Towards visualization of possible fluid pathways using gravity in Los Humeros and Acoculco geothermal fields

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1 Introduction

GEMex is a cooperation project in geothermal energy research is being carried out between Mexico and the European Union. GEMex focusses on resource assessment, reservoir characterization and concept development of two unconventional geothermal system located in the Trans-Mexican volcanic belt: Acoculco (Enhanced Geothermal System, EGS) and Los Humeros (Superhot Geothermal System, SHGS).

Los Humeros field in currently under exploitation and the area to the north of the current production if significantly hotter, with more than 380°C. The high temperatures and the water chemistry are the principal challenges in this part of the reservoir. On the other hand, in Acoculco, only two exploration wells have been drilled. The temperatures rise to about 300°C at a depth of 2 km. The high temperature gradient and the undiscovered resource makes it an interesting target for exploitation and testing of our knowledge.

This study aims at visualize and characterize reservoir condition in Los Humeros using gravity by calibrating the data with data from the geothermal wells. In a second step the transferability of the findings to the northern part of Los Humeros and in a third step to Acoculco site will be tested.

2 Fieldwork and data

Local gravity data have been acquired in the two geothermal fields using a CG-5 Autograv Gravity Meter (Scintrex Ltd.) with an accuracy of 0.001 mGal. This gravimeter measures continuously by averaging a series of 6 Hz samples. The coordinates of each gravity station were determined by differential GPS using two Trimble 5700 receivers and two Trimble antennas (TRM39105 and TRM41249).

Acoculco: 84 gravity stations were acquired in an about 5 x 3 km rectangular grid oriented NE-SW and NW-SE with a typical station distance of 400 m to each other.

Los Humeros: 344 gravity stations were measured in two different surveys. 263 stations were measured along ten E-W profiles of 5.5 km length with typical inter-station and inter-profile distances of 200 m and 500 m, and a NE-SW oriented and 31 km long profile across the study area. This profile includes 81 gravity station with an inter-station distance of about 375 m.

The data quality bases on the measurement accuracy of the differential GPS (vertical: 5 mm), the gravimeter (0.001 mGal) and the standard deviation of the gravity and GPS measurements

On the other hand, regional gravity data of both areas were kindly provided to GEMex consortium by the Comision Nacional de Hidrocarburos in form of Bouguer corrected values using a material density of 2670 kg m^{-3}.

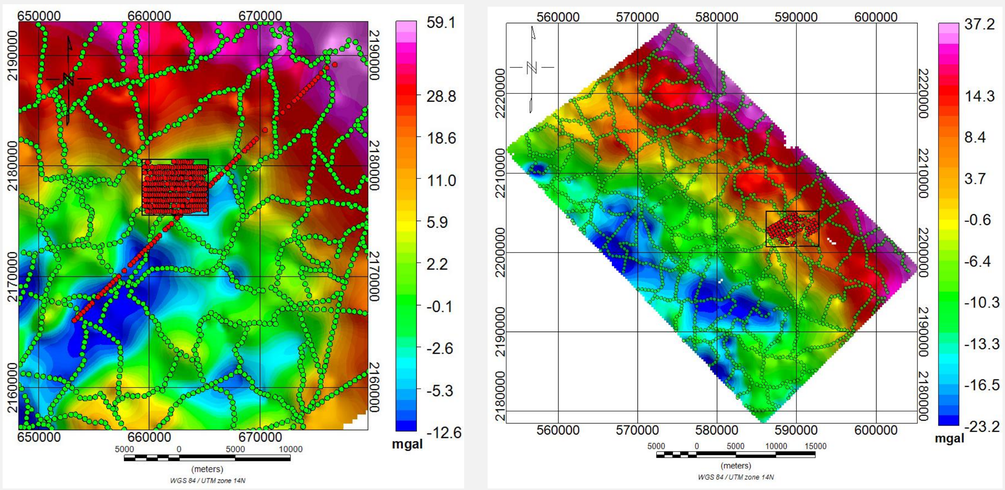

Figure 1. Regional Complete Bouguer Anomalies for a material density of 2670 kg m-3 of Los Humeros (a) and Acoculco (b). Green dots corresponds to regional gravity data provided by the Comisión Nacional de Hidrocarburos, (http://www.gob.mx/cnh). Small black square: extension of the geothermal field and new local gravity data acquired by GEMex (red dots).

3 Processing

Processing of the data has been carried out using the software GravProcess (Cattin et al., 2015). The procedure includes the following steps:

- integration of gravity data, station location, and gravity line connection input files,
- gravity data reduction applying solid-Earth tide and instrumental drift corrections,
- automatic network adjustment and alignment to the base stations, and
- free air and simple Bouguer reduction.

The calculation of the terrain correction was performed with the software Oasis Montaj™ Gravity and terrain Correction extension (Geosoft), bases on algorithms formulated in Kane (1962) and Nagy (1966) and incorporates advancements in grid-mesh interpolation, zoning and desampling techniques.

4 Results and discussion

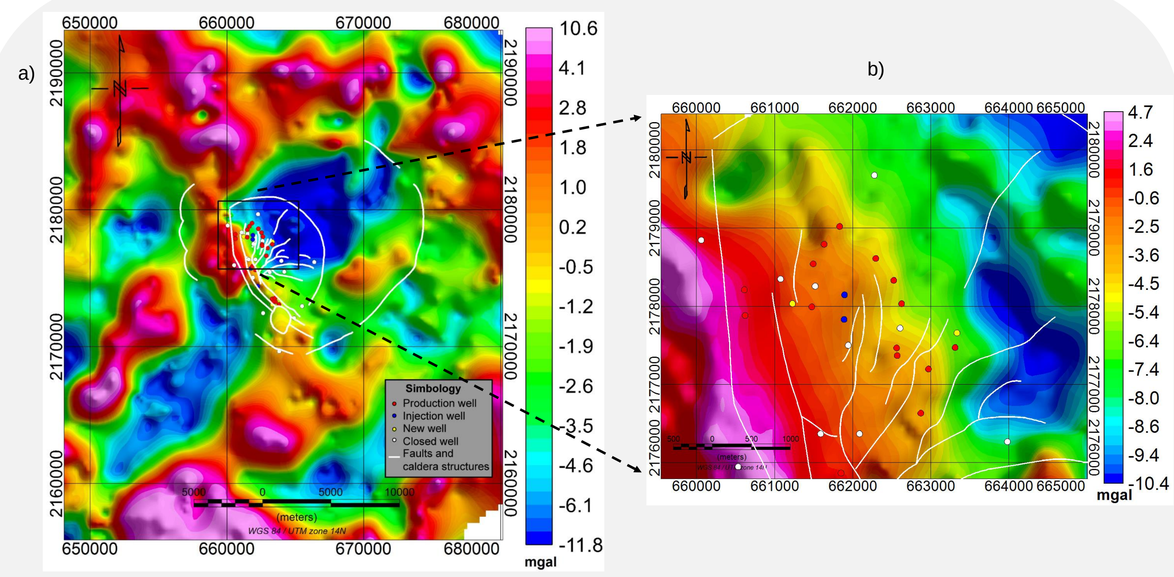

Figure 2. Residual anomalies of the Los Humeros caldera area (a) and geothermal field (b) compared to the fault zones and caldera structures.

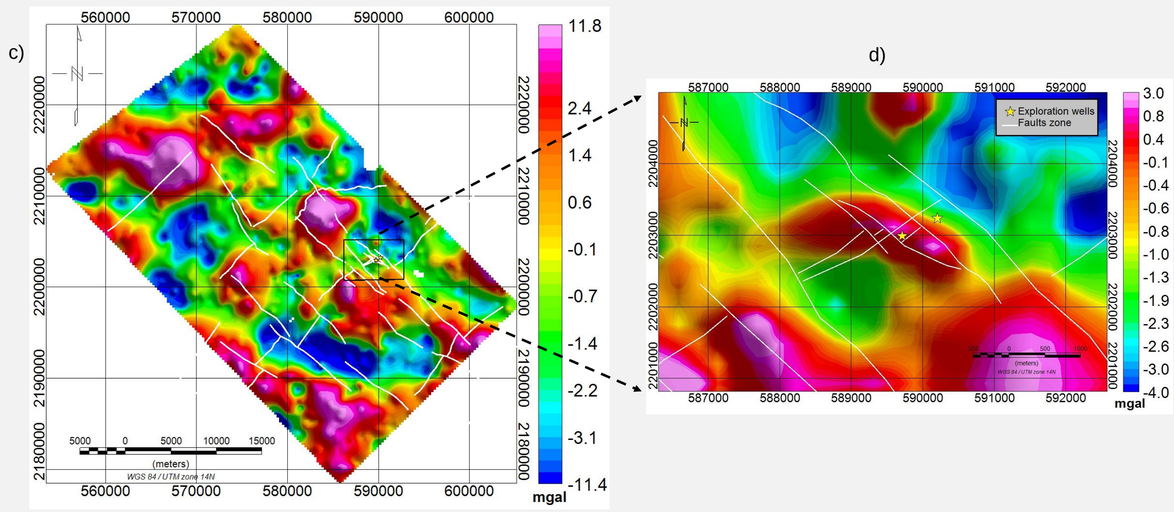

Figure 3. Residual anomalies of the Acoculco caldera area (a) and geothermal field (b) compared to the fault zones.

Residual anomalies reveal a high fault control on the gravity and thus the density distribution. In a) and c), the alignment of the majority of the anomalies follows NE-SW and NW-SE trending fault orientations. This observation provides new insights into the structural setting of the two areas and may contribute to the improvement of the geological models. At a reservoir scale, in Acoculco, areas of high-density anomalies coincide with areas of relatively low-quality geothermal condition. At Los Humeros, the N-S trending secondary faults in the northern part of the geothermal field also coincide with relatively high-density anomalies, whereas the NE-SW to E-W trending secondary faults are characterized by low-density.

5 References

Carrasco-Núñez, G., López-Martínez, M., Hernández, J., and Vargas, V.: Subsurface stratigraphy and its correlation with the surficial geology at Los Humeros geothermal field, eastern Trans-Mexican Volcanic Belt, Geothermics, 67, 1–17, https://doi.org/10.1016/j.geothermics.2017.01.001, 2017a.
Carrasco-Núñez, G., Hernández, J., De Léon, L., Dávilla, P., Norini, G., Bernal, J. P., Jicha, B., Jicha, B., Navarro, M., and López-Quiroz, P.: Geologic Map of Los Humeros volcanic complex and geothermal field eastern Trans-Mexican Volcanic Belt, Terra Digitalis, 1, 1–11, 2017b.
Cattin, R., Mazzotti, S., Baratin, L.-M., 2015. GravProcess: an easy-to-use MATLABsoftware to process campaign gravity data and evaluate the associated un-certainties. Comput. Geosci. 81, 20–27.http://dx.doi.org/10.1016/j.cageo.2015.04.005
Norini, G. Gropelli, G., Sulpizio, R., Carrasco-Núñez, G., Dávila-Harris, P., Pellicioli, C., Zucca, F., and De Franco, R.: Structural analysis and thermal remote sensing of the Los Humeros Volcanic Complex: Implications for volcano structure and geothermal exploration, J. Volcanol. Geoth. Res., 301, 221–237, 2015.

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