mintec, Casilla 13790, La Paz, Bolivia

(2) Minera Newcrest Chile Ltda., Ave. Providencia 1979, 3er Piso B, Providencia, Santiago, Chile.

(3) Calle Sucre 741, 3er Piso, La Paz, Bolivia.

RESUMEN: La mineralización de oro - polimetalico en Ubina (SW Bolivia) se presenta en un sistema hidrotermal grande relacionado a un intrusivo. Las estructuras forman vetas y han canalizado los fluidos para formar mantos que reemplazan rocas calcáreas. La intrusión y la mineralización han side controladas por una zona de cizallamiento siniestral que tiene un rumbo de 135° y que está relacionada con la compresión hacia el Este (antepais) durante el acortamiento de la corteza de los Andes centrales.

KEY WORDS: Andes, Mineralization, Crustal Shortening, Shear Zone, Ubina

INTRODUCTION

This paper describes the relationship between hydrothermal mineralisation and crustal shortening in the Central Andes, using the Ubina gold - polymetallic deposit as an example. Ubina is a large diameter, intrusion centred hydrothermal system located in SW Bolivia on the western edge of the Eastern Cordillera (Fig. 1). It has been mined on a small scale since Spanish colonial times for Sn, W, Ag, Au, Pb, Zn, Cu and Bi in veins and carbonate replacement mantos. Intrusion, flow dome extrusion and mineralisation are controlled by dilational zones within a 135° trending sinistral shear zone related to regional E-W compression and crustal shortening.

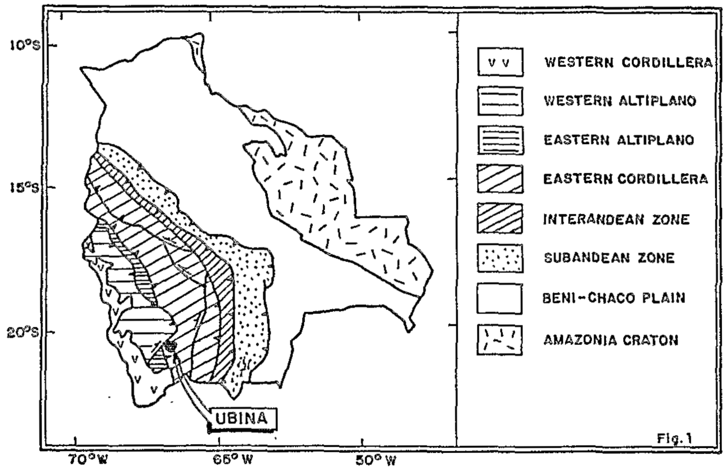

Figure 1: Tectonic map of Bolivia (ORSTOM) and location of Ubina.

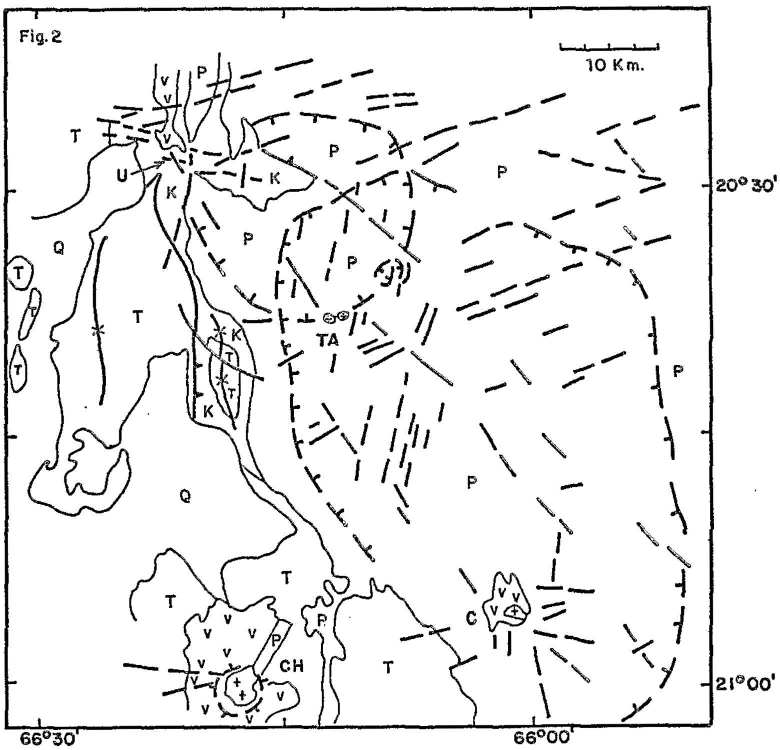

Figure 2: The structure and geology of the Ubina - Chorolque region. Mines: U - Ubina, TA - Tasna, C - Chorolque, CH - Chocaya (Animas, Siete Suyos, Gran Chocaya). Geology: P - Paleozoic, K - Cretaceous, T - Lower Tertiary, Q - Quaternary, V - volcanic rocks, + - intrusions.

GEOLOGICAL SETTING

Ubina is located in the autochthon just east of the Calazaya nappe at the junction of the Khenayani Fault System and the Main Altiplano Thrust (Fig. 1) which has at least 40 km of eastward (foreland) displacement (Baby *et al.*, 1992). This crustal shortening took place in the Late Oligocene - Early Miocene during the major tectonic crisis in the Bolivian Andes (Sempere *et al.*, 1990).

The Ubina deposit lies within a 10 - 15 km wide 135° trending structurally controlled belt of igneous related polymetallic systems of Middle Miocene age (16.2 - 16.4 Ma; Grant *et al.*, 1979), which include the Tasna and Chorolque Sn-W-Bi-Cu-Au-Ag-Pb-Zn-As-Sb deposits (Fig. 2). They have the same metallogenic signature as Ubina and are considered to be cogenetic. The three deposits are localised at the intersection of the 135° trending structural corridor with 060° and 080° structures (Fig. 2). Two large elliptical features evident on satellite images appear to have influenced the emplacement of these igneous centres, with Ubina and Tasna lying on the margin of the same circular structure (Fig. 2). These features may represent collapse above deep seated intrusive bodies but are not collapse calderas in the classic sense as they are not accompanied by voluminous volcanic outpourings.

DEPOSIT GEOLOGY AND MODEL

The Ubina district comprises Ordovician sediments overlain unconformably by Late Cretaceous - Paleocene red-bed sediments with marine carbonates, with Eocene - Middle Oligocene red bed sediments to the west (Fig. 3). These are cut by the mushroom shaped Ubina flow-dome of plagioclase-biotite-quartz phyric dacite. Minor porphyritic dacite stocks and dykes intrude the Cretaceous to the SE (Fig. 3).

Ubina belongs to the Bolivian Polymetallic Vein Deposit type (Ludington *et al.*, 1992) and is unusual in carrying significant gold. Fault structures form vein and stockwork mineralisation in all lithologies and have acted as feeders for stratabound, carbonate replacement, manto style mineralisation in the calcareous sediments of the Late Cretaceous Chaunaca and El Molino Formations. These have a combined thickness of about 530 metres of red marls with limestone beds and calcareous shales, siltstones and sandstones.

Mineralisation is zoned with an inner Sn-W-Au zone, a middle Au-Ag-Bi-Cu zone and an outer Ag-Sb-Hg-Ba-Pb zone. Arsenic and zinc are present in all zones. Zonation occurs over a vertical interval about 450 meters and has a radius of 4 km. The system is centred on the Manta Dorada plateau SE of the flow-dome. The minor dacitic intrusives are interpreted as apophyses of a stock beneath this area which has driven the hydrothermal system, with the Ubina flow-dome as a marginal volcanic offshoot (Fig. 3). The dome and flows are pervasively altered but have weak mineralisation due to lack of fracturing. Hydrothermal fluids may have ponded beneath the relatively impermeable flows to give telescoped mineralisation adjacent to the dome. The coincidence of the middle gold zone with the reactive carbonate formations on the Manta Dorada plateau is favorable for the development of large, replacement style deposits of gold, as supported by extensive rock and soil gold anomalies.

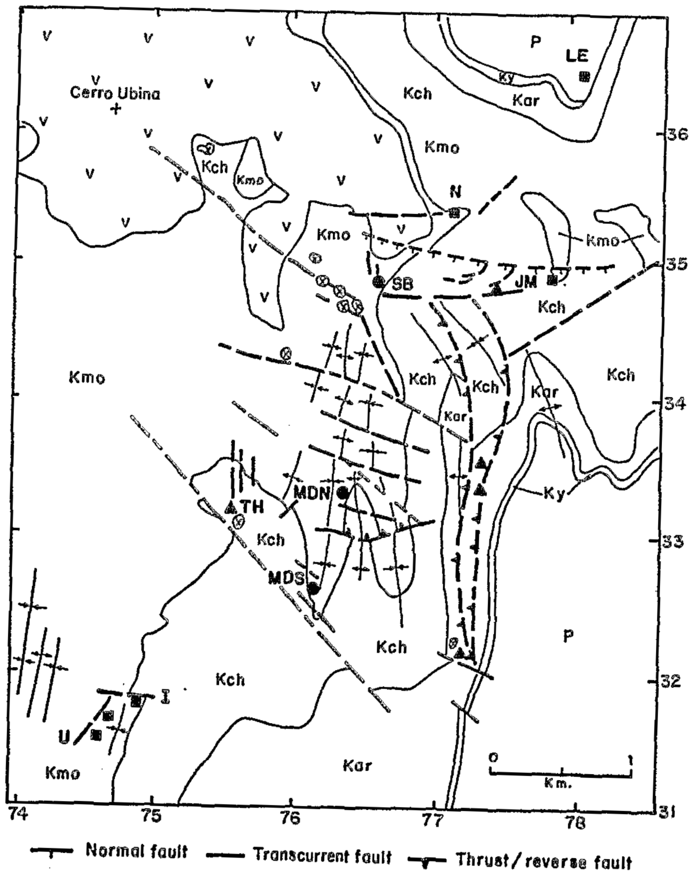

Figure 3: The geology and structure of the Ubina deposit. Stratigraphy: P - Paleozoic, K - Cretaceous, Ky - Yura Formation, Kar - Aroifilla Formation, Kch - Chaunaca Formation, Kmo - El Molino Formation, X - intrusions, V - volcanic/subvolcanic dacite.
Mines: ▲ - Sn-W-Au; ● - Au-Ag-Cu-Bi; ■ - Ag-Sb-Hg-Ba-Pb. Mine names: U - Ubina, I - Irma, TH - Tres Hugos, MDS - Manta Dorada South, MDN - Manta Dorada North, SB - Santa Barbara, JM - Jayaj Mayu, N - Normandia, LE - La Esperanza. UTM grid coordinates (Zone 19K GT).

STRUCTURAL CONTROL

Regional compression produced open N-S trending folds in the Cretaceous and Lower Tertiary sediments which overprint earlier, tight NW-SE trending folds in the Ordovician. The 135° trending shear zone postdates N-S folding and controlled the emplacement of the intrusions, flow-dome and hydrothermal activity at Ubina. The structural pattern at the deposit scale (Fig. 3) is interpreted to represent a brittle, simple (Riedel) shear zone with the main shear faults parallel to the regional 135° trend, with left lateral displacements of tens of meters.

The orientation and sinistral sense of displacement of the shear zone indicate E-W compression which is consistent with the crustal scale, eastward (foreland) directed compression that produced the large scale folding and thrusting in the Bolivian Andes. The Middle Miocene age inferred for igneous and hydrothermal activity at Ubina indicates continuation or reactivation of the regional compression following the main tectonic crisis in the Late Oligocene - Early Miocene.

CONCLUSIONS

1. Intrusion, flow-dome extrusion and hydrothermal gold - polymetallic mineralisation at Ubina are controlled by a sinistral 135° trending shear zone contemporaneous with, or immediately following crustal scale, eastward (foreland) directed compression.

2. Structures form veins in all lithologies at Ubina and acted as feeders for carbonate replacement, manto style mineralisation in calcareous lithologies.

2. A direct relationship between crustal shortening and hydrothermal mineralisation in the Central Andean margin is indicated.

REFERENCES

Baby, P., Sempere, T. Oller, J. and Herail, G., 1992, Evidence for major shortening on the eastern edge of the Bolivian Altiplano: the Calazaya nappe. *Tectonophysics*, **205**, 155 - 169.

Grant, J. N., Halls, C., Avila, W. and Snelling, N. J., 1979, K-Ar ages of igneous rocks and mineralization in part of the Bolivian tin belt. *Economic Geology*, **74**, 838 - 851.

Ludington, S., Orris, G. J., Cox, D. P., Long, K. R. and Asher-Bolinder, S., 1992, Mineral Deposit Models. In: United States Geological Survey and Servicio Geologico de Bolivia, *Geology and Mineral Resources of the Altiplano and Cordillera Occidental, Bolivia. USGS Bulletin*, **1975**, 63 - 89.

Sempere, T., Herail, G., Oller, J. and Bonhomme, M. G., 1990, Late Oligocene - Early Miocene major tectonic crisis and related basins in Bolivia. *Geology*, **18**, 946 - 949.