Case Study and First Look: Contemporary Magnetotelluric Studies Within Nereidas Valley, Nevado Del Ruiz Volcano, Colombia

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ABSTRACT

Empresas Públicas de Medellín E.S.P. (EPM) and its subsidiary Central Hydroelectric de Caldas S.A. (CHEC) are presently evaluating the geothermal potential within the Nereidas Valley near Nevado del Ruiz, a volcano located on the border of the departments of Caldas and Tolima in Colombia, about 129 kilometers (80 mi) west of the capital city Bogotá (Figure 1). EPM has contracted with the Dewhurst Group, LLC (DG) to perform the evaluation, and to provide expertise and recommendations to move the project forward. As part of that effort, DG together with CHEC has formed a working partnership with the University of Caldas, Manizales, Colombia. In addition to a review of legacy data, geological mapping and geochemistry, DG is performing a magnetotelluric survey consisting of over 300 soundings to help guide the construction of a new geologic conceptual model. Currently, it appears that the survey area has significant geothermal potential. A review of the project and exploration efforts, which are on-going, will be presented as a student-led poster presentation.

Colombia Energy Requirements

Deriving the majority of its power from hydroelectric facilities, Colombia has an energy supply deficit. As a result, frequent and massive brown/black-outs impact the economy. In addition, there is a concerted effort within EPM, one of the major energy suppliers, to maintain a "green" footprint, leading to the diversification of their energy portfolio. EPM's effort requires research and development of renewable energy sources, such as from biomass, wind, solar and existing geothermal sources.

Nevado Del Ruiz, one of the most active and notorious volcanoes in South America (Thouret et al, 1990) is of current interest due to its perceived potential (based largely on surface manifestations and legacy investigations). The tectonic, regional, and local geology appear nearly ideal as a source for the generation of geothermal power. Indeed, a single wellbore in 1997 proved that sufficient temperature (greater than 200°C) can be found at drillable depths but the location of thermal waters proved ellusive. Nonetheless, new surveys and methods were brought to the project in 2013 with the goal of discovering a significant geothermal source appropriate for exploitation to help meet local energy requirements of the rural community as well as nearby urban centers near Manizales, thereby supplementing power from existing hydroelectric facilities.

The completion of this study is of great importance for future development in the region. Geothermal reservoirs if correctly managed may be able to provide much needed base load power for the area over an indefinite and substantial time. It is believed that energy derived from these geothermal sources will hopefully lessen environmental impacts compared to conventional sources and provide sufficient clean, renewable energy for rural farming activities and other economic development.

Figure 1. Survey Area.

General Discussion

Three tectonic plates, the Nazca (oceanic), Caribbean and South American (continental) plates collide within Colombia and are further impacted by two additional micro-plates as in Panama, Costa Rica and the northern Andes(González, 1993, James, 1986). The study area is controlled by a system of major fault groups including the Romeral, Mulattoes and Palestine systems. Local faults associated with Villa Maria thermal failures, Nereidas and Rio Claro river valleys constrain the structural scheme and control the location of fumeroles and hot springs in the study area. Further, the survey area is structurally influenced by the intersection of faults, fracture zones and structural failures with NS to NNE-SSW orientation coinciding with the Andina Chain having a transverse direction with general orientation of NW-SE and EW (Mejia Toro, 2012).

The lithological characteristics (Cajamarca Complex - Complex Quebradagrande) of the area influence the results obtained from magnetotelluric surveys. Both low-frequency (LMT – 0.0001 to 8Hz) and broad-band (BMT – 0.01 to 1000Hz) magnetotelluric soundings were made.

Resistivity values vary significantly within the lithology with the Cajamarca Complex, having units of graphite and the Quebradagrande Complex containing volcanic and sedimentary units. Resistivity contrasts can be significant but in general interpretation is complicated by the presence of conductive rock units within the metamorphic, sedimentary and volcanic sequences.

The magnetotelluric surveys, together with legacy and new geologic and geochemistry data, permit the development of a new geologic model for the area. Subsurface electrical resistivity derived from 1-D, 2-D and 3-D inversions of the MT data, with the addition of photo-liniment mapping, geochemistry, and ground mapping of the structural geology, help to imply rock type, layering geometries and spatial separation between geologic units. Further, it is possible to infer and map the presence of water, dikes, faults, discontinuities, fractures and zones of mineralization at depth.

A primary goal of this work is the execution of new exploratory wells and reservoir simulation.

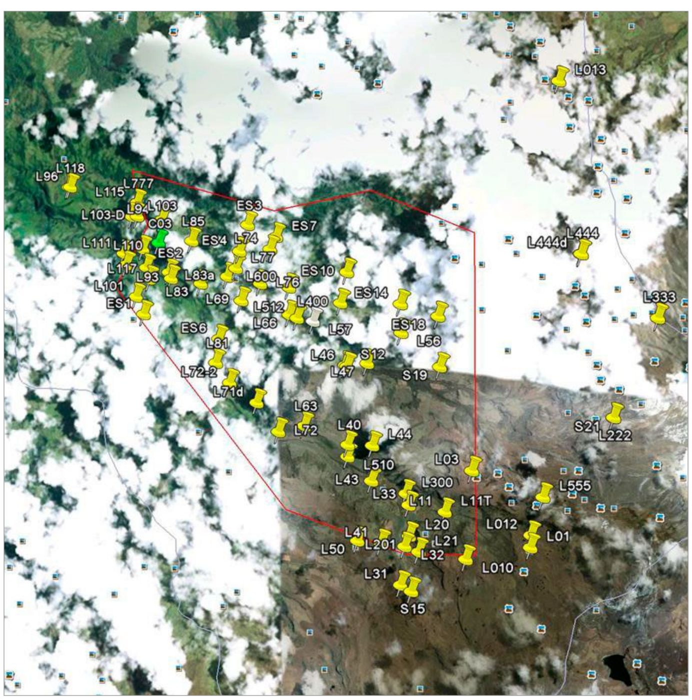

Figure 2. LMT station distribution. Note that the terrain is quite severe in Nereidas Valley and some areas are impossible to visit.

Results

The LMT survey indicates that a number of possible geothermal sources can exist within the Nereidas Valley. This survey also suggests why the previous drilling efforts in 1997 failed – they simply missed the target by perhaps 1.5km.

The BMT survey, which is still ongoing, is expected to show apparent localized faulting and fractures as well as defining regions of conductance that are possibly related to graphitic metamorphic rock, geothermally altered cap rock, and or concentrations of brine.

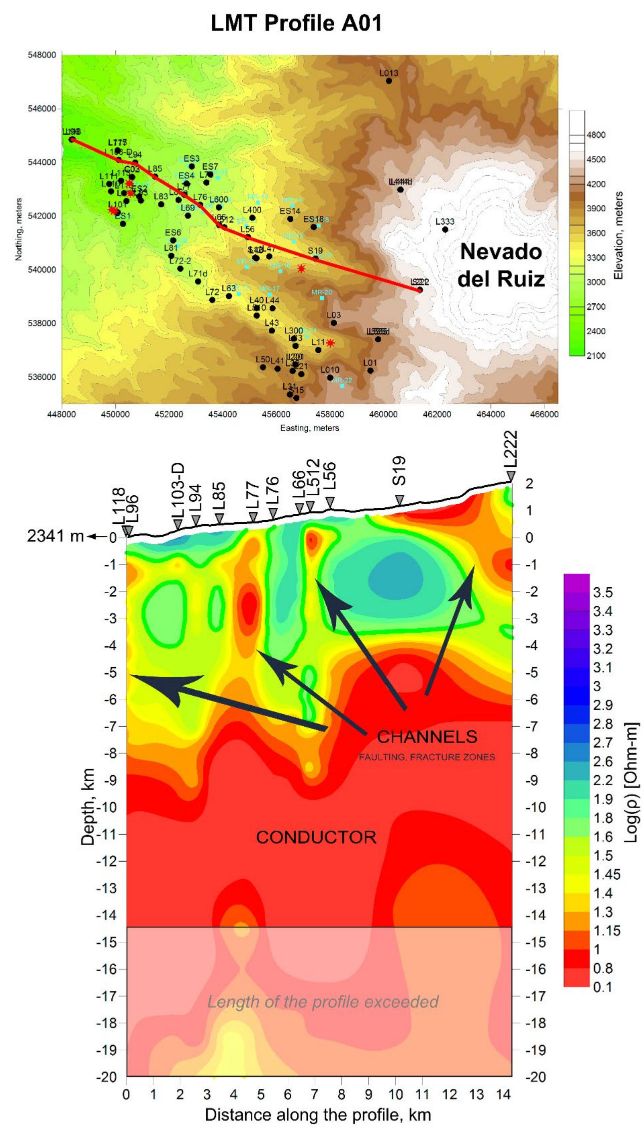

Figure 3. 2-D profile inversion for Profile A01. Apparent faulting and fracture zones can be seen as areas of low resistivity.

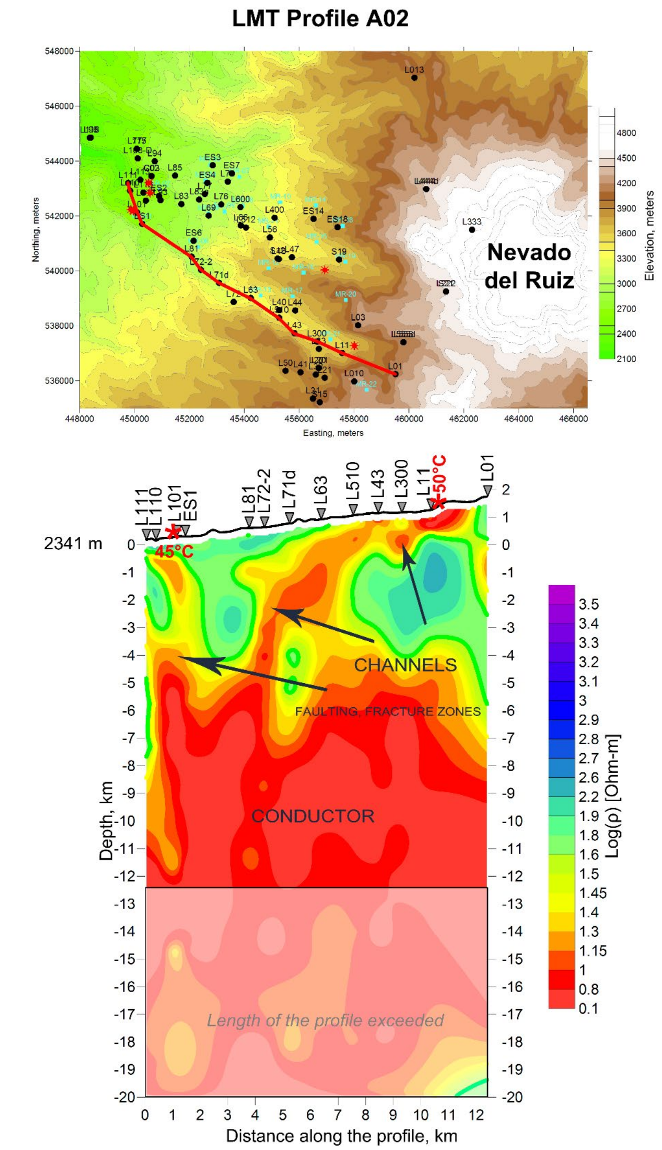

Figure 4. 2-D inversion of Profile A02. Again, areas of low resistivity appear to vertically connect from a deeper conductor to surface manifestations, such as hot springs and fumaroles. Measured temperature of surface hot springs are noted.

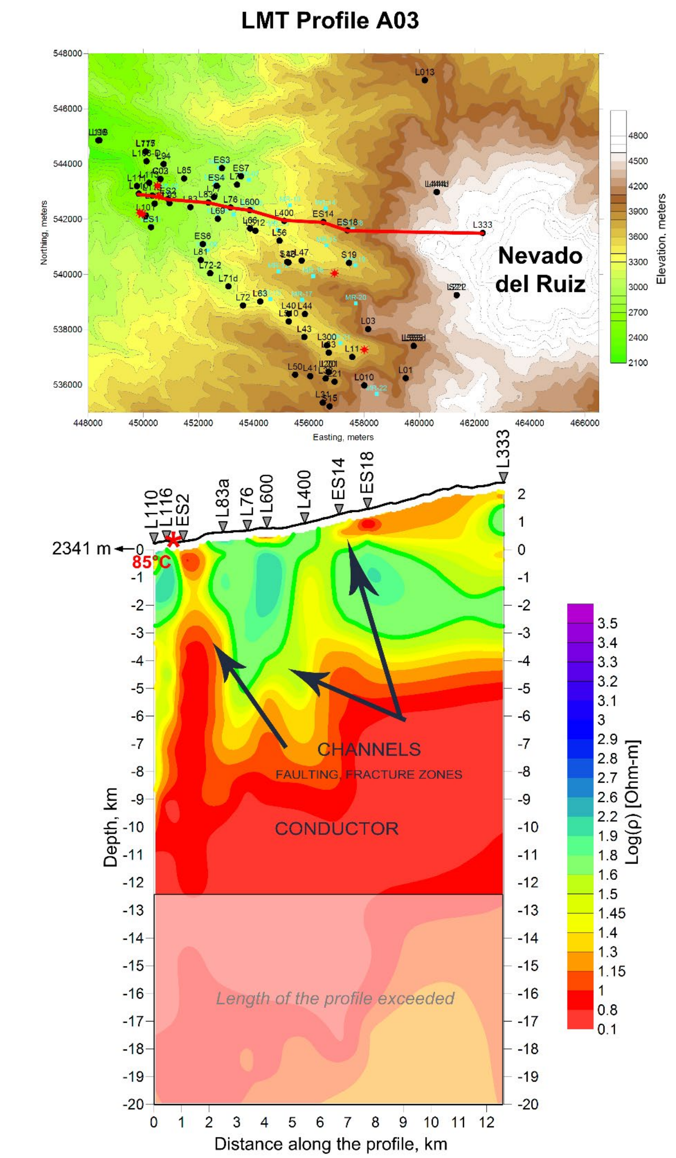

Figure 5. 2-D inversion of Profile A03. More "channeling" conductors from a large deeper conductor to the surface is apparent. It is believed that these vertical conductors are related to geothermally altered rock along fault and fracture zones. Temperature of a nearby surface hot spring is noted.

The BMT results will be more fully developed and presented with the poster presentation.

Poster Presentation

An in-depth presentation of our experiences and the results obtained from these survey efforts, along with information about the importance of this project from both a scientific and social perspective, will be presented.

Acknowledgements

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