

# Biostratigraphic Markers as Mineral Exploration Guides at the Cañón Florida Mississippi Valley Type Deposit (MVT), Northern Peru

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**Abstract:** The Pucará Group is an important metalotect that hosts base metal deposits (Zn-Pb-Ag) throughout the Peruvian Andes; Mississippi Valley Type (MVT) mineral deposits such as the San Vicente Mine, the Grande Mine, the Chica Mine, the Cañón Florida Project, the Cristal, Florcita, San José prospects and others in northern Peru were located between the Eastern Cordillera and the Subandean Belt, all hosted in the carbonate rocks of the Pucará Group. Review of more than 100,000 meters diamond drill cores, observation of geological maps and cross sections, field observations, elaboration of the stratigraphic columns and geological interpretation indicate that Late Triassic/Early Jurassic Pucará Group rocks hosts mineralized bodies of (Zn-Pb-Ag) from the Cañón Florida Project and they were deposited at certain favorable stratigraphic levels between the Intact Bivalve Marker (IBM) and Coquina Marker (COQ) biostratigraphic horizons in dolomitized carbonate rocks of the Chambará 2 Member of the Chambará Formation of the Pucará Group, in this way the biostratigraphic controls in combination with other methods and exploration techniques are guides for mineral exploration of Mississippi Valley Type (MVT) deposits.

**Key words:** horizon, biostratigraphic, guide, mineralized, bivalve, coquina, dolomitized, carbonated, member, formation, group

## 1. Introduction

The Pucará Group is an important metalotect that hosts base metal deposits (Zn-Pb-Ag) throughout the Peruvian Andes. Mississippi Valley Type (MVT) deposits were located between the Eastern Cordillera and the Sub-Andean Belt, such as the San Vicente Mine (+/- 35Mt, 11% Zn + Pb) in Chanchamayo, Mina Grande and Mina Chica in Bongará (1 Mt, 30% OxZn) and the Cañón Florida Project in Bongará (+18 Mt 10% Zn + Pb (Ag), in addition to the Cristal, Florcita and others prospects in Bongará-Amazonas, all hosted in Pucará Group carbonate rocks.

The objective was to determine the Biostratigraphic control and its relationship with favorable zones for the exploration of zinc and lead mineral deposits in

the Mississippi Valley Type Cañón Florida deposit, with the purpose of preparing practical guides for the prospecting and exploration of MVT-type mineral deposits in the Utcubamba-Bongará corridor.

The review of the cores of the diamond drilling of more than 100,000 meters, the observation of geological plans, field observations, elaboration of the stratigraphic columns and the interpretation of the same, indicate that the rocks of the Pucará Group of the late Triassic/Early Jurassic that The mineralized bodies of the Florida Canyon Project were deposited along a shoreline of the basin, similar to the one that exists today along the Tribute Coast of the United Arab Emirates (Persian Gulf, Middle East).

Biostratigraphic markers are associated with lithological, stratigraphic and structural controls of the mineral deposit. The recognition and characteristics of the biostratigraphic horizons were important guides in

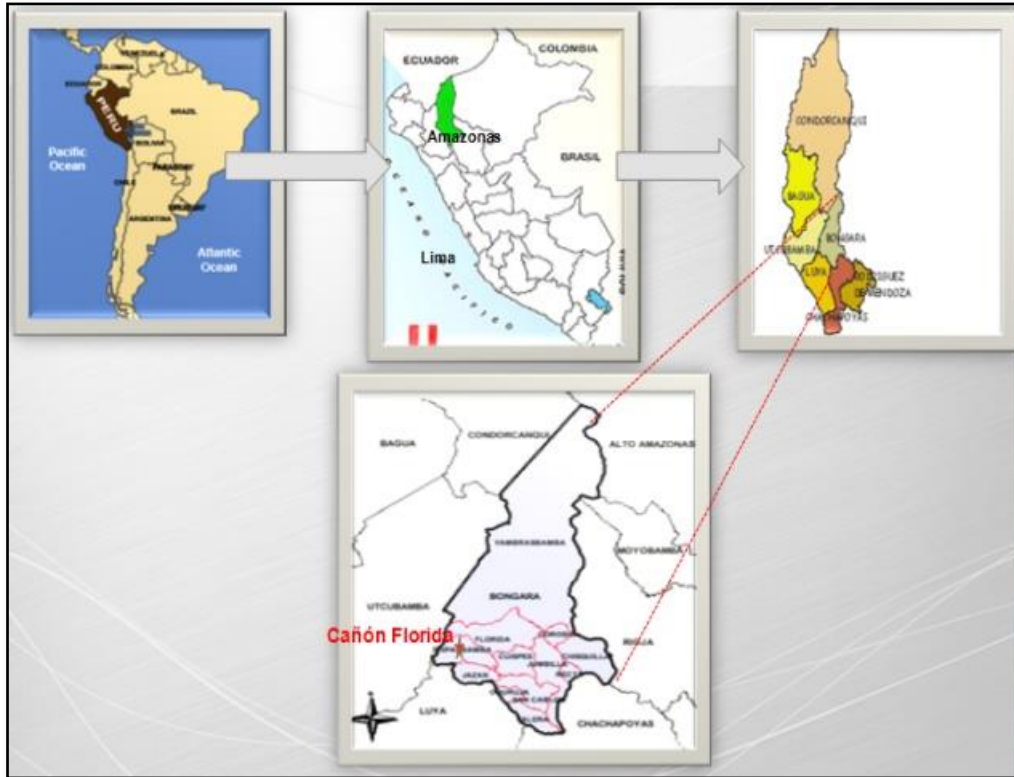
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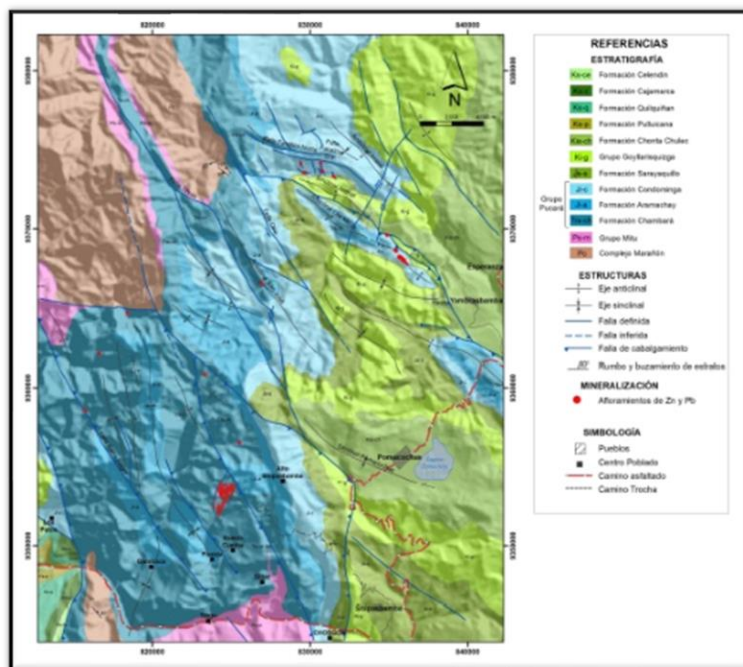
the control of diamond drilling in the areas of exploratory interest.

The project locates in the Shipasbamba district, Bongará province and Amazonas Region in Northern Peru (Fig. 1).

**2. Location**



**Fig. 1** Project location.



**Fig. 2** Cañón Florida Project Regional Geological Map (Modified from INGEMMET, 1995).

### 3. Research Materials and Methods

The research method was exploratory and based on geological characteristics definition of the Mississippi Valley Type Deposit on the Cañón Florida Project, Northern Peru.

Works consisted in the compilation and elaboration of interpretive geological sections, stratigraphic columns, diagrams, tables, figures, etc. Diamond drill holes analysis (core logging and interpretation), macroscopic, microscopic description of rocks and minerals; to understand the lithology, alteration, assemblies and petro-mineragraphic characterization. Analysis and interpretation of metallogenetic, geological, stratigraphic, sedimentological, structural, lithological, textural data, observation and measurement of biostratigraphic and mineralogical horizons and the conceptualization of the geological model.

### 4. Results and Discussion

Based on the analysis of the geotectonic and metallogenetic environment, it has been established that the study area is located at the limit of the Eastern

Cordillera and the Sub-Andean Belt and is framed in the Andean orogen foreland basin (Fig. 3); The analysis of the regional geology allowed to determine the location of the Florida Canyon Project on the edge of the Pucará Basin, a favorable place to locate thick facies of the sabkha (littoral) carbonate type sequences in platform environments with reefs. Sedimentological analysis indicates that it was dominated by carbonate rocks along a sabkha-type coastal plain. The mainly anhydrite evaporites associated with this coastal plain, along with the thick marine anoxic silt-carbonate lodolites, provided most of the components necessary to host the lead-zinc mineralized bodies of Cañón Florida.

Reviewing of more than 100 000 meters of ddh drilling core logging, corroborate the existence of dolomitized levels with medium to coarse texture corresponding to the Chambará Formation and due to the proximity to faults that behaved as feeder channels for mineralizing fluids (feeders) allowed the circulation and later mineral precipitation in favorable zones with the presence of bitumen, porosity, permeability and structural traps.

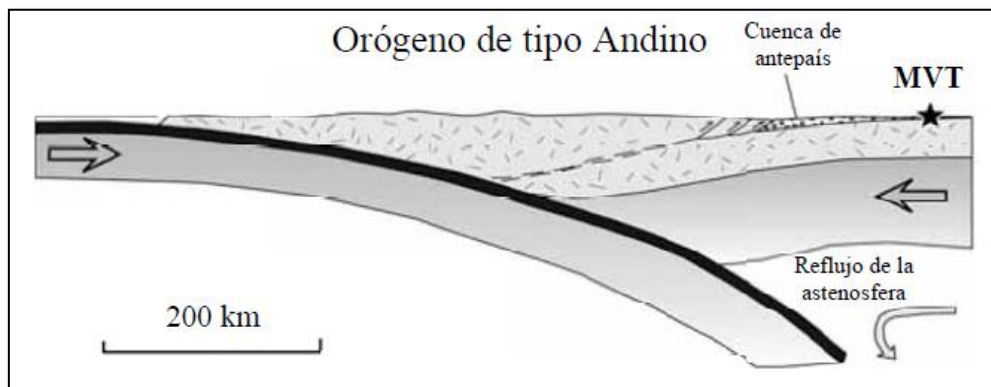


Fig. 3 MVT Deposits Occurrence in Foreland Basins (Bradley & Leach, 2003).

District (Fig. 4) and local (Fig. 5) stratigraphy have allowed us to recognize the different types of lithological sequence of carbonate and clastic rocks; The evaluation and analysis of the sedimentary sequences allowed the identification of dolomitized levels (porous and permeable) of the Chambará

Formation favorable for the concentration of Zn and Pb mineralization in the Mississippi Valley Type Deposit of the Cañón Florida Project, Northern Peru (Fig. 6).

Structural analysis at regional and district scale has been based on the interpretation of structural

geological mapping and field structural guidelines and reports from previous studies.

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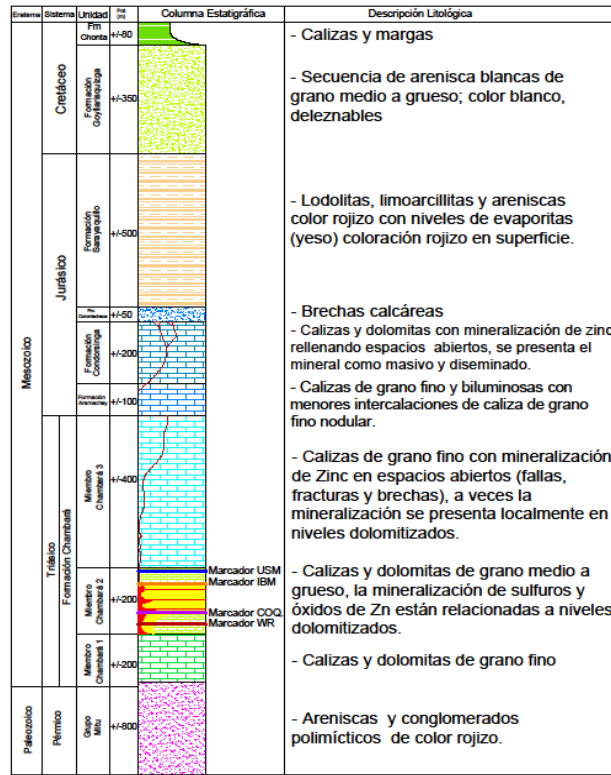


Fig. 4 Distric stratigraphy column.

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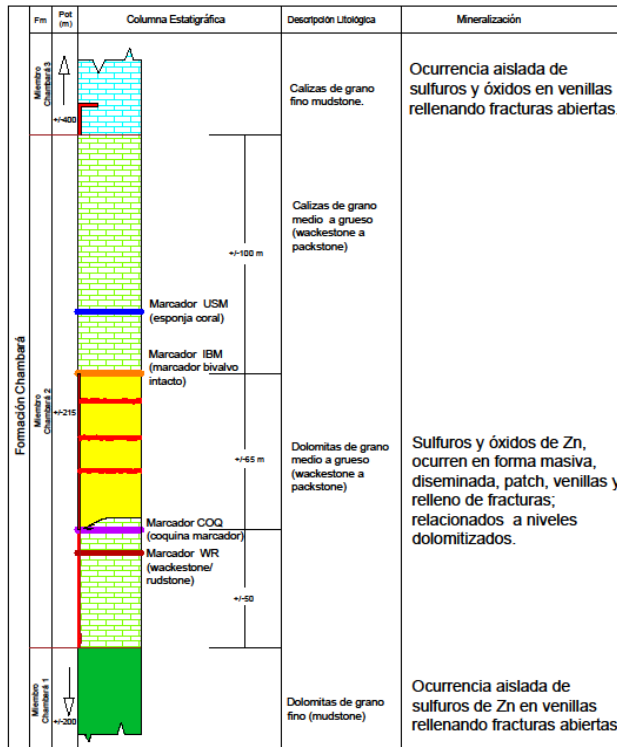


Fig. 5 Local stratigraphy column.

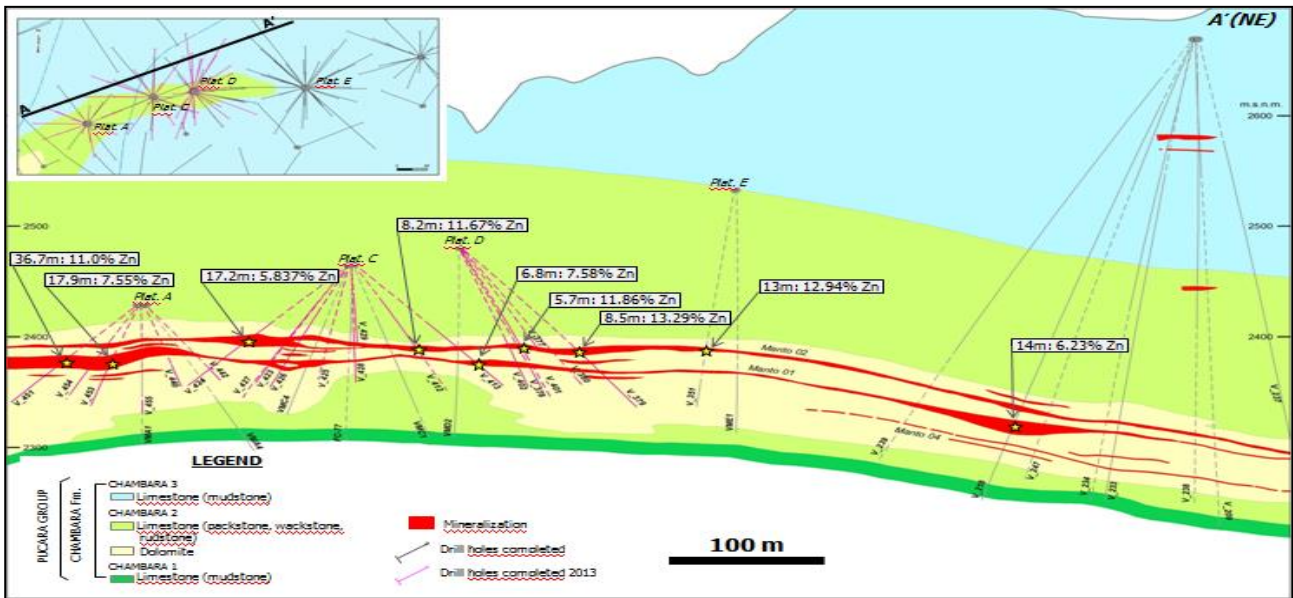


Fig. 6 Geological cross section - karen milagros sector – Cañón Florida Project.

Geological mapping at regional scale and the its structural analysis have allowed to identify a regional structural corridor (faults and folds) of Andean orientation called Utcubamba-Bongará that affects the Pucará Group carbonate sequences and the Sam and El Tesoro Faults with NNE-SSW and SSE-NNW orientations respectively, they control the Mississippi Valley Type deposit of the Cañón Florida Project; Northern Peru, whose geological and structural characteristics will serve as a pattern to infer the possibility of finding new similar deposits.

Microscopic studies with light microscopy, X-ray diffraction and scanning electron microscope, corroborate the minerals recognized macroscopically in the field.

The identification and paragenesis corroborate that the mineralogy is simple (sphalerite-galena association and dolomite, calcite, pyrite and marcasite) typical of Mississippi Valley Type deposits in carbonated environments.

Chambará 2 Member belongs to Chambará Formation of Grupo Pucará and consists of carbonate rocks sequence; originated in a sedimentary environment of high energy, in barriers with the development of local reefs; represented by carbonate

rocks with floatstone, wackestone, packstone and rudstone textures. From diamond drilling observations this unit contains biostratigraphic horizons, markers of local continuity, in the Cañón Florida area, they have been named: Upper Coral Sponge Marker (USM); Intact Bivalve Marker (IBM), Coquina Marker (COQ) and Wackestone-Rudstone Marker (WRM) as detailed below:

(1) Upper Coral Sponge Marker (USM)

It is in the upper part of the Chambará 2 unit, it corresponds to a floatstone-rudstone with few coral-sponge fossils; It has a thickness of 1 to 2 m. It occurs approximately 40 m below the contact of the Chambará 3 unit with the Chambará 2 unit and 20-25 meters above the IBM; it has frequent discontinuities and has local occurrence. See Fig. 7 A.

(2) Intact Bivalve Marker (IBM)

It is located at the top of the Chambará 2 unit; it has 3 to 6 meters thickness; consists of abundant intact bivalve shells of 1 to 2 cm, the shells are uniform in size with very few crinoids. It often has pseudo breccia textures and occasionally mineralized; The most conspicuous thing about this marker is that it presents intact, uniform and rounded shells. It has a certain

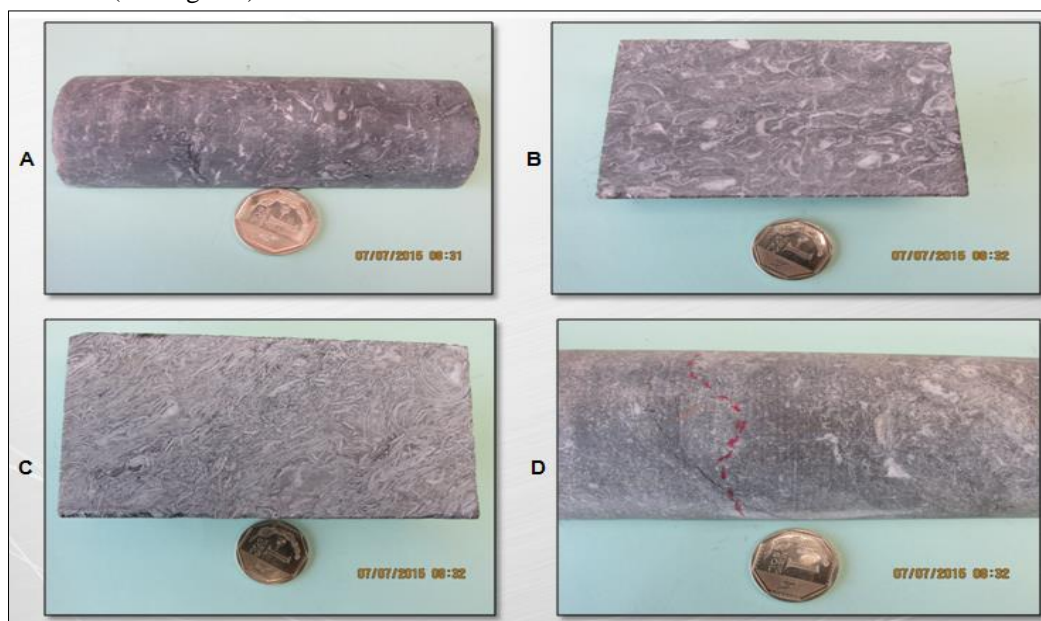
continuity but sometimes it is mineralized making its identification difficult (see Fig. 7B).

(3) Coquina Marker (COQ)

It is located at the bottom of the Chambará 2 unit; it has a thickness of 1.10 to 1.20 m; consists of thin shells of compacted and imbricated bivalves; it has a certain continuity and is easily recognized by the conspicuous characteristics of its flattened bivalves. It contains very little or no crinoids (see Fig. 7C).

(4) Wackestone-Rudstone Marker (WRM)

It occurs in the lower part of Chambará 2 it is a wackestone level (1-2 meters thick) of black matrix with star shaped crinoid fossils in contact with rudstone limestone (3 to 6 meters thick) with large and thick intact shells. It usually occurs approximately 25 meters below the COQ marker and occurs with some discontinuity (see Fig. 7D).



**Fig. 7 A: Upper Coral Sponge Marker (USM), B: Intact Bivalve Marker (IBM), C: Coquina Marker (COQ), D: Wackestone-Rudstone Marker (WRM).**

## 5. Conclusions

Reviewing of more than 100,000 m of cores, review of geological plans, analysis of stratigraphic columns and interpreted geological sections indicate that the Intact Bivalve Marker (IBM) and Coquina Marker (COQ) biostratigraphic markers control dolomitized levels which contain the Zn-Pb mineralized mantles at the Florida Canyon Project.

The Upper Coral Sponge Marker (USM) horizon marks the proximity to contact of packstone limestone and packstone Dolomite of Chambará Member 2.

The Wackestone-Rudstone (MWR) horizon indicates that it is located between packstone limestones and close to the Chambará 1 Member with fine granulometry (mudstone).

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