[PS]Seismic, Magnetotelluric, Geological Surface and Wells Data Integration in the Exploratory Potential Evaluation of the Bolivian Sub-Andean: Case Study in the Muchirí Anticline*

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Abstract

The Bolivian South Sub-Andean is a regional fold and thrust belt, thin skinned, with a remarkable regularity and continuity north-south in the geometry of the structures. In the area of study there are three parallel lineaments, which extend from south to north. In the east section, is the Charagua Range, which is named Muchirí in this zone. At the beginning of the exploratory activities in the Sub-Andean, a prospect was identified with Devonian objectives in the Muchirí Anticline. In the central zone of this area is located the Caipipendi Monocline. Finally, in the western sector of the area is the Tatarenda Range.

In the Muchiri Anticline there is a high geological uncertainty. This is the reason why, in 2016, a magnetotelluric (MT) geophysical survey was carried out. The MT results supported the analysis by providing new information that allowed identifying the interface between the Los Monos and Huamampampa formations (Devonian) and enhancing the definition of the structure's geometry in depth. The goal of this work was to integrate in a balanced structural model the seismic data (250 km), the surface geology and wells with the magnetotelluric data. With this integration, it was possible to perform an evaluation of the exploratory potential of the area, focused on the Muchirí Anticline, obtaining a reliable geological-structural model.

The interpretation process began with the construction of the geological model based on the 2D seismic information, the geological map, dip and azimuth data from the surface, and the well data, independent of the MT sections. Afterward, the MT-Resistivity sections were added to the interpreted sections in order to compare both responses. The matching verification between the geo-electric sections and the seismic sections was done. Once the information was confirmed, it was used as the input for the constrained inversion. Firstly, the geological model matched the anomalies of the MT sections. Secondly, the interpretation process continued, refining the geological model on the sections and the MT volume with blind and constrained inversion. Finally, the sections were improved and constrained. The structural maps were prepared for the reservoirs.

The model generated for the Muchirí Anticline corresponds to a fault bend fold with a lower detachment in the shales of the base of the Silurian and an upper detachment in the upper lutitic levels of the lower Emsian-Pragian that transfers shortening by passive-roof duplex to the Eifelian-Givetian structural level and then by passive-roof duplex at the Frasnian-Cenozoic structural level. The result of the integration showed that the Muchirí Anticline would correspond to the plunge of the Charagua Range. Because of this study, the idea of drilling wells in the Muchirí is not being considered without more research of the highest part of the structure in the Charagua area.

SEISMIC, MAGNETOTELLURIC, GEOLOGICAL SURFACE AND WELLS DATA INTEGRATION IN THE EXPLORATORY POTENTIAL EVALUATION OF THE BOLIVIAN SUB-ANDEAN: CASE STUDY IN THE MUCHIRÍ ANTICLINE

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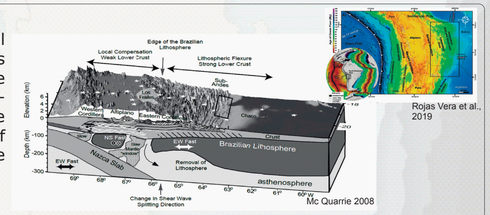
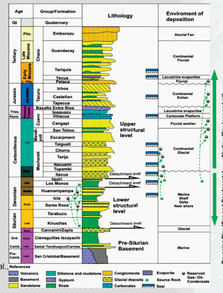
- Geological Settings

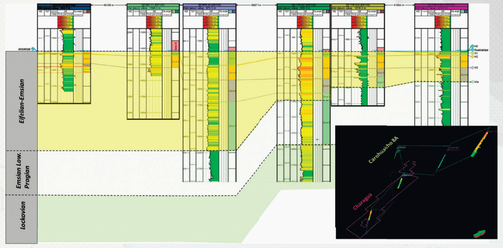
Bolivian South Sub-Andean is a regional thin skinned fold and thrust belt. Its geometry delineates a remarkable regularity and continuity in the North-South orientation. It corresponds to the most important geological province of Bolivia in reserves and gas condensate production.



Rojas Vera et al., 2019



Rojas Vera et al., 2019



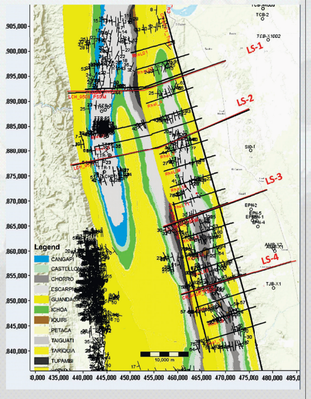
The oil exploration carried out in the sub-Andean during the last 15 years allowed for gas mega fields discovery with reservoirs of the Huamampampa, Icla and Santa Rosa formations of Devonian age.

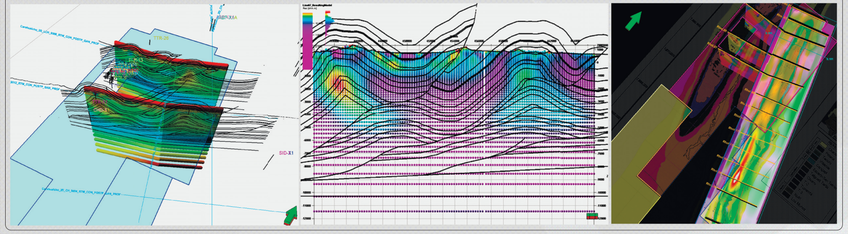
-Project Background

At the beginning of the exploration activities in the sub-Andean, it was identified a prospect with Devonian objectives in the Muchirí anticline.

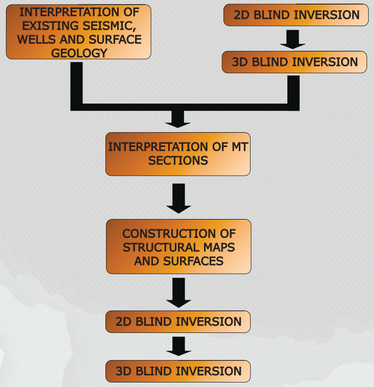
In the work area, there is the following information available: Geological Surface Map with dip and azimuth information, 6 seismic lines (250km) migrated in PSTM and PSDM and several wells (two of them drilled the Devonian reservoirs).

The MT results supported the analysis at providing new information that allowed identifying the interface between Los Monos and Huamampampa formations (Devonian). The MT results allow to get a better definition of the structure´s geometry in depth.





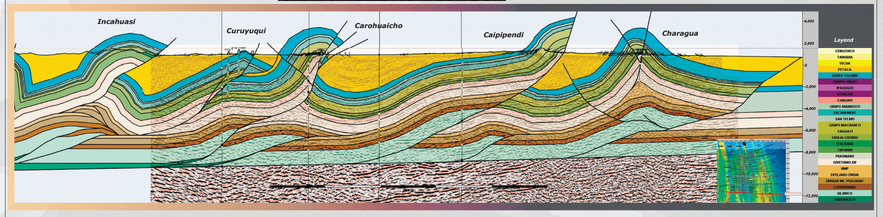
- Workflow



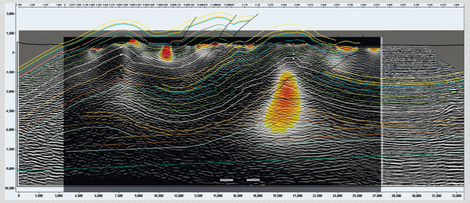
The interpretation process began with the generation of a geological model based on the 2D seismic information, the geological map, dip and azimuth data from the surface, and the well data. Secondly, the MT – Resistivity sections were added to the interpreted sections in order to compare both responses. Then, the geo-electric sections and seismic sections were correlated. Finally, once the information was confirmed it was used as the input for the constrained inversión.

The Muchirí anticline Model corresponds to a fault bend fold with a lower detachment in the shales of the bottom of the Silurian and an upper detachment in the upper shale levels of the lower Emsian-Pragian. It transfers a shortening by passive-roof duplex to the Eifelian-Givetian structural level and then by passive-roof duplex at the Frasnian-Cenozoic structural level. The shallow structures correspond to anticlines generated by the shortening transmission of a fault bend fold structure that is generated below the Tatarenda structure.

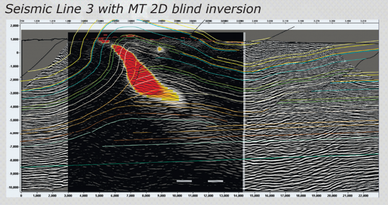
Subandean Thrust and Fold Belt



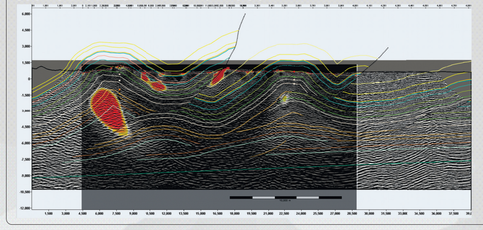
Seismic Line 1 with MT 2D blind inversion



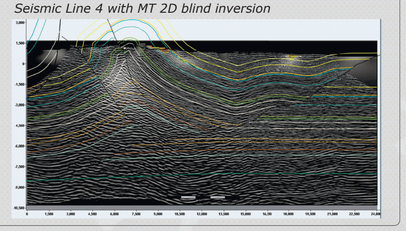
Seismic Line 3 with MT 2D blind inversion



Seismic Line 2 with MT 2D blind inversion

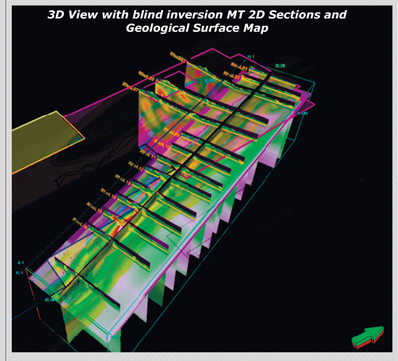


Seismic Line 4 with MT 2D blind inversion

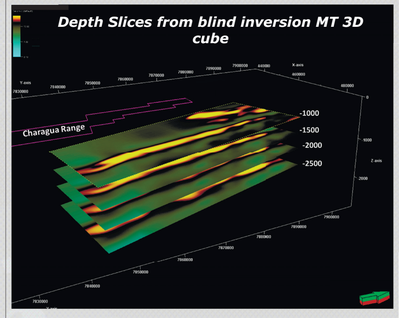


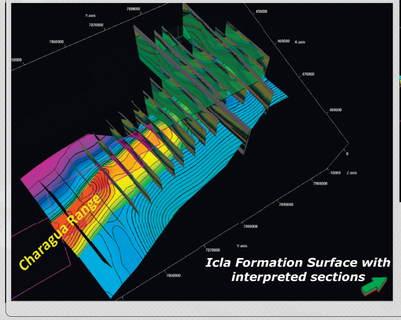
Firstly, the geological model and the anomalies of the MT sections were correlated. Secondly, the interpretation process continue and the geological model was refined on the new sections and on the MT volume with blind and constrained inversion.

3D View with blind inversion MT 2D Sections and Geological Surface Map



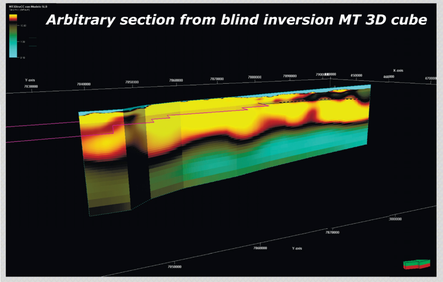
Depth Slices from blind inversion MT 3D cube

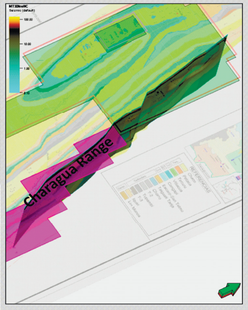




Icla Formation Surface with interpreted sections

Arbitrary section from blind inversion MT 3D cube





Arbitrary Section are illustrated above

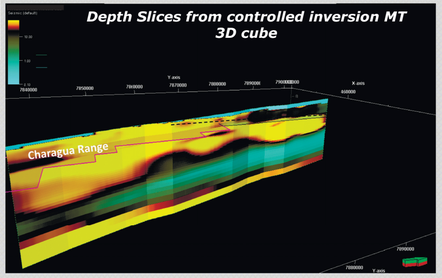
The arbitrary line was deployed on the axis of the anticline, in the structure's orientation.

The anomaly of the resistivity gets deeper in the study area.

Depth Slices illustrate that the resistivity anomaly is stronger in the South area. The display has vertical exaggeration x10.

Likewise, the resistivity anomaly is identified in a shallower depth in Charagua area.

Depth Slices from controlled inversion MT 3D cube



Finally, the sections were improved and constrained. The structural maps were prepared for the reservoirs of interest that correspond to the Devonian sands. This map shows that the crest of the structure is in the south of this area.