Local earthquake tomography at Los Humeros geothermal field (Mexico)

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Motivation and objectives

Los Humeros geothermal field is located in the eastern part of the two Mexican transcurrent faults (MTW), it is one of the largest geothermal fields in Mexico with around 40 wells operated by the Federal Electric Commission (CFE, by its Spanish acronym). From a geostatistical point of view it is divided into 4 main units: basement (mainly limestone and chalk), pre-caldara (andesites hosting the geothermal reservoir), caldera (gimnísintes), and post-caldara units (gimnísintes and basalt).

Between September 2017 and September 2018, a seismic network consisting of 45 seismic stations was deployed to monitor the geothermal field. This experiment, in addition to several geophysical, geological, and geochronological surveys, has been conducted in the framework of the European H2020 project SIMUL (for a better understanding of the structures and behavior of the geothermal reservoir under current exploitation, and for investigating future development areas).

We analyzed the continuous records to detect local microseismicity. The retrieved catalog was used to derive a minimum 1D velocity model. We then performed a joint inversion to obtain the 3D Vp and Vs/Vs structures of the geothermal field. Our main objective is the identification of underground structures, and possible variations due to changes in fluid content, temperature, and rock porosity for future development of the geothermal field. [11]

Local seismicity

To obtain a minimum 1D velocity model, simultaneous inversions of hypocentral parameters, velocities and station corrections were performed using the VELSTF software [7]. We inverted for a grid of around 2000 initial velocity models with varying top velocities and gradients. We compared the results and selected the model with lowest resulting RMS as an initial reference model for the seismic tomography.

Minimum 1D Velocity model

We performed the simultaneous inversion for the 3D tomographic structures and stress hypocenters using the SIMUL1D code [9]. We extended the classical tomographic method by inverting for several different initial grids and averaging the results.

Conclusions and outlook

Results of this study reveal several new insights of the geothermal field. First, a new seismogenic zone has been identified towards the east of the main production area (cluster C3). In addition we have identified several known and inferred structures with our tomographic results.

The retrieved seismic properties, in combination with alternative geophysical and laboratory measurements have allowed the understanding of the geometry of the underground units and the rheology of the system. Although at the moment interpretation is performed in a qualitative manner, the next step would be a quantitative analysis of the gathered data from the different techniques via cluster analysis for better discrimination of different units.

References


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3D Velocity model

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